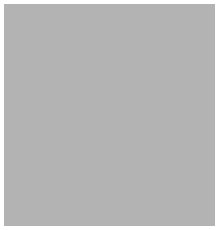
LEVEL II SCOUR ANALYSIS FOR BRIDGE 41 (ROCKTH00390041) on TOWN HIGHWAY 39, crossing the SAXTONS RIVER, ROCKINGHAM, VERMONT

U.S. Geological Survey
Open-File Report 97-377



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

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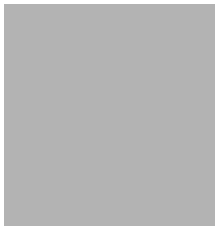

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	MC	main channel
D_{50}	median diameter of bed material	RAB	right abutment
DS	downstream	RABUT	face of right abutment
elev.	elevation	RB	right bank
f/p	flood plain	ROB	right overbank
ft^2	square feet	RWW	right wingwall
ft/ft	feet per foot	TH	town highway
JCT	junction	UB	under bridge
LAB	left abutment	US	upstream
LABUT	face of left abutment	USGS	United States Geological Survey
LB	left bank	VTAOT	Vermont Agency of Transportation
LOB	left overbank	WSPRO	water-surface profile model

In this report, the words “right” and “left” refer to directions that would be reported by an observer facing downstream.

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929-- a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

In the appendices, the above abbreviations may be combined. For example, USLB would represent upstream left bank.

LEVEL II SCOUR ANALYSIS FOR BRIDGE 41 (ROCKTH00390041) ON TOWN HIGHWAY 39, CROSSING THE SAXTONS RIVER, ROCKINGHAM, VERMONT

By **Erick M. Boehmler and James R. Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure ROCKTH00390041 on Town Highway 39 crossing the Saxtons River, Rockingham, 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 southeastern Vermont. The 57.4-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover consists of forest on the left bank and pasture with some trees on the right bank.

In the study area, the Saxtons River has an sinuous channel with a slope of approximately 0.009 ft/ft, an average channel top width of 112 ft and an average bank height of 10 ft. The channel bed material ranges from sand to cobbles with a median grain size (D_{50}) of 103 mm (0.339 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 15, 1996, indicated that the reach was laterally unstable. There are wide point bars, cut-banks with fallen trees, and areas of localized channel scour along the left bank, where there is bedrock exposure at the surface.

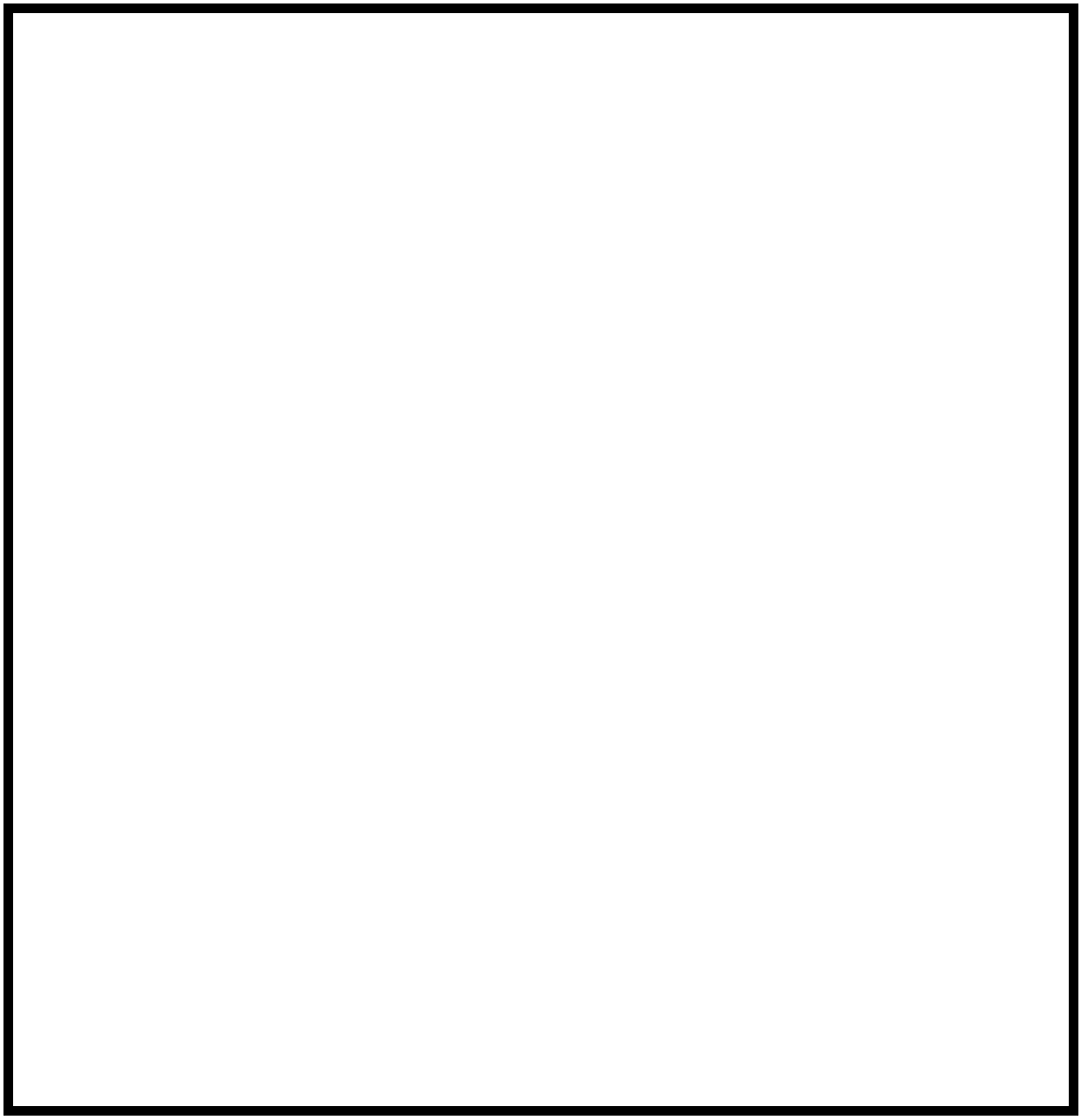
The Town Highway 39 crossing of the Saxtons River is an 85-ft-long, one-lane bridge consisting of one 82-foot steel-beam span (Vermont Agency of Transportation, written communication, March 31, 1995). The bridge is supported by vertical, concrete abutments without wingwalls. The channel is skewed approximately 30 degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 3 ft deeper than the mean thalweg depth was observed during the Level I assessment along the left side of the channel under the bridge exposing the left abutment footing 5.5 feet. The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) on the left banks upstream and downstream and the left abutment wall. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). 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 2.2 to 3.8 feet. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 21.4 to 23.2 feet and 26.2 to 32.4 feet at the left and right abutments respectively. The worst-case abutment scour occurred for the right abutment at the incipient overtopping 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. Bedrock was exposed at the surface in some areas of the channel and potentially is located at a shallower depth than the scour depths indicated above. Nevertheless, 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.

