LEVEL II SCOUR ANALYSIS FOR BRIDGE 25 (STOCTH00360025) on TOWN HIGHWAY 36, crossing STONY BROOK, STOCKBRIDGE, VERMONT

Open-File Report 98-197

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 25 (STOCTH00360025) on TOWN HIGHWAY 36, crossing STONY BROOK, STOCKBRIDGE, VERMONT

By MICHAEL A. IVANOFF AND LORA K. STRIKER

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Pembroke, New Hampshire

1998

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

U.S. GEOLOGICAL SURVEY
Thomas J. Casadevall, Acting Director

For additional information
write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275-3718

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Box 25286
Denver, CO 80225-0286

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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 25 (STOCTH00360025) ON TOWN HIGHWAY 36, CROSSING STONY BROOK, STOCKBRIDGE, VERMONT

By **Michael A. Ivanoff and Lora K. Striker**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure STOCTH00360025 on Town Highway 36 crossing Stony Brook, Stockbridge, Vermont (figures 1–8). The stream is listed as Stoney Brook in the Vermont Agency of Transportation (VTAOT) files. 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 VTAOT files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Green Mountain section of the New England physiographic province in central Vermont. The 7.49-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest.

In the study area, Stony Brook has a sinuous channel with a slope of approximately 0.030 ft/ft, an average channel top width of 62 ft and an average bank height of 8 ft. The channel bed material ranges from gravel to boulder including some bedrock outcrops, with a median grain size (D_{50}) of 67.6 mm (0.222 ft). The geomorphic assessment at the time of the Level I site visit on April 12, 1995 and Level II site visit on July 9, 1996, indicated that the reach was stable.

The Town Highway 36 crossing of Stony Brook is a 37-ft-long, one-lane bridge consisting of one 35-foot concrete slab span (Vermont Agency of Transportation, written communication, March 9, 1995). The opening length of the structure parallel to the bridge face is 33.5 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 25 degrees to the opening while the opening-skew-to-roadway is 20 degrees.

A scour hole 1 ft deeper than the mean thalweg depth was observed in the upstream channel during the Level I assessment. The only scour protection measure at the site was type-1 stone fill (less than 12 inches diameter) along the entire base length of the upstream and downstream left and right wingwalls and along the upstream and downstream left and right banks. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.4 to 1.8 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 11.9 to 13.6 ft. The worst-case left abutment scour occurred at the 500-year discharge. Right abutment scour ranged from 6.0 to 6.7 ft. The worst-case right abutment scour occurred at the incipient roadway-overtopping discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and Davis, 1995, p. 46). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Delectable Mountain, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

NORTH

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

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

LEVEL II SUMMARY

Structure Number STOCTH00360025 ***Stream*** Stony Brook

County Windsor ***Road*** TH 36 ***District*** 4

Description of Bridge

Bridge length 37 ***ft*** ***Bridge width*** 19.3 ***ft*** ***Max span length*** 35 ***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*** 4/12/95

Description of stone fill Type-1, along the upstream and downstream left and right wingwalls.

Abutments and wingwalls are concrete.

Yes

Is bridge skewed to flood flow according to - ***survey?*** ***Angle*** 25 No

4/12/95

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	0	0	7/9/96
Level II	0	0	Moder

ate. There is some debris caught on boulders and trees leaning over the upstream channel.

Potential for debris

Perkins Brook merges with Stony Brook downstream of this site (4/12/95).

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

Description of the Geomorphic Setting

General topography The channel is located in a high relief valley with little or no flood plains.

4/12/95

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

Date of inspection Steep channel

DS left: bank to a narrow overbank

DS right: Steep valley wall

US left: Steep valley wall

US right: Steep channel bank to a narrow flood plain

Description of the Channel

Average top width 62 ***ft*** ***Average depth*** 8 ***ft***

Predominant bed material Gravel ***Bank material*** Gravel

Sinuous and perennial

with semi-alluvial channel boundaries and narrow point bars.

4/12/95

Vegetative co Trees and brush with a small grass area near the bridge.

DS left: Trees and brush

DS right: Trees and brush

US left: Trees and brush with a small grass area near the bridge.

US right: Yes

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

There is bedrock in the upstream and downstream channel (4/12/95).

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 7.49 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 2,060 ***ft³/s*** ***Q500*** 3,000 ***ft³/s***

The 100- and 500-year discharges are based on flood frequency estimates available from the VTAOT database (written communication, May 1995). The database values were within the range defined by flood frequency curves developed from several 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 Subtract 1.9 ft from the USGS arbitrary survey datum to obtain VTAOT datum.

Description of reference marks used to determine USGS datum. RM1 is a State of Vermont brass tablet on top of the downstream end of the right abutment (elev. 500.06 ft, arbitrary survey datum). RM2 is a chiseled X on top of bedrock on the upstream left bank, 40 ft upstream of the upstream bridge face (elev. 492.54 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-30	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APTEM	62	1	Approach section as surveyed (Used as a template)
APPRO	69	2	Modelled Approach section (Templated from APTEM)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.055 to 0.075.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.030 ft/ft, which was estimated from surveyed thalweg points downstream of the bridge.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.007 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

For the 100-year discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for this discharge. After analyzing both the supercritical and subcritical profiles for each discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.8 ***ft***
Average low steel elevation 498.0 ***ft***

100-year discharge 2,060 ***ft³/s***
Water-surface elevation in bridge opening 494.6 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 161 ***ft²***
Average velocity in bridge opening 12.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 15.6 ***ft/s***

Water-surface elevation at Approach section with bridge 498.5
Water-surface elevation at Approach section without bridge 497.2
Amount of backwater caused by bridge 1.3 ***ft***

500-year discharge 3,000 ***ft³/s***
Water-surface elevation in bridge opening 497.8 ***ft***
Road overtopping? Yes ***Discharge over road*** 330 ***ft³/s***
Area of flow in bridge opening 260 ***ft²***
Average velocity in bridge opening 10.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.4 ***ft/s***

Water-surface elevation at Approach section with bridge 500.9
Water-surface elevation at Approach section without bridge 498.5
Amount of backwater caused by bridge 2.4 ***ft***

Incipient overtopping discharge 2,430 ***ft³/s***
Water-surface elevation in bridge opening 498.2 ***ft***
Area of flow in bridge opening 266 ***ft²***
Average velocity in bridge opening 9.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.8 ***ft/s***

Water-surface elevation at Approach section with bridge 500.1
Water-surface elevation at Approach section without bridge 497.7
Amount of backwater caused by bridge 2.4 ***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. For this site the total 500-year scour depths were less than the 100-year results, therefore the 500-year depths were not shown in figure 8.

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

For comparison, contraction scour for the discharges resulting in orifice flow was also computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). Furthermore, for those discharges resulting in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these alternative computations are provided in appendix F.

Abutment scour was computed by use of the Froehlich equation (Richardson and Davis, 1995, p. 48, equation 28). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour Results

Contraction scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.3	1.8	0.4
Depth to armoring	36.4	7.6	9.2
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	11.9	13.6	13.6
Right abutment	6.0	6.1	6.7
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	500-year discharge (D_{50} in feet)	Incipient overtopping discharge
Abutments:			
Left abutment	2.2	2.5	2.6
Right abutment	2.2	2.5	2.6
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

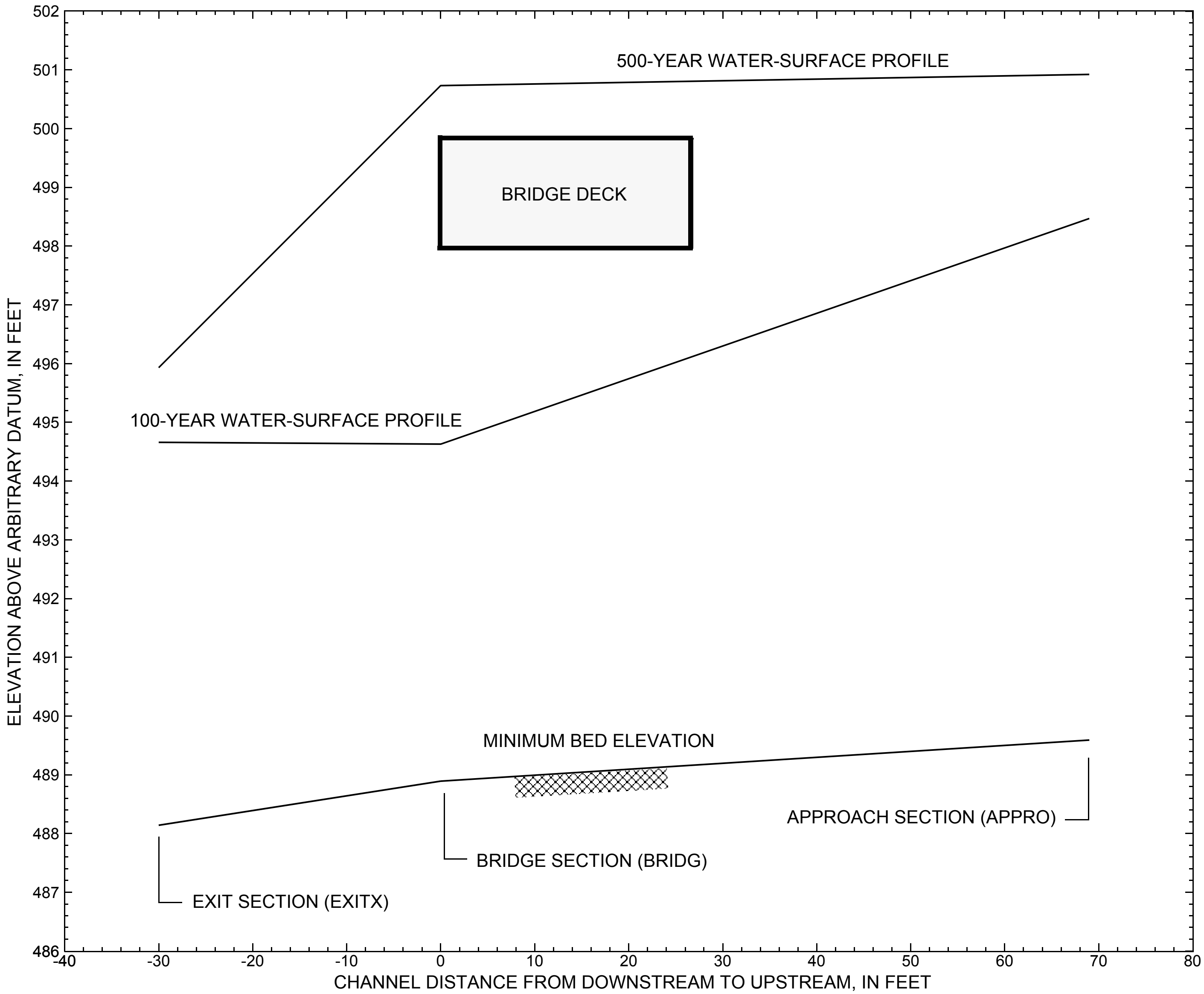

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure STOCTH00360025 on Town Highway 36, crossing Stony Brook, Stockbridge, Vermont.

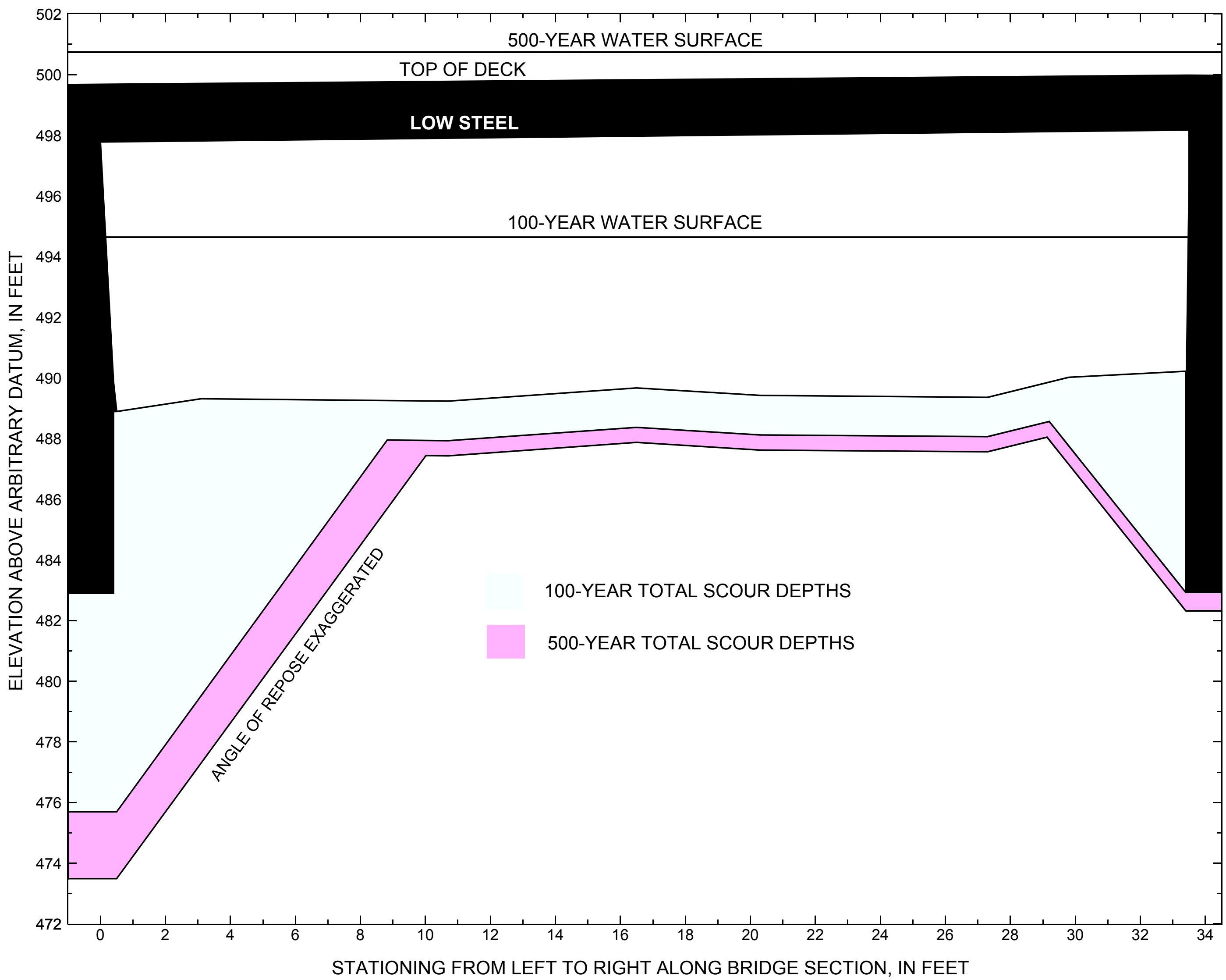

Figure 8. Scour elevations for the 100- and 500-year discharges at structure STOCTH00360025 on Town Highway 36, crossing Stony Brook, Stockbridge, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure STOCTH00360025 on Town Highway 36, crossing Stony Brook, Stockbridge, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat 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 2,060 cubic-feet per second											
Left abutment	0.0	493.6	497.8	482.9	488.9	1.3	11.9	--	13.2	475.7	-7.2
Right abutment	33.5	493.6	498.2	482.9	490.2	1.3	6.0	--	7.3	482.9	0.0

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure STOCTH00360025 on Town Highway 36, crossing Stony Brook, Stockbridge, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat 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 3,000 cubic-feet per second											
Left abutment	0.0	493.6	497.8	482.9	488.9	1.8	13.6	--	15.4	473.5	-9.4
Right abutment	33.5	493.6	498.2	482.9	490.2	1.8	6.1	--	7.9	482.3	-0.6

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

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U.S. Geological Survey, 1966, Delectable Mountain, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1983, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File stoc025.wsp
T2        Hydraulic analysis for structure STOCTH00360025   Date: 30-DEC-97
T3        TH 36 CROSSING STONEY BROOK, 0.85 MILES TO JCT WITH C3 TH 51,    LKS
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2060.0   3000.0   2430.0
SK          0.0300   0.0300   0.0300
*
XS   EXITX    -30           0.
GR          -92.7, 513.72    -74.4, 499.38    -55.4, 499.04    -40.1, 499.02
GR           -7.1, 494.00      0.0, 492.27      3.6, 489.02      5.0, 488.37
GR            7.8, 488.14     13.7, 488.42     23.7, 488.27     30.8, 488.94
GR           37.5, 491.95     45.4, 493.64     59.9, 503.49     77.7, 505.83
GR           89.6, 516.30
N           0.075
*
XS   FULLV      0  * * *   0.0190
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.78      20.0
GR            0.0, 497.78      0.4, 489.89      0.5, 488.89      3.1, 489.31
GR           10.7, 489.23     16.5, 489.67     20.3, 489.42     27.3, 489.36
GR           29.8, 490.02     33.4, 490.22     33.5, 498.17      0.0, 497.78
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      33.4 * *     37.1      9.0
N           0.055
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      19.3     2
GR          -40.5, 508.53    -29.7, 499.43      0.0, 499.68     33.8, 499.98
GR           54.6, 500.09    108.9, 501.80    127.6, 518.66
*
XT   APTEM     62           0.
GR          -23.0, 508.86    -17.2, 505.84    -10.0, 498.68      0.0, 490.19
GR            1.9, 489.61      5.0, 489.60      8.5, 490.39     11.1, 489.96
GR           13.1, 489.78     16.0, 489.54     20.9, 489.72     22.4, 490.37
GR           30.1, 495.49     33.9, 497.52     52.9, 500.31     73.6, 501.30
GR          146.6, 501.23    187.3, 502.43    202.4, 513.20
*         118.5, 500.49
AS   APPRO     69 * * * 0.007
GT
N           0.075
*
HP 1 BRIDG  494.63 1 494.63
HP 2 BRIDG  494.63 * * 2060
HP 1 APPRO  498.47 1 498.47
HP 2 APPRO  498.47 * * 2060
*
HP 1 BRIDG  497.78 1 497.78
HP 2 BRIDG  497.78 * * 2689
HP 1 BRIDG  496.95 1 496.95
HP 2 RDWAY  500.73 * *  330
HP 1 APPRO  500.92 1 500.92
HP 2 APPRO  500.92 * * 3000
*
HP 1 BRIDG  498.17 1 498.17
HP 2 BRIDG  498.17 * * 2430
HP 1 BRIDG  496.20 1 496.20
HP 1 APPRO  500.08 1 500.08
HP 2 APPRO  500.08 * * 2430
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
      U.S. Geological Survey WSPRO Input File stoc025.wsp
      Hydraulic analysis for structure STOCTH00360025   Date: 30-DEC-97
      TH 36 CROSSING STONEY BROOK, 0.85 MILES TO JCT WITH C3 TH 51,    LKS
         *** RUN DATE & TIME: 05-12-98  09:41
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     161.   10776.    31.    41.                        2066.
 494.63          161.   10776.    31.    41.  1.00     0.    33.   2066.



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

       WSEL     LEW     REW    AREA        K        Q    VEL
     494.63     0.2    33.5   160.7   10776.    2060.  12.82

X STA.        0.2        4.2        5.5        6.8        8.1        9.4
  A(I)           19.8        6.7        6.6        6.6        6.7
  V(I)           5.20      15.35      15.52      15.60      15.39

X STA.        9.4       10.7       12.1       13.5       14.9       16.4
  A(I)            6.6        6.9        6.7        6.9        7.0
  V(I)          15.61      15.01      15.27      14.93      14.79

X STA.       16.4       17.9       19.3       20.7       22.1       23.5
  A(I)            6.9        7.0        6.8        6.8        6.8
  V(I)          14.91      14.62      15.25      15.19      15.12

X STA.       23.5       24.8       26.2       27.6       29.1       33.5
  A(I)            6.7        6.8        6.7        7.0       18.7
  V(I)          15.45      15.09      15.39      14.76       5.52

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      69.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     285.   16888.    50.    55.                        3868.
 498.47          285.   16888.    50.    55.  1.00   -10.    40.   3868.



  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      69.

       WSEL     LEW     REW    AREA        K        Q    VEL
     498.47    -9.7    40.0   284.8   16888.    2060.   7.23

X STA.       -9.7       -0.8        0.7        2.0        3.2        4.4
  A(I)           33.6       12.1       11.0       10.8       11.0
  V(I)           3.07       8.48       9.38       9.54       9.34

X STA.        4.4        5.7        7.0        8.4        9.9       11.2
  A(I)           11.1       11.1       11.5       11.6       11.2
  V(I)           9.27       9.26       8.94       8.85       9.16

X STA.       11.2       12.4       13.7       14.9       16.1       17.3
  A(I)           10.6       10.8       10.7       10.5       10.5
  V(I)           9.68       9.55       9.66       9.81       9.77

X STA.       17.3       18.5       19.7       20.9       22.2       40.0
  A(I)           10.5       10.5       10.6       10.8       54.1
  V(I)           9.77       9.85       9.74       9.50       1.90
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        U.S. Geological Survey WSPRO Input File stoc025.wsp
        Hydraulic analysis for structure STOCTH00360025   Date: 30-DEC-97
        TH 36 CROSSING STONEY BROOK, 0.85 MILES TO JCT WITH C3 TH 51,    LKS
           *** RUN DATE & TIME: 05-12-98  09:41
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     260.   21795.    31.    48.                       4228.
   497.78          260.   21795.    31.    48.  1.00     0.    33.   4228.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.78     0.0    33.5   259.5   21795.    2689.  10.36

 X STA.        0.0        5.0        6.2        7.5        8.7       10.0
   A(I)            38.6        9.8       10.1       10.0       10.1
   V(I)            3.48      13.74      13.36      13.44      13.27

 X STA.       10.0       11.3       12.6       13.9       15.2       16.6
   A(I)            10.4       10.1       10.5       10.3       10.8
   V(I)           12.96      13.32      12.85      13.11      12.48

 X STA.       16.6       18.0       19.4       20.7       22.0       23.3
   A(I)            10.5       10.6       10.5       10.2       10.3
   V(I)           12.82      12.68      12.85      13.14      13.10

 X STA.       23.3       24.6       25.9       27.1       28.5       33.5
   A(I)            10.0       10.3       10.1       10.5       36.1
   V(I)           13.39      13.09      13.35      12.85       3.73

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     233.   18703.    31.    46.                       3609.
   496.95          233.   18703.    31.    46.  1.00     0.    33.   3609.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.73   -31.2    74.9    87.3    1517.     330.   3.78

 X STA.      -31.2      -27.3      -24.5      -21.7      -18.7      -15.6
   A(I)             4.1        3.6        3.5        3.6        3.8
   V(I)            4.07       4.60       4.68       4.59       4.38

 X STA.      -15.6      -12.4       -9.1       -5.6       -2.0        0.5
   A(I)             3.7        3.8        3.8        4.0        2.6
   V(I)            4.50       4.34       4.30       4.17       6.25

 X STA.        0.5        2.8        6.6       10.7       15.0       19.7
   A(I)             2.4        3.9        3.9        4.0        4.2
   V(I)            6.94       4.28       4.18       4.10       3.90

 X STA.       19.7       24.8       30.6       37.2       44.4       74.9
   A(I)             4.4        4.6        5.0        5.1       13.3
   V(I)            3.77       3.56       3.33       3.21       1.24

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      69.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     432.   25718.    77.    83.                       5822.
   500.92          432.   25718.    77.    83.  1.00   -12.    65.   5822.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      69.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.92   -12.2    64.6   432.4   25718.    3000.   6.94

 X STA.      -12.2       -2.9       -0.9        0.7        2.1        3.5
   A(I)            39.0       18.5       16.8       15.8       15.7
   V(I)            3.84       8.11       8.90       9.49       9.56

 X STA.        3.5        4.9        6.4        8.0        9.6       10.8
   A(I)            16.1       16.3       17.1       16.8       13.3
   V(I)            9.33       9.19       8.79       8.95      11.28

 X STA.       10.8       11.8       13.1       14.3       15.6       16.8
   A(I)            10.3       14.2       13.9       14.2       13.7
   V(I)           14.58      10.54      10.76      10.59      10.96

 X STA.       16.8       18.0       19.2       20.4       21.7       64.6
   A(I)            13.6       14.0       13.4       14.1      125.7
   V(I)           11.06      10.70      11.17      10.65       1.19
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        U.S. Geological Survey WSPRO Input File stoc025.wsp
        Hydraulic analysis for structure STOCTH00360025   Date: 30-DEC-97
        TH 36 CROSSING STONEY BROOK, 0.85 MILES TO JCT WITH C3 TH 51,    LKS
           *** RUN DATE & TIME: 05-12-98  09:41
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     266.   16096.     0.    79.                           0.
   498.17          266.   16096.     0.    79.  1.00     0.    34.      0.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.17     0.0    33.5   265.6   16096.    2430.   9.15

X STA.         0.0         3.9         5.3         6.7         8.1         9.6
  A(I)            29.9        11.3        11.5        11.4        11.5
  V(I)            4.07       10.77       10.54       10.67       10.60

X STA.         9.6        11.0        12.4        13.8        15.3        16.8
  A(I)            11.4        11.4        11.5        11.7        11.6
  V(I)           10.62       10.70       10.54       10.40       10.52

X STA.        16.8        18.2        19.7        21.1        22.5        23.9
  A(I)            11.8        11.6        11.6        11.4        11.4
  V(I)           10.30       10.48       10.45       10.68       10.62

X STA.        23.9        25.3        26.7        28.1        29.6        33.5
  A(I)            11.2        11.5        11.2        11.8        29.0
  V(I)           10.84       10.58       10.84       10.28        4.19

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     210.   16016.    31.    44.                        3079.
   496.20          210.   16016.    31.    44.  1.00     0.    33.   3079.

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      69.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     375.   23119.    62.    69.                        5220.
   500.08          375.   23119.    62.    69.  1.00   -11.    51.   5220.


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      69.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.08   -11.4    51.0   375.1   23119.    2430.   6.48

X STA.       -11.4        -1.9        -0.1         1.3         2.7         4.0
  A(I)            39.5        16.6        14.1        14.0        13.9
  V(I)            3.08        7.33        8.59        8.67        8.75

X STA.         4.0         5.4         6.8         8.3         9.8        11.2
  A(I)            14.3        14.3        14.9        15.0        13.5
  V(I)            8.47        8.47        8.14        8.12        8.99

X STA.        11.2        12.4        13.7        14.9        16.2        17.4
  A(I)            11.9        13.2        13.3        13.1        13.0
  V(I)           10.23        9.21        9.11        9.30        9.34

X STA.        17.4        18.7        19.9        21.2        22.5        51.0
  A(I)            12.8        13.1        12.9        13.6        88.1
  V(I)            9.52        9.29        9.45        8.94        1.38
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        U.S. Geological Survey WSPRO Input File stoc025.wsp
        Hydraulic analysis for structure STOCTH00360025   Date: 30-DEC-97
        TH 36 CROSSING STONEY BROOK, 0.85 MILES TO JCT WITH C3 TH 51,    LKS
           *** RUN DATE & TIME: 05-12-98  09:41

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

EXITX:XS   ******   -11.     240.  1.14 *****  495.80  493.73   2060.  494.66
      -30. ******    47.   11893.  1.00 ***** *******    0.74    8.57

FULLV:FV      30.   -14.     265.  0.94  0.79  496.58 *******   2060.  495.65
        0.    30.    48.   13520.  1.00  0.00   -0.01    0.66    7.76
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      69.    -8.     226.  1.30  1.68  498.44 *******   2060.  497.15
       69.    69.    33.   12913.  1.00  0.18    0.00    0.69    9.13
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    2060.     494.63

            <<<<<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      30.     0.     161.  2.56 *****  497.19  494.63   2060.  494.63
        0.    30.    33.   10767.  1.00 ***** *******    1.00   12.83

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.78 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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      36.   -10.     285.  0.81  0.88  499.28  495.72   2060.  498.47
       69.    37.    40.   16884.  1.00  1.22    0.01    0.53    7.23

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.191  0.000   18997.    -5.    29.   497.73

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -30.   -11.    47.   2060.   11893.     240.    8.57  494.66
   FULLV:FV       0.   -14.    48.   2060.   13520.     265.    7.76  495.65
   BRIDG:BR       0.     0.    33.   2060.   10767.     161.   12.83  494.63
   RDWAY:RG      13.**************      0.*****************    2.00********
   APPRO:AS      69.   -10.    40.   2060.   16884.     285.    7.23  498.47

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -5.    29.   18997.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF     HO   VHD      EGL    WSEL
   EXITX:XS    493.73    0.74  488.14  516.30************  1.14  495.80  494.66
   FULLV:FV  ********    0.66  488.71  516.87  0.79  0.00  0.94  496.58  495.65
   BRIDG:BR    494.63    1.00  488.89  498.17************  2.56  497.19  494.63
   RDWAY:RG  ****************  499.43  518.66**********************************
   APPRO:AS    495.72    0.53  489.59  513.25  0.88  1.22  0.81  499.28  498.47
```

WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File stoc025.wsp
        Hydraulic analysis for structure STOCTH00360025   Date: 30-DEC-97
        TH 36 CROSSING STONEY BROOK, 0.85 MILES TO JCT WITH C3 TH 51,    LKS
           *** RUN DATE & TIME: 05-12-98  09:41

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

EXITX:XS   ******   -20.     321.  1.36 *****  497.29  494.94   3000.  495.93
      -30. ******    49.   17310.  1.00 ***** *******    0.76    9.34

FULLV:FV      30.   -23.     353.  1.12  0.80  498.08 *******   3000.  496.95
        0.    30.    49.   19564.  1.00  0.00   -0.01    0.68    8.50
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      69.   -10.     288.  1.69  1.86  500.22 *******   3000.  498.53
       69.    69.    40.   17067.  1.00  0.28    0.00    0.77   10.43
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   500.64       0.00     496.09     499.43

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   503.92         0.      3000.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

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

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

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

BRIDG:BR      30.     0.     260.  1.67 *****  499.45  495.63   2689.  497.78
        0. ******    33.   21795.  1.00 ***** *******    0.64   10.36

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.480 ******  497.78 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    50.  0.68  0.75  500.99    0.01    330.  500.73

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    219.    48.   -31.    17.   1.3   1.1   5.1   4.2   1.4   2.9
   RT:    111.    38.    17.    55.   0.9   0.8   4.3   3.8   1.0   2.8

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

APPRO:AS      36.   -12.     433.  0.75  0.54  501.67  497.16   3000.  500.92
       69.    37.    65.   25725.  1.00  0.00    0.01    0.52    6.93

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS      -30.   -20.    49.   3000.   17310.     321.    9.34  495.93
   FULLV:FV        0.   -23.    49.   3000.   19564.     353.    8.50  496.95
   BRIDG:BR        0.     0.    33.   2689.   21795.     260.   10.36  497.78
   RDWAY:RG       13.*******   219.    330.       0.       0.    2.00  500.73
   APPRO:AS       69.   -12.    65.   3000.   25725.     433.    6.93  500.92

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS  **********************

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    494.94     0.76  488.14  516.30************  1.36  497.29  495.93
   FULLV:FV  ********     0.68  488.71  516.87  0.80  0.00  1.12  498.08  496.95
   BRIDG:BR    495.63     0.64  488.89  498.17************  1.67  499.45  497.78
   RDWAY:RG  ****************  499.43  518.66  0.68******  0.75  500.99  500.73
   APPRO:AS    497.16     0.52  489.59  513.25  0.54  0.00  0.75  501.67  500.92
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        U.S. Geological Survey WSPRO Input File stoc025.wsp
        Hydraulic analysis for structure STOCTH00360025   Date: 30-DEC-97
        TH 36 CROSSING STONEY BROOK, 0.85 MILES TO JCT WITH C3 TH 51,    LKS
           *** RUN DATE & TIME: 05-12-98  09:41

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

EXITX:XS   ******   -15.     273.  1.23 *****  496.43  494.23   2430.  495.20
      -30. ******    48.   14018.  1.00 ***** *******    0.75    8.90

FULLV:FV      30.   -18.     301.  1.01  0.79  497.21 *******   2430.  496.20
        0.    30.    48.   15901.  1.00  0.00   -0.01    0.67    8.08
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      69.    -9.     249.  1.48  1.75  499.18 *******   2430.  497.70
       69.    69.    35.   14661.  1.00  0.23   -0.01    0.72    9.76
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.22     498.47     499.34     497.78

 ===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      30.     0.     266.  1.28 *****  499.45  495.20   2412.  498.17
        0. ******    34.   16096.  1.00 ***** *******    0.57    9.08

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.450 ******  497.78 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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      36.   -11.     375.  0.65  0.59  500.73  496.32   2430.  500.08
       69.    37.    51.   23101.  1.00  1.23   -0.01    0.47    6.48

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   499.53

  FIRST USER DEFINED TABLE.

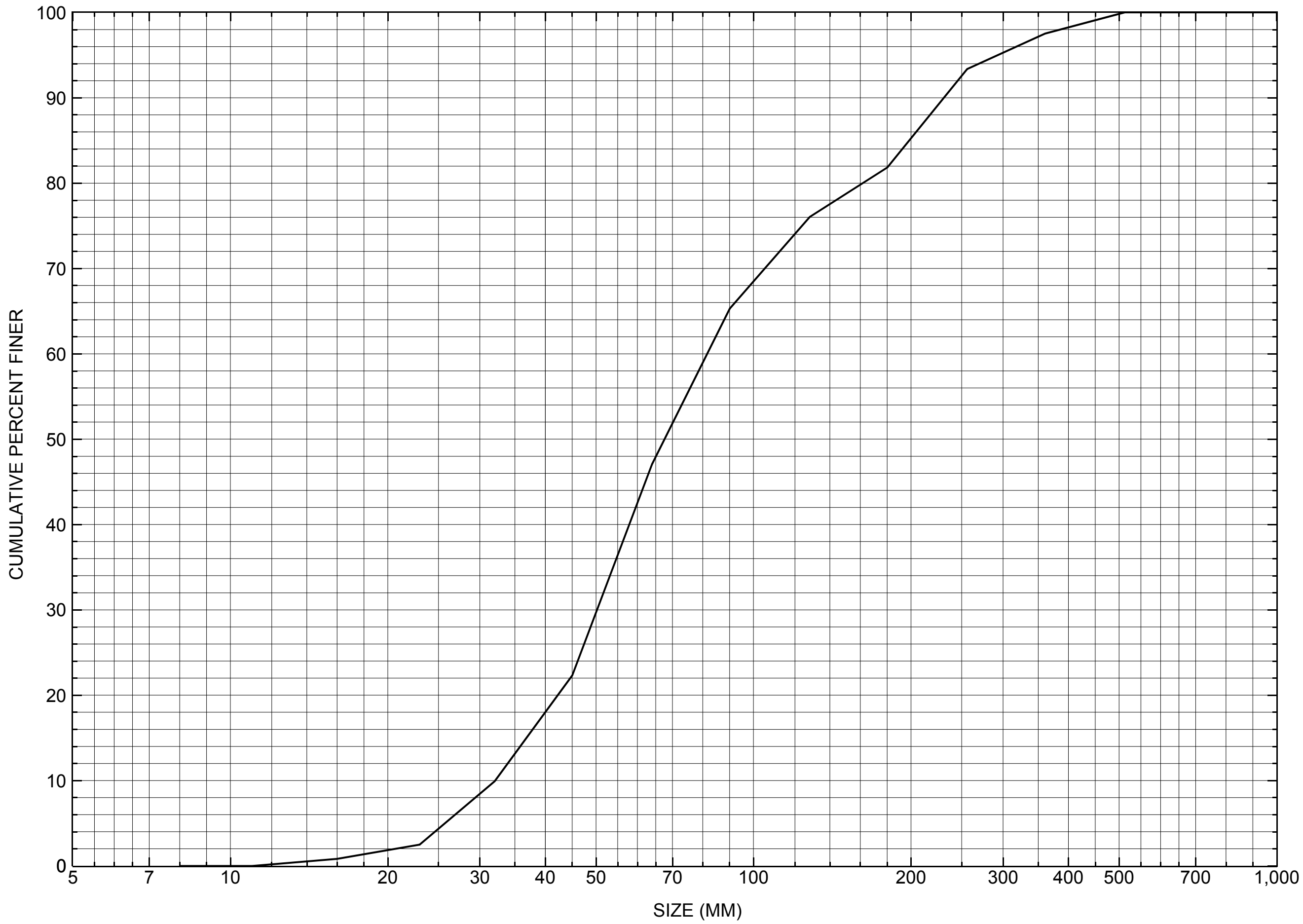
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -30.   -15.    48.   2430.   14018.     273.    8.90  495.20
   FULLV:FV       0.   -18.    48.   2430.   15901.     301.    8.08  496.20
   BRIDG:BR       0.     0.    34.   2412.   16096.     266.    9.08  498.17
   RDWAY:RG      13.**************      0.       0.       0.    2.00********
   APPRO:AS      69.   -11.    51.   2430.   23101.     375.    6.48  500.08

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    494.23    0.75  488.14  516.30************  1.23  496.43  495.20
   FULLV:FV  ********    0.67  488.71  516.87  0.79  0.00  1.01  497.21  496.20
   BRIDG:BR    495.20    0.57  488.89  498.17************  1.28  499.45  498.17
   RDWAY:RG  ****************  499.43  518.66************  0.65  500.18********
   APPRO:AS    496.32    0.47  489.59  513.25  0.59  1.23  0.65  500.73  500.08
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure STOCTH00360025, in Stockbridge, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number STOCTH00360025

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 09 / 95

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

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

Town *(FIPS place code; I - 4; nnnnn)* 70375

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

Waterway *(I - 6)* Stony Brook

Road Name *(I - 7):* -

Route Number TH036

Vicinity *(I - 9)* 0.85 MI TO JCT W C3 TH51

Topographic Map Delectable Mountain

Hydrologic Unit Code: 01080105

Latitude *(I - 16; nnnn.n)* 43427

Longitude *(i - 17; nnnnn.n)* 72433

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10141900251419

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

Maximum span length *(I - 48; nnnn)* 0035

Year built *(I - 27; YYYY)* 1992

Structure length *(I - 49; nnnnnn)* 000037

Average daily traffic, ADT *(I - 29; nnnnnn)* 000025

Deck Width *(I - 52; nn.n)* 193

Year of ADT *(I - 30; YY)* 90

Channel & Protection *(I - 61; n)* 8

Opening skew to Roadway *(I - 34; nn)* 20

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

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*) 30.0

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

Vertical clearance from streambed (*nnn.n ft*) 8.0

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

Waterway of full opening (*nnn.n* ft^2) 240.0

Comments:

The structural inspection report of 7/1/94 indicates the structure is a concrete slab type bridge. The concrete abutments are clean and the footings are not in view at the surface. The waterway has a straight alignment with the abutment walls. The streambed is noted to consist of stone and gravel. There are some boulders just downstream of the bridge. The banks are noted to be protected with stone fill. Bedrock is indicated in the channel just upstream from the right abutment.

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **7.4**

Terrain character: **Hilly to mountainous and mostly forested**

Stream character & type: -

Streambed material: **Stone and gravel**

Discharge Data *(cfs)*: $Q_{2.33}$ **300** Q_{10} **960** Q_{25} **1360**

Q_{50} **1720** Q_{100} **2060** Q_{500} -

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

Estimated Discharge *(cfs)*: - Velocity at Q **25** *(ft/s)*: **9.9**

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*)	**490.1**	**492.1**	**493.2**	**494.6**	**495.7**
Velocity (*ft / sec*)	-	-	**9.9**	-	-

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*): **Y** *If No or Unknown, type ctrl-n os*

Upstream distance (*miles*): **0.44** Town: **Stockbridge** Year Built: **1977**

Highway No. : **TH36** Structure No. : **026** Structure Type: **Concrete slab**

Clear span (*ft*): **25.0** Clear Height (*ft*): **9.0** Full Waterway (*ft²*): **225.0**

Downstream distance (*miles*): 0.1 Town: Stockbridge Year Built: 1977
Highway No. : TH36 Structure No. : 24 Structure Type: -
Clear span (*ft*): 30.0 Clear Height (*ft*): 9.0 Full Waterway (ft^2): 270.0

Comments:
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 7.49 mi^2 Lake/pond/swamp area 0 mi^2
Watershed storage *(ST)* 0 %
Bridge site elevation 1100 ft Headwater elevation 2625 ft
Main channel length 4.27 mi
10% channel length elevation 1130 ft 85% channel length elevation 1980 ft
Main channel slope *(S)* 265.41 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):* **03** / **1991**

Project Number **BTN 2004(2)** Minimum channel bed elevation: **487.0**

Low superstructure elevation: USLAB **493.6*** DSLAB **-** USRAB **493.6** DSRAB **-**

Benchmark location description:

BM#2, chiseled square in the concrete at the corner junction on top of the upstream left wingwall and left abutment of bridge 24, on TH36, just downstream of this bridge about 0.1 mile, elevation 489.48.

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 **2.0** Footing bottom elevation: **481.0**

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

If 3: Footing bottom elevation: **-**

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

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

Briefly describe material at foundation bottom elevation or around piles:

The plans show how construction engineers were to dowel the bottom left abutment footing into the bedrock. The right abutment is not on bedrock. It is probably set in regolith. The footing on the right is shown as the same as that for the left abutment.

Comments:

BM # 1 is a railroad spike in a 12 inch white birch tree about 50 feet right bankward from the right abutment and about 20 feet upstream from the centerline of the roadway.

***The bridge seat elevation was noted as 493.6 from general notes on the plans. Also noted were elevations of the top of the concrete abutments: right abutment upstream at 498.23 and downstream at 498.14; left abutment upstream end at 497.78 and downstream at 497.69.**

Cross-sectional Data

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

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

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

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

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

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **10/04/96**
Computerized by: **RB** Date: **10/04/96**
Reviewd by: **LKS** Date: **12/30/97**

Structure Number **STOCTH00360025**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M. Weber** Date *(MM/DD/YY)* **04** / **12** / 19**95**
2. Highway District Number **04** Mile marker **0000**
County **Windsor (027)** Town **Stockbridge (70375)**
Waterway *(I - 6)* **Stony Brook** Road Name **-**
Route Number **TH036** Hydrologic Unit Code: **01080105**
3. Descriptive comments:
The bridge is located 0.85 miles from the junction with Town Highway 51. There is a State of Vermont bridge plaque on the DS right wingwall face says "Bridge No. BTN 2004(2) 1992."

B. Bridge Deck Observations

4. Surface cover... LBUS **6** RBUS **6** LBDS **6** RBDS **6** Overall **6**
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US **2** UB **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 **37** *(feet)* Span length **35** *(feet)* Bridge width **19.3** *(feet)*

Road approach to bridge:

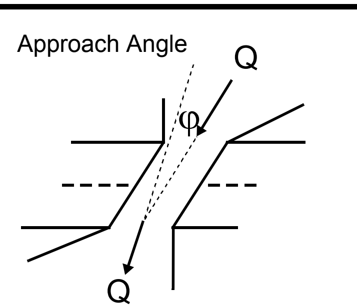
8. LB **0** RB **0** *(**0** even, **1**- lower, **2**- higher)*
9. LB **2** RB **2** *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left **3.7:1** US right **5.3:1**

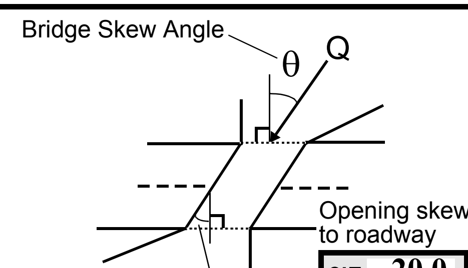
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: **5** 16. Bridge skew: **25**





α= **20.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **40** feet **US** *(US, UB, DS)* to **60** feet **US**
Channel impact zone 2: Exist? **N** *(Y or N)*
Where? **-** *(LB, RB)* Severity **-**
Range? **-** feet **-** *(US, UB, DS)* to **-** feet **-**

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

18. Bridge Type: **4**

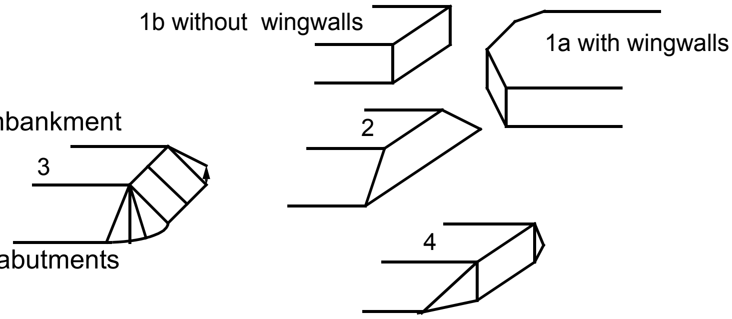
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

7. Bridge dimension values are from the VTAOT files. The measured bridge length was 37 ft, span length was 34 ft, and the bridge width was 19.5 ft.
4. The predominant surface cover is heavy forest; however, all the road approach embankments are cleared and the areas near the bridge on the US right and DS left are also cleared.
17. Impact zone 1 is at the bedrock outcrop on the US left bank.

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
42.0	8.5			7.0	4	3	3246	3246	0	1

23. Bank width **40.0** 24. Channel width **30.0** 25. Thalweg depth **44.0** 29. Bed Material **346**

30 .Bank protection type: LB **1** RB **1** 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.):

26. There is minimal vegetative cover on the right bank from the US bridge face to 60 ft US and on the left bank from the US bridge face to 25 ft US; beyond these areas the banks are forested.
27. Bank material is gravel, sand, cobble and boulder with some bedrock exposures on the left bank. The closest bedrock exposure to the bridge is from 70 ft US to 30 ft US.
29. Bed material is variable in the US reach; in some riffles it is cobble and boulders while in other riffles it is predominantly gravel. There is bedrock exposure in the middle of the channel 50 ft to 60 ft US.
30. Bank protection exists to 30 ft US on both banks. Further US the left bank is naturally protected by bedrock to 70 ft US.

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

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

37. Material: -

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

There are no point bars upstream at this site.

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

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

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

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

There are no cut-banks upstream at this site.

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 40

47. Scour dimensions: Length 10 Width 5 Depth : 1 Position 5 %LB to 15 %RB

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

The scour is caused by eddies around the bedrock protrusion into the channel noted as impact zone 1. It is from 30 ft US to 40 ft US.

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

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

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

54. Confluence comments (eg. confluence name):

There are no major confluences upstream at this site.

D. Under Bridge Channel Assessment

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

56. Height (BF) 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
22.5		0.5		2	7	7	-

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

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

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

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

34

63. The bed material under the bridge is finer than in the US reach. The bed material is predominantly gravel and cobble.

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

67. Debris Potential **1**____ *(1- Low; 2- Moderate; 3- High)* 68. Capture Efficiency **2**____ *(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 are some branches and logs caught on the banks in the US reach and trees leaning into the channel. The bridge will not constrict much of the bank full flow; therefore, the capture efficiency is low.

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**	**0**	**-**	**-**	**90.0**
RABUT	**1**	**-**	**90**			**2**	**0**	**31.5**

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

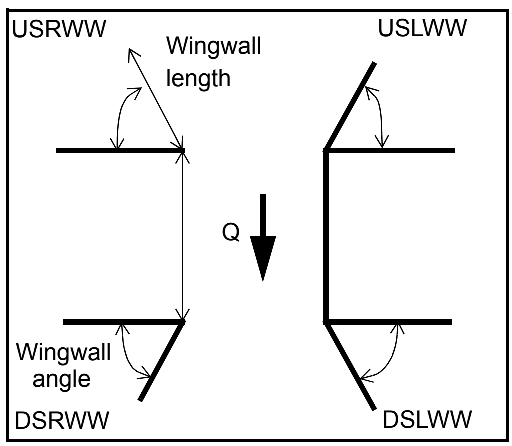
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

-
-
1
-

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**31.5**	
USRWW:	**Y**		**1**		**0**	**0.5**	
DSLWW:	**-**		**-**		**Y**	**26.5**	
DSRWW:	**1**		**0**		**-**	**27.0**	

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



82. **Bank / Bridge Protection**:

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

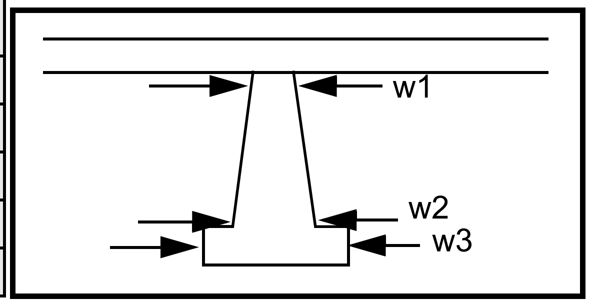
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				**50.0**	**10.5**	**25.0**
Pier 2				**12.5**	**25.0**	**12.5**
Pier 3			-	**50.0**	**10.5**	-
Pier 4	-	-	-	-	-	-



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

99. Pier comments (eg. undermined penetration, protection and protection extent, unusual scour processes, etc.):
-
-
-
-
-
-
-
-
-
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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.):
-
-
-
-
-
-
There are no piers.

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

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

105. Drop structure comments (eg. downstream scour depth):
4
3246
3246
0
1
346

106. Point/Side bar present? 1 (Y or N. if N type ctrl-n pb) Mid-bar distance: 1 Mid-bar width: 1

Point bar extent: 1 feet Th (US, UB, DS) to e feet per (US, UB, DS) positioned cen %LB to t %RB

Material: veg

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

etation cover is minimal to 45 ft DS on the left bank and to 35 ft DS on the right; beyond these areas the downstream banks are forested. The bank material is gravel, sand, cobble and boulder. The bed material is gravel, cobble, and boulder. The bank protection continues to 35 ft DS on both banks.

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 ____ (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.):

N

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

Scour dimensions: Length DRO Width P Depth: STR Positioned UC %LB to TU %RB

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

RE

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

Confluence 1: Distance Y Enters on 65 (LB or RB) Type 7 (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance 50 Enters on DS (LB or RB) Type 85 (**1**- perennial; **2**- ephemeral)

Confluence comments (eg. confluence name):

DS
90

F. Geomorphic Channel Assessment

107. Stage of reach evolution 100

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)*:

3

The bar is gravel with cobble and boulders at its US end. It is not vegetated.

N

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109. G. Plan View Sketch

- T

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: STOCTH00360025 Town: Stockbridge
Road Number: TH 36 County: Windsor
Stream: Stoney Brook

Initials MAI Date: 03/12/98 Checked: ECW

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 Davis, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	2060	3000	2430
Main Channel Area, ft2	285	432	375
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	50	77	62
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.2217	0.2217	0.2217
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.7	5.6	6.0
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	16888	25718	23119
Conveyance, main channel	16888	25718	23119
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	2060.0	3000.0	2430.0
Ql, discharge, LOB, cfs	0.0	0.0	0.0
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	7.2	6.9	6.5
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	9.1	9.0	9.2
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 Davis, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	2060	3000	2430
(Q) discharge thru bridge, cfs	2060	2689	2430
Main channel conveyance	10776	21795	16096
Total conveyance	10776	21795	16096
Q2, bridge MC discharge,cfs	2060	2689	2430
Main channel area, ft2	161	260	266
Main channel width (normal), ft	31.3	31.5	31.5
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	31.3	31.5	31.5
y_bridge (avg. depth at br.), ft	5.14	8.24	8.44
Dm, median (1.25*D50), ft	0.277125	0.277125	0.277125
y2, depth in contraction,ft	6.46	8.08	7.40
ys, scour depth (y2-ybridge), ft	**1.32**	-0.16	-1.04

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 Davis, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	2060	3000	2430
Q, thru bridge MC, cfs	2060	2689	2430
Vc, critical velocity, ft/s	9.07	9.04	9.16
Va, velocity MC approach, ft/s	7.23	6.94	6.48
Main channel width (normal), ft	31.3	31.5	31.5
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	31.3	31.5	31.5
qbr, unit discharge, ft2/s	65.8	85.4	77.1
Area of full opening, ft2	161.0	259.5	266.0
Hb, depth of full opening, ft	5.14	8.24	8.44
Fr, Froude number, bridge MC	0	0.63	0.56
Cf, Fr correction factor (<=1.0)	0.00	1.00	1.00
**Area at downstream face, ft2	N/A	233	210
**Hb, depth at downstream face, ft	N/A	7.40	6.67
**Fr, Froude number at DS face	ERR	0.75	0.79
**Cf, for downstream face (<=1.0)	N/A	1.00	1.00
Elevation of Low Steel, ft	0	497.78	497.78

Elevation of Bed, ft	-5.14	489.54	489.34
Elevation of Approach, ft	0	500.92	500.08
Friction loss, approach, ft	0	0.54	0.59
Elevation of WS immediately US, ft	0.00	500.38	499.49
ya, depth immediately US, ft	5.14	10.84	10.15
Mean elevation of deck, ft	0	499.83	499.83
w, depth of overflow, ft (>=0)	0.00	0.55	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.95	0.95
**Cc, for downstream face (<=1.0)	ERR	0.916083	0.888248
Ys, scour w/Chang equation, ft	N/A	**1.75**	**0.38**
Ys, scour w/Umbrell equation, ft	N/A	1.63	0.64

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

**Ys, scour w/Chang equation, ft	N/A	2.91	2.82
**Ys, scour w/Umbrell equation, ft	ERR	2.47	2.42

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	6.46	8.08	7.40
WSEL at downstream face, ft	--	496.95	496.20
Depth at downstream face, ft	N/A	7.40	6.67
Ys, depth of scour (Laursen), ft	N/A	0.68	0.74

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	2060	2689	2430
Main channel area (DS), ft2	161	233	210
Main channel width (normal), ft	31.3	31.5	31.5
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	31.3	31.5	31.5
D90, ft	0.7576	0.7576	0.7576
D95, ft	0.9593	0.9593	0.9593
Dc, critical grain size, ft	0.8460	0.5877	0.6174
Pc, Decimal percent coarser than Dc	0.065	0.186	0.167
Depth to armoring, ft	**36.39**	**7.72**	**9.23**

Abutment Scour

Froehlich's Abutment Scour

Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1

(Richardson and Davis, 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	2060	3000	2430	2060	3000	2430
a', abut.length blocking flow, ft	10.9	13.2	12.4	7.5	32.1	18.5
Ae, area of blocked flow ft2	49.93	64.24	67.18	22.79	77.35	57.19
Qe, discharge blocked abut.,cfs	245.62	--	338.46	43.4	--	78.87
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.92	6.21	5.04	1.90	1.19	1.38

ya, depth of f/p flow, ft	4.58	4.87	5.42	3.04	2.41	3.09

--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	110	110	110	70	70	70
K2	1.03	1.03	1.03	0.97	0.97	0.97
Fr, froude number f/p flow	0.405	0.451	0.381	0.193	0.123	0.138
ys, scour depth, ft	**11.90**	**13.65**	**13.63**	**5.99**	**6.09**	**6.69**

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and Davis, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	10.9	13.2	12.4	7.5	32.1	18.5
y1 (depth f/p flow, ft)	4.58	4.87	5.42	3.04	2.41	3.09
a'/y1	2.38	2.71	2.29	2.47	13.32	5.98
Skew correction (p. 49, fig. 16)	1.04	1.04	1.04	0.93	0.93	0.93
Froude no. f/p flow	0.41	0.45	0.38	0.19	0.12	0.14
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 Davis, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	0.74	0.79	1	0.74	0.79
y, depth of flow in bridge, ft	5.14	7.40	6.67	5.14	7.40	6.67
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	**2.51**	**2.57**	ERR	**2.51**	**2.57**
Fr>0.8 (vertical abut.)	**2.15**	ERR	ERR	**2.15**	ERR	ERR