LEVEL II SCOUR ANALYSIS FOR BRIDGE 65 (NEWBTH00500065) on TOWN HIGHWAY 50, crossing PEACH BROOK, NEWBURY, VERMONT

Open-File Report 97-804

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 TIM SEVERANCE

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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 65 (NEWBTH00500065) ON TOWN HIGHWAY 50, CROSSING PEACH BROOK, NEWBURY, VERMONT

By **Ronda L. Burns and Tim Severance**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure NEWBTH00500065 on Town Highway 50 crossing Peach 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 15.3-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest upstream of the bridge and shrub and brushland downstream of the bridge.

In the study area, Peach Brook has an incised, sinuous channel with a slope of approximately 0.005 ft/ft, an average channel top width of 40 ft and an average bank height of 8 ft. The channel bed material ranges from cobble to boulder with a median grain size (D_{50}) of 83.1 mm (0.273 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 stable.

The Town Highway 50 crossing of the Peach Brook is a 29-ft-long, two-lane bridge consisting of one 25-foot steel-beam span (Vermont Agency of Transportation, written communication, March 27, 1995). The opening length of the structure parallel to the bridge face is 24.9 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 50 degrees to the opening while the computed opening-skew-to-roadway is 20 degrees.

A channel scour hole 0.75 ft deeper than the mean thalweg depth was observed under the bridge during the Level I assessment. Also observed was channel scour 0.75 ft deeper than the mean thalweg at the upstream face of the bridge and channel scour 0.25 ft deeper than the mean thalweg along the right bank downstream. The scour protection measures at the site included type-1 stone fill (less than 12 inches diameter) along the upstream and downstream right wingwalls and type-2 stone fill (less than 36 inches diameter) along the upstream right bank and along the downstream left wingwall and bank. In addition, there are four 3 ft square concrete blocks at the corner where the upstream right wingwall joins the right abutment. The upstream left wingwall and upstream half of the left abutment were constructed on top of a bedrock outcrop. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 1.3 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge, which was less than the 100-year discharge. The right abutment scour ranged from 6.1 to 7.2 ft. The worst-case right abutment scour occurred at the incipient roadway-overtopping discharge. The left abutment scour ranged from 7.1 to 10.3 ft. The worst-case left abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and others, 1995, p. 47). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

NEWBURY VT. Quadrangle, 1:24,000, 1973

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 NEWBTH00500065 ***Stream*** Peach Brook

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

Description of Bridge

Bridge length 29 ***ft*** ***Bridge width*** 21 ***ft*** ***Max span length*** 25 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** None

Stone fill on abutment? No ***Date of inspection*** 8/29/95

Description of stone fill Type-1, along the upstream and downstream right wingwalls. Type-2, along the upstream right bank and along the downstream left wingwall and bank.

Abutments and wingwalls are concrete. The upstream half of the left abutment and upstream left

Brief description of piers/abutments wingwall are on bedrock. There is a 0.75 foot deep channel scour hole under the bridge.

Yes

Is bridge skewed to flood flow according to survey? Yes ***Angle*** 50

There is a mild channel bend in the upstream reach. The bank material is eroded and bedrock is exposed where the stream impacts the upstream left 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. The banks are well vegetated and some trees are leaning over the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date) A bedrock outcrop is exposed along the upstream left bank and under the upstream half of the left abutment as of 8/29/95. Channel scour has developed where the stream impacts the bedrock at the upstream bridge face and under the bridge.

Description of the Geomorphic Setting

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

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

Date of inspection 8/29/95

DS left: Steep channel bank

DS right: Narrow flood plain

US left: Steep valley wall

US right: Steep channel bank to a narrow flood plain

Description of the Channel

Average top width 40 ***ft*** ***Average depth*** 8 ***ft***

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

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

Vegetative co 8/29/95

DS left: Brush and trees

DS right: Brush and trees

US left: Trees

US right: Trees

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

Describe any obstructions in channel and date of observation. There are four 3 ft square concrete blocks at the upstream end of the right abutment and along the upstream right wingwall as of 8/29/95.

Hydrology

Drainage area 15.3 ***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 2,880 ***ft³/s*** ***Q500*** 4,300 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(15.3/15.8)exp 0.67] with bridge number 6 in Newbury. Bridge number 6 crosses Peach Brook downstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 6 is 15.8 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) USGS survey

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the right abutment (elev. 499.15 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the right abutment (elev. 498.93 ft, arbitrary survey datum). RM3 is a chiseled square in the bedrock on the upstream left bank (elev. 491.48 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT2	-20	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT2)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APPR2	50	1	Approach section

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

Data and Assumptions Used in WSPRO Model

Hydraulic analyses of the reach were done by use of the Federal Highway Administration's WSPRO step-backwater computer program (Sherman and others, 1986, and Sherman, 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 0.045 to 0.050, and overbank "n" values ranged from 0.070 to 0.075.

Normal depth at the exit section (EXIT2) 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 (Sherman, 1990). The slope used was 0.0054 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1973).

The modeled approach section (APPR2) was surveyed one bridge length upstream of the upstream face as recommended by Sherman and others (1986). This location provides a consistent method for determining scour variables.

For the incipient-overtopping discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for this discharge. After analyzing both the supercritical and subcritical profiles for this discharge, it was determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.2 ***ft***
Average low steel elevation 497.7 ***ft***

100-year discharge 2,880 ***ft³/s***
Water-surface elevation in bridge opening 497.7 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,137 ***ft³/s***
Area of flow in bridge opening 204 ***ft²***
Average velocity in bridge opening 8.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.1 ***ft/s***

Water-surface elevation at Approach section with bridge 499.1
Water-surface elevation at Approach section without bridge 496.5
Amount of backwater caused by bridge 2.6 ***ft***

500-year discharge 4,300 ***ft³/s***
Water-surface elevation in bridge opening 497.7 ***ft***
Road overtopping? Yes ***Discharge over road*** 2,358 ***ft³/s***
Area of flow in bridge opening 204 ***ft²***
Average velocity in bridge opening 9.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.9 ***ft/s***

Water-surface elevation at Approach section with bridge 499.9
Water-surface elevation at Approach section without bridge 499.6
Amount of backwater caused by bridge 0.3 ***ft***

Incipient overtopping discharge 1,780 ***ft³/s***
Water-surface elevation in bridge opening 494.6 ***ft***
Area of flow in bridge opening 131 ***ft²***
Average velocity in bridge opening 13.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 18.7 ***ft/s***

Water-surface elevation at Approach section with bridge 498.0
Water-surface elevation at Approach section without bridge 494.2
Amount of backwater caused by bridge 3.8 ***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. However, there is bedrock in the channel along the upstream left bank and under the upstream half of the left abutment. 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 incipient roadway-overtopping discharge was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 100-year and 500-year discharges 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 these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). Results of this scour analysis are shown in Tables 1 and 2 and Figure 8. The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

For comparison, estimates of contraction scour for the 100-year and 500-year discharges also were computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and are presented in Appendix F. At the 500-year discharge the average channel velocity and the incipient-motion velocity of the bed material are nearly the same, therefore, estimates of contraction scour at this discharge were also computed by use of the Laursen live-bed contraction scour equation (Richardson and others, 1995, p.30, equation 17). Furthermore, for those discharges resulting in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions are provided in Appendix F.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	0.0	--
Clear-water scour	0.0	--	1.3
Depth to armoring	10.6	7.2	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
Abutment scour			
Left abutment	8.7	10.3	7.1
Right abutment	6.1	7.0	7.2
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	2.3	2.2	2.4
Right abutment	2.3	2.2	2.4
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

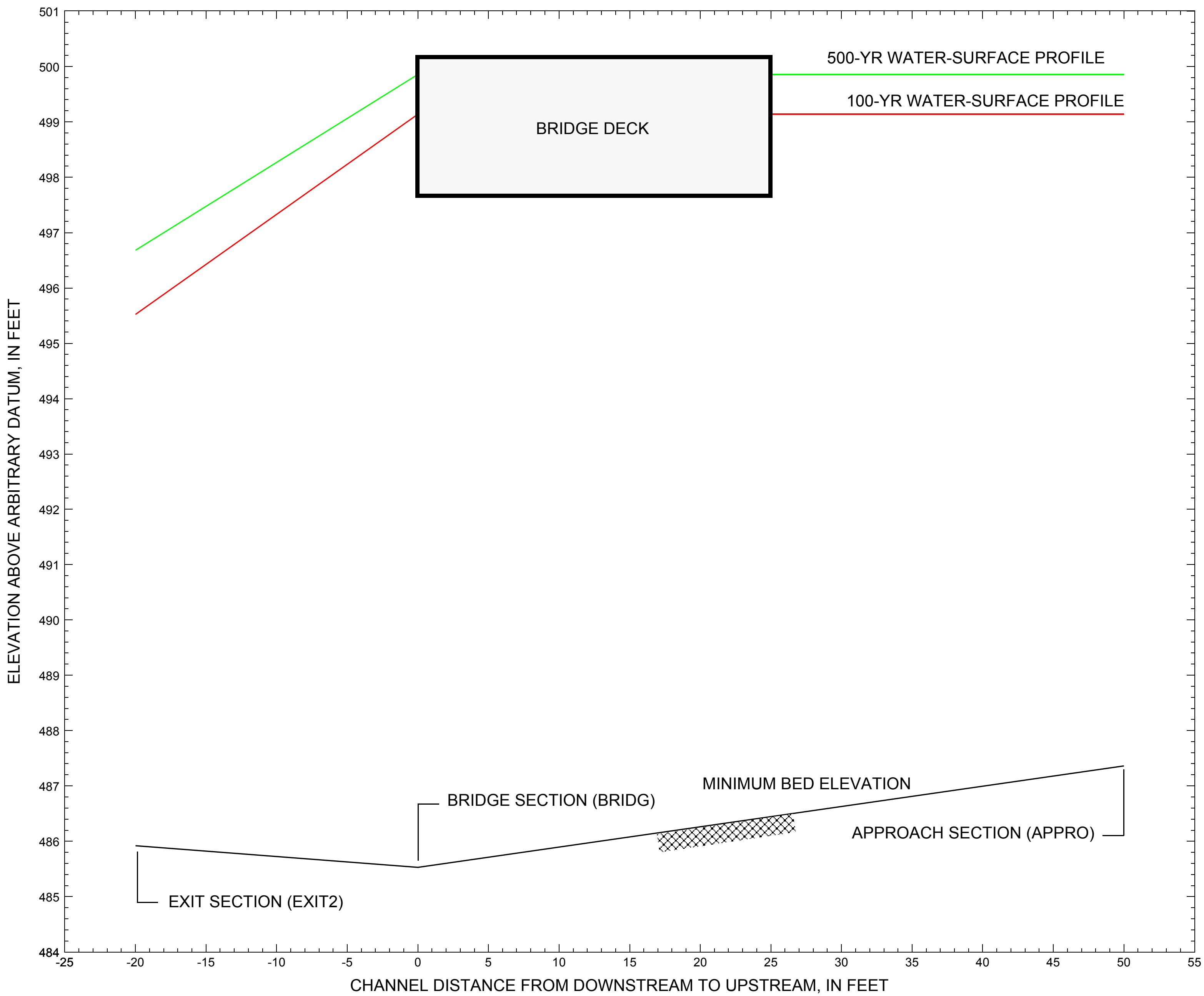

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure NEWBTH00500065 on Town Highway 50, crossing Peach Brook, Newbury, Vermont.

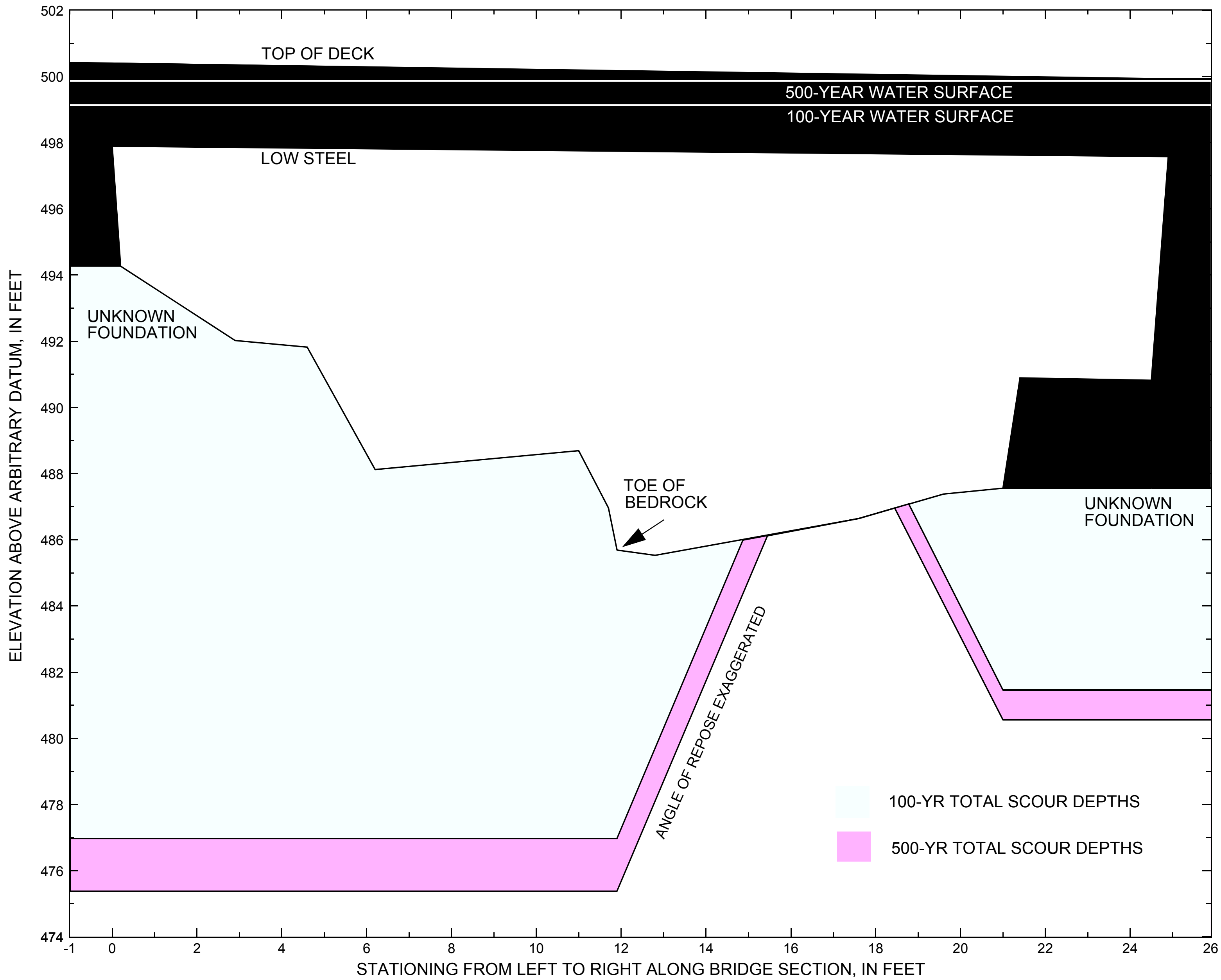

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure NEWBTH00500065 on Town Highway 50, crossing Peach Brook, Newbury, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure NEWBTH00500065 on Town Highway 50, crossing Peach 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)	VTAOT bottom of footing elevation (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 2,880 cubic-feet per second											
Left abutment	0.0	--	497.9	485.5	494.3	--	--	--	--	--	--
Toe of bedrock	11.9	--	--	--	485.7	0.0	8.7	--	8.7	477.0	--
Right abutment	24.9	--	497.6	485.5	487.6	0.0	6.1	--	6.1	481.5	--

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 NEWBTH00500065 on Town Highway 50, crossing Peach 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)	VTAOT bottom of footing elevation (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 4,300 cubic-feet per second											
Left abutment	0.0	--	497.9	485.5	494.3	--	--	--	--	--	--
Toe of bedrock	11.9	--	--	--	485.7	0.0	10.3	--	10.3	475.4	--
Right abutment	24.9	--	497.6	485.5	487.6	0.0	7.0	--	7.0	480.6	--

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 newb065.wsp
T2        Hydraulic analysis for structure NEWBTH00500065   Date: 15-SEP-97
T3        TH 50 CROSSING PEACH 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           2880.0   4300.0   1930.0
SK          0.0054   0.0054   0.0054
*
XS   EXIT2    -20           0.
GR          -96.8, 511.15    -76.8, 502.19    -34.7, 500.65    -10.1, 499.44
GR            0.0, 490.46      4.1, 488.85      6.7, 487.40      7.6, 486.55
GR            9.2, 486.32     11.1, 485.92     13.3, 486.11     15.6, 486.80
GR           16.2, 487.39     19.7, 490.06     33.3, 491.97     54.7, 491.05
GR          155.6, 493.40    232.0, 496.67    290.8, 499.63    323.8, 505.95
GR          396.1, 519.43
N           0.050        0.075
SA                  33.3
*
XS   FULLV      0  * * *   0.0
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.74      20.0
GR            0.0, 497.89      0.2, 494.27      2.9, 492.02      4.6, 491.82
GR            6.2, 488.12     11.0, 488.69     11.7, 486.97     11.9, 485.69
GR           12.8, 485.53     15.7, 486.18     17.6, 486.64     19.6, 487.38
GR           21.0, 487.56     21.4, 490.89     24.5, 490.82     24.9, 497.58
GR            0.0, 497.89
*
*        BRTYPE  BRWDTH        WWANGL    WWWID
CD          1      29.3 * *     66.2      5.4
N           0.050
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      21.0     2
GR          -69.0, 516.10    -37.7, 500.59    -26.0, 500.77      0.0, 500.42
GR           25.5, 499.93     85.5, 497.86    138.4, 497.24    253.7, 501.37
GR          456.0, 526.34
*
AS   APPR2     50           0.
GR          -34.0, 515.44    -13.3, 504.12     -5.3, 498.33      0.0, 495.19
GR            5.0, 487.96      6.1, 487.44     11.4, 487.36     15.3, 487.98
GR           19.9, 488.39     27.0, 492.36     27.4, 495.60     31.0, 497.43
GR           44.1, 498.30    131.6, 497.04    253.7, 501.37    456.0, 526.34
N           0.045        0.070
SA                  31.0
*
*           For the incipient road-overtopping discharge a vertical wall was placed
*           at the top of the right bank, station 44.1.
*
HP 1 BRIDG  497.74 1 497.74
HP 2 BRIDG  497.74 * * 1722
HP 1 BRIDG  495.67 1 495.67
HP 2 RDWAY  499.14 * * 1137
HP 1 APPR2  499.14 1 499.14
HP 2 APPR2  499.14 * * 2880
*
HP 1 BRIDG  497.74 1 497.74
HP 2 BRIDG  497.74 * * 1975
HP 1 BRIDG  496.83 1 496.83
HP 2 RDWAY  499.86 * * 2358
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File newb065.wsp
        Hydraulic analysis for structure NEWBTH00500065   Date: 15-SEP-97
        TH 50 CROSSING PEACH BROOK IN NEWBURY, VT                      RLB
           *** RUN DATE & TIME: 10-22-97  14:35

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      204     14712     11     54                         4911
   497.74           204     14712     11     54  1.00      0     25     4911

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.74     0.0    24.9   203.9   14712.    1722.   8.45

X STA.         0.0         3.6         5.5         6.7         7.5         8.4
  A(I)             15.5        11.6        10.0         7.7         7.6
  V(I)             5.56        7.39        8.61       11.20       11.29

X STA.         8.4         9.2        10.1        10.9        12.1        12.8
  A(I)              7.4         7.2         7.1        11.4         8.3
  V(I)            11.70       11.94       12.13        7.56       10.42

X STA.        12.8        13.5        14.3        15.0        15.9        16.7
  A(I)              8.2         8.4         8.8         8.9         9.2
  V(I)            10.46       10.29        9.79        9.67        9.34

X STA.        16.7        17.7        18.7        19.8        21.6        24.9
  A(I)              9.8        10.3        11.3        15.5        19.8
  V(I)             8.81        8.37        7.61        5.56        4.36

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      157     11991     23     38                         2311
   495.67           157     11991     23     38  1.00      0     25     2311

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.14    48.4   191.4   158.3    3362.    1137.   7.18

X STA.        48.4        77.1        85.4        91.7        97.4       102.5
  A(I)             14.2         9.4         8.2         7.9         7.4
  V(I)             4.00        6.02        6.93        7.19        7.71

X STA.       102.5       107.1       111.5       115.7       119.6       123.4
  A(I)              7.0         6.8         6.7         6.5         6.5
  V(I)             8.09        8.30        8.44        8.76        8.79

X STA.       123.4       127.0       130.5       134.0       137.4       141.0
  A(I)              6.3         6.3         6.4         6.3         6.7
  V(I)             9.00        9.07        8.93        8.97        8.54

X STA.       141.0       144.8       149.5       155.4       163.5       191.4
  A(I)              6.7         7.4         8.2         9.3        13.9
  V(I)             8.50        7.64        6.93        6.09        4.08

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR2;  SRD =      50.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      295     33224     37     47                         4690
             2      208      5255    160    160                         1342
   499.14           502     38479    197    207  1.88     -5    191     3311

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR2;  SRD =      50.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.14    -6.4   190.8   502.1   38479.    2880.   5.74

X STA.        -6.4         3.2         5.4         6.9         8.2         9.4
  A(I)             33.3        22.4        16.9        15.3        14.5
  V(I)             4.33        6.43        8.51        9.42        9.91

X STA.         9.4        10.6        11.8        12.9        14.0        15.2
  A(I)             13.9        13.6        13.2        13.1        13.3
  V(I)            10.39       10.58       10.87       10.96       10.80

X STA.        15.2        16.4        17.6        18.9        20.3        21.8
  A(I)             13.2        13.5        13.8        14.6        15.6
  V(I)            10.89       10.66       10.44        9.85        9.23

X STA.        21.8        23.7        26.4        83.8       122.2       190.8
  A(I)             17.3        21.3        77.0        64.9        81.2
  V(I)             8.34        6.76        1.87        2.22        1.77
```

```
        U.S. Geological Survey WSPRO Input File newb065.wsp
        Hydraulic analysis for structure NEWBTH00500065   Date: 15-SEP-97
        TH 50 CROSSING PEACH BROOK IN NEWBURY, VT                      RLB
           *** RUN DATE & TIME: 10-22-97  14:35

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      204     14712     11     54                         4911
   497.74           204     14712     11     54  1.00      0     25     4911

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.74     0.0    24.9   203.9   14712.    1975.   9.69

X STA.        0.0        3.6        5.5        6.7        7.5        8.4
  A(I)            15.5       11.6       10.0        7.7        7.6
  V(I)            6.37       8.48       9.88      12.84      12.95

X STA.        8.4        9.2       10.1       10.9       12.1       12.8
  A(I)             7.4        7.2        7.1       11.4        8.3
  V(I)           13.42      13.70      13.91       8.67      11.96

X STA.       12.8       13.5       14.3       15.0       15.9       16.7
  A(I)             8.2        8.4        8.8        8.9        9.2
  V(I)           12.00      11.80      11.22      11.09      10.71

X STA.       16.7       17.7       18.7       19.8       21.6       24.9
  A(I)             9.8       10.3       11.3       15.5       19.8
  V(I)           10.10       9.59       8.73       6.38       5.00

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      184     15018     23     40                         2925
   496.83           184     15018     23     40  1.00      0     25     2925

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.86    27.5   211.5   276.0    7314.    2358.   8.54

X STA.       27.5       64.6       75.7       83.6       90.1       96.2
  A(I)            23.7       16.3       14.2       13.1       12.8
  V(I)            4.97       7.21       8.33       9.00       9.20

X STA.       96.2      101.8      107.0      112.1      116.9      121.5
  A(I)            11.9       11.6       11.6       11.2       11.1
  V(I)            9.88      10.12      10.14      10.55      10.64

X STA.      121.5      126.1      130.5      134.9      139.1      143.8
  A(I)            11.2       11.0       11.2       11.1       11.8
  V(I)           10.57      10.68      10.54      10.63       9.98

X STA.      143.8      149.0      155.3      163.1      174.3      211.5
  A(I)            12.0       13.5       14.6       17.1       24.9
  V(I)            9.81       8.74       8.06       6.90       4.74

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR2;  SRD =      50.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      322     37854     38     48                         5287
             2      330     10508    180    180                         2533
   499.86           652     48362    219    228  2.01     -6    211     4509

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR2;  SRD =      50.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.86    -7.4   211.1   651.8   48362.    4300.   6.60

X STA.       -7.4        3.1        5.5        7.1        8.6       10.0
  A(I)            39.5       26.4       19.8       18.5       17.2
  V(I)            5.44       8.15      10.84      11.65      12.53

X STA.       10.0       11.3       12.6       13.9       15.3       16.6
  A(I)            16.5       16.2       16.0       15.9       16.1
  V(I)           13.04      13.26      13.42      13.55      13.32

X STA.       16.6       18.0       19.4       21.0       22.9       25.2
  A(I)            16.1       16.4       17.6       19.7       21.6
  V(I)           13.38      13.10      12.19      10.90       9.98

X STA.       25.2       43.1       84.3      112.9      137.4      211.1
  A(I)            52.9       76.0       67.0       66.1       96.3
  V(I)            4.06       2.83       3.21       3.25       2.23
```

```
        U.S. Geological Survey WSPRO Input File newb065.wsp
        Hydraulic analysis for structure NEWBTH00500065   Date: 15-SEP-97
        TH 50 CROSSING PEACH BROOK IN NEWBURY, VT                      RLB
           *** RUN DATE & TIME: 10-22-97  14:29

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      131      9311     23     36                         1781
   494.58           131      9311     23     36  1.00      0     25     1781

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.58     0.2    24.7   131.5    9311.    1780.  13.54

X STA.         0.2         5.8         7.1         8.2         9.3        10.3
  A(I)            12.6         7.9         6.5         6.0         5.6
  V(I)            7.08       11.28       13.77       14.80       15.85

X STA.        10.3        11.5        12.4        13.0        13.6        14.1
  A(I)             7.0         7.4         4.9         4.8         4.8
  V(I)           12.71       12.01       18.06       18.43       18.70

X STA.        14.1        14.7        15.3        15.9        16.6        17.3
  A(I)             4.8         4.8         4.9         5.0         5.2
  V(I)           18.43       18.72       18.16       17.93       17.09

X STA.        17.3        18.0        18.8        19.8        20.9        24.7
  A(I)             5.5         5.9         6.3         7.8        13.8
  V(I)           16.16       15.04       14.06       11.44        6.46

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR2;  SRD =      50.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      253     26525     36     45                         3816
             2        2        23      9      9                            7
   498.00           255     26548     44     53  1.02     -4     40     3447

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR2;  SRD =      50.

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.00    -4.7    39.6   255.3   26548.    1780.   6.97

X STA.        -4.7         3.6         5.3         6.6         7.7         8.7
  A(I)            25.8        16.3        13.2        11.6        10.9
  V(I)            3.45        5.46        6.74        7.70        8.16

X STA.         8.7         9.7        10.6        11.6        12.5        13.4
  A(I)            10.3         9.9        10.0         9.8         9.6
  V(I)            8.62        8.99        8.91        9.09        9.22

X STA.        13.4        14.4        15.3        16.4        17.4        18.5
  A(I)             9.9         9.7        10.1        10.3        10.4
  V(I)            9.01        9.14        8.83        8.64        8.54

X STA.        18.5        19.6        20.8        22.4        24.4        39.6
  A(I)            10.7        12.0        13.3        15.1        26.3
  V(I)            8.31        7.40        6.67        5.90        3.39
```

WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File newb065.wsp
        Hydraulic analysis for structure NEWBTH00500065   Date: 15-SEP-97
        TH 50 CROSSING PEACH BROOK IN NEWBURY, VT                      RLB
           *** RUN DATE & TIME: 10-22-97  14:35

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

EXIT2:XS   ******     -5      701  0.43 *****  495.95  494.17    2880  495.52
       -19 ******    205    39160  1.63 ***** *******    0.51    4.11

FULLV:FV       20     -5      733  0.39  0.10  496.06 *******    2880  495.67
         0     20    209    41401  1.61  0.00    0.01    0.48    3.93
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===110 WSEL NOT FOUND AT SECID "APPR2":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   495.17     526.34    0.50
 ===115 WSEL NOT FOUND AT SECID "APPR2":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   495.17     526.34     496.46
 ===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 "APPR2"
                   WSBEG,WSEND,CRWS =   496.46     526.34     496.46

APPR2:AS       50     -1      201  3.20 *****  499.66  496.46    2880  496.46
        50     50     29    19593  1.00 ***** *******    1.00   14.35
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   501.69       0.00     496.76     497.24
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   501.00         0.       2880.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===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       20      0      204  1.11 *****  498.85  494.45    1722  497.74
         0 ******     25    14712  1.00 ***** *******    0.52    8.45

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.421  0.000  497.74 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    29.  0.16  0.97  499.94   -0.01   1137.  499.14

            Q    WLEN    LEW     REW   DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.    52.   -38.     14.    0.7   0.3   4.3  10.1   1.0   2.9
   RT:   1137.   143.    49.    191.    1.9   1.1   6.3   7.2   1.9   3.0

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

APPR2:AS       21     -5      501  0.97  0.20  500.10  496.46    2880  499.14
        50     21    191    38436  1.88  0.00   -0.01    0.87    5.74

       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
   EXIT2:XS     -20.    -6.   205.   2880.   39160.     701.    4.11  495.52
   FULLV:FV       0.    -6.   209.   2880.   41401.     733.    3.93  495.67
   BRIDG:BR       0.     0.    25.   1722.   14712.     204.    8.45  497.74
   RDWAY:RG      13.*******     0.   1137.        0.*********   2.00  499.14
   APPR2:AS      50.    -6.   191.   2880.   38436.     501.    5.74  499.14

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR2:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT2:XS    494.17    0.51  485.92  519.43************  0.43  495.95  495.52
   FULLV:FV  ********    0.48  485.92  519.43  0.10  0.00  0.39  496.06  495.67
   BRIDG:BR    494.45    0.52  485.53  497.89************  1.11  498.85  497.74
   RDWAY:RG  ***************  497.24  526.34  0.16******  0.97  499.94  499.14
   APPR2:AS    496.46    0.87  487.36  526.34  0.20  0.00  0.97  500.10  499.14
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File newb065.wsp
        Hydraulic analysis for structure NEWBTH00500065   Date: 15-SEP-97
        TH 50 CROSSING PEACH BROOK IN NEWBURY, VT                      RLB
           *** RUN DATE & TIME: 10-22-97  14:35

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

EXIT2:XS   ******     -6      961  0.48 *****  497.16  494.97    4300  496.68
       -19 ******    232    58507  1.55 ***** *******    0.49    4.47

FULLV:FV       20     -6      997  0.44  0.10  497.27 *******    4300  496.83
         0     20    235    61397  1.54  0.00    0.01    0.46    4.31
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===110 WSEL NOT FOUND AT SECID "APPR2":  REDUCED DELTAY.
                WSLIM1,WSLIM2,DELTAY =   496.33     526.34    0.50
 ===115 WSEL NOT FOUND AT SECID "APPR2":  USED WSMIN = CRWS.
                WSLIM1,WSLIM2,CRWS =   496.33     526.34     499.62
 ===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 "APPR2"
                WSBEG,WSEND,CRWS =   499.62     526.34     499.62

APPR2:AS       50     -6      600  1.58 *****  501.20  499.62    4300  499.62
        50     50    204    44867  1.98 ***** *******    1.05    7.16
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   507.06       0.00     497.70     497.24
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                WS,QBO,QRD =   501.54         0.      4300.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                QRD,QRDMAX,RATIO =    2358.      2284.    1.03
            <<<<<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       20      0      204  1.46 *****  499.20  495.00    1975  497.74
         0 ******     25    14712  1.00 ***** *******    0.60    9.69

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.450  0.000  497.74 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    29.  0.23  1.36  500.99    0.01   2358.  499.86

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.    52.   -39.    14.   0.9   0.5   4.9   8.2   1.3   2.9
   RT:  2358.   184.    27.   212.   2.6   1.5   7.3   8.5   2.6   3.0

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

APPR2:AS       21     -6      652  1.36  0.37  501.22  499.62    4300  499.86
        50     27    211    48402  2.01  0.00    0.01    0.95    6.59

       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
   EXIT2:XS     -20.    -7.   232.   4300.   58507.     961.    4.47  496.68
   FULLV:FV       0.    -7.   235.   4300.   61397.     997.    4.31  496.83
   BRIDG:BR       0.     0.    25.   1975.   14712.     204.    9.69  497.74
   RDWAY:RG      13.*******     0.   2358.       0.*********    2.00  499.86
   APPR2:AS      50.    -7.   211.   4300.   48402.     652.    6.59  499.86

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR2:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXIT2:XS    494.97    0.49  485.92  519.43************  0.48  497.16  496.68
   FULLV:FV  ********    0.46  485.92  519.43  0.10  0.00  0.44  497.27  496.83
   BRIDG:BR    495.00    0.60  485.53  497.89************  1.46  499.20  497.74
   RDWAY:RG  ***************  497.24  526.34  0.23******  1.36  500.99  499.86
   APPR2:AS    499.62    0.95  487.36  526.34  0.37  0.00  1.36  501.22  499.86
```

```
        U.S. Geological Survey WSPRO Input File newb065.wsp
        Hydraulic analysis for structure NEWBTH00500065   Date: 15-SEP-97
        TH 50 CROSSING PEACH BROOK IN NEWBURY, VT                      RLB
           *** RUN DATE & TIME: 10-22-97  14:29

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

EXIT2:XS   ******     -3      477  0.37 *****  494.76  493.31    1780  494.39
       -19 ******    179    24222  1.72 ***** *******    0.53    3.73

FULLV:FV       20     -4      504  0.33  0.10  494.86 *******    1780  494.53
         0     20    182    25918  1.71  0.00    0.00    0.49    3.53
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===110 WSEL NOT FOUND AT SECID "APPR2":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   494.03     515.44    0.50
 ===115 WSEL NOT FOUND AT SECID "APPR2":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   494.03     515.44     494.23
 ===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 "APPR2"
                   WSBEG,WSEND,CRWS =   494.23     515.44     494.23

APPR2:AS       50      1      138  2.59 *****  496.82  494.23    1780  494.23
        50     50     27    11910  1.00 ***** *******    1.00   12.91
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    1780.      494.58

            <<<<<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       20      0      131  2.86 *****  497.43  494.58    1780  494.58
         0     20     25     9301  1.00 ***** *******    1.00   13.55

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.74 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD      EGL      ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPR2:AS       21     -4      255  0.77  0.27  498.77  494.23    1780  498.00
        50     21     40    26572  1.02  1.07    0.01    0.52    6.97

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.076  0.000   27824.    -1.    24.   497.87

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT2:XS     -20.    -4.   179.   1780.   24222.     477.    3.73  494.39
   FULLV:FV       0.    -5.   182.   1780.   25918.     504.    3.53  494.53
   BRIDG:BR       0.     0.    25.   1780.    9301.     131.   13.55  494.58
   RDWAY:RG      13.**************      0.******************    2.00********
   APPR2:AS      50.    -5.    40.   1780.   26572.     255.    6.97  498.00

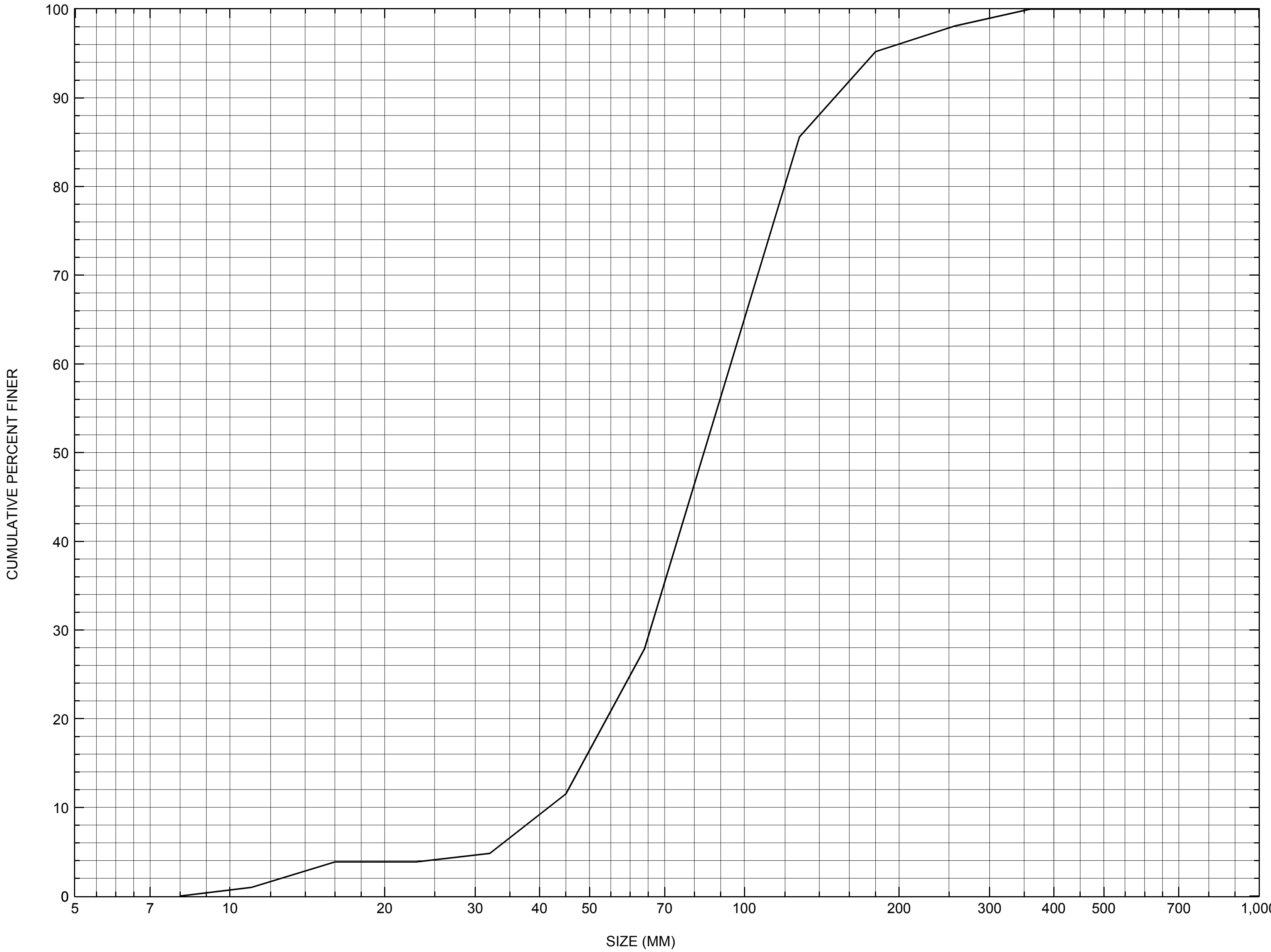
    XSID:CODE   XLKQ   XRKQ       KQ
   APPR2:AS      -1.    24.   27824.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT2:XS    493.31    0.53  485.92  519.43************  0.37  494.76  494.39
   FULLV:FV  ********    0.49  485.92  519.43  0.10  0.00  0.33  494.86  494.53
   BRIDG:BR    494.58    1.00  485.53  497.89************  2.86  497.43  494.58
   RDWAY:RG  ****************  498.30  516.10**********************************
   APPR2:AS    494.23    0.52  487.36  515.44  0.27  1.07  0.77  498.77  498.00
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure NEWBTH00500065, in Newbury, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number NEWBTH00500065

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) 17

Town (FIPS place code; I - 4; nnnnn) 48175

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

Waterway (I - 6) PEACH BROOK

Road Name (I - 7): -

Route Number TH050

Vicinity (I - 9) 0.6 MI JCT TH 50 + TH 55

Topographic Map Newbury

Hydrologic Unit Code: 01080104

Latitude (I - 16; nnnn.n) 44044

Longitude (i - 17; nnnnn.n) 72058

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10090700650907

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0025

Year built (I - 27; YYYY) 1953

Structure length (I - 49; nnnnnn) 000029

Average daily traffic, ADT (I - 29; nnnnnn) 000200

Deck Width (I - 52; nn.n) 210

Year of ADT (I - 30; YY) 93

Channel & Protection (I - 61; n) 5

Opening skew to Roadway (I - 34; nn) 22

Waterway adequacy (I - 71; n) 6

Operational status (I - 41; X) P

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) 012.5

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 abutment walls and wingwalls are concrete, which have minor fine cracks and small spalls reported overall. The right abutment has a large diagonal settlement crack reported on its upstream half. Four large concrete blocks are reported as having been placed in front of the upstream right wingwall and the upstream end of the right abutment along with stone fill in an effort to prevent further erosion and settlement. The left abutment has a vertical crack reported just upstream of its center. The left abutment is resting on bedrock with some stone fill around its ends. There is stone fill reported **(Continued, page 33)**

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:
on all of the wingwalls. Bedrock is clearly exposed in the photographs of the left bank upstream and is reportedly exposed elsewhere along the channel edges downstream.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 15.32 mi^2 Lake/pond/swamp area 0.17 mi^2
Watershed storage *(ST)* 1 %
Bridge site elevation 600 ft Headwater elevation 1440 ft
Main channel length 7.66 mi
10% channel length elevation 620 ft 85% channel length elevation 970 ft
Main channel slope *(S)* 46 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)*: - / 1952

Project Number **T-3-1952** Minimum channel bed elevation: **489.0**

Low superstructure elevation: USLAB **N/A** DSLAB **N/A** USRAB **N/A** DSRAB **N/A**

Benchmark location description:

BM#1, spike in a root of an 18 inch elm tree, located about 70 feet to the right from the right abutment to the end of the upstream guardrail, then about 10 feet perpendicularly to the roadway centerline from the end of the guardrail toward the stream, upstream from the bridge, elevation 500.00.

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

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

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

If 2: Pile Type: **1** (*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 detail is provided on the low steel elevation. The bottom of the concrete section of the footings is 485.5 on the plans. There is very little detail provided on the plans. There are no points where the elevation might be used as a reference mark.

Cross-sectional Data

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

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

Comments: **Orientation of the cross sections is inconsistent with any cross section data surveyed for this study and is not comparable. Data was not retrieved.**

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

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: 03/08/96
Computerized by: EW Date: 03/11/96
Reviewd by: RB Date: 10/28/97

Structure Number NEWBTH00500065

A. General Location Descriptive

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

2. Highway District Number 07 Mile marker -

County ORANGE (17) Town NEWBURY (48175)

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

Route Number TH050 Hydrologic Unit Code: 01080104

3. Descriptive comments:

Located 0.6 miles from the junction of TH50 and TH55.

B. Bridge Deck Observations

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

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

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

7. Bridge length 29 *(feet)* Span length 25 *(feet)* Bridge width 21 *(feet)*

Road approach to bridge:

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

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

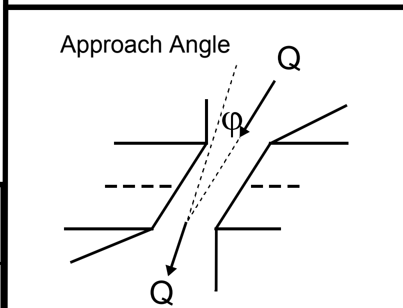
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

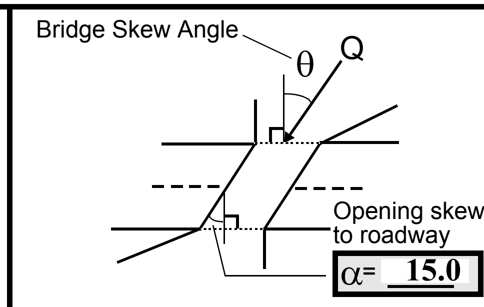
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	1	1	0	-
RBDS	0	-	0	-
LBDS	0	-	2	1

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

Channel approach to bridge (BF):

15. Angle of approach: 20 16. Bridge skew: 50





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 2
Range? 40 feet US *(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**

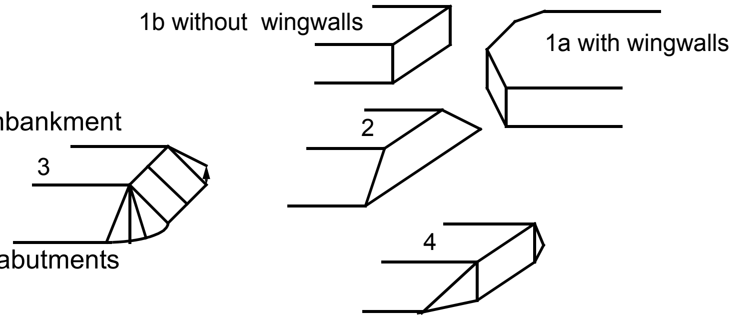
1a- Vertical abutments with wingwalls

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.)

#4: There are small trees on the DS banks in addition to the bushes.
#7: Values are from the VTAOT database. Measured values are: bridge length= 28 feet; span length= 25.5 feet; and bridge width= 21 feet.
#8: The right road approach is lower than the bridge, but becomes higher after 3 bridge lengths.
#9: There is gravel over the concrete bridge deck.

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
28.0	**10.5**			**5.0**	**4**	**4**	**6432**	**54**	**2**	**2**

23. Bank width **45.0** 24. Channel width **55.0** 25. Thalweg depth **36.5** 29. Bed Material **4**

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.):

#27: There is a large bedrock outcrop at 40 feet US of the left abutment that extends under the bridge.
#28: On the LB, erosion has exposed much of bedrock. The sediment overlying the bedrock has been washed away exposing the root systems of the trees on the bank. The most severe erosion is at 50 feet US where the bank material (sand, gravel, cobble) is washing out.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 70 35. Mid-bar width: 3

36. Point bar extent: 55 feet US (US, UB) to 75 feet US (US, UB, DS) positioned 85 %LB to 100 %RB

37. Material: 4

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

-

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

41. Mid-bank distance: 48 42. Cut bank extent: 10 feet US (US, UB) to 75 feet US (US, UB, DS)

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

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

-

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 18

47. Scour dimensions: Length 4 Width 3 Depth : 0.75 Position 20 %LB to 80 %RB

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

-

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
22.5		0.5		2	7	7	0

58. Bank width (BF) - 59. Channel width (Amb) - 60. Thalweg depth (Amb) 90.0 63. Bed Material 0

*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.):

45

#63: The bed material is large cobbles and small boulders and bedrock along the US half of the left abutment. There is a scour hole under the bridge which is 1.75 feet deep at the US bridge face and decreases to 0.75 feet deep at the DS bridge face.

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

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

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

70. Debris and Ice Comments:

2

#67: The debris potential is moderate because the surface cover US is forest and some trees are hanging over the channel on the left bank US.

#68: There is moderate capture efficiency because of the constriction of the bridge opening.

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		**40**	**85**	**2**	**1**	**0.75**	**0**	**90.0**
RABUT	**1**	**-**	**85**			**2**	**1**	**24.0**

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

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

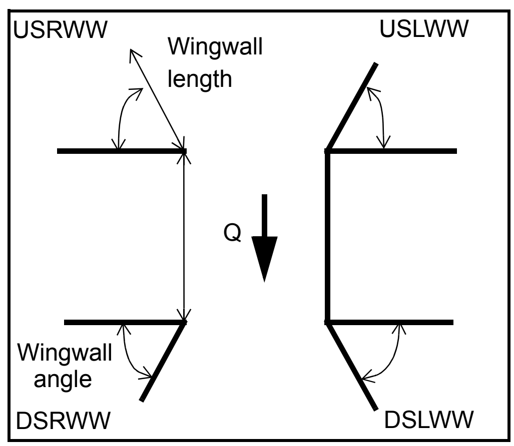
0.75
0
1

#75: The scour is 0.75 ft deep at the center of the RABUT and at the DS end of the LABUT.
#77: Most of the LABUT is poured over bedrock.
There is some accumulation of small branches and twigs in areas UB.
A point bar exists along the RABUT from 12 feet UB to 28 feet UB, mid-bar distance is 25 feet, bar width is 8 feet, and it is composed of sand and some cobbles.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**24.0**	**1.5**
USRWW:	**Y**		**1**		**0**	**22.0**	
DSLWW:	**-**		**-**		**Y**	**28.0**	
DSRWW:	**1**		**0**		**-**	**115.0**	

*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**	**-**	**-**	**1**	**-**	**-**
Condition	**Y**	**-**	**1**	**-**	**-**	**1**	**-**	**-**
Extent	**1**	**-**	**0**	**0**	**1**	**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*

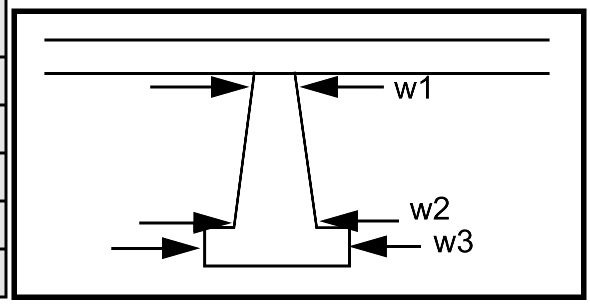
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
2
1
1
1
2
2

Piers:

84. Are there piers? **#82** (*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	**5.0**			**20.0**	**11.5**	**45.0**
Pier 2	**7.0**	**8.0**	-	**10.0**	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**: The**	**g the**	**three 3**	**g the**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**USL**	**base**	**ft**	**entir**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**WW**	**at**	**squa**	**e**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**is**	**the**	**re**	**base**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**con-**	**DS**	**con-**	**lengt**	*Y- yes; N- no*
91. Attack ∠ (BF)	**crete**	**end**	**crete**	**h.**	
92. Pushed	**pour**	**of**	**bloc**	**An**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**ed**	**the**	**ks**	**addi-**	
95. Cross-members	**onto**	**USR**	**and**	**tiona**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**bed-**	**WW**	**stone**	**l**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**rock.**	**there**	**fill**	**con-**	
98. Exposure depth	**Alon**	**are**	**alon**	**crete**	

99. Pier comments (eg. undermined penetration, protection and protection extent, unusual scour processes, etc.):
block is at the US end of the RABUT.

N

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 (Amb) - Thalweg depth (Amb) - 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):
-
-
-
-
-
-

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

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

Material: -

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

-
-
-
-

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

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

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

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

Is channel scour present? ____ (Y or if N type ctrl-n cs) Mid-scour distance: 3

Scour dimensions: Length 3 Width 0 Depth: 0 Positioned 0 %LB to 1 %RB

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

4
2
0
1

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

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

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

Confluence comments (eg. confluence name):

continues up the embankment at a 40 degree slope.

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

- -

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: NEWBTH00500065 Town: NEWBURY
Road Number: TH 50 County: ORANGE
Stream: PEACH BROOK

Initials RLB Date: 10/22/97 Checked: ECW

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	2880	4300	1780
Main Channel Area, ft2	295	322	253
Left overbank area, ft2	0	0	0
Right overbank area, ft2	208	330	2
Top width main channel, ft	37	38	36
Top width L overbank, ft	0	0	0
Top width R overbank, ft	160	180	9
D50 of channel, ft	0.2727	0.2727	0.2727
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	8.0	8.5	7.0
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	1.3	1.8	0.2
Total conveyance, approach	38479	48362	26548
Conveyance, main channel	33224	37854	26525
Conveyance, LOB	0	0	0
Conveyance, ROB	5255	10508	23
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	2486.7	3365.7	1778.5
Ql, discharge, LOB, cfs	0.0	0.0	0.0
Qr, discharge, ROB, cfs	393.3	934.3	1.5
Vm, mean velocity MC, ft/s	8.4	10.5	7.0
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	1.9	2.8	0.8
Vc-m, crit. velocity, MC, ft/s	10.3	10.4	10.1
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	1	0
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Live-Bed Contraction Scour

Laursen’s Live Bed Contraction Scour
y2/y1 = (Q2/Q1)^(6/7)*(W1/W2)^(k1)
ys=y2-y_bridge
(Richardson and others, 1995, p. 30, eq. 17 and 18)

	Approach			Bridge		
Characteristic	100 yr	500 yr	Other Q	100 yr	500 yr	Other Q
Q1, discharge, cfs	2880	4300	1780	0	1975	0
Total conveyance	38479	48362	26548	0	14712	0
Main channel conveyance	33224	37854	26525	0	14712	0
Main channel discharge	2487	3366	1778	ERR	1975	ERR
Area - main channel, ft2	295	322	253	0	204	0
(W1) channel width, ft	37	38	36	0	23.4	0
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	37	38	36	0	23.4	0
D50, ft	0.2727	0.2727	0.2727			
w, fall velocity, ft/s (p. 32)	0	4.2725	0			
y, ave. depth flow, ft	7.97	8.47	7.03	ERR	8.72	ERR
S1, slope EGL	0	0.0786	0			
P, wetted perimeter, MC, ft	0	48	0			
R, hydraulic Radius, ft	ERR	6.708	ERR			
V*, shear velocity, ft/s	N/A	4.120	N/A			
V*/w	ERR	0.964	ERR			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0	0.64	0			
y2,depth in contraction, ft	ERR	7.32	ERR			
ys, scour depth, ft (y2-y_bridge)	N/A	-1.40	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	2880	4300	1780
(Q) discharge thru bridge, cfs	1722	1975	1780
Main channel conveyance	14712	14712	9311
Total conveyance	14712	14712	9311
Q2, bridge MC discharge,cfs	1722	1975	1780
Main channel area, ft2	204	204	132
Main channel width (normal), ft	23.4	23.4	23.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	23.4	23.4	23

y_bridge (avg. depth at br.), ft	8.71	8.71	5.72
Dm, median (1.25*D50), ft	0.340875	0.340875	0.340875
y2, depth in contraction,ft	6.70	7.54	7.00
ys, scour depth (y2-ybridge), ft	-2.01	-1.17	1.28

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	2880	4300	1780
Q, thru bridge MC, cfs	1722	1975	1780
Vc, critical velocity, ft/s	10.27	10.38	10.06
Va, velocity MC approach, ft/s	8.43	10.45	7.03
Main channel width (normal), ft	23.4	23.4	23.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	23.4	23.4	23.0
qbr, unit discharge, ft2/s	73.6	84.4	77.4
Area of full opening, ft2	203.9	204.0	131.5
Hb, depth of full opening, ft	8.71	8.72	5.72
Fr, Froude number, bridge MC	0.52	0.6	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	157	184	N/A
**Hb, depth at downstream face, ft	6.71	7.86	N/A
**Fr, Froude number at DS face	0.75	0.67	ERR
**Cf, for downstream face (<=1.0)	1.00	1.00	N/A
Elevation of Low Steel, ft	497.74	497.74	0
Elevation of Bed, ft	489.03	489.02	-5.72
Elevation of Approach, ft	499.14	499.86	0
Friction loss, approach, ft	0.2	0.37	0
Elevation of WS immediately US, ft	498.94	499.49	0.00
ya, depth immediately US, ft	9.91	10.47	5.72
Mean elevation of deck, ft	500.18	500.18	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.97	0.96	1.00
**Cc, for downstream face (<=1.0)	0.898066	0.928266	ERR
Ys, scour w/Chang equation, ft	-1.32	-0.20	N/A
Ys, scour w/Umbrell equation, ft	0.98	2.87	N/A

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

**Ys, scour w/Chang equation, ft	1.27	0.90	N/A

**Ys, scour w/Umbrell equation, ft	2.99	3.72	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	6.70	7.32	7.00
WSEL at downstream face, ft	495.67	496.83	--
Depth at downstream face, ft	6.71	7.86	N/A
Ys, depth of scour (Laursen), ft	-0.01	-0.54	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	1722	1975	1780
Main channel area (DS), ft2	157	184	131.5
Main channel width (normal), ft	23.4	23.4	23.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	23.4	23.4	23.0
D90, ft	0.4913	0.4913	0.4913
D95, ft	0.5865	0.5865	0.5865
Dc, critical grain size, ft	0.4636	0.4177	0.7523
Pc, Decimal percent coarser than Dc	0.116	0.149	0.028
Depth to armoring, ft	10.60	7.16	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	2880	4300	1780	2880	4300	1780
a’, abut.length blocking flow, ft	7.2	8.2	5.7	166.6	186.9	15.6
Ae, area of blocked flow ft2	24.97	30.85	17.72	82.66	92.06	29.32
Qe, discharge blocked abut.,cfs	108	167.9	61.12	--	--	106.8
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.32	5.44	3.45	2.28	3.18	3.64
ya, depth of f/p flow, ft	3.47	3.76	3.11	0.50	0.49	1.88
--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	110	110	110	70	70	70
K2	1.03	1.03	1.03	0.97	0.97	0.97
Fr, froude number f/p flow	0.409	0.495	0.345	0.335	0.399	0.468
ys, scour depth, ft	8.72	10.31	7.13	6.09	7.00	7.17

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)	7.2	8.2	5.7	166.6	186.9	15.6
y1 (depth f/p flow, ft)	3.47	3.76	3.11	0.44	0.49	1.88
a'/y1	2.08	2.18	1.83	335.78	379.44	8.30
Skew correction (p. 49, fig. 16)	1.04	1.04	1.04	0.93	0.93	0.93
Froude no. f/p flow	0.41	0.50	0.34	0.34	0.40	0.47
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	2.35	2.47	ERR
vertical w/ ww's	ERR	ERR	ERR	1.92	2.02	ERR
spill-through	ERR	ERR	ERR	1.29	1.36	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	0.75	0.67	1	0.75	0.67	1
y, depth of flow in bridge, ft	6.71	7.86	5.72	6.71	7.86	5.72
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	2.33	2.18	ERR	2.33	2.18	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	2.39	ERR	ERR	2.39