LEVEL II SCOUR ANALYSIS FOR BRIDGE 5 (CHELTH00030005) on TOWN HIGHWAY 3, crossing JENKINS BROOK, CHELSEA, VERMONT

U.S. Geological Survey
Open-File Report 96-743

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

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By MICHAEL A. IVANOFF

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Pembroke, New Hampshire

1996

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

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information write to:

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

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 5 (CHELTH00030005) ON TOWN HIGHWAY 3, CROSSING JENKINS BROOK, CHELSEA, VERMONT

By Michael A. Ivanoff

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure CHELTH00030005 on town highway 3 crossing Jenkins Brook, Chelsea, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I study provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the New England Upland section of the New England physiographic province of central Vermont in the town of Chelsea. The 6.97-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, Jenkins Brook has an incised, sinuous channel with a slope of approximately 0.04 ft/ft, an average channel top width of 48 ft and an average channel depth of 3 ft. The predominant channel bed material is cobble with a median grain size (D_{50}) of 154 mm (0.506 ft). The geomorphic assessment at the time of the Level I and Level II site visit on November 17, 1994, indicated that the reach was stable.

The town highway 3 crossing of Jenkins Brook is a 23-ft-long bridge consisting of one 20-foot concrete span (Vermont Agency of Transportation, written communication, August 25, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The upstream wingwalls are protected by type-3 stone fill (less than 48 inches diameter) and the downstream wingwalls have type-2 stone fill (less than 36 inches diameter). The footings of both abutments are exposed. The channel is skewed approximately 25 degrees to the opening while the opening-skew-to-roadway is 15 degrees. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows was 0.0 ft. Abutment scour ranged from 7.6 to 12.4 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and others, 1995, p. 47). 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.

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

NORTH

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

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

LEVEL II SUMMARY

Structure Number CHELTH00030005 ***Stream*** Jenkins Brook

County Orange ***Road*** TH3 ***District*** 4

Description of Bridge

Bridge length 23 ***ft*** ***Bridge width*** 21.1 ***ft*** ***Max span length*** 20 ***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*** 11/17/94

Description of stone fill Type-3 along the base of the upstream wingwalls and type-2 at the downstream ends of the downstream wingwalls.

Brief description of piers/abutments Abutments and wingwalls are concrete. The footings of both abutments are exposed.

Is bridge skewed to flood flow according to Y ***survey?*** Y ***Angle*** 25

There is a moderate channel bend in both the upstream and downstream reaches.

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	11/17/94	0	0
Level II	11/17/94	--	--

Potential for debris Low. Although the banks are forested, they appear stable.

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

--, November 17, 1994

Description of the Geomorphic Setting

General topography The stream is in a moderate relief, upland valley setting with steep valley walls and no floodplains.

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

Date of inspection 11/17/94

DS left: Steep valley wall.

DS right: Mild sloping bank and narrow terrace to steep valley wall.

US left: Mild sloping bank and narrow terrace to steep valley wall.

US right: Steep valley wall.

Description of the Channel

Average top width 48 ***ft*** ***Average depth*** 3 ***ft***

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

Small, sinuous but stable, perennial but flashy with non-alluvial channel boundaries.

11/17/94

Vegetative co Forested

DS left: Forested

DS right: Forested

US left: Forested

US right: Y

Do banks appear stable? -

date of observation.

None.

November 17, 1994

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 6.97 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England Upland/New England	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 1,200 ***ft³/s*** ***Q500*** 1,400 ***ft³/s***

The 100- and 500-year discharges were selected from a range of values defined by several empirical methods applicable to drainage basins of this size in this region (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887) and flood frequency estimates in the VTAOT database (VTAOT, written communication, May, 1995).

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is the center of a a chiseled X on top of the left end of the downstream guardrail base (elev. 499.96 ft, arbitrary datum). RM2 is the center of a chiseled X on top of the right end of the upstream guardrail base (elev. 499.33 ft, arbitrary datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-52	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	12	1	Road Grade section
APPRO	43	2	Modelled Approach section (Templated from ATEMP)
ATEMP	72	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, Jr. and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.050 to 0.060.

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 0.0365 ft/ft which was determined from surveyed thalweg points downstream of the structure.

The surveyed approach section (ATEMP) was moved along the approach channel slope (0.031 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

For the incipient-overtopping discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for this discharge. Analyzing both the supercritical and subcritical profiles, 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 498.8 *ft*

Average low steel elevation 497.0 *ft*

100-year discharge 1,200 *ft³/s*

Water-surface elevation in bridge opening 497.4 *ft*

Road overtopping? Y *Discharge over road* 205 *ft³/s*

Area of flow in bridge opening 123 *ft²*

Average velocity in bridge opening 8.2 *ft/s*

Maximum WSPRO tube velocity at bridge 9.9 *ft/s*

Water-surface elevation at Approach section with bridge 498.7

Water-surface elevation at Approach section without bridge 495.9

Amount of backwater caused by bridge 2.8 *ft*

500-year discharge 1,400 *ft³/s*

Water-surface elevation in bridge opening 497.4 *ft*

Road overtopping? Y *Discharge over road* 326 *ft³/s*

Area of flow in bridge opening 123 *ft²*

Average velocity in bridge opening 8.7 *ft/s*

Maximum WSPRO tube velocity at bridge 10.5 *ft/s*

Water-surface elevation at Approach section with bridge 499.0

Water-surface elevation at Approach section without bridge 496.2

Amount of backwater caused by bridge 2.8

Incipient overtopping discharge 760 *ft³/s*

Water-surface elevation in bridge opening 494.2 *ft*

Area of flow in bridge opening 70 *ft²*

Average velocity in bridge opening 10.9 *ft/s*

Maximum WSPRO tube velocity at bridge 13.9 *ft/s*

Water-surface elevation at Approach section with bridge 497.1

Water-surface elevation at Approach section without bridge 495.0

Amount of backwater caused by bridge 2.1 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour for the incipient overtopping discharge was computed by use of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The 100-year and 500-year discharges resulted in orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for the 100-year and 500-year discharges were computed by use of the Chang equation (Richardson and others, 1995, p. 145-146) The results of Laursen's clear-water contraction scour for these events were also computed and can be found in appendix F.

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

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	0.0
Depth to armoring	0.5	0.8	11.1
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	7.8	8.0	7.6
Right abutment	11.9	12.4	9.6
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	1.3	1.5	1.6
Right abutment	1.3	1.5	1.6
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

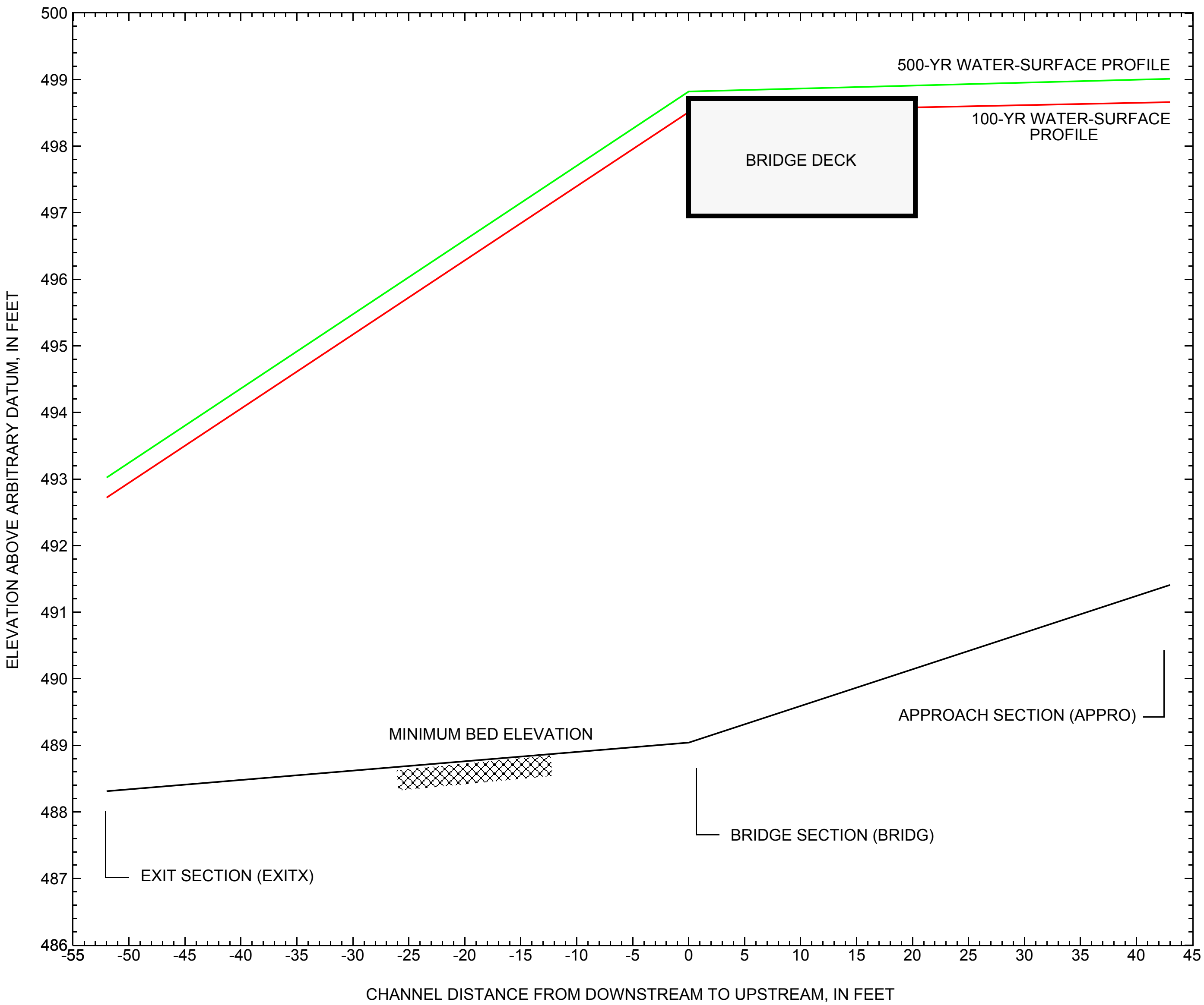

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure CHELTH00030005 on town highway 3, crossing Jenkins Brook, Chelsea, Vermont.

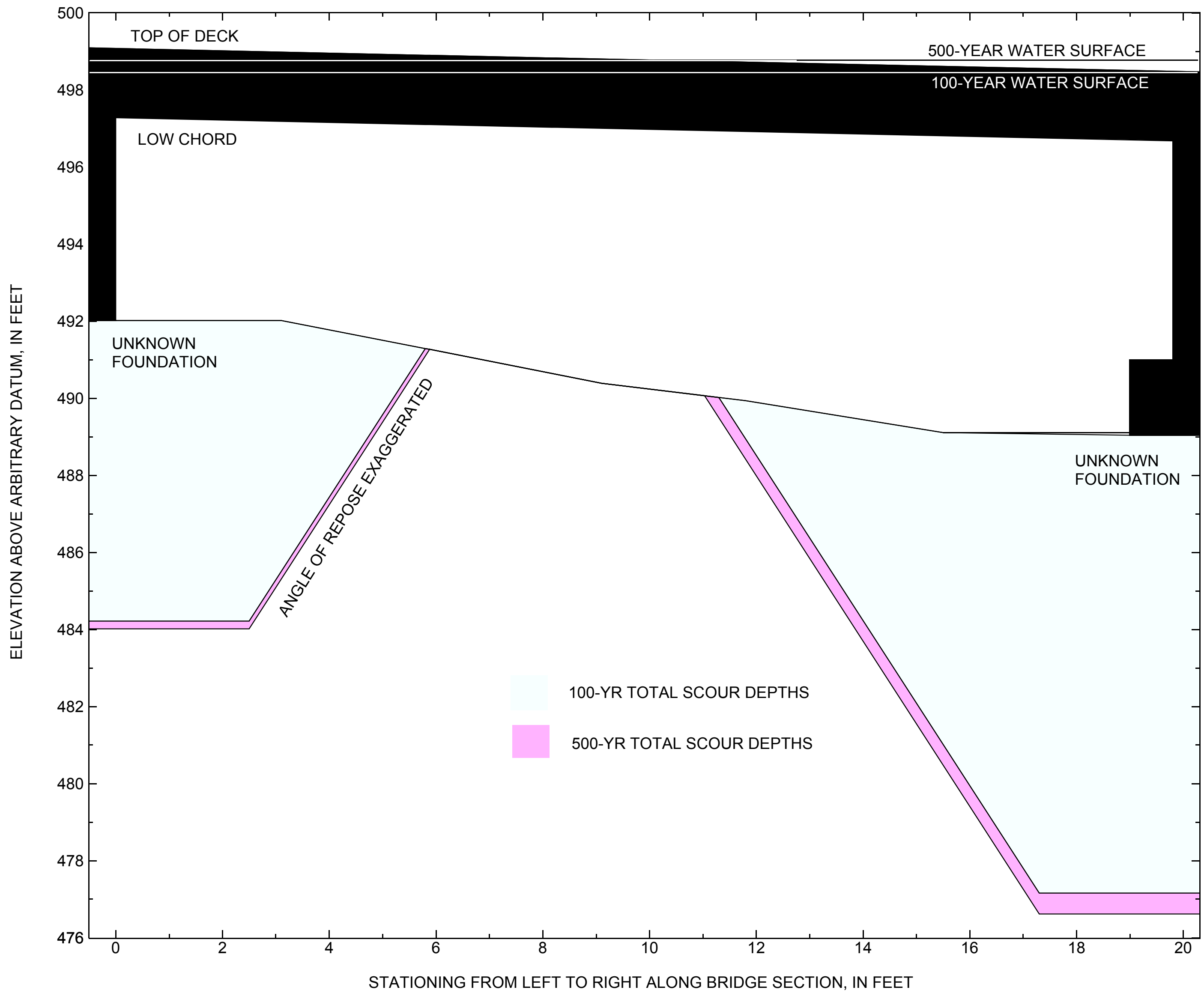

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure CHELTH00030005 on town highway 3, crossing Jenkins Brook, Chelsea, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure CHELTH00030005 on Town Highway 3, crossing Jenkins Brook, Chelsea, 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 elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,200 cubic-feet per second											
Left abutment	0.0	--	497.4	--	492.0	0.0	7.8	--	7.8	484.2	--
Right abutment	19.8	--	496.6	--	489.0	0.0	11.9	--	11.9	477.1	--

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 CHELTH00030005 on Town Highway 3, crossing Jenkins Brook, Chelsea, 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 elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 1,400 cubic-feet per second											
Left abutment	0.0	--	497.4	--	492.0	0.0	8.0	--	8.0	484.0	--
Right abutment	19.8	--	496.6	--	489.0	0.0	12.4	--	12.4	476.6	--

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

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File chel005.wsp
T2        Hydraulic analysis for structure CHELTH00030005   Date: 30-APR-96
T3        Hydraulic Analysis for Chelsea bridge 5 over Jenkins Brook by MAI
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          1200 1400 760
SK         0.0365 0.0365 0.0365
*
XS   EXITX    -52
GR          -19.5, 505.92     -4.7, 492.31      0.0, 489.43      3.8, 488.81
GR            9.9, 488.31     16.0, 488.81     23.0, 489.63     29.2, 490.80
GR           39.4, 491.39     56.5, 495.70     69.7, 497.12     79.4, 498.00
GR           88.5, 506.78
N            0.060
*
XS   FULLV     0 * * * 0.031
*
BR   BRIDG     0 497.0 15
GR            0.0, 497.37      0.2, 492.02      3.1, 492.02      9.1, 490.39
GR           11.8, 489.94     15.5, 489.11     18.9, 489.04     19.0, 490.48
GR           19.0, 490.97     19.6, 490.97     19.8, 496.61      0.0, 497.37
N            0.050
CD           1 29.7 * * 28 14.2
*
XR   RDWAY    12 21 2
GR          -97.7, 504.06      0.0, 499.08     20.8, 498.45     65.1, 497.12
GR           76.4, 497.12     89.8, 506.78
*
XT   ATEMP     72
GR          -50.1, 501.44    -32.3, 500.10    -21.4, 499.47    -13.7, 499.02
GR           -8.3, 496.57     -3.7, 493.52      3.7, 493.11      8.7, 492.31
GR           17.9, 492.39     18.4, 492.98     26.6, 494.00     42.4, 496.20
GR           55.8, 498.00     67.6, 506.78
*
AS   APPRO     43
GT             -0.90
N              0.060
*
HP 1 BRIDG   497.37 1 497.37
HP 2 BRIDG   497.37 * * 1005
HP 2 RDWAY   498.51 * * 205
HP 1 APPRO   498.66 1 498.66
HP 2 APPRO   498.66 * * 1200
*
HP 1 BRIDG   497.37 1 497.37
HP 2 BRIDG   497.37 * * 1070
HP 2 RDWAY   498.82 * * 326
HP 1 APPRO   499.01 1 499.01
HP 2 APPRO   499.01 * * 1400
*
HP 1 BRIDG   494.18 1 494.18
HP 2 BRIDG   494.18 * * 760
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File chel005.wsp
       Hydraulic analysis for structure CHELTH00030005   Date: 30-APR-96
       Hydraulic Analysis for Chelsea bridge 5 over Jenkins Brook by MAI
          *** RUN DATE & TIME: 07-02-96  14:57
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     123.    6601.     0.    51.                           0.
  497.37          123.    6601.     0.    51.  1.00     0.    20.      0.

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
      497.37     0.0    19.8   123.2    6601.    1005.   8.16
X STA.         0.0         2.2         3.6         4.8         5.9         6.9
  A(I)            10.6         7.1         6.4         6.1         5.9
  V(I)            4.73        7.07        7.85        8.30        8.46

X STA.         6.9         7.8         8.7         9.5        10.3        11.1
  A(I)             5.6         5.4         5.3         5.3         5.1
  V(I)            9.04        9.22        9.43        9.41        9.87

X STA.        11.1        11.9        12.6        13.4        14.1        14.8
  A(I)             5.2         5.1         5.2         5.1         5.1
  V(I)            9.73        9.87        9.75        9.83        9.88

X STA.        14.8        15.5        16.3        17.1        18.0        19.8
  A(I)             5.3         5.5         5.8         6.7        11.3
  V(I)            9.46        9.12        8.63        7.49        4.43

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      12.
        WSEL     LEW     REW    AREA        K        Q    VEL
      498.51    18.8    78.3    49.2    1072.     205.   4.16
X STA.        18.8        37.9        43.7        47.7        51.0        53.7
  A(I)             5.5         3.8         3.3         3.0         2.7
  V(I)            1.87        2.70        3.12        3.47        3.77

X STA.        53.7        56.0        58.1        60.0        61.7        63.3
  A(I)             2.6         2.4         2.2         2.2         2.1
  V(I)            3.99        4.24        4.57        4.69        4.95

X STA.        63.3        64.8        66.2        67.6        68.9        70.2
  A(I)             2.0         1.9         1.9         1.8         1.9
  V(I)            5.07        5.28        5.42        5.55        5.45

X STA.        70.2        71.6        72.9        74.2        75.5        78.3
  A(I)             1.8         1.8         1.8         1.9         2.6
  V(I)            5.58        5.65        5.60        5.52        3.98

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     338.   21302.    81.    84.                        3919.
  498.66          338.   21302.    81.    84.  1.00   -23.    58.   3919.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
        WSEL     LEW     REW    AREA        K        Q    VEL
      498.66   -23.0    57.9   337.9   21302.    1200.   3.55
X STA.       -23.0        -3.5        -0.4         2.3         4.7         6.9
  A(I)            33.7        19.4        17.1        15.4        14.6
  V(I)            1.78        3.10        3.51        3.90        4.12

X STA.         6.9         8.8        10.7        12.5        14.4        16.2
  A(I)            14.0        13.7        13.2        13.1        13.0
  V(I)            4.30        4.37        4.53        4.60        4.61

X STA.        16.2        18.0        20.2        22.4        24.9        27.5
  A(I)            13.3        14.1        14.0        14.5        15.0
  V(I)            4.52        4.25        4.29        4.13        4.01

X STA.        27.5        30.6        34.1        38.5        44.5        57.9
  A(I)            15.9        16.7        18.8        20.8        27.7
  V(I)            3.78        3.60        3.20        2.88        2.16
```

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        U.S. Geological Survey WSPRO Input File chel005.wsp
        Hydraulic analysis for structure CHELTH00030005   Date: 30-APR-96
        Hydraulic Analysis for Chelsea bridge 5 over Jenkins Brook by MAI
           *** RUN DATE & TIME: 07-02-96  14:57
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     123.    6601.     0.    51.                           0.
   497.37          123.    6601.     0.    51.  1.00     0.    20.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       497.37     0.0    19.8   123.2    6601.    1070.   8.69
X STA.         0.0         2.2         3.6         4.8         5.9         6.9
  A(I)             10.6         7.1         6.4         6.1         5.9
  V(I)             5.04        7.53        8.36        8.84        9.01

X STA.         6.9         7.8         8.7         9.5        10.3        11.1
  A(I)              5.6         5.4         5.3         5.3         5.1
  V(I)             9.63        9.82       10.04       10.02       10.51

X STA.        11.1        11.9        12.6        13.4        14.1        14.8
  A(I)              5.2         5.1         5.2         5.1         5.1
  V(I)            10.36       10.50       10.38       10.46       10.52

X STA.        14.8        15.5        16.3        17.1        18.0        19.8
  A(I)              5.3         5.5         5.8         6.7        11.3
  V(I)            10.08        9.71        9.18        7.98        4.72

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      12.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.82     8.6    78.8    69.3    1698.     326.   4.70
X STA.         8.6        31.3        38.1        42.8        46.8        50.0
  A(I)              7.8         5.4         4.5         4.3         3.8
  V(I)             2.09        3.03        3.58        3.81        4.25

X STA.        50.0        52.7        55.3        57.5        59.5        61.4
  A(I)              3.6         3.4         3.2         3.1         2.9
  V(I)             4.57        4.76        5.11        5.25        5.54

X STA.        61.4        63.2        64.8        66.4        67.9        69.4
  A(I)              2.8         2.7         2.7         2.6         2.6
  V(I)             5.80        5.99        6.04        6.31        6.25

X STA.        69.4        70.9        72.4        73.9        75.5        78.8
  A(I)              2.5         2.6         2.6         2.6         3.6
  V(I)             6.46        6.38        6.33        6.24        4.55

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     367.   23265.    87.    90.                        4273.
   499.01          367.   23265.    87.    90.  1.00   -29.    58.   4273.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
         WSEL     LEW     REW    AREA        K        Q    VEL
       499.01   -29.0    58.4   367.3   23265.    1400.   3.81
X STA.       -29.0        -3.9        -0.4         2.4         5.0         7.3
  A(I)             39.4        22.6        18.9        17.8        16.0
  V(I)             1.78        3.09        3.70        3.94        4.37

X STA.         7.3         9.3        11.3        13.2        15.0        16.9
  A(I)             15.3        14.9        14.4        14.2        14.1
  V(I)             4.57        4.70        4.87        4.94        4.95

X STA.        16.9        18.9        21.1        23.4        25.9        28.6
  A(I)             14.7        14.5        15.1        15.1        16.0
  V(I)             4.75        4.83        4.63        4.63        4.38

X STA.        28.6        31.8        35.4        39.7        45.7        58.4
  A(I)             17.0        17.8        18.7        22.3        28.5
  V(I)             4.13        3.93        3.74        3.13        2.46
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       U.S. Geological Survey WSPRO Input File chel005.wsp
       Hydraulic analysis for structure CHELTH00030005   Date: 30-APR-96
       Hydraulic Analysis for Chelsea bridge 5 over Jenkins Brook by MAI
          *** RUN DATE & TIME: 07-02-96  14:57
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1      70.    3978.    19.    26.                        759.
  494.18           70.    3978.    19.    26.  1.00     0.    20.    759.

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
      494.18     0.1    19.7    69.7    3978.     760.  10.90
X STA.        0.1        3.1        4.9        6.3        7.5        8.5
  A(I)            6.1        4.4        3.9        3.5        3.3
  V(I)           6.27       8.73       9.81      10.82      11.34

X STA.        8.5        9.3       10.1       10.9       11.6       12.3
  A(I)            3.1        3.0        2.9        2.8        2.8
  V(I)          12.20      12.53      12.98      13.45      13.47

X STA.       12.3       12.9       13.6       14.2       14.8       15.3
  A(I)            2.8        2.8        2.7        2.7        2.8
  V(I)          13.74      13.73      13.92      13.87      13.59

X STA.       15.3       15.9       16.5       17.2       18.0       19.7
  A(I)            2.9        3.0        3.3        3.9        6.9
  V(I)          12.99      12.57      11.44       9.85       5.50

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     227.   12457.    67.    69.                       2368.
  497.11          227.   12457.    67.    69.  1.00    -11.    56.   2368.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
        WSEL     LEW     REW    AREA        K        Q    VEL
      497.11   -11.5    55.8   227.1   12457.     760.   3.35
X STA.      -11.5       -3.4       -1.0        1.1        3.1        5.0
  A(I)           17.1       11.2       10.0        9.6        9.4
  V(I)           2.22       3.40       3.78       3.95       4.04

X STA.        5.0        6.8        8.4        9.9       11.5       13.0
  A(I)            9.2        8.9        8.7        8.9        8.8
  V(I)           4.13       4.27       4.39       4.29       4.30

X STA.       13.0       14.6       16.3       18.0       20.0       22.3
  A(I)            9.0        9.2        9.5       10.4       10.7
  V(I)           4.23       4.11       3.99       3.65       3.55

X STA.       22.3       24.9       27.9       31.8       37.1       55.8
  A(I)           11.4       12.2       13.8       15.3       23.7
  V(I)           3.34       3.12       2.75       2.48       1.60
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File chel005.wsp
        Hydraulic analysis for structure CHELTH00030005   Date: 30-APR-96
        Hydraulic Analysis for Chelsea bridge 5 over Jenkins Brook by MAI
           *** RUN DATE & TIME: 07-02-96  14:57
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******    -5.     134.  1.26 *****  493.98  492.67   1200.  492.72
      -52. ******    45.    6277.  1.00 ***** *******    0.97    8.99

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.85     494.60     494.28

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   492.22     508.39    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   492.22     508.39     494.28

FULLV:FV      52.    -5.     147.  1.04  1.65  495.64  494.28   1200.  494.60
        0.    52.    46.    7228.  1.00  0.00    0.01    0.85    8.17
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.85     495.86     495.53

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.10     505.88    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.10     505.88     495.53

APPRO:AS      43.    -9.     150.  0.99  1.20  496.85  495.53   1200.  495.85
       43.    43.    47.    7130.  1.00  0.00    0.01    0.85    7.99
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   499.08       0.00     495.50     497.12

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   495.09     498.24     498.41     497.00

 ===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      52.     0.     123.  1.04 *****  498.41  494.95   1005.  497.37
        0. ******    20.    6601.  1.00 ***** *******    0.58    8.16

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.462  0.000  497.00 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.    22.  0.07  0.20  498.79    0.01    205.  498.51

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.     8.     4.    12.   0.2   0.1   2.8   7.6   0.5   2.7
   RT:   205.    60.    19.    78.   1.4   0.8   4.6   4.1   1.1   2.9

APPRO:AS      13.   -23.     338.  0.20  0.12  498.86  495.53   1200.  498.66
       43.    15.    58.   21328.  1.00  1.09    0.01    0.31    3.55

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS     -52.    -5.    45.   1200.    6277.     134.    8.99  492.72
   FULLV:FV       0.    -5.    46.   1200.    7228.     147.    8.17  494.60
   BRIDG:BR       0.     0.    20.   1005.    6601.     123.    8.16  497.37
   RDWAY:RG      12.*******     0.    205.       0.*********    2.00  498.51
   APPRO:AS      43.   -23.    58.   1200.   21328.     338.    3.55  498.66

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    492.67    0.97  488.31  506.78************  1.26  493.98  492.72
   FULLV:FV    494.28    0.85  489.92  508.39  1.65  0.00  1.04  495.64  494.60
   BRIDG:BR    494.95    0.58  489.04  497.37************  1.04  498.41  497.37
   RDWAY:RG  ****************  497.12  506.78  0.07******  0.20  498.79  498.51
   APPRO:AS    495.53    0.31  491.41  505.88  0.12  1.09  0.20  498.86  498.66
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        U.S. Geological Survey WSPRO Input File chel005.wsp
        Hydraulic analysis for structure CHELTH00030005   Date: 30-APR-96
        Hydraulic Analysis for Chelsea bridge 5 over Jenkins Brook by MAI
           *** RUN DATE & TIME: 07-02-96  14:57
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS      Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******    -5.     148.  1.39 *****  494.40  492.97   1400.  493.02
      -52. ******    46.    7323.  1.00 ***** *******    0.98    9.44

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.86     494.91     494.58

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   492.52     508.39    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   492.52     508.39     494.58

FULLV:FV      52.    -6.     163.  1.14  1.65  496.06  494.58   1400.  494.91
        0.    52.    47.    8425.  1.00  0.00    0.00    0.86    8.58
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.85     496.20     495.84

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.41     505.88    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.41     505.88     495.84

APPRO:AS      43.    -9.     169.  1.06  1.19  497.26  495.84   1400.  496.19
       43.    43.    49.    8396.  1.00  0.00    0.00    0.86    8.26
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   499.90       0.00     496.05     497.12

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.36     498.60     498.78     497.00

 ===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      52.     0.     123.  1.17 *****  498.54  495.13   1070.  497.37
        0. ******    20.    6601.  1.00 ***** *******    0.61    8.69

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.475  0.000  497.00 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.    22.  0.08  0.23  499.16    0.00    326.  498.82

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     2.     3.     9.    12.   0.1   0.0   2.5  13.1   0.4   2.6
   RT:   324.    67.    12.    79.   1.7   1.0   5.3   4.7   1.4   3.0

APPRO:AS      13.   -29.     367.  0.23  0.15  499.24  495.84   1400.  499.01
       43.    15.    58.   23276.  1.00  1.09    0.00    0.33    3.81

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -52.    -5.    46.   1400.    7323.     148.    9.44  493.02
   FULLV:FV       0.    -6.    47.   1400.    8425.     163.    8.58  494.91
   BRIDG:BR       0.     0.    20.   1070.    6601.     123.    8.69  497.37
   RDWAY:RG      12.*******     2.    326.       0.*********    2.00  498.82
   APPRO:AS      43.   -29.    58.   1400.   23276.     367.    3.81  499.01

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    492.97    0.98  488.31  506.78************  1.39  494.40  493.02
   FULLV:FV    494.58    0.86  489.92  508.39  1.65  0.00  1.14  496.06  494.91
   BRIDG:BR    495.13    0.61  489.04  497.37************  1.17  498.54  497.37
   RDWAY:RG  ***************  497.12  506.78  0.08******  0.23  499.16  498.82
   APPRO:AS    495.84    0.33  491.41  505.88  0.15  1.09  0.23  499.24  499.01
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        U.S. Geological Survey WSPRO Input File chel005.wsp
        Hydraulic analysis for structure CHELTH00030005   Date: 30-APR-96
        Hydraulic Analysis for Chelsea bridge 5 over Jenkins Brook by MAI
           *** RUN DATE & TIME: 07-02-96  14:57
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS      Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******    -4.      98.  0.93 *****  492.92  491.89    760.  491.98
      -52. ******    42.    3977.  1.00 ***** *******    0.94    7.75

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.82     493.80     493.50

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   491.48     508.39    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   491.48     508.39     493.50

FULLV:FV      52.    -5.     108.  0.78  1.66  494.58  493.50    760.  493.80
        0.    52.    43.    4560.  1.00  0.00    0.00    0.82    7.07
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.84     495.01     494.73

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   493.30     505.88    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   493.30     505.88     494.73

APPRO:AS      43.    -7.     107.  0.78  1.21  495.80  494.73    760.  495.02
       43.    43.    40.    4490.  1.00  0.00    0.01    0.83    7.09
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =      760.     494.18

            <<<<<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      52.     0.      70.  1.85 *****  496.03  494.18    760.  494.18
        0.    52.    20.    3973.  1.00 ***** *******    1.00   10.91

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.00 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG      12.        <<<<<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      13.   -11.     227.  0.17  0.17  497.28  494.73    760.  497.11
       43.    14.    56.   12460.  1.00  1.09    0.00    0.32    3.35

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.590  0.371    7852.    -1.    18.   497.03

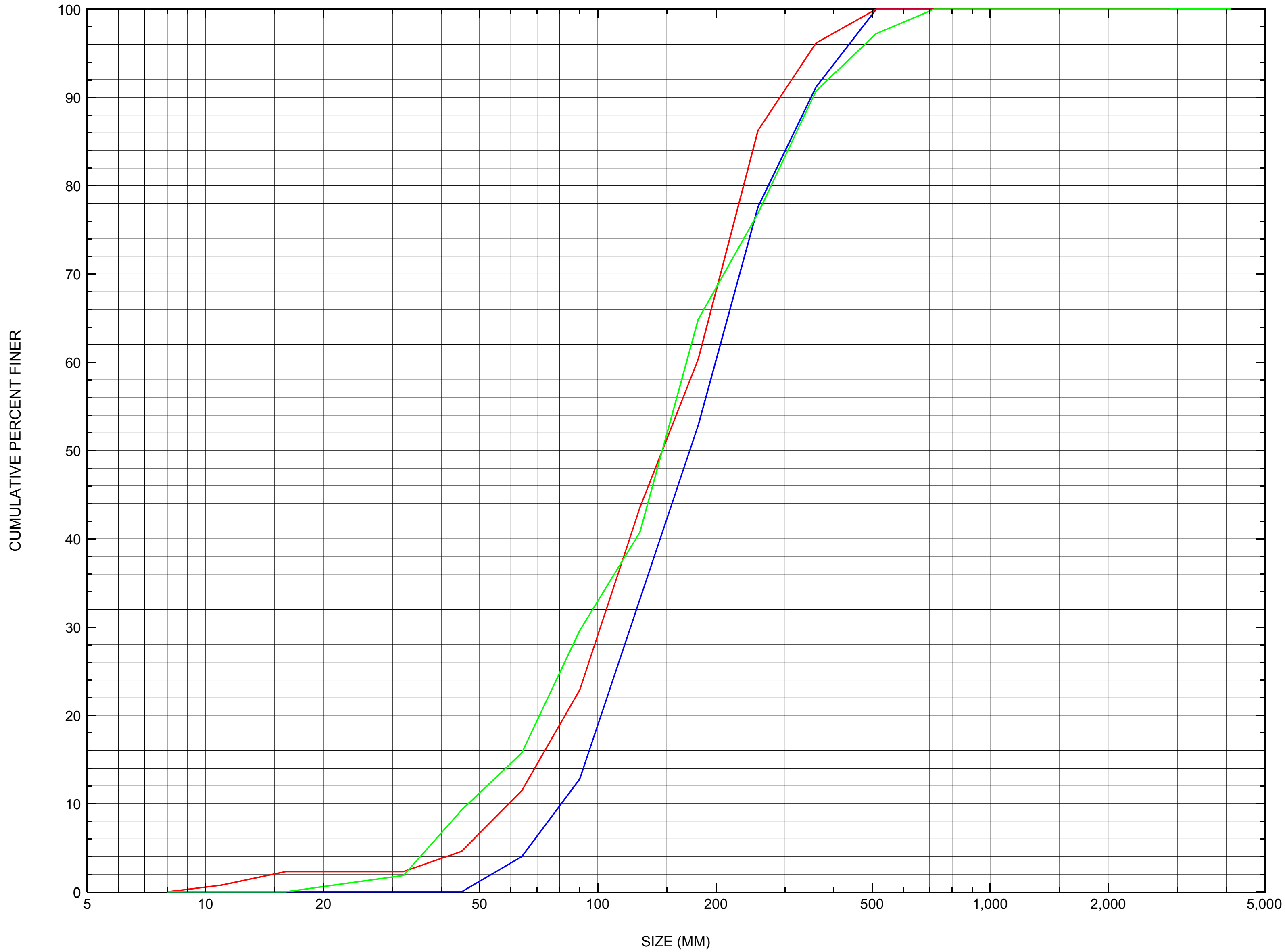
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -52.    -4.    42.    760.    3977.      98.    7.75  491.98
   FULLV:FV       0.    -5.    43.    760.    4560.     108.    7.07  493.80
   BRIDG:BR       0.     0.    20.    760.    3973.      70.   10.91  494.18
   RDWAY:RG      12.**************      0.******************    2.00********
   APPRO:AS      43.   -11.    56.    760.   12460.     227.    3.35  497.11

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -1.    18.    7852.

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    491.89    0.94  488.31  506.78************  0.93  492.92  491.98
   FULLV:FV    493.50    0.82  489.92  508.39  1.66  0.00  0.78  494.58  493.80
   BRIDG:BR    494.18    1.00  489.04  497.37************  1.85  496.03  494.18
   RDWAY:RG  ***************  497.12  506.78**********************************
   APPRO:AS    494.73    0.32  491.41  505.88  0.17  1.09  0.17  497.28  497.11
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for three pebble count transects at the approach cross-section for structure CHELTH00030005, in Chelsea, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number CHELTH0030005

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 25 / 94

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

County *(FIPS county code; I - 3; nnn)* 017

Town *(FIPS place code; I - 4; nnnnn)* 13525

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

Waterway *(I - 6)* JENKINS BROOK

Road Name *(I - 7):* C3003

Route Number 0.3 MI

Vicinity *(I - 9)* JCT TH 3 + VT 110

Topographic Map Chelsea

Hydrologic Unit Code: 01080105

Latitude *(I - 16; nnnn.n)* 43584

Longitude *(i - 17; nnnnn.n)* 72266

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10090400050904

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

Maximum span length *(I - 48; nnnn)* 0020

Year built *(I - 27; YYYY)* 1931

Structure length *(I - 49; nnnnnn)* 000023

Average daily traffic, ADT *(I - 29; nnnnnn)* 000200

Deck Width *(I - 52; nn.n)* 211

Year of ADT *(I - 30; YY)* 94

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

Opening skew to Roadway *(I - 34; nn)* 30

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

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

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

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

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

Comments:

Structural report of 9/8/93 indicates a concrete slab type bridge with a gravel road approach. The right concrete abutment has a horizontal pour line open 3/16 inch approximately 24 inches below the top of abutment. Some diagonal cracks are noted just off fascias of both abutments. The left abutment has 1/8 inch crack at upstream end. The footing is exposed along right abutment. The streambed at the upstream end right abutment is 24 inches below the top of the footing and 9 inches below at the downstream end with no apparent undermining. All flow runs along the right abut. The footing is exposed at the downstream end of the left abutment flush with the streambed. The stream banks are protected with boulders. Erosion is not addressed. No apparent settlement or drift/vegetation was noted. A minor gravel bar exists along left abutment.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: **Moderate to sharp turn into structure**

Streambed material: **Stone and gravel with quite a few random boulders**

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -
-

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

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

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

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

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

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

Downstream distance (*miles*): - Town: - Year Built: -
Highway No. : - Structure No. : - Structure Type: -
Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (ft^2): -

Comments:
-
-
-
-
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 6.97 mi^2 Lake and pond area 0.05 mi^2
Watershed storage *(ST)* 0.7 %
Bridge site elevation 860 ft Headwater elevation 2250 ft
Main channel length 4.59 mi
10% channel length elevation 975 ft 85% channel length elevation 1700 ft
Main channel slope *(S)* 196.56 ft / mi

Watershed Precipitation Data

Average site precipitation ______ in Average headwater precipitation ______ in

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

Average seasonal snowfall *(Sn)* ______ ft

Bridge Plan Data

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

Project Number -- Minimum channel bed elevation: --

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

Benchmark location description:
NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness ______ Footing bottom elevation: ______

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

If 3: Footing bottom elevation: ______

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

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

Briefly describe material at foundation bottom elevation or around piles:
NO FOUNDATION MATERIAL INFORMATION

Comments:
NO PLANS

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: -

NO CROSS SECTION INFORMATION

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **DLS** Date: **2/6/95**

Computerized by: **MAI** Date: **3/15/95**

Reviewd by: **SAO** Date: **7/3/96**

Structure Number **CHELTH00030005**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M. IVANOFF** Date *(MM/DD/YY)* **11** / **17** / 19**94**

2. Highway District Number **04**

Mile marker **0**

County **ORANGE (017)**

Town **CHELSEA (13525)**

Waterway *(I - 6)* **JENKINS BROOK**

Road Name **-**

Route Number **TH003**

Hydrologic Unit Code: **01080105**

3. Descriptive comments:

Located 0.3 miles from the junction of TH 3 and VT 110.

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 **23** *(feet)* Span length **20** *(feet)* Bridge width **21.1** *(feet)*

Road approach to bridge:

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

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

10. Embankment slope (*run / rise in feet / foot*):
US left **-:1** US right **4.6:1**

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

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*

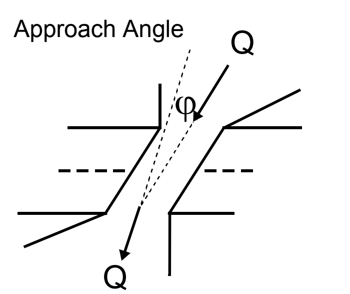
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

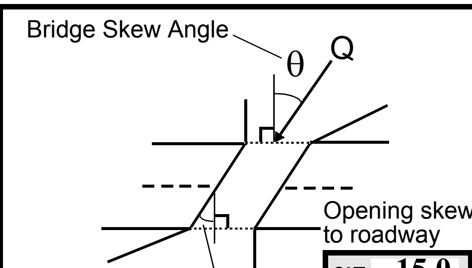
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: **10** 16. Bridge skew: **25**





α= **15.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*

Where? **RB** *(LB, RB)* Severity **0**

Range? **0** feet **US** *(US, UB, DS)* to **30** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*

Where? **LB** *(LB, RB)* Severity **0**

Range? **20** feet **DS** *(US, UB, DS)* to **50** feet **DS**

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

18. Level II Bridge Type: **1a**

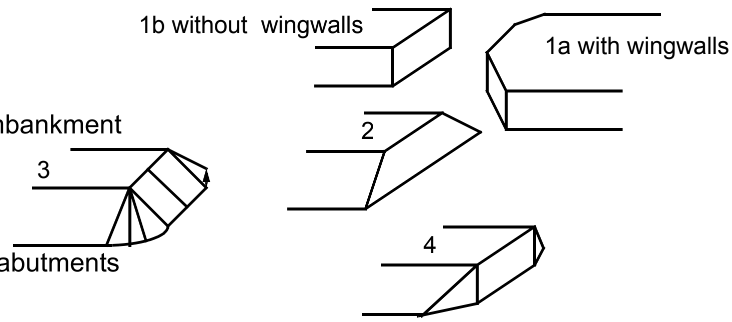
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4. Upstream left bank and downstream right bank surface cover is predominantly forested with TH 003 in the area.

7. Measured bridge length: 23, span: 20, and width: 21 feet.

Road approach overflow width is 22 ft. along the right approach.

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
70.4	3.0			3.0	4	4	54	54	0	0

23. Bank width	24. Channel width	25. Thalweg depth	29. Bed Material
35.0	5.0	51.5	435

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

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.):

27. Bank material is boulders and cobble with fine material overlying.

29. Bed material consists of cobble with some gravel and boulders.

The upstream channel is very steep.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **5** 35. Mid-bar width: **8**

36. Point bar extent: **17** feet **US** *(US, UB)* to **14** feet **DS** *(US, UB, DS)* positioned **0** %LB to **50** %RB

37. Material: **3**

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

Point bar consists of gravel material and noted on historical form.

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

41. Mid-bank distance: **35** 42. Cut bank extent: **20** feet **US** *(US, UB)* to **50** feet **US** *(US, UB, DS)*

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

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

Old cut bank behind placed boulders now covered with moss and ferns; boulders now protecting and preventing a cut towards the right road approach.

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

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

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

NO CHANNEL SCOUR

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
15.0		0.5		2	7	7	0

58. Bank width (BF) **-** 59. Channel width (Amb) **-** 60. Thalweg depth (Amb) **90.0** 63. Bed Material **0**

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.):

435

Thalweg is along right abutment. Channel flattens under the bridge from where it is very steep upstream. Bridge constricts channel significantly.

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

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

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

70. Debris and Ice Comments:

1

67. No debris accumulation near the bridge, upstream section is laterally stable, has few cut banks, and bed material is cobble and some boulders.

68. High gradient channel and the span constricts the flow to 50% of the upstream bank width.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	-	2	0	0.5	90.0
RABUT	1	0	90			-	2	19.8

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

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

0

2.0

1

71. RABUT: slight attack angle, however, at bank full flow the attack angle is minimized.

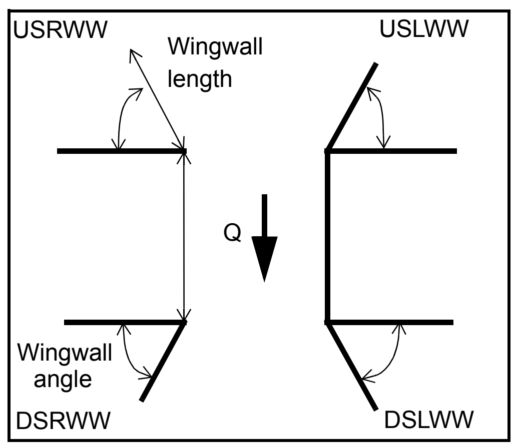
76. LABUT: exposure is along the last 10 ft. at the downstream end.

RABUT: exposed along the entire length and noted on the historical form from previous VTAOT inspections.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						9.5	
USRWW:	Y		1		0	1.5	
DSLWW:	0		0		Y	24.0	
DSRWW:	1		2		0	24.0	

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



82. Bank / Bridge Protection:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	1.5	2	Y	0	1	1	-	-
Condition	Y	0	1	1	1	1	-	-
Extent	1	0.5	2	3	3	0	0	-

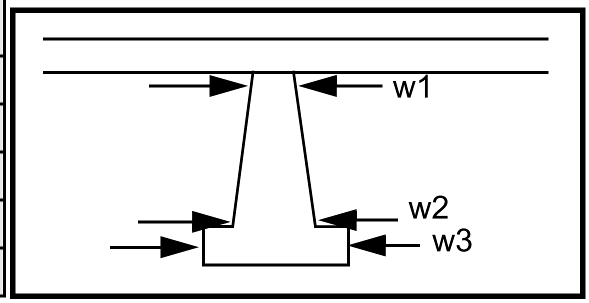
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1			45.0	10.0	21.0	11.0
Pier 2	75.0		9.5	9.0	35.0	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	strea	rd	flow,	h.	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	m	end.	but		1- Solid pier, 2- column, 3- bent
88. Material	right	The	there		1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	wing	upst	is		1- Round; 2- Square; 3- Pointed
90. Inclined?	wall	ream	stone		Y- yes; N- no
91. Attack ∠ (BF)	foot-	right	fill		
92. Pushed	ing	wing	alon		LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	expo	wall	g the		
95. Cross-members	sed	is	entir		0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	on	impa	e		0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	strea	cted	base	N	
98. Exposure depth	mwa	by	lengt	-	

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 (Amb) - Thalweg depth (Amb) - Bed Material -

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

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

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

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

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

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

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

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

Material: ____

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

Is a cut-bank present? ____ (Y or if N type ctrl-n cb) Where? 4 (LB or RB) Mid-bank distance: 4

Cut bank extent: 54 feet 54 (US, UB, DS) to 0 feet 0 (US, UB, DS)

Bank damage: 435 (**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)

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

0

0

-

-

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

Scour dimensions: Length mate Width rial Depth: con- Positioned sist %LB to pri- %RB

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

marily of boulders and cobble with overlying fines.

Bed material consist of cobbles and gravel with some boulders.

The channel gradient downstream is like that under the bridge and then steepens again about 60 feet downstream.

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

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

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

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

N

-

NO DROP STRUCTURE

N

-

-

-

-

109. G. Plan View Sketch

- -

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: CHELTH00030005 Town: Chelsea
Road Number: TH 3 County: Orange
Stream: Jenkins Brook

Initials MAI Date: 06/11/96 Checked: SAO

I. 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	1200	1400	760
Main Channel Area, ft2	338	367	227
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	81	87	67
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.506	0.506	0.506
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	4.2	4.2	3.4
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	21302	23265	12457
Conveyance, main channel	21302	23265	12457
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1200.0	1400.0	760.0
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	3.6	3.8	3.3
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	11.3	11.4	10.9
Vc-l, crit. velocity, LOB, ft/s	N/A	N/A	N/A
Vc-r, crit. velocity, ROB, ft/s	N/A	N/A	N/A

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)

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	338	367	227
Main channel width, ft	81	87	67
y1, main channel depth, ft	4.17	4.22	3.39

Bridge Section			
(Q) total discharge, cfs	1200	1400	760
(Q) discharge thru bridge, cfs	1005	1070	760
Main channel conveyance	6601	6601	3978
Total conveyance	6601	6601	3978
Q2, bridge MC discharge,cfs	1005	1070	760
Main channel area, ft2	123	123	70
Main channel width (skewed), ft	19.1	19.1	18.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	19.1	19.1	18.9
y_bridge (avg. depth at br.), ft	6.45	6.45	3.70
Dm, median (1.25*D50), ft	0.6325	0.6325	0.6325
y2, depth in contraction,ft	4.21	4.45	3.35
ys, scour depth (y2-ybridge), ft	-2.24	-2.00	-0.36
(y2-y1), ft	0.04	0.23	-0.04

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	1005	1070	0
Vc, critical velocity, ft/s	11.3	11.4	0
Vc, critical velocity, m/s	3.44	3.47	0
Main channel width (skewed), ft	19.1	19.1	0
Cum. width of piers, ft	0	0	0
W, adjusted width, ft	19.1	19.1	0
qbr, unit discharge, ft2/s	52.6	56.0	ERR
qbr, unit discharge, m2/s	4.89	5.20	N/A
Area of full opening, ft2	123.2	123.2	0
Hb, depth of full opening, ft	6.45	6.45	ERR
Hb, depth of full opening, m	1.966	1.966	N/A
Fr, Froude number MC	0.58	0.61	1
Cf, Fr correction factor (<=1.0)	1	1	1.5
Elevation of Low Steel, ft	496.99	496.99	0
Elevation of Bed, ft	490.54	490.54	N/A
Elevation of approach WS, ft	498.66	499.01	0
HF, bridge to approach, ft	0.12	0.15	0
Elevation of WS immediately US, ft	498.54	498.86	0
ya, depth immediately US, ft	8.00	8.32	N/A
ya, depth immediately US, m	2.49	2.58	N/A
Mean elev. of deck, ft	498.76	498.76	0
w, depth of overflow, ft (>=0)	0	0.1	0
Cc, vert contrac correction (<=1.0)	0.947	0.940	ERR
Ys, depth of scour (chang), ft	-1.532	-1.222	N/A

ARMORING

D90	1.09	1.09	1.09
D95	1.33	1.33	1.33
Critical grain size,Dc, ft	0.3663	0.4152	0.8562
Decimal-percent coarser than Dc	0.678	0.616	0.188
Depth to armoring,ft	0.52	0.78	11.09

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	1200	1400	760	1200	1400	760
a', abut.length blocking flow, ft	23.4	29.4	11.9	38.4	38.9	36.5
Ae, area of blocked flow ft2	58.2	67.4	35	125	127.4	90.7
Qe, discharge blocked abut.,cfs	137.8	160	101.3	--	--	241.3
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve manually)						
Ve, (Qe/Ae), ft/s	2.37	2.37	2.89	3.37	3.79	2.66
ya, depth of f/p flow, ft	2.49	2.29	2.94	3.26	3.28	2.48
--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	75	75	75	105	105	105
K2	0.98	0.98	0.98	1.02	1.02	1.02
Fr, froude number f/p flow	0.265	0.276	0.297	0.303	0.329	0.297
ys, scour depth, ft	7.76	7.98	7.60	11.88	12.42	9.64

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)	23.4	29.4	11.9	38.4	38.9	36.5
y1 (depth f/p flow, ft)	2.49	2.29	2.94	3.26	3.28	2.48
a'/y1	9.41	12.82	4.05	11.80	11.88	14.69
Skew correction	0.00	0.00	0.00	0.00	0.00	0.00
Froude no. f/p flow	0.27	0.28	0.30	0.30	0.33	0.30
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.58	0.61	1	0.58	0.61	1
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	6.45	6.45	3.7	6.45	6.45	3.7
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.34	1.48	ERR	1.34	1.48	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	1.55	ERR	ERR	1.53