LEVEL II SCOUR ANALYSIS FOR BRIDGE 36 (ANDOVT00110036) on STATE ROUTE 11, crossing the MIDDLE BRANCH WILLIAMS RIVER, ANDOVER, VERMONT

U.S. Geological Survey
Open-File Report 97-393

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

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By Lora K. Striker and Ronda L. Burns

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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Denver, CO 80225-0286

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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 36 (ANDOVT00110036) ON STATE ROUTE 11, CROSSING THE MIDDLE BRANCH WILLIAMS RIVER, ANDOVER, VERMONT

By **Lora K. Striker and Ronda L. Burns**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure ANDOVT00110036 on State Route 11 crossing the Middle Branch Williams River, Andover, 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 south-central Vermont. The 5.10-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture on the upstream left bank and forested elsewhere throughout the reach.

In the study area, the Middle Branch Williams River has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 38 ft and an average bank height of 2 ft. The channel bed material ranges from sand to boulders with a median grain size (D_{50}) of 60.1 mm (0.197 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 28, 1996, indicated that the reach was laterally unstable due to a cut-bank on the left bank upstream, side bar formation on the left bank upstream, and a combination of side bar formation and erosion occurring on the downstream right bank.

The State Route 11 crossing of the Middle Branch Williams River is a 28-ft-long, two-lane bridge consisting of one 25-foot concrete-beam span (Vermont Agency of Transportation, written communication, March 28, 1995). The opening length of the structure parallel to the bridge face is 25.3 ft.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 is also 30 degrees.

A scour hole 0.5 ft deeper than the mean thalweg depth was observed 5 feet upstream of the bridge during the Level I assessment. Scour protection measures at the site include: type-2 stone fill (less than 36 inches diameter) along the left bank upstream, and type-4 stone fill (less than 60 inches diameter) along the entire base length of the upstream left wingwall, and at the upstream end of the upstream right wing 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 0.0 to 2.8 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 9.5 to 13.7 ft. The worst-case abutment scour also 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.

Saxtons River, VT. Quadrangle, 1:25,000, 1984

NORTH

Figure 1. Location of study area on USGS 1:25,000 scale map.

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

LEVEL II SUMMARY

Structure Number ANDOVT00110036 ***Stream*** The Middle Branch Williams River

County Windsor ***Road*** VT 11 ***District*** 2

Description of Bridge

Bridge length 28 ***ft*** ***Bridge width*** 31.8 ***ft*** ***Max span length*** 25 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 08/28/96

Description of stone fill There is type-4 stone fill (less than 60 inches diameter) in the left and right upstream wing wall areas.

Brief description of piers/abutments Abutments and wingwalls are concrete.

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

There is a mild channel bend in the upstream reach.

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	08/28/96	0	0
Level II	08/28/96	0	0

Potential for debris Moderate. There is some debris along the banks upstream and downstream. Some trees upstream are scarred from debris and ice.

Describe any features near or at the bridge that may affect flow (include observation date) -

Description of the Geomorphic Setting

General topography The incised channel is located within a moderate relief valley with narrow flood plains and semi-alluvial channel boundaries.

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

Date of inspection 08/28/96

DS left: Moderately sloped overbank

DS right: Steep channel bank to narrow terrace.

US left: Steep channel bank to moderately sloped overbank

US right: Steep channel bank.

Description of the Channel

Average top width 38 *ft* ***Average depth*** 2 *ft*

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

Meandering and laterally unstable with semi-alluvial channel boundaries.

08/28/96

Vegetative co Trees

DS left: Trees

DS right: Trees and grass in the overbank area

US left: Trees and brush.

US right: N

Do banks appear stable? ***If not, describe location and type of instability and date of observation.*** The assessment of 08/28/96 noted that lateral instability of the channel was indicated by a cut-bank on the left bank upstream, side bar formation on the left bank upstream, and a combination of side bar formation and erosion occurring on the downstream right bank.

-

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 5.10 ***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? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

-

-

Calculated Discharges

Q100 1,780 ***ft³/s*** ***Q500*** 2,610 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(5.10/1.44) exp 0.83] with bridge number 10 in Windham and graphically extrapolated to the 500-year event. Bridge number 10 crosses the Middle Branch Williams River upstream of this site and has flood frequency estimates available from the VT AOT database (written communication, VTAOT, May 1995). The drainage area above bridge number 10 is 1.44 square miles.

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

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

Datum tie between USGS survey and VTAOT plans None. There is a datum tie between USGS and NGVD 1988, add 772.26 ft to USGS survey to obtain NGVD 1988.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream right wing wall near bridge deck (elev. 498.98 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream left wing wall near bridge deck (elev. 499.37 ft, arbitrary survey datum). RM3 is a bronze survey disk on the downstream left bank corner of the abutment (499.25 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-22	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	14	1	Road Grade section
APPRO	71	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. Channel "n" values for the reach ranged from 0.043 to 0.053, and overbank "n" values ranged from 0.046 to 0.090.

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 0.0159 ft/ft which was estimated from thalweg points surveyed downstream of the bridge.

The surveyed approach section (APPRO) was 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.

At the 100- and 500-year discharge there is the possibility of flow escaping the channel along the right road approach and being diverted from the exit section. The model was developed under the assumption that flow along the right road approach returns to the main channel in the exit section.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.4 ***ft***
Average low steel elevation 496.3 ***ft***

100-year discharge 1,780 ***ft³/s***
Water-surface elevation in bridge opening 496.5 ***ft***
Road overtopping? Y ***Discharge over road*** 388 ***ft³/s***
Area of flow in bridge opening 140 ***ft²***
Average velocity in bridge opening 10.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.7 ***ft/s***

Water-surface elevation at Approach section with bridge 499.8
Water-surface elevation at Approach section without bridge 496.5
Amount of backwater caused by bridge 3.3 ***ft***

500-year discharge 2,610 ***ft³/s***
Water-surface elevation in bridge opening 496.5 ***ft***
Road overtopping? Y ***Discharge over road*** 909 ***ft³/s***
Area of flow in bridge opening 140 ***ft²***
Average velocity in bridge opening 12.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 14.3 ***/s***

Water-surface elevation at Approach section with bridge 500.4
Water-surface elevation at Approach section without bridge 497.6
Amount of backwater caused by bridge 2.8 ***ft***

Incipient overtopping discharge 1,090 ***ft³/s***
Water-surface elevation in bridge opening 496.5 ***ft***
Area of flow in bridge opening 140 ***ft²***
Average velocity in bridge opening 7.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.2 ***ft/s***

Water-surface elevation at Approach section with bridge 497.9
Water-surface elevation at Approach section without bridge 495.3
Amount of backwater caused by bridge 2.6 ***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.

At this site, the 100-year discharge, 500-year discharge, and incipient roadway overflow discharge resulted in unsubmerged orifice flow with road overflow, submerged orifice flow with road overflow, and unsubmerged orifice flow, respectively. 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). Thus, contraction scour was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). Results of this analysis are presented in figure 8 and tables 1 and 2. The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

Additional estimates of contraction scour also were computed by use of Laursen's clear-water scour equation (Richardson and others, 1995, p. 32, equation 20) and the results are presented in Appendix F. Furthermore, since the discharges resulted in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow in the bridge at the downstream face in the Laursen's clear-water equation. Contraction scour results with respect to these substitutions also are provided in Appendix F.

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

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.2	2.8	0.0
Depth to armoring	5.6	29.2	1.2
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	12.2	13.7	9.5
Right abutment	11.5	12.4	9.7
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	2.2	2.6	1.4
Right abutment	2.2	2.6	1.4
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

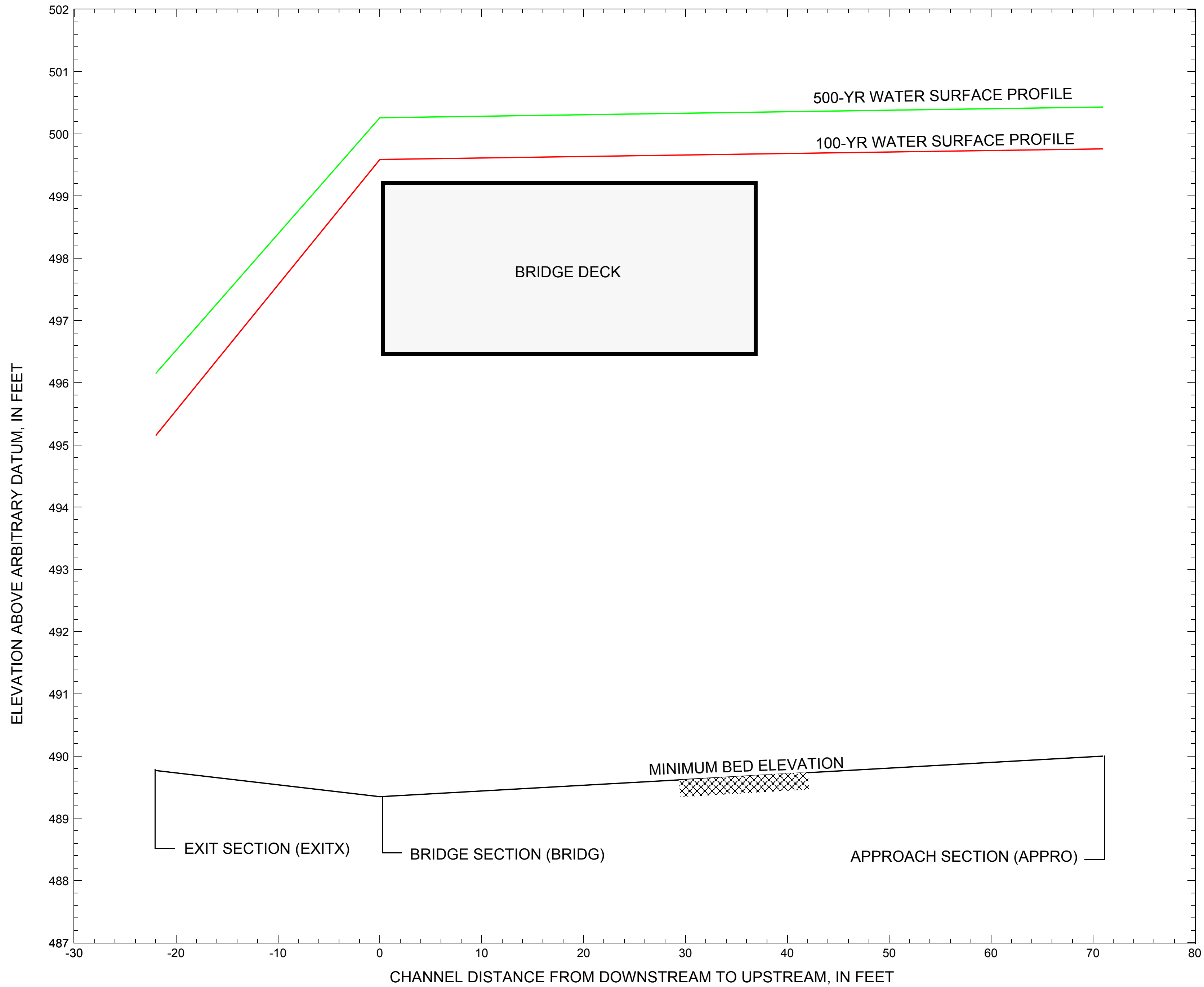

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure ANDOVT00110036 on State Route 11, crossing the Middle Branch Williams River, Andover, Vermont.

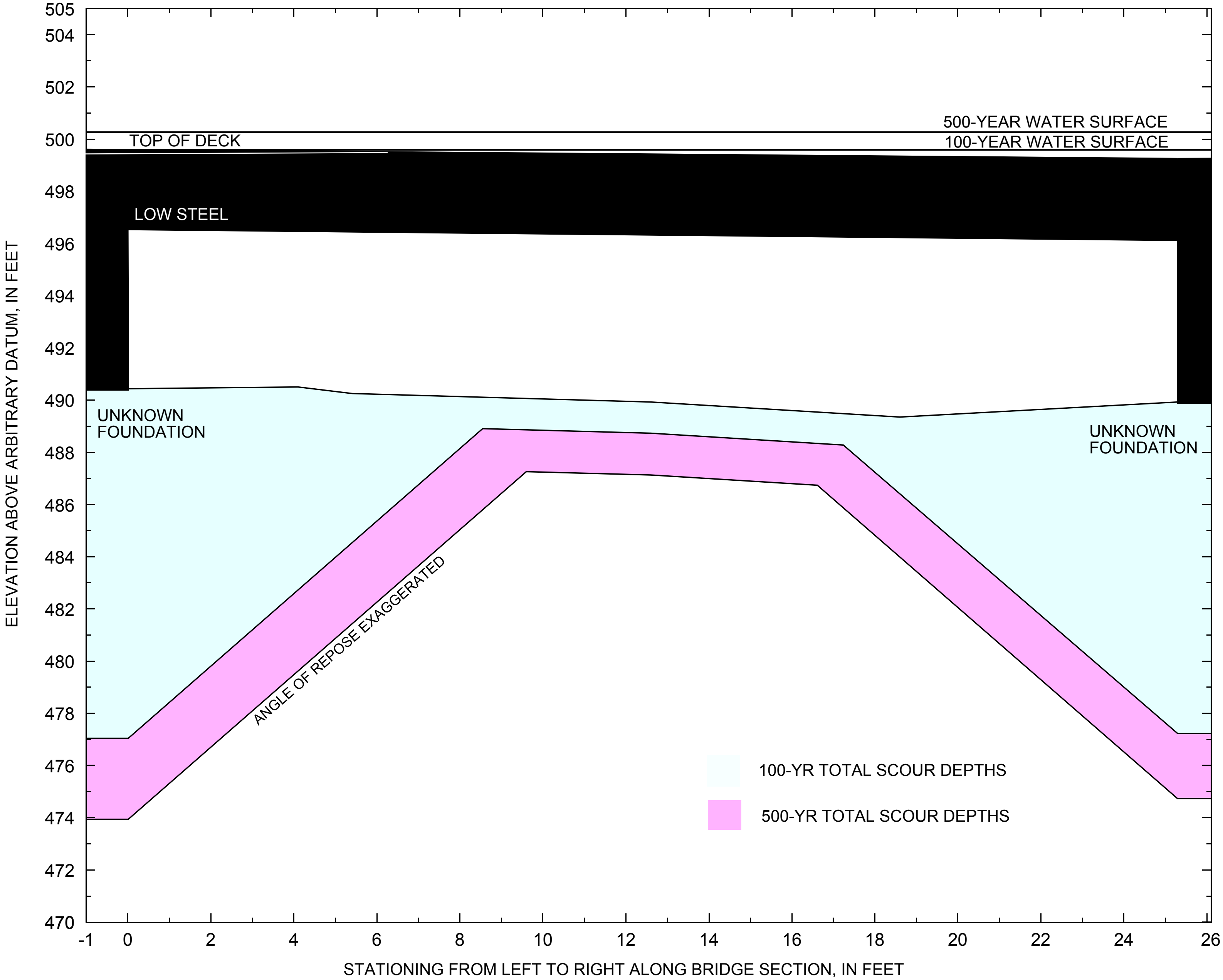

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure ANDOVT00110036 on State Route 11, crossing the Middle Branch Williams River, Andover, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure ANDOVT00110036 on State Route 11, crossing the Middle Branch Williams River, Andover, 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 1780 cubic-feet per second											
Left abutment	0.0	--	496.5	--	490.4	1.2	12.2	--	13.4	477.0	--
Right abutment	25.3	--	496.1	--	489.9	1.2	11.5	--	12.7	477.2	--

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 ANDOVT00110036 on State Route 11, crossing the Middle Branch Williams River, Andover, 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 2610 cubic-feet per second											
Left abutment	0.0	--	496.5	--	490.4	2.8	13.7	--	16.5	473.9	--
Right abutment	25.3	--	496.1	--	489.9	2.8	12.4	--	15.2	474.7	--

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

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U.S. Geological Survey, 1984, Saxtons River, Vermont 7.5 x 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T2        Hydraulic analysis for structure ANDOVT00110036   Date: 07-MAR-97
T3        LOCATED 2.2 MILES E OF JUNCT. WITH VT 121, VT 11 MIDDLE BR WILLIAMS R
*
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           1780.0   2610.0   1090.0
SK          0.0159   0.0159 0.0159
*
XS   EXITX    -22           0.
GR         -199.6, 518.36   -132.3, 509.32    -83.8, 501.44    -36.5, 498.95
GR          -28.5, 496.90      0.0, 493.85      2.9, 492.18      7.4, 491.02
GR           10.6, 490.47     11.6, 490.19     16.9, 490.16     25.2, 489.77
GR           32.1, 490.07     32.5, 490.35     38.9, 491.90     45.2, 493.95
GR           51.3, 495.75     68.6, 498.07     96.5, 497.82    113.7, 499.50
GR          126.4, 507.93    145.1, 512.79
*
N           0.090        0.049        0.046
SA                   0.0         51.3
*
*
XS   FULLV      0  * * *   0.0000
*
*              SRD     LSEL    XSSKEW
BR   BRIDG     0    496.33      30.0
GR            0.0, 496.53      0.1, 490.44      4.1, 490.50      5.4, 490.25
GR           12.6, 489.93     18.6, 489.35     25.3, 489.93     25.3 496.12
GR            0.0, 496.53
*
*         BRTYPE BRWDTH        WWANGL    WWWID
CD           1      39.8 * *     70.2      5.8
N           0.043
*
*
*              SRD    EMBWID   IPAVE
XR   RDWAY     14      31.8     1
GR         -235.3, 522.49   -110.7, 504.80    -72.3, 501.11    -42.7, 500.47
GR            0.0, 499.60     24.8, 499.25     66.8, 498.30     85.1, 497.82
GR          101.9, 500.06    122.0, 512.78
*
*
*
AS   APPRO     71           0.
GR         -215.3, 516.53   -204.0, 509.34   -192.5, 507.35    -45.2, 501.30
GR          -26.1, 497.85    -20.9, 495.57      0.0, 493.23      6.1, 491.44
GR            8.2, 490.65     13.7, 490.58     14.5, 490.34     16.8, 490.00
GR           18.6, 490.05     23.3, 490.09     24.3, 490.78     27.2, 490.96
GR           30.9, 493.65     39.0, 494.59     47.5, 496.45     58.0, 497.09
GR           78.6, 506.35
*
N           0.046        0.053        0.090
SA                   0.0         30.9
*
HP 1 BRIDG   496.53 1 496.53
HP 2 BRIDG   496.53 * * 1390
HP 2 RDWAY   499.59 * *  388
HP 1 APPRO   499.76 1 499.76
HP 2 APPRO   499.76 * * 1780
*
HP 1 BRIDG   496.53 1 496.53
HP 2 BRIDG   496.53 * * 1698
HP 2 RDWAY   500.26 * *  909
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       Hydraulic analysis for structure ANDOVT00110036   Date: 07-MAR-97
       LOCATED 2.2 MILES E OF JUNCT. WITH VT 121, VT 11 MIDDLE BR WILLIAMS R
          *** RUN DATE & TIME: 05-22-97  10:47
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      140      8884      0     56                      6779228
  496.53           140      8884      0     56  1.00      0     25  6779228

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
      496.53     0.0    25.3   139.6    8884.    1390.   9.95

X STA.        0.0        2.3        3.8        5.1        6.4        7.6
  A(I)           11.9        7.5        7.1        6.8        6.3
  V(I)           5.83       9.25       9.74      10.25      10.98

X STA.        7.6        8.8        9.9       11.0       12.1       13.2
  A(I)            6.5        6.2        6.1        6.2        6.0
  V(I)          10.74      11.25      11.34      11.24      11.53

X STA.       13.2       14.3       15.4       16.4       17.4       18.5
  A(I)            6.1        6.0        6.0        6.0        6.2
  V(I)          11.36      11.57      11.51      11.67      11.22

X STA.       18.5       19.5       20.6       21.8       23.1       25.3
  A(I)            6.1        6.4        6.9        7.4       11.8
  V(I)          11.38      10.88      10.04       9.41       5.87

 VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      14.
        WSEL     LEW     REW    AREA        K        Q    VEL
      499.59     0.7    98.4    78.1    2452.     388.   4.97

X STA.        0.7       36.8       45.6       51.8       55.5       59.0
  A(I)            9.8        6.2        5.4        3.7        3.7
  V(I)           1.97       3.12       3.58       5.19       5.24

X STA.       59.0       62.0       64.7       67.3       69.6       71.9
  A(I)            3.5        3.3        3.3        3.1        3.1
  V(I)           5.60       5.85       5.95       6.17       6.29

X STA.       71.9       73.9       75.9       77.8       79.6       81.3
  A(I)            3.0        2.9        2.9        2.9        2.9
  V(I)           6.47       6.64       6.61       6.70       6.79

X STA.       81.3       83.1       84.8       86.7       89.3       98.4
  A(I)            3.0        3.0        3.2        3.6        5.5
  V(I)           6.55       6.51       6.04       5.41       3.50

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      71.
    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      138     10661     37     37                         1519
            2      269     30999     31     32                         4507
            3      121      4683     33     34                         1315
  499.76           528     46343    101    104  1.35    -36     64     5909

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      71.
        WSEL     LEW     REW    AREA        K        Q    VEL
      499.76   -36.7    63.9   528.2   46343.    1780.   3.37

X STA.      -36.7      -16.7      -10.8       -6.1       -2.2        1.4
  A(I)           44.4       29.3       26.4       24.0       23.4
  V(I)           2.00       3.03       3.37       3.70       3.80

X STA.        1.4        4.5        7.0        9.2       11.3       13.4
  A(I)           22.5       21.2       19.6       19.0       19.1
  V(I)           3.96       4.19       4.54       4.68       4.67

X STA.       13.4       15.4       17.3       19.2       21.1       23.0
  A(I)           18.7       18.7       18.0       18.7       18.6
  V(I)           4.77       4.76       4.95       4.77       4.80

X STA.       23.0       25.2       27.5       31.2       39.8       63.9
  A(I)           20.0       20.5       26.7       48.4       71.1
  V(I)           4.46       4.35       3.33       1.84       1.25
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WSPRO OUTPUT FILE (continued)

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        Hydraulic analysis for structure ANDOVT00110036   Date: 07-MAR-97
        LOCATED 2.2 MILES E OF JUNCT. WITH VT 121, VT 11 MIDDLE BR WILLIAMS R
           *** RUN DATE & TIME: 05-22-97  10:47

WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      140      8884      0     56                     6779228
   496.53           140      8884      0     56  1.00      0     25  6779228

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       496.53     0.0    25.3   139.6    8884.    1698.  12.16

X STA.        0.0        2.3        3.8        5.1        6.4        7.6
  A(I)            11.9        7.5        7.1        6.8        6.3
  V(I)            7.12      11.30      11.90      12.52      13.41

X STA.        7.6        8.8        9.9       11.0       12.1       13.2
  A(I)             6.5        6.2        6.1        6.2        6.0
  V(I)           13.12      13.75      13.86      13.73      14.08

X STA.       13.2       14.3       15.4       16.4       17.4       18.5
  A(I)             6.1        6.0        6.0        6.0        6.2
  V(I)           13.88      14.13      14.06      14.26      13.71

X STA.       18.5       19.5       20.6       21.8       23.1       25.3
  A(I)             6.1        6.4        6.9        7.4       11.8
  V(I)           13.90      13.29      12.27      11.49       7.17

 VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      14.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.26   -32.4   102.2   156.2    6118.     909.   5.82

X STA.      -32.4       12.0       23.9       32.9       39.9       45.8
  A(I)            19.6       10.9        9.8        8.9        8.4
  V(I)            2.31       4.17       4.65       5.08       5.41

X STA.       45.8       50.9       55.1       58.9       62.3       65.6
  A(I)             7.9        6.8        6.6        6.3        6.2
  V(I)            5.78       6.69       6.90       7.17       7.33

X STA.       65.6       68.7       71.6       74.3       77.0       79.5
  A(I)             6.1        5.9        5.8        5.8        5.8
  V(I)            7.48       7.66       7.88       7.79       7.87

X STA.       79.5       81.9       84.4       87.1       90.8      102.2
  A(I)             5.6        6.0        6.3        7.0       10.5
  V(I)            8.06       7.60       7.23       6.49       4.33

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      71.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      164     13310     40     41                        1872
             2      290     35074     31     32                        5037
             3      144      6039     35     36                        1663
   500.43           597     54423    106    109  1.35    -39     65     6918

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      71.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.43   -40.4    65.4   597.3   54423.    2610.   4.37

X STA.      -40.4      -18.2      -12.1       -7.4       -3.2        0.4
  A(I)            51.1       33.7       28.9       27.5       25.6
  V(I)            2.55       3.88       4.52       4.75       5.10

X STA.        0.4        3.7        6.4        8.7       10.9       13.1
  A(I)            25.5       23.6       22.4       21.3       21.3
  V(I)            5.12       5.52       5.82       6.13       6.12

X STA.       13.1       15.2       17.2       19.2       21.2       23.2
  A(I)            21.4       20.8       20.3       21.1       20.4
  V(I)            6.10       6.28       6.42       6.19       6.38

X STA.       23.2       25.5       28.0       32.5       41.7       65.4
  A(I)            22.9       23.0       33.8       55.2       77.5
  V(I)            5.70       5.67       3.86       2.37       1.68
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        Hydraulic analysis for structure ANDOVT00110036   Date: 07-MAR-97
        LOCATED 2.2 MILES E OF JUNCT. WITH VT 121, VT 11 MIDDLE BR WILLIAMS R
           *** RUN DATE & TIME: 05-22-97  10:47
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      140      8884      0     56                      6779228
   496.53           140      8884      0     56  1.00      0     25  6779228

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       496.53     0.0    25.3   139.6    8884.    1090.   7.81

X STA.        0.0         2.3         3.8         5.1         6.4         7.6
  A(I)            11.9         7.5         7.1         6.8         6.3
  V(I)            4.57        7.25        7.64        8.04        8.61

X STA.        7.6         8.8         9.9        11.0        12.1        13.2
  A(I)             6.5         6.2         6.1         6.2         6.0
  V(I)            8.42        8.82        8.89        8.82        9.04

X STA.       13.2        14.3        15.4        16.4        17.4        18.5
  A(I)             6.1         6.0         6.0         6.0         6.2
  V(I)            8.91        9.07        9.03        9.15        8.80

X STA.       18.5        19.5        20.6        21.8        23.1        25.3
  A(I)             6.1         6.4         6.9         7.4        11.8
  V(I)            8.92        8.53        7.88        7.38        4.60

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      71.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       80      5296     26     27                          784
             2      212     20822     31     32                         3151
             3       64      1768     29     29                          537
   497.91           355     27886     86     89  1.31    -25     60     3570

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      71.
         WSEL     LEW     REW    AREA        K        Q    VEL
       497.91   -26.4    59.8   355.3   27886.    1090.   3.07

X STA.      -26.4       -13.2        -7.5        -3.0         0.7         3.9
  A(I)            27.6        20.2        18.5        16.9        17.1
  V(I)            1.97        2.70        2.95        3.23        3.18

X STA.        3.9         6.4         8.4        10.3        12.1        13.9
  A(I)            15.0        14.4        13.5        13.3        13.4
  V(I)            3.63        3.78        4.05        4.09        4.07

X STA.       13.9        15.7        17.3        18.9        20.6        22.2
  A(I)            13.2        12.8        12.5        13.0        12.9
  V(I)            4.12        4.25        4.35        4.19        4.22

X STA.       22.2        24.0        25.9        28.2        33.3        59.8
  A(I)            13.6        14.0        15.6        23.8        53.9
  V(I)            3.99        3.89        3.50        2.29        1.01
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WSPRO OUTPUT FILE (continued)

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        Hydraulic analysis for structure ANDOVT00110036   Date: 07-MAR-97
        LOCATED 2.2 MILES E OF JUNCT. WITH VT 121, VT 11 MIDDLE BR WILLIAMS R
           *** RUN DATE & TIME: 05-22-97  10:47

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

EXITX:XS   ******    -11      199  1.33 ***** 496.48  494.70    1780  495.15
       -21 ******     49    14112  1.06 ***** *******    0.91    8.97

FULLV:FV       22    -17      241  0.94  0.27  496.74 *******    1780  495.79
         0     22     52    18000  1.11  0.00   -0.01    0.74    7.40
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       71    -22      240  1.07  0.74  497.55 *******    1780  496.49
        71     71     48    16968  1.25  0.06    0.02    0.80    7.42
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   499.79       0.00     495.86     497.82

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.46     498.93     499.17     496.33

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

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

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

BRIDG:BR       22      0      140  1.54 ***** 498.07  494.95    1390  496.53
         0 ******     25     8884  1.00 ***** *******    0.75    9.95

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.497  0.000  496.33 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.    39.  0.06  0.24  499.94    0.00    388.  499.59

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     11.    13.     1.    13.   0.2   0.1   3.0   9.9   0.4   3.0
   RT:    377.    85.    13.    98.   1.8   0.9   5.3   4.9   1.3   3.1

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

APPRO:AS       31    -36      528  0.24  0.20  500.00  495.87    1780  499.76
        71     33     64    46370  1.35  1.02    0.00    0.30    3.37

      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
   EXITX:XS     -22.   -12.    49.   1780.   14112.     199.    8.97  495.15
   FULLV:FV       0.   -18.    52.   1780.   18000.     241.    7.40  495.79
   BRIDG:BR       0.     0.    25.   1390.    8884.     140.    9.95  496.53
   RDWAY:RG      14.*******    11.    388.       0.*********    1.00  499.59
   APPRO:AS      71.   -37.    64.   1780.   46370.     528.    3.37  499.76

 SECOND USER DEFINED TABLE.
   XSID:CODE    CRWS     FR#   YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    494.70    0.91  489.77  518.36************  1.33  496.48  495.15
   FULLV:FV   ********   0.74  489.77  518.36  0.27  0.00  0.94  496.74  495.79
   BRIDG:BR    494.95    0.75  489.35  496.53************  1.54  498.07  496.53
   RDWAY:RG  ***************  497.82  522.49  0.06******  0.24  499.94  499.59
   APPRO:AS    495.87    0.30  490.00  516.53  0.20  1.02  0.24  500.00  499.76
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WSPRO OUTPUT FILE (continued)

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        Hydraulic analysis for structure ANDOVT00110036   Date: 07-MAR-97
        LOCATED 2.2 MILES E OF JUNCT. WITH VT 121, VT 11 MIDDLE BR WILLIAMS R
           *** RUN DATE & TIME: 05-22-97  10:47

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

EXITX:XS   ******    -21      267  1.70 *****  497.85  495.84    2610  496.15
       -21 ******     54    20689  1.14 ***** *******    0.98    9.78

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.80     496.90     495.84

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.65     518.36    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.65     518.36     495.84

FULLV:FV       22    -28      331  1.18  0.27  498.11  495.84    2610  496.93
         0     22     60    27196  1.23  0.00    0.00    0.80    7.89
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.82     497.59     496.82

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.43     516.53    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.43     516.53     496.82

APPRO:AS       71    -25      328  1.29  0.71  498.88  496.82    2610  497.59
        71     71     59    25162  1.31  0.05    0.01    0.81    7.95
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   496.93     496.33

            <<<<<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       22      0      140  2.30 *****  498.83  495.67    1698  496.53
         0 ******     25     8884  1.00 ***** *******    0.91   12.16

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  496.33 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.    39.  0.09  0.40  500.74    0.00    909.  500.26

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    127.    45.   -32.    13.   0.8   0.5   4.5   6.2   0.9   3.1
   RT:    781.    89.    13.   102.   2.4   1.5   6.6   5.8   2.0   3.1

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

APPRO:AS       31    -39      598  0.40  0.32  500.83  496.82    2610  500.43
        71     33     65    54455  1.35  1.02    0.00    0.38    4.37

       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
   EXITX:XS     -22.   -22.    54.   2610.   20689.     267.    9.78  496.15
   FULLV:FV       0.   -29.    60.   2610.   27196.     331.    7.89  496.93
   BRIDG:BR       0.     0.    25.   1698.    8884.     140.   12.16  496.53
   RDWAY:RG      14.*******   127.    909.       0.*********    1.00  500.26
   APPRO:AS      71.   -40.    65.   2610.   54455.     598.    4.37  500.43

  SECOND USER DEFINED TABLE.
   XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.84    0.98  489.77  518.36************  1.70  497.85  496.15
   FULLV:FV    495.84    0.80  489.77  518.36  0.27  0.00  1.18  498.11  496.93
   BRIDG:BR    495.67    0.91  489.35  496.53************  2.30  498.83  496.53
   RDWAY:RG  ****************  497.82  522.49  0.09******  0.40  500.74  500.26
   APPRO:AS    496.82    0.38  490.00  516.53  0.32  1.02  0.40  500.83  500.43
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WSPRO OUTPUT FILE (continued)

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        Hydraulic analysis for structure ANDOVT00110036   Date: 07-MAR-97
        LOCATED 2.2 MILES E OF JUNCT. WITH VT 121, VT 11 MIDDLE BR WILLIAMS R
           *** RUN DATE & TIME: 05-22-97  10:47

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

 EXITX:XS   ******     -1      138  0.97 *****  495.01  493.57    1090  494.04
        -21 ******     46     8641  1.00 ***** *******    0.81    7.88

 FULLV:FV       22     -6      166  0.69  0.27  495.27 *******    1090  494.59
          0     22     47    11172  1.03  0.00    0.00    0.67    6.56
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.81     495.27     494.61

  ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   494.09     516.53    0.50

  ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   494.09     516.53     494.61

 APPRO:AS       71    -17      158  0.88  0.76  496.13  494.61    1090  495.25
         71     71     42     9942  1.19  0.10    0.00    0.82    6.89
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   494.21     497.07     497.31     496.33

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

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

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

 BRIDG:BR       22      0      140  0.95 *****  497.48  494.21    1089  496.53
          0 ******     25     8884  1.00 ***** *******    0.59    7.80

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   2.  0.465  0.000  496.33 ****** ****** ******

     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       31    -25      355  0.19  0.16  498.10  494.61    1090  497.91
         71     32     60    27870  1.31  1.00    0.00    0.31    3.07

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      ****** ****** ******** ****** ******   497.85

                       <<<<<END OF BRIDGE COMPUTATIONS>>>>>
   FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXITX:XS     -22.    -2.    46.   1090.    8641.     138.    7.88  494.04
    FULLV:FV       0.    -7.    47.   1090.   11172.     166.    6.56  494.59
    BRIDG:BR       0.     0.    25.   1089.    8884.     140.    7.80  496.53
    RDWAY:RG      14.**************       0.       0.       0.    1.00********
    APPRO:AS      71.   -26.    60.   1090.   27870.     355.    3.07  497.91


SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
    EXITX:XS    493.57    0.81  489.77  518.36************  0.97  495.01  494.04
    FULLV:FV  ********    0.67  489.77  518.36  0.27  0.00  0.69  495.27  494.59
    BRIDG:BR    494.21    0.59  489.35  496.53************  0.95  497.48  496.53
    RDWAY:RG  ****************  497.82  522.49************  0.19  498.04********
    APPRO:AS    494.61    0.31  490.00  516.53  0.16  1.00  0.19  498.10  497.91
```
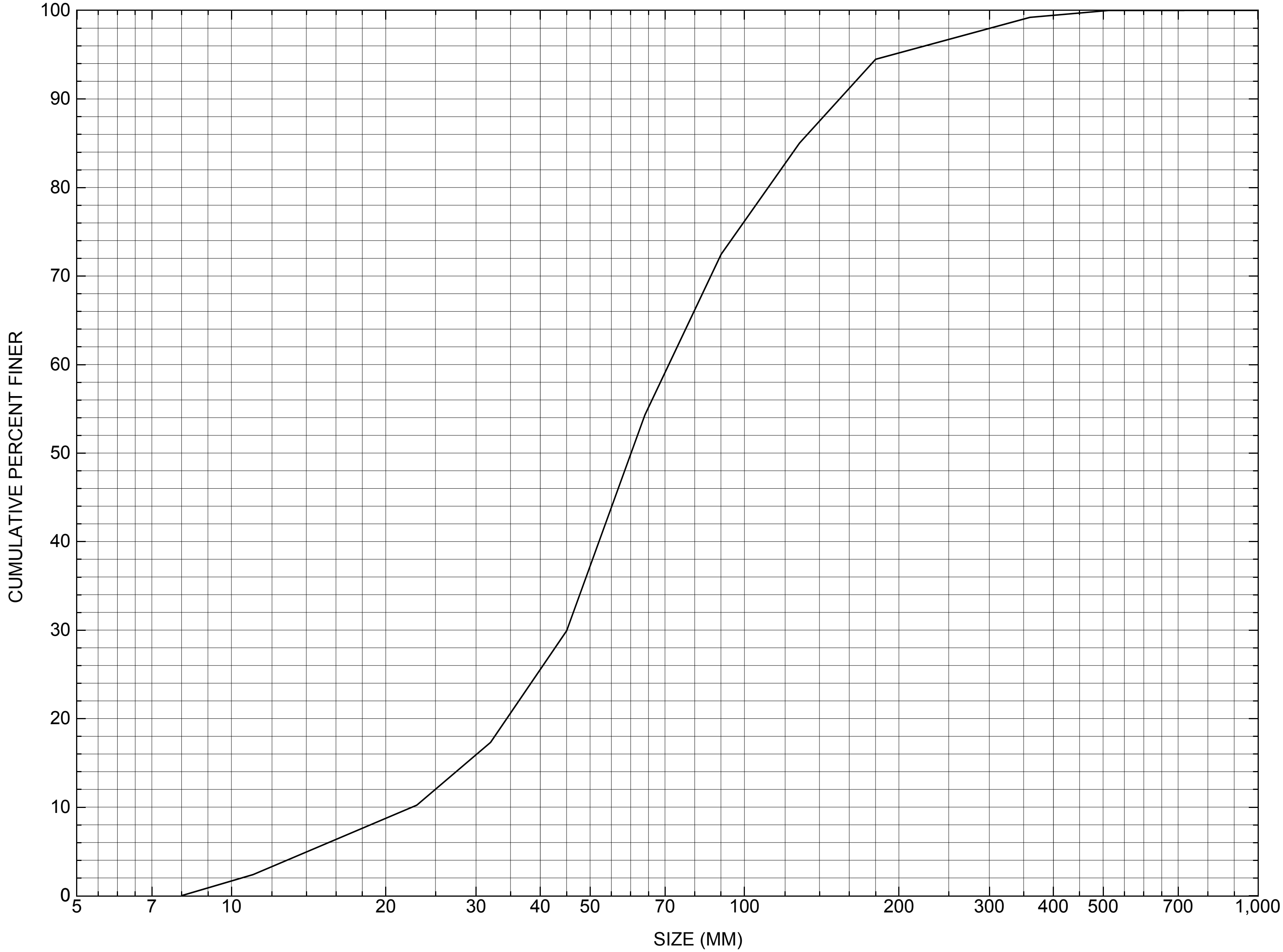

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure ANDOVT00110036, in Andover, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number ANDOVT00110036

General Location Descriptive

Data collected by *(First Initial, Full last name)* M. IVANOFF

Date *(MM/DD/YY)* 03 / 28 / 95

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

County *(FIPS county code; I - 3; nnn)* 027

Town *(FIPS place code; I - 4; nnnnn)* 01300

Mile marker *(I - 11; nnn.nnn)* 000930

Waterway *(I - 6)* Middle Branch Williams River

Road Name *(I - 7):* -

Route Number VT 11

Vicinity *(I - 9)* 2.2 MI E JCT VT 121

Topographic Map Saxtons River

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 43148

Longitude *(i - 17; nnnnn.n)* 72424

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20001600361401

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

Maximum span length *(I - 48; nnnn)* 0025

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

Structure length *(I - 49; nnnnnn)* 000028

Average daily traffic, ADT *(I - 29; nnnnnn)* 002736

Deck Width *(I - 52; nn.n)* 318

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

Channel & Protection *(I - 61; n)* 8

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

Waterway adequacy *(I - 71; n)* 6

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

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

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

Year Reconstructed *(I - 106)* 1970

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*) 7.0

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

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

Comments:

The structural inspection report of 11/10/93 indicates that the structure is a concrete T-beam type bridge with an asphalt road surface. There is heavy spalling reported at the upstream end of the right abutment with some reinforcement bar exposed. A few pockets of spalling are noted at the downstream end. The structure was widened in 1970. Both concrete abutments have a few vertical hairline shrinkage cracks reported. The footings are not in view. There is minor scaling along the flow line. The streambed consists of stone and gravel. There is large granite block riprap along the upstream left wingwall.

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:
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **5.10** mi^2 Lake/pond/swamp area **0** mi^2
Watershed storage *(ST)* **0** %
Bridge site elevation **1272** ft Headwater elevation **2894** ft
Main channel length **4.29** mi
10% channel length elevation **1286** ft 85% channel length elevation **2165** ft
Main channel slope *(S)* **273.60** 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:

There is no benchmark information available.

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

Briefly describe material at foundation bottom elevation or around piles:

There is no foundation material information available.

Comments:

There are no bridge plans available.

Cross-sectional Data

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

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

Comments: **There is no cross section information available.**

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*)? **NO**

Comments: **There is no cross section information available.**

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: **EW** Date: **9/24/96**
Computerized by: **EW** Date: **9/25/96**
Reviewd by: **LKS** Date: **05/23/97**

Structure Number **ANDOVT00110036**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **R. BURNS** Date *(MM/DD/YY)* **08** / **28** / 19**96**
2. Highway District Number **02** Mile marker **000930**
County **WINDSOR 027** Town **ANDOVER 01300**
Waterway *(I - 6)* **the Middle Branch Williams River** Road Name **-**
Route Number **VT 11** Hydrologic Unit Code: **01080107**
3. Descriptive comments:
The bridge is located 2.2 miles east of the junction with VT 121. The bridge is located at the intersection of VT 11 and Gates Road.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **6** LBDS **6** RBDS **6** 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 **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 **28** *(feet)* Span length **25** *(feet)* Bridge width **31.8** *(feet)*

Road approach to bridge:

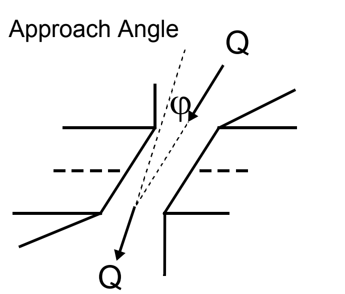
8. LB **2** RB **1** *(**0** even, **1**- lower, **2**- higher)*
9. LB **1** RB **1** *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

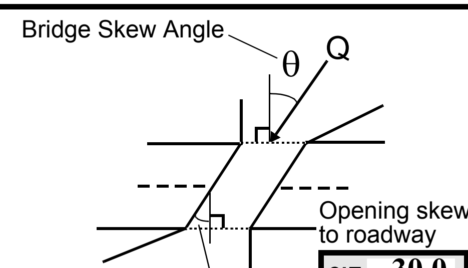
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	3	1
LBDS	1	1	3	1

*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: **15** 16. Bridge skew: **30**





α= **30.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **200** feet **DS** *(US, UB, DS)* to **250** feet **DS**
Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **200** feet **US** *(US, UB, DS)* to **250** feet **US**

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

18. Bridge Type: **1a**

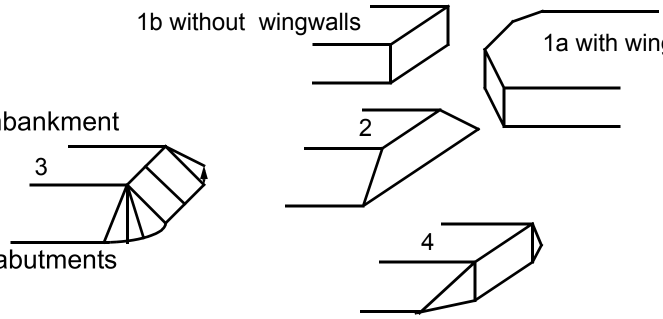
1a- Vertical abutments with wingwalls

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: On the USLB the land cover is primarily grass, there are trees along the immediate bank and the bottom of the road embankment. There is an old road on the USRB which runs parallel to the stream. On the DSRB, there is a wide strip of trees along the bank then a lawn and gravel driveway to a house.

#7: Measured bridge length = 29 feet; bridge span = 25 feet; and bridge width = 37 feet. The bridge was widened in 1970.

#11: There is road embankment protection on the DSLB. The protection is a 1 foot wide strip of asphalt about 2 feet below the top of the DSLWW extending along its base length. The protection on the USLB is 3 feet of asphalt. It extends perpendicularly from the road to the upstream end of the USLWW.

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
42.5	**2.0**			**2.5**		**3**	**4**	**342**	**542**	**2**

23. Bank width **15.0** 24. Channel width **35.0** 25. Thalweg depth **31.0** 29. Bed Material **1435**

30 .Bank protection type: LB **2** RB **0** 31. Bank protection condition: LB **1** 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.):

There is a small bridge for a driveway 300 feet upstream. It has concrete abutments and a timber deck.

At 230 feet upstream, the stream makes a sharp bend.

#30: Left bank protection extends from the end of the wingwall to 45 feet upstream. Right bank protection is natural protection from boulder bank material.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **61** 35. Mid-bar width: **12**

36. Point bar extent: **76** feet **US** *(US, UB)* to **38** feet **US** *(US, UB, DS)* positioned **0** %LB to **50** %RB

37. Material: **432**

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

There is a cut-bank above the side bar. The material is similar to that found in the bank. Another side bar is positioned 65% LB to 100% RB, from 151 feet upstream to 109 feet upstream. It is comprised of gravel, cobbles and sand. The mid-bar distance is 125 feet upstream. At this point the bar is 4 feet wide. There is an additional point bar on the left bank from 300 feet upstream to 142 feet upstream.

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: **123** 42. Cut bank extent: **170** feet **US** *(US, UB)* to **55** 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.):

There is another cut-bank from 243 feet upstream to 160 feet upstream.

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **5 US**

47. Scour dimensions: Length **10** Width **8** Depth : **0.5** Position **20** %LB to **90** %RB

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

The scour depth of 0.5 feet assumes a thalweg in the pool of 1.0 foot.

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):

There are no major confluences upstream at this site.

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
21.0		**0.5**		**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.):

432

The predominate bed material along the LABUT and the USLWW is sand.

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? **2**___ *(Y or N)* Ice Blockage Potential **Y**____ *(1- Low; 2- Moderate; 3- High)*

70. Debris and Ice Comments:

2

There is debris along the banks upstream and downstream. Some of the trees upstream have scars at their base from ice and debris.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		-	90	2	0	-	-	90.0
RABUT	1	0	90			2	0	23.0

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

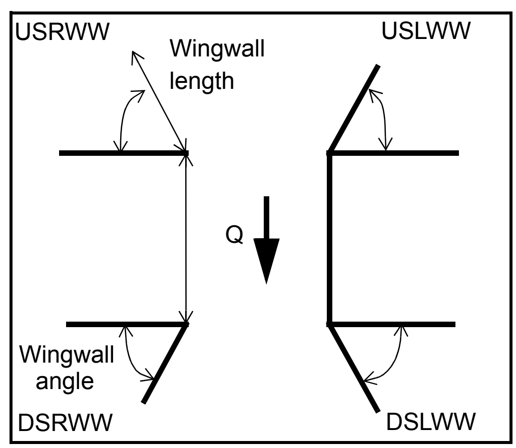
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

-
-
1
-

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						23.0	
USRWW:	Y		1		2	2.0	
DSLWW:	0		2.25		Y	26.5	
DSRWW:	1		0		-	27.5	

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



82. **Bank / Bridge Protection**:

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

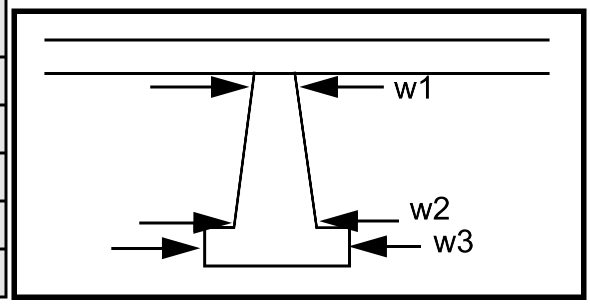
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				**50.0**	**18.0**	**90.0**
Pier 2			**9.5**	**11.5**	**90.0**	**35.0**
Pier 3		-	-	**19.0**	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**e**	**ders.**	**of 08/**	**N**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**USL**	**The**	**28/**	-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**WW**	**foot-**	**96.**	-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**foot-**	**ing**		-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**ing is**	**was**		-	*Y- yes; N- no*
91. Attack ∠ (BF)	**well**	**expo**		-	
92. Pushed	**pro-**	**sed a**		-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**tecte**	**max-**		-	
95. Cross-members	**d**	**imu**		-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**with**	**m of**		-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**large**	**2.25**		-	
98. Exposure depth	**boul-**	**ft as**		-	

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.):
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

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

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

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

ere are no piers.

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

Point bar extent: ______ feet **4** *(US, UB, DS)* to **3** feet **234** *(US, UB, DS)* positioned **432** %LB to **1** %RB

Material: **1**

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

435
0
0
-

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

Cut bank extent: **nel** feet **wid** *(US, UB, DS)* to **ens** feet **do** *(US, UB, DS)*

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

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

stream of bridge. The banks are low, and there are no significant cut-banks though bank erosion has exposed some tree roots along both the left and right bank.

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

Scour dimensions: Length ______ Width ______ Depth: _____ Positioned ____ %LB to ____ %RB

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

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

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

Confluence 2: Distance **no** Enters on **dro** *(LB or RB)* Type **p** *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

structures present at this site.

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
75
10
48
DS
55
DS
75
100
432

109. G. Plan View Sketch

\- T

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: ANDOVT00110036 Town: ANDOVER
Road Number: VT 11 County: WINDOSR
Stream: THE MIDDLE BRANCH WILLIAMS RIVER

Initials LKS Date: 04/10/97 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	1780	2610	1090
Main Channel Area, ft2	269	290	212
Left overbank area, ft2	138	164	80
Right overbank area, ft2	121	144	64
Top width main channel, ft	31	31	31
Top width L overbank, ft	37	40	26
Top width R overbank, ft	33	35	29
D50 of channel, ft	0.1973	0.1973	0.1973
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	8.7	9.4	6.8
y1, average depth, LOB, ft	3.7	4.1	3.1
y1, average depth, ROB, ft	3.7	4.1	2.2
Total conveyance, approach	46343	54423	27886
Conveyance, main channel	30999	35074	20822
Conveyance, LOB	10661	13310	5296
Conveyance, ROB	4683	6039	1768
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1190.6	1682.1	813.9
Ql, discharge, LOB, cfs	409.5	638.3	207.0
Qr, discharge, ROB, cfs	179.9	289.6	69.1
Vm, mean velocity MC, ft/s	4.4	5.8	3.8
Vl, mean velocity, LOB, ft/s	3.0	3.9	2.6
Vr, mean velocity, ROB, ft/s	1.5	2.0	1.1
Vc-m, crit. velocity, MC, ft/s	9.4	9.5	9.0
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
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

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	269	290	212
Main channel width, ft	31	31	31
y1, main channel depth, ft	8.68	9.35	6.84

Bridge Section	Q100	Q500	Qother
(Q) total discharge, cfs	1780	2610	1090
(Q) discharge thru bridge, cfs	1390	1698	1090
Main channel conveyance	8884	8884	8884
Total conveyance	8884	8884	8884
Q2, bridge MC discharge,cfs	1390	1698	1090
Main channel area, ft2	140	140	140
Main channel width (skewed), ft	21.9	21.9	21.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	21.9	21.9	21.9
y_bridge (avg. depth at br.), ft	6.37	6.37	6.37
Dm, median (1.25*D50), ft	0.246625	0.246625	0.246625
y2, depth in contraction,ft	6.48	7.69	5.26
ys, scour depth (y2-ybridge), ft	0.10	1.31	-1.12

ARMORING			
D90	0.5023	0.5023	0.5023
D95	0.6374	0.6374	0.6374
Critical grain size,Dc, ft	0.3932	0.5868	0.2418
Decimal-percent coarser than Dc	0.17314	0.05688	0.38172
Depth to armoring,ft	5.63	29.19	1.17

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	1780	2610	1090
Q, thru bridge, cfs	1390	1698	1090
Total Conveyance, bridge	8884	8884	8884
Main channel(MC) conveyance, bridge	8884	8884	8884
Q, thru bridge MC, cfs	1390	1698	1090
Vc, critical velocity, ft/s	9.36	9.47	8.99
Vc, critical velocity, m/s	2.85	2.89	2.74
Main channel width (skewed), ft	21.9	21.9	21.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	21.9	21.9	21.9
qbr, unit discharge, ft2/s	63.5	77.5	49.8
qbr, unit discharge, m2/s	5.9	7.2	4.6
Area of full opening, ft2	139.6	139.6	139.6
Hb, depth of full opening, ft	6.37	6.37	6.37
Hb, depth of full opening, m	1.94	1.94	1.94
Fr, Froude number, bridge MC	0.75	0.91	0.59
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
Elevation of Low Steel, ft	496.33	496.33	496.33
Elevation of Bed, ft	489.96	489.96	489.96
Elevation of Approach, ft	499.76	500.43	497.91
Friction loss, approach, ft	0.2	0.32	0.16
Elevation of WS immediately US, ft	499.56	500.11	497.75
ya, depth immediately US, ft	9.60	10.15	7.79
ya, depth immediately US, m	2.93	3.09	2.38
Mean elevation of deck, ft	499.43	499.43	499.43
w, depth of overflow, ft (>=0)	0.13	0.68	0.00
Cc, vert contrac correction (<=1.0)	0.90	0.90	0.95
Ys, depth of scour, ft	1.20	2.76	-0.55

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

y2, from Laursen's equation, ft	6.476827	7.68896	5.258453
Full valley WSEL, ft	495.79	N/A	494.59
Full valley depth, ft	5.834429	N/A	4.634429
Ys, depth of scour (y2-yfullv), ft	0.642398	N/A	0.624024

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	Left Abutment 500 yr Q	Left Abutment Other Q	Right Abutment 100 yr Q	Right Abutment 500 yr Q	Right Abutment Other Q
(Qt), total discharge, cfs	1780	2610	1090	1780	2610	1090
a', abut.length blocking flow, ft	38.4	42.1	28.1	40.3	41.8	36.2
Ae, area of blocked flow ft2	149.41	161.8	88.54	158.67	159.56	110.32
Qe, discharge blocked abut.,cfs	--	--	235.03	--	--	230.11
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.03	3.98	2.65	2.32	3.02	2.09
ya, depth of f/p flow, ft	3.89	3.84	3.15	3.94	3.82	3.05
--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	0.271	0.342	0.264	0.193	0.238	0.211
ys, scour depth, ft	12.18	13.72	9.47	11.52	12.42	9.65

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)	38.4	42.1	28.1	40.3	41.8	36.2
y1 (depth f/p flow, ft)	3.89	3.84	3.15	3.94	3.82	3.05
a'/y1	9.87	10.95	8.92	10.24	10.95	11.88
Skew correction (p. 49, fig. 16)	0.90	0.90	0.90	1.07	1.07	1.07
Froude no. f/p flow	0.27	0.34	0.26	0.19	0.24	0.21
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	0.75	0.91	0.59	0.75	0.91	0.59
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	6.37	6.37	6.37	6.37	6.37	6.37
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	2.22	ERR	1.37	2.22	ERR	1.37
Fr>0.8 (vertical abut.)	ERR	2.60	ERR	ERR	2.60	ERR