LEVEL II SCOUR ANALYSIS FOR BRIDGE 5C (CORITH0003005C) on TOWN HIGHWAY 3 (FAS192), crossing COOKSVILLE BROOK, CORINTH, VERMONT

U.S. Geological Survey
Open-File Report 97-111

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 5C (CORITH0003005C) on TOWN HIGHWAY 3 (FAS192), crossing COOKSVILLE BROOK, CORINTH, VERMONT

By MICHAEL A. IVANOFF & TIM SEVERANCE

U.S. Geological Survey
Open-File Report 97-111

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

Pembroke, New Hampshire

1997

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
Branch of Information Services
Open-File Reports Unit
Box 25286
Denver, CO 80225-0286

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 5C (CORITH0003005C) ON TOWN HIGHWAY 3 (FAS192), CROSSING COOKSVILLE BROOK, CORINTH, VERMONT

By **Michael A. Ivanoff and Tim Severance**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure CORITH0003005C on Town Highway 3 crossing Cooksville Brook, Corinth, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the New England Upland section of the New England physiographic province in east-central Vermont. The 20.2-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture with a residence on the upstream right bank near the bridge. The immediate channel banks have some woody vegetation cover.

In the study area, Cooksville Brook has an incised, sinuous channel with a slope of approximately 0.005 ft/ft, an average channel top width of 46 ft and an average channel depth of 8 ft. The channel bed material ranged from sand to cobble and had a median grain size (D_{50}) of 41.0 mm (0.135 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 5, 1995, indicated that the reach was stable.

The Town Highway 3 crossing of Cooksville Brook is a 39-ft-long, two-lane bridge consisting of one 37-foot steel-beam span (Vermont Agency of Transportation, written communication, March 17, 1995). The bridge is supported by vertical, concrete abutments with wingwalls on the left abutment. The channel is skewed approximately 30 degrees to the opening while the opening-skew-to-roadway is 0 degrees.

A scour hole 0.5 ft deeper than the mean thalweg depth was observed along the right abutment during the Level I assessment. The only scour protection measures at the site were type-2 stone fill (less than 36 inches diameter) at the upstream and downstream ends of the right abutment and type-4 (less than 60 inches diameter) along the upstream right bank below the residence. Also, there is a wall along the upstream right bank. 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, 1995). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 2.7 to 3.3 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 7.0 to 19.0 ft. The worst-case left abutment scour occurred at the incipient overtopping discharge. The worst-case right abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

West Topsham, 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 CORITH0003005C ***Stream*** Cooksville Brook

County Orange ***Road*** TH3 ***District*** 7

Description of Bridge

Bridge length 39 ***ft*** ***Bridge width*** 31.7 ***ft*** ***Max span length*** 37 ***ft***

Alignment of bridge to road (on curve or straight) Straight with 'T' intersection left bank

Abutment type Vertical, concrete ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 09/05/95

Description of stone fill Type-2, at the upstream and downstream ends of the right abutment. Type-4, along the upstream right bank below the residence. There is also a wall along the upstream right bank.

Abutments and wingwalls are concrete. There is a half foot deep scour hole along the front of the right abutment.

Is bridge skewed to flood flow according to […] survey? Yes ***Angle*** 30

Yes

There is a mild channel bend in the upstream reach. *(mild, moderate, severe)*

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	09/05/95	10%	0
Level II	09/05/95	10%	0

Potential for debris Moderate. There were some debris caught under the bridge on the point bar along the left abutment and the upstream end of the right abutment.

Describe any features near or at the bridge that may affect flow (include observation date) A point bar under the bridge along the left abutment 09/05/95.

Description of the Geomorphic Setting

General topography The channel is in a 550 ft wide valley with a flat to slightly irregular flood plain and steep valley walls on both sides.

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

Date of inspection 09/05/95

DS left: Steep channel bank to a narrow terrace

DS right: Flood plain

US left: Steep channel bank to a narrow terrace

US right: Flood plain

Description of the Channel

Average top width 45.5 ft ***Average depth*** 7.5 ft

Predominant bed material Gravel / Cobbles ***Bank material*** Cobbles

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

09/05/95

Vegetative co Some trees on immediate bank with grass and woods on the valley wall

DS left: Pasture

DS right: Brush and trees on immediate bank with grass and woods on the valley wall

US left: Pasture

US right: Yes

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

The assessment of 09/05/95 noted a point bar under the bridge along the left abutment. There was also a log at the upstream end of the right abutment and another at the downstream bridge face.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 20.2 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: There is a house and barn on the upstream right bank near the bridge.

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 2,750 ***ft³/s*** ***Q500*** 3,750 ***ft³/s***

The 100- and 500-year discharges are based on median values of empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887; Vermont Agency of Transportation, 1996)

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the left abutment wingwall (elev. 225.87 ft, arbitrary survey datum). RM2 is a chiseled X on top of concrete curb above the downstream end of the right abutment (elev. 227.26 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	-31	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	18	1	Road Grade section
APPRO	67	1	Approach section as surveyed

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.035 to 0.055, and overbank "n" values ranged from 0.035 to 0.044.

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 0.0046 ft/ft which was determined from downstream surveyed thalweg points.

The surveyed approach section (APPRO) was located 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.

Bridge Hydraulics Summary

Average bridge embankment elevation 226.4 *ft*
Average low steel elevation 223.4 *ft*

100-year discharge 2,750 *ft³/s*
Water-surface elevation in bridge opening 220.6 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 209 *ft²*
Average velocity in bridge opening 13.2 *ft/s*
Maximum WSPRO tube velocity at bridge 16.5 *ft/s*

Water-surface elevation at Approach section with bridge 223.2
Water-surface elevation at Approach section without bridge 222.1
Amount of backwater caused by bridge 1.1 *ft*

500-year discharge 3,750 *ft³/s*
Water-surface elevation in bridge opening 223.6 *ft*
Road overtopping? Yes *Discharge over road* 462 *ft³/s*
Area of flow in bridge opening 305 *ft²*
Average velocity in bridge opening 10.9 *ft/s*
Maximum WSPRO tube velocity at bridge 13.0 *ft/s*

Water-surface elevation at Approach section with bridge 226.6
Water-surface elevation at Approach section without bridge 223.0
Amount of backwater caused by bridge 3.6

Incipient overtopping discharge 2,890 *ft³/s*
Water-surface elevation in bridge opening 220.7 *ft*
Area of flow in bridge opening 210 *ft²*
Average velocity in bridge opening 13.8 *ft/s*
Maximum WSPRO tube velocity at bridge 17.2 *ft/s*

Water-surface elevation at Approach section with bridge 223.6
Water-surface elevation at Approach section without bridge 222.2
Amount of backwater caused by bridge 1.4 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour was computed for the 100-year and incipient overtopping discharges by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The 500-year discharge resulted in unsubmerged orifice flow. Contraction scour at bridges with unsubmerged orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour was computed by the Chang equation (Richardson and others, 1995, p. 145-146). The results of Laursen's clear-water contraction scour for this event was also computed and can be found in appendix F.

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

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	2.7	3.3	3.0
Depth to armoring	42.4 6.3	62.7	--
Left overbank	--	--	--
Right overbank	--	--	8.1 7.0

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour	8.3	12.7	19.0
Left abutment	13.7	--	--
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	2.5	2.2
Pier 3			

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:	2.5	2.5	2.2
Left abutment	2.5	--	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--		
Pier 2			

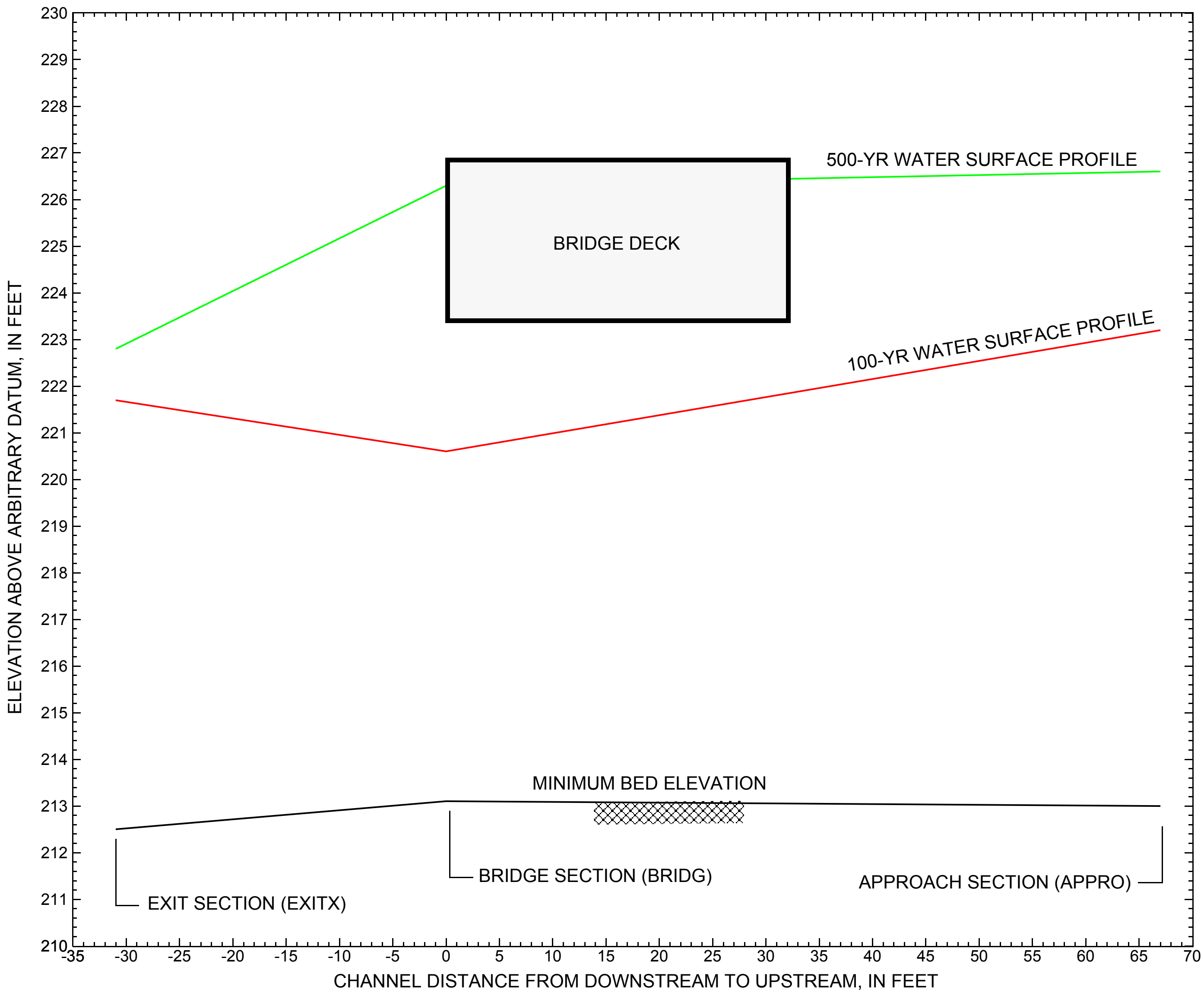


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure CORITH0003005C on Town Highway 3, crossing Cooksville Brook, Corinth, Vermont.

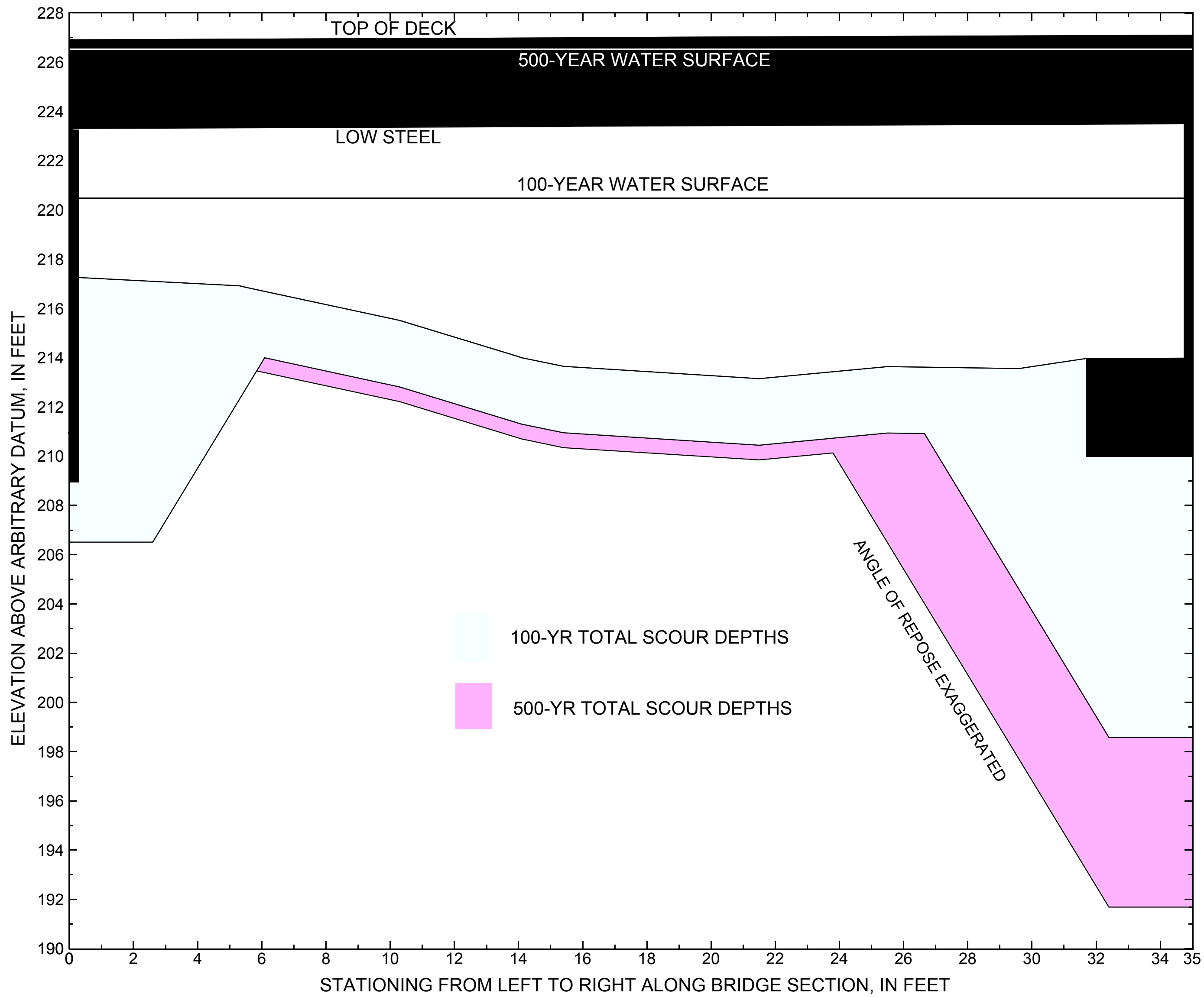


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure CORITH0003005C on Town Highway 3, crossing Cooksville Brook, Corinth, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure CORITH0003005C on Town Highway 3, crossing Cooksville Brook, Corinth, 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 2,750 cubic-feet per second											
Left abutment	0.0	223.1	223.1	209.0	217.3	2.7	8.1	--	10.8	206.5	-2.5
Right abutment	35.0	223.6	223.6	210.0	214.0	2.7	12.7	--	15.4	198.6	-11.4

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 CORITH0003005C on Town Highway 3, crossing Cooksville Brook, Corinth, 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 3,750 cubic-feet per second											
Left abutment	0.0	223.1	223.1	209.0	217.3	3.3	7.0	--	10.3	207.0	-2
Right abutment	35.0	223.6	223.6	210.0	214.0	3.3	19.0	--	22.3	191.7	-18.3

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

SELECTED REFERENCES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

U.S. Geological Survey, 1981, West Topsham, 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 cori05c.wsp
T2        Hydraulic analysis for structure CORITH0003005C   Date: 16-SEP-96
T3        Bridge 5C over Cooksville Brook in Corinth, VT  by MAI
Q           2750.0   3750.0  2890.0
SK          0.0046   0.0046  0.0046
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EXITX    -31
GR          -83.8, 233.07    -63.2, 222.67    -30.8, 224.69    -15.9, 224.13
GR           -6.4, 217.66      0.0, 213.72      3.0, 212.82      4.6, 212.48
GR            7.0, 212.46     12.8, 212.98     15.8, 213.67     21.7, 216.61
GR           26.2, 217.69     53.3, 218.01     65.9, 219.51    105.1, 223.79
GR          125.5, 225.92    166.9, 226.74    175.8, 227.90    214.1, 228.52
GR          243.6, 228.29    275.2, 229.50
N           0.045       0.035
SA                  26.2
*
XS   FULLV      0  * * *   0.0071
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    223.36       0.0
GR            0.0, 223.07      0.1, 217.31      5.3, 216.92     10.3, 215.51
GR           14.1, 214.00     15.4, 213.65     21.5, 213.15     25.5, 213.64
GR           29.6, 213.56     31.7, 213.97     34.9, 213.98     35.0, 223.65
GR            0.0, 223.07
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      39.9 * *     30.0     13.9
N           0.035
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     18      31.7     1
GR          -88.8, 235.48    -59.8, 223.93    -33.8, 225.85    -10.1, 224.99
GR           -9.7, 226.60     -6.5, 226.65     -0.4, 226.72      0.0, 226.81
GR            8.0, 226.91     15.4, 227.10     35.0, 227.20     51.3, 227.29
GR           51.5, 226.05    130.1, 226.95    203.2, 228.07    377.5, 233.90
GR          459.8, 238.27
*
AS   APPRO     67
GR          -92.7, 234.10    -67.4, 224.21    -41.8, 226.47    -20.6, 226.36
GR           -8.8, 223.40     -4.1, 220.85      0.0, 219.03      5.1, 214.42
GR           11.6, 213.99     13.6, 213.49     17.9, 212.96     21.0, 213.25
GR           25.4, 213.48     26.6, 213.93     28.1, 214.07     33.5, 218.03
GR           43.6, 220.37     77.2, 223.94    117.1, 224.96    142.8, 225.29
GR          150.9, 226.47    203.2, 228.07    377.5, 233.90    459.8, 238.27
N           0.055     0.044
SA                  43.6
*
HP 1 BRIDG    220.61 1 220.61
HP 2 BRIDG    220.61 * * 2750
HP 1 APPRO    223.23 1 223.23
HP 2 APPRO    223.23 * * 2750
*
HP 1 BRIDG    223.65 1 223.65
HP 2 BRIDG    223.65 * * 3283
HP 2 RDWAY    226.42 * * 462
HP 1 APPRO    226.62 1 226.62
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
     U.S. Geological Survey WSPRO Input File cori05c.wsp
    Hydraulic analysis for structure CORITH0003005C   Date: 16-SEP-96
    Bridge 5C over Cooksville Brook in Corinth, VT  by MAI
       *** RUN DATE & TIME: 12-19-96  11:57
 CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      209     24581     35     45                         2896
220.61           209     24581     35     45  1.00      0     35     2896

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

     WSEL     LEW     REW    AREA        K        Q    VEL
   220.61     0.0    35.0   208.7   24581.    2750.  13.17

X STA.        0.0        5.3        8.5       10.8       12.7       14.2
  A(I)          18.2       13.2       11.4       10.6       10.0
  V(I)          7.55      10.44      12.01      12.95      13.81

X STA.       14.2       15.6       16.9       18.1       19.2       20.4
  A(I)           9.2        9.0        8.6        8.5        8.3
  V(I)         14.98      15.34      15.91      16.19      16.48

X STA.       20.4       21.5       22.6       23.8       25.0       26.3
  A(I)           8.3        8.3        8.5        8.6        8.9
  V(I)         16.48      16.54      16.10      15.93      15.49

X STA.       26.3       27.6       28.9       30.4       32.1       35.0
  A(I)           9.1        9.4       10.1       11.4       19.0
  V(I)         15.17      14.66      13.59      12.09       7.22

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      67.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          2      352     32251     52     57                         5195
          3       38      1648     27     27                          261
223.23           391     33900     79     84  1.07     -7     71     4761

 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      67.

     WSEL     LEW     REW    AREA        K        Q    VEL
   223.23    -8.5    70.5   390.6   33900.    2750.   7.04

X STA.       -8.5        2.9        5.8        7.9        9.9       11.6
  A(I)          34.9       22.8       19.0       17.9       16.4
  V(I)          3.93       6.04       7.25       7.69       8.40

X STA.       11.6       13.4       14.9       16.5       17.9       19.4
  A(I)          16.6       15.1       15.2       14.8       14.8
  V(I)          8.30       9.10       9.02       9.28       9.27

X STA.       19.4       20.8       22.3       23.9       25.4       27.1
  A(I)          14.8       14.7       15.2       15.3       16.4
  V(I)          9.28       9.38       9.03       9.01       8.41

X STA.       27.1       29.0       31.7       36.0       43.3       70.5
  A(I)          17.0       20.3       22.7       27.5       39.2
  V(I)          8.08       6.79       6.05       5.00       3.50
```

```
      U.S. Geological Survey WSPRO Input File cori05c.wsp
      Hydraulic analysis for structure CORITH0003005C   Date: 16-SEP-96
      Bridge 5C over Cooksville Brook in Corinth, VT  by MAI
         *** RUN DATE & TIME: 12-19-96  11:57
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      305     30206      0     86                            0
 223.65           305     30206      0     86  1.00      0     35        0

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     223.65     0.0    35.0   304.9   30206.    3314.  10.87

X STA.         0.0        4.2         7.1         9.5        11.5        13.2
  A(I)            24.9        18.6        16.6        16.2        14.6
  V(I)            6.66        8.92       10.00       10.22       11.35

X STA.        13.2       14.8        16.2        17.5        18.8        20.1
  A(I)            14.1        13.6        13.2        12.7        12.9
  V(I)           11.79       12.17       12.59       13.02       12.86

X STA.        20.1       21.3        22.5        23.8        25.1        26.4
  A(I)            12.6        12.7        12.7        12.9        13.3
  V(I)           13.10       13.06       13.07       12.81       12.47

X STA.        26.4       27.8        29.2        30.6        32.3        35.0
  A(I)            13.5        13.4        14.8        16.2        25.4
  V(I)           12.29       12.33       11.21       10.21        6.52

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      18.

       WSEL     LEW     REW    AREA        K        Q    VEL
     226.42   -66.1    83.8    77.5    4032.     462.   5.96

X STA.       -66.1      -61.3       -59.9       -58.8       -57.8       -56.6
  A(I)             4.5         3.0         2.6         2.5         2.6
  V(I)            5.19        7.58        8.73        9.06        8.86

X STA.       -56.6      -55.5       -54.2       -52.8       -51.4       -49.7
  A(I)             2.6         2.7         2.8         2.8         3.0
  V(I)            8.96        8.62        8.30        8.18        7.68

X STA.       -49.7      -47.8       -45.6       -42.8       -39.0       -29.9
  A(I)             3.1         3.4         3.7         4.2         6.4
  V(I)            7.36        6.71        6.31        5.48        3.61

X STA.       -29.9      -23.9       -19.8       -16.6       -12.7        83.8
  A(I)             5.0         4.1         3.7         4.9         9.8
  V(I)            4.66        5.63        6.28        4.67        2.36

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      67.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1       65      2409     65     66                          370
           2      530     63439     52     57                         9557
           3      281     17559    112    112                         2529
 226.62           876     83406    229    235  1.30    -73    156     8527

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      67.

       WSEL     LEW     REW    AREA        K        Q    VEL
     226.62   -73.6   155.8   876.2   83406.    3750.   4.28

X STA.       -73.6       -3.3         2.9         6.1         8.8        11.4
  A(I)            91.2        47.8        37.8        33.0        32.0
  V(I)            2.06        3.93        4.95        5.68        5.87

X STA.        11.4       13.7        16.0        18.1        20.2        22.4
  A(I)            30.6        29.7        29.3        28.5        29.0
  V(I)            6.13        6.31        6.39        6.58        6.46

X STA.        22.4       24.6        27.0        29.6        33.5        38.4
  A(I)            29.3        30.5        32.4        39.1        39.1
  V(I)            6.40        6.15        5.78        4.80        4.80

X STA.        38.4       45.2        53.7        66.5        91.2       155.8
  A(I)            45.2        48.2        57.3        69.8        96.4
  V(I)            4.15        3.89        3.27        2.68        1.95
```

```
     U.S. Geological Survey WSPRO Input File cori05c.wsp
     Hydraulic analysis for structure CORITH0003005C   Date: 16-SEP-96
     Bridge 5C over Cooksville Brook in Corinth, VT  by MAI
        *** RUN DATE & TIME: 12-19-96  11:57
 CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      210     24827     35     45                         2925
220.65           210     24827     35     45  1.00      0     35     2925

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

      WSEL     LEW     REW    AREA        K        Q    VEL
    220.65     0.0    35.0   210.1   24827.    2890.  13.75

X STA.        0.0        5.3        8.4       10.7       12.7       14.2
  A(I)           18.4       13.0       11.5       10.9       10.0
  V(I)           7.85      11.11      12.52      13.22      14.44

X STA.       14.2       15.6       16.8       18.1       19.2       20.4
  A(I)            9.2        9.0        8.7        8.4        8.5
  V(I)          15.67      16.04      16.64      17.20      16.98

X STA.       20.4       21.5       22.6       23.8       25.0       26.3
  A(I)            8.4        8.4        8.6        8.7        8.9
  V(I)          17.21      17.26      16.80      16.62      16.17

X STA.       26.3       27.6       28.9       30.4       32.1       35.0
  A(I)            9.1        9.4       10.2       11.5       19.2
  V(I)          15.83      15.30      14.19      12.61       7.53

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      67.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1        0         0      1      1                            0
          2      370     34867     52     57                         5576
          3       48      2224     30     30                          346
223.57           418     37091     83     88  1.08     -8     74     5124

 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      67.

      WSEL     LEW     REW    AREA        K        Q    VEL
    223.57    -9.5    73.7   418.1   37091.    2890.   6.91

X STA.       -9.5        2.7        5.6        7.8        9.8       11.6
  A(I)           37.1       24.6       20.2       18.6       17.5
  V(I)           3.90       5.89       7.16       7.78       8.27

X STA.       11.6       13.4       15.0       16.6       18.1       19.6
  A(I)           17.4       16.7       15.8       15.9       15.9
  V(I)           8.32       8.66       9.15       9.10       9.11

X STA.       19.6       21.1       22.7       24.2       25.9       27.6
  A(I)           15.7       16.0       15.8       16.8       17.0
  V(I)           9.23       9.04       9.14       8.58       8.49

X STA.       27.6       29.7       32.9       37.7       45.4       73.7
  A(I)           19.0       22.7       24.8       28.3       42.6
  V(I)           7.61       6.38       5.84       5.10       3.39
```

```
       U.S. Geological Survey WSPRO Input File cori05c.wsp
       Hydraulic analysis for structure CORITH0003005C   Date: 16-SEP-96
       Bridge 5C over Cooksville Brook in Corinth, VT  by MAI
          *** RUN DATE & TIME: 12-19-96  11:57

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

EXITX:XS   ******    -11      412  0.73 *****  222.42  220.25    2750  221.70
       -30 ******     86    40512  1.05 ***** *******    0.59    6.68

FULLV:FV       31    -11      405  0.75  0.15  222.60 *******    2750  221.85
         0     31     85    39614  1.05  0.01    0.02    0.60    6.79
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  0.63

APPRO:AS       67     -5      307  1.30  0.51  223.38 *******    2750  222.08
        67     67     60    24928  1.04  0.27   -0.01    0.75    8.95
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

            <<<<<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       31      0      209  2.70  0.24  223.31  220.42    2750  220.61
         0     31     35    24555  1.00  0.65    0.00    0.95   13.18

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  223.36 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.        <<<<<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       27     -7      390  0.83  0.25  224.05  220.66    2750  223.23
        67     28     70    33869  1.07  0.50    0.02    0.58    7.05

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.471  0.063   31622.    -1.    34.   222.99

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -31.   -12.    86.   2750.   40512.     412.    6.68  221.70
   FULLV:FV       0.   -12.    85.   2750.   39614.     405.    6.79  221.85
   BRIDG:BR       0.     0.    35.   2750.   24555.     209.   13.18  220.61
   RDWAY:RG      18.**************       0.******************    1.00********
   APPRO:AS      67.    -8.    70.   2750.   33869.     390.    7.05  223.23

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -1.    34.   31622.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    220.25    0.59  212.46  233.07************  0.73  222.42  221.70
   FULLV:FV  ********    0.60  212.68  233.29  0.15  0.01  0.75  222.60  221.85
   BRIDG:BR    220.42    0.95  213.15  223.65  0.24  0.65  2.70  223.31  220.61
   RDWAY:RG  p***************  223.93  238.27**********************************
   APPRO:AS    220.66    0.58  212.96  238.27  0.25  0.50  0.83  224.05  223.23
```

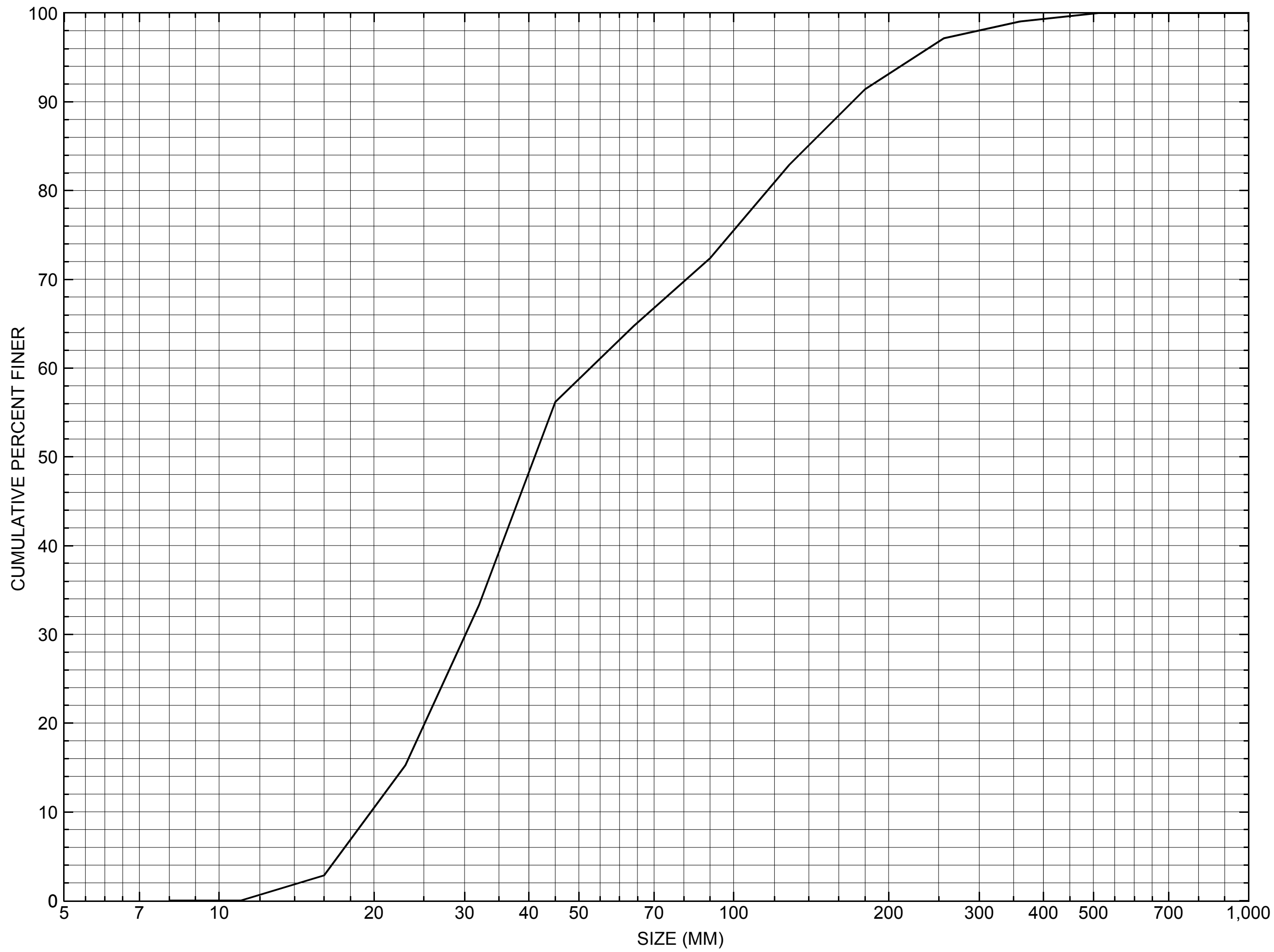
```
        U.S. Geological Survey WSPRO Input File cori05c.wsp
        Hydraulic analysis for structure CORITH0003005C   Date: 16-SEP-96
        Bridge 5C over Cooksville Brook in Corinth, VT  by MAI
           *** RUN DATE & TIME: 12-19-96  11:57

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

EXITX:XS   ******    -62      518  0.84 *****  223.56  221.09    3750  222.72
       -30 ******     95    55290  1.03 ***** *******    0.60    7.24

FULLV:FV       31    -13      508  0.87  0.15  223.73 *******    3750  222.85
         0     31     94    53851  1.03  0.02    0.00    0.61    7.38
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.83     222.98     222.02

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   222.35     238.27    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   222.35     238.27     222.02

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.60

APPRO:AS       67     -7      374  1.67  0.55  224.69  222.02    3750  223.02
        67     67     69    32097  1.07  0.40    0.02    0.83   10.02
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   225.35       0.00     221.74     223.93

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   221.63     224.92     225.14     223.36

 ===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       31      0      305  1.84 *****  225.49  221.18    3314  223.65
         0 ******     35    30206  1.00 ***** *******    0.65   10.87

     TYPE PPCD FLOW       C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    5.  0.484 ******  223.36 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.    35.  0.07  0.37  226.92    0.01    462.  226.42

           Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   406.    56.   -66.   -10.   2.5   1.3   6.1   5.7   1.8   3.1
   RT:    56.    33.    51.    84.   0.4   0.2   3.8   9.2   0.7   3.0

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

APPRO:AS       27    -73      877  0.37  0.14  226.99  222.02    3750  226.62
        67     28    156    83442  1.30  0.56    0.01    0.44    4.28

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -31.   -63.    95.   3750.   55290.     518.    7.24  222.72
   FULLV:FV       0.   -14.    94.   3750.   53851.     508.    7.38  222.85
   BRIDG:BR       0.     0.    35.   3314.   30206.     305.   10.87  223.65
   RDWAY:RG      18.*******   406.    462.*********       0.    1.00  226.42
   APPRO:AS      67.   -74.   156.   3750.   83442.     877.    4.28  226.62

SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    221.09    0.60  212.46  233.07************  0.84  223.56  222.72
   FULLV:FV  ********    0.61  212.68  233.29  0.15  0.02  0.87  223.73  222.85
   BRIDG:BR    221.18    0.65  213.15  223.65************  1.84  225.49  223.65
   RDWAY:RG ****************  223.93  238.27  0.07******  0.37  226.92  226.42
   APPRO:AS    222.02    0.44  212.96  238.27  0.14  0.56  0.37  226.99  226.62
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File cori05c.wsp
        Hydraulic analysis for structure CORITH0003005C   Date: 16-SEP-96
        Bridge 5C over Cooksville Brook in Corinth, VT  by MAI
           *** RUN DATE & TIME: 12-19-96  11:57

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

 EXITX:XS   ******    -12      427   0.74 *****  222.60  220.38    2890  221.85
       -30 ******      87    42591   1.04 ***** *******    0.59    6.76

 FULLV:FV       31    -11      421   0.77  0.15  222.77 *******    2890  222.01
          0     31     87    41668   1.05  0.01    0.02    0.60    6.87
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.62

 APPRO:AS       67     -6      317   1.36  0.52  223.58 *******    2890  222.22
         67     67     61    25924   1.05  0.30   -0.01    0.76    9.13
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

            <<<<<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       31      0      210   2.94  0.24  223.59  220.60    2890  220.65
          0     31     35    24848   1.00  0.75    0.00    0.99   13.75

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   1.  1.000 ******  223.36 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      18.        <<<<<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       27     -8      418   0.80  0.25  224.37  220.86    2890  223.57
         67     28     74    37126   1.08  0.54    0.02    0.56    6.91

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.483  0.084   33823.    -1.    34.   223.36

   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXITX:XS     -31.   -13.    87.   2890.   42591.     427.    6.76  221.85
    FULLV:FV       0.   -12.    87.   2890.   41668.     421.    6.87  222.01
    BRIDG:BR       0.     0.    35.   2890.   24848.     210.   13.75  220.65
    RDWAY:RG      18.**************      0.******************    1.00********
    APPRO:AS      67.    -9.    74.   2890.   37126.     418.    6.91  223.57

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS      -1.    34.   33823.

  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX     HF     HO   VHD      EGL    WSEL
    EXITX:XS    220.38    0.59  212.46  233.07************  0.74  222.60  221.85
    FULLV:FV  ********    0.60  212.68  233.29  0.15  0.01  0.77  222.77  222.01
    BRIDG:BR    220.60    0.99  213.15  223.65  0.24  0.75  2.94  223.59  220.65
    RDWAY:RG ****************  223.93  238.27**********************************
    APPRO:AS    220.86    0.56  212.96  238.27  0.25  0.54  0.80  224.37  223.57
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure CORITH0003005C, in Corinth, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number CORITH0003005C

General Location Descriptive

Data collected by *(First Initial, Full last name)* E. BOEHMLER

Date *(MM/DD/YY)* 03 / 17 / 95

Highway District Number *(I - 2; nn)* 07

County *(FIPS county code; I - 3; nnn)* 017

Town *(FIPS place code; I - 4; nnnnn)* 15700

Mile marker *(I - 11; nnn.nnn)* 005700

Waterway *(I - 6)* COOKSVILLE BROOK

Road Name *(I - 7):* -

Route Number TH003

Vicinity *(I - 9)* 4.6 MI W JCT. VT.25

Topographic Map West.Topsham

Hydrologic Unit Code: 01080103

Latitude *(I - 16; nnnn.n)* 44008

Longitude *(i - 17; nnnnn.n)* 72157

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 200192005C0905

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

Maximum span length *(I - 48; nnnn)* 0037

Year built *(I - 27; YYYY)* 1955

Structure length *(I - 49; nnnnnn)* 000039

Average daily traffic, ADT *(I - 29; nnnnnn)* 000350

Deck Width *(I - 52; nn.n)* 317

Year of ADT *(I - 30; YY)* 91

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

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

Waterway adequacy *(I - 71; n)* 5

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 035.0

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

Vertical clearance from streambed (*nnn.n ft*) 010.0

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

Waterway of full opening (*nnn.n* ft^2) 350.0

Comments:

The structural inspection report of 5/13/94 indicates the structure is a single span, steel stringer type bridge. The abutment walls are concrete and there are no wingwalls. The abutment walls have a few random full height hairline shrinkage cracks reported. Along the flow line of the right abutment there is some minor concrete scaling noted. Currently, all the flow is against the right abutment. There is a large point bar that has deposited along the left abutment. The footings are noted as not in view at the surface. The streambed material is noted as consisting of stone and gravel. The waterway makes a moderate turn into the structure. The ends of the right abutment are protected with some placed **(Continued, page 33)**

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area (*mi^2*): -

Terrain character: -

Stream character & type: -

Streambed material: Stone and gravel.

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

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

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

Ice conditions (*Heavy, Moderate, Light*) : - Debris (*Heavy, Moderate, Light*): -

The stage increases to maximum highwater elevation (*Rapidly, Not rapidly*): -

The stream response is (*Flashy, Not flashy*): -

Describe any significant site conditions upstream or downstream that may influence the stream's stage: -

Watershed storage area (*in percent*): - %

The watershed storage area is: - (*1-mainly at the headwaters; 2- uniformly distributed; 3-immediatly upstream oi the site*)

Water Surface Elevation Estimates for Existing Structure:

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*)	-	-	-	-	-
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

Is the roadway overtopped below the Q_{100}? (*Yes, No, Unknown*): U Frequency: -

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft^3/ sec*): -

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

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

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

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

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

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

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

Comments:

boulders and granite blocks. This bridge is on the Federal Aid System and is listed under the route number FAS192.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 20.15 mi^2 Lake and pond area 0.37 mi^2

Watershed storage *(ST)* 1.8 %

Bridge site elevation 810 ft Headwater elevation 2267 ft

Main channel length 11.11 mi

10% channel length elevation 850 ft 85% channel length elevation 1800 ft

Main channel slope *(S)* 114.01 ft / mi

Watershed Precipitation Data

Average site precipitation ______ in Average headwater precipitation ______ in

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

Average seasonal snowfall *(Sn)* ______ ft

Bridge Plan Data

Are plans available? **Y** *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: **08** / **1954**

Project Number **SA 6 1953** Minimum channel bed elevation: **213.0**

Low superstructure elevation: USLAB **223.07** DSLAB **223.07** USRAB **223.60** DSRAB **223.60**

Benchmark location description:

BM#5, [spike in root or truck of] an 18 inch elm tree located on the left bank upstream, elevation 223.65. To find tree, go about 30 feet left bankward from the left abutment at the bridge's roadway centerline to the roadway centerline of the intersecting roadway, then go about 48 feet in an upstream direction toward the upstream right corner of the intersection.

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

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

If 1: Footing Thickness **2.5** Footing bottom elevation: **209.***

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

If 3: Footing bottom elevation: _______

Is boring information available? **Y** *If no, type ctrl-n bi* Number of borings taken: **4**

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

Briefly describe material at foundation bottom elevation or around piles:

The left abutment footing is set in a gravel material that grades into a partially cemented sand, gravel, and clay banded material from up- to downstream. The right abutment footing is set in a sand, gravel, and clay binder material which grades to a gravel material from up- to downstream.

Comments:

***The bottom of the right abutment footing elevation was noted as variable on the plans after the construction (marked in red). Generally, the variation is shown to be left and right abutment elevations 209.0 and 210.0, respectively. There are 90 degree wingwalls on the right abutment and angled wingwalls on the left abutment shown. Other points depicted on the plans with elevations are: 1) the point on the top streamward edge of the upstream left wingwall concrete at the upstream end of the wall behind the concrete curb, elevation 225.98, and 2) the point at the same location described in (1) but at the junction of the downstream left wingwall, elevation 225.28.**

The spread footings extend 3.5 feet into the channel with a top elevation of 211.5 and a base of 209.

Cross-sectional Data

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

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

Comments: **Upstream channel cross section at stationing 0 +90, 10 feet from the center line of the roadway on the bridge deck. The channel baseline runs along the left bank perpendicular to the bridge 2 feet from the streamward face of the left abutment.**

Station	2.0	10.0	18.0	28.0	42.0						
Feature	LCL				LCR						
Low cord elevation	223.2				223.6						
Bed elevation	214.5	213.3	213.8	213.3	213.0						
Low cord to bed length	8.7										

Station											
Feature											
Low cord elevation											
Bed elevation											
Low cord to bed length											

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

Comments: **Downstream channel cross section at stationing 1 + 10, 10 feet from the center line of the roadway on the bridge deck.**

Station	2.0	10.0	20.0	30.0	37.0						
Feature	LCL				LCR						
Low cord elevation	223.2				223.6						
Bed elevation	212.8	212.4	212.6	212.8	213.0						
Low cord to bed length											

Station											
Feature											
Low cord elevation											
Bed elevation											
Low cord to bed length											

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 2/20/96
Computerized by: EW Date: 2/21/96
Reviewd by: MAI Date: 11/26/96

Structure Number CORITH00030005C

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* T. SEVERANCE Date *(MM/DD/YY)* 09 / 05 / 1995

2. Highway District Number 7 Mile marker 005700

County ORANGE 017 Town CORNITH 15700

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

Route Number TH03 Hydrologic Unit Code: 01080103

3. Descriptive comments:

Located 4.6 miles to junction with VT 25, at intersection of town highway 2 and 3

B. Bridge Deck Observations

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

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

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

7. Bridge length 39 *(feet)* Span length 37 *(feet)* Bridge width 31.7 *(feet)*

Road approach to bridge:

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

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

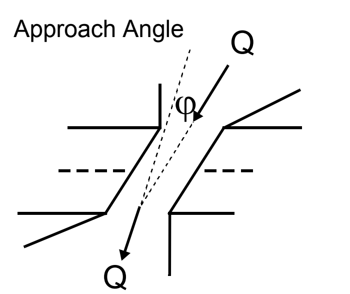
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

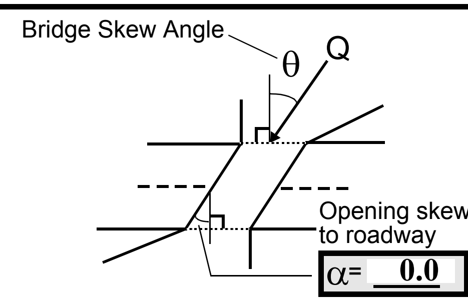
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	0	-	2	1
RBDS	0	-	2	1
LBDS	0	-	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: 40 16. Bridge skew: 30





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 50 feet US *(US, UB, DS)* to 20 feet DS

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

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

18. Bridge Type: 1a*

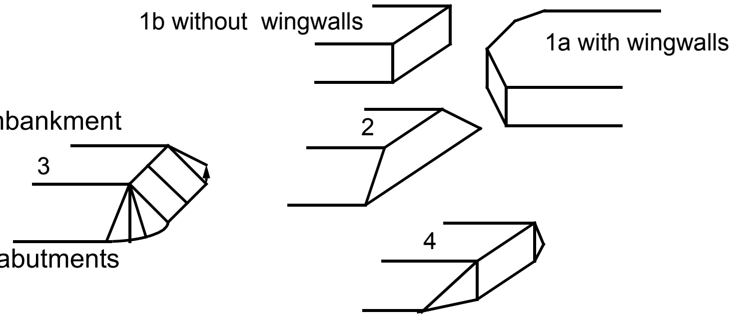
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls perpendicular to abut. face

3- Spill through abutments

4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.



19. Bridge Deck Comments (surface cover variations, measured bridge and span lengths, bridge type variations, approach overflow width, etc.)

#5: There are small riffles under the bridge at both the US and DS bridge faces
#7: Values are from VTAOT. The measured values are: bridge length 42.7; span length 40.7. The bridge is curved, the width was the same as the VTAOT value.
Town highway 2 runs along left bank with trees and shrubs growing between it and the stream. The “non-river” side of TH2 is steeply inclined with grass growing on it within 1-2 bridge lengths US and DS.
The right bank surface cover consists of trees and shrubs along the immediate bank with pasture and lawn beyond. On the RBUS there is a house with a barn attached. On the DSRB there is a barn 2-3 bridge lengths from channel. A dirt road intersects TH3 on RBUS.
***#18- The left abutment is type 1a. The right abutment is type 1b**

C. Upstream Channel Assessment

20. SRD	21. Bank height (BF) LB	21. Bank height (BF) RB	22. Bank angle (BF) LB	22. Bank angle (BF) RB	26. % Veg. cover (BF) LB	26. % Veg. cover (BF) RB	27. Bank material (BF) LB	27. Bank material (BF) RB	28. Bank erosion (BF) LB	28. Bank erosion (BF) RB
34.5	9.0			6.5	1	1	145	145	1	1

23. Bank width 30.0 24. Channel width 20.0 25. Thalweg depth 50.5 29. Bed Material 314

30 .Bank protection type: LB 0 RB 45 31. Bank protection condition: LB - RB 2

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

32. Comments (bank material variation, minor inflows, protection extent, etc.):
Roots exposed on both right and left banks.
Right bank has stone protection (boulder and cobble)

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **33** 35. Mid-bar width: **5**

36. Point bar extent: **18** feet **US** *(US, UB)* to **36** feet **US** *(US, UB, DS)* positioned **0** %LB to **25** %RB

37. Material: **34**

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

Additional point bar 71 feet US. Mid-bar width is 9 feet, positioned 0% LB to 55% RB.

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

41. Mid-bank distance: **36** 42. Cut bank extent: **23** feet **US** *(US, UB)* to **50** feet **US** *(US, UB, DS)*

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

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

Roots exposed, there are a lot of cobbles and boulders in the bank.

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **8**

47. Scour dimensions: Length **18** Width **3** Depth : **0.5** Position **40** %LB to **60** %RB

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

There is also some localized scour (0.5 feet) US.

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
23.0		1.0		2	7	7	-

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

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

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

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

234

#55: At bank full conditions the left bank under bridge is covered

Point bar under bridge along the left abutment starts at the DS bridge face and extends 27 feet US. Mid-bar distance is 9 feet US from DS bridge face. Mid-bar width is 7 feet. Material is gravel and sand. There is scour along the center of channel at toe of point bar (0.5- 1.0 feet) and along RABUT along the footing (0.5 feet).

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

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

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

70. Debris and Ice Comments:

1

Debris at US RABUT and left wingwall and also on point bar and left bank under the bridge

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**-**	**90**	**0**	**0**	**-**	**-**	**90.0**
RABUT	**1**	**30**	**90**			**2**	**2**	**35.0**

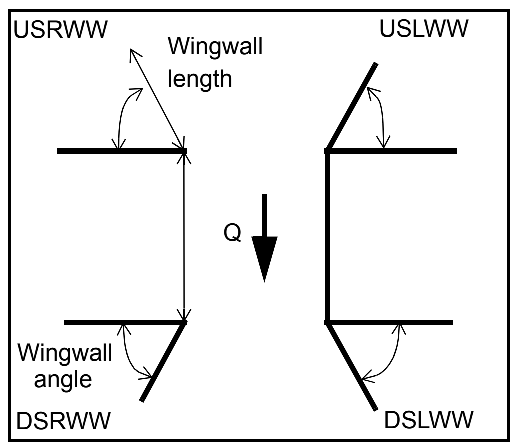
Pushed: LB or RB *Toe Location (Loc.): **0**- even, **1**- set back, **2**- protrudes*
*Scour cond.: **0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**-undermined footing; **4**- piling exposed; **5**- settled; **6**- failed*
Materials: **1**- Concrete; **2**- Stone masonry or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

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

0.5
0.1
1
No undermining or penetration
Debris (log) at the US end of the RABUT and across channel at DS bridge face

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**35.0**	
USRWW:	**Y**		**1**		**0**	**1.0**	
DSLWW:	**-**		**-**		**N**	**39.5**	
DSRWW:	**-**		**-**		**-**	**32.5**	



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

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	**-**	**0**	**N**	**-**	**-**	**-**	**-**	**1**
Condition	**Y**	**-**	**-**	**-**	**-**	**-**	**-**	**4**
Extent	**1**	**-**	**-**	**0**	**-**	**0**	**2**	**0**

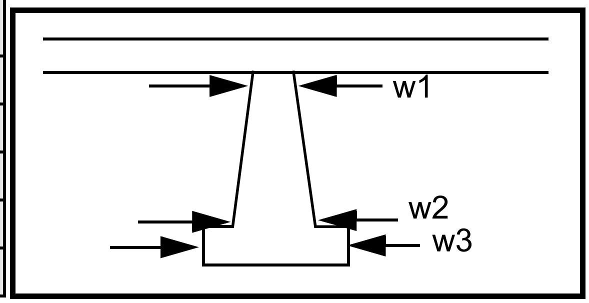
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1			-	**30.0**	**16.0**	-
Pier 2			-	**20.0**	**12.0**	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**e**	**dept**	**ked**	**the**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**sand**	**h of**	**at 4**	**US**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**mate**	**1.5-2**	**loca-**	**and**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**rial**	**feet**	**tions**	**DS**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**alon**	**with**	**)**	**ends.**	*Y- yes; N- no*
91. Attack ∠ (BF)	**g the**	**no**	**#82:**		
92. Pushed	**LAB**	**pro-**	**RAB**		*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**UT**	**tec-**	**UT**		
95. Cross-members	**was**	**tion**	**pro-**		***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**pen-**	**belo**	**tec-**		***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**etrat**	**w**	**tion**		
98. Exposure depth	**ed a**	**(chec**	**is at**		

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

N
-
-
-
-
-
-
-
-

E. Downstream Channel Assessment

100.

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

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

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

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

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

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

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

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

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

Point bar extent: - feet - (US, UB, DS) to - feet NO (US, UB, DS) positioned PI %LB to ER %RB

Material: S

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

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

Cut bank extent: _____ feet _____ (US, UB, DS) to 1 feet 1 (US, UB, DS)

Bank damage: 143 (**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)

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

145
1
1
423

Is channel scour present? 0 (Y or if N type ctrl-n cs) Mid-scour distance: 0

Scour dimensions: Length - Width - Depth: The Positioned re %LB to are %RB

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

boulders on the DS right bank.
The left bank is also the road embankment of TH2, and consists of gravel and cobble

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

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

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

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

N

-

NO DROP STRUCTURE

N

-

-

-

-

109. G. Plan View Sketch

point bar	debris	flow	stone wall
cut-bank	rip rap or stone fill	cross-section	other wall
scour hole		ambient channel	

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: CORITH0003005C Town: Corinth
Road Number: TH 2 County: Orange
Stream: Cooksville Brook

Initials MAI Date: 11/08/96 Checked: RF

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	2750	3750	2890
Main Channel Area, ft2	352	530	370
Left overbank area, ft2	0	65	0
Right overbank area, ft2	38	281	48
Top width main channel, ft	52	52	52
Top width L overbank, ft	0	65	1
Top width R overbank, ft	27	112	30
D50 of channel, ft	0.1346	0.1346	0.1346
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	6.8	10.2	7.1
y1, average depth, LOB, ft	ERR	1.0	0.0
y1, average depth, ROB, ft	1.4	2.5	1.6
Total conveyance, approach	33900	83406	37091
Conveyance, main channel	32251	63439	34867
Conveyance, LOB	0	2409	0
Conveyance, ROB	1648	17559	2224
Percent discrepancy, conveyance	0.0029	-0.0012	0.0000
Qm, discharge, MC, cfs	2616.2	2852.3	2716.7
Ql, discharge, LOB, cfs	0.0	108.3	0.0
Qr, discharge, ROB, cfs	133.7	789.5	173.3
Vm, mean velocity MC, ft/s	7.4	5.4	7.3
Vl, mean velocity, LOB, ft/s	ERR	1.7	ERR
Vr, mean velocity, ROB, ft/s	3.5	2.8	3.6
Vc-m, crit. velocity, MC, ft/s	7.9	8.5	8.0
Vc-l, crit. velocity, LOB, ft/s	N/A	0.0	0.0
Vc-r, crit. velocity, ROB, ft/s	0.0	0.0	0.0

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?

Main Channel	0	0	0

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	352	530	370
Main channel width, ft	52	52	52
y1, main channel depth, ft	6.77	10.19	7.12

Bridge Section			
(Q) total discharge, cfs	2750	3750	2890
(Q) discharge thru bridge, cfs	2750	3283	2890
Main channel conveyance	24581	30206	24888
Total conveyance	24581	30206	24888
Q2, bridge MC discharge,cfs	2750	3283	2890
Main channel area, ft2	209	305	211
Main channel width (skewed), ft	35.0	35.0	35.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	35	35	35
y_bridge (avg. depth at br.), ft	5.96	8.71	6.01
Dm, median (1.25*D50), ft	0.16825	0.16825	0.16825
y2, depth in contraction,ft	8.67	10.10	9.05
ys, scour depth (y2-ybridge), ft	2.71	1.39	3.04

Pressure Flow Scour (contraction scour for orifice flow conditions)

Hb+Ys=Cq*qbr/Vc   Cq=1/Cf*Cc   Cf=1.5*Fr^0.43 (<=1)
Chang Equation   Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
(Richarson and others, 1995, p. 145-146)

	Q100	Q500	OtherQ
Q, total, cfs	0	3750	0
Q, thru bridge, cfs	0	3283	0
Total Conveyance, bridge	0	30206	0
Main channel(MC) conveyance, bridge	0	30206	0
Q, thru bridge MC, cfs	ERR	3283	ERR
Vc, critical velocity, ft/s	7.90	8.46	7.97
Vc, critical velocity, m/s	2.41	2.58	2.43
Main channel width (skewed), ft	0.0	35.0	0.0
Cum. width of piers in MC, ft	0	0	0
W, adjusted width, ft	0.0	35.0	0.0
qbr, unit discharge, ft2/s	ERR	93.8	ERR
qbr, unit discharge, m2/s	N/A	8.7	N/A
Area of full opening, ft2	0	304.9	0
Hb, depth of full opening, ft	ERR	8.71	ERR
Hb, depth of full opening, m	N/A	2.66	N/A
Fr, Froude number, bridge MC	1	0.65	1

Cf, Fr correction factor (<=1.0)	1.50	1.00	1.50
Elevation of Low Steel, ft	0	223.36	0
Elevation of Bed, ft	N/A	214.65	N/A
Elevation of Approach, ft	0	226.62	0
Friction loss, approach, ft	0	0.14	0
Elevation of WS immediately US, ft	0.00	226.48	0.00
ya, depth immediately US, ft	N/A	11.83	N/A
ya, depth immediately US, m	N/A	3.61	N/A
Mean elevation of deck, ft	0	226.4	0
w, depth of overflow, ft (>=0)	0.00	0.08	0.00
Cc, vert contrac correction (<=1.0)	ERR	0.92	ERR
Ys, depth of scour, ft	N/A	3.28	N/A

Comparison of Chang and Laursen results (for unsubmerged orifice flow)

y2, from Laursen's equation, ft	0	10.1	0
Full valley WSEL, ft	0	222.85	0
Full valley depth, ft	N/A	8.201429	N/A
Ys, depth of scour (y2-yfullv), ft	N/A	1.898571	N/A
ARMORING			
D90	0.5579	0.5579	0.5579
D95	0.736	0.736	0.736
Critical grain size,Dc, ft	0.7380	0.4243	0.7984
Decimal-percent coarser than Dc	0.0496	0.1688	0.0368
Depth to armoring,ft	42.42	6.27	62.69

Abutment Scour

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

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	2750	3750	2890	2750	3750	2890
a', abut.length blocking flow, ft	8.5	73.6	9.5	35.5	120.8	38.7
Ae, area of blocked flow ft2	26	71	28.9	72	340.1	84.8
Qe, discharge blocked abut.,cfs	102.5	--	112.5	307	--	370.3
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.94	2.46	3.89	4.26	3.10	4.37
ya, depth of f/p flow, ft	3.06	0.96	3.04	2.03	2.82	2.19
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	1	1	1
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.397	0.345	0.393	0.528	0.324	0.520
ys, scour depth, ft	8.09	7.01	8.27	12.70	19.00	13.66

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	8.5	73.6	9.5	35.5	120.8	38.7

y1 (depth f/p flow, ft)	3.06	0.96	3.04	2.03	2.82	2.19
a'/y1	2.78	76.30	3.12	17.50	42.84	17.66
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.40	0.35	0.39	0.53	0.32	0.52
Ys w/ corr. factor K1/0.55:						
vertical	ERR	4.94	ERR	ERR	14.14	ERR
vertical w/ ww's	ERR	4.05	ERR	ERR	11.58	ERR
spill-through	ERR	2.72	ERR	ERR	7.78	ERR

Abutment riprap Sizing

Isbash Relationship

D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)

(Richardson and others, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.95	0.64	0.99	0.95	0.64	0.99
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	5.96	8.71	6.01	5.96	8.71	6.01

Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	2.21	ERR	ERR	2.21	ERR
Fr>0.8 (vertical abut.)	2.46	ERR	2.51	2.46	ERR	2.51