LEVEL II SCOUR ANALYSIS FOR BRIDGE 13 (JERITH00030013) on TOWN HIGHWAY 3, crossing MILL BROOK, JERICHO, VERMONT

Open-File Report 98-259

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 13 (JERITH00030013) on TOWN HIGHWAY 3, crossing MILL BROOK, JERICHO, VERMONT

By RONDA L. BURNS and JAMES R. DEGNAN

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Pembroke, New Hampshire

1998

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

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 13 (JERITH00030013) ON TOWN HIGHWAY 3, CROSSING MILL BROOK, JERICHO, VERMONT

By **Ronda L. Burns and James R. Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure JERITH00030013 on Town Highway 3 crossing Mill Brook, Jericho, 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 and the Champlain section of the St. Lawrence physiographic province in northwestern Vermont. The 6.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is shrub and brushland with a few trees upstream and downstream of the bridge.

In the study area, Mill Brook has a meandering channel with a slope of approximately 0.005 ft/ft, an average channel top width of 31 ft and an average bank height of 2 ft. The channel bed material ranges from silt to cobble with a median grain size (D_{50}) of 19.3 mm (0.063 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 24, 1996, indicated that the reach was laterally unstable. There is moderate fluvial erosion of the banks and cut-banks upstream and downstream of the bridge.

The Town Highway 3 crossing of Mill Brook is a 54-ft-long, two-lane bridge consisting of one 50-foot steel-beam span (Vermont Agency of Transportation, written communication, December 12, 1995). The opening length of the structure parallel to the bridge face is 49.8 ft. The bridge is supported by vertical, concrete abutments with short wingwalls parallel to the abutment faces. The channel is skewed approximately 90 degrees to the opening while the opening-skew-to-roadway is zero degrees.

During the Level I assessment, a scour hole 1.5 ft deeper than the mean thalweg depth was observed along the upstream left bank and the left abutment. An additional channel scour hole is along the downstream right bank and is 0.5 ft deeper than the mean thalweg. The scour countermeasures at the site included type-1 stone fill (less than 12 inches diameter) in front of the left abutment and downstream left wingwall and type-2 stone fill (less than 36 inches diameter) along the upstream left wingwall and the upstream left and right banks. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

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

Contraction scour for all modelled flows ranged from 1.6 to 4.6 ft. The worst-case contraction scour occurred at the 500-year discharge. The left abutment scour ranged from 14.1 to 14.7 ft. The worst case left abutment scour occurred at the 500-year discharge. The right abutment scour ranged from 5.1 to 6.1 ft. The worst-case right abutment scour occurred at the incipient road-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.

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 JERITH00030013 ***Stream*** Mill Brook

County Chittenden ***Road*** TH 3 ***District*** 5

Description of Bridge

Bridge length 54 ***ft*** ***Bridge width*** 23.4 ***ft*** ***Max span length*** 50 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 6/24/96

Description of stone fill Type-1, along the base of the left abutment and downstream left wingwall. Type-2, along the upstream left wingwall and upstream banks.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a one and a half foot deep scour hole along the left bank and left abutment.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 90

There are severe channel bends in the upstream and downstream reach. A scour hole has developed in the location where the bend impacts the upstream left bank and abutment.

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*
	6/24/96	0	0
Level I	6/24/96	0	0

Level II Low. There is some debris, small branches, caught on the cobbles in a riffle in the upstream channel.

Potential for debris

A large sand point bar is along the right abutment as of 6/24/96.

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

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a wide, irregular flood plain.

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

Date of inspection 6/24/96

DS left: Steep channel bank to a moderately sloped overbank and Town Highway 3

DS right: Steep channel bank to a wide flood plain

US left: Steep channel bank to a moderately sloped overbank and Town Highway 27

US right: Steep road embankment to Town Highway 3

Description of the Channel

Average top width 31 *ft* ***Average depth*** 2 *ft*

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

Meandering with semi-alluvial channel boundaries and a wide flood plain.

6/24/96

Vegetative co Shrubs and brush

DS left: Shrubs and brush

DS right: Shrubs and brush

US left: Short grass, shrubs, and brush

US right:

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

There is moderate fluvial erosion of the banks and cut-banks upstream and downstream of the bridge as of 6/24/96.

None as of 6/24/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 6.9 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/Green Mountain	80
St. Lawrence Valley/Champlain	20

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 [illegible] No

Calculated Discharges

Q100 1,590 ***ft³/s*** ***Q500*** 2,250 ***ft³/s***

The 100-year discharge is based on a drainage area relationship [(6.9/5.1)exp 0.67] with bridge number 47 in Jericho. Bridge number 47 crosses the Mill Brook upstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 47 is 5.1 square miles. The values computed are within a range defined by several empirical flood frequency curves which were 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 None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream left end of the bridge curb (elev. 500.22 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream right end of the bridge curb (elev. 500.27 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	-53	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	75	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 0.030 to 0.045.

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 0.0049 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1948).

The modelled approach section (APPRO) was 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 499.5 *ft*
Average low steel elevation 496.0 *ft*

100-year discharge 1,590 *ft^3/s*
Water-surface elevation in bridge opening 496.0 *ft*
Road overtopping? No *Discharge over road* -- *ft^3/s*
Area of flow in bridge opening 201 *ft^2*
Average velocity in bridge opening 7.9 *ft/s*
Maximum WSPRO tube velocity at bridge 9.7 *ft/s*

Water-surface elevation at Approach section with bridge 497.7
Water-surface elevation at Approach section without bridge 496.2
Amount of backwater caused by bridge 1.5 *ft*

500-year discharge 2,250 *ft^3/s*
Water-surface elevation in bridge opening 496.0 *ft*
Road overtopping? Yes *Discharge over road* 97 *ft^3/s*
Area of flow in bridge opening 201 *ft^2*
Average velocity in bridge opening 10.8 *ft/s*
Maximum WSPRO tube velocity at bridge 13.2 *ft/s*

Water-surface elevation at Approach section with bridge 499.5
Water-surface elevation at Approach section without bridge 496.7
Amount of backwater caused by bridge 2.8 *ft*

Incipient overtopping discharge 2,030 *ft^3/s*
Water-surface elevation in bridge opening 496.0 *ft*
Area of flow in bridge opening 201 *ft^2*
Average velocity in bridge opening 10.1 *ft/s*
Maximum WSPRO tube velocity at bridge 12.3 *ft/s*

Water-surface elevation at Approach section with bridge 499.0
Water-surface elevation at Approach section without bridge 496.5
Amount of backwater caused by bridge 2.5 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

At this site, the 100-year, 500-year and incipient roadway-overtopping discharges resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). For comparison, contraction scour for the discharges resulting in orifice flow was also computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and is presented in appendix F. The computed streambed armoring depths suggest that armoring will not limit the depth of contraction scour.

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

For the 500-year and incipient road-overtopping discharges, abutment scour also was computed by the HIRE equation (Richardson and others, 1993, p. 50, equation 25) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The results for these but are presented in appendix F.

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	1.6	4.6	3.5
Depth to armoring	9.7	N/A	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour	14.2	14.7	14.1
Left abutment	5.3	5.1	6.1
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:	1.2	1.7	1.6
Left abutment	1.2	1.7	1.6
Right abutment			
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

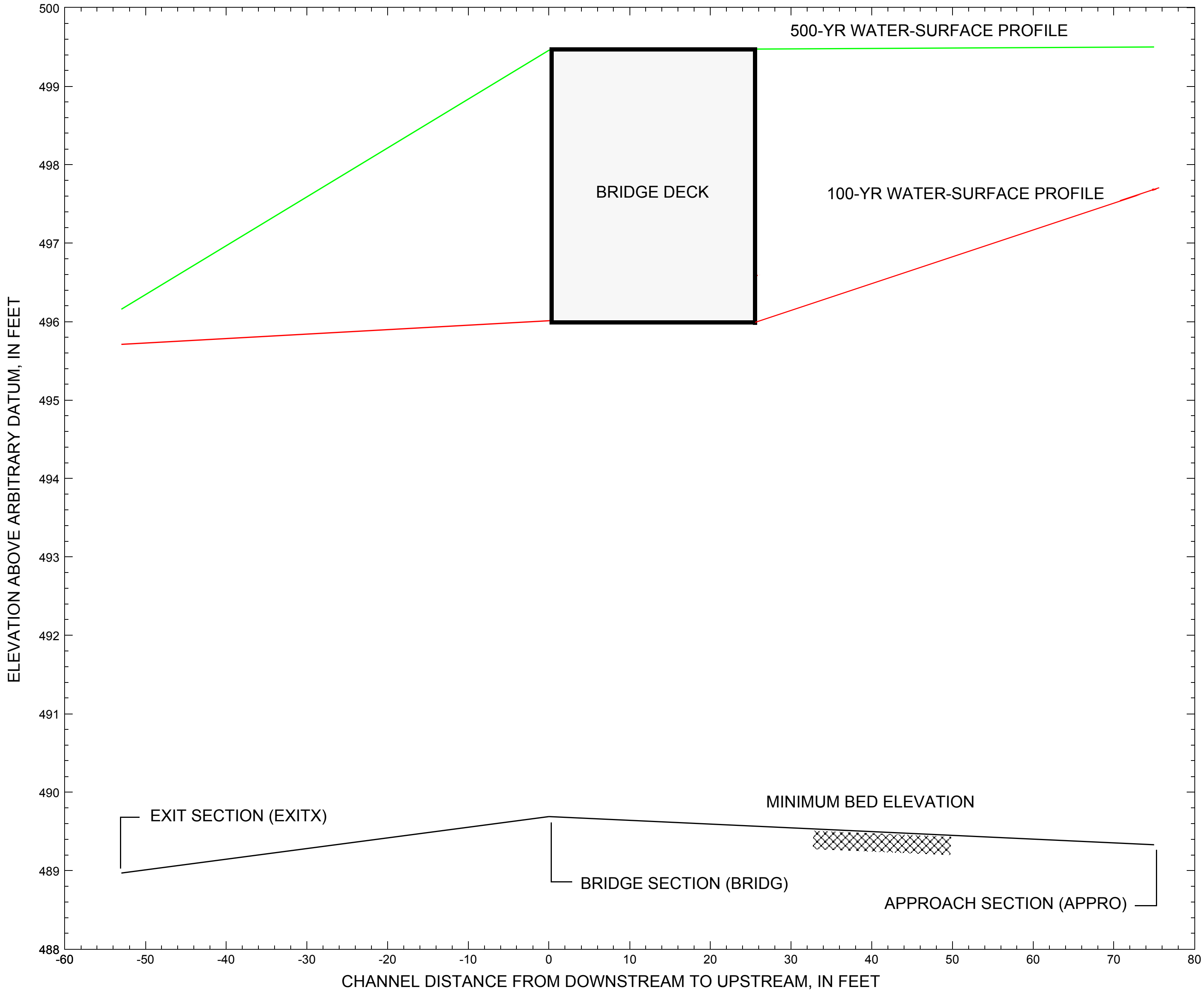

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure JERITH00030013 on Town Highway 3, crossing Mill Brook, Jericho, Vermont.

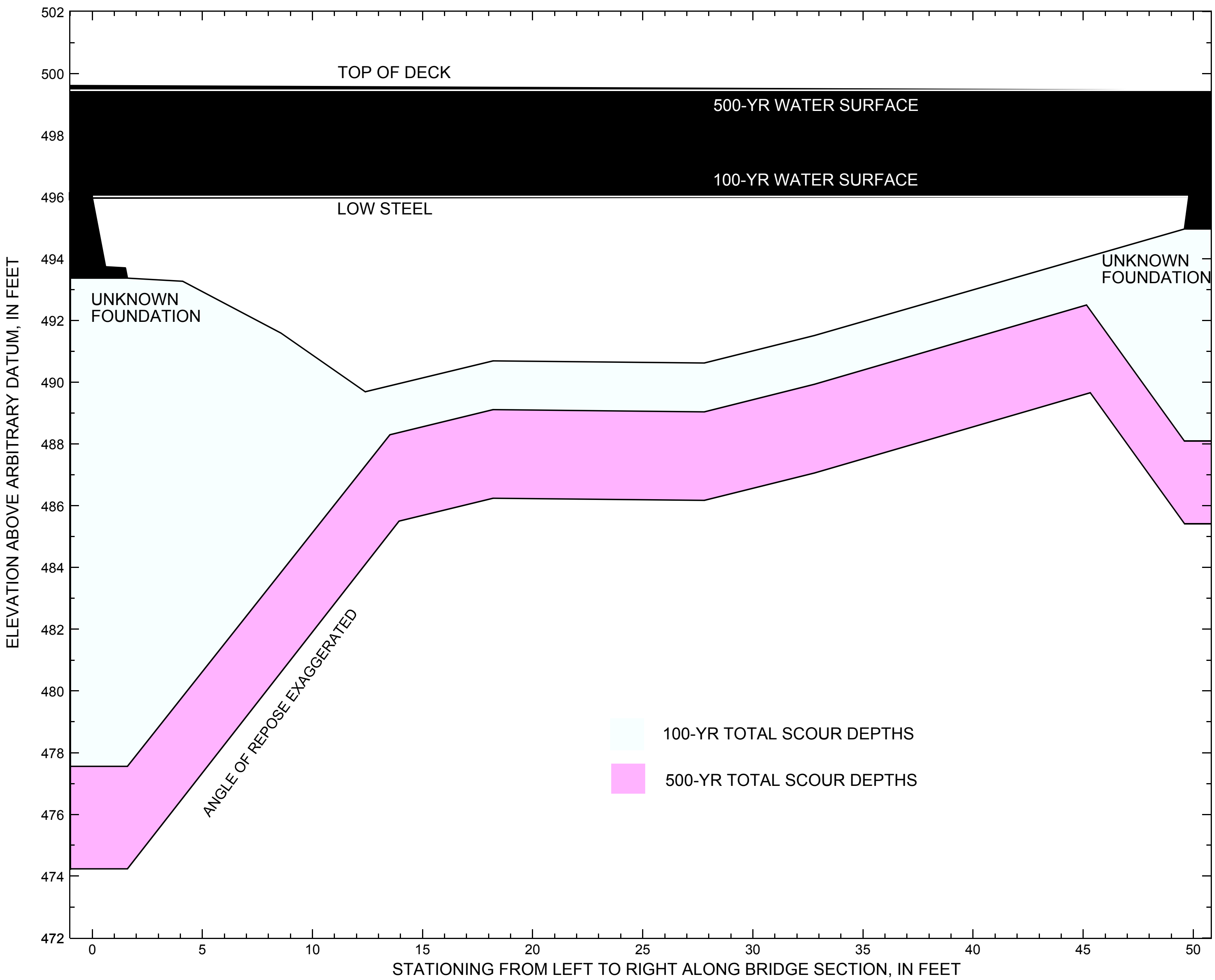

Figure 8. Scour elevations for the 100- and 500-yr discharges at structure JERITH00030013 on Town Highway 3, crossing Mill Brook, Jericho, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure JERITH00030013 on Town Highway 3, crossing Mill Brook, Jericho, 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 1,590 cubic-feet per second											
Left abutment	0.0	--	496.0	--	493.4	1.6	14.2	--	15.8	477.6	--
Right abutment	49.8	--	496.0	--	495.0	1.6	5.3	--	6.9	488.1	--

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 JERITH00030013 on Town Highway 3, crossing Mill Brook, Jericho, 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 2,250 cubic-feet per second											
Left abutment	0.0	--	496.0	--	493.4	4.6	14.7	--	19.3	474.1	--
Right abutment	49.8	--	496.0	--	495.0	4.6	5.1	--	9.7	485.3	--

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

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APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File jeri013.wsp
T2        Hydraulic analysis for structure JERITH00030013   Date: 24-JUN-97
T3        TH 13 CROSSING MILL BROOK IN JERICHO, VT                  RLB
*
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           1590.0   2250.0   2030.0
SK          0.0049   0.0049   0.0049
*
XS   EXITX    -53           0.
GR         -111.2, 499.59    -86.2, 498.96    -76.3, 495.30
GR            0.0, 494.04      5.8, 492.66     11.0, 491.55     12.8, 490.67
GR           18.0, 489.90     22.6, 489.49     26.2, 488.97     27.5, 489.74
GR           30.1, 491.56     31.8, 493.61     33.1, 495.03    119.7, 493.77
GR          169.7, 495.28    262.0, 496.80    308.7, 500.43
*
N           0.040        0.045        0.040
SA                   0.0         33.1
*
XS   FULLV      0  * * *   0.0
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.98       0.0
GR            0.0, 495.96      0.6, 493.74      1.5, 493.70      1.6, 493.37
GR            4.1, 493.27      8.6, 491.58     12.4, 489.69     18.2, 490.69
GR           27.8, 490.62     32.8, 491.51     42.7, 493.59     49.6, 494.96
GR           49.8, 496.01      0.0, 495.96
*
*        BRTYPE  BRWDTH        WWANGL   WWWID
CD           1      27.9  *  *    90.0     0.0
N           0.045
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      23.4     2
GR         -599.8, 503.33   -376.5, 500.92   -207.9, 499.48    -45.4, 499.65
GR            0.0, 499.61     50.9, 499.45     89.3, 498.95    145.0, 499.11
GR          198.1, 499.56    264.1, 500.23    463.0, 503.04    705.7, 504.37
GR          914.9, 505.61
*
AS   APPRO     75           0.
GR         -380.4, 507.82   -332.5, 503.70   -206.1, 499.55    -96.7, 498.06
GR          -90.0, 498.01    -80.1, 494.55      0.0, 492.54      5.2, 491.67
GR            6.8, 490.43     13.3, 489.33     20.6, 489.67     25.4, 491.53
GR           28.5, 493.72     89.3, 498.95    145.0, 499.11
GR          198.1, 499.56    264.1, 500.23    463.0, 503.04    705.7, 504.37
* GR          176.9, 496.56    308.4, 498.72    371.4, 502.27
*
N           0.045        0.045        0.030
SA                   0.0         28.5
*
HP 1 BRIDG  496.01 1 496.01
HP 2 BRIDG  496.01 * * 1590
HP 1 APPRO  497.69 1 497.69
HP 2 APPRO  497.69 * * 1590
*
HP 1 BRIDG  496.01 1 496.01
HP 2 BRIDG  496.01 * * 2164
HP 2 RDWAY  499.46 * * 97
HP 1 APPRO  499.50 1 499.50
HP 2 APPRO  499.50 * * 2250
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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       U.S. Geological Survey WSPRO Input File jeri013.wsp
       Hydraulic analysis for structure JERITH00030013   Date: 24-JUN-97
       TH 13 CROSSING MILL BROOK IN JERICHO, VT                  RLB
          *** RUN DATE & TIME: 11-06-97  13:02

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      201     10370      0    104                            0
  496.01           201     10370      0    104  1.00      0     50        0

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

        WSEL     LEW     REW    AREA       K        Q    VEL
      496.01     0.0    49.8   201.3   10370.    1590.  7.90

X STA.        0.0        6.0        8.8       10.8       12.3       13.6
  A(I)           15.3       11.0        9.9        8.9        8.2
  V(I)           5.21       7.21       8.00       8.97       9.67

X STA.       13.6       15.0       16.5       18.0       19.7       21.3
  A(I)            8.3        8.3        8.5        8.5        8.5
  V(I)           9.53       9.54       9.32       9.37       9.35

X STA.       21.3       22.9       24.5       26.1       27.8       29.5
  A(I)            8.6        8.6        8.8        8.9        9.1
  V(I)           9.22       9.20       9.07       8.93       8.72

X STA.       29.5       31.6       33.8       36.7       40.7       49.8
  A(I)            9.8       10.1       11.5       12.8       17.4
  V(I)           8.09       7.83       6.91       6.20       4.56

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      75.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      346     28206     89     90                         3871
            2      200     23375     29     30                         3005
            3       92      7169     46     46                          732
  497.69           638     58750    164    166  1.10    -88     75     6796

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      75.

        WSEL     LEW     REW    AREA       K        Q    VEL
      497.69   -89.1    74.7   637.7   58750.    1590.  2.49

X STA.      -89.1      -69.1      -58.0      -48.1      -39.2      -31.2
  A(I)           50.1       39.6       37.7       35.9       34.6
  V(I)           1.59       2.01       2.11       2.22       2.30

X STA.      -31.2      -23.6      -16.5       -9.8       -3.6        2.2
  A(I)           33.7       32.8       32.5       30.9       30.2
  V(I)           2.36       2.42       2.45       2.58       2.63

X STA.        2.2        6.9       10.0       12.9       15.6       18.3
  A(I)           28.7       23.5       22.7       22.5       22.1
  V(I)           2.77       3.38       3.49       3.53       3.60

X STA.       18.3       21.2       24.9       31.8       41.3       74.7
  A(I)           23.2       26.3       31.7       31.0       47.9
  V(I)           3.43       3.02       2.51       2.56       1.66
```

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        U.S. Geological Survey WSPRO Input File jeri013.wsp
        Hydraulic analysis for structure JERITH00030013   Date: 24-JUN-97
        TH 13 CROSSING MILL BROOK IN JERICHO, VT                   RLB
           *** RUN DATE & TIME: 11-06-97  13:02

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      201     10370      0    104                            0
   496.01           201     10370      0    104  1.00      0     50        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.01     0.0    49.8   201.3   10370.    2164.  10.75

X STA.         0.0        6.0        8.8       10.8       12.3       13.6
  A(I)            15.3       11.0        9.9        8.9        8.2
  V(I)            7.09       9.82      10.89      12.21      13.16

X STA.        13.6       15.0       16.5       18.0       19.7       21.3
  A(I)             8.3        8.3        8.5        8.5        8.5
  V(I)           12.98      12.98      12.69      12.75      12.73

X STA.        21.3       22.9       24.5       26.1       27.8       29.5
  A(I)             8.6        8.6        8.8        8.9        9.1
  V(I)           12.55      12.51      12.34      12.15      11.86

X STA.        29.5       31.6       33.8       36.7       40.7       49.8
  A(I)             9.8       10.1       11.5       12.8       17.4
  V(I)           11.01      10.66       9.41       8.44       6.21

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.46    47.7   186.3    41.2     683.      97.   2.36

X STA.        47.7       73.5       80.1       84.9       88.7       92.1
  A(I)             3.6        2.3        2.0        1.8        1.7
  V(I)            1.36       2.12       2.39       2.72       2.81

X STA.        92.1       95.5       98.8      102.2      105.8      109.4
  A(I)             1.7        1.7        1.6        1.7        1.7
  V(I)            2.88       2.94       2.99       2.93       2.90

X STA.       109.4      113.2      117.2      121.3      125.8      130.4
  A(I)             1.7        1.7        1.7        1.8        1.9
  V(I)            2.88       2.77       2.81       2.64       2.60

X STA.       130.4      135.5      141.1      147.5      156.3      186.3
  A(I)             2.0        2.1        2.2        2.6        3.8
  V(I)            2.47       2.36       2.17       1.89       1.27

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      75.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      595     40322    202    203                         5786
             2      252     34267     29     30                         4240
             3      228     14135    163    163                         1528
   499.50          1074     88724    393    396  1.45   -201    191     8372

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      75.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.50  -202.4   191.0  1073.9   88724.    2250.   2.10

X STA.      -202.4      -74.7      -59.9      -47.8      -37.6      -28.7
  A(I)           144.8       78.3       67.7       60.1       54.4
  V(I)            0.78       1.44       1.66       1.87       2.07

X STA.       -28.7      -20.8      -13.5       -6.8       -0.5        4.5
  A(I)            50.1       47.7       45.2       42.8       36.5
  V(I)            2.24       2.36       2.49       2.63       3.08

X STA.         4.5        8.5       11.6       14.5       17.4       20.5
  A(I)            34.6       30.0       29.2       29.5       30.4
  V(I)            3.25       3.76       3.86       3.82       3.71

X STA.        20.5       24.0       30.0       39.2       53.3      191.0
  A(I)            32.2       41.3       48.5       60.0      110.7
  V(I)            3.49       2.72       2.32       1.87       1.02
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File jeri013.wsp
        Hydraulic analysis for structure JERITH00030013   Date: 24-JUN-97
        TH 13 CROSSING MILL BROOK IN JERICHO, VT                  RLB
           *** RUN DATE & TIME: 11-06-97  13:02

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      201     10370      0    104                            0
   496.01           201     10370      0    104  1.00      0     50        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.01     0.0    49.8   201.3   10370.    2030.  10.09

X STA.         0.0         6.0         8.8        10.8        12.3        13.6
  A(I)            15.3        11.0         9.9         8.9         8.2
  V(I)            6.65        9.21       10.21       11.46       12.34

X STA.        13.6        15.0        16.5        18.0        19.7        21.3
  A(I)             8.3         8.3         8.5         8.5         8.5
  V(I)           12.17       12.18       11.90       11.96       11.94

X STA.        21.3        22.9        24.5        26.1        27.8        29.5
  A(I)             8.6         8.6         8.8         8.9         9.1
  V(I)           11.77       11.74       11.57       11.40       11.13

X STA.        29.5        31.6        33.8        36.7        40.7        49.8
  A(I)             9.8        10.1        11.5        12.8        17.4
  V(I)           10.33       10.00        8.82        7.92        5.83

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      75.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      501     34714    165    166                         4956
             2      237     31031     29     30                         3878
             3      162     13410     75     75                         1350
   498.99           900     79155    268    271  1.29   -164    103     8231

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      75.

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.99  -165.0   103.2   899.8   79155.    2030.   2.26

X STA.      -165.0       -68.8       -54.8       -43.9       -34.1       -25.8
  A(I)           116.7        68.7        56.9        53.3        47.3
  V(I)            0.87        1.48        1.78        1.91        2.14

X STA.       -25.8       -18.1       -11.2        -4.7         1.2         6.0
  A(I)            45.4        42.4        40.2        38.2        33.8
  V(I)            2.23        2.39        2.53        2.66        3.00

X STA.         6.0         9.5        12.4        15.3        18.2        21.1
  A(I)            30.1        27.5        27.2        27.6        27.6
  V(I)            3.37        3.69        3.74        3.68        3.67

X STA.        21.1        24.8        31.1        38.7        49.7       103.2
  A(I)            30.9        37.6        36.2        42.8        69.4
  V(I)            3.29        2.70        2.80        2.37        1.46
```

```
       U.S. Geological Survey WSPRO Input File jeri013.wsp
       Hydraulic analysis for structure JERITH00030013   Date: 24-JUN-97
       TH 13 CROSSING MILL BROOK IN JERICHO, VT                    RLB
          *** RUN DATE & TIME: 11-06-97  13:02

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

EXITX:XS   ******    -76      406  0.36 *****  496.07  495.42    1590  495.71
       -52 ******    196    22709  1.51 ***** *******    0.69    3.91

FULLV:FV       53    -77      498  0.22  0.20  496.26 *******    1590  496.03
         0     53    215    29227  1.41  0.00   -0.01    0.51    3.19
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       75    -84      411  0.28  0.21  496.49 *******    1590  496.21
        75     75     57    31282  1.19  0.03    0.00    0.44    3.86
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                         WS3N,LSEL =    496.03      495.98

            <<<<<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       53      0      201  0.98 *****  496.99  495.11    1597  496.01
         0 ******     50    10370  1.00 ***** *******    0.70    7.94

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   3.  0.800  0.000  495.98 ****** ****** ******

    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       47    -88      638  0.11  0.24  497.80  494.97    1590  497.69
        75     57     75    58784  1.10  0.00    0.00    0.23    2.49

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   497.65

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -53.   -77.   196.   1590.   22709.     406.    3.91  495.71
   FULLV:FV       0.   -78.   215.   1590.   29227.     498.    3.19  496.03
   BRIDG:BR       0.     0.    50.   1597.   10370.     201.    7.94  496.01
   RDWAY:RG      13.**************      0.       0.       0.    2.00********
   APPRO:AS      75.   -89.    75.   1590.   58784.     638.    2.49  497.69

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.42    0.69  488.97  500.43************  0.36  496.07  495.71
   FULLV:FV  ********    0.51  488.97  500.43  0.20  0.00  0.22  496.26  496.03
   BRIDG:BR    495.11    0.70  489.69  496.01************  0.98  496.99  496.01
   RDWAY:RG  ****************  498.95  505.61************  0.06  499.02********
   APPRO:AS    494.97    0.23  489.33  507.82  0.24  0.00  0.11  497.80  497.69
```

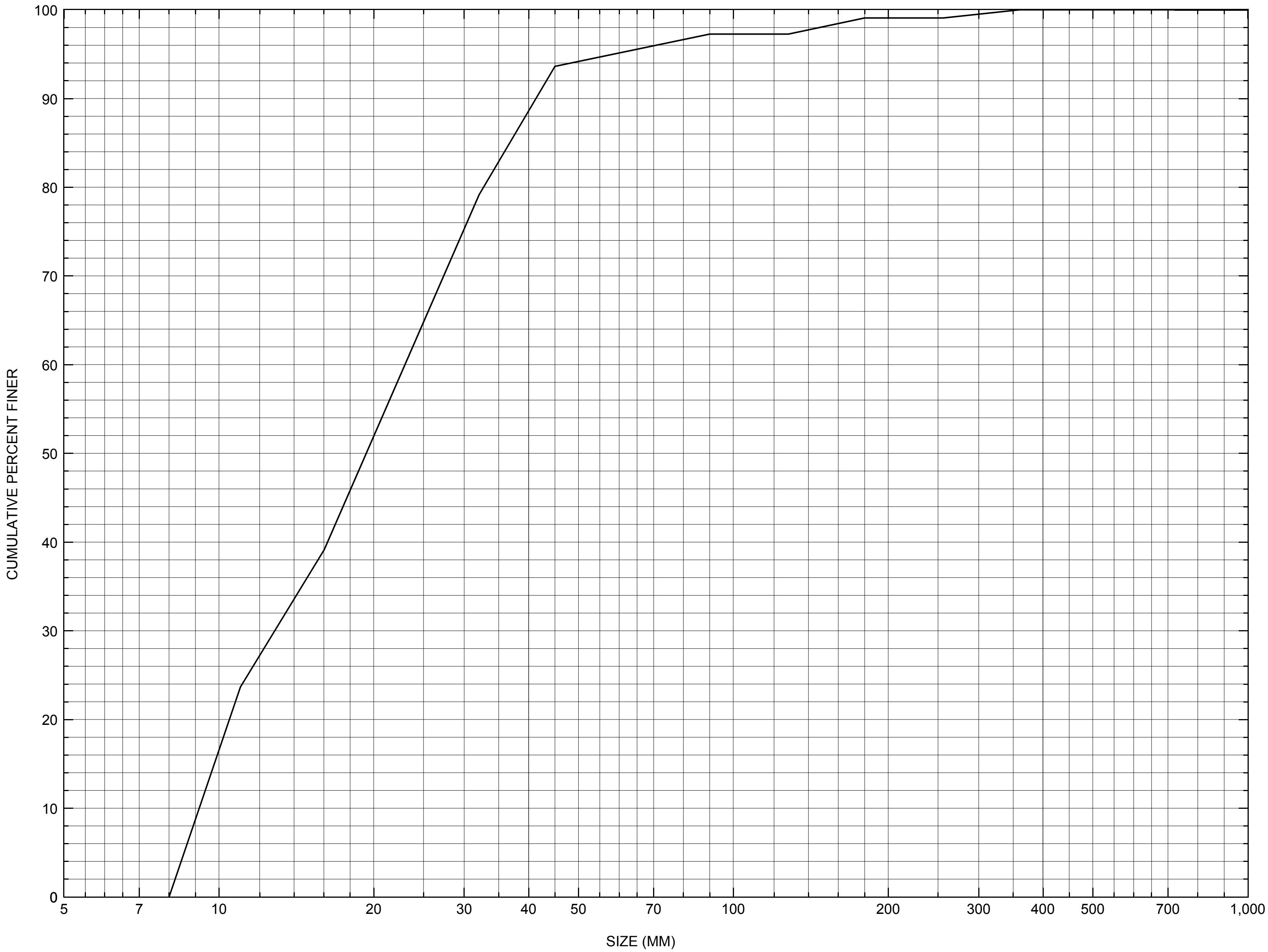
WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File jeri013.wsp
        Hydraulic analysis for structure JERITH00030013   Date: 24-JUN-97
        TH 13 CROSSING MILL BROOK IN JERICHO, VT                RLB
           *** RUN DATE & TIME: 11-06-97  13:02

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

EXITX:XS   ******    -78      537  0.38 *****  496.54  495.76    2250  496.16
       -52 ******    223    32137  1.38 ***** *******    0.65    4.19

FULLV:FV       53    -79      638  0.25  0.21  496.74 *******    2250  496.49
         0     53    243    40178  1.32  0.00   -0.01    0.51    3.53
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       75    -85      475  0.40  0.25  497.05 *******    2250  496.65
        75     75     63    38465  1.16  0.07   -0.01    0.50    4.73
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   496.49     495.98

            <<<<<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       53      0      201  1.80 *****  497.81  495.82    2164  496.01
         0 ******     50    10370  1.00 ***** *******    0.94   10.75

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  495.98 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    52.  0.03  0.10  499.56    0.00     97.  499.46

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.   150.  -222.    21.   0.1   0.1   1.7   3.7   0.2   2.6
   RT:    97.   139.    47.   186.   0.5   0.3   2.6   2.3   0.4   2.8

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

APPRO:AS       47   -201     1073  0.10  0.30  499.60  495.47    2250  499.50
        75     58    191    88662  1.45  0.00    0.00    0.27    2.10

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

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -53.   -79.   223.   2250.   32137.     537.    4.19  496.16
   FULLV:FV       0.   -80.   243.   2250.   40178.     638.    3.53  496.49
   BRIDG:BR       0.     0.    50.   2164.   10370.     201.   10.75  496.01
   RDWAY:RG      13.*******     0.     97.       0.*********    2.00  499.46
   APPRO:AS      75.  -202.   191.   2250.   88662.    1073.    2.10  499.50

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    495.76    0.65  488.97  500.43************  0.38  496.54  496.16
   FULLV:FV  ********    0.51  488.97  500.43  0.21  0.00  0.25  496.74  496.49
   BRIDG:BR    495.82    0.94  489.69  496.01************  1.80  497.81  496.01
   RDWAY:RG  ****************  498.95  505.61  0.03******  0.10  499.56  499.46
   APPRO:AS    495.47    0.27  489.33  507.82  0.30  0.00  0.10  499.60  499.50
```

```
        U.S. Geological Survey WSPRO Input File jeri013.wsp
        Hydraulic analysis for structure JERITH00030013   Date: 24-JUN-97
        TH 13 CROSSING MILL BROOK IN JERICHO, VT                   RLB
           *** RUN DATE & TIME: 11-06-97  13:02

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

EXITX:XS   ******    -77      495  0.37 *****  496.39  495.67    2030  496.02
       -52 ******    215    28997  1.42 ***** *******    0.66    4.10

FULLV:FV       53    -78      593  0.24  0.21  496.59 *******    2030  496.35
         0     53    234    36548  1.34  0.00   -0.01    0.51    3.42
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       75    -85      455  0.36  0.23  496.88 *******    2030  496.52
        75     75     61    36161  1.17  0.06   -0.01    0.48    4.46
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   496.35     495.98

            <<<<<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       53      0      201  1.58 *****  497.59  495.66    2026  496.01
         0 ******     50    10370  1.00 ***** *******    0.88   10.07

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   3.  0.800  0.000  495.98 ****** ****** ******

    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       47   -164      900  0.10  0.29  499.09  495.31    2030  498.99
        75     57    104    79136  1.29  0.00    0.00    0.25    2.26

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   498.96

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -53.   -78.   215.   2030.   28997.     495.    4.10  496.02
   FULLV:FV       0.   -79.   234.   2030.   36548.     593.    3.42  496.35
   BRIDG:BR       0.     0.    50.   2026.   10370.     201.   10.07  496.01
   RDWAY:RG      13.**************      0.       0.       0.    2.00********
   APPRO:AS      75.  -165.   104.   2030.   79136.     900.    2.26  498.99

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.67    0.66  488.97  500.43************  0.37  496.39  496.02
   FULLV:FV  ********    0.51  488.97  500.43  0.21  0.00  0.24  496.59  496.35
   BRIDG:BR    495.66    0.88  489.69  496.01************  1.58  497.59  496.01
   RDWAY:RG  ****************  498.95  505.61************  0.10  499.06********
   APPRO:AS    495.31    0.25  489.33  507.82  0.29  0.00  0.10  499.09  498.99
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure JERITH00030013, in Jericho, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number JERITH00030013

General Location Descriptive

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

Date *(MM/DD/YY)* 12 / 12 / 95

Highway District Number *(I - 2; nn)* 05

County *(FIPS county code; I - 3; nnn)* 007

Town *(FIPS place code; I - 4; nnnnn)* 36700

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

Waterway *(I - 6)* Mill Brook

Road Name *(I - 7):* -

Route Number C2003

Vicinity *(I - 9)* Jct of CL2 TH3 &CL3 TH27

Topographic Map Richmond

Hydrologic Unit Code: 02010005

Latitude *(I - 16; nnnn.n)* 44271

Longitude *(i - 17; nnnnn.n)* 72556

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10040900130409

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

Maximum span length *(I - 48; nnnn)* 0050

Year built *(I - 27; YYYY)* 1939

Structure length *(I - 49; nnnnnn)* 000054

Average daily traffic, ADT *(I - 29; nnnnnn)* 000570

Deck Width *(I - 52; nn.n)* 234

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

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

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

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

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*) -

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

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

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

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

Comments:

According to the structural inspection report dated 8/15/95, the bridge deck is poured concrete with an asphalt overlay. The abutments and backwalls are concrete with a concrete footing exposed on the left abutment. US of the bridge centerline, there is a 5 ft long section of undermining on this footing, 12 inches horizontally and 3-4 inches deep. The abutments have alligator cracks and leaks on their US and DS ends with several fine cracks and small leaks overall. Boulder stone fill has been placed in front of and US of the left and right abutments. Sections of the stone fill have washed away from against the left abutment. A silt and gravel bar at the right abutment blocks 1/3 of the channel flow. **(Continued p. 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: Sand and silt with some stones

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} (*ft³/ 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 (*ft²*): -

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

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

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

Comments:

The US channel flows in at 90 degrees. A 2-3 ft scour hole has formed along the front edge of the stone fill near the US end of the left abutment.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **6.91** mi^2

Lake/pond/swamp area **0.01** mi^2

Watershed storage *(ST)* **0.14** %

Bridge site elevation **750** ft

Headwater elevation **3680** ft

Main channel length **4.97** mi

10% channel length elevation **780** ft

85% channel length elevation **2300** ft

Main channel slope *(S)* **407.79** 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)*: - / -

Project Number -

Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB -

Benchmark location description:

NO BENCKMARK INFORMATION

Reference Point (*MSL, Arbitrary, Other*): -

Datum (*NAD27, NAD83, Other*): -

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

If 1: Footing Thickness - Footing bottom elevation: -

If 2: Pile Type: - (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: -

If 3: Footing bottom elevation: -

Is boring information available? **N** *If no, type ctrl-n bi* Number of borings taken: -

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

Briefly describe material at foundation bottom elevation or around piles:

NO DRILL BORING INFORMATION

Comments:

Bridge plan data is available.

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 elevations are from the survey log completed for this report on 6/24/96. The low chord to bed length data is from the sketch attached to a bridge inspection report dated 8/15/95. The sketch was done on 11/4/93.**

Station	0	13	18	26	50	-	-	-	-	-	-
Feature	LAB				RAB	-	-	-	-	-	-
Low chord elevation	496.0	496.0	496.0	496.0	496.0	-	-	-	-	-	-
Bed elevation	494.3	487.6	487.6	488.8	494.1	-	-	-	-	-	-
Low chord-bed	1.7	8.4	8.4	7.2	1.9	-	-	-	-	-	-
Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord-bed	-	-	-	-	-	-	-	-	-	-	-

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

Comments: -

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: RB Date: 8/2/96
Computerized by: RB Date: 8/2/96
Reviewd by: RB Date: 9/25/97

Structure Number JERITH00030013

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN Date *(MM/DD/YY)* 06 / 24 / 1996

2. Highway District Number 05 Mile marker 0000

County CHITTENDEN (007) Town JERICHO (36700)

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

Route Number C2003 Hydrologic Unit Code: 02010005

3. Descriptive comments:

The bridge is located at the junction of CL2 TH3 and CL3 TH27. This bridge has a concrete deck with an asphalt overlay supported by steel I-beams.

B. Bridge Deck Observations

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

5. Ambient water surface... US 2 UB 1 DS 1 *(**1**- pool; **2**- riffle)*

6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*

7. Bridge length 54 *(feet)* Span length 50 *(feet)* Bridge width 23.4 *(feet)*

Road approach to bridge:

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

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

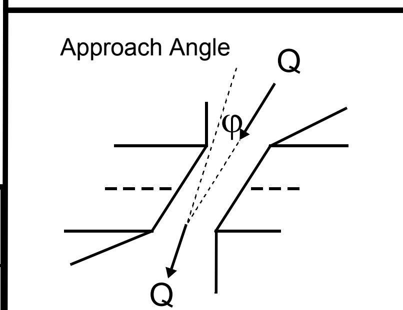
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

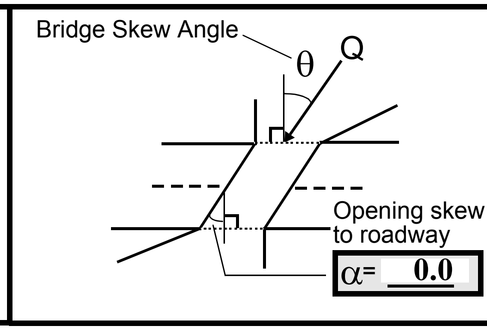
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	0	-	2	1
RBUS	0	-	1	2
RBDS	0	-	2	1
LBDS	0	-	2	1

*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: 70 16. Bridge skew: 90





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 140 feet US *(US, UB, DS)* to 90 feet US

Channel impact zone 2: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 3
Range? 38 feet US *(US, UB, DS)* to 0 feet DS

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

18. Bridge Type: **1a**

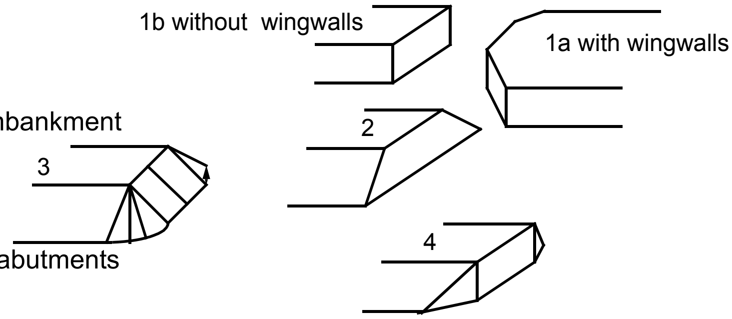
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

9. The pavement on the bridge deck overlaps the roadway 44 feet past the left abutment on the left road approach and 40 feet past the right abutment on the right road approach, beyond this, the road is not paved.
10. The right and left bank upstream have dumped stone protection that also serves as roadway protection. The right bank US road embankment erosion is at 50 feet US from the right 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
45.0	1.0			2.0	2	1	213	342	2	2

23. Bank width **10.0** 24. Channel width **35.0** 25. Thalweg depth **29.0** 29. Bed Material **234**

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

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

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

30. The right bank protection extent is from 90 feet US to the US end of the US right wingwall.
The left bank protection extends from 0 feet US to 38 feet US.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **0** 35. Mid-bar width: **12**

36. Point bar extent: **10** feet **US** *(US, UB)* to **10** feet **DS** *(US, UB, DS)* positioned **66** %LB to **100** %RB

37. Material: **21**

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

This point bar is under the bridge and along the right abutment.

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

41. Mid-bank distance: **130** 42. Cut bank extent: **140** feet **US** *(US, UB)* to **90** feet **US** *(US, UB, DS)*

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

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

This is a minor cutbank on the left bank, just US of the protection.

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **25**

47. Scour dimensions: Length **50** Width **7** Depth : **1.5** Position **0** %LB to **80** %RB

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

Scour depth assumes a 1.5 foot thalweg.

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
20.0		**2.5**		**2**	**7**	**7**	**-**

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

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

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

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

32

There is some type 1 protection on the bed along the left abutment. Some of the protection is missing along the left abutment footing.

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

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

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

70. Debris and Ice Comments:

1

The debris is in the US channel. There are small branches caught in a riffle in the stream.

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		**45**	**90**	**0**	**3**	**0**	**2**	**90.0**
RABUT	**1**	**-**	**90**			**0**	**0**	**50.0**

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

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

0

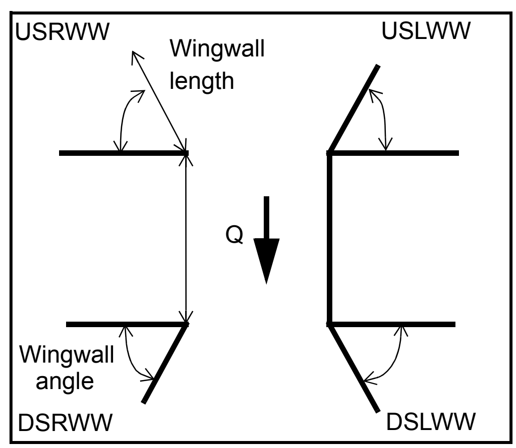
0

1

The left abutment can be penetrated 1 foot under the footing.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**50.0**	
USRWW:	**Y**		**-**		**-**	**2.0**	
DSLWW:	**-**		**-**		**Y**	**26.0**	
DSRWW:	**-**		**-**		**-**	**25.5**	



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

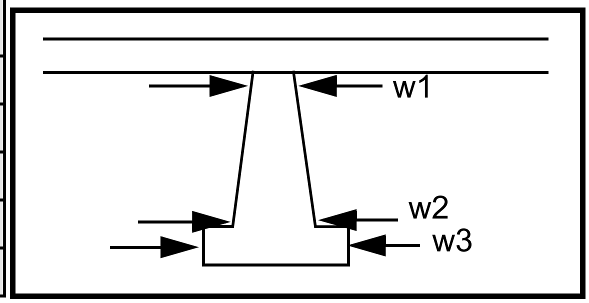
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
1
1
1
0
-
-

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1	90	90	90	2.25	2.25	2.25
Pier 2	90	-	-	2.25	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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.):
-
-
NO PIERS

1
1
231

101. Is a drop structure present? **23** *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

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

105. Drop structure comments (eg. downstream scour depth):
1
2
231
0
0
-

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

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

Material: _____

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

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

Cut bank extent: - ____ feet NO (US, UB, DS) to DRO feet P ____ (US, UB, DS)

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

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

RUCTURE

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

Scour dimensions: Length Y ____ Width 55 ____ Depth: 4 ____ Positioned 30 ____ %LB to DS ____ %RB

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

105

DS

0

70

Are there major confluences? 30 ____ (Y or if N type ctrl-n mc) How many? 1 ____

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

Confluence 2: Distance par- ____ Enters on allel ____ (LB or RB) Type to ____ (1- perennial; 2- ephemeral)

Confluence comments (eg. confluence name):

the point bar is sand with grass.

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

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

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

Y
RB
35
30
DS
50
DS
1
-

109. G. Plan View Sketch

Y

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: JERITH00030013 Town: JERICHO
Road Number: TH 3 County: CHITTENDEN
Stream: MILL BROOK

Initials RLB Date: 7/22/97 Checked: RF

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	1590	2250	2030
Main Channel Area, ft2	200	252	237
Left overbank area, ft2	346	595	501
Right overbank area, ft2	92	228	162
Top width main channel, ft	29	29	29
Top width L overbank, ft	89	202	165
Top width R overbank, ft	46	163	75
D50 of channel, ft	0.0634	0.0634	0.0634
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.9	8.7	8.2
y1, average depth, LOB, ft	3.9	2.9	3.0
y1, average depth, ROB, ft	2.0	1.4	2.2
Total conveyance, approach	58750	88724	79155
Conveyance, main channel	23375	34267	31031
Conveyance, LOB	28206	40322	34714
Conveyance, ROB	7169	14135	13410
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	632.6	869.0	795.8
Ql, discharge, LOB, cfs	763.4	1022.5	890.3
Qr, discharge, ROB, cfs	194.0	358.5	343.9
Vm, mean velocity MC, ft/s	3.2	3.4	3.4
Vl, mean velocity, LOB, ft/s	2.2	1.7	1.8
Vr, mean velocity, ROB, ft/s	2.1	1.6	2.1
Vc-m, crit. velocity, MC, ft/s	6.2	6.4	6.3
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	1590	2250	2030
(Q) discharge thru bridge, cfs	1590	2164	2030
Main channel conveyance	10370	10370	10370
Total conveyance	10370	10370	10370
Q2, bridge MC discharge,cfs	1590	2164	2030
Main channel area, ft2	201	201	201
Main channel width (normal), ft	49.8	49.8	49.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	49.8	49.8	49.8
y_bridge (avg. depth at br.), ft	4.04	4.04	4.04
Dm, median (1.25*D50), ft	0.07925	0.07925	0.07925
y2, depth in contraction,ft	4.97	6.47	6.13
ys, scour depth (y2-ybridge), ft	0.93	2.44	2.09

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	1590	2164	2030
Main channel area (DS), ft2	201	201	201
Main channel width (normal), ft	49.8	49.8	49.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	49.8	49.8	49.8
D90, ft	0.1356	0.1356	0.1356
D95, ft	0.1923	0.1923	0.1923
Dc, critical grain size, ft	0.1817	0.3365	0.2961
Pc, Decimal percent coarser than Dc	0.053	N/A	N/A
Depth to armoring, ft	9.74	N/A	N/A

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	1590	2250	2030
Q, thru bridge MC, cfs	1590	2164	2030
Vc, critical velocity, ft/s	6.17	6.41	6.34
Va, velocity MC approach, ft/s	3.16	3.45	3.36
Main channel width (normal), ft	49.8	49.8	49.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	49.8	49.8	49.8
qbr, unit discharge, ft2/s	31.9	43.5	40.8
Area of full opening, ft2	201.0	201.0	201.0
Hb, depth of full opening, ft	4.04	4.04	4.04
Fr, Froude number, bridge MC	0.69	0.94	0.88
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	495.98	495.98	495.98
Elevation of Bed, ft	491.94	491.94	491.94
Elevation of Approach, ft	497.69	499.5	498.99
Friction loss, approach, ft	0.25	0.32	0.3
Elevation of WS immediately US, ft	497.44	499.18	498.69
ya, depth immediately US, ft	5.50	7.24	6.75
Mean elevation of deck, ft	499.53	499.53	499.53
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.92	0.79	0.85
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	1.58	4.55	3.51
Ys, scour w/Umbrell equation, ft	0.01	1.45	1.03

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	1590	2250	2030	1590	2250	2030
a', abut.length blocking flow, ft	89.1	202.4	165	24.9	141.2	53.4
Ae, area of blocked flow ft2	346.54	594.75	501.33	35.71	84.58	69.27
Qe, discharge blocked abut.,cfs	764.84	1023.75	892.86	59.27	--	101.31
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.21	1.72	1.78	1.66	1.12	1.46
ya, depth of f/p flow, ft	3.89	2.94	3.04	1.43	0.60	1.30
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.197	0.177	0.180	0.244	0.209	0.226
ys, scour depth, ft	14.23	14.68	14.11	5.29	5.09	6.12

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)	89.1	202.4	165	24.9	141.2	53.4
y1 (depth f/p flow, ft)	3.89	2.94	3.04	1.43	0.60	1.30
a'/y1	22.91	68.88	54.31	17.36	235.72	41.17
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.20	0.18	0.18	0.24	0.21	0.23
Ys w/ corr. factor K1/0.55:						
vertical	ERR	12.07	12.55	ERR	2.60	5.78
vertical w/ ww's	ERR	9.90	10.29	ERR	2.13	4.74
spill-through	ERR	6.64	6.90	ERR	1.43	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	0.69	0.94	0.88	0.69	0.94	0.88
y, depth of flow in bridge, ft	4.04	4.04	4.04	4.04	4.04	4.04
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	1.19	ERR	ERR	1.19	ERR	ERR
Fr>0.8 (vertical abut.)	ERR	1.66	1.63	ERR	1.66	1.63