LEVEL II SCOUR ANALYSIS FOR BRIDGE 32 (NFIEVT012A0032) on STATE ROUTE 12A, crossing the DOG RIVER, NORTHFIELD, VERMONT

U.S. Geological Survey
Open-File Report 97-188

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 32 (NFIEVT012A0032) on STATE ROUTE 12A, crossing the DOG RIVER, NORTHFIELD, VERMONT

By Erick M. Boehmler and Michael A. Ivanoff

U.S. Geological Survey
Open-File Report 97-188

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 32 (NFIEVT012A0032) ON STATE ROUTE 12A, CROSSING THE DOG RIVER, NORTHFIELD, VERMONT

By **Erick M. Boehmler and Michael A. Ivanoff**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure NFIEVT012A0032 on State Route 12A crossing the Dog River, Northfield, 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 Green Mountain section of the New England physiographic province in central Vermont. The 13.5-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture (golf course).

In the study area, the Dog River has a straight channel with a slope of approximately 0.01 ft/ft, an average channel top width of 47 ft and an average bank height of 7 ft. The predominant channel bed materials are gravel and cobbles with a median grain size (D_{50}) of 39.0 mm (0.128 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 22, 1996, indicated that the reach was stable.

The State Route 12A crossing of the Dog River is a 35-ft-long, two-lane bridge consisting of one 32-foot concrete span (Vermont Agency of Transportation, written communication, October 13, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 30 degrees to the opening and the opening-skew-to-roadway also is 30 degrees.

A scour hole 1.5 ft deeper than the mean thalweg depth was observed along the upstream end of the right abutment wall during the Level I assessment. The scour protection measures at the site were type-1 stone fill (less than 12 inches diameter) on the right bank downstream and type-2 stone fill (less than 36 inches diameter) on the upstream banks, the downstream left bank and the upstream right wingwall. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 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 1.5 to 2.9 ft. The worst-case contraction scour occurred at the incipient-overtopping discharge, which was less than the 100-year discharge. Abutment scour ranged from 7.2 to 12.7 ft. The worst-case 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.

Roxbury, VT. Quadrangle, 1:24,000, 1980
Aerial photography, 1973, Contour interval 20 feet

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 NFIEVT012A0032 ***Stream*** Dog River

County Washington ***Road*** VT 12A ***District*** 6

Description of Bridge

Bridge length 35 ***ft*** ***Bridge width*** 23.5 ***ft*** ***Max span length*** 32 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 7/22/96

Description of stone fill Type-1 on the downstream right bank and type-2 on the downstream left bank, both upstream banks and the upstream right wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a 1.5 foot deep scour hole along the upstream end of the exposed right abutment footing.

Is bridge skewed to flood flow according to Y ***survey?*** Y ***Angle*** 30

There is a mild channel bend in the upstream reach. The scour hole has developed in the location where the bend impacts the upstream end of the right abutment.

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	7/22/96	0	0
Level II	7/22/96	0	0

Potential for debris Moderate. Beyond 100 feet upstream of this site the channel has a more sinuous configuration and more significant vegetation growth on the banks

Describe any features near or at the bridge that may affect flow (include observation date) There are golf cart bridges crossing the Dog River upstream and downstream of this site noted on 7/22/96.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with narrow, irregular flood plains and moderately steep valley walls on both sides.

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

Date of inspection 7/22/96

DS left: Moderately sloping channel bank to a narrow overbank.

DS right: Moderately sloping channel bank to a narrow flood plain.

US left: Moderately sloping channel bank to a narrow overbank.

US right: Moderately sloping channel bank to a narrow flood plain.

Description of the Channel

Average top width 47 ***ft*** ***Average depth*** 7 ***ft***

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

Generally straight and stable with semi-alluvial channel boundaries.

7/22/96

Vegetative co

Short grass, brush, and a few shrubs

DS left: Short grass

DS right: Short grass, brush, and shrubs

US left: Short grass.

US right:

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

The footings of both abutment walls were exposed at the surface at the time of the level I assessment on 7/22/96 and partially block all flows.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 13.5 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England / 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? Yes

USGS gage description Dog River at Northfield Falls, VT

USGS gage number 04287000

Gage drainage area 76.1 ***mi²***

Is there a lake/p No

-

Calculated Discharges

Q100 3,540 ***ft³/s*** ***Q500*** 4,600 ***ft³/s***

The 100- and 500-year discharges are based on discharge frequency curves computed by use of several empirical equations (Benson, 1962; FHWA, 1983; Johnson and Tasker, 1974; Potter, 1957 a&b; and Talbot, 1887) and additional curves available from the VTAOT database (written communication, VTAOT, May 1995) and the Flood Insurance Study for the Town / Village of Northfield (FEMA, 1977). The discharge values selected for this analysis were taken from the VTAOT database due to the central tendency of the curve relative to those from the other methods.

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 Add 310.31 feet to the USGS arbitrary survey datum to obtain NGVD.

Description of reference marks used to determine USGS datum. RM1 is the center point of a chiseled "X" on top of the concrete curb at the upstream right corner of the bridge deck (elev. 500.83 feet, arbitrary survey datum). RM2 (FEMA RM# 3) is a chiseled square on top of the concrete curb at the downstream left corner of the bridge deck (elev. 501.26 feet, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT4	-194	2	Exit section templated from EXTEM
EXIT3 / EXTEM	-47	1	Surveyed exit section (Also used as a template)
EXIT2	-24	2	Exit section templated from EXTEM
EXIT1	-19	3	Modified EXTEM for crest of drop structure
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	14	1	Road Grade section
APPRO	55	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach, considering those applied for the modeling documented in the flood insurance study (Federal Emergency Management Agency, 1977). Channel "n" values for the reach ranged from 0.035 to 0.040, and overbank "n" values ranged from 0.040 to 0.070.

The starting water surface was computed based on a rating of the discharges from the flood insurance study model at cross section "BL", 35,866 feet upstream of the Northfield town boundary (Federal Emergency Management Agency, 1977) and approximately 3,590 feet upstream of the confluence of Stony Brook. The surveyed exit section (EXIT3) was templated to the location of cross section "BL" (EXIT4) using a bed correction slope of 0.0106 ft/ft, which was estimated from surveyed thalweg points.

A drop structure was located about 19 feet downstream of the bridge section. Hence, additional sections were positioned immediately downstream and across the crest of the drop structure. The EXIT2 section, immediately downstream of the drop structure, was templated from EXIT3 without bed elevation correction. For the EXIT1 section, the surveyed exit section was modified to include the crest of the drop structure and the right overbank geometry in the flood insurance study model at the EXIT1 section.

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

For the 100- and 500-year discharges, WSPRO assumes critical depth at the EXIT1 and EXIT3 sections, respectively. Supercritical models were developed for these discharges. Analyzing both the supercritical and subcritical profiles for each discharge, it can be determined that the water surface profile does falls through critical depth between the EXIT1 and EXIT2 sections for the 100-year event and between the EXIT2 and EXIT4 sections for the 500-year event.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.3 *ft*
Average low steel elevation 497.6 *ft*

100-year discharge 3,540 *ft³/s*
Water-surface elevation in bridge opening 497.9 *ft*
Road overtopping? Yes *Discharge over road* 1410 *ft³/s*
Area of flow in bridge opening 238 *ft²*
Average velocity in bridge opening 9.0 *ft/s*
Maximum WSPRO tube velocity at bridge 10.8 *ft/s*

Water-surface elevation at Approach section with bridge 500.4
Water-surface elevation at Approach section without bridge 499.0
Amount of backwater caused by bridge 1.4 *ft*

500-year discharge 4,600 *ft³/s*
Water-surface elevation in bridge opening 497.9 *ft*
Road overtopping? Yes *Discharge over road* 2440 *ft³/s*
Area of flow in bridge opening 238 *ft²*
Average velocity in bridge opening 9.0 *ft/s*
Maximum WSPRO tube velocity at bridge 10.9 */s*

Water-surface elevation at Approach section with bridge 500.9
Water-surface elevation at Approach section without bridge 499.4
Amount of backwater caused by bridge 1.5

Incipient overtopping discharge 2,110 *ft³/s*
Water-surface elevation in bridge opening 494.6 *ft*
Area of flow in bridge opening 162 *ft²*
Average velocity in bridge opening 13.0 *ft/s*
Maximum WSPRO tube velocity at bridge 16.2 *ft/s*

Water-surface elevation at Approach section with bridge 497.7
Water-surface elevation at Approach section without bridge 497.1
Amount of backwater caused by bridge 0.6 *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 for the incipient overtopping discharge model was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The 100- and 500-year discharges resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Therefore, contraction scour for the 100- and 500-year events was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The results of Laursen's clear-water contraction scour for the 100- and 500-year events also were computed and can be found in appendix F. The worst case contraction scour occurred at the incipient overtopping discharge.

Scour at the left abutment 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 at the right abutment was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.5	1.5	2.9
Depth to armoring	2.7	2.8	26.7
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	8.3	9.3	7.5
Right abutment	11.6	12.7	7.2
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	1.8	1.8	2.6
Right abutment	1.8	1.8	2.6
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

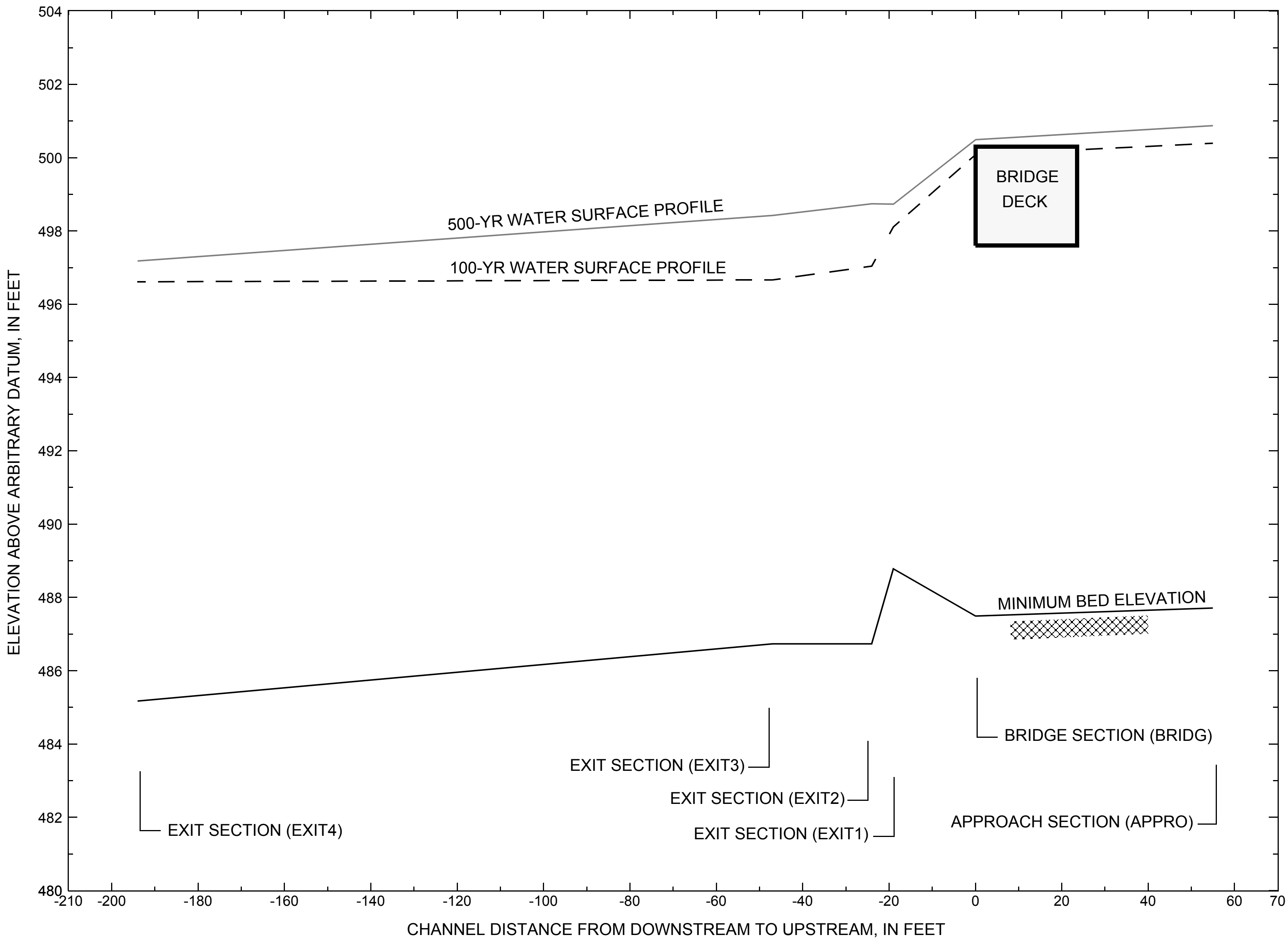


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure NFIEVT012A0032 on State Route 12a, crossing the Dog River, Northfield, Vermont.

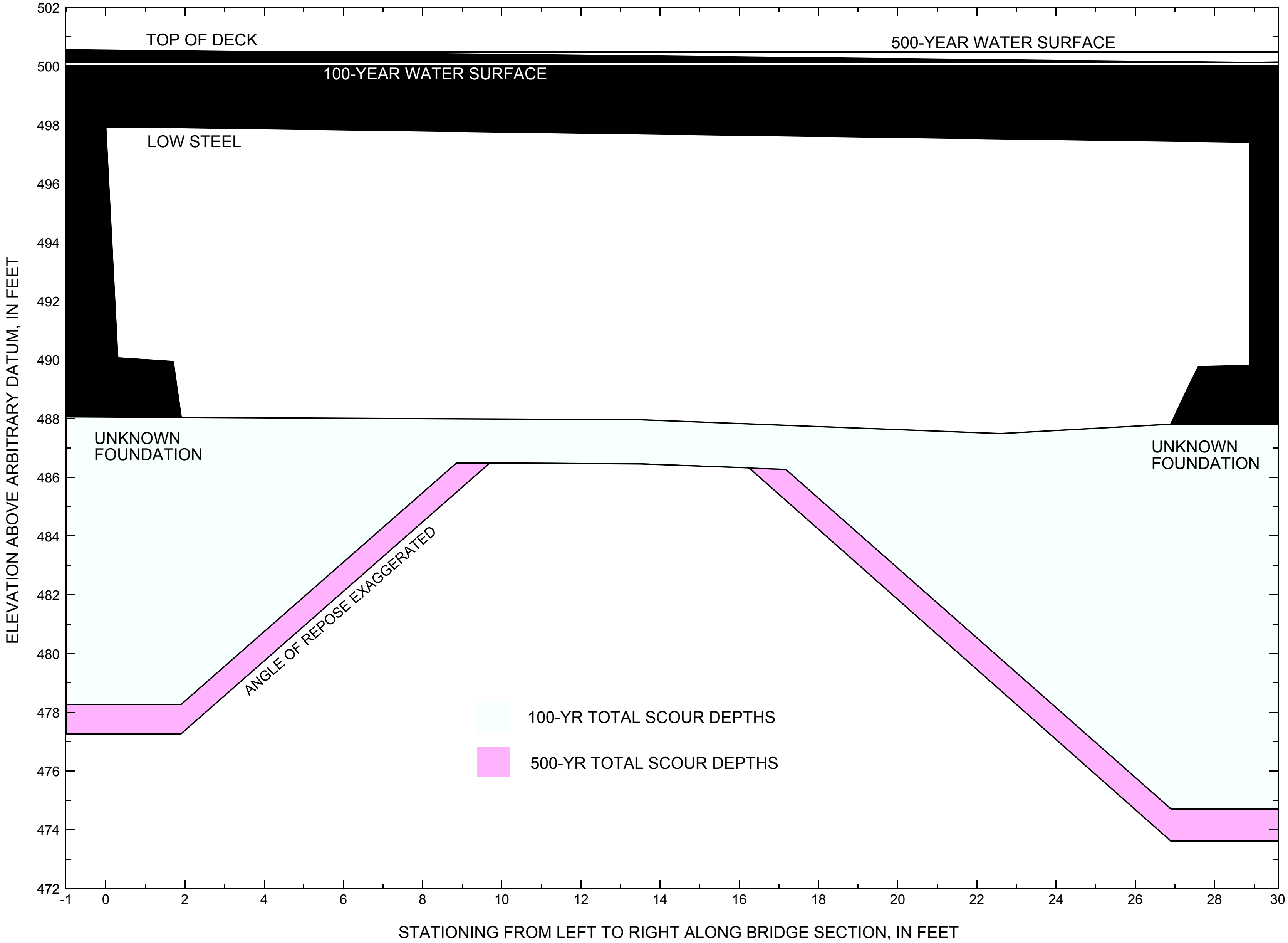


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure NFIEVT012A0032 on State Route 12A, crossing the Dog River, Northfield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure NFIEVT012A0032 on State Route 12a, crossing Dog River, Northfield, 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 3,540 cubic-feet per second											
Left abutment	0.0	--	497.9	--	488.1	1.5	8.3	--	9.8	478.3	--
Right abutment	28.9	--	497.4	--	487.8	1.5	11.6	--	13.1	474.7	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure NFIEVT012A0032 on State Route 12A, crossing Dog River, Northfield, 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 4,600 cubic-feet per second											
Left abutment	0.0	--	497.9	--	488.1	1.5	9.3	--	10.8	477.3	--
Right abutment	28.9	--	497.4	--	487.8	1.5	12.7	--	14.2	473.6	--

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

SELECTED REFERENCES

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

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

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

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

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

Federal Emergency Management Agency, 1977, Flood Insurance Study, Town and Village of Northfield, Washington County, Vermont: Washington, D.C., November 1977.

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, 1980, Roxbury, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Aerial photography, 1973, Contour interval, 20 feet; Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File nfie032.wsp
T2        Hydraulic analysis for structure NFIEVT012A0032   Date: 12-DEC-96
T3        State Route 12A Crossing the Dog River, Northfield, VT            EMB
*
J1         * * 0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3540.0,  4600.0,  2110.0
WS          496.61,  497.18,  494.76
*
XT   EXTEM    -47
GR         -283.7, 510.29   -262.2, 502.71   -234.5, 501.23   -216.3, 504.65
GR         -135.8, 501.13    -14.9, 496.69     -8.6, 494.17      0.0, 487.75
GR            2.2, 486.91      5.5, 486.73      9.4, 487.11     14.6, 487.19
GR           17.1, 487.78     20.5, 488.24     26.0, 491.71     29.8, 493.99
GR           45.2, 496.80     71.0, 497.13    329.2, 497.13    430.0, 498.40
GR          565.0, 506.34    627.9, 509.13
*           Replaced: 102.8, 499.01    329.2, 498.40 with 329.2, 497.13
*                     430.0, 498.40 in order to make right overbank more
*                     realistic relative to photos of the site and validate
*                     weir flow over the right road approach.
*
XS   EXIT4   -194  *  *  *  0.0106
GT
N           0.070        0.040        0.040
SA                 -14.9         29.8
*
XS   EXIT3    -47  *  *  *  0.
GT
N           0.040        0.040        0.040
SA                 -14.9         29.8
*
XS   EXIT2    -24  *  *  *  0.
GT
N           0.040        0.040        0.040
SA                 -14.9         29.8
*
XS   EXIT1    -19
GR         -283.7, 510.29   -262.2, 502.71   -234.5, 501.23   -216.3, 504.65
GR         -135.8, 501.13    -14.9, 496.69     -8.6, 494.17      0.0, 489.26
GR            2.9, 488.89     13.0, 488.78     23.8, 488.97     24.9, 489.09
GR           26.0, 491.71     29.8, 493.99     45.2, 496.80     71.0, 497.13
GR          329.2, 497.13    430.0, 498.40    565.0, 506.34    627.9, 509.13
*
*          Replaced  102.8, 499.01    329.2, 498.40  with 329.2, 497.13
*                    430.0, 498.40 in order to make exit right overbank
*                    more realistic relative to photos of the site.
*
XS   FULLV      0  * * *   0.
*
*             SRD      LSEL    XSSKEW
BR   BRIDG      0    497.65      30.0
GR            0.0, 497.92      0.3, 490.07      1.7, 489.94      1.9, 489.25
GR            1.9, 488.06      4.7, 488.02     13.5, 487.96     22.6, 487.49
GR           26.9, 487.81     27.4, 489.25     27.6, 489.77     28.9, 489.81
GR           28.9, 497.39      0.0, 497.92
*
```

```
*          BRTYPE  BRWDTH       WWANGL    WWWID
CD            1      36.3 * *     46.9      7.7
N           0.035
*
*              SRD    EMBWID   IPAVE
XR   RDWAY      14      23.5     1
GR          -342.0, 509.14   -285.5, 504.35   -270.7, 504.40      0.0, 500.55
GR            29.4, 500.13    354.6, 498.40    590.4, 506.34    653.3, 509.13
*
AS   APPRO      55
GR          -344.3, 511.41   -273.7, 504.63   -240.9, 503.95    -94.3, 501.66
GR           -64.2, 499.87     -9.8, 496.35      0.0, 489.28      2.6, 488.61
GR            15.8, 488.02     22.3, 487.71     24.4, 488.56     25.7, 489.23
GR            32.6, 492.64     39.0, 496.34    319.2, 493.56    344.3, 496.44
GR           537.9, 497.99    593.4, 508.64    615.5, 510.50
*
N           0.040        0.040        0.040
SA                 -9.8         39.0
*
HP 1 BRIDG 497.92 1 497.92
HP 2 BRIDG 497.92 * * 2139
HP 2 RDWAY 500.08 * * 1412
HP 1 APPRO 500.39 1 500.39
HP 2 APPRO 500.39 * * 3540
*
HP 1 BRIDG 497.92 1 497.92
HP 2 BRIDG 497.92 * * 2152
HP 2 RDWAY 500.49 * * 2436
HP 1 APPRO 500.87 1 500.87
HP 2 APPRO 500.87 * * 4600
*
HP 1 BRIDG 494.60 1 494.60
HP 2 BRIDG 494.60 * * 2110
HP 1 APPRO 497.74 1 497.74
HP 2 APPRO 497.74 * * 2110
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File nfie032.wsp
        Hydraulic analysis for structure NFIEVT012A0032   Date: 12-DEC-96
        State Route 12A Crossing the Dog River, Northfield, VT            EMB
           *** RUN DATE & TIME: 01-02-97  08:08

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      238     23308     0     68                            0
   497.92           238     23308     0     68  1.00      0     29        0

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.92     0.0    28.9   238.3   23308.    2139.   8.98

X STA.        0.0        3.1        4.6        6.0        7.3        8.6
  A(I)            22.1       13.0       12.0       11.1       10.6
  V(I)            4.83       8.20       8.94       9.62      10.08

X STA.        8.6        9.8       11.0       12.2       13.4       14.6
  A(I)            10.4       10.3       10.2       10.0       10.0
  V(I)           10.31      10.37      10.52      10.65      10.64

X STA.       14.6       15.8       17.0       18.2       19.3       20.6
  A(I)            10.1       10.1        9.9       10.1       10.3
  V(I)           10.64      10.59      10.80      10.59      10.35

X STA.       20.6       21.8       23.1       24.4       25.9       28.9
  A(I)            10.6       11.1       11.5       13.1       21.8
  V(I)           10.09       9.62       9.33       8.17       4.91

    VELOCITY DISTRIBUTION:  ISEQ =  7;  SECID = RDWAY;  SRD =      14.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.08    38.8   404.5   307.2   10186.    1412.   4.60

X STA.       38.8      151.0      184.7      209.0      227.5      243.3
  A(I)            33.5       23.2       20.4       17.6       16.6
  V(I)            2.11       3.05       3.46       4.01       4.26

X STA.      243.3      257.4      269.4      280.6      290.5      299.9
  A(I)            15.9       14.3       14.1       13.1       12.7
  V(I)            4.44       4.95       5.02       5.41       5.54

X STA.      299.9      308.6      316.9      324.6      331.9      339.1
  A(I)            12.4       12.0       11.6       11.2       11.4
  V(I)            5.70       5.88       6.08       6.32       6.21

X STA.      339.1      345.9      352.7      360.0      370.2      404.5
  A(I)            11.0       11.3       11.7       13.5       19.8
  V(I)            6.39       6.27       6.02       5.24       3.56

    CROSS-SECTION PROPERTIES:  ISEQ =  8;  SECID = APPRO;  SRD =      55.

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      126      7459    63     63                         1014
             2      488     79678    49     53                         8770
             3     2289    231496   511    512                        27485
   500.39          2904    318633   623    628  1.18    -72    550    32791

    VELOCITY DISTRIBUTION:  ISEQ =  8;  SECID = APPRO;  SRD =      55.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.39   -72.9   550.4  2904.1  318633.    3540.   1.22

X STA.      -72.9       -0.5        7.3       14.4       20.9       28.8
  A(I)           194.7       91.9       85.3       81.9       90.5
  V(I)            0.91       1.93       2.07       2.16       1.96

X STA.       28.8       60.1       95.5      127.6      156.4      182.7
  A(I)           158.1      157.2      152.7      146.5      140.5
  V(I)            1.12       1.13       1.16       1.21       1.26

X STA.      182.7      207.8      231.3      253.3      275.0      295.7
  A(I)           140.2      137.3      133.9      135.8      134.7
  V(I)            1.26       1.29       1.32       1.30       1.31

X STA.      295.7      316.6      345.2      394.9      457.1      550.4
  A(I)           140.2      156.3      186.2      204.9      235.2
  V(I)            1.26       1.13       0.95       0.86       0.75
```

```
     U.S. Geological Survey WSPRO Input File nfie032.wsp
     Hydraulic analysis for structure NFIEVT012A0032   Date: 12-DEC-96
     State Route 12A Crossing the Dog River, Northfield, VT            EMB
        *** RUN DATE & TIME: 01-02-97  08:08

 CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = BRIDG;  SRD =       0.

  WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
          1      238     23308     0     68                              0
497.92           238     23308     0     68  1.00      0     29        0

 VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = BRIDG;  SRD =       0.

      WSEL     LEW     REW    AREA        K        Q    VEL
    497.92     0.0    28.9   238.3   23308.    2152.   9.03

X STA.        0.0        3.1        4.6        6.0        7.3        8.6
  A(I)           22.1       13.0       12.0       11.1       10.6
  V(I)           4.86       8.25       9.00       9.68      10.14

X STA.        8.6        9.8       11.0       12.2       13.4       14.6
  A(I)           10.4       10.3       10.2       10.0       10.0
  V(I)          10.37      10.43      10.58      10.72      10.71

X STA.       14.6       15.8       17.0       18.2       19.3       20.6
  A(I)           10.1       10.1        9.9       10.1       10.3
  V(I)          10.70      10.66      10.87      10.66      10.41

X STA.       20.6       21.8       23.1       24.4       25.9       28.9
  A(I)           10.6       11.1       11.5       13.1       21.8
  V(I)          10.15       9.67       9.39       8.22       4.94

 VELOCITY DISTRIBUTION:  ISEQ =  7;  SECID = RDWAY;  SRD =      14.

      WSEL     LEW     REW    AREA        K        Q    VEL
    500.49     4.2   416.7   467.8   19502.    2436.   5.21

X STA.        4.2       99.5      138.6      167.1      190.3      209.9
  A(I)           42.9       32.7       28.9       26.8       24.8
  V(I)           2.84       3.72       4.21       4.54       4.90

X STA.      209.9      227.3      242.5      256.5      269.6      281.5
  A(I)           23.7       22.2       21.5       21.0       19.9
  V(I)           5.14       5.49       5.68       5.81       6.13

X STA.      281.5      292.9      303.5      313.5      323.1      332.5
  A(I)           19.6       19.1       18.4       18.2       18.2
  V(I)           6.20       6.39       6.60       6.70       6.69

X STA.      332.5      341.6      350.5      360.0      372.9      416.7
  A(I)           18.3       18.2       19.3       21.7       32.3
  V(I)           6.66       6.70       6.30       5.61       3.77

 CROSS-SECTION PROPERTIES:  ISEQ =  8;  SECID = APPRO;  SRD =      55.

  WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
          1      159     10057    71     71                           1342
          2      512     86147    49     53                           9408
          3     2535    273529   514    514                          31955
500.87          3206    369733   634    639  1.15    -80    553    38119

 VELOCITY DISTRIBUTION:  ISEQ =  8;  SECID = APPRO;  SRD =      55.

      WSEL     LEW     REW    AREA        K        Q    VEL
    500.87   -81.0   552.9  3205.8  369733.    4600.   1.43

X STA.      -81.0       -1.1        7.4       15.2       22.3       32.7
  A(I)          225.5      102.8       98.3       92.2      111.4
  V(I)           1.02       2.24       2.34       2.49       2.06

X STA.       32.7       69.1      103.6      134.0      162.0      188.3
  A(I)          181.3      172.2      162.0      157.0      154.5
  V(I)           1.27       1.34       1.42       1.47       1.49

X STA.      188.3      213.0      236.2      258.8      280.4      301.7
  A(I)          151.7      148.0      149.1      147.3      149.5
  V(I)           1.52       1.55       1.54       1.56       1.54

X STA.      301.7      323.3      357.8      406.3      464.6      552.9
  A(I)          155.6      177.0      200.4      215.7      254.2
  V(I)           1.48       1.30       1.15       1.07       0.90
```

```
        U.S. Geological Survey WSPRO Input File nfie032.wsp
        Hydraulic analysis for structure NFIEVT012A0032   Date: 12-DEC-96
        State Route 12A Crossing the Dog River, Northfield, VT            EMB
           *** RUN DATE & TIME: 01-02-97  08:08

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      162     18367     25     37                          2345
   494.60           162     18367     25     37  1.00      0     29      2345

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.60     0.1    28.9   162.0   18367.    2110.  13.02

X STA.         0.1        3.5        5.1        6.5        7.9        9.1
  A(I)            15.8        9.2        8.1        7.5        7.3
  V(I)            6.67      11.47      12.96      14.00      14.41

X STA.         9.1       10.3       11.5       12.7       13.8       15.0
  A(I)             6.8        6.9        6.7        6.6        6.6
  V(I)           15.51      15.32      15.82      15.98      15.87

X STA.        15.0       16.1       17.2       18.3       19.4       20.6
  A(I)             6.5        6.6        6.5        6.7        6.9
  V(I)           16.11      15.98      16.22      15.83      15.40

X STA.        20.6       21.7       22.9       24.2       25.7       28.9
  A(I)             7.1        7.2        8.2        9.1       15.8
  V(I)           14.95      14.62      12.94      11.60       6.70

    CROSS-SECTION PROPERTIES:  ISEQ =  8;  SECID = APPRO;  SRD =      55.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       15       436     21     22                            71
             2      359     47724     49     53                          5529
             3      956     57350    468    468                          7757
   497.74          1330    105509    538    543  1.58    -30    507      9440

    VELOCITY DISTRIBUTION:  ISEQ =  8;  SECID = APPRO;  SRD =      55.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.74   -31.3   506.7  1330.1  105509.    2110.   1.59

X STA.       -31.3        0.4        4.6        8.4       11.9       15.4
  A(I)            66.9       37.3       35.2       33.5       33.4
  V(I)            1.58       2.83       3.00       3.15       3.16

X STA.        15.4       18.7       22.0       25.9       32.7       92.7
  A(I)            32.5       33.0       36.0       45.7      109.9
  V(I)            3.25       3.19       2.93       2.31       0.96

X STA.        92.7      133.1      164.6      191.7      215.7      237.8
  A(I)            86.3       78.3       75.2       72.9       72.1
  V(I)            1.22       1.35       1.40       1.45       1.46

X STA.       237.8      258.5      278.9      299.0      322.3      506.7
  A(I)            72.0       74.9       78.2       94.9      161.8
  V(I)            1.46       1.41       1.35       1.11       0.65
```

```
        U.S. Geological Survey WSPRO Input File nfie032.wsp
        Hydraulic analysis for structure NFIEVT012A0032   Date: 12-DEC-96
        State Route 12A Crossing the Dog River, Northfield, VT            EMB
           *** RUN DATE & TIME: 01-02-97  08:08

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

EXIT4:XS   ******    -54      783  0.69 *****  497.30  494.18    3540  496.61
      -193 ******    412    67363  2.17 ***** *******    0.91    4.52

 ===125 FR# EXCEEDS FNTEST AT SECID "EXIT3":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.86     496.66     495.73

 ===110 WSEL NOT FOUND AT SECID "EXIT3":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.11     510.29    0.50

 ===115 WSEL NOT FOUND AT SECID "EXIT3":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.11     510.29     495.73

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "EXIT3"     KRATIO =  0.57

EXIT3:XS      147    -14      320  2.02  0.71  498.68  495.73    3540  496.66
       -46    147     44    38341  1.06  0.66    0.00    0.86   11.06

 ===125 FR# EXCEEDS FNTEST AT SECID "EXIT2":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.95     497.02     495.73

 ===110 WSEL NOT FOUND AT SECID "EXIT2":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.16     510.29    0.50

 ===115 WSEL NOT FOUND AT SECID "EXIT2":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.16     510.29     495.73

EXIT2:XS       23    -23      347  1.81  0.18  498.85  495.73    3540  497.04
       -23     23     64    41912  1.12  0.00   -0.01    0.96   10.21

 ===125 FR# EXCEEDS FNTEST AT SECID "EXIT1":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.02     496.74     498.11

 ===110 WSEL NOT FOUND AT SECID "EXIT1":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.54     510.29    0.50

 ===115 WSEL NOT FOUND AT SECID "EXIT1":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.54     510.29     498.11

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "EXIT1"
                  WSBEG,WSEND,CRWS =   498.11     510.29     498.11

EXIT1:XS        5    -52      718  0.80 *****  498.91  498.11    3540  498.11
       -18      5    407    57722  2.13 ***** *******    1.01    4.93

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.82     498.38     498.11

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   497.61     510.29    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   497.61     510.29     498.11

FULLV:FV       19    -61      863  0.56  0.06  498.97  498.11    3540  498.41
         0     19    430    68379  2.12  0.00    0.00    0.80    4.10
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  2.74

APPRO:AS       55    -49     2033  0.06  0.05  499.02 *******    3540  498.96
        55     55    543   187542  1.32  0.00    0.00    0.19    1.74
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   498.41     497.65

            <<<<<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       19      0      238  1.25 *****  499.17  494.22    2139  497.92
         0 ******     29    23308  1.00 ***** *******    0.55    8.97
```

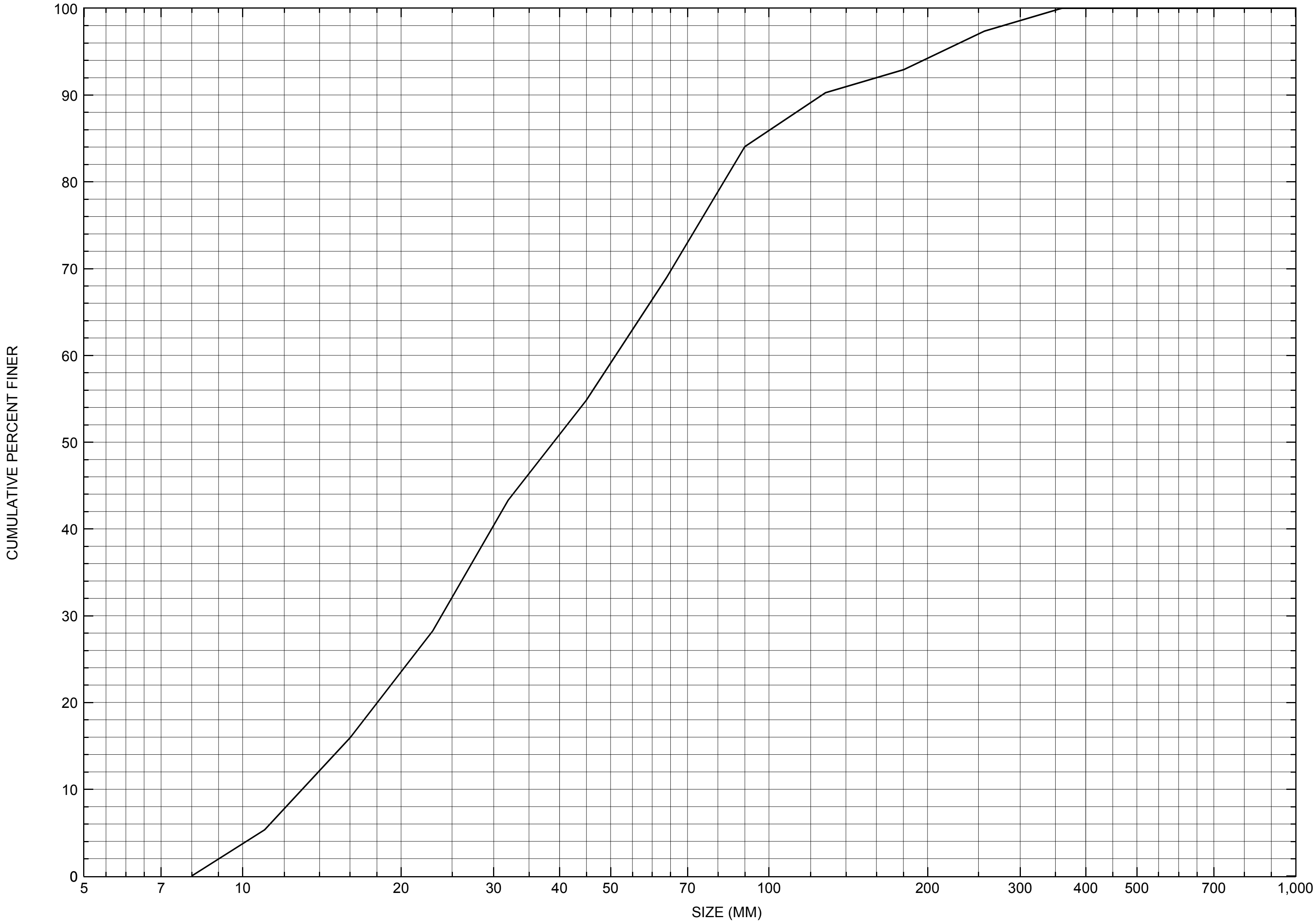
```
     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.65 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.    32.  0.00  0.03  500.41    0.00   1412.  500.08

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.     8.     7.    15.   0.1   0.1   3.1  16.9   0.5   3.0
   RT:   1412.   365.    39.   404.   1.7   0.8   4.9   4.6   1.2   3.0

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

APPRO:AS       19    -72     2904  0.03  0.05  500.42  495.97    3540  500.39
        55     50    550   318684  1.18  0.00    0.00    0.11    1.22

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

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT4:XS    -194.   -55.   412.   3540.   67363.     783.    4.52  496.61
   EXIT3:XS     -47.   -15.    44.   3540.   38341.     320.   11.06  496.66
   EXIT2:XS     -24.   -24.    64.   3540.   41912.     347.   10.21  497.04
   EXIT1:XS     -19.   -53.   407.   3540.   57722.     718.    4.93  498.11
   FULLV:FV       0.   -62.   430.   3540.   68379.     863.    4.10  498.41
   BRIDG:BR       0.     0.    29.   2139.   23308.     238.    8.97  497.92
   RDWAY:RG      14.*******     0.   1412.       0.*********    1.00  500.08
   APPRO:AS      55.   -73.   550.   3540.  318684.    2904.    1.22  500.39

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT4:XS    494.18    0.91  485.17  508.73************  0.69  497.30  496.61
   EXIT3:XS    495.73    0.86  486.73  510.29  0.71  0.66  2.02  498.68  496.66
   EXIT2:XS    495.73    0.96  486.73  510.29  0.18  0.00  1.81  498.85  497.04
   EXIT1:XS    498.11    1.01  488.78  510.29************  0.80  498.91  498.11
   FULLV:FV    498.11    0.80  488.78  510.29  0.06  0.00  0.56  498.97  498.41
   BRIDG:BR    494.22    0.55  487.49  497.92************  1.25  499.17  497.92
   RDWAY:RG  ****************  498.40  509.14  0.00******  0.03  500.41  500.08
   APPRO:AS    495.97    0.11  487.71  511.41  0.05  0.00  0.03  500.42  500.39

       U.S. Geological Survey WSPRO Input File nfie032.wsp
       Hydraulic analysis for structure NFIEVT012A0032   Date: 12-DEC-96
       State Route 12A Crossing the Dog River, Northfield, VT            EMB
          *** RUN DATE & TIME: 01-02-97  08:08

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

EXIT4:XS   ******    -70     1062  0.62 *****  497.80  496.86    4600  497.18
      -193 ******    436    89802  2.14 ***** *******    0.77    4.33

 ===125 FR# EXCEEDS FNTEST AT SECID "EXIT3":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    1.12     496.72     498.42

 ===110 WSEL NOT FOUND AT SECID "EXIT3":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   496.68     510.29    0.50

 ===115 WSEL NOT FOUND AT SECID "EXIT3":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   496.68     510.29     498.42

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
            ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "EXIT3"
                 WSBEG,WSEND,CRWS =    498.42     510.29     498.42

EXIT3:XS      147    -61      905  0.87 *****  499.29  498.42    4600  498.42
       -46    147    430    77054  2.16 ***** *******    0.97    5.08

EXIT2:XS       23    -70     1061  0.61  0.07  499.34 *******    4600  498.74
       -23     23    436    90596  2.08  0.00   -0.02    0.76    4.34

EXIT1:XS        5    -70     1025  0.63  0.01  499.37 *******    4600  498.73
       -18      5    436    82180  2.01  0.01    0.00    0.79    4.49

FULLV:FV       19    -73     1089  0.55  0.06  499.41 *******    4600  498.86
         0     19    438    88063  1.96  0.00   -0.02    0.72    4.22
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
```

```
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                          "APPRO"     KRATIO =  2.54

APPRO:AS       55    -56     2289  0.08  0.06  499.46 *******    4600  499.39
        55     55    545   223282  1.26  0.00    0.00    0.20    2.01
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                     WS3N,LSEL =   498.86     497.65

            <<<<<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       19      0      238  1.27 *****  499.19  494.24    2152  497.92
         0 ******     29    23308  1.00 ***** *******    0.55    9.03

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.65 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.    32.  0.00  0.04  500.90    0.00   2436.  500.49

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     10.    10.     5.    15.   0.1   0.1   3.2  14.3   0.5   3.0
   RT:   2426.   402.    15.   417.   2.1   1.2   5.8   5.2   1.6   3.1

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

APPRO:AS       19    -80     3206  0.04  0.07  500.91  496.44    4600  500.87
        55     52    553   369753  1.15  0.00    0.00    0.12    1.43

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

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXIT4:XS    -194.   -71.   436.   4600.   89802.    1062.    4.33  497.18
   EXIT3:XS     -47.   -62.   430.   4600.   77054.     905.    5.08  498.42
   EXIT2:XS     -24.   -71.   436.   4600.   90596.    1061.    4.34  498.74
   EXIT1:XS     -19.   -71.   436.   4600.   82180.    1025.    4.49  498.73
   FULLV:FV       0.   -74.   438.   4600.   88063.    1089.    4.22  498.86
   BRIDG:BR       0.     0.    29.   2152.   23308.     238.    9.03  497.92
   RDWAY:RG      14.*******    10.   2436.       0.*********    1.00  500.49
   APPRO:AS      55.   -81.   553.   4600.  369753.    3206.    1.43  500.87

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF     HO  VHD      EGL    WSEL
   EXIT4:XS    496.86    0.77  485.17  508.73************  0.62  497.80  497.18
   EXIT3:XS    498.42    0.97  486.73  510.29************  0.87  499.29  498.42
   EXIT2:XS  ********    0.76  486.73  510.29  0.07  0.00  0.61  499.34  498.74
   EXIT1:XS  ********    0.79  488.78  510.29  0.01  0.01  0.63  499.37  498.73
   FULLV:FV  ********    0.72  488.78  510.29  0.06  0.00  0.55  499.41  498.86
   BRIDG:BR    494.24    0.55  487.49  497.92************  1.27  499.19  497.92
   RDWAY:RG  ***************  498.40  509.14  0.00******  0.04  500.90  500.49
   APPRO:AS    496.44    0.12  487.71  511.41  0.07  0.00  0.04  500.91  500.87

        U.S. Geological Survey WSPRO Input File nfie032.wsp
        Hydraulic analysis for structure NFIEVT012A0032   Date: 12-DEC-96
        State Route 12A Crossing the Dog River, Northfield, VT            EMB
           *** RUN DATE & TIME: 01-02-97  08:08

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

EXIT4:XS   ******    -13      301  0.81 *****  495.57  491.93    2110  494.76
      -193 ******     43    35446  1.05 ***** *******    0.55    7.02

EXIT3:XS      147    -10      245  1.18  0.67  496.44 *******    2110  495.26
       -46    147     37    27404  1.02  0.19    0.01    0.68    8.61

EXIT2:XS       23    -11      257  1.08  0.13  496.58 *******    2110  495.50
       -23     23     38    29131  1.03  0.00    0.02    0.65    8.21

 ===125 FR# EXCEEDS FNTEST AT SECID "EXIT1":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80     0.86     495.25     494.56
```

```
 ===110 WSEL NOT FOUND AT SECID "EXIT1":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.00     510.29    0.50

 ===115 WSEL NOT FOUND AT SECID "EXIT1":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.00     510.29     494.56

EXIT1:XS        5    -10      210  1.61  0.04  496.88  494.56    2110  495.27
       -18      5     37    21163  1.03  0.27   -0.01    0.86   10.05

FULLV:FV       19    -11      232  1.33  0.17  497.05 *******    2110  495.71
         0     19     39    24165  1.04  0.00    0.00    0.77    9.09
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  3.17

APPRO:AS       55    -20      998  0.11  0.13  497.17 *******    2110  497.06
        55     55    422    76702  1.62  0.00   -0.01    0.32    2.12
         <<<<<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       19      0      162  2.63  0.22  497.24  494.16    2110  494.60
         0     19     29    18381  1.00  0.13   -0.01    0.90   13.01

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.65 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.        <<<<<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       19    -30     1330  0.06  0.10  497.80  494.74    2110  497.74
        55     43    507   105452  1.58  0.48    0.01    0.22    1.59

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.935  0.768   24340.    14.    43.   497.73

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT4:XS    -194.   -14.    43.   2110.   35446.     301.    7.02  494.76
   EXIT3:XS     -47.   -11.    37.   2110.   27404.     245.    8.61  495.26
   EXIT2:XS     -24.   -12.    38.   2110.   29131.     257.    8.21  495.50
   EXIT1:XS     -19.   -11.    37.   2110.   21163.     210.   10.05  495.27
   FULLV:FV       0.   -12.    39.   2110.   24165.     232.    9.09  495.71
   BRIDG:BR       0.     0.    29.   2110.   18381.     162.   13.01  494.60
   RDWAY:RG      14.**************       0.******************    1.00********
   APPRO:AS      55.   -31.   507.   2110.  105452.    1330.    1.59  497.74

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      14.    43.   24340.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXIT4:XS    491.93    0.55  485.17  508.73************  0.81  495.57  494.76
   EXIT3:XS  ********    0.68  486.73  510.29  0.67  0.19  1.18  496.44  495.26
   EXIT2:XS  ********    0.65  486.73  510.29  0.13  0.00  1.08  496.58  495.50
   EXIT1:XS    494.56    0.86  488.78  510.29  0.04  0.27  1.61  496.88  495.27
   FULLV:FV  ********    0.77  488.78  510.29  0.17  0.00  1.33  497.05  495.71
   BRIDG:BR    494.16    0.90  487.49  497.92  0.22  0.13  2.63  497.24  494.60
   RDWAY:RG  ****************  498.40  509.14**********************************
   APPRO:AS    494.74    0.22  487.71  511.41  0.10  0.48  0.06  497.80  497.74
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure NFIEVT012A0032, in Northfield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

NFIEVT012A0032

NFIEVT012A0032

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number NFIEVT012A0032

General Location Descriptive

Data collected by *(First Initial, Full last name)* L. Medalie

Date *(MM/DD/YY)* 10 / 13 / 95

Highway District Number *(I - 2; nn)* 06

County *(FIPS county code; I - 3; nnn)* 023

Town *(FIPS place code; I - 4; nnnnn)* 50275

Mile marker *(I - 11; nnn.nnn)* 002230

Waterway *(I - 6)* DOG RIVER

Road Name *(I - 7):* -

Route Number VT 12A

Vicinity *(I - 9)* ALT 2.4 MI S JCT. VT.12 N

Topographic Map Roxbury

Hydrologic Unit Code: -

Latitude *(I - 16; nnnn.n)* 44068

Longitude *(i - 17; nnnnn.n)* 72412

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20018700321213

Maintenance responsibility *(I - 21; nn)* 01

Maximum span length *(I - 48; nnnn)* 0032

Year built *(I - 27; YYYY)* 1929

Structure length *(I - 49; nnnnnn)* 000035

Average daily traffic, ADT *(I - 29; nnnnnn)* 001450

Deck Width *(I - 52; nn.n)* 235

Year of ADT *(I - 30; YY)* 92

Channel & Protection *(I - 61; n)* 5

Opening skew to Roadway *(I - 34; nn)* 30

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

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

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

Structure type *(I - 43; nnn)* 104

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) ______

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

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

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

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

Comments:

According to the structural inspection report of 7/6/93, the structure is a single span, concrete T-beam bridge. Both abutment walls are concrete. The left abutment wall has areas of cracking with leakage, and minor scaling, particularly near the footing, which is heavily scaled and exposed but not undermined. The back-walls of both abutments have areas of staining and cracking, with leakage. The right abutment wall has minor staining, cracking, and scaling. There is heavy scaling of the concrete footing at the right abutment. Some scour is noted along the right abutment footing, and the upstream end is slightly undermined. The channel is straight through the structure. There is some stream bank erosion **(continued, page 35)**

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: -

Terrain character: -

Stream character & type: -

Streambed material: -

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

Q_{50} - Q_{100} - Q_{500} -

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft³/ 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 (*ft²*): -

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

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

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

Comments:

on the both sides of the channel upstream. There is stone fill noted on the downstream banks.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **13.49** mi^2 Lake and pond area **0.021** mi^2

Watershed storage *(ST)* **0.16** %

Bridge site elevation **790** ft Headwater elevation **2733** ft

Main channel length **7.76** mi

10% channel length elevation **830** ft 85% channel length elevation **1600** ft

Main channel slope *(S)* **132.30** ft / mi

Watershed Precipitation Data

Average site precipitation ____ in Average headwater precipitation ____ in

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

Average seasonal snowfall *(Sn)* ____ ft

Bridge Plan Data

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

Project Number - Minimum channel bed elevation: -

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

Benchmark location description:

-

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

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

If 1: Footing Thickness _______ Footing bottom elevation: ______

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

If 3: Footing bottom elevation: ______

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

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

Briefly describe material at foundation bottom elevation or around piles:

-

Comments:

NO PLANS.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
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: **RB** Date: **09/23/96**

Computerized by: **RB** Date: **09/24/96**

Reviewd by: **EMB** Date: **1/23/97**

Structure Number **NFIEVT012A0032**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M. IVANOFF** Date *(MM/DD/YY)* **07** / **22** / 19**96**

2. Highway District Number **06**

County **WASHINGTON (023)**

Waterway *(I - 6)* **Dog River**

Route Number **VT 12A**

Mile marker **002230**

Town **NORTHFIELD (50275)**

Road Name **-**

Hydrologic Unit Code: **02010003**

3. Descriptive comments:
Located 2.4 miles south of the junction with VT 12.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **4** 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 **35** *(feet)* Span length **32** *(feet)* Bridge width **23.5** *(feet)*

Road approach to bridge:

8. LB **0** RB **0** *(**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 **0.0:1** US right **0.0:1**

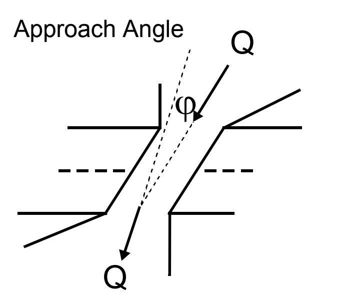
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	1	1
RBDS	0	-	2	3
LBDS	0	-	0	-

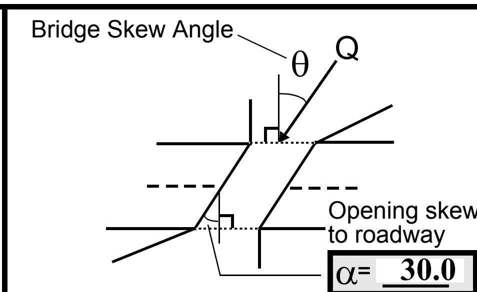
*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash;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

Channel approach to bridge (BF):

15. Angle of approach: **0**

16. Bridge skew: **30**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **30** feet **US** *(US, UB, DS)* to **10** feet **UB**

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**

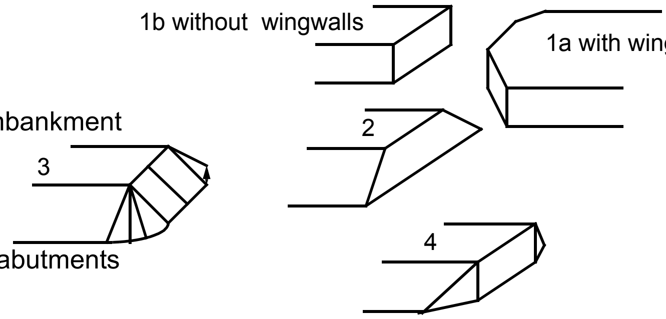
1a- Vertical abutments with wingwalls

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.)

4. The bridge is located in the middle of a golf course with short cut grass on all banks.

7. Values are from the VT AOT files. Measured values are the same.

C. Upstream Channel Assessment

20. SRD	21. Bank height (BF) LB	21. Bank height (BF) RB	22. Bank angle (BF) LB	22. Bank angle (BF) RB	26. % Veg. cover (BF) LB	26. % Veg. cover (BF) RB	27. Bank material (BF) LB	27. Bank material (BF) RB	28. Bank erosion (BF) LB	28. Bank erosion (BF) RB
28.5	**7.0**			**7.0**	**1**	**1**	**435**	**543**	**2**	**1**

23. Bank width **35.0** 24. Channel width **30.0** 25. Thalweg depth **49.0** 29. Bed Material **432**

30 .Bank protection type: LB **2** RB **2** 31. Bank protection condition: LB **1** 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.):

30. The left bank protection begins at 60 ft. US and goes to 116 ft. US. On the right bank the protection is slumped and extends from 62 ft. US to 100 ft. US.
There are two bridges US constructed of laid up stone abutments with stone fill along the base. The first bridge is at 108 ft. US and the second is at 350 ft. US.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **250** 35. Mid-bar width: **10**

36. Point bar extent: **194** feet **US** (US, UB) to **310** feet **US** (US, UB, DS) positioned **80** %LB to **100** %RB

37. Material: **43**

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

This is a cobble and gravel side bar.

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

41. Mid-bank distance: **40** 42. Cut bank extent: **25** feet **US** (US, UB) to **60** feet **US** (US, UB, DS)

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

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

The cut bank is an old slip failure that has been revegetated.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **53**

47. Scour dimensions: Length **10** Width **10** Depth : **1** Position **0** %LB to **40** %RB

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

Average thalweg depth US is 1 ft. Scour hole is 2 ft. deep below the cut bank.

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
26.0		1.5		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.):

342

Stream bed consists of gravel and cobble and sand.

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

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

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

70. Debris and Ice Comments:

2

Upstream the banks are forested and beyond 100 ft. upstream the stream meanders.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	2	2	0	2	90.0
RABUT	1	0	90			2	2	25.0

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.):

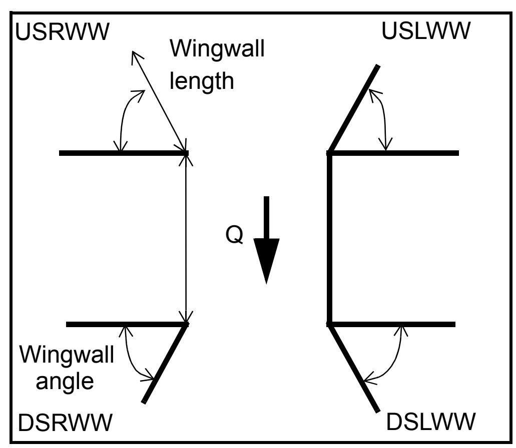
1.5
3
1

The right abutment scour is deepest at the US end. At the DS end of the right abutment, the footing is only exposed 2 feet. The average thalweg depth through the reach is 1 ft.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						25.0	
USRWW:	Y		1		0	2.0	
DSLWW:	-		-		Y	28.5	
DSRWW:	1		2		1.5	28.5	

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	3	2	Y	0.3	-	1	-	-
Condition	Y	0	1	1.8	-	2	-	-
Extent	1	2.2	2	0	2	0	0	-

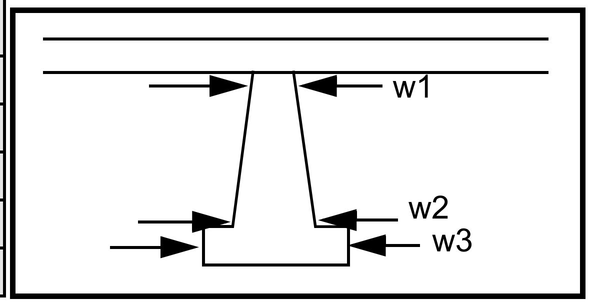
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? __-__ *(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				**25.0**	**12.5**	**70.0**
Pier 2			**8.5**	**11.0**	**125.0**	**60.0**
Pier 3	**9.0**	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)		-	-	-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type		-	-	-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material		-	-	-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape		-	-	-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?		-	-	-	*Y- yes; N- no*
91. Attack ∠ (BF)		-	-	-	
92. Pushed		-	-	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles		-	-	-	
95. Cross-members		-	-	-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition		-	-	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**N**	-	-	-	
98. Exposure depth	-	-	-	-	

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

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
-	-			-	-	NO	PIE	RS		

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.):

1
1
3
3
1
1
453
2
1
3
3
Both banks DS are protected with stone fill and blocks of granite from the ends of the wingwalls to 210 ft. DS. There is bedrock on the left bank at 270 ft. DS.

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

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

105. Drop structure comments (eg. downstream scour depth):
e is a golf cart bridge crossing the Dog River 219 ft. DS.

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

Point bar extent: ______ feet ____ *(US, UB, DS)* to ______ feet ____ *(US, UB, DS)* positioned **Y** %LB to **4** %RB

Material: **Th**

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

e drop structure is made of large cut stones.

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

Cut bank extent: **-** feet **-** *(US, UB, DS)* to **-** feet **-** *(US, UB, DS)*

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

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

-
-
-
-

Is channel scour present? **NO** *(Y or if N type ctrl-n cs)* Mid-scour distance: **POIN**

Scour dimensions: Length **T** Width **BAR** Depth: **S** Positioned ____ %LB to ____ %RB

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

N
-
-

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 **NO** Enters on **CU** *(LB or RB)* Type **T** *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

BANKS

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)*:

Y
27
6
12
1
0
55
DS of the drop structure the water depth is 2 ft.

N

109. G. Plan View Sketch

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

APPENDIX F:

SCOUR COMPUTATIONS

Structure Number: NFIEVT012A0032 Town: Northfield
Road Number: VT 12A County: Washington
Stream: Dog River

Initials EMB Date: 1/22/97 Checked: SAO

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	3540	4600	2110
Main Channel Area, ft2	488	512	359
Left overbank area, ft2	126	159	15
Right overbank area, ft2	2289	2535	956
Top width main channel, ft	49	49	49
Top width L overbank, ft	63	71	21
Top width R overbank, ft	511	514	468
D50 of channel, ft	0.128	0.128	0.128
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	10.0	10.4	7.3
y1, average depth, LOB, ft	2.0	2.2	0.7
y1, average depth, ROB, ft	4.5	4.9	2.0
Total conveyance, approach	318633	369733	105509
Conveyance, main channel	79678	86147	47724
Conveyance, LOB	7459	10057	436
Conveyance, ROB	231496	273529	57350
Percent discrepancy, conveyance	0.0000	0.0000	-0.0009
Qm, discharge, MC, cfs	885.2	1071.8	954.4
Ql, discharge, LOB, cfs	82.9	125.1	8.7
Qr, discharge, ROB, cfs	2571.9	3403.1	1146.9
Vm, mean velocity MC, ft/s	1.8	2.1	2.7
Vl, mean velocity, LOB, ft/s	0.7	0.8	0.6
Vr, mean velocity, ROB, ft/s	1.1	1.3	1.2
Vc-m, crit. velocity, MC, ft/s	8.3	8.4	7.9
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Main Channel	0	0	0

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	488	512	359
Main channel width, ft	49	49	49
y1, main channel depth, ft	9.96	10.45	7.33

Bridge Section			
(Q) total discharge, cfs	3540	4600	2110
(Q) discharge thru bridge, cfs	2139	2152	2110
Main channel conveyance	23308	23308	18367
Total conveyance	23308	23308	18367
Q2, bridge MC discharge,cfs	2139	2152	2110
Main channel area, ft2	238	238	162
Main channel width (skewed), ft	25.0	25.0	24.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25	25	24.9
y_bridge (avg. depth at br.), ft	9.53	9.53	6.51
Dm, median (1.25*D50), ft	0.16	0.16	0.16
y2, depth in contraction,ft	9.47	9.52	9.39
ys, scour depth (y2-ybridge), ft	-0.06	-0.02	2.88

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	3540	4600	2110
Q, thru bridge, cfs	2139	2152	2110
Total Conveyance, bridge	23308	23308	18367
Main channel(MC) conveyance, bridge	23308	23308	18367
Q, thru bridge MC, cfs	2139	2152	2110
Vc, critical velocity, ft/s	8.29	8.35	7.87
Vc, critical velocity, m/s	2.53	2.55	2.40
Main channel width (skewed), ft	25.0	25.0	24.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25.0	25.0	24.9
qbr, unit discharge, ft2/s	85.6	86.1	84.7
qbr, unit discharge, m2/s	7.9	8.0	7.9
Area of full opening, ft2	238.3	238.3	162.0
Hb, depth of full opening, ft	9.53	9.53	6.51
Hb, depth of full opening, m	2.91	2.91	1.98
Fr, Froude number, bridge MC	0.55	0.55	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
Elevation of Low Steel, ft	497.65	497.65	497.65
Elevation of Bed, ft	488.12	488.12	491.14
Elevation of Approach, ft	500.39	500.87	0
Friction loss, approach, ft	0.05	0.07	0
Elevation of WS immediately US, ft	500.34	500.80	0.00
ya, depth immediately US, ft	12.22	12.68	-491.14
ya, depth immediately US, m	3.73	3.87	-149.69
Mean elevation of deck, ft	500.34	500.34	500.34
w, depth of overflow, ft (>=0)	0.00	0.46	0.00
Cc, vert contrac correction (<=1.0)	0.94	0.94	ERR
Ys, depth of scour, ft	1.47	1.45	N/A

ARMORING			
D90	0.4136	0.4136	0.4136
D95	0.6969	0.6969	0.6969
Critical grain size,Dc, ft	0.2556	0.2587	0.6191
Decimal-percent coarser than Dc	0.223	0.218	0.065
Depth to armoring,ft	2.67	2.78	26.72

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	3540	4600	2110	3540	4600	2110
a', abut.length blocking flow, ft	74.8	82.9	33.4	523.4	525.9	479.8
Ae, area of blocked flow ft2	223	261.8	82	2073.1	2179.1	1015.5
Qe, discharge blocked abut.,cfs	231.5	311.2	148.2	--	--	1250.5
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.04	1.19	1.81	1.13	1.36	1.23
ya, depth of f/p flow, ft	2.98	3.16	2.46	3.96	4.14	2.12
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	60	60	60	120	120	120
K2	0.95	0.95	0.95	1.04	1.04	1.04
Fr, froude number f/p flow	0.106	0.118	0.203	0.094	0.107	0.149
ys, scour depth, ft	8.33	9.33	7.49	18.74	20.58	15.31

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)	74.8	82.9	33.4	523.4	525.9	479.8
y1 (depth f/p flow, ft)	2.98	3.16	2.46	3.96	4.14	2.12
a'/y1	25.09	26.25	13.60	132.14	126.92	226.69
Skew correction (p. 49, fig. 16)	0.90	0.90	0.90	1.07	1.07	1.07
Froude no. f/p flow	0.11	0.12	0.20	0.09	0.11	0.15
Ys w/ corr. factor K1/0.55:						
vertical	9.30	10.21	ERR	14.13	15.42	8.79
vertical w/ ww's	7.63	8.37	ERR	11.58	12.65	7.21
spill-through	5.12	5.61	ERR	7.77	8.48	4.83

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	0.55	0.55	0.9	0.55	0.55	0.9
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	9.53	9.53	6.51	9.53	9.53	6.51
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.78	1.78	ERR	1.78	1.78	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	2.64	ERR	ERR	2.64