LEVEL II SCOUR ANALYSIS FOR BRIDGE 3 (EASTTH00010003) on TOWN HIGHWAY 1, crossing the EAST BRANCH PASSUMPSIC RIVER, EAST HAVEN, VERMONT

Open-File Report 97-759

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior

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By RONDA L. BURNS and ERICK M. BOEHMLER

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Pembroke, New Hampshire

1997

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

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 3 (EASTTH00010003) ON TOWN HIGHWAY 1, CROSSING THE EAST BRANCH PASSUMPSIC RIVER, EAST HAVEN, VERMONT

By **Ronda L. Burns and Erick M. Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure EASTTH00010003 on Town Highway 1 crossing the East Branch Passumpsic River, East Haven, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the White Mountain section of the New England physiographic province in northeastern Vermont. The 50.4-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover on the left bank upstream is forest. On the remaining three banks the surface cover is pasture while the immediate banks have dense woody vegetation.

In the study area, the East Branch Passumpsic River has an incised, sinuous channel with a slope of approximately 0.003 ft/ft, an average channel top width of 62 ft and an average bank height of 5 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 61.5 mm (0.187 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 14, 1995, indicated that the reach was stable.

The Town Highway 1 crossing of the East Branch Passumpsic River is a 89-ft-long, two-lane bridge consisting of one 87-foot steel-beam span (Vermont Agency of Transportation, written communication, March 17, 1995). The opening length of the structure parallel to the bridge face is 84.7 ft. The bridge is supported by vertical, concrete abutments with sloped stone fill in front that creates a spill through embankment. The channel is skewed approximately zero degrees to the opening and the opening-skew-to-roadway is also zero degrees.

Channel scour 0.5 ft deeper than the mean thalweg depth was observed to the left of the center of the channel under the bridge during the Level I assessment. The scour countermeasures at the site are type-2 stone fill (less than 36 inches diameter) along the downstream left bank and type-4 stone fill (less than 60 inches diameter) in front of the abutments creating spill through slopes. 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 ranged from 0 to 1.8 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 6.4 to 11.7 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 EASTTH00010003 ***Stream*** East Branch Passumpsic River

County Essex ***Road*** TH 1 ***District*** 7

Description of Bridge

Bridge length 89 ***ft*** ***Bridge width*** 29 ***ft*** ***Max span length*** 87 ***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*** 8/14/95

Description of stone fill Type-4, in front of the left and right abutments creating spillthrough slopes.

Brief description of piers/abutments Abutments are concrete with stone fill spillthrough slopes in front. Channel scour 0.5 ft deep is under the bridge to the left of the center of the channel.

Is bridge skewed to flood flow according to No ***survey?*** ***Angle*** 0

Yes

Is there a channel bend in the upstream reach? If so, describe (mild, moderate, severe) There is a mild channel bend in the upstream reach.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	8/14/95	0	0
Level II	8/14/95	0	0

Potential for debris Moderate. There is an abundance of trees along the banks and the stream is sinuous.

Describe any features near or at the bridge that may affect flow (include observation date) None as of 8/14/95.

Description of the Geomorphic Setting

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

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

Date of inspection 8/14/95

DS left: Steep channel bank

DS right: Narrow flood plain

US left: Steep channel bank

US right: Narrow flood plain

Description of the Channel

Average top width 62 ***ft*** ***Average depth*** 5 ***ft***

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

Sinuous but stable

with semi-alluvial channel boundaries and a narrow flood plain.

8/14/95

Vegetative co Trees and brush with grass on the overbank

DS left: Trees and brush with grass on the overbank

DS right: Trees

US left: Trees and brush with grass on the overbank

US right:

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

None as of 8/14/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 50.4 ***mi^2***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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

USGS gage description East Branch Passumpsic near East Haven, VT

USGS gage number 01133000

Gage drainage area 53.8 ***mi^2***

Is there a lake/p [illegible] No

Calculated Discharges

Q100 3,750 ***ft^3/s*** ***Q500*** 5,200 ***ft^3/s***

The 100- and 500-year discharges are based on a drainage area relationship [(50.4/53.8)exp 0.67] with gage number 01133000 near East Haven. The 100- and 500- year discharges at the gage were developed using a log-Pearson type-III analysis of annual peak-flow data (Interagency Advisory Committee on Water Data, 1982). The values used were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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 Add 0.28 to the VT AOT plans to obtain the USGS arbitrary survey datum.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the concrete guard rail post on the downstream left bank (elev. 979.38 ft, arbitrary survey datum). RM2 is a chiseled X on top of the concrete guard rail post on the upstream right bank (elev. 979.10 ft, arbitrary survey datum). RM3 is a metal disc stamped “VT Highway Department Benchmark” on the concrete guard rail post on the downstream right bank (elev. 979.66 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	-66	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	15	1	Road Grade section
APTEM	109	1	Approach section as surveyed (Used as a template)
APPRO	114	2	Modelled Approach section (Templated from APTEM)

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

[2] Cross-section development: (1) survey at SRD, (2) shift of survey data to SRD, (3) modification of survey data, (4) composite bridge section, (5) other.

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 0.050, and the overbank "n" value was 0.040.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0032 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1988).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0084 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 975.9 *ft*
Average low steel elevation 971.4 *ft*

100-year discharge 3,750 *ft³/s*
Water-surface elevation in bridge opening 966.7 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 399 *ft²*
Average velocity in bridge opening 9.4 *ft/s*
Maximum WSPRO tube velocity at bridge 11.3 *ft/s*

Water-surface elevation at Approach section with bridge 968.7
Water-surface elevation at Approach section without bridge 967.9
Amount of backwater caused by bridge 0.8 *ft*

500-year discharge 5,200 *ft³/s*
Water-surface elevation in bridge opening 966.8 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 405 *ft²*
Average velocity in bridge opening 12.8 *ft/s*
Maximum WSPRO tube velocity at bridge 15.7 *ft/s*

Water-surface elevation at Approach section with bridge 971.0
Water-surface elevation at Approach section without bridge 968.6
Amount of backwater caused by bridge 2.4 *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 100-year and 500-year discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The computed streambed armoring depths suggest that armoring will not limit the depth of contraction scour.

Abutment scour for the left abutment 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 at the right abutment was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

Because the influence of scour processes on the material of the spill-through embankments is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, the total scour depth computed at the toe of the embankments was applied for the entire spill-through embankment as shown in figure 8.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	1.8	--
Depth to armoring	4.8	26.7	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	6.4	8.2	--
Right abutment	6.9	11.7	--
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	1.5	2.3	--
Right abutment	1.5	2.3	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

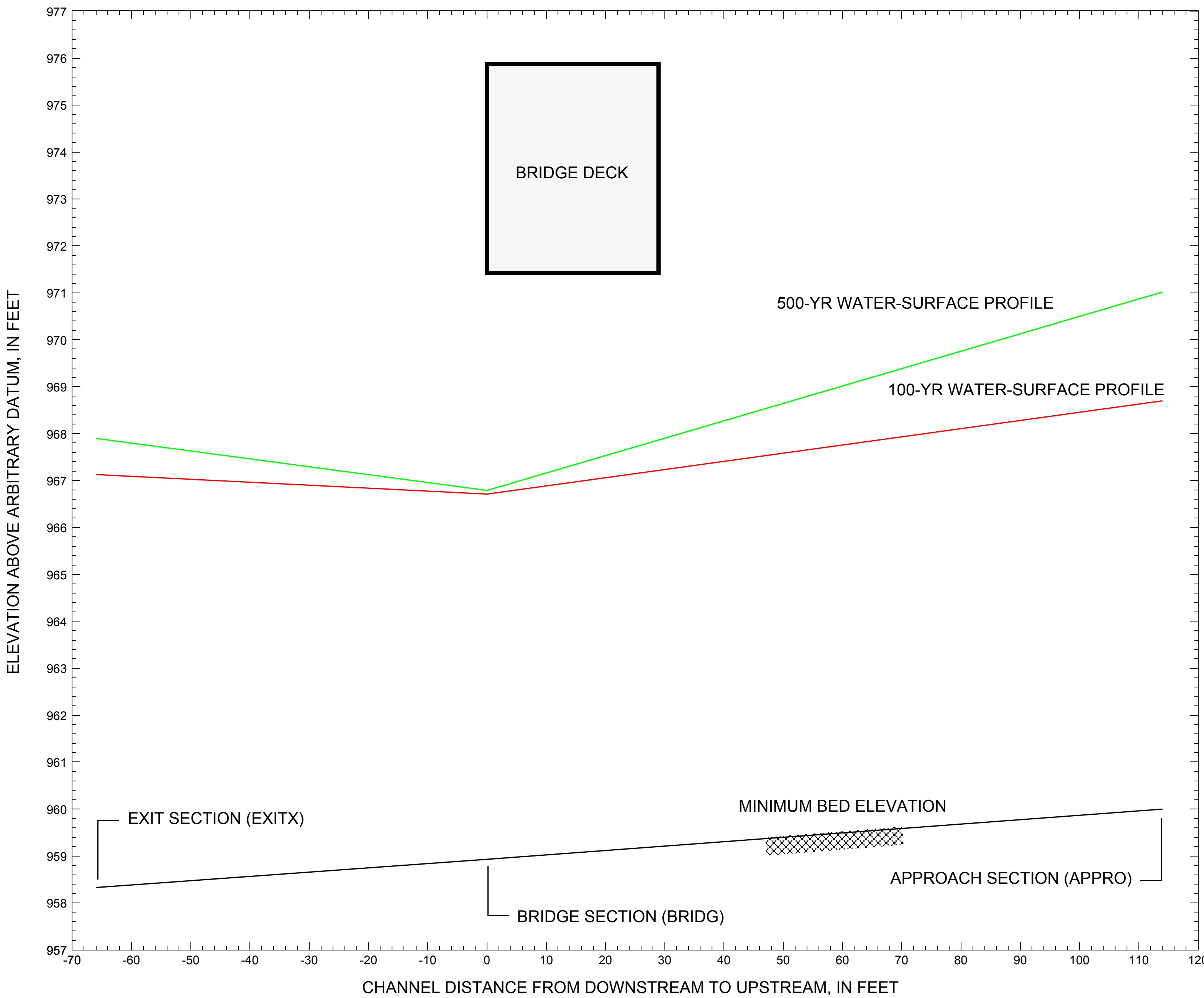

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure EASTTH00010003 on Town Highway 1, crossing the East Branch Passumpsic River, East Haven, Vermont.

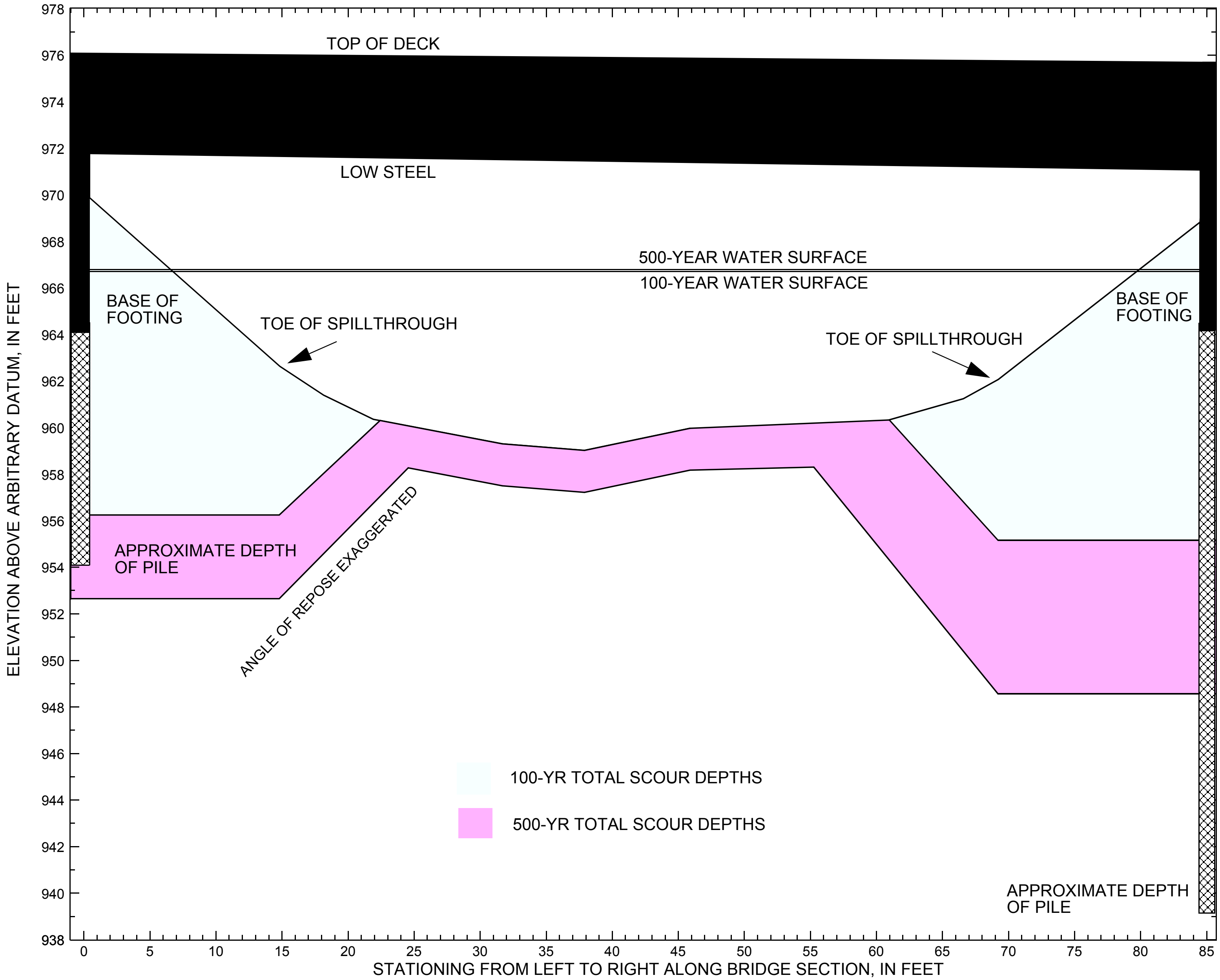

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure EASTTH00010003 on Town Highway 1, crossing the East Branch Passumpsic River, East Haven, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure EASTTH00010003 on Town Highway 1, crossing the East Branch Passumpsic River, East Haven, 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 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 3,750 cubic-feet per second											
Left abutment	0.0	970.6	971.8	954.1	--	--	--	--	--	--	2.2
LABUT toe	14.8	--	--	--	962.7	0.0	6.4	--	6.4	956.3	--
RABUT toe	69.2	--	--	--	962.1	0.0	6.9	--	6.9	955.2	--
Right abutment	84.7	970.3	971.1	939.2	--	--	--	--	--	--	16.0

1.Measured along the face of the most constricting side of the bridge.

2.Arbitrary datum for this study.

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure EASTTH00010003 on Town Highway 1, crossing the East Branch Passumpsic River, East Haven, 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 5,200 cubic-feet per second											
Left abutment	0.0	970.6	971.8	954.1	--	--	--	--	--	--	-1.4
LABUT toe	14.8	--	--	--	962.7	1.8	8.2	--	10.0	952.7	--
RABUT toe	69.2	--	--	--	962.1	1.8	11.7	--	13.5	948.6	--
Right abutment	84.7	970.3	971.1	939.2	--	--	--	--	--	--	9.4

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 east003.wsp
T2        Hydraulic analysis for structure EASTTH00010003   Date: 04-AUG-97
T3        TH 1 CROSSING THE EAST BRANCH PASSUMPSIC RIVER IN EAST HAVEN, VT   RLB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3750.0   5200.0
SK          0.0032   0.0032
*
XS   EXITX    -66           0.
*          -182.6, 971.97   -158.1, 971.73    -89.5, 967.21
GR          -73.8, 982.00    -73.8, 974.03      0.0, 970.34      9.4, 969.99
GR           20.2, 961.28     21.1, 961.09     24.9, 959.96     28.7, 959.72
GR           30.7, 958.84     33.6, 958.42     36.9, 958.44     42.7, 959.58
GR           48.7, 960.53     59.3, 960.89     63.8, 961.74     69.6, 964.43
GR          113.1, 965.32    137.3, 963.98    165.8, 965.18    217.2, 963.98
GR          229.0, 965.24    264.6, 964.72    301.2, 973.56
*
N            0.050        0.040
SA                  69.6
*
XS   FULLV      0  * * *   0.0092
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    971.43       0.0
GR            0.0, 971.78      0.4, 969.89     14.8, 962.65     18.2, 961.38
GR           21.9, 960.36     31.7, 959.30     37.9, 959.02     45.9, 959.97
GR           55.5, 959.70     60.9, 960.32     66.6, 961.24     69.2, 962.06
GR           84.5, 968.83     84.7, 971.07      0.0, 971.78
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV
CD           3      29.3      3.2    975.9
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     15      29.0     1
GR         -901.7,1012.86   -839.1,1007.58   -693.7, 997.16   -565.7, 988.99
GR         -454.3, 983.82   -284.5, 978.83   -136.5, 976.71    -45.7, 976.08
GR           -0.6, 975.74     -0.6, 976.60     88.1, 976.29     88.2, 975.53
GR          317.8, 974.79    504.5, 974.03    527.2, 973.23    656.1, 972.94
GR          707.5, 976.74    808.7, 988.35
*             0.0, 976.08     87.3, 975.69
*           533.4, 972.70    541.8, 970.10    547.3, 970.91    578.0, 970.62
*
XT   APTEM    109           0.
*          -430.9, 981.94   -416.3, 980.35   -392.6, 974.55   -253.2, 973.97
*          -185.0, 973.50   -179.4, 975.61   -167.8, 975.74   -154.1, 975.40
*          -139.0, 973.70    -76.4, 970.97   -66.3, 967.60    -26.0, 967.19
*           -18.6, 964.89    -12.1, 963.22
GR            0.0, 982.00      0.0, 972.02     12.5, 966.13     16.5, 962.03
GR           18.9, 961.65     22.2, 960.83     28.2, 960.05     35.1, 960.11
GR           41.7, 960.83     53.0, 961.38     60.9, 961.72     63.8, 961.94
GR           74.2, 965.93    113.1, 966.82    137.3, 965.48    165.8, 966.68
GR          217.2, 965.48    229.0, 966.74    264.6, 966.22    301.2, 975.06
*
AS   APPRO    114  * * *  0.0084
GT
N            0.050        0.040
SA                  74.2
*
HP 1 BRIDG  966.71 1 966.71
HP 2 BRIDG  966.71 * * 3750
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File east003.wsp
        Hydraulic analysis for structure EASTTH00010003   Date: 04-AUG-97
        TH 1 CROSSING THE EAST BRANCH PASSUMPSIC RIVER IN EAST HAVEN, VT   RLB
           *** RUN DATE & TIME: 08-19-97  12:07

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      399     45124     73     76                         5304
   966.71           399     45124     73     76  1.00      7     80     5304

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       966.71     6.7    79.7   399.5   45124.    3750.   9.39

X STA.         6.7        18.3       22.2        25.2        27.9        30.5
  A(I)            33.1        22.6        20.0        18.5        18.1
  V(I)            5.66        8.29        9.38       10.11       10.38

X STA.        30.5        32.8       35.1        37.2        39.4        41.7
  A(I)            17.5        16.7        16.6        16.8        16.7
  V(I)           10.69       11.25       11.27       11.17       11.20

X STA.        41.7        44.1       46.7        49.3        51.9        54.5
  A(I)            17.1        17.5        17.7        17.7        18.0
  V(I)           10.97       10.72       10.58       10.57       10.42

X STA.        54.5        57.1       60.0        63.3        67.2        79.7
  A(I)            18.4        19.0        20.6        22.7        34.1
  V(I)           10.19        9.87        9.12        8.28        5.49

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     114.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      439     44326     67     70                         6371
             2      475     31442    200    201                         4154
   968.70           914     75768    268    271  1.13      7    275     9009

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     114.

         WSEL     LEW     REW    AREA        K        Q    VEL
       968.70     7.1   274.7   914.3   75768.    3750.   4.10

X STA.         7.1        21.0       25.7        29.7        33.6        37.5
  A(I)            56.6        37.6        34.2        33.5        32.3
  V(I)            3.31        4.98        5.48        5.59        5.80

X STA.        37.5        41.5       45.9        50.3        55.0        60.0
  A(I)            32.7        33.6        33.3        34.5        35.6
  V(I)            5.73        5.58        5.63        5.44        5.26

X STA.        60.0        65.7       80.0       105.7       132.1       149.2
  A(I)            37.6        52.7        59.1        59.3        50.5
  V(I)            4.99        3.55        3.17        3.16        3.71

X STA.       149.2       175.9      198.7       215.7       241.2       274.7
  A(I)            59.8        56.4        50.1        59.2        65.4
  V(I)            3.13        3.32        3.74        3.16        2.86
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File east003.wsp
        Hydraulic analysis for structure EASTTH00010003   Date: 04-AUG-97
        TH 1 CROSSING THE EAST BRANCH PASSUMPSIC RIVER IN EAST HAVEN, VT   RLB
           *** RUN DATE & TIME: 08-19-97  12:07

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      405     46078     73     76                          5408
   966.79           405     46078     73     76  1.00      7     80     5408

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       966.79     6.6    79.9   405.3   46078.    5200.  12.83

X STA.         6.6        18.2        22.1        25.2        27.9        30.4
  A(I)            33.5        22.9        20.3        18.8        18.3
  V(I)            7.76       11.34       12.81       13.81       14.18

X STA.        30.4        32.8        35.0        37.3        39.4        41.7
  A(I)            17.8        16.9        17.3        16.6        17.1
  V(I)           14.61       15.36       15.04       15.69       15.23

X STA.        41.7        44.1        46.7        49.3        51.9        54.5
  A(I)            17.4        17.8        18.0        17.7        18.2
  V(I)           14.96       14.62       14.42       14.72       14.28

X STA.        54.5        57.1        60.0        63.4        67.4        79.9
  A(I)            18.6        19.2        21.4        23.0        34.5
  V(I)           13.98       13.53       12.13       11.31        7.54

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     114.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      600     71062     72     76                          9834
             2      952     96829    210    211                         11494
   971.02          1552    167891    282    287  1.02      2    284    20481

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     114.

         WSEL     LEW     REW    AREA        K        Q    VEL
       971.02     2.2   284.3  1551.9  167891.    5200.   3.35

X STA.         2.2        22.1        28.5        34.3        40.2        46.5
  A(I)           105.3        67.4        64.0        62.7        63.5
  V(I)            2.47        3.86        4.06        4.15        4.09

X STA.        46.5        53.0        59.8        67.7        82.6       100.0
  A(I)            63.2        64.2        68.7        82.7        81.2
  V(I)            4.12        4.05        3.79        3.14        3.20

X STA.       100.0       119.7       135.4       149.5       167.5       185.5
  A(I)            84.8        78.2        74.4        82.6        82.0
  V(I)            3.06        3.33        3.49        3.15        3.17

X STA.       185.5       201.3       215.8       233.0       252.6       284.3
  A(I)            78.3        76.7        81.9        87.3       102.8
  V(I)            3.32        3.39        3.17        2.98        2.53
```

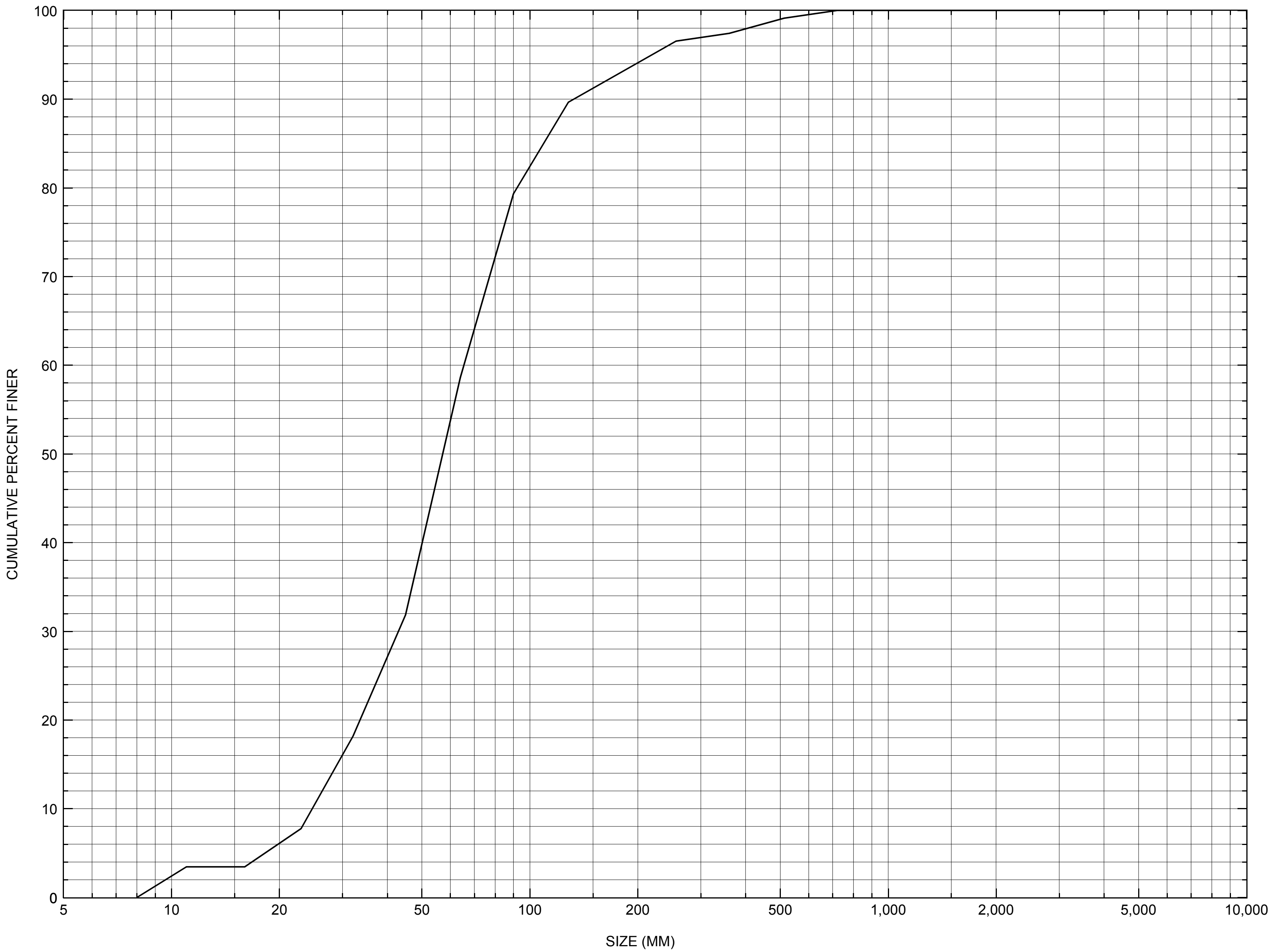
```
        U.S. Geological Survey WSPRO Input File east003.wsp
        Hydraulic analysis for structure EASTTH00010003   Date: 04-AUG-97
        TH 1 CROSSING THE EAST BRANCH PASSUMPSIC RIVER IN EAST HAVEN, VT   RLB
           *** RUN DATE & TIME: 08-19-97  12:07

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

EXITX:XS   ******     13      836  0.35 *****  967.48  966.07    3750  967.13
       -65 ******    275    66286  1.12 ***** *******    0.47    4.48

FULLV:FV       66     13      728  0.49  0.26  967.81 *******    3750  967.32
         0     66    273    54163  1.18  0.07    0.00    0.59    5.15
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      114      9      691  0.57  0.58  968.43 *******    3750  967.86
       114    114    271    51438  1.25  0.04    0.00    0.66    5.43
         <<<<<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       66      7      399  1.54  0.31  968.24  965.43    3750  966.71
         0     66     80    45101  1.12  0.45   -0.01    0.75    9.39

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  0.945 ******  971.43 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS       85      7      915  0.30  0.40  969.00  967.32    3750  968.70
       114     97    275    75830  1.13  0.36    0.01    0.42    4.10

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.712  0.363   48031.    16.    89.   968.49

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -66.    13.   275.   3750.   66286.     836.    4.48  967.13
   FULLV:FV       0.    13.   273.   3750.   54163.     728.    5.15  967.32
   BRIDG:BR       0.     7.    80.   3750.   45101.     399.    9.39  966.71
   RDWAY:RG      15.**************      0.******************    1.00********
   APPRO:AS     114.     7.   275.   3750.   75830.     915.    4.10  968.70

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      16.    89.   48031.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    966.07    0.47  958.42  982.00************  0.35  967.48  967.13
   FULLV:FV  ********    0.59  959.03  982.61  0.26  0.07  0.49  967.81  967.32
   BRIDG:BR    965.43    0.75  959.02  971.78  0.31  0.45  1.54  968.24  966.71
   RDWAY:RG  ****************  972.94 1012.86**********************************
   APPRO:AS    967.32    0.42  960.09  982.04  0.40  0.36  0.30  969.00  968.70
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File east003.wsp
        Hydraulic analysis for structure EASTTH00010003   Date: 04-AUG-97
        TH 1 CROSSING THE EAST BRANCH PASSUMPSIC RIVER IN EAST HAVEN, VT   RLB
           *** RUN DATE & TIME: 08-19-97  12:07

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

EXITX:XS   ******     12     1039  0.41 *****  968.31  966.54    5200  967.90
       -65 ******    278    91875  1.06 ***** *******    0.46    5.00

FULLV:FV       66     13      926  0.53  0.25  968.61 *******    5200  968.08
         0     66    276    77077  1.09  0.06   -0.01    0.55    5.62
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      114      7      882  0.62  0.56  969.20 *******    5200  968.58
       114    114    274    71948  1.15  0.04   -0.01    0.61    5.90
         <<<<<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       66      7      405  3.48  0.42  970.27  966.64    5200  966.79
         0     66     80    46083  1.36  1.53    0.00    1.12   12.83

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  0.858 ******  971.43 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS       85      2     1550  0.18  0.36  971.19  967.87    5200  971.02
       114    102    284   167658  1.02  0.57    0.01    0.25    3.35

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.705  0.553   74770.    23.    97.   970.93

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW      Q        K     AREA     VEL    WSEL
   EXITX:XS     -66.    12.   278.   5200.   91875.    1039.    5.00  967.90
   FULLV:FV      0.     13.   276.   5200.   77077.     926.    5.62  968.08
   BRIDG:BR      0.      7.    80.   5200.   46083.     405.   12.83  966.79
   RDWAY:RG     15.**************      0.******************    1.00********
   APPRO:AS    114.      2.   284.   5200.  167658.    1550.    3.35  971.02

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      23.    97.   74770.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    966.54    0.46  958.42  982.00************  0.41  968.31  967.90
   FULLV:FV  ********    0.55  959.03  982.61  0.25  0.06  0.53  968.61  968.08
   BRIDG:BR    966.64    1.12  959.02  971.78  0.42  1.53  3.48  970.27  966.79
   RDWAY:RG  ****************  972.94 1012.86**********************************
   APPRO:AS    967.87    0.25  960.09  982.04  0.36  0.57  0.18  971.19  971.02
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure EASTTH00010003, in East Haven, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number EASTTH00010003

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 17 / 95

Highway District Number *(I - 2; nn)* 07

County *(FIPS county code; I - 3; nnn)* 009

Town *(FIPS place code; I - 4; nnnnn)* 21250

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

Waterway *(I - 6)* EAST BRANCH PASSUMPSIC R.

Road Name *(I - 7):* -

Route Number TH001

Vicinity *(I - 9)* 0.1 MI JCT TH 1 + VT 114

Topographic Map West.Burke

Hydrologic Unit Code: 01080102

Latitude *(I - 16; nnnn.n)* 44385

Longitude *(i - 17; nnnnn.n)* 71535

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 100508000305081

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

Maximum span length *(I - 48; nnnn)* 0087

Year built *(I - 27; YYYY)* 1961

Structure length *(I - 49; nnnnnn)* 000089

Average daily traffic, ADT *(I - 29; nnnnnn)* 000750

Deck Width *(I - 52; nn.n)* 290

Year of ADT *(I - 30; YY)* 94

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

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

Waterway adequacy *(I - 71; n)* 7

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

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*) 035.0

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

Vertical clearance from streambed (*nnn.n ft*) 011.3

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

Waterway of full opening (*nnn.n* ft^2) 700.0

Comments:

The structural inspection report of 9/19/94 indicates the structure is a steel beam type bridge with a concrete deck and an asphalt roadway surface. The abutment walls are concrete and have minor fine cracks, a few leaks, and small spalls reported, mostly at the extreme upstream and downstream ends. There is boulder fill protection noted as placed on the embankment fill which slopes down in front of the abutment walls and around the ends of the walls. Some of the stone fill is noted as present along the upstream and downstream banks. Most of the flow appears to be along the protected embankment of the left abutment as the channel makes a gradual bend just upstream.

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: -

Terrain character: Hilly and forested

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)* : light Debris *(Heavy, Moderate, Light)*: light

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

Clear span (*ft*): 27.0 Clear Height (*ft*): - Full Waterway (*ft^2*): 350.0

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

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

Clear span (*ft*): 10 Clear Height (*ft*): - Full Waterway (ft^2): 420.0

Comments:

Some hydrologic information that was printed on the plans is given above.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 50.38 mi^2

Lake/pond/swamp area 0.41 mi^2

Watershed storage *(ST)* 0.8 %

Bridge site elevation 975 ft

Headwater elevation 3300 ft

Main channel length 11.72 mi

10% channel length elevation 1000 ft

85% channel length elevation 1880 ft

Main channel slope *(S)* 100.15 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)*: **10** / **1958**

Project Number **RAD 2(1)** Minimum channel bed elevation: **958.5**

Low superstructure elevation: USLAB **970.57** DSLAB **970.57** USRAB **970.33** DSRAB **970.33**

Benchmark location description:

BM#3 is a spike in the root of a 15 in. diameter elm tree located about 120 feet to intersection of side road from the left abutment at the centerline of the bridge's roadway, then about 1000 feet along the centerline of the side roadway to a cross road intersection, then diagonally into woods about 100 feet from the center of the intersection in a generally downstream and left direction, elevation 1010.76.

Reference Point (*MSL, Arbitrary, Other*): **MSL** Datum (*NAD27, NAD83, Other*): **NGVD1929**

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

If 1: Footing Thickness **-** Footing bottom elevation: **964.5**

If 2: Pile Type: **2** (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: **7.0***

If 3: Footing bottom elevation: **-**

Is boring information available? **Y** *If no, type ctrl-n bi* Number of borings taken: **4**

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

Briefly describe material at foundation bottom elevation or around piles:

The highest elevation of boring refusal was approximately 957.0 ft. Hence, the piles are driven at least 7 feet from the bottom of the concrete base of the abutments. From the borings, the piles are driven into primarily coarse gravel.

Comments:

***The piles on the right abutment are proposed to be driven 25 feet and on the left, 10 feet. The piles are steel H-type piles. Other points provided with elevations on the plans are: 1) the point on the lowest of 3 step type concrete posts at the bottom of the rounded edge at the upstream right abutment corner of the post, elevation 978.78, and 2) The point at the same location as in (1) but on the downstream left abutment corner of the end post, elevation 979.14.**

Cross-sectional Data

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

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

Comments: **Upstream bridge channel cross section at stationing 4 + 90, 10 feet from the centerline of the roadway on the bridge deck. The channel baseline runs down the middle of the stream channel parallel to and 54 feet from the left abutment. Note: b is the base of abutment footing.**

Station	-54.0	-51.5	-38.8	-36.0	+15	+17	30.5	33.0	-	-	-
Feature	LCL	-	LEW	BLB	BRB	REW	-	LCR	-	-	-
Low chord elevation	970.5	-	-	-	-	-	-	970.5	-	-	-
Bed elevation	-	968.4	960	958.4	958.4	960	968.4	-	-	-	-
Low chord-bed	-	b964.4	-	-	-	-	b964.5	-	-	-	-

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

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

Comments: **Downstream bridge channel cross section at stationing 5 + 10, 10 feet from the centerline of the roadway on the bridge deck. b: base of abutment footing.**

Station	-54	-51.5	-38.0	-36.0	+13	+15	28.4	31.0	-	-	-
Feature	LCL	-	LEW	BLB	BRB	REW	-	LCR	-	-	-
Low chord elevation	970.5	-	-	-	-	-	-	970.5	-	-	-
Bed elevation	-	968.4	960	958.2	958.2	960	968.8	-	-	-	-
Low chord-bed	-	b964.5	-	-	-	-	b964.5	-	-	-	-

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: **4/23/96**

Computerized by: **RB** Date: **4/23/96**

Reviewd by: **RB** Date: **8/19/97**

Structure Number **EASTTH00010003**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E**. **BOEHMLER** Date *(MM/DD/YY)* **8** / **14** / 19**95**

2. Highway District Number **07** Mile marker **0000**

County **ESSEX 009** Town **EASTHAVEN 21250**

Waterway *(I - 6)* **EAST BRANCH PASSUMPSIC R.** Road Name **-**

Route Number **TH01** Hydrologic Unit Code: **01080102**

3. Descriptive comments:
Located about 0.1 miles east from TH01 intersection with VT114.

B. Bridge Deck Observations

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

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

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

7. Bridge length **89** *(feet)* Span length **87** *(feet)* Bridge width **29** *(feet)*

Road approach to bridge:

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

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

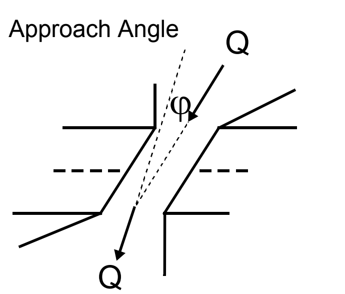
10. Embankment slope (*run / rise in feet / foot*):
US left **3.2:1** US right **0.8:1**

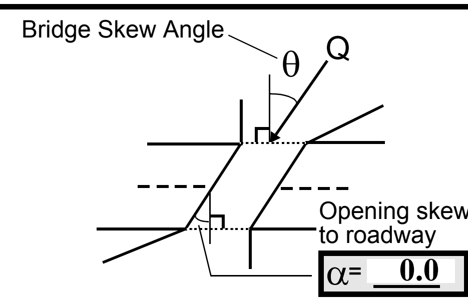
	Protection: 11.Type	Protection: 12.Cond.	13.Erosion	14.Severity
LBUS	0	-	0	0
RBUS	0	-	2	1
RBDS	0	-	0	0
LBDS	0	-	2	1

*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: **30** 16. Bridge skew: **0**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **40** feet **US** *(US, UB, DS)* to **10** feet **UB**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **15** feet **DS** *(US, UB, DS)* to **80** feet **DS**

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

18. Bridge Type: 3

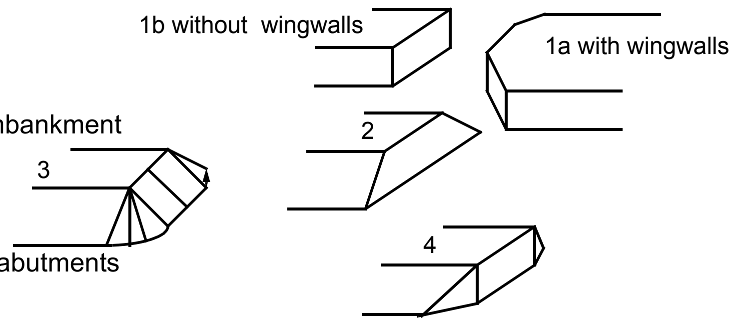
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

7. Values are from the VT AOT files. Measured bridge dimensions were the same except the bridge width which is 28.9 feet.

4. The surface cover on the US left bank is forest for a plot about 50 feet wide, then the cover is grass lawn with a few trailer homes and a side road. The DS left bank is suburban due to town public works garage, parking lot, gas tanks, etc. on the bank with grass surrounding the urban area and trees along the immediate bank. The US and DS right bank areas are back yard lawns for the homes on VT 114.

18. The abutments are concrete with stone fill placed in front acting as spill through embankments.

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
81.0	**4.0**			**4.0**	**4**	**2**	**432**	**342**	**1**	**1**

23. Bank width **45.0** 24. Channel width **20.0** 25. Thalweg depth **62.5** 29. Bed Material **453**

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

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

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

The thalweg US runs along the left bank side of the channel and is between 1 and 2 feet deep. No bank protection is evident.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **115** 35. Mid-bar width: **20**

36. Point bar extent: **165** feet **US** *(US, UB)* to **185** feet **US** *(US, UB, DS)* positioned **70** %LB to **100** %RB

37. Material: **345**

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

The point bar is partially submerged and is not vegetated. It is narrow in comparison with the channel width.

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: **60** 42. Cut bank extent: **135** feet **US** *(US, UB)* to **20** 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.):

The bank cutting is in the form of small eroded pockets of bank material or scallops formed between tree trunks near the channel edge. It is minor.

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

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

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

NO CHANNEL SCOUR

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

51. Confluence 1: Distance **50** 52. Enters on **LB** *(LB or RB)* 53. Type **1** *(**1**- perennial; **2**- ephemeral)*

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

54. Confluence comments (eg. confluence name):

-

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
48.0		1.5		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.):

453

There is sone minor channel scour under the bridge with a length of 35 feet and a width of 15 feet. It is 0.5 feet deep and positioned 30% LB to 50% RB beginning at the US bridge face.

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

67. Debris Potential -____ *(1- Low; 2- Moderate; 3- High)* 68. Capture Efficiency 2____ *(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 debris potential is moderate because of the abundance of trees on the banks and the sinuosity of the stream. The bridge, however, is wide and the stream passes straight beneath it and has a high gradient so debris and ice are unlikely to build up. On the left bank just DS of the bridge there are large scars in the bark of the trees about 6 feet above the current water level showing evidence of ice build up or impact.

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	35	2	0	0	0	90.0
RABUT	1	-	25			2	0	84.5

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

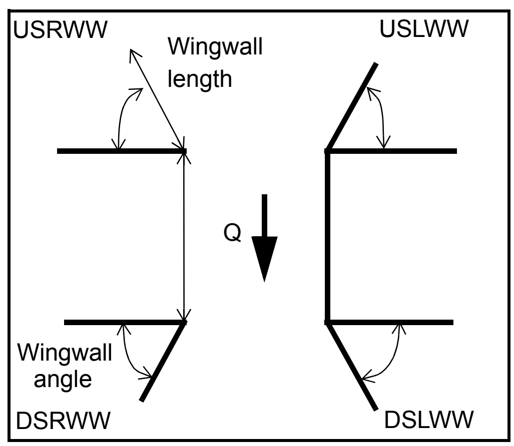
0

1

Both abutments are vertical concrete protected with a sloping embankment of type 4 stone fill blocks carefully placed on the finer fill beneath.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						84.5	
USRWW:	N		-		-	2.5	
DSLWW:	-		-		N	29.5	
DSRWW:	-		-		-	29.5	



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

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	-	N	-	-	-	1	1
Condition	N	-	-	-	-	-	1	1
Extent	-	-	-	-	-	4	4	-

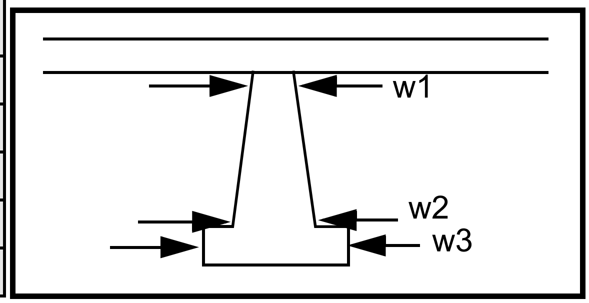
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? **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	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

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):

3
1

106. Point/Side bar present? **32** (Y or N. if N type ctrl-n pb) Mid-bar distance: **4** Mid-bar width: **324**

Point bar extent: **1** feet **1** (US, UB, DS) to **453** feet **2** (US, UB, DS) positioned **0** %LB to **2** %RB

Material: **-**

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

The left bank protection extends from the DS bridge face to 125 feet DS. The protection forms a nearly flat shelf at the edge of the left bank. Further up on the bank, however, there is some bank cutting. Beyond the 125 feet DS the reach is mainly straight and there is some slight bank cutting along the toes of each bank to greater than 200 feet DS.

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

Cut bank extent: _____ feet ____ (US, UB, DS) to _____ feet ____ (US, UB, DS)

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

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

N

Is channel scour present? **-** (Y or if N type ctrl-n cs) Mid-scour distance: **NO**

Scour dimensions: Length **DRO** Width **P** Depth: **STR** Positioned **UC** %LB to **TU** %RB

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

RE

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

Confluence 1: Distance **Y** Enters on **100** (LB or RB) Type **11** (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance **30** Enters on **DS** (LB or RB) Type **125** (**1**- perennial; **2**- ephemeral)

Confluence comments (eg. confluence name):

DS
85

F. Geomorphic Channel Assessment

107. Stage of reach evolution **100**

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)*:

324

This point bar is narrow and not vegetated.

Y
LB
50
20
DS
75
DS
1

109. G. Plan View Sketch

Ba

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: EASTTH00010003 Town: EAST HAVEN
Road Number: TH 1 County: ESSEX
Stream: EAST BRANCH PASSUMPSIC RIVER

Initials RLB Date: 8/7/97 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	3750	5200	0
Main Channel Area, ft2	439	600	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	475	952	0
Top width main channel, ft	67	72	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	200	210	0
D50 of channel, ft	0.1874	0.1874	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.6	8.3	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	2.4	4.5	ERR
Total conveyance, approach	75768	167891	0
Conveyance, main channel	44326	71062	0
Conveyance, LOB	0	0	0
Conveyance, ROB	31442	96829	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	2193.8	2201.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	1556.2	2999.0	ERR
Vm, mean velocity MC, ft/s	5.0	3.7	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	3.3	3.2	ERR
Vc-m, crit. velocity, MC, ft/s	8.8	9.1	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	3750	5200	0
(Q) discharge thru bridge, cfs	3750	5200	0
Main channel conveyance	45124	46078	0
Total conveyance	45124	46078	0
Q2, bridge MC discharge,cfs	3750	5200	ERR
Main channel area, ft2	399.5	405.3	0
Main channel width (normal), ft	63.7	63.9	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	63.7	63.9	0
y_bridge (avg. depth at br.), ft	6.27	6.34	ERR
Dm, median (1.25*D50), ft	0.23425	0.23425	0
y2, depth in contraction,ft	6.16	8.13	ERR
ys, scour depth (y2-ybridge), ft	-0.11	1.79	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	3750	5200	N/A
Main channel area (DS), ft2	399.5	405.3	0
Main channel width (normal), ft	63.7	63.9	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	63.7	63.9	0.0
D90, ft	0.4345	0.4345	0.0000
D95, ft	0.7168	0.7168	0.0000
Dc, critical grain size, ft	0.3323	0.6181	ERR
Pc, Decimal percent coarser than Dc	0.172	0.065	0.000
Depth to armoring, ft	4.80	26.67	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	3750	5200	0	3750	5200	0
a’, abut.length blocking flow, ft	3.7	8.5	0	200.2	209.7	0
Ae, area of blocked flow ft2	15.07	44.98	0	480.07	954.6	0
Qe, discharge blocked abut.,cfs	49.91	111.06	0	1572.12	2999.6	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.31	2.47	ERR	3.27	3.14	ERR
ya, depth of f/p flow, ft	4.07	5.29	ERR	2.40	4.55	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0	0.55	0.55	0
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	0	90	90	0
K2	1.00	1.00	0.00	1.00	1.00	0.00
Fr, froude number f/p flow	0.289	0.189	ERR	0.373	0.260	ERR
ys, scour depth, ft	6.36	8.22	N/A	13.39	17.51	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)	3.7	8.5	0	200.2	209.7	0
y1 (depth f/p flow, ft)	4.07	5.29	ERR	2.40	4.55	ERR
a’/y1	0.91	1.61	ERR	83.49	46.07	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.29	0.19	N/A	0.37	0.26	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	12.59	21.21	ERR
vertical w/ ww’s	ERR	ERR	ERR	10.32	17.39	ERR
spill-through	ERR	ERR	ERR	6.93	11.67	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	0.66	0.9	0	0.66	0.9	0
y, depth of flow in bridge, ft	6.27	6.34	0.00	6.27	6.34	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	1.69	ERR	0.00	1.69	ERR	0.00
Fr>0.8 (vertical abut.)	ERR	2.57	ERR	ERR	2.57	ERR
Fr<=0.8 (spillthrough abut.)	1.47	ERR	0.00	1.47	ERR	0.00
Fr>0.8 (spillthrough abut.)	ERR	2.28	ERR	ERR	2.28	ERR