LEVEL II SCOUR ANALYSIS FOR BRIDGE 42 (BETHTH00860042) on TOWN HIGHWAY 86, crossing GILEAD BROOK, BETHEL, VERMONT

U.S. Geological Survey
Open-File Report 96-310

Prepared in cooperation with
VERMONT AGENCY OF TRANSPORTATION
and
FEDERAL HIGHWAY ADMINISTRATION

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By JOSEPH D. AYOTTE and DONALD L. SONG

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Pembroke, New Hampshire

1996

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

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

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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 42 (BETHTH00860042) ON TOWN HIGHWAY 86, CROSSING GILEAD BROOK, BETHEL, VERMONT

***By* Joseph D. Ayotte and Donald L. Song**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BETHTH00860042 on town highway 86 crossing Gilead Brook, Bethel, 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). A Level I study is included in Appendix E of this report. A Level I study provides a qualitative geomorphic characterization of the study site. Information on the bridge available from VTAOT files were compiled prior to conducting Level I and Level II analyses and can be found in Appendix D.

The site is in the Green Mountain physiographic province of central Vermont in the town of Bethel. The 11.4-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the upstream banks are tree covered and the downstream banks are covered with shrubs and brush.

In the study area, Gilead Brook is probably incised, has a sinuous channel with a slope of approximately 0.012 ft/ft, an average channel top width of 53 ft, and an average channel depth of 5 ft. The predominant channel bed material is gravel to cobbles (D_{50} is 85.6 mm or 0.281 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 30, 1994, indicated that the reach was stable.

The town highway 86 crossing of Gilead Brook is a 28-ft-long, one-lane bridge consisting of one 25-foot clear-span structure with a concrete deck (Vermont Agency of Transportation, written commun., August 24, 1994). The bridge is supported by concrete abutments with wingwalls. The bridge skew is approximately 5 degrees and there is no opening-skew-to-roadway.

A scour hole approximately 1 ft deeper than the mean thalweg depth was observed along the left bank, near the upstream bridge face during the Level I assessment. There is also approximately 1 ft of scour along the left abutment of the bridge, near the upstream wing wall, exposing the footing. There is type-one (less than 12 in diameter) protection on the US left wingwall and type-two (less than 36 in diameter) along the US and DS right wingwalls. There is no protection along the abutments. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995).
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 to 1.9 ft. The worst-case contraction scour occurred at the incipient-overtopping discharge and the 100-year discharge. Abutment scour ranged from 8.6 to 15.7 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 others, 1995, p. 47). Many factors, including historical performance during flood events, the geomorphic assessment, scour protection, and the results of the hydraulic analyses, must be considered to properly assess the validity of abutment scour results. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein, based on the consideration of additional contributing factors and engineering judgement.

Randolph, VT. Quadrangle, 1:24,000, 1981

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 BETHTH00860042 ***Stream*** Gilead Brook

County Windsor ***Road*** TH086 ***District*** 04

Description of Bridge

Bridge length 28 ***ft*** ***Bridge width*** 14.4 ***ft*** ***Max span length*** 25 ***ft***

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

Abutment type Vertical ***Embankment type*** Sloping

Stone fill on abutment? No ***Date of inspection*** 9/30/94

Description of stone fill Some type-1 on US left wingwall and type-2 on US and DS right wingwalls; stone fill is in good condition except along the US left wingwall where it is slumped.

Abutments are concrete and in good condition.

Brief description of piers/abutments

Y

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

N

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

9/30/94

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	9/30/
Level II	94	--	--

Potential for debris Low.

None--9/30/94.

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 upland valley with steep valley walls.

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

Date of inspection 9/30/94

DS left: Narrow flood plain to steep valley wall

DS right: Narrow flood plain to steep valley wall

US left: Narrow flood plain to steep valley wall

US right: Narrow flood plain to steep valley wall

Description of the Channel

Average top width 53 ***ft*** ***Average depth*** 5 ***ft***

Predominant bed material gravel/cobble ***Bank material*** gravel/cobble

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

9/30/94

Vegetative co Shrub and brush land

DS left: Shrub and brush land

DS right: Forest

US left: Forest

US right: Y

Do banks appear stable? Only a minor cut bank reported on the US left bank ***If not, describe location and type of instability and date of observation.***

The assessment of 9/30/94 noted no channel obstructions

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 11.4 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province	***Percent of drainage area***
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 ***mi²***

Is there a lake/p -- No

Calculated Discharges

Q100 2,200 ***ft³/s*** ***Q500*** 2,800 ***ft³/s***

The 100- and 500-year discharges are taken from the Vermont Agency of Transportation data base (VTAOT, written comm., May, 1995) and were compared against several empirical methods (Johnson and Tasker, 1974; Potter, 1957a; Potter, 1957b; Talbot, 1887; Benson, 1962; Federal Highway Administration, 1983).

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 concrete abutment at junction with US right wingwall (elev. 502.76 ft, arbitrary datum). RM2 is a chiseled X on top of concrete abutment at junction with DS left wingwall (elev. 503.35 ft, arbitrary datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT1	-49	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
DSBRG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPRO	43	2	Modelled Approach section (Templated from APPR1)
APPR1	49	1	Surveyed 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). 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, Jr. and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values ranged from 0.05 to 0.055, and overbank "n" values were 0.09.

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 0.012 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1986).

The surveyed approach section (APPR1) was moved along the approach channel slope (0.012 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

The modeled 100-year discharge does not overtop the roadway embankment but the modelled 500-year discharge does.

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

Bridge Hydraulics Summary

Average bridge embankment elevation 503.2 *ft*
Average low steel elevation 501.7 *ft*

100-year discharge 2,200 *ft^3/s*
Water-surface elevation in bridge opening 497.8 *ft*
Road overtopping? N *Discharge over road* -- *ft^3/s*
Area of flow in bridge opening 155 *ft^2*
Average velocity in bridge opening 14.2 *ft/s*
Maximum WSPRO tube velocity at bridge 17.8 *ft/s*

Water-surface elevation at Approach section with bridge 501.8
Water-surface elevation at Approach section without bridge 499.1
Amount of backwater caused by bridge 2.7 *ft*

500-year discharge 2,800 *ft^3/s*
Water-surface elevation in bridge opening 501.8 *ft*
Road overtopping? Y *Discharge over road* 310 *ft^3/s*
Area of flow in bridge opening 249 *ft^2*
Average velocity in bridge opening 9.8 *ft/s*
Maximum WSPRO tube velocity at bridge 11.9 *ft/s*

Water-surface elevation at Approach section with bridge 504.0
Water-surface elevation at Approach section without bridge 499.8
Amount of backwater caused by bridge 4.2

Incipient overtopping discharge 2,240 *ft^3/s*
Water-surface elevation in bridge opening 497.8 *ft*
Area of flow in bridge opening 156 *ft^2*
Average velocity in bridge opening 14.3 *ft/s*
Maximum WSPRO tube velocity at bridge 17.8 *ft/s*

Water-surface elevation at Approach section with bridge 501.9
Water-surface elevation at Approach section without bridge 499.2
Amount of backwater caused by bridge 2.7 *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, 1993). 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 was computed by use of the clear-water contraction scour equation (Richardson and others, 1993, p. 35, equation 18) for the 100-year and incipient road-overflow discharges. Contraction scour for the 500-year discharge was computed by use of the Chang pressure-flow scour equation (Richardson and others, 1995, p. 145-146). For the 500-year modelled discharge, there was orifice flow at the bridge. 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). The results of Laursen's clear-water contraction scour (Richardson and others, 1993, p. 35, equation 18) were also computed for the 500-year discharge and can be found in appendix F. For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. In this case, the incipient road-overflow model resulted in the worst-case contraction scour with a scour depth of 2.8 ft.

Abutment scour for the left and right abutment at all modelled discharges was computed by use of the Froehlich equation (Richardson and others, 1993, p. 49, equation 24). The Froehlich equation gives "excessively conservative estimates of scour depths" (Richardson and others, 1993, p. 48). 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.

Worst-case abutment scour occurred at the 500-year discharge for both abutments with scour at left abutment of 11.4 ft and scour at the right abutment of 15.7 ft.

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	1.9	0.0	1.9
Depth to armoring	48.7	2.3	52.9
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	8.6	11.4	8.7
Left abutment	14.7	15.7	14.8
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:	2.7	1.8	2.7
Left abutment	2.7	1.8	2.7
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

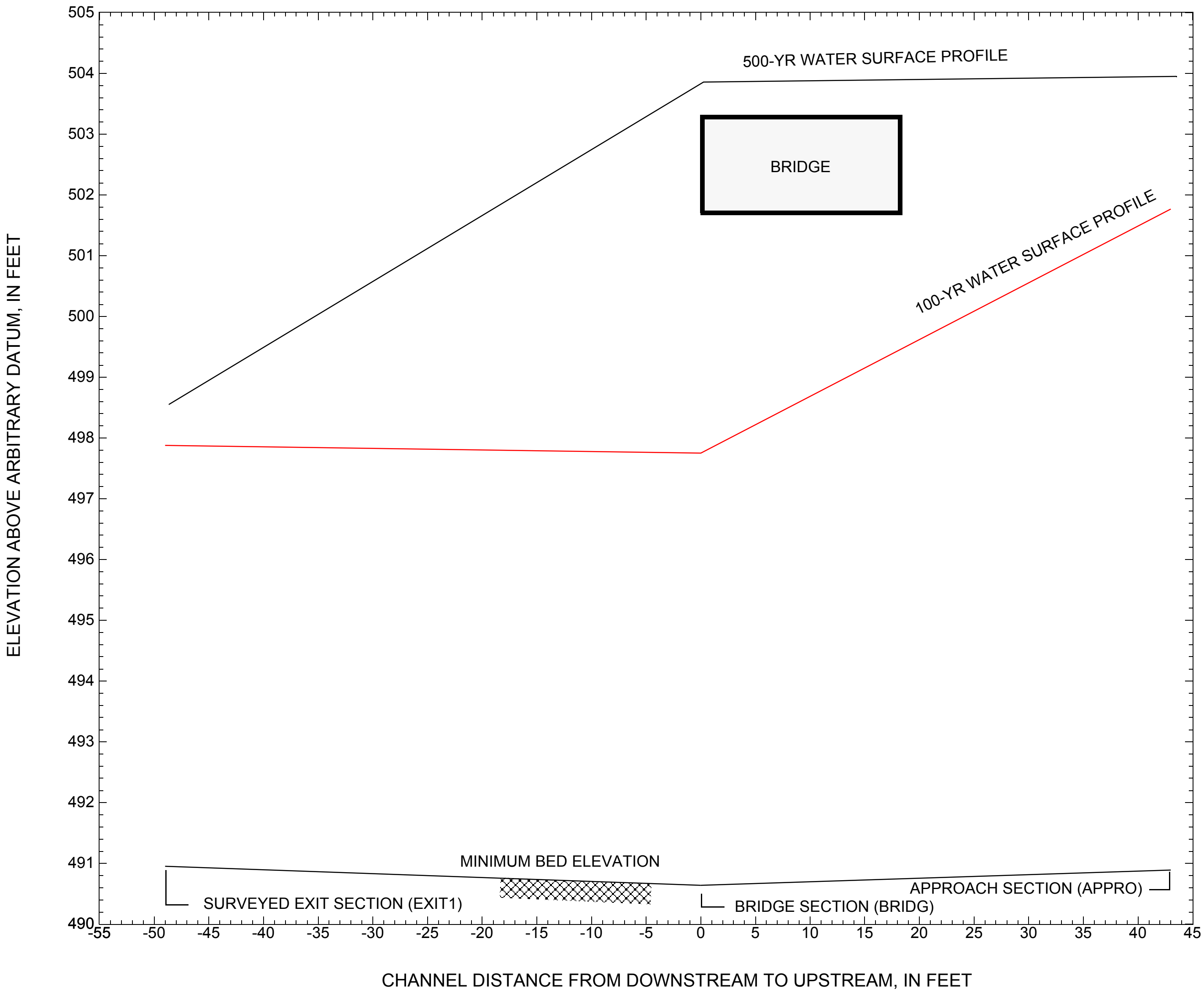

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BRIDTH00340026 on town highway 34, crossing Ottauquechee River, Bridgewater, Vermont.

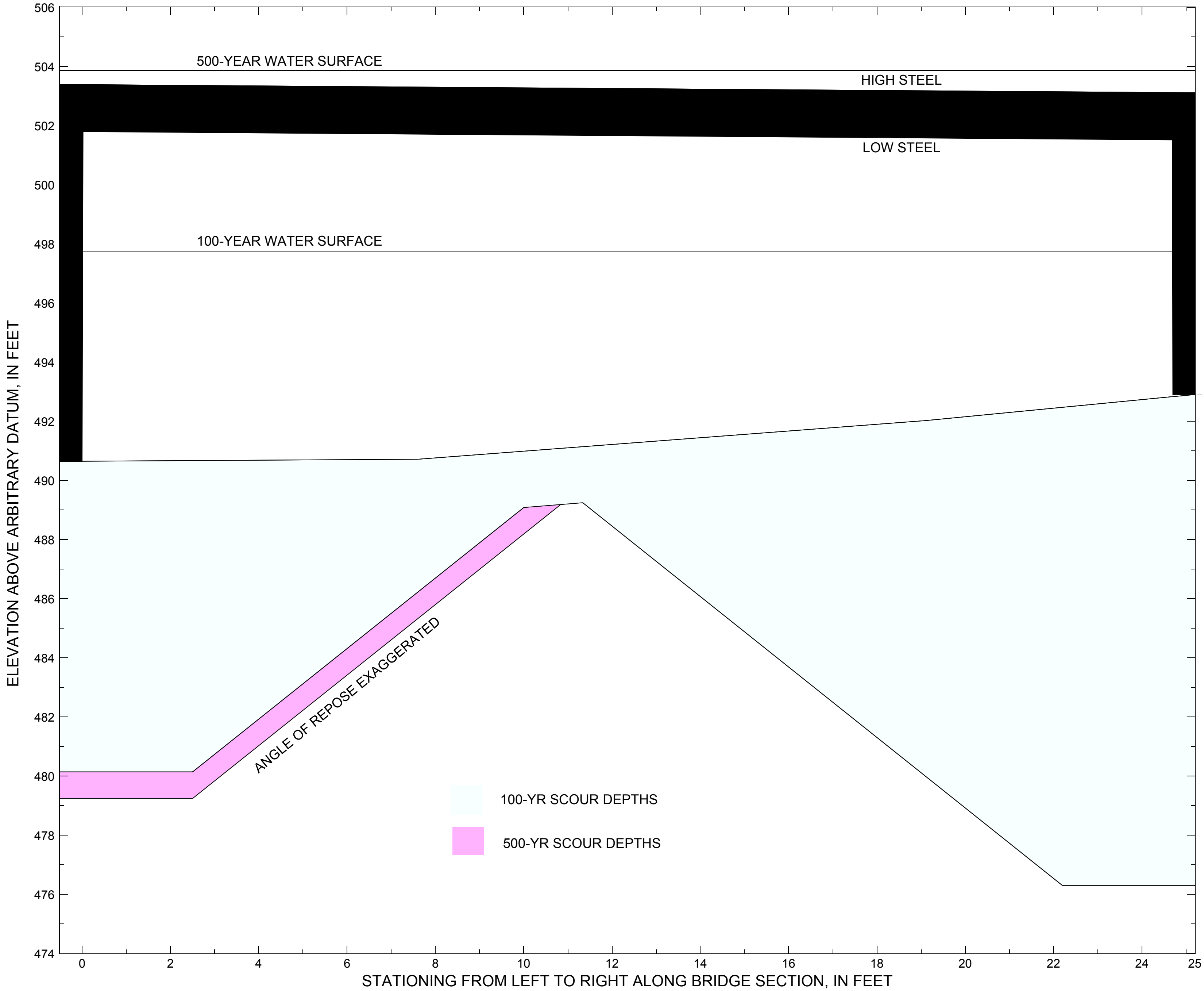

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BRIDTH00340026 on town highway 34, crossing Ottauquechee River, Bridgewater, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BETHTH00860042 on Town Highway 86, crossing Gilead Brook, Bethel, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT minimum low-chord elevation feet)	USGS minimum low-chord elevation[2] (feet)	Bottom of footing 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 2,200 cubic-feet per second											
Left abutment	0.0	--	501.8	--	490.6	1.9	8.6	--	10.5	480.1	--
Right abutment	24.7	--	501.4	--	492.9	1.9	14.7	--	16.6	476.3	--

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 BETHTH00860042 on Town Highway 86, crossing Gilead Brook, Bethel, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	USGS minimum low-chord elevation[2] (feet)	Bottom of footing 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 2,800 cubic-feet per second											
Left abutment	0.0	--	501.8	--	490.6	0.0	11.4	--	11.4	479.2	--
Right abutment	24.7	--	501.4	--	492.9	0.0	15.7	--	15.7	477.2	--

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, 1981, Randolph, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Map, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File beth042.wsp
T2        Hydraulic analysis for structure BETHTH00860042   Date: 07-FEB-96
T3        Bethel bridge 42, town highway 86, ...JDA...
Q           2200.0,   2800.0,  2240
SK          0.012,   0.012,   0.012
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EXIT1    -49           0.
GR         -200.0, 514.43   -184.4, 506.23   -143.8, 502.96   -129.7, 502.45
GR          -88.4, 503.78    -78.0, 502.62    -53.0, 503.22    -43.7, 500.18
GR          -14.7, 498.68     -5.4, 495.15      0.0, 491.94     13.1, 490.95
GR           30.5, 492.03     38.1, 496.74     61.8, 496.94     94.5, 498.33
GR          110.0, 511.59
*
N           0.09        0.055        0.09
SA                 -14.7         38.1
*
XS   FULLV      0  * * *   0.012
*
*            SRD     LSEL    XSSKEW
BR   DSBRG     0     501.7       0.0
GR            0.0, 501.80      0.2, 490.64      7.6, 490.71     19.1, 492.02
GR           24.4, 492.9      24.7, 501.38      0.0, 501.80
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV   WWANGL
CD           4      18.4      0.0    503.0     45.1
N           0.05
*
*            SRD    EMBWID   IPAVE
XR   RDWAY      9      14.4      2
GR         -133.7, 511.19   -107.4, 504.78    -88.0, 504.83    -65.0, 504.94
GR          -64.8, 504.94      0.0, 503.52     25.2, 502.97     67.0, 502.49
GR           84.7, 504.33    108.4, 509.55
*
XT   APPR1     49
GR         -139.6, 514.95    -70.4, 506.53    -57.0, 504.44    -57.0, 504.38
GR          -52.9, 501.87     -7.1, 498.81      0.0, 492.52      0.3, 492.26
GR            3.8, 491.52      7.0, 490.96     12.9, 491.73     19.9, 492.61
GR           27.4, 494.38     36.6, 495.19     53.1, 499.24     69.9, 498.81
GR           88.3, 499.02    106.3, 511.53
*
AS   APPRO      43
GT            -0.072
N           0.09        0.055        0.09
SA                  -7.1         53.1
*
HP 1 DSBRG  497.75 1 497.75
HP 2 DSBRG  497.75 * * 2200
HP 1 APPRO  501.77 1 501.77
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HP 2 APPRO  501.77 * * 2200
*
HP 1 DSBRG  501.80 1 501.80
HP 2 DSBRG  501.80 * * 2440
HP 2 RDWAY  503.86 * * 310
HP 1 APPRO  503.96 1 503.96
HP 2 APPRO  503.96 * * 2800
*
HP 1 DSBRG  497.82 1 497.82
HP 2 DSBRG  497.82 * * 2240
HP 1 APPRO  501.90 1 501.90
HP 2 APPRO  501.90 * * 2240
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File beth042.wsp
        Hydraulic analysis for structure BETHTH00860042   Date: 07-FEB-96
        Bethel bridge 42, town highway 86, ...JDA...
           *** RUN DATE & TIME: 02-14-96  07:46
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = DSBRG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     155.   12114.    24.    36.                        2206.
   497.75          155.   12114.    24.    36.  1.00     0.    25.   2206.
1
  HP 2 DSBRG  497.75 * * 2200
    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = DSBRG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.75     0.1    24.6   154.7   12114.    2200.  14.22

 X STA.        0.1        2.3        3.6        4.6        5.6        6.6
  A(I)            15.6        8.8        7.6        7.0        6.7
  V(I)            7.07      12.48      14.55      15.65      16.38

 X STA.        6.6        7.5        8.4        9.3       10.2       11.2
  A(I)             6.6        6.3        6.2        6.3        6.2
  V(I)           16.76      17.48      17.65      17.50      17.78

 X STA.       11.2       12.1       13.1       14.1       15.2       16.3
  A(I)             6.4        6.3        6.4        6.6        6.7
  V(I)           17.30      17.59      17.09      16.55      16.39

 X STA.       16.3       17.5       18.7       20.1       21.7       24.6
  A(I)             7.1        7.2        7.9        8.7       14.2
  V(I)           15.59      15.24      13.90      12.64       7.77
1
  HP 1 APPRO  501.77 1 501.77
    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      69.    1501.    45.    45.                         481.
             2     449.   44736.    60.    64.                        6957.
             3     107.    3400.    39.    40.                        1001.
   501.77          625.   49637.   145.   149.  1.43   -52.    92.   6155.
1
  HP 2 APPRO  501.77 * * 2200
    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.77   -52.5    92.4   624.7   49637.    2200.   3.52

 X STA.      -52.5       -3.6        0.2        2.6        4.7        6.7
  A(I)            85.1       29.9       23.4       21.5       21.0
  V(I)            1.29       3.68       4.70       5.11       5.24

 X STA.        6.7        8.6       10.5       12.5       14.5       16.7
  A(I)            20.3       20.2       20.6       20.6       21.4
  V(I)            5.42       5.46       5.34       5.34       5.15

 X STA.       16.7       19.0       21.5       24.2       27.4       30.9
  A(I)            21.5       22.7       23.5       24.8       26.0
  V(I)            5.12       4.85       4.68       4.43       4.23

 X STA.       30.9       34.7       39.2       45.5       63.4       92.4
  A(I)            26.5       29.1       33.0       54.9       78.7
  V(I)            4.14       3.78       3.34       2.00       1.40
1
  *
  HP 1 DSBRG  501.80 1 501.80
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = DSBRG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     249.   17527.     0.    69.                           0.
   501.80          249.   17527.     0.    69.  1.00     0.    25.      0.
1
  HP 2 DSBRG  501.80 * * 2440
1
```

```
    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = DSBRG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.80     0.0    24.7   249.2   17527.    2440.   9.79

 X STA.         0.0        2.2        3.4        4.6        5.6        6.6
   A(I)            23.7       13.5       12.4       11.2       11.0
   V(I)            5.15       9.02       9.86      10.89      11.07

 X STA.         6.6        7.5        8.5        9.5       10.4       11.4
   A(I)            10.5       10.5       10.2       10.4       10.2
   V(I)           11.56      11.58      11.90      11.76      11.91

 X STA.        11.4       12.4       13.4       14.5       15.6       16.7
   A(I)            10.5       10.4       10.7       10.7       11.2
   V(I)           11.60      11.75      11.37      11.40      10.90

 X STA.        16.7       17.9       19.1       20.4       22.0       24.7
   A(I)            11.2       11.7       12.5       14.3       22.2
   V(I)           10.86      10.40       9.76       8.56       5.51
1
   HP 2 RDWAY  503.86 * * 310
     VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.

         WSEL     LEW     REW    AREA        K        Q    VEL
       503.86   -15.5    80.2    74.4    1320.     310.   4.17

 X STA.       -15.5        8.1       15.3       20.3       24.3       27.7
   A(I)             6.1        4.3        3.7        3.3        3.1
   V(I)            2.53       3.64       4.23       4.77       4.99

 X STA.        27.7       30.8       33.7       36.3       39.2       42.7
   A(I)             2.9        2.8        2.7        2.9        3.8
   V(I)            5.44       5.52       5.83       5.26       4.08

 X STA.        42.7       46.1       49.2       52.3       55.2       58.0
   A(I)             3.7        3.6        3.6        3.6        3.5
   V(I)            4.16       4.28       4.27       4.34       4.40

 X STA.        58.0       60.8       63.5       66.2       69.3       80.2
   A(I)             3.5        3.5        3.7        4.0        6.1
   V(I)            4.38       4.41       4.18       3.89       2.54
1
   HP 1 APPRO  503.96 1 503.96
     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     173.    6543.    49.    50.                      1837.
             2     581.   68710.    60.    64.                     10237.
             3     196.    8812.    42.    44.                      2397.
   503.96          950.   84065.   152.   158.  1.50   -56.    96.  10999.
1
   HP 2 APPRO  503.96 * * 2800
1     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.

         WSEL     LEW     REW    AREA        K        Q    VEL
       503.96   -56.4    95.5   950.0   84065.    2800.   2.95

 X STA.       -56.4      -18.1       -3.5        0.5        3.3        5.7
   A(I)           119.5       78.2       40.9       32.9       30.4
   V(I)            1.17       1.79       3.42       4.26       4.61

 X STA.         5.7        8.0       10.3       12.8       15.2       17.9
   A(I)            30.4       29.7       30.3       30.4       31.5
   V(I)            4.60       4.71       4.62       4.61       4.45

 X STA.        17.9       20.7       23.7       27.1       30.9       34.8
   A(I)            31.6       32.8       35.0       35.7       36.4
   V(I)            4.44       4.26       4.00       3.93       3.84

 X STA.        34.8       39.4       45.1       54.6       72.5       95.5
   A(I)            39.2       42.8       53.1       90.4       98.8
   V(I)            3.57       3.27       2.63       1.55       1.42
1
   *
   HP 1 DSBRG  497.82 1 497.82
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     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = DSBRG;  SRD =       0.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     156.   12307.    25.    36.                       2242.
    497.82          156.   12307.    25.    36.  1.00     0.    25.   2242.
1
   HP 2 DSBRG  497.82 * * 2240
     VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = DSBRG;  SRD =       0.

          WSEL     LEW     REW    AREA        K        Q    VEL
        497.82     0.1    24.6   156.4   12307.    2240.  14.32

 X STA.         0.1        2.3        3.6        4.6        5.6        6.6
   A(I)            15.7        8.9        7.7        7.1        6.8
   V(I)            7.11      12.56      14.63      15.74      16.48

 X STA.         6.6        7.5        8.4        9.3       10.3       11.2
   A(I)             6.6        6.3        6.3        6.4        6.3
   V(I)           16.86      17.87      17.66      17.51      17.79

 X STA.        11.2       12.1       13.1       14.1       15.2       16.3
   A(I)             6.3        6.4        6.5        6.6        6.9
   V(I)           17.73      17.47      17.24      17.03      16.23

 X STA.        16.3       17.5       18.7       20.1       21.7       24.6
   A(I)             7.1        7.3        7.8        9.0       14.3
   V(I)           15.72      15.37      14.43      12.40       7.82
1
   HP 1 APPRO  501.90 1 501.90
     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1      75.    1708.    46.    46.                        541.
              2     457.   46043.    60.    64.                       7140.
              3     112.    3662.    39.    40.                       1071.
    501.90          644.   51413.   146.   150.  1.44   -53.    93.   6397.
1
   HP 2 APPRO  501.90 * * 2240
     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.

          WSEL     LEW     REW    AREA        K        Q    VEL
        501.90   -53.1    92.5   643.6   51413.    2240.   3.48

 X STA.       -53.1       -3.9        0.1        2.5        4.7        6.6
   A(I)            89.3       31.5       23.3       22.7       21.0
   V(I)            1.25       3.56       4.81       4.93       5.34

 X STA.         6.6        8.5       10.5       12.5       14.6       16.8
   A(I)            20.9       20.8       21.2       21.3       22.0
   V(I)            5.35       5.39       5.28       5.27       5.09

 X STA.        16.8       19.1       21.6       24.4       27.6       31.2
   A(I)            22.1       22.6       24.6       25.4       26.7
   V(I)            5.07       4.95       4.55       4.41       4.19

 X STA.        31.2       35.1       39.6       46.0       64.2       92.5
   A(I)            27.3       29.8       33.5       57.2       80.3
   V(I)            4.10       3.76       3.34       1.96       1.40
1
   *
   EX

 +++ BEGINNING PROFILE CALCULATIONS --   3
1
  XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
        SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

 EXIT1:XS   ******   -13.     290.  1.08 *****  498.95  496.60   2200.  497.88
       -49. ******    84.   20073.  1.20 ***** *******    0.85    7.58

  ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.84     498.49     497.19

  ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   497.38     515.02    0.50
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 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   497.38     515.02     497.19

 FULLV:FV      49.   -13.     291.  1.07  0.59  499.55  497.19   2200.  498.48
         0.    49.    84.   20143.  1.20  0.00    0.01    0.84    7.56
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS      43.   -13.     299.  0.89  0.48  500.01 *******   2200.  499.13
        43.    43.    89.   21663.  1.06  0.00   -0.01    0.77    7.36
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "DSBRG"     Q,CRWS =    2200.     497.75

             <<<<<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

 DSBRG:BR      49.     0.     155.  3.48 *****  501.23  497.75   2200.  497.75
         0.    49.    25.   12110.  1.11 ***** *******    1.05   14.23

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   1.  0.951 ******  501.70 ****** ****** ******

    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      25.   -52.     625.  0.28  0.21  502.05  497.51   2200.  501.77
        43.    26.    92.   49648.  1.43  0.61    0.01    0.36    3.52

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.758  0.419   28802.     2.    27.   501.71

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

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -49.   -13.    84.   2200.   20073.     290.    7.58  497.88
   FULLV:FV       0.   -13.    84.   2200.   20143.     291.    7.56  498.48
   DSBRG:BR       0.     0.    25.   2200.   12110.     155.   14.23  497.75
   RDWAY:RG       9.**************      0.*****************     2.00********
   APPRO:AS      43.   -52.    92.   2200.   49648.     625.    3.52  501.77

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       2.    27.   28802.
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    496.60    0.85  490.95  514.43************  1.08  498.95  497.88
   FULLV:FV    497.19    0.84  491.54  515.02  0.59  0.00  1.07  499.55  498.48
   DSBRG:BR    497.75    1.05  490.64  501.80************  3.48  501.23  497.75
   RDWAY:RG  ****************  502.49  511.19**********************************
   APPRO:AS    497.51    0.36  490.89  514.88  0.21  0.61  0.28  502.05  501.77
1
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

 EXIT1:XS   ******   -15.     367.  1.19 *****  499.81  497.64   2800.  498.61
       -49. ******    95.   25547.  1.32 ***** *******    0.84    7.62

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.84     499.22     498.22

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   498.11     515.02    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   498.11     515.02     498.22

 FULLV:FV      49.   -15.     370.  1.18  0.58  500.40  498.22   2800.  499.22
         0.    49.    95.   25713.  1.32  0.00    0.01    0.84    7.58
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WSPRO OUTPUT FILE (continued)

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          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS      43.   -24.     375.  1.03  0.47  500.87 *******   2800.  499.84
        43.    43.    90.   27756.  1.19  0.00   -0.01    0.79    7.46
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
            WS1,WSSD,WS3,RGMIN =   503.63       0.00     498.84     502.49

  ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

  ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
            WS3,WSIU,WS1,LSEL =   498.67     503.13     503.32     501.70

  ===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

 DSBRG:BR      49.     0.     249.  1.49 *****  503.29  498.21   2440.  501.80
         0. ******    25.   17527.  1.00 ***** *******    0.54    9.79

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        4. ****    5.  0.449 ******  501.70 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG       9.    29.  0.03  0.20  504.14   -0.02    310.  503.86

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
    LT:     32.    27.   -16.    11.   0.6   0.3   3.2   4.0   0.6   2.8
    RT:    277.    69.    11.    80.   1.4   1.0   4.9   4.2   1.2   2.9

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

 APPRO:AS      25.   -56.     951.  0.20  0.13  504.17  498.25   2800.  503.96
        43.    26.    96.   84154.  1.50  0.62   -0.02    0.25    2.94

        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     -49.   -15.    95.   2800.   25547.     367.    7.62  498.61
    FULLV:FV       0.   -15.    95.   2800.   25713.     370.    7.58  499.22
    DSBRG:BR       0.     0.    25.   2440.   17527.     249.    9.79  501.80
    RDWAY:RG       9.*******    32.    310.       0.*********    2.00  503.86
    APPRO:AS      43.   -56.    96.   2800.   84154.     951.    2.94  503.96

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS  ***********************
1  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXIT1:XS    497.64    0.84  490.95  514.43************  1.19  499.81  498.61
    FULLV:FV    498.22    0.84  491.54  515.02  0.58  0.00  1.18  500.40  499.22
    DSBRG:BR    498.21    0.54  490.64  501.80************  1.49  503.29  501.80
    RDWAY:RG  ****************  502.49  511.19  0.03******  0.20  504.14  503.86
    APPRO:AS    498.25    0.25  490.89  514.88  0.13  0.62  0.20  504.17  503.96
1
  XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
        SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

 EXIT1:XS   ******   -13.     295.  1.08 *****  499.02  496.64   2240.  497.93
       -49. ******    85.   20438.  1.21 ***** *******    0.85    7.58

  ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
               FNTEST,FR#,WSEL,CRWS =  0.80     0.84     498.54     497.23

  ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   497.43     515.02     0.50
```

WSPRO OUTPUT FILE (continued)

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 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   497.43     515.02     497.23

FULLV:FV      49.   -13.     296.  1.08  0.59  499.61  497.23   2240.  498.53
        0.    49.    85.   20510.  1.21  0.00    0.01    0.85    7.56
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      43.   -14.     304.  0.90  0.48  500.08 *******   2240.  499.18
       43.    43.    89.   22044.  1.07  0.00   -0.01    0.78    7.36
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID “DSBRG”     Q,CRWS =    2240.     497.82

            <<<<<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

DSBRG:BR      49.     0.     156.  3.54 *****  501.36  497.82   2240.  497.82
        0.    49.    25.   12302.  1.11 ***** *******    1.05   14.33

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   1.  0.950 ******  501.70 ****** ****** ******

    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      25.   -53.     644.  0.27  0.21  502.17  497.56   2240.  501.90
       43.    26.    93.   51460.  1.44  0.61    0.01    0.35    3.48

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.760  0.427   29452.     2.    27.   501.85

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

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXIT1:XS     -49.   -13.    85.   2240.   20438.     295.    7.58  497.93
   FULLV:FV       0.   -13.    85.   2240.   20510.     296.    7.56  498.53
   DSBRG:BR       0.     0.    25.   2240.   12302.     156.   14.33  497.82
   RDWAY:RG       9.**************      0.******************    2.00********
   APPRO:AS      43.   -53.    93.   2240.   51460.     644.    3.48  501.90

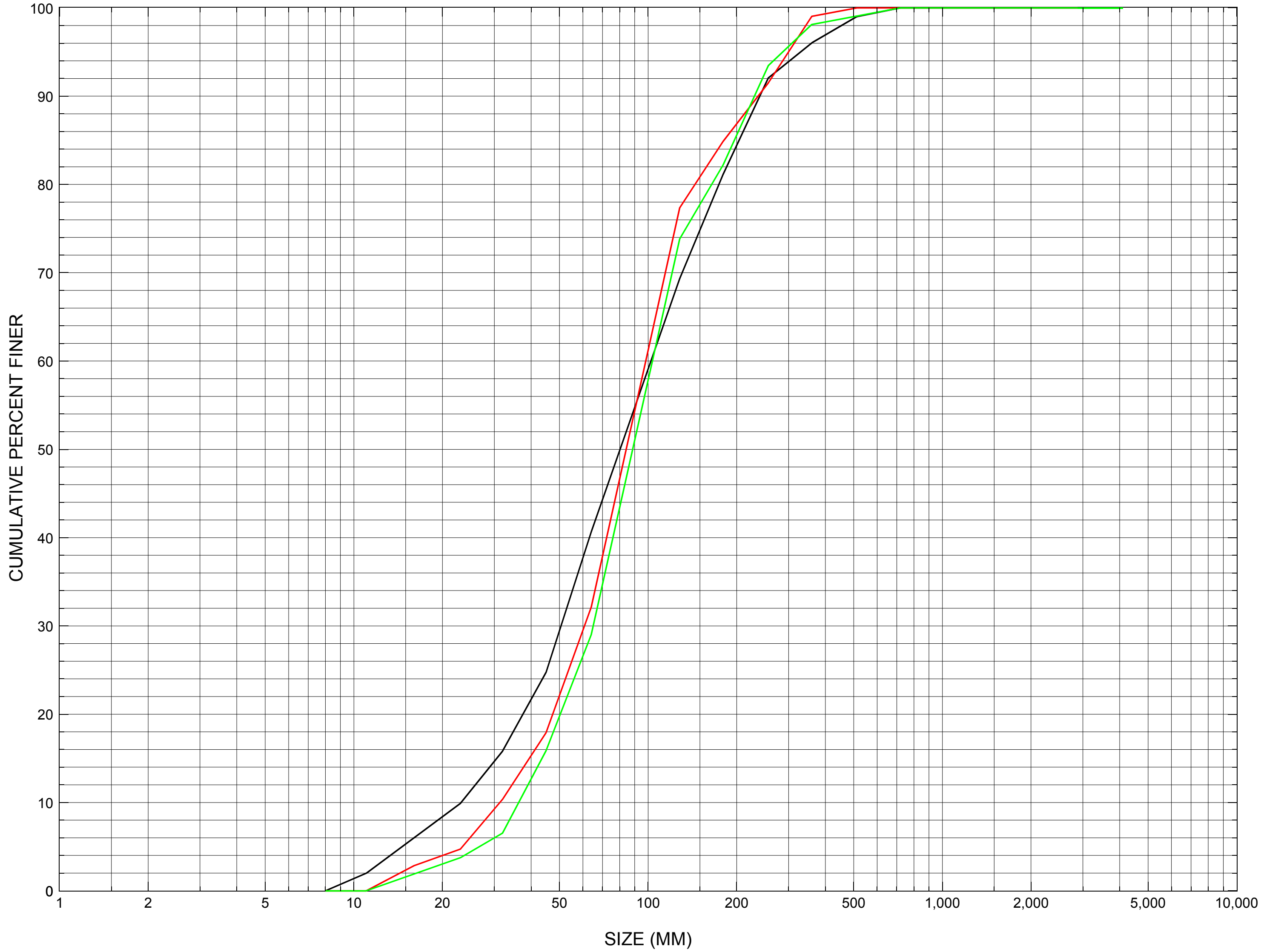
    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       2.    27.   29452.
 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    496.64    0.85  490.95  514.43************  1.08  499.02  497.93
   FULLV:FV    497.23    0.85  491.54  515.02  0.59  0.00  1.08  499.61  498.53
   DSBRG:BR    497.82    1.05  490.64  501.80************  3.54  501.36  497.82
   RDWAY:RG  ****************  502.49  511.19**********************************
   APPRO:AS    497.56    0.35  490.89  514.88  0.21  0.61  0.27  502.17  501.90
  ER

1  NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for three pebble count transects at the approach cross-section for structure BRIDTH00340026, in Bridgewater, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BETHTH00860042

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 24 / 94

Highway District Number *(I - 2; nn)* 04

County *(FIPS county code; I - 3; nnn)* 027

Town *(FIPS place code; I - 4; nnnnn)* 05800

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

Waterway *(I - 6)* GILEAD BROOK

Road Name *(I - 7):* -

Route Number TH086

Vicinity *(I - 9)* AT JCT TH 86 + TH 7

Topographic Map Randolph

Hydrologic Unit Code: 01080105

Latitude *(I - 16; nnnn.n)* 43527

Longitude *(i - 17; nnnnn.n)* 72403

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10140400421404

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

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

Year built *(I - 27; YYYY)* 1974

Structure length *(I - 49; nnnnnn)* 000028

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

Deck Width *(I - 52; nn.n)* 144

Year of ADT *(I - 30; YY)* 91

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

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

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

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 009.5

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

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

Comments:

Structural inspection report of 5/25/93 indicates a concrete slab type bridge. Minor cracks and concrete scaling on the abutments and wingwalls is reported. The footings are noted as not in view at the surface with no apparent settlement. Minor channel scour at the upstream end of the left abutment is reported. Minor embankment erosion noted. A shallow gravel bar is reported along the right abutment. The channel makes a bend about 100 feet upstream and then aligns straight into bridge crossing. Riprap reported as stone and concrete rubble in fair condition. The roadway has a gravel surface.

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: Stone and gravel

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)* **11.44** mi^2 Lake and pond area **0.04** mi^2

Watershed storage *(ST)* **0.3** %

Bridge site elevation **770** ft Headwater elevation **2700** ft

Main channel length **6.81** mi

10% channel length elevation **810** ft 85% channel length elevation **1580** ft

Main channel slope *(S)* **150.76** 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 NO BENCHMARK Minimum channel bed elevation: INFOR-

Low superstructure elevation: USLAB MATI DSLAB ON USRAB _______ DSRAB _______

Benchmark location description:

-
-
-

Reference Point (*MSL, Arbitrary, Other*): - Datum (*NAD27, NAD83, Other*): 4

Foundation Type: ____ (*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: N

Is boring information available? - *If no, type ctrl-n bi* Number of borings taken: 3

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

Briefly describe material at foundation bottom elevation or around piles:

O FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: MAI Date: 01/27/95
Computerized by: MAW Date: 03/09/95
Reviewd by: JDA Date: 3/18/96

Structure Number BETHTH00860042

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* D. SONG Date *(MM/DD/YY)* 09 / 30 / 1994

2. Highway District Number 04 Mile marker 000000

County WINDSOR Town BETHEL

Waterway *(I - 6)* GILEAD BROOK Road Name -

Route Number TH086 Hydrologic Unit Code: 01080105

3. Descriptive comments:

The bridge is at the junction of TH086 and TH007. Level II information was measured in the field
.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 5 RBDS 5 Overall 5
*(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 28 *(feet)* Span length 25 *(feet)* Bridge width 14.4 *(feet)*

Road approach to bridge:

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

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

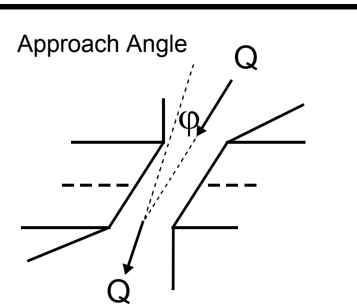
10. Embankment slope (*run / rise in feet / foot*):
US left 4:1 US right 4:2

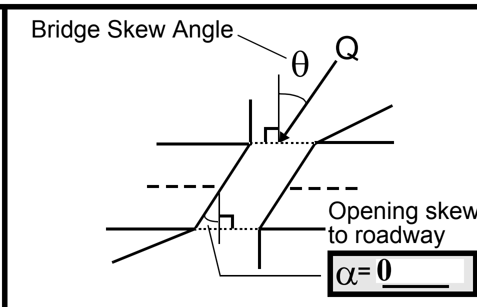
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	-	-	1	2
RBUS	2	1	0	-
RBDS	-	-	0	-
LBDS	-	-	2	2

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

Channel approach to bridge (BF):

15. Angle of approach: 0 16. Bridge skew: 5





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 60 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. Level II Bridge Type: 4

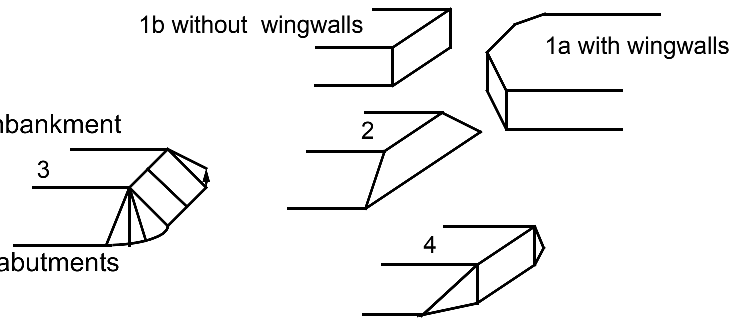
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls perpendicular 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.)

Measured bridge dimensions: bridge length=28 ft.; span length=25 ft.; roadway width=14.4ft. Overall the surface cover is shrub and brushland on the banks immediately upstream and downstream with forest on the banks beyond 2 bridge lengths and clearings on the overbanks (pavement or mowed field). There is an exposure immediately upstream of the upstream left wingwall, slumped concrete slab rip rap. Erosion of the downstream left road approach may also be due to channel scour from eddying downstream of the left abutment.

3

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
31.0	***4**			***3**	**2**	**3**	**4**	**1**	**1**	**3**

23. Bank width **40**   24. Channel width **15**   25. Thalweg depth ***53.0**   29. Bed Material **0**

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

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.):

re is a minor tributary 3 ft. wide, thalweg depth less than 6 in., 60 ft. upstream entering on the left bank. The left bank is cut opposite the point bar on the right bank, left bank material is organics over sand, gravel, cobbles and boulders. Right bank material is finer due to point bar accumulation. Stones line the right bank beyond the point bar; greater than 150 ft. upstream the right bank is lined with protective rip rap on the outside of a bend in the channel (artificial bank). The bed material is gravel and cobble, and looks well armored.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **60** 35. Mid-bar width: **16**

36. Point bar extent: **120** feet **US** *(US, UB)* to **15** feet **UB** *(US, UB, DS)* positioned **60** %LB to **100** %RB

37. Material: **3**

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

This is a well developed point bar made of silt, pebbles and cobbles. Thick vegetation growth immediately upstream of the bridge.

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: **50** 42. Cut bank extent: **5** feet **US** *(US, UB)* to **65** 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.):

It starts at a minor tributary on the left bank at outer bend of channel opposite point bar and continues to the embankment. The material is exposed cobble under organics. The thalweg is noticeably deeper near the left bank due to pooling. Another point bar is present >100 ft. upstream in mid channel.

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **-2**

47. Scour dimensions: Length **14** Width **5** Depth : **0.8** Position **0** %LB to **30** %RB

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

Due to channel constriction at bridge, abutment 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
20.0		**1.5**		**2**	**7**	**7**	**-**

58. Bank width (BF) **-** 59. Channel width (Amb) **-** 60. Thalweg depth (Amb) **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.):

4

There is a point bar under the bridge 70-100% channel made of sands to pebbles. Thalweg deepens under bridge, channel scour evident.

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

70. Debris and Ice Comments:

2

No debris evident, vegetation is in good shape. Stream has a moderate gradient; bridge span length is about 50% of upstream bank width.

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		5	90	2	2	1	0	90.0
RABUT	1	-	90			2	0	24.5

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

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

0

-

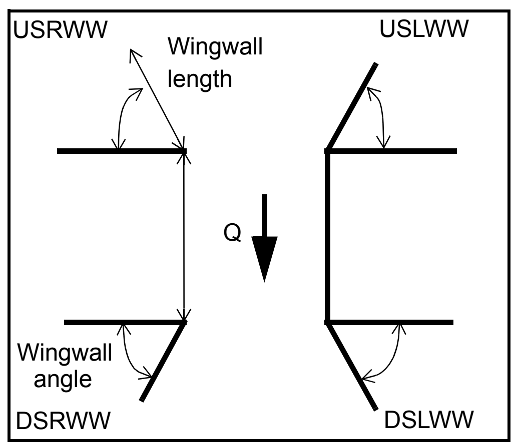
1

Abutment and channel scour evident. The left abutment protrudes significantly into flow, footing is now exposed whereas historical form shows no exposure. Scour depth at the left abutment is about 2.8 ft. - 2 ft. = 0.8 ft. concentrated at upstream corner of abutment and wingwall.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						24.5	
USRWW:	Y		1		0	1.5	
DSLWW:	0		-		Y	18.5	
DSRWW:	1		0		0	18.5	

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



82. Bank / Bridge Protection:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	0	Y	0	2	1	-	-
Condition	Y	0	1	-	2	4	-	-
Extent	1	-	0	1	2	0	0	0

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

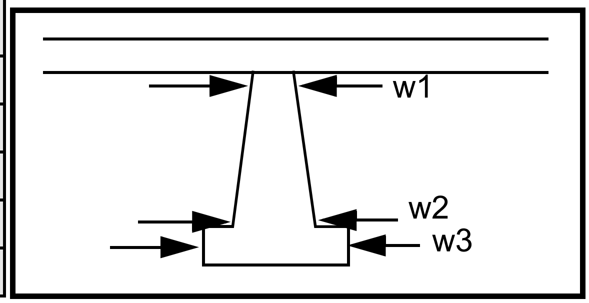
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
0
-
-
0
-
-
2
1
1

Piers:

84. Are there piers? **Sto** (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	**45.0**	**45.0**	**45.0**	**13.0**	**14.0**	**13.0**
Pier 2	**45.0**	-	-	**10.0**	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**nes**	**ream**	**at**	**from**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**line**	**right**	**the**	**chan**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**the**	**wing**	**upst**	**nel**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**chan**	**wall**	**ream**	**ero-**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**nel**	**and**	**right**	**sion**	*Y- yes; N- no*
91. Attack ∠ (BF)	**imm**	**beyo**	**wing**	**imm**	
92. Pushed	**edi-**	**nd**	**wall**	**edi-**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**ately**	**point**	**looks**	**ately**	
95. Cross-members	**beyo**	**bar.**	**like**	**upst**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**nd**	**Pro-**	**expo**	**ream**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**the**	**tec-**	**sed**	**that**	
98. Exposure depth	**upst**	**tion**	**fill**	**is**	

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

washed to the wingwall.

N

E. Downstream Channel Assessment

100.

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

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

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

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

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

-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

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

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

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

-
-
-
-
-
-

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

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

Material: -____

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

-
-
-
-

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

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

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

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

Is channel scour present? _____ *(Y or if N type ctrl-n cs)* Mid-scour distance: 2_____

Scour dimensions: Length 2_____ Width 4_____ Depth: 4_____ Positioned 0____ %LB to 1____ %RB

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

4
2
0
1

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

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

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

Confluence comments (eg. confluence name):

fines overlying cobbles and boulders. Bank vegetation consists mainly of brush and immature trees. Bed material is cobbles to pebbles; looks well armored. The channel is more straight and more uniform down-

F. Geomorphic Channel Assessment

107. Stage of reach evolution str___

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)*:

eam of the bridge. Concrete slabs and stone protect bank to 50 ft. downstream of the bridge.

109. G. Plan View Sketch

48. N

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: bethth00860042 Town: Gilead
Road Number: th86 County: Windsor
Stream: Gilead Brook

Initials JDA Date: 2/13/96 Checked: SAO Date: 2/14/96

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

Neills Equation
Vc=11.52*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and others, 1993, p. 31, eq. 14)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	2200	2800	2240
Main Channel Area, ft2	449	581	457
Left overbank area, ft2	69	173	75
Right overbank area, ft2	107	196	112
Top width main channel, ft	60	60	60
Top width L overbank, ft	45	49	46
Top width R overbank, ft	39	42	39
D50 of channel, ft	0.281	0.281	0.281
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	7.5	9.7	7.6
y1, average depth, LOB, ft	1.5	3.5	1.6
y1, average depth, ROB, ft	2.7	4.7	2.9
Total conveyance, approach	49637	84065	51413
Conveyance, main channel	44736	68710	46043
Conveyance, LOB	1501	6543	1708
Conveyance, ROB	3400	8812	3662
Percent discrepancy, conveyance	0	0	0
Qm, discharge, MC, cfs	1982.779	2288.562	2006.036
Ql, discharge, LOB, cfs	66.52699	217.9314	74.41542
Qr, discharge, ROB, cfs	150.694	293.5062	159.5488
Vm, mean velocity MC, ft/s	4.4	3.9	4.4
Vl, mean velocity, LOB, ft/s	1.0	1.3	1.0
Vr, mean velocity, ROB, ft/s	1.4	1.5	1.4
Vc-m, crit. velocity, MC, ft/s	10.6	11.0	10.6
Vc-l, crit. velocity, LOB, ft/s	0.0	0.0	0.0
Vc-r, crit. velocity, ROB, ft/s	0.0	0.0	0.0

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	0

Clear Water Contraction Scour in MAIN CHANNEL

y2 = (Q2^2/(120*Dm^(2/3)*W2^2))^(3/7)
ys=y2-y_bridge or ys=y2-y1
(Richardson and others, 1993, p. 35, eq. 18, 19)

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	449	581	457
Main channel width, ft	60	60	60
y1, main channel depth, ft	7.483333	9.683333	7.616667

Bridge Section	Q100	Q500	Qother
(Q) total discharge, cfs	2200	2800	2240
(Q) discharge thru bridge, cfs	2200	2440	2240
Main channel conveyance	12114	17527	12307
Total conveyance	12114	17527	12307
Q2, bridge MC discharge,cfs	2200	2440	2240
Main channel area, ft2	155	249	156
Main channel width (skewed), ft	24.5	24.7	24.5
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	24.5	24.7	24.5
y_bridge (avg. depth at br.), ft	6.326531	10.08097	6.367347
Dm, median (1.25*D50), ft	0.35125	0.35125	0.35125
y2, depth in contraction,ft	8.18401	8.881432	8.311389
ys, scour depth (y2-ybridge), ft	1.86	-1.20	1.94
ys, scour depth (y2-y1), ft	0.70	-0.80	0.69
ys, scour depth (y2-yfullv), ft	N/A	1.28	N/A

ARMORING

	Q100	Q500	Qother
D90	0.77	0.77	0.77
D95	0.992	0.992	0.992
Critical grain size,Dc, ft	0.956736	0.376204	0.976444
Decimal-percent coarser than Dc	0.0557	0.328979	0.05251
Depth to armoring,ft	48.65958	2.302042	52.85682

PRESSURE FLOW SCOUR COMPUTATION

Structure Number: BETH042 Town: Bethel
Road Number: TH 86 County: Windsor
Stream: Gilead
Initial: SAO Date: 10/10/96 Checked:
Pressure Flow Scour (contraction scour for orifice flow conditions)

Hb+Ys=Cq*qbr/Vc Cq=1/Cf*Cc Cf=1.5*Fr^0.43 (<=1)
Chang Equation Cc=SQRT[0.10*(Hb/(ya-w)-0.56)]+0.79 (<=1)
(Richardson and others, 1995, p. 145-146)

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	0	2440	0
Vc, critical velocity, ft/s	0	11	0
Vc, critical velocity, m/s	0	3.352636	0
Main channel width (skewed), ft	0	24.7	0
Cum. width of piers, ft	0	0	0
W, adjusted width, ft	0	24.7	0
qbr, unit discharge, ft^2/s	ERR	98.78543	ERR
qbr, unit discharge, m^2/s	N/A	9.176571	N/A
Area of full opening, ft^2	0	249	0
Hb, depth of full opening, ft	ERR	10.08097	ERR
Hb, depth of full opening, m	N/A	3.07253	N/A
Fr, Froude number MC	1	0.54	1
Cf, Fr correction factor (<=1.0)	1.5	1	1.5
Elevation of Low Steel, ft	0	501.7	0
Elevation of Bed, ft	N/A	491.619	N/A
Elevation of approach WS, ft	0	503.96	0
HF, bridge to approach, ft	0	0.13	0
Elevation of WS immediately US, ft	0	503.83	0
ya, depth immediately US, ft	N/A	12.21097	N/A
ya, depth immediately US, m	N/A	3.794584	N/A
Mean elev. of deck, ft	0	503.25	0
w, depth of overflow, ft (>=0)	0	0.58	0
Cc, vert contrac correction (<=1.0)	ERR	0.965139	ERR
Ys, depth of scour (chang), ft	N/A	-0.7761	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, 1993, p. 49, eq. 24)

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	2200	2800	2240	2200	2800	2240
a', abut.length blocking flow, ft	52.5	56.4	53.1	67.7	70.8	67.8
Ae, area of blocked flow ft2	113.43	229.48	120.01	269.13	364.47	277.82
Qe, discharge blocked abut.,cfs	214.21	--	221.2	752.81	--	773.5
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve manually)						
Ve, (Qe/Ae), ft/s	1.888477	1.72	1.84318	2.797198	2.56	2.784177
ya, depth of f/p flow, ft	2.16	4.07	2.26	3.98	5.15	4.10
--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	1	1	1	1	1
Fr, froude number f/p flow	0.23	0.15	0.22	0.25	0.19	0.24
ys, scour depth, ft	8.57	11.41	8.68	14.65	15.72	14.84

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1993, p. 50, eq. 25)

a'(abut length blocked, ft)	52.5	56.4	53.1	67.7	70.8	67.8
y1 (depth fp flow, ft)	2.16	4.07	2.26	3.98	5.15	4.10
a'/y1	24.30	13.86	23.49	17.03	13.75	16.55
Froude no. f/p flow	0.23	0.15	0.22	0.25	0.19	0.24
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, 1993, p118-119, eq. 93,94)

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	1.05	0.54	1.05			
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	6.33	10.08	6.37			
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	1.82	ERR	0.00	0.00	0
Fr>0.8 (vertical abut.)	2.68	ERR	2.70	ERR	ERR	ERR
Fr<=0.8 (spillthrough abut.)	ERR	1.59	ERR	0.00	0.00	0
Fr>0.8 (spillthrough abut.)	2.37	ERR	2.39	ERR	ERR	ERR