LEVEL II SCOUR ANALYSIS FOR BRIDGE 6 (GLOVTH00030006) on TOWN HIGHWAY 3, crossing the BARTON RIVER, GLOVER, VERMONT

Open-File Report 98-552

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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U.S. Department of the Interior
U.S. Geological Survey

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By SCOTT A. OLSON

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Pembroke, New Hampshire

1998

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

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 6 (GLOVTH00030006) ON TOWN HIGHWAY 3, CROSSING THE BARTON RIVER, GLOVER, VERMONT

By **Scott A. Olson**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure GLOVTH00030006 on Town Highway 3 crossing the Barton River, Glover, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the New England Upland section of the New England physiographic province in northern Vermont. The 19.0-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is primarily lawns with homes and a few trees.

In the study area, the Barton River has a straight, constructed channel with a slope of approximately 0.01 ft/ft, an average channel top width of 39 ft and an average bank height of 6 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 48.7 mm (0.160 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 25 and 26, 1994, indicated that the reach was constructed.

The Town Highway 3 crossing of the Barton River is a 41-ft-long, two-lane bridge consisting of one 37-foot concrete span (Vermont Agency of Transportation, written communication, August 4, 1994). The opening length of the structure parallel to the bridge face is 35 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 30 degrees to the opening while the opening-skew-to-roadway is 45 degrees.

Scour 2.0 ft deeper than the mean thalweg depth was observed along the left abutment during the Level I assessment. Scour countermeasures at the site include masonry walls along both banks upstream of the bridge, type-2 stone fill (less than 36 inches diameter) along the upstream right wingwall and downstream right bank, type-3 stone fill (less than 48 inches diameter) along the upstream left wingwall and both downstream wingwalls, and type-4 stone fill (less than 60 inches diameter) along the downstream left bank. Additional details describing conditions at the site are included in the Level II Summary and appendices D
and E.

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

Contraction scour for all modelled flows ranged from 0.1 to 0.9 ft. The worst-case contraction scour occurred at the 100-year discharge. Abutment scour ranged from 3.0 to 5.2 ft at the left abutment with the worst case scour occurring at the 500-year discharge. Abutment scour ranged from 10.3 to 11.3 at the right abutment with the worst case scour occurring 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.

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.

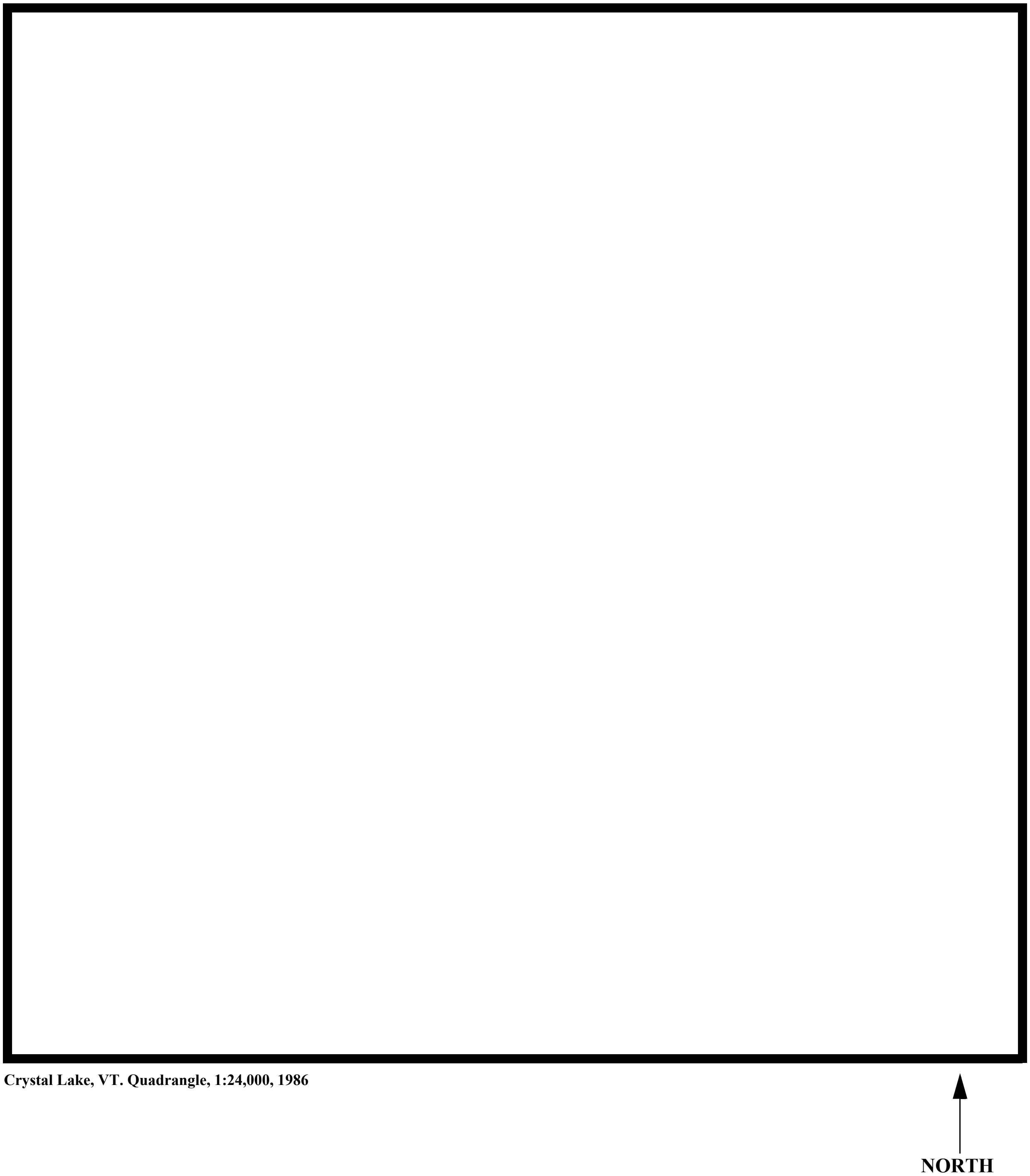

Figure 1. Location of study area on USGS 1:24,000 scale map.

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

LEVEL II SUMMARY

Structure Number GLOVTH00030006 ***Stream*** Barton River

County Orleans ***Road*** TH 3 ***District*** 9

Description of Bridge

Bridge length 41 ***ft*** ***Bridge width*** 29 ***ft*** ***Max span length*** 37 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 10/25-26/94

Description of stone fill Type-2, along the upstream right wingwall and type-3 stone fill along the upstream left wingwall and both downstream wingwalls. Masonry walls are along both upstream banks.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is 2 ft of scour along the left abutment.

Is bridge skewed to flood flow according to No ***Level I survey?*** Yes ***Angle*** 30

Is bridge located on a bend in channel? If so, describe (mild, moderate, severe) Through the study area the channel is constructed straight.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	10/25/94	0	0
Level II	10/26/94	0	0

Potential for debris Low. Furthermore, there is minimal constriction at the bridge site to catch debris.

Describe any features near or at the bridge that may affect flow (include observation date) The upstream banks are constructed of masonry walls channelizing the flow-- October 25, 1994.

Description of the Geomorphic Setting

General topography The channel is located in a medium relief valley setting with narrow flood plains and steep valley walls.

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

Date of inspection 10/25/94

DS left: Steep channel bank to a narrow overbank

DS right: Steep channel bank to a mildly sloping overbank

US left: Steep channel bank to a mildly sloping overbank

US right: Steep channel bank to a wide, relatively flat overbank

Description of the Channel

Average top width 39 ft ***Average depth*** 6 ft

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

Constructed straight and stable with semi-alluvial to non-alluvial channel boundaries.

10/25/94

Vegetative co Trees and brush on immediate bank with lawn further from channel.

DS left: Field grasses on immediate bank with pavement and lawns on overbank.

DS right: Trees and brush on immediate bank with lawn further from channel.

US left: Lawn with a few trees and a home.

US right:

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

State Route 16 bridge is about 100 ft downstream of Glover bridge 6.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 19.0 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: The site is located in the Village of Glover. However, the drainage is considered rural.

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 2,640 ***ft³/s*** ***Q500*** 3,650 ***ft³/s***

The 100-year discharge is based on a drainage area relationship [(19.0/23.4)exp 0.7] with flood frequency estimates available from the Flood Insurance Study for the Town of Glover (Federal Emergency Management Agency, 1991). Extrapolation to the 500-year discharge was done graphically based on the slopes of frequency curves developed from several empirical methods. The values used were within a range defined by various empirical methods (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 Add 399.0 ft to the USGS arbitrary survey datum to obtain VAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X in a chiseled square on the downstream end of the left abutment (elev. 100.73 ft, arbitrary survey datum). RM2 is a chiseled square on the upstream end of the right abutment (elev. 100.28 ft, arbitrary survey datum). RM3 is a chiseled square on the upstream end of the right abutment of the State Route 16 bridge (elev 100.98, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	*Section Reference Distance (SRD) in feet*	*[2]Cross-section development*	*Comments*
EVT16	-224	1	Exit section of State Route 16 bridge
FVT16	-159	2	Downstream Full-valley section (Templated from EVT16)
BVT16	-159	1	State Route 16 Bridge section
RVT16	-129	1	State Route 16 Road Grade section
AVT16	-47	1	Exit section of study site
FULL1	0	2	Downstream Full-valley section (Templated from AVT16)
BRIDG	0	1	Bridge section
RDWAY	22	1	Road Grade section
APPR1	69	2	Modelled Approach section (Templated from APTEM)
APTEM	94	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.045 to 0.055, and overbank "n" values ranged from 0.045 to 0.093.

Due to the proximity of the State Route 16 bridge downstream of Glover bridge 6, it is likely that backwater from the State Route 16 bridge will affect hydraulics at Glover bridge 6 over a wide range of discharges. Therefore, the State Route 16 bridge was included in this model. Normal depth at the most downstream section (EVT16) 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 0.013 ft/ft, which was measured from the 100-year water-surface profile downstream of the State Route 16 bridge over the Barton River in the Flood Insurance Study for the Town of Glover (Federal Emergency Management Agency, 1991). Since normal depth for the 500-year discharge at section EVT16 was computed only 0.1 ft below critical depth, critical depth was allowed for this discharge.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.019 ft/ft) to establish the modelled approach section (APPR1), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 100.9 *ft*
Average low steel elevation 98.6 *ft*

100-year discharge 2,640 *ft³/s*
Water-surface elevation in bridge opening 98.8 *ft*
Road overtopping? Y *Discharge over road* 847 *ft³/s*
Area of flow in bridge opening 192 *ft²*
Average velocity in bridge opening 9.2 *ft/s*
Maximum WSPRO tube velocity at bridge 10.8 *ft/s*

Water-surface elevation at Approach section with bridge 101.9
Water-surface elevation at Approach section without bridge 100.0
Amount of backwater caused by bridge 1.9 *ft*

500-year discharge 3,650 *ft³/s*
Water-surface elevation in bridge opening 98.8 *ft*
Road overtopping? Y *Discharge over road* 1,990 *ft³/s*
Area of flow in bridge opening 192 *ft²*
Average velocity in bridge opening 9.0 *ft/s*
Maximum WSPRO tube velocity at bridge 10.6 *ft/s*

Water-surface elevation at Approach section with bridge 102.8
Water-surface elevation at Approach section without bridge 100.9
Amount of backwater caused by bridge 1.9 *ft*

Incipient overtopping discharge 1,590 *ft³/s*
Water-surface elevation in bridge opening 98.8 *ft*
Area of flow in bridge opening 192 *ft²*
Average velocity in bridge opening 8.3 *ft/s*
Maximum WSPRO tube velocity at bridge 9.8 *ft/s*

Water-surface elevation at Approach section with bridge 100.4
Water-surface elevation at Approach section without bridge 98.5
Amount of backwater caused by bridge 1.9 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

At this site, the 100-year, the 500-year, and the incipient roadway-overtopping discharges resulted in 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 was computed by use of the Chang equation (Richardson and Davis, 1995, p. 145-146). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour also was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20) and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). Results from these computations are presented in appendix F. Furthermore, for the incipient-overtopping discharge, which resulted in unsubmerged orifice flow, contraction scour was computed 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 also are provided in appendix F.

Abutment scour was computed by use of the HIRE equation (Richardson and Davis, 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 include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour Results

Contraction scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.9	0.6	0.1
Depth to armoring	3.6	3.2	2.8
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
Abutment scour	4.4	5.2	3.0
Left abutment	10.3–	11.2–	11.3-
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-year discharge	500-year discharge (D_{50} in feet)	Incipient overtopping discharge
Abutments:	2.3	2.2	1.8
Left abutment	2.3	2.2	1.8
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

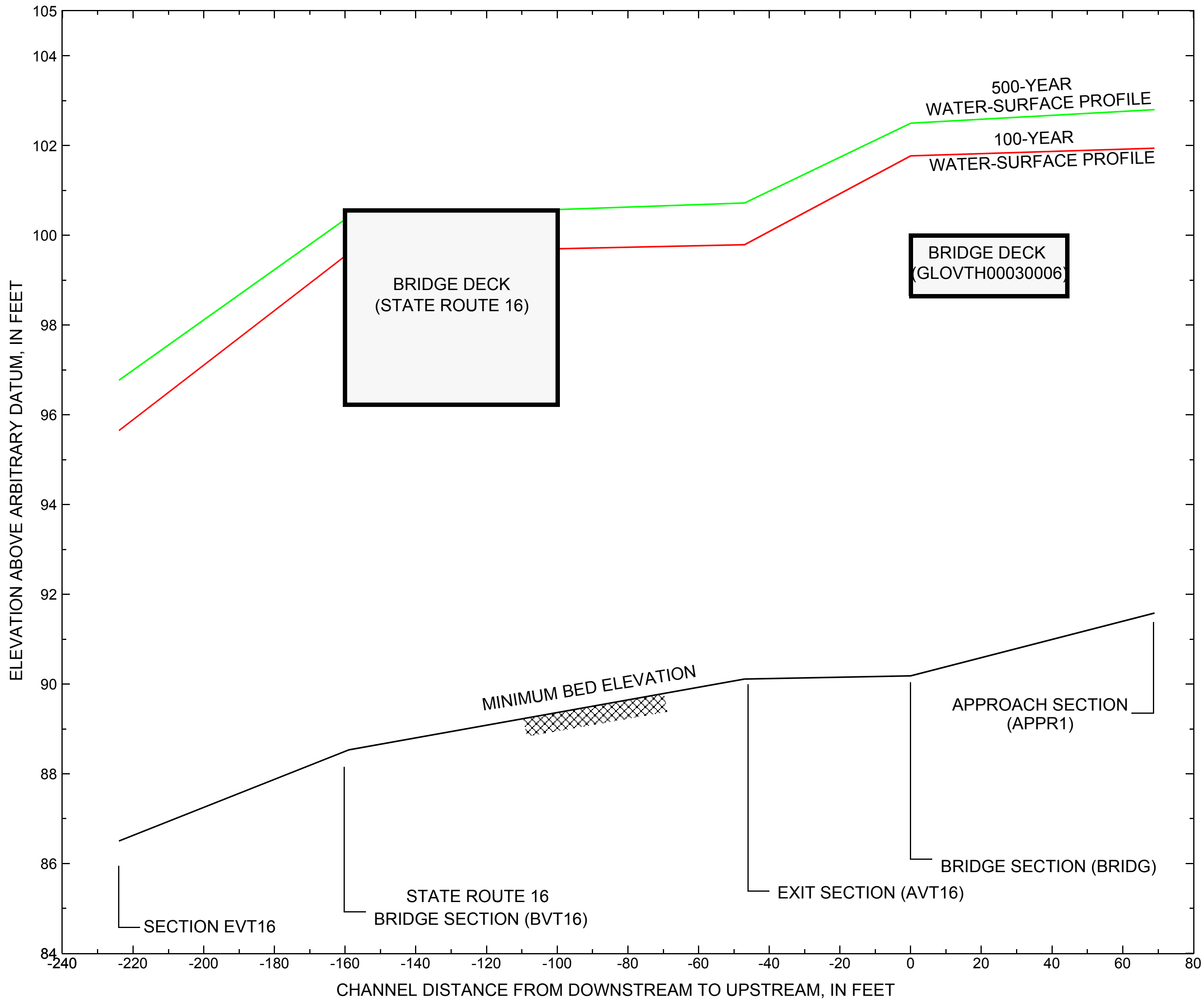

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure GLOVTH00030006 on Town Highway 3, crossing the Barton River, Glover, Vermont.

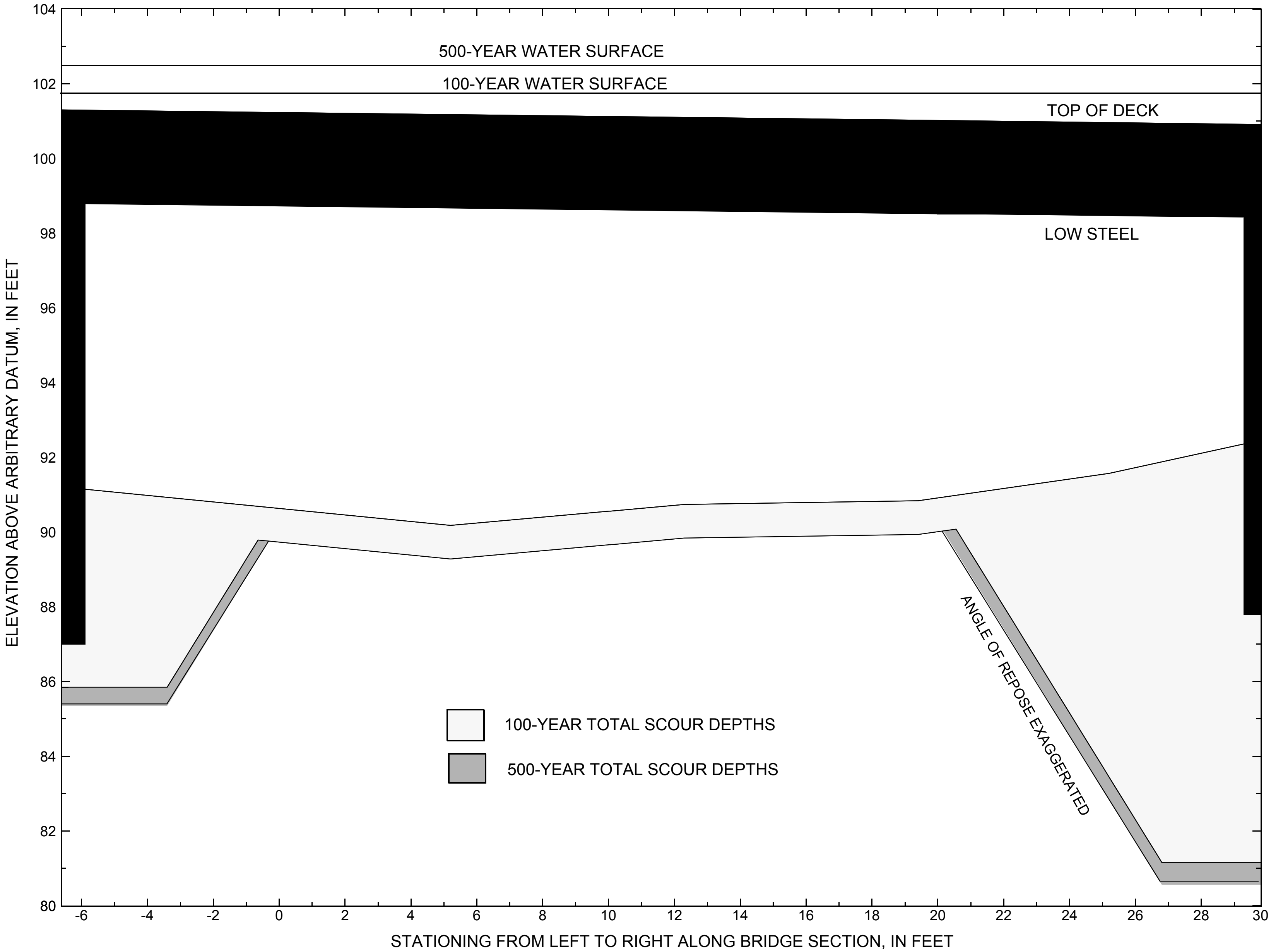

Figure 8. Scour elevations for the 100- and 500-year discharges at structure GLOVTH00030006 on Town Highway 3, crossing the Barton River, Glover, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure GLOVTH00030006 on Town Highway 3, crossing the Barton River, Glover, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-year discharge is 2,640 cubic-feet per second											
Left abutment	-6.1	497.7	98.8	87.0	91.2	0.9	4.4	--	5.3	85.9	-1.1
Right abutment	29.3	497.3	98.4	87.8	92.4	0.9	10.3	--	11.2	81.2	-6.6

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 GLOVTH00030006 on Town Highway 3, crossing the Barton River, Glover, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year discharge is 3,650 cubic-feet per second											
Left abutment	-6.1	497.7	98.8	87.0	91.2	0.6	5.2	--	5.8	85.4	-1.6
Right abutment	29.3	497.3	98.4	87.8	92.4	0.6	11.2	--	11.8	80.6	-7.2

1.Measured along the face of the most constricting side of the bridge.

2.Arbitrary datum for this study.

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APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File glov006.wsp
T2        Hydraulic analysis for structure GLOVTH00030006   Date: 01-MAY-96
T3        Glover Br 6, th 3, Barton R.
*
Q           2640     3650    1590
SK          0.013    0.013   0.013
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EVT16    -224
GR         -226.8, 108.95   -182.9,  98.16    -50.2,  97.84    -34.2,  94.80
GR            0.0,  94.65      7.8,  88.82      9.8,  88.73     14.1,  87.69
GR           21.6,  86.45     26.7,  87.46     27.2,  88.70     38.2,  96.16
GR           69.2,  98.10    113.9, 101.96    191.8, 108.44
N           0.065        0.045        0.045
SA                   0.0         38.2
*
XS   FVT16    -159 * * *   0.03
*
BR   BVT16    -159 96.12 45
GR            0.0,  95.97      4.9,  93.13     13.7,  91.14     16.7,  89.93
GR           21.1,  88.87     30.5,  88.53     40.7,  88.58     45.6,  88.86
GR           46.1,  89.97     50.7,  93.69     60.4,  96.27      0.0,  95.97
N             0.050
CD            3 61 7.9 98
*
XR   RVT16   -129 61
GR         -226.8, 108.95   -182.9,  98.16     -8.1,  99.24      0.0, 100.29
GR           65.6, 100.82     92.1, 100.01    143.6, 100.45    181.7, 102.11
GR          299.2, 113.08
*
AS   AVT16   -47
GR         -226.8, 108.95   -126.2,  96.84    -68.1,  95.93    -55.7,  96.94
GR          -27.9,  96.36     -8.9,  96.00      0.0,  91.16      3.8,  90.51
GR           12.4,  90.11     17.5,  90.39     21.4,  91.12     23.5,  91.67
GR           31.8,  95.82     44.2, 100.53     76.4, 100.27    110.3, 100.97
GR          140.8, 100.48    150.0, 101.76    194.7, 104.43
N           0.06        0.055        0.06
SA                  -8.9         44.2
*
XS   FULL1     0  * * *   0.0133
*
BR   BRIDG     0     98.58     45.0
GR           -6.1,  98.76     -6.0,  92.14     -5.6,  91.15      5.2,  90.18
GR           12.3,  90.74     19.4,  90.84     25.2,  91.57     29.3,  92.36
GR           29.3,  98.40     -6.1,  98.76
N            0.050
CD           4      43.5      4.7    101.0     44.7
*
XR   RDWAY     22 29
GR         -170.6, 106.36   -107.0, 103.11    -56.8, 101.66    -17.0, 101.13
GR            0.0, 101.08     20.5, 100.94     35.7, 100.81     35.7, 100.72
GR           76.4, 100.27    110.3, 100.97    140.8, 100.48    150.0, 101.76
GR          194.7, 104.43
*
*
XT   APTEM     94
```

```
GR          -110.1, 106.38    -93.2, 102.36    -46.0, 100.31    -25.2, 100.58
GR            -9.8,  99.30     -0.9,  98.22      0.1,  92.78      7.4,  92.06
GR            14.2,  92.55     19.0,  93.66     23.4,  94.95     23.8,  98.35
GR            25.4,  98.01     25.6,  96.86     28.7,  96.90     53.6,  96.95
GR           124.6,  98.20    135.1, 100.62    162.5, 101.57    181.9, 100.98
GR           215.1, 103.95
*


AS   APPR1   69 *  * * 0.0193
GT
N           0.066        0.052        0.093
SA                -0.9          23.8
*
HP 1 BRIDG  98.76 1 98.76
HP 2 BRIDG  98.76 * * 1765
HP 2 RDWAY 101.77 * * 847
HP 1 APPR1 101.94 1 101.94
HP 2 APPR1 101.94 * * 2640
*
HP 1 BRIDG  98.76 1 98.76
HP 2 BRIDG  98.76 * * 1730
HP 2 RDWAY 102.50 * * 1989
HP 1 APPR1 102.80 1 102.80
HP 2 APPR1 102.80 * * 3650
*
HP 1 BRIDG  98.76 1 98.76
HP 2 BRIDG  98.76 * * 1590
HP 1 BRIDG  98.21 1 98.21
HP 1 APPR1 100.41 1 100.41
HP 2 APPR1 100.41 * * 1590
*
EX
ER
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APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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      U.S. Geological Survey WSPRO Input File glov006.wsp
      Hydraulic analysis for structure GLOVTH00030006   Date: 01-MAY-96
      Glover Br 6, th 3, Barton R.

  CROSS-SECTION PROPERTIES:  ISEQ =  7;  SECID = BRIDG;  SRD =       0.
   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     192.   11936.     0.    64.                     ********
  98.76          192.   11936.     0.    64.  1.00    -6.    29.********

  VELOCITY DISTRIBUTION:  ISEQ =  7;  SECID = BRIDG;  SRD =       0.
       WSEL     LEW     REW    AREA        K        Q    VEL
      98.76    -6.1    29.3   191.9   11936.    1765.   9.20
X STA.       -6.1        -3.0        -1.1         0.5         2.1         3.6
  A(I)            16.6        10.3         9.3         9.1         8.5
  V(I)            5.32        8.53        9.44        9.73       10.33

X STA.        3.6         4.9         6.3         7.7         9.1        10.6
  A(I)             8.1         8.3         8.2         8.2         8.3
  V(I)           10.83       10.64       10.74       10.82       10.65

X STA.       10.6        12.1        13.6        15.1        16.7        18.3
  A(I)             8.3         8.4         8.3         8.6         8.6
  V(I)           10.69       10.49       10.59       10.29       10.21

X STA.       18.3        19.9        21.6        23.5        25.7        29.3
  A(I)             8.9         9.1         9.8        10.7        16.2
  V(I)            9.97        9.70        8.99        8.22        5.44

  VELOCITY DISTRIBUTION:  ISEQ =  8;  SECID = RDWAY;  SRD =      22.
       WSEL     LEW     REW    AREA        K        Q    VEL
     101.77   -60.6   150.2   184.4    4553.     847.   4.59
X STA.      -60.6       -13.0         3.7        17.0        28.4        37.7
  A(I)            17.7        11.3        10.1         9.7         8.8
  V(I)            2.39        3.74        4.19        4.37        4.79

X STA.       37.7        44.8        51.7        58.0        63.8        69.2
  A(I)             7.9         8.3         7.9         7.6         7.5
  V(I)            5.34        5.12        5.36        5.54        5.63

X STA.       69.2        74.2        79.2        84.8        91.1        99.0
  A(I)             7.3         7.3         7.8         8.0         8.8
  V(I)            5.76        5.82        5.46        5.29        4.79

X STA.       99.0       109.8       121.2       129.8       137.2       150.2
  A(I)             9.9        10.1         8.9         8.7        10.5
  V(I)            4.26        4.20        4.76        4.86        4.02

  CROSS-SECTION PROPERTIES:  ISEQ =  9;  SECID = APPR1;  SRD =      69.
   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     163.    5376.    93.    93.                        1231.
           2     231.   24495.    25.    33.                        4021.
           3     608.   22289.   174.   176.                        6444.
 101.94         1003.   52160.   291.   301.  2.20   -93.   198.   7120.

  VELOCITY DISTRIBUTION:  ISEQ =  9;  SECID = APPR1;  SRD =      69.
       WSEL     LEW     REW    AREA        K        Q    VEL
     101.94   -93.5   198.0  1002.7   52160.    2640.   2.63
X STA.      -93.5       -23.8        -1.6         3.0         5.3         7.4
  A(I)            95.2        65.4        37.7        23.1        21.5
  V(I)            1.39        2.02        3.50        5.72        6.14

X STA.        7.4         9.4        11.4        13.5        15.7        18.1
  A(I)            20.6        20.7        20.8        21.3        22.2
  V(I)            6.40        6.39        6.35        6.20        5.96

X STA.       18.1        20.9        30.2        40.3        50.7        61.6
  A(I)            24.1        55.6        55.5        57.5        59.1
  V(I)            5.47        2.38        2.38        2.30        2.24

X STA.       61.6        73.3        86.3       101.3       118.6       198.0
  A(I)            60.9        65.5        71.3        77.4       127.6
  V(I)            2.17        2.02        1.85        1.71        1.03
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        U.S. Geological Survey WSPRO Input File glov006.wsp
        Hydraulic analysis for structure GLOVTH00030006   Date: 01-MAY-96
        Glover Br 6, th 3, Barton R.

    CROSS-SECTION PROPERTIES:  ISEQ =  7;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1     192.   11936.    0.    64.                    ********
    98.76          192.   11936.    0.    64.  1.00    -6.    29.********

    VELOCITY DISTRIBUTION:  ISEQ =  7;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
        98.76    -6.1    29.3   191.9   11936.    1730.   9.01
X STA.        -6.1        -3.0        -1.1         0.5         2.1         3.6
  A(I)            16.6        10.3         9.3         9.1         8.5
  V(I)            5.21        8.36        9.25        9.54       10.13

X STA.         3.6         4.9         6.3         7.7         9.1        10.6
  A(I)             8.1         8.3         8.2         8.2         8.3
  V(I)           10.62       10.43       10.53       10.60       10.44

X STA.        10.6        12.1        13.6        15.1        16.7        18.3
  A(I)             8.3         8.4         8.3         8.6         8.6
  V(I)           10.48       10.29       10.38       10.08       10.01

X STA.        18.3        19.9        21.6        23.5        25.7        29.3
  A(I)             8.9         9.1         9.8        10.7        16.2
  V(I)            9.77        9.51        8.81        8.06        5.34

    VELOCITY DISTRIBUTION:  ISEQ =  8;  SECID = RDWAY;  SRD =      22.
         WSEL     LEW     REW    AREA        K        Q    VEL
       102.50   -85.9   162.4   351.9   11694.    1989.   5.65
X STA.       -85.9       -36.6       -18.3        -4.1         7.6        18.4
  A(I)            31.9        22.5        19.7        16.8        16.3
  V(I)            3.11        4.42        5.04        5.94        6.09

X STA.        18.4        28.6        37.7        45.7        53.5        60.9
  A(I)            16.1        15.4        14.8        15.2        14.9
  V(I)            6.20        6.47        6.74        6.54        6.67

X STA.        60.9        67.9        74.5        81.1        88.5        96.9
  A(I)            14.7        14.3        14.5        15.0        16.0
  V(I)            6.77        6.96        6.84        6.61        6.23

X STA.        96.9       107.0       118.1       128.1       137.0       162.4
  A(I)            17.1        17.7        17.3        16.8        24.8
  V(I)            5.80        5.62        5.74        5.91        4.01

    CROSS-SECTION PROPERTIES:  ISEQ =  9;  SECID = APPR1;  SRD =      69.
     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1     244.   10259.   96.    96.                       2212.
             2     253.   28355.   25.    33.                       4587.
             3     762.   31334.  184.   185.                       8801.
   102.80         1259.   69948.  305.   314.  1.98   -97.   208.  10315.

    VELOCITY DISTRIBUTION:  ISEQ =  9;  SECID = APPR1;  SRD =      69.
         WSEL     LEW     REW    AREA        K        Q    VEL
       102.80   -97.1   207.6  1259.1   69948.    3650.   2.90
X STA.       -97.1       -42.8       -15.9         0.5         3.7         6.3
  A(I)           103.2        78.4        74.8        34.3        28.4
  V(I)            1.77        2.33        2.44        5.32        6.42

X STA.         6.3         8.6        11.0        13.4        16.0        18.8
  A(I)            26.1        26.2        26.3        26.9        27.9
  V(I)            6.99        6.96        6.93        6.78        6.54

X STA.        18.8        22.2        34.7        45.3        56.5        68.0
  A(I)            32.1        80.0        67.2        70.9        71.4
  V(I)            5.69        2.28        2.71        2.57        2.56

X STA.        68.0        80.6        94.1       109.8       128.7       207.6
  A(I)            75.0        77.7        85.8        96.0       150.3
  V(I)            2.43        2.35        2.13        1.90        1.21
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        U.S. Geological Survey WSPRO Input File glov006.wsp
        Hydraulic analysis for structure GLOVTH00030006   Date: 01-MAY-96
        Glover Br 6, th 3, Barton R.

    CROSS-SECTION PROPERTIES:  ISEQ =  7;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     192.   11936.     0.    64.                    ********
    98.76          192.   11936.     0.    64.  1.00    -6.    29.********

    VELOCITY DISTRIBUTION:  ISEQ =  7;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
        98.76    -6.1    29.3   191.9   11936.    1590.   8.28
X STA.       -6.1        -3.0        -1.1         0.5         2.1         3.6
  A(I)            16.6        10.3         9.3         9.1         8.5
  V(I)            4.79        7.68        8.50        8.77        9.31

X STA.        3.6         4.9         6.3         7.7         9.1        10.6
  A(I)             8.1         8.3         8.2         8.2         8.3
  V(I)            9.76        9.59        9.67        9.75        9.60

X STA.       10.6        12.1        13.6        15.1        16.7        18.3
  A(I)             8.3         8.4         8.3         8.6         8.6
  V(I)            9.63        9.45        9.54        9.27        9.20

X STA.       18.3        19.9        21.6        23.5        25.7        29.3
  A(I)             8.9         9.1         9.8        10.7        16.2
  V(I)            8.98        8.74        8.10        7.41        4.90

    CROSS-SECTION PROPERTIES:  ISEQ =  7;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     183.   15534.    25.    38.                       2800.
    98.21          183.   15534.    25.    38.  1.00    -6.    29.   2800.

    CROSS-SECTION PROPERTIES:  ISEQ =  9;  SECID = APPR1;  SRD =      69.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      47.     911.    59.    59.                        238.
             2     194.   18200.    25.    33.                       3078.
             3     368.   12439.   119.   120.                       3676.
   100.41          609.   31550.   202.   212.  2.07   -59.   143.   4168.

    VELOCITY DISTRIBUTION:  ISEQ =  9;  SECID = APPR1;  SRD =      69.
         WSEL     LEW     REW    AREA        K        Q    VEL
       100.41   -59.4   143.0   609.0   31550.    1590.   2.61
X STA.      -59.4         1.3         3.5         5.3         7.0         8.6
  A(I)            62.0        18.1        16.0        14.5        14.3
  V(I)            1.28        4.40        4.98        5.49        5.56

X STA.        8.6        10.2        11.8        13.5        15.3        17.1
  A(I)            13.9        13.9        14.0        14.6        14.8
  V(I)            5.73        5.71        5.68        5.44        5.37

X STA.       17.1        19.3        22.0        34.1        44.2        54.4
  A(I)            15.9        18.1        49.4        40.4        40.3
  V(I)            4.99        4.39        1.61        1.97        1.97

X STA.       54.4        65.4        77.7        90.9       107.1       143.0
  A(I)            41.9        44.6        45.1        50.8        66.5
  V(I)            1.90        1.78        1.76        1.57        1.20
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        U.S. Geological Survey WSPRO Input File glov006.wsp
        Hydraulic analysis for structure GLOVTH00030006   Date: 01-MAY-96
        Glover Br 6, th 3, Barton R.

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

EVT16:XS   ******   -39.     258.  1.97 *****   97.62   95.50   2640.   95.65
     -224. ******    37.   23133.  1.21 ***** *******    1.08   10.25

 ===125 FR# EXCEEDS FNTEST AT SECID "FVT16":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.27      96.01      97.45
 ===110 WSEL NOT FOUND AT SECID "FVT16":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =    95.15     110.90    0.50
 ===115 WSEL NOT FOUND AT SECID "FVT16":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =    95.15     110.90      97.45
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "FVT16"
                  WSBEG,WSEND,CRWS =    97.45     110.90      97.45

FVT16:FV      65.   -38.     247.  2.11 *****   99.56   97.45   2640.   97.45
     -159.    65.    37.   22146.  1.18 ***** *******    1.13   10.70
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "AVT16"     KRATIO =  2.58

AVT16:AS     112.  -152.     806.  0.21  0.62  100.16 *******   2640.   99.95
      -47.   112.    43.   57237.  1.24  0.00   -0.02    0.32    3.28
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    97.45      96.12

             <<<<<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

BVT16:BR      65.     0.     217.  1.29 *****   97.56   94.84   1975.   96.27
     -159. ******    60.   11577.  1.00 ***** *******    0.85    9.12

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   6.  0.800  0.000    96.12 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RVT16:RG    -129.    51.  0.12  0.23   99.89    0.02    712.   99.60

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    712.   183.  -189.    -5.   1.4   0.9   5.0   4.4   1.2   3.0
   RT:      0.     4.    91.    95.   0.0   0.0   2.8  58.4   0.4   3.0

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

AVT16:AS      51.  -151.     774.  0.23  0.55  100.01   97.64   2640.   99.79
      -47.    66.    42.   54202.  1.25  0.00    0.02    0.34    3.41

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

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

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

FULL1:FV      47.  -146.     671.  0.31  0.13  100.18 *******   2640.   99.87
        0.    47.    41.   44809.  1.31  0.04   -0.01    0.42    3.93
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPR1"     KRATIO =  0.62

APPR1:AS      69.   -50.     533.  0.76  0.39  100.78 *******   2640.  100.02
       69.    69.   135.   27636.  2.01  0.22   -0.02    0.71    4.95
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    99.87      98.58

             <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>
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 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
      SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

BRIDG:BR      47.     -6.     192.  1.31 *****  100.07   96.28   1765.   98.76
        0. ******    29.   11936.  1.00 ***** *******    0.70    9.19

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   6.  0.800  0.000   98.58 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      22.    40.  0.10  0.24  102.08   -0.01    847.  101.77

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    153.    71.   -61.    11.   0.8   0.5   4.1   4.4   0.8   3.1
   RT:    694.   140.    11.   150.   1.5   1.1   5.4   4.6   1.4   3.1

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

APPR1:AS      26.    -93.    1003.  0.24  0.26  102.18   99.21   2640.  101.94
       69.    33.   198.   52188.  2.20  0.00   -0.01    0.37    2.63

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EVT16:XS    -224.   -39.    37.   2640.   23133.     258.   10.25   95.65
   FVT16:FV    -159.   -38.    37.   2640.   22146.     247.   10.70   97.45
   BVT16:BR    -159.     0.    60.   1975.   11577.     217.    9.12   96.27
   RVT16:RG    -129.*******   712.    712.*********       0.    1.00   99.60
   AVT16:AS     -47.  -151.    42.   2640.   54202.     774.    3.41   99.79
   FULL1:FV      0.  -146.    41.   2640.   44809.     671.    3.93   99.87
   BRIDG:BR      0.    -6.    29.   1765.   11936.     192.    9.19   98.76
   RDWAY:RG      22.*******   153.    847.******************    1.00  101.77
   APPR1:AS      69.   -93.   198.   2640.   52188.    1003.    2.63  101.94

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EVT16:XS     95.50    1.08   86.45  108.95************  1.97   97.62   95.65
   FVT16:FV     97.45    1.13   88.40  110.90************  2.11   99.56   97.45
   BVT16:BR     94.84    0.85   88.53   96.27************  1.29   97.56   96.27
   RVT16:RG  ****************   98.16  113.08  0.12******  0.23   99.89   99.60
   AVT16:AS     97.64    0.34   90.11  108.95  0.55  0.00  0.23  100.01   99.79
   FULL1:FV  ********    0.42   90.74  109.58  0.13  0.04  0.31  100.18   99.87
   BRIDG:BR     96.28    0.70   90.18   98.76************  1.31  100.07   98.76
   RDWAY:RG  ****************  100.27  106.36  0.10******  0.24  102.08  101.77
   APPR1:AS     99.21    0.37   91.58  105.90  0.26  0.00  0.24  102.18  101.94


        U.S. Geological Survey WSPRO Input File glov006.wsp
        Hydraulic analysis for structure GLOVTH00030006   Date: 01-MAY-96
        Glover Br 6, th 3, Barton R.

 ===015 WSI IN WRONG FLOW REGIME AT SECID “EVT16”:  USED WSI = CRWS.
                          WSI,CRWS =    96.73      96.77

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

EVT16:XS   ******    -45.     350.  2.24 *****   99.01   96.77   3650.   96.77
     -224. ******    48.   32381.  1.33 ***** *******    1.09   10.41

 ===125 FR# EXCEEDS FNTEST AT SECID “FVT16”:  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.63      96.27      98.72
 ===110 WSEL NOT FOUND AT SECID “FVT16”:  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =    96.27     110.90    0.50
 ===115 WSEL NOT FOUND AT SECID “FVT16”:  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =    96.27     110.90      98.72
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID “FVT16”
                   WSBEG,WSEND,CRWS =    98.72     110.90      98.72

FVT16:FV      65.    -45.     350.  2.24 *****  100.96   98.72   3650.   98.72
     -159.    65.    48.   32381.  1.33 ***** *******    1.09   10.41
          <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                          “AVT16”     KRATIO =  2.71

AVT16:AS     112.   -163.    1147.  0.20  0.53  101.49 *******   3650.  101.29
      -47.   112.   147.   87609.  1.27  0.00    0.00    0.33    3.18
          <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    98.72      96.12
```

WSPRO OUTPUT FILE (continued)

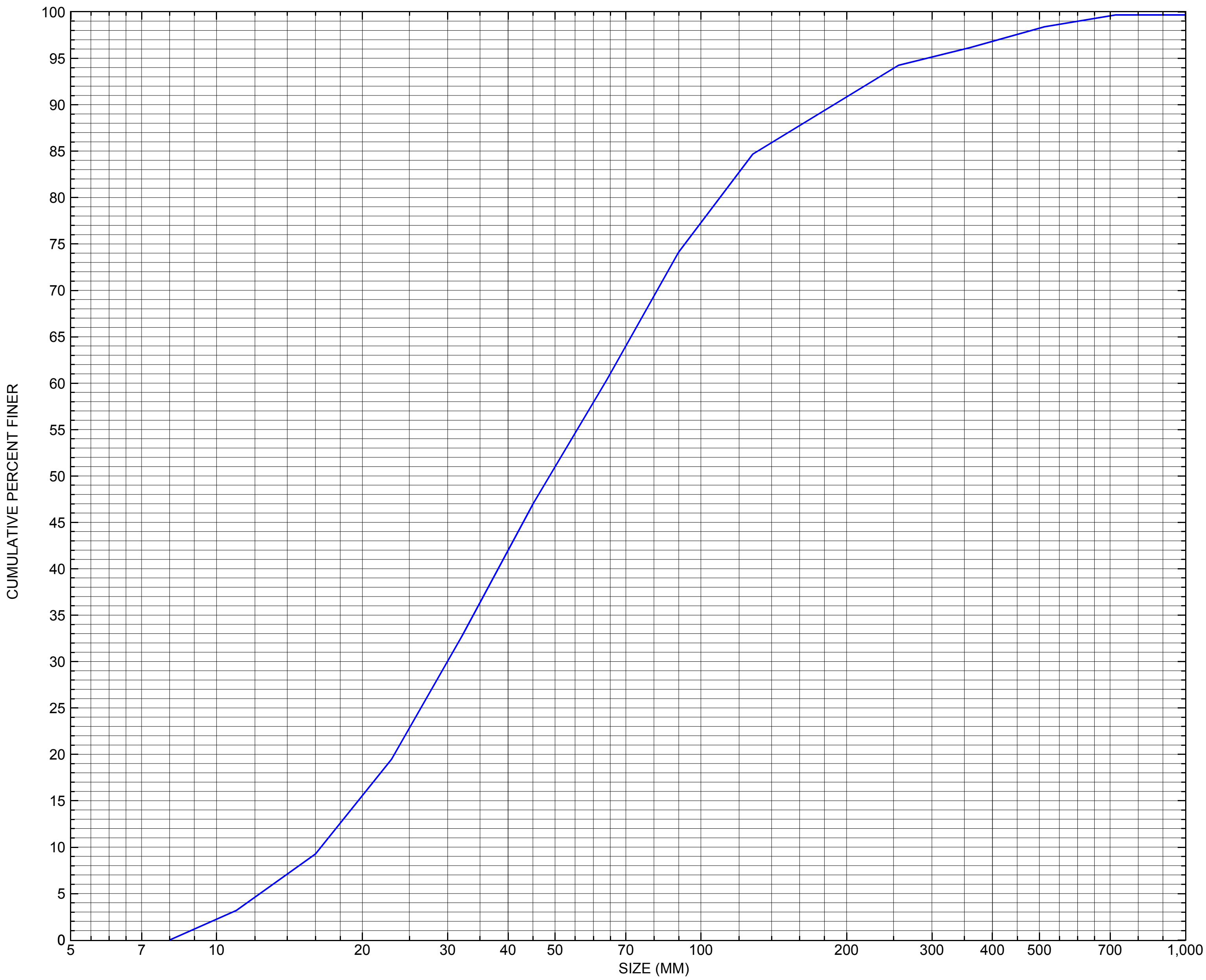
```
           <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

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

BVT16:BR      65.     0.     217.  1.08 *****   97.35   94.54   1809.   96.27
     -159. ******    60.   11577.  1.00 ***** *******    0.78    8.35

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   6.  0.800  0.000   96.12 ****** ****** ******

   XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RVT16:RG    -129.    51.  0.13  0.27  100.86    0.01   1883.  100.41

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1788.   207.  -192.    15.   2.3   1.5   6.6   5.7   2.0   3.1
   RT:     95.    60.    79.   139.   0.4   0.2   3.7   7.9   0.7   3.0

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

AVT16:AS      51.  -158.     976.  0.27  0.57  100.99   98.23   3650.  100.72
      -47.    66.   143.   73057.  1.23  0.00    0.01    0.39    3.74

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

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

FULL1:FV      47.  -154.     852.  0.35  0.14  101.16 *******   3650.  100.81
        0.    47.    43.   61778.  1.22  0.04   -0.01    0.40    4.28
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPR1"     KRATIO =  0.59

APPR1:AS      69.   -72.     729.  0.90  0.41  101.85 *******   3650.  100.94
       69.    69.   187.   36461.  2.32  0.28    0.00    0.79    5.01
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   100.81      98.58

           <<<<<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      47.    -6.     192.  1.26 *****  100.02   96.20   1730.   98.76
        0. ******    29.   11936.  1.00 ***** *******    0.68    9.01

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   6.  0.800  0.000   98.58 ****** ****** ******

   XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG      22.    40.  0.11  0.26  102.95    0.02   1989.  102.50

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    520.    97.   -86.    11.   1.5   1.0   5.6   5.4   1.4   3.1
   RT:   1469.   152.    11.   162.   2.2   1.7   6.8   5.7   2.1   3.1

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

APPR1:AS      26.   -97.    1259.  0.26  0.28  103.06   99.83   3650.  102.80
       69.    33.   208.   69929.  1.98  0.00    0.02    0.35    2.90

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

 FIRST USER DEFINED TABLE.
   XSID:CODE     SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EVT16:XS     -224.   -45.    48.   3650.   32381.     350.   10.41   96.77
   FVT16:FV     -159.   -45.    48.   3650.   32381.     350.   10.41   98.72
   BVT16:BR     -159.     0.    60.   1809.   11577.     217.    8.35   96.27
   RVT16:RG     -129.******* 1788.   1883.*********       0.    1.00  100.41
   AVT16:AS      -47.  -158.   143.   3650.   73057.     976.    3.74  100.72
   FULL1:FV       0.  -154.    43.   3650.   61778.     852.    4.28  100.81
   BRIDG:BR       0.    -6.    29.   1730.   11936.     192.    9.01   98.76
   RDWAY:RG      22.*******   520.   1989.*****************    1.00  102.50
   APPR1:AS      69.   -97.   208.   3650.   69929.    1259.    2.90  102.80
```

```
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EVT16:XS     96.77    1.09   86.45  108.95************  2.24   99.01   96.77
   FVT16:FV     98.72    1.09   88.40  110.90************  2.24  100.96   98.72
   BVT16:BR     94.54    0.78   88.53   96.27************  1.08   97.35   96.27
   RVT16:RG  ****************   98.16  113.08  0.13******  0.27  100.86  100.41
   AVT16:AS     98.23    0.39   90.11  108.95  0.57  0.00  0.27  100.99  100.72
   FULL1:FV  ********    0.40   90.74  109.58  0.14  0.04  0.35  101.16  100.81
   BRIDG:BR     96.20    0.68   90.18   98.76************  1.26  100.02   98.76
   RDWAY:RG  ****************  100.27  106.36  0.11******  0.26  102.95  102.50
   APPR1:AS     99.83    0.35   91.58  105.90  0.28  0.00  0.26  103.06  102.80

          U.S. Geological Survey WSPRO Input File glov006.wsp
          Hydraulic analysis for structure GLOVTH00030006   Date: 01-MAY-96
          Glover Br 6, th 3, Barton R.

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

EVT16:XS   ******     1.     161.  1.51 *****   95.41   93.12   1590.   93.90
     -224. ******    35.   13932.  1.00 ***** *******    0.80    9.86

 ===125 FR# EXCEEDS FNTEST AT SECID "FVT16":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.18      94.55      95.07
 ===110 WSEL NOT FOUND AT SECID "FVT16":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =    93.40     110.90    0.50
 ===115 WSEL NOT FOUND AT SECID "FVT16":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =    93.40     110.90      95.07
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "FVT16"
                   WSBEG,WSEND,CRWS =    95.07     110.90      95.07

FVT16:FV      65.     2.     136.  2.13 *****   97.20   95.07   1590.   95.07
     -159.    65.    34.   10977.  1.00 ***** *******    1.00   11.71
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "AVT16"     KRATIO =  2.34

AVT16:AS     112.  -135.     427.  0.32  1.01   98.20 *******   1590.   97.89
      -47.   112.    37.   25664.  1.47  0.00    0.00    0.50    3.72
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =    94.98      96.84      97.42      96.12
 ===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

BVT16:BR      65.     0.     217.  0.87 *****   97.14   94.18   1618.   96.27
     -159. ******    60.   11577.  1.00 ***** *******    0.70    7.47

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   2.  0.491  0.000   96.12 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RVT16:RG    -129.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

AVT16:AS      51.  -137.     469.  0.26  0.46   98.38   95.42   1590.   98.12
      -47.    61.    38.   28557.  1.44  1.00    0.02    0.44    3.39

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

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

FULL1:FV      47.  -132.     377.  0.41  0.19   98.63 *******   1590.   98.21
        0.    47.    36.   22359.  1.49  0.08   -0.02    0.61    4.22
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
```

```
APPR1:AS      69.    -7.     312.  0.84  0.52   99.35   98.20   1590.   98.52
       69.    69.   128.   14975.  2.07  0.21   -0.01    0.85    5.10
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =    97.86      99.40      99.63      98.58
 ===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      47.    -6.     192.  1.03 *****   99.79   95.84   1559.   98.76
        0. ******    29.   11936.  1.00 ***** *******    0.62    8.12

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   2.  0.475  0.000   98.58 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      22.        <<<<<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      26.    -59.     609.  0.22  0.21  100.63   98.20   1590.  100.41
       69.    31.   143.   31543.  2.07  0.60   -0.02    0.38    2.61

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EVT16:XS    -224.     1.    35.   1590.   13932.     161.    9.86   93.90
   FVT16:FV    -159.     2.    34.   1590.   10977.     136.   11.71   95.07
   BVT16:BR    -159.     0.    60.   1618.   11577.     217.    7.47   96.27
   RVT16:RG    -129.**************      0.*********       0.    1.00********
   AVT16:AS     -47.  -137.    38.   1590.   28557.     469.    3.39   98.12
   FULL1:FV       0.  -132.    36.   1590.   22359.     377.    4.22   98.21
   BRIDG:BR       0.    -6.    29.   1559.   11936.     192.    8.12   98.76
   RDWAY:RG      22.**************      0.       0.       0.    1.00********
   APPR1:AS      69.   -59.   143.   1590.   31543.     609.    2.61  100.41

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EVT16:XS     93.12    0.80   86.45  108.95************  1.51   95.41   93.90
   FVT16:FV     95.07    1.00   88.40  110.90************  2.13   97.20   95.07
   BVT16:BR     94.18    0.70   88.53   96.27************  0.87   97.14   96.27
   RVT16:RG  ****************   98.16  113.08************  0.19   98.60********
   AVT16:AS     95.42    0.44   90.11  108.95  0.46  1.00  0.26   98.38   98.12
   FULL1:FV  ********    0.61   90.74  109.58  0.19  0.08  0.41   98.63   98.21
   BRIDG:BR     95.84    0.62   90.18   98.76************  1.03   99.79   98.76
   RDWAY:RG  ****************  100.27  106.36************  0.22  100.53********
   APPR1:AS     98.20    0.38   91.58  105.90  0.21  0.60  0.22  100.63  100.41
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure GLOVTH00030006, in Glover, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number GLOVTH00030006

General Location Descriptive

Data collected by *(First Initial, Full last name)* M. WEBER

Date *(MM/DD/YY)* 08 / 04 / 94

Highway District Number *(I - 2; nn)* 09

County *(FIPS county code; I - 3; nnn)* 019

Town *(FIPS place code; I - 4; nnnnn)* 28075

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

Waterway *(I - 6)* BARTON RIVER

Road Name *(I - 7):* -

Route Number TH003

Vicinity *(I - 9)* 0.02 MI TO JCT W VT16

Topographic Map Crystal.Lake

Hydrologic Unit Code: 01110000

Latitude *(I - 16; nnnn.n)* 44424

Longitude *(i - 17; nnnnn.n)* 72112

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10100800061008

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

Maximum span length *(I - 48; nnnn)* 0037

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

Structure length *(I - 49; nnnnnn)* 000041

Average daily traffic, ADT *(I - 29; nnnnnn)* 000270

Deck Width *(I - 52; nn.n)* 288

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

Channel & Protection *(I - 61; n)* 6

Opening skew to Roadway *(I - 34; nn)* 45

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

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

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

Structure type *(I - 43; nnn)* 501

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*) 007.0

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

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

Comments:

Structural inspection report of 7/20/93 indicated the structure is a prestressed, precast, concrete-slab bridge. There is 2-3 feet of channel scour along the left abutment. The abutment and wingwall concrete was reportedly in good condition with no settlement cracks. The channel makes moderate to sharp bend towards bridge. A low gravel point bar along right abutment has developed. Minor embankment erosion was noted. The ambient mid-surface velocity is 3 feet per second.

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: 18.9

Terrain character: -

Stream character & type: -

Streambed material: Boulders and stones

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} 1200 Q_{25} 2000

Q_{50} 2600 Q_{100} 3200 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)* : Light Debris *(Heavy, Moderate, Light)*: Light

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 19.03 mi^2

Lake/pond/swamp area 0.73 mi^2

Watershed storage *(ST)* 3.5 %

Bridge site elevation 948 ft

Headwater elevation 2277 ft

Main channel length 7.08 mi

10% channel length elevation 994 ft

85% channel length elevation 1260 ft

Main channel slope *(S)* 50.01 ft / mi

Watershed Precipitation Data

Average site precipitation - in

Average headwater precipitation - in

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

Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY):* **04** / **1974**

Project Number **SAB - 7316** Minimum channel bed elevation: **489.0**

Low superstructure elevation: USLAB **497.91** DSLAB **497.72** USRAB **497.53** DSRAB **497.34**

Benchmark location description:

-

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

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

If 1: Footing Thickness **2** Footing bottom elevation: **486.3**

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? **Y** *If no, type ctrl-n bi* Number of borings taken: **2**

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

Briefly describe material at foundation bottom elevation or around piles:

Silt and gravel

Comments:

The footing bottom elevation shown above is an average of that for the left abutment (486.0 feet) and the right abutment (486.75 feet).

Cross-sectional Data

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

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

Comments: **FEMA**
This cross-section is the downstream face.

Station		7.3	7.5	6.1	-	-	-	-	-	-	-
Feature	0	20	40	-	-	-	-	-	-	-	-
Low chord elevation	LAB	-	RAB	-	-	-	-	-	-	-	-
Bed elevation	933.6	933.3	933.0	-	-	-	-	-	-	-	-
Low chord to bed	926.3	925.8	926.9	-	-	-	-	-	-	-	-

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: **DLS** Date: **2/9/95**

Computerized by: **EMB** Date: **2/27/95**

Reviewd by: **SAO** Date: **7/20/98**

Structure Number **GLOVTH00030006**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E. BOEHMLER** Date *(MM/DD/YY)* **10** / **25** / 19**94**

2. Highway District Number **09** Mile marker **-**

County **ORLEANS (019)** Town **GLOVER (28075)**

Waterway *(I - 6)* **BARTON RIVER** Road Name **-**

Route Number **TH03** Hydrologic Unit Code: **01110000**

3. Descriptive comments:

The structure is a prestressed concrete slab type bridge. It is located about 0.02 miles from the intersection of TH03 with VT16. Two other individual assessments were conducted at this bridge site on the same date by M. Weber and R. Hammond.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **2** LBDS **2** RBDS **2** Overall **2**
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

5. Ambient water surface... US **2** UB **1** DS **2** *(**1**- pool; **2**- riffle)*

6. Bridge structure type **1** *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*

7. Bridge length **41.0** *(feet)* Span length **37.0** *(feet)* Bridge width **28.8** *(feet)*

Road approach to bridge:

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

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

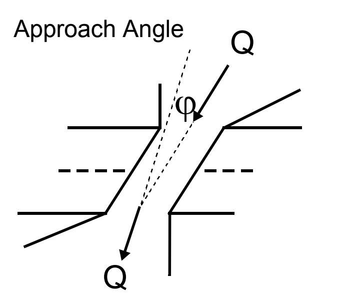
10. Embankment slope (*run / rise in feet / foot*):
US left **5.8:1** US right **3.5:1**

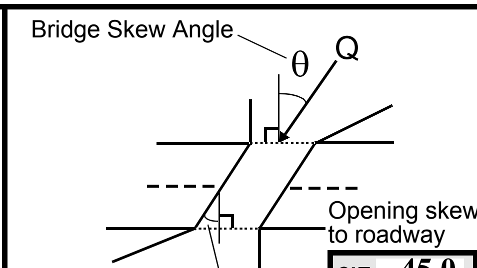
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	0	-	0	0
RBDS	2	1	0	0
LBDS	3	1	0	0

*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: **30**





α= **45.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **27** feet **US** *(US, UB, DS)* to **10** feet **UB**

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

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

18. Bridge Type: **4**

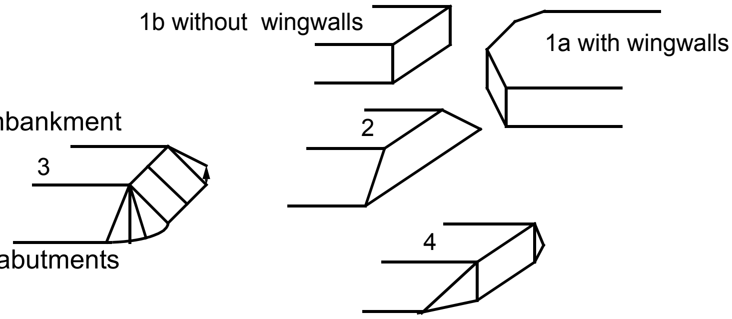
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

Measurements of bridge dimensions were the same as found on the historical form except for the roadway width measured curb to curb which was 26.0 feet.
Surface coverage on the left bank upstream is mainly a lawn with a narrow row of trees near the top of the stream bank. The right bank downstream surface cover also is a lawn with a house in close proximity to the channel (within about 30 feet) and a gravel driveway. Surface cover on the left bank downstream has a house set back only 20 feet or so from the bank with mainly a grass yard surrounding it. The right bank downstream is covered by asphalt (VT16). Stone fill protection on the left downstream road approach is protecting against erosion by a small storm drainage gully, which runs down along the embankment. The roadwash effect appears very slight on the upstream left road approach. Protection on the downstream right road approach is also protecting against erosion of the fill supporting the roadway to a bridge just downstream on Vermont State Route 16.

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
53.6	**5.5**			**3.5**	**3**	**1**	**7**	**7**	**0**	**0**

23. Bank width **80.0** 24. Channel width **80.0** 25. Thalweg depth **25.0** 29. Bed Material **354**

30 .Bank protection type: LB **5** RB **5** 31. Bank protection condition: LB **1** RB **1**

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

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

The boulder material on the bed apparently is “float” material on top of a dense clay, sand, and fine to coarse gravel material perhaps placed to protect bed against erosion. For the most part, the boulders are not inter-connected with the finer material below. A field-stone dry-masonry wall extends from the upstream end of the upstream left wingwall beyond 100 feet upstream on the left bank. A predominantly cut stone slab dry-wall extends from the upstream end of the upstream right wingwall beyond 100 feet upstream. The stream overall is channelized upstream of the bridge.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 13 35. Mid-bar width: 14

36. Point bar extent: 8 feet US (US, UB) to 0 feet DS (US, UB, DS) positioned 40 %LB to 100 %RB

37. Material: 3

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

The mid-bar distance given is 13 feet under the bridge from the upstream face along the thalweg. The point bar ends at the downstream face of the bridge. The predominant material is a medium size gravel with a few cobbles and boulders.

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

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

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

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

NO CUT BANKS

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

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

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

NO CHANNEL SCOUR

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
19.0		1.5		2	7	7	-

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

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

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

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

345

While the bed material at the right bank side under the bridge is a medium gravel, the left bank side is boulder material mostly. The predominant size is in the coarse gravel and cobble range probably.

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

There is little or no constriction of the channel at the bridge due to the channelization upstream. The stream gradient is moderate. Therefore, debris is likely to be pushed through the bridge and ice is unlikely to accumulate.

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		20	90	2	2	2.0	0.0	90.0
RABUT	1	0	90			1	0	35.5

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.):

-

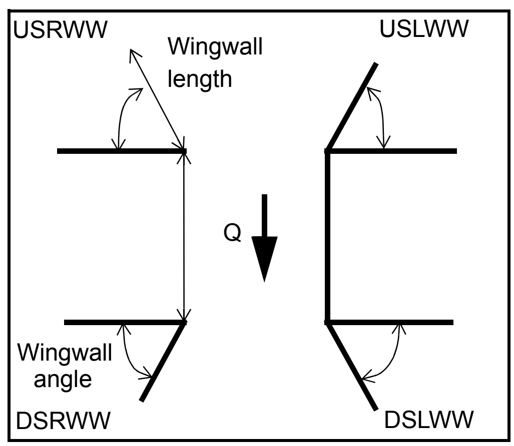
-

1

A local scour hole has developed along the left abutment wall measuring 29 feet long, 3 feet wide, and 2 feet deep. The center of the scour hole is located 15 feet under the bridge from the upstream face and is positioned in the channel from 0 %RB to 10 %LB. The upstream end of the left abutment is an impact zone where the flow attack on the wall and the erosion appears to be concentrated. The top of the left abutment footer is exposed from the upstream face of the bridge to nearly 30 feet under the bridge. While the top of the footer is exposed, the footing is countersunk relative to the surrounding streambed material by about 2 feet. The top of the footer is at the thalweg under the bridge.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						31.0	
USRWW:	Y		1		0	1.5	
DSLWW:	-		-		Y	43.5	
DSRWW:	1		0		-	43.5	



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

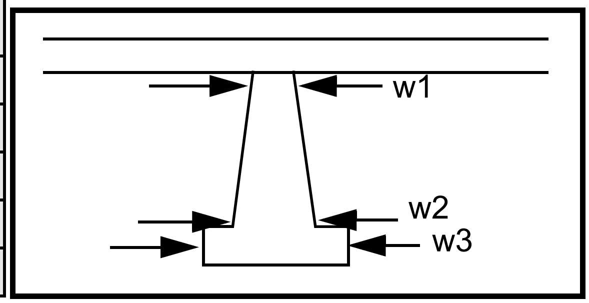
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
3
1
1
3
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				**20.0**	**16.0**	**70.0**
Pier 2	**6.5**	**8.0**		**70.0**	**20.0**	**16.5**
Pier 3	**-**	**-**	**-**	**-**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**ne fill**	**the**	**storm**	**the**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**on**	**wing**	**drai**	**end**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**the**	**wall**	**nage**	**of**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**dow**	**from**	**gully**	**the**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**nstre**	**ero-**	**whic**	**wing**	*Y- yes; N- no*
91. Attack ∠ (BF)	**am**	**sion**	**h**	**wall.**	
92. Pushed	**left**	**by**	**enter**		*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**wing**	**wate**	**s 5 ft**		
95. Cross-members	**wall**	**r**	**dow**		***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**also**	**flow-**	**nstre**		***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**pro-**	**ing**	**am**		
98. Exposure depth	**tects**	**in a**	**from**		

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

N
-
-
-
-
-
-

E. Downstream Channel Assessment

100.

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

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

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

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

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

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

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

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

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

Point bar extent: - feet - (US, UB, DS) to - feet - (US, UB, DS) positioned - %LB to NO %RB

Material: PI

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

ERS

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

Cut bank extent: _____ feet _____ (US, UB, DS) to _____ feet 1 (US, UB, DS)

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

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

7
2
0
0

Is channel scour present? 4 (Y or if N type ctrl-n cs) Mid-scour distance: 4

Scour dimensions: Length 2 Width 1 Depth: 1 Positioned The %LB to rig %RB

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

ht bank material is fill with placed quarried boulders embedded in the fill. Protection on the left bank is a very poorly constructed dry wall or simply, very large stone fill. The coverage of the protection on the left bank is complete such that an estimate of the bank material is impossible. The predominant bed material downstream appears to be cobbles, which are loosely embedded in a loose medium to coarse sand and fine

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

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

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

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

N

-

NO DROP STRUCTURE

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: GLOVTH00030006 Town: Glover
Road Number: TH3 County: Orleans
Stream: Barton R

Initials SAO Date: 10/28/97 Checked: RB

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	2640	3650	1590
Main Channel Area, ft2	231	253	194
Left overbank area, ft2	163	244	47
Right overbank area, ft2	608	762	368
Top width main channel, ft	25	25	25
Top width L overbank, ft	93	96	59
Top width R overbank, ft	174	184	119
D50 of channel, ft	0.16	0.16	0.16
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	9.2	10.1	7.8
y1, average depth, LOB, ft	1.8	2.5	0.8
y1, average depth, ROB, ft	3.5	4.1	3.1
Total conveyance, approach	52160	69948	31550
Conveyance, main channel	24495	28355	18200
Conveyance, LOB	5376	10259	911
Conveyance, ROB	22289	31334	12439
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1239.8	1479.6	917.2
Ql, discharge, LOB, cfs	272.1	535.3	45.9
Qr, discharge, ROB, cfs	1128.1	1635.1	626.9
Vm, mean velocity MC, ft/s	5.4	5.8	4.7
Vl, mean velocity, LOB, ft/s	1.7	2.2	1.0
Vr, mean velocity, ROB, ft/s	1.9	2.1	1.7
Vc-m, crit. velocity, MC, ft/s	8.8	9.0	8.6
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	0
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	2640	3650	1590
(Q) discharge thru bridge, cfs	1765	1730	1590
Main channel conveyance	11936	11936	11936
Total conveyance	11936	11936	11936
Q2, bridge MC discharge,cfs	1765	1730	1590
Main channel area, ft2	192	192	192
Main channel width (normal), ft	25.0	25.0	25.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25	25	25
y_bridge (avg. depth at br.), ft	7.68	7.68	7.68
Dm, median (1.25*D50), ft	0.2	0.2	0.2
y2, depth in contraction,ft	7.53	7.41	6.89
ys, scour depth (y2-ybridge), ft	-0.15	-0.27	-0.79

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	1765	1730	1590
Main channel area (DS), ft2	192	192	183
Main channel width (normal), ft	25.0	25	25.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	25.0	25.0	25.0
D90, ft	0.6146	0.6146	0.6146
D95, ft	0.9599	0.9599	0.9599
Dc, critical grain size, ft	0.3372	0.3240	0.3071
Pc, Decimal percent coarser than Dc	0.219	0.231	0.247
Depth to armoring, ft	3.61	3.24	2.81

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	2640	3650	1590
Q, thru bridge MC, cfs	1765	1730	1590
Vc, critical velocity, ft/s	8.82	8.95	8.56
Va, velocity MC approach, ft/s	5.37	5.85	4.73
Main channel width (normal), ft	25.0	25.0	25.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25.0	25.0	25.0
qbr, unit discharge, ft2/s	70.6	69.2	63.6
Area of full opening, ft2	192.0	192.0	192.0
Hb, depth of full opening, ft	7.68	7.68	7.68
Fr, Froude number, bridge MC	0.7	0.68	0.62
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	N/A	N/A	183
**Hb, depth at downstream face, ft	N/A	N/A	7.32
**Fr, Froude number at DS face	ERR	ERR	0.57
**Cf, for downstream face (<=1.0)	N/A	N/A	1.00
Elevation of Low Steel, ft	98.58	98.58	98.58
Elevation of Bed, ft	90.90	90.90	90.90
Elevation of Approach, ft	101.94	102.8	100.41
Friction loss, approach, ft	0.26	0.28	0.21
Elevation of WS immediately US, ft	101.68	102.52	100.20
ya, depth immediately US, ft	10.78	11.62	9.30
Mean elevation of deck, ft	101	101	101
w, depth of overflow, ft (>=0)	0.68	1.52	0.00
Cc, vert contrac correction (<=1.0)	0.93	0.93	0.95
**Cc, for downstream face (<=1.0)	ERR	ERR	0.940697
Ys, scour w/Chang equation, ft	**0.92**	**0.62**	**0.11**
Ys, scour w/Umbrell equation, ft	0.79	1.42	-0.52

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

**Ys, scour w/Chang equation, ft	N/A	N/A	0.58

**Ys, scour w/Umbrell equation, ft	N/A	N/A	-0.16

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	7.53	7.41	6.89
WSEL at downstream face, ft	--	--	98.21
Depth at downstream face, ft	N/A	N/A	7.32
Ys, depth of scour (Laursen), ft	N/A	N/A	-0.43

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	2640	3650	1590	2640	3650	1590
a', abut.length blocking flow, ft	92.4	96	58.3	174.1	183.7	119.1
Ae, area of blocked flow ft2	138.2	169.1	59.6	484.1	546.9	371.2
Qe, discharge blocked abut.,cfs	--	--	76.4	--	--	623.5
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.69	2.13	1.28	1.87	2.12	1.68
ya, depth of f/p flow, ft	1.50	1.76	1.02	2.78	2.98	3.12
--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	45	45	45	135	135	135
K2	0.91	0.91	0.91	1.05	1.05	1.05
Fr, froude number f/p flow	0.223	0.233	0.223	0.176	0.183	0.168
ys, scour depth, ft	7.49	8.64	4.99	13.98	15.18	12.97

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)	92.4	96	58.3	174.1	183.7	119.1
y1 (depth f/p flow, ft)	1.50	1.76	1.02	2.78	2.98	3.12
a'/y1	61.78	54.50	57.03	62.61	61.70	38.21
Skew correction (p. 49, fig. 16)	0.80	0.80	0.80	1.10	1.10	1.10
Froude no. f/p flow	0.22	0.23	0.22	0.18	0.18	0.17
Ys w/ corr. factor K1/0.55:						
vertical w/ ww's	**4.35**	**5.20**	**2.97**	**10.28**	**11.15**	**11.34**

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	0.7	0.68	0.62	0.7	0.68	0.62
y, depth of flow in bridge, ft	7.68	7.68	7.68	7.68	7.68	7.68
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	2.33	2.20	1.82	2.33	2.20	1.82
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR