LEVEL II SCOUR ANALYSIS FOR BRIDGE 63 (CHESTH00090063) on TOWN HIGHWAY 9, crossing the WILLIAMS RIVER, CHESTER, VERMONT

U.S. Geological Survey
Open-File Report 97-423

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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By ROBERT H. FLYNN

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Pembroke, New Hampshire

1997

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

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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 63 (CHESTH00090063) ON TOWN HIGHWAY 9, CROSSING THE WILLIAMS RIVER, CHESTER, VERMONT

By **Robert H. Flynn**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure CHESTH00090063 on Town Highway 9 crossing the Williams River, Chester, 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 investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the New England Upland section of the New England physiographic province in eastern Vermont. The 24.0-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is grass with trees and brush along the immediate banks.

In the study area, the the Williams River has an incised, sinuous channel with a slope of approximately 0.005 ft/ft, an average channel top width of 64 ft and an average bank height of 6 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 57.7 mm (0.189 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 18, 1996, indicated that the reach was stable.

The Town Highway 9 crossing of the Williams River is a 45-ft-long, two-lane bridge consisting of one 35-foot steel-beam span with a timber deck (Vermont Agency of Transportation, written communication, April 6, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 5 degrees to the opening while the opening-skew-to-roadway is 0 degrees.

A scour hole 1.8 ft deeper than the mean thalweg depth was observed along the left abutment during the Level I assessment. The scour hole undermines the left abutment and extends from 50 ft upstream of the upstream bridge face to 50 ft downstream of the downstream bridge face. The scour protection measures at the site included type-3 stone fill (less than 48 inches diameter) under the bridge along the entire base length of the right abutment and along the right bank from 50 to 88 ft upstream. Type-2 (less than 36 inches diameter) stone fill scour protection was observed along the downstream left bank from 18 ft to 115 ft, along the downstream right bank from 8 ft to 25 ft and along the upstream left bank from 50 to 75 ft. 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 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 computed to be 0.0 ft. Abutment scour ranged from 10.1 ft to 11.0 ft along the left abutment and from 14.1 ft to 15.1 ft along the right abutment. The worst-case abutment scour for the left abutment occurred at the 500-year discharge while the worst-case abutment scour for the right abutment occurred at the 100-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.

Chester, VT. Quadrangle, 1:24,000, 1972

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 CHESTH00090063 ***Stream*** Williams River

County Windsor ***Road*** TH9 ***District*** 2

Description of Bridge

Bridge length 45 ***ft*** ***Bridge width*** 14.7 ***ft*** ***Max span length*** 35 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 9/18/96

Description of stone fill Type-3, along the entire base length of the right abutment

Abutments and wingwalls are concrete. The right abutment is formed by stacked 3’ x 3’ x 3’ concrete blocks while the left abutment is poured concrete. There is a 1.75 foot deep scour hole along the left abutment.

Y 5

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

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*
	9/18/96	0	0
Level I	9/18/96	0	0
Level II			

Potential for debris Moderate. The channel is sinuous with cutbanks evident and tree cover on the banks immediately adjacent to the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date) In an extreme flood event, the right floodplain will provide relief by accepting all excess flow

Description of the Geomorphic Setting

General topography The channel is located within a wide, flat to slightly irregular flood plain. 9/18/96

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

Date of inspection Steep channel

DS left: bank to a narrow flood plain.

DS right: Steep channel bank to a wide flood plain.

US left: Steep channel bank to a narrow flood plain.

US right: Steep channel bank to a wide flood plain.

Description of the Channel

Average top width 64 ***ft*** ***Average depth*** 6 ***ft***

Predominant bed material Gravel / Cobbles ***Bank material*** Cobbles / Boulder

Sinuous but stable

with semi-alluvial channel boundaries.

9/18/96

Vegetative co

TH 9 on overbank with brush and trees along banks

DS left: Grass on overbank with trees and brush along the banks.

DS right: TH 9 on overbank with brush and trees along banks

US left: Grass on overbank with trees and brush along the banks.

US right: Yes

Do banks appear stable? It was noted that although cutbanks are evident both upstream and downstream, the channel is constrained by rock protection and one ft (and larger) diameter trees are growing along the lower banks, indicating that the channel has not moved recently. 9/18/96

If not, describe location and type of instability and date of observation.

None. 9/18/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 24.0 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: There are houses along the left overbank area

Is there a USGS gage on the stream of interest? Yes

USGS gage description Williams River at Brockways Mills

USGS gage number 01153500

Gage drainage area 103 ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 5,210 ***ft³/s*** ***Q500*** 7,640 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(24.0/25.1)exp 0.75] with the Williams River above Trebo Brook in Chester which has flood frequency estimates available from the Flood Insurance Study for Chester (Federal Emergency Management Agency (FEMA), 1982).

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. RM3 is a chiseled X on top of the upstream end of the left abutment (elev. 488.82 ft, arbitrary survey datum). RM4 is a nail head, four ft above the ground, in a telephone pole (#CTCVT 3-1) on the right bank approximately 8 ft downstream of the bridge face (elev. 494.40 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-43	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	11	1	Road Grade section
APPRO	55	2	Modelled Approach section (Templated from APTEM)
APTEM	60	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 0.035 to 0.055, and overbank "n" values ranged from 0.032 to 0.042.

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 0.0054 ft/ft which was the slope of the 100-year profile from the flood insurance study for the town of Chester (Federal Emergency Management Agency, 1982).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0037 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.

Bridge Hydraulics Summary

Average bridge embankment elevation 491.5 ***ft***
Average low steel elevation 489.1 ***ft***

100-year discharge 5,210 ***ft^3/s***
Water-surface elevation in bridge opening 489.2 ***ft***
Road overtopping? Y ***Discharge over road*** 2,654 ***ft^3/s***
Area of flow in bridge opening 303 ***ft^2***
Average velocity in bridge opening 8.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.2 ***ft/s***

Water-surface elevation at Approach section with bridge 491.3
Water-surface elevation at Approach section without bridge 489.7
Amount of backwater caused by bridge 1.6 ***ft***

500-year discharge 7,640 ***ft^3/s***
Water-surface elevation in bridge opening 489.2 ***ft***
Road overtopping? Y ***Discharge over road*** 4,994 ***ft^3/s***
Area of flow in bridge opening 303 ***ft^2***
Average velocity in bridge opening 8.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.6 ***/s***

Water-surface elevation at Approach section with bridge 492.1
Water-surface elevation at Approach section without bridge 490.5
Amount of backwater caused by bridge 1.6 ***ft***

Incipient overtopping discharge 2,280 ***ft^3/s***
Water-surface elevation in bridge opening 487.7 ***ft***
Area of flow in bridge opening 259 ***ft^2***
Average velocity in bridge opening 8.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.1 ***ft/s***

Water-surface elevation at Approach section with bridge 489.0
Water-surface elevation at Approach section without bridge 488.5
Amount of backwater caused by bridge 0.5 ***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 road-overflow discharge model was computed by use of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) . The 100- and 500-year discharge models resulted in submerged orifice flow with road overflow. 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, the Chang equation (Richardson and others, 1995, pp. 145-146) was applied to compute the contraction scour for the 100- and 500-year discharges. The results of Laursen's clear-water contraction scour were also computed for these discharges and can be found in appendix F. All of the models resulted in a computed contraction scour of 0.0 ft.

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	1.5	1.9	2.3
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	10.1	11.0	10.1
Right abutment	15.1	14.4	14.1
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	1.4	1.5	1.5
Right abutment	1.4	1.5	1.5
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

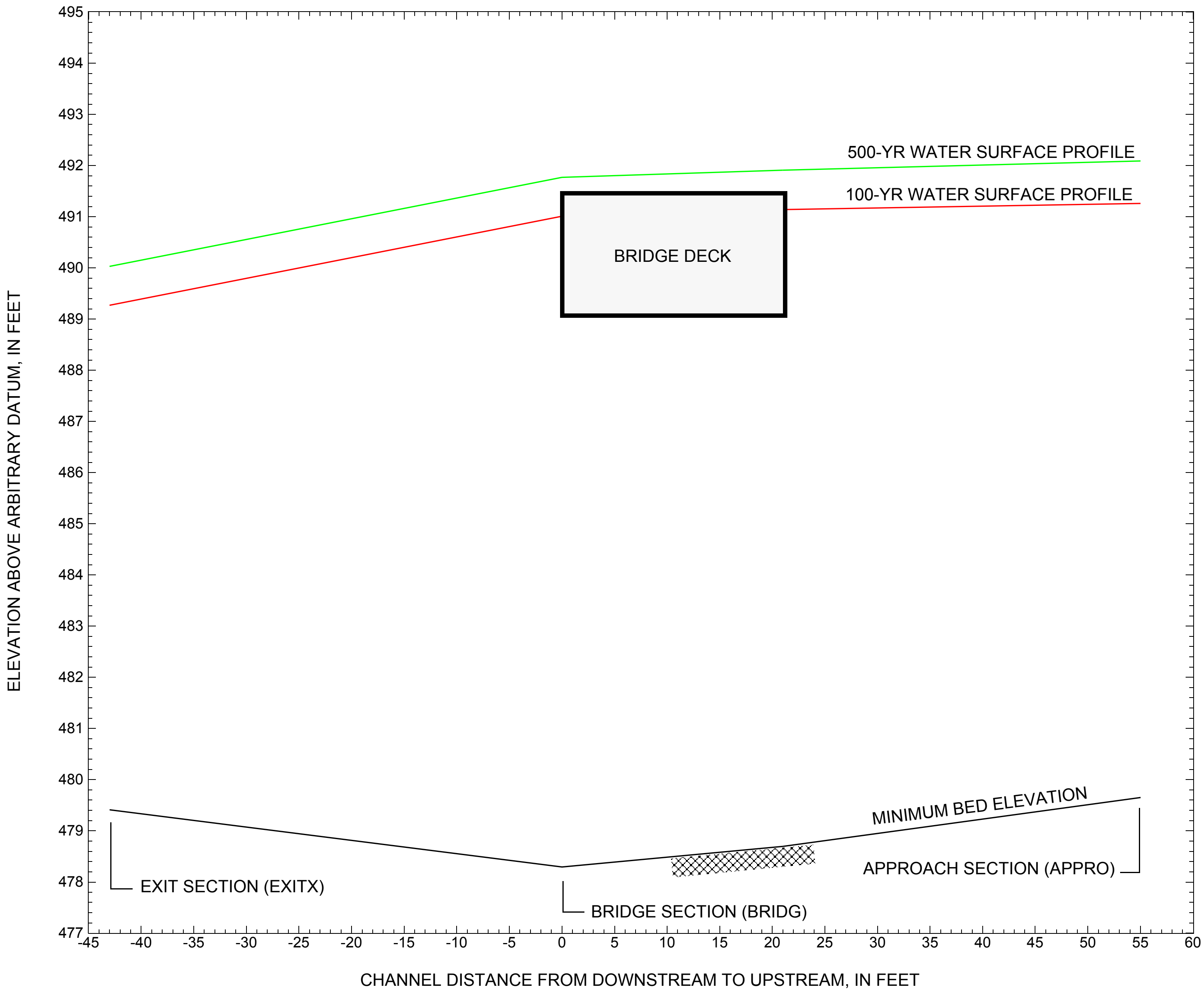

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure CHESTH00090063 on Town Highway 9, crossing the Williams River, Chester, Vermont.

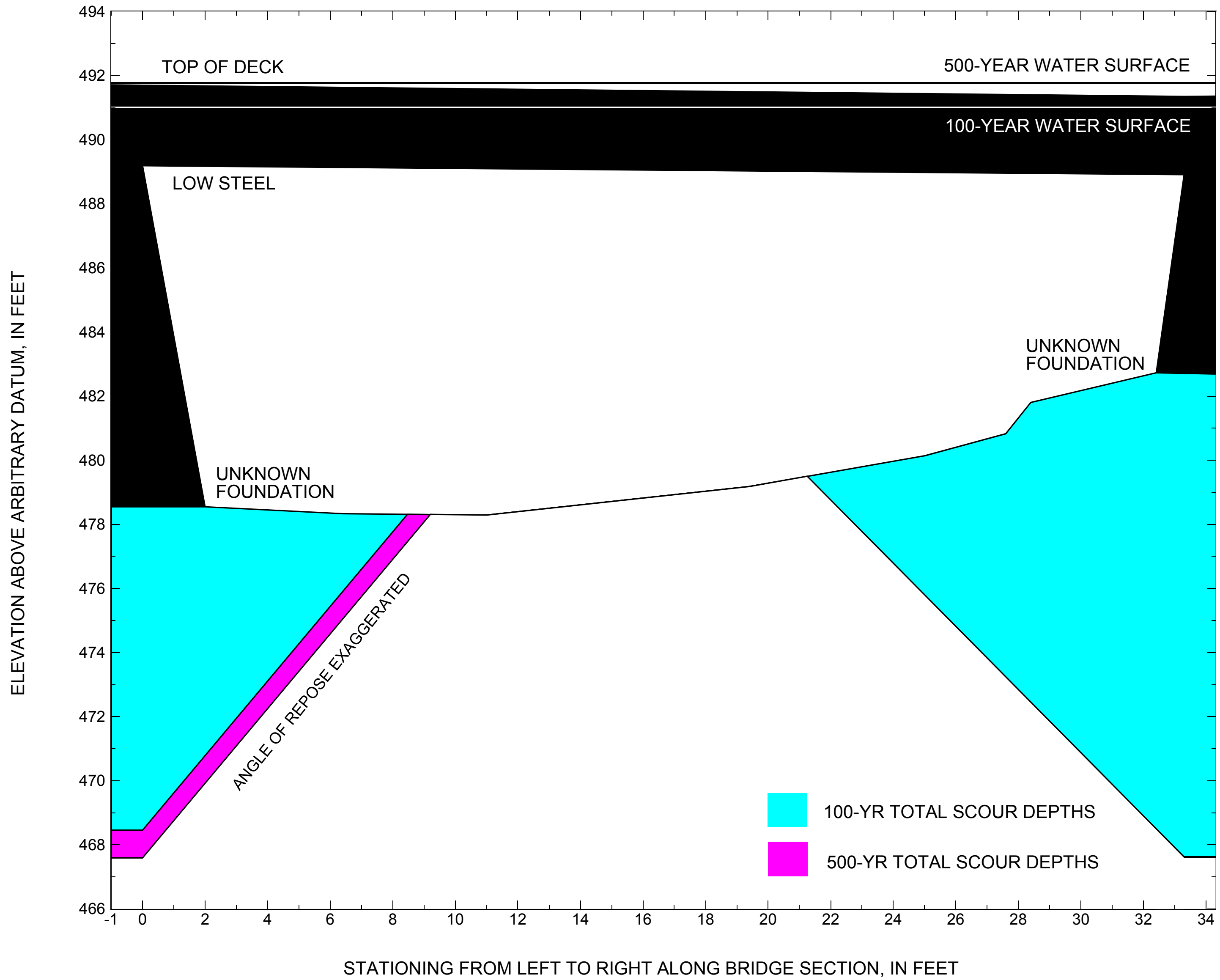

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure CHESTH00090063 on Town Highway 9, crossing the Williams River, Chester, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure CHESTH00090063 on Town Highway 9, crossing the Williams River, Chester, 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 5,210 cubic-feet per second											
Left abutment	0.0	--	489.2	--	478.6	0.0	10.1	--	10.1	468.5	--
Right abutment	33.3	--	488.9	--	482.7	0.0	15.1	--	15.1	467.6	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure CHESTH00090063 on Town Highway 9, crossing the Williams River, Chester, 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 7,640 cubic-feet per second											
Left abutment	0.0	--	489.2	--	478.6	0.0	11.0	--	11.0	467.6	--
Right abutment	33.3	--	488.9	--	482.7	0.0	14.4	--	14.4	468.3	--

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, 1972, Chester, 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 ches063.wsp
T2        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
T3        Bridge #63 over the Williams River in Chester, VT.  RHF
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           5210.0   7640.0   2280.0
SK          0.0054   0.0054   0.0054
*
XS   EXITX    -43           0.
GR         -229.7, 518.86   -223.3, 510.97    -83.2, 493.31    -47.4, 491.62
GR          -25.1, 491.35    -12.1, 488.58     -9.4, 485.22     -4.1, 482.05
GR            0.0, 480.81      2.8, 479.52     14.7, 479.73     15.8, 479.41
GR           19.7, 480.19     20.4, 480.82     23.2, 481.58
GR           28.3, 484.16     32.9, 485.94     43.2, 486.94    348.7, 487.75
GR          354.8, 489.33    395.2, 491.03    521.8, 494.81    683.6, 501.47
*
N           0.037        0.055        0.035
SA                 -25.1         43.2
*
*
XS   FULLV      0
*
*              SRD     LSEL    XSSKEW
BR   BRIDG     0    489.05      0.0
GR            0.0, 489.19      1.8, 480.80      2.0, 478.55      6.4, 478.33
GR           11.0, 478.29     19.4, 479.18     25.0, 480.14     27.6, 480.83
GR           28.4, 481.80     32.4, 482.73     33.3, 488.91      0.0, 489.19
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD          1      28.9 * *      44.4      5.6
N           0.035
*
*              SRD    EMBWID   IPAVE
XR   RDWAY     11      14.7     1
GR         -164.3, 501.81   -131.5, 498.29    -67.7, 493.28    -22.2, 491.89
GR           -4.9, 491.60      0.0, 491.70     32.1, 491.35     53.9, 490.74
GR          130.9, 488.88    257.9, 489.00    336.2, 490.45    368.2, 490.60
GR          391.2, 491.44    459.6, 493.89    556.1, 496.77    662.7, 501.59
*
*
XT   APTEM     60
GR         -196.9, 506.93   -185.0, 500.04   -163.1, 495.00    -50.1, 492.00
GR          -18.0, 490.51    -13.2, 489.02     -7.5, 484.98     -3.9, 482.64
GR            0.0, 480.85      0.8, 480.48      5.2, 479.67     13.5, 480.06
GR           23.9, 480.12     27.4, 480.86     30.4, 482.02     37.4, 484.82
GR           42.2, 487.07    287.4, 487.99    297.3, 492.23    432.3, 492.57
GR          642.4, 501.37
*
AS   APPRO     55 * * * 0.0037
GT
N           0.042        0.045        0.032
SA                 -18.0         42.2
*
HP 1 BRIDG   489.19 1 489.19
HP 2 BRIDG   489.19 * * 2591
HP 2 RDWAY   491.01 * * 2654
HP 1 APPRO   491.26 1 491.26
HP 2 APPRO   491.26 * * 5210
*
HP 1 BRIDG   489.19 1 489.19
HP 2 BRIDG   489.19 * * 2665
HP 2 RDWAY   491.77 * * 4994
HP 1 APPRO   492.09 1 492.09
HP 2 APPRO   492.09 * * 7640
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APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V090192            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     303.   30937.     0.    82.                           0.
   489.19          303.   30937.     0.    82.  1.00     0.    33.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       489.19     0.0    33.3   303.0   30937.    2591.   8.55

X STA.         0.0        3.6        5.2        6.5        7.8        9.0
  A(I)             26.9       16.7       14.5       13.6       13.4
  V(I)             4.82       7.77       8.95       9.53       9.66

X STA.         9.0       10.2       11.4       12.6       13.8       15.0
  A(I)             12.9       12.7       12.7       12.8       12.6
  V(I)            10.07      10.18      10.23      10.12      10.26

X STA.        15.0       16.3       17.5       18.9       20.2       21.7
  A(I)             12.8       13.0       13.2       13.1       13.9
  V(I)            10.13       9.95       9.79       9.86       9.31

X STA.        21.7       23.2       24.8       26.7       29.0       33.3
  A(I)             14.3       14.9       15.7       18.2       25.1
  V(I)             9.08       8.70       8.24       7.12       5.16


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      11.

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.01    44.3   379.4   475.0   25513.    2654.   5.59

X STA.        44.3       99.5      116.3      128.2      138.1      147.9
  A(I)             38.8       26.4       23.0       20.9       20.6
  V(I)             3.42       5.03       5.77       6.34       6.43

X STA.       147.9      157.2      166.6      175.9      185.3      194.8
  A(I)             19.7       19.7       19.4       19.7       19.6
  V(I)             6.73       6.72       6.86       6.73       6.76

X STA.       194.8      204.3      214.1      223.9      234.0      244.4
  A(I)             19.6       20.1       20.0       20.6       21.2
  V(I)             6.77       6.59       6.64       6.45       6.25

X STA.       244.4      255.3      267.2      282.2      304.4      379.4
  A(I)             21.9       23.1       25.5       30.2       45.0
  V(I)             6.05       5.75       5.20       4.40       2.95


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1       6.     119.    17.    17.                          22.
             2     512.   67710.    60.    64.                        8485.
             3     932.  103314.   253.   254.                       10149.
   491.26         1451.  171143.   330.   334.  1.03   -35.   295.  17020.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.26   -34.6   295.1  1450.6  171143.    5210.   3.59

X STA.       -34.6       -0.2        5.6       10.5       15.4       20.3
  A(I)             99.7       64.6       56.9       55.0       54.8
  V(I)             2.61       4.03       4.58       4.74       4.75

X STA.        20.3       25.3       31.1       43.6       60.6       78.1
  A(I)             55.2       58.1       80.3       70.9       72.0
  V(I)             4.72       4.49       3.25       3.67       3.62

X STA.        78.1       96.0      114.5      133.6      153.6      173.8
  A(I)             72.4       73.4       74.4       76.8       75.8
  V(I)             3.60       3.55       3.50       3.39       3.44

X STA.       173.8      195.3      217.1      239.8      263.7      295.1
  A(I)             79.1       78.0       79.8       81.9       91.5
  V(I)             3.29       3.34       3.26       3.18       2.85
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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V090192              MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     303.  30937.     0.    82.                            0.
   489.19          303.  30937.     0.    82.  1.00     0.    33.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       489.19     0.0    33.3   303.0   30937.    2665.   8.80

X STA.        0.0        3.6        5.2        6.5        7.8        9.0
  A(I)            26.9       16.7       14.5       13.6       13.4
  V(I)            4.96       7.99       9.21       9.80       9.94

X STA.        9.0       10.2       11.4       12.6       13.8       15.0
  A(I)            12.9       12.7       12.7       12.8       12.6
  V(I)           10.35      10.47      10.52      10.41      10.55

X STA.       15.0       16.3       17.5       18.9       20.2       21.7
  A(I)            12.8       13.0       13.2       13.1       13.9
  V(I)           10.41      10.24      10.07      10.14       9.57

X STA.       21.7       23.2       24.8       26.7       29.0       33.3
  A(I)            14.3       14.9       15.7       18.2       25.1
  V(I)            9.34       8.95       8.48       7.32       5.30


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      11.

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.77   -15.0   400.4   754.2   51190.    4994.   6.62

X STA.      -15.0       82.4      103.3      118.2      130.4      141.5
  A(I)            64.3       41.2       35.8       33.3       31.9
  V(I)            3.89       6.06       6.97       7.49       7.82

X STA.      141.5      152.2      163.2      174.1      185.2      196.3
  A(I)            30.8       31.6       31.0       31.6       31.5
  V(I)            8.11       7.90       8.05       7.90       7.93

X STA.      196.3      207.5      219.0      230.4      242.2      254.5
  A(I)            31.4       32.3       32.1       33.0       34.1
  V(I)            7.95       7.73       7.79       7.56       7.32

X STA.      254.5      267.6      283.2      302.2      331.9      400.4
  A(I)            35.4       38.2       40.4       49.7       64.5
  V(I)            7.06       6.54       6.18       5.03       3.87


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      28.     818.    36.    36.                          137.
             2     562.   79066.    60.    64.                         9756.
             3    1142.  144317.   255.   256.                        13727.
   492.09         1733.  224201.   351.   356.  1.03    -54.   297.  21518.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.09   -54.2   297.0  1732.5  224201.    7640.   4.41

X STA.      -54.2       -0.5        5.9       11.7       17.4       23.0
  A(I)           133.0       76.4       71.0       68.7       66.9
  V(I)            2.87       5.00       5.38       5.56       5.71

X STA.       23.0       29.0       39.1       56.4       73.5       90.5
  A(I)            69.7       86.8       88.8       84.5       83.5
  V(I)            5.48       4.40       4.30       4.52       4.58

X STA.       90.5      108.0      126.1      144.6      163.4      182.5
  A(I)            84.3       85.8       87.2       86.8       86.6
  V(I)            4.53       4.45       4.38       4.40       4.41

X STA.      182.5      202.6      223.4      244.4      266.4      297.0
  A(I)            90.1       91.3       90.8       93.2      107.3
  V(I)            4.24       4.19       4.20       4.10       3.56
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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V090192            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      259.   35126.    33.    46.                       4130.
   487.72           259.   35126.    33.    46.  1.00     0.    33.   4130.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       487.72     0.3    33.1   259.0   35126.    2280.   8.80

X STA.         0.3        4.1        5.6        7.0        8.3        9.4
  A(I)             25.9       14.5       12.9       11.9       11.1
  V(I)             4.41       7.88       8.86       9.56      10.29

X STA.         9.4       10.6       11.7       12.8       14.0       15.1
  A(I)             10.9       10.6       10.3       10.5       10.3
  V(I)            10.50      10.72      11.02      10.91      11.05

X STA.        15.1       16.3       17.5       18.7       20.0       21.4
  A(I)             10.5       10.6       10.8       10.7       11.4
  V(I)            10.90      10.71      10.54      10.61      10.02

X STA.        21.4       22.8       24.4       26.2       28.5       33.1
  A(I)             11.7       12.5       13.3       15.6       23.1
  V(I)             9.78       9.13       8.59       7.30       4.93


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2      379.   43233.    55.    59.                       5625.
             3      361.   21630.   248.   248.                       2476.
   488.98           740.   64863.   303.   307.  1.29   -13.   290.   5790.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

         WSEL     LEW     REW    AREA        K        Q    VEL
       488.98   -13.2   289.8   740.2   64863.    2280.   3.08

X STA.       -13.2       -1.6        2.1        4.9        7.7       10.3
  A(I)             45.8       30.1       26.0       25.3       24.2
  V(I)             2.49       3.79       4.38       4.51       4.71

X STA.        10.3       13.0       15.7       18.4       21.1       23.8
  A(I)             24.2       24.1       23.7       24.2       24.2
  V(I)             4.70       4.73       4.81       4.71       4.71

X STA.        23.8       26.7       30.4       36.2       58.4       85.2
  A(I)             25.2       28.1       33.8       50.5       48.8
  V(I)             4.52       4.06       3.37       2.26       2.33

X STA.        85.2      114.2      146.8      184.5      229.5      289.8
  A(I)             49.6       52.2       55.2       59.0       65.9
  V(I)             2.30       2.18       2.07       1.93       1.73
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        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20

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

EXITX:XS   ******   -15.     959.  0.49 *****  489.76  488.76   5210.  489.27
      -43. ******   355.   70897.  1.07 ***** *******    0.61    5.43

FULLV:FV      43.   -17.    1072.  0.38  0.20  489.95 *******   5210.  489.57
        0.    43.   361.   83270.  1.04  0.00    0.00    0.52    4.86
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      55.   -15.     958.  0.52  0.20  490.22 *******   5210.  489.69
       55.    55.   291.   91729.  1.14  0.07    0.00    0.58    5.44
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   489.57     489.05

            <<<<<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      43.     0.     303.  1.14 *****  490.33  485.53   2591.  489.19
        0. ******    33.   30937.  1.00 ***** *******    0.50    8.55

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  489.05 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.    40.  0.04  0.21  491.43    0.01   2654.  491.01

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.    77.   -62.    15.   1.6   1.0   6.3   7.8   1.9   3.1
   RT:  2654.   335.    44.   379.   2.1   1.4   6.5   5.6   1.8   3.2

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

APPRO:AS      26.   -35.    1452.  0.21  0.12  491.47  488.98   5210.  491.26
       55.    44.   295.  171391.  1.03  0.00    0.01    0.31    3.59

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

                      <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V090192             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -43.   -15.   355.   5210.   70897.     959.    5.43  489.27
   FULLV:FV       0.   -17.   361.   5210.   83270.    1072.    4.86  489.57
   BRIDG:BR       0.     0.    33.   2591.   30937.     303.    8.55  489.19
   RDWAY:RG      11.*******     0.   2654.       0.*********    1.00  491.01
   APPRO:AS      55.   -35.   295.   5210.  171391.    1452.    3.59  491.26

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS  **********************
1
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V090192             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20
 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS     488.76    0.61  479.41  518.86************  0.49  489.76  489.27
   FULLV:FV   ********    0.52  479.41  518.86  0.20  0.00  0.38  489.95  489.57
   BRIDG:BR     485.53    0.50  478.29  489.19************  1.14  490.33  489.19
   RDWAY:RG   ****************  488.88  501.81  0.04******  0.21  491.43  491.01
   APPRO:AS     488.98    0.31  479.65  506.91  0.12  0.00  0.21  491.47  491.26
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20

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

 EXITX:XS   ******   -19.    1247.  0.59 *****  490.62  489.23   7640.  490.03
      -43. ******   371.  103894.  1.01 ***** *******    0.61    6.12

 FULLV:FV      43.   -20.    1370.  0.49  0.20  490.82 *******   7640.  490.34
         0.    43.   379.  119272.  1.01  0.00    0.00    0.53    5.58
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS      55.   -18.    1194.  0.67  0.21  491.13 *******   7640.  490.46
        55.    55.   293.  126554.  1.05  0.09    0.00    0.59    6.40
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   490.34     489.05

             <<<<<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      43.     0.     303.  1.20 *****  490.39  485.66   2665.  489.19
         0. ******    33.   30937.  1.00 ***** *******    0.51    8.80

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****    6.  0.800  0.000  489.05 ****** ****** ******

     XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      11.    40.  0.05  0.31  492.35    0.00   4994.  491.77

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
    LT:     54.    30.   -15.    15.   0.2   0.1   3.8  14.2   0.7   3.0
    RT:   4940.   385.    15.   400.   2.9   1.9   7.6   6.6   2.5   3.2

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

 APPRO:AS      26.   -54.    1731.  0.31  0.18  492.40  489.57   7640.  492.09
        55.    48.   297.  223908.  1.03  0.00    0.00    0.36    4.41

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

                      <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20
   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXITX:XS     -43.   -19.   371.   7640.  103894.    1247.    6.12  490.03
    FULLV:FV       0.   -20.   379.   7640.  119272.    1370.    5.58  490.34
    BRIDG:BR       0.     0.    33.   2665.   30937.     303.    8.80  489.19
    RDWAY:RG      11.*******    54.   4994.       0.*********    1.00  491.77
    APPRO:AS      55.   -54.   297.   7640.  223908.    1731.    4.41  492.09

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS  **********************
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20
  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
    EXITX:XS    489.23    0.61  479.41  518.86************  0.59  490.62  490.03
    FULLV:FV  ********    0.53  479.41  518.86  0.20  0.00  0.49  490.82  490.34
    BRIDG:BR    485.66    0.51  478.29  489.19************  1.20  490.39  489.19
    RDWAY:RG  ****************  488.88  501.81  0.05******  0.31  492.35  491.77
    APPRO:AS    489.57    0.36  479.65  506.91  0.18  0.00  0.31  492.40  492.09
```
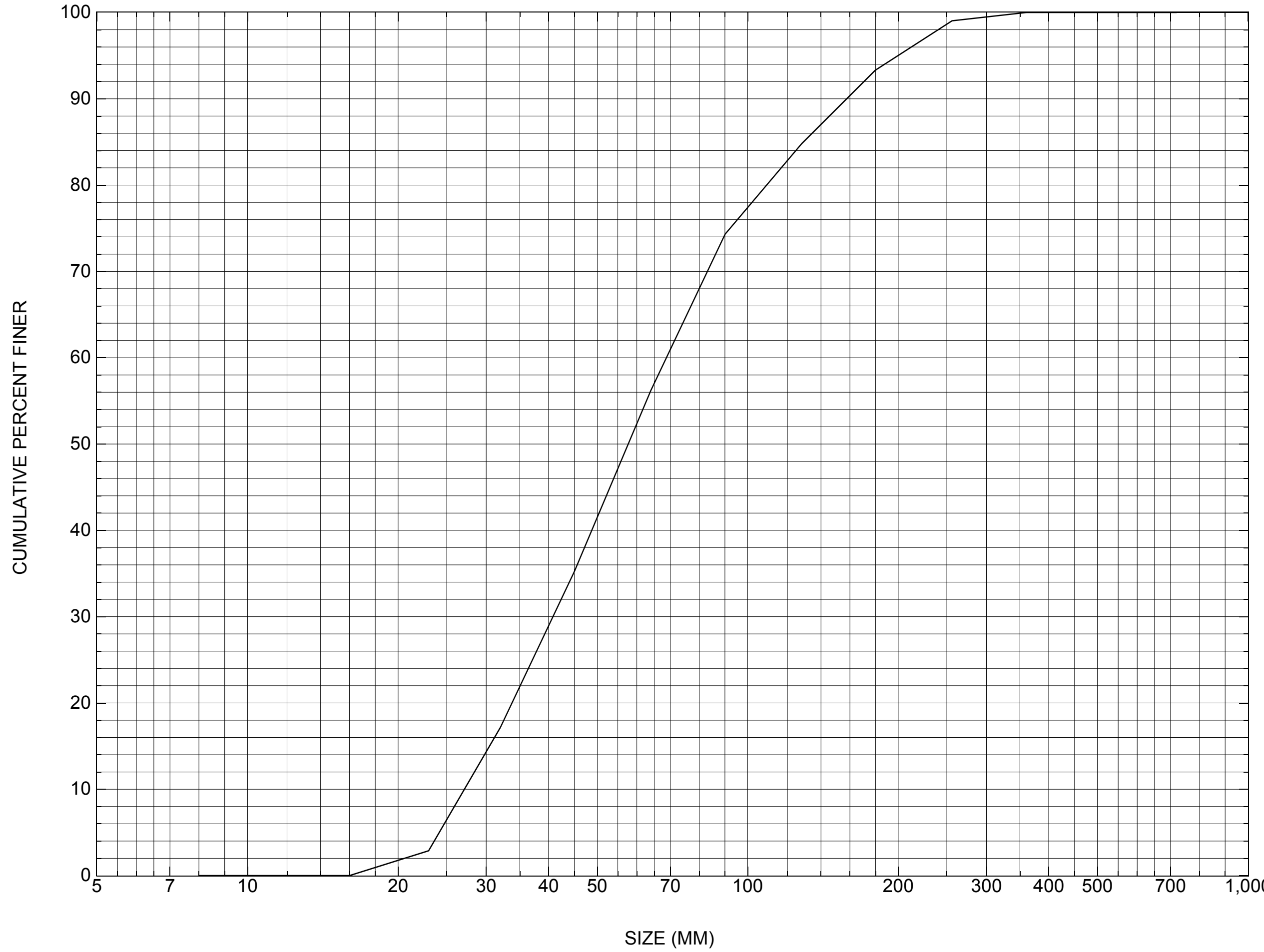

```
        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20

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

 EXITX:XS   ******   -12.     513.  0.43 *****  488.48  485.97   2280.  488.05
      -43. ******   350.   31018.  1.41 ***** *******    0.78    4.45

 FULLV:FV      43.   -12.     635.  0.26  0.18  488.64 *******   2280.  488.38
         0.    43.   351.   40084.  1.29  0.00   -0.02    0.54    3.59
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS      55.   -12.     591.  0.32  0.14  488.81 *******   2280.  488.49
        55.    55.   289.   49471.  1.40  0.03   -0.01    0.57    3.86
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   488.98       0.00     487.72     488.88

  ===260 ATTEMPTING FLOW CLASS 4 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      43.     0.     259.  1.25  0.21  488.97  485.06   2280.  487.72
         0.    43.    33.   35108.  1.04  0.28    0.00    0.56    8.80

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.983 ******  489.05 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.        <<<<<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      26.   -13.     739.  0.19  0.08  489.17  485.51   2280.  488.98
        55.    35.   290.   64698.  1.29  0.12    0.01    0.40    3.09

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.890  0.461   34723.     5.    37. ********

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20
   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -43.   -12.   350.   2280.   31018.     513.    4.45  488.05
   FULLV:FV       0.   -12.   351.   2280.   40084.     635.    3.59  488.38
   BRIDG:BR       0.     0.    33.   2280.   35108.     259.    8.80  487.72
   RDWAY:RG      11.**************      0.       0.       0.    1.00********
   APPRO:AS      55.   -13.   290.   2280.   64698.     739.    3.09  488.98

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       5.    37.   34723.
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches063.wsp
        Hydraulic analysis for structure CHESTH00090063   Date: 19-FEB-97
        Bridge #63 over the Williams River in Chester, VT.  RHF
           *** RUN DATE & TIME: 03-17-97  07:20
  SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    485.97    0.78  479.41  518.86************  0.43  488.48  488.05
   FULLV:FV  ********    0.54  479.41  518.86  0.18  0.00  0.26  488.64  488.38
   BRIDG:BR    485.06    0.56  478.29  489.19  0.21  0.28  1.25  488.97  487.72
   RDWAY:RG  ****************  488.88  501.81  0.05******  0.19  489.11********
   APPRO:AS    485.51    0.40  479.65  506.91  0.08  0.12  0.19  489.17  488.98
   ER
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure CHESTH00090063, in Chester, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number CHESTH00090063

General Location Descriptive

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

Date *(MM/DD/YY)* 04 / 06 / 95

Highway District Number *(I - 2; nn)* 02

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

Town *(FIPS place code; I - 4; nnnnn)* 13600

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

Waterway *(I - 6)* WILLIAMS RIVER

Road Name *(I - 7)*: -

Route Number TH009

Vicinity *(I - 9)* @ JCT OF CL2 TH9 & TH6

Topographic Map Chester

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 43161

Longitude *(i - 17; nnnnn.n)* 72351

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10140700631407

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

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

Year built *(I - 27; YYYY)* 1919

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

Average daily traffic, ADT *(I - 29; nnnnnn)* 000150

Deck Width *(I - 52; nn.n)* 147

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

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

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

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

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

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

Structure type *(I - 43; nnn)* 302

Year Reconstructed *(I - 106)* 1989

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*) 9.0

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

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

Comments:

The structural inspection report of 09/23/95 indicates that the structure is a steel beam type bridge with a timber deck. The right abutment is a laid up concrete block wall with a thin concrete bearing cap. There is good stone fill along the banks at both ends of the abutment which acts as a retaining wall. The left abutment is a solid concrete wall with minor rust stains due to the structural steel above. There is some minor spalling at the bottom downstream end of the left abutment wall. The top of the right wingwall has a horizontal crack with some spalling along it. The waterway passes straight through the structure. The streambed consists of stone and gravel. The footing is not exposed along the left abutment.

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: -

Terrain character: -

Stream character & type: -

Streambed material: -

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

Q_{50} - Q_{100} - Q_{500} -

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft^3/ sec*): -

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

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

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

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

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

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

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

Comments:

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **23.99** mi^2 Lake and pond area **0.08** mi^2

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

Bridge site elevation **580** ft Headwater elevation **2882** ft

Main channel length **14.55** mi

10% channel length elevation **620** ft 85% channel length elevation **1580** ft

Main channel slope *(S)* **87.97** 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: RB Date: 10/15/96

Computerized by: RB Date: 10/30/96

Reviewd by: RF Date: 03/25/97

Structure Number CHESTH00090063

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. HAMMOND Date *(MM/DD/YY)* 09 / 18 / 1996
2. Highway District Number 02 Mile marker 0000
   County 027 WINDSOR Town 1360 CHESTER
   Waterway *(I - 6)* WILLIAMS RIVER Road Name -
   Route Number TH009 Hydrologic Unit Code: 01080107
3. Descriptive comments:
Located at the junction of CL2 TH9 and TH6, also 0.1 miles from the junction of TH6, Green Mountain Road, with VT 103.

B. Bridge Deck Observations

4. Surface cover... LBUS 2 RBUS 4 LBDS 2 RBDS 4 Overall 4
*(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 35 *(feet)* Bridge width 14.7 *(feet)*

Road approach to bridge:

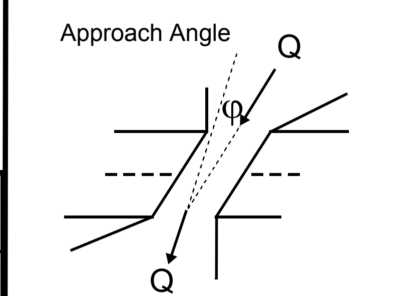
8. LB 2 RB 1 *(**0** even, **1-** lower, **2-** higher)*
9. LB 1 RB 1 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

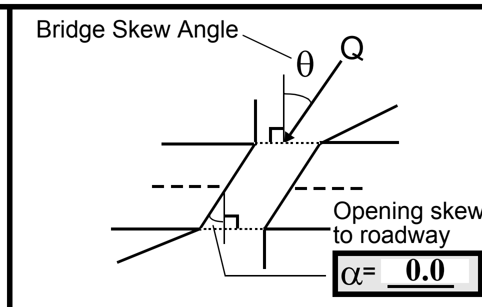
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	0	2	1
RBUS	0	0	2	1
RBDS	0	0	0	0
LBDS	1	3	2	2

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

Channel approach to bridge (BF):

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





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 110 feet US *(US, UB, DS)* to 5 feet DS
Channel impact zone 2: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 2
Range? 90 feet DS *(US, UB, DS)* to 400 feet DS

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

18. Bridge Type: 1a

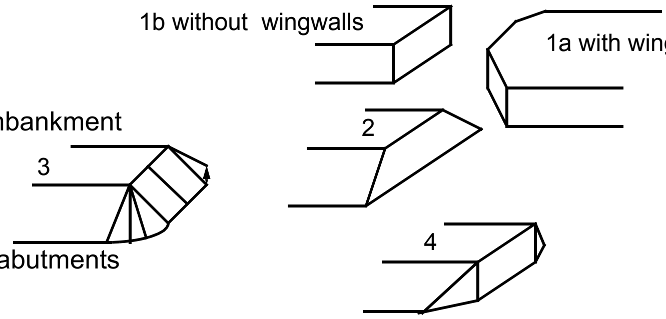
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

At 350 ft. DS, the channel makes a 90 degree bend to the right where there is a severe impact.
4. The left bank has houses with lawns US and DS. The right bank is mowed grass fields both US and DS with some trees along the immediate bank.
7. Values are from the VTAOT files. Measured bridge length is 45.2 ft., span length is 33 ft., and bridge width is 14.5 ft.

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	6.5			5.0	2	2	7	7	1	1

23. Bank width 35.0   24. Channel width 25.0   25. Thalweg depth 60.0   29. Bed Material 342

30 .Bank protection type: LB 2 RB 3   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.):

30. Protection on the right bank extends from 50 ft US to 88 ft US and then from 175 ft US to 285 ft US. The left bank protection exists from 50 ft US to 75 ft US, from 100 ft US to 160 ft US, and from 210 ft US to 300 ft US.
The DS corner of the Grist Mill Gallery building is 273 ft. US.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **100** 35. Mid-bar width: **10**

36. Point bar extent: **115** feet **US** *(US, UB)* to **55** feet **US** *(US, UB, DS)* positioned **80** %LB to **100** %RB

37. Material: **342**

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

Another channel bar exists from 260 ft. US to 170 ft. US. It is positioned from 10% LB to 50% RB. It is comprised of gravel and sand and is 25 ft. wide with woody plants growing on it.

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: **160** 42. Cut bank extent: **170** feet **US** *(US, UB)* to **88** 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.):

-

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **5 DS**

47. Scour dimensions: Length **114.5** Width **20** Depth : **1.8** Position **0** %LB to **70** %RB

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

Scour is from 50 ft. US to 50 ft. DS.

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
34.5		1.0		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.):

3425

The left abutment and wingwalls are poured concrete. The right abutment is comprised of 3 ft. x 3 ft. x 3 ft. concrete blocks stacked and overlapping. The right abutment wingwalls are placed stone at a slope varying from 70 degree to 45 degrees. The wingwall stones are 3 ft. to 4 ft. long and 1 ft. to 2 ft. thick.

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

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

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

70. Debris and Ice Comments:

2

Trees are scarred along both banks.

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		10	75	2	3	1.8	0.7	90.0
RABUT	1	-	80			2	0	30.0

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

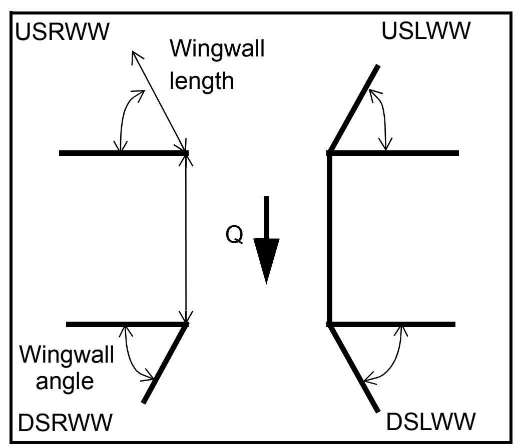
The DS end of the left abutment and wingwall are undermined. The maximum penetration is 0.8 ft. The left abutment is a poured concrete wall. The undermined base is on top of boulders and the undermining is where one stone is missing. The right abutment is stacked concrete blocks capped with poured concrete to form the bridge seat.

76. The exposure depth along the LABUT refers to the undermined depth from the bottom of the concrete wall to the streambed.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						30.0	
USRWW:	Y		1		1	2.5	
DSLWW:	0.1		-		Y	28.0	
DSRWW:	2		0		-	14.5	

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	-	3	Y	-	-	-	-	1
Condition	Y	1.75	2	-	-	-	-	1
Extent	1	0.7	0	0	0	0	3	-

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

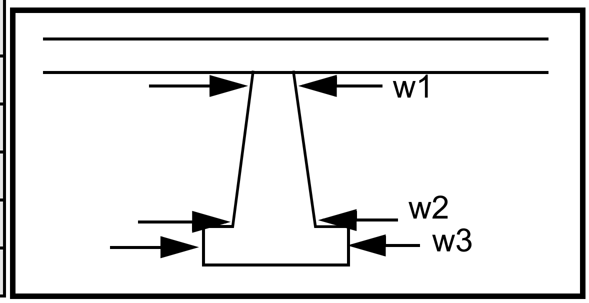
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
0
-
-
0
-
-

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1		**6.5**		**20.0**	**70.0**	**14.0**
Pier 2		**7.5**	**7.5**	**50.0**	**90.0**	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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):

NO PIERS

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

Point bar extent: ______ feet **1** (US, UB, DS) to **4** feet **453** (US, UB, DS) positioned **453** %LB to **1** %RB

Material: **2**

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

435
2
2
1

Is a cut-bank present? **2** *(Y or if N type ctrl-n cb)* Where? **The** *(LB or RB)* Mid-bank distance: **left**

Cut bank extent: **bank** feet **pro** *(US, UB, DS)* to **tec-** feet **tio** *(US, UB, DS)*

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

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

from the end of the wingwall at 18 ft DS to 115 ft DS. The right bank protection is slumped and extends from end of the wingwall at 8 ft DS to 25 ft DS.

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

Scour dimensions: Length ______ Width ______ Depth: _____ Positioned ____ %LB to ____ %RB

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

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

Confluence 1: Distance **NO** Enters on **DR** *(LB or RB)* Type **OP** *(**1**- perennial; **2**- ephemeral)*

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

Confluence comments (eg. confluence name):

RE

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)*:

Y
50
5
28
DS
90
DS
90
100
453

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: CHESTH00090063   Town: Chester
Road Number: TH009   County: Windsor
Stream: Williams River

Initials RHF   Date: 2/27/97   Checked: SAO

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	5210	7640	2280
Main Channel Area, ft2	512	562	379
Left overbank area, ft2	6	28	0
Right overbank area, ft2	932	1142	361
Top width main channel, ft	60	60	55
Top width L overbank, ft	17	36	0
Top width R overbank, ft	253	255	248
D50 of channel, ft	0.1892	0.1892	0.1892
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	8.5	9.4	6.9
y1, average depth, LOB, ft	0.4	0.8	ERR
y1, average depth, ROB, ft	3.7	4.5	1.5
Total conveyance, approach	171143	224201	64863
Conveyance, main channel	67710	79066	43233
Conveyance, LOB	119	818	0
Conveyance, ROB	103314	144317	21630
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	2061.3	2694.3	1519.7
Ql, discharge, LOB, cfs	3.6	27.9	0.0
Qr, discharge, ROB, cfs	3145.1	4917.8	760.3
Vm, mean velocity MC, ft/s	4.0	4.8	4.0
Vl, mean velocity, LOB, ft/s	0.6	1.0	ERR
Vr, mean velocity, ROB, ft/s	3.4	4.3	2.1
Vc-m, crit. velocity, MC, ft/s	9.2	9.3	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

ARMORING

D90	0.5172	0.5172	0.5172
D95	0.6544	0.6544	0.6544
Critical grain size,Dc, ft	0.2558	0.2707	0.2860
Decimal-percent coarser than Dc	0.3333	0.3033	0.2741
Depth to armoring,ft	1.54	1.87	2.27

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	512	562	379
Main channel width, ft	60	60	55
y1, main channel depth, ft	8.53	9.37	6.89
Bridge Section			
(Q) total discharge, cfs	5210	7640	2280
(Q) discharge thru bridge, cfs	2591	2665	2280
Main channel conveyance	30937	30937	35126
Total conveyance	30937	30937	35126
Q2, bridge MC discharge,cfs	2591	2665	2280
Main channel area, ft2	303	303	259
Main channel width (skewed), ft	33.3	33.3	32.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	33.3	33.3	32.8
y_bridge (avg. depth at br.), ft	9.10	9.10	7.90
Dm, median (1.25*D50), ft	0.2365	0.2365	0.2365
y2, depth in contraction,ft	7.81	8.00	7.09
ys, scour depth (y2-ybridge), ft	-1.29	-1.10	-0.81

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)
(Richarson and others, 1995, p. 145-146)

	Q100	Q500	OtherQ
Q, total, cfs	5210	7640	2280
Q, thru bridge, cfs	2591	2665	2280
Total Conveyance, bridge	30937	30937	35126
Main channel(MC) conveyance, bridge	30937	30937	35126
Q, thru bridge MC, cfs	2591	2665	2280
Vc, critical velocity, ft/s	9.20	9.34	8.88
Vc, critical velocity, m/s	2.80	2.85	2.71
Main channel width (skewed), ft	33.3	33.3	32.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	33.3	33.3	32.8
qbr, unit discharge, ft2/s	77.8	80.0	69.5
qbr, unit discharge, m2/s	7.2	7.4	6.5

Area of full opening, ft2	303.0	303.0	259.0
Hb, depth of full opening, ft	9.10	9.10	7.90
Hb, depth of full opening, m	2.77	2.77	2.41
Fr, Froude number, bridge MC	0.50	0.51	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
Elevation of Low Steel, ft	489.05	489.05	0
Elevation of Bed, ft	479.95	479.95	-7.90
Elevation of Approach, ft	491.26	492.09	0
Friction loss, approach, ft	0.12	0.18	0
Elevation of WS immediately US, ft	491.14	491.91	0.00
ya, depth immediately US, ft	11.19	11.96	7.90
ya, depth immediately US, m	3.41	3.64	2.41
Mean elevation of deck, ft	491.53	491.53	0
w, depth of overflow, ft (>=0)	0.00	0.38	0.00
Cc, vert contrac correction (<=1.0)	0.95	0.94	1.00
Ys, depth of scour, ft	-0.19	0.01	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	5210	7640	2280	5210	7640	2280
a’, abut.length blocking flow, ft	34.6	54.2	13.5	41.5	7.1	256.7
Ae, area of blocked flow ft2	101.9	129.1	61.3	195.5	56.5	399.3
Qe, discharge blocked abut.,cfs	269.5	--	172.5	686.5	248.1	858.9
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.64	2.96	2.81	3.51	4.39	2.15
ya, depth of f/p flow, ft	2.95	2.38	4.54	4.71	7.96	1.56
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.272	0.326	0.233	0.285	0.274	0.304
ys, scour depth, ft	10.09	10.96	10.09	15.11	14.36	14.14

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)	34.6	54.2	13.5	41.5	7.1	256.7
y1 (depth f/p flow, ft)	2.95	2.38	4.54	4.71	7.96	1.56
a’/y1	11.75	22.75	2.97	8.81	0.89	165.03
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.27	0.33	0.23	0.29	0.27	0.30
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	7.64
vertical w/ ww’s	ERR	ERR	ERR	ERR	ERR	6.26

spill-through	ERR	ERR	ERR	ERR	ERR	4.20

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	Q100	Q500	Qother
Fr, Froude Number	0.50	0.51	0.56	0.50	0.51	0.56
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	9.10	9.10	7.90	9.10	9.10	7.90
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.41	1.46	1.53	1.41	1.46	1.53
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr<=0.8 (spillthrough abut.)	1.23	1.28	1.34	1.23	1.28	1.34
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR