LEVEL II SCOUR ANALYSIS FOR BRIDGE 39 (PEACTH00620039) on TOWN HIGHWAY 62, crossing SOUTH PEACHAM BROOK, PEACHAM, VERMONT

Open-File Report 97-775

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 39 (PEACTH00620039) on TOWN HIGHWAY 62, crossing SOUTH PEACHAM BROOK, PEACHAM, VERMONT

By RONDA L. BURNS and JAMES R. DEGNAN

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Pembroke, New Hampshire

1997

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

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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 39 (PEACTH00620039) ON TOWN HIGHWAY 62, CROSSING SOUTH PEACHAM BROOK, PEACHAM, 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 PEACTH00620039 on Town Highway 62 crossing South Peacham Brook, Peacham, 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 northeastern Vermont. The 9.1-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest on the left bank upstream and downstream of the bridge. The surface cover on the right bank upstream and downstream is shrubs and brush.

In the study area, South Peacham Brook has an incised, straight channel with a slope of approximately 0.02 ft/ft, an average channel top width of 43 ft and an average bank height of 8 ft. The channel bed material ranges from sand to boulder with a median grain size (D_{50}) of 51.4 mm (0.168 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 23, 1995, indicated that the reach was stable.

The Town Highway 62 crossing of South Peacham Brook is a 23-ft-long, one-lane bridge consisting of one 22-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 20.1 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 15 degrees to the opening while the computed opening-skew-to-roadway is 10 degrees.

The footing on the right abutment and the footing on the upstream left wingwall were exposed during the Level I assessment. The scour countermeasures at the site included type-2 stone fill (less than 36 inches diameter) along the upstream and downstream right wingwalls and at the upstream end of the upstream left wingwall and at the downstream end of the downstream left wingwall. Type-3 stone fill (less than 48 inches diameter) was along the upstream left and right banks and the downstream right bank. On the downstream left bank, the scour countermeasure was a stone wall. 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 1.0 to 1.6 ft. The worst-case contraction scour occurred at the 100-year discharge. Abutment scour ranged from 5.9 to 7.4 ft. The worst-case abutment scour occurred at the incipient roadway-overtopping discharge, which is less than the 100-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. However, there is a bedrock outcrop across the channel just upstream of the bridge.

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

Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

NORTH

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

LEVEL II SUMMARY

Structure Number PEACTH00620039 ***Stream*** South Peacham Brook

County Caledonia ***Road*** TH 62 ***District*** 7

Description of Bridge

Bridge length 23 ***ft*** ***Bridge width*** 16 ***ft*** ***Max span length*** 22 ***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*** 8/23/95

Description of stone fill Type-2, along the base of all four wingwalls.

Abutments and wingwalls are concrete. The concrete footing on the right abutment and the footing on the upstream left wingwall are exposed.

Yes

Is bridge skewed to flood flow according to There ***survey?*** 15 ***Angle*** Yes

is a mild channel bend in the upstream reach.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	8/23/95	0	0
Level II	8/23/95	0	0

Potential for debris Low. The stream channel is straight and steep and the surrounding forest is young.

Describe any features near or at the bridge that may affect flow (include observation date) There is a bedrock outcrop across the channel just upstream of the bridge as of 8/23/95.

Description of the Geomorphic Setting

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

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

Date of inspection 11/08/94

DS left: Steep channel bank to a moderately sloped overbank

DS right: Steep channel bank to Town Highway 1

US left: Steep channel bank to a narrow terrace

US right: Steep channel bank to Town Highway 1

Description of the Channel

Average top width 43 ***ft*** ***Average depth*** 8 ***ft***

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

Straight but stable with non-alluvial channel boundaries.

8/23/95

Vegetative co Trees and brush with pasture on the overbank

DS left: Shrubs and brush with a few trees

DS right: Trees

US left: Grass with a few trees.

US right:

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

None as of 8/23/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 9.1 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***:

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

USGS gage description --

USGS gage number --

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

Is there a lake/p No

Calculated Discharges

Q100 1,450 ***ft***^{3}***/s*** ***Q500*** 2,100 ***ft***^{3}***/s***

The 100- and 500-year discharges are based on a drainage area relationship [(9.1/12.5)exp 0.67] with bridge number 37 in Barnet. Bridge number 37 crosses the South Peacham Brook downstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 37 is 12.5 square miles. The values computed are within a range defined by several empirical flood frequency curves (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans None

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. 496.80 ft, arbitrary survey datum). RM2 is an existing chiseled square on top of the downstream end of the left abutment (elev. 497.16 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	*Section Reference Distance (SRD) in feet*	*[2]Cross-section development*	*Comments*
EXIT1	-18	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPR1	39	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.040 to 0.065, and overbank "n" values ranged from 0.035 to 0.075.

Normal depth at the exit section (EXIT1) 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 0.0241 ft/ft, which was determined from surveyed thalweg points downstream.

The modelled approach section (APPR1) was surveyed one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 497.1 ***ft***
Average low steel elevation 495.0 ***ft***

100-year discharge 1,450 ***ft^3/s***
Water-surface elevation in bridge opening 495.2 ***ft***
Road overtopping? Yes ***Discharge over road*** 328 ***ft^3/s***
Area of flow in bridge opening 113 ***ft^2***
Average velocity in bridge opening 9.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.6 ***ft/s***

Water-surface elevation at Approach section with bridge 498.5
Water-surface elevation at Approach section without bridge 497.6
Amount of backwater caused by bridge 0.9 ***t***

500-year discharge 2,100 ***ft^3/s***
Water-surface elevation in bridge opening 495.2 ***ft***
Road overtopping? Yes ***Discharge over road*** 988 ***ft^3/s***
Area of flow in bridge opening 113 ***ft^2***
Average velocity in bridge opening 9.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.3 ***/s***

Water-surface elevation at Approach section with bridge 499.4
Water-surface elevation at Approach section without bridge 498.8
Amount of backwater caused by bridge 0.6 ***t***

Incipient overtopping discharge 1,000 ***ft^3/s***
Water-surface elevation in bridge opening 495.2 ***t***
Area of flow in bridge opening 113 ***ft^2***
Average velocity in bridge opening 8.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.5 ***ft/s***

Water-surface elevation at Approach section with bridge 497.2
Water-surface elevation at Approach section without bridge 496.5
Amount of backwater caused by bridge 0.7 ***t***

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 a bedrock outcrop across the channel just upstream of the bridge. The results of the scour analysis are presented in Tables 1 and 2 and a graph of the scour depths is presented in Figure 8. For this site, only the 100-year scour depths are shown in Figure 8 since they are deeper than the 500-year scour depths.

At this site, the 100-year, 500-year and incipient roadway-overtopping discharges resulted in submerged 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 from these computations are presented in Tables 1 and 2 and Figure 8. For comparison, estimates of contraction scour for all discharges was also computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and are presented in Appendix F. The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

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

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	1.6	1.2	1.0
Depth to armoring	6.7	5.5	3.3
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour	6.1	5.9	7.4
Left abutment	6.3	6.1	6.8
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:	1.8	1.8	1.5
Left abutment	1.8	1.8	1.5
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

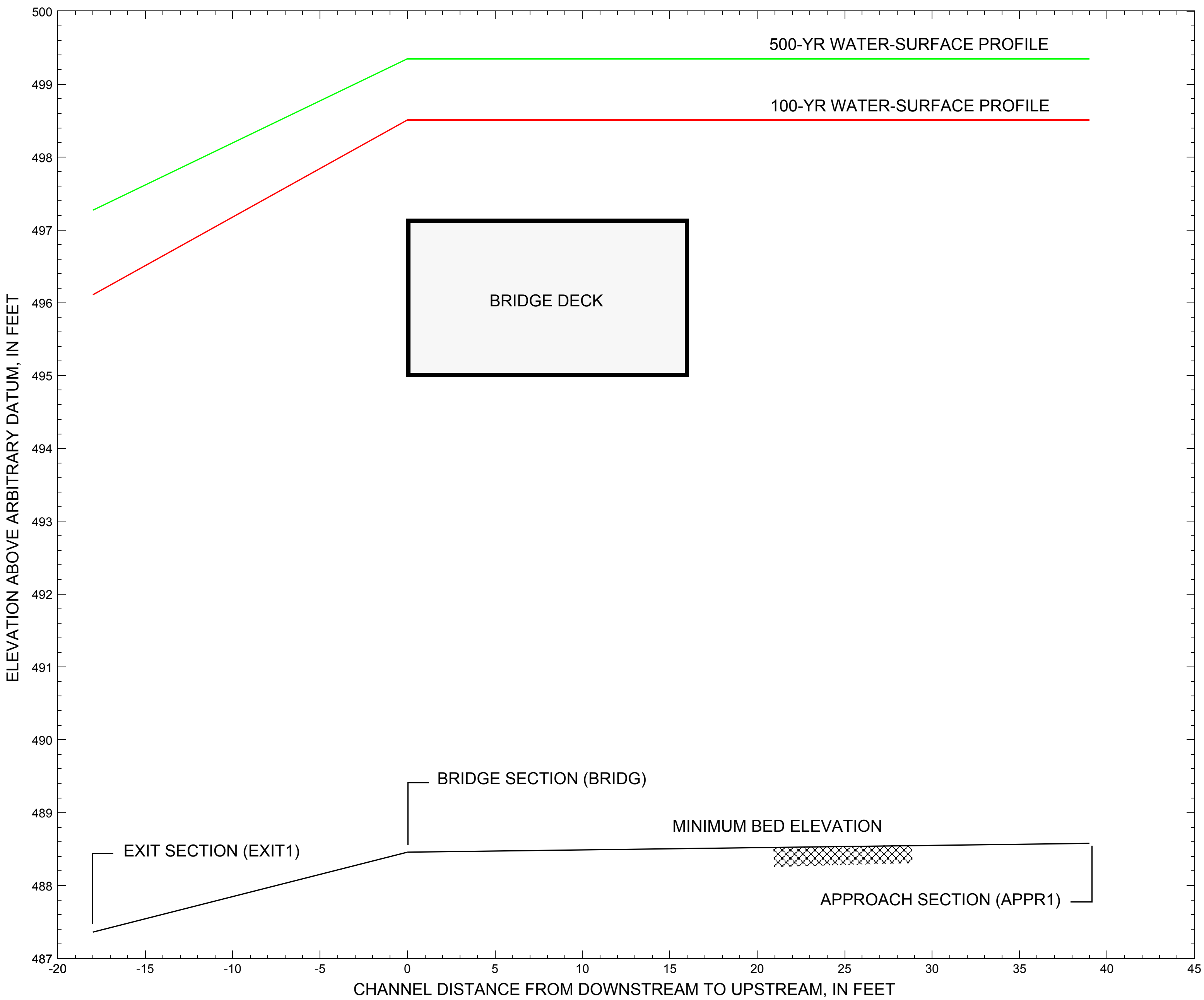

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure PEACTH00620039 on Town Highway 62, crossing South Peacham Brook, Peacham, Vermont.

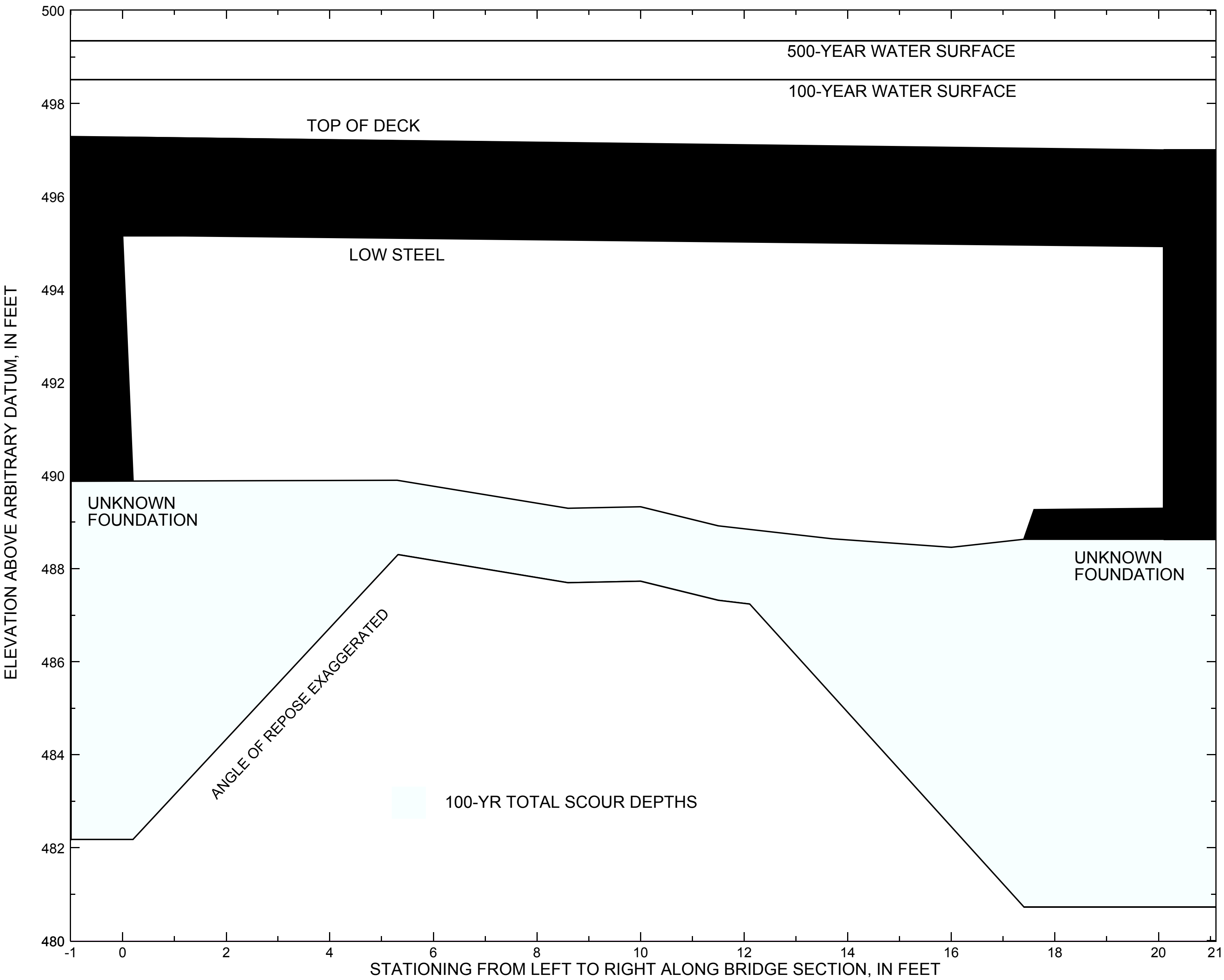

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure PEACTH00620039 on Town Highway 62, crossing South Peacham Brook, Peacham, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure PEACTH00620039 on Town Highway 62, crossing South Peacham Brook, Peacham, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,450 cubic-feet per second											
Left abutment	0.0	--	495.2	--	489.9	1.6	6.1	--	7.7	482.2	--
Right abutment	20.1	--	494.9	--	488.6	1.6	6.3	--	7.9	480.7	--

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 PEACTH00620039 on Town Highway 62, crossing South Peacham Brook, Peacham, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2,100 cubic-feet per second											
Left abutment	0.0	--	495.2	--	489.9	1.2	5.9	--	7.1	482.8	--
Right abutment	20.1	--	494.9	--	488.6	1.2	6.1	--	7.3	481.3	--

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

SELECTED REFERENCES

Arcement, G.J., Jr., and Schneider, V.R., 1989, Guide for selecting Manning's roughness coefficients for natural channels and flood plains: U.S. Geological Survey Water-Supply Paper 2339, 38 p.

Barnes, H.H., Jr., 1967, Roughness characteristics of natural channels: U.S. Geological Survey Water-Supply Paper 1849, 213 p.

Benson, M. A., 1962, Factors Influencing the Occurrence of Floods in a Humid Region of Diverse Terrain: U.S. Geological Survey Water-Supply Paper 1580-B, 64 p.

Brown, S.A. and Clyde, E.S., 1989, Design of riprap revetment: Federal Highway Administration Hydraulic Engineering Circular No. 11, Publication FHWA-IP-89-016, 156 p.

Federal Highway Administration, 1983, Runoff estimates for small watersheds and development of sound design: Federal Highway Administration Report FHWA-RD-77-158.

Federal Highway Administration, 1993, Stream Stability and Scour at Highway Bridges: Participant Workbook: Federal Highway Administration Report FHWA-HI-91-011.

Froehlich, D.C., 1989, Local scour at bridge abutments *in* Ports, M.A., ed., Hydraulic Engineering--Proceedings of the 1989 National Conference on Hydraulic Engineering: New York, American Society of Civil Engineers, p. 13-18.

Hayes, D.C.,1993, Site selection and collection of bridge-scour data in Delaware, Maryland, and Virginia: U.S. Geological Survey Water-Resources Investigation Report 93-4017, 23 p.

Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency: U.S. Geological Survey, Bulletin 17B of the Hydrology Subcommittee, 190 p.

Johnson, C.G. and Tasker, G.D.,1974, Progress report on flood magnitude and frequency of Vermont streams: U.S. Geological Survey Open-File Report 74-130, 37 p.

Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., Chang, F., 1995, Stream Stability at Highway Structures: Federal Highway Administration Hydraulic Engineering Circular No. 20, Publication FHWA-IP-90-014, 144 p.

Laursen, E.M., 1960, Scour at bridge crossings: Journal of the Hydraulics Division, American Society of Civil Engineers, v. 86, no. HY2, p. 39-53.

Potter, W. D., 1957a, Peak rates of runoff in the Adirondack, White Mountains, and Maine woods area, Bureau of Public Roads

Potter, W. D., 1957b, Peak rates of runoff in the New England Hill and Lowland area, Bureau of Public Roads

Richardson, E.V. and Davis, S.R., 1995, Evaluating scour at bridges: Federal Highway Administration Hydraulic Engineering Circular No. 18, Publication FHWA-IP-90-017, 204 p.

Richardson, E.V., Simons, D.B., and Julien, P.Y., 1990, Highways in the river environment: Federal Highway Administration Publication FHWA-HI-90-016.

Ritter, D.F., 1984, Process Geomorphology: W.C. Brown Co., Debuque, Iowa, 603 p.

Shearman, J.O., 1990, User's manual for WSPRO--a computer model for water surface profile computations: Federal Highway Administration Publication FHWA-IP-89-027, 187 p.

Shearman, J.O., Kirby, W.H., Schneider, V.R., and Flippo, H.N., 1986, Bridge waterways analysis model; research report: Federal Highway Administration Publication FHWA-RD-86-108, 112 p.

Talbot, A.N., 1887, The determination of water-way for bridges and culverts.

U.S. Department of Transportation, 1993, Stream stability and scour at highway bridges, Participant Workbook: Federal Highway Administration Publication FHWA HI-91-011.

U.S. Geological Survey, 1983, Barnet, Vermont 7.5 x 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File peac039.wsp
T2        Hydraulic analysis for structure PEACTH00620039   Date: 10-SEP-97
T3        TH 62 CROSSING SOUTH PEACHAM BROOK IN PEACHAM, VT              RLB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1450.0   2100.0  1000.0
SK          0.0241   0.0241  0.0241
WS          496.11   497.27  495.11
*
XS   EXIT1    -18           0.
GR          -83.8, 500.91    -70.9, 499.25    -63.8, 498.89    -56.1, 497.29
GR          -47.9, 497.02    -30.6, 497.32    -21.5, 497.06     -7.6, 494.72
GR           -2.9, 494.50      0.0, 492.82      3.1, 492.40      4.3, 488.36
GR            6.2, 487.36      8.8, 487.58     11.2, 487.89     15.2, 488.05
GR           16.7, 488.46     19.2, 492.85     24.2, 494.19     34.2, 497.35
GR           43.8, 497.88     85.7, 498.63    105.0, 498.77    117.8, 504.44
GR          124.4, 505.20
*
N           0.050       0.065       0.035
SA                 -7.6        34.2
*
XS   FULLV      0  * * *   0.0285
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.03      10.0
GR            0.0, 495.15      0.2, 489.88      5.3, 489.90      8.6, 489.30
GR           10.0, 489.33     11.5, 488.92     13.7, 488.64     16.0, 488.46
GR           17.4, 488.63     17.4, 488.94     17.6, 489.27     20.1, 489.30
GR           20.1, 494.91      0.0, 495.15
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD          1      23.7 * *     57.7      3.6
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      9      16.0     2
GR          -70.6, 503.38    -42.2, 500.06    -32.2, 498.23      0.0, 497.29
GR           20.4, 497.00     41.4, 498.43     88.7, 499.20    108.2, 499.65
GR          118.0, 504.01    122.8, 505.09
*
AS   APPR1     39           0.
GR          -93.8, 503.49    -61.3, 500.69    -32.4, 498.90    -28.2, 497.99
GR          -11.6, 497.79     -5.4, 495.08      0.0, 490.77      1.7, 490.73
GR            5.5, 490.57      7.0, 490.60     10.2, 489.55     12.1, 488.64
GR           14.6, 488.58     18.3, 489.56     19.8, 489.97     22.7, 493.48
GR           25.0, 495.56     32.5, 498.60     42.7, 499.70     82.1, 500.47
GR           93.1, 499.74    106.1, 500.51    126.9, 503.59
*
N           0.075        0.055      0.035
SA                 -11.6       32.5
*
HP 1 BRIDG  495.15 1 495.15
HP 2 BRIDG  495.15 * * 1101
HP 2 RDWAY  498.51 * * 328
HP 1 APPR1  498.51 1 498.51
HP 2 APPR1  498.51 * * 1450
*
HP 1 BRIDG  495.15 1 495.15
HP 2 BRIDG  495.15 * * 1073
HP 2 RDWAY  499.35 * * 988
HP 1 APPR1  499.35 1 499.35
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File peac039.wsp
        Hydraulic analysis for structure PEACTH00620039   Date: 10-SEP-97
        TH 62 CROSSING SOUTH PEACHAM BROOK IN PEACHAM, VT              RLB
           *** RUN DATE & TIME: 09-22-97  17:36

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      113      7165      0     51                      4937548
   495.15           113      7165      0     51  1.00      0     20  4937548

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.15     0.0    20.1   113.0    7165.    1101.   9.74

X STA.         0.0         2.0         3.1         4.3         5.4         6.4
  A(I)              9.6         6.1         5.7         5.6         5.4
  V(I)             5.73        9.00        9.58        9.89       10.18

X STA.         6.4         7.3         8.3         9.2        10.0        10.9
  A(I)              5.1         5.1         5.0         5.0         4.9
  V(I)            10.79       10.71       11.07       11.06       11.20

X STA.        10.9        11.7        12.5        13.3        14.0        14.8
  A(I)              4.8         4.8         4.8         4.8         4.8
  V(I)            11.43       11.55       11.48       11.38       11.43

X STA.        14.8        15.6        16.4        17.2        18.4        20.1
  A(I)              4.9         5.0         5.5         6.5         9.6
  V(I)            11.29       10.90       10.09        8.48        5.75

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.51   -33.7    46.3    69.1    1697.     328.   4.75

X STA.       -33.7       -20.8       -15.3       -11.0        -7.7        -4.2
  A(I)              5.3         3.8         3.5         3.2         3.6
  V(I)             3.09        4.27        4.65        5.10        4.54

X STA.        -4.2        -1.3         1.5         4.0         6.4         8.7
  A(I)              3.3         3.3         3.1         3.2         3.1
  V(I)             4.92        4.93        5.22        5.16        5.36

X STA.         8.7        10.9        13.1        15.2        17.3        19.2
  A(I)              3.0         3.0         2.9         3.0         2.9
  V(I)             5.40        5.45        5.57        5.47        5.63

X STA.        19.2        21.2        23.5        26.4        30.5        46.3
  A(I)              3.0         3.1         3.5         3.9         5.2
  V(I)             5.48        5.30        4.71        4.17        3.18

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      39.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       11       150     19     19                           47
             2      255     20625     44     50                         3493
   498.51           266     20775     63     69  1.06    -30     32     3012

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      39.

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.51   -30.6    32.3   266.2   20775.    1450.   5.45

X STA.       -30.6        -3.6        -0.9         0.9         2.4         3.8
  A(I)             31.2        16.1        13.2        11.8        11.4
  V(I)             2.32        4.49        5.48        6.17        6.36

X STA.         3.8         5.2         6.5         7.9         9.1        10.3
  A(I)             10.8        10.8        10.8        10.4        10.2
  V(I)             6.73        6.74        6.72        6.96        7.08

X STA.        10.3        11.4        12.4        13.4        14.5        15.5
  A(I)             10.2        10.1        10.0        10.0        10.7
  V(I)             7.08        7.16        7.26        7.26        6.80

X STA.        15.5        16.7        18.0        19.5        21.7        32.3
  A(I)             11.2        11.6        13.3        16.8        25.4
  V(I)             6.46        6.25        5.44        4.30        2.85
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        U.S. Geological Survey WSPRO Input File peac039.wsp
        Hydraulic analysis for structure PEACTH00620039   Date: 10-SEP-97
        TH 62 CROSSING SOUTH PEACHAM BROOK IN PEACHAM, VT              RLB
           *** RUN DATE & TIME: 09-22-97  17:36

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      113      7165      0     51                      4937548
   495.15           113      7165      0     51  1.00      0     20  4937548

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.15     0.0    20.1   113.0    7165.    1073.   9.49

 X STA.        0.0        2.0        3.1        4.3        5.4        6.4
   A(I)            9.6        6.1        5.7        5.6        5.4
   V(I)           5.58       8.78       9.33       9.64       9.92

 X STA.        6.4        7.3        8.3        9.2       10.0       10.9
   A(I)            5.1        5.1        5.0        5.0        4.9
   V(I)          10.52      10.44      10.79      10.78      10.91

 X STA.       10.9       11.7       12.5       13.3       14.0       14.8
   A(I)            4.8        4.8        4.8        4.8        4.8
   V(I)          11.14      11.26      11.18      11.09      11.14

 X STA.       14.8       15.6       16.4       17.2       18.4       20.1
   A(I)            4.9        5.0        5.5        6.5        9.6
   V(I)          11.00      10.63       9.83       8.26       5.61

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.35   -38.3    95.2   159.7    5567.     988.   6.19

 X STA.      -38.3      -26.5      -20.6      -15.7      -11.5       -7.8
   A(I)           10.3        8.1        7.4        7.0        6.7
   V(I)           4.81       6.08       6.66       7.09       7.35

 X STA.       -7.8       -3.6        0.2        3.7        7.2       10.4
   A(I)            7.8        7.6        7.4        7.4        7.1
   V(I)           6.32       6.48       6.69       6.64       6.91

 X STA.       10.4       13.7       16.8       19.8       22.9       26.7
   A(I)            7.2        7.1        6.9        7.1        7.8
   V(I)           6.88       6.96       7.13       6.97       6.33

 X STA.       26.7       31.4       37.1       44.8       56.8       95.2
   A(I)            8.4        7.9        7.7        9.2       13.6
   V(I)           5.90       6.26       6.40       5.39       3.64

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      39.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       30       610     28     28                          173
             2      292     25767     44     50                         4270
             3        3        58      7      7                            9
   499.35           325     26435     79     85  1.14    -39     39     3488

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      39.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.35   -39.7    39.5   324.5   26435.    2100.   6.47

 X STA.      -39.7       -6.3       -2.3       -0.1        1.5        3.1
   A(I)           44.2       20.5       16.9       14.0       13.2
   V(I)           2.37       5.12       6.20       7.52       7.94

 X STA.        3.1        4.6        6.0        7.4        8.8       10.1
   A(I)           13.1       12.8       12.4       12.3       12.1
   V(I)           8.03       8.22       8.44       8.55       8.69

 X STA.       10.1       11.3       12.4       13.5       14.6       15.8
   A(I)           12.1       12.0       11.8       12.1       12.4
   V(I)           8.68       8.77       8.87       8.68       8.50

 X STA.       15.8       17.1       18.5       20.1       22.9       39.5
   A(I)           13.3       13.7       15.7       20.6       29.5
   V(I)           7.92       7.67       6.71       5.10       3.56
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        U.S. Geological Survey WSPRO Input File peac039.wsp
        Hydraulic analysis for structure PEACTH00620039   Date: 10-SEP-97
        TH 62 CROSSING SOUTH PEACHAM BROOK IN PEACHAM, VT              RLB
           *** RUN DATE & TIME: 09-22-97  17:36

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      113      7165      0     51                      4937548
   495.15           113      7165      0     51  1.00      0     20  4937548

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.15     0.0    20.1   113.0    7165.    1000.   8.85

X STA.         0.0         2.0         3.1         4.3         5.4         6.4
  A(I)             9.6         6.1         5.7         5.6         5.4
  V(I)            5.20        8.18        8.70        8.99        9.25

X STA.         6.4         7.3         8.3         9.2        10.0        10.9
  A(I)             5.1         5.1         5.0         5.0         4.9
  V(I)            9.80        9.73       10.05       10.04       10.17

X STA.        10.9        11.7        12.5        13.3        14.0        14.8
  A(I)             4.8         4.8         4.8         4.8         4.8
  V(I)           10.38       10.49       10.42       10.34       10.39

X STA.        14.8        15.6        16.4        17.2        18.4        20.1
  A(I)             4.9         5.0         5.5         6.5         9.6
  V(I)           10.25        9.90        9.16        7.70        5.22

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      39.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      199     14660     39     44                         2548
   497.17           199     14660     39     44  1.00     -9     29     2548

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      39.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.17   -10.2    29.0   199.1   14660.    1000.   5.02

X STA.       -10.2        -1.5         0.5         2.1         3.5         4.9
  A(I)            19.0        12.1        10.2         9.4         9.0
  V(I)            2.64        4.14        4.92        5.34        5.54

X STA.         4.9         6.2         7.5         8.7         9.8        10.9
  A(I)             8.6         8.7         8.4         8.1         8.0
  V(I)            5.80        5.76        5.98        6.17        6.24

X STA.        10.9        11.8        12.7        13.6        14.5        15.5
  A(I)             7.8         7.7         7.8         7.6         8.3
  V(I)            6.38        6.51        6.43        6.58        6.03

X STA.        15.5        16.5        17.7        18.9        20.6        29.0
  A(I)             8.3         9.0         9.8        11.8        19.5
  V(I)            6.00        5.53        5.08        4.25        2.56
```

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        U.S. Geological Survey WSPRO Input File peac039.wsp
        Hydraulic analysis for structure PEACTH00620039   Date: 10-SEP-97
        TH 62 CROSSING SOUTH PEACHAM BROOK IN PEACHAM, VT              RLB
           *** RUN DATE & TIME: 09-22-97  17:36

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

EXIT1:XS   ******    -15      173  1.13 *****  497.24  495.18    1450  496.11
       -17 ******     30     9335  1.03 ***** *******    0.78    8.40

FULLV:FV       18    -14      168  1.19  0.45  497.71 *******    1450  496.53
         0     18     30     9019  1.03  0.03    0.00    0.80    8.62
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPR1"     KRATIO =  1.79

APPR1:AS       39    -10      214  0.71  0.56  498.26 *******    1450  497.55
        39     39     30    16114  1.00  0.00   -0.01    0.52    6.76
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   496.53     495.03

            <<<<<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       18      0      113  1.48 *****  496.63  493.91    1101  495.15
         0 ******     20     7165  1.00 ***** *******    0.72    9.74

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  495.03 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    23.  0.11  0.49  498.89   -0.01    328.  498.51

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    182.    45.   -34.    11.   1.4   0.9   4.9   4.7   1.2   2.9
   RT:    146.    31.    11.    41.   1.5   1.0   5.2   4.8   1.4   3.0

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

APPR1:AS       15    -30      266  0.49  0.17  499.00  494.98    1450  498.51
        39     16     32    20789  1.06  0.00   -0.01    0.48    5.44

       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
   EXIT1:XS     -18.   -16.    30.   1450.    9335.    173.    8.40  496.11
   FULLV:FV       0.   -15.    30.   1450.    9019.    168.    8.62  496.53
   BRIDG:BR       0.     0.    20.   1101.    7165.    113.    9.74  495.15
   RDWAY:RG       9.*******   182.    328.******************    2.00  498.51
   APPR1:AS      39.   -31.    32.   1450.   20789.    266.    5.44  498.51

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT1:XS    495.18    0.78  487.36  505.20************  1.13  497.24  496.11
   FULLV:FV  ********    0.80  487.87  505.71  0.45  0.03  1.19  497.71  496.53
   BRIDG:BR    493.91    0.72  488.46  495.15************  1.48  496.63  495.15
   RDWAY:RG  ****************  497.00  505.09  0.11******  0.49  498.89  498.51
   APPR1:AS    494.98    0.48  488.58  503.59  0.17  0.00  0.49  499.00  498.51
```

WSPRO OUTPUT FILE (continued)

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       U.S. Geological Survey WSPRO Input File peac039.wsp
       Hydraulic analysis for structure PEACTH00620039   Date: 10-SEP-97
       TH 62 CROSSING SOUTH PEACHAM BROOK IN PEACHAM, VT              RLB
          *** RUN DATE & TIME: 09-22-97  17:36

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

EXIT1:XS   ******    -55      236  1.37 *****  498.64  496.47    2100  497.27
      -17 ******     34    13515  1.11 ***** *******    0.99    8.91

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.95     497.68     496.98

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.77     505.71    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.77     505.71     496.98

FULLV:FV       18    -52      228  1.43  0.45  499.12  496.98    2100  497.69
         0     18     34    13146  1.09  0.03    0.00    0.96    9.20
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPR1"     KRATIO =  1.70

APPR1:AS       39    -31      282  0.93  0.59  499.69 *******    2100  498.76
        39     39     34    22320  1.08  0.00   -0.02    0.66    7.44
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   497.69     495.03

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                  QRD,QRDMAX,RATIO =     988.       984.    1.00

            <<<<<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       18      0      113  1.40 *****  496.55  493.82    1073  495.15
         0 ******     20     7165  1.00 ***** *******    0.71    9.49

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  495.03 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    23.  0.15  0.74  499.95   -0.02    988.  499.35

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    479.    49.   -38.    11.   2.2   1.6   6.7   6.1   2.2   3.0
   RT:    510.    78.    11.    89.   2.3   1.0   6.0   6.3   1.6   3.1

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

APPR1:AS       15    -39      325  0.74  0.22  500.09  496.37    2100  499.35
        39     16     39    26435  1.14  0.00   -0.02    0.60    6.47

       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
   EXIT1:XS     -18.   -56.    34.   2100.   13515.     236.    8.91  497.27
   FULLV:FV       0.   -53.    34.   2100.   13146.     228.    9.20  497.69
   BRIDG:BR       0.     0.    20.   1073.    7165.     113.    9.49  495.15
   RDWAY:RG       9.*******   479.    988.*****************    2.00  499.35
   APPR1:AS      39.   -40.    39.   2100.   26435.     325.    6.47  499.35

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT1:XS     496.47    0.99  487.36  505.20************  1.37  498.64  497.27
   FULLV:FV     496.98    0.96  487.87  505.71  0.45  0.03  1.43  499.12  497.69
   BRIDG:BR     493.82    0.71  488.46  495.15************  1.40  496.55  495.15
   RDWAY:RG  ***************  497.00  505.09  0.15******  0.74  499.95  499.35
   APPR1:AS     496.37    0.60  488.58  503.59  0.22  0.00  0.74  500.09  499.35
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        U.S. Geological Survey WSPRO Input File peac039.wsp
        Hydraulic analysis for structure PEACTH00620039   Date: 10-SEP-97
        TH 62 CROSSING SOUTH PEACHAM BROOK IN PEACHAM, VT              RLB
           *** RUN DATE & TIME: 09-22-97  17:36

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

EXIT1:XS   ******     -9      131  0.91 *****  496.02  493.75    1000  495.11
       -17 ******     27     6441  1.00 ***** *******    0.72    7.63

FULLV:FV       18     -8      128  0.96  0.45  496.49 *******    1000  495.53
         0     18     27     6203  1.00  0.02   -0.01    0.74    7.84
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPR1"     KRATIO =  1.98

APPR1:AS       39     -8      173  0.52  0.51  496.99 *******    1000  496.47
        39     39     27    12262  1.00  0.00   -0.01    0.46    5.78
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    495.53     495.03

            <<<<<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       18      0      113  1.21 *****  496.36  493.61     995  495.15
         0 ******     20     7165  1.00 ***** *******    0.65    8.81

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   3.  0.800  0.000  495.03 ****** ****** ******

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

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

APPR1:AS       15     -9      199  0.39  0.15  497.56  493.91    1000  497.17
        39     16     29    14644  1.00  0.00    0.00    0.39    5.03

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   497.06

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -18.   -10.    27.   1000.    6441.     131.    7.63  495.11
   FULLV:FV       0.    -9.    27.   1000.    6203.     128.    7.84  495.53
   BRIDG:BR       0.     0.    20.    995.    7165.     113.    8.81  495.15
   RDWAY:RG       9.**************      0.       0.       0.    2.00********
   APPR1:AS      39.   -10.    29.   1000.   14644.     199.    5.03  497.17

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXIT1:XS    493.75    0.72  487.36  505.20************  0.91  496.02  495.11
   FULLV:FV  ********    0.74  487.87  505.71  0.45  0.02  0.96  496.49  495.53
   BRIDG:BR    493.61    0.65  488.46  495.15************  1.21  496.36  495.15
   RDWAY:RG  ****************  497.00  505.09************  0.39  497.45********
   APPR1:AS    493.91    0.39  488.58  503.59  0.15  0.00  0.39  497.56  497.17
```
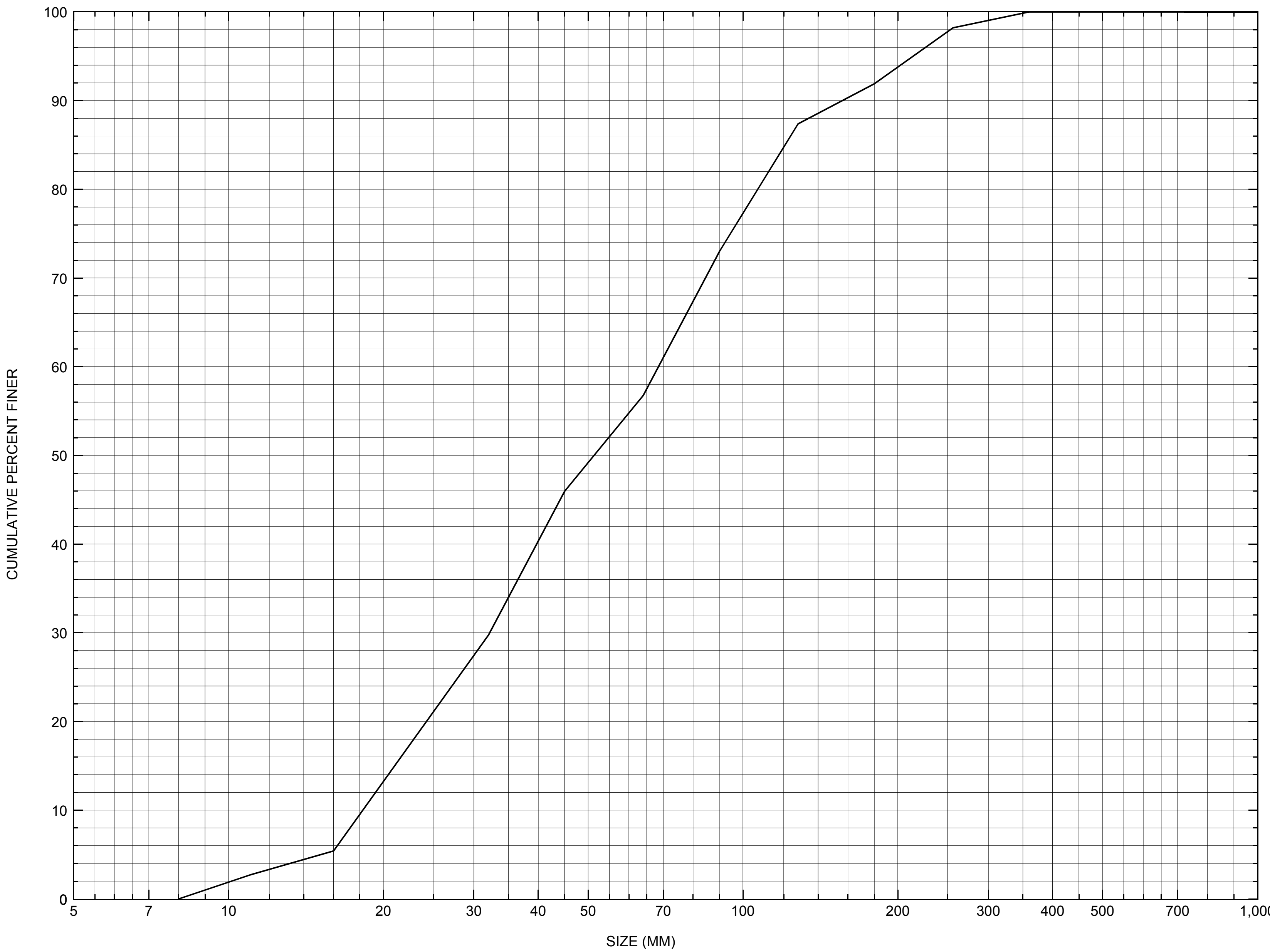

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure PEACTH00620039, in Peacham, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number PEACTH00620039

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)* 005

Town *(FIPS place code; I - 4; nnnnn)* 54400

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

Waterway *(I - 6)* SOUTH PEACHAM BROOK

Road Name *(I - 7)*: -

Route Number TH062

Vicinity *(I - 9)* AT JCT TH 62 + TH 1

Topographic Map Barnet

Hydrologic Unit Code: 01080103

Latitude *(I - 16; nnnn.n)* 44188

Longitude *(i - 17; nnnnn.n)* 72099

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10030900390309

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

Maximum span length *(I - 48; nnnn)* 0022

Year built *(I - 27; YYYY)* 1974

Structure length *(I - 49; nnnnnn)* 000023

Average daily traffic, ADT *(I - 29; nnnnnn)* 000020

Deck Width *(I - 52; nn.n)* 160

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

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

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

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

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

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

Structure type *(I - 43; nnn)* 302

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 006.0

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

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

Comments:

The structural inspection report of 8/30/93 indicates the structure is a steel stringer type bridge with a timber deck. The abutment walls and wingwalls are concrete. The footings on each abutment also are concrete and have minor spalling reported. A low, coarse gravel point bar is noted blocking half the channel from the left abutment side directing the flow toward the right abutment. Boulder fill is reported as placed around the ends of the wingwalls and along the banks. Bedrock is reported exposed on the channel bed upstream. At least a portion of the left abutment is resting on bedrock. While the footings are exposed, the report mentions there has been no undermining or settling. **(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:

Debris accumulation is noted as minor at this bridge site. The streambed consists of mainly gravel and boulders. The foundation type recorded for this bridge is an unknown foundation.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **6.88** mi^2 Lake/pond/swamp area **0.37** mi^2

Watershed storage *(ST)* **5.4** %

Bridge site elevation **971** ft Headwater elevation **2369** ft

Main channel length **4.20** mi

10% channel length elevation **1073** ft 85% channel length elevation **1595** ft

Main channel slope *(S)* **165.71** ft / mi

Watershed Precipitation Data

Average site precipitation - in Average headwater precipitation - in

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

Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

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

Project Number - Minimum channel bed elevation: -

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

Benchmark location description:

NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness - Footing bottom elevation: -

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS

Cross-sectional Data

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

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

Comments: **This cross-section is the upstream face. The low cord elevation is from the survey log done for this report on 8/23/95. The low cord to bed length data is from the sketch attached to a bridge inspection report dated 8/30/93. The sketch was done on 9/3/93.**

Station	0	6	11	16	20	-	-	-	-	-	-
Feature	LAB	-	-	-	RAB	-	-	-	-	-	-
Low chord elevation	495.2	495.1	495.0	494.9	494.9	-	-	-	-	-	-
Bed elevation	491.5	489.8	488.9	488.7	489.5	-	-	-	-	-	-
Low chord-bed	3.7	5.3	6.1	6.2	5.4	-	-	-	-	-	-

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

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

Comments: -

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 03/14/96
Computerized by: EW Date: 03/18/96
Reviewd by: RB Date: 09/29/97

Structure Number PEACTH006200039

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN Date *(MM/DD/YY)* 08 / 23 / 1996

2. Highway District Number 07 Mile marker -

County 005 Town PEACHAM 54400

Waterway *(I - 6)* SOUTH PEACHAM BROOK Road Name -

Route Number TH062 Hydrologic Unit Code: 01080103

3. Descriptive comments:

This is a steel stringer type bridge with a recently replaced timber deck. The abutments and wingwalls are concrete. The bridge is located at the junction of TH62 and TH1.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 5 LBDS 6 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 2 DS 2 *(**1**- pool; **2**- riffle)*

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

7. Bridge length 23 *(feet)* Span length 22 *(feet)* Bridge width 16 *(feet)*

Road approach to bridge:

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

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

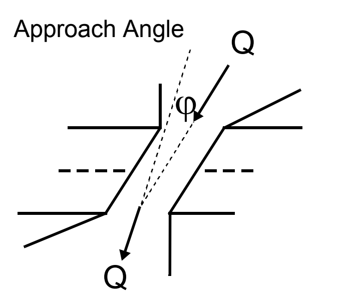
10. Embankment slope *(run / rise in feet / foot)*:
US left -- US right --

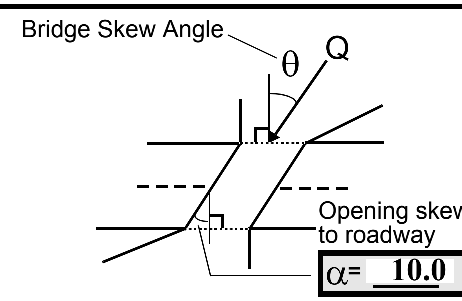
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	0
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	0	-	0	0

*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: 10 16. Bridge skew: 15





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

Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 40 feet US *(US, UB, DS)* to 15 feet US

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

18. Bridge Type: **1a**

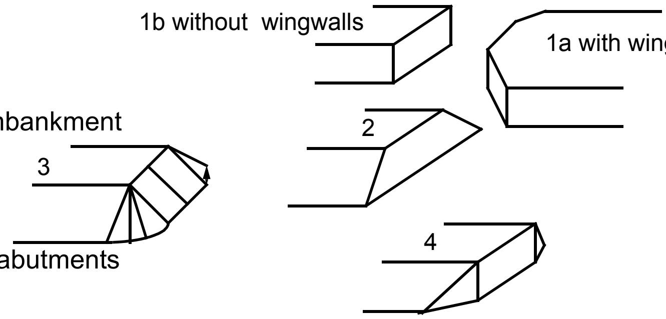
1a- Vertical abutments with wingwalls

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: On the right bank there are shrubs and small trees along the channel then TH1 runs parallel to the channel and there is forest beyond the road. On the left bank, there are trees along the channel and then pasture with a home on the upstream left bank.

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
22.5	**7.0**			**8.5**	**2**	**1**	**542**	**542**	**1**	**1**

23. Bank width **30.0**   24. Channel width **35.0**   25. Thalweg depth **44.0**   29. Bed Material **654**

30 .Bank protection type: LB **3** RB **3**   31. Bank protection condition: LB **1** 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.):

#29: A bedrock outcrop in the stream extends from the LABUT diagonally across the channel to 20 feet US, where it intersects the right bank. The bedrock also extends US to 70 ft.
#30: The right bank protection extends from 0 feet US to 40 feet US. The left bank protection extends from 14 feet US to 23 feet US.
A culvert exists 32 feet US on the right bank. It is a storm drain from TH1.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **0 UB** 35. Mid-bar width: **13**

36. Point bar extent: **9** feet **US** (US, UB) to **10** feet **DS** (US, UB, DS) positioned **0** %LB to **80** %RB

37. Material: **453**

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

A second point bar is in front of the culvert. It extends from 51 feet US to 40 feet US, is three feet wide and is positioned from 95% LB to 100% RB. The bar is made up of boulders, cobbles and gravel.

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: **62** 42. Cut bank extent: **70** feet **US** (US, UB) to **42** feet **US** (US, UB, DS)

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

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

The left cut-bank is protected naturally by large boulders, three to six feet in diameter.

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

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

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

NO CHANNEL SCOUR

The bedrock is scoured locally where the culvert enters the channel. There is a pool 2 feet deep cut diagonally across the channel.

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

51. Confluence 1: Distance **32** 52. Enters on **RB** (LB or RB) 53. Type **1** (**1**- perennial; **2**- ephemeral)

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

54. Confluence comments (eg. confluence name):

-

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
20.0		**1.5**		**2**	**7**	**7**	**-**

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

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

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

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

453

The upstream point bar extends under the bridge along the left abutment.

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 1 ____ *(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:

1

This bridge is on a straight stretch of a high gradient stream and the forest surrounding it is young and healthy, therefore the debris potential and ice blockage potential are low.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	0	0	0	0	90.0
RABUT	1	5	90			2	2	20.0

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

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

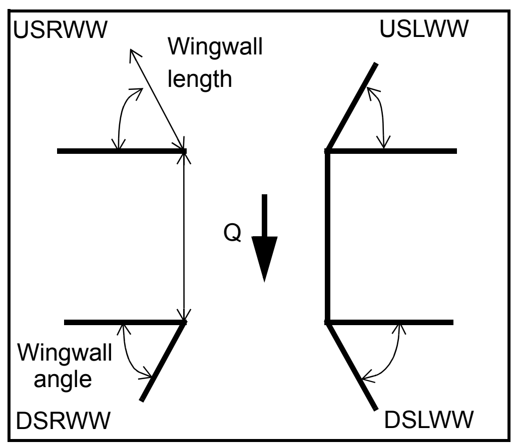
0
0.3
1

An extension of the exposed footing on the US left wingwall is visible for 4 ft at the US end of the left abutment. The right abutment footing is exposed the entire base length.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						20.0	
USRWW:	Y		1		2	0.5	
DSLWW:	0		2		Y	18.0	
DSRWW:	1		0		0	17.5	

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



82. **Bank / Bridge Protection**:

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

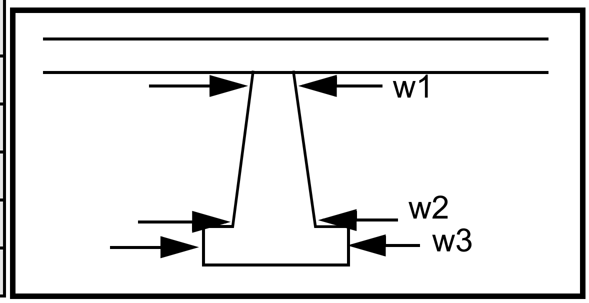
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
2
1
3
2
1
1

Piers:

84. Are there piers? **Sli** *(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		**7.5**	**6.5**	**70.0**	**45.0**	**75.0**
Pier 2	**8.0**	**5.5**	-	**40.0**	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**ght**	**the**	**sed 2**	**expose**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**road**	**wing**	**feet.**	**d**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**wash**	**walls**	**It**	**bed-**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**ero-**	**.**	**was**	**rock.**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**sion**	**The**	**pour**		*Y- yes; N- no*
91. Attack ∠ (BF)	**is**	**US**	**ed**		
92. Pushed	**evi-**	**left**	**direc**		*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**dent**	**wing**	**tly**		
95. Cross-members	**at**	**wall**	**on**		***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**the**	**foot-**	**top**		***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**ends**	**ing is**	**of**		
98. Exposure depth	**of all**	**expo**	**the**		

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

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 - 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):
-
-
-
-
-
-

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 NO (US, UB, DS) positioned PI %LB to ER %RB

Material: S

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

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

Cut bank extent: ____ feet ____ (US, UB, DS) to 2 feet 3 (US, UB, DS)

Bank damage: 543 (*1- eroded and/or creep; 2- slip failure; 3- block failure)*

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

543
1
1
425

Is channel scour present? 5 (Y or if N type ctrl-n cs) Mid-scour distance: 3

Scour dimensions: Length 1 Width 2 Depth: The Positioned left %LB to ban %RB

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

k protection is a stone wall extending from 15 feet DS to 127 feet DS and type-2 stone fill at the DS end of the DS left wingwall. The right bank protection extends from 0 feet DS to 110 feet DS, parallel to TH1. Beyond 110 feet DS, there is channel erosion on the right road embankment.

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

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

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

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

N

-

NO DROP STRUCTURE

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: PEACTH00620039 Town: PEACHAM
Road Number: TH 62 County: CALEDONIA
Stream: SOUTH PEACHAM BROOK

Initials RLB Date: 9/23/97 Checked: MAI

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	1450	2100	1000
Main Channel Area, ft2	255	292	199
Left overbank area, ft2	11	30	0
Right overbank area, ft2	0	3	0
Top width main channel, ft	44	44	39
Top width L overbank, ft	19	28	0
Top width R overbank, ft	0	7	0
D50 of channel, ft	0.1685	0.1685	0.1685
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.8	6.6	5.1
y1, average depth, LOB, ft	0.6	1.1	ERR
y1, average depth, ROB, ft	ERR	0.4	ERR
Total conveyance, approach	20775	26435	14660
Conveyance, main channel	20625	25767	14660
Conveyance, LOB	150	610	0
Conveyance, ROB	0	58	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1439.5	2046.9	1000.0
Ql, discharge, LOB, cfs	10.5	48.5	0.0
Qr, discharge, ROB, cfs	0.0	4.6	0.0
Vm, mean velocity MC, ft/s	5.6	7.0	5.0
Vl, mean velocity, LOB, ft/s	1.0	1.6	ERR
Vr, mean velocity, ROB, ft/s	ERR	1.5	ERR
Vc-m, crit. velocity, MC, ft/s	8.3	8.5	8.1
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	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	1450	2100	1000
(Q) discharge thru bridge, cfs	1101	1073	1000
Main channel conveyance	7165	7165	7165
Total conveyance	7165	7165	7165
Q2, bridge MC discharge,cfs	1101	1073	1000
Main channel area, ft2	113	113	113
Main channel width (normal), ft	19.8	19.8	19.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	19.8	19.8	19.8
y_bridge (avg. depth at br.), ft	5.71	5.71	5.71
Dm, median (1.25*D50), ft	0.210625	0.210625	0.210625
y2, depth in contraction,ft	6.05	5.92	5.57
ys, scour depth (y2-ybridge), ft	0.34	0.21	-0.14

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	1101	1073	1000
Main channel area (DS), ft2	113	113	113
Main channel width (normal), ft	19.8	19.8	19.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	19.8	19.8	19.8
D90, ft	0.5118	0.5118	0.5118
D95, ft	0.7025	0.7025	0.7025
Dc, critical grain size, ft	0.3966	0.3767	0.3272
Pc, Decimal percent coarser than Dc	0.150	0.171	0.228
Depth to armoring, ft	6.74	5.48	3.32

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	1450	2100	1000
Q, thru bridge MC, cfs	1101	1073	1000
Vc, critical velocity, ft/s	8.30	8.49	8.12
Va, velocity MC approach, ft/s	5.65	7.01	5.03
Main channel width (normal), ft	19.8	19.8	19.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	19.8	19.8	19.8
qbr, unit discharge, ft2/s	55.6	54.2	50.5
Area of full opening, ft2	113.0	113.0	113.0
Hb, depth of full opening, ft	5.71	5.71	5.71
Fr, Froude number, bridge MC	0.72	0.71	0.65
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	495.03	495.03	495.03
Elevation of Bed, ft	489.32	489.32	489.32
Elevation of Approach, ft	498.51	499.35	497.17
Friction loss, approach, ft	0.17	0.22	0.15
Elevation of WS immediately US, ft	498.34	499.13	497.02
ya, depth immediately US, ft	9.02	9.81	7.70
Mean elevation of deck, ft	497.15	497.15	497.15
w, depth of overflow, ft (>=0)	1.19	1.98	0.00
Cc, vert contrac correction (<=1.0)	0.92	0.92	0.92
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	1.58	1.23	1.02
Ys, scour w/Umbrell equation, ft	1.53	2.70	0.64

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

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

**Ys, scour w/Umbrell equation, ft N/A   N/A   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	1450	2100	1000	1450	2100	1000
a', abut.length blocking flow, ft	30.8	39.9	10.4	12.3	19.5	9
Ae, area of blocked flow ft2	32.25	32.25	29.28	24.91	24.91	23.66
Qe, discharge blocked abut.,cfs	--	--	92.5	--	--	67.65
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.42	3.97	3.16	3.35	4.24	2.86
ya, depth of f/p flow, ft	1.05	0.81	2.82	2.03	1.28	2.63
--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	80	80	80	100	100	100
K2	0.98	0.98	0.98	1.01	1.01	1.01
Fr, froude number f/p flow	0.449	0.482	0.332	0.334	0.462	0.311
ys, scour depth, ft	6.09	5.88	7.43	6.28	6.14	6.76

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)	30.8	39.9	10.4	12.3	19.5	9
y1 (depth f/p flow, ft)	1.05	0.81	2.82	2.03	1.28	2.63
a'/y1	29.42	49.36	3.69	6.07	15.26	3.42
Skew correction (p. 49, fig. 16)	0.97	0.97	0.97	1.02	1.02	1.02
Froude no. f/p flow	0.45	0.48	0.33	0.33	0.46	0.31
Ys w/ corr. factor K1/0.55:						
vertical	5.65	4.47	ERR	ERR	ERR	ERR
vertical w/ ww's	4.64	3.66	ERR	ERR	ERR	ERR
spill-through	3.11	2.46	ERR	ERR	ERR	ERR

Abutment riprap Sizing

Isbash Relationship
D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)
(Richardson and others, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.72	0.71	0.65	0.72	0.71	0.65
y, depth of flow in bridge, ft	5.71	5.71	5.71	5.71	5.71	5.71
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	1.83	1.78	1.49	1.83	1.78	1.49
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR