LEVEL II SCOUR ANALYSIS FOR BRIDGE 38 (BETHTH00070038) on TOWN HIGHWAY 7, crossing GILEAD BROOK, BETHEL, VERMONT

U.S. Geological Survey
Open-File Report 96-189

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 38 (BETHTH00070038) on TOWN HIGHWAY 7, crossing GILEAD BROOK, BETHEL, VERMONT

By MICHAEL A. IVANOFF and DONALD L. SONG

U.S. Geological Survey
Open-File Report 96-189

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

Introduction 1
Level II summary 7
Description of Bridge 7
Description of the Geomorphic Setting 8
Description of the Channel 8
Hydrology 9
Calculated Discharges 9
Description of the Water-Surface Profile Model (WSPRO) Analysis 10
Cross-Sections Used in WSPRO Analysis 10
Data and Assumptions Used in WSPRO Model 11
Bridge Hydraulics Summary 12
Scour Analysis Summary 13
Special Conditions or Assumptions Made in Scour Analysis 13
Scour Results 14
Rock Riprap Sizing 14
References 18

Appendixes:
A. WSPRO input file 19
B. WSPRO output file 22
C. Bed-material particle-size distribution 29
D. Historical data form 30
E. Level I data form 36
F. Scour computations 46

FIGURES

1. Map showing location of study area on USGS 1:24,000 scale map 3
2. Map showing location of study area on Vermont Agency of Transportation town highway map 4
3. Structure BETHTH00070038 viewed from upstream (October 18, 1994) 5
4. Downstream channel viewed from structure BETHTH00070038 (October 18, 1994). 5
5. Upstream channel viewed from structure BETHTH00070038 (October 18, 1994). 6
6. Structure BETHTH00070038 viewed from downstream (October 18, 1994). 6
7. Water-surface profiles for the 100- and 500-year discharges at structure BETHTH00070038 on Town Highway 7, crossing Gilead Brook, Bethel, Vermont. 15
8. Scour elevations for the 100- and 500-year discharges at structure BETHTH00070038 on Town Highway 7, crossing Gilead Brook, Bethel, Vermont. 16

TABLES

1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BETHTH00070038 on Town Highway 7, crossing Gilead Brook, Bethel, Vermont 17
2. Remaining footing/pile depth at abutments for the 500-year discharge at structure BETHTH00070038 on Town Highway 7, crossing Gilead Brook, Bethel, Vermont 17

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 38 (BETHTH00070038) ON TOWN HIGHWAY 7, CROSSING GILEAD BROOK, BETHEL, VERMONT

***By* Michael A. Ivanoff and Donald L. Song**

INTRODUCTION

This report provides the results of a detailed Level II analysis of scour potential at structure BETHTH00070038 on town highway 7 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 available from VTAOT files was compiled prior to conducting 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 8.83-mi^2 drainage area is predominantly rural and forested. In the vicinity of the study site, the banks have dense woody vegetation coverage.

In the study area, Gilead Brook is an incised, straight channel with a slope of approximately 0.028 ft/ft, an average channel top width of 46 ft and an average channel depth of 3 ft. The predominant channel bed material is gravel (D_{50} is 43.9 mm or 0.144 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 18, 1994, indicated that the reach was stable.

The town highway 7 crossing of Gilead Brook is a 40-ft-long, two-lane bridge consisting of one 38-foot span concrete deck (Vermont Agency of Transportation, written commun., August 24, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 55 degrees to the opening while the opening-skew-to-roadway is 25 degrees.

The scour protection measure at the site included type-2 stone fill (less than 36 inches diameter) at the US and DS left and right wingwalls, US left and right banks, and US and DS side of the left and right road embankments. 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.

Randolph, VT. Quadrangle, 1:24,000, 1981

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 BETHTH00070038 ***Stream*** Gilead Brook

County Windsor ***Road*** TH007 ***District*** 04

Description of Bridge

Bridge length 40 ***ft*** ***Bridge width*** 38 ***ft*** ***Max span length*** 25.3 ***ft***

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

Abutment type Vertical ***Embankment type*** N/A

Stone fill on abutment? No ***Date of inspection*** 10/18/94

Description of stone fill Type-2, around US and DS left and right wingwalls, US left and right banks, and the US and DS side of the left and right road embankments.

Brief description of piers/abutments Concrete abutments and wingwalls.

Is bridge skewed to flood flow according to Y ***survey?*** Y ***Angle*** 55

There is a moderate channel bend into the upstream bridge face impacting the left abutment.

10/18/94

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	10/18/94	0	0
Level II		--	--

Potential for debris Moderate.

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 has a flat to slightly irregular flood plain with steep valley walls on both sides.

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

Date of inspection 10/18/94

DS left: Moderate channel bank slope to a narrow terrace

DS right: Steep channel bank

US left: Steep channel bank

US right: Moderate channel bank slope to a narrow terrace

Description of the Channel

Average top width 45.5 ***ft*** ***Average depth*** 3.1 ***ft***

Predominant bed material Gravel ***Bank materia*** Cobbles

Straight and stable with semi-alluvial channel boundaries and a narrow flood plain.

10/18/95

Vegetative co

Brush

DS left: Trees

DS right: Shrubs and brush

US left: Brush with gravel road on terrace.

US right:

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

Site assessment of 10/18/94 noted a cobble bar through the bridge opening

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 8.83 ***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:***

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/ [illegible] No

Calculated Discharges

Q100 2,000 ***ft***^{3}***/s*** ***Q500*** 2,650 ***ft***^{3}***/s***

The 100- year discharge was taken from the VTAOT database (VTAOT, written communication, 1995). The 500-year discharge was graphically extrapolated from flood frequency values found in the VTAOT database for this site.

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 56.55 ft. from USGS survey to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a State of Vermont brass tablet on the US end of the right abutment (elev. 999.57 ft, arbitrary survey datum). RM2 is a chiseled square on top of the DS end of the left abutment (elev. 997.62 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-50	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	16	1	Road Grade section
APPRO	65	2	Modelled Approach section (Templated from ATEMP)
ATEMP	93	1	Approach section as surveyed (Used as a template)

[1] For location of cross-sections see plan-view plot 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 0.040 to 0.065, and overbank "n" values ranged from 0.045 to 0.060.

Normal depth at the exit section (EXITX) 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 0.0280 ft/ft determined from thalweg points downstream of the bridge.

The surveyed approach section (ATEMP) was moved along the approach channel slope (0.029 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.

The modeled 100 and 500-yr discharge overtops the left roadway embankment but not the bridge deck. The incipient overtopping discharge was determined to be 1840 cfs.

Bridge Hydraulics Summary

Average bridge embankment elevation 998.6 *ft*
Average low steel elevation 996.2 *ft*

100-year discharge 2,000 *ft³/s*
Water-surface elevation in bridge opening 996.2 *ft*
Road overtopping? Y *Discharge over road* 447 *s*
Area of flow in bridge opening 242 *ft²*
Average velocity in bridge opening 6.5 *ft/s*
Maximum WSPRO tube velocity at bridge 8.6 *ft/s*

Water-surface elevation at Approach section with bridge 997.0
Water-surface elevation at Approach section without bridge 994.6
Amount of backwater caused by bridge 2.4 *t*

500-year discharge 2,650 *ft³/s*
Water-surface elevation in bridge opening 996.2 *ft*
Road overtopping? Y *Discharge over road* 787 */s*
Area of flow in bridge opening 242 *ft²*
Average velocity in bridge opening 7.7 *ft/s*
Maximum WSPRO tube velocity at bridge 10.1 */s*

Water-surface elevation at Approach section with bridge 997.4
Water-surface elevation at Approach section without bridge 995.3
Amount of backwater caused by bridge 2.1

Incipient overtopping discharge 1,840 *ft³/s*
Water-surface elevation in bridge opening 993.4 *ft*
Area of flow in bridge opening 152 *ft²*
Average velocity in bridge opening 12.1 *ft/s*
Maximum WSPRO tube velocity at bridge 15.0 *ft/s*

Water-surface elevation at Approach section with bridge 996.0
Water-surface elevation at Approach section without bridge 994.4
Amount of backwater caused by bridge 1.6 *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, 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, 1993, p. 35, equation 18) for the incipient road-overflow discharge. Contraction scour was computed by use of the Chang pressure-flow scour equation (Richardson and others, 1995, p. 145-146) for the 100-year and 500-year discharges. For the 100-year and 500-year modelled discharges, there was orifice flow at the bridge. 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). The results of Laursen's clear-water contraction scour equation (Richardson and others, 1993, p. 35, equation 18) were also computed for the 100-year and 500-year discharges 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.

Abutment scour was computed by use of the Froehlich equation (Richardson and others, 1993, p. 49, equation 24). The Froehlich equation gives "excessively conservative estimates of scour depths" (Richardson and others, 1993, p. 48). 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	0 0	2.0	0.4
Depth to armoring	1.3	34.7	
Left overbank	--	--	--
Right overbank	--	--	11.1

Local scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
Abutment scour	12.5	7.6	6.1
Left abutment	7.2	6.0	--
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	0.9
Pier 3			

Rock Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	1.2	1.9	0.9
Left abutment	1.2	1.9	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	
Pier 2			

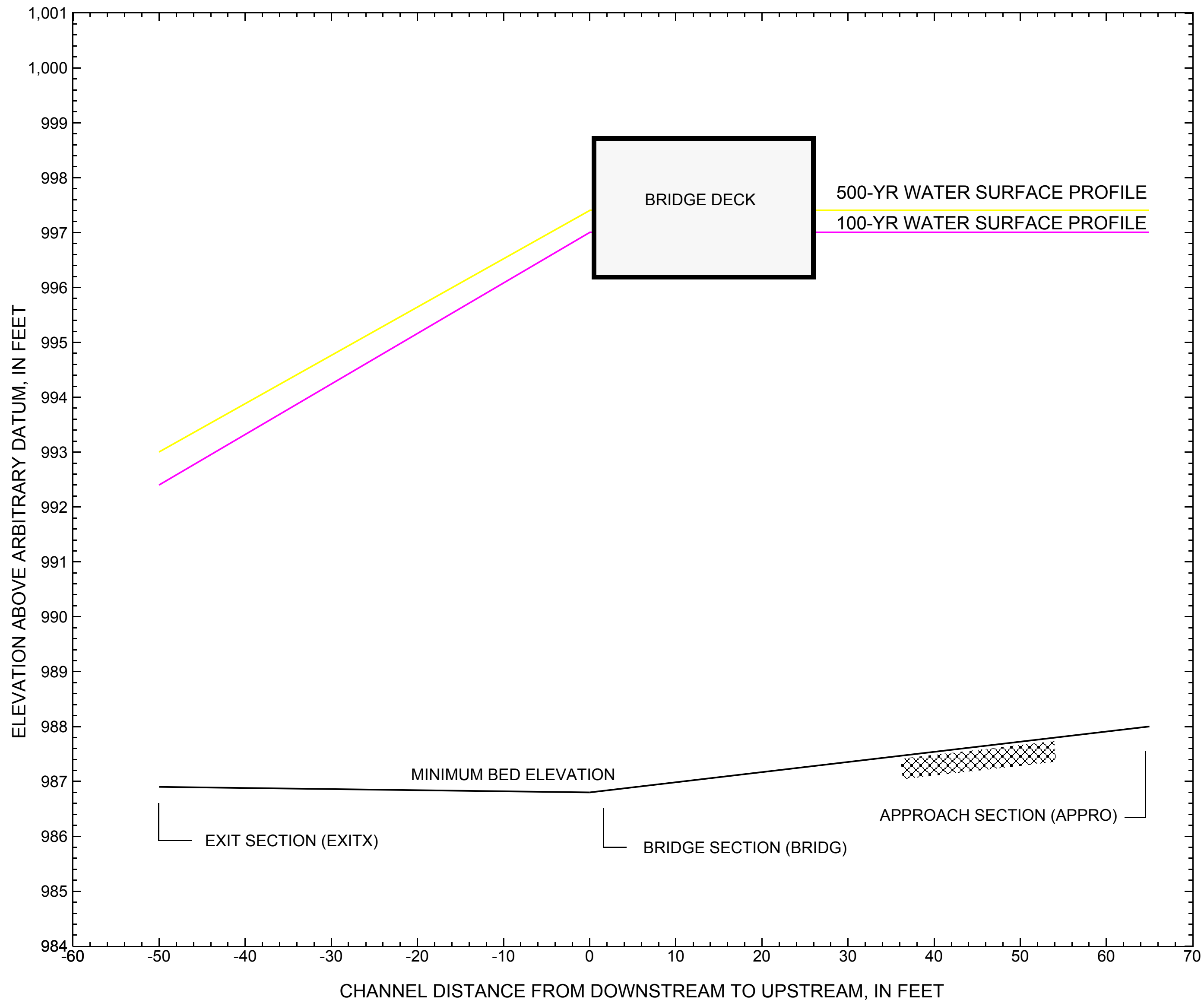


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BETHTH00070038 on town highway 7, crossing Gilead Brook, Bethel, Vermont.

