LEVEL II SCOUR ANALYSIS FOR BRIDGE 16 (NEWBTH00500016) on TOWN HIGHWAY 50, crossing HALLS BROOK, NEWBURY, VERMONT

Open-File Report 97-814

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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By RONDA L. BURNS and JAMES R. DEGNAN

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Pembroke, New Hampshire

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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 16 (NEWBTH00500016) ON TOWN HIGHWAY 50, CROSSING HALLS BROOK, NEWBURY, VERMONT

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

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure NEWBTH00500016 on Town Highway 50 crossing Halls 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 (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 New England Upland section of the New England physiographic province in east-central Vermont. The 23.4-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is shrub and brushland.

In the study area, Halls Brook has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 53 ft and an average bank height of 7 ft. The channel bed material ranges from silt to gravel with a median grain size (D_{50}) of 40.4 mm (0.133 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 29, 1995, indicated that the reach was laterally unstable. The channel bed and banks are composed of fine material and show signs of erosion. There is also evidence of beaver activity in the area.

The Town Highway 50 crossing of Halls Brook is a 44-ft-long, two-lane bridge consisting of one 38-foot prestressed concrete slab span (Vermont Agency of Transportation, written communication, March 27, 1995). The opening length of the structure parallel to the bridge face is 35.2 ft. The bridge is supported by vertical, stone masonry abutments. The channel is skewed approximately 40 degrees to the opening while the computed opening-skew-to-roadway is 5 degrees.

A channel scour hole 1.0 ft deeper than the mean thalweg depth was observed just upstream of the bridge behind the remains of a beaver dam during the Level I assessment. An additional channel scour hole 4.5 ft deeper than the mean thalweg depth was observed in the downstream reach. The scour countermeasures at the site included type-1 stone fill (less than 12 inches diameter) along the left abutment and type-2 stone fill (less than 36 inches diameter) along the right abutment and left bank upstream and downstream. Along the downstream right bank is type-3 stone fill (less than 48 inches diameter) and along the upstream right bank is type-4 stone fill (less than 60 inches diameter). Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 2.6 to 4.6 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge. The left abutment scour ranged from 11.6 to 12.1 ft. The worst-case left abutment scour occurred at the incipient road-overtopping discharge. The right abutment scour ranged from 13.6 to 17.9 ft. The worst-case right 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. 46). 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 NEWBTH00500016 ***Stream*** Halls Brook

County Orange ***Road*** TH 50 ***District*** 7

Description of Bridge

Bridge length 44 ***ft*** ***Bridge width*** 20.5 ***ft*** ***Max span length*** 38 ***ft***

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

Abutment type Vertical, stone masonry ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 8/29/95

Description of stone fill Type-1, along the left abutment. Type-2, along the right abutment and left bank upstream and downstream. Type-3, along the downstream right bank. Type-4, along the upstream right bank.

Brief description of piers/abutments Abutments are grouted, laid-up stone. Bank material and stone fill along the left abutment create a spill-through embankment.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 40

There is a severe channel bend in the upstream reach. A cut-bank has formed where the flow impacts the upstream right bank.

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	8/29/95	0	0
Level II	8/29/95	0	0

Potential for debris Moderate. There is debris in the channel from the old beaver dam upstream of the bridge.

Describe any features near or at the bridge that may affect flow (include observation date) The stone fill along the abutments also extends into and covers the channel bed under the bridge as of 8/29/95.

Description of the Geomorphic Setting

General topography The channel is located within a low relief valley with a narrow, flat to slightly irregular flood plain.

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

Date of inspection 8/29/95

DS left: Moderately sloped channel bank to a narrow flood plain

DS right: Moderately sloped overbank

US left: Steep channel bank to TH 50

US right: Moderately sloped overbank

Description of the Channel

Average top width 53 *ft*

Average depth 7 *ft*

Predominant bed material Sand/Gravel

Bank material Silt/Sand

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

8/29/95

Vegetative co Shrubs and brush

DS left: Shrubs and brush with a few trees

DS right: Shrubs and brush

US left: Shrubs and brush with a few trees

US right: No

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

The bank material is fine. There is a cut bank on the upstream right bank and light fluvial erosion on the other banks. There is also beaver activity in the area.

The assessment of 8/29/95 noted that flow conditions are influenced by the remains of a beaver dam at the upstream face of the bridge.

Describe any obstructions in channel and date of observation.

There is also a small hand-made dam under the bridge constructed from the stone fill along the abutments.

Hydrology

Drainage area 23.4 ***mi²***

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 -- ***mi²***

Is there a lake/p ... No

Calculated Discharges

Q100 3,700 ***ft³/s*** ***Q500*** 5,700 ***ft³/s***

The 100-year discharge is from flood frequency estimates available from the VTAOT database which were extended graphically to the 500-year discharge. The drainage area above bridge number 16 is reported as 23.5 square miles while the computed drainage area is 23.4 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).

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

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

Datum tie between USGS survey and VTAOT plans The USGS arbitrary survey datum was decreased by 1.4 to obtain the VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the right abutment (elev. 502.96 ft, VTAOT plans' datum). RM2 is a chiseled X on top of the roadway at the upstream end of the left abutment (elev. 506.67 ft, VTAOT plans' datum). RM3 is a nail in a telephone pole on the down-stream right bank, 20 ft from the right abutment (elev. 509.84, VTAOT plans' datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITA	-48	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	11	1	Road Grade section
APPR1	58	2	Modelled Approach section (Templated from APTEM)
APTEM	67	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 0.050 to 0.063, and overbank "n" values ranged from 0.040 to 0.085.

Normal depth at the exit section (EXITA) 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 0.0167 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1973). For the 500-year discharge, the normal depth calculated is also the critical depth.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0090 ft/ft) to establish the modelled approach section (APPR1), 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 incipient-overtopping discharges, 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 was 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 506.4 ***ft***
Average low steel elevation 504.8 ***ft***

100-year discharge 3,700 ***ft^3/s***
Water-surface elevation in bridge opening 500.4 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft^3/s***
Area of flow in bridge opening 245 ***ft^2***
Average velocity in bridge opening 15.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 19.3 ***ft/s***

Water-surface elevation at Approach section with bridge 504.6
Water-surface elevation at Approach section without bridge 500.7
Amount of backwater caused by bridge 3.9 ***ft***

500-year discharge 5,700 ***ft^3/s***
Water-surface elevation in bridge opening 505.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,637 ***ft^3/s***
Area of flow in bridge opening 398 ***ft^2***
Average velocity in bridge opening 10.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.6 ***ft/s***

Water-surface elevation at Approach section with bridge 507.3
Water-surface elevation at Approach section without bridge 502.5
Amount of backwater caused by bridge 4.8 ***ft***

Incipient overtopping discharge 3,940 ***ft^3/s***
Water-surface elevation in bridge opening 500.7 ***ft***
Area of flow in bridge opening 256 ***ft^2***
Average velocity in bridge opening 15.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 19.6 ***ft/s***

Water-surface elevation at Approach section with bridge 505.0
Water-surface elevation at Approach section without bridge 501.0
Amount of backwater caused by bridge 4.0 ***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 incipient roadway-overtopping discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 500-year discharge resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for this discharge was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146).

For comparison, contraction scour for the 500-year discharge, which resulted in orifice flow, was also computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and is presented in Appendix F. Furthermore, for the 500-year discharge, contraction scour was computed by substituting an estimate for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to this substitution are provided in Appendix F.

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.

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	4.3	2.6	4.6
Depth to armoring	N/A	N/A	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	12.0	11.6	12.1
Right abutment	13.6	17.9	15.1
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	3.0	3.2	3.1
Right abutment	3.0	3.2	3.1
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

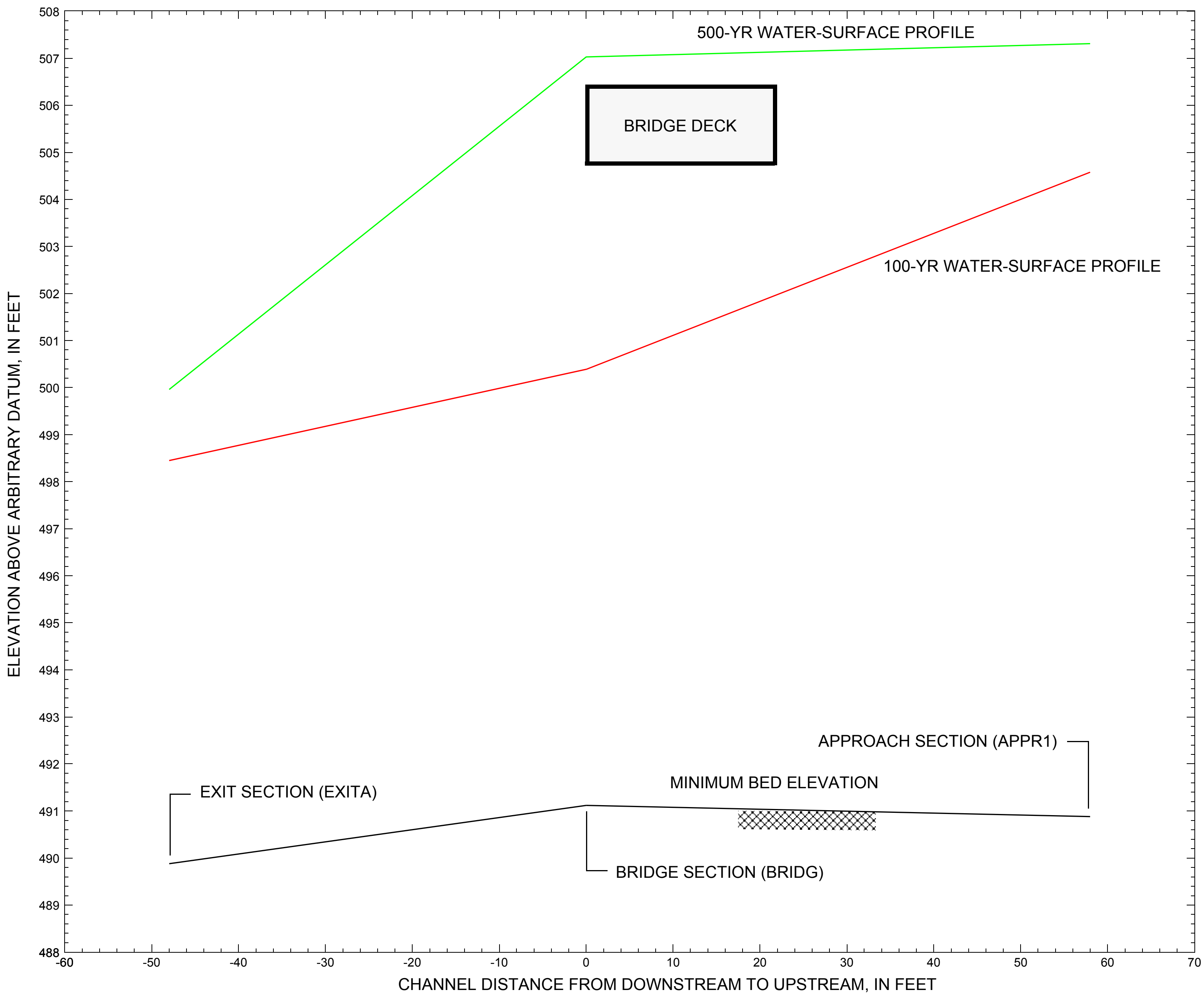

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure NEWBTH00500016 on Town Highway 50, crossing Halls Brook, Newbury, Vermont.

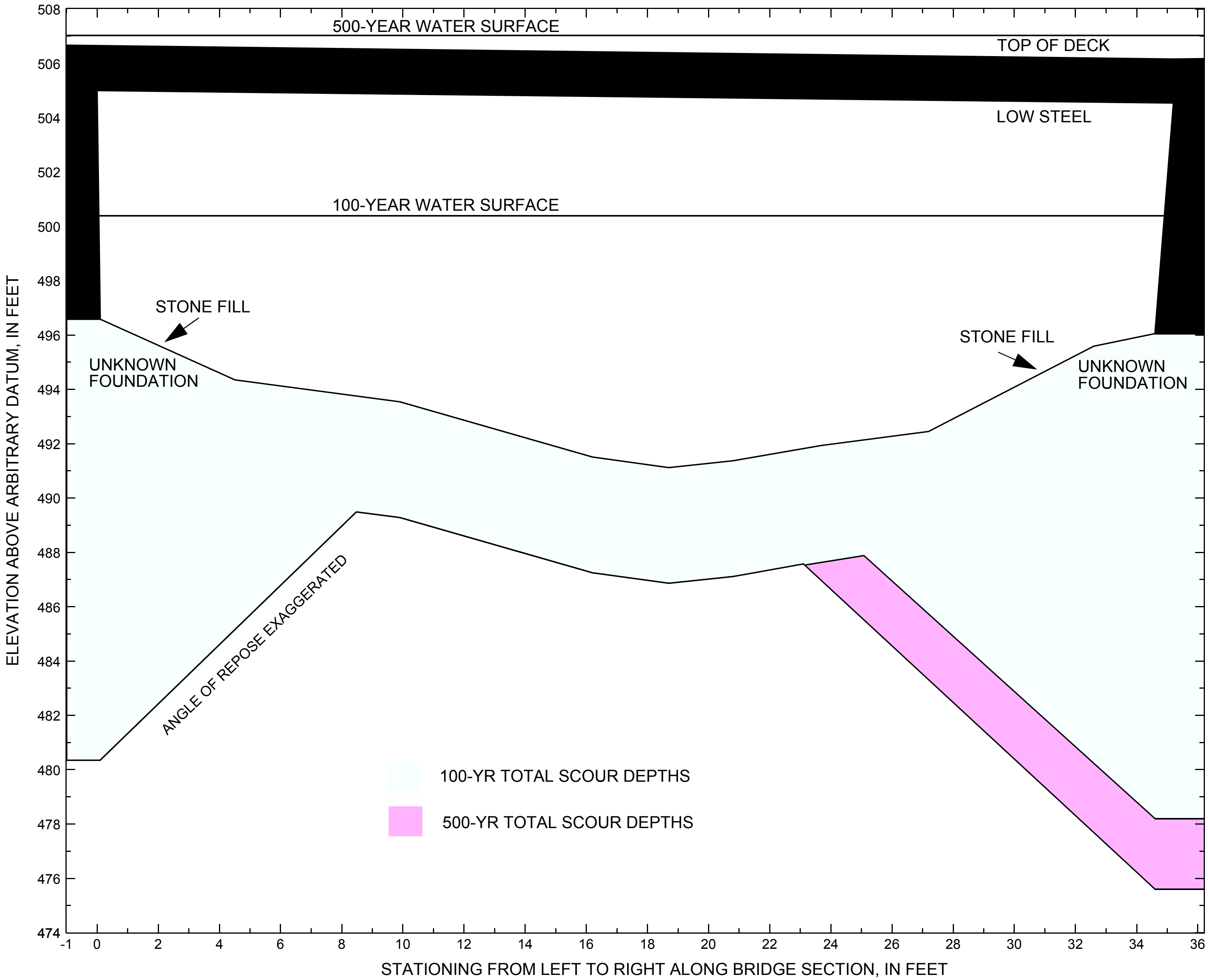

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure NEWBTH00500016 on Town Highway 50, crossing Halls Brook, Newbury, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure NEWBTH00500016 on Town Highway 50, crossing Halls Brook, Newbury, Vermont.

[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 3,700 cubic-feet per second											
Left abutment	0.0	505.0	505.0	--	496.6	4.3	12.0	--	16.3	480.3	--
Right abutment	35.2	504.3	504.5	--	496.1	4.3	13.6	--	17.9	478.2	--

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 NEWBTH00500016 on Town Highway 50, crossing Halls Brook, Newbury, Vermont.

[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum bridge seat 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 5,700 cubic-feet per second											
Left abutment	0.0	505.0	505.0	--	496.6	2.6	11.6	--	14.2	482.4	--
Right abutment	35.2	504.3	504.5	--	496.1	2.6	17.9	--	20.5	475.6	--

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

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U.S. Geological Survey, 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 newb016.wsp
T2        Hydraulic analysis for structure NEWBTH00500016   Date: 04-SEP-97
T3        TH 50 CROSSING HALLS BROOK IN NEWBURY, VT                        RLB
*
J1         * * 0.01
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3700.0   5700.0   3940.0
SK          0.0167   0.0167   0.0167
*
XS   EXITA    -48           0.
GR         -333.6, 518.24   -311.3, 514.58   -279.1, 502.71   -209.7, 502.16
GR         -139.3, 500.74    -92.1, 500.63    -42.6, 499.29    -12.0, 497.73
GR           -8.5, 497.08     -3.9, 495.49      0.0, 492.03      4.4, 490.13
GR           11.1, 489.88     16.9, 490.42     21.4, 490.48     28.8, 491.96
GR           35.1, 493.58     41.2, 494.76     46.2, 497.14
GR           73.1, 499.32     96.0, 500.71    149.8, 501.90    170.6, 505.16
*
N           0.070       0.054       0.085
SA                -12.0        46.2
*
XS   FULLV      0  * * *   0.0115
*
*            SRD     LSEL    XSSKEW
BR   BRIDG     0    504.77       5.0
GR            0.0, 505.00      0.1, 496.58      4.5, 494.35      9.9, 493.54
GR           14.8, 491.97     16.2, 491.51     18.7, 491.12     20.8, 491.37
GR           23.7, 491.94     27.2, 492.45     32.6, 495.59     34.6, 496.05
GR           35.2, 504.54      0.0, 505.00
*
*        BRTYPE  BRWDTH
CD           1      22.5
N           0.050
*
*            SRD    EMBWID   IPAVE
XR   RDWAY     11      20.5     1
GR         -180.5, 511.49   -107.9, 508.80    -15.4, 506.76      0.0, 506.66
GR           35.3, 506.16     65.8, 505.84    109.8, 505.10    148.9, 505.01
GR          235.8, 506.75    261.4, 508.40
*
XT   APTEM     67           0.
GR         -180.5, 511.49   -107.9, 508.80
GR          -29.1, 506.93    -19.0, 506.51      0.0, 495.38      4.2, 492.35
GR            6.3, 491.43     17.4, 491.12     22.9, 490.96     25.5, 491.32
GR           27.0, 492.36     29.0, 493.37     32.2, 496.97     37.8, 497.32
GR           47.2, 496.60     64.7, 497.22     84.8, 498.07     91.3, 501.48
GR          104.1, 502.52    124.1, 503.29    137.4, 503.65    171.1, 502.36
GR          241.0, 504.64    257.0, 506.25    261.4, 508.40
*
AS   APPR1     58  * * *   0.0090
GT
N           0.040       0.063       0.065
SA                -19.0        32.2
*
HP 1 BRIDG  500.39 1 500.39
HP 2 BRIDG  500.39 * * 3700
HP 1 APPR1  504.58 1 504.58
HP 2 APPR1  504.58 * * 3700
*
HP 1 BRIDG  505.00 1 505.00
HP 2 BRIDG  505.00 * * 4094
HP 1 BRIDG  501.24 1 501.24
HP 2 RDWAY  507.03 * * 1637
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File newb016.wsp
        Hydraulic analysis for structure NEWBTH00500016   Date: 04-SEP-97
        TH 50 CROSSING HALLS BROOK IN NEWBURY, VT                       RLB
           *** RUN DATE & TIME: 10-31-97  09:47

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      245     22809     35     44                         3699
   500.39           245     22809     35     44  1.00      0     35     3699

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.39     0.1    34.9   245.3   22809.    3700.  15.09

X STA.        0.1        4.5        6.8        8.8       10.6       12.1
  A(I)           21.8       13.9       13.1       12.1       11.3
  V(I)           8.47      13.30      14.12      15.34      16.30

X STA.       12.1       13.5       14.8       16.0       17.1       18.2
  A(I)           11.1       10.5       10.3       10.0        9.9
  V(I)          16.64      17.65      18.01      18.56      18.78

X STA.       18.2       19.3       20.3       21.5       22.6       23.8
  A(I)            9.6        9.8        9.9       10.2       10.5
  V(I)          19.32      18.92      18.64      18.15      17.69

X STA.       23.8       25.1       26.5       28.2       30.3       34.9
  A(I)           10.8       11.3       12.7       14.6       22.0
  V(I)          17.19      16.35      14.61      12.65       8.40

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      58.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      478     48329     48     54                         8543
             3      645     31227    209    210                         6428
   504.58          1122     79556    257    264  1.42    -15    241    11162

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      58.

         WSEL     LEW     REW    AREA        K        Q    VEL
       504.58   -15.8   241.2  1122.4   79556.    3700.   3.30

X STA.      -15.8       -0.4        4.3        7.3       10.1       12.7
  A(I)           70.1       50.0       38.9       36.8       34.8
  V(I)           2.64       3.70       4.75       5.03       5.31

X STA.       12.7       15.2       17.6       19.9       22.2       24.6
  A(I)           33.7       32.2       31.9       31.7       31.6
  V(I)           5.49       5.75       5.79       5.83       5.85

X STA.       24.6       27.3       31.2       38.3       45.5       52.7
  A(I)           35.0       42.5       53.8       54.9       57.8
  V(I)           5.29       4.35       3.44       3.37       3.20

X STA.       52.7       61.0       70.5       81.6      119.4      241.2
  A(I)           63.6       70.2       77.5      115.4      159.7
  V(I)           2.91       2.63       2.39       1.60       1.16
```

```
        U.S. Geological Survey WSPRO Input File newb016.wsp
        Hydraulic analysis for structure NEWBTH00500016   Date: 04-SEP-97
        TH 50 CROSSING HALLS BROOK IN NEWBURY, VT                       RLB
           *** RUN DATE & TIME: 10-31-97  09:47

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      398     32372     0     88                            0
   505.00           398     32372     0     88  1.00      0     35        0

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      505.00     0.0    35.2   398.1   32372.    4094.  10.28

X STA.        0.0        3.8        5.9        7.7        9.5       11.1
  A(I)            34.4       22.0       20.3       19.3       18.7
  V(I)            5.94       9.29      10.06      10.60      10.96

X STA.       11.1       12.6       14.0       15.4       16.6       17.8
  A(I)            18.2       17.1       17.2       16.6       16.3
  V(I)           11.28      11.98      11.93      12.35      12.53

X STA.       17.8       19.1       20.3       21.5       22.8       24.2
  A(I)            16.4       16.3       16.9       16.7       17.4
  V(I)           12.49      12.56      12.15      12.26      11.80

X STA.       24.2       25.6       27.1       28.9       31.1       35.2
  A(I)            17.8       18.7       20.7       22.8       34.4
  V(I)           11.48      10.94       9.91       8.98       5.95

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      275     26887    35     46                         4382
   501.24           275     26887    35     46  1.00      0     35     4382

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      11.

        WSEL     LEW     REW    AREA        K        Q    VEL
      507.03   -27.6   240.1   306.3    6554.    1637.   5.34

X STA.      -27.6       25.7       42.8       59.2       73.2       84.0
  A(I)            20.8       14.5       17.0       16.8       15.1
  V(I)            3.94       5.64       4.81       4.87       5.40

X STA.       84.0       92.9      100.7      107.8      114.3      120.8
  A(I)            14.0       13.4       12.9       12.5       12.7
  V(I)            5.85       6.10       6.32       6.53       6.46

X STA.      120.8      127.2      133.6      140.1      146.5      153.2
  A(I)            12.6       12.7       12.9       12.9       13.4
  V(I)            6.51       6.46       6.34       6.34       6.12

X STA.      153.2      160.9      169.7      181.0      196.3      240.1
  A(I)            14.3       14.9       16.8       18.8       27.3
  V(I)            5.74       5.50       4.86       4.36       3.00

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      58.
     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1       11       220    30     30                           39
             2      614     70406    51     58                        12077
             3     1247     88647   227    229                        16587
   507.31          1873    159273   308    316  1.19    -48    259    24016

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      58.

        WSEL     LEW     REW    AREA        K        Q    VEL
      507.31   -48.5   259.3  1873.0  159273.    5700.   3.04

X STA.      -48.5       -0.9        5.0        9.1       12.9       16.6
  A(I)           122.8       79.5       65.0       62.4       58.7
  V(I)            2.32       3.58       4.39       4.57       4.85

X STA.       16.6       20.0       23.5       27.2       33.3       41.1
  A(I)            56.2       56.6       59.0       76.4       79.7
  V(I)            5.08       5.03       4.83       3.73       3.57

X STA.       41.1       48.5       56.2       64.7       73.7       83.6
  A(I)            79.1       81.7       87.8       88.9       95.6
  V(I)            3.60       3.49       3.25       3.20       2.98

X STA.       83.6      103.0      137.7      169.9      199.7      259.3
  A(I)           123.9      148.5      140.7      136.3      174.1
  V(I)            2.30       1.92       2.02       2.09       1.64
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File newb016.wsp
        Hydraulic analysis for structure NEWBTH00500016   Date: 04-SEP-97
        TH 50 CROSSING HALLS BROOK IN NEWBURY, VT                        RLB
           *** RUN DATE & TIME: 10-31-97  09:47

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      256     24324     35     45                         3952
   500.71           256     24324     35     45  1.00      0     35     3952

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.71     0.1    34.9   256.4   24324.    3940.  15.37

X STA.         0.1        4.4        6.8        8.7       10.5       12.1
  A(I)            22.7       15.0       13.4       12.6       11.9
  V(I)            8.67      13.13      14.70      15.59      16.62

X STA.        12.1       13.5       14.8       16.0       17.1       18.2
  A(I)            11.6       10.9       10.7       10.5       10.1
  V(I)           17.01      18.07      18.47      18.75      19.58

X STA.        18.2       19.3       20.3       21.4       22.6       23.9
  A(I)            10.1       10.3       10.1       10.7       10.9
  V(I)           19.48      19.07      19.44      18.49      18.01

X STA.        23.9       25.2       26.6       28.2       30.4       34.9
  A(I)            11.3       11.9       13.3       15.0       23.4
  V(I)           17.48      16.62      14.85      13.12       8.40

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      58.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      500     51567     49     55                         9074
             3      742     38895    214    215                         7849
   505.04          1242     90462    262    269  1.37    -16    246    13116

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      58.

         WSEL     LEW     REW    AREA        K        Q    VEL
       505.04   -16.6   245.8  1241.9   90462.    3940.   3.17

X STA.       -16.6       -0.2        4.5        7.7       10.6       13.4
  A(I)            79.1       52.5       43.7       40.0       38.2
  V(I)            2.49       3.75       4.51       4.92       5.16

X STA.        13.4       16.0       18.6       21.1       23.6       26.3
  A(I)            36.6       36.6       35.5       35.3       36.8
  V(I)            5.39       5.38       5.55       5.57       5.36

X STA.        26.3       29.8       36.4       43.8       50.9       58.7
  A(I)            42.4       56.8       58.9       59.8       64.8
  V(I)            4.65       3.47       3.34       3.29       3.04

X STA.        58.7       67.4       77.4       92.3      158.3      245.8
  A(I)            69.0       75.6       92.1      141.8      146.6
  V(I)            2.86       2.61       2.14       1.39       1.34
```

```
        U.S. Geological Survey WSPRO Input File newb016.wsp
        Hydraulic analysis for structure NEWBTH00500016   Date: 04-SEP-97
        TH 50 CROSSING HALLS BROOK IN NEWBURY, VT                       RLB
           *** RUN DATE & TIME: 10-31-97  09:47

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

EXITA:XS   ******    -25      349  1.88 *****  500.33  497.78    3700  498.45
       -47 ******     62    28615  1.07 ***** *******    0.98   10.61

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.91     499.44     498.33

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   497.95     518.79    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   497.95     518.79     498.33

FULLV:FV       48    -34      392  1.57  0.70  501.03  498.33    3700  499.46
         0     48     68    32769  1.14  0.00    0.00    0.91    9.43
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       58     -8      501  0.97  0.69  501.70 *******    3700  500.73
        58     58     90    35372  1.14  0.00   -0.02    0.62    7.39
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                 SECID "BRIDG"     Q,CRWS =    3700.     500.39

            <<<<<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       48      0      245  3.54 *****  503.93  500.39    3700  500.39
         0     48     35    22813  1.00 ***** *******    1.00   15.08

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  504.77 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPR1:AS       36    -15     1121  0.24  0.29  504.82  499.45    3700  504.58
        58     39    241    79457  1.42  0.59   -0.01    0.33    3.30

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.650  0.381   49314.     3.    38.   504.49

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITA:XS     -48.   -26.    62.   3700.   28615.     349.   10.61  498.45
   FULLV:FV       0.   -35.    68.   3700.   32769.     392.    9.43  499.46
   BRIDG:BR       0.     0.    35.   3700.   22813.     245.   15.08  500.39
   RDWAY:RG      11.**************       0.*****************    1.00********
   APPR1:AS      58.   -16.   241.   3700.   79457.    1121.    3.30  504.58

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS       3.    38.   49314.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITA:XS    497.78    0.98  489.88  518.24************  1.88  500.33  498.45
   FULLV:FV    498.33    0.91  490.43  518.79  0.70  0.00  1.57  501.03  499.46
   BRIDG:BR    500.39    1.00  491.12  505.00************  3.54  503.93  500.39
   RDWAY:RG  ***************  505.01  511.49**********************************
   APPR1:AS    499.45    0.33  490.88  511.41  0.29  0.59  0.24  504.82  504.58
```

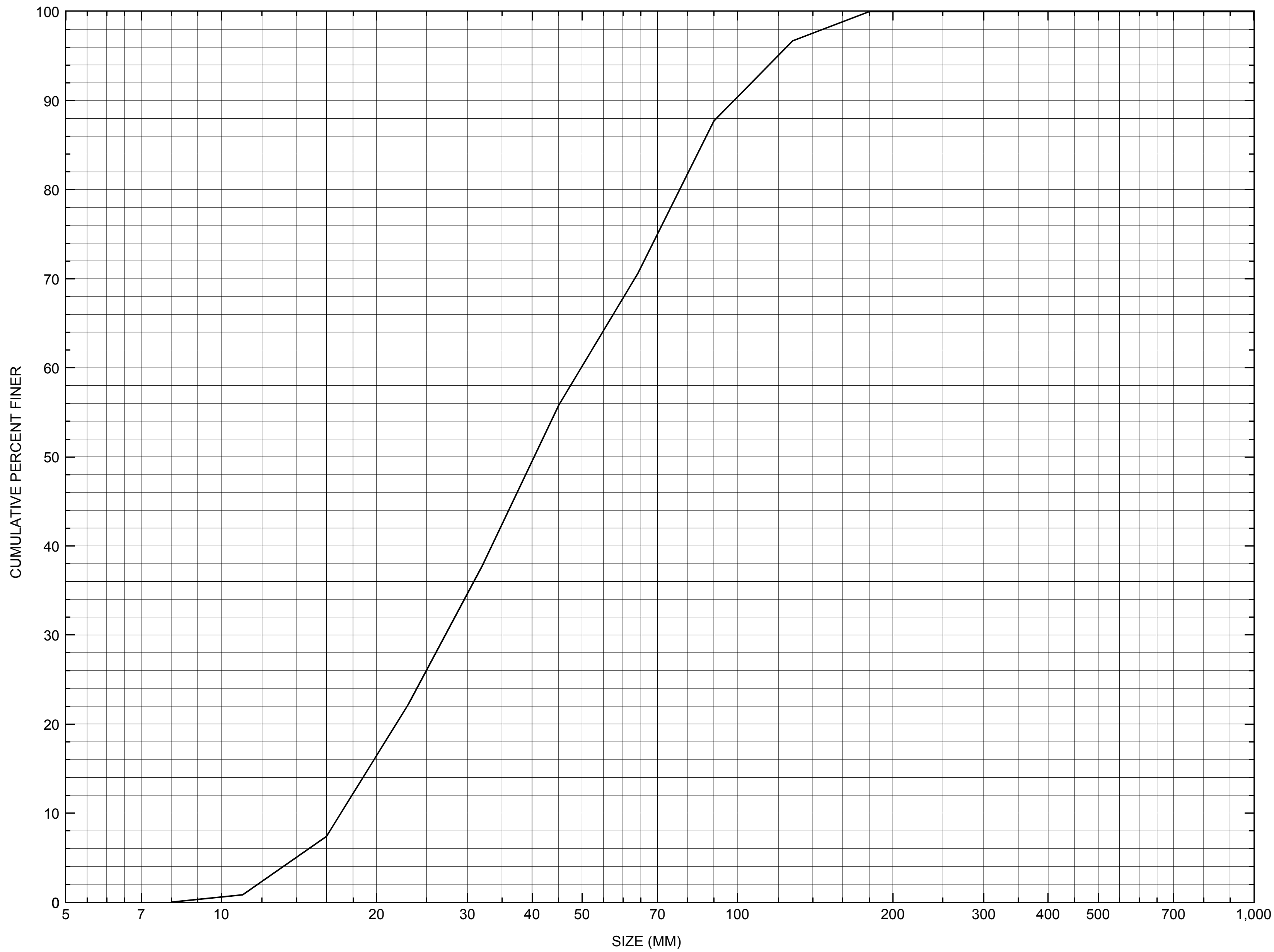
```
        U.S. Geological Survey WSPRO Input File newb016.wsp
        Hydraulic analysis for structure NEWBTH00500016   Date: 04-SEP-97
        TH 50 CROSSING HALLS BROOK IN NEWBURY, VT                        RLB
           *** RUN DATE & TIME: 10-31-97  09:47

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

EXITA:XS   ******    -66      523  2.46 *****  502.42  499.96    5700  499.96
       -47 ******     84    44096  1.34 ***** *******    1.19   10.89

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.10     501.23     500.51

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   499.46     518.79    0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   499.46     518.79     500.51

FULLV:FV       48   -115      648  1.85  0.66  503.09  500.51    5700  501.24
         0     48     96    53384  1.54  0.00    0.01    1.10    8.80
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       58    -11      692  1.27  0.69  503.78 *******    5700  502.51
        58     58    178    51531  1.20  0.00    0.00    0.69    8.24
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   508.86       0.00     502.76     505.01

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   501.66     506.54     506.80     504.77

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

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

BRIDG:BR       48      0      398  1.64 *****  506.64  500.90    4094  505.00
         0 ******     35    32372  1.00 ***** *******    0.54   10.28

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.448 ******  504.77 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.    38.  0.05  0.17  507.43    0.01   1637.  507.03

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     91.    46.   -28.    18.   0.6   0.3   4.0   5.8   0.7   3.1
   RT:   1546.   222.    18.   240.   2.0   1.3   6.1   5.3   1.7   3.1

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

APPR1:AS       36    -48     1873  0.17  0.18  507.48  500.74    5700  507.31
        58     39    259   159327  1.19  0.60    0.01    0.24    3.04

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

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITA:XS     -48.   -67.    84.   5700.   44096.     523.   10.89  499.96
   FULLV:FV      0.  -116.    96.   5700.   53384.     648.    8.80  501.24
   BRIDG:BR      0.      0.    35.   4094.   32372.     398.   10.28  505.00
   RDWAY:RG      11.*******    91.   1637.       0.*********    1.00  507.03
   APPR1:AS      58.   -49.   259.   5700.  159327.    1873.    3.04  507.31

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS  ***********************

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITA:XS    499.96    1.19  489.88  518.24************  2.46  502.42  499.96
   FULLV:FV    500.51    1.10  490.43  518.79  0.66  0.00  1.85  503.09  501.24
   BRIDG:BR    500.90    0.54  491.12  505.00************  1.64  506.64  505.00
   RDWAY:RG  ****************  505.01  511.49  0.05******  0.17  507.43  507.03
   APPR1:AS    500.74    0.24  490.88  511.41  0.18  0.60  0.17  507.48  507.31
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File newb016.wsp
        Hydraulic analysis for structure NEWBTH00500016   Date: 04-SEP-97
        TH 50 CROSSING HALLS BROOK IN NEWBURY, VT                       RLB
           *** RUN DATE & TIME: 10-31-97  09:47

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

EXITA:XS   ******    -29      368  1.97 *****  500.62  498.04    3940  498.66
       -47 ******     65    30460  1.10 ***** *******    1.01   10.71

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.93     499.67     498.59

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   498.16     518.79    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   498.16     518.79     498.59

FULLV:FV       48    -39      417  1.63  0.70  501.32  498.59    3940  499.69
         0     48     71    35093  1.17  0.00    0.00    0.93    9.44
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       58     -9      528  0.98  0.67  501.98 *******    3940  501.00
        58     58     91    38045  1.13  0.00   -0.02    0.61    7.47
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   505.04       0.00     500.71     505.01

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    3940.     500.71

            <<<<<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       48      0      256  3.68 *****  504.38  500.71    3940  500.71
         0     48     35    24308  1.00 ***** *******    1.00   15.38

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  1.000 ******  504.77 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
   RDWAY:RG      11.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPR1:AS       36    -16     1241  0.21  0.28  505.25  499.62    3940  505.04
        58     39    246    90396  1.37  0.59    0.00    0.30    3.17

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.653  0.423   52211.     3.    38. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITA:XS     -48.   -30.    65.   3940.   30460.     368.   10.71  498.66
   FULLV:FV       0.   -40.    71.   3940.   35093.     417.    9.44  499.69
   BRIDG:BR       0.     0.    35.   3940.   24308.     256.   15.38  500.71
   RDWAY:RG      11.**************      0.       0.       0.    1.00********
   APPR1:AS      58.   -17.   246.   3940.   90396.    1241.    3.17  505.04

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS       3.    38.   52211.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITA:XS    498.04    1.01  489.88  518.24************  1.97  500.62  498.66
   FULLV:FV    498.59    0.93  490.43  518.79  0.70  0.00  1.63  501.32  499.69
   BRIDG:BR    500.71    1.00  491.12  505.00************  3.68  504.38  500.71
   RDWAY:RG  ****************  505.01  511.49  0.07******  0.21  505.18********
   APPR1:AS    499.62    0.30  490.88  511.41  0.28  0.59  0.21  505.25  505.04
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure NEWBTH00500016, in Newbury, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number NEWBTH00500016

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)* 48175

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

Waterway *(I - 6)* HALLS BROOK

Road Name *(I - 7):* -

Route Number TH050

Vicinity *(I - 9)* 0.05 MI JCT TH 50 + TH 1

Topographic Map Newbury

Hydrologic Unit Code: 01080104

Latitude *(I - 16; nnnn.n)* 44032

Longitude *(i - 17; nnnnn.n)* 072056

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10090700160907

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

Maximum span length *(I - 48; nnnn)* 0038

Year built *(I - 27; YYYY)* 1976

Structure length *(I - 49; nnnnnn)* 000044

Average daily traffic, ADT *(I - 29; nnnnnn)* 000150

Deck Width *(I - 52; nn.n)* 205

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

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

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

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

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

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

Structure type *(I - 43; nnn)* 501

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*) 012.8

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 prestressed concrete slab type bridge. The abutment walls are grouted, laid up stone blocks with grouted stone and concrete retaining walls and concrete caps. Sections of the grouting have broken or spalled out on the right abutment. Stone and boulder fill is reported in front of and around the ends of each abutment. Some of this same stone fill is noted on the banks upstream and downstream of the bridge. The banks are described as showing signs of erosion from previous flooding. A small, "home-made", stone dam is reported across the channel under the bridge. There is no indication made on the report as to the footings being **(Continued, page 33)**

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: 23.5

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} 1500 Q_{25} 2200
Q_{50} 3000 Q_{100} 3700 Q_{500} -

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

Estimated Discharge *(cfs)*: - Velocity at Q 25 *(ft/s)*: 12.1

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*)	-	496.8	498.5	500.8	502.2
Velocity (*ft / sec*)	-	-	12.1	-	-

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} (*ft³/ sec*): -

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

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

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

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (*ft²*): -

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

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

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

Comments:

exposed, undermining, or settling.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **23.35** mi^2 Lake/pond/swamp area **0.39** mi^2

Watershed storage *(ST)* **1.7** %

Bridge site elevation **500** ft Headwater elevation **1440** ft

Main channel length **9.74** mi

10% channel length elevation **530** ft 85% channel length elevation **960** ft

Main channel slope *(S)* **44** 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)*: 01 / 1976

Project Number TH3606 Minimum channel bed elevation: 492.04

Low superstructure elevation: USLAB 505.0 DSLAB 505.0 USRAB 504.37 DSRAB 504.3

Benchmark location description:

BM#1, Spike in root of a 14 inch elm tree on the right bank downstream, elevation 500.00. Tree is located about 36 feet right-bankward from the right abutment then about 43 feet perpendicular to the centerline of the roadway in a downstream direction.

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

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:

The plans call for the original stone wall abutments to remain and be capped with concrete. Other locations shown on the plans with elevations are: 1) On top of the concrete at the corner of the upstream end of the right abutment where it meets the wingwall at the base of the guard rail, elevation 506.04, and 2) the point at the same location on the upstream left abutment corner, elevation 506.67. The wingwalls are parallel with the trend of the roadway.

Cross-sectional Data

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

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

Comments: **This is the upstream bridge face cross section from left to right bank. The channel baseline runs along the left bank 4 feet from the streamward face of the left abutment.**

Station	4	12	13.2	15.5	19.0	24.0	34.0	40.0	-	-	-
Feature	LCL	-	LEW	-	TD	-	REW	LCR	-	-	-
Low chord elevation	505.2	-	-	-	-	-	-	505.0	-	-	-
Bed elevation	499.6	499.6	493.7	492.2	492.0	492.0	494.2	496.5	-	-	-
Low chord to bed	6.6	-	-	-	-	-	-	8.5	-	-	-

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

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

Comments: **A downstream bridge face cross section exists 4 feet under the bridge.**

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: 03/06/96
Computerized by: EW Date: 03/07/96
Reviewd by: RB Date: 10/31/97

Structure Number NEWBURYTH00500016

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN Date *(MM/DD/YY)* 08 / 29 / 1995

2. Highway District Number 07 Mile marker -

County ORANGE (017) Town NEWBURY (48175)

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

Route Number TH050 Hydrologic Unit Code: 01080104

3. Descriptive comments:

This is a pre-stressed concrete slab type bridge. The abutment walls are grouted laid-up stone with cement caps. It is located 0.05 miles from the junction with TH1.

B. Bridge Deck Observations

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

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

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

7. Bridge length 44 *(feet)* Span length 38 *(feet)* Bridge width 20.5 *(feet)*

Road approach to bridge:

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

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

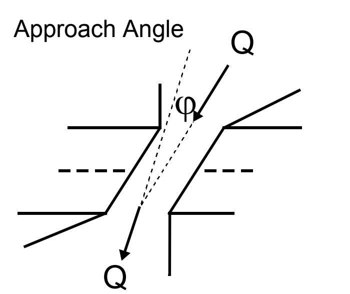
10. Embankment slope *(run / rise in feet / foot)*:
US left -- US right --

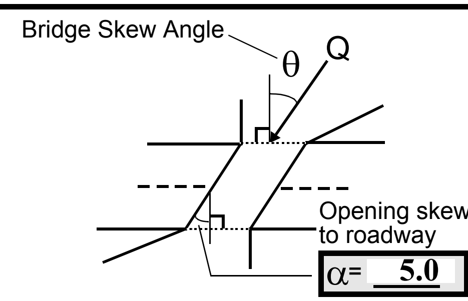
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	1	3	2	3
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	0	-	0	-

*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: 30 16. Bridge skew: 40





α= 5.0

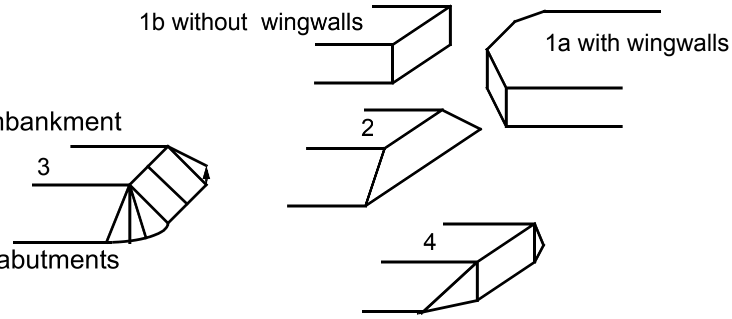
17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 3
Range? 50 feet US *(US, UB, DS)* to 0 feet US

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

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

18. Bridge Type: **1b**

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 files. The measured bridge length is 42 feet and the width is 21 feet.
#17: There is another, moderate impact zone beyond two bridge lengths. It starts at 150 feet US on the left and impacts the base of the left road approach.

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
50.5	**14.0**			**3.5**	**1**	**1**	**12**	**12**	**1**	**3**

23. Bank width **30.0** 24. Channel width **50.0** 25. Thalweg depth **51.5** 29. Bed Material **231**

30 .Bank protection type: LB **2** RB **4** 31. Bank protection condition: LB **2** RB **3**

*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 extends from 0 feet US to 30 feet US where it has been eroded and has subsequently slumped into the channel near the cut-bank. The LB protection extends from 0 feet US to 70 feet US along the base of the road approach. Protection may have existed as far as 150 feet US but has been eroded as a result of the channel impact noted in #19.

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

36. Point bar extent: - feet - (US, UB) to - feet - (US, UB, DS) positioned - %LB to - %RB

37. Material: -

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

NO POINT BARS

Beyond two bridge lengths, and opposite the LB impact, a silt-sand bar exists on RB with an approximate width of 4 feet and length of 20 feet.

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: 35 42. Cut bank extent: 115 feet US (US, UB) to 22 feet US (US, UB, DS)

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

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

Many minor inflows enter through the cut-bank, draining the flood plain during low flows.

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 20

47. Scour dimensions: Length 15 Width 7 Depth : 1 Position 40 %LB to 65 %RB

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

Scour depth is based on a thalweg depth of 1 foot.

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) 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
25.0		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.):

7

#63: The channel bed under the bridge is type-2 stone fill. The stone fill is also piled at the base of the abutments.

There is a small “homemade” dam constructed out of the stone fill under the bridge with a scour hole immediately US.

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

67. Debris Potential DS__ *(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 N____ *(1- Low; 2- Moderate; 3- High)*

70. Debris and Ice Comments:

2

#69: The bridge is located after a large bend in the stream, increasing the ice blockage potential.

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		-	90	2	0	-	-	90.0
RABUT	2	35	90			2	0	35.0

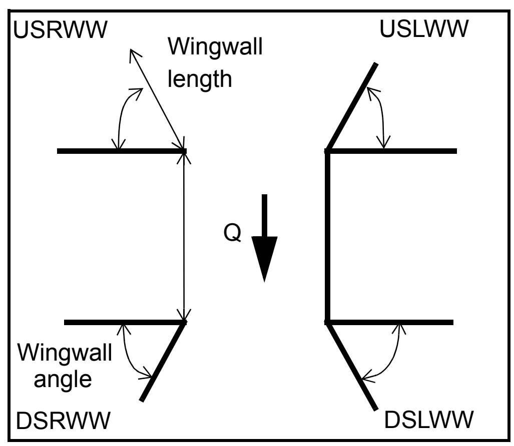
Pushed: LB or RB *Toe Location (Loc.): 0- even, 1- set back, 2- protrudes*
Scour cond.: 0- not evident; 1- evident (comment); 2- footing exposed; 3-undermined footing; 4- piling exposed; 5- settled; 6- failed
Materials: 1- Concrete; 2- Stone masonry or drywall; 3- steel or metal; 4- wood

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

-
-
2
-

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						35.0	
USRWW:	N		-		-	1.0	
DSLWW:	-		-		N	22.0	
DSRWW:	-		-		-	23.0	



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	-	-	N	-	-	-	2	2
Condition	N	-	-	-	-	-	1	1
Extent	-	-	-	0	0	1	2	-

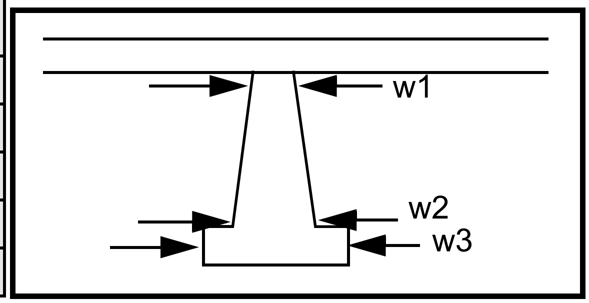
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

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



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	ere are	road-	extend		LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	no	way	for		1- Solid pier, 2- column, 3- bent
88. Material	tra-	are	abou	N	1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	ditio	ceme	t 8	-	1- Round; 2- Square; 3- Pointed
90. Inclined?	nal	nt	feet.	-	Y- yes; N- no
91. Attack ∠ (BF)	wing	road		-	
92. Pushed	walls	appr		-	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	.	oach		-	
95. Cross-members	Par-	retai		-	0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	allel	ning		-	0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	to	walls		-	
98. Exposure depth	the	that		-	

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

E. Downstream Channel Assessment

100.

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

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

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

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

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

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

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

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

NO PIERS

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

Point bar extent: ______ feet ____ *(US, UB, DS)* to **1** feet **1** *(US, UB, DS)* positioned **12** %LB to **12** %RB

Material: **2**

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

1
213
2
3

Is a cut-bank present? **2** *(Y or if N type ctrl-n cb)* Where? **2** *(LB or RB)* Mid-bank distance: **The**

Cut bank extent: **RB** feet **typ** *(US, UB, DS)* to **e-3** feet **pro** *(US, UB, DS)*

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

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

tion extends from 0 feet DS to 38 feet DS. There is also some slumped type 1 protection that extends to 88 feet DS.
The LB type-2 protection extends from 0 feet DS to 47 feet DS.
The bed has stone fill extending into the scour hole.

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

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

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

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

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

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

Confluence comments (eg. confluence name):

RE

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

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

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

N
-
-
-
-
-
-
-
-
-

109. G. Plan View Sketch

N

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: NEWBTH00500016 Town: NEWBURY
Road Number: TH 50 County: ORANGE
Stream: HALLS BROOK

Initials RLB Date: 10/16/97 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	3700	5700	3940
Main Channel Area, ft2	478	614	500
Left overbank area, ft2	0	11	0
Right overbank area, ft2	645	1247	742
Top width main channel, ft	48	51	49
Top width L overbank, ft	0	30	0
Top width R overbank, ft	209	227	214
D50 of channel, ft	0.1325	0.1325	0.1325
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	10.0	12.0	10.2
y1, average depth, LOB, ft	ERR	0.4	ERR
y1, average depth, ROB, ft	3.1	5.5	3.5
Total conveyance, approach	79556	159273	90462
Conveyance, main channel	48329	70406	51567
Conveyance, LOB	0	220	0
Conveyance, ROB	31227	88647	38895
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	2247.7	2519.7	2246.0
Ql, discharge, LOB, cfs	0.0	7.9	0.0
Qr, discharge, ROB, cfs	1452.3	3172.5	1694.0
Vm, mean velocity MC, ft/s	4.7	4.1	4.5
Vl, mean velocity, LOB, ft/s	ERR	0.7	ERR
Vr, mean velocity, ROB, ft/s	2.3	2.5	2.3
Vc-m, crit. velocity, MC, ft/s	8.4	8.7	8.4
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	3700	5700	3940
(Q) discharge thru bridge, cfs	3700	4094	3940
Main channel conveyance	22809	32372	24324
Total conveyance	22809	32372	24324
Q2, bridge MC discharge,cfs	3700	4094	3940
Main channel area, ft2	245	398	256
Main channel width (normal), ft	34.7	35.1	34.7
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	34.7	35.1	34.7
y_bridge (avg. depth at br.), ft	7.06	11.34	7.38
Dm, median (1.25*D50), ft	0.165625	0.165625	0.165625
y2, depth in contraction,ft	11.32	12.23	11.95
ys, scour depth (y2-ybridge), ft	4.26	0.89	4.57

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	3700	4094	3940
Main channel area (DS), ft2	245	275	256
Main channel width (normal), ft	34.7	35.1	34.7
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	34.7	35.1	34.7
D90, ft	0.3230	0.3230	0.3230
D95, ft	0.3926	0.3926	0.3926
Dc, critical grain size, ft	0.7372	0.6905	0.7538
Pc, Decimal percent coarser than Dc	0.000	0.000	0.000
Depth to armoring, ft	N/A	N/A	N/A

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	3700	5700	3940
Q, thru bridge MC, cfs	3700	4094	3940
Vc, critical velocity, ft/s	8.38	8.65	8.42
Va, velocity MC approach, ft/s	4.70	4.10	4.49
Main channel width (normal), ft	34.7	35.1	34.7
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	34.7	35.1	34.7
qbr, unit discharge, ft2/s	106.6	116.6	113.5
Area of full opening, ft2	245.0	398.0	256.0
Hb, depth of full opening, ft	7.06	11.34	7.38
Fr, Froude number, bridge MC	0	0.54	0
Cf, Fr correction factor (<=1.0)	0.00	1.00	0.00
**Area at downstream face, ft2	N/A	275	N/A
**Hb, depth at downstream face, ft	N/A	7.83	N/A
**Fr, Froude number at DS face	ERR	0.94	ERR
**Cf, for downstream face (<=1.0)	N/A	1.00	N/A
Elevation of Low Steel, ft	0	504.77	0
Elevation of Bed, ft	-7.06	493.43	-7.38
Elevation of Approach, ft	0	507.31	0
Friction loss, approach, ft	0	0.18	0
Elevation of WS immediately US, ft	0.00	507.13	0.00
ya, depth immediately US, ft	7.06	13.70	7.38
Mean elevation of deck, ft	0	506.41	0
w, depth of overflow, ft (>=0)	0.00	0.72	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.97	1.00
**Cc, for downstream face (<=1.0)	ERR	0.856066	ERR
Ys, scour w/Chang equation, ft	N/A	2.60	N/A
Ys, scour w/Umbrell equation, ft	N/A	-2.02	N/A

**=for UNsubmerged orifice flow using estimated downstream bridge face properties.

**Ys, scour w/Chang equation, ft	N/A	7.91	N/A

**Ys, scour w/Umbrell equation, ft	ERR	1.48	ERR

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	11.32	12.23	11.95
WSEL at downstream face, ft	--	501.24	--
Depth at downstream face, ft	N/A	7.83	N/A
Ys, depth of scour (Laursen), ft	N/A	4.39	N/A

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	3700	5700	3940	3700	5700	3940
a', abut.length blocking flow, ft	16	48.6	16.8	206.3	224.1	210.9
Ae, area of blocked flow ft2	76.48	125.46	83.57	624.86	939.45	721.51
Qe, discharge blocked abut.,cfs	208.62	--	213.77	1383.59	--	1620.77
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.73	2.45	2.56	2.21	2.52	2.25
ya, depth of f/p flow, ft	4.78	2.58	4.97	3.03	4.19	3.42
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	1	1	1
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	85	85	85	95	95	95
K2	0.99	0.99	0.99	1.01	1.01	1.01
Fr, froude number f/p flow	0.220	0.257	0.202	0.224	0.191	0.214
ys, scour depth, ft	11.97	11.55	12.11	20.10	23.51	21.39

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)	16	48.6	16.8	206.3	224.1	210.9
y1 (depth f/p flow, ft)	4.78	2.58	4.97	3.03	4.19	3.42
a'/y1	3.35	18.83	3.38	68.11	53.46	61.65
Skew correction (p. 49, fig. 16)	0.98	0.98	0.98	1.01	1.01	1.01
Froude no. f/p flow	0.22	0.26	0.20	0.22	0.19	0.21
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	13.59	17.85	15.12
vertical w/ ww's	ERR	ERR	ERR	11.15	14.64	12.40
spill-through	ERR	ERR	ERR	7.48	9.82	8.32

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	1	0.94	1	1	0.94	1
y, depth of flow in bridge, ft	7.06	7.83	7.38	7.06	7.83	7.38
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	2.95	3.22	3.09	2.95	3.22	3.09
Fr<=0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (spillthrough abut.)	2.61	2.85	2.73	2.61	2.85	2.73