LEVEL II SCOUR ANALYSIS FOR BRIDGE 7 (WARRTH00010007) ON TOWN HIGHWAY 1 (FAS 188), CROSSING FREEMAN BROOK, WARREN, VERMONT

U.S. Geological Survey
Open-File Report 97-8

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

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By ROBERT H. FLYNN AND RONDA L. BURNS

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Pembroke, New Hampshire

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

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 7 (WARRTH00010007) ON TOWN HIGHWAY 1 (FAS 188), CROSSING FREEMAN BROOK, WARREN, VERMONT

By **Robert H. Flynn and Ronda L. Burns**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure WARRTH00010007 on Town Highway 1 crossing Freeman Brook, Warren, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province in central Vermont. The 6.45-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the predominant surface cover is grass and trees with the exception of the upstream left overbank which is forest. The banks of the channel are tree covered.

In the study area, Freeman Brook has an incised, straight channel with a slope of approximately 0.03 ft/ft, an average channel top width of 51 ft and an average channel depth of 6 ft. The predominant channel bed material ranges from gravel to bedrock with a median grain size (D_{50}) of 86.8 mm (0.285 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 22, 1996 indicated that the reach was stable.

The Town Highway 1 crossing of Freeman Brook is a 64-ft-long, two-lane bridge consisting of one 62-foot steel-beam span (Vermont Agency of Transportation, written communication, February 1, 1996). The bridge is supported by vertical, concrete abutments with spill-through slopes. The channel is skewed approximately 25 degrees to the opening while the opening-skew-to-roadway is 30 degrees.

The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) along the entire length of the left and right abutments and along the downstream channel banks. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

The computed contraction scour for all modelled flows was 0.0 feet. Abutment scour ranged from 5.3 to 8.2 ft. The worst-case abutment scour occurred at the right abutment for the incipient-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 others, 1995, p. 47). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Warren, VT. Quadrangle, 1:24,000, 1970
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 WARRTH00010007 ***Stream*** Freeman Brook

County Washington ***Road*** TH1 ***District*** 6

Description of Bridge

Bridge length 64 ***ft*** ***Bridge width*** 22 ***ft*** ***Max span length*** 62 ***ft***

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

Abutment type Spill-through ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 7/22/96

Description of stone fill Type-2, along the entire base length of the left and right abutments in good condition.

Brief description of piers/abutments Abutments are concrete. The concrete abutments are protected by large placed boulders which extend the entire base length, from the abutments to 20 feet out into the stream on both sides..

Is bridge skewed to flood flow according to Y survey? No ***Angle*** 25

However, there is a moderate (60 degrees) bend approximately 60 ft. upstream of the bridge.

7/22/96

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***
	0	0	7/22/
Level I	96	0	0
Level II	Moderate. There is some debris caught on boulders upstream.		

Potential for debris

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

A large pile of boulders upstream and a large boulder on the upstream right bank may affect flow due to debris accumulation during flood conditions (observed on 7/22/96).

Description of the Geomorphic Setting

General topography The channel is located in a narrow flood plain within a moderate relief valley setting with moderate valley wall slopes to either side.

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

Date of inspection 7/22/96

DS left: Steep channel bank to a narrow overbank.

DS right: Steep channel bank to a moderate overbank.

US left: Steep channel bank to valley wall.

US right: Steep channel bank to the road surface.

Description of the Channel

Average top width 51.0 ***ft*** ***Average depth*** 6.0 ***ft***

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

Straight and stable with non-alluvial channel boundaries and a narrow overbank area.

7/22/96

Vegetative co Short grass and brush with a few trees.

DS left: Trees and brush

DS right: Trees and brush

US left: Trees and brush with short grass.

US right:

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

The assessment of 7/22/96 noted flow conditions may be influenced by a pile of boulders on the right bank side of

Describe any obstructions in channel and date of observation.

the channel upstream. In addition, some debris is caught on boulders in the channel upstream.

Hydrology

Drainage area 6.45 ***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***: There are a few houses on the overbank areas upstream and downstream.

No

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

USGS gage description --

USGS gage number --

Gage drainage area No ***mi²***

Is there a lake/p -

-

1,800

Calculated Discharges

Q100 2,450 ***ft³/s*** ***Q500*** ***ft³/s***

The 100- and 500-year discharges are based on flood frequency estimates available from a Flood Insurance Study conducted by the Federal Emergency Management Agency (Federal Emergency Management Agency, 1977). FEMA values were selected for this analysis as these values fell within the range as determined by discharge frequency curves which were developed from empirical relationships and extended to the 500-year discharge (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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 Subtract 404.4 feet from USGS survey datum to obtain VTAOT plans' datum to the nearest tenth of a foot.

Description of reference marks used to determine USGS datum. RM1 is a chiseled "X" on the end of the downstream left curbing above the downstream end of the left abutment (elev. 501.03 ft, arbitrary survey datum). RM2 is a chiseled "X" on top of a boulder on the upstream right bank, approximately 60 ft. upstream of the right abutment and 3.5 ft. above the ground (elev. 507.33 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	-60	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APPRO	77	2	Modelled Approach section (Templated from APTEM)
APTEM	88	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.058 to 0.060, and overbank "n" values ranged from 0.039 to 0.049.

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 0.0296 ft/ft, which was estimated from surveyed thalweg and water surface points downstream of the bridge.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0449 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.4 ***ft***
Average low steel elevation 498.0 ***ft***

100-year discharge 1,800 ***ft^3/s***
Water-surface elevation in bridge opening 498.0 ***ft***
Road overtopping? Y ***Discharge over road*** 87 ***s***
Area of flow in bridge opening 265 ***ft^2***
Average velocity in bridge opening 6.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.5 ***ft/s***

Water-surface elevation at Approach section with bridge 499.3
Water-surface elevation at Approach section without bridge 497.3
Amount of backwater caused by bridge 2.0 ***t***

500-year discharge 2,450 ***ft^3/s***
Water-surface elevation in bridge opening 498.0 ***ft***
Road overtopping? Y ***Discharge over road*** 278
Area of flow in bridge opening 265 ***ft^2***
Average velocity in bridge opening 8.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.0 ***/s***

Water-surface elevation at Approach section with bridge 500.2
Water-surface elevation at Approach section without bridge 498.4
Amount of backwater caused by bridge 1.8

Incipient overtopping discharge 1,450 ***ft^3/s***
Water-surface elevation in bridge opening 495.7 ***ft***
Area of flow in bridge opening 160 ***ft^2***
Average velocity in bridge opening 9.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.0 ***ft/s***

Water-surface elevation at Approach section with bridge 498.0
Water-surface elevation at Approach section without bridge 496.7
Amount of backwater caused by bridge 1.3 ***t***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for the 100-year discharge, 500-year discharge and incipient road-overflow models. The 100- and 500-year discharges resulted in unsubmerged 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 and Richarson and others, 1995, p. 145-146) and thus, was applied to compute the contraction scour for the 100- and 500-year discharges. The results of the Chang pressure-flow scour equation and Laursen's clear-water contraction scour can be found in appendix F. In this case, the 100-year, 500-year and incipient road-overflow models all resulted in a computed contraction scour depth of 0.0 ft., using either equation.

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

Because the influence of scour processes on the spill-through embankment material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, the total scour depths were applied for the entire spill-through embankment below the elevation at the toe of each embankment and extended to the vertical concrete abutment wall as shown in figure 8.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	0.0
Depth to armoring	0.6	1.8	4.0
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	5.6	6.7	5.3
Right abutment	5.7	7.0	8.2
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	0.8	1.3	1.3
Right abutment	0.8	1.3	1.3
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

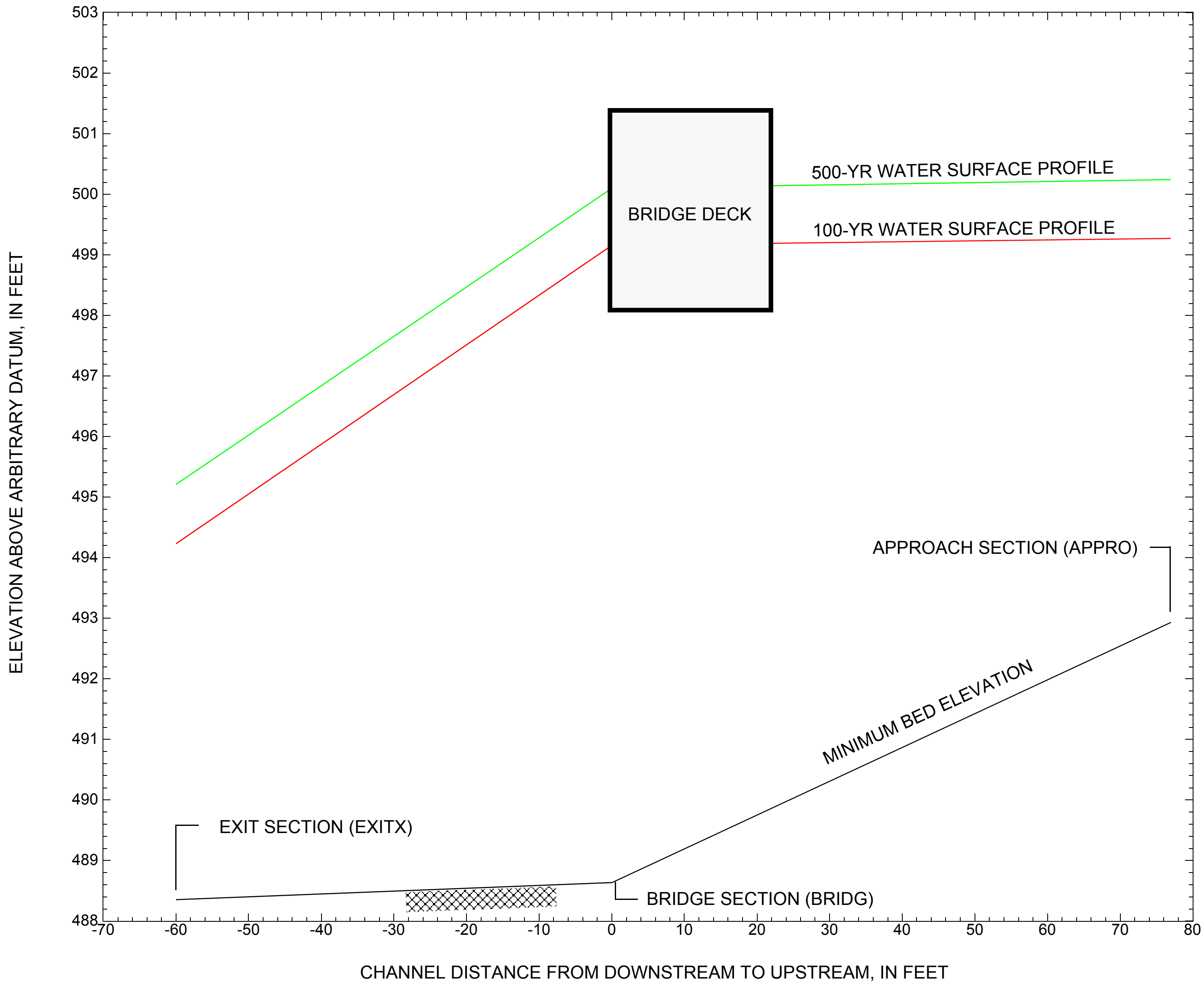

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure WARRTH00010007 on Town Highway 1 (FAS 188), crossing Freeman Brook, Warren, Vermont.

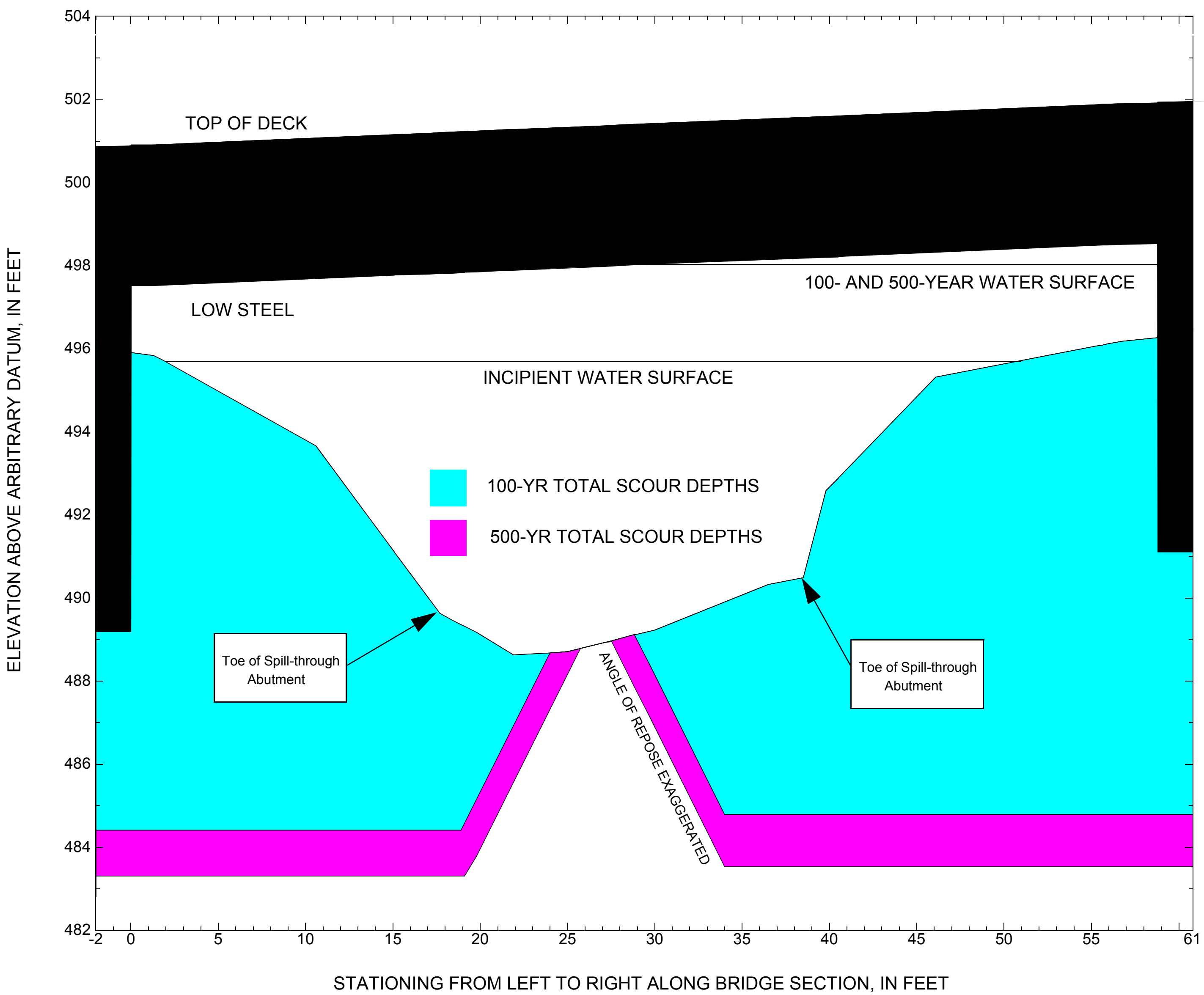

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure WARRTH00010007 on Town Highway 1 (FAS 188), crossing Freeman Brook, Warren, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure WARRTH00010007 on Town Highway 1 (FAS 188), crossing Freeman Brook, Warren, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT Bridge Seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,800 cubic-feet per second											
Left abutment	0.0	92.4	497.1	489.2	496.2	0.0	--	--	--	--	-4.8
Toe of LABUT	17.1	--	--	--	490.0	0.0	5.6	--	5.6	484.4	--
Toe of RABUT	38.5	--	--	--	490.5	0.0	5.7	--	5.7	484.8	--
Right abutment	58.8	94.4	499.0	491.1	496.4	0.0	--	--	--	--	-6.3

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 WARRTH00010007 on Town Highway 1 (FAS 188), crossing Freeman Brook, Warren, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT Bridge Seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2,450 cubic-feet per second											
Left abutment	0.0	92.4	497.1	489.2	496.2	0.0	--	--	--	--	-5.9
Toe of LABUT	17.1	--	--	--	490.0	0.0	6.7	--	6.7	483.3	--
Toe of RABUT	38.5	--	--	--	490.5	0.0	7.0	--	7.0	483.5	--
Right abutment	58.8	94.4	499.0	491.1	496.4	0.0	--	--	--	--	-7.6

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

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U.S. Geological Survey, 1970, Warren, 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 warr007.wsp
T2        Hydraulic analysis for structure warrth00010007   Date: 23-SEP-96
T3        Bridge #7 over Freeman Brook.  RHF
*
J1         *  *  0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1800.0   2450.0   1450.0
SK          0.0296   0.0296   0.0296
*
XS   EXITX    -60
GR          -96.8, 497.54    -80.1, 497.70    -56.2, 498.67    -20.5, 496.55
GR            0.0, 495.15      6.1, 490.72     11.7, 489.33     13.9, 488.80
GR           22.1, 488.35     25.8, 488.51     30.6, 489.28     35.4, 491.18
GR           46.2, 497.99    127.3, 500.68    175.4, 501.96    203.5, 503.30
GR          283.3, 510.48
*
N           0.045        0.058        0.049
SA                   0.0         46.2
*
*
XS   FULLV      0  * * *   0.00610
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    498.03      30.0
GR            0.0, 497.05      0.0, 496.81      0.1, 496.15     10.6, 493.66
GR           17.1, 489.96     17.7, 489.63     19.8, 489.17     21.9, 488.63
GR           25.0, 488.71     30.0, 489.23     36.5, 490.33     38.5, 490.49
GR           39.8, 492.58     46.1, 495.32     58.7, 496.35     58.8, 498.72
GR           58.8, 499.01      0.0, 497.05
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV
CD           3      26.4     1.8    501.4
N           0.060
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      22.0     1
GR          -66.6, 507.71    -41.2, 497.70    -31.1, 498.11    -22.6, 499.34
GR           -2.3, 500.35     -2.0, 500.63      0.0, 500.70     56.1, 502.37
GR           57.6, 502.19     60.9, 502.13    116.0, 504.18    160.7, 505.76
GR          418.9, 518.17    613.6, 538.36
*
XT   APTEM     88
GR           -5.9, 508.27      0.0, 499.66      7.2, 494.99     17.0, 493.88
GR           19.5, 493.30     24.7, 492.93     32.2, 493.54     35.0, 493.65
GR           39.8, 493.66     44.4, 493.39     57.4, 499.87     69.6, 502.68
*
AS   APPRO     77 * * * 0.0449
GT
N           0.059        0.039
SA                  57.4
*
HP 1 BRIDG  498.03 1 498.03
HP 2 BRIDG  498.03 * * 1718
HP 2 RDWAY  499.16 * *   87
HP 1 APPRO  499.27 1 499.27
HP 2 APPRO  499.27 * * 1800
*
HP 1 BRIDG  498.03 1 498.03
HP 2 BRIDG  498.03 * * 2182
HP 2 RDWAY  500.10 * *  278
HP 1 APPRO  500.24 1 500.24
```

APPENDIX B:

WSPRO OUTPUT FILE

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

        U.S. Geological Survey WSPRO Input File warr007.wsp
        Hydraulic analysis for structure warrth00010007   Date: 23-SEP-96
        Bridge #7 over Freeman Brook.  RHF
           *** RUN DATE & TIME: 11-06-96  10:25
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     265.   14339.    25.    83.                       4860.
   498.03          265.   14339.    25.    83.  1.00     0.    59.   4860.


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

         WSEL     LEW     REW    AREA         K        Q    VEL
       498.03     0.0    58.8   265.2   14339.    1718.   6.48

X STA.         0.0        12.3        16.0        18.4        20.3        22.1
  A(I)            27.2        19.3        15.9        14.0        13.4
  V(I)            3.15        4.45        5.41        6.13        6.40

X STA.        22.1        23.6        25.2        26.7        28.1        29.6
  A(I)            12.3        12.2        11.7        11.6        11.1
  V(I)            6.97        7.05        7.33        7.39        7.71

X STA.        29.6        30.8        32.1        33.3        34.7        36.1
  A(I)             9.3         9.3         9.1         9.5         9.5
  V(I)            9.26        9.19        9.46        9.03        9.02

X STA.        36.1        37.6        39.5        42.4        47.8        58.8
  A(I)            10.0        12.0        12.5        15.2        20.1
  V(I)            8.63        7.17        6.88        5.66        4.28



    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      77.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     285.   20232.    57.    60.                       3604.
   499.27          285.   20232.    57.    60.  1.00     0.    57.   3604.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      77.

         WSEL     LEW     REW    AREA         K        Q    VEL
       499.27    -0.1    57.2   284.8   20232.    1800.   6.32

X STA.        -0.1         8.4        11.5        14.2        16.6        18.8
  A(I)            23.6        15.5        14.6        14.1        13.0
  V(I)            3.81        5.82        6.18        6.40        6.91

X STA.        18.8        20.7        22.6        24.4        26.1        27.9
  A(I)            12.4        12.2        12.1        11.8        11.9
  V(I)            7.26        7.35        7.46        7.62        7.54

X STA.        27.9        29.8        31.7        33.7        35.7        37.8
  A(I)            12.2        12.3        12.4        12.6        12.8
  V(I)            7.40        7.35        7.28        7.15        7.02

X STA.        37.8        40.0        42.1        44.4        47.3        57.2
  A(I)            13.0        13.4        14.2        16.7        24.1
  V(I)            6.95        6.72        6.33        5.38        3.73
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       U.S. Geological Survey WSPRO Input File warr007.wsp
       Hydraulic analysis for structure warrth00010007   Date: 23-SEP-96
       Bridge #7 over Freeman Brook.  RHF
          *** RUN DATE & TIME: 11-06-96  10:25
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     265.  14339.    25.    83.                         4860.
  498.03          265.  14339.    25.    83.  1.00     0.    59.   4860.

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

        WSEL     LEW     REW    AREA         K         Q    VEL
      498.03     0.0    58.8   265.2   14339.    2182.   8.23

X STA.         0.0        12.3        16.0        18.4        20.3        22.1
  A(I)            27.2        19.3        15.9        14.0        13.4
  V(I)            4.01        5.65        6.88        7.78        8.12

X STA.        22.1        23.6        25.2        26.7        28.1        29.6
  A(I)            12.3        12.2        11.7        11.6        11.1
  V(I)            8.85        8.95        9.31        9.39        9.80

X STA.        29.6        30.8        32.1        33.3        34.7        36.1
  A(I)             9.3         9.3         9.1         9.5         9.5
  V(I)           11.76       11.68       12.02       11.47       11.46

X STA.        36.1        37.6        39.5        42.4        47.8        58.8
  A(I)            10.0        12.0        12.5        15.2        20.1
  V(I)           10.96        9.11        8.73        7.19        5.44



   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      77.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     341.  26877.    58.    62.                         4684.
            2       2.     35.     4.     4.                            6.
  500.24          342.  26912.    62.    66.  1.01    -1.    61.   4559.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      77.

        WSEL     LEW     REW    AREA         K         Q    VEL
      500.24    -0.7    61.2   342.5   26912.    2450.   7.15

X STA.        -0.7         7.8        11.0        13.8        16.3        18.5
  A(I)            28.7        19.1        17.4        16.4        15.9
  V(I)            4.27        6.43        7.04        7.46        7.71

X STA.        18.5        20.6        22.6        24.4        26.3        28.2
  A(I)            15.3        14.8        14.2        14.6        14.3
  V(I)            7.98        8.27        8.60        8.37        8.54

X STA.        28.2        30.2        32.2        34.3        36.4        38.5
  A(I)            14.6        14.8        15.0        15.0        15.2
  V(I)            8.36        8.29        8.17        8.16        8.07

X STA.        38.5        40.7        42.9        45.4        48.5        61.2
  A(I)            15.7        15.8        17.4        19.3        28.9
  V(I)            7.83        7.78        7.02        6.34        4.24
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        U.S. Geological Survey WSPRO Input File warr007.wsp
        Hydraulic analysis for structure warrth00010007   Date: 23-SEP-96
        Bridge #7 over Freeman Brook.  RHF
           *** RUN DATE & TIME: 11-06-96  10:25
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     160.    9234.    42.    45.                       1783.
   495.66          160.    9234.    42.    45.  1.00     2.    50.   1783.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.66     2.2    50.3   160.2    9234.    1450.   9.05

X STA.        2.2       13.9       16.4       18.1       19.4       20.6
  A(I)           15.7       10.0        8.2        7.4        6.9
  V(I)           4.62       7.25       8.79       9.82      10.45

X STA.       20.6       21.7       22.8       23.8       24.8       25.8
  A(I)            6.5        6.4        6.0        6.1        6.1
  V(I)          11.22      11.35      12.06      11.82      11.91

X STA.       25.8       26.8       27.9       29.0       30.2       31.4
  A(I)            6.1        6.2        6.3        6.5        6.6
  V(I)          11.93      11.75      11.58      11.21      10.93

X STA.       31.4       32.7       34.2       35.9       38.0       50.3
  A(I)            7.1        7.5        8.4        9.6       16.7
  V(I)          10.20       9.72       8.63       7.52       4.35



    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      77.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     213.   13271.    53.    55.                       2434.
   497.97          213.   13271.    53.    55.  1.00     2.    55.   2434.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      77.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.97     1.8    54.6   213.3   13271.    1450.   6.80

X STA.        1.8        9.4       12.4       15.1       17.4       19.4
  A(I)           17.1       11.8       11.2       10.4       10.1
  V(I)           4.23       6.13       6.46       6.99       7.18

X STA.       19.4       21.2       22.9       24.6       26.2       27.9
  A(I)            9.3        9.2        8.9        9.1        8.9
  V(I)           7.77       7.87       8.15       7.95       8.15

X STA.       27.9       29.7       31.5       33.4       35.4       37.4
  A(I)            9.1        9.4        9.3        9.6        9.6
  V(I)           7.97       7.70       7.79       7.53       7.53

X STA.       37.4       39.5       41.6       43.6       46.1       54.6
  A(I)           10.0       10.1       10.4       11.9       17.8
  V(I)           7.25       7.19       6.98       6.10       4.08
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WSPRO OUTPUT FILE (continued)

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       U.S. Geological Survey WSPRO Input File warr007.wsp
       Hydraulic analysis for structure warrth00010007   Date: 23-SEP-96
       Bridge #7 over Freeman Brook.  RHF

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

EXITX:XS   ******     1.     164.  1.88 *****  496.12  494.08   1800.  494.23
      -60. ******    40.   10453.  1.00 ***** *******    0.95   11.01

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "FULLV"     KRATIO =  1.67

FULLV:FV      60.   -11.     235.  0.93  1.07  497.18 *******   1800.  496.25
        0.    60.    43.   17455.  1.02  0.00    0.00    0.65    7.64
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.93     497.32     497.16

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.75     507.78    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.75     507.78     497.16

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  0.59

APPRO:AS      77.     3.     180.  1.56  1.39  498.88  497.16   1800.  497.32
       77.    77.    53.   10319.  1.00  0.31    0.00    0.93   10.01
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   498.52       0.00     496.50     497.70
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   503.26         0.      1800.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===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      60.     0.     265.  0.65 *****  498.68  495.49   1718.  498.03
        0. ******    59.   14339.  1.00 ***** *******    0.54    6.48

     TYPE PPCD FLOW       C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****    5.  0.427  0.000  498.03 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    55.  0.44  0.62  499.45    0.00     87.  499.16

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    87.    21.   -45.   -24.   1.5   0.9   5.1   4.5   1.2   3.1
   RT:     0.    23.    25.    61.   0.7   0.3   5.0  12.3   1.2   3.0

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

APPRO:AS      51.     0.     285.  0.62  0.54  499.89  497.16   1800.  499.27
       77.    51.    57.   20215.  1.00  0.00    0.00    0.50    6.32

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -60.     1.    40.   1800.   10453.     164.   11.01  494.23
   FULLV:FV       0.   -11.    43.   1800.   17455.     235.    7.64  496.25
   BRIDG:BR       0.     0.    59.   1718.   14339.     265.    6.48  498.03
   RDWAY:RG      13.*******    87.     87.*********       0.    1.00  499.16
   APPRO:AS      77.     0.    57.   1800.   20215.     285.    6.32  499.27

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS  ***********************
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS   494.08    0.95  488.35  510.48************  1.88  496.12  494.23
   FULLV:FV  ********   0.65  488.72  510.85  1.07  0.00  0.93  497.18  496.25
   BRIDG:BR   495.49    0.54  488.63  499.01************  0.65  498.68  498.03
   RDWAY:RG  ***************  497.70  538.36  0.44******  0.62  499.45  499.16
   APPRO:AS   497.16    0.50  492.44  507.78  0.54  0.00  0.62  499.89  499.27
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WSPRO OUTPUT FILE (continued)

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      U.S. Geological Survey WSPRO Input File warr007.wsp
      Hydraulic analysis for structure warrth00010007   Date: 23-SEP-96
      Bridge #7 over Freeman Brook.  RHF

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

EXITX:XS   ******    -1.     203.  2.26 *****  497.47  495.09   2450.  495.21
      -60. ******    42.   14229.  1.00 ***** *******    0.98   12.06

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "FULLV"     KRATIO =  1.73

FULLV:FV      60.   -30.     312.  1.04  1.03  498.50 *******   2450.  497.46
        0.    60.    45.   24608.  1.09  0.00   -0.01    0.70    7.85
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.89     498.35     497.99

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   496.96     507.78    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   496.96     507.78     497.99

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.62

APPRO:AS      77.     1.     234.  1.71  1.24  500.06  497.99   2450.  498.36
       77.    77.    55.   15198.  1.00  0.33    0.00    0.89   10.47
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
            WS1,WSSD,WS3,RGMIN =   500.18       0.00     498.03     497.70
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   503.81         0.      2450.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===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      60.     0.     265.  1.05 *****  499.08  496.43   2182.  498.03
        0. ******    59.   14339.  1.00 ***** *******    0.68    8.23

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   5.  0.480  0.000  498.03 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    55.  0.46  0.80  500.58    0.00    278.  500.10

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    278.    40.   -47.    -7.   2.4   1.2   6.3   5.9   1.7   3.3
   RT:      0.    30.    27.    63.   0.7   0.3   5.0  13.6   1.2   3.0

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

APPRO:AS      51.    -1.     342.  0.80  0.70  501.04  497.99   2450.  500.24
       77.    51.    61.   26898.  1.01  0.00    0.00    0.54    7.16

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -60.    -1.    42.   2450.   14229.     203.   12.06  495.21
   FULLV:FV       0.   -30.    45.   2450.   24608.     312.    7.85  497.46
   BRIDG:BR       0.     0.    59.   2182.   14339.     265.    8.23  498.03
   RDWAY:RG      13.*******   278.    278.*********       0.    1.00  500.10
   APPRO:AS      77.    -1.    61.   2450.   26898.     342.    7.16  500.24

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS  ***********************
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    495.09    0.98  488.35  510.48************  2.26  497.47  495.21
   FULLV:FV  ********    0.70  488.72  510.85  1.03  0.00  1.04  498.50  497.46
   BRIDG:BR    496.43    0.68  488.63  499.01************  1.05  499.08  498.03
   RDWAY:RG  ***************  497.70  538.36  0.46******  0.80  500.58  500.10
   APPRO:AS    497.99    0.54  492.44  507.78  0.70  0.00  0.80  501.04  500.24
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WSPRO OUTPUT FILE (continued)

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       U.S. Geological Survey WSPRO Input File warr007.wsp
       Hydraulic analysis for structure warrth00010007   Date: 23-SEP-96
       Bridge #7 over Freeman Brook.  RHF

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

EXITX:XS   ******     2.     141.  1.65 *****  495.29  493.44   1450.  493.63
      -60. ******    39.    8426.  1.00 ***** *******    0.93   10.31

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                          "FULLV"     KRATIO =  1.67

FULLV:FV      60.     0.     201.  0.81  1.07  496.34 *******   1450.  495.54
        0.    60.    42.   14045.  1.00  0.00   -0.01    0.58    7.20
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.98     496.69     496.64

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.04     507.78    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.04     507.78     496.64

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                          "APPRO"     KRATIO =  0.55

APPRO:AS      77.     4.     148.  1.48  1.49  498.17  496.64   1450.  496.68
       77.    77.    52.    7752.  1.00  0.34    0.00    0.98    9.77
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   497.97       0.00     495.66     497.70
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   502.93         0.      1450.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                       YU/Z,WSIU,WS = 1.10     498.48     498.92
 ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS      Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

BRIDG:BR      60.     2.     160.  1.28  1.62  496.93  488.83   1450.  495.66
        0.    60.    50.    9228.  1.00  0.02    0.00    0.81    9.06

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  1.000 ******  498.03 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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      51.     2.     213.  0.72  0.96  498.69  496.64   1450.  497.97
       77.    56.    55.   13278.  1.00  0.80    0.00    0.60    6.80

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.044  0.000   13848.     4.    52.   497.31

  FIRST USER DEFINED TABLE.

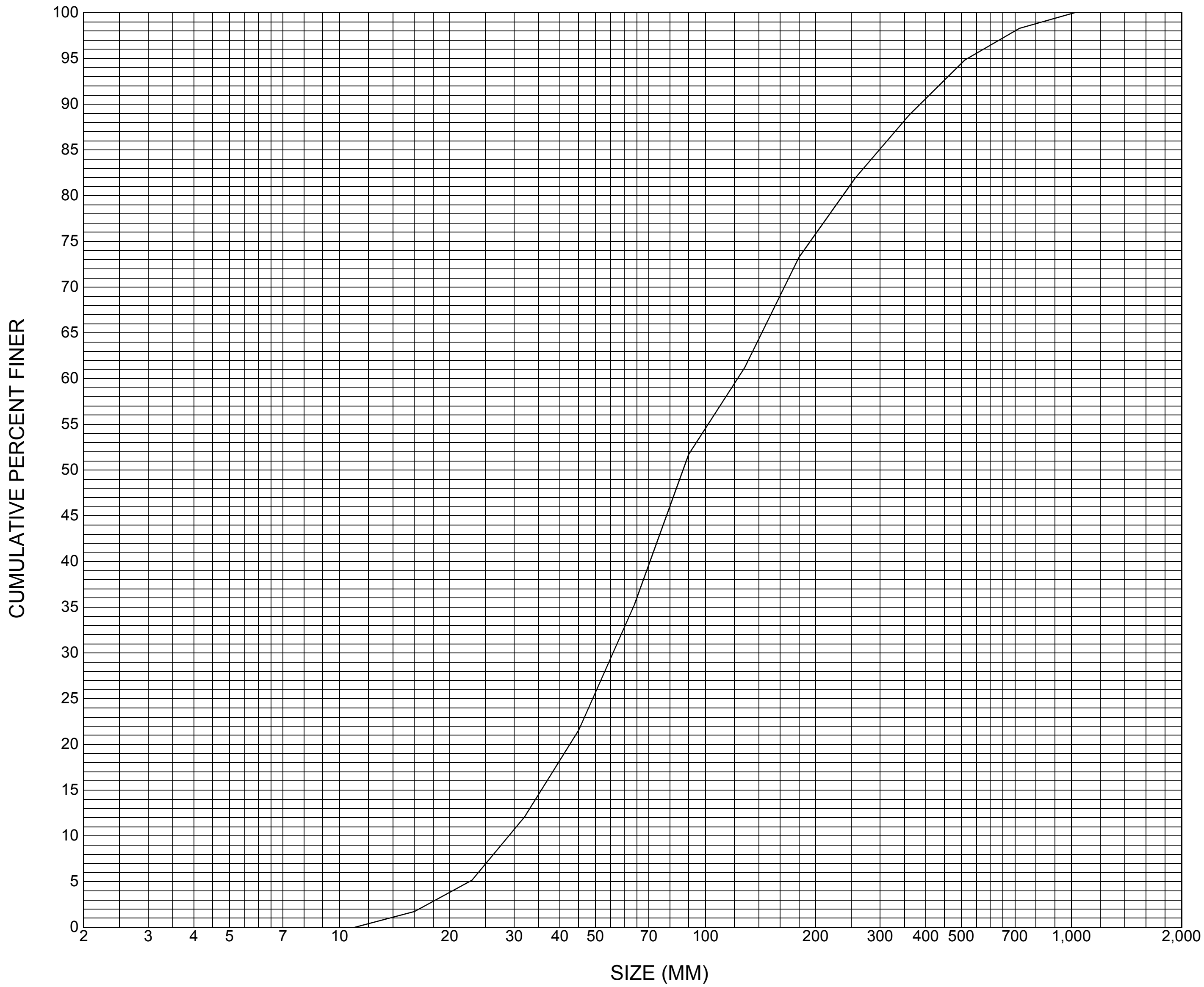
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -60.     2.    39.   1450.    8426.     141.   10.31  493.63
   FULLV:FV       0.     0.    42.   1450.   14045.     201.    7.20  495.54
   BRIDG:BR       0.     2.    50.   1450.    9228.     160.    9.06  495.66
   RDWAY:RG      13.**************      0.*********       0.    1.00********
   APPRO:AS      77.     2.    55.   1450.   13278.     213.    6.80  497.97

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       4.    52.   13848.
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    493.44    0.93  488.35  510.48************  1.65  495.29  493.63
   FULLV:FV  ********    0.58  488.72  510.85  1.07  0.00  0.81  496.34  495.54
   BRIDG:BR    488.83    0.81  488.63  499.01  1.62  0.02  1.28  496.93  495.66
   RDWAY:RG  ****************  497.70  538.36************  0.47  499.03********
   APPRO:AS    496.64    0.60  492.44  507.78  0.96  0.80  0.72  498.69  497.97
  ER
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure WARRTH00010007, in Warren, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number WARRTH00010007

General Location Descriptive

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

Date *(MM/DD/YY)* 02 / 01 / 96

Highway District Number *(I - 2; nn)* 06

County *(FIPS county code; I - 3; nnn)* 023

Town *(FIPS place code; I - 4; nnnnn)* 76525

Mile marker *(I - 11; nnn.nnn)* 004490

Waterway *(I - 6)* Freeman Brook

Road Name *(I - 7):* -

Route Number TH 1

Vicinity *(I - 9)* 0.4 MI E JCT. VT.100 N

Topographic Map Warren

Hydrologic Unit Code: -

Latitude *(I - 16; nnnn.n)* 44069

Longitude *(i - 17; nnnnn.n)* 72512

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20018800071217

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

Maximum span length *(I - 48; nnnn)* 0062

Year built *(I - 27; YYYY)* 1947

Structure length *(I - 49; nnnnnn)* 000064

Average daily traffic, ADT *(I - 29; nnnnnn)* 001242

Deck Width *(I - 52; nn.n)* 220

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

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

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

Waterway adequacy *(I - 71; n)* 8

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 45

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

Vertical clearance from streambed (*nnn.n ft*) 7

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

Waterway of full opening (*nnn.n* ft^2) 315

Comments:

According to the structural inspection report dated 9/2/94, the structure is a single span rolled beam bridge. It is part of the Federal Aid System (188). The curtain wall at the Labut has slight scaling and the stem has areas of staining, cracking, and moderate scaling at the ends. The short wingwalls are in fair condition with minor scaling. The curtain wall at the Rabut has heavy leakage at the top, particularly in bay #3. The stem of the Rabut and the left wingwall have minor cracking and scaling. The right wingwall has areas of cracking and heavy scaling. Both abutments are protected with heavy stone fill. The channel takes a moderate turn into and a slight turn out of the structure. There is minor **(Continued, page 33).**

Bridge Hydrologic Data

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

Terrain character: ____

Stream character & type:

Streambed material: ____

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

Q_{50} ____________ Q_{100} ____________ Q_{500} ____________

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

Estimated Discharge *(cfs)*: __________ Velocity at Q ____ *(ft/s)*: _________

Ice conditions *(Heavy, Moderate, Light)* : ___________ Debris *(Heavy, Moderate, Light)*: _____________

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes:

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

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

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

Upstream distance (*miles*): ____________ Town: ____________________ Year Built: _______

Highway No. : _________________ Structure No. : _______ Structure Type: ______________________

Clear span (*ft*): _______ Clear Height (*ft*): _______ Full Waterway (*ft²*): ________

Downstream distance (*miles*): ___________ Town: ____________________ Year Built: ______

Highway No. : _________________ Structure No. : ______ Structure Type: ______________________

Clear span (*ft*): _____ Clear Height (*ft*): ______ Full Waterway (ft^2): _______

Comments:

stream bank erosion both upstream and downstream.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **6.45** mi^2

Lake and pond area **0** mi^2

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

Bridge site elevation **715** ft

Headwater elevation **1964** ft

Main channel length **5.22** mi

10% channel length elevation **760** ft

85% channel length elevation **1240** ft

Main channel slope *(S)* **122.68** 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? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY):* -- / 1945

Project Number S.A. 12 - 1945 Minimum channel bed elevation: ________

Low superstructure elevation: USLAB 92.05 DSLAB 92.44 USRAB 93.97 DSRAB 94.43

Benchmark location description:

BM #1, spot on lower step, elev. 84.23’, on upstream side of left road approach, approx. 260’ from Labut
BM #2, spot on boulder, elev. 100’, on upstream side of right road approach, approx. 60’ from Rabut
BM #3, spot on corner of walk, elev. 109.45’, on upstream side of right road approach, approx. 300’ from Rabut

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

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

If 1: Footing Thickness 2.25 Footing bottom elevation: 84.8

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

Briefly describe material at foundation bottom elevation or around piles:

Comments:

Footing bottom elevation for Labut is 84.8’; for Rabut it is 86.72’.
The low superstructure elevations are the bridge seat elevations from the bridge plans.

Cross-sectional Data

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

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

Comments: --

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

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

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

Comments: --

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **EW** Date: **11/07/96**
Computerized by: **EW** Date: **11/07/96**
Reviewd by: **RF** Date: **11/21/96**

Structure Number **WARRTH00010007**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **R BURNS** Date *(MM/DD/YY)* **07** / **22** / 19**96**
2. Highway District Number **06** Mile marker **004490**
   County **WASHINGTON (023)** Town **WARREN (76525)**
   Waterway *(I - 6)* **FREEMAN BROOK** Road Name **-**
   Route Number **TH 1** Hydrologic Unit Code: **02010003**
3. Descriptive comments:
Located 0.4 miles east of junction Vermont 100 North.

B. Bridge Deck Observations

4. Surface cover... LBUS **6** RBUS **2** LBDS **2** RBDS **2** Overall **2**
*(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 **64** *(feet)* Span length **62** *(feet)* Bridge width **22** *(feet)*

Road approach to bridge:

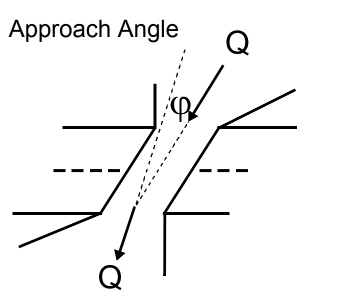
8. LB **1** RB **2** *(**0** even, **1-** lower, **2-** higher)*
9. LB **1** RB **1** *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left **--1** US right **--**

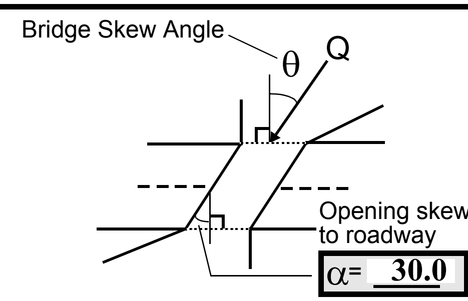
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	2	2
RBDS	0	-	0	-
LBDS	0	-	0	-

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

Channel approach to bridge (BF):

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





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **80** feet **US** *(US, UB, DS)* to **50** feet **US**
Channel impact zone 2: Exist? **N** *(Y or N)*
Where? ____ *(LB, RB)* Severity ____
Range? ____ feet ____ *(US, UB, DS)* to ____ feet ____

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

18. Bridge Type: **3/1b**

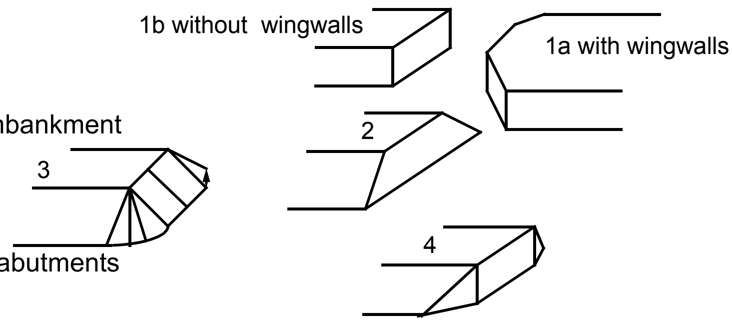
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4: Small trees are along all the banks.

18: Bridge concrete abutments are type 1b. However, dumped stone protection acts as type 3 spill-through abutment.

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
65.5	**4.5**			**6.5**	**4**	**1**	**652**	**543**	**1**	**1**

23. Bank width **30.0** 24. Channel width **25.0** 25. Thalweg depth **56.5** 29. Bed Material **654**

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.):

The stream makes a 60 degree bend at 60 feet upstream.

The left bank is bedrock from 0 feet upstream to 30 feet upstream. On the right bank, there are many natural boulders which act as protection.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **95** 35. Mid-bar width: **12**

36. Point bar extent: **117** feet **US** *(US, UB)* to **75** feet **US** *(US, UB, DS)* positioned **0** %LB to **30** %RB

37. Material: **432**

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

This point bar is just upstream of the bend in stream. The bank is steeper at this point than it is for the rest of the left bank.

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

The right bank is steep like downstream, but because of natural boulders there are no cut-banks.

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **80**

47. Scour dimensions: Length **10** Width **10** Depth : **1** Position **50** %LB to **70** %RB

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

Scour is around a large boulder in the stream. More scour is occurring over the bedrock drop from 15 feet upstream to the bridge face with a scour hole depth of 2 feet from 30% LB to 40% RB.

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

A culvert enters the right bank at 95 feet upstream.

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
37.0		**1.0**		**2**	**7**	**7**	**-**

58. Bank width (BF) **-** 59. Channel width (Amb) **-** 60. Thalweg depth (Amb) **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.):

43

The concrete abutments are protected with large placed boulders which extend the entire base length and 20 feet out into the stream.

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

67. Debris Potential 2____ (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:

2

Debris potential is moderate. Capture efficiency is moderate due to debris which is currently caught on boulders and the low clearance of the bridge.

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		5	40	0	0	-	-	90.0
RABUT	1	-	40			0	0	51.0

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

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

-

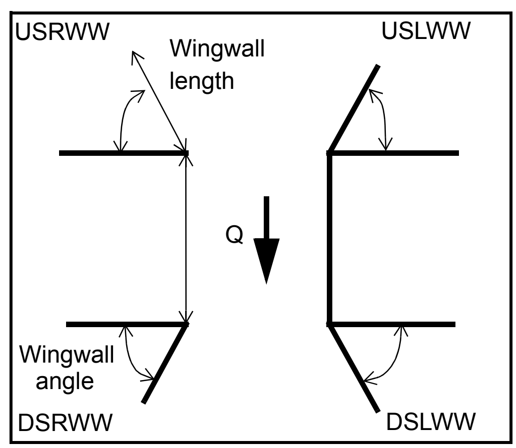
-

1

The concrete part of the abutment is even with the top of banks upstream and downstream. The abutment protection protrudes into the channel and is sloping at approximately a 40 degree angle.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						51.0	
USRWW:	N		-		-	1.5	
DSLWW:	-		-		N	25.0	
DSRWW:	-		-		-	27.5	



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

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	-	N	-	-	-	1	1
Condition	N	-	-	-	-	-	1	1
Extent	-	-	-	-	-	2	2	-

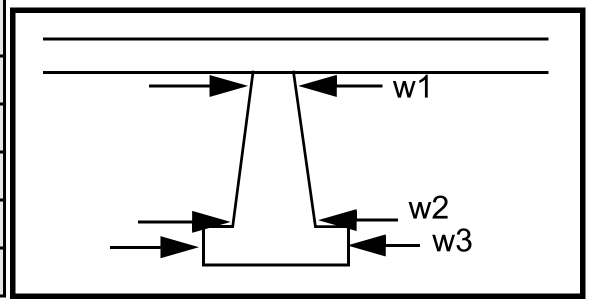
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)		-	-	-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type		-	-	-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material		-	-	-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape		-	-	-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?		-	-	-	*Y- yes; N- no*
91. Attack ∠ (BF)		-	-	-	
92. Pushed		-	-	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles		-	-	-	
95. Cross-members		-	-	-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition		-	-	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**N**	-	-	-	
98. Exposure depth	-	-	-	-	

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
-	-			-	-	NO	PIE	RS		

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

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

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

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

3
3
432
432
2
2
435
2
2
1
1
Right bank protection is piled stone, extending from 43 feet downstream to 60 feet downstream. From 14 feet downstream to 43 feet downstream, the dumped stone is larger (type 3 protection).

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

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

105. Drop structure comments (eg. downstream scour depth):
t abutment and left bank protection extends from under the bridge to 27 feet downstream.

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 **N** *(US, UB, DS)* positioned **-** %LB to **NO** %RB

Material: **DR**

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

OP STRUCTURE

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

Cut bank extent: **26** feet **6** *(US, UB, DS)* to **19** feet **DS** *(US, UB, DS)*

Bank damage: **37** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

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

DS
0
35
32

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

Scour dimensions: Length **tiona** Width **l** Depth: **grav** Positioned **el** %LB to **and** %RB

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

sand bar exists from 88 feet downstream to 120 feet downstream on the left bank. It grades from fine to coarse in the downstream direction.

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

Confluence 1: Distance **119** Enters on **108** *(LB or RB)* Type **DS** *(**1**- perennial; **2**- ephemeral)*

Confluence 2: Distance **136** Enters on **DS** *(LB or RB)* Type **1** *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

Both banks are steep and eroded with some roots exposed. This cut-bank has some small trees leaning into the stream.

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

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

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

N
-
-
-
-
-
-
NO CHANNEL SCOUR

N

109. G. Plan View Sketch

-

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: WARRTH00010007   Town: WARREN
Road Number: TH1   County: WASHINGTON
Stream: FREEMANS BROOK

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	1800	2450	1450	
Main Channel Area, ft2	284.8	342.5	213.3	
Left overbank area, ft2	0	0	0	
Right overbank area, ft2	0	2	0	
Top width main channel, ft	57.3	61.9	52.8	
Top width L overbank, ft	0	0	0	
Top width R overbank, ft	0	4	0	Old D50
D50 of channel, ft	0.28487	0.28487	0.28487	0.20233
D50 left overbank, ft	0	0	0	
D50 right overbank, ft	0	0	0	
y1, average depth, MC, ft	5.0	5.5	4.0	
y1, average depth, LOB, ft	ERR	ERR	ERR	
y1, average depth, ROB, ft	ERR	0.5	ERR	
Total conveyance, approach	20232	26912	13271	
Conveyance, main channel	20232	26877	13271	
Conveyance, LOB	0	0	0	
Conveyance, ROB	0	35	0	
Percent discrepancy, conveyance	0.0000	0.0000	0.0000	
Qm, discharge, MC, cfs	1800.0	2446.8	1450.0	
Ql, discharge, LOB, cfs	0.0	0.0	0.0	
Qr, discharge, ROB, cfs	0.0	3.2	0.0	
Vm, mean velocity MC, ft/s	6.3	7.1	6.8	
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR	
Vr, mean velocity, ROB, ft/s	ERR	1.6	ERR	
Vc-m, crit. velocity, MC, ft/s	9.6	9.8	9.3	
Vc-l, crit. velocity, LOB, ft/s	N/A	N/A	N/A	
Vc-r, crit. velocity, ROB, ft/s	N/A	0.0	N/A	

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	284.8	342.5	213.3
Main channel width, ft	57.3	61.9	52.8
y1, main channel depth, ft	4.97	5.53	4.04

Bridge Section			
(Q) total discharge, cfs	1800	2450	1450
(Q) discharge thru bridge, cfs	1718	2182	1450
Main channel conveyance	14339	14339	9234
Total conveyance	14339	14339	9234
Q2, bridge MC discharge,cfs	1718	2182	1450
Main channel area, ft2	265	265	160
Main channel width (skewed), ft	41.6	41.6	32.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	41.6	41.6	32
y_bridge (avg. depth at br.), ft	6.38	6.38	5.01
Dm, median (1.25*D50), ft	0.356088	0.356088	0.356088
y2, depth in contraction,ft	4.03	4.95	4.37
ys, scour depth (y2-ybridge), ft	-2.34	-1.42	-0.64

ARMORING			
D90	1.2673	1.2673	1.2673
D95	1.70867	1.70867	1.70867
Critical grain size,Dc, ft	0.2496	0.4026	0.5497
Decimal-percent coarser than Dc	0.5635	0.3993	0.2926
Depth to armoring,ft	0.58	1.82	3.99

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	1800	2450	0
Q, thru bridge, cfs	1718	2182	0
Total Conveyance, bridge	14339	14339	0
Main channel(MC) conveyance, bridge	14339	14339	0
Q, thru bridge MC, cfs	1718	2182	ERR
Vc, critical velocity, ft/s	9.64	9.81	9.31
Vc, critical velocity, m/s	2.94	2.99	2.84
Main channel width (skewed), ft	41.6	41.6	0.0
Cum. width of piers in MC, ft	0	0	0
W, adjusted width, ft	41.6	41.6	0.0
qbr, unit discharge, ft^2/s	41.3	52.5	ERR
qbr, unit discharge, m^2/s	3.8	4.9	N/A
Area of full opening, ft^2	265.2	265.2	0
Hb, depth of full opening, ft	6.38	6.38	ERR
Hb, depth of full opening, m	1.94	1.94	N/A
Fr, Froude number, bridge MC	0.54	0.68	1
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.50
Elevation of Low Steel, ft	498.03	498.03	0
Elevation of Bed, ft	491.66	491.66	N/A
Elevation of Approach, ft	499.27	500.24	0
Friction loss, approach, ft	0.54	0.7	0
Elevation of WS immediately US, ft	498.73	499.54	0.00
ya, depth immediately US, ft	7.07	7.88	N/A
ya, depth immediately US, m	2.16	2.40	N/A
Mean elevation of deck, ft	501.413	501.413	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.97	0.95	ERR
Ys, depth of scour, ft	-1.98	-0.73	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)

Characteristic	Left Abutment 100 yr Q	Left Abutment 500 yr Q	Left Abutment Other Q	Right Abutment 100 yr Q	Right Abutment 500 yr Q	Right Abutment Other Q
(Qt), total discharge, cfs	1800	2450	1450	1800	2450	1450
a', abut.length blocking flow, ft	5.5	6.1	6.7	10.1	14.1	14.1
Ae, area of blocked flow ft2	15.27	20.6	15.08	25.25	37.62	45.39
Qe, discharge blocked abut.,cfs	58.24	87.91	63.91	96.21	177.82	255.48
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.81	4.27	4.24	3.81	4.73	5.63
ya, depth of f/p flow, ft	2.78	3.38	2.25	2.50	2.67	3.22
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0.55	0.55	0.55	0.55
--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	0.403	0.409	0.498	0.425	0.510	0.553
ys, scour depth, ft	5.55	6.65	5.30	5.70	6.96	8.23

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)	5.5	6.1	6.7	10.1	14.1	14.1
y1 (depth f/p flow, ft)	2.78	3.38	2.25	2.50	2.67	3.22
a'/y1	1.98	1.81	2.98	4.04	5.28	4.38
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.40	0.41	0.50	0.42	0.51	0.55
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.54	0.68	0.81	0.54	0.68	0.81
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	5.208	5.208	3.846	5.208	5.208	3.846

Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	0.94	1.49	ERR	0.94	1.49	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	1.52	ERR	ERR	1.52
Fr<=0.8 (spillthrough abut.)	0.82	1.30	ERR	0.82	1.30	ERR
Fr>0.8 (spillthrough abut.)	ERR	ERR	1.34	ERR	ERR	1.34