LEVEL II SCOUR ANALYSIS FOR BRIDGE 38 (JERITH00200038) on TOWN HIGHWAY 20, crossing the LEE RIVER, JERICHO, VERMONT

Open-File Report 97-773

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

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

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JERICHO, VERMONT

By EMILY C. WILD and JAMES DEGNAN

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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U.S. GEOLOGICAL SURVEY
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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 38 (JERITH00200038) ON TOWN HIGHWAY 20, CROSSING THE LEE RIVER, JERICHO, VERMONT

By **Emily C. Wild and James Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure JERITH00200038 on Town Highway 20 crossing the Lee River, 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 (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, obtained 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 12.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover on the upstream and downstream right overbank is pasture while the immediate banks have dense woody vegetation. The surface cover on the upstream and downstream left overbank is forested.

In the study area, the Lee River has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 89 ft and an average bank height of 14 ft. The channel bed material ranges from sand to boulder with a median grain size (D_{50}) of 45.9 mm (0.151 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 2, 1996, indicated that the reach was stable.

The Town Highway 20 crossing of the Lee River is a 49-ft-long, one-lane bridge consisting of a steel through truss span (Vermont Agency of Transportation, written communication, December 12, 1995). The opening length of the structure parallel to the bridge face is 44 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening while the computed opening-skew-to-roadway is 5 degrees.

A scour hole 1 ft deeper than the mean thalweg depth was observed in the center of the channel during the Level I assessment. Scour countermeasures at the site include type-1 stone fill (less than 12 inches diameter) at the downstream left road embankment. Type-2 stone fill (less than 36 inches diameter) protects the upstream left wingwall, the upstream and downstream right wingwalls and the upstream end of the right abutment. Type-3 stone fill (less than 48 inches diameter) protects the left abutment. 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. 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 was zero. Abutment scour ranged from 4.9 to 10.7 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled "Scour Results". Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives "excessively conservative estimates of scour depths" (Richardson and 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 JERITH00200038 ***Stream*** Lee River

County Chittenden ***Road*** TH20 ***District*** 5

Description of Bridge

Bridge length 49 ***ft*** ***Bridge width*** 11.8 ***ft*** ***Max span length*** 47 ***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*** 7/02/96

Description of stone fill Type-2, along the upstream left wingwall, the upstream and downstream right wingwalls and the upstream end of the right abutment. Type-3, along the left abutment.

Abutments and wingwalls are concrete.

Y 10

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

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	7/02/96	0	0
Level II	7/02/96	0	0

Potential for debris Low. There is some debris along upstream banks and at the bridge.

None, 7/02/96.

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 narrow, irregular flood plain with steep valley walls on both sides.

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

Date of inspection 7/02/96

DS left: Steep channel bank with a narrow flood plain.

DS right: Steep channel bank with a narrow flood plain.

US left: Steep channel bank with a narrow flood plain.

US right: Steep valley wall.

Description of the Channel

Average top width 89 ***ft*** ***Average depth*** 14 ***ft***

Predominant bed material Gravel / Boulders ***Bank material*** Gravel/Boulders

Sinuous but stable with alluvial channel boundaries and a narrow flood plain.

7/02/96

Vegetative co Short grass with trees and brush along the immediate bank.

DS left: Trees with Town Highway 2 along the immediate bank.

DS right: Short grass with trees and brush along the immediate bank.

US left: Trees with Town Highway 2 along the immediate bank.

US right:

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

No obstructions were observed during July 2, 1996 site visit.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 12.9 ***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***: A house and a garage are on the upstream left overbank.

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 1,640 ***ft³/s*** ***Q500*** 2,860 ***ft³/s***

The 100-year and 500-year discharges are based on a drainage area relationship [(12.9/16.7)exp 0.67] with the Town of Jericho Flood Insurance Study discharge values of the Lee River at the confluence with Brown River (Federal Emergency Management Agency, 1980). Brown River enters the Lee River downstream of this site. The values computed are within a range defined by several empirical flood frequency curves (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 To obtain National Geodetic Vertical Datum of 1929, add 85.18 to USGS arbitrary survey datum.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the right abutment (elev. 500.10 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the left abutment (elev. 499.74 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	-47	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPRO	68	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.040 to 0.075, and overbank "n" values ranged from 0.040 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 0.0164 ft/ft, which was calculated from thalweg slopes surveyed downstream.

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

Bridge Hydraulics Summary

Average bridge embankment elevation 499.9 ***ft***
Average low steel elevation 497.3 ***ft***

100-year discharge 1,640 ***ft³/s***
Water-surface elevation in bridge opening 490.4 ***ft***
Road overtopping? N ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 276 ***ft²***
Average velocity in bridge opening 5.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 7.3 ***ft/s***

Water-surface elevation at Approach section with bridge 491.0
Water-surface elevation at Approach section without bridge 491.2
Amount of backwater caused by bridge N/A ***ft***

500-year discharge 2,860 ***ft³/s***
Water-surface elevation in bridge opening 492.2 ***ft***
Road overtopping? N ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 353 ***ft²***
Average velocity in bridge opening 8.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.0 ***ft/s***

Water-surface elevation at Approach section with bridge 493.1
Water-surface elevation at Approach section without bridge 493.2
Amount of backwater caused by bridge N/A ***ft***

Incipient overtopping discharge -- ***ft³/s***
Water-surface elevation in bridge opening -- ***ft***
Area of flow in bridge opening -- ***ft²***
Average velocity in bridge opening -- ***ft/s***
Maximum WSPRO tube velocity at bridge -- ***ft/s***

Water-surface elevation at Approach section with bridge --
Water-surface elevation at Approach section without bridge --
Amount of backwater caused by bridge -- ***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 are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour for the modelled discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the modelled discharges resulted in free surface flow. 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.

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	--
Depth to armoring	0.7	2.7	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	4.9	7.4	--
Right abutment	6.5	10.7	--
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	0.7	1.3	--
Right abutment	0.7	1.3	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

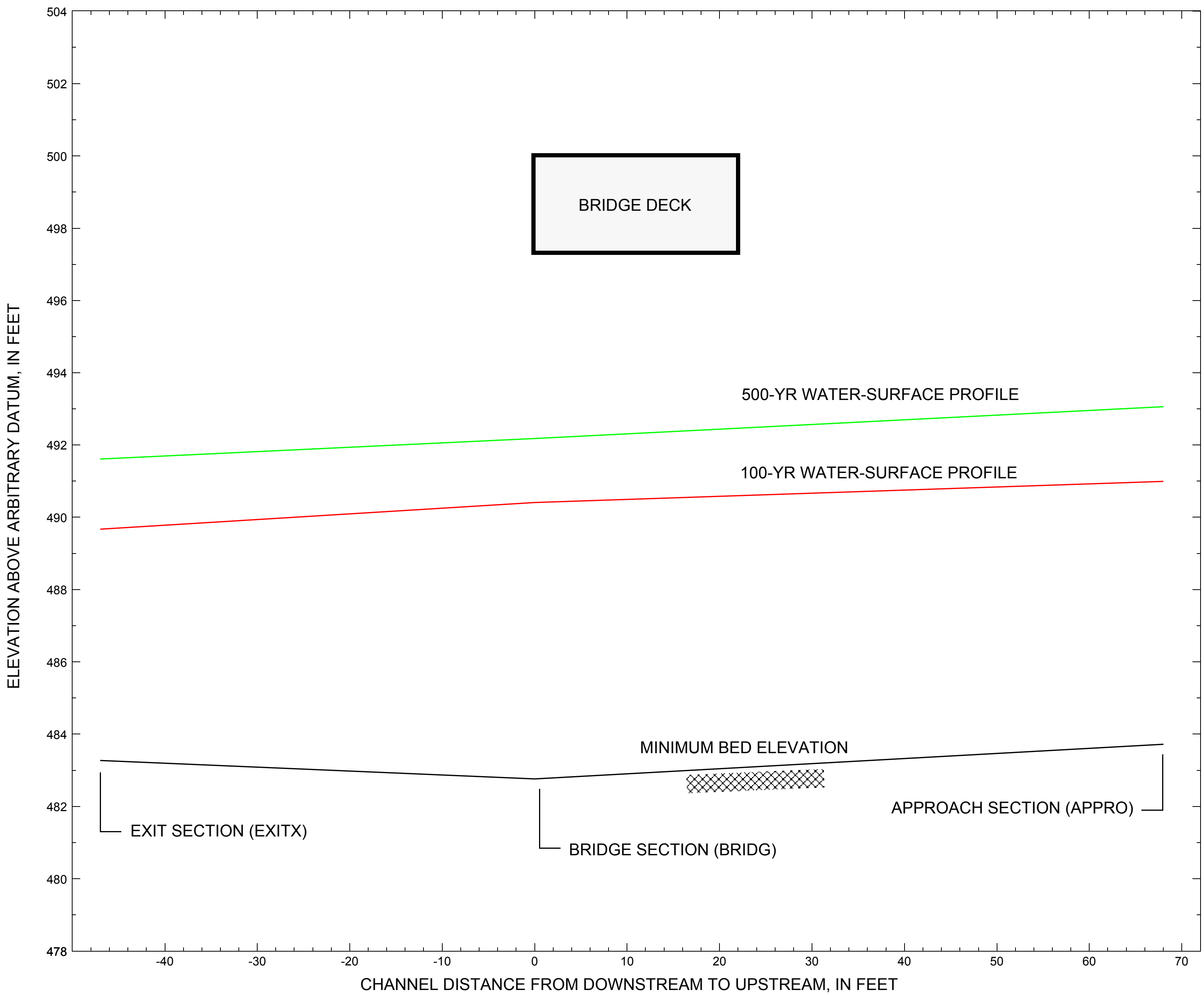

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure JERITH00200038 on Town Highway 20, crossing the Lee River, Jericho, Vermont.

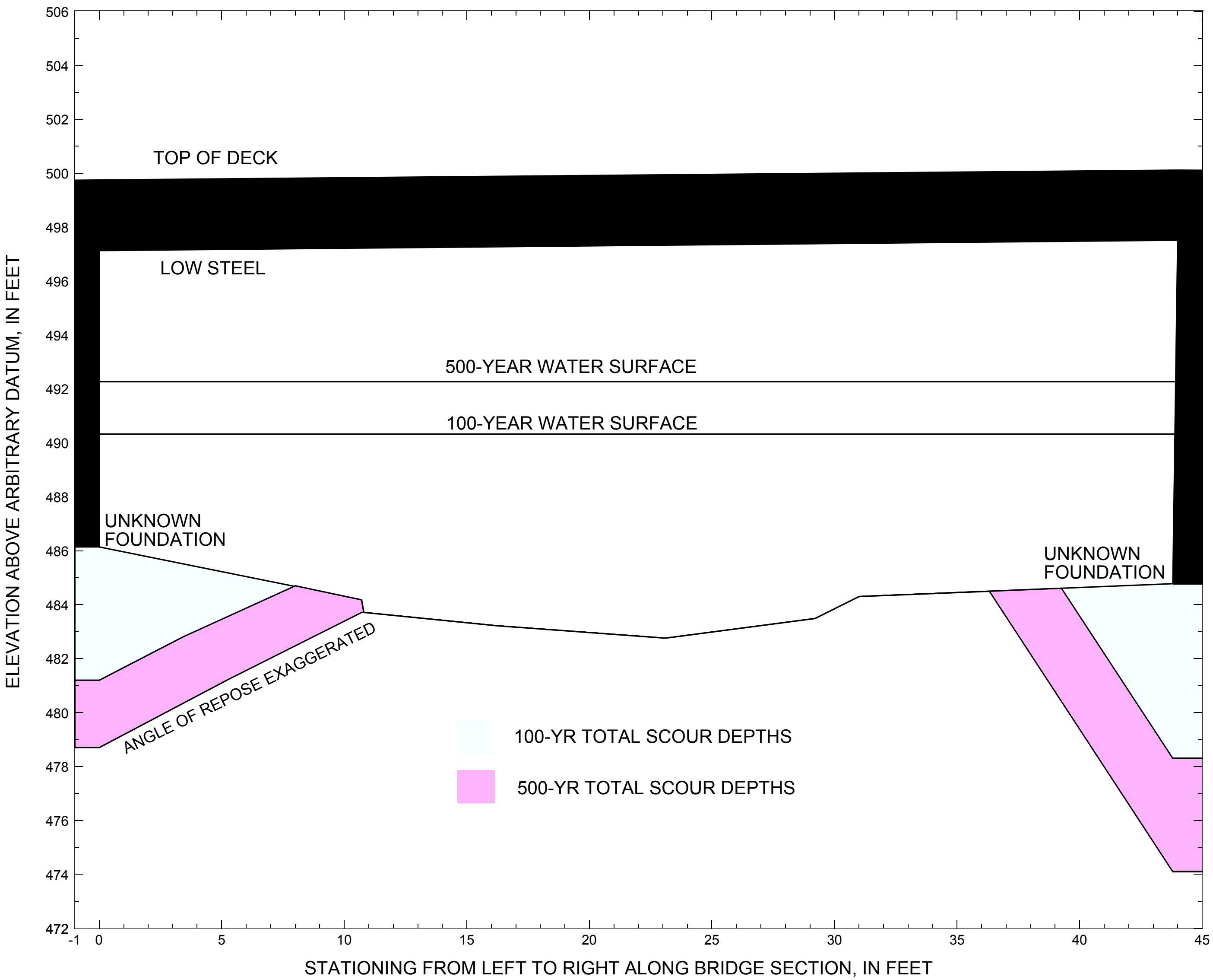

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure JERITH00200038 on Town Highway 20, crossing the Lee River, Jericho, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure JERITH00200038 on Town Highway 20, crossing the Lee River, 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-yr. discharge is 1,640 cubic-feet per second											
Left abutment	0.0		497.1	--	486.1	0.0	4.9	--	4.9	481.2	--
Right abutment	44.0		497.5	--	484.8	0.0	6.5	--	6.5	478.3	--

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 JERITH00200038 on Town Highway 20, crossing the Lee River, 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-yr. discharge is 2,860 cubic-feet per second											
Left abutment	0.0		497.1	--	486.1	0.0	7.4	--	7.4	478.7	--
Right abutment	44.0		497.5	--	484.8	0.0	10.7	--	10.7	474.1	--

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, 1948, Richmond, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1980, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File jeri038.wsp
T2        Hydraulic analysis for structure JERITH00200038   Date: 17-JUN-97
T3        Town Highway 20, Lee River, Jericho, Vermont            ECW
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1640.0   2860.0
SK          0.0164   0.0164
*
XS   EXITX    -47           0.
GR          -28.5, 497.17     -8.0, 489.52      0.0, 488.03      5.5, 484.11
GR           14.8, 483.74     24.3, 483.30     29.3, 483.27     31.9, 483.72
GR           37.5, 484.23     49.2, 490.04     57.4, 497.75     64.6, 499.60
GR           88.0, 499.23    145.4, 501.62
*
N           0.040        0.075        0.045
SA                 -28.5         64.6
*
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.32       5.0
GR            0.0, 497.13      0.0, 486.14     10.7, 484.18     10.8, 483.71
GR           16.2, 483.22     23.1, 482.76     29.2, 483.49     31.0, 484.30
GR           43.8, 484.78     44.0, 497.52      0.0, 497.13
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      22.0 * *     25.8      9.7
N           0.040
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     9      11.8     2
GR         -202.5, 508.24   -167.4, 498.53    -24.1, 498.38      0.0, 499.75
GR           44.1, 500.12     67.0, 500.36     91.3, 500.18    123.7, 504.05
*
*
*
AS   APPRO     68           0.
GR          -55.6, 500.24    -11.2, 498.93      0.0, 490.03      7.2, 485.48
GR           14.7, 484.83     20.5, 483.92     27.9, 483.72     31.7, 484.20
GR           34.9, 484.86     42.5, 485.75     46.0, 488.25     59.3, 491.53
GR           72.1, 500.80     74.6, 501.21     97.7, 500.79    107.7, 500.64
GR          149.4, 513.92
*
N           0.040        0.075        0.045
SA                 -11.2         74.6
*
HP 1 BRIDG 490.41 1 490.41
HP 2 BRIDG 490.41 * * 1640
HP 1 APPRO 490.99 1 490.99
HP 2 APPRO 490.99 * * 1640
*
HP 1 BRIDG 492.18 1 492.18
HP 2 BRIDG 492.18 * * 2860
HP 1 APPRO 493.06 1 493.06
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
     U.S. Geological Survey WSPRO Input File jeri038.wsp
     Hydraulic analysis for structure JERITH00200038   Date: 17-JUN-97
     Town Highway 20, Lee River, Jericho, Vermont            ECW
        *** RUN DATE & TIME: 07-14-97  12:24

