LEVEL II SCOUR ANALYSIS FOR BRIDGE 20 (CONCTH00110020) on TOWN HIGHWAY 11, crossing MILES STREAM, CONCORD, VERMONT

Open-File Report 98-421

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 20 (CONCTH00110020) on TOWN HIGHWAY 11, crossing MILES STREAM, CONCORD, VERMONT

By EMILY C. WILD AND ROBERT H. FLYNN

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Pembroke, New Hampshire

1998

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

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

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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 20 (CONCTH00110020) ON TOWN HIGHWAY 11, CROSSING MILES STREAM, CONCORD, VERMONT

By **Emily C. Wild and Robert H. Flynn**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure CONCTH00110020 on Town Highway 11 crossing Miles Stream, Concord, 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 White Mountain section of the New England physiographic province in northeastern Vermont. The 24.6-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is grass and trees upstream of the bridge and grass downstream of the bridge. The immediate banks have grass and brush.

In the study area, Miles Stream has an incised, straight channel with a slope of approximately 0.0036 ft/ft, an average channel top width of 52 ft and an average bank height of 7 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 64.0 mm (0.210 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 15, 1995, indicated that the reach was stable.

The Town Highway 11 crossing of Miles Stream is a 45-ft-long, two-lane bridge consisting of one 42-foot concrete slab span (Vermont Agency of Transportation, written communication, March 16, 1995). The opening length of the structure parallel to the bridge face is 41.9 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 55 degrees to the opening while the computed opening-skew-to-roadway is 45 degrees.

A scour hole 2.5 ft deeper than the mean thalweg depth was observed approximately 100 ft downstream of the bridge along the left bank during the Level I assessment. The scour protection measures at the site included type-1 stone fill (less than 12 inches diameter) along the upstream and downstream right banks and along the entire base length of the upstream right wingwall. Type-2 stone fill (less than 36 inches diameter) was present along the upstream and downstream left banks and along the entire base length of the left abutment, right abutment, upstream left wingwall and downstream left and right wingwalls. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995) for the 100- and 500-year discharges. 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 was computed to be zero ft. Abutment scour ranged from 8.2 to 12.1 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Miles Pond, VT. Quadrangle, 1:24,000, 1967
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 CONCTH00110020 ***Stream*** Miles Stream

County Essex ***Road*** TH 11 ***District*** 7

Description of Bridge

Bridge length 45 ***ft*** ***Bridge width*** 25.4 ***ft*** ***Max span length*** 42 ***ft***

Alignment of bridge to road (on curve or straight) Straight, right/ Curve, left

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

Stone fill on abutment? Yes ***Date of inspection*** 8/15/95

Description of stone fill Type-1 stone fill is present along the upstream right wingwall. Type-2 stone fill is present along the right and left abutments, the upstream left wingwall, and downstream left and right wingwalls.

Brief description of piers/abutments Abutments and wingwalls are concrete.

Is bridge skewed to flood flow according to No ***survey?*** Yes ***Angle*** 55

If yes, describe (mild, moderate, severe) There is a severe channel bend in the downstream reach.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	8/15/95	0	0
Level II	8/15/95	0	0

Potential for debris Low.

Describe any features near or at the bridge that may affect flow (include observation date) None, 8/15/95.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with little to no flood plains.

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

Date of inspection 8/15/95

DS left: Moderately sloped overbank

DS right: Moderately sloped overbank

US left: Steep road embankment to TH 11 and a moderately sloped overbank

US right: Moderately sloped overbank

Description of the Channel

Average top width 52 ***ft*** ***Average depth*** 7 ***ft***

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

Straight and stable with semi-alluvial channel boundaries and narrow point bars.

8/15/95

Vegetative co

DS left: Grass and trees

DS right: Grass and brush

US left: Brush, a gravel road and trees

US right: Grass and trees.

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

None, 8/15/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 24.6 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: There is a a house on the downstream left overbank.

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 3,150 ***ft³/s*** ***Q500*** 4,360 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(24.6/24.9)exp 0.67] with flood frequency estimates available from the VTAOT database (written communication, May 1995) for bridge number 34 in Concord. Bridge number 34 crosses the Miles Stream downstream of this site and has a drainage area above of 24.9 square miles. The values used were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve was extended graphically to the 500-year event.

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

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

Datum tie between USGS survey and VTAOT plans The USGS arbitrary survey datum was adjusted to the VTAOT datum by subtracting 397.68 ft.

Description of reference marks used to determine USGS datum. RM1 is a State of Vermont metal tablet on top of the downstream end of the upstream left wingwall (elev. 502.40 ft, VTAOT datum). RM2 is a chiseled X on top of the downstream end of the right abutment (elev. 502.85 ft, VTAOT datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-33	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	21	1	Road Grade section
APPRO	72	2	Modelled Approach section (Templated from APTEM)
APTEM	84	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.
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 0.045 to 0.050, and the overbank "n" value was 0.040.

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 0.0036 ft/ft, which was estimated from thalweg points surveyed downstream of the bridge.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0043 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.

Bridge Hydraulics Summary

Average bridge embankment elevation 502.9 *ft*
Average low steel elevation 500.5 *ft*

100-year discharge 3,150 *ft³/s*
Water-surface elevation in bridge opening 500.7 *ft*
Road overtopping? Yes *Discharge over road* 1,780 *ft³/s*
Area of flow in bridge opening 225 *ft²*
Average velocity in bridge opening 6.1 *ft/s*
Maximum WSPRO tube velocity at bridge 7.1 *ft/s*

Water-surface elevation at Approach section with bridge 503.8
Water-surface elevation at Approach section without bridge 503.5
Amount of backwater caused by bridge 0.3 *ft*

500-year discharge 4,360 *ft³/s*
Water-surface elevation in bridge opening 500.7 *ft*
Road overtopping? Yes *Discharge over road* 3,160 *ft³/s*
Area of flow in bridge opening 225 *ft²*
Average velocity in bridge opening 5.3 *ft/s*
Maximum WSPRO tube velocity at bridge 6.2 */s*

Water-surface elevation at Approach section with bridge 504.5
Water-surface elevation at Approach section without bridge 504.4
Amount of backwater caused by bridge 0.1 *ft*

Incipient overtopping discharge 1,620 *ft³/s*
Water-surface elevation in bridge opening 500.7 *ft*
Area of flow in bridge opening 225 *ft²*
Average velocity in bridge opening 7.2 *ft/s*
Maximum WSPRO tube velocity at bridge 8.4 *ft/s*

Water-surface elevation at Approach section with bridge 501.9
Water-surface elevation at Approach section without bridge 501.1
Amount of backwater caused by bridge 0.8 *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, 500-year and incipient roadway-overtopping discharges resulted in submerged 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 these discharges were computed by use of the Chang equation (Richardson and Davis, 1995, p. 145-146).

For comparison, contraction scour for the modelled discharges were 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 substitutions 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.

Because the influence of scour processes on the extensive stone fill material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, scour depths as computed at the toe of each embankment, were shown in figure 8 for the entire stone fill area.

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	0.0	0.0	0.0
Depth to armoring	0.2 0.2	0.7	--
Left overbank	--	--	--
Right overbank	--	--	8.2 9.1

Local scour:			
Abutment scour			
Left abutment	8.4	11.4	12.1
Right abutment	9.8	--	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	1.0	0.8

Riprap Sizing

	100-year discharge	*500-year discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	1.4	1.0	0.8
Right abutment	1.4	--	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

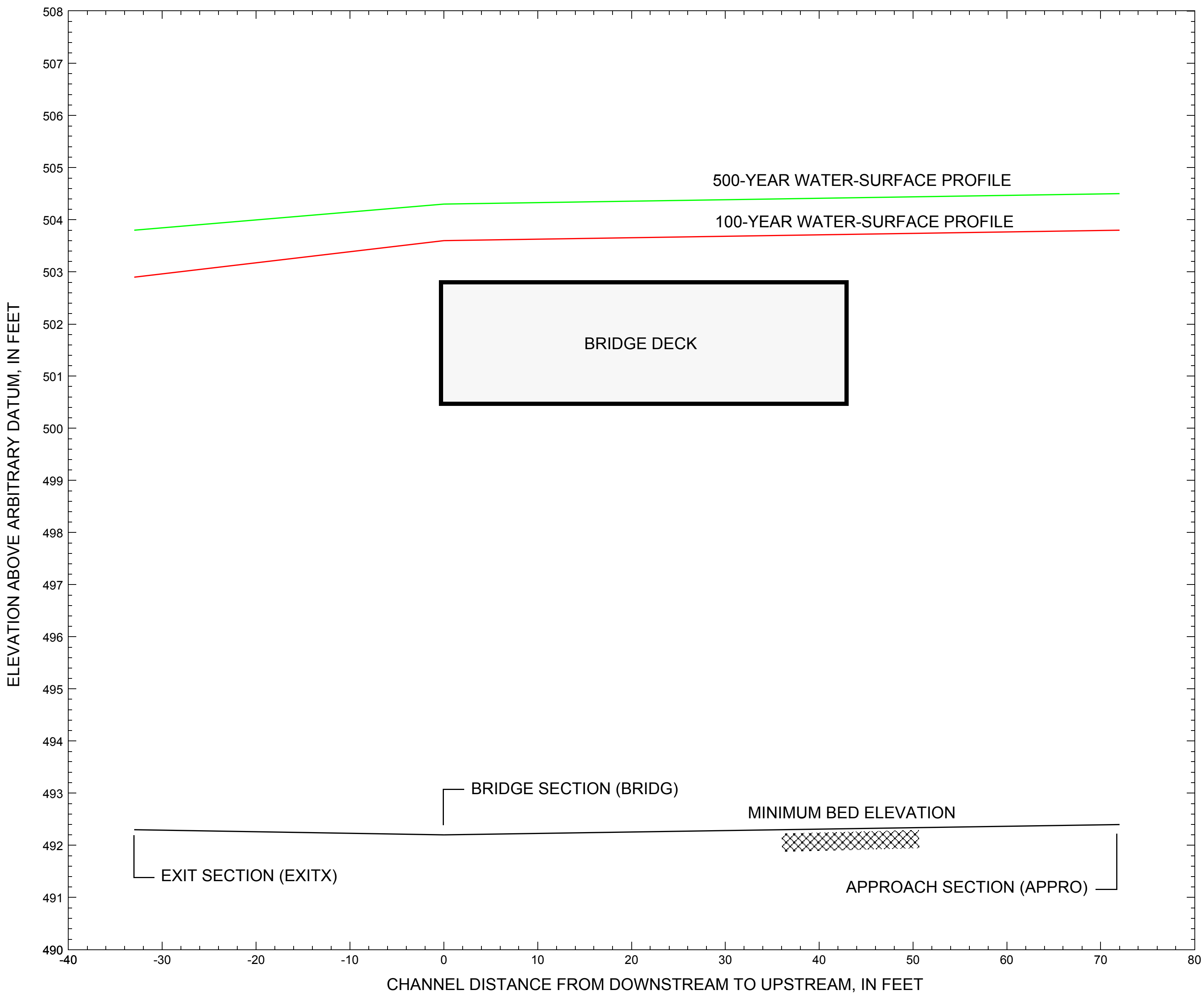

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure CONCTH00110020 on Town Highway 11, crossing Miles Stream, Concord, Vermont.

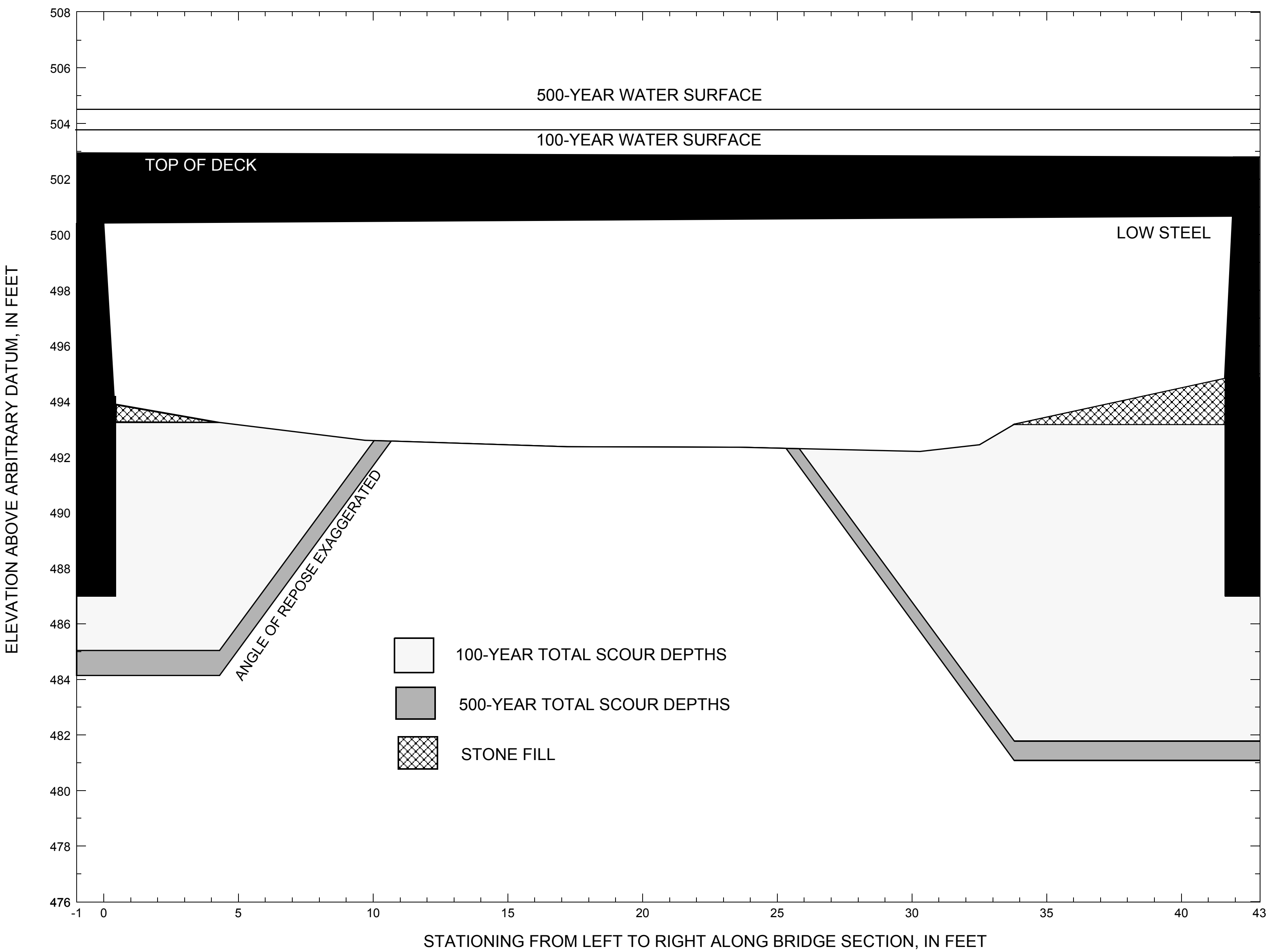

Figure 8. Scour elevations for the 100- and 500-year discharges at structure CONCTH00110020 on Town Highway 11, crossing Miles Stream, Concord, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure CONCTH00110020 on Town Highway 11, crossing Miles Stream, Concord, 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 3,150 cubic-feet per second											
Left abutment	0.0	500.4	500.4	487.0	493.2	0.0	8.2	--	8.2	485.0	-2.0
Right abutment	41.9	500.6	500.7	487.0	493.2	0.0	11.4	--	11.4	481.8	-5.2

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure CONCTH00110020 on Town Highway 11, crossing Miles Stream, Concord, 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 4,360 cubic-feet per second											
Left abutment	0.0	500.4	500.4	487.0	493.2	0.0	9.1	--	9.1	484.1	-2.9
Right abutment	41.9	500.6	500.7	487.0	493.2	0.0	12.1	--	12.1	481.1	-5.9

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, 1967, Miles Pond, 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 conc020.wsp
T2        Hydraulic analysis for structure CONCTH00110020   Date: 27-AUG-97
T3        Bridge #20 over Miles Stream in East Concord, Vt.   RHF
*
J1         * * 0.002
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3150.0   4360.0   1620.0
SK          0.0036   0.0036   0.0036
*
XS   EXITX    -33           0.
GR          -94.0, 518.80    -59.9, 502.88     -8.9, 502.09      0.0, 496.76
GR            6.1, 493.16      8.1, 492.69     12.1, 492.46     17.8, 492.31
GR           20.3, 492.29     24.9, 492.44     27.2, 493.16     33.4, 496.11
GR           40.3, 498.57     64.1, 501.11    119.2, 501.79    151.2, 504.48
GR          170.0, 506.06
*
N           0.040         0.050         0.040
SA                  -8.9          40.3
*
XS   FULLV      0  * * *   0.0
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    500.54      45.0
GR            0.0, 500.42      0.4, 493.90      4.3, 493.24      9.7, 492.60
GR           17.2, 492.37     23.6, 492.35     30.3, 492.20     32.5, 492.44
GR           33.8, 493.18     41.6, 494.82     41.9, 500.66      0.0, 500.42
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      49.6 * *     42.5     13.0
N           0.045
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     21      25.4     2
GR         -164.9, 513.66   -148.4, 503.65   -130.8, 503.18   -126.9, 502.03
GR          -80.8, 501.97    -52.5, 502.65      0.0, 502.94     39.3, 502.79
GR           71.5, 501.84    122.2, 501.75    132.7, 502.47    148.9, 505.40
GR          170.0, 508.30
*
XT   APTEM     84           0.
GR         -164.9, 513.66   -148.4, 503.65   -130.8, 503.18   -126.9, 502.03
GR          -80.8, 501.97    -42.5, 502.50    -14.2, 501.86     -6.6, 500.12
GR            0.0, 497.70      6.8, 493.29      9.0, 492.60     12.3, 492.46
GR           15.0, 492.41     19.0, 492.68     22.5, 492.79     24.5, 493.25
GR           32.4, 497.20     39.8, 499.23     85.2, 501.05     96.7, 506.96
GR          108.6, 508.81
*
AS   APPRO     72 * * * 0.0043
GT
N           0.040         0.050         0.040
SA                -14.2          39.8
*
HP 1 BRIDG  500.66 1 500.66
HP 2 BRIDG  500.66 * * 1370
HP 2 RDWAY  503.64 * * 1782
HP 1 APPRO  503.81 1 503.81
HP 2 APPRO  503.81 * * 3150
*
HP 1 BRIDG  500.66 1 500.66
HP 2 BRIDG  500.66 * * 1194
HP 2 RDWAY  504.26 * * 3163
HP 1 APPRO  504.49 1 504.49
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File conc020.wsp
        Hydraulic analysis for structure CONCTH00110020   Date: 27-AUG-97
        Bridge #20 over Miles Stream in Concord, Vt.   RHF
           *** RUN DATE & TIME: 10-10-97  10:05

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

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      225     15923     0     72                             0
   500.66           225     15923     0     72  1.00      0     42         0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.66     0.0    41.9   224.7   15923.    1370.   6.10

X STA.         0.0        4.1        6.4        8.5       10.5       12.3
  A(I)            18.7       12.2       11.2       10.7       10.3
  V(I)            3.66       5.60       6.11       6.41       6.67

X STA.        12.3       14.1       15.8       17.5       19.2       20.9
  A(I)            10.1       10.0        9.8        9.7        9.7
  V(I)            6.81       6.84       7.02       7.08       7.06

X STA.        20.9       22.6       24.2       25.9       27.6       29.3
  A(I)             9.8        9.8        9.6        9.8       10.1
  V(I)            7.00       6.99       7.12       6.97       6.80

X STA.        29.3       31.0       32.8       35.0       37.5       41.9
  A(I)            10.1       10.6       11.7       12.4       18.5
  V(I)            6.81       6.49       5.85       5.50       3.69

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      21.

         WSEL     LEW     REW    AREA        K        Q    VEL
       503.64  -148.0   139.2   352.1   15224.    1782.   5.06

X STA.      -148.0     -116.9     -106.4      -96.8      -87.3      -78.2
  A(I)            24.2       17.1       15.7       15.7       15.1
  V(I)            3.69       5.20       5.68       5.66       5.88

X STA.       -78.2      -67.0      -50.2      -25.3       12.8       46.3
  A(I)            16.5       19.2       22.6       28.7       27.9
  V(I)            5.41       4.65       3.94       3.10       3.19

X STA.        46.3       60.5       69.9       77.7       85.3       92.8
  A(I)            17.9       15.1       14.1       13.8       13.6
  V(I)            4.97       5.89       6.31       6.43       6.54

X STA.        92.8      100.4      107.8      115.1      122.9      139.2
  A(I)            14.0       13.8       13.6       14.6       18.6
  V(I)            6.36       6.44       6.57       6.09       4.78

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      72.

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      209     10388   135    135                          1473
             2      420     47141    54     57                          6636
             3      177     14950    51     52                          1868
   503.81           805     72479   239    244  1.24   -148     91      7524

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      72.

         WSEL     LEW     REW    AREA        K        Q    VEL
       503.81  -148.7    90.7   804.7   72479.    3150.   3.91

X STA.      -148.7      -91.4      -52.1       -9.3        1.3        5.7
  A(I)            78.6       68.6       73.7       50.4       37.6
  V(I)            2.00       2.29       2.14       3.13       4.18

X STA.         5.7        8.6       11.1       13.5       15.8       18.1
  A(I)            30.7       27.5       27.5       26.3       26.0
  V(I)            5.13       5.73       5.74       5.99       6.05

X STA.        18.1       20.4       22.8       25.4       28.7       33.3
  A(I)            26.4       26.2       27.3       31.0       34.3
  V(I)            5.96       6.01       5.76       5.08       4.59

X STA.        33.3       40.8       49.3       58.9       70.8       90.7
  A(I)            40.2       37.8       38.8       43.4       52.3
  V(I)            3.92       4.17       4.06       3.63       3.01
```

WSPRO OUTPUT FILE (continued)

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     U.S. Geological Survey WSPRO Input File conc020.wsp
     Hydraulic analysis for structure CONCTH00110020   Date: 27-AUG-97
     Bridge #20 over Miles Stream in Concord, Vt.   RHF
        *** RUN DATE & TIME: 10-10-97  10:05

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

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      225     15923      0     72                            0
500.66           225     15923      0     72  1.00      0     42        0

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

      WSEL     LEW     REW    AREA        K        Q    VEL
    500.66     0.0    41.9   224.7   15923.    1194.   5.31

X STA.        0.0        4.1        6.4        8.5       10.5       12.3
  A(I)            18.7       12.2       11.2       10.7       10.3
  V(I)            3.19       4.88       5.33       5.59       5.81

X STA.       12.3       14.1       15.8       17.5       19.2       20.9
  A(I)            10.1       10.0        9.8        9.7        9.7
  V(I)            5.94       5.96       6.12       6.17       6.16

X STA.       20.9       22.6       24.2       25.9       27.6       29.3
  A(I)             9.8        9.8        9.6        9.8       10.1
  V(I)            6.10       6.09       6.21       6.07       5.92

X STA.       29.3       31.0       32.8       35.0       37.5       41.9
  A(I)            10.1       10.6       11.7       12.4       18.5
  V(I)            5.94       5.65       5.10       4.80       3.22

 VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      21.

      WSEL     LEW     REW    AREA        K        Q    VEL
    504.26  -149.4   142.6   531.8   29201.    3163.   5.95

X STA.     -149.4     -121.0     -109.6      -99.2      -88.9      -78.5
  A(I)            34.8       25.5       23.6       23.3       23.7
  V(I)            4.55       6.19       6.70       6.77       6.66

X STA.      -78.5      -67.2      -52.0      -32.9      -11.2       17.7
  A(I)            23.7       27.2       29.6       31.4       39.0
  V(I)            6.68       5.82       5.34       5.04       4.05

X STA.       17.7       43.7       58.3       68.9       78.1       87.1
  A(I)            37.6       26.5       23.2       22.2       21.8
  V(I)            4.20       5.97       6.82       7.12       7.25

X STA.       87.1       95.9      104.8      113.6      122.6      142.6
  A(I)            21.8       21.9       21.9       22.6       30.5
  V(I)            7.27       7.24       7.23       7.01       5.19

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      72.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      300     18967    136    136                         2536
          2      456     54216     54     57                         7526
          3      212     19833     52     53                         2419
504.49           968     93016    242    246  1.18   -149     92    10110

 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      72.

      WSEL     LEW     REW    AREA        K        Q    VEL
    504.49  -149.9    92.0   968.4   93016.    4360.   4.50

X STA.     -149.9     -105.0      -78.4      -47.2      -16.2       -0.3
  A(I)            83.4       68.0       72.4       71.1       67.7
  V(I)            2.61       3.20       3.01       3.07       3.22

X STA.       -0.3        5.2        8.5       11.3       14.1       16.7
  A(I)            45.9       37.1       33.8       33.0       32.0
  V(I)            4.75       5.87       6.46       6.60       6.80

X STA.       16.7       19.4       22.1       25.0       28.7       33.9
  A(I)            32.2       31.8       33.6       36.9       41.6
  V(I)            6.78       6.85       6.49       5.91       5.23

X STA.       33.9       42.0       50.4       60.3       72.0       92.0
  A(I)            47.7       42.6       46.3       49.6       61.5
  V(I)            4.57       5.11       4.71       4.39       3.55
```

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        U.S. Geological Survey WSPRO Input File conc020.wsp
        Hydraulic analysis for structure CONCTH00110020   Date: 27-AUG-97
        Bridge #20 over Miles Stream in Concord, Vt.   RHF
           *** RUN DATE & TIME: 10-10-97  10:05

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      225     15923      0     72                            0
   500.66           225     15923      0     72  1.00      0     42        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.66     0.0    41.9   224.7   15923.    1620.   7.21

X STA.         0.0        4.1        6.4        8.5       10.5       12.3
  A(I)            18.7       12.2       11.2       10.7       10.3
  V(I)            4.33       6.62       7.23       7.58       7.88

X STA.        12.3       14.1       15.8       17.5       19.2       20.9
  A(I)            10.1       10.0        9.8        9.7        9.7
  V(I)            8.05       8.09       8.30       8.37       8.35

X STA.        20.9       22.6       24.2       25.9       27.6       29.3
  A(I)             9.8        9.8        9.6        9.8       10.1
  V(I)            8.28       8.26       8.42       8.24       8.04

X STA.        29.3       31.0       32.8       35.0       37.5       41.9
  A(I)            10.1       10.6       11.7       12.4       18.5
  V(I)            8.06       7.67       6.92       6.51       4.37

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      72.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1        0         1      4      4                            0
             2      316     29457     54     57                         4347
             3       83      4495     47     47                          625
   501.90           400     33952    105    109  1.10    -17     87     4223

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      72.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.90   -18.3    87.0   399.7   33952.    1620.   4.05

X STA.       -18.3        2.0        5.5        7.8        9.7       11.4
  A(I)            37.2       23.9       19.6       17.3       16.1
  V(I)            2.18       3.39       4.13       4.68       5.02

X STA.        11.4       13.1       14.6       16.2       17.7       19.2
  A(I)            15.6       14.7       14.8       14.5       14.3
  V(I)            5.18       5.52       5.48       5.60       5.66

X STA.        19.2       20.8       22.4       24.0       25.9       28.2
  A(I)            14.4       14.4       14.7       15.8       17.1
  V(I)            5.61       5.64       5.50       5.14       4.73

X STA.        28.2       31.3       36.6       46.3       59.4       87.0
  A(I)            18.9       23.0       27.0       29.0       37.3
  V(I)            4.29       3.52       3.00       2.79       2.17
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File conc020.wsp
        Hydraulic analysis for structure CONCTH00110020   Date: 27-AUG-97
        Bridge #20 over Miles Stream in Concord, Vt.   RHF
           *** RUN DATE & TIME: 10-10-97  10:05

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

EXITX:XS   ******    -59      567  0.61 *****  503.50  500.03    3150  502.89
       -32 ******    132    52469  1.28 ***** *******    0.65    5.56

FULLV:FV       33    -59      604  0.54  0.11  503.62 *******    3150  503.08
         0     33    135    56153  1.29  0.00    0.01    0.59    5.21
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       72   -142      719  0.37  0.20  503.82 *******    3150  503.45
        72     72     90    63025  1.25  0.00    0.00    0.49    4.38
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   503.08     500.54

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                   QRD,QRDMAX,RATIO =     1782.      1753.    1.02

            <<<<<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       33      0      225  0.58 *****  501.24  496.98    1370  500.66
         0 ******     42    15923  1.00 ***** *******    0.46    6.10

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  500.54 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      21.    47.  0.09  0.29  504.02    0.00   1782.  503.64

           Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    898.   169.  -148.    21.   1.7   1.1   5.5   4.9   1.5   3.0
   RT:    885.   118.    21.   139.   1.9   1.4   6.1   5.2   1.8   3.0

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

APPRO:AS       22   -148      806  0.29  0.13  504.11  501.15    3150  503.81
        72     29     91    72594  1.24  0.00    0.00    0.42    3.91

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

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -33.   -60.   132.   3150.   52469.     567.    5.56  502.89
   FULLV:FV      0.   -60.   135.   3150.   56153.     604.    5.21  503.08
   BRIDG:BR      0.     0.    42.   1370.   15923.     225.    6.10  500.66
   RDWAY:RG     21.*******   898.   1782.******************    2.00  503.64
   APPRO:AS     72.  -149.    91.   3150.   72594.     806.    3.91  503.81

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    500.03    0.65  492.29  518.80************  0.61  503.50  502.89
   FULLV:FV  ********    0.59  492.29  518.80  0.11  0.00  0.54  503.62  503.08
   BRIDG:BR    496.98    0.46  492.20  500.66************  0.58  501.24  500.66
   RDWAY:RG  ****************  501.75  513.66  0.09******  0.29  504.02  503.64
   APPRO:AS    501.15    0.42  492.36  513.61  0.13  0.00  0.29  504.11  503.81
```

```
        U.S. Geological Survey WSPRO Input File conc020.wsp
        Hydraulic analysis for structure CONCTH00110020   Date: 27-AUG-97
        Bridge #20 over Miles Stream in Concord, Vt.   RHF
           *** RUN DATE & TIME: 10-10-97  10:05

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

EXITX:XS   ******    -61      755  0.66 *****  504.49  502.20    4360  503.83
       -32 ******    143    72626  1.27 ***** *******    0.60    5.78

FULLV:FV       33    -61      794  0.59  0.11  504.61 *******    4360  504.02
         0     33    146    77275  1.26  0.00    0.01    0.56    5.49
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       72   -149      950  0.39  0.20  504.80 *******    4360  504.42
        72     72     92    90630  1.19  0.00    0.00    0.44    4.59
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   504.02     500.54

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                   QRD,QRDMAX,RATIO =     3163.      2853.     1.11

            <<<<<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       33      0      225  0.44 *****  501.10  496.61    1194  500.66
         0 ******     42    15923  1.00 ***** *******    0.40    5.31

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  500.54 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      21.    47.  0.10  0.37  504.76    0.00   3163.  504.26

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1675.   170.  -149.    21.   2.3   1.7   6.8   5.8   2.2   3.0
   RT:   1488.   122.    21.   143.   2.5   2.0   7.3   6.1   2.5   3.1

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

APPRO:AS       22   -149      969  0.37  0.16  504.87  502.51    4360  504.49
        72     31     92    93136  1.18  0.00    0.00    0.43    4.50

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

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -33.   -62.   143.   4360.   72626.     755.    5.78  503.83
   FULLV:FV      0.    -62.   146.   4360.   77275.     794.    5.49  504.02
   BRIDG:BR      0.     0.     42.   1194.   15923.     225.    5.31  500.66
   RDWAY:RG     21.*******  1675.   3163.******************    2.00  504.26
   APPRO:AS     72.  -150.    92.   4360.   93136.     969.    4.50  504.49

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    502.20    0.60  492.29  518.80************  0.66  504.49  503.83
   FULLV:FV  ********    0.56  492.29  518.80  0.11  0.00  0.59  504.61  504.02
   BRIDG:BR    496.61    0.40  492.20  500.66************  0.44  501.10  500.66
   RDWAY:RG  ****************  501.75  513.66  0.10******  0.37  504.76  504.26
   APPRO:AS    502.51    0.43  492.36  513.61  0.16  0.00  0.37  504.87  504.49
```

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        U.S. Geological Survey WSPRO Input File conc020.wsp
        Hydraulic analysis for structure CONCTH00110020   Date: 27-AUG-97
        Bridge #20 over Miles Stream in Concord, Vt.   RHF
           *** RUN DATE & TIME: 10-10-97  10:05

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

 EXITX:XS   ******     -6      300  0.48 *****  501.14  497.63    1620  500.65
       -32 ******     60    26980  1.06 ***** *******    0.46    5.40

 FULLV:FV       33     -6      310  0.45  0.11  501.26 *******    1620  500.81
         0     33     61    28161  1.06  0.00    0.01    0.44    5.22
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS       72    -10      319  0.45  0.26  501.54 *******    1620  501.09
        72     72     85    25726  1.12  0.00    0.02    0.52    5.08
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   500.81     500.54

            <<<<<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       33      0      225  0.81 *****  501.47  497.46    1618  500.66
         0 ******     42    15923  1.00 ***** *******    0.55    7.20

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   3.  0.800  0.000  500.54 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      21.        <<<<<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       22    -17      400  0.28  0.12  502.18  498.26    1620  501.90
        72     24     87    33965  1.10  0.00    0.00    0.38    4.05

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      ****** ****** ******** ****** ******   501.79

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

   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXITX:XS     -33.    -7.    60.   1620.   26980.     300.    5.40  500.65
    FULLV:FV       0.    -7.    61.   1620.   28161.     310.    5.22  500.81
    BRIDG:BR       0.     0.    42.   1618.   15923.     225.    7.20  500.66
    RDWAY:RG      21.**************      0.       0.       0.    2.00********
    APPRO:AS      72.   -18.    87.   1620.   33965.     400.    4.05  501.90

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

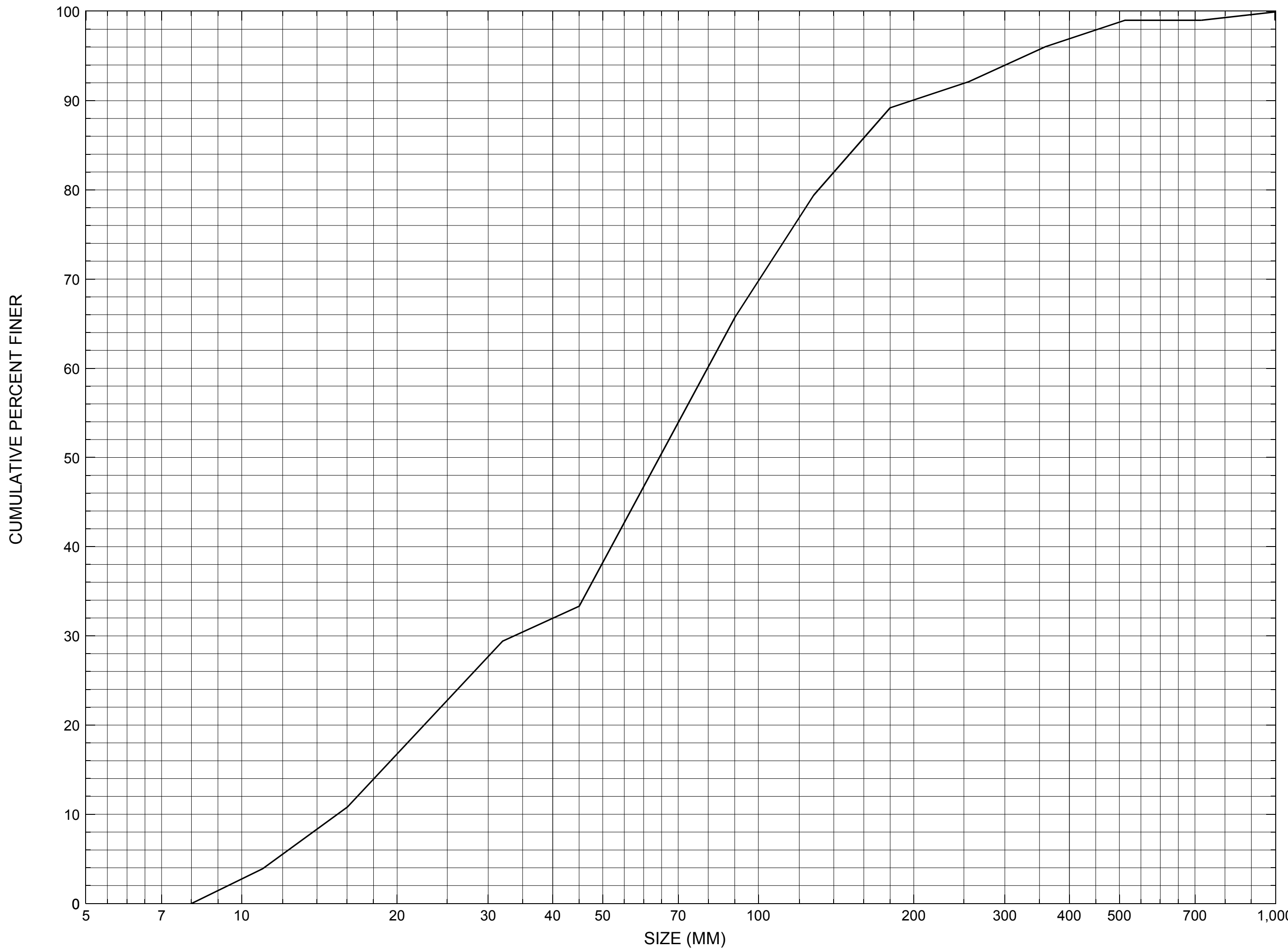
  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXITX:XS    497.63    0.46  492.29  518.80************  0.48  501.14  500.65
    FULLV:FV  ********    0.44  492.29  518.80  0.11  0.00  0.45  501.26  500.81
    BRIDG:BR    497.46    0.55  492.20  500.66************  0.81  501.47  500.66
    RDWAY:RG  ****************  501.75  513.66************  0.28  502.07********
    APPRO:AS    498.26    0.38  492.36  513.61  0.12  0.00  0.28  502.18  501.90
   ER

NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure CONCTH00110020, in Concord, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number CONCTH00110020

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 16 / 95

Highway District Number *(I - 2; nn)* 07

County *(FIPS county code; I - 3; nnn)* 009

Town *(FIPS place code; I - 4; nnnnn)* 15250

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

Waterway *(I - 6)* MILES STREAM

Road Name *(I - 7):* -

Route Number TH011

Vicinity *(I - 9)* 0.1 MI TO JCT W CL2 TH4

Topographic Map Miles Pond

Hydrologic Unit Code: 01080102

Latitude *(I - 16; nnnn.n)* 44253

Longitude *(i - 17; nnnnn.n)* 71453

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10050700200507

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

Maximum span length *(I - 48; nnnn)* 0042

Year built *(I - 27; YYYY)* 1985

Structure length *(I - 49; nnnnnn)* 000045

Average daily traffic, ADT *(I - 29; nnnnnn)* 000060

Deck Width *(I - 52; nn.n)* 254

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

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

Opening skew to Roadway *(I - 34; nn)* 38

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*) 030.0

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

Vertical clearance from streambed (*nnn.n ft*) 006.5

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

Waterway of full opening (*nnn.n ft²*) 212.0

Comments:

The structural inspection report of 8/15/94 indicates the structure is a concrete slab type bridge. The abutment walls and wingwalls are concrete. The left abutment wall has a diagonal crack and leak reported at the downstream end. Otherwise, the abutment and wingwall concrete is in good condition. There is stone and boulder fill reported as placed along the abutment walls and wingwalls and partially along the banks upstream and downstream of the bridge. The concrete slab deck is curved. The downstream left wingwall reportedly is cracked and broken off of the abutment at the joint where the two walls meet.

(Continued p. 33)

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: 23.8

Terrain character: Hilly

Stream character & type: It is a straight stream and a tributary to the Connecticut river.

Streambed material: Sand, gravel, and small boulders.

Discharge Data *(cfs)*: $Q_{2.33}$ 850 Q_{10} 1550 Q_{25} 2175
Q_{50} 2650 Q_{100} 3150 Q_{500} -

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

Estimated Discharge *(cfs)*: - Velocity at Q 25 *(ft/s)*: 11.0

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

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

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

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

Watershed storage area (*in percent*): 5 %

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*)	497.0	499.3	501.2	501.9	502.4
Velocity (*ft / sec*)	8.2	9.8	11.0	12.5	14.8

Long term stream bed changes: Estimated scour depth expected is 2 to 4 feet.

Is the roadway overtopped below the Q_{100}? (*Yes, No, Unknown*): Y Frequency: Q14

Relief Elevation (*ft*): 500.0 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*): 0.4 Town: Concord Year Built: -

Highway No. : TH58 Structure No. : 33 Structure Type: -

Clear span (*ft*): 24.0 Clear Height (*ft*): 8.0 Full Waterway (*ft²*): 192.0

Downstream distance (*miles*): **0.4** Town: **Concord** Year Built: **-**
Highway No. : **TH11** Structure No. : **34** Structure Type: **-**
Clear span (*ft*): **24.0** Clear Height (*ft*): **9.0** Full Waterway (ft^2): **216.0**

Comments:

The previous structure was a wood beam bridge with concrete abutments and a timber deck. The watershed storage estimate given is mainly due to the storage of Miles Pond upstream, near the headwaters. Relief over the road occurs with discharges greater than about the Q14, or 1775 cfs. The discharge over the road given at the Q100 should be greater than or equal to 1375 cfs.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **24.62** mi^2 Lake/pond/swamp area **.517** mi^2
Watershed storage *(ST)* **2.1** %
Bridge site elevation **838** ft Headwater elevation **1560** ft
Main channel length **7.963** mi
10% channel length elevation **890** ft 85% channel length elevation **1295** ft
Main channel slope *(S)* **67.81** 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)*: 05 / 1985

Project Number BRZ 14447(10) Minimum channel bed elevation: 492.0

Low superstructure elevation: USLAB 500.42 DSLAB 501.25 USRAB 500.63 DSRAB 500.84

Benchmark location description:

BM#1, spike in the root of a 10 inch maple tree located about 10 feet right bankward of the right abutment wall and about 75 feet upstream along a line projected along the trend of the right abutment wall, from the centerline of the roadway, elevation 500.00. BM#2, [A mark] on the top of the concrete near the middle of the upstream left wingwall, elevation 502.36.

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: 487.0

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? 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:

The bottom of both abutment footings are probably set in a sandy gravel.

Comments:

A couple of other points provided on the plans with elevations are: 1) The point on top bankward edge of the concrete upstream left wingwall where the concrete slope changes from horizontal to downward, elevation 502.42, and 2) the point at the same location described in (1) but on the upstream right wingwall, elevation 502.63.

Cross-sectional Data

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

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

Comments: **Orientation of the cross sections is inconsistent with any cross section data surveyed for this study and is not comparable. Data was not retrieved.**

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:

-

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 2/14/96
Computerized by: EW Date: 2/14/96
Reviewd by: EW Date: 6/23/98

Structure Number CONCTH00110020

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* L. MEDALIE Date *(MM/DD/YY)* 08 / 15 / 1995

2. Highway District Number 07 Mile marker -

County ESSEX (009) Town CONCORD (15250)

Waterway *(I - 6)* MILES STREAM Road Name -

Route Number TH011 Hydrologic Unit Code: 01080102

3. Descriptive comments:

This bridge is located 0.1 mile to the junction with TH4.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 645 LBDS 46 RBDS 45 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 1 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 45 *(feet)* Span length 42 *(feet)* Bridge width 25.4 *(feet)*

Road approach to bridge:

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

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

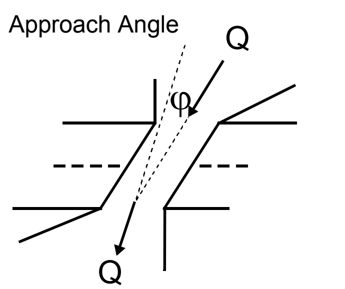
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

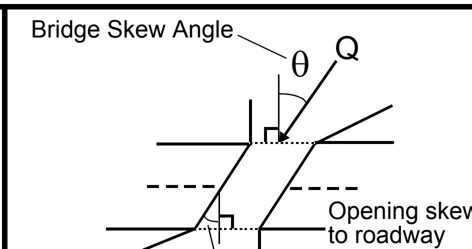
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

*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: 0 16. Bridge skew: 55





α= 45.0

17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 3
Range? 99 feet DS *(US, UB, DS)* to 130 feet DS

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

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

18. Bridge Type: **1a**

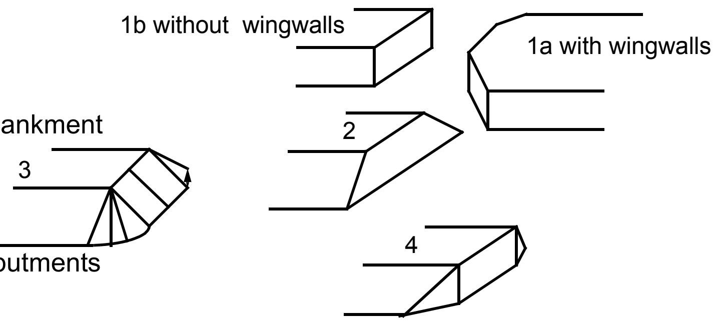
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

#4- Refer to the plan view sketch for variations in the surface cover.

#5- The stream is riffle from 62 feet US and further US. The water surface is pool from 62 feet to bridge face.

#7- Values are from the VTAOT database. During the site visit, the bridge length measured was 43.9 feet, the span length was 38.6 feet and the bridge width was 25.8 feet.

#11- The LBUS road approach protection is described in questions 30 and 32.

#16- The bridge is slightly concave (facing US). The skew was measured at the thalweg.

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
42.5	**8.5**			**6.0**	**2**	**3**	**2**	**2**	**1**	**1**

23. Bank width **20.0** 24. Channel width **20.0** 25. Thalweg depth **54.0** 29. Bed Material **435**

30 .Bank protection type: LB **2** 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 brush on the right bank from the bridge to 75 feet upstream, then trees.

On the left bank, there is no vegetation cover from the bridge to 50 feet upstream, then there is brush until 105 feet where the vegetation cover is trees.

#28- There is light fluvial bank erosion on both banks where protection ends.

#30- The right bank protection extends from the bridge face to 67 feet upstream.

The left bank protection extends from the bridge face to 105 feet upstream. The protection consists of large material, especially along the wingwall where the bank protection doubles as road embankment protection.

***All measurements were made from thalweg at the bridge face.**

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

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

37. Material: -

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

NO POINT BARS

39. Is a cut-bank present? **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 SCOUR PRESENT

***From about 20 feet US to 20 feet DS in pool area, water depth is fairly even 1 foot across the channel. Whereas further US and DS, depth is about 0.5 - 1 foot. Minor local scour occasionally is present around the large boulders.**

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):

***A corrugated metal culvert (1.5 ft in diameter) enters on the left bank from under the road at 58 feet from bridge.**

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
17.5		1.0		2	7	7	-

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

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

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

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

43

#61- The stone fill is mostly 1-2 feet in diameter, and has been placed at the base of both abutments.

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

67. Debris Potential -____ *(**1**- Low; **2**- Moderate; **3**- High)* 68. Capture Efficiency 1____ *(**1**- Low; **2**- Moderate; **3**- High)*

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

70. Debris and Ice Comments:

1

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	2	0	-	-	90.0
RABUT	1	0	90			2	0	29.5

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

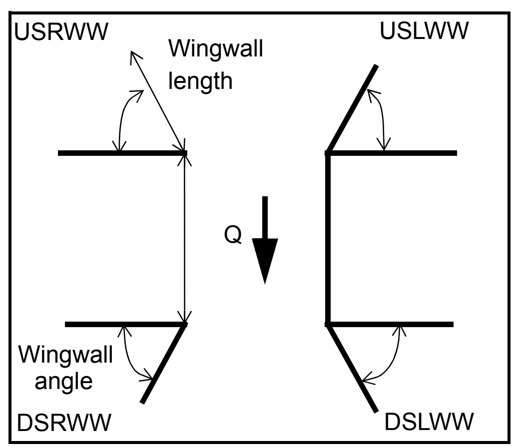
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

-
-
1

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						29.5	
USRWW:	Y		1		0	1.0	
DSLWW:	-		-		Y	46.0	
DSRWW:	1		0		-	39.5	

*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	-	1	1	1	1
Condition	Y	-	1	-	1	1	1	1
Extent	1	-	0	2	1	2	2	-

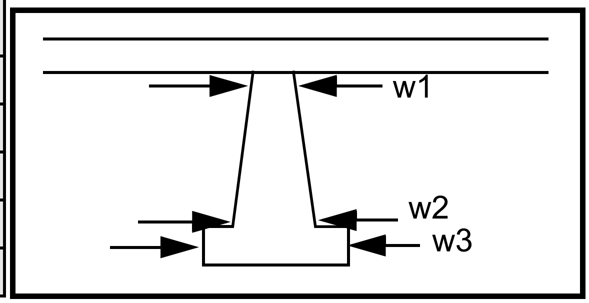
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

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

Piers:

84. Are there piers? **All** (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				**15.0**	**24.0**	**70.0**
Pier 2	**9.0**	**9.0**		**55.0**	**10.0**	**16.5**
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

E. Downstream Channel Assessment

100.

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

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

Bank protection type (Qmax): LB - RB - Bank protection condition: LB - RB NO

*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.):

PIERS

1
1
2*
2
2*

101. Is a drop structure present? **0** *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

103. Drop: - feet 104. Structure material: **43** *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

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

2
1
1
1

The LB protection extends from the bridge to 100 feet upstream, covering the entire bank. At 100 feet, where the LB protection ends, erosion becomes moderately fluvial. From 100 feet to 125 feet downstream, the LB

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

Point bar extent: **sand** feet **; at** (US, UB, DS) to **125** feet **feet** (US, UB, DS) positioned **it** %LB to **is** %RB

Material: **be**

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

drock and weathered bedrock.

The RB protection extends from the bridge to 82 feet downstream, covering the entire surface of bank. The RB protection type is predominately type 1, though there is some type 2.

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

Cut bank extent: **reme** feet **nts** (US, UB, DS) to **from** feet **this** (US, UB, DS)

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

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

tion were made from thalweg at DS bridge face.

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

Scour dimensions: Length ______ Width ______ Depth: **N** Positioned ____ %LB to **NO** %RB

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

DROP STRUCTURE

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

Confluence 1: Distance **Y** Enters on **125** (LB or RB) Type **8** (*1*- perennial; *2*- ephemeral)

Confluence 2: Distance **85** Enters on **DS** (LB or RB) Type **140** (*1*- perennial; *2*- ephemeral)

Confluence comments (eg. confluence name):

DS
60

F. Geomorphic Channel Assessment

107. Stage of reach evolution **90**

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)*:

324

Y
LB
110
99
DS
130
DS
3

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: CONCTH00110020 Town: Concord
Road Number: TH11 County: Essex
Stream: Miles Stream

Initials RHF Date: 10/10/97 Checked: RLB

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	3150	4360	1620
Main Channel Area, ft2	420	456	316
Left overbank area, ft2	209	300	1
Right overbank area, ft2	177	212	83
Top width main channel, ft	54	54	54
Top width L overbank, ft	135	136	4
Top width R overbank, ft	51	52	47
D50 of channel, ft	0.20997	0.20997	0.20997
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.8	8.4	5.9
y1, average depth, LOB, ft	1.5	2.2	0.3
y1, average depth, ROB, ft	3.5	4.1	1.8
Total conveyance, approach	72479	93016	33952
Conveyance, main channel	47141	54216	29457
Conveyance, LOB	10388	18967	1
Conveyance, ROB	14950	19833	4495
Percent discrepancy, conveyance	0.0000	0.0000	-0.0029
Qm, discharge, MC, cfs	2048.8	2541.3	1405.5
Ql, discharge, LOB, cfs	451.5	889.1	0.0
Qr, discharge, ROB, cfs	649.7	929.6	214.5
Vm, mean velocity MC, ft/s	4.9	5.6	4.4
Vl, mean velocity, LOB, ft/s	2.2	3.0	0.0
Vr, mean velocity, ROB, ft/s	3.7	4.4	2.6
Vc-m, crit. velocity, MC, ft/s	9.4	9.5	8.9
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	3150	4360	1620
(Q) discharge thru bridge, cfs	1370	1194	1620
Main channel conveyance	15923	15923	15923
Total conveyance	15923	15923	15923
Q2, bridge MC discharge,cfs	1370	1194	1620
Main channel area, ft2	225	225	225
Main channel width (normal), ft	29.6	29.6	29.6
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	29.6	29.6	29.6
y_bridge (avg. depth at br.), ft	7.60	7.60	7.60
Dm, median (1.25*D50), ft	0.262463	0.262463	0.262463
y2, depth in contraction,ft	4.85	4.31	5.60
ys, scour depth (y2-ybridge), ft	-2.75	-3.29	-2.00

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	1370	1194	1620
Main channel area (DS), ft2	225	225	225
Main channel width (normal), ft	29.6	29.6	29.6
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	29.6	29.6	29.6
D90, ft	0.6487	0.6487	0.6487
D95, ft	1.0754	1.0754	1.0754
Dc, critical grain size, ft	0.1518	0.1153	0.2123
Pc, Decimal percent coarser than Dc	0.654	0.695	0.495
Depth to armoring, ft	0.24	0.15	0.65

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	3150	4360	1620
Q, thru bridge MC, cfs	1370	1194	1620
Vc, critical velocity, ft/s	9.38	9.51	8.94
Va, velocity MC approach, ft/s	4.88	5.57	4.45
Main channel width (normal), ft	29.6	29.6	29.6
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	29.6	29.6	29.6
qbr, unit discharge, ft2/s	46.3	40.3	54.7
Area of full opening, ft2	225.0	225.0	225.0
Hb, depth of full opening, ft	7.60	7.60	7.60
Fr, Froude number, bridge MC	0.46	0.4	0.55
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	500.54	500.54	500.54
Elevation of Bed, ft	492.94	492.94	492.94
Elevation of Approach, ft	503.81	504.49	501.9
Friction loss, approach, ft	0.13	0.16	0.12
Elevation of WS immediately US, ft	503.68	504.33	501.78
ya, depth immediately US, ft	10.74	11.39	8.84
Mean elevation of deck, ft	502.86	502.86	502.86
w, depth of overflow, ft (>=0)	0.82	1.47	0.00
Cc, vert contrac correction (<=1.0)	0.93	0.93	0.96
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	-2.32	-3.06	-1.25
Ys, scour w/Umbrell equation, ft	0.01	0.77	-1.21

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

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

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	4.85	4.31	5.60
WSEL at downstream face, ft	--	--	--
Depth at downstream face, ft	N/A	N/A	N/A
Ys, depth of scour (Laursen), ft	N/A	N/A	N/A

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	3150	4360	1620	3150	4360	1620
a', abut.length blocking flow, ft	154.9	156.1	24.5	54.9	56.2	51.2
Ae, area of blocked flow ft2	149.03	161.83	67.07	124.75	128.07	96.77
Qe, discharge blocked abut.,cfs	-	-	186.65	-	-	255.23
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.59	3.27	2.78	3.69	4.39	2.64
ya, depth of f/p flow, ft	0.96	1.04	2.74	2.27	2.28	1.89
--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	0.321	0.352	0.296	0.342	0.377	0.338
ys, scour depth, ft	8.24	9.09	8.43	11.39	12.06	9.80

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)	154.9	156.1	24.5	54.9	56.2	51.2
y1 (depth f/p flow, ft)	0.96	1.04	2.74	2.27	2.28	1.89
a'/y1	161.00	150.57	8.95	24.16	24.66	27.09
Skew correction (p. 49, fig. 16)	0.80	0.80	0.80	1.10	1.10	1.10
Froude no. f/p flow	0.32	0.35	0.30	0.34	0.38	0.34
Ys w/ corr. factor K1/0.55:						
vertical	3.85	4.27	ERR	ERR	ERR	10.57
vertical w/ ww's	3.15	3.50	ERR	ERR	ERR	8.67
spill-through	2.12	2.35	ERR	ERR	ERR	5.81

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	0.46	0.4	0.55	0.46	0.4	0.55
y, depth of flow in bridge, ft	7.60	7.60	7.60	7.60	7.60	7.60
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	0.99	0.75	1.42	0.99	0.75	1.42
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr<=0.8 (spillthrough abut.)	0.87	0.66	1.24	0.87	0.66	1.24
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR