LEVEL II SCOUR ANALYSIS FOR BRIDGE 14 (SHARTH00040014) on TOWN HIGHWAY 4, crossing BROAD BROOK, SHARON, VERMONT

Open-File Report 98-162

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 14 (SHARTH00040014) on TOWN HIGHWAY 4, crossing BROAD BROOK, SHARON, VERMONT

By RONDA L. BURNS and MATTHEW A. WEBER

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

U.S. GEOLOGICAL SURVEY
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CONTENTS

FIGURES

TABLES

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 14 (SHARTH00040014) ON TOWN HIGHWAY 4, CROSSING BROAD BROOK, SHARON, VERMONT

By **Ronda L. Burns and Matthew A. Weber**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure SHARTH00040014 on Town Highway 4 crossing Broad Brook, Sharon, 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 central Vermont. The 15.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest except on the right bank upstream where it is pasture.

In the study area, Broad Brook has an incised, sinuous channel with a slope of approximately 0.011 ft/ft, an average channel top width of 54 ft and an average bank height of 4 ft. The channel bed material ranges from sand to boulder with a median grain size (D_{50}) of 72.1 mm (0.237 ft). The geomorphic assessment at the time of the Level I site visit on April 11, 1995 and Level II site visit on July 11, 1996, indicated that the reach was laterally unstable. There is heavy fluvial erosion on the upstream left bank and downstream right bank.

The Town Highway 4 crossing of Broad Brook is a 34-ft-long, two-lane bridge consisting of one 30-foot steel-beam span (Vermont Agency of Transportation, written communication, March 23, 1995). The opening length of the structure parallel to the bridge face is 29.8 ft. The bridge is supported by near vertical, concrete abutments with wingwalls. The channel is skewed approximately 45 degrees to the opening while the computed opening-skew-to-roadway is 30 degrees.

A scour hole 1.5 ft deeper than the mean thalweg depth was observed along the downstream end of the left abutment and downstream left wingwall during the Level I assessment. A second scour hole 0.5 ft deeper than the mean thalweg depth was observed along the upstream end of the right abutment and upstream right wingwall. The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) at the downstream end of the downstream left wingwall. 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 1.8 to 5.1 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 14.2 to 17.9 ft. The worst-case left abutment scour occurred at the 500-year discharge and the worst-case right abutment scour occurred at the incipient roadway-overtopping discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

NORTH

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

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

Figure 3. Structure SHARTH00040014 viewed from upstream (July 11, 1996).

Figure 4. Downstream channel viewed from structure SHARTH00040014 (July 11, 1996).

Figure 5. Upstream channel viewed from structure SHARTH00040014 (July 11, 1996).

Figure 6. Structure SHARTH00040014 viewed from downstream (July 11, 1996).

LEVEL II SUMMARY

Structure Number SHARTH00040014 ***Stream*** Broad Brook

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

Description of Bridge

Bridge length 34 ***ft*** ***Bridge width*** 23.3 ***ft*** ***Max span length*** 30 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 4/11/95

Description of stone fill Type-2, at the downstream end of the downstream left wingwall.

Abutments and wingwalls are concrete. There is a 1.5 ft deep scour hole along the downstream end of the left abutment and downstream left wingwall.

Brief description of piers/abutments Another scour hole, 0.5 ft deep, is along the upstream end of the right abutment and upstream right wingwall.

Yes

Is bridge skewed to flood flow according to There ***survey?*** ***Angle*** 45 Yes

is a mild channel bend through the bridge.

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	4/11/95	0	0
Level II	7/11/96	0	0

Potential for debris Moderate. There is some debris in the upstream channel and many trees are leaning into the channel at the upstream left cut-bank.

Describe any features near or at the bridge that may affect flow (include observation date) None as of 4/11/95.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a narrow flood plain.

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

Date of inspection 4/11/95

DS left: Narrow flood plain

DS right: Steep valley wall

US left: Steep valley wall

US right: Narrow flood plain

Description of the Channel

Average top width 54 *ft* ***Average depth*** 4 *ft*

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

Sinuous with semi-alluvial channel boundaries and narrow point bars.

4/11/95

Vegetative co Trees and brush with a gravel road on the overbank

DS left: Trees

DS right: Trees

US left: Few trees with short grass and a gravel road on the overbank

US right:

Do banks appear stable? No ***If not, describe location and type of instability and date of observation.***

There is heavy fluvial erosion on the upstream left bank and downstream right bank.

None as of 4/11/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 15.9 ***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? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/ No

-

Calculated Discharges

Q100 3,100 ***ft³/s*** ***Q500*** 4,150 ***ft³/s***

The 100- and 500-year discharges are the median values from a range of discharges defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). The flood frequency estimates were 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 upstream end of the left abutment (elev. 497.87 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the right abutment (elev. 497.98 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	-36	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	15	1	Road Grade section
APTEM	51	1	Approach section as surveyed (Used as a template)
APPRO	56	2	Modelled Approach section (Templated from APTEM)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.040 to 0.060, and the overbank "n" value was 0.040.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0105 ft/ft, which was estimated from surveyed thalweg points downstream of the bridge.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0318 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.7 *ft*
Average low steel elevation 495.8 *ft*

100-year discharge 3,100 *ft³/s*
Water-surface elevation in bridge opening 496.0 *ft*
Road overtopping? Yes *Discharge over road* 350 *ft³/s*
Area of flow in bridge opening 225 *ft²*
Average velocity in bridge opening 12.2 *ft/s*
Maximum WSPRO tube velocity at bridge 15.5 *ft/s*

Water-surface elevation at Approach section with bridge 501.1
Water-surface elevation at Approach section without bridge 495.9
Amount of backwater caused by bridge 5.2 *ft*

500-year discharge 4,150 *ft³/s*
Water-surface elevation in bridge opening 496.0 *ft*
Road overtopping? Yes *Discharge over road* 818 *ft³/s*
Area of flow in bridge opening 225 *ft²*
Average velocity in bridge opening 14.9 *ft/s*
Maximum WSPRO tube velocity at bridge 18.9 */s*

Water-surface elevation at Approach section with bridge 501.8
Water-surface elevation at Approach section without bridge 497.2
Amount of backwater caused by bridge 4.6

Incipient overtopping discharge 2,480 *ft³/s*
Water-surface elevation in bridge opening 496.0 *ft*
Area of flow in bridge opening 225 *ft²*
Average velocity in bridge opening 11.0 *ft/s*
Maximum WSPRO tube velocity at bridge 13.9 *ft/s*

Water-surface elevation at Approach section with bridge 499.4
Water-surface elevation at Approach section without bridge 495.0
Amount of backwater caused by bridge 4.4 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analyses for the 100- and 500-year discharges are presented in tables 1 and 2 and the scour depths are shown graphically in figure 8.

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

For comparison, contraction scour for the discharges resulting in orifice flow also was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20) and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). Furthermore, for those discharges resulting in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these additional computations are provided in appendix F.

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

Scour Results

Contraction scour:	*100-year discharge*	*500-year discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	2.8	5.1	1.8
Depth to armoring	14.5	31.0	17.1
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	15.2	16.0	14.2
Right abutment	15.4	15.2	17.9
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	3.2	3.6	3.0
Right abutment	3.2	3.6	3.0
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

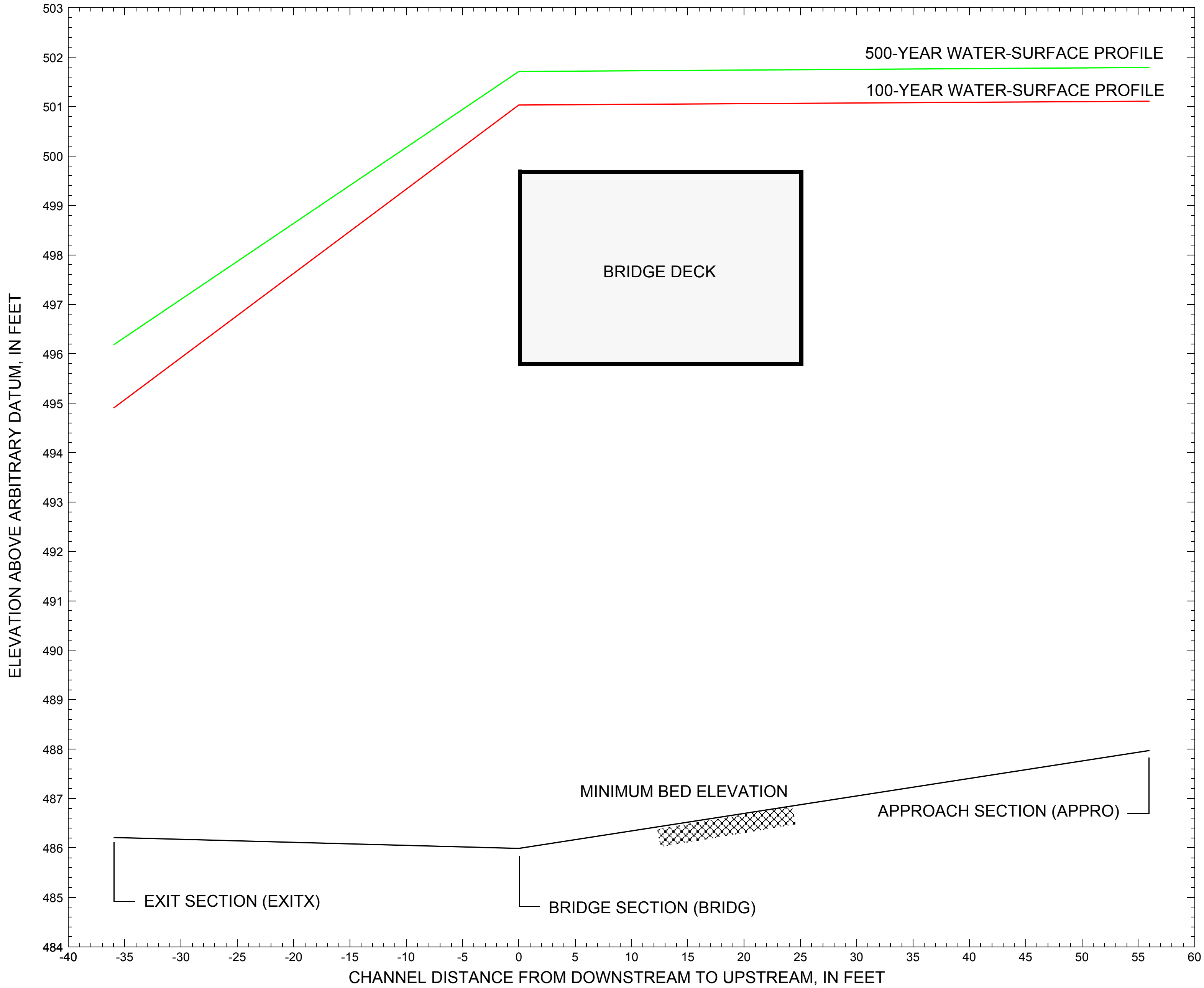

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure SHARTH00040014 on Town Highway 4, crossing Broad Brook, Sharon, Vermont.

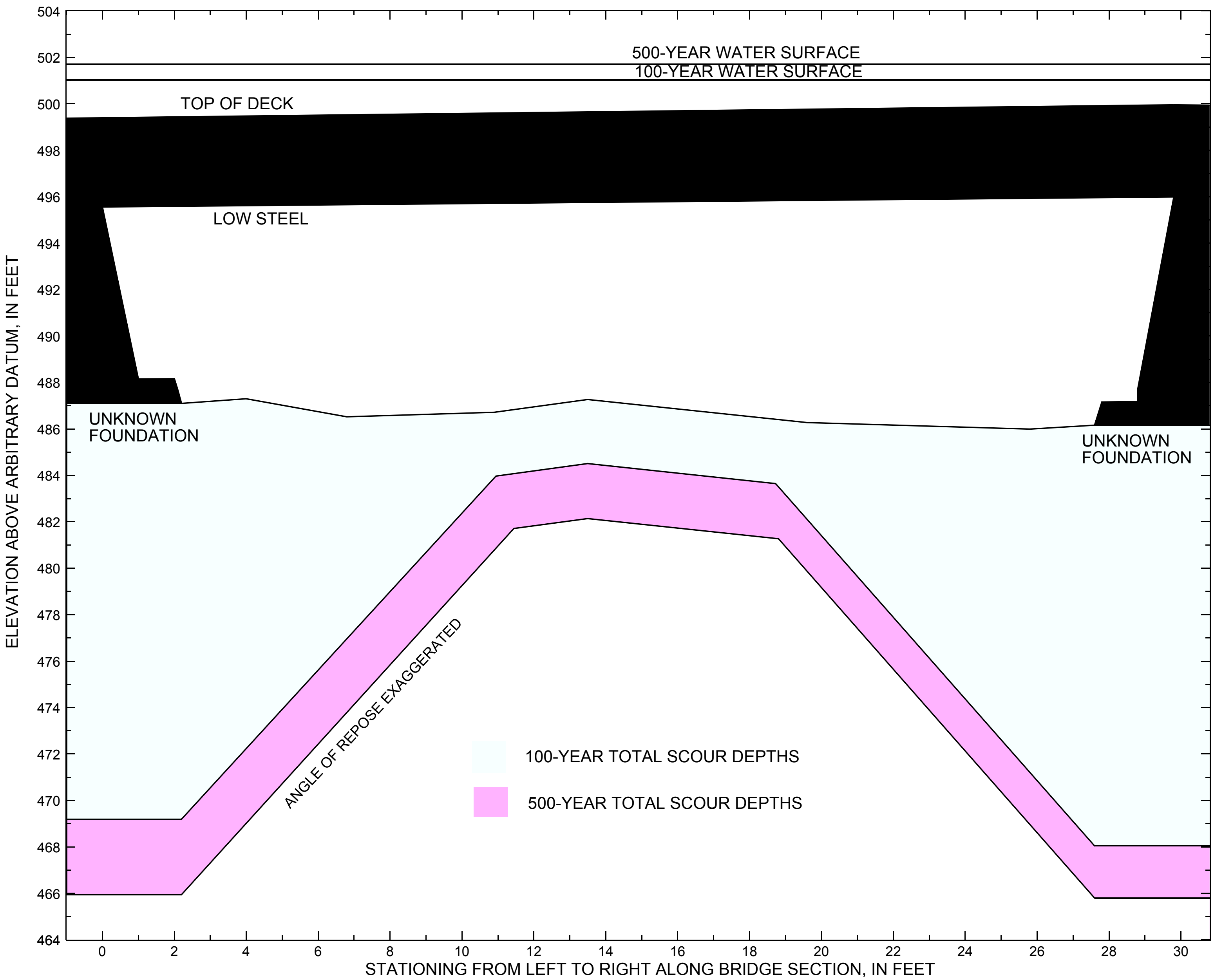

Figure 8. Scour elevations for the 100- and 500-year discharges at structure SHARTH00040014 on Town Highway 4, crossing Broad Brook, Sharon, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure SHARTH00040014 on Town Highway 4, crossing Broad Brook, Sharon, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-year discharge is 3,100 cubic-feet per second											
Left abutment	0.0	--	495.6	--	487.1	2.8	15.2	--	18.0	469.1	--
Right abutment	29.8	--	496.0	--	486.2	2.8	15.4	--	18.2	468.0	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure SHARTH00040014 on Town Highway 4, crossing Broad Brook, Sharon, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year discharge is 4,150 cubic-feet per second											
Left abutment	0.0	--	495.6	--	487.1	5.1	16.0	--	21.1	466.0	--
Right abutment	29.8	--	496.0	--	486.2	5.1	15.2	--	20.3	465.9	--

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

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U.S. Geological Survey, 1981, South Royalton, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1983, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File shar014.wsp
T2        Hydraulic analysis for structure SHARTH00040014   Date: 30-JAN-98
T3        TH 4 CROSSING BROAD BROOK IN SHARON, VT      RLB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3100.0   4150.0   2480.0
SK          0.0105   0.0105   0.0105
*
XS   EXITX    -36           0.
GR          -92.5, 510.80    -81.3, 505.91    -70.7, 500.15    -30.6, 498.64
GR          -18.1, 497.93     -5.4, 490.40      0.0, 487.72      1.0, 487.19
GR            3.2, 486.21      8.2, 486.27     12.7, 486.31     20.2, 487.42
GR           24.5, 487.77     36.6, 489.38     44.9, 492.86     54.4, 496.98
GR           67.2, 507.02
*
N           0.040        0.055
SA                 -18.1
*
XS   FULLV      0  * * *   0.0007
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.78      30.0
GR            0.0, 495.56      1.0, 488.15      2.0, 488.16      2.1, 487.67
GR            2.2, 487.10      4.0, 487.30      6.8, 486.52     10.9, 486.72
GR           13.5, 487.27     19.6, 486.27     25.8, 485.99     27.6, 486.16
GR           27.8, 487.16     28.8, 487.18     28.8, 487.73     29.8, 495.99
GR            0.0, 495.56
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      42.0 * *     57.5      9.4
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     15      23.3     2
GR          -71.0, 515.13    -55.4, 508.88    -38.0, 506.25    -25.7, 504.57
GR          -15.6, 502.14      0.0, 499.40     31.9, 499.96
GR           63.6, 500.70     98.1, 501.30    108.5, 508.65
* GR            -84.7, 511.65    -66.4, 499.23     77.3, 500.24     81.5, 504.87
*
XT   APTEM     51           0.
* GR          -84.7, 511.65    -79.1, 495.95    -46.8, 495.22    -11.0, 495.38
GR          -71.0, 515.13    -55.4, 508.88    -38.0, 506.25    -25.7, 504.57
GR          -15.6, 502.14    -10.2, 495.10     -4.8, 489.77      0.0, 489.05
GR            2.0, 488.49      8.4, 488.36     15.1, 488.29     18.1, 488.09
GR           22.9, 488.05     29.3, 487.81     33.2, 488.48     40.8, 489.58
GR           47.9, 494.49     51.1, 499.64     63.6, 500.70     98.1, 501.30
GR          108.5, 508.65
*
AS   APPRO     56  * * * 0.0318
GT
N           0.060        0.040
SA                   51.1
*
HP 1 BRIDG  495.99 1 495.99
HP 2 BRIDG  495.99 * * 2758
HP 1 BRIDG  495.40 1 495.40
HP 2 RDWAY  501.03 * * 350
HP 1 APPRO  501.11 1 501.11
HP 2 APPRO  501.11 * * 3100
*
HP 1 BRIDG  495.99 1 495.99
HP 2 BRIDG  495.99 * * 3361
HP 2 RDWAY  501.71 * * 818
```

APPENDIX B:

WSPRO OUTPUT FILE

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U.S. Geological Survey WSPRO Input File shar014.wsp
Hydraulic analysis for structure SHARTH00040014   Date: 30-JAN-98
TH 4 CROSSING BROAD BROOK IN SHARON, VT     RLB
   *** RUN DATE & TIME: 02-11-98  11:57

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     225.   18624.     0.    68.                           0.
   495.99          225.   18624.     0.    68.  1.00     0.    30.      0.

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

         WSEL     LEW     REW    AREA         K         Q    VEL
       495.99     0.0    29.8   225.4   18624.    2758.  12.23

X STA.         0.0         4.5         5.9         7.0         8.2         9.4
  A(I)              28.1         9.8         9.3         9.3         9.2
  V(I)              4.91       14.03       14.77       14.75       15.02

X STA.         9.4        10.6        11.8        13.1        14.5        15.7
  A(I)               9.4         9.6         9.5         9.9         9.6
  V(I)             14.59       14.43       14.44       13.88       14.42

X STA.        15.7        17.0        18.1        19.3        20.4        21.5
  A(I)               9.6         9.6         9.4         9.1         9.3
  V(I)             14.33       14.43       14.74       15.15       14.89

X STA.        21.5        22.6        23.6        24.7        25.7        29.8
  A(I)               9.0         8.9         8.9         9.1        28.8
  V(I)             15.29       15.50       15.41       15.22        4.79

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     216.   24048.    26.    42.                        3546.
   495.40          216.   24048.    26.    42.  1.00     0.    30.   3546.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      15.

         WSEL     LEW     REW    AREA         K         Q    VEL
       501.03    -9.3    82.6    75.9    1810.     350.   4.61

X STA.        -9.3        -2.0         0.1         1.9         3.7         5.6
  A(I)               4.7         3.0         2.9         2.8         3.0
  V(I)              3.71        5.87        6.04        6.16        5.87

X STA.         5.6         7.6         9.7        11.8        14.1        15.4
  A(I)               3.0         3.1         3.1         3.2         1.8
  V(I)              5.80        5.70        5.64        5.43        9.90

X STA.        15.4        16.4        18.5        20.7        23.0        25.5
  A(I)               1.3         2.8         2.8         2.9         3.0
  V(I)             13.48        6.25        6.26        6.10        5.77

X STA.        25.5        28.0        30.9        34.0        37.4        82.6
  A(I)               3.0         3.2         3.3         3.4        19.7
  V(I)              5.88        5.54        5.30        5.18        0.89

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      56.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     703.   77309.    66.    76.                       13050.
             2      12.     245.    27.    27.                          43.
   501.11          715.   77554.    93.   103.  1.02   -15.    78.  11135.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      56.

         WSEL     LEW     REW    AREA         K         Q    VEL
       501.11   -14.7    78.0   714.9   77554.    3100.   4.34

X STA.       -14.7        -2.1         0.6         3.0         5.3         7.7
  A(I)              90.3        31.6        29.8        28.7        30.2
  V(I)              1.72        4.91        5.20        5.40        5.13

X STA.         7.7        10.0        12.4        14.7        17.0        19.3
  A(I)              29.1        29.3        29.6        29.4        29.7
  V(I)              5.32        5.29        5.23        5.27        5.21

X STA.        19.3        21.6        23.9        26.2        28.5        30.7
  A(I)              29.7        29.7        29.2        29.9        29.0
  V(I)              5.23        5.21        5.31        5.19        5.35

X STA.        30.7        33.1        35.4        38.0        40.7        78.0
  A(I)              29.9        29.5        30.5        30.9        88.9
  V(I)              5.18        5.26        5.08        5.02        1.74
```

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        U.S. Geological Survey WSPRO Input File shar014.wsp
        Hydraulic analysis for structure SHARTH00040014   Date: 30-JAN-98
        TH 4 CROSSING BROAD BROOK IN SHARON, VT      RLB
           *** RUN DATE & TIME: 02-11-98  11:57

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     225.   18624.     0.    68.                           0.
  495.99           225.   18624.     0.    68.  1.00     0.    30.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.99     0.0    29.8   225.4   18624.    3361.  14.91

X STA.         0.0        4.5        5.9        7.0        8.2        9.4
  A(I)            28.1        9.8        9.3        9.3        9.2
  V(I)            5.99      17.10      18.00      17.97      18.30

X STA.         9.4       10.6       11.8       13.1       14.5       15.7
  A(I)             9.4        9.6        9.5        9.9        9.6
  V(I)           17.78      17.58      17.60      16.92      17.58

X STA.        15.7       17.0       18.1       19.3       20.4       21.5
  A(I)             9.6        9.6        9.4        9.1        9.3
  V(I)           17.46      17.59      17.96      18.47      18.15

X STA.        21.5       22.6       23.6       24.7       25.7       29.8
  A(I)             9.0        8.9        8.9        9.1       28.8
  V(I)           18.64      18.89      18.78      18.55       5.83

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      15.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.71   -13.2    98.7   148.3    4840.     818.   5.52

X STA.       -13.2       -2.3        0.4        2.9        5.6        8.3
  A(I)            10.3        5.9        5.8        5.9        6.0
  V(I)            3.99       6.98       7.08       6.94       6.78

X STA.         8.3       11.2       14.1       17.1       20.3       22.8
  A(I)             6.0        6.1        6.2        6.3        4.8
  V(I)            6.78       6.74       6.55       6.49       8.56

X STA.        22.8       25.0       28.2       31.7       35.3       39.3
  A(I)             4.2        5.9        6.2        6.2        6.5
  V(I)            9.83       6.90       6.60       6.61       6.30

X STA.        39.3       43.8       48.9       55.1       63.7       98.7
  A(I)             6.9        7.2        7.9        9.6       24.5
  V(I)            5.94       5.68       5.17       4.27       1.67

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      56.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     748.   85068.    66.    76.                       14264.
             2      40.    1332.    47.    48.                         209.
  501.79           788.   86401.   114.   124.  1.06   -15.    99.  11433.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      56.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.79   -15.2    98.6   788.4   86401.    4150.   5.26

X STA.       -15.2       -2.0        0.7        3.1        5.5        7.9
  A(I)           100.2       32.8       32.1       31.7       31.6
  V(I)            2.07       6.32       6.47       6.55       6.57

X STA.         7.9       10.3       12.6       15.0       17.4       19.7
  A(I)            31.3       31.5       31.8       32.1       31.4
  V(I)            6.63       6.59       6.52       6.46       6.60

X STA.        19.7       22.1       24.5       26.8       29.1       31.4
  A(I)            32.2       32.3       31.7       31.1       31.7
  V(I)            6.44       6.42       6.54       6.67       6.54

X STA.        31.4       33.8       36.3       39.0       41.9       98.6
  A(I)            32.1       32.6       32.9       35.3      109.9
  V(I)            6.47       6.37       6.31       5.88       1.89
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        U.S. Geological Survey WSPRO Input File shar014.wsp
        Hydraulic analysis for structure SHARTH00040014   Date: 30-JAN-98
        TH 4 CROSSING BROAD BROOK IN SHARON, VT     RLB
           *** RUN DATE & TIME: 02-11-98  11:57

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     225.   18624.     0.    68.                          0.
   495.99          225.   18624.     0.    68.  1.00     0.    30.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.99     0.0    29.8   225.4   18624.    2480.  11.00

X STA.         0.0        4.5        5.9        7.0        8.2        9.4
  A(I)            28.1        9.8        9.3        9.3        9.2
  V(I)            4.42      12.62      13.28      13.26      13.50

X STA.         9.4       10.6       11.8       13.1       14.5       15.7
  A(I)             9.4        9.6        9.5        9.9        9.6
  V(I)           13.12      12.97      12.98      12.48      12.97

X STA.        15.7       17.0       18.1       19.3       20.4       21.5
  A(I)             9.6        9.6        9.4        9.1        9.3
  V(I)           12.88      12.98      13.25      13.63      13.39

X STA.        21.5       22.6       23.6       24.7       25.7       29.8
  A(I)             9.0        8.9        8.9        9.1       28.8
  V(I)           13.75      13.94      13.86      13.69       4.31

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     193.   20633.    26.    40.                       3022.
   494.53          193.   20633.    26.    40.  1.00     0.    30.   3022.

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      56.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     595.   59772.    64.    73.                      10262.
   499.44          595.   59772.    64.    73.  1.00   -13.    51.  10262.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      56.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.44   -13.4    50.9   594.6   59772.    2480.   4.17

X STA.       -13.4       -2.0        0.7        3.0        5.3        7.6
  A(I)            71.3       26.6       25.2       25.0       25.0
  V(I)            1.74       4.67       4.91       4.96       4.97

X STA.         7.6        9.9       12.2       14.5       16.7       19.0
  A(I)            24.7       24.9       25.2       25.0       25.3
  V(I)            5.02       4.98       4.93       4.96       4.90

X STA.        19.0       21.2       23.5       25.7       27.8       29.9
  A(I)            25.1       25.2       24.7       24.3       24.5
  V(I)            4.93       4.92       5.01       5.11       5.07

X STA.        29.9       32.2       34.5       37.0       39.5       50.9
  A(I)            25.4       24.9       25.7       25.9       70.9
  V(I)            4.89       4.99       4.83       4.79       1.75
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File shar014.wsp
        Hydraulic analysis for structure SHARTH00040014   Date: 30-JAN-98
        TH 4 CROSSING BROAD BROOK IN SHARON, VT     RLB
           *** RUN DATE & TIME: 02-11-98  11:57

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

EXITX:XS   ******   -13.     360.  1.15 *****  496.05  493.11   3100.  494.90
      -36. ******    50.   30242.  1.00 ***** *******    0.63    8.60

FULLV:FV      36.   -14.     391.  0.98  0.34  496.38 *******   3100.  495.40
        0.    36.    51.   33856.  1.00  0.00   -0.01    0.57    7.94
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      56.   -11.     376.  1.06  0.53  496.96 *******   3100.  495.90
       56.    56.    49.   30234.  1.00  0.04    0.01    0.58    8.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   494.66     498.97     499.10     495.78

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

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

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

BRIDG:BR      36.     0.     225.  2.33 *****  498.32  494.07   2758.  495.99
        0. ******    30.   18624.  1.00 ***** *******    0.78   12.24

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.500  0.000  495.78 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.    33.  0.05  0.30  501.36    0.00    350.  501.03

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    145.    25.    -9.    15.   1.6   1.2   5.6   4.7   1.6   3.0
   RT:    205.    67.    15.    83.   1.4   0.7   4.5   4.5   1.0   3.0

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

APPRO:AS      14.   -15.     715.  0.30  0.10  501.41  493.80   3100.  501.11
       56.    17.    78.   77606.  1.02  0.90    0.00    0.28    4.33

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

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD     LEW     REW       Q         K      AREA      VEL    WSEL
   EXITX:XS     -36.    -13.     50.   3100.   30242.      360.     8.60  494.90
   FULLV:FV       0.    -14.     51.   3100.   33856.      391.     7.94  495.40
   BRIDG:BR       0.      0.     30.   2758.   18624.      225.    12.24  495.99
   RDWAY:RG      15.*******    145.    350.*****************     2.00  501.03
   APPRO:AS      56.    -15.     78.   3100.   77606.      715.     4.33  501.11

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF     HO   VHD      EGL    WSEL
   EXITX:XS     493.11    0.63  486.21  510.80************  1.15   496.05  494.90
   FULLV:FV   ********    0.57  486.24  510.83   0.34   0.00  0.98   496.38  495.40
   BRIDG:BR     494.07    0.78  485.99  495.99************  2.33   498.32  495.99
   RDWAY:RG   ****************  499.40  515.13   0.05******  0.30   501.36  501.03
   APPRO:AS     493.80    0.28  487.97  515.29   0.10   0.90  0.30   501.41  501.11
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        U.S. Geological Survey WSPRO Input File shar014.wsp
        Hydraulic analysis for structure SHARTH00040014   Date: 30-JAN-98
        TH 4 CROSSING BROAD BROOK IN SHARON, VT     RLB
           *** RUN DATE & TIME: 02-11-98  11:57

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

EXITX:XS   ******   -15.     444.  1.36 *****  497.54  494.18   4150.  496.18
      -36. ******    53.   40476.  1.00 ***** *******    0.64    9.35

FULLV:FV      36.   -16.     478.  1.17  0.34  497.88 *******   4150.  496.71
        0.    36.    54.   44940.  1.00  0.00    0.00    0.58    8.67
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      56.   -12.     453.  1.31  0.54  498.48 *******   4150.  497.17
       56.    56.    49.   39965.  1.00  0.07    0.00    0.59    9.17
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   496.71      495.78

            <<<<<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      36.     0.     225.  3.46 *****  499.45  495.11   3361.  495.99
        0. ******    30.   18624.  1.00 ***** *******    0.96   14.91

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  495.78 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.    33.  0.08  0.46  502.17    0.01    818.  501.71

           Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    282.    29.   -13.    16.   2.3   1.7   6.8   5.7   2.2   3.1
   RT:    536.    83.    16.    99.   2.0   1.2   5.9   5.4   1.7   3.0

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

APPRO:AS      14.   -15.     788.  0.46  0.14  502.25  494.84   4150.  501.79
       56.    17.    99.   86375.  1.06  0.90    0.01    0.36    5.27

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

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -36.   -15.    53.   4150.   40476.     444.     9.35  496.18
   FULLV:FV       0.   -16.    54.   4150.   44940.     478.     8.67  496.71
   BRIDG:BR       0.     0.    30.   3361.   18624.     225.    14.91  495.99
   RDWAY:RG      15.*******   282.    818.******************     2.00  501.71
   APPRO:AS      56.   -15.    99.   4150.   86375.     788.     5.27  501.79

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    494.18    0.64  486.21  510.80************  1.36  497.54  496.18
   FULLV:FV  ********    0.58  486.24  510.83  0.34  0.00  1.17  497.88  496.71
   BRIDG:BR    495.11    0.96  485.99  495.99************  3.46  499.45  495.99
   RDWAY:RG  ****************  499.40  515.13  0.08******  0.46  502.17  501.71
   APPRO:AS    494.84    0.36  487.97  515.29  0.14  0.90  0.46  502.25  501.79
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        U.S. Geological Survey WSPRO Input File shar014.wsp
        Hydraulic analysis for structure SHARTH00040014   Date: 30-JAN-98
        TH 4 CROSSING BROAD BROOK IN SHARON, VT     RLB
           *** RUN DATE & TIME: 02-11-98  11:57

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

EXITX:XS   ******   -12.     308.  1.01 *****  495.04  492.38   2480.  494.03
      -36. ******    48.   24187.  1.00 ***** *******    0.62    8.06

FULLV:FV      36.   -12.     336.  0.85  0.33  495.38 *******   2480.  494.53
        0.    36.    49.   27418.  1.00  0.00    0.00    0.55    7.38
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      56.   -10.     325.  0.91  0.52  495.94 *******   2480.  495.03
       56.    56.    48.   24258.  1.00  0.03    0.01    0.57    7.64
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   493.58     497.37     497.52     495.78

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

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

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

BRIDG:BR      36.     0.     225.  1.86 *****  497.85  493.54   2463.  495.99
        0. ******    30.   18624.  1.00 ***** *******    0.70   10.93

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.494  0.000  495.78 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.        <<<<<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      14.   -13.     594.  0.27  0.09  499.71  493.12   2480.  499.44
       56.    17.    51.   59753.  1.00  0.89   -0.01    0.24    4.17

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   499.38

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -36.   -12.    48.   2480.   24187.     308.    8.06  494.03
   FULLV:FV       0.   -12.    49.   2480.   27418.     336.    7.38  494.53
   BRIDG:BR       0.     0.    30.   2463.   18624.     225.   10.93  495.99
   RDWAY:RG      15.**************       0.       0.       0.    2.00********
   APPRO:AS      56.   -13.    51.   2480.   59753.     594.    4.17  499.44

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    492.38    0.62  486.21  510.80************  1.01  495.04  494.03
   FULLV:FV   ********    0.55  486.24  510.83  0.33  0.00  0.85  495.38  494.53
   BRIDG:BR    493.54    0.70  485.99  495.99************  1.86  497.85  495.99
   RDWAY:RG  ****************  499.40  515.13************  0.27  499.65********
   APPRO:AS    493.12    0.24  487.97  515.29  0.09  0.89  0.27  499.71  499.44
```
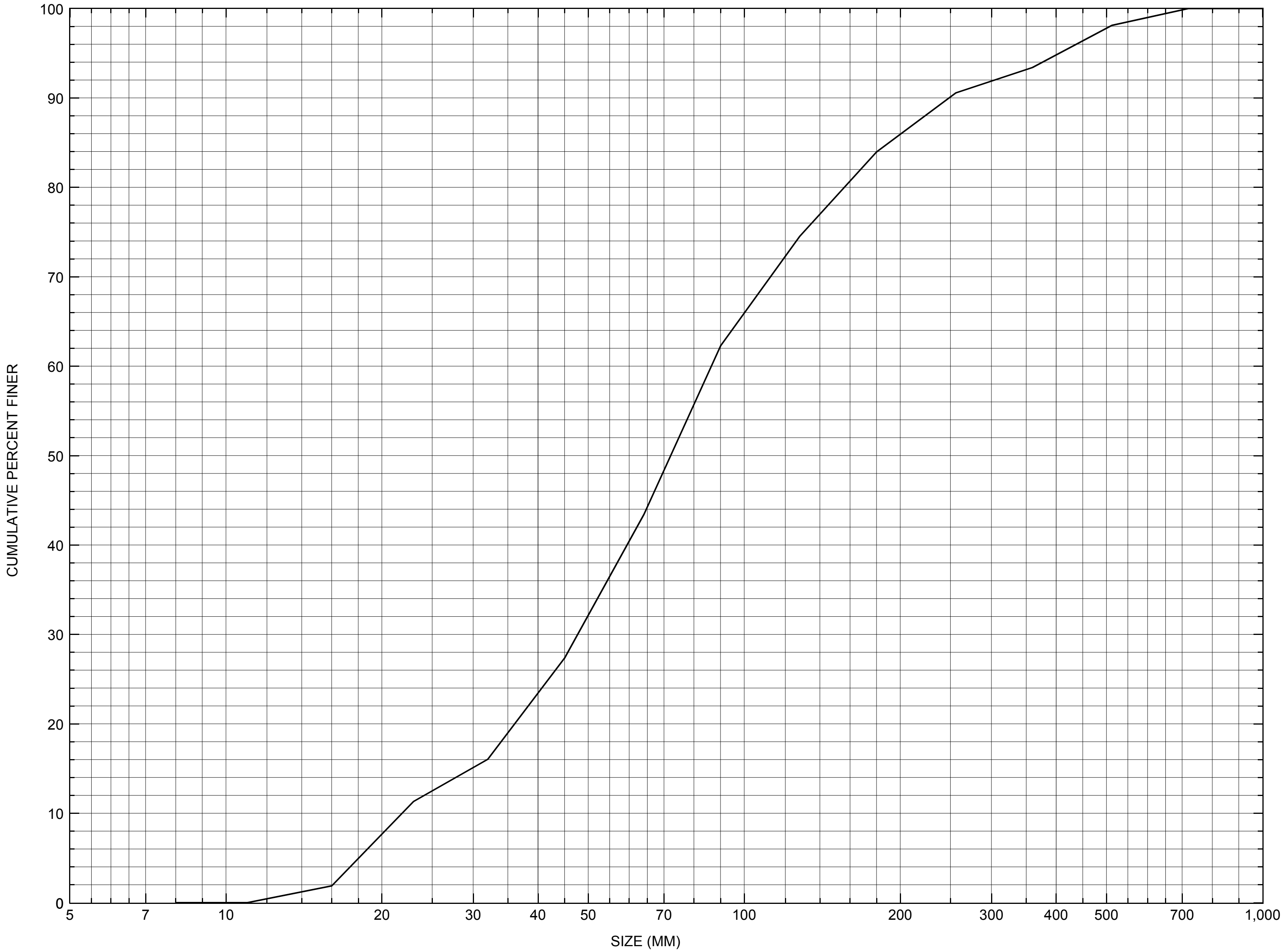

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure SHARTH00040014, in Sharon, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number SHARTH00040014

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 23 / 95

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

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

Town *(FIPS place code; I - 4; nnnnn)* 63775

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

Waterway *(I - 6)* BROAD BROOK

Road Name *(I - 7):* -

Route Number TH004

Vicinity *(I - 9)* 0.5 MI JCT TH 4 + TH 34

Topographic Map South Royalton

Hydrologic Unit Code: 01080105

Latitude *(I - 16; nnnn.n)* 43467

Longitude *(i - 17; nnnnn.n)* 72301

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10141700141417

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

Maximum span length *(I - 48; nnnn)* 0030

Year built *(I - 27; YYYY)* 1928

Structure length *(I - 49; nnnnnn)* 000034

Average daily traffic, ADT *(I - 29; nnnnnn)* 000125

Deck Width *(I - 52; nn.n)* 233

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

Channel & Protection *(I - 61; n)* 5

Opening skew to Roadway *(I - 34; nn)* 35

Waterway adequacy *(I - 71; n)* 5

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

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

Structure type *(I - 43; nnn)* 104

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*) 009.0

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

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

Comments:

The structural inspection report of 6/22/94 indicates the structure is a concrete T-beam bridge. Both abutment walls are noted as concrete. The right abutment has a vertical crack and minor spalling just above the footing. The footing is noted as slightly in view at the upstream end. While the left abutment also has a vertical settlement crack and minor spalling, the report notes the wall is relatively clean. There is a newer concrete subfooting below the original footing, under the area where the settlement crack appears in the wall. The new subfooting now is cracked below the crack in the original footing and abutment wall. The settling problem at the downstream end appears to be stabilized. **(Continued, page 33)**

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:

The wingwalls are concrete and in good condition. A stone retaining wall extends from the upstream end of the upstream right wingwall. The waterway is noted as making a moderate bend into the crossing with most of the flow directed into the left abutment. The streambed at the downstream end of the left abutment is up to 2 feet below the top of the subfooting. There is no apparent undermining. The streambed consists of stone and gravel with some boulders. A bedrock outcrop is evident about 300 feet upstream.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **15.94** mi^2

Lake/pond/swamp area **0** mi^2

Watershed storage *(ST)* **0** %

Bridge site elevation **580** ft

Headwater elevation **1958** ft

Main channel length **7.67** mi

10% channel length elevation **660** ft

85% channel length elevation **1280** ft

Main channel slope *(S)* **109.52** 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*)? **VTAOT**

Comments: **The station and low chord to bed differences are taken from a sketch dated 6/22/94 that is attached to a bridge inspection report. The low chord elevation is from the 7/11/96 survey done for this report. This section is the upstream bridge face.**

Station	0	1	1.01	2	2.01	7	15	30	-	-	-
Feature	LAB	-	-	-	-	-	-	RAB	-	-	-
Low chord elevation	495.57	495.58	495.58	495.60	495.60	495.67	495.78	495.99	-	-	-
Bed elevation	488.17	488.18	487.18	487.20	486.60	486.24	486.78	487.59	-	-	-
Low chord to bed	7.4	7.4	8.4	8.4	9.0	9.4	9.0	8.4	-	-	-
Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

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

Comments: -
-

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **10/03/96**

Computerized by: **RB** Date: **10/03/96**

Reviewd by: **RB** Date: **2/17/98**

Structure Number **SHARTH00040014**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M. WEBER** Date *(MM/DD/YY)* **04** / **11** / 19**95**

2. Highway District Number **04** Mile marker **0000**

County **WINDSOR (027)** Town **SHARON (63775)**

Waterway *(I - 6)* **BROAD BROOK** Road Name **-**

Route Number **TH 4** Hydrologic Unit Code: **01080105**

3. Descriptive comments:

Located 0.5 miles to the junction of TH 4 and TH34. The DS concrete bridge rail reads, “DOWNER” and “1928”.

B. Bridge Deck Observations

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

5. Ambient water surface... US **2** UB **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 **34** *(feet)* Span length **30** *(feet)* Bridge width **23.3** *(feet)*

Road approach to bridge:

8. LB **0** 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	0	-	3	2
RBUS	5	1	2	1
RBDS	2	1	2	2
LBDS	2	2	2	1

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

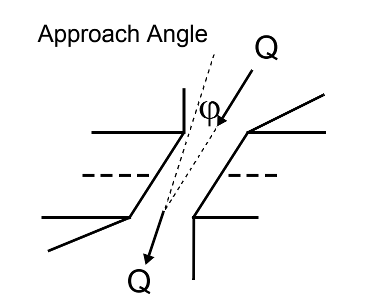
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

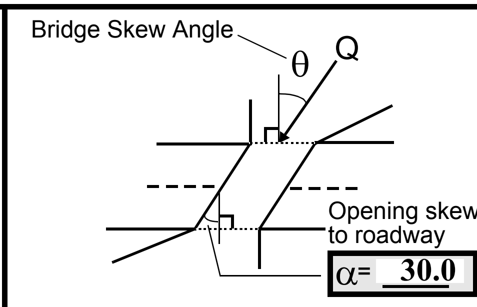
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

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

Channel approach to bridge (BF):

15. Angle of approach: **5** 16. Bridge skew: **45**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **20** feet **US** *(US, UB, DS)* to **0** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **20** feet **US** *(US, UB, DS)* to **10** feet **DS**

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

18. Bridge Type: **1a/4**

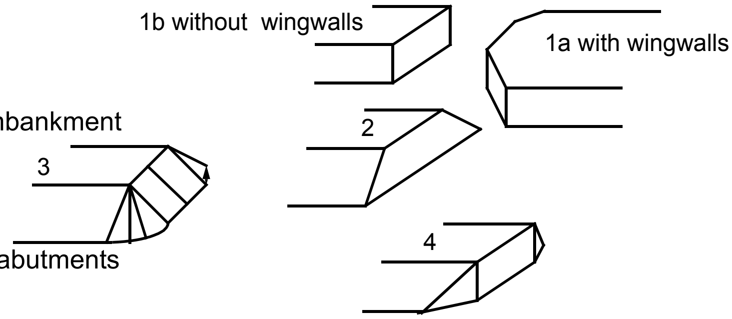
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4. The road follows the stream valley on the DS left bank and the US right bank. The pasture on the US right bank begins at 100 ft US and the forest on the DS left bank begins at 80 ft DS.
7. Values are from the VTAOT files. Measured bridge length is 34 ft, span length is 31 ft, and the width is 23 ft.
18. The US right wingwall is type 1a and the US left wingwall is type 4.
11. The US right road approach protection is a drywall extension of the wingwall. Other noted road approach protection is sparse coverage at the wingwall ends.
13. The US left road approach channel erosion and road wash has undermined the US end of the US left wingwall.
17. Impact zone 1 on the right bank is at the US right wingwall. The channel is wider US than under the bridge and water is flowing into the wingwall. Another impact zone is DS on the right bank from 70 ft DS to 170 ft DS. It is moderately severe.

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
33.0	**5.5**			**5.0**	**4**	**1**	**2**	**2**	**3**	**0**

23. Bank width **45.0** 24. Channel width **35.0** 25. Thalweg depth **58.0** 29. Bed Material **3**

30 .Bank protection type: LB **0** RB **0** 31. 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*

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

29. Bed material is gravel, cobble, sand and boulder. There is bedrock in the channel US at 100 ft US.
27. Bank material is sand, gravel, cobble and boulder.
A small inflow enters at 60 ft US on the left bank.

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

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

37. Material: -

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

NO POINT BARS

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

41. Mid-bank distance: 85 42. Cut bank extent: 60 feet US (US, UB) to 100 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.):

Many trees are leaning into the channel and their roots are undercut. There is also some erosion at 20 ft US at the end of the US left wingwall. There is a very large slip failure from 250 ft US to 350 ft US on the left bank where clay and gravel are exposed.

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
45.5		0.5		2	7	7	-

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

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

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

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

3

63. Bed material is gravel, sand, cobbles and boulders.

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

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

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

70. Debris and Ice Comments:

1

There are some logs in the channel US as well as many trees leaning into the channel from the US left cut bank. The channel width under the bridge is 75% of the bank full width US. There is also a large slip failure far US on the left bank which wiped out several trees, some of which are still lying on the steep bank.

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		15	80	2	2	1.5	2.5	90.0
RABUT	1	-	80			2	2	26.0

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.):

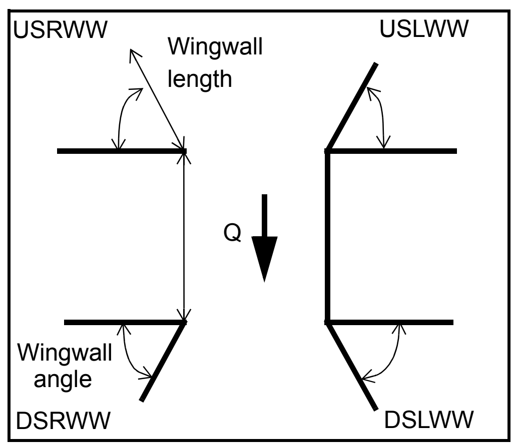
0.5
1.5
1

There are two footings on the left abutment and the exposure depth above refers to the lower footing. The left abutment lower footing is exposed most of the base length, but scour is deepest at the DS end. The higher footing is exposed the entire abutment length. The right abutment footing is exposed at the US end.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						26.0	
USRWW:	Y		1		2	1.5	
DSLWW:	0		0.5		Y	32.0	
DSRWW:	1		2		0.5	29.0	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	1.5	2	Y	-	-	-	-	-
Condition	Y	1.5	1	-	-	-	-	-
Extent	1	2.5	0	0	0	0	0	-

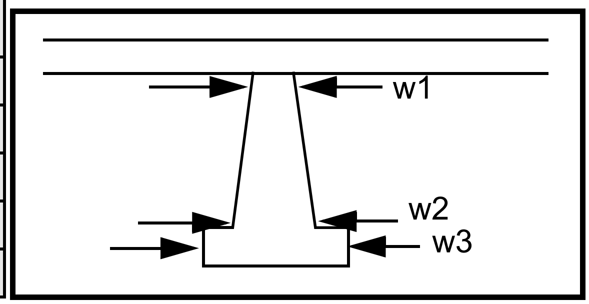
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
2
2
3
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			5.0	110.0	22.0	19.0
Pier 2		9.5		15.0	70.0	10.0
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e US	foot-	for	is 1	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	left	ing	the	ft	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	wing	and	lowe	abov	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	wall	the	r	e the	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	expo	DS	foot-	lowe	*Y- yes; N- no*
91. Attack ∠ (BF)	sure	left	ing.	r	
92. Pushed	dept	wing	The	foot-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	h is	wall	high	ing	
95. Cross-members	for	expo	er	top.	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	the	sure	foot-	On	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	high	dept	ing	the	
98. Exposure depth	er	h is	top	DS	

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

left wingwall the footing is only exposed at the US end. The entire US left wingwall footing is exposed. The US right wingwall footing is exposed at the DS end.

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: 1______

Scour dimensions: Length 4_____ Width 2_____ Depth: 2_____ Positioned 0____ %LB to 3____ %RB

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

3
0
0
-

Are there major confluences? -____ *(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 less near the bridge but increases to between 76% and 100% at 80 ft DS. The bed material is gravel, cobbles, sand and boulders. The bank material is sand, gravel, cobble and boulder. A drainage ditch enters

F. Geomorphic Channel Assessment

107. Stage of reach evolution at____

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)*:

25 ft DS on the right bank.

109. G. Plan View Sketch

N

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: SHARTH00040014 Town: SHARON
Road Number: TH 4 County: WINDSOR
Stream: BROAD BROOK

Initials RLB Date: 2/11/98 Checked: ECW

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	3100	4150	2480
Main Channel Area, ft2	703	748	595
Left overbank area, ft2	0	0	0
Right overbank area, ft2	12	40	0
Top width main channel, ft	66	66	64
Top width L overbank, ft	0	0	0
Top width R overbank, ft	27	47	0
D50 of channel, ft	0.237	0.237	0.237
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	10.7	11.3	9.3
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	0.4	0.9	ERR
Total conveyance, approach	77554	86401	59772
Conveyance, main channel	77309	85068	59772
Conveyance, LOB	0	0	0
Conveyance, ROB	245	1332	0
Percent discrepancy, conveyance	0.0000	0.0012	0.0000
Qm, discharge, MC, cfs	3090.2	4086.0	2480.0
Ql, discharge, LOB, cfs	0.0	0.0	0.0
Qr, discharge, ROB, cfs	9.8	64.0	0.0
Vm, mean velocity MC, ft/s	4.4	5.5	4.2
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	0.8	1.6	ERR
Vc-m, crit. velocity, MC, ft/s	10.3	10.4	10.1
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	3100	4150	2480
(Q) discharge thru bridge, cfs	2758	3361	2480
Main channel conveyance	18624	18624	18624
Total conveyance	18624	18624	18624
Q2, bridge MC discharge,cfs	2758	3361	2480
Main channel area, ft2	225	225	225
Main channel width (normal), ft	25.8	25.8	25.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25.8	25.8	25.8
y_bridge (avg. depth at br.), ft	8.72	8.72	8.72
Dm, median (1.25*D50), ft	0.29625	0.29625	0.29625
y2, depth in contraction,ft	9.61	11.38	8.77
ys, scour depth (y2-ybridge), ft	0.89	2.66	0.05

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	2758	3361	2480
Main channel area (DS), ft2	216	225	193
Main channel width (normal), ft	25.8	25.8	25.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	25.8	25.8	25.8
D90, ft	0.8149	0.8149	0.8149
D95, ft	1.3314	1.3314	1.3314
Dc, critical grain size, ft	0.7044	0.9480	0.7478
Pc, Decimal percent coarser than Dc	0.127	0.084	0.116
Depth to armoring, ft	14.53	31.01	17.10

Pressure Flow Scour (contraction scour for orifice flow conditions)

Chang pressure flow equation   Hb+Ys=Cq*qbr/Vc
Cq=1/Cf*Cc   Cf=1.5*Fr^0.43 (<=1)   Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
Umbrell pressure flow equation
(Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031
(Richardson and Davis, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	3100	4150	2480
Q, thru bridge MC, cfs	2758	3361	2480
Vc, critical velocity, ft/s	10.29	10.40	10.06
Va, velocity MC approach, ft/s	4.40	5.46	4.17
Main channel width (normal), ft	25.8	25.8	25.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25.8	25.8	25.8
qbr, unit discharge, ft2/s	106.9	130.3	96.1
Area of full opening, ft2	225.0	225.0	225.0
Hb, depth of full opening, ft	8.72	8.72	8.72
Fr, Froude number, bridge MC	0.78	0.96	0.7
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	216	N/A	193
**Hb, depth at downstream face, ft	8.37	N/A	7.48
**Fr, Froude number at DS face	0.78	ERR	0.83
**Cf, for downstream face (<=1.0)	1.00	N/A	1.00
Elevation of Low Steel, ft	495.78	495.78	495.78
Elevation of Bed, ft	487.06	487.06	487.06
Elevation of Approach, ft	501.11	501.79	499.44
Friction loss, approach, ft	0.1	0.14	0.09
Elevation of WS immediately US, ft	501.01	501.65	499.35
ya, depth immediately US, ft	13.95	14.59	12.29
Mean elevation of deck, ft	499.68	499.68	499.68
w, depth of overflow, ft (>=0)	1.33	1.97	0.00
Cc, vert contrac correction (<=1.0)	0.90	0.90	0.91
**Cc, for downstream face (<=1.0)	0.891661	ERR	0.859735
Ys, scour w/Chang equation, ft	2.76	5.13	1.75
Ys, scour w/Umbrell equation, ft	-0.06	1.27	-0.76

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

**Ys, scour w/Chang equation, ft	3.28	N/A	3.63

**Ys, scour w/Umbrell equation, ft	0.29	N/A	0.48

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

y2, from Laursen's equation, ft	9.61	11.38	8.77
WSEL at downstream face, ft	495.40	--	494.53
Depth at downstream face, ft	8.37	N/A	7.48
Ys, depth of scour (Laursen), ft	1.24	N/A	1.29

Abutment Scour

Froehlich's Abutment Scour

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

(Richardson and Davis, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	3100	4150	2480	3100	4150	2480
a', abut.length blocking flow, ft	16.7	17.2	15.4	50.2	70.8	23.1
Ae, area of blocked flow ft2	131.72	135.06	112.14	222.19	219.98	197.3
Qe, discharge blocked abut.,cfs	--	--	318.09	--	--	744
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.87	3.51	2.84	3.94	4.66	3.77
ya, depth of f/p flow, ft	7.89	7.85	7.28	4.43	3.11	8.54
--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	120	120	120	60	60	60
K2	1.04	1.04	1.04	0.95	0.95	0.95
Fr, froude number f/p flow	0.175	0.209	0.185	0.313	0.405	0.227
ys, scour depth, ft	15.15	16.03	14.22	15.36	15.23	17.91

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)	16.7	17.2	15.4	50.2	70.8	23.1
y1 (depth f/p flow, ft)	7.89	7.85	7.28	4.43	3.11	8.54
a'/y1	2.12	2.19	2.11	11.34	22.79	2.70
Skew correction (p. 49, fig. 16)	1.07	1.07	1.07	0.90	0.90	0.90
Froude no. f/p flow	0.18	0.21	0.19	0.31	0.41	0.23

Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.78	0.96	0.83	0.78	0.96	0.83
y, depth of flow in bridge, ft	8.37	8.72	7.48	8.37	8.72	7.48
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	3.15	ERR	ERR	3.15	ERR	ERR
Fr>0.8 (vertical abut.)	ERR	3.61	2.97	ERR	3.61	2.97