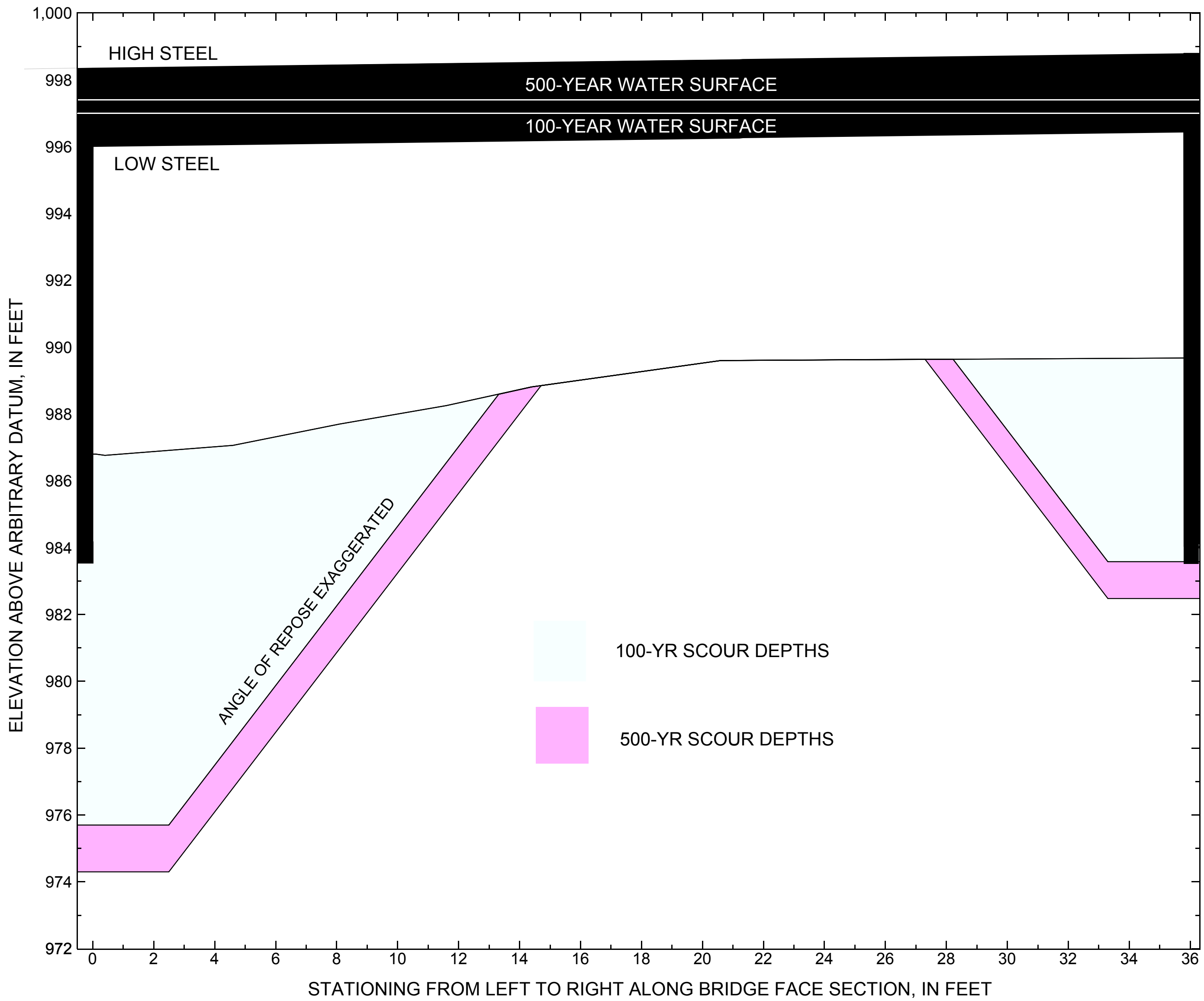


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BETHTH00070038 on town highway 7, crossing Gilead Brook, Bethel, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BETHTH00070038 on Town Highway 7, crossing Gilead Brook, Bethel, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 2,000 cubic-feet per second											
Left abutment	0.0	--	995.7	983.6	986.8	0.0	11.1	--	11.1	975.7	-7.9
Right abutment	35.9	--	996.7	983.6	989.7	0.0	6.1	--	6.1	983.6	0

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 BETHTH00070038 on Town Highway 7, crossing Gilead Brook, Bethel, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2,650 cubic-feet per second											
Left abutment	0.0	--	995.7	983.6	986.8	0.0	12.5	--	12.5	974.3	-9.3
Right abutment	35.9	--	996.7	983.6	989.7	0.0	7.2	--	7.2	982.5	-1.1

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.

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

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.

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, 1981, Randolph, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File beth038.wsp
T2        Hydraulic analysis for structure BETHTH00070038   Date: 30-JAN-96
T3        Hydraulic analysis for Bethel bridge 38 over Gilead Brook by MAI
Q          2000.0,   2650.0   1840.0
SK         0.0280,  0.0280    0.0280
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EXITX    -50
GR          -38.8, 994.88    -21.4, 995.63     -9.6, 995.18     -5.1, 991.95
GR           -0.5, 989.65      0.0, 987.60     11.6, 986.89     18.3, 987.02
GR           22.9, 987.63     31.5, 988.77     38.8, 988.33     48.7, 990.95
GR           57.4, 991.77     62.0, 997.97     65.9,1000.37     86.1,1014.77
*
N           0.045        0.065        0.060
SA                  -5.1         57.4
*
XS   FULLV      0  * * *  0.0127
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0     996.2      23.0
GR            0.0, 995.73      0.0, 988.21      0.1, 986.80      0.4, 986.76
GR            4.6, 987.06      8.1, 987.70     11.6, 988.25     14.4, 988.81
GR           20.6, 989.60     35.8, 989.68     35.9, 996.72      0.0, 995.73
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      41.7 * *     44.3      9.7
N           0.040
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     16      26.0     2
GR         -165.2, 998.04   -112.9, 995.64    -93.2, 995.56    -63.0, 996.23
GR          -19.4, 997.87      0.0, 998.11     36.4, 999.02     61.0, 999.54
GR           80.4, 999.87    130.7, 999.73    187.4, 999.39    229.0, 999.72
GR          270.4,1000.98    320.4,1002.86
*
*           EXPECTED SRD =   62 AT ONE BR. LENGTH BUT COMPUTED SRD =   93
*
XT   ATEMP    93
GR          -29.3,1013.48     -5.5, 994.76     -1.4, 993.19      0.0, 990.48
GR            2.7, 989.84      2.9, 989.66      5.1, 989.05      8.4, 989.44
GR           13.2, 989.19     17.6, 989.19     22.4, 988.79     26.4, 989.53
GR           26.8, 989.73     27.7, 989.99     31.3, 992.86     32.8, 995.41
GR           50.2, 997.23     56.4, 999.65     65.3, 999.95
*
AS   APPRO     65
GT            -0.81
N           0.065        0.055
SA                  28.4
*
HP 1 BRIDG   996.20 1 996.20
HP 2 BRIDG   996.20 * * 1576
HP 2 RDWAY   997.04 * * 445
HP 1 APPRO   997.04 1 997.04
HP 2 APPRO   997.04 * * 2000
*
HP 1 BRIDG   996.20 1 996.20
HP 2 BRIDG   996.20 * * 1855
HP 2 RDWAY   997.36 * * 787
HP 1 APPRO   997.36 1 997.36
HP 2 APPRO   997.36 * * 2650
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
     U.S. Geological Survey WSPRO Input File beth038.wsp
     Hydraulic analysis for structure BETHTH00070038   Date: 30-JAN-96
     Hydraulic analysis for Bethel bridge 38 over Gilead Brook by MAI
        *** RUN DATE & TIME: 02-06-96  11:55
 CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      242     21867     17     64                           5138
996.20           242     21867     17     64  1.00      0     36     5138

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

      WSEL     LEW     REW    AREA         K        Q    VEL
    996.20     0.0    35.9   242.3   21867.    1576.   6.50

X STA.        0.0        2.7        4.5        6.1        7.8        9.4
 A(I)            22.2       14.3       13.4       12.5       12.4
 V(I)            3.55       5.50       5.90       6.31       6.36

X STA.        9.4       11.1       12.8       14.7       16.7       18.3
 A(I)            12.2       12.6       12.8       13.3       10.0
 V(I)            6.45       6.24       6.17       5.94       7.85

X STA.       18.3       19.8       21.3       22.8       24.3       25.9
 A(I)             9.5        9.2        9.3        9.2        9.4
 V(I)            8.31       8.52       8.47       8.55       8.39

X STA.       25.9       27.5       29.1       30.8       32.7       35.9
 A(I)             9.6        9.7       10.3       11.6       18.8
 V(I)            8.22       8.12       7.62       6.81       4.20

 VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      16.

      WSEL     LEW     REW    AREA         K        Q    VEL
    997.04  -143.4   -41.5    93.0    2897.     445.   4.78

X STA.     -143.4     -124.7     -119.4     -115.4     -112.3     -109.4
 A(I)             8.1        5.2        4.7        4.2        4.0
 V(I)            2.76       4.27       4.72       5.26       5.52

X STA.     -109.4     -106.7     -104.1     -101.5      -98.9      -96.4
 A(I)             3.8        3.8        3.7        3.8        3.7
 V(I)            5.80       5.83       5.98       5.92       6.06

X STA.      -96.4      -93.8      -91.2      -88.5      -85.6      -82.3
 A(I)             3.8        3.8        3.8        4.0        4.2
 V(I)            5.87       5.90       5.86       5.61       5.28

X STA.      -82.3      -78.6      -74.4      -69.3      -62.7      -41.5
 A(I)             4.4        4.7        5.1        5.8        8.5
 V(I)            5.05       4.76       4.36       3.86       2.62

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      65.
  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      272     21850     38     41                           4139
          2       51      2138     23     26                            421
997.04           323     23988     61     67  1.09     -8     52     4021
 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      65.
      WSEL     LEW     REW    AREA         K        Q    VEL
    997.04    -9.4    51.8   322.5   23988.    2000.   6.20
X STA.       -9.4        0.1        2.6        4.6        6.4        8.1
 A(I)            31.4       19.2       16.7       15.6       14.5
 V(I)            3.19       5.22       5.98       6.41       6.89

X STA.        8.1        9.8       11.4       13.0       14.5       16.1
 A(I)            14.2       14.0       13.7       13.2       13.2
 V(I)            7.05       7.13       7.28       7.59       7.59

X STA.       16.1       17.6       19.0       20.5       21.9       23.2
 A(I)            13.0       12.7       12.8       12.6       12.4
 V(I)            7.69       7.89       7.84       7.94       8.08

X STA.       23.2       24.7       26.2       28.0       31.0       51.8
 A(I)            12.7       12.8       14.2       19.5       34.2
 V(I)            7.87       7.83       7.04       5.12       2.92
```

WSPRO OUTPUT FILE (continued)

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      242     21867     17     64                         5138
   996.20           242     21867     17     64  1.00      0     36     5138

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       996.20     0.0    35.9   242.3   21867.    1855.   7.66

X STA.         0.0        2.7        4.5        6.1        7.8        9.4
  A(I)             22.2       14.3       13.4       12.5       12.4
  V(I)             4.17       6.47       6.95       7.42       7.49

X STA.         9.4       11.1       12.8       14.7       16.7       18.3
  A(I)             12.2       12.6       12.8       13.3       10.0
  V(I)             7.60       7.34       7.26       6.99       9.23

X STA.        18.3       19.8       21.3       22.8       24.3       25.9
  A(I)              9.5        9.2        9.3        9.2        9.4
  V(I)             9.78      10.03       9.97      10.06       9.88

X STA.        25.9       27.5       29.1       30.8       32.7       35.9
  A(I)              9.6        9.7       10.3       11.6       18.8
  V(I)             9.68       9.56       8.97       8.02       4.94

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      16.

         WSEL     LEW     REW    AREA        K        Q    VEL
       997.36  -150.4   -33.0   128.1    4494.     784.   6.12

X STA.      -150.4     -128.2     -121.9     -117.4     -113.7     -110.5
  A(I)             11.3        7.4        6.3        5.9        5.5
  V(I)             3.47       5.33       6.20       6.60       7.09

X STA.      -110.5     -107.4     -104.4     -101.5      -98.7      -95.8
  A(I)              5.3        5.2        5.1        5.1        5.1
  V(I)             7.43       7.48       7.68       7.72       7.67

X STA.       -95.8      -93.0      -90.0      -86.9      -83.5      -79.8
  A(I)              5.1        5.2        5.3        5.4        5.8
  V(I)             7.69       7.59       7.39       7.21       6.77

X STA.       -79.8      -75.6      -71.0      -65.4      -58.0      -33.0
  A(I)              6.1        6.3        7.0        7.9       11.8
  V(I)             6.44       6.20       5.64       4.94       3.32

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      65.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      284     23310     38     42                         4396
             2       58      2642     24     27                          511
   997.36           342     25952     62     69  1.09     -9     53     4360

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      65.

         WSEL     LEW     REW    AREA        K        Q    VEL
       997.36    -9.8    52.6   342.3   25952.    2650.   7.74

X STA.        -9.8       -0.1        2.5        4.6        6.4        8.1
  A(I)             32.9       20.3       18.1       16.4       15.3
  V(I)             4.02       6.54       7.31       8.06       8.66

X STA.         8.1        9.8       11.5       13.1       14.7       16.2
  A(I)             15.0       15.0       14.1       14.2       13.8
  V(I)             8.86       8.83       9.41       9.33       9.62

X STA.        16.2       17.7       19.2       20.7       22.1       23.5
  A(I)             13.8       13.5       13.6       13.1       13.3
  V(I)             9.61       9.83       9.77      10.12       9.94

X STA.        23.5       25.0       26.6       28.5       32.4       52.6
  A(I)             13.4       13.9       15.2       22.9       34.5
  V(I)             9.90       9.55       8.70       5.78       3.84
```

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

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      152     13055     33     43                         1849
    993.35           152     13055     33     43  1.00      0     36     1849

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        993.35     0.0    35.9   151.9   13055.    1840.  12.12

 X STA.         0.0        2.3        3.6        4.8        5.9        7.0
   A(I)             13.5        7.7        7.0        6.5        6.1
   V(I)             6.81      11.89      13.22      14.09      15.04

 X STA.         7.0        8.2        9.4       10.7       12.0       13.4
   A(I)              6.2        6.2        6.2        6.3        6.4
   V(I)            14.80      14.72      14.95      14.59      14.44

 X STA.        13.4       15.0       16.8       18.6       20.7       22.9
   A(I)              6.8        6.8        7.0        7.3        7.6
   V(I)            13.61      13.47      13.06      12.53      12.07

 X STA.        22.9       25.1       27.3       29.7       32.2       35.9
   A(I)              7.5        7.8        8.0        8.5       12.4
   V(I)            12.30      11.78      11.48      10.87       7.44

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      65.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      232     17195     36     40                         3311
              2       27       922     17     20                          195
    995.95           259     18117     54     59  1.08     -7     46     3101

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      65.

          WSEL     LEW     REW    AREA        K        Q    VEL
        995.95    -8.0    45.7   258.8   18117.    1840.   7.11

 X STA.        -8.0        0.7        3.0        4.9        6.5        8.2
   A(I)             25.1       15.8       13.9       12.5       12.2
   V(I)             3.66       5.83       6.62       7.34       7.52

 X STA.         8.2        9.8       11.3       12.8       14.2       15.7
   A(I)             11.6       11.3       11.3       10.9       10.9
   V(I)             7.91       8.11       8.11       8.43       8.43

 X STA.        15.7       17.1       18.5       19.8       21.2       22.5
   A(I)             10.6       10.6       10.5       10.4       10.3
   V(I)             8.70       8.68       8.76       8.87       8.95

 X STA.        22.5       23.8       25.2       26.7       28.5       45.7
   A(I)             10.1       10.7       11.0       12.1       26.9
   V(I)             9.07       8.61       8.38       7.61       3.42
```

WSPRO OUTPUT FILE (continued)

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

EXITX:XS   ******     -5      227  1.21 *****  993.57  991.89    2000  992.36
       -49 ******     58    11948  1.00 ***** *******    0.82    8.81

FULLV:FV       50     -6      277  0.82  1.01  994.58 *******    2000  993.77
         0     50     58    16505  1.01  0.00    0.00    0.62    7.22
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.81     994.59     993.88

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   993.27    1012.67    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   993.27    1012.67     993.88

APPRO:AS       65     -5      196  1.66  1.25  996.25  993.88    2000  994.59
        65     65     33    12617  1.02  0.42    0.00    0.81   10.21
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   996.32       0.00     993.60     995.56

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   998.93         0.      2000.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

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

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

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

BRIDG:BR       50      0      242  0.66 *****  996.86  992.90    1576  996.20
         0 ******     36    21867  1.00 ***** *******    0.44    6.51

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.373  0.000  996.20 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      16.    39.  0.27  0.65  997.42    0.01    447.  997.04

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    447.   102.  -143.   -42.   1.5   0.9   5.1   4.8   1.3   3.0
   RT:      0.   130.    14.   220.   1.2   0.3   4.7  11.4   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       23     -8      322  0.65  0.14  997.69  993.88    2000  997.04
        65     23     52    23966  1.09  0.00    0.01    0.50    6.21

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -50.    -6.    58.   2000.   11948.     227.    8.81  992.36
   FULLV:FV       0.    -7.    58.   2000.   16505.     277.    7.22  993.77
   BRIDG:BR       0.     0.    36.   1576.   21867.     242.    6.51  996.20
   RDWAY:RG      16.*******   447.    447.*********       0.    2.00  997.04
   APPRO:AS      65.    -9.    52.   2000.   23966.     322.    6.21  997.04

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    991.89    0.82  986.89 1014.77************  1.21  993.57  992.36
   FULLV:FV  ********    0.62  987.53 1015.41  1.01  0.00  0.82  994.58  993.77
   BRIDG:BR    992.90    0.44  986.76  996.72************  0.66  996.86  996.20
   RDWAY:RG  ***************  995.56 1002.86  0.27******  0.65  997.42  997.04
   APPRO:AS    993.88    0.50  987.98 1012.67  0.14  0.00  0.65  997.69  997.04
```

WSPRO OUTPUT FILE (continued)

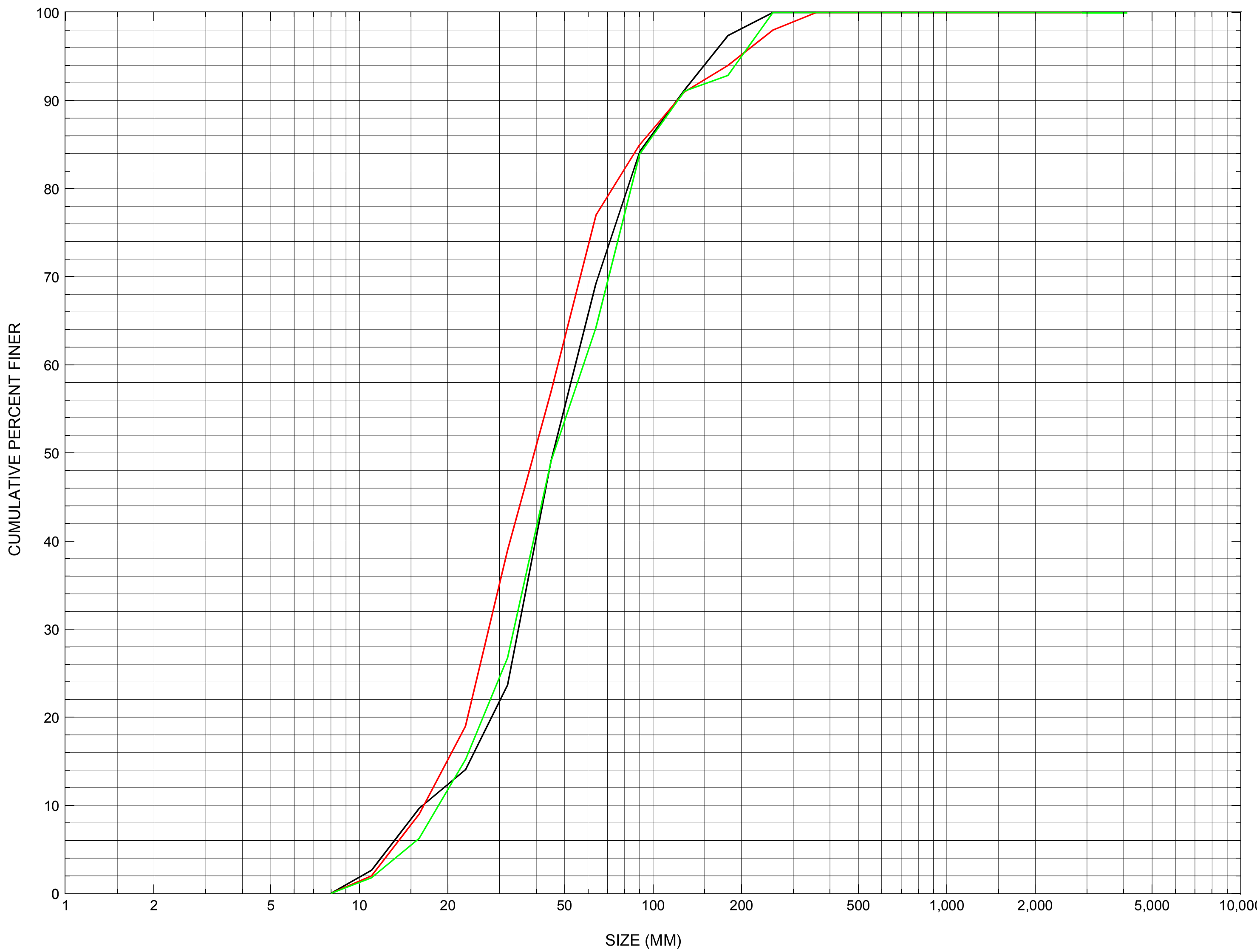
```
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******     -6      270  1.51 *****  994.53  992.56    2650  993.02
       -49 ******     58    15833  1.01 ***** *******    0.85    9.82

FULLV:FV       50     -7      327  1.04  1.03  995.56 *******    2650  994.52
         0     50     59    21570  1.01  0.00    0.00    0.65    8.11
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.97     995.30     994.62

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   994.02    1012.67    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   994.02    1012.67     994.62

APPRO:AS       65     -6      226  2.26  1.39  997.56  994.62    2650  995.30
        65     65     39    15252  1.06  0.61    0.00    0.97   11.72
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   997.80       0.00     994.59     995.56

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   999.27         0.      2650.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

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

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

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

BRIDG:BR       50      0      242  0.91 *****  997.11  993.37    1858  996.20
         0 ******     36    21867  1.00 ***** *******    0.52    7.67

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.414  0.000  996.20 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      16.    39.  0.41  1.01  997.97    0.00    787.  997.36

           Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    787.   117.  -150.   -33.   1.8   1.1   5.9   6.2   1.7   3.0
   RT:      0.   164.    15.   230.   1.3   0.3   4.7  11.3   1.2   2.9

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

APPRO:AS       23     -9      342  1.01  0.21  998.37  994.62    2650  997.36
        65     24     53    25940  1.09  0.00    0.00    0.61    7.74

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -50.    -7.    58.   2650.   15833.     270.    9.82  993.02
   FULLV:FV      0.     -8.    59.   2650.   21570.     327.    8.11  994.52
   BRIDG:BR      0.      0.    36.   1858.   21867.     242.    7.67  996.20
   RDWAY:RG     16.*******   787.    787.*********       0.    2.00  997.36
   APPRO:AS     65.   -10.    53.   2650.   25940.     342.    7.74  997.36

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    992.56    0.85  986.89 1014.77************  1.51  994.53  993.02
   FULLV:FV  ********    0.65  987.53 1015.41  1.03  0.00  1.04  995.56  994.52
   BRIDG:BR    993.37    0.52  986.76  996.72************  0.91  997.11  996.20
   RDWAY:RG  ****************  995.56 1002.86  0.41******  1.01  997.97  997.36
   APPRO:AS    994.62    0.61  987.98 1012.67  0.21  0.00  1.01  998.37  997.36
```

WSPRO OUTPUT FILE (continued)

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

EXITX:XS   ******     -4      216  1.13 *****  993.31  991.70    1840  992.18
       -49 ******     58    10992  1.00 ***** *******    0.81    8.52

FULLV:FV       50     -5      264  0.76  1.01  994.33 *******    1840  993.57
         0     50     58    15259  1.01  0.00    0.00    0.61    6.98
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       65     -5      188  1.52  1.21  995.92 *******    1840  994.40
        65     65     33    11901  1.02  0.38    0.00    0.79    9.77
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   995.95       0.00     993.35     995.56

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   998.84         0.      1840.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

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

 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                        YU/Z,WSIU,WS = 1.09     996.81     996.94

 ===270 REJECTED 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       50      0      152  2.29  1.18  995.63  986.96    1840  993.35
         0     50     36    13040  1.00  0.20    0.00    1.00   12.12

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  996.20 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      16.        <<<<<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       23     -7      259  0.85  0.34  996.80  993.61    1840  995.95
        65     24     46    18118  1.08  0.83    0.00    0.59    7.11

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.075  0.003   18044.     2.    38.   995.55

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -50.    -5.    58.   1840.   10992.     216.    8.52  992.18
   FULLV:FV       0.    -6.    58.   1840.   15259.     264.    6.98  993.57
   BRIDG:BR       0.     0.    36.   1840.   13040.     152.   12.12  993.35
   RDWAY:RG      16.**************      0.*********       0.    2.00********
   APPRO:AS      65.    -8.    46.   1840.   18118.     259.    7.11  995.95

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       2.    38.   18044.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS      FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    991.70    0.81  986.89 1014.77************  1.13  993.31  992.18
   FULLV:FV  ********    0.61  987.53 1015.41  1.01  0.00  0.76  994.33  993.57
   BRIDG:BR    986.96    1.00  986.76  996.72  1.18  0.20  2.29  995.63  993.35
   RDWAY:RG  ****************  995.56 1002.86************  0.57  997.27********
   APPRO:AS    993.61    0.59  987.98 1012.67  0.34  0.83  0.85  996.80  995.95
```

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 BETHTH00070038, in Bethel, Vermont.

APPENDIX D:

HISTORICAL DATA FORM