LEVEL II SCOUR ANALYSIS FOR BRIDGE 13 (CHESTH00060013) on TOWN HIGHWAY 6, crossing the WILLIAMS RIVER, CHESTER, VERMONT

Open-File Report 98-403

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

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By MICHAEL A. IVANOFF AND LAURA MEDALIE

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Pembroke, New Hampshire

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

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 13 (CHESTH00060013) ON TOWN HIGHWAY 6, CROSSING THE WILLIAMS RIVER, CHESTER, VERMONT

By **Michael A. Ivanoff and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure CHESTH00060013 on Town Highway 6 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 (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the New England Upland section of the New England physiographic province in south eastern Vermont. The 80.6-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture on the right bank downstream of the bridge while the immediate banks have dense woody vegetation. There are row crops along the left bank. The right bank upstream of the bridge is forested.

In the study area, the Williams River has a sinuous channel with a slope of approximately 0.008 ft/ft, an average channel top width of 129 ft and an average bank height of 8 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 97.4 mm (0.320 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 19, 1996, indicated that the reach was stable.

The Town Highway 6 crossing of the Williams River is a 82-ft-long, one-lane bridge consisting of one 78-foot steel-beam span (Vermont Agency of Transportation, written communication, April 5, 1995). The opening length of the structure parallel to the bridge face is 75.7 ft. The bridge is supported by vertical, concrete abutments. The channel is skewed approximately zero degrees to the opening while the opening-skew-to-roadway is also zero degrees.

A scour hole 2.0 ft deeper than the mean thalweg depth was observed along the right abutment during the Level I assessment. The scour protection counter measures at the site included type-2 stone fill (less than 36 inches diameter) at the upstream and downstream ends of the right abutment, along the upstream left bank, and along the downstream left and right banks and type-4 stone fill (less than 60 inches diameter) along the upstream right bank. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 0.9 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge. Abutment scour ranged from 4.9 to 26.8 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in
tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Saxtons River, VT. Quadrangle, 1:25,000, 1984

NORTH

Figure 1. Location of study area on USGS 1:25,000 scale map.

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

LEVEL II SUMMARY

Structure Number CHESTH00060013 ***Stream*** Williams River

County Windsor ***Road*** TH 6 ***District*** 2

Description of Bridge

Bridge length 82 ***ft*** ***Bridge width*** 12.8 ***ft*** ***Max span length*** 78 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 8/19/96

Description of stone fill Type-2, at the upstream and downstream ends of the right abutment.

Abutments are concrete. There is a two ft deep scour hole in front of the right abutment.

No

0

Is bridge skewed to flood flow according to a ' survey? No ***Angle*** There is a moderate channel bend in the upstream reach.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	8/19/96	0	0
Level II	8/19/96	0	0

Potential for debris Low.

Describe any features near or at the bridge that may affect flow (include observation date) None as of 8/19/96.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a flat narrow flood plain on the left bank.

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

Date of inspection 8/19/96

DS left: Steep channel bank to a narrow flood plain

DS right: Steep channel bank to the steep valley wall

US left: Steep channel bank to a narrow flood plain

US right: Steep channel bank to the steep valley wall

Description of the Channel

Average top width 129 ft ***Average depth*** 8 ft

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

Sinuous but stable, perennial with semi-alluvial channel boundaries.

8/19/96

Vegetative co Trees and brush on the bank with row crops on the flood plain

DS left: Trees and brush

DS right: Trees and brush on the bank with row crops on the flood plain

US left: Trees and brush

US right:

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

None as of 8/19/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 80.6 ***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***: None

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

USGS gage description Williams River at Brockways Mills, VT

USGS gage number 01153500

Gage drainage area 103 ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 12,000 ***ft³/s*** ***Q500*** 17,600 ***ft³/s***

The 100- and 500-year discharges are based on the hydrologic data for the Williams River above Hall Brook presented in the Flood Insurance Study for Chester, VT (Federal Emergency Management Agency, February 1982). The values used were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve was extended graphically to the 500-year event.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the right abutment (elev. 498.74 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the left abutment (elev. 496.11 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	-85	5	Exit section as surveyed for the Flood Insurance Study (February 1982)
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPRO	96	1	Approach section

[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 0.050 to 0.051, and overbank "n" values ranged from 0.040 to 0.070.

Normal depth at the exit section (EXITX) was based on a known water surface. The starting water surface was from the profile plot in the Flood Insurance Study for Chester, VT (Federal Emergency Management Agency, February 1982).

The approach section (APPRO) was surveyed one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

For the 500-year discharge, the roadway wier is submerged. The WSPRO bridge routines failed to find a solution which balanced the total discharge and energy at the APPRO section with the sum of the discharges and energy over the roadway and through the bridge opening. Therefore, the bridge deck was removed from the section, and the channel underneath the bridge was combined with the roadway cross-section to represent a full-valley cross-section at the bridge location.

Bridge Hydraulics Summary

Average bridge embankment elevation 498.1 ***ft***
Average low steel elevation 495.4 ***ft***

100-year discharge 12,000 ***ft³/s***
Water-surface elevation in bridge opening 491.1 ***ft***
Road overtopping? Yes ***Discharge over road*** 3,780 ***ft³/s***
Area of flow in bridge opening 902 ***ft²***
Average velocity in bridge opening 9.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.4 ***ft/s***

Water-surface elevation at Approach section with bridge 492.9
Water-surface elevation at Approach section without bridge 492.1
Amount of backwater caused by bridge 0.8 ***ft***

500-year discharge 17,600 ***ft³/s***
Water-surface elevation in bridge opening 494.5 ***ft***
Road overtopping? Yes ***Discharge over road*** 6,670 ***ft³/s***
Area of flow in bridge opening 1153 ***ft²***
Average velocity in bridge opening 9.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.2 ***/s***

Water-surface elevation at Approach section with bridge --
Water-surface elevation at Approach section without bridge --
Amount of backwater caused by bridge N/A ***ft***

Incipient overtopping discharge 10,000 ***ft³/s***
Water-surface elevation in bridge opening 488.7 ***ft***
Area of flow in bridge opening 724 ***ft²***
Average velocity in bridge opening 13.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 17.0 ***ft/s***

Water-surface elevation at Approach section with bridge 492.2
Water-surface elevation at Approach section without bridge 491.1
Amount of backwater caused by bridge 1.1 ***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 Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analyses for the 100- and 500-year discharges are presented in tables 1 and 2 and the scour depths are shown graphically in figure 8.

Contraction scour for the 100-year, 500-year, and incipient roadway-overtopping discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

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

Scour at the left abutment was computed by use of the HIRE equation (Richardson and Davis, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

Scour Results

Contraction scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	0.9
Depth to armoring	1.1	1.0	14.8
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	5.0	8.4	7.4
Right abutment	24.9	26.8	25.6
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	500-year discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	2.4	1.8	4.2
Right abutment	2.4	1.8	4.2
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

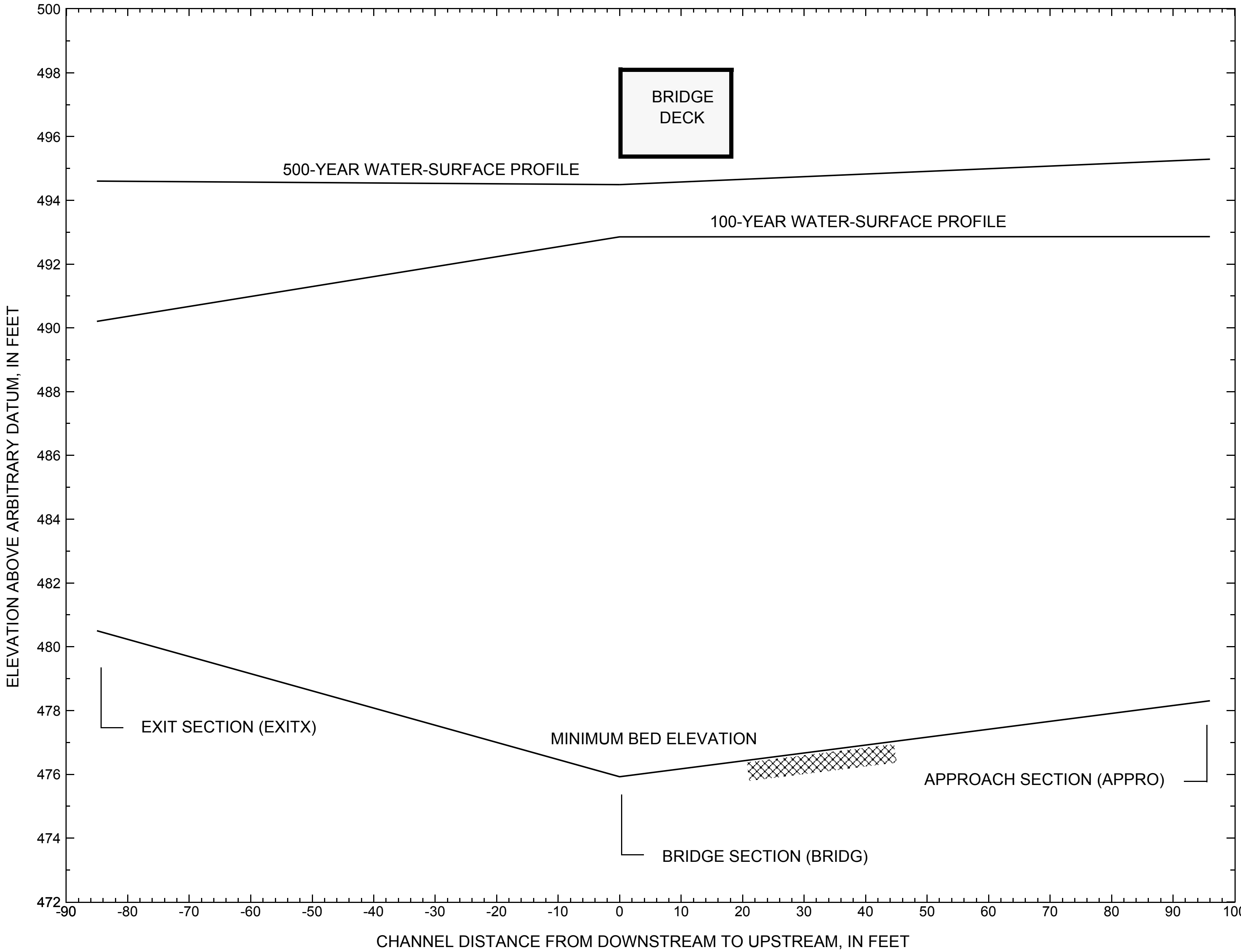

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure CHESTH00060013 on Town Highway 6, crossing the Williams River, Chester, Vermont.

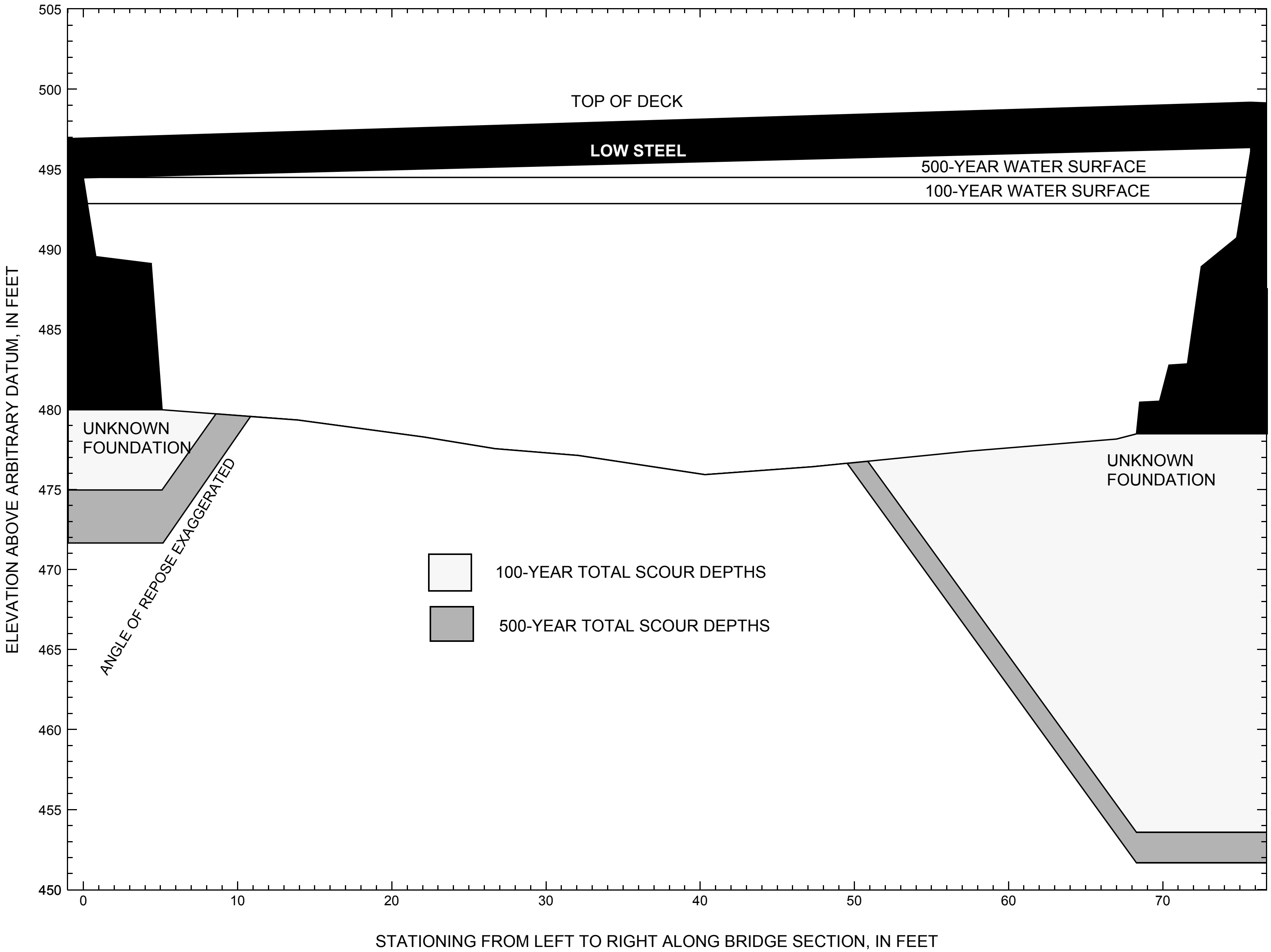

Figure 8. Scour elevations for the 100- and 500-year discharges at structure CHESTH00060013 on Town Highway 6, crossing the Williams River, Chester, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure CHESTH00060013 on Town Highway 6, 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/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-year discharge is 12,000 cubic-feet per second											
Left abutment	0.0	--	494.5	--	480.0	0.0	5.0	--	5.0	475.0	--
Right abutment	75.7	--	496.4	--	478.5	0.0	24.9	--	24.9	453.6	--

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 CHESTH00060013 on Town Highway 6, 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/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year discharge is 17,600 cubic-feet per second											
Left abutment	0.0	--	494.5	--	480.0	0.0	8.2	--	8.2	471.8	--
Right abutment	75.7	--	496.4	--	478.5	0.0	26.8	--	26.8	451.7	--

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, 1984, Saxtons River, Vermont 7.5 X 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File ches013.1.wsp
T2        Hydraulic analysis for structure CHESTH00060013   Date: 18-FEB-98
T3        Bridge 13 on Town Highway 6 over Williams river Chester, VT  by MAI
*                * * This file was generated by AWISPP v2.5 * *
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          12000.0  10000.0
WS           490.2  488.85
*
XS   EXITX    -85
GR         -994.1, 510.88   -767.0, 493.40   -717.0, 492.10   -670.0, 491.90
GR         -618.0, 491.40   -569.0, 491.30   -518.0, 490.80   -484.0, 489.70
GR         -422.0, 490.60   -383.0, 491.50   -342.0, 491.80   -302.0, 491.40
GR         -241.0, 490.00   -175.0, 489.50   -113.0, 489.70    -51.0, 490.50
GR            0.0, 490.10     27.0, 480.50     97.0, 480.50    119.0, 484.20
GR          145.0, 489.50    175.0, 490.50    191.0, 491.80    229.0, 491.30
GR          286.0, 493.80    342.0, 494.60    385.0, 496.10    427.0, 497.60
GR          468.0, 495.50    490.0, 505.50
N           0.065        0.051        0.040
SA                   0.0        145.0
*
XS   FULLV      0  * * *   0.0000
*
*              SRD     LSEL    XSSKEW
BR   BRIDG      0    495.41       0.0
GR             0.0, 494.46       0.0, 494.40       0.8, 489.54       4.4, 489.11
GR             5.1, 479.97      13.9, 479.33      22.1, 478.27      26.7, 477.54
GR            32.1, 477.12      40.3, 475.92      47.3, 476.42      57.5, 477.40
GR            67.0, 478.15      68.3, 478.47      68.5, 480.44      69.8, 480.51
GR            70.4, 482.76      71.6, 482.84      72.5, 488.91      74.8, 490.71
GR            75.7, 496.05      75.7, 496.36       0.0, 494.46
*
*         BRTYPE  BRWDTH
CD            1      17.3
N           0.05
*
*              SRD    EMBWID   IPAVE
XR   RDWAY      9      12.8     2
GR         -994.1, 510.88   -807.0, 498.46   -793.0, 494.90   -583.0, 491.28
GR         -314.0, 491.31   -235.6, 491.13   -156.0, 492.08    -74.5, 495.16
GR           -5.7, 496.43     -2.6, 496.64      0.0, 496.94     75.7, 499.18
GR           77.9, 499.09     78.0, 498.51    170.7, 502.07    227.2, 507.52
GR          266.1, 510.21
*
AS   APPRO     96
GR         -994.1, 510.88   -807.0, 498.46   -793.0, 494.90   -583.0, 491.28
GR         -314.0, 491.31   -235.6, 491.13
GR          -15.1, 487.81      0.0, 486.78     15.6, 481.48     29.8, 480.30
GR           37.4, 479.43     44.7, 478.30     53.4, 478.47     62.0, 478.58
GR           74.8, 478.92     82.6, 479.22     97.1, 487.96    109.5, 492.48
GR          121.5, 504.82
N           0.070        0.050
SA                 -15.1
*
HP 1 BRIDG   491.13 1 491.13
HP 2 BRIDG   491.13 * * 8220
HP 2 RDWAY   492.85 * * 3780
HP 1 APPRO   492.86 1 492.86
HP 2 APPRO   492.86 * * 12000
*
HP 2 BRIDG   494.49 * * 10933
HP 2 RDWAY   494.49 * *  6667
HP 1 APPRO   495.29 1 495.29
HP 2 APPRO   495.29 * * 17600
*
HP 1 BRIDG   488.67 1 488.67
HP 2 BRIDG   488.67 * * 10000
HP 1 APPRO   492.18 1 492.18
HP 2 APPRO   492.18 * * 10000
*
EX
ER
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T1        U.S. Geological Survey WSPRO Input File ches013.2.wsp
T2        Hydraulic analysis for structure CHESTH00060013   Date: 18-FEB-98
T3        Bridge 13 on Town Highway 6 over Williams river Chester, VT  by MAI
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          17600.0
WS         494.6
*
XS    EXITX    -85    *
GR         -994.1, 510.88   -767.0, 493.40   -717.0, 492.10   -670.0, 491.90
GR         -618.0, 491.40   -569.0, 491.30   -518.0, 490.80   -484.0, 489.70
GR         -422.0, 490.60   -383.0, 491.50   -342.0, 491.80   -302.0, 491.40
GR         -241.0, 490.00   -175.0, 489.50   -113.0, 489.70    -51.0, 490.50
GR            0.0, 490.10     27.0, 480.50     97.0, 480.50    119.0, 484.20
GR          145.0, 489.50    175.0, 490.50    191.0, 491.80    229.0, 491.30
GR          286.0, 493.80    342.0, 494.60    385.0, 496.10    427.0, 497.60
GR          468.0, 495.50    490.0, 505.50
N           0.065        0.051        0.040
SA                   0.0        145.0
*
*             SRD  XSSKEW
XT    BRTEM     0
GR         -994.1, 510.88   -807.0, 498.46   -793.0, 494.90   -583.0, 491.28
GR         -314.0, 491.31   -235.6, 491.13   -156.0, 492.08    -74.5, 495.16
GR           -5.7, 496.43     -2.6, 496.64      0.0, 496.94      0.1, 494.40
GR            0.8, 489.54      4.4, 489.11      5.1, 479.97     13.9, 479.33
GR           22.1, 478.27     26.7, 477.54     32.1, 477.12     40.3, 475.92
GR           47.3, 476.42     57.5, 477.40     67.0, 478.15     68.3, 478.47
GR           68.5, 480.44     69.8, 480.51     70.4, 482.76     71.6, 482.84
GR           72.5, 488.91     74.8, 490.71     75.5, 496.05     75.6, 496.36
GR           75.7, 499.18     77.9, 499.09     78.0, 498.51    170.7, 502.07
GR          227.2, 507.52    266.1, 510.21
*
*            LCL  0.0, 494.46    LCR  75.7, 496.36
XS    DSBRG      0 * * * 0.00
GT
N           0.045     0.05          0.045
SA                0.0         75.7
*
XS    USBRG     17 * * * 0.00
GT
N           0.045     0.05         0.045
SA                0.0         75.7
*
XS    APPRO     96  *  0.5  0.
GR         -994.1, 510.88   -807.0, 498.46   -793.0, 494.90   -583.0, 491.28
GR         -314.0, 491.31   -235.6, 491.13
GR          -15.1, 487.81      0.0, 486.78     15.6, 481.48     29.8, 480.30
GR           37.4, 479.43     44.7, 478.30     53.4, 478.47     62.0, 478.58
GR           74.8, 478.92     82.6, 479.22     97.1, 487.96    109.5, 492.48
GR          121.5, 504.82
N           0.070        0.050
SA                 -15.1
*
HP 1 DSBRG   494.49 1 494.49
*
EX
ER
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APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches013.1.wsp
        Hydraulic analysis for structure CHESTH00060013   Date: 18-FEB-98
        Bridge 13 on Town Highway 6 over Williams river Chester, VT  by MAI
           *** RUN DATE & TIME: 07-08-98  13:22

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     902.  121037.    74.    94.                       17817.
   491.13          902.  121037.    74.    94.  1.00     1.    75.  17817.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.13     0.5    74.9   901.6  121037.    8220.   9.12

X STA.         0.5       15.1       18.2       21.2       24.2       27.0
  A(I)            126.0       38.5       37.8       38.2       37.3
  V(I)             3.26      10.67      10.87      10.75      11.03

X STA.        27.0       29.6       32.2       34.7       37.2       39.6
  A(I)             36.0       36.1       36.5       36.3       36.0
  V(I)            11.41      11.39      11.27      11.33      11.41

X STA.        39.6       42.0       44.4       46.9       49.3       51.9
  A(I)             36.4       36.0       36.0       36.0       36.4
  V(I)            11.30      11.41      11.41      11.42      11.29

X STA.        51.9       54.4       57.1       59.7       62.5       74.9
  A(I)             35.9       36.9       36.4       37.2      115.7
  V(I)            11.45      11.15      11.28      11.05       3.55

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.85  -674.1  -135.6   724.5   20242.    3780.   5.22

X STA.      -674.1     -582.7     -561.1     -540.7     -519.2     -498.4
  A(I)             72.0       33.8       32.0       33.6       32.5
  V(I)             2.63       5.58       5.90       5.63       5.81

X STA.      -498.4     -477.2     -456.0     -434.6     -413.4     -392.2
  A(I)             33.0       33.1       33.3       32.9       32.8
  V(I)             5.73       5.71       5.68       5.75       5.76

X STA.      -392.2     -370.7     -349.2     -327.4     -305.8     -284.9
  A(I)             33.3       33.2       33.6       33.3       33.2
  V(I)             5.68       5.69       5.63       5.67       5.69

X STA.      -284.9     -265.0     -246.1     -227.5     -204.8     -135.6
  A(I)             32.4       31.5       31.6       33.8       59.6
  V(I)             5.83       6.00       5.98       5.60       3.17

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      96.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1369.   47441.   660.   660.                       11198.
             2    1296.  179320.   125.   129.                       23675.
   492.86         2665.  226761.   785.   789.  2.13  -675.   110.  19113.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      96.

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.86  -674.7   109.9  2665.2  226761.   12000.   4.50

X STA.      -674.7     -240.1     -118.2      -63.1      -21.8        6.5
  A(I)            614.3      314.6      215.6      191.5      164.0
  V(I)             0.98       1.91       2.78       3.13       3.66

X STA.         6.5       15.5       21.8       27.8       33.4       38.5
  A(I)             88.4       73.3       73.0       71.1       67.8
  V(I)             6.78       8.19       8.21       8.44       8.85

X STA.        38.5       43.5       48.2       52.9       57.6       62.3
  A(I)             69.7       67.9       68.1       67.4       67.9
  V(I)             8.61       8.84       8.80       8.90       8.84

X STA.        62.3       67.0       71.8       76.6       81.4      109.9
  A(I)             66.4       67.8       66.4       67.0      183.0
  V(I)             9.03       8.85       9.04       8.96       3.28
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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches013.2.wsp
        Hydraulic analysis for structure CHESTH00060013   Date: 18-FEB-98
        Bridge 13 on Town Highway 6 over Williams river Chester, VT  by MAI
           *** RUN DATE & TIME: 07-08-98  14:26

    CROSS-SECTION PROPERTIES:  ISEQ =  2;  SECID = DSBRG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1721.  106154.   677.   677.                       15573.
             2    1153.  174052.    75.   101.                       25609.
   494.49         2874.  280205.   752.   778.  1.64  -769.    75.  24881.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.49     0.0    75.4  1153.2  172811.   10933.   9.48

X STA.         0.0        15.0        18.0        21.0        23.8        26.5
  A(I)            174.2        47.5        46.6        45.9        46.1
  V(I)             3.14       11.51       11.74       11.91       11.86

X STA.        26.5        29.2        31.9        34.5        37.0        39.5
  A(I)             45.6        45.6        45.9        44.7        45.6
  V(I)            11.98       11.98       11.92       12.22       11.98

X STA.        39.5        42.0        44.4        46.9        49.4        52.0
  A(I)             46.0        45.6        45.7        44.8        45.1
  V(I)            11.89       11.99       11.96       12.19       12.12

X STA.        52.0        54.6        57.2        59.9        62.7        75.4
  A(I)             45.4        45.4        46.2        45.6       155.5
  V(I)            12.03       12.03       11.83       11.98        3.51

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.49  -769.2   -92.2  1721.2   73491.    6667.   3.87

X STA.      -769.2      -607.6      -582.0      -558.9      -536.0      -512.6
  A(I)            225.1        76.8        74.4        73.2        75.1
  V(I)             1.48        4.34        4.48        4.55        4.44

X STA.      -512.6      -489.5      -466.2      -442.8      -419.7      -396.5
  A(I)             74.0        74.3        74.8        73.9        73.9
  V(I)             4.50        4.49        4.45        4.51        4.51

X STA.      -396.5      -372.8      -349.1      -325.2      -301.4      -278.3
  A(I)             75.5        75.5        76.3        75.8        74.7
  V(I)             4.41        4.42        4.37        4.40        4.46

X STA.      -278.3      -255.7      -233.4      -210.1      -182.6       -92.2
  A(I)             74.1        74.4        74.4        79.7       145.1
  V(I)             4.50        4.48        4.48        4.18        2.30

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      96.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    3139.  169148.   779.   780.                       35752.
             2    1602.  251104.   127.   133.                       32252.
   495.29         4742.  420251.   907.   912.  2.02  -795.   112.  43324.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      96.

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.29  -794.5   112.2  4741.6  420251.   17600.   3.71

X STA.      -794.5      -525.1      -423.4      -323.6      -219.8      -149.5
  A(I)            694.4       406.4       397.8       424.9       346.5
  V(I)             1.27        2.17        2.21        2.07        2.54

X STA.      -149.5       -96.2       -53.7       -17.2         6.6        17.0
  A(I)            312.5       279.3       261.7       200.2       130.5
  V(I)             2.82        3.15        3.36        4.40        6.74

X STA.        17.0        25.3        33.6        40.9        47.6        54.3
  A(I)            118.4       124.4       115.5       112.3       112.9
  V(I)             7.43        7.08        7.62        7.83        7.80

X STA.        54.3        61.0        67.5        74.4        81.2       112.2
  A(I)            112.2       108.2       114.5       110.0       259.2
  V(I)             7.84        8.13        7.69        8.00        3.40
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WSPRO OUTPUT FILE (continued)

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches013.1.wsp
        Hydraulic analysis for structure CHESTH00060013   Date: 18-FEB-98
        Bridge 13 on Town Highway 6 over Williams river Chester, VT  by MAI
           *** RUN DATE & TIME: 07-08-98  13:22

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

     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1     724.  90033.    68.    85.                      13411.
   488.67          724.  90033.    68.    85.  1.00     4.    72.  13411.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       488.67     4.4    72.5   724.3   90033.   10000.  13.81

X STA.         4.4       14.2       17.7       21.0       24.0       26.8
  A(I)              85.2       33.4       32.8       32.2       30.7
  V(I)              5.87      14.95      15.26      15.55      16.27

X STA.        26.8       29.6       32.3       34.8       37.3       39.7
  A(I)              31.0       30.7       29.9       29.9       29.9
  V(I)             16.11      16.29      16.70      16.71      16.75

X STA.        39.7       42.0       44.4       46.8       49.2       51.8
  A(I)              29.8       29.5       29.4       30.0       30.4
  V(I)             16.76      16.96      16.99      16.69      16.42

X STA.        51.8       54.3       57.0       59.7       62.5       72.5
  A(I)              29.3       30.9       30.7       30.3       88.2
  V(I)             17.04      16.16      16.29      16.49       5.67

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      96.

     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1     934.  26140.   620.   620.                       6508.
             2    1211. 161389.   124.   128.                      21496.
   492.18         2145. 187528.   744.   748.  2.01  -635.   109.  14566.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      96.

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.18  -635.2   108.7  2145.4  187528.   10000.   4.66

X STA.      -635.2     -105.3      -47.3       -4.9       11.4       18.1
  A(I)             601.6      199.9      180.9      109.4       68.8
  V(I)              0.83       2.50       2.76       4.57       7.26

X STA.        18.1       23.8       29.1       34.1       38.8       43.1
  A(I)              63.2       61.4       61.1       58.7       58.0
  V(I)              7.92       8.15       8.19       8.51       8.62

X STA.        43.1       47.3       51.5       55.8       60.0       64.2
  A(I)              58.2       58.1       58.4       57.7       57.2
  V(I)              8.59       8.61       8.56       8.66       8.74

X STA.        64.2       68.5       72.8       77.2       81.5      108.7
  A(I)              57.5       57.3       58.2       56.9      162.9
  V(I)              8.70       8.72       8.60       8.78       3.07
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WSPRO OUTPUT FILE (continued)

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches013.1.wsp
        Hydraulic analysis for structure CHESTH00060013   Date: 18-FEB-98
        Bridge 13 on Town Highway 6 over Williams river Chester, VT  by MAI
           *** RUN DATE & TIME: 07-08-98  13:22

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

EXITX:XS   ******  -499.    1169.  1.89 *****  492.09  488.63  12000.  490.20
      -85. ******   166.  118573.  1.15 ***** *******    1.14   10.26

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     0.88     491.73     488.63

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   489.70     510.88    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   489.70     510.88     488.63

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "FULLV"     KRATIO =  1.53

FULLV:FV      85.  -652.    2107.  0.93  0.57  492.66  488.63  12000.  491.73
        0.    85.   239.  181775.  1.84  0.00    0.00    0.88    5.70
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     0.85     492.10     489.10

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   491.23     510.88    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   491.23     510.88     489.10

APPRO:AS      96.  -630.    2083.  1.03  0.42  493.12  489.10  12000.  492.10
       96.    96.   108.  183163.  1.99  0.05    0.00    0.85    5.76
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   494.98       0.00     488.66     491.13

 ===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      85.     1.     902.  1.97  0.61  493.10  485.67   8220.  491.13
        0.    85.    75.  121051.  1.52  0.40    0.00    0.57    9.12

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.810 ******  495.41 ****** ****** ******

   XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG       9.    83.  0.23  0.68  493.29    0.00   3780.  492.85

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   3780.   538.  -674.  -136.   1.7   1.3   5.9   5.2   1.8   2.9
   RT:      0.    61.    40.   101.   1.3   0.6   6.7  16.7   2.3   3.0

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

APPRO:AS      79.  -674.    2662.  0.67  0.35  493.53  489.10  12000.  492.86
       96.    95.   110.  226544.  2.13  0.08    0.02    0.63    4.51

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.899  0.305  156659.     5.    79. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS      -85.  -499.   166.  12000.  118573.    1169.   10.26  490.20
   FULLV:FV        0.  -652.   239.  12000.  181775.    2107.    5.70  491.73
   BRIDG:BR        0.     1.    75.   8220.  121051.     902.    9.12  491.13
   RDWAY:RG        9.******* 3780.   3780.*********       0.    2.00  492.85
   APPRO:AS       96.  -674.   110.  12000.  226544.    2662.    4.51  492.86

    XSID:CODE   XLKQ   XRKQ        KQ
   APPRO:AS       5.    79.  156659.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS      FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     488.63     1.14  480.50  510.88************  1.89  492.09  490.20
   FULLV:FV     488.63     0.88  480.50  510.88  0.57  0.00  0.93  492.66  491.73
   BRIDG:BR     485.67     0.57  475.92  496.36  0.61  0.40  1.97  493.10  491.13
   RDWAY:RG  ****************  491.13  510.88  0.23******  0.68  493.29  492.85
   APPRO:AS     489.10     0.63  478.30  510.88  0.35  0.08  0.67  493.53  492.86
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WSPRO OUTPUT FILE (continued)

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches013.2.wsp
        Hydraulic analysis for structure CHESTH00060013   Date: 18-FEB-98
        Bridge 13 on Town Highway 6 over Williams river Chester, VT  by MAI
           *** RUN DATE & TIME: 07-08-98  14:26

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

EXITX:XS   ******  -783.    5045.  0.35 *****  494.95  492.23  17600.  494.60
      -85. ******   342.  442574.  1.85 ***** *******    0.40    3.49

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "DSBRG"     KRATIO =  0.63

DSBRG:XS      85.  -769.    2873.  0.96  0.21  495.45 *******  17600.  494.49
        0.    85.    75.  280156.  1.64  0.30   -0.02    0.71    6.13

USBRG:XS      17.  -779.    3006.  0.86  0.06  495.53 *******  17600.  494.66
       17.    17.    75.  293959.  1.62  0.00    0.02    0.66    5.85

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  1.43

APPRO:XS      79.  -795.    4740.  0.43  0.20  495.72 *******  17600.  495.29
       96.    79.   112.  420039.  2.02  0.00    0.00    0.41    3.71

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS     -85.  -783.   342.  17600.  442574.    5045.    3.49  494.60
   DSBRG:XS       0.  -769.    75.  17600.  280156.    2873.    6.13  494.49
   USBRG:XS      17.  -779.    75.  17600.  293959.    3006.    5.85  494.66
   APPRO:XS      96.  -795.   112.  17600.  420039.    4740.    3.71  495.29

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    492.23    0.40  480.50  510.88************  0.35  494.95  494.60
   DSBRG:XS  ********    0.71  475.92  510.88  0.21  0.30  0.96  495.45  494.49
   USBRG:XS  ********    0.66  475.92  510.88  0.06  0.00  0.86  495.53  494.66
   APPRO:XS  ********    0.41  478.30  510.88  0.20  0.00  0.43  495.72  495.29
  ER
```
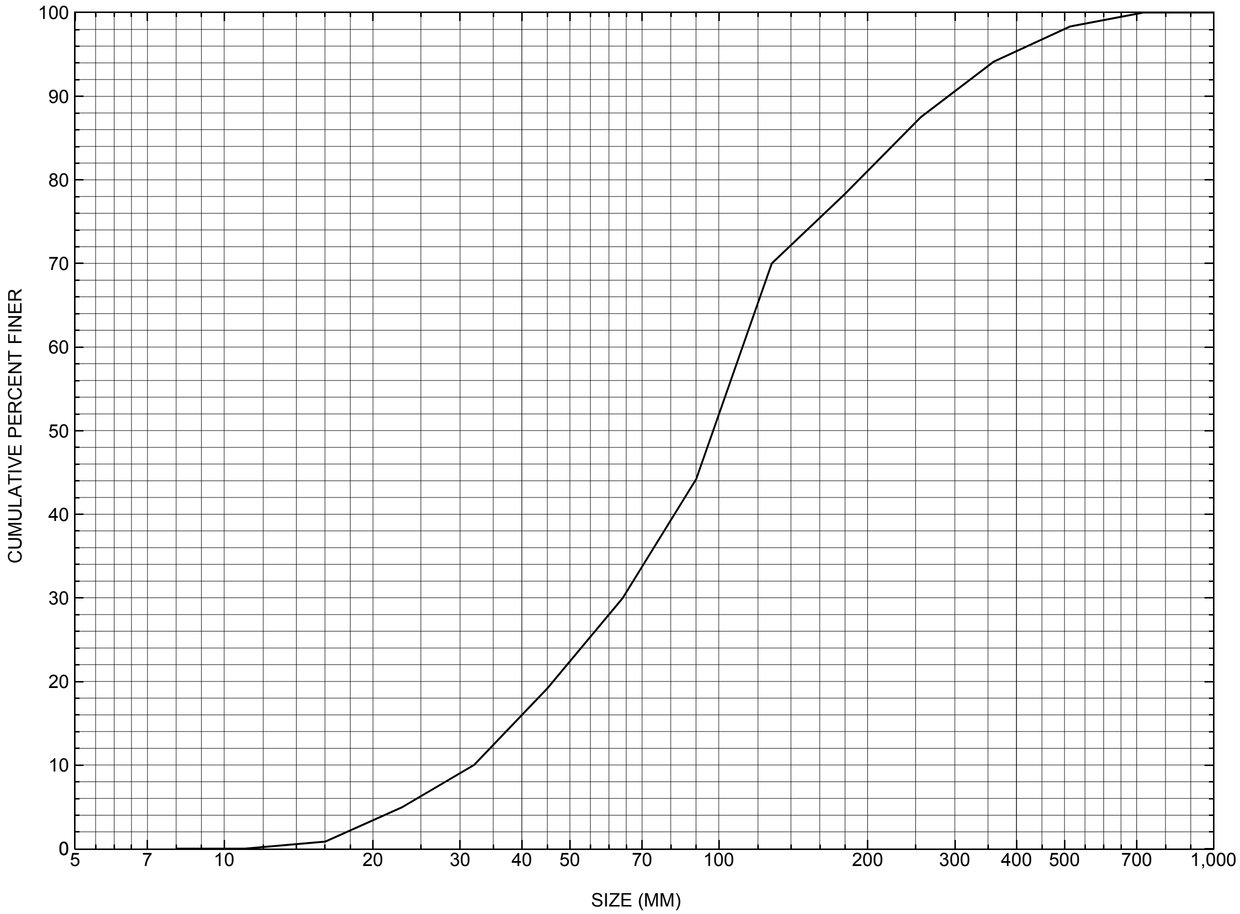

```
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ches013.1.wsp
        Hydraulic analysis for structure CHESTH00060013   Date: 18-FEB-98
        Bridge 13 on Town Highway 6 over Williams river Chester, VT  by MAI
           *** RUN DATE & TIME: 07-08-98  13:22

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

EXITX:XS   ******     4.     879.  2.01 *****  490.86  487.82  10000.  488.85
      -85. ******   142.   87118.  1.00 ***** *******    0.80   11.38

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.96     490.44     487.82

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   488.35     510.88    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   488.35     510.88     487.82

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "FULLV"     KRATIO =  1.45

FULLV:FV      85.  -507.    1278.  1.20  0.77  491.64  487.82  10000.  490.44
        0.    85.   173.  126409.  1.26  0.00    0.00    0.96    7.82
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      96.  -232.    1431.  1.08  0.52  492.16 *******  10000.  491.08
       96.    96.   106.  145363.  1.42  0.00    0.00    0.71    6.99
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   492.17       0.00     488.68     491.13

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   491.62      9096.       904.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

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

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   495.41         0.     14175.

 ===270 REJECTED 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      85.     4.     724.  3.48  1.08  492.15  486.20  10000.  488.67
        0.    85.    72.   90048.  1.17  0.20   -0.01    0.81   13.80

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  0.923 ******  495.41 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.        <<<<<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      79.  -635.    2146.  0.68  0.51  492.86  487.89  10000.  492.18
       96.    86.   109.  187557.  2.01  0.21    0.01    0.69    4.66

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.782  0.253  139737.    12.    80.  491.94

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -85.     4.   142.  10000.   87118.     879.   11.38  488.85
   FULLV:FV       0.  -507.   173.  10000.  126409.    1278.    7.82  490.44
   BRIDG:BR       0.     4.    72.  10000.   90048.     724.   13.80  488.67
   RDWAY:RG       9.**************      0.       0.       0.    2.00********
   APPRO:AS      96.  -635.   109.  10000.  187557.    2146.    4.66  492.18

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      12.    80.  139737.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    487.82    0.80  480.50  510.88************  2.01  490.86  488.85
   FULLV:FV    487.82    0.96  480.50  510.88  0.77  0.00  1.20  491.64  490.44
   BRIDG:BR    486.20    0.81  475.92  496.36  1.08  0.20  3.48  492.15  488.67
   RDWAY:RG  ****************  491.13  510.88************  0.13  495.50********
   APPRO:AS    487.89    0.69  478.30  510.88  0.51  0.21  0.68  492.86  492.18
  ER
 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure CHESTH00060013, in Chester, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number CHESTH00060013

General Location Descriptive

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

Date *(MM/DD/YY)* 04 / 05 / 95

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

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

Town *(FIPS place code; I - 4; nnnnn)* 13675

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

Waterway *(I - 6)* Williams River

Road Name *(I - 7)*: -

Route Number TH006

Vicinity *(I - 9)* 0.3 miles to jct with VT 103

Topographic Map Sextons River

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 43144

Longitude *(i - 17; nnnnn.n)* 72333

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10140700131407

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

Maximum span length *(I - 48; nnnn)* 0078

Year built *(I - 27; YYYY)* 1960

Structure length *(I - 49; nnnnnn)* 000082

Average daily traffic, ADT *(I - 29; nnnnnn)* 000030

Deck Width *(I - 52; nn.n)* 128

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

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

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

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

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

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

Structure type *(I - 43; nnn)* 303

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*) 17.0

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

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

Comments:

The structural inspection report of 09/29/93 indicates the structure is a steel stringer type bridge with a bare concrete deck. At the upstream end of the right abutment wall there is a large void, with a rotten log foundation exposed. There is some settlement in the stone work above this log. The main portion of the right abutment wall is clean. The left abutment wall consists of a lower mortared stone section with newer concrete cap above. It appears that the US end of the concrete has settled. There is a shallow void still beneath it, near the center line of roadway. Along the bottom of the stone work there is a log foundation exposed. There is a large flat rock on top of the stone work at the US end of the wall, **(Continued, page 33)**

Bridge Hydrologic Data

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

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:

which apparently has settled at its right end, directly below the concrete section of the wall. The downstream end of the left abutment is in good condition. There is some wash at this location. All four wingwalls are laid up stone. They have some bulges and lean out somewhat at the right abutment. The waterway has a slight turn just upstream. The streambed consists of stone and gravel, with some random boulders. The right abutment side of the channel is well protected with stone fill.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **80.61** mi^2

Lake/pond/swamp area **0.217** mi^2

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

Bridge site elevation **532** ft

Headwater elevation **2882** ft

Main channel length **17.53** mi

10% channel length elevation **560** ft

85% channel length elevation **1480** ft

Main channel slope *(S)* **69.96** 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? Yes *If no, type ctrl-n xs*

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

Comments: **The elevations and stations are measured in feet.**

Station	1380	1380.5	1381	1381.1	1383	1383.1	1413	1448.9	1449	1450.5	1451.1
Feature	LB	-	-	-	-	-	-	-	-	-	
Low chord elevation	530.1	530.1	530.1	530.1	530.2	530.2	530.8	531.5	531.5	531.5	531.5
Bed elevation	530.1	527.1	527.1	525.1	525.1	516.6	514.6	516.7	519.7	519.7	525.7
Low chord to bed	0	3.0	3.0	5.0	5.1	13.6	16.2	14.8	11.8	11.8	5.8

Station	1453.9	1454	1455	1456	-	-	-	-	-	-	-
Feature	-	-	-	RB	-	-	-	-	-	-	-
Low chord elevation	531.6	531.6	531.6	531.7	-	-	-	-	-	-	-
Bed elevation	525.7	526.7	526.7	531.7	-	-	-	-	-	-	-
Low chord to bed	5.9	4.9	4.9	0	-	-	-	-	-	-	-

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

Comments:

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: RB Date: 01/27/97
Computerized by: RB Date: 04/24/97
Reviewd by: MAI Date: 05/07/98

Structure Number CHESTH00060013

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* L. MEDALIE Date *(MM/DD/YY)* 08 / 19 / 1996

2. Highway District Number 02 Mile marker 0000

County Windsor (27) Town Chester (13675)

Waterway *(I - 6)* Williams River Road Name -

Route Number TH006 Hydrologic Unit Code: 01080107

3. Descriptive comments:

This site is located 0.3 miles from the junction with VT 103.

B. Bridge Deck Observations

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

5. Ambient water surface... US 2 UB 1 DS 1 *(**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 82 *(feet)* Span length 78 *(feet)* Bridge width 12.8 *(feet)*

Road approach to bridge:

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

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

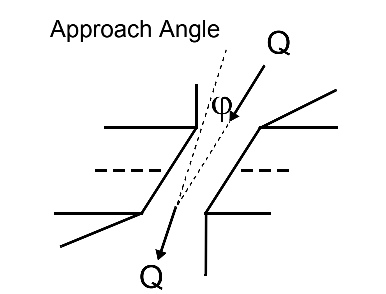
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

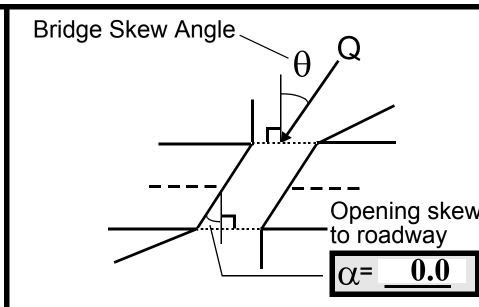
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	3	2	2	2
RBUS	5	1	2	2
RBDS	0	-	0	1
LBDS	0	-	0	-

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

Channel approach to bridge (BF):

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





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 330 feet US *(US, UB, DS)* to 100 feet US

Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 315 feet DS *(US, UB, DS)* to 450 feet DS

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

18. Bridge Type: **1b**

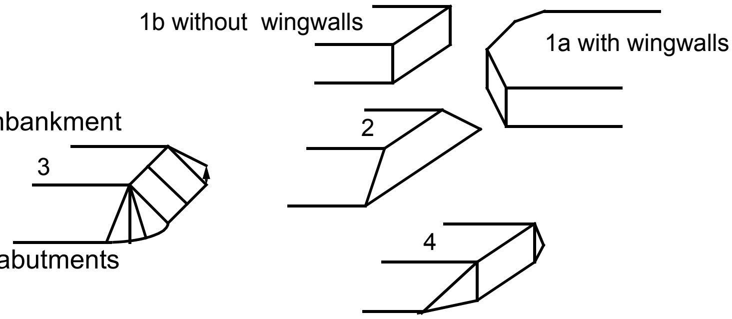
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

7. The bridge dimension values are from the VTAOT files. The measured bridge length is 81.5 ft, bridge span is 77.5 ft and bridge width is 15.3 ft from the outside base plate of the metal rail on both sides.
18. The wingwalls mentioned in the historical form are laid up stone walls wrapping around the sides of both abutments except the at the US end of the left abutment.
11. The laid up stone wingwall is considered protection for the right bank US. The DS left wingwall also acts as protection.

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
80.0	6.5			8.5	2	3	23	457	1	2

23. Bank width **10.0** 24. Channel width **30.0** 25. Thalweg depth **112.5** 29. Bed Material **45**

30 .Bank protection type: LB **12** RB **4** 31. Bank protection condition: LB **2** RB **2**

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. The right and left bank protection extends from the bridge to 28 ft US.
27. For a 10 ft stretch, there are a few long flat stones built into a wall halfway up the right bank at the approach.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 37 35. Mid-bar width: 22

36. Point bar extent: 230 feet US (US, UB) to 39 feet DS (US, UB, DS) positioned 5 %LB to 35 %RB

37. Material: 34

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

Point bar consisting of gravel and boulder.

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: 275 42. Cut bank extent: 46 feet US (US, UB) to 290 feet US (US, UB, DS)

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

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

Some type-3 protection on the right bank is slumped from 285 ft US to 245 ft US.

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
67.0		1.0		2	7	7	-

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

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

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

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

435

63. The bed material is gravel towards the left of the channel and boulders toward the right.

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

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

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

70. Debris and Ice Comments:

1

-

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**0**	**90**	**2**	**0**	**-**	**-**	**90.0**
RABUT	**1**	**0**	**85**			**2**	**3**	**75.5**

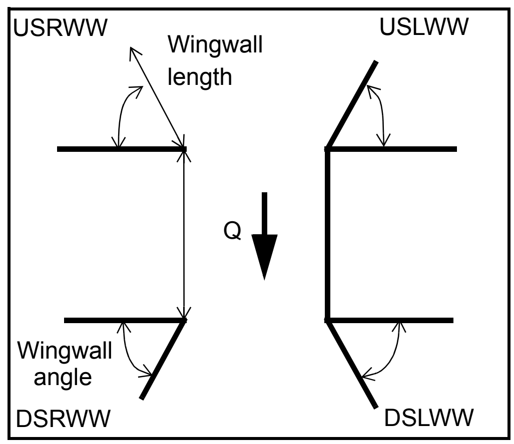
Pushed: LB or RB *Toe Location (Loc.): **0**- even, **1**- set back, **2**- protrudes*
*Scour cond.: **0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**-undermined footing; **4**- piling exposed; **5**- settled; **6**- failed*
Materials: ***1**- Concrete; **2**- Stone masonry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

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

2
4
1
77. The left abutment has a stone and log base 8.5 ft high with a concrete cap set back from it. The right abutment has a concrete base with a concrete cap set back from it at a different angle.
71. The bottom half of the right abutment is parallel to flow. The top half of the abutment has a 45 degree attack angle. The US end of the right abutment protrudes into the channel and water is hitting it straight on.
74. The lower footing of the right abutment is undermined 1.5 ft at the US most corner only.
75. Average thalweg depth is 1 ft and the water depth at the US end is 3 ft.
76. The lower footing is exposed 4 ft at the US end and only 1 ft at the DS end.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**75.5**	
USRWW:	**N**		**-**		**-**	**2.5**	
DSLWW:	**-**		**-**		**N**	**17.5**	
DSRWW:	**-**		**-**		**-**	**17.5**	



*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	**-**	**-**	**N**	**-**	**-**	**-**	**-**	**2**
Condition	**N**	**-**	**-**	**-**	**-**	**-**	**-**	**4**
Extent	**-**	**-**	**-**	**-**	**-**	**0**	**2**	**-**

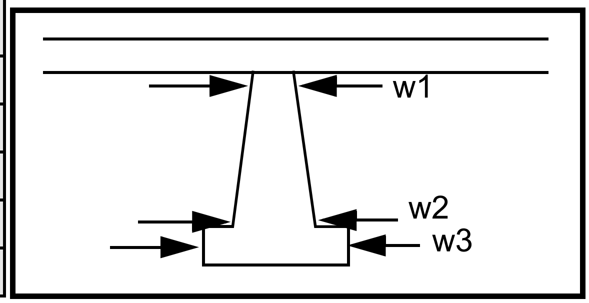
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

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

Piers:

84. Are there piers? 82. (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	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	The	ends,	in	allel to	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	right	not	front	the	1- Solid pier, 2- column, 3- bent
88. Material	abut	in	of	road.	1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	ment	the	the	In	1- Round; 2- Square; 3- Pointed
90. Inclined?	pro-	cen-	laid-	front	Y- yes; N- no
91. Attack ∠ (BF)	tec-	ter.	up	of	
92. Pushed	tion	Ther	stone	the	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	is at	e is	wing	DS	
95. Cross-members	the	also	walls	left	0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	US	pro-	that	and	0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	and	tec-	are	right	
98. Exposure depth	DS	tion	par-	wing	

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

walls there is type-2 protection that is slumped along the entire base length of the wall. In front of the US right wingwall is type-3 protection that is also slumped along the base. The US right wingwall bottom stone is also undermined up to 3 ft. It is resting on stones on either end with the void in the middle.

N

E. Downstream Channel Assessment

100.

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

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

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

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

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

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

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

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

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

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

Material: -

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

-
-
-
-

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

Cut bank extent: RS feet ____ (US, UB, DS) to ____ feet ____ (US, UB, DS)

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

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

Is channel scour present? ____ (Y or if N type ctrl-n cs) Mid-scour distance: 3

Scour dimensions: Length 2 Width 23 Depth: 23 Positioned 1 %LB to 2 %RB

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

345
2
2
1

Are there major confluences? 1 (Y or if N type ctrl-n mc) How many? The

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

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

Confluence comments (eg. confluence name):

cover is small trees and large shrubs. The right bank protection consists of boulders in the channel from the DS face to 53 ft DS. The left bank protection extends from the bridge face to 35 ft DS. It is grown over with

F. Geomorphic Channel Assessment

107. Stage of reach evolution veg

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)*:

etation. A railroad bridge is located 500 ft DS, just DS of the confluence.

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:	CHESTH00060013	Town:	Chester
Road Number:	TH 6	County:	Windsor
Stream:	Williams River		

Initials MAI   Date: 03/04/98 Checked: RLB

Analysis of contraction scour, live-bed or clear water?

Critical Velocity of Bed Material (converted to English units)
Vc=11.21*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and Davis, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	12000	17600	10000
Main Channel Area, ft2	1296	1602	1211
Left overbank area, ft2	1369	3139	934
Right overbank area, ft2	0	0	0
Top width main channel, ft	125	127	124
Top width L overbank, ft	660	779	620
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.3197	0.3197	0.3197
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	10.4	12.6	9.8
y1, average depth, LOB, ft	2.1	4.0	1.5
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	226761	420251	187528
Conveyance, main channel	179320	251104	161389
Conveyance, LOB	47441	169148	26140
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	-0.0002	-0.0005
Qm, discharge, MC, cfs	9489.5	10516.2	8606.1
Ql, discharge, LOB, cfs	2510.5	7083.9	1393.9
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	7.3	6.6	7.1
Vl, mean velocity, LOB, ft/s	1.8	2.3	1.5
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	11.3	11.7	11.2
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	0
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Clear Water Contraction Scour in MAIN CHANNEL

```
y2 = (Q2^2/(131*Dm^(2/3)*W2^2))^(3/7)    Converted to English Units
ys=y2-y_bridge
(Richardson and Davis, 1995, p. 32, eq. 20, 20a)
```

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	12000	17600	10000
(Q) discharge thru bridge, cfs	8220	10933	10000
Main channel conveyance	121037	174095	90033
Total conveyance	121037	174095	90033
Q2, bridge MC discharge,cfs	8220	10933	10000
Main channel area, ft2	902	1153	724
Main channel width (normal), ft	74.4	75.4	68.1
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	74.4	75.4	68.1
y_bridge (avg. depth at br.), ft	12.12	15.29	10.64
Dm, median (1.25*D50), ft	0.399625	0.399625	0.399625
y2, depth in contraction,ft	9.07	11.46	11.58
ys, scour depth (y2-ybridge), ft	**-3.04**	**-3.84**	**0.94**

Armoring

```
Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)
```

(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	8220	10933	10000
Main channel area (DS), ft2	901.6	1153	724.3
Main channel width (normal), ft	74.4	75.4	68.1
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	74.4	75.4	68.1
D90, ft	0.9544	0.9544	0.9544
D95, ft	1.2673	1.2673	1.2673
Dc, critical grain size, ft	0.3296	0.3258	0.7965
Pc, Decimal percent coarser than Dc	0.478	0.486	0.139
Depth to armoring, ft	**1.08**	**1.03**	**14.83**

Abutment Scour

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

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	12000	17600	10000	12000	17600	10000
a', abut.length blocking flow, ft	675.2	794.5	639.6	35	36.8	36.2
Ae, area of blocked flow ft2	740.73	1547.2	1044.82	273.52	353.02	282
Qe, discharge blocked abut.,cfs	--	--	1785.28	1412.5	1630.59	1534.88
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.96	2.35	1.71	5.16	4.62	5.44
ya, depth of f/p flow, ft	1.10	1.95	1.63	7.81	9.59	7.79
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	1	1	1
--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	0.235	0.204	0.236	0.326	0.263	0.344
ys, scour depth, ft	17.39	24.18	21.64	**24.86**	**26.77**	**25.63**

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

a'(abut length blocked, ft)	675.2	794.5	639.6	35	36.8	36.2
y1 (depth f/p flow, ft)	1.10	1.95	1.63	7.81	9.59	7.79
a'/y1	615.47	407.98	391.54	4.48	3.84	4.65
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.24	0.20	0.24	0.33	0.26	0.34
Ys w/ corr. factor K1/0.55:						
vertical	**4.95**	**8.38**	**7.37**	ERR	ERR	ERR
vertical w/ ww's	4.06	6.87	6.05	ERR	ERR	ERR

spill-through	2.72	4.61	4.06	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.57	0.43	0.81	0.57	0.43	0.81
y, depth of flow in bridge, ft	12.12	15.29	10.64	12.12	15.29	10.64
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	**2.43**	**1.75**	ERR	**2.43**	**1.75**	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	**4.19**	ERR	ERR	**4.19**