LEVEL II SCOUR ANALYSIS FOR BRIDGE 40 (BETHTH00230040) on TOWN HIGHWAY 23, crossing GILEAD BROOK, BETHEL, VERMONT

U.S. Geological Survey
Open-File Report 96-198

Prepared in cooperation with
VERMONT AGENCY OF TRANSPORTATION
and
FEDERAL HIGHWAY ADMINISTRATION

LEVEL II SCOUR ANALYSIS FOR BRIDGE 40 (BETHTH00230040) on TOWN HIGHWAY 23, crossing GILEAD BROOK, BETHEL, VERMONT

By Erick M. Boehmler

U.S. Geological Survey
Open-File Report 96-198

Prepared in cooperation with
VERMONT AGENCY OF TRANSPORTATION
and
FEDERAL HIGHWAY ADMINISTRATION

Pembroke, New Hampshire

1996

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

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information
write to:

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

Copies of this report may be
purchased from:

U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
Federal Center
Denver, CO 80225

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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 40 (BETHTH00230040) ON TOWN HIGHWAY 23, CROSSING GILEAD BROOK, Bethel, VERMONT

By **Erick M. Boehmler**

INTRODUCTION

This report provides the results of a detailed Level II analysis of scour potential at structure BETHTH00230040 on town highway 23 crossing Gilead Brook, Bethel, 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). A Level I study is included in Appendix E of this report. A Level I study provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from VTAOT files, was compiled prior to conducting the Level I and Level II analyses and can be found in Appendix D.

The site is in the Green Mountain physiographic province of central Vermont in the town of Bethel. The 10.2-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the banks have moderately dense woody vegetation coverage.

In the study area, the Gilead Brook has an incised, sinuous channel downstream of the site and a meandering channel upstream, with narrow flood plains and a slope of approximately 0.015 ft/ft, an average channel top width of 47.0 ft and an average channel depth of 2.75 ft. The predominant channel bed materials are gravel and cobble (D_{50} is 94.8 mm or 0.311 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 14, 1994, indicated that the reach was laterally unstable.

The town highway 23 crossing of Gilead Brook is a 37-ft-long, one-lane bridge consisting of one 34-foot span steel-stringer type superstructure (Vermont Agency of Transportation, written commun., August 24, 1994). The bridge is supported by vertical, concrete abutments with concrete wingwalls. The channel is skewed 25 degrees to the opening and the opening-skew-to-roadway is zero degrees.

A scour hole 1.0 ft deeper than the mean thalweg depth was observed along the downstream right wingwall during the Level I assessment. The scour protection measures at the site were type-2 stone fill (less than 36 inches diameter) on the upstream and downstream right roadway embankments, at the extreme upstream and downstream ends of the upstream and downstream right wingwalls, and along the entire base length of the downstream left wingwall. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1993). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The scour analysis results are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

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 BETHTH00230040 ***Stream*** Gilead Brook

County Windsor ***Road*** TH 23 ***District*** 04

Description of Bridge

Bridge length 37 ***ft*** ***Bridge width*** 14.5 ***ft*** ***Max span length*** 34 ***ft***

Alignment of bridge to road (on curve or straight) Left, Straight; Right, Curve

Abutment type Vertical ***Embankment type*** Sloping

Stone fill on abutment? No ***Date of inspection*** 10/14/94

Description of stone fill Type 2 stone fill is present on the US and DS right roadway embankments, at the extreme US and DS ends of the US and DS right wingwalls, and along the entire base length of the DS left wingwall

Brief description of piers/abutments Abutments are vertical concrete walls and the wingwalls are concrete and sloping. There is a one foot deep scour hole in front of the downstream right wingwall.

Y 25

Is bridge skewed to flood flow according to Y ***' survey?*** ***Angle***

There is a moderate channel bend in the approaching reach to the bridge. The bend is situated such that the right abutment is impacted most severely by flood flows.

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	10/14/94	0	0
Level II	10/14/94	--	--

Potential for debris Moderate due to greater than 50% tree cover on a laterally unstable channel reach upstream.

Describe any features near or at the bridge that may affect flow (include observation date) None.

Description of the Geomorphic Setting

General topography The channel is in a 300 foot-wide, moderate relief valley, with flat to slightly irregular, narrow flood plains, and steep valley walls on both sides.

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

Date of inspection 10/14/94

DS left: mildly sloped bank with a hummocky, well vegetated flood plain.

DS right: steep bank to a narrow, flat artificial terrace (roadway) to a steep valley wall

US left: steep bank with a slightly irregular flood plain and steep valley wall

US right: moderately sloped bank to a narrow, flat roadway (?) terrace.

Description of the Channel

Average top width 47 ***ft*** ***Average depth*** 2.75 ***ft***

Predominant bed material cobbles ***Bank material*** cobbles

high gradient, meandering, upland stream with narrow flood plains.

10/14/94

Vegetative co Forested

DS left: Forested on the bank and valley wall to short grass on roadway terrace.

DS right: Pasture with a few scattered trees.

US left: Forested

US right: N

Do banks appear stable? 10/14/94--Cut banks are noted within the upstream reach. ***If not, describe location and type of instability and date of observation.***

Downstream the channel is more incised than upstream.

No major obstructions as of 10/14/94.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 10.2 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province	***Percent of drainage area***
Green Mountain	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None. Basin is primarily forested with some open agricultural areas.

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/ No

Calculated Discharges

Q100 2100 ***ft***^{3}***/s*** ***Q500*** 2700 ***ft***^{3}***/s***

The 100-year discharge was estimated by use of a drainage area relationship (Qt/2040=10.2/11.4)exp0.67) with bridge number 42 in Bethel, which is just downstream of this site, and several empirical methods. Bridge 42 had a 100-year discharge of 2,040 taken from the VTAOT database and a drainage area of 11.4 square miles.

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 Subtract 2 feet from the USGS survey to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is the center point of a chiseled 'X' on the top of the concrete upstream end of the right abutment, elev. 499.90 feet, arbitrary datum. RM2 is the center point of a chiseled 'X' on the top of the concrete downstream end of the left abutment, elev. 500.09.

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT-	-43	1	Exit section.
FULLV	0	2	Downstream full valley section templated from EXIT-.
BRIDG	0	1	Downstream bridge opening.
RDWAY	9	1	Roadway section.
APPRO	51	3	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). 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, Jr. and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.050 to 0.060, and overbank "n" values ranged from 0.030 to 0.140. The roughness factor of 0.14 was applied to the downstream left overbank, where flow depths modeled were extremely shallow for the 100-year discharge. This roughness factor was reduced to 0.09 for the 500-year discharge model due to an increased flow depth.

Normal depth at the exit section (EXIT-) 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 0.015 ft/ft which was estimated from the topographic maps (U.S. Geological Survey, 1980).

The surveyed approach section (APPRO) was moved along the approach channel slope (0.035 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables. For this case, because the overbank portions of the approach section sloped at a smaller ratio than the channel, the slope indicated above was applied to the channel points only, when moving the cross section.

Although the upstream channel is skewed to the bridge opening, flow was assumed to align with the abutment wall trend when passing through the bridge.

The modeled 100- and 500-year discharges overtop the roadway embankments but not the bridge deck.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.9 *ft*
Average low steel elevation 499.5 *ft*

100-year discharge 2100 *ft³/s*
Water-surface elevation in bridge opening 496.8 *ft*
Road overtopping? Y *Discharge over road* 142 *ft³/s*
Area of flow in bridge opening 182 *ft²*
Average velocity in bridge opening 10.8 *ft/s*
Maximum WSPRO tube velocity at bridge 13.0 *ft/s*

Water-surface elevation at Approach section with bridge 499.3
Water-surface elevation at Approach section without bridge 498.2
Amount of backwater caused by bridge 1.1 *ft*

500-year discharge 2700 *ft³/s*
Water-surface elevation in bridge opening 499.3 *ft*
Road overtopping? Y *Discharge over road* 812 *ft³/s*
Area of flow in bridge opening 261 *ft²*
Average velocity in bridge opening 7.1 *ft/s*
Maximum WSPRO tube velocity at bridge 8.4 *ft/s*

Water-surface elevation at Approach section with bridge 500.3
Water-surface elevation at Approach section without bridge 498.9
Amount of backwater caused by bridge 1.4

Incipient overtopping discharge 1624 *ft³/s*
Water-surface elevation in bridge opening 496.2 *ft*
Area of flow in bridge opening 162 *ft²*
Average velocity in bridge opening 10.0 *ft/s*
Maximum WSPRO tube velocity at bridge 12.3 *ft/s*

Water-surface elevation at Approach section with bridge 498.3
Water-surface elevation at Approach section without bridge 497.3
Amount of backwater caused by bridge 1.0 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1993). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for the 100-year and incipient road-overflow discharges. Contraction scour was computed by use of Chang pressure-flow scour equation (Richardson and others, 1995, p. 145-146) for the 500-year discharge, where orifice flow was present at the bridge. Contraction scour at bridges with orifice flow is best estimated by use of Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). The results of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) was also computed for the 500-year discharge and can be found in appendix F. For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. In this case, the 100-year discharge model resulted in the worst case contraction scour with a scour depth of 0.1 ft.

Abutment scour for all of the modeled discharges was computed by use of the HIRE equation (Richardson and others, 1993, p. 50, equation 25) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. Variables for the HIRE abutment scour 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.

Because the total scour depths computed for the 500-year discharge are less than those for the 100-year discharge, figure 8 shows total scour depths for the 100-year discharge only.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.1	0.0	0.0
Depth to armoring	7.5	0.3	5.0
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	7.2	7.8	5.9
Right abutment	9.6	9.2	7.2
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Rock Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	2.2	1.0	1.9
Right abutment	2.2	1.0	1.9
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

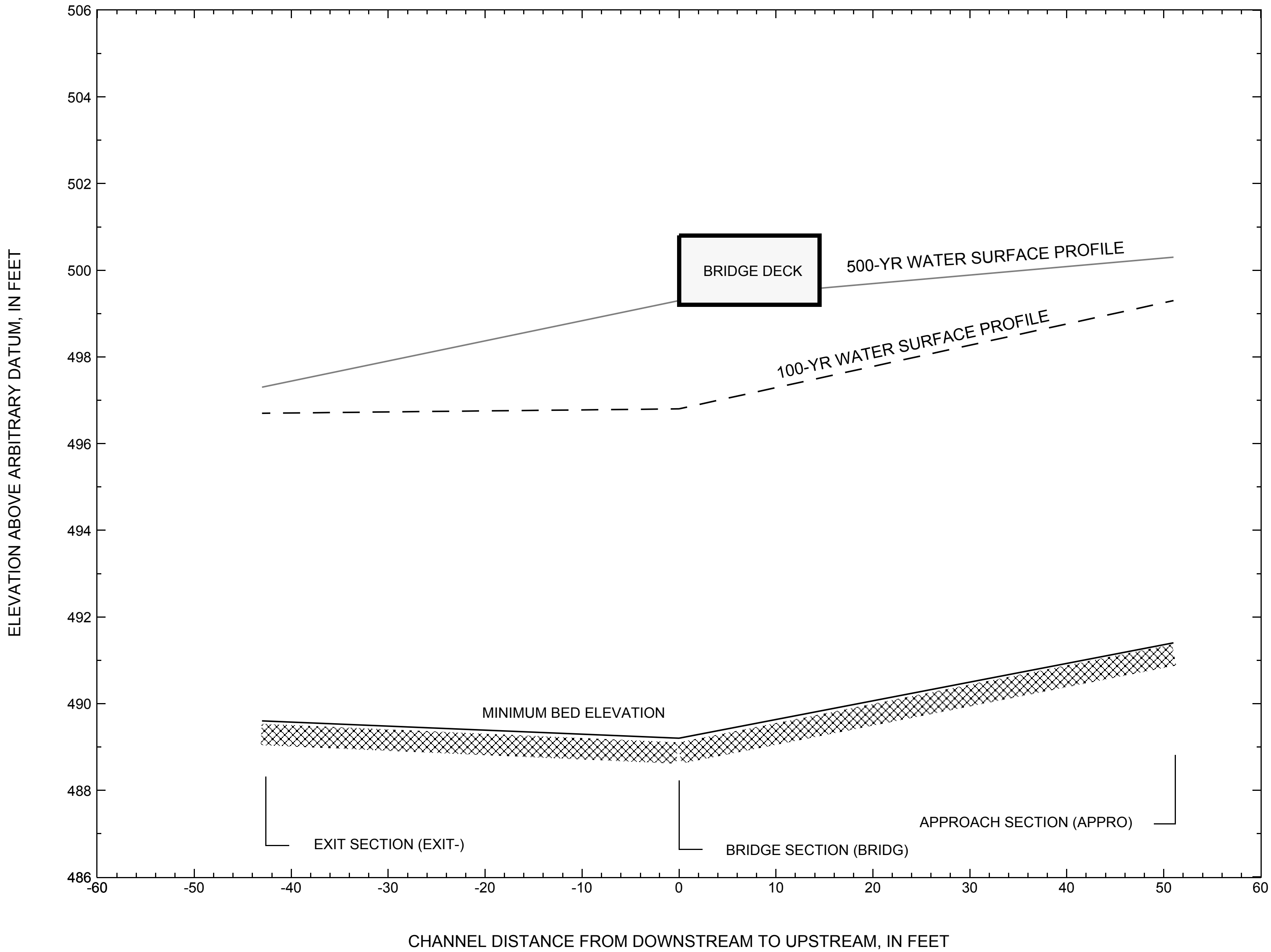


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BETHTH00230040 on town highway 23, crossing Gilead Brook, Bethel, Vermont.

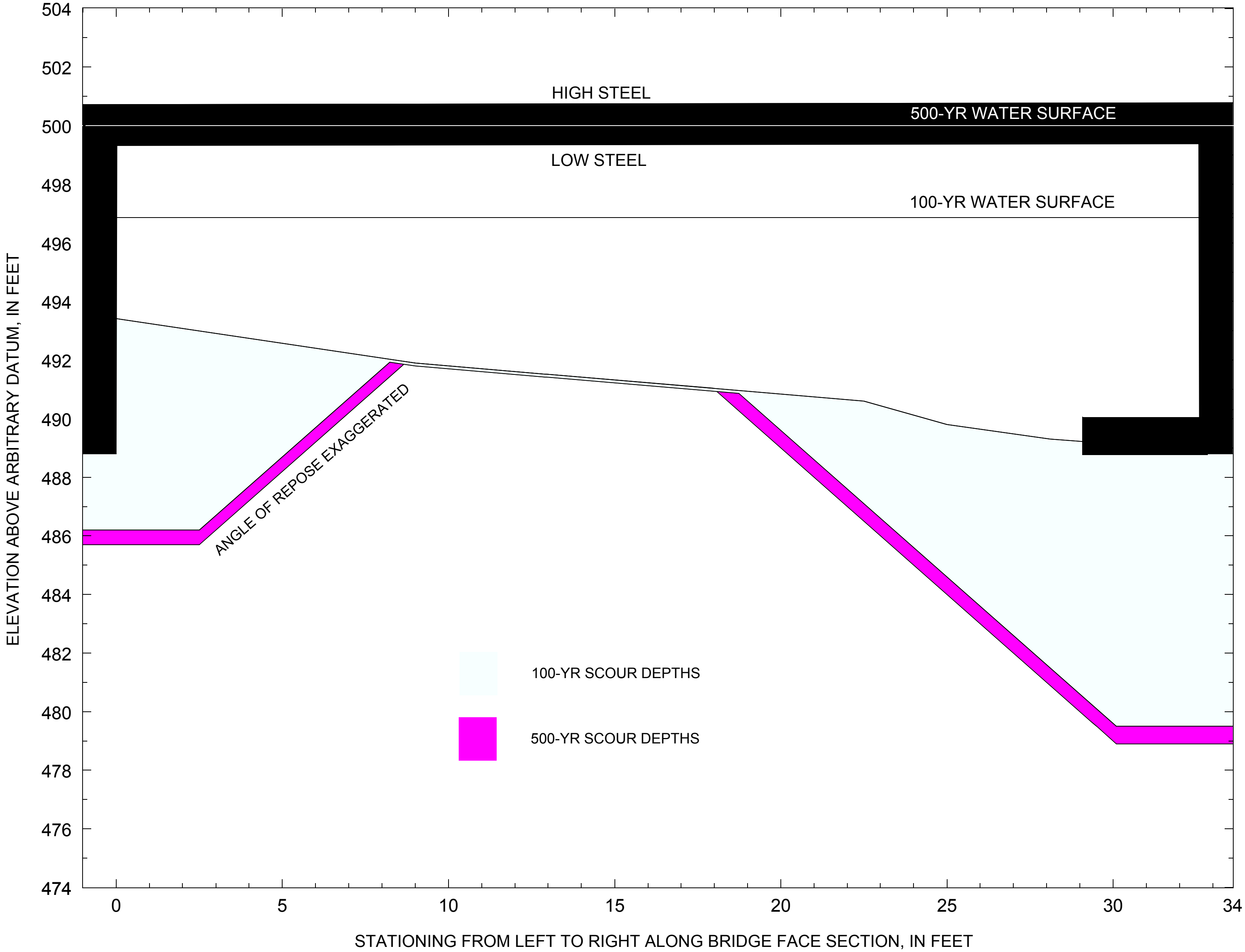


Figure 8. Scour elevations for the 100-yr discharge at structure BETHTH00230040 on town highway 23, crossing Gilead Brook, Bethel, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BETHTH00230040 on Town Highway 23, crossing Gilead Brook, Bethel, Vermont.

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

Description	Station[1]	VTAOT plans' bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 2,100 cubic-feet per second											
Left abutment	0.0	497.4	499.2	489	493.5	0.1	7.2	--	7.3	486.2	-3
Right abutment	32.6	497.4	499.2	489	489.2	0.1	9.6	--	9.7	479.5	-10

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 BETHTH00230040 on Town Highway 23, crossing Gilead Brook, Bethel, Vermont.

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

Description	Station[1]	VTAOT plans' bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2,700 cubic-feet per second											
Left abutment	0.0	497.4	499.2	489	493.5	0.0	7.8	--	7.8	485.7	-3
Right abutment	32.6	497.4	499.2	489	489.2	0.0	9.2	--	9.2	480.0	-9

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

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.

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.

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., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges: Federal Highway Administration Hydraulic Engineering Circular No. 18, Publication FHWA-IP-90-017, 131 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, 1980, Bethel, Vermont 7.5 Minute Series Quadrangle Map: U.S. Geological Survey Topographic Maps, Aerial Photographs, 1973; Field checked, 1975; Scale, 1:24,000; Contour Interval, 20 feet.

U.S. Geological Survey, 1981, Randolph, Vermont 7.5 Minute Series Quadrangle Map: U.S. Geological Survey Topographic Maps, Aerial Photographs, 1973; Field checked, 1975; Scale, 1:24,000; Contour Interval, 20 feet.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE beth040.wsp
T2        CREATED ON 06-NOV-95 FOR BRIDGE BETHTH00230040 USING FILE beth040.dca
T3        Town Highway 23 Bridge Over Gilead Brook in Bethel, VT
Q          2100.0, 2700.0, 1624.0
SK         0.015   0.015   0.015
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
XS   EXIT-    -43          0.
GR         -213.2, 509.50   -197.3, 502.71   -166.1, 502.09   -146.6, 499.83
GR         -130.1, 498.54   -118.3, 497.14    -93.1, 496.30    -53.2, 496.41
GR          -13.5, 496.11     -2.3, 494.60      0.0, 492.64     13.3, 490.48
GR           17.7, 489.82     21.5, 489.55     26.2, 489.73     31.0, 490.52
GR           35.8, 492.15     48.2, 498.99     80.3, 499.79    100.5, 499.34
GR          111.0, 507.01
*
*          The n value for the left overbank subarea shown here was used at
*          the Q100 level. The n value used here for the Q500 was 0.09
*
N           0.14        0.060        0.030
SA                -13.5         48.2
*
XS   FULLV      0  * * *    0.0037
*
BR   BRIDG   0     499.2       0.0
GR            0.0, 499.26      0.1, 493.48      9.0, 491.93     22.5, 490.65
GR           25.0, 489.85     28.1, 489.28     29.3, 489.25     29.5, 490.05
GR           32.6, 489.92     32.6, 490.68     32.6, 499.21      0.0, 499.26
*
CD         4     18.3      4.5    499.5     58.3      0.0
N           0.050
*
XR   RDWAY      9      14.5   2
GR         -202.7, 509.50   -186.6, 501.71   -161.0, 500.96    -84.5, 498.07
GR           -0.2, 499.96     -0.1, 500.74      0.0, 500.73     32.6, 500.81
GR           32.6, 500.80     34.8, 499.92     79.4, 499.29    110.8, 499.71
GR          127.5, 509.76
*
*
AS   APPRO    51
GR         -177.5, 507.13   -141.9, 501.19   -123.8, 498.97    -98.7, 497.89
GR          -71.2, 497.15    -49.1, 496.70     -7.8, 497.68     -3.3, 492.12
GR            0.0, 491.85      2.4, 491.43      5.4, 491.41     10.2, 491.66
GR           15.4, 492.16     20.9, 492.39     26.4, 492.63     33.4, 492.45
GR           45.5, 493.28     48.1, 494.97     62.0, 498.15     86.3, 497.77
GR           94.5, 497.77    110.9, 500.11    163.2, 501.04    176.8, 508.16
*
N           0.030        0.050        0.055
SA                 -7.8         110.9
*
HP 1 BRIDG   496.82 1 496.82
HP 2 BRIDG   496.82 * * 1958
HP 2 RDWAY   499.16 * *  142
HP 1 APPRO   499.28 1 499.28
HP 2 APPRO   499.28 * * 2100
*
*
HP 1 BRIDG   499.26 1 499.26
```

```
HP 2 BRIDG   499.26 * * 1860
HP 2 RDWAY   500.02 * *  812
HP 1 APPRO   500.32 1 500.32
HP 2 APPRO   500.32 * * 2700



*
HP 1 BRIDG   496.21 1 496.21
HP 2 BRIDG   496.21 * * 1624
HP 1 APPRO   498.29 1 498.29
HP 2 APPRO   498.29 * * 1624
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V042094           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

           *** RUN DATE & TIME: 12-12-95  07:48

   T1        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE beth040.wsp
   T2        CREATED ON 06-NOV-95 FOR BRIDGE BETHTH00230040 USING FILE beth040.dca
   T3        Town Highway 23 Bridge Over Gilead Brook in Bethel, VT
   Q          2100.0, 1624.0
 *** Q-DATA FOR SEC-ID, ISEQ =           1
   SK         0.015   0.015
   *
   J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
1
     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      182     14028     33     44                         2441
    496.82           182     14028     33     44  1.00      0     33     2441
1
   HP 2 BRIDG   496.82 * * 1958

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        496.82     0.0    32.6   182.0   14028.    1958.  10.76

 X STA.         0.0        4.2        6.7        8.7       10.5       12.2
   A(I)            15.2       10.6        9.2        9.1        8.5
   V(I)            6.43       9.21      10.60      10.76      11.52

 X STA.        12.2       13.7       15.2       16.7       18.1       19.4
   A(I)             8.3        8.1        7.9        7.9        7.6
   V(I)           11.80      12.10      12.42      12.32      12.82

 X STA.        19.4       20.7       21.9       23.1       24.3       25.4
   A(I)             7.6        7.5        7.6        7.5        7.6
   V(I)           12.90      13.05      12.83      13.02      12.88

 X STA.        25.4       26.4       27.5       28.7       30.2       32.6
   A(I)             7.7        7.9        8.8       10.6       16.6
   V(I)           12.73      12.32      11.18       9.27       5.89
1
   HP 2 RDWAY   499.16 * *  142

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        499.16  -113.4   -35.9    42.2     300.     142.   3.36

 X STA.      -113.4      -99.5      -95.5      -92.7      -90.4      -88.5
   A(I)             3.6        2.4        2.0        1.9        1.8
   V(I)            1.97       2.97       3.49       3.71       4.02

 X STA.       -88.5      -86.7      -85.2      -83.7      -82.2      -80.6
   A(I)             1.7        1.6        1.6        1.6        1.6
   V(I)            4.24       4.33       4.50       4.48       4.36

 X STA.       -80.6      -78.9      -77.2      -75.2      -73.1      -70.8
   A(I)             1.6        1.7        1.7        1.8        1.9
   V(I)            4.34       4.25       4.08       3.87       3.83

 X STA.       -70.8      -68.1      -64.9      -60.9      -55.1      -35.9
   A(I)             2.1        2.2        2.4        2.9        4.1
   V(I)            3.44       3.24       2.93       2.48       1.72
1
   HP 1 APPRO   499.28 1 499.28
     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      51.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      208     15083    119    119                         1569
              2      465     34895    113    117                         5363
    499.28           674     49978    231    235  1.00   -125    105     6523
1
   HP 2 APPRO   499.28 * * 2100
```

```
     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      51.

          WSEL     LEW     REW    AREA        K        Q    VEL
        499.28  -126.3   105.1   673.9   49978.    2100.   3.12

 X STA.      -126.3      -82.2      -65.3      -52.4      -40.5      -26.9
   A(I)            48.3       34.8       30.7       29.5       30.3
   V(I)            2.17       3.02       3.42       3.56       3.46

 X STA.       -26.9       -8.8       -1.4        2.0        5.0        8.1
   A(I)            33.2       35.1       25.2       24.3       24.1
   V(I)            3.17       2.99       4.17       4.33       4.35

 X STA.         8.1       11.4       14.9       18.7       22.8       27.2
   A(I)            24.9       25.5       26.7       28.4       29.5
   V(I)            4.21       4.12       3.93       3.70       3.56

 X STA.        27.2       31.8       36.7       42.5       52.1      105.1
   A(I)            31.1       33.1       36.9       47.3       75.0
   V(I)            3.38       3.17       2.84       2.22       1.40
1
   *
   *
   HP 1 BRIDG   499.26 1 499.26

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

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      261     16907      0     81                            0
    499.26           261     16907      0     81  1.00      0     33        0
1
   HP 2 BRIDG   499.26 * * 1860

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        499.26     0.0    32.6   260.7   16907.    1860.   7.14

 X STA.         0.0        3.5        5.8        7.7        9.5       11.2
   A(I)            20.9       14.8       13.6       13.0       12.2
   V(I)            4.44       6.29       6.82       7.15       7.60

 X STA.        11.2       12.8       14.3       15.8       17.3       18.7
   A(I)            12.5       11.7       11.8       11.6       11.5
   V(I)            7.45       7.94       7.88       7.99       8.11

 X STA.        18.7       20.0       21.4       22.7       24.0       25.2
   A(I)            11.3       11.2       11.2       11.3       11.0
   V(I)            8.19       8.33       8.27       8.20       8.45

 X STA.        25.2       26.4       27.5       28.8       30.3       32.6
   A(I)            11.4       11.5       12.1       14.2       21.6
   V(I)            8.13       8.11       7.67       6.55       4.30
1
   HP 2 RDWAY   500.02 * *  812

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        500.02  -136.1   111.3   170.0    2552.     812.   4.78

 X STA.      -136.1     -105.7      -96.6      -90.1      -85.0      -80.3
   A(I)            17.5       12.0       10.5        9.4        8.9
   V(I)            2.33       3.39       3.87       4.31       4.56

 X STA.       -80.3      -75.4      -69.8      -63.8      -56.6      -47.7
   A(I)             9.0        9.3        9.4       10.1       10.9
   V(I)            4.53       4.37       4.31       4.03       3.71

 X STA.       -47.7      -34.4       49.1       61.9       69.3       75.0
   A(I)            12.9       18.1        5.0        3.9        3.6
   V(I)            3.14       2.24       8.05      10.38      11.25

 X STA.        75.0       79.9       84.8       90.9       98.6      111.3
```

```
   A(I)             3.4       3.4       3.8       4.0       4.9
   V(I)           11.91     11.95     10.80     10.03      8.35
1
   HP 1 APPRO   500.32 1 500.32

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      51.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      336     31926    127    127                          3103
              2      586     49642    119    123                          7397
              3        1         7     12     12                             2
    500.32           924     81575    258    261  1.01   -134    123      9871
1

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      51.

          WSEL     LEW     REW    AREA        K        Q    VEL
        500.32  -134.8   122.7   923.9   81575.    2700.   2.92

 X STA.      -134.8      -95.7      -79.2      -65.8      -54.3      -44.0
   A(I)            62.4       44.9       41.9       39.1       36.8
   V(I)            2.16       3.01       3.22       3.45       3.67

 X STA.       -44.0      -32.9      -20.1       -4.8        0.3        4.4
   A(I)            37.6       39.5       47.8       40.9       35.9
   V(I)            3.60       3.42       2.83       3.30       3.76

 X STA.         4.4        8.5       12.7       17.3       22.4       27.7
   A(I)            36.1       36.3       38.3       40.4       41.0
   V(I)            3.73       3.72       3.53       3.34       3.29

 X STA.        27.7       33.4       39.4       46.6       67.2      122.7
   A(I)            44.1       46.1       52.0       72.5       90.5
   V(I)            3.06       2.93       2.60       1.86       1.49
1
   *
   HP 1 BRIDG   496.21 1 496.21

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

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      162     11791     33     43                          2053
    496.21           162     11791     33     43  1.00      0     33      2053
1
   HP 2 BRIDG   496.21 * * 1624

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        496.21     0.1    32.6   162.1   11791.    1624.  10.02

 X STA.         0.1        4.4        7.0        9.1       10.9       12.6
   A(I)            13.3        9.6        8.7        8.1        7.6
   V(I)            6.09       8.46       9.37      10.05      10.72

 X STA.        12.6       14.2       15.7       17.2       18.5       19.8
   A(I)             7.6        7.3        7.2        6.9        6.9
   V(I)           10.74      11.07      11.29      11.74      11.82

 X STA.        19.8       21.1       22.3       23.5       24.6       25.7
   A(I)             6.9        6.6        6.9        6.6        6.7
   V(I)           11.78      12.27      11.71      12.33      12.12

 X STA.        25.7       26.7       27.7       28.8       30.3       32.6
   A(I)             6.7        7.1        7.6        9.3       14.6
   V(I)           12.12      11.42      10.75       8.78       5.55
1
   HP 1 APPRO   498.29 1 498.29

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      51.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1       99      4846    100    100                           555
              2      357     23386    106    110                          3720
    498.29           456     28233    206    210  1.03   -107     98      3782
1
```

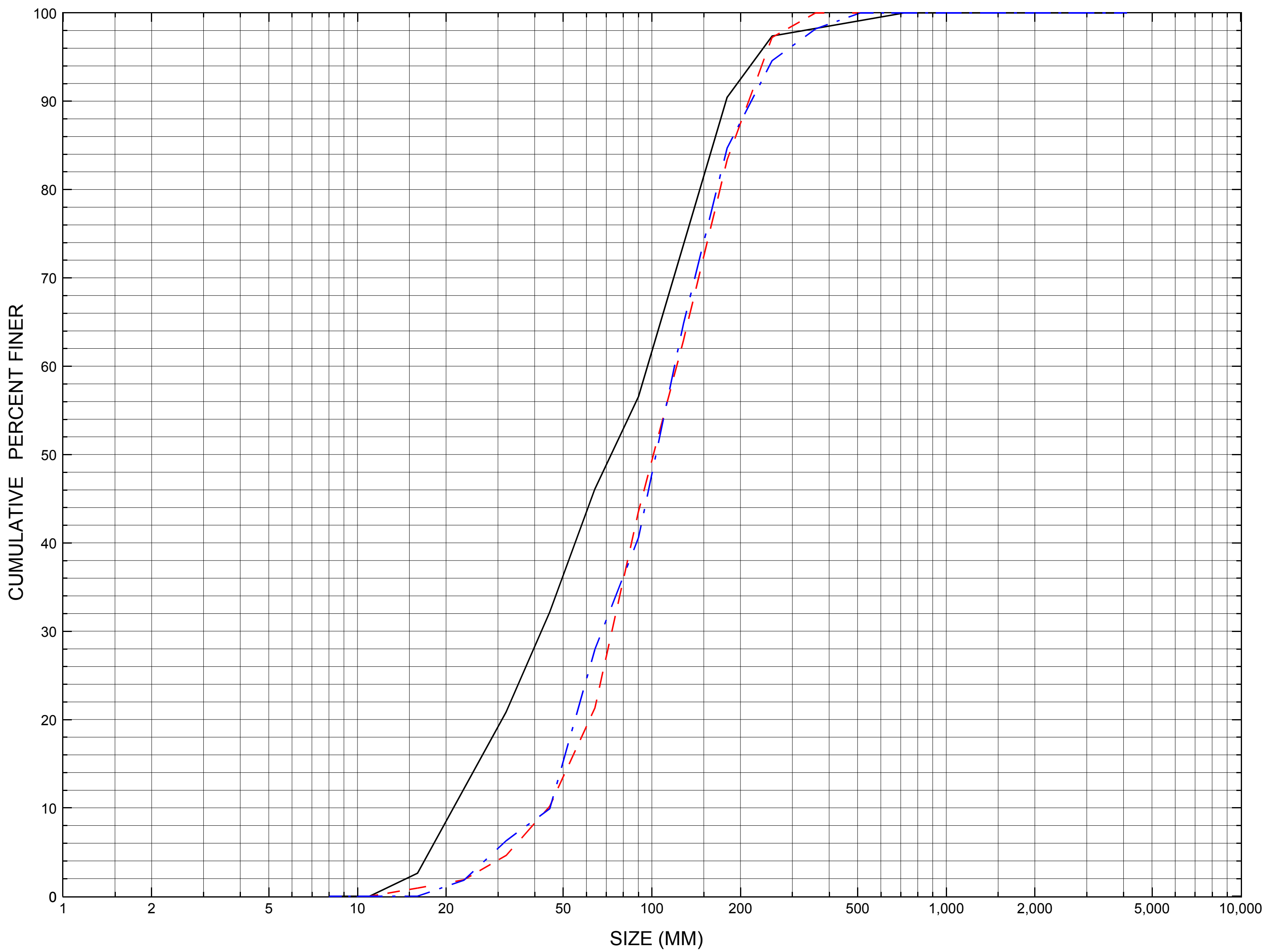
```
  HP 2 APPRO   498.29 * * 1624

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      51.

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.29  -108.0    98.1   455.7   28233.    1624.   3.56

 X STA.      -108.0      -61.5      -45.1      -25.8       -3.1       -0.4
  A(I)            35.0       24.4       24.4       31.3       17.0
  V(I)            2.32       3.33       3.33       2.60       4.78

 X STA.        -0.4        2.0        4.2        6.3        8.6       11.0
  A(I)            15.8       14.9       15.0       15.4       15.6
  V(I)            5.14       5.44       5.42       5.26       5.20

 X STA.        11.0       13.5       16.3       19.2       22.4       25.8
  A(I)            16.5       16.9       17.9       18.4       20.1
  V(I)            4.92       4.81       4.53       4.42       4.05

 X STA.        25.8       29.5       33.4       38.0       43.7       98.1
  A(I)            21.1       22.3       26.4       29.9       57.4
  V(I)            3.85       3.64       3.07       2.71       1.41
1
  *
  EX

 +++ BEGINNING PROFILE CALCULATIONS --   2

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

 EXIT-:XS   ******   -106      296  0.99 *****  497.74  495.56    2100  496.75
       -42 ******     44    17139  1.27 ***** *******    1.00    7.09

 FULLV:FV       43   -119      399  0.68  0.50  498.23 *******    2100  497.55
         0      43     45    21956  1.57  0.00   -0.02    0.75    5.26
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS       51   -106      446  0.36  0.37  498.60 *******    2100  498.24
        51      51     98    27361  1.04  0.00    0.00    0.57    4.71
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   499.74       0.00     496.47     498.07

  ===260 ATTEMPTING FLOW CLASS 4 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       43      0      182  2.02  0.74  498.84  496.06    1958  496.82
         0      43     33    14022  1.12  0.36   -0.01    0.85   10.76

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        4. ****   4.  0.943 ******  499.20 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    37.  0.06  0.15  499.38    0.00    142.  499.16

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    142.    77.  -113.   -36.   1.1   0.5   3.6   3.4   0.8   2.8
   RT:      0.    78.    34.   112.   0.9   0.6   4.4   4.9   1.1   2.9

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

 APPRO:AS       33   -125      674  0.15  0.22  499.43  496.11    2100  499.28
```

```
      51     37    105    49981  1.00  0.38    0.01    0.32    3.12

     M(G)   M(K)        KQ   XLKQ   XRKQ    OTEL
    0.841  0.533   23148.    -8.    25. ********

                   <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT-:XS     -43.  -107.    44.   2100.   17139.     296.    7.09  496.75
   FULLV:FV       0.  -120.    45.   2100.   21956.     399.    5.26  497.55
   BRIDG:BR       0.     0.    33.   1958.   14022.     182.   10.76  496.82
   RDWAY:RG       9.*******   142.    142.*********       0.    2.00  499.16
   APPRO:AS      51.  -126.   105.   2100.   49981.     674.    3.12  499.28

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -8.    25.   23148.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT-:XS    495.56    1.00  489.55  509.50************  0.99  497.74  496.75
   FULLV:FV  ********    0.75  489.71  509.66  0.50  0.00  0.68  498.23  497.55
   BRIDG:BR    496.06    0.85  489.25  499.26  0.74  0.36  2.02  498.84  496.82
   RDWAY:RG  ****************  498.07  509.76  0.06******  0.15  499.38  499.16
   APPRO:AS    496.11    0.32  491.41  508.16  0.22  0.38  0.15  499.43  499.28

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

EXIT-:XS   ******   -119      390  1.08 *****  498.41  496.84    2700  497.33
       -42 ******     45    22039  1.44 ***** *******    0.95    6.93

FULLV:FV       43   -125      515  0.66  0.48  498.89 *******    2700  498.23
         0     43     47    29516  1.53  0.00    0.00    0.66    5.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       51   -120      578  0.34  0.32  499.20 *******    2700  498.86
        51     51    102    39670  1.01  0.00   -0.01    0.51    4.67
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   501.28       0.00     497.22     498.07

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   497.67     499.76     499.96     499.20

 ===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       43      0      261  0.79 *****  500.05  495.89    1860  499.26
         0 ******     33    16907  1.00 ***** *******    0.44    7.14

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   5.  0.394  0.000  499.20 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    37.  0.04  0.13  500.41   -0.01    812.  500.02

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    645.   136.  -136.     0.   2.0   1.0   5.1   4.8   1.4   2.9
   RT:    168.    77.    35.   111.   0.7   0.5   3.9   4.8   0.8   2.8

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

APPRO:AS       33   -134      924  0.13  0.15  500.45  496.86    2700  500.32
        51     39    123    81575  1.01  0.30   -0.01    0.27    2.92

     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
   EXIT-:XS     -43.  -120.    45.   2700.   22039.     390.    6.93  497.33
   FULLV:FV       0.  -126.    47.   2700.   29516.     515.    5.25  498.23
   BRIDG:BR       0.     0.    33.   1860.   16907.     261.    7.14  499.26
   RDWAY:RG       9.*******   645.    812.*********       0.    2.00  500.02
   APPRO:AS      51.  -135.   123.   2700.   81575.     924.    2.92  500.32

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT-:XS    496.84    0.95  489.55  509.50************  1.08  498.41  497.33
   FULLV:FV  ********    0.66  489.71  509.66  0.48  0.00  0.66  498.89  498.23
   BRIDG:BR    495.89    0.44  489.25  499.26************  0.79  500.05  499.26
   RDWAY:RG  ****************  498.07  509.76  0.04******  0.13  500.41  500.02
   APPRO:AS    496.86    0.27  491.41  508.16  0.15  0.30  0.13  500.45  500.32

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

EXIT-:XS   ******    -12      221  0.84 *****  496.94  494.75    1624  496.09
       -42 ******     43    13247  1.00 ***** *******    0.66    7.36

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.81     496.82     494.91

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.59     509.66    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.59     509.66     494.91

FULLV:FV       43   -103      285  0.62  0.51  497.45  494.91    1624  496.83
         0     43     44    16624  1.22  0.00    0.00    0.80    5.70
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       51    -77      297  0.50  0.38  497.83 *******    1624  497.33
        51     51     58    21399  1.07  0.00    0.00    0.64    5.48
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   498.29       0.00     496.21     498.07

 ===260 ATTEMPTING FLOW CLASS 4 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       43      0      162  1.56  0.72  497.77  495.50    1624  496.21
         0     43     33    11805  1.00  0.11   -0.01    0.79   10.01

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   4.  1.000 ******  499.20 ****** ****** ******

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

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

APPRO:AS       33   -107      456  0.20  0.28  498.49  495.52    1624  498.29
        51     35     98    28220  1.03  0.45    0.02    0.43    3.56

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.761  0.268   20455.    -2.    30. ********
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for three pebble count transects at the approach cross-section for structure BETHTH00230040, in Bethel, Vermont.

APPENDIX D:

HISTORICAL DATA FORM