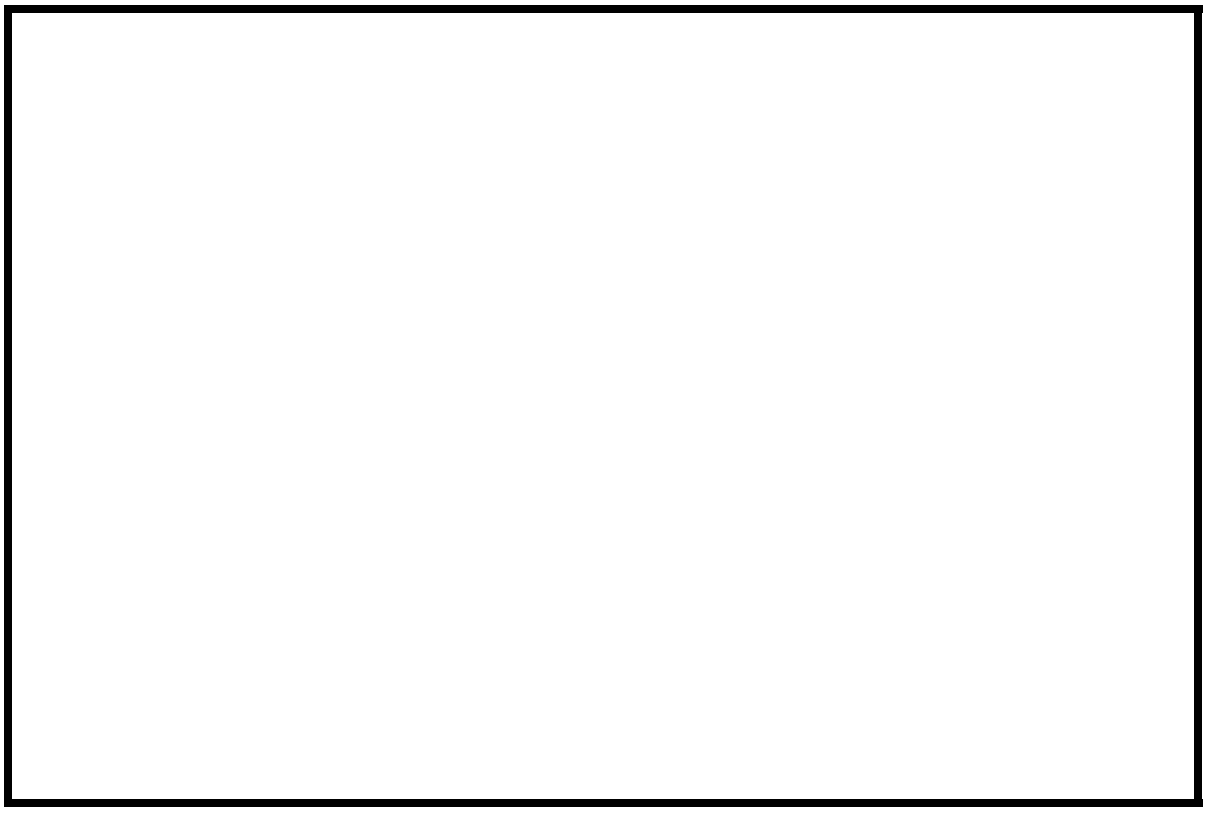


Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

NORTH

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

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



LEVEL II SUMMARY

Structure Number ROCKTH00390041 ***Stream*** Saxtons River

County Windham ***Road*** TH 39 ***District*** 2

Description of Bridge

Bridge length 85 ***ft*** ***Bridge width*** 15.8 ***ft*** ***Max span length*** 82 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 8/15/96

Description of stone fill Type-2 on the left abutment and the left banks upstream and downstream.

Abutments are concrete. There is a scour hole along the left abutment, which is one foot deeper than the average thalweg depth elsewhere in the reach.

Yes

Is bridge skewed to flood flow according to There ' ***survey?*** 30 ***Angle*** Yes

is a moderate channel bend in the upstream reach. The scour hole has developed in the location where flow impacts the left abutment at the channel bend.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	8/15/96	0	0
Level II	8/15/96	0	0

Potential for debris Moderate. There are large areas of the banks covered by vegetation and the channel is laterally unstable.

Describe any features near or at the bridge that may affect flow (include observation date) On the assessment of 8/15/96, there was a sand and gravel point bar noted along the right abutment through the bridge and a scour hole evident along the left abutment through the bridge.

Description of the Geomorphic Setting

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

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

Date of inspection 8/15/96

DS left: Steep channel bank to VT 121 roadway surface.

DS right: Mildly sloping channel bank to a narrow overbank.

US left: Steep channel bank to VT 121 roadway surface.

US right: Mildly sloping channel bank to a narrow overbank.

Description of the Channel

Average top width 112 ft ***Average depth*** 10 ft

Predominant bed material Sand to Cobbles ***Bank material*** Sand to Cobbles

Sinuous with semi-alluvial channel boundaries and wide point bars.

8/15/96

Vegetative co Trees

DS left: Trees

DS right: Trees

US left: Trees

US right: Trees

Do banks appear stable? No

If not, describe location and type of instability and date of observation.

The upstream reach was described on 8/15/96 as sinuous with alternating point bars and cut banks. There were several cut-banks and point bars measured in the assessment both upstream and downstream of the bridge.

Describe any obstructions in channel and date of observation.

No significant channel obstructions noted on 8/15/96.

Hydrology

Drainage area 57.4 ***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***:

Is there a USGS gage on the stream of interest? Yes

USGS gage description Saxtons River at Saxtons River, VT

USGS gage number 01154000 (Discontinued, 1982)

Gage drainage area 72.2 ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 9,100 ***ft³/s*** ***Q500*** 13,800 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(57.4/59.1)exp 0.75] with the flood frequency curve values for the Saxtons River above the confluence of Leach Creek from the Flood Insurance Study for the Town of Rockingham and Village of Bellows Falls (Federal Emergency Management Agency, 1979). The computed discharges were within a range defined by flood frequency curves computed by use of several empirical methods (Benson, 1962; FHWA, 1983; Johnson and Tasker, 1974; Potter, 1957a&b; Talbot, 1887) and values available from the VTAOT database (VTAOT, written communication, May 1995).

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 7.0 feet to the USGS arbitrary survey datum to obtain the VTAOT plans' datum.

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 downstream left corner of the bridge deck (elev. 499.73 feet, arbitrary survey datum). RM2 is a metallic tablet engraved with "VT highway dept. bench mark" set in the top of the concrete curb at the downstream right corner of the bridge deck (elev. 497.08 feet, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-84	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	10	1	Road Grade section
APPRO	97	2	Modelled Approach section (Templated from APTEM)
APTEM	105	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.040 to 0.050, and overbank "n" values ranged from 0.035 to 0.070.

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 0.0085 ft/ft, which was estimated from the 100-year water surface slope downstream of this site documented in the Flood Insurance Study for the Town of Rockingham and Village of Bellows Falls (Federal Emergency Management Agency, 1979).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0336 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

For the 500-year and incipient overtopping discharges modeled, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. After analyzing both the supercritical and subcritical profiles for each discharge, it was determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge are satisfactory solutions.

Bridge Hydraulics Summary

Average bridge embankment elevation 497.6 *ft*
Average low steel elevation 494.2 *ft*

100-year discharge 9,100 *ft³/s*
Water-surface elevation in bridge opening 486.5 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 566 *ft²*
Average velocity in bridge opening 16.1 *ft/s*
Maximum WSPRO tube velocity at bridge 20.0 *ft/s*

Water-surface elevation at Approach section with bridge 490.7
Water-surface elevation at Approach section without bridge 489.2
Amount of backwater caused by bridge 1.5 *ft*

500-year discharge 13,800 *ft³/s*
Water-surface elevation in bridge opening 488.9 *ft*
Road overtopping? Yes *Discharge over road* 413 *ft³/s*
Area of flow in bridge opening 733 *ft²*
Average velocity in bridge opening 18.3 *ft/s*
Maximum WSPRO tube velocity at bridge 22.5 *ft/s*

Water-surface elevation at Approach section with bridge 494.4
Water-surface elevation at Approach section without bridge 491.4
Amount of backwater caused by bridge 3.0

Incipient overtopping discharge 12,130 *ft³/s*
Water-surface elevation in bridge opening 488.2 *ft*
Area of flow in bridge opening 686 *ft²*
Average velocity in bridge opening 17.7 *ft/s*
Maximum WSPRO tube velocity at bridge 21.9 *ft/s*

Water-surface elevation at Approach section with bridge 493.6
Water-surface elevation at Approach section without bridge 490.8
Amount of backwater caused by bridge 2.8 *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 by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. The depth to armoring computed for each modeled discharge indicates streambed armoring will not limit contraction scour.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	2.2	3.8	3.3
Depth to armoring	43.4	73.6	63.6
Left overbank	--	--	--
Right overbank			

Local scour:			
Abutment scour	21.4	23.2	22.1
Left abutment	26.2	31.6	32.4
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	3.4	4.3	4.1
Left abutment	3.4	4.3	4.1
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

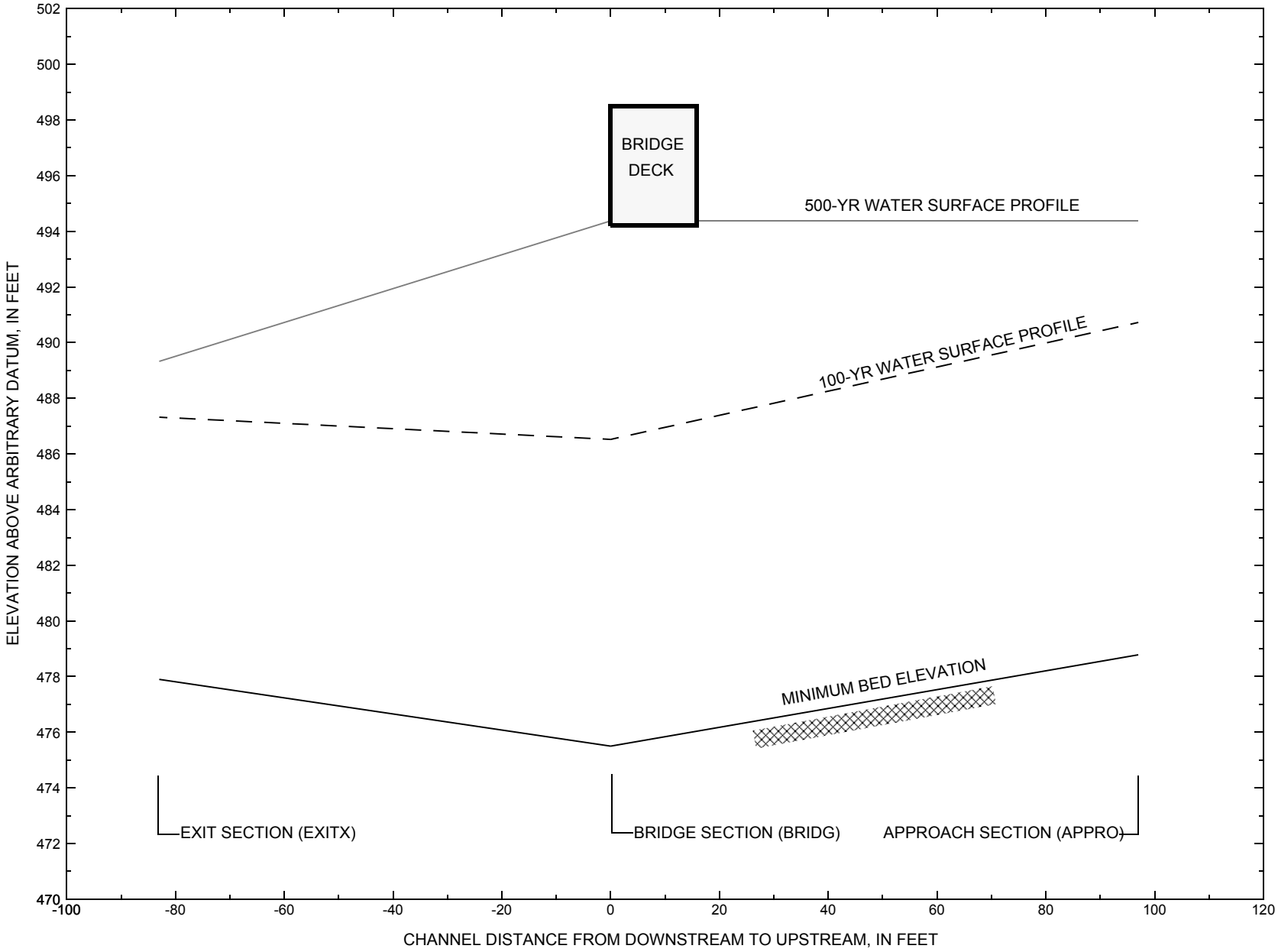


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure ROCKTH00390041 on Town Highway 39, crossing Saxtons River, Rockingham, Vermont.

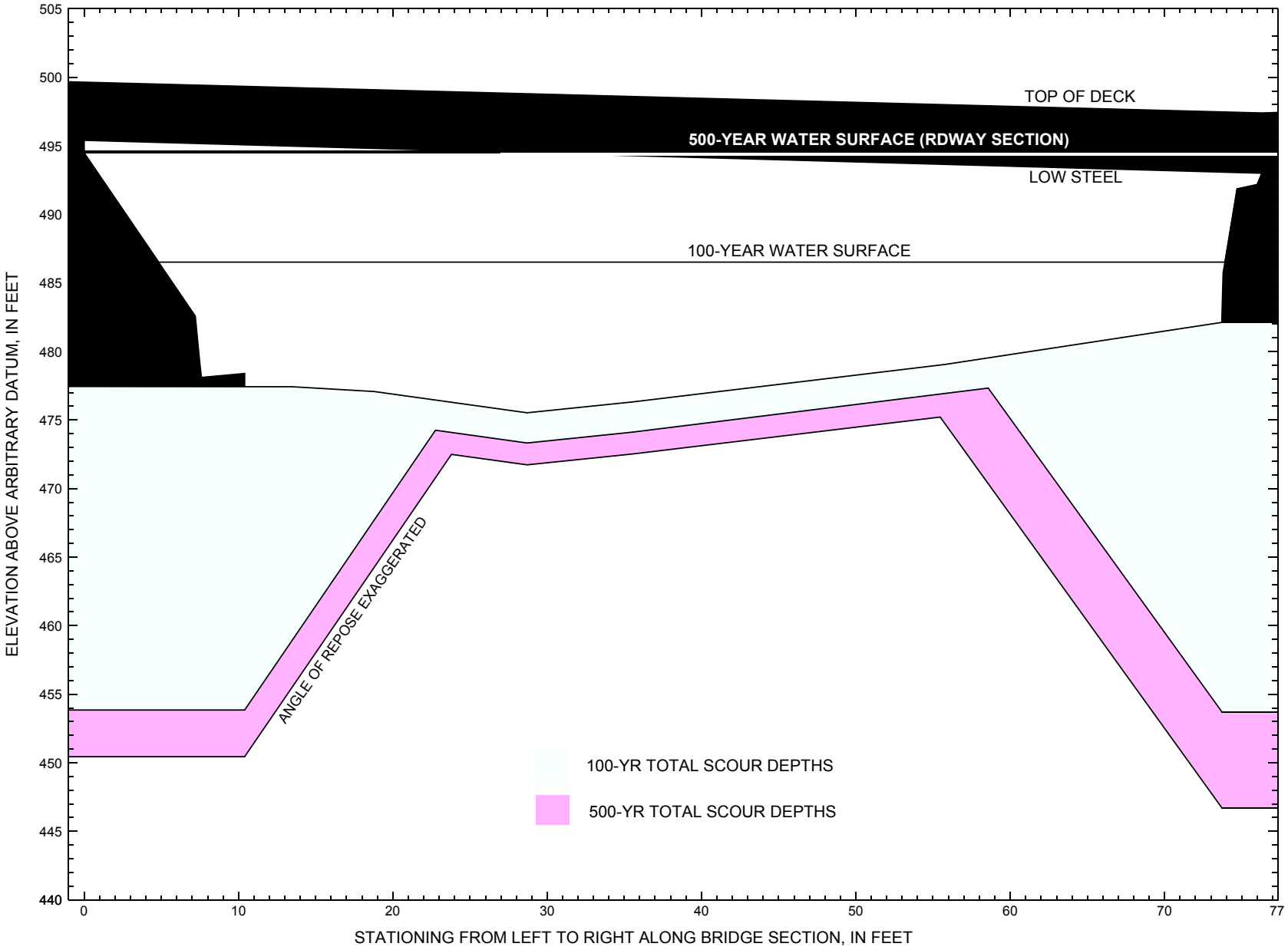


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure ROCKTH00390041 on Town Highway 39, crossing Saxtons River, Rockingham, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure ROCKTH00390041 on Town Highway 39, crossing Saxtons River, Rockingham, Vermont.

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

Description	Station[1]	VTAOT bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 9,100 cubic-feet per second											
Left abutment	0.0	501.8	495.4	478	477.4	2.2	21.4	--	23.6	453.8	-24
Right abutment	76.3	499.4	493.0	483	482.1	2.2	26.2	--	28.4	453.7	-29

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 ROCKTH00390041 on Town Highway 39, crossing Saxtons River, Rockingham, Vermont.

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

Description	Station[1]	VTAOT bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 13,800 cubic-feet per second											
Left abutment	0.0	501.8	495.4	478	477.4	3.8	23.2	--	27.0	450.4	-28
Right abutment	76.3	499.4	493.0	483	482.1	3.8	31.6	--	35.4	446.7	-36

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, 1979, Flood Insurance Study, Town of Rockingham and Village of Bellows Falls, Windham County, Vermont: Washington, D.C., November, 1979.

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, 1984, Saxtons River, Vermont 7.5 by 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Aerial photographs, 1977, Contour interval, 6 meters; Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File rock041.wsp
T2        Hydraulic analysis for structure ROCKTH00390041   Date: 24-FEB-97
T3        Town Highway 39 crossing the Saxtons River, Rockingham, VT         EMB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           9100.0  13800.0   12130.0
SK          0.0085   0.0085   0.0085
*
XS   EXITX    -84
GR          -72.5, 507.21    -58.7, 496.84    -36.8, 497.03    -24.8, 496.70
GR          -14.2, 483.58     -8.1, 482.11      0.0, 479.17      7.9, 477.90
GR           34.6, 477.93     53.7, 478.10     62.7, 479.22     67.0, 480.57
GR           82.4, 483.78     84.8, 485.09     95.4, 486.88    205.1, 488.84
GR          238.7, 494.39    323.3, 496.07    338.5, 494.69    358.8, 495.27
GR          369.7, 504.33
*
N           0.035        0.045        0.060
SA               -24.8         84.8
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    494.20       0.0
GR           0.0, 495.40      0.0, 494.46      7.2, 482.58      7.5, 479.12
GR           7.6, 478.10     10.4, 478.39     10.4, 477.44     13.5, 477.42
GR          18.8, 477.07     28.7, 475.53     35.5, 476.32     42.5, 477.32
GR          55.8, 479.05     73.7, 482.12     73.8, 485.72     74.7, 491.85
GR          76.0, 492.17     76.2, 492.68     76.3, 493.00      0.0, 495.40
*
*         BRTYPE  BRWDTH
CD           1      20.8
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     10      15.8     2
GR          -58.6, 511.17    -44.9, 500.56    -12.3, 499.39    -11.2, 499.82
GR            0.0, 499.64     73.2, 497.40     83.7, 497.01     83.9, 495.82
GR          133.6, 494.25    177.3, 493.14    339.8, 497.32    402.8, 502.03
GR          431.7, 512.76
*
XT   APTEM    105
GR          -36.5, 510.48    -30.9, 509.37    -10.4, 491.40     -2.9, 480.61
GR            0.0, 480.08      4.0, 479.05     14.5, 479.85     25.9, 479.67
GR           29.0, 479.11     42.5, 479.49     50.0, 480.04     59.3, 481.17
GR           62.5, 481.83    101.8, 485.68    138.9, 486.01    157.2, 488.45
GR          166.2, 488.54    184.0, 494.25    188.2, 494.03    227.8, 493.14
GR          390.2, 497.32    453.1, 502.03    482.1, 512.76
*
            For the incipient overtopping discharge model, the approach section was
            ended at station 184.0. The points right of station 184.0 were physically
            surveyed on the roadway. Without ending the section at 184.0, WSPRO models
            flow right of station 184.0 at this discharge but no roadway overtopping.
*
AS   APPRO    97  * * *  0.0336
GT
N           0.050        0.070
SA                101.8
*
HP 1 BRIDG 486.52 1 486.52
HP 2 BRIDG 486.52 * * 9100
HP 1 APPRO 490.72 1 490.72
HP 2 APPRO 490.72 * * 9100
*
HP 1 BRIDG 488.91 1 488.91
HP 2 BRIDG 488.91 * * 13387
HP 2 RDWAY 494.37 * * 413
HP 1 APPRO 494.37 1 494.37
HP 2 APPRO 494.37 * * 13800
*
HP 1 BRIDG 488.24 1 488.24
HP 2 BRIDG 488.24 * * 12450
HP 1 APPRO 493.57 1 493.57
HP 2 APPRO 493.57 * * 12130
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File rock041.wsp
        Hydraulic analysis for structure ROCKTH00390041   Date: 24-FEB-97
        Town Highway 39 crossing the Saxtons River, Rockingham, VT         EMB
           *** RUN DATE & TIME: 03-06-97  10:30

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      566     76984     69     81                        9197
   486.52           566     76984     69     81  1.00      5     74     9197

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      486.52     4.8    73.9   566.2   76984.    9100.  16.07

X STA.          4.8       12.4       15.8       18.8       21.4       23.9
  A(I)             49.0       30.5       27.9       25.5       24.9
  V(I)             9.29      14.93      16.31      17.83      18.31

X STA.         23.9       26.2       28.4       30.5       32.6       34.9
  A(I)             24.2       23.4       22.7       23.2       23.4
  V(I)            18.82      19.47      20.02      19.60      19.47

X STA.         34.9       37.2       39.7       42.3       45.1       48.2
  A(I)             23.6       24.3       24.6       25.7       26.0
  V(I)            19.29      18.76      18.53      17.67      17.47

X STA.         48.2       51.5       55.2       59.4       64.8       73.9
  A(I)             27.2       29.1       30.4       34.3       46.5
  V(I)            16.70      15.66      14.97      13.25       9.79

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      97.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1     1052    134896    112    118                       18311
           2      291     15669     72     73                        3326
   490.72          1344    150565    184    191  1.20     -9    174    18840

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      97.

        WSEL     LEW     REW    AREA        K        Q    VEL
      490.72   -10.1   173.8  1343.7  150565.    9100.   6.77

X STA.        -10.1        1.7        6.7       11.5       16.2       20.9
  A(I)             87.3       58.7       55.6       52.4       52.7
  V(I)             5.21       7.75       8.18       8.69       8.63

X STA.         20.9       25.6       29.9       34.2       38.5       43.0
  A(I)             52.5       50.6       50.5       50.4       51.5
  V(I)             8.67       8.98       9.00       9.02       8.84

X STA.         43.0       47.6       52.5       57.8       64.0       71.0
  A(I)             51.9       53.4       54.9       59.3       60.8
  V(I)             8.77       8.52       8.28       7.67       7.48

X STA.         71.0       79.5       89.7      104.0      127.8      173.8
  A(I)             66.5       71.5       83.1      123.7      156.3
  V(I)             6.84       6.37       5.48       3.68       2.91
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File rock041.wsp
        Hydraulic analysis for structure ROCKTH00390041   Date: 24-FEB-97
        Town Highway 39 crossing the Saxtons River, Rockingham, VT         EMB
           *** RUN DATE & TIME: 03-06-97  10:30

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      734    113706     71     86                        13388
  488.91           734    113706     71     86  1.00      3     74    13388

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      488.91     3.4    74.3   733.5  113706.   13387.  18.25

X STA.          3.4       12.2       15.7       18.7       21.6       24.2
  A(I)            66.6       40.4       35.0       34.6       31.9
  V(I)           10.05      16.57      19.12      19.32      20.98

X STA.         24.2       26.6       28.9       31.2       33.5       35.8
  A(I)            31.7       30.0       30.1       29.8       30.1
  V(I)           21.12      22.31      22.20      22.48      22.26

X STA.         35.8       38.3       40.9       43.6       46.5       49.5
  A(I)            30.4       31.5       31.0       32.8       33.2
  V(I)           21.99      21.28      21.62      20.40      20.17

X STA.         49.5       52.9       56.5       60.7       65.6       74.3
  A(I)            34.8       36.3       39.1       42.0       62.2
  V(I)           19.23      18.42      17.10      15.95      10.76

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

        WSEL     LEW     REW    AREA        K        Q    VEL
      494.37   129.8   225.1    59.1    1068.     413.   6.98

X STA.        129.8      149.6      155.6      160.0      163.3      166.3
  A(I)             5.4        3.6        3.2        2.8        2.7
  V(I)            3.84       5.70       6.44       7.42       7.64

X STA.        166.3      168.8      171.1      173.3      175.2      177.1
  A(I)             2.5        2.4        2.4        2.3        2.2
  V(I)            8.29       8.49       8.77       9.10       9.30

X STA.        177.1      178.9      180.9      183.0      185.3      187.9
  A(I)             2.2        2.3        2.3        2.4        2.5
  V(I)            9.20       9.01       8.97       8.49       8.11

X STA.        187.9      190.7      194.1      198.5      204.5      225.1
  A(I)             2.7        2.9        3.2        3.6        5.5
  V(I)            7.78       7.23       6.41       5.67       3.77

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      97.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1     1468    227959    116    123                        29640
           2      662     32955    184    185                         7126
  494.37          2130    260914    300    309  1.43    -13    286    26971

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      97.

        WSEL     LEW     REW    AREA        K        Q    VEL
      494.37   -14.1   286.0  2130.1  260914.   13800.   6.48

X STA.        -14.1        1.6        7.3       12.8       18.1       23.1
  A(I)            135.1       88.4       83.2       78.5       75.3
  V(I)             5.11       7.81       8.29       8.79       9.16

X STA.         23.1       28.3       33.0       37.7       42.6       47.5
  A(I)             77.4       72.1       73.4       74.5       73.3
  V(I)             8.91       9.57       9.40       9.26       9.42

X STA.         47.5       52.7       58.3       64.5       71.1       78.6
  A(I)             75.6       77.0       81.3       81.5       87.4
  V(I)             9.13       8.96       8.48       8.47       7.90

X STA.         78.6       87.0       96.8      112.5      137.0      286.0
  A(I)             90.0       97.4      141.7      214.1      352.8
  V(I)             7.67       7.08       4.87       3.22       1.96
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File rock041.io.wsp
        Hydraulic analysis for structure ROCKTH00390041   Date: 24-FEB-97
        Town Highway 39 crossing the Saxtons River, Rockingham, VT         EMB
           *** RUN DATE & TIME: 03-21-97  09:04

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      686    102904     70     85                        12157
  488.24           686    102904     70     85  1.00      4     74    12157

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      488.24     3.8    74.2   686.2  102904.   12130.  17.68

X STA.          3.8       12.2       15.7       18.8       21.6       24.1
  A(I)             60.6       37.7       34.4       31.4       30.4
  V(I)            10.01      16.09      17.62      19.33      19.94

X STA.         24.1       26.5       28.8       31.0       33.3       35.6
  A(I)             28.9       28.5       28.1       27.7       28.0
  V(I)            20.97      21.27      21.57      21.86      21.65

X STA.         35.6       38.1       40.6       43.3       46.2       49.2
  A(I)             28.8       28.8       29.8       30.8       31.1
  V(I)            21.04      21.03      20.37      19.70      19.51

X STA.         49.2       52.5       56.3       60.4       65.4       74.2
  A(I)             32.5       34.8       36.5       39.9       57.4
  V(I)            18.65      17.44      16.62      15.19      10.57

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      97.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1     1375    205912    115    122                       26994
           2      509     36665     81     82                        7252
  493.57          1885    242576    196    204  1.20    -12    183    30337

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      97.

        WSEL     LEW     REW    AREA        K        Q    VEL
      493.57   -13.2   182.7  1884.8  242576.   12130.   6.44

X STA.        -13.2        2.0        7.6       13.0       18.4       23.7
  A(I)            129.0       82.1       77.6       75.6       74.3
  V(I)             4.70       7.38       7.82       8.02       8.16

X STA.         23.7       28.7       33.5       38.4       43.3       48.4
  A(I)             71.9       70.0       71.2       71.1       71.9
  V(I)             8.44       8.66       8.52       8.53       8.44

X STA.         48.4       53.8       59.5       66.1       73.3       81.6
  A(I)             73.0       74.0       79.9       81.2       87.4
  V(I)             8.30       8.20       7.59       7.47       6.94

X STA.         81.6       90.8      102.4      120.4      139.7      182.7
  A(I)             89.9      100.6      145.4      152.2      206.6
  V(I)             6.75       6.03       4.17       3.98       2.94
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File rock041.wsp
       Hydraulic analysis for structure ROCKTH00390041   Date: 24-FEB-97
       Town Highway 39 crossing the Saxtons River, Rockingham, VT         EMB
          *** RUN DATE & TIME: 03-06-97  10:30

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

EXITX:XS   ******    -16      801  2.09 *****  489.41  485.94    9100  487.32
       -83 ******    120    98624  1.04 ***** *******    0.85   11.36

FULLV:FV       84    -17      992  1.51  0.56  489.96 *******    9100  488.45
         0     84    183   124932  1.16  0.00   -0.01    0.78    9.17
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       97     -8     1069  1.34  0.59  490.54 *******    9100  489.20
        97     97    169   109528  1.19  0.00   -0.01    0.67    8.52
          <<<<<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       84      5      566  4.20  0.92  490.72  486.47    9100  486.52
         0     84     74    77019  1.05  0.39    0.00    1.01   16.07

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  0.978 ******  494.20 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<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       76     -9     1344  0.85  0.57  491.58  487.31    9100  490.72
        97     80    174   150642  1.20  0.29    0.01    0.48    6.77

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.604  0.310  103808.     9.    78.   490.43

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -84.   -17.   120.   9100.   98624.     801.   11.36  487.32
   FULLV:FV       0.   -18.   183.   9100.  124932.     992.    9.17  488.45
   BRIDG:BR       0.     5.    74.   9100.   77019.     566.   16.07  486.52
   RDWAY:RG      10.**************      0.******************    2.00********
   APPRO:AS      97.   -10.   174.   9100.  150642.    1344.    6.77  490.72

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       9.    78.  103808.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    485.94    0.85  477.90  507.21************  2.09  489.41  487.32
   FULLV:FV  ********    0.78  477.90  507.21  0.56  0.00  1.51  489.96  488.45
   BRIDG:BR    486.47    1.01  475.53  495.40  0.92  0.39  4.20  490.72  486.52
   RDWAY:RG  ***************  493.14  512.76**********************************
   APPRO:AS    487.31    0.48  478.78  512.49  0.57  0.29  0.85  491.58  490.72
```

WSPRO OUTPUT FILE (continued)

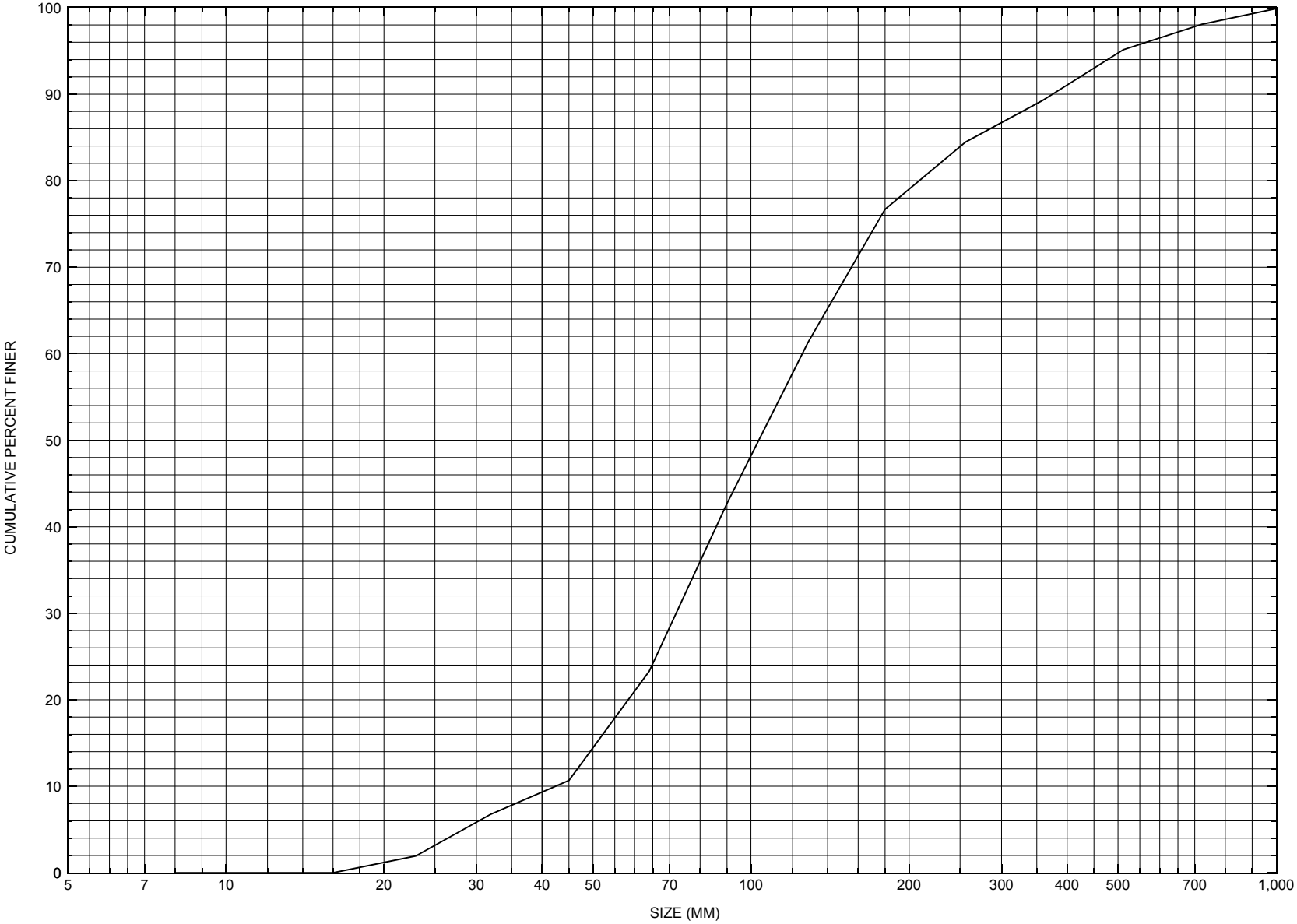
```
       U.S. Geological Survey WSPRO Input File rock041.wsp
       Hydraulic analysis for structure ROCKTH00390041   Date: 24-FEB-97
       Town Highway 39 crossing the Saxtons River, Rockingham, VT         EMB
          *** RUN DATE & TIME: 03-06-97  10:30

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

EXITX:XS   ******    -18     1185  2.65 *****  491.98  488.56   13800  489.33
       -83 ******    208   149629  1.26 ***** *******    1.01   11.65

FULLV:FV       84    -19     1533  1.67  0.53  492.50 *******   13800  490.83
         0     84    217   200248  1.33  0.00   -0.01    0.72    9.00
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       97    -10     1469  1.64  0.54  493.04 *******   13800  491.40
        97     97    176   170671  1.20  0.00    0.00    0.65    9.39
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   494.79       0.00     489.14     493.14

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =   13387.     488.91

            <<<<<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       84      3      733  5.60 *****  494.51  488.91   13387  488.91
         0     84     74   113682  1.08 ***** *******    1.04   18.25

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.962 ******  494.20 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    81.  0.23  0.93  495.07    0.00    413.  494.37

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.    82.   -46.    36.   2.8   1.7   8.4  10.8   3.4   3.0
   RT:    413.    91.   134.   225.   1.2   0.6   5.0   7.0   1.3   2.9

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

APPRO:AS       76    -13     2130  0.93  0.51  495.30  489.19   13800  494.37
        97     81    286   260929  1.43  0.29    0.02    0.51    6.48

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.612  0.347  169917.    11.    82. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -84.   -19.   208.  13800.  149629.    1185.   11.65  489.33
   FULLV:FV       0.   -20.   217.  13800.  200248.    1533.    9.00  490.83
   BRIDG:BR       0.     3.    74.  13387.  113682.     733.   18.25  488.91
   RDWAY:RG      10.*******     0.    413.       0.*********    2.00  494.37
   APPRO:AS      97.   -14.   286.  13800.  260929.    2130.    6.48  494.37

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      11.    82.  169917.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    488.56    1.01  477.90  507.21************  2.65  491.98  489.33
   FULLV:FV  ********    0.72  477.90  507.21  0.53  0.00  1.67  492.50  490.83
   BRIDG:BR    488.91    1.04  475.53  495.40************  5.60  494.51  488.91
   RDWAY:RG  ***************  493.14  512.76  0.23******  0.93  495.07  494.37
   APPRO:AS    489.19    0.51  478.78  512.49  0.51  0.29  0.93  495.30  494.37
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File rock041.io.wsp
       Hydraulic analysis for structure ROCKTH00390041   Date: 24-FEB-97
       Town Highway 39 crossing the Saxtons River, Rockingham, VT         EMB
          *** RUN DATE & TIME: 03-21-97  09:04

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

EXITX:XS   ******    -17     1044  2.50 *****  491.20  487.46   12130  488.70
       -83 ******    197   131448  1.19 ***** *******    1.02   11.61

FULLV:FV       84    -18     1371  1.59  0.53  491.73 *******   12130  490.14
         0     84    213   175849  1.31  0.00    0.00    0.73    8.85
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       97     -9     1351  1.50  0.54  492.26 *******   12130  490.76
        97     97    174   151649  1.20  0.00   -0.01    0.64    8.98
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   493.57       0.00     488.24     493.14

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =   12130.     488.24

            <<<<<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       84      4      686  5.33 *****  493.57  488.24   12130  488.24
         0     84     74   102901  1.10 ***** *******    1.05   17.68

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.955 ******  494.20 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF    VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<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       76    -12     1884  0.77  0.48  494.34  488.63   12130  493.57
        97     81    183   242427  1.20  0.29    0.01    0.40    6.44

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.610  0.363  154200.    11.    81. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -84.   -18.   197.  12130.  131448.    1044.   11.61  488.70
   FULLV:FV       0.   -19.   213.  12130.  175849.    1371.    8.85  490.14
   BRIDG:BR       0.     4.    74.  12130.  102901.     686.   17.68  488.24
   RDWAY:RG      10.**************      0.       0.       0.    2.00********
   APPRO:AS      97.   -13.   183.  12130.  242427.    1884.    6.44  493.57

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      11.    81.  154200.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    487.46    1.02  477.90  507.21************  2.50  491.20  488.70
   FULLV:FV  ********    0.73  477.90  507.21  0.53  0.00  1.59  491.73  490.14
   BRIDG:BR    488.24    1.05  475.53  495.40************  5.33  493.57  488.24
   RDWAY:RG  ****************  493.14  512.76  0.20******  0.77  494.12********
   APPRO:AS    488.63    0.40  478.78  512.49  0.48  0.29  0.77  494.34  493.57
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure ROCKTH00390041, in Rockingham, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number ROCKTH00390041

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 31 / 95

Highway District Number *(I - 2; nn)* 02

County *(FIPS county code; I - 3; nnn)* 025

Town *(FIPS place code; I - 4; nnnnn)* 60250

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

Waterway *(I - 6)* SAXTONS RIVER

Road Name *(I - 7):* -

Route Number TH039

Vicinity *(I - 9)* 0.02 MI TO JCT W VT121

Topographic Map Saxtons.River

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 43084

Longitude *(i - 17; nnnnn.n)* 72324

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10131400411314

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

Maximum span length *(I - 48; nnnn)* 0082

Year built *(I - 27; YYYY)* 1964

Structure length *(I - 49; nnnnnn)* 000085

Average daily traffic, ADT *(I - 29; nnnnnn)* 000030

Deck Width *(I - 52; nn.n)* 158

Year of ADT *(I - 30; YY)* 90

Channel & Protection *(I - 61; n)* 7

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

Waterway adequacy *(I - 71; n)* 7

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)* 73.5

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

Vertical clearance from streambed *(nnn.n ft)* 16

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

Waterway of full opening *(nnn.n ft^2)* 1176

Comments:

The structural inspection report indicates that the structure is a single span, steel beam type bridge. Both abutments are concrete. The abutment concrete has very minor staining reported. The waterway makes a slight turn through the structure. The streambed consists of stone and gravel with some random boulders. There is a shallow sand (mud and gravel) point bar with minor vegetation growth in front of the right abutment. There is a bedrock outcrop upstream from the left abutment. There report noted that there was no channel scour, embankment erosion, or structure settlement apparent. The footings are noted as "not in view".

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*): - Frequency: -

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

Are there other structures nearby? (*Yes, No, Unknown*): - *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:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **57.38** mi^2 Lake and pond area **0.23** mi^2

Watershed storage *(ST)* **0.6** %

Bridge site elevation **551** ft Headwater elevation **2126** ft

Main channel length **6.80** mi

10% channel length elevation **571** ft 85% channel length elevation **866** ft

Main channel slope *(S)* **57.92** 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):* 03 / 1964

Project Number TH 3010 & TF 41/62 Minimum channel bed elevation: 485.0

Low superstructure elevation: USLAB 501.81 DSLAB 501.81 USRAB 499.35 DSRAB 499.35

Benchmark location description:

BM #1: at or near an 18 inch elm tree, elevation 500.0, 94 feet right bankward of the right abutment then 8.8 feet from the centerline of roadway on the downstream side of the roadway.

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

Foundation Type: 3 (*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: 484.5

Is boring information available? Y *If no, type ctrl-n bi* Number of borings taken: 6

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

Briefly describe material at foundation bottom elevation or around piles:

Referencing Right abutment: B1 hit ledge/boulder at 2.0 feet depth (489.5) upstream right bank

B2 hit ledge/boulder at 3.0 feet depth (490.7) downstream right bank

B3 hit ledge/boulder at 11.5 feet depth (493.3) downstream of the right abutment

B4 hit ledge/boulder at 10.0 feet depth (495.5) upstream right abutment

Referencing Left abutment: B5 hit ledge/boulder at 4.0 feet depth (484.2) downstream left bank

B6 hit ledge/boulder at 7.0 feet depth (482.0) upstream of the left bank

Comments:

***Footing bottom elevation left: 484.5 and right: 490.0. Both abutments sit on boulders or bedrock.**

Cross-sectional Data

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

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

Comments: **Upstream bridge face cross section at stationing 1 + 89.5, 10.5 feet from the centerline of the roadway on the bridge deck. The channel baseline runs along the left bank 12 feet from the end of the bridge deck parallel to the abutment wall.**

Station	12.0	14.0	15.4	21.1	30.0	36.5	46.0	50.5	51.0	51.5	53.0
Feature	LCL	top of wall	LEW	BLB			REW	BRB	top of wall	LCR	
Low cord elevation	498.5	498.0							493.8	497.3	497.3
Bed elevation			490.7	489.8	489.8	490.0	490.7	491.6			
Low cord to bed length											

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

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

Comments: **Downstream bridge face cross section at stationing 2 + 10, 10 feet from the centerline of the roadway on the bridge deck.**

Station	12.5	15.0	16.2	24.5	29.8	38.0	45.0	50.5	51.0	51.5	
Feature	LCL	top of wall	BLB / LEW			TD		BRB / REW	top of wall	LCR	
Low cord elevation	498.5	498.5							493.8		
Bed elevation			490.7	490.5	489.8	489.3	489.8	490.7		497.3	
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: 10/09/96
Computerized by: RB Date: 10/10/96
Reviewd by: EB Date: 3/7/97

Structure Number ROCKTH00390041

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN Date *(MM/DD/YY)* 08 / 15 / 1996

2. Highway District Number 02
Mile marker 0000
County Windham (025)
Town Rockingham (60250)
Waterway *(I - 6)* Saxtons River
Road Name -
Route Number TH 39
Hydrologic Unit Code: 01080107

3. Descriptive comments:
This concrete deck bridge is 0.02 miles from the intersection of TH 39 with VT 121 (TH 1, FAS 125).

B. Bridge Deck Observations

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

5. Ambient water surface... US 2 UB 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 85 *(feet)* Span length 82 *(feet)* Bridge width 15.8 *(feet)*

Road approach to bridge:

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

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

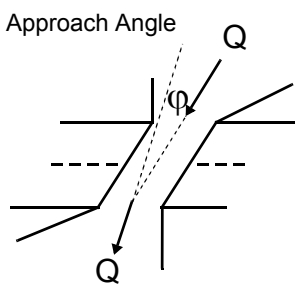
10. Embankment slope (*run / rise in feet / foot*):
US left - US right -

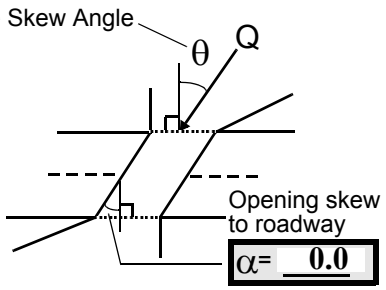
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	1	3	2
RBUS	3	2	1	2
RBDS	3	1	1	1
LBDS	2	1	3	1

*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: 35 16. Bridge skew: 30





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 2
Range? 100 feet US *(US, UB, DS)* to 30 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: **1b**

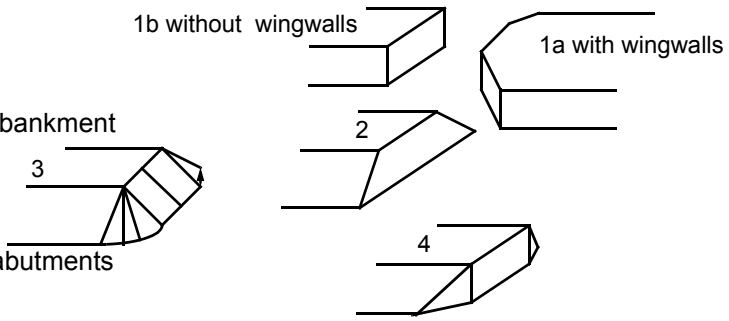
1a- Vertical abutments with wingwalls

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. There are two houses on the DS right bank.

7. Values are from the VT AOT files. Measured bridge dimensions are the same.

10. The right bank road approach protection is rip rap. The left bank road approach protection is dumped stone that also acts as bank protection.

11. The US right bank road approach protection is being slumped by the dry confluence cut bank.

C. Upstream Channel Assessment

	21. Bank height (BF)		22. Bank angle (BF)		26. % Veg. cover (BF)		27. Bank material (BF)		28. Bank erosion (BF)	
20. SRD	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB
93.0	**11.0**			**4.5**	**3**	**3**	**645**	**234**	**2**	**1**

23. Bank width **55.0** 24. Channel width **5.0** 25. Thalweg depth **112.0** 29. Bed Material **432**

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

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

29. There are some boulders in the bed US of the approach cross section and slumped protection on the left bank side just US and under the bridge.

31. The left bank protection protects the road approach also and extends from 40 ft. US to 0 ft. US. The bedrock on the left bank extends from 95 ft. US to 35 ft. US. The channel US consists of alternating point bars and cut banks.

33. Point/Side bar present? Y *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: 65 35. Mid-bar width: 30

36. Point bar extent: 175 feet US *(US, UB)* to 50 feet DS *(US, UB, DS)* positioned 66 %LB to 100 %RB

37. Material: 234

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

The material becomes coarser moving from DS to US. There is some grass and bushes at the US end.

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: 45 42. Cut bank extent: 65 feet US *(US, UB)* to 35 feet US *(US, UB, DS)*

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

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

The cut bank is on top of the bedrock. There is an additional cut bank on the right bank of the confluence that is cutting into the roadway protection.

45. Is channel scour present? Y *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: 0

47. Scour dimensions: Length 90 Width 25 Depth : 3 Position 0 %LB to 50 %RB

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

The scour hole extends from 40 ft. US to 40 ft. DS.

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 There is a dry channel running along the right bank US road approach protection at the bottom of the road embankment.

D. Under Bridge Channel Assessment

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

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
62.0		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

-

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

67. Debris Potential **1** *(**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

-

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		**30**	**75**	**2**	**2**	**1**	**5.5**	**90.0**
RABUT	**1**	**0**	**90**			**2**	**0**	**76.0**

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.):

-

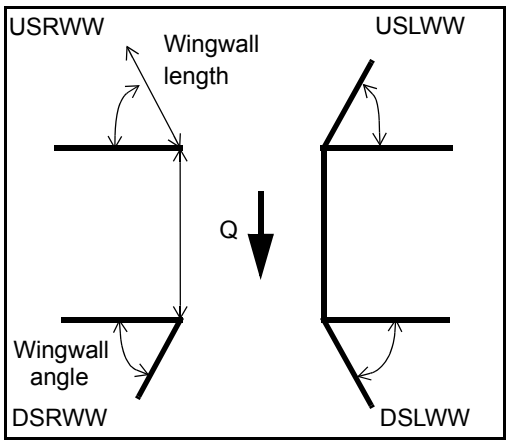
-

1

The scour depth assumes a 1 ft. thalweg.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**76.0**	
USRWW:	**N**		-		-	**3.5**	
DSLWW:	-		-		**N**	**23.0**	
DSRWW:	-		-		-	**18.5**	



*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	-	-	**N**	-	-	-	**3**	-
Condition	**N**	-	-	-	-	-	**1**	-
Extent	-	-	-	-	-	**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*

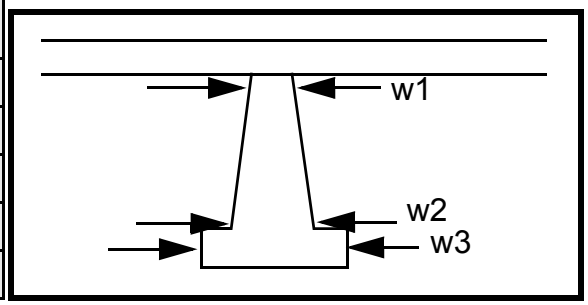
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
-
-
-
-
-
-

Piers:

84. Are there piers? **La** *(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	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4
86. Location (BF)	**rge**	**r the**		-
87. Type	**boul-**	**wate**	**N**	-
88. Material	**ders**	**r.**	-	-
89. Shape	**are**		-	-
90. Inclined?	**in**		-	-
91. Attack ∠ (BF)	**front**		-	-
92. Pushed	**of**		-	-
93. Length (feet)	-	-	-	-
94. # of piles	**the**		-	-
95. Cross-members	**left**		-	-
96. Scour Condition	**abut**		-	-
97. Scour depth	**ment**		-	-
98. Exposure depth	**unde**		-	-

LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP

***1**- Solid pier, **2**- column, **3**- bent*

***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*

***1**- Round; **2**- Square; **3**- Pointed*

Y- yes; N- no

LB or RB

***0**- none; **1**- laterals; **2**- diagonals; **3**- both*

***0**- not evident; **1**- evident (comment);*
***2**- footing exposed; **3**- piling exposed;*
***4**- undermined footing; **5**- settled; **6**- failed*

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
-	-			-	-	-	-	-	-	-

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.):

-
-
-
-
-

NO PIERS

101. Is a drop structure present? 3 *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

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

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

234
234
1
1
234
2

106. Point/Side bar present? 0 *(Y or N. if N type ctrl-n pb)* Mid-bar distance: 1 Mid-bar width: -

Point bar extent: The feet ma *(US, UB, DS)* to teria feet lon (*US, UB, DS)* positioned the %LB to ba %RB

Material: nk

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

s and in the channels has boulders buried underneath it. Beyond the exit cross section, the boulders and cobbles make up the channel banks. The left bank protection extends from 0 ft. DS to 38 ft. DS and also serves as road approach protection.

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 _____ 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.):

N

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

Scour dimensions: Length DRO Width P Depth: STR Positioned UC %LB to TU %RB

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

RE

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

Confluence 1: Distance Y Enters on 215 *(LB or RB)* Type 65 *(**1**- perennial; **2**- ephemeral)*

Confluence 2: Distance 140 Enters on DS *(LB or RB)* Type 360 *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

DS
35

F. Geomorphic Channel Assessment

107. Stage of reach evolution 100

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

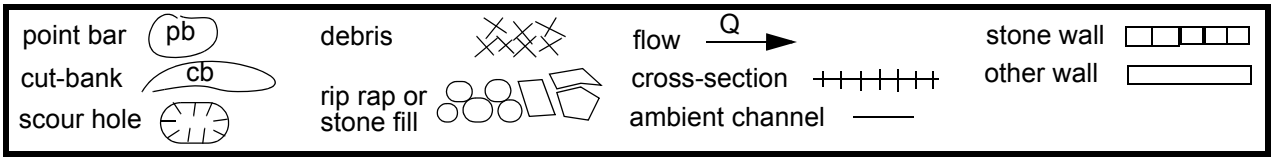
108. Evolution comments *(Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors)*:

543

There is a shallower, narrower extension of this bar which reaches to 580 ft. DS.

Y
LB
160
80
DS
580
DS
1

109. G. Plan View Sketch



APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: ROCKTH00390041 Town: Rockingham
Road Number: TH 39 County: Windham
Stream: Saxtons River

Initials EMB Date: 3/6/97 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	9100	13800	12130
Main Channel Area, ft2	1052	1468	1375
Left overbank area, ft2	0	0	0
Right overbank area, ft2	291	662	509
Top width main channel, ft	112	116	115
Top width L overbank, ft	0	0	0
Top width R overbank, ft	72	184	81
D50 of channel, ft	0.3393	0.3393	0.3393
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	9.4	12.7	12.0
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	4.0	3.6	6.3
Total conveyance, approach	150565	260914	242576
Conveyance, main channel	134896	227959	205912
Conveyance, LOB	0	0	0
Conveyance, ROB	15669	32955	36665
Percent discrepancy, conveyance	0.0000	0.0000	-0.0004
Qm, discharge, MC, cfs	8153.0	12057.0	10296.6
Ql, discharge, LOB, cfs	0.0	0.0	0.0
Qr, discharge, ROB, cfs	947.0	1743.0	1833.4
Vm, mean velocity MC, ft/s	7.7	8.2	7.5
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	3.3	2.6	3.6
Vc-m, crit. velocity, MC, ft/s	11.4	11.9	11.8
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	1052	1468	1375
Main channel width, ft	112	116	115
y1, main channel depth, ft	9.39	12.66	11.96
Bridge Section			
(Q) total discharge, cfs	9100	13800	12130
(Q) discharge thru bridge, cfs	9100	13387	12130
Main channel conveyance	76984	113706	102904
Total conveyance	76984	113706	102904
Q2, bridge MC discharge,cfs	9100	13387	12130
Main channel area, ft2	566	734	686
Main channel width (skewed), ft	69.1	70.9	70.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	69.1	70.9	70.4
y_bridge (avg. depth at br.), ft	8.19	10.35	9.75
Dm, median (1.25*D50), ft	0.424125	0.424125	0.424125
y2, depth in contraction,ft	10.37	14.12	13.06
ys, scour depth (y2-ybridge), ft	2.18	3.78	3.31
ARMORING			
D90	1.231	1.231	1.231
D95	1.665	1.665	1.665
Critical grain size,Dc, ft	1.3469	1.5665	1.5081
Decimal-percent coarser than Dc	0.0851	0.06	0.0664
Depth to armoring,ft	43.44	73.63	63.61

Abutment Scour

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

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	9100	13800	12130	9100	13800	12130
a', abut.length blocking flow, ft	14.9	17.5	16.9	99.9	109.7	108.5
Ae, area of blocked flow ft2	123.7	163	153.9	478.4	693.6	772.6
Qe, discharge blocked abut.,cfs	737.1	907.9	790.6	2120	--	3573
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	5.96	5.57	5.14	4.43	4.06	4.62
ya, depth of f/p flow, ft	8.30	9.31	9.11	4.79	6.32	7.12
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	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	0.364	0.322	0.300	0.357	0.339	0.305
ys, scour depth, ft	21.39	23.20	22.05	26.20	31.63	32.41

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)	14.9	17.5	16.9	99.9	109.7	108.5
y1 (depth f/p flow, ft)	8.30	9.31	9.11	4.79	6.32	7.12
a'/y1	1.79	1.88	1.86	20.86	17.35	15.24
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.36	0.32	0.30	0.36	0.34	0.31
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	1	1	1	1	1	1
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	8.19	10.35	9.75	8.19	10.35	9.75
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	3.43	4.33	4.08	3.43	4.33	4.08