LEVEL II SCOUR ANALYSIS FOR BRIDGE 53 (NEWBTH00750053) on TOWN HIGHWAY 75, crossing HARRIMAN BROOK, NEWBURY, VERMONT

Open-File Report 98-262

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 53 (NEWBTH00750053) on TOWN HIGHWAY 75, crossing HARRIMAN BROOK, NEWBURY, VERMONT

By RONDA L. BURNS and LAURA MEDALIE

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Pembroke, New Hampshire

1998

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

U.S. GEOLOGICAL SURVEY
Thomas J. Casadevall, Acting Director

For additional information
write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275-3718

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Box 25286
Denver, CO 80225-0286

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 53 (NEWBTH00750053) ON TOWN HIGHWAY 75, CROSSING HARRIMAN BROOK, NEWBURY, VERMONT

By **Ronda L. Burns and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure NEWBTH00750053 on Town Highway 75 crossing Harriman Brook, Newbury, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the New England Upland section of the New England physiographic province in east-central Vermont. The 3.2-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forested. Town Highway 4 runs parallel to the stream on the right bank.

In the study area, the Harriman Brook has an incised, straight channel with a slope of approximately 0.20 ft/ft, an average channel top width of 72 ft and an average bank height of 16 ft. The channel bed material ranges from silt to boulder with a median grain size (D_{50}) of 31.4 mm (0.103 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 30, 1995, indicated that the reach was stable.

The Town Highway 75 crossing of Harriman Brook is a 26-ft-long, one-lane bridge consisting of one 23-foot concrete slab span supported by steel I-beams which receive additional support from log bents (Vermont Agency of Transportation, written communication, March 27, 1995). The opening length of the structure parallel to the bridge face is 22 ft. The bridge is supported by a vertical, concrete abutment with concrete wingwalls on the right and a vertical, laid-up stone abutment with stone wingwalls on the left. The channel is skewed approximately 5 degrees to the opening while the computed opening-skew-to-roadway is 5 degrees.

The upstream most log bent was sitting on top of two horizontal wood blocks, one foot above the channel bed during the Level I assessment. The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) along the upstream right bank. 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 0.5 to 1.0 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 2.8 to 4.4 ft. The worst-case abutment scour occurred at the 500-year discharge. Pier scour ranged from 2.5 to 3.0 ft. The worst-case pier 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 NEWBTH00750053 ***Stream*** Harriman Brook

County Orange ***Road*** TH 75 ***District*** 7

Description of Bridge

Bridge length 26 ***ft*** ***Bridge width*** 13.9 ***ft*** ***Max span length*** 23 ***ft***

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

Abutment type Concrete, right/Stone, left ***Embankment type*** Sloping

Stone fill on abutment? No ***Date of inspection*** 8/30/95

Description of stone fill Type-2, along the upstream right bank.

The right abutment and wingwalls are concrete. The left abutment and wingwalls are laid-up stone.

Is bridge skewed to flood flow according to No ***survey?*** Yes ***Angle*** 5

There is a severe channel bend 70 ft upstream of the bridge.

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	8/30/95	0	0
Level II	8/30/95	0	0

Potential for debris High. There is some debris caught on the upstream banks and at the bridge. There are many small and medium sized trees on the banks.

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

The concrete bridge deck is supported by steel I-beams which are supported by log bents along the left and right abutments and at the center of the channel as of 8/30/95.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley.

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

Date of inspection 8/30/95

DS left: Steep channel bank to a moderately sloped overbank

DS right: Steep channel bank to a narrow terrace to a steep valley wall

US left: Moderately sloped overbank

US right: Moderately sloped channel bank to a steep valley wall

Description of the Channel

Average top width 72 ft ***Average depth*** 16 ft

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

Straight and stable with non-alluvial channel boundaries.

Vegetative co 8/30/95

Trees and brush

DS left: Trees and brush

DS right: Trees and brush

US left: Trees and brush

US right:

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

The assessment of 8/30/95 noted flow conditions are influenced by a concrete drop structure 61 ft downstream of the bridge that is 0.4 ft high above the channel bed.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 3.2 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi***^{2}

Is there a lake/p No

Calculated Discharges

Q100 365 ***ft***^{3}***/s*** ***Q500*** 550 ***ft***^{3}***/s***

The 100- and 500-year discharges are based on a drainage area relationship [(3.22/3.3)exp 0.67] with bridge number 20 in Newbury. Bridge number 20 crosses Harriman Brook downstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 20 is 3.3 square miles. The values used were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve was extended graphically to the 500-year event.

Description of the Water-Surface Profile Model (WSPRO) Analysis

Datum for WSPRO analysis (USGS survey, sea level, VTAOT plans) USGS survey.

Datum tie between USGS survey and VTAOT plans None.

Description of reference marks used to determine USGS datum. RM1 is the high point on a bedrock exposure located 7 ft from the right side of TH 4 in line with the downstream bridge face (elev. 901.98 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the right abutment footing (elev. 892.12 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	-32	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	40	2	Modelled Approach section (Templated from APTEM)
APTEM	47	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.055 to 0.070, and overbank "n" values ranged from 0.070 to 0.080.

Critical depth at the exit section (EXITX) was assumed as the starting water surface. Normal depth was computed as 0.9 ft below critical depth for the 100-year discharge and 1.2 ft for the 500-year discharge. 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 0.2 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1973).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0029 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.

For the 100-year and 500-year discharge, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. After analyzing both the supercritical and subcritical profiles for each discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge are satisfactory solutions.

Bridge Hydraulics Summary

Average bridge embankment elevation 899.9 ***ft***
Average low steel elevation 897.6 ***ft***

100-year discharge 365 ***ft³/s***
Water-surface elevation in bridge opening 888.5 ***ft***
Road overtopping? No ***Discharge over road*** - ***ft³/s***
Area of flow in bridge opening 46 ***ft²***
Average velocity in bridge opening 8.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.4 ***ft/s***

Water-surface elevation at Approach section with bridge 890.5
Water-surface elevation at Approach section without bridge 890.3
Amount of backwater caused by bridge 0.2 ***ft***

500-year discharge 550 ***ft³/s***
Water-surface elevation in bridge opening 889.2 ***ft***
Road overtopping? No ***Discharge over road*** - ***ft³/s***
Area of flow in bridge opening 60 ***ft²***
Average velocity in bridge opening 9.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.9 ***ft/s***

Water-surface elevation at Approach section with bridge 891.4
Water-surface elevation at Approach section without bridge 891.5
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 for the 100- and 500-year discharges are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

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 streambed armoring depths computed 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.

Pier scour was computed by use of an equation developed at Colorado State University (Richardson and others, 1995, p. 36, equation 21) for all discharges modeled. Variables for the pier scour equation include pier length, pier width, average depth and maximum velocity (for the froude number) immediately upstream of the bridge, and correction factors for pier shape, flow attack angle, streambed-form, and streambed armoring.

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	0.5	1.0	--
Depth to armoring	16.8	24.4	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	3.5	4.4	--
Left abutment	2.8	3.8	--
Right abutment			
Pier scour	2.5	3.0	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:	0.9	1.2	--
Left abutment	0.9	1.2	--
Right abutment			
Piers:	0.9	1.4	--
Pier 1	--	--	--
Pier 2	--	--	--

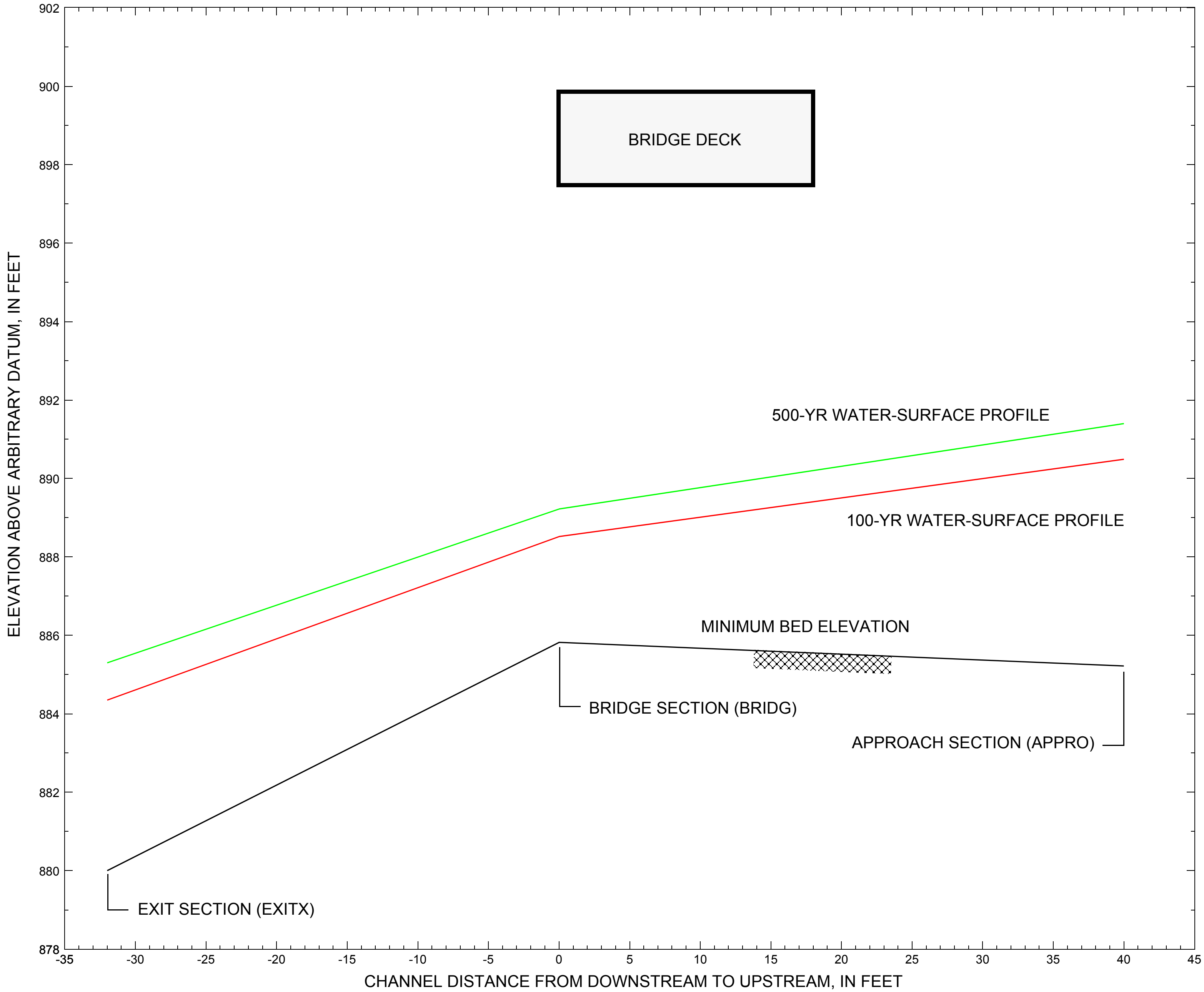

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure NEWBTH00750053 on Town Highway 75, crossing Harriman Brook, Newbury, Vermont.

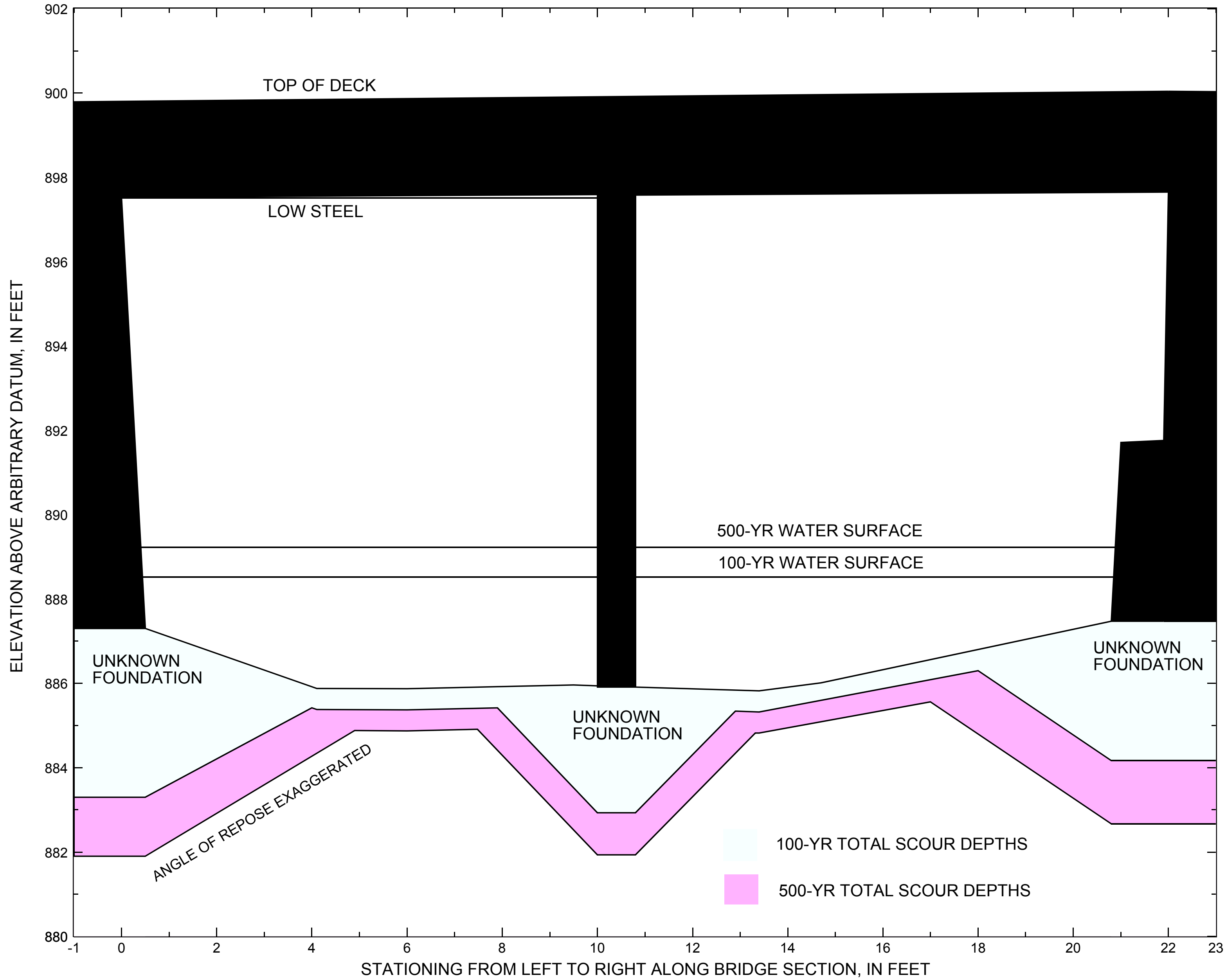

Figure 8. Scour elevations for the 100- and 500-yr discharges at structure NEWBTH00750053 on Town Highway 75, crossing Harriman Brook, Newbury, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure NEWBTH00750053 on Town Highway 75, crossing Harriman Brook, Newbury, 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 elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-year. discharge is 365 cubic-feet per second											
Left abutment	0.0	--	897.5	--	887.3	0.5	3.5	--	4.0	883.3	--
Pier	10.4	--	--	--	885.8	0.5	--	2.5	3.0	882.8	--
Right abutment	22.0	--	897.7	--	887.5	0.5	2.8	--	3.3	884.2	--

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 NEWBTH00750053 on Town Highway 75, crossing Harriman Brook, Newbury, 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 elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year. discharge is 550 cubic-feet per second											
Left abutment	0.0	--	897.5	--	887.3	1.0	4.4	--	5.4	881.9	--
Pier	10.4	--	--	--	885.8	1.0	--	3.0	4.0	881.8	--
Right abutment	22.0	--	897.7	--	887.5	1.0	3.8	--	4.8	882.7	--

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

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U.S. Geological Survey, 1973, Newbury, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File newb053.wsp
T2        Hydraulic analysis for structure NEWBTH00750053   Date: 15-SEP-97
T3        TH 75 CROSSING HARRIMAN BROOK IN NEWBURY, VT                RLB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q            365.0    550.0
SK          0.2000   0.2000
*
XS   EXITX    -32           0.
GR          -98.5, 916.88    -69.2, 904.11    -31.4, 901.43     -7.9, 898.12
GR            8.0, 884.21     10.1, 881.44     11.7, 880.25     13.2, 880.00
GR           14.6, 880.62     21.0, 882.72     24.5, 888.21     31.3, 893.13
GR           49.2, 898.47     95.4, 898.52    112.9, 902.24    123.2, 908.50
*
N            0.080      0.070      0.080
SA                 -7.9       49.2
*
XS   FULLV      0  * * *   0.1251
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    897.58       5.0
GR            0.0, 897.51      0.5, 887.30      4.1, 885.88      6.0, 885.87
GR            9.5, 885.96     13.4, 885.82     14.7, 886.01     20.8, 887.47
GR           21.0, 891.71     21.9, 891.76     22.0, 897.65      0.0, 897.51
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      32.3 * *     44.0     17.3
N           0.055
PW 1      885.91, 0.8
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      9      13.9     2
GR         -161.8, 912.36   -109.1, 906.16    -52.5, 901.37      0.0, 899.80
GR           23.6, 900.04     48.6, 900.86     76.0, 901.76     99.5, 914.82
*
XT   APTEM     47           0.
GR         -153.8, 909.10   -104.3, 903.47    -43.9, 899.47    -25.6, 896.53
GR           -6.0, 891.66      3.3, 887.21      4.3, 885.85      6.9, 885.96
GR            8.4, 885.81     13.3, 885.24     16.3, 885.95     22.2, 891.31
GR           41.3, 902.10     53.1, 904.29     86.3, 905.65     93.1, 915.86
*
AS   APPRO     40  * * *  0.0029
GT
N            0.070       0.060      0.070
SA                 -43.9       41.3
*
HP 1 BRIDG  888.52 1 888.52
HP 2 BRIDG  888.52 * * 365
HP 1 APPRO  890.49 1 890.49
HP 2 APPRO  890.49 * * 365
*
HP 1 BRIDG  889.22 1 889.22
HP 2 BRIDG  889.22 * * 550
HP 1 APPRO  891.40 1 891.40
HP 2 APPRO  891.40 * * 550
*
HP 2 BRIDG  889.66 * * 365
HP 2 BRIDG  890.35 * * 550
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File newb053.wsp
        Hydraulic analysis for structure NEWBTH00750053   Date: 15-SEP-97
        TH 75 CROSSING HARRIMAN BROOK IN NEWBURY, VT                RLB
           *** RUN DATE & TIME: 10-17-97  16:15

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       45      1944     20     23                          386
   888.52            45      1944     20     23  1.00      0     21      386

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       888.52     0.4    20.8    45.5    1944.     365.   8.03

X STA.         0.4         2.7         3.8         4.6         5.4         6.2
  A(I)              3.6         2.5         2.2         2.1         2.0
  V(I)             5.03        7.34        8.21        8.67        9.20

X STA.         6.2         6.9         7.7         8.5         9.2        10.0
  A(I)              2.0         2.0         2.0         2.0         2.0
  V(I)             9.10        9.13        9.34        9.19        9.23

X STA.        10.0        10.8        11.5        12.3        13.0        13.8
  A(I)              2.0         2.0         1.9         2.0         2.0
  V(I)             9.35        9.25        9.37        9.14        8.92

X STA.        13.8        14.6        15.5        16.6        18.1        20.8
  A(I)              2.1         2.3         2.4         2.7         3.8
  V(I)             8.82        7.96        7.75        6.74        4.81

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      40.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2       85      4391     25     28                          889
   890.49            85      4391     25     28  1.00     -3     21      889

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      40.

         WSEL     LEW     REW    AREA        K        Q    VEL
       890.49    -3.6    21.3    84.9    4391.     365.   4.30

X STA.        -3.6         2.2         4.0         5.0         5.8         6.7
  A(I)              8.1         5.7         4.6         4.0         3.9
  V(I)             2.26        3.18        3.94        4.51        4.72

X STA.         6.7         7.5         8.3         9.0         9.7        10.4
  A(I)              3.8         3.6         3.5         3.5         3.4
  V(I)             4.86        5.04        5.21        5.28        5.35

X STA.        10.4        11.1        11.8        12.4        13.1        13.7
  A(I)              3.3         3.4         3.4         3.3         3.5
  V(I)             5.47        5.39        5.43        5.50        5.20

X STA.        13.7        14.4        15.2        16.1        17.2        21.3
  A(I)              3.5         3.8         4.0         4.9         7.6
  V(I)             5.24        4.75        4.51        3.70        2.41

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       889.66     0.4    20.9    68.7    3630.     365.   5.31

X STA.         0.4         2.6         3.7         4.6         5.5         6.3
  A(I)              5.9         3.8         3.4         3.1         3.1
  V(I)             3.11        4.74        5.34        5.83        5.90

X STA.         6.3         7.1         7.9         8.6         9.4        10.2
  A(I)              3.0         3.0         3.0         2.9         2.9
  V(I)             6.18        6.18        6.16        6.27        6.27

X STA.        10.2        11.0        11.8        12.6        13.3        14.1
  A(I)              2.9         2.9         3.0         3.0         3.0
  V(I)             6.33        6.28        6.16        6.16        6.10

X STA.        14.1        15.0        16.0        17.1        18.5        20.9
  A(I)              3.1         3.4         3.5         4.1         5.8
  V(I)             5.84        5.35        5.20        4.43        3.14
```

```
        U.S. Geological Survey WSPRO Input File newb053.wsp
        Hydraulic analysis for structure NEWBTH00750053   Date: 15-SEP-97
        TH 75 CROSSING HARRIMAN BROOK IN NEWBURY, VT                RLB
           *** RUN DATE & TIME: 10-17-97  16:15

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       60      2943     20     24                          580
   889.22            60      2943     20     24  1.00      0     21      580

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       889.22     0.4    20.9    59.7    2943.     550.   9.21

X STA.         0.4        2.6        3.7        4.6        5.4        6.2
  A(I)             5.0        3.3        2.9        2.7        2.6
  V(I)            5.49       8.29       9.50      10.03      10.40

X STA.         6.2        7.0        7.8        8.6        9.4       10.2
  A(I)             2.6        2.6        2.5        2.6        2.6
  V(I)           10.38      10.65      10.88      10.69      10.71

X STA.        10.2       10.9       11.7       12.5       13.2       14.0
  A(I)             2.6        2.6        2.5        2.6        2.6
  V(I)           10.74      10.65      10.82      10.56      10.42

X STA.        14.0       14.9       15.8       17.0       18.4       20.9
  A(I)             2.7        2.9        3.1        3.5        5.0
  V(I)           10.01       9.47       8.82       7.82       5.48

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      40.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      109      6148     28     32                         1221
   891.40           109      6148     28     32  1.00     -4     22     1221

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      40.

         WSEL     LEW     REW    AREA        K        Q    VEL
       891.40    -5.5    22.4   108.9    6148.     550.   5.05

X STA.        -5.5        1.1        3.0        4.4        5.3        6.2
  A(I)            10.3        7.0        6.6        5.3        4.8
  V(I)            2.66       3.95       4.16       5.17       5.69

X STA.         6.2        7.1        7.9        8.7        9.5       10.2
  A(I)             4.7        4.6        4.4        4.4        4.3
  V(I)            5.84       5.96       6.18       6.28       6.38

X STA.        10.2       11.0       11.7       12.4       13.1       13.8
  A(I)             4.2        4.3        4.2        4.3        4.5
  V(I)            6.50       6.41       6.47       6.42       6.18

X STA.        13.8       14.6       15.4       16.4       17.7       22.4
  A(I)             4.6        4.8        5.3        6.5        9.7
  V(I)            6.04       5.75       5.16       4.26       2.82

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       890.35     0.4    20.9    82.8    4784.     550.   6.64

X STA.         0.4        2.6        3.7        4.6        5.5        6.3
  A(I)             7.3        4.7        4.1        3.8        3.7
  V(I)            3.74       5.88       6.71       7.15       7.48

X STA.         6.3        7.1        7.9        8.7        9.5       10.3
  A(I)             3.6        3.5        3.4        3.5        3.5
  V(I)            7.67       7.85       8.01       7.86       7.86

X STA.        10.3       11.1       11.9       12.6       13.4       14.2
  A(I)             3.4        3.5        3.5        3.5        3.6
  V(I)            8.00       7.95       7.81       7.82       7.57

X STA.        14.2       15.1       16.1       17.2       18.5       20.9
  A(I)             3.7        4.0        4.3        4.8        7.3
  V(I)            7.38       6.90       6.46       5.71       3.75
```

WSPRO OUTPUT FILE (continued)

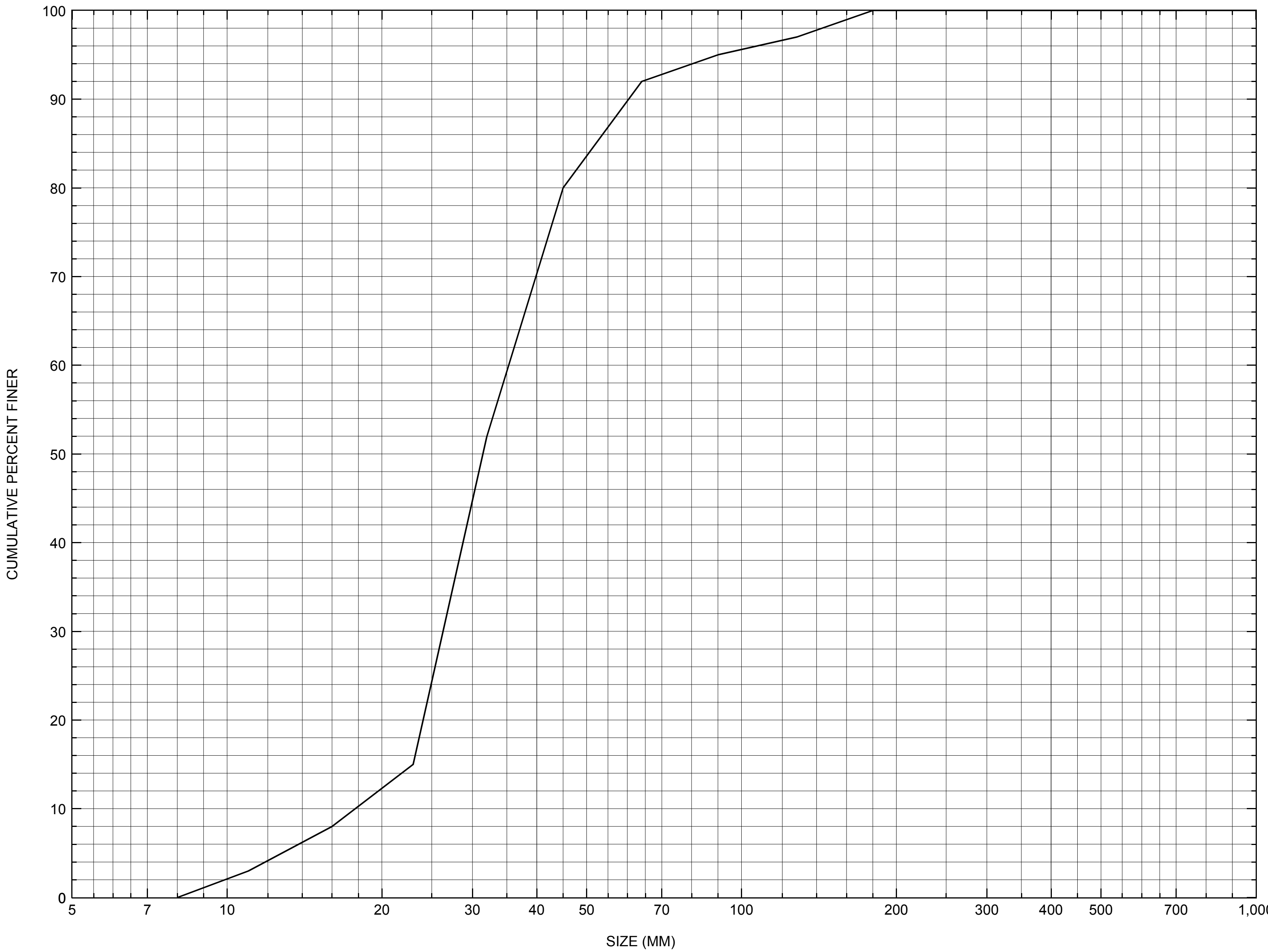
```
        U.S. Geological Survey WSPRO Input File newb053.wsp
        Hydraulic analysis for structure NEWBTH00750053   Date: 15-SEP-97
        TH 75 CROSSING HARRIMAN BROOK IN NEWBURY, VT                RLB
           *** RUN DATE & TIME: 10-17-97  16:15

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                             WSI,CRWS =   883.43     884.35

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

EXITX:XS   ******      8       39  1.38 *****  885.73  884.35     365  884.35
       -31 ******     22     1409  1.00 ***** *******    1.00    9.41

 ===105 WSMIN BELOW YMIN AT SECID "FULLV":  USED WSMIN = CRWS.
                        YMIN,WSMIN,CRWS =   884.00     883.85     888.35
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   888.35     920.88    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   888.35     920.88     888.35
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "FULLV"
                   WSBEG,WSEND,CRWS =   888.35     920.88     888.35

FULLV:FV       32      8       39  1.38 *****  889.73  888.35     365  888.35
         0     32     22     1409  1.00 ***** *******    1.00    9.41
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  2.93

APPRO:AS       40     -2       81  0.31  0.92  890.65 *******     365  890.34
        40     40     21     4130  1.00  0.00    0.01    0.44    4.50
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =     365.     888.52

             <<<<<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       32      0       46  1.00 *****  889.52  888.52     365  888.52
         0     32     21     1945  1.00 ***** *******    0.95    8.02

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1.   0.   1.  1.000  0.046  897.58 ****** ****** ******

    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        8     -3       85  0.29  0.12  890.78  888.56     365  890.49
        40      8     21     4397  1.00  1.14    0.00    0.41    4.30

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.165  0.000    4542.     1.    21.   890.31

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -32.     8.    22.    365.    1409.      39.    9.41  884.35
   FULLV:FV       0.     8.    22.    365.    1409.      39.    9.41  888.35
   BRIDG:BR       0.     0.    21.    365.    1945.      46.    8.02  888.52
   RDWAY:RG       9.**************      0.******************    2.00********
   APPRO:AS      40.    -4.    21.    365.    4397.      85.    4.30  890.49

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       1.    21.    4542.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    884.35    1.00  880.00  916.88************  1.38  885.73  884.35
   FULLV:FV    888.35    1.00  884.00  920.88************  1.38  889.73  888.35
   BRIDG:BR    888.52    0.95  885.82  897.65************  1.00  889.52  888.52
   RDWAY:RG  ****************  899.80  914.82**********************************
   APPRO:AS    888.56    0.41  885.22  915.84  0.12  1.14  0.29  890.78  890.49
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File newb053.wsp
        Hydraulic analysis for structure NEWBTH00750053   Date: 15-SEP-97
        TH 75 CROSSING HARRIMAN BROOK IN NEWBURY, VT                RLB
           *** RUN DATE & TIME: 10-17-97  16:15

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =   884.09     885.30

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

EXITX:XS   ******      7       53  1.67 *****  886.97  885.30     550  885.30
       -31 ******     23     2172  1.00 ***** *******    1.00   10.35

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    7.48     886.19     889.31
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   884.80     920.88    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   884.80     920.88     889.31
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "FULLV"
                  WSBEG,WSEND,CRWS =   889.31     920.88     889.31

FULLV:FV       32      7       53  1.67 *****  890.97  889.31     550  889.31
         0     32     23     2172  1.00 ***** *******    1.00   10.35
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  2.91

APPRO:AS       40     -5      111  0.38  0.88  891.86 *******     550  891.48
        40     40     23     6313  1.00  0.00    0.01    0.44    4.95
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =     550.     889.22

             <<<<<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       32      0       60  1.32 *****  890.54  889.22     550  889.22
         0     32     21     2942  1.00 ***** *******    0.95    9.21

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1.   0.   1.  1.000  0.044  897.58 ****** ****** ******

    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        8     -5      109  0.40  0.13  891.80  889.35     550  891.40
        40      8     22     6150  1.00  1.13    0.00    0.45    5.05

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.274  0.000    6515.     0.    21.   891.19

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -32.     7.    23.    550.    2172.      53.   10.35  885.30
   FULLV:FV       0.     7.    23.    550.    2172.      53.   10.35  889.31
   BRIDG:BR       0.     0.    21.    550.    2942.      60.    9.21  889.22
   RDWAY:RG       9.**************       0.******************     2.00********
   APPRO:AS      40.    -6.    22.    550.    6150.     109.    5.05  891.40

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       0.    21.    6515.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    885.30    1.00  880.00  916.88************  1.67  886.97  885.30
   FULLV:FV    889.31    1.00  884.00  920.88************  1.67  890.97  889.31
   BRIDG:BR    889.22    0.95  885.82  897.65************  1.32  890.54  889.22
   RDWAY:RG ****************  899.80  914.82**********************************
   APPRO:AS    889.35    0.45  885.22  915.84  0.13  1.13  0.40  891.80  891.40
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure NEWBTH00750053, in Newbury, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number NEWBTH00750053

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 27 / 95

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

County *(FIPS county code; I - 3; nnn)* 017

Town *(FIPS place code; I - 4; nnnnn)* 48100

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

Waterway *(I - 6)* HARRIMAN BROOK

Road Name *(I - 7):* -

Route Number TH075

Vicinity *(I - 9)* 0.05 MI JCT TH 75 + TH 4

Topographic Map Newbury

Hydrologic Unit Code: 01080104

Latitude *(I - 16; nnnn.n)* 44050

Longitude *(i - 17; nnnnn.n)* 72037

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10090700530907

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

Maximum span length *(I - 48; nnnn)* 0023

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

Structure length *(I - 49; nnnnnn)* 000026

Average daily traffic, ADT *(I - 29; nnnnnn)* 000025

Deck Width *(I - 52; nn.n)* 139

Year of ADT *(I - 30; YY)* 93

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

Opening skew to Roadway *(I - 34; nn)* 08

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

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

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

Structure type *(I - 43; nnn)* 101

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 011.8

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

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

Comments:

The structural inspection report of 10/11/93 indicates that the structure is a concrete slab type bridge. The left abutment and wingwalls are "laid-up" stone blocks. The right abutment and wingwalls are concrete. The deck is partially supported by 5 steel I-beam stringers. The stringers are badly rusted, and log bents have been added under the stringers at mid-span and at the abutments to provide additional support. The laid-up stone of the left abutment has a few small voids overall where stones have chipped or slid out. On the right abutment, the footing is exposed and a concrete subfooting or kneewall is also visible at the surface. There are a few fine cracks and spalls reported overall in the concrete, **(Continued, page 31)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

Q_{50} - Q_{100} - Q_{500} -

Record flood date (MM / DD / YY): - / / Water surface elevation (ft): -

Estimated Discharge (cfs): - Velocity at Q - (ft/s): -

Ice conditions (Heavy, Moderate, Light) : - Debris (Heavy, Moderate, Light): -

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

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

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

Watershed storage area (in percent): -%

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

with a random vertical crack in the abutment face. The upstream right wingwall has a few deep spalls, with a vertical crack reported about 5 feet from its end. A few boulders and bedrock are exposed on the banks upstream and downstream of the bridge. The streambed consists of mainly gravel with some boulders. The bridge is reported as having an unknown foundation.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **3.22** mi^2 Lake/pond/swamp area **0.08** mi^2

Watershed storage *(ST)* **2.5** %

Bridge site elevation **540** ft Headwater elevation **1205** ft

Main channel length **4.71** mi

10% channel length elevation **610** ft 85% channel length elevation **990** ft

Main channel slope *(S)* **81** ft / mi

Watershed Precipitation Data

Average site precipitation - in Average headwater precipitation - in

Maximum 2yr-24hr precipitation event *(I24,2)* - in

Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? N *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: - / -

Project Number - Minimum channel bed elevation: -

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

Benchmark location description:
NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness - Footing bottom elevation: -

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:
NO FOUNDATION MATERIAL INFORMATION

Comments:
NO PLANS.

Cross-sectional Data

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

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

Comments: **This cross-section is the upstream face. The low chord elevation is from the survey log done for this report on 8/30/95. The low chord to bed length data is from the sketch attached to a bridge inspection report dated10/11/93. The sketch was done on 10/13/93.**

Station	0	5	11	17	22	-	-	-	-	-	-
Feature	LAB	-	-	-	RAB	-	-	-	-	-	-
Low chord elevation	897.5	897.5	897.6	897.7	897.7	-	-	-	-	-	-
Bed elevation	887.0	885.6	885.6	886.0	887.5	-	-	-	-	-	-
Low chord to bed	10.5	11.9	12.0	11.7	10.2	-	-	-	-	-	-

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

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

Comments: -

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **EW** Date: **03/07/96**
Computerized by: **EW** Date: **03/08/96**
Reviewd by: **RB** Date: **10/23/97**

Structure Number **NEWBTH00750053**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **L. MEDALIE** Date *(MM/DD/YY)* **08** / **30** / 19**95**

2. Highway District Number **07** Mile marker **-**
County **ORANGE (017)** Town **NEWBURY (48100)**
Waterway *(I - 6)* **HARRIMAN BROOK** Road Name **-**
Route Number **TH75** Hydrologic Unit Code: **01080104**

3. Descriptive comments:
The bridge is located 0.05 mile from the junction with Town Highway 4.

B. Bridge Deck Observations

4. Surface cover... LBUS **6** RBUS **6** LBDS **6** 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 **1** 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 **26** *(feet)* Span length **23** *(feet)* Bridge width **13.9** *(feet)*

Road approach to bridge:

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

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

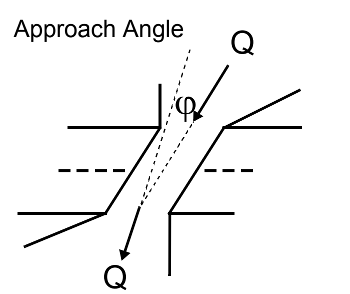
10. Embankment slope (*run / rise in feet / foot*):
US left **4.3:1** US right **3.5:1**

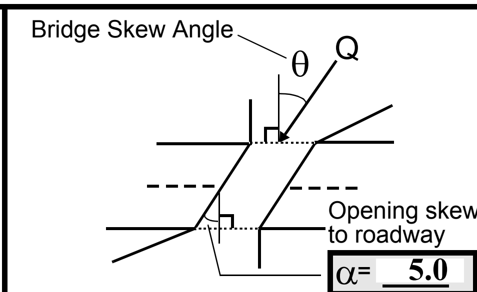
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: **0** 16. Bridge skew: **5**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **0**
Range? **UB** feet **7** *(US, UB, DS)* to **10** 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**

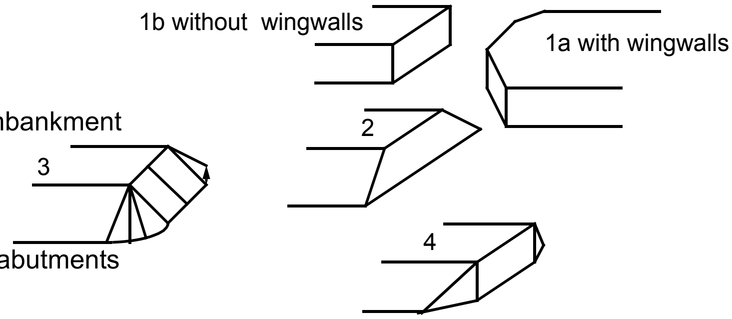
1a- Vertical abutments with wingwalls

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: Values are from the VTAOT database. Measured values are; bridge length= 28.5 feet, bridge span= 22 feet, and bridge width= 14 feet.
#9: The RB road approach is not paved for 28 feet until the junction with TH4 which is paved.
#17: The impact zone noted on the right bank has very slight severity.

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
33.0	**13.5**			**16.0**	**4**	**3**	**12**	**5**	**0**	**1**

23. Bank width **15.0** 24. Channel width **35.0** 25. Thalweg depth **86.5** 29. Bed Material **123**

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

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

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

#30: The RB protection consists of one granite slab at 14 feet US then there is uninterrupted protection from 25 feet US to 65 feet US.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **64** 35. Mid-bar width: **4**

36. Point bar extent: **32** feet **US** (US, UB) to **72** feet **US** (US, UB, DS) positioned **0** %LB to **35** %RB

37. Material: **1**

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

This is a point bar.

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

41. Mid-bank distance: **70** 42. Cut bank extent: **63** feet **US** (US, UB) to **78** feet **US** (US, UB, DS)

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

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

The stream makes a 90 degree bend to the left at 70 feet US.

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

A culvert from under TH4 enters on the high right bank 30 feet US from the bridge.

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
12.0		0.5		2	7	7	-

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

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

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

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

34

-

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 **3**____ *(**1**- Low; **2**- Moderate; **3**- High)*

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

70. Debris and Ice Comments:

2

#67: The debris potential is high due to the large number of small and medium-sized trees and limbs on the banks and the amount of debris already in the channel and at the bridge.
#68: The support for the bridge which consists of 3 central vertical timbers and 3 sets of sloping timbers (log bents) increases the capture efficiency.

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		**0**	**90**	**2**	**0**	**-**	**-**	**90.0**
RABUT	**2**	**5**	**85**			**0**	**0**	**22.0**

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

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

-

-

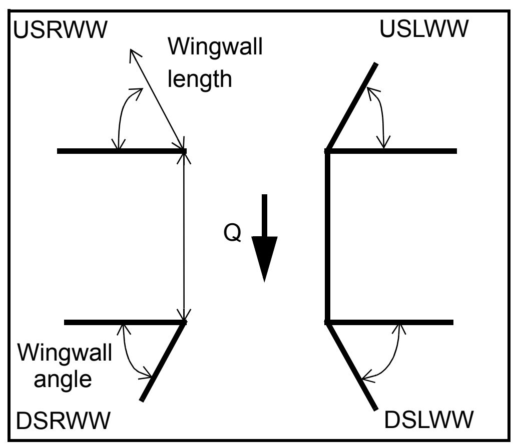
1

The LABUT is constructed of large granite blocks of varying sizes, generally 1.5 feet high. Against the LABUT are three 1 foot in diameter vertical timbers supporting one horizontal wooden beam upon which rests the steel I-beams. There are some voids between the stones on the LABUT and wingwalls.
The lower 5 feet of the RABUT is at an 85 degree angle and is constructed of concrete. Set back 1 foot from the lower section of the RABUT is another concrete section which is 7 feet high. Six vertical timbers rest on lower section. A horizontal wooden beam rests on top of the six timbers which lie under the I-beams (low chord).

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**22.0**	
USRWW:	**Y**		**2**		**0**	**0.0**	
DSLWW:	**-**		**-**		**Y**	**16.5**	
DSRWW:	**1**		**0**		**-**	**19.0**	

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



82. **Bank / Bridge Protection**:

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

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

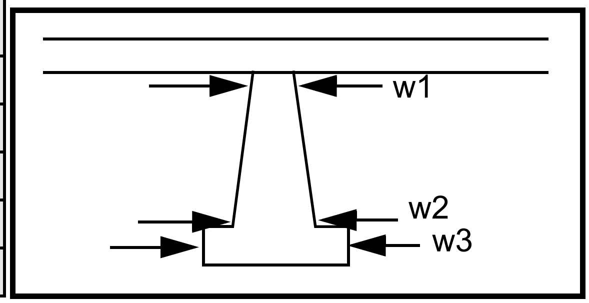
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
0
-
-
0
-
-

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				**30.0**	**29.5**	**60.0**
Pier 2				**17.0**	**60.0**	**15.0**
Pier 3			**0.8**	**65.0**	**16.0**	**885.91**
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)		**M**	-	-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type		**2**	-	-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material		**1**	-	-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape		**21**	-	-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?		**N**	-	-	*Y- yes; N- no*
91. Attack ∠ (BF)		**0**	-	-	
92. Pushed		**N/A**	-	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles		**3**	-	-	
95. Cross-members		**2**	-	-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition		**2**	-	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**Y**	-	-	-	
98. Exposure depth	**MC**	**1**	-	-	

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
-	-			-	-	-	The	pier	is	com

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

Bank protection type (Qmax): LB d of RB thr Bank protection condition: LB ee RB post

*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.):

s. Some debris has accumulated at the US end.
#89: The US most post is square and the next two posts DS are round.
#96: The US most post is 1 foot above the stream channel and rests on top of 2 horizontal wooden blocks. The next two posts have no evidence of scour and extend directly into streambed.

4
4
6
5
0

101. Is a drop structure present? **0** *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

103. Drop: - feet 104. Structure material: **5** *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

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

0
0
-
-
The downstream channel and banks are full of boulders, some natural and some placed granite blocks.
A horizontal, 1.5 feet in diameter post on RB acts as protection. It extends from 9 feet DS to 23 feet DS.

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

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

Material: _____

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

Y

Is a cut-bank present? **3** *(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: **N** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

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

-
-
-
-

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

Scour dimensions: Length **-** Width **-** Depth: **-** Positioned **NO** %LB to **PO** %RB

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

INT BARS

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

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

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

Confluence comments (eg. confluence name):

NO CUT BANKS

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

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

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

N
-
-
-
-
-
-
NO CHANNEL SCOUR

N

109. G. Plan View Sketch

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: NEWBTH00750053 Town: NEWBURY
Road Number: TH 75 County: ORANGE
Stream: HARRIMAN BROOK

Initials RLB Date: 10/17/97 Checked: LKS

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	365	550	0
Main Channel Area, ft2	85	109	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	25	28	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.1031	0.1031	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	3.4	3.9	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	4391	6148	0
Conveyance, main channel	4391	6148	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	365.0	550.0	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	4.3	5.0	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	6.4	6.6	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	365	550	0
(Q) discharge thru bridge, cfs	365	550	0
Main channel conveyance	1944	2943	0
Total conveyance	1944	2943	0
Q2, bridge MC discharge,cfs	365	550	ERR
Main channel area, ft2	43	57	0
Main channel width (normal), ft	20.3	20.4	0.0
Cum. width of piers in MC, ft	0.8	0.8	0.0
W, adjusted width, ft	19.5	19.6	0
y_bridge (avg. depth at br.), ft	2.23	2.91	ERR
Dm, median (1.25*D50), ft	0.128875	0.128875	0
y2, depth in contraction,ft	2.74	3.87	ERR
ys, scour depth (y2-ybridge), ft	0.51	0.96	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	365	550	N/A
Main channel area (DS), ft2	43.4	57.1	0
Main channel width (normal), ft	20.3	20.4	0.0
Cum. width of piers, ft	0.8	0.8	0.0
Adj. main channel width, ft	19.5	19.6	0.0
D90, ft	0.1980	0.1980	0.0000
D95, ft	0.2953	0.2953	0.0000
Dc, critical grain size, ft	0.2945	0.3473	ERR
Pc, Decimal percent coarser than Dc	0.050	0.041	0.000
Depth to armoring, ft	16.79	24.37	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	365	550	0	365	550	0
a', abut.length blocking flow, ft	4.1	6	0	0.5	1.5	0
Ae, area of blocked flow ft2	5.73	9.36	0	0.93	3.1	0
Qe, discharge blocked abut.,cfs	12.9	25	0	2.23	8.78	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.25	2.67	ERR	2.40	2.84	ERR
ya, depth of f/p flow, ft	1.40	1.56	ERR	1.86	2.07	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	95	95	95	85	85	85
K2	1.01	1.01	1.01	0.99	0.99	0.99
Fr, froude number f/p flow	0.336	0.377	ERR	0.311	0.348	ERR
ys, scour depth, ft	3.54	4.44	N/A	2.82	3.81	N/A

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

	Left 100 yr Q	Left 500 yr Q	Left Other Q	Right 100 yr Q	Right 500 yr Q	Right Other Q
a'(abut length blocked, ft)	4.1	6	0	0.5	1.5	0
y1 (depth f/p flow, ft)	1.40	1.56	ERR	1.86	2.07	ERR
a'/y1	2.93	3.85	ERR	0.27	0.73	ERR
Skew correction (p. 49, fig. 16)	1.01	1.01	1.01	0.98	0.98	0.98
Froude no. f/p flow	0.34	0.38	N/A	0.31	0.35	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	0.95	0.95	0	0.95	0.95	0
y, depth of flow in bridge, ft	2.24	2.93	0.00	2.24	2.93	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	0.92	1.21	ERR	0.92	1.21	ERR

Pier Scour

ys/y1=2.0*K1*K2*K3*K4*(a/y1)^0.65*Fr1^0.43
(Richardson and others, 1995, p. 36, eq. 21)

K1, corr. factor for pier nose shape
  Sharp nose, 0.9; round nose, cylinder, or cylinder grp., 1.0; square nose, 1.1

K2, corr. factor attack angle (see Table 3, p 37)
  K2=[cos(attackangle)+L/a*sin(attackangle)]^0.65

K3, corr. factor for bed condition
  Clear-water, plane bed, antidune, 1.1; med. dunes, 1.1-1.2 (see Tab.4,p37)

K4, corr. factor for armoring (the following equations are in Si units)
  K4=[1-0.89*(1-Vr)^2]^0.5
    Vr=(V1-Vi)/(Vc90-Vi)
    V1=0.645*((D50/a)^0.053)*Vc50
    Vc=6.19*(y^1/6)*(Dc^1/3)

Note for round nose piers:
  ys<=2.4 times the pier width (a) for Fr<=0.8
  ys<=3.0 times the pier width (a) for Fr>0.8

Pier 1	Q100	Q500	Qother
Pier stationing, ft	10.4	10.4	0
Area of WSPRO flow tube, ft2	2.9	3.4	0
Skewed width of flow tube, ft	1.2	0.8	0
y1, pier approach depth, ft	2.42	4.25	ERR
y1 in meters	0.737	1.295	N/A
V1, pier approach velocity, ft/s	6.33	8.01	0
a, pier width, ft	0.8	0.8	0

L, pier length, ft	2.4	2.4	0
Fr1, Froude number at pier	0.718	0.685	ERR
Pier attack angle, degrees	0	0	0
K1, shape factor	1.1	1.1	0
K2, attack factor	1.00	1.00	ERR
K3, bed condition factor	1.1	1.1	0
D50, ft	0.1031	0.1031	0
D50, m	0.031423	0.031423	0
D90, ft	0.198	0.198	0
D90, m	0.060347	0.060347	0
Vc50,critical velocity(D50),m/s	1.856	2.039	N/A
Vc90,critical velocity(D90),m/s	2.307	2.535	N/A
Vi,incipient velocity,m/s	1.074	1.180	ERR
Vr, velocity ratio	0.693	0.931	ERR
K4, armor factor	0.00	0.00	N/A
ys, scour depth (K4 applicable) ft	ERR	ERR	ERR
ys, scour depth (K4 not applied)ft	2.47	2.95	ERR

Pier rip-rap sizing

D50=0.692(K*V)^2/(Ss-1)*2*g
(Richardson and others, 1995, p.115, eq. 83)

Pier-shape coefficient (K), round nose, 1.5; square nose, 1.7
Characteristic avg. channel velocity, V, (Q/A):
(Mult. by 0.9 for bankward piers in a straight, uniform reach,
up to 1.7 for a pier in main current of flow around a bend)

Pier 1	Q100	Q500	Qother
K, pier shape coeff.	1.7	1.7	0
V, velocity on pier, ft/s	6.903	8.632	0
D50, median stone diameter, ft	0.90	1.40	0.00