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

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      276     30375     44     54                         3935
490.41           276     30375     44     54  1.00      0     44     3935


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

      WSEL     LEW     REW    AREA        K        Q    VEL
    490.41     0.0    43.9   276.0   30375.    1640.   5.94

X STA.         0.0        4.8        7.8       10.2       12.3       14.1
  A(I)            22.7       16.1       13.8       14.1       12.4
  V(I)            3.61       5.11       5.93       5.80       6.61

X STA.        14.1       15.8       17.5       19.0       20.6       22.1
  A(I)            11.9       12.1       11.4       11.6       11.4
  V(I)            6.88       6.79       7.20       7.08       7.20

X STA.        22.1       23.6       25.1       26.7       28.4       30.3
  A(I)            11.2       11.4       11.9       11.9       12.5
  V(I)            7.31       7.20       6.92       6.91       6.55

X STA.        30.3       32.4       34.6       37.1       39.7       43.9
  A(I)            13.0       13.5       14.5       15.2       23.4
  V(I)            6.29       6.08       5.65       5.40       3.50


 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      68.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          2      279     15199     58     61                         3460
490.99           279     15199     58     61  1.00      0     57     3460


 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      68.

      WSEL     LEW     REW    AREA        K        Q    VEL
    490.99    -1.2    57.1   278.8   15199.    1640.   5.88

X STA.        -1.2        7.0        9.6       11.9       14.1       16.1
  A(I)            22.6       14.8       13.4       12.8       12.5
  V(I)            3.62       5.54       6.13       6.39       6.56

X STA.        16.1       17.9       19.6       21.2       22.8       24.3
  A(I)            11.8       11.7       11.2       11.2       11.3
  V(I)            6.95       7.03       7.31       7.32       7.27

X STA.        24.3       25.9       27.5       29.1       30.8       32.6
  A(I)            11.3       11.3       11.4       12.0       12.5
  V(I)            7.27       7.23       7.17       6.85       6.58

X STA.        32.6       34.6       37.0       39.6       42.8       57.1
  A(I)            12.8       14.3       15.0       17.1       27.8
  V(I)            6.39       5.74       5.45       4.80       2.95
```

```
     U.S. Geological Survey WSPRO Input File jeri038.wsp
     Hydraulic analysis for structure JERITH00200038   Date: 17-JUN-97
     Town Highway 20, Lee River, Jericho, Vermont            ECW
        *** RUN DATE & TIME: 07-14-97  12:24
 CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      353     43973     44     58                         5700
492.18           353     43973     44     58  1.00      0     44     5700


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

     WSEL     LEW     REW    AREA        K        Q    VEL
   492.18     0.0    43.9   353.4   43973.    2860.   8.09

X STA.         0.0        4.7        7.6        9.9       12.0       13.9
  A(I)            30.5       20.3       18.1       17.2       15.9
  V(I)            4.68       7.05       7.91       8.32       9.01

X STA.        13.9       15.6       17.3       18.9       20.5       22.0
  A(I)            15.4       14.8       14.8       14.3       14.5
  V(I)            9.26       9.66       9.64       9.99       9.87

X STA.        22.0       23.6       25.2       26.8       28.5       30.4
  A(I)            14.6       14.4       14.7       14.9       16.0
  V(I)            9.83       9.95       9.70       9.62       8.92

X STA.        30.4       32.5       34.6       37.0       39.6       43.9
  A(I)            16.7       16.8       17.9       20.3       31.4
  V(I)            8.58       8.52       8.00       7.04       4.56

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      68.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          2      408     26345     65     70                         5786
493.06           408     26345     65     70  1.00     -3     61     5786


 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      68.

     WSEL     LEW     REW    AREA        K        Q    VEL
   493.06    -3.8    61.4   407.8   26345.    2860.   7.01

X STA.        -3.8        5.8        8.8       11.3       13.6       15.8
  A(I)            33.9       22.4       19.4       18.6       17.8
  V(I)            4.22       6.40       7.36       7.67       8.04

X STA.        15.8       17.8       19.7       21.5       23.3       25.1
  A(I)            17.5       17.2       16.4       16.4       16.4
  V(I)            8.18       8.32       8.71       8.74       8.70

X STA.        25.1       26.9       28.7       30.5       32.5       34.6
  A(I)            16.5       16.6       17.0       17.4       18.3
  V(I)            8.66       8.64       8.41       8.22       7.80

X STA.        34.6       37.0       39.6       42.6       47.2       61.4
  A(I)            19.2       19.8       22.4       26.5       38.0
  V(I)            7.44       7.21       6.37       5.40       3.76
```

WSPRO OUTPUT FILE (continued)

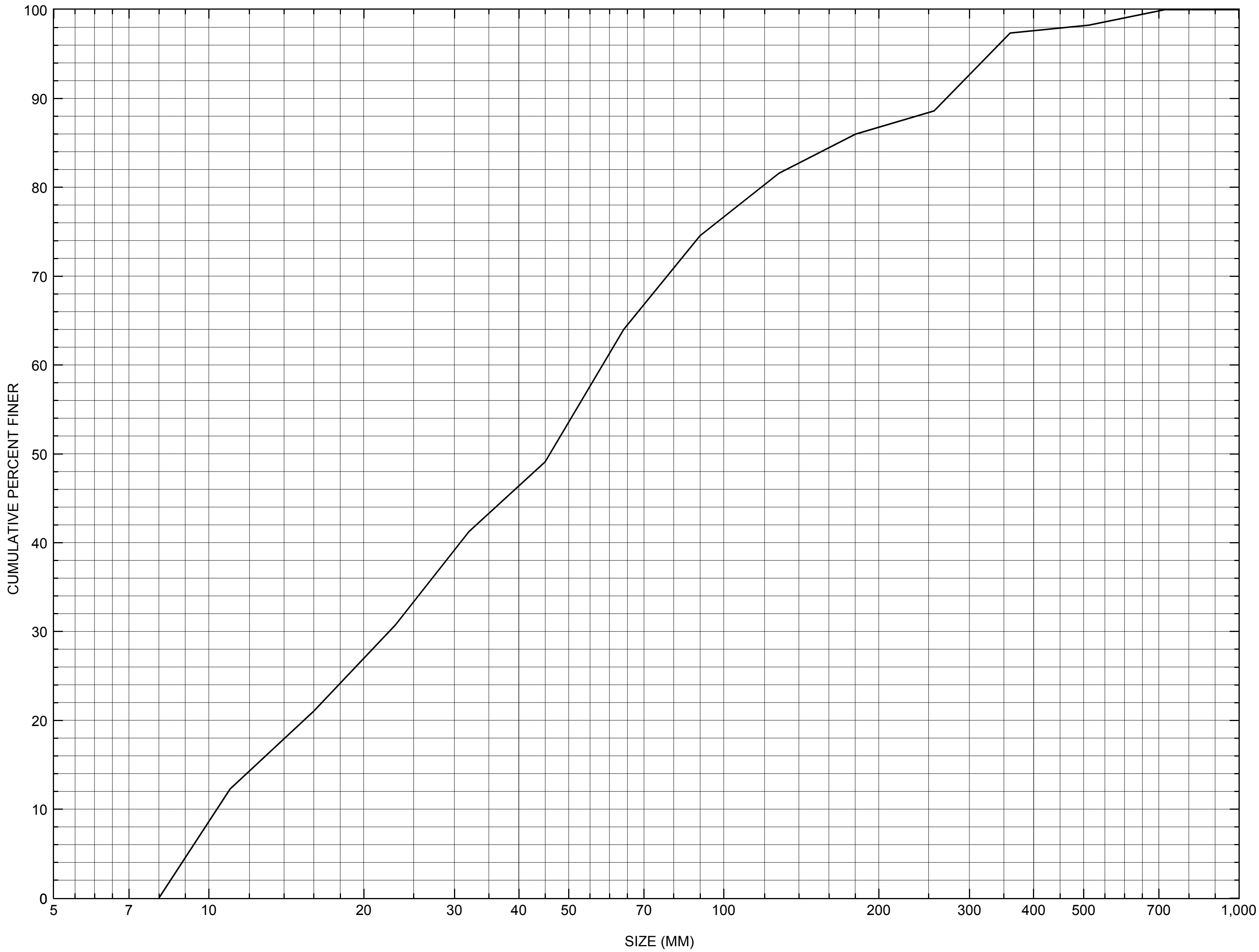
```
         U.S. Geological Survey WSPRO Input File jeri038.wsp
         Hydraulic analysis for structure JERITH00200038   Date: 17-JUN-97
         Town Highway 20, Lee River, Jericho, Vermont            ECW
            *** RUN DATE & TIME: 07-14-97  12:24

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

EXITX:XS   ******     -7      249  0.68 *****  490.35  487.83    1640  489.67
      -46 ******     48    12802  1.00 ***** *******    0.56    6.59

FULLV:FV       47    -10      295  0.48  0.60  490.95 *******    1640  490.47
        0     47     50    16381  1.00  0.00    0.00    0.44    5.55
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       68      0      289  0.50  0.70  491.67 *******    1640  491.17
       68     68     58    15997  1.00  0.01    0.01    0.45    5.67
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

            <<<<<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       47      0      276  0.55  0.60  490.96  487.63    1640  490.41
        0     47     44    30370  1.00  0.01    0.00    0.42    5.94

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.32 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS       46      0      279  0.54  0.50  491.53  488.62    1640  490.99
       68     47     57    15184  1.00  0.06   -0.01    0.47    5.89

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.260  0.000   16419.     2.    46.   490.33

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA      VEL    WSEL
   EXITX:XS     -47.    -8.    48.   1640.   12802.     249.     6.59  489.67
   FULLV:FV       0.   -11.    50.   1640.   16381.     295.     5.55  490.47
   BRIDG:BR       0.     0.    44.   1640.   30370.     276.     5.94  490.41
   RDWAY:RG       9.**************      0.******************     2.00********
   APPRO:AS      68.    -1.    57.   1640.   15184.     279.     5.89  490.99

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       2.    46.   16419.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    487.83    0.56  483.27  501.62************  0.68  490.35  489.67
   FULLV:FV  ********    0.44  483.27  501.62  0.60  0.00  0.48  490.95  490.47
   BRIDG:BR    487.63    0.42  482.76  497.52  0.60  0.01  0.55  490.96  490.41
   RDWAY:RG  ****************  498.38  508.24**********************************
   APPRO:AS    488.62    0.47  483.72  513.92  0.50  0.06  0.54  491.53  490.99
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File jeri038.wsp
        Hydraulic analysis for structure JERITH00200038   Date: 17-JUN-97
        Town Highway 20, Lee River, Jericho, Vermont            ECW
           *** RUN DATE & TIME: 07-14-97  12:24

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

 EXITX:XS   ******    -13      367  0.95 *****  492.56  489.57    2860  491.61
        -46 ******     51    22317  1.00 ***** *******    0.58    7.80

 FULLV:FV       47    -15      423  0.71  0.63  493.18 *******    2860  492.47
          0     47     52    27398  1.00  0.00   -0.01    0.48    6.75
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS       68     -3      418  0.73  0.74  493.95 *******    2860  493.22
         68     68     62    27358  1.00  0.01    0.02    0.48    6.84
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

             <<<<<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       47      0      353  1.02  0.64  493.20  489.20    2860  492.18
          0     47     44    43967  1.00  0.00   -0.01    0.50    8.09

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.32 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

 APPRO:AS       46     -3      408  0.76  0.54  493.82  490.32    2860  493.06
         68     47     61    26344  1.00  0.09    0.00    0.49    7.01

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.331  0.000   27087.     3.    47.  492.40

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

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -47.   -14.    51.   2860.   22317.     367.    7.80  491.61
   FULLV:FV       0.   -16.    52.   2860.   27398.     423.    6.75  492.47
   BRIDG:BR       0.     0.    44.   2860.   43967.     353.    8.09  492.18
   RDWAY:RG       9.**************      0.*****************    2.00********
   APPRO:AS      68.    -4.    61.   2860.   26344.     408.    7.01  493.06

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       3.    47.   27087.

  SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    489.57    0.58  483.27  501.62************  0.95  492.56  491.61
   FULLV:FV  ********    0.48  483.27  501.62  0.63  0.00  0.71  493.18  492.47
   BRIDG:BR    489.20    0.50  482.76  497.52  0.64  0.00  1.02  493.20  492.18
   RDWAY:RG  ****************  498.38  508.24**********************************
   APPRO:AS    490.32    0.49  483.72  513.92  0.54  0.09  0.76  493.82  493.06
  ER

NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure JERITH00200038, in Jericho, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number JERITH00200038

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)* LEE RIVER

Road Name *(I - 7):* -

Route Number C3020

Vicinity *(I - 9)* 0.01 MI TO JCT W CL2 TH2

Topographic Map Richmond

Hydrologic Unit Code: -

Latitude *(I - 16; nnnn.n)* 44289

Longitude *(i - 17; nnnnn.n)* 72584

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10040900380409

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

Maximum span length *(I - 48; nnnn)* 0047

Year built *(I - 27; YYYY)* 1914

Structure length *(I - 49; nnnnnn)* 000049

Average daily traffic, ADT *(I - 29; nnnnnn)* 000010

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

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

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

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

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

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 32

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

Vertical clearance from streambed (*nnn.n ft*) 11.98

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

Waterway of full opening (*nnn.n* ft^2) 383.2

Comments:

According to the structural inspection report dated 8/30/95, structure consists of 2 large riveted plate bo beams with wood planks and runners. The abutments, backwalls and wingwalls concrete faced laid-up stone. The RABUT has a four foot long section which has been undermined up to a foot, and can be penetrated 2-3 inches at the centerline. A small crack and leak is present in the top right corner of the right abutment. The left abutment has a few fine cracks and small leaks, with surface spalls along the bottom of the abutment. There are a few large boulders in front of both abutments.

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} (*ft³/ 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:
-
-
-
-
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 12.93 mi^2 Lake/pond/swamp area 0.01 mi^2
Watershed storage *(ST)* 0.08 %
Bridge site elevation 550 ft Headwater elevation 3680 ft
Main channel length 8.14 mi
10% channel length elevation 600 ft 85% channel length elevation 1880 ft
Main channel slope *(S)* 209.56 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? -____ *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY):* N / -

Project Number -

Minimum channel bed elevation: -

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

Benchmark location description:

-
-
-
-

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

Foundation Type: - (*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? - *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:

-
-
-
-
-
-

Cross-sectional Data

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

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

Comments: **FEMA**
The low cord elevations and the bed elevations are from the FEMA cross sections (National

Station	**Geo-**	**m of**	**582.5**						**582.5**	**-**	**-**
Feature	**detic**	**1929**	**570.2**	**567.9**	**567.6**	**568.8**	**568.4**	**568.8**	**572.7**	**-**	**-**
Low cord elevation	**Ver-**	**).**	**12.3**	**14.6**	**14.9**	**13.7**	**14.1**	**13.7**	**9.8**	**-**	**-**
Bed elevation	**tical**	**215.0**	**226.0**	**241.0**	**245.0**	**247.0**	**248.0**	**259.0**	**-**	**-**	**-**
Low cord bed length	**Datu**	**TLB**						**TRB**	**-**	**-**	**-**

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: 8/13/96
Computerized by: EW Date: 8/14/96
Reviewd by: EW Date: 7/22/97

Structure Number JERITH00200038

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN Date *(MM/DD/YY)* 07 / 02 / 1996

2. Highway District Number 05 Mile marker 000000

County Chittenden (007) Town Jericho (36700)

Waterway *(I - 6)* LEE RIVER Road Name -

Route Number TH 20 Hydrologic Unit Code: 02010005

3. Descriptive comments:

Steel bridge with wooden a deck. The bridge seat/ low cord gap is 0.3 feet on both left and right abutments. The bridge is located 0.01 miles to junction with Class 3 Town Highway 2.

B. Bridge Deck Observations

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

5. Ambient water surface... US 2 UB 2 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 49 *(feet)* Span length 47 *(feet)* Bridge width 11.8 *(feet)*

Road approach to bridge:

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

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

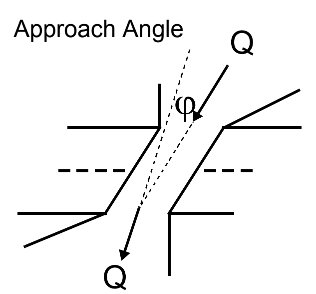
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

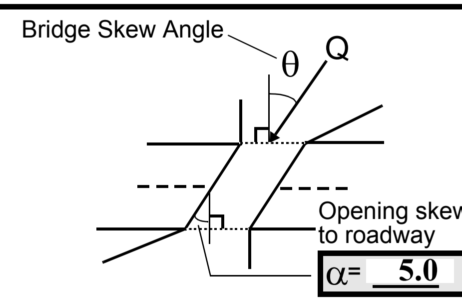
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

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

Channel approach to bridge (BF):

15. Angle of approach: 15 16. Bridge skew: 10





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 50 feet US *(US, UB, DS)* to 0 feet DS

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: **1a**

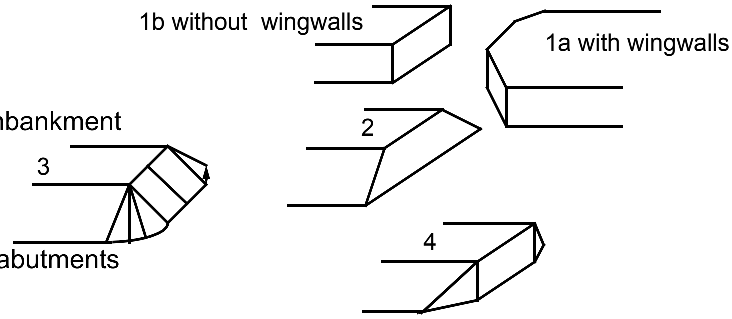
1a- Vertical abutments with wingwalls

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.)

#7: During site visit, measured the following: bridge length = 50 feet (from back of left abutment to back of right abutment); bridge width = 13.6 feet (from outside edge of steel rails), the wooden deck is 12 feet.
#9: The road approach is not paved, however Town Highway 2 runs parallel with stream.
#11: The downstream left road approach protection is a stone wall extended from the end of the wingwall.

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
56.5	**13.5**			**15.5**	**3**	**2**	**543**	**325**	**2**	**2**

23. Bank width **35.0** 24. Channel width **25.0** 25. Thalweg depth **86.0** 29. Bed Material **543**

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.):

Bank erosion forms small cut-banks upstream of the approach section.
#29: Coarse sand is also in the bed.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **50 US** 35. Mid-bar width: **5**

36. Point bar extent: **60** feet **US** (US, UB) to **45** feet **DS** (US, UB, DS) positioned **90** %LB to **100** %RB

37. Material: **324**

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

Material is coarser at downstream end of bar.

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

41. Mid-bank distance: **70** 42. Cut bank extent: **95** feet **US** (US, UB) to **60** 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.):

Tree roots support bank along cut-bank. Smaller cut-banks exists along both banks.

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

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

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

NO CHANNEL SCOUR

49. Are there major confluences? **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
35.5		**1.0**		**2**	**7**	**7**	**-**

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

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

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

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

543

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

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

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

70. Debris and Ice Comments:

1

The bridge deck is above the top of the banks. The present debris in the channel and under bridge is small, though large trees on cut-bank provide some potential for debris accumulation.

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	90	2	0	0	0	90.0
RABUT	1	-	90			0	0	44.0

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

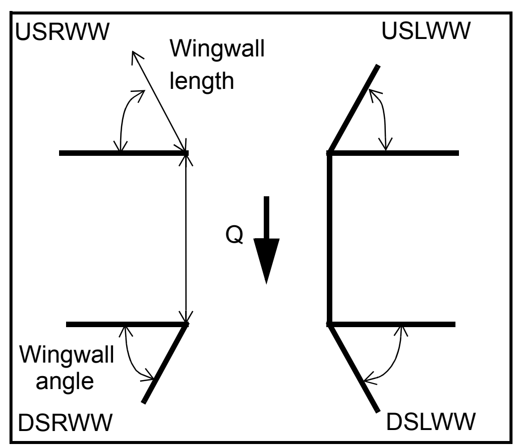
0

1

The right abutment has been recently repaired. The left abutment has spalled near its base.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						44.0	
USRWW:	Y		1		0	1.5	
DSLWW:	-		-		Y	17.0	
DSRWW:	1		0		-	17.5	



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

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	0	Y	-	3	1	1	3
Condition	Y	-	1	-	1	1	1	2
Extent	1	-	0	2	2	3	2	-

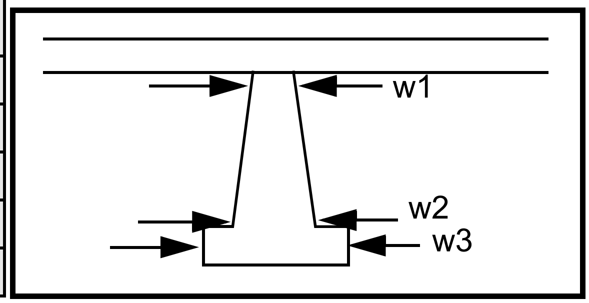
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
0
-
-
2
1
1

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		**9.5**		**25.0**	**30.0**	**12.0**
Pier 2		**8.5**		**25.0**	**30.0**	**12.5**
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

E. Downstream Channel Assessment

100.

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

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

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

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

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

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

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

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

NO PIERS

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 **3** feet **3** *(US, UB, DS)* positioned **543** %LB to **432** %RB

Material: **2**

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

1
325
0
0

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

Cut bank extent: **t of** feet **the** *(US, UB, DS)* to **boul-** feet **der** *(US, UB, DS)*

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

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

exist between the bridge cross-section and the exit cross-section, the bed is mostly gravel beyond this area.

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

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

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

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

Confluence 1: Distance **NO** Enters on **DR** *(LB or RB)* Type **OP** *(**1**- perennial; **2**- ephemeral)*

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

Confluence comments (eg. confluence name):

RE

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
15 DS
2
0
DS
30
DS
95
100
2

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: JERITH00200038 Town: JERICHO
Road Number: TH 20 County: Chittenden
Stream: LEE RIVER

Initials ECW Date: 7/14/97 Checked: MAI

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	1640	2860	0
Main Channel Area, ft2	279	408	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	58	65	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.151	0.151	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	4.8	6.3	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	15199	26345	0
Conveyance, main channel	15199	26345	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	1640.0	2860.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	5.9	7.0	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	7.8	8.1	N/A
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	N/A
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	1640	2860	0
(Q) discharge thru bridge, cfs	1640	2860	0
Main channel conveyance	30375	43973	0
Total conveyance	30375	43973	0
Q2, bridge MC discharge,cfs	1640	2860	ERR
Main channel area, ft2	276	353	0
Main channel width (normal), ft	43.7	43.7	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	43.7	43.7	0
y_bridge (avg. depth at br.), ft	6.32	8.09	ERR
Dm, median (1.25*D50), ft	0.18875	0.18875	0
y2, depth in contraction,ft	4.46	7.18	ERR
ys, scour depth (y2-ybridge), ft	-1.86	-0.91	N/A

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	1640	2860	N/A
Main channel area (DS), ft2	276	353.4	0
Main channel width (normal), ft	43.7	43.7	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	43.7	43.7	0.0
D90, ft	0.8870	0.8870	0.0000
D95, ft	1.0772	1.0772	0.0000
Dc, critical grain size, ft	0.1786	0.2975	ERR
Pc, Decimal percent coarser than Dc	0.428	0.252	0.000

Depth to armoring, ft	0.72	2.65	ERR

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	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	1640	2860	0	1640	2860	0
a', abut.length blocking flow, ft	1.3	3.9	0	13.3	17.6	0
Ae, area of blocked flow ft2	3.6	13.8	0	25.9	57.6	0
Qe, discharge blocked abut.,cfs	13	58.1	0	76.3	248.7	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.63	4.21	ERR	2.95	4.32	ERR
ya, depth of f/p flow, ft	2.77	3.54	ERR	1.95	3.27	ERR
--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	0.384	0.394	ERR	0.372	0.421	ERR
ys, scour depth, ft	4.85	7.43	N/A	6.48	10.68	N/A

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)	1.3	3.9	0	13.3	17.6	0
y1 (depth f/p flow, ft)	2.77	3.54	ERR	1.95	3.27	ERR
a'/y1	0.47	1.10	ERR	6.83	5.38	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.38	0.39	N/A	0.37	0.42	N/A
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	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.42	0.5	0	0.42	0.5	0
y, depth of flow in bridge, ft	6.32	8.09	0.00	6.32	8.09	0.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	0.69	1.25	0.00	0.69	1.25	0.00
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR