LEVEL II SCOUR ANALYSIS FOR BRIDGE 20 (SHELTH00220020) on TOWN HIGHWAY 22, crossing BLACK CREEK, SHELDON, VERMONT

Open-File Report 98-422

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 20 (SHELTH00220020) on TOWN HIGHWAY 22, crossing BLACK CREEK, SHELDON, VERMONT

By RONDA L. BURNS and SCOTT A. OLSON

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Pembroke, New Hampshire

1998

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

U.S. GEOLOGICAL SURVEY
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Box 25286
Denver, CO 80225-0286

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 20 (SHELTH00220020) ON TOWN HIGHWAY 22, CROSSING BLACK CREEK, SHELDON, VERMONT

By **Ronda L. Burns and Scott A. Olson**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure SHELTH00220020 on Town Highway 22 crossing Black Creek, Sheldon, 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 Green Mountain section of the New England physiographic province in northwestern Vermont. The 120-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture upstream of the bridge, though the immediate right bank has a few trees. Downstream of the bridge is the Missisquoi River.

In the study area, Black Creek has a sinuous channel with a slope of approximately 0.0007 ft/ft, an average channel top width of 110 ft and an average bank height of 9 ft. The channel bed material ranges from silt and clay to sand with a median grain size (D_{50}) of 1.02 mm (0.003 ft). However, there is stone fill material in the channel under the bridge that ranges from gravel to boulder and extends from the approach cross section to the exit cross section. The geomorphic assessment at the time of the Level I and Level II site visit on July 13, 1995, indicated that the reach was stable.

The Town Highway 22 crossing of Black Creek is an 82-ft-long, one-lane bridge consisting of one 79-foot steel thru-truss span (Vermont Agency of Transportation, written communication, March 8, 1995). The opening length of the structure parallel to the bridge face is 73.5 ft. The bridge is supported by vertical, concrete abutments with wingwalls on the left abutment. The channel is skewed approximately 15 degrees to the opening while the computed opening-skew-to-roadway is 5 degrees.

It was observed during the Level I assessment that the left abutment footing is exposed 3 ft and undermined at the upstream end. The scour protection measures at the site included type-1 stone fill (less than 12 inches diameter) along the right abutment and downstream right bank and type-2 stone fill (less than 36 inches diameter) along the upstream right bank and at the downstream end of the upstream 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 0.3 to 7.7 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge, which was less than the 100-year discharge. Abutment scour ranged from 15.7 to 22.1 ft for the left and from 5.8 to 10.2 ft for the right abutment. 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.

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.

LEVEL II SUMMARY

Structure Number SHELTH00220020 ***Stream*** Black Creek

County Franklin ***Road*** TH 22 ***District*** 8

Description of Bridge

Bridge length 82 ***ft*** ***Bridge width*** 11.8 ***ft*** ***Max span length*** 79 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 7/13/95

Description of stone fill Type-1, along the right abutment. Type-2, at the downstream end of the upstream left wingwall.

The left abutment and wingwalls and the right abutment are concrete. The left abutment footing is exposed 3 ft and undermined at the upstream end.

Yes 15

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

There is a mild 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*
	7/13/95	0	0
Level I	7/13/95	0	0
Level II			

Potential for debris Low.

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

The Missisquoi River is immediately downstream of the bridge, as observed on 7/13/95.

Description of the Geomorphic Setting

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

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

Date of inspection 7/13/95

DS left: Missisquoi River

DS right: Missisquoi River

US left: Moderately sloped channel bank and overbank

US right: Steep channel bank to a narrow flood plain

Description of the Channel

Average top width 110 *ft*

Average depth 9 *ft*

Predominant bed material Silt/Clay

Bank material Sand/Gravel

Sinuous but stable with alluvial channel boundaries.

7/13/95

Vegetative co N/A

DS left: Shrubs and brush

DS right: Grass

US left: Few trees with grass on the overbank

US right:

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

None observed on 7/13/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 120 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None.

Is there a USGS gage on the stream of interest? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No However, Black Creek enters the Missisquoi River immediately downstream of the bridge.

Calculated Discharges

Q100 9,700 ***ft³/s*** ***Q500*** 14,000 ***ft³/s***

The 100- and 500-year discharges are based on flood frequency estimates available from the VTAOT database (written communication, May 1995) for this site. 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 concrete backwall (elev. 502.26 ft, arbitrary survey datum). RM2 is the high point on a knob of a bedrock outcrop located on the left bank 200 ft from the bridge (elev. 507.56 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	-20	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	10	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. The channel "n" value for the reach was 0.045, and overbank "n" values ranged from 0.045 to 0.047.

The Missisquoi River is immediately downstream of the bridge and an exit section could not be surveyed. However, WSPRO bridge routines require an exit so the approach geometry was used.

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 0.00071 ft/ft, which was estimated from upstream contour lines on the topographic map (U.S. Geological Survey, 1986). There is a possibility of backwater from the Missisquoi River if peaks at the confluence occur simultaneously. Assuming normal depth as the starting water surface will provide the worst-case scour scenario for each modeled discharge.

The surveyed approach section (APPRO) was modelled 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 499.1 ***ft***
Average low steel elevation 497.4 ***ft***

100-year discharge 9,700 ***ft^3/s***
Water-surface elevation in bridge opening 493.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,540 ***ft^3/s***
Area of flow in bridge opening 1,023 ***ft^2***
Average velocity in bridge opening 8.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.5 ***ft/s***

Water-surface elevation at Approach section with bridge 494.2 ***ft***
Water-surface elevation at Approach section without bridge 493.4 ***ft***
Amount of backwater caused by bridge 0.8 ***ft***

500-year discharge 14,000 ***ft^3/s***
Water-surface elevation in bridge opening 495.3 ***ft***
Road overtopping? Yes ***Discharge over road*** 7,350 ***ft^3/s***
Area of flow in bridge opening 1,189 ***ft^2***
Average velocity in bridge opening 5.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 7.4 ***ft/s***

Water-surface elevation at Approach section with bridge 495.8 ***ft***
Water-surface elevation at Approach section without bridge 495.3 ***ft***
Amount of backwater caused by bridge 0.5 ***ft***

Incipient overtopping discharge 7,680 ***ft^3/s***
Water-surface elevation in bridge opening 491.3 ***ft***
Area of flow in bridge opening 901 ***ft^2***
Average velocity in bridge opening 8.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.3 ***ft/s***

Water-surface elevation at Approach section with bridge 492.6 ***ft***
Water-surface elevation at Approach section without bridge 492.0 ***ft***
Amount of backwater caused by bridge 0.6 ***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. For this site, only the 100-year scour depths are shown in figure 8 since they are deeper than the 500-year scour depths.

Contraction scour for the 100-year, 500-year and incipient roadway-overtopping discharges was computed by use of the Laursen live-bed contraction scour equation (Richardson and Davis, 1995, p. 30, equation 17). Variables for the Laursen equation include the discharge in the channel at the approach and at the bridge and the bottom width of the channel at the approach and at the bridge.

Abutment scour for the left 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 right 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.

The median grain size (D50) used for the contraction scour and armoring analysis was based on a sieve analysis of the natural bed material. During the Level I site visit, it was observed that stone fill exists in the channel under the bridge.

Scour Results

Contraction scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	7.4	0.3	7.7
Clear-water scour	--	--	--
Depth to armoring	N/A	1.8	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	19.1	22.1	15.7
Right abutment	7.2	10.2	5.8
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	500-year discharge (D_{50} in feet)	Incipient overtopping discharge
Abutments:			
Left abutment	1.7	1.0	1.7
Right abutment	1.7	1.0	1.7
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

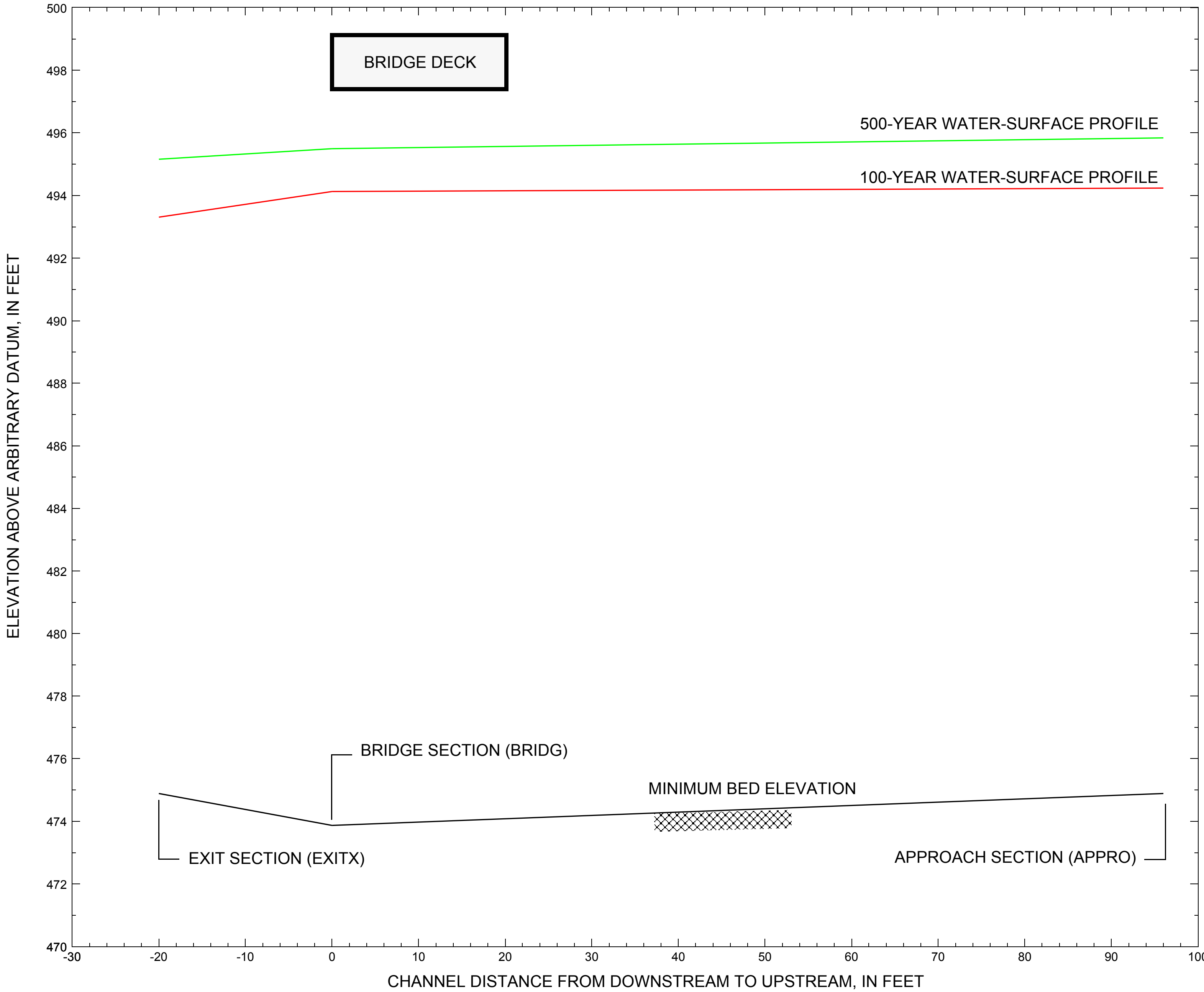

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure SHELTH00220020 on Town Highway 22, crossing Black Creek, Sheldon, Vermont.

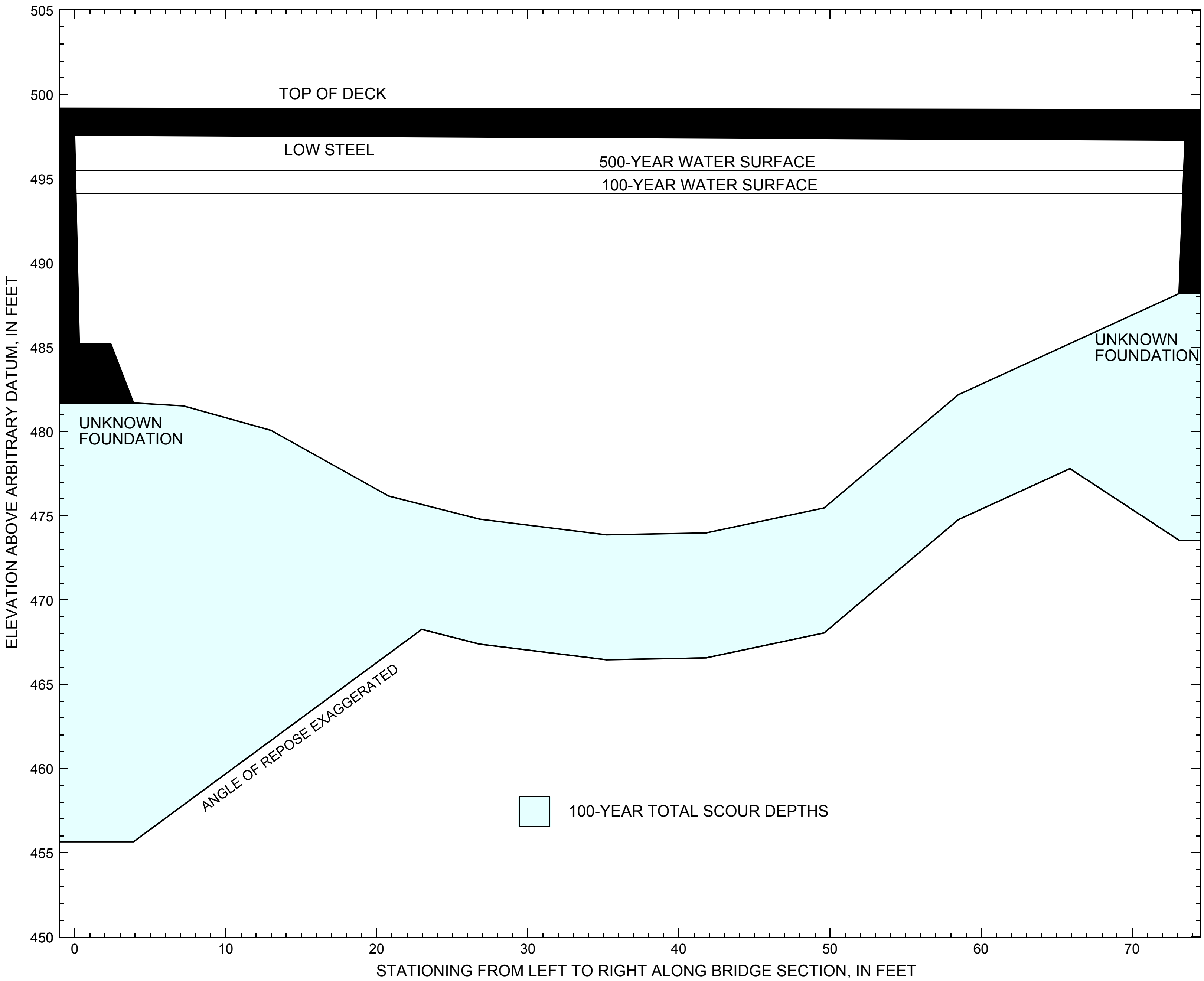

Figure 8. Scour elevations for the 100- and 500-year discharges at structure SHELTH00220020 on Town Highway 22, crossing Black Creek, Sheldon, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure SHELTH00220020 on Town Highway 22, crossing Black Creek, Sheldon, 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 9,700 cubic-feet per second											
Left abutment	0.0	--	497.6	--	481.7	7.4	19.1	--	26.5	455.2	--
Right abutment	73.5	--	497.3	--	488.2	7.4	7.2	--	14.6	473.6	--

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 SHELTH00220020 on Town Highway 22, crossing Black Creek, Sheldon, 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 14,000 cubic-feet per second											
Left abutment	0.0	--	497.6	--	481.7	0.3	22.1	--	22.4	459.3	--
Right abutment	73.5	--	497.3	--	488.2	0.3	10.2	--	10.5	477.7	--

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, 1986, Sheldon Springs, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File shel020.wsp
T2        Hydraulic analysis for structure SHELTH00220020   Date: 30-SEP-97
T3        Hydraulic analysis of Sheldon bridge 20 over Black Creek
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           9700 14000 7680
SK          0.00071 0.00071 0.00071
*
*           The Missisquoi River is immediately downstream of the
*           bridge and an exit section could not be surveyed. However,
*           WSPRO bridge routines require an exit so the approach
*           geometry was used.
*
XS   EXITX     -20
GR         -159.3, 507.03   -125.1, 495.81    -83.0, 487.44    -23.0, 490.38
GR            0.0, 489.01     10.2, 482.16     21.0, 478.12     54.9, 474.89
GR           63.4, 475.05     77.6, 476.05     88.9, 476.54     96.3, 478.17
GR          100.6, 482.21    110.4, 488.51    121.6, 491.58    246.6, 492.18
GR          444.4, 492.87    594.4, 493.97    609.0, 503.30
N           0.045        0.045        0.047
SA                   0.0        110.4
*
XS   FULLV      0  * * *   0.0000
*
BR   BRIDG     0 497.44 5
GR            0.0, 497.58      0.3, 485.19      2.4, 485.18      3.9, 482.15
GR            3.9, 481.70      7.2, 481.52     13.0, 480.06     20.8, 476.16
GR           26.8, 474.80     35.2, 473.87     41.8, 473.98     49.6, 475.46
GR           54.0, 478.76     58.5, 482.19     73.1, 488.19     73.5, 497.29
GR            0.0, 497.58
N             0.045
CD           1 25 * * 10 26
*
XR   RDWAY     10 12 2
GR         -446.0, 496.21   -289.0, 492.56   -140.1, 493.37    -61.5, 496.35
GR          -14.8, 499.34      0.0, 499.18     72.2, 499.09    121.8, 495.45
GR          175.2, 493.30    269.1, 493.60    380.1, 493.88    455.2, 494.44
GR          606.8, 504.05
*
AS   APPRO     96
GR         -180.3, 507.03   -146.1, 495.81   -104.0, 487.44    -44.0, 490.38
GR          -21.0, 489.01    -10.8, 482.16      0.0, 478.12     33.9, 474.89
GR           42.4, 475.05     56.6, 476.05     67.9, 476.54     75.3, 478.17
GR           79.6, 482.21     89.4, 488.51    100.6, 491.58    225.6, 492.18
GR          423.4, 492.87    573.4, 493.97    588.0, 503.30
N           0.045        0.045        0.047
SA                 -21.0         89.4
*
HP 1 BRIDG    493.00 1 493.00
HP 2 BRIDG    493.00 * * 8159
HP 2 RDWAY    494.13 * * 1541
HP 1 APPRO    494.24 1 494.24
HP 2 APPRO    494.24 * * 9700
*
HP 1 BRIDG    495.27 1 495.27
HP 2 BRIDG    495.27 * * 6646
HP 2 RDWAY    495.50 * * 7354
HP 1 APPRO    495.84 1 495.84
HP 2 APPRO    495.84 * * 14000
*
HP 1 BRIDG    491.33 1 491.33
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
      U.S. Geological Survey WSPRO Input File shel020.wsp
      Hydraulic analysis for structure SHELTH00220020   Date: 30-SEP-97
      Hydraulic analysis of Sheldon bridge 20 over Black Creek
         *** RUN DATE & TIME: 12-08-97  14:51

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

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1    1023.  168267.    73.    92.                        21742.
 493.00         1023.  168267.    73.    92.  1.00     0.    73.  21742.

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

     WSEL     LEW     REW    AREA        K        Q    VEL
   493.00     0.1    73.3  1023.0  168267.    8159.   7.98

X STA.        0.1       12.9       16.3       19.2       21.8       24.1
  A(I)          137.7       47.1       44.4       42.7       39.8
  V(I)           2.96       8.65       9.20       9.56      10.25

X STA.       24.1       26.4       28.5       30.7       32.8       34.9
  A(I)           40.5       38.8       39.6       39.7       40.2
  V(I)          10.06      10.52      10.30      10.29      10.16

X STA.       34.9       37.0       39.1       41.1       43.2       45.3
  A(I)           39.7       39.7       38.7       39.1       39.0
  V(I)          10.26      10.28      10.55      10.45      10.45

X STA.       45.3       47.5       49.7       52.6       56.2       73.3
  A(I)           39.0       39.8       46.1       50.8      140.7
  V(I)          10.46      10.24       8.85       8.03       2.90

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

     WSEL     LEW     REW    AREA        K        Q    VEL
   494.13  -356.5   413.6   354.0    9973.    1541.   4.35

X STA.     -356.5     -305.8     -295.9     -287.7     -280.0     -271.9
  A(I)           29.9       12.8       12.2       11.9       12.1
  V(I)           2.57       6.01       6.30       6.47       6.35

X STA.     -271.9     -263.3     -254.4     -244.6     -234.6     -224.0
  A(I)           12.5       12.5       13.2       13.0       13.3
  V(I)           6.15       6.15       5.84       5.91       5.80

X STA.     -224.0     -213.2     -201.0     -187.2     -171.0     -151.9
  A(I)           12.8       13.7       14.5       15.7       16.8
  V(I)           6.02       5.61       5.30       4.91       4.59

X STA.     -151.9      181.6      206.9      236.6      276.6      413.6
  A(I)           30.8       19.4       20.2       22.9       43.6
  V(I)           2.50       3.97       3.81       3.37       1.77

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

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     541.   49383.   117.   118.                         6589.
           2    1746.  350374.   110.   117.                        39406.
           3     804.   35725.   484.   485.                         5881.
 494.24         3091.  435483.   712.   720.  1.69  -138.   574.  28130.

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

     WSEL     LEW     REW    AREA        K        Q    VEL
   494.24  -138.2   573.8  3091.0  435483.    9700.   3.14

X STA.     -138.2      -84.3      -34.2       -5.5        1.7        7.8
  A(I)          241.0      235.8      221.1      110.1      101.8
  V(I)           2.01       2.06       2.19       4.40       4.77

X STA.        7.8       13.6       19.1       24.4       29.6       34.4
  A(I)           99.8       97.7       95.5       96.6       93.0
  V(I)           4.86       4.97       5.08       5.02       5.21

X STA.       34.4       39.3       44.2       49.2       54.3       59.7
  A(I)           94.8       94.2       93.9       95.2       96.9
  V(I)           5.12       5.15       5.17       5.09       5.00

X STA.       59.7       65.1       70.7       77.9      173.5      573.8
  A(I)           96.7       99.8      113.8      337.3      576.2
  V(I)           5.02       4.86       4.26       1.44       0.84
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     U.S. Geological Survey WSPRO Input File shel020.wsp
     Hydraulic analysis for structure SHELTH00220020   Date: 30-SEP-97
     Hydraulic analysis of Sheldon bridge 20 over Black Creek
        *** RUN DATE & TIME: 12-08-97  14:51

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

  WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
          1    1189.  209300.    73.    97.                        27205.
495.27         1189.  209300.    73.    97.  1.00     0.    73.  27205.

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

     WSEL     LEW     REW    AREA        K        Q    VEL
   495.27     0.1    73.4  1188.7  209300.    6646.   5.59

X STA.        0.1       12.9       16.2       19.1       21.7       24.1
  A(I)          167.4       52.6       50.4       48.3       46.2
  V(I)           1.99       6.32       6.60       6.88       7.20

X STA.       24.1       26.4       28.6       30.8       33.0       35.2
  A(I)           46.0       45.7       45.7       45.7       46.2
  V(I)           7.22       7.27       7.27       7.27       7.19

X STA.       35.2       37.3       39.5       41.6       43.8       45.9
  A(I)           46.1       46.1       44.9       45.2       45.2
  V(I)           7.20       7.21       7.40       7.35       7.35

X STA.       45.9       48.2       50.6       53.6       57.6       73.4
  A(I)           45.3       47.4       54.1       60.0      160.1
  V(I)           7.34       7.01       6.14       5.54       2.08

 VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

     WSEL     LEW     REW    AREA        K        Q    VEL
   495.50  -415.5   471.9  1180.6   55484.    7354.   6.23

X STA.     -415.5     -318.2     -299.4     -284.4     -269.0     -253.3
  A(I)          110.0       46.7       42.7       44.2       43.8
  V(I)           3.34       7.87       8.61       8.32       8.40

X STA.     -253.3     -236.5     -218.6     -199.5     -178.8     -157.4
  A(I)           45.5       46.7       47.8       49.6       48.7
  V(I)           8.08       7.88       7.68       7.42       7.55

X STA.     -157.4     -136.1      173.1      200.3      227.4      255.6
  A(I)           45.9      107.2       58.9       56.2       56.1
  V(I)           8.01       3.43       6.25       6.54       6.55

X STA.      255.6      285.9      318.5      353.4      392.0      471.9
  A(I)           57.5       59.1       60.5       63.0       90.7
  V(I)           6.39       6.22       6.08       5.84       4.05

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

  WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
          1     735.   78734.   125.   126.                        10097.
          2    1923.  411418.   110.   117.                        45534.
          3    1581.  109796.   487.   488.                        16171.
495.84         4239.  599947.   723.   731.  1.69  -146.   576.  44861.

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

     WSEL     LEW     REW    AREA        K        Q    VEL
   495.84  -146.2   576.3  4238.7  599947.   14000.   3.30

X STA.     -146.2      -88.4      -48.6       -9.3        0.1        7.4
  A(I)          302.8      264.8      292.2      150.5      131.4
  V(I)           2.31       2.64       2.40       4.65       5.33

X STA.        7.4       14.2       20.8       27.0       33.0       38.8
  A(I)          129.2      126.7      124.2      123.9      122.0
  V(I)           5.42       5.52       5.64       5.65       5.74

X STA.       38.8       44.8       50.8       57.0       63.5       70.1
  A(I)          124.0      121.9      125.0      126.6      127.1
  V(I)           5.64       5.74       5.60       5.53       5.51

X STA.       70.1       78.8      141.2      243.6      366.4      576.3
  A(I)          151.7      347.4      391.1      415.5      540.8
  V(I)           4.61       2.02       1.79       1.68       1.29
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        U.S. Geological Survey WSPRO Input File shel020.wsp
        Hydraulic analysis for structure SHELTH00220020   Date: 30-SEP-97
        Hydraulic analysis of Sheldon bridge 20 over Black Creek
           *** RUN DATE & TIME: 12-08-97  14:51

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     901.  139637.    73.    89.                      17995.
   491.33          901.  139637.    73.    89.  1.00     0.    73.  17995.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.33     0.2    73.2   901.3  139637.    7680.   8.52

X STA.        0.2       13.1       16.6       19.5       22.0       24.3
  A(I)          118.8       43.1       38.8       37.5       35.8
  V(I)           3.23       8.91       9.91      10.25      10.74

X STA.       24.3       26.4       28.5       30.6       32.6       34.7
  A(I)           34.9       34.8       34.8       34.9       35.3
  V(I)          11.01      11.04      11.03      11.01      10.87

X STA.       34.7       36.7       38.7       40.7       42.7       44.7
  A(I)           35.0       35.0       34.1       34.5       34.5
  V(I)          10.97      10.99      11.27      11.14      11.13

X STA.       44.7       46.8       49.0       51.5       54.9       73.2
  A(I)           34.4       35.1       38.1       44.5      127.6
  V(I)          11.15      10.93      10.08       8.63       3.01

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     354.   25634.   109.   110.                       3623.
             2    1564.  291599.   110.   117.                      33403.
             3     141.    3030.   254.   254.                        599.
   492.59         2059.  320263.   473.   481.  1.33  -130.   343.  21173.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.59  -129.9   343.1  2059.4  320263.    7680.   3.73

X STA.     -129.9      -71.3       -7.6       -0.3        5.2       10.3
  A(I)          208.9      251.4       95.2       80.7       78.1
  V(I)           1.84       1.53       4.03       4.76       4.91

X STA.       10.3       15.3       20.1       24.6       28.9       33.2
  A(I)           78.4       76.6       74.8       74.3       73.8
  V(I)           4.90       5.01       5.14       5.17       5.20

X STA.       33.2       37.3       41.5       45.8       50.1       54.6
  A(I)           73.9       73.6       73.8       75.1       74.6
  V(I)           5.20       5.22       5.20       5.12       5.15

X STA.       54.6       59.1       63.8       68.5       73.7      343.1
  A(I)           75.5       76.2       75.6       80.2      288.5
  V(I)           5.08       5.04       5.08       4.79       1.33
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        U.S. Geological Survey WSPRO Input File shel020.wsp
        Hydraulic analysis for structure SHELTH00220020   Date: 30-SEP-97
        Hydraulic analysis of Sheldon bridge 20 over Black Creek
           *** RUN DATE & TIME: 12-08-97  14:51

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

EXITX:XS   ******  -113.    2460.  0.36 *****  493.67  484.05   9700.  493.31
      -20. ******   504.  363715.  1.51 ***** *******    0.43    3.94

FULLV:FV      20.  -113.    2479.  0.36  0.01  493.70 *******   9700.  493.34
        0.    20.   508.  365761.  1.52  0.00    0.01    0.43    3.91
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      96.  -134.    2534.  0.35  0.07  493.78 *******   9700.  493.43
       96.    96.   499.  371778.  1.54  0.00    0.01    0.42    3.83
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   494.49       0.00     492.53     492.56

 ===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      20.     0.    1023.  1.35  0.03  494.35  485.99   8159.  493.00
        0.    20.    73.  168186.  1.36  0.65    0.00    0.44    7.98

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.856 ******  497.44 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    84.  0.04  0.26  494.45    0.00   1541.  494.13

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1036.   237.  -357.  -120.   1.6   1.0   5.0   4.4   1.3   2.9
   RT:    506.   259.   155.   414.   0.8   0.5   3.8   4.2   0.8   2.8

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

APPRO:AS      71.  -138.    3089.  0.26  0.09  494.50  484.05   9700.  494.24
       96.    84.   574.  435167.  1.69  0.06    0.00    0.35    3.14

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.884  0.310  300215.    -2.    72. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS     -20.  -113.   504.   9700.  363715.    2460.    3.94  493.31
   FULLV:FV       0.  -113.   508.   9700.  365761.    2479.    3.91  493.34
   BRIDG:BR       0.     0.    73.   8159.  168186.    1023.    7.98  493.00
   RDWAY:RG      10.******* 1036.   1541.*****************    2.00  494.13
   APPRO:AS      96.  -138.   574.   9700.  435167.    3089.    3.14  494.24

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -2.    72.  300215.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS     484.05    0.43  474.89  507.03************  0.36  493.67  493.31
   FULLV:FV   ********    0.43  474.89  507.03  0.01  0.00  0.36  493.70  493.34
   BRIDG:BR     485.99    0.44  473.87  497.58  0.03  0.65  1.35  494.35  493.00
   RDWAY:RG   ****************  492.56  504.05  0.04******  0.26  494.45  494.13
   APPRO:AS     484.05    0.35  474.89  507.03  0.09  0.06  0.26  494.50  494.24
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        U.S. Geological Survey WSPRO Input File shel020.wsp
        Hydraulic analysis for structure SHELTH00220020   Date: 30-SEP-97
        Hydraulic analysis of Sheldon bridge 20 over Black Creek
           *** RUN DATE & TIME: 12-08-97  14:51

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

EXITX:XS   ******  -122.    3752.  0.37 *****  495.54  486.05  14000.  495.16
      -20. ******   596.  525295.  1.71 ***** *******    0.38    3.73

FULLV:FV      20.  -122.    3773.  0.37  0.01  495.56 *******  14000.  495.19
        0.    20.   596.  528404.  1.71  0.00    0.01    0.37    3.71
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      96.  -143.    3836.  0.35  0.07  495.64 *******  14000.  495.28
       96.    96.   575.  537733.  1.71  0.00    0.01    0.36    3.65
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   497.68       0.00     493.98     492.56

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                  QRD,QRDMAX,RATIO =     7354.      6582.     1.12

            <<<<<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      20.     0.    1189.  0.76  0.02  496.03  484.76   6646.  495.27
        0.    20.    73.  209269.  1.56  0.47    0.00    0.31    5.59

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.800 ******  497.44 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    84.  0.05  0.28  496.09    0.00   7354.  495.50

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   3952.   332.  -416.   -84.   2.9   1.9   7.2   6.3   2.5   3.1
   RT:   3402.   351.   121.   472.   2.2   1.6   6.7   6.1   2.2   3.0

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

APPRO:AS      71.  -146.    4241.  0.29  0.08  496.13  486.05  14000.  495.84
       96.    89.   576.  600242.  1.69  0.03    0.00    0.31    3.30

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.898  0.421  347208.     2.    75. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -20.  -122.   596.  14000.  525295.    3752.    3.73  495.16
   FULLV:FV       0.  -122.   596.  14000.  528404.    3773.    3.71  495.19
   BRIDG:BR       0.     0.    73.   6646.  209269.    1189.    5.59  495.27
   RDWAY:RG      10.******* 3952.   7354.       0.       0.    2.00  495.50
   APPRO:AS      96.  -146.   576.  14000.  600242.    4241.    3.30  495.84

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       2.    75.  347208.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF     HO   VHD      EGL     WSEL
   EXITX:XS     486.05    0.38  474.89  507.03************  0.37  495.54  495.16
   FULLV:FV   ********    0.37  474.89  507.03  0.01  0.00  0.37  495.56  495.19
   BRIDG:BR     484.76    0.31  473.87  497.58  0.02  0.47  0.76  496.03  495.27
   RDWAY:RG   ****************  492.56  504.05  0.05******  0.28  496.09  495.50
   APPRO:AS     486.05    0.31  474.89  507.03  0.08  0.03  0.29  496.13  495.84
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        U.S. Geological Survey WSPRO Input File shel020.wsp
        Hydraulic analysis for structure SHELTH00220020   Date: 30-SEP-97
        Hydraulic analysis of Sheldon bridge 20 over Black Creek
           *** RUN DATE & TIME: 12-08-97  14:51

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

EXITX:XS   ******  -106.    1808.  0.34 *****  492.27  482.99   7680.  491.93
      -20. ******   194.  287938.  1.21 ***** *******    0.34    4.25

FULLV:FV      20.  -106.    1816.  0.34  0.01  492.29 *******   7680.  491.96
        0.    20.   200.  289106.  1.22  0.00    0.01    0.34    4.23
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      96.  -127.    1842.  0.33  0.07  492.37 *******   7680.  492.04
       96.    96.   196.  292877.  1.23  0.00    0.01    0.34    4.17
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   492.59       0.00     491.33     492.56

 ===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      20.     0.     901.  1.38  0.03  492.70  485.64   7680.  491.33
        0.    20.    73.  139561.  1.22  0.40   -0.01    0.47    8.52

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.905 ******  497.44 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD      EGL      ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<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      71.  -130.    2060.  0.29  0.10  492.88  482.99   7680.  492.59
       96.    76.   343.  320304.  1.33  0.08    0.02    0.36    3.73

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.774  0.200  255613.    -1.    72. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -20.  -106.   194.   7680.  287938.    1808.    4.25  491.93
   FULLV:FV       0.  -106.   200.   7680.  289106.    1816.    4.23  491.96
   BRIDG:BR       0.     0.    73.   7680.  139561.     901.    8.52  491.33
   RDWAY:RG      10.**************      0.       0.       0.    2.00********
   APPRO:AS      96.  -130.   343.   7680.  320304.    2060.    3.73  492.59

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -1.    72.  255613.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    482.99    0.34  474.89  507.03************  0.34  492.27  491.93
   FULLV:FV  ********    0.34  474.89  507.03  0.01  0.00  0.34  492.29  491.96
   BRIDG:BR    485.64    0.47  473.87  497.58  0.03  0.40  1.38  492.70  491.33
   RDWAY:RG  ***************  492.56  504.05  0.05******  0.29  492.83********
   APPRO:AS    482.99    0.36  474.89  507.03  0.10  0.08  0.29  492.88  492.59
```
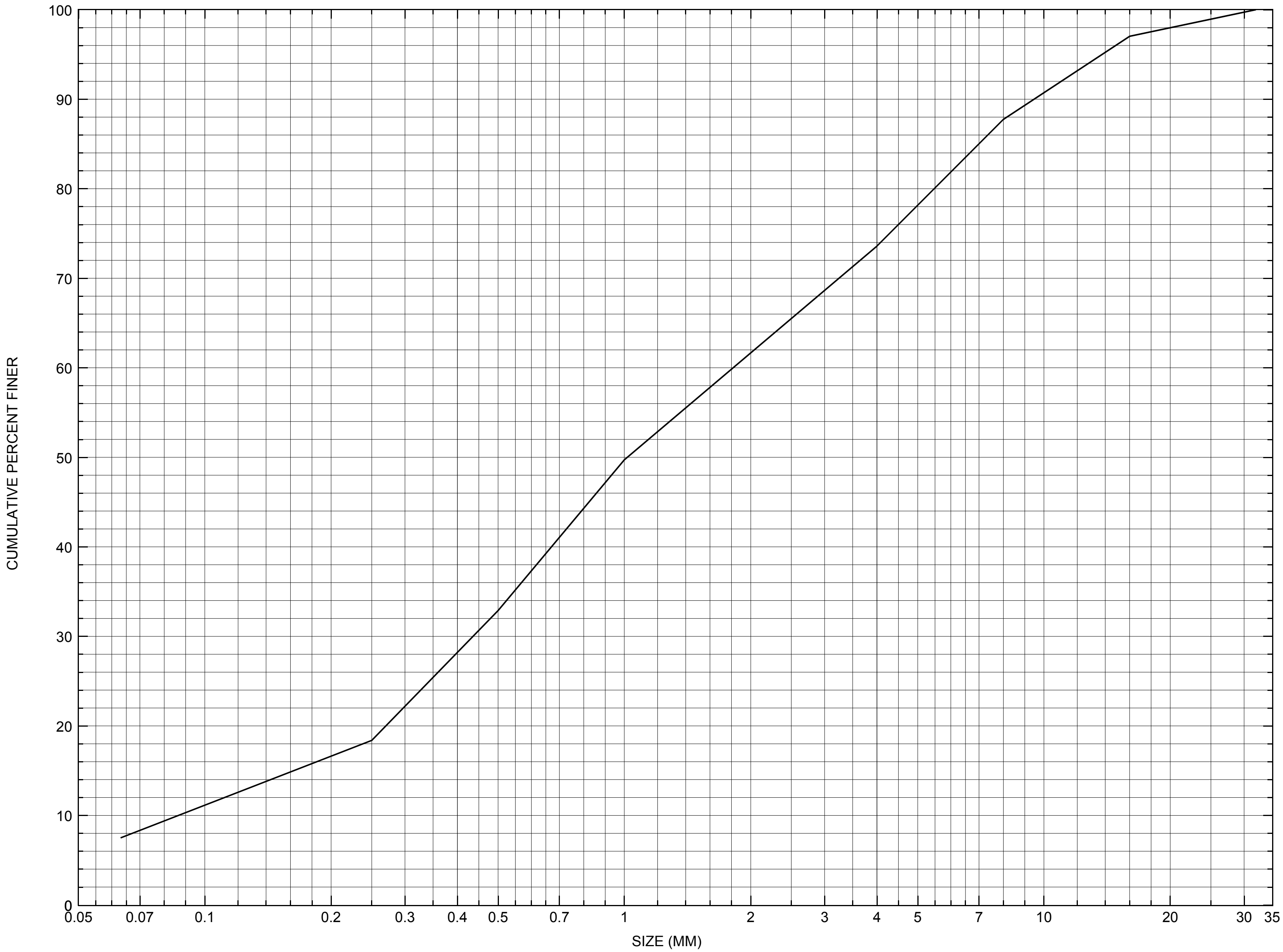

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure SHELTH00220020, in Sheldon, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number SHELTH00220020

General Location Descriptive

Data collected by *(First Initial, Full last name)* L. MEDALIE

Date *(MM/DD/YY)* 03 / 08 / 95

Highway District Number *(I - 2; nn)* 08

County *(FIPS county code; I - 3; nnn)* 011

Town *(FIPS place code; I - 4; nnnnn)* 64600

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

Waterway *(I - 6)* BLACK CREEK

Road Name *(I - 7):* -

Route Number TH022

Vicinity *(I - 9)* 0.1 MI TO JCT C2 TH 4

Topographic Map Sheldon Springs

Hydrologic Unit Code: 02010007

Latitude *(I - 16; nnnn.n)* 44537

Longitude *(i - 17; nnnnn.n)* 72567

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10061400200614

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

Maximum span length *(I - 48; nnnn)* 0079

Year built *(I - 27; YYYY)* 1903

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

Average daily traffic, ADT *(I - 29; nnnnnn)* 000070

Deck Width *(I - 52; nn.n)* 118

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

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

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

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

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

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

Structure type *(I - 43; nnn)* 310

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 73.5

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

Vertical clearance from streambed (*nnn.n ft*) 15

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

Waterway of full opening (*nnn.n* ft^2) 1100

Comments:

The structural inspection report of 8/1/94 indicates the structure is a steel pony thru-truss type bridge with a timber deck. The abutments and wingwalls are concrete. There are a few alligator cracks and leaks reported overall, with surface spalls and some section loss on the ends of each abutment ends and the wingwalls, especially on the left abutment. The left abutment has a 2.0 foot concrete footing, which has small voids along its bottom upstream end. Stone and boulder riprap has been placed on the embankment in front of right abutment and its wingwalls, as well as in front of upstream left wingwall. The structural inspection report of 8/26/92 indicates there has been no channel **(continued on 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:

scour around the abutments. Furthermore, there are no signs of bank erosion, and only minor gravel bars and debris. Riprap protection is reported sound at both abutments.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **119.7** mi^2 Lake/pond/swamp area **3.06** mi^2
Watershed storage *(ST)* **2.55** %
Bridge site elevation **234.56** ft Headwater elevation **1620** ft
Main channel length **22.90** mi
10% channel length elevation **354.24** ft 85% channel length elevation **520** ft
Main channel slope *(S)* **9.65** 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: 1* (*1-Spreadfooting; 2-Pile; 3- Gravity; 4-Unknown*)

If 1: Footing Thickness 2.0 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
***The footing type is inferred here from descriptions provided in the structural inspection reports.**

Cross-sectional Data

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

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

Comments: **This cross-section is the upstream face. The low chord elevation is from the survey log done for this report dated 7/13/95. The low chord to bed length and the station measurement data is from the sketch attached to a bridge inspection report dated 8/01/94.**

Station	0	2	2.01	12.67	29.92	38.17	46.34	54.51	73.51	-	-
Feature	LAB	-	-	-	-	-	-	-	RAB	-	-
Low chord elevation	497.58	497.57	497.57	497.53	497.46	497.43	497.40	497.36	497.29	-	-
Bed elevation	485.19	485.19	482.07	481.2	474.96	474.35	474.9	480.94	487.96	-	-
Low chord to bed	12.39	12.38	15.5	16.33	22.25	23.08	22.5	16.42	9.33	-	-
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: **3/5/96**
Computerized by: **RB** Date: **3/5/96**
Reviewd by: **RB** Date: **6/23/98**

Structure Number **SHELTH00220020**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **L. MEDALIE** Date *(MM/DD/YY)* **7** / **13** / 19**95**
2. Highway District Number **8** Mile marker **0**
County **FRANKLIN (011)** Town **SHELDON (64600)**
Waterway *(I - 6)* **BLACK CREEK** Road Name **-**
Route Number **TH022** Hydrologic Unit Code: **02010007**
3. Descriptive comments:
The bridge is located 0.1 miles to the junction with TH04.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **4** LBDS **-** RBDS **7** Overall **4**
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US **1** UB **1** DS **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 **79** *(feet)* Bridge width **11.8** *(feet)*

Road approach to bridge:

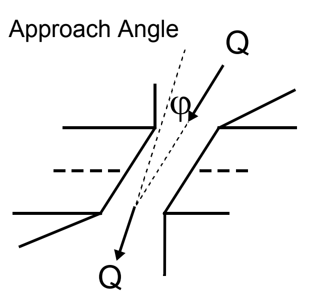
8. LB **1** RB **1** *(**0** even, **1**- lower, **2**- higher)*
9. LB **2** RB **2** *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

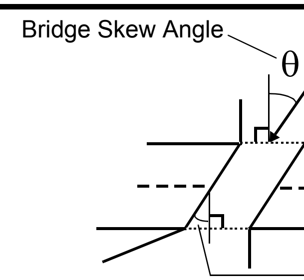
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	1	0	-
RBUS	0	-	0	-
RBDS	0	-	3	1
LBDS	1	1	2	1

*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: **0** 16. Bridge skew: **15**





Opening skew to roadway
α= **5.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **18** feet **US** *(US, UB, DS)* to **110** feet **US**
Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **17** feet **US** *(US, UB, DS)* to **50** feet **US**

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

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

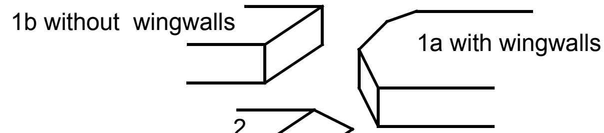
1a- Vertical abutments with wingwalls

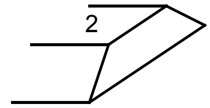
1b- Vertical abutments without wingwalls

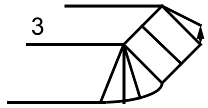
2- Vertical abutments and wingwalls, sloping embankment
Wingwalls parallel to abut. face

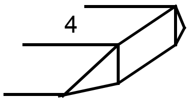
3- Spill through abutments

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. Values are from VTAOT files. Measured bridge length is 81.7 feet, span length is 79.2 feet, and the bridge width is 14.3 feet outside the steel and 11.7 feet inside the steel.
4. There is a thin strip of forest cover on the right bank DS between the road and the Missisquoi River.
8. The right road approach width is 11.5 feet at 10 feet from the bridge and widens to 27 feet at the low point, 40 feet from the bridge. The left road approach width is 11.0 feet at 10 feet from the bridge and widens to 21 feet at the low point, 50 feet from the bridge.
11. The right bank DS channel erosion of the road embankment is actually due to high water in the Missisquoi River. On the left bank DS, it is difficult to tell if the cobbles are meant for protection or are naturally occurring. All the road embankments are given some protection from the wingwalls.
18. The left abutment is type 1a and the right abutment is type 1b.

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
78.0	**7.0**			**10.5**	**1**	**3**	**2**	**234**	**1**	**1**

23. Bank width **35.0** 24. Channel width **35.0** 25. Thalweg depth **110.0** 29. Bed Material **34**

30 .Bank protection type: LB **0** RB **2** 31. Bank protection condition: LB **-** RB **1**

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

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

30. Protection along the right bank extends from the bridge to 85 feet US.
29. At the approach section there is natural stone that is gravel and cobble sized. Towards the left bank there is some more fine material.

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

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

37. Material: -

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

NO POINT BARS

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

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

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

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

NO CUT BANKS

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

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

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

NO CHANNEL SCOUR

49. Are there major confluences? Y (Y or if N type ctrl-n mc) 50. How many? 1

51. Confluence 1: Distance 250 52. Enters on RB (LB or RB) 53. Type 2 (*1*- perennial; *2*- ephemeral)

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

54. Confluence comments (eg. confluence name):

This is a minor tributary that is about 8 feet from the bottom of the channel to the top of the banks and 15 feet between the banks.

D. Under Bridge Channel Assessment

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

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
88.5		7.5		2	7	7	-

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

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

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

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

54

63. There are many boulders, but no loose sediment.

61. The right bank is a concrete abutment over natural gravel, sand, and cobbles.

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		15	90	2	3	-	3.1	90.0
RABUT	1	-	90			0	0	73.0

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

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

-

-

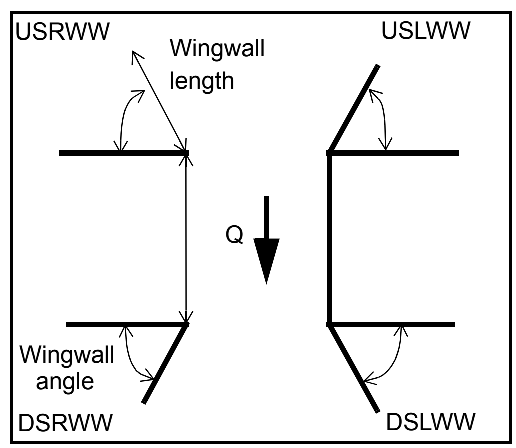
1

72. The right abutment natural bank is supplemented with stones along the concrete abutment and is at about a 35 to 45 degree angle.

74. Some undermining of the left abutment, up to 1 foot penetration, is at the US end only. The footing is 3 feet thick.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						73.0	
USRWW:	Y		1		0	8.5	
DSLWW:	-		-		N	19.0	
DSRWW:	-		-		-	23.0	



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	-	0	N	-	1	-	-	1
Condition	Y	-	-	-	3	-	-	1
Extent	1	-	-	2	0	0	1	-

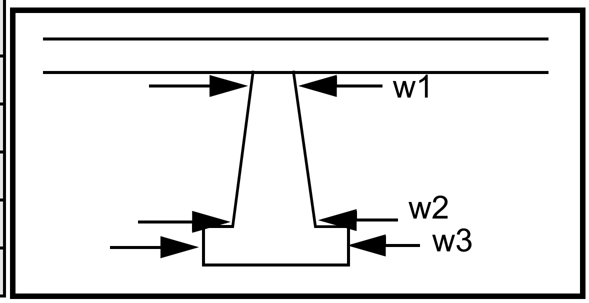
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
0
-
-
0
-
-

Piers:

84. Are there piers? **81.** *(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			--	20.0	24.5	--
Pier 2			--	30.0	25.0	--
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	The	allel to	the		*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	con-	the	cor-		***1**- Solid pier, **2**- column, **3**- bent*
88. Material	crete	road	ners		***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	wing	way	wher		***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	walls	and	e		*Y- yes; N- no*
91. Attack ∠ (BF)	on	have	they		
92. Pushed	the	type-	join		*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	right	2	the		
95. Cross-members	abut	pro-	abut	N	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	ment	tec-	ment	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	are	tion	.	-	
98. Exposure depth	par-	at		-	

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

E. Downstream Channel Assessment

100.

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

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

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

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: NO ____ Mid-bar width: PIE ____

Point bar extent: RS ____ 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? 2 ____ (Y or if N type ctrl-n cb) Where? - ____ (LB or RB) Mid-bank distance: 432 ____

Cut bank extent: - ____ feet 1 ____ (US, UB, DS) to 45 ____ feet - ____ (US, UB, DS)

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

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

-

1

There is no DS left bank because the confluence with the Missisquoi is immediately after the bridge. The right bank is only a 15 feet long strip of land before the corner with the confluence.

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

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

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

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

Confluence 1: Distance N ____ Enters on - ____ (LB or RB) Type NO ____ (1- perennial; 2- ephemeral)

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

Confluence comments (eg. confluence name):

UCTURE

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

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

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

N
-
-
-
-
-
-
-
-
-

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: SHELTH00220020 Town: Sheldon
Road Number: TH22 County: Franklin
Stream: Black Creek

Initials SAO Date: 12/8/97 Checked: MAI

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

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

Approach Section Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	9700	14000	7680
Main Channel Area, ft2	1746	1923	1564
Left overbank area, ft2	541	735	354
Right overbank area, ft2	804	1581	141
Top width main channel, ft	110	110	110
Top width L overbank, ft	117	125	109
Top width R overbank, ft	484	487	254
D50 of channel, ft	0.003331	0.003331	0.003331
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	15.9	17.5	14.2
y1, average depth, LOB, ft	4.6	5.9	3.2
y1, average depth, ROB, ft	1.7	3.2	0.6
Total conveyance, approach	435483	599947	320263
Conveyance, main channel	350374	411418	291599
Conveyance, LOB	49383	78734	25634
Conveyance, ROB	35725	109796	3030
Percent discrepancy, conveyance	0.0002	-0.0002	0.0000
Qm, discharge, MC, cfs	7804.3	9600.6	6992.6
Ql, discharge, LOB, cfs	1100.0	1837.3	614.7
Qr, discharge, ROB, cfs	795.7	2562.1	72.7
Vm, mean velocity MC, ft/s	4.5	5.0	4.5
Vl, mean velocity, LOB, ft/s	2.0	2.5	1.7
Vr, mean velocity, ROB, ft/s	1.0	1.6	0.5
Vc-m, crit. velocity, MC, ft/s	2.7	2.7	2.6
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	1	1	1
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Live-Bed Contraction Scour

Laursen’s Live Bed Contraction Scour
y2/y1 = (Q2/Q1)^(6/7)*(W1/W2)^(k1)
ys=y2-y_bridge
(Richardson and others, 1995, p. 30, eq. 17 and 18)

	Approach			Bridge		
Characteristic	100 yr	500 yr	Other Q	100 yr	500 yr	Other Q
Q1, discharge, cfs	9700	14000	7680	8159	6646	7680
Total conveyance	435483	599947	320263	168267	209300	139637
Main channel conveyance	350374	411418	291599	168267	209300	139637
Main channel discharge	7804	9601	6993	8159	6646	7680
Area - main channel, ft2	1746	1923	1564	1023	1189	901
(W1) channel width, ft	110	110	110	72.9	73	72.7
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	110	110	110	72.9	73	72.7
D50, ft	0.003331	0.003331	0.003331			
w, fall velocity, ft/s (p. 32)	0.45	0.45	0.45			
y, ave. depth flow, ft	15.87	17.48	14.22	14.03	16.29	12.39
S1, slope EGL	0.00083	0.00083	0.00083			
P, wetted perimeter, MC, ft	117	117	117			
R, hydraulic Radius, ft	14.923	16.436	13.368			
V*, shear velocity, ft/s	0.632	0.663	0.598			
V*/w	1.403	1.473	1.328			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0.64	0.64	0.64			
y2,depth in contraction, ft	21.46	16.58	20.08			
ys, scour depth, ft (y2-y_bridge)	7.42	0.29	7.69			

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	8159	6646	7680
Main channel area (DS), ft2	1023	1189	901
Main channel width (normal), ft	72.9	73	72.7
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	72.9	73.0	72.7
D90, ft	0.0311	0.0311	0.0311
D95, ft	0.0451	0.0451	0.0451
Dc, critical grain size, ft	0.0865	0.0411	0.1018

Pc, Decimal percent coarser than Dc	0.010	0.065	0.000
Depth to armoring, ft	N/A	1.77	N/A

Abutment Scour

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

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	9700	14000	7680	9700	14000	7680
a', abut.length blocking flow, ft	136	144	128	503	506	272
Ae, area of blocked flow ft2	736	891	528	906	1280	333
Qe, discharge blocked abut.,cfs	--	--	1040	--	--	598
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.23	2.69	1.97	1.41	1.88	1.80
ya, depth of f/p flow, ft	5.41	6.19	4.13	1.80	2.53	1.22
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	1	1	1
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	95	95	95	85	85	85
K2	1.01	1.01	1.01	0.99	0.99	0.99
Fr, froude number f/p flow	0.168	0.183	0.171	0.174	0.174	0.286
ys, scour depth, ft	19.08	22.12	15.65	17.54	21.67	14.35

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

a'(abut length blocked, ft)	136	144	128	503	506	272
y1 (depth f/p flow, ft)	5.41	6.19	4.13	1.80	2.53	1.22
a'/y1	25.13	23.27	31.03	279.26	200.03	222.17
Skew correction (p. 49, fig. 16)	1.01	1.01	1.01	0.98	0.98	0.98
Froude no. f/p flow	0.17	0.18	0.17	0.17	0.17	0.29
Ys w/ corr. factor K1/0.55:						
vertical	22.09	ERR	16.93	7.23	10.16	5.79
vertical w/ ww's	18.11	ERR	13.88	5.93	8.33	4.75
spill-through	12.15	ERR	9.31	3.98	5.59	3.18

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.44	0.31	0.47	0.44	0.31	0.47
y, depth of flow in bridge, ft	14.0	16.3	12.4	14.0	16.3	12.4
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.68	0.97	1.69	1.68	0.97	1.69
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr<=0.8 (spillthrough abut.)	1.46	0.84	1.48	1.46	0.84	1.48
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR