LEVEL II SCOUR ANALYSIS FOR BRIDGE 30 (BRNATH00470030) on TOWN HIGHWAY 47, crossing LOCUST CREEK, BARNARD, VERMONT

U.S. Geological Survey
Open-File Report 97-210

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

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By ERICK M. BOEHMLER and DONALD L. SONG

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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Denver, CO 80225-0286

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 30 (BRNATH00470030) ON TOWN HIGHWAY 47, CROSSING LOCUST CREEK, BARNARD, VERMONT

By **Erick M. Boehmler and Donald L. Song**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BRNATH00470030 on Town Highway 47 crossing Locust Creek, Barnard, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province in central Vermont. The 4.18-mi^2 drainage area is a predominantly rural and forested basin. In the vicinity of the study site, the surface cover consists of trees, shrubs, and brush.

In the study area, Locust Creek has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 32 ft and an average bank height of 4 ft. The predominant channel bed material is gravel with a median grain size (D_{50}) of 49.5 mm (0.162 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 13, 1994, indicated that the reach was stable.

The Town Highway 47 crossing of Locust Creek is a 28-ft-long, one-lane bridge consisting of one 25-foot concrete span (Vermont Agency of Transportation, written communication, August 23, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 40 degrees to the opening. Historical bridge data indicates that the opening-skew-to-roadway is 45 degrees, but 35 degrees was computed by use of survey data from this study.

A minor scour hole, 0.5 ft deeper than the mean thalweg depth was observed along the left abutment wall during the Level I assessment. The scour protection measures at the site were type-2 stone fill (less than 36 inches diameter) on the upstream wingwalls. There also is type-3 stone fill on the downstream right wingwall. 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 1.4 feet. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 2.3 to 8.9 feet. The worst-case abutment scour occurred at the 100-year discharge at the right abutment. 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.

Delectable Mountain, VT. Quadrangle, 1:24,000, 1966p
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 BRNATH00470030 ***Stream*** Locust Creek

County Windsor ***Road*** TH 47 ***District*** 4

Description of Bridge

Bridge length 28 ***ft*** ***Bridge width*** 15.5 ***ft*** ***Max span length*** 25 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** Sloping right; none left

Stone fill on abutment? No ***Date of inspection*** 10/13/94

Description of stone fill Type-2 along the base of the upstream wingwalls. Type-3 stone fill was present on the downstream right wingwall.

Abutments and wingwalls are concrete. There is a one half foot deep scour hole along the left abutment.

Yes 40

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

There is a mild channel bend immediately upstream of the bridge. The scour hole has developed in the same location where the bend occurs.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	10/13/94	0	0
Level II	10/13/94	0	0

Potential for debris Moderate. There is significant vegetation growth on channel banks that have been undermined and eroded.

Describe any features near or at the bridge that may affect flow (include observation date) None evident on 10/13/94.

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 10/13/94

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

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

US left: Steep channel bank to valley wall

US right: Steep channel bank to a narrow overbank

Description of the Channel

Average top width 32 *ft*   ***Average depth*** 4 *ft*

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

Sinuous but stable with semi-alluvial channel boundaries.

10/13/94

Vegetative co

Trees and brush

DS left: Trees and brush

DS right: Trees

US left: Trees with some brush.

US right:

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

None were noted in the assessment of 10/13/94.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 4.18 ***mi***^{2}

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 -- ***mi***^{2}

Is there a lake/p No

Calculated Discharges

Q100 1,150 ***ft***^{3}***/s*** ***Q500*** 1,540 ***ft***^{3}***/s***

The 100- and 500-year discharges are based on flood frequency estimates available in the VTAOT database. These values were selected from within a range of flood frequency curves defined by several empirical equations (Benson, 1962; FHWA, 1983; Johnson and Laraway, unpublished draft, 1972; Johnson and Tasker, 1974; Potter, 1957 a&b; and Talbot, 1887).

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 2.1 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 upstream end of the left abutment (elev. 499.57 feet, arbitrary survey datum). RM2 is the center point of a chiseled "X" on top of the downstream end of the left abutment (elev. 499.61 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	-36	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	12	1	Road Grade section
APPRO	42	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 0.055 to 0.065, and overbank "n" values ranged from 0.030 to 0.075.

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 0.0171 ft/ft, which was estimated from surveyed points downstream of the bridge.

The approach section (APPRO) was surveyed at 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 incipient overtopping discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for this discharge. After analyzing both the supercritical and subcritical profiles, it was determined that the water surface profile passes through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.7 ***ft***
Average low steel elevation 498.2 ***ft***

100-year discharge 1,150 ***ft³/s***
Water-surface elevation in bridge opening 498.2 ***ft***
Road overtopping? Yes ***Discharge over road*** 74 ***ft³/s***
Area of flow in bridge opening 135 ***ft²***
Average velocity in bridge opening 7.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.5 ***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 ***t***

500-year discharge 1,540 ***ft³/s***
Water-surface elevation in bridge opening 498.2 ***ft***
Road overtopping? Yes ***Discharge over road*** 345 ***ft³/s***
Area of flow in bridge opening 135 ***ft²***
Average velocity in bridge opening 8.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.9 ***/s***

Water-surface elevation at Approach section with bridge 500.3
Water-surface elevation at Approach section without bridge 496.9
Amount of backwater caused by bridge 3.4

Incipient overtopping discharge 989 ***ft³/s***
Water-surface elevation in bridge opening 495.5 ***ft***
Area of flow in bridge opening 83 ***ft²***
Average velocity in bridge opening 11.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 14.8 ***ft/s***

Water-surface elevation at Approach section with bridge 498.9
Water-surface elevation at Approach section without bridge 496.2
Amount of backwater caused by bridge 2.7 ***t***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the incipient overtopping discharge was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The 100- and 500-year discharges resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, the reported contraction scour for the 100- and 500-year events were computed by use of the Chang equation (Richardson and others, 1995, P. 145-146). Results from the Chang equation are shown in figure 8 and tables 1 and 2. The results of Laursen's clear-water contraction scour for the 100- and 500-year events also were computed and are provided in appendix F. The streambed armoring depths computed suggest that armoring will not limit the depth of 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	0.0	0.7	1.4
Depth to armoring	1.6	3.1	30.2
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	7.0	5.1	7.4
Right abutment	8.9	2.3	6.3
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	1.5	1.9	1.8
Right abutment	1.5	1.9	1.8
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

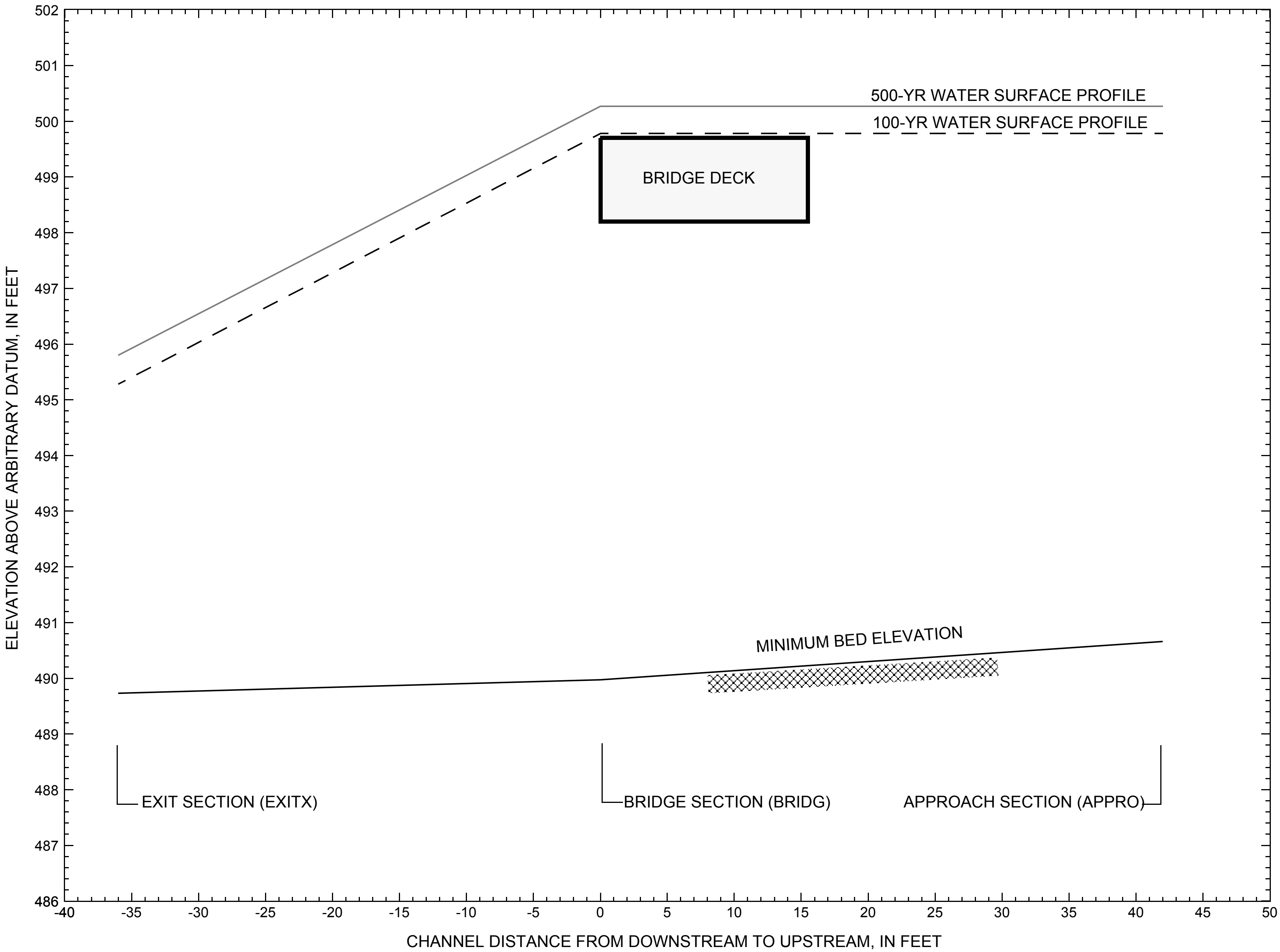

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BRNATH00470030 on Town Highway 47, crossing Locust Creek, Barnard, Vermont.

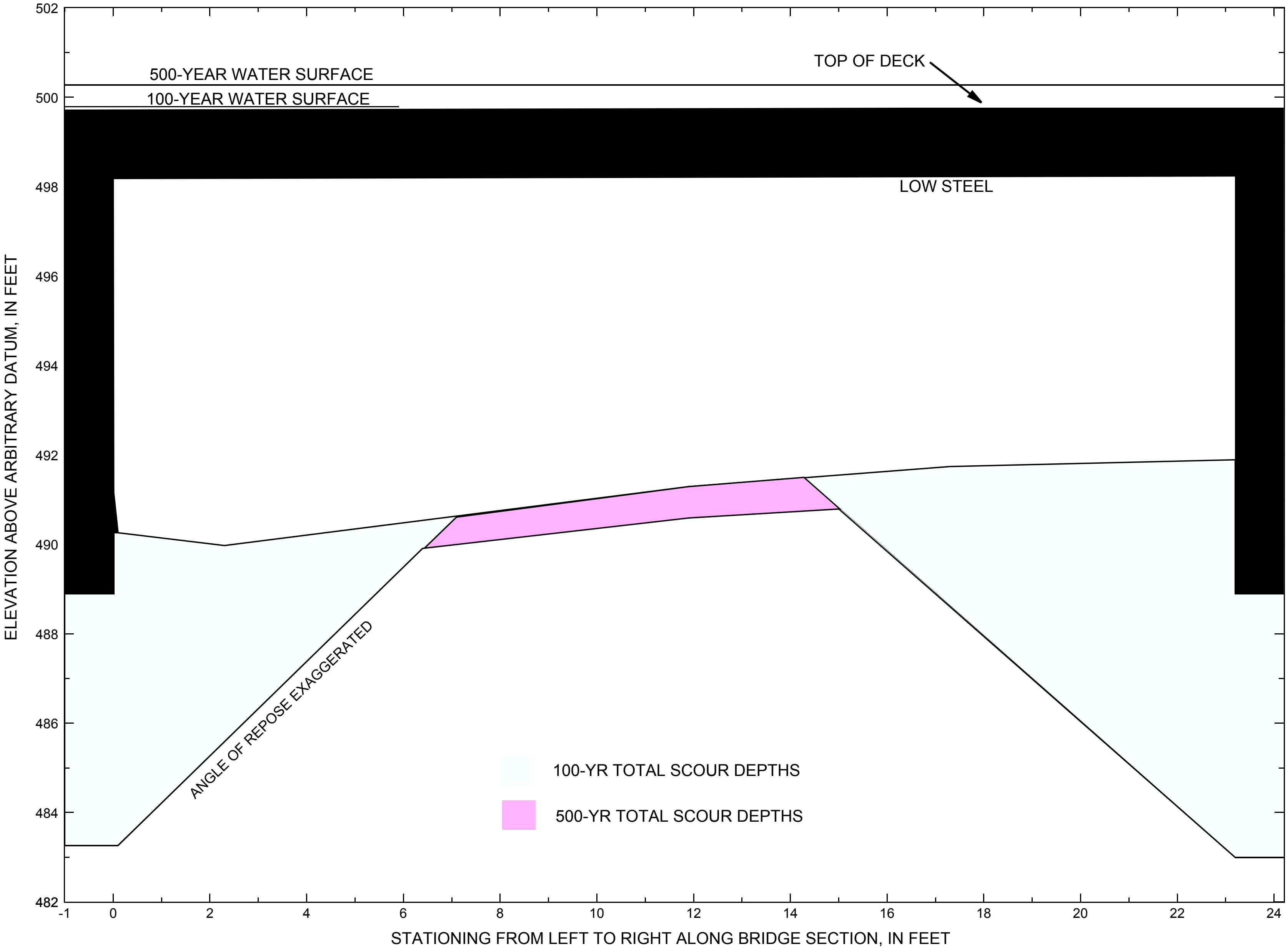

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BRNATH00470030 on Town Highway 47, crossing Locust Creek, Barnard, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BRNATH00470030 on Town Highway 47, crossing Locust Creek, Barnard, 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 1,150 cubic-feet per second											
Left abutment	0.0	500.3	498.2	488.9	490.3	0.0	7.0	--	7.0	483.3	-5.6
Right abutment	23.2	500.3	498.2	488.9	491.9	0.0	8.9	--	8.9	483.0	-5.9

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 BRNATH00470030 on Town Highway 47, crossing Locust Creek, Barnard, 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 1,540 cubic-feet per second											
Left abutment	0.0	500.3	498.2	488.9	490.3	0.7	5.1	--	5.8	484.5	-4.4
Right abutment	23.2	500.3	498.2	488.9	491.9	0.7	2.3	--	3.0	488.9	0.0

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, 1966, Delectable Mountain, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Aerial photographs, 1964; Photoinspected 1983, Contour interval, 20 feet; Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brna030.wsp
T2        CREATED ON 13-DEC-95 FOR BRIDGE BRNATH00470030 USING FILE brna030.dca
T3        Town Highway 47 Bridge Over Locust Creek, Barnard, VT      EMB
Q          1150.0  1540.0   989.0
SK         0.0171  0.0171  0.0171
*
J1         * * 0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EXITX    -36          0.
*
GR          -99.7, 504.29    -80.6, 501.69    -56.0, 499.16    -40.9, 499.00
GR          -26.1, 495.00    -11.5, 495.13     -7.0, 493.83      0.0, 490.58
GR            3.0, 490.21      5.0, 489.73     10.0, 490.09     12.5, 490.65
GR           17.0, 490.52     24.4, 491.96     38.4, 494.52     64.8, 495.30
GR           70.8, 499.29     84.1, 499.79     99.0, 507.77
*
N           0.030       0.060       0.065        0.060
SA                 -40.9       -11.5        24.4
*
XS   FULLV      0  * * *   0.0171
*
BR   BRIDG   0     498.2      35.0
*
GR            0.0, 498.18      0.0, 491.16      0.1, 490.26      2.3, 489.97
GR            6.0, 490.46     11.9, 491.29     17.3, 491.74     23.2, 491.89
GR           23.2, 498.24      0.0, 498.18
*
CD         4     23.0      6.1    500.0     39.8      0.0
N           0.055
*
XR   RDWAY     12      15.5   2
*
GR          -90.7, 504.29    -75.5, 501.69    -53.9, 499.16      0.0, 499.71
GR           27.5, 499.77     50.3, 500.14     95.6, 500.79    100.1, 501.35
GR          116.6, 508.07
*
AS   APPRO     42  0.0
*
GR          -36.2, 509.72    -20.2, 497.98    -12.9, 498.25     -6.9, 498.58
GR           -4.6, 497.91      0.0, 492.04      7.0, 490.66      9.8, 491.11
GR           19.0, 491.95     26.4, 500.01     39.0, 500.04     52.9, 500.07
GR           79.3, 500.93    107.0, 501.35    118.4, 508.07
*
N           0.075       0.065        0.075
SA                 -6.9         26.4
*
HP 1 BRIDG   498.24 1 498.24
HP 2 BRIDG   498.24 * * 1071
HP 2 RDWAY   499.78 * *   74
HP 1 APPRO   499.78 1 499.78
HP 2 APPRO   499.78 * * 1150
*
HP 1 BRIDG   498.20 1 498.20
HP 2 BRIDG   498.20 * * 1194
HP 2 RDWAY   500.27 * *  345
HP 1 APPRO   500.27 1 500.27
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brna030.wsp
        CREATED ON 13-DEC-95 FOR BRIDGE BRNATH00470030 USING FILE brna030.dca
        Town Highway 47 Bridge Over Locust Creek, Barnard, VT       EMB
           *** RUN DATE & TIME: 03-05-97  08:58

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

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      135      6911     0     52                            0
   498.24           135      6911     0     52  1.00      0     23        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.24     0.0    23.2   135.4    6911.    1071.   7.91

X STA.         0.0         1.9         3.0         4.0         4.9         5.8
  A(I)             12.4         7.2         6.6         6.0         5.9
  V(I)             4.33        7.43        8.11        8.97        9.08

X STA.         5.8         6.7         7.6         8.6         9.5        10.5
  A(I)              5.8         5.7         5.7         5.7         5.7
  V(I)             9.27        9.44        9.35        9.45        9.33

X STA.        10.5        11.5        12.5        13.6        14.7        15.8
  A(I)              5.8         5.8         5.9         6.0         6.1
  V(I)             9.29        9.18        9.01        8.85        8.78

X STA.        15.8        17.0        18.2        19.5        20.9        23.2
  A(I)              6.2         6.5         6.9         7.5        11.9
  V(I)             8.58        8.18        7.79        7.15        4.49

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      12.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.78   -59.2    28.1    21.3     399.      74.   3.47

X STA.       -59.2       -54.9       -53.7       -52.7       -51.7       -50.7
  A(I)              1.1         0.7         0.6         0.6         0.6
  V(I)             3.50        5.21        5.91        6.05        6.24

X STA.       -50.7       -49.6       -48.6       -47.5       -46.4       -45.3
  A(I)              0.6         0.6         0.6         0.6         0.6
  V(I)             6.15        6.12        6.23        6.08        6.02

X STA.       -45.3       -44.1       -42.8       -41.6       -39.6       -36.5
  A(I)              0.6         0.6         0.6         1.0         1.4
  V(I)             6.03        5.80        5.86        3.78        2.62

X STA.       -36.5       -32.9       -28.8       -23.8       -16.9        28.1
  A(I)              1.5         1.6         1.7         1.9         3.7
  V(I)             2.45        2.34        2.17        1.94        0.99

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      42.

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1       23       555    16     16                          153
             2      214     15036    33     40                         3079
   499.78           236     15591    49     56  1.10    -22     26     2808

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      42.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.78   -22.7    26.2   236.1   15591.    1150.   4.87

X STA.       -22.7        -3.1        -0.1         1.4         2.7         3.9
  A(I)             30.3        17.3        11.7        10.6         9.9
  V(I)             1.90        3.32        4.90        5.40        5.80

X STA.         3.9         5.0         6.1         7.0         8.0         9.0
  A(I)              9.6         9.1         9.0         8.8         8.9
  V(I)             5.96        6.32        6.39        6.57        6.48

X STA.         9.0        10.0        11.1        12.1        13.2        14.4
  A(I)              8.9         8.8         9.1         9.3         9.4
  V(I)             6.46        6.54        6.32        6.20        6.14

X STA.        14.4        15.6        16.8        18.2        20.0        26.2
  A(I)              9.9        10.4        10.9        13.6        20.7
  V(I)             5.84        5.54        5.29        4.23        2.77
```

WSPRO OUTPUT FILE (continued)

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      135      8292     13     40                          2506
   498.20           135      8292     13     40  1.00      0     23      2506

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.20     0.0    23.2   135.2    8292.    1194.   8.83

X STA.         0.0         2.2         3.5         4.7         5.8         7.0
  A(I)             14.3         8.9         7.9         7.3         7.1
  V(I)             4.17        6.75        7.59        8.22        8.42

X STA.         7.0         8.1         8.9         9.8        10.7        11.6
  A(I)              6.7         5.4         5.3         5.2         5.1
  V(I)             8.90       11.10       11.20       11.53       11.74

X STA.        11.6        12.5        13.4        14.3        15.3        16.2
  A(I)              5.1         5.0         5.0         5.1         5.3
  V(I)            11.78       11.91       11.90       11.64       11.36

X STA.        16.2        17.2        18.3        19.5        20.8        23.2
  A(I)              5.4         5.7         6.1         7.2        12.2
  V(I)            11.08       10.54        9.73        8.32        4.88

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      12.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.27   -63.4    59.4    72.6    1771.     345.   4.75

X STA.       -63.4       -56.0       -53.8       -52.0       -50.3       -48.6
  A(I)              3.2         2.2         1.9         1.8         1.8
  V(I)             5.38        7.91        9.03        9.37        9.42

X STA.       -48.6       -46.9       -45.2       -43.4       -41.6       -38.4
  A(I)              1.8         1.8         1.8         1.8         3.0
  V(I)             9.63        9.73        9.51        9.54        5.68

X STA.       -38.4       -34.4       -30.1       -25.3       -20.0       -14.0
  A(I)              3.7         3.9         4.0         4.2         4.4
  V(I)             4.63        4.41        4.35        4.09        3.91

X STA.       -14.0        -6.5         3.1        13.9        25.4        59.4
  A(I)              5.0         5.6         5.9         5.9         8.8
  V(I)             3.47        3.10        2.94        2.91        1.95

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      42.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       30       885     16     17                           235
             2      230     16907     33     40                          3427
             3        7        46     33     33                            17
   500.27           267     17838     82     90  1.16    -22     59      2535

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      42.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.27   -23.3    59.0   267.0   17838.    1540.   5.77

X STA.       -23.3        -6.7        -0.9         0.9         2.3         3.5
  A(I)             30.7        21.9        14.3        11.7        10.9
  V(I)             2.51        3.51        5.39        6.60        7.09

X STA.         3.5         4.7         5.7         6.8         7.8         8.9
  A(I)             10.6        10.0         9.9         9.8         9.7
  V(I)             7.28        7.72        7.81        7.83        7.96

X STA.         8.9         9.9        11.0        12.1        13.2        14.4
  A(I)              9.7         9.9         9.7        10.3        10.3
  V(I)             7.94        7.81        7.92        7.44        7.48

X STA.        14.4        15.6        16.9        18.4        20.3        59.0
  A(I)             10.8        11.1        12.6        14.7        28.4
  V(I)             7.11        6.94        6.09        5.23        2.71
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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brna030.wsp
        CREATED ON 13-DEC-95 FOR BRIDGE BRNATH00470030 USING FILE brna030.dca
        Town Highway 47 Bridge Over Locust Creek, Barnard, VT      EMB
           *** RUN DATE & TIME: 03-05-97  08:58

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       83      4685     19     28                          990
   495.47            83      4685     19     28  1.00      0     23      990

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.47     0.0    23.2    83.3    4685.     989.  11.87

X STA.         0.0         1.8         2.9         3.8         4.7         5.5
  A(I)             8.0         4.8         3.9         3.7         3.6
  V(I)            6.17       10.39       12.58       13.53       13.79

X STA.         5.5         6.3         7.2         8.0         8.9         9.9
  A(I)             3.4         3.4         3.3         3.3         3.5
  V(I)           14.46       14.47       14.80       14.78       14.27

X STA.         9.9        10.8        11.8        12.9        14.0        15.1
  A(I)             3.4         3.5         3.6         3.7         3.8
  V(I)           14.46       14.03       13.73       13.37       13.18

X STA.        15.1        16.4        17.7        19.1        20.7        23.2
  A(I)             3.9         4.0         4.3         4.8         7.4
  V(I)           12.81       12.23       11.59       10.24        6.68

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      42.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1        9       130     15     15                           41
             2      185     12026     32     38                         2503
   498.89           194     12156     47     53  1.07    -20     25     2163

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      42.

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.89   -21.4    25.4   193.6   12156.     989.   5.11

X STA.       -21.4        -0.6         1.1         2.5         3.7         4.7
  A(I)            24.6        11.8         9.6         9.0         8.2
  V(I)            2.01        4.21        5.13        5.50        6.04

X STA.         4.7         5.7         6.7         7.6         8.5         9.5
  A(I)             7.9         7.8         7.5         7.5         7.4
  V(I)            6.27        6.35        6.63        6.58        6.70

X STA.         9.5        10.4        11.4        12.4        13.4        14.5
  A(I)             7.5         7.4         7.7         7.7         7.9
  V(I)            6.58        6.66        6.43        6.45        6.30

X STA.        14.5        15.6        16.8        18.1        19.8        25.4
  A(I)             8.3         8.7         9.1        11.2        17.0
  V(I)            5.99        5.68        5.44        4.43        2.91
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WSPRO OUTPUT FILE (continued)

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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brna030.wsp
        CREATED ON 13-DEC-95 FOR BRIDGE BRNATH00470030 USING FILE brna030.dca
        Town Highway 47 Bridge Over Locust Creek, Barnard, VT      EMB
           *** RUN DATE & TIME: 03-05-97  08:58

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

 EXITX:XS   ******    -26      182  0.75 *****  496.03  494.41    1150  495.28
        -35 ******     64     8788  1.22 ***** *******    0.87    6.31

  ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.86     495.92     495.02
  ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   494.78     508.39    0.50
  ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   494.78     508.39     495.02

 FULLV:FV       36    -26      183  0.75  0.61  496.65  495.02    1150  495.91
          0     36     64     8835  1.22  0.00    0.01    0.86    6.28
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.85     496.50     496.01
  ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   495.41     509.72    0.50
  ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   495.41     509.72     496.01

 APPRO:AS       42     -3      115  1.56  1.00  498.06  496.01    1150  496.51
         42     42     23     6307  1.00  0.40    0.01    0.85   10.00
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   499.42       0.00     495.94     499.16
  ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
  ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.94     499.08     499.42     498.20
  ===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       36      0      135  0.97 *****  499.21  495.72    1071  498.24
          0 ******     23     6911  1.00 ***** *******    0.58    7.91

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        4. ****   5.  0.456  0.000  498.20 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      12.    27.  0.14  0.41  500.04    0.00     74.  499.78

             Q   WLEN    LEW     REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
    LT:     74.    59.   -59.     0.   0.6   0.3   3.1   3.7   0.6   2.7
    RT:      0.    17.    10.    28.   0.3   0.2   2.8   3.7   0.5   2.7

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

 APPRO:AS       19    -22      236  0.41  0.23  500.18  496.01    1150  499.78
         42     20     26    15570  1.10  1.19    0.00    0.41    4.87

        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     -36.   -27.    64.   1150.    8788.     182.    6.31  495.28
    FULLV:FV       0.   -27.    64.   1150.    8835.     183.    6.28  495.91
    BRIDG:BR       0.     0.    23.   1071.    6911.     135.    7.91  498.24
    RDWAY:RG      12.*******    74.     74.       0.       0.    2.00  499.78
    APPRO:AS      42.   -23.    26.   1150.   15570.     236.    4.87  499.78

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

  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
    EXITX:XS    494.41    0.87  489.73  507.77************  0.75  496.03  495.28
    FULLV:FV    495.02    0.86  490.35  508.39  0.61  0.00  0.75  496.65  495.91
    BRIDG:BR    495.72    0.58  489.97  498.24************  0.97  499.21  498.24
    RDWAY:RG    ****************  499.16  508.07  0.14******  0.41  500.04  499.78
    APPRO:AS    496.01    0.41  490.66  509.72  0.23  1.19  0.41  500.18  499.78
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WSPRO OUTPUT FILE (continued)

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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brna030.wsp
        CREATED ON 13-DEC-95 FOR BRIDGE BRNATH00470030 USING FILE brna030.dca
        Town Highway 47 Bridge Over Locust Creek, Barnard, VT      EMB
           *** RUN DATE & TIME: 03-05-97  08:58

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

EXITX:XS   ******    -28      231  0.85 *****  496.65  495.51    1540  495.80
       -35 ******     66    11773  1.22 ***** *******    0.83    6.66

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.82     496.44     496.13
 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.30     508.39    0.50
 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.30     508.39     496.13

FULLV:FV       36    -28      232  0.84  0.61  497.27  496.13    1540  496.43
         0     36     66    11857  1.22  0.00    0.01    0.83    6.63
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID “APPRO”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.03     496.84     496.93
 ===110 WSEL NOT FOUND AT SECID “APPRO”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.93     509.72    0.50
 ===115 WSEL NOT FOUND AT SECID “APPRO”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.93     509.72     496.93
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID “APPRO”
                  WSBEG,WSEND,CRWS =   496.93     509.72     496.93

APPRO:AS       42     -3      126  2.31 *****  499.24  496.93    1540  496.93
        42     42     24     7221  1.00 ***** *******    1.00   12.17
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   500.83       0.00     496.97     499.16
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   501.81         0.      1540.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR       36      0      135  1.21 *****  499.41  496.06    1194  498.20
         0 ******     23     8292  1.00 ***** *******    0.65    8.84

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   5.  0.477  0.000  498.20 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.    27.  0.20  0.60  500.67    0.00    345.  500.27

               Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    265.    74.   -63.    10.   1.1   0.8   4.6   4.7   1.2   2.9
   RT:     81.    40.    10.    50.   0.5   0.4   3.8   5.0   0.8   2.8

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

APPRO:AS       19    -22      267  0.60  0.25  500.87  496.93    1540  500.27
        42     20     59    17838  1.16  0.00    0.00    0.61    5.77

       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     -36.   -29.    66.   1540.   11773.     231.    6.66  495.80
   FULLV:FV       0.   -29.    66.   1540.   11857.     232.    6.63  496.43
   BRIDG:BR       0.     0.    23.   1194.    8292.     135.    8.84  498.20
   RDWAY:RG      12.*******   265.    345.       0.       0.    2.00  500.27
   APPRO:AS      42.   -23.    59.   1540.   17838.     267.    5.77  500.27

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.51    0.83  489.73  507.77************  0.85  496.65  495.80
   FULLV:FV    496.13    0.83  490.35  508.39  0.61  0.00  0.84  497.27  496.43
   BRIDG:BR    496.06    0.65  489.97  498.24************  1.21  499.41  498.20
   RDWAY:RG  ***************  499.16  508.07  0.20******  0.60  500.67  500.27
   APPRO:AS    496.93    0.61  490.66  509.72  0.25  0.00  0.60  500.87  500.27
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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brna030.wsp
        CREATED ON 13-DEC-95 FOR BRIDGE BRNATH00470030 USING FILE brna030.dca
        Town Highway 47 Bridge Over Locust Creek, Barnard, VT      EMB
           *** RUN DATE & TIME: 03-05-97  08:58

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

 EXITX:XS   ******    -10      157  0.70 *****  495.67  494.08     989  494.97
       -35 ******     54     7556  1.14 ***** *******    0.76    6.30

 FULLV:FV       36    -10      159  0.69  0.61  496.30 *******     989  495.61
          0     36     54     7633  1.15  0.00    0.02    0.76    6.24
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS       42     -2      108  1.31  0.94  497.54 *******     989  496.23
        42      42     23     5749  1.00  0.31    0.00    0.80    9.18
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.47     498.55     498.89     498.20
  ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
  ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   499.42        979.        15.
  ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.
  ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =      989.      495.47

             <<<<<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       36      0       83  2.19 *****  497.66  495.47     989  495.47
          0     36     23     4692  1.00 ***** *******    1.00   11.86

      TYPE PPCD FLOW       C    P/A    LSEL   BLEN   XLAB   XRAB
        4. ****   1.  1.000 ******  498.20 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      12.         <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

 APPRO:AS       19    -20      193  0.43  0.34  499.32  495.59     989  498.89
        42      20     25    12149  1.07  1.32    0.00    0.46    5.11

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.115  0.000   13115.    -1.    23.   498.71

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

   FIRST USER DEFINED TABLE.

     XSID:CODE     SRD    LEW     REW       Q        K      AREA     VEL    WSEL
    EXITX:XS      -36.   -11.     54.    989.    7556.     157.    6.30  494.97
    FULLV:FV        0.   -11.     54.    989.    7633.     159.    6.24  495.61
    BRIDG:BR        0.     0.     23.    989.    4692.      83.   11.86  495.47
    RDWAY:RG       12.**************       0.       0.       0.    2.00********
    APPRO:AS       42.   -21.     25.    989.   12149.     193.    5.11  498.89

     XSID:CODE    XLKQ   XRKQ       KQ
    APPRO:AS       -1.    23.   13115.

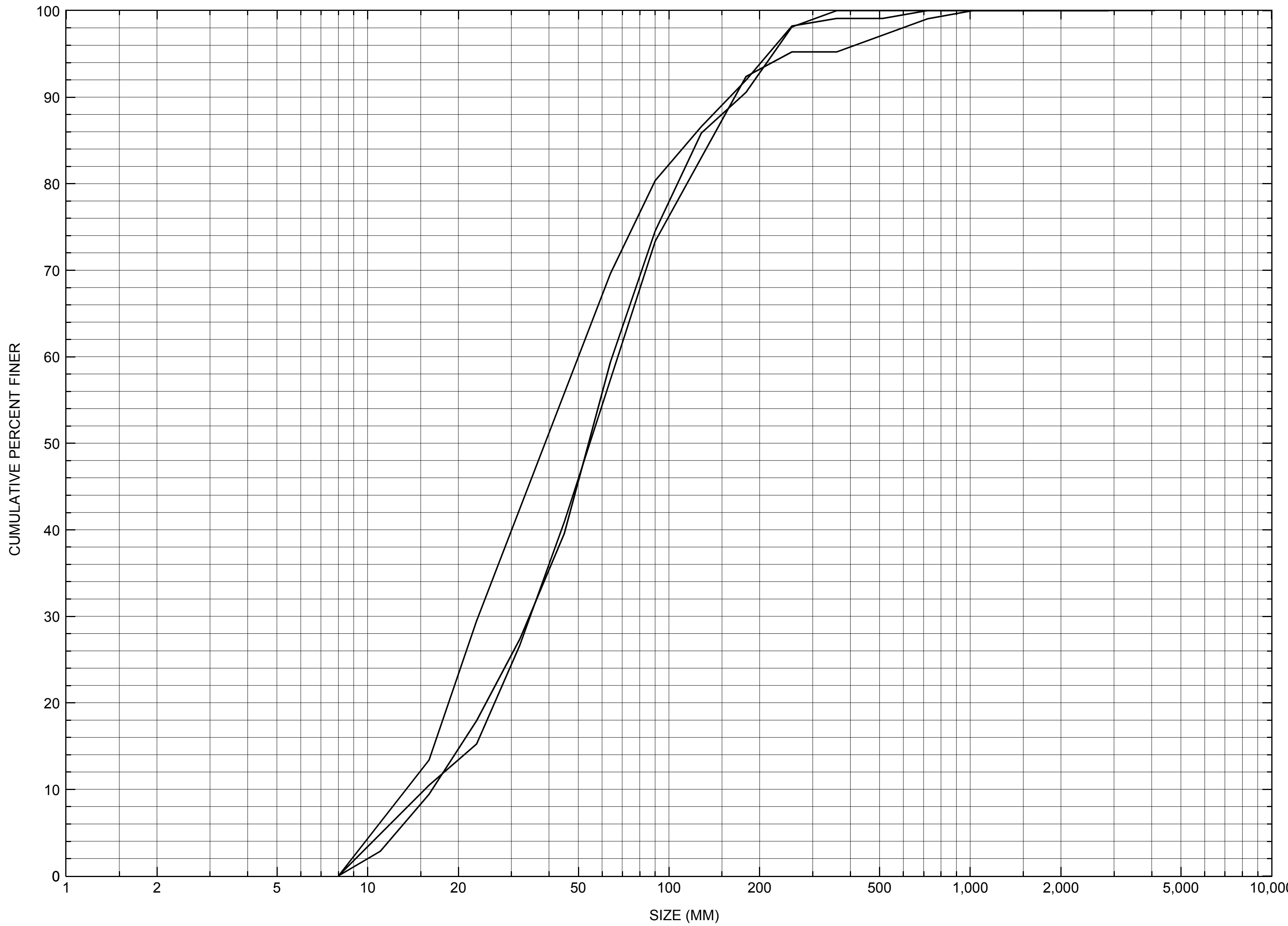
  SECOND USER DEFINED TABLE.

     XSID:CODE     CRWS     FR#    YMIN    YMAX    HF     HO   VHD     EGL    WSEL
    EXITX:XS     494.08    0.76  489.73  507.77************  0.70  495.67  494.97
    FULLV:FV   ********    0.76  490.35  508.39  0.61  0.00  0.69  496.30  495.61
    BRIDG:BR     495.47    1.00  489.97  498.24************  2.19  497.66  495.47
    RDWAY:RG   ****************  499.16  508.07************  0.35  499.64********
    APPRO:AS     495.59    0.46  490.66  509.72  0.34  1.32  0.43  499.32  498.89
   ER

  NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for three pebble count transects in the channel approach of structure BRNATH00470030, in Barnard, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number **BRNATH00470030**

General Location Descriptive

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

Date *(MM/DD/YY)* **08 / 23 / 94**

Highway District Number *(I - 2; nn)* **04**

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

Town *(FIPS place code; I - 4; nnnnn)* **02725**

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

Waterway *(I - 6)* **Locust Creek**

Road Name *(I - 7):* **-**

Route Number **TH 47**

Vicinity *(I - 9)* **0.05 MI TO JCT W C3 TH48**

Topographic Map **Delectable.Mtn**

Hydrologic Unit Code: **01080105**

Latitude *(I - 16; nnnn.n)* **43426**

Longitude *(i - 17; nnnnn.n)* **72388**

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* **10140300301403**

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

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

Year built *(I - 27; YYYY)* **1977**

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

Average daily traffic, ADT *(I - 29; nnnnnn)* **000010**

Deck Width *(I - 52; nn.n)* **155**

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

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

Opening skew to Roadway *(I - 34; nn)* **45**

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

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

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

Structure type *(I - 43; nnn)* **101**

Year Reconstructed *(I - 106)* **0000**

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

Clear span (*nnn.n ft*) **021.0**

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

Vertical clearance from streambed (*nnn.n ft*) **006.5**

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

Waterway of full opening (*nnn.n* ft^2) **105.0**

Comments:

Structural inspection report of 5/23/94 indicates the abutment footings are not in view [at the surface] and no settlement is apparent. Status of embankment erosion and channel scour are not addressed in the report. Report noted a straight stream alignment through bridge crossing. Riprap and drift/vegetation are not addressed in the report.

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: 5.2

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} 500 Q_{25} 750
Q_{50} 950 Q_{100} 1150 Q_{500} -

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

Estimated Discharge *(cfs)*: - Velocity at Q 25 *(ft/s)*: 11.47

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*)	-	4.3	5.6	6.8	7.6
Velocity (*ft / sec*)	-	-	11.47	-	-

Long term stream bed changes: -

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

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

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

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

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

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

Downstream distance (*miles*): - Town: - Year Built: -
Highway No. : - Structure No. : - Structure Type: -
Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (ft^2): -

Comments:
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 4.18 mi^2 Lake and pond area 0 mi^2
Watershed storage *(ST)* 0 %
Bridge site elevation 1370 ft Headwater elevation 2836 ft
Main channel length 3.59 mi
10% channel length elevation 1440 ft 85% channel length elevation 2140 ft
Main channel slope *(S)* 259.99 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)*: **04** / **1977**

Project Number **DSR 0024** Minimum channel bed elevation: **495.5**

Low superstructure elevation: USLAB **500.31** DSLAB **500.29** USRAB **500.36** DSRAB **500.34**

Benchmark location description:

BM#1, S.I.T. (spike in tree); 8 inch yellow birch at upstream edge of old roadway leading to the water at the downstream right abutment, stationing 13 + 17, 23 feet right, elevation 500.00. BM#2, S.I.T.; 30 inch pine at downstream side of old roadway leading to the water at the downstream left abutment, stationing 15 + 00, 24 feet right, elevation 501.40.

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

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

If 1: Footing Thickness **2.0** Footing bottom elevation: **491.0**

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:

NO FOUNDATION MATERIAL INFORMATION

Comments:

Some hydraulic data is also included on plans: Q10=500, height 4.3 feet, Q25=750, height 5.6 feet, Q50=950, height 6.8 feet, Q100=1150, height 7.6 feet, outlet velocity at Q25=11.47 feet per second, drainage area=4.2 square miles.

Cross-sectional Data

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

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

Comments: **There are several cross sections that are printed and kept with the plans, and may be retrieved if needed. There are no reproducible bridge face cross sections.**

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

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

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

Comments:

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: **EMB** Date: **1/26/95**

Computerized by: **EMB** Date: **1/26/95**

Reviewd by: **JDA** Date: **11/4/95**

Structure Number **BRNATH00470030**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **D. SONG** Date *(MM/DD/YY)* **10** / **13** / 19**94**

2. Highway District Number **04** Mile marker **-**

County **Windsor (027)** Town **Barnard (02725)**

Waterway *(I - 6)* **Locust Creek** Road Name **-**

Route Number **TH47** Hydrologic Unit Code: **01080105**

3. Descriptive comments:

Small, remote bridge on cobble bed stream located about 250 feet (0.05 miles) from town highway 47's intersection with town highway 48.

B. Bridge Deck Observations

4. Surface cover... LBUS **6** RBUS **6** LBDS **5** RBDS **5** 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 **2** *(**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 **28.0** *(feet)* Span length **25.0** *(feet)* Bridge width **15.5** *(feet)*

Road approach to bridge:

8. LB **0** RB **0** *(**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 **8.1:1** US right **4.1:1**

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

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*

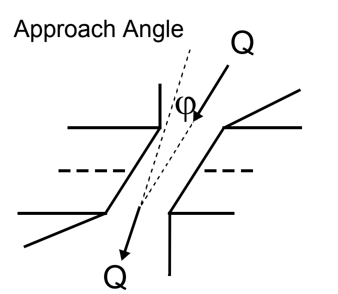
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

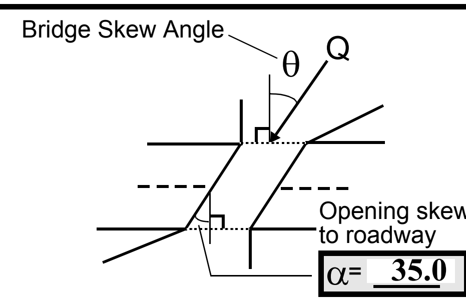
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

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





α= **35.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*

Where? **LB** *(LB, RB)* Severity **1**

Range? **10** feet **US** *(US, UB, DS)* to **0** 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: **4**

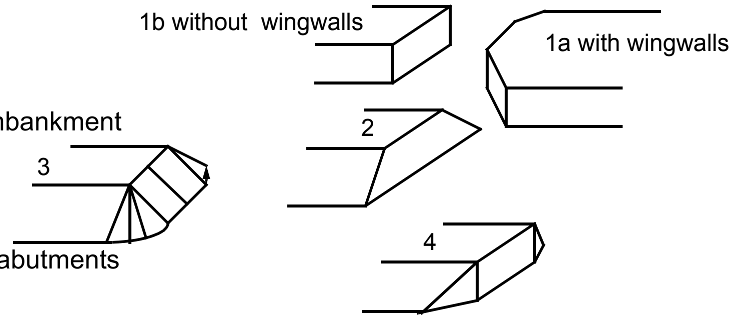
1a- Vertical abutments with wingwalls

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.)

Predominantly young trees, brush with forest land beyond 1 bridge length on left and right bank downstream. Measured bridge dimensions are: Bridge length = 28.0; Span length = 24.0; and roadway width = 15.0 feet.

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
52.5	**5.0**			**7.0**	**3**	**3**	**4**	**4**	**2**	**2**

23. Bank width **45.0** 24. Channel width **40.0** 25. Thalweg depth **31.5** 29. Bed Material **3**

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

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

Bank material is mainly organics and sand overlying cobbles with interstitial fines. While banks are undermined, they appear stabilized by trees. The streambed material is predominantly coarse gravel with some cobbles and a few boulders.

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

36. Point bar extent: - feet - (US, UB) to - feet - (US, UB, DS) positioned - %LB to - %RB

37. Material: -

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

NO POINT BARS

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

41. Mid-bank distance: 40.0 42. Cut bank extent: 75.0 feet US (US, UB) to 10 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.):

Severe undermining stabilized by trees (the cutbank ends around the upstream left wingwall due to boulder protection). Another cutbank is present on right bank just upstream of the upstream end of the above defined cutbank. Bank is steep and slumped (mass wasting) which appears due to the entrance of a confluence on left bank. The cut bank extent is from 70 feet upstream to 120 feet upstream on the right bank.

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

47. Scour dimensions: Length - Width - Depth : - Position - %LB to - %RB

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

NO CHANNEL SCOUR

49. Are there major confluences? Y (Y or if N type ctrl-n mc) 50. How many? 1

51. Confluence 1: Distance 130 52. Enters on LB (LB or RB) 53. Type 1 (1- perennial; 2- ephemeral)

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

54. Confluence comments (eg. confluence name):

The confluence is about 10 feet wide with an ambient flow depth of less than 0.5 feet. However, it will deliver a good percentage of flow and has influenced bank degradation on right bank just downstream of its

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
19.0		1.5		ance.	2	2	7

58. Bank width (BF) - 59. Channel width (Amb) - 60. Thalweg depth (Amb) 90.0 63. Bed Material 7

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.):

-
-
3
-

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

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

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

70. Debris and Ice Comments:

2
N
2
Relatively small bridge opening with alot of deadwood. A point bar under the bridge constricts the opening, raising the potential for blockage at this site.

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				**10**	**90**	**2**	**1**	**90.0**
RABUT	**0.5**		**1**			**-**	**90**	**19.0**

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

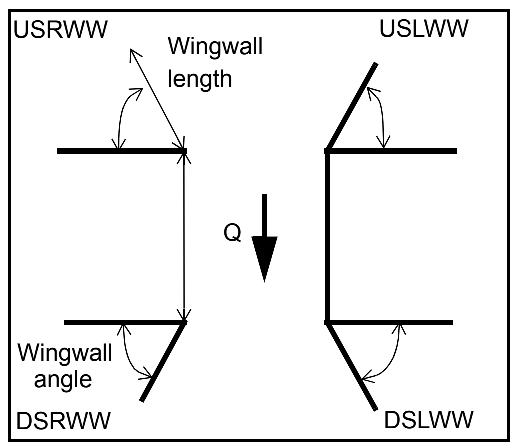
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

2
0
-

1
The streambed elevation along the left abutment is lower than on the right abutment where the flow impacts the left abutment and scour has occurred.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**19.0**	
USRWW:					**Y**	**1.5**	
DSLWW:	**1**		**0**		**-**	**23.0**	
DSRWW:			**Y**		**1**	**23.0**	



*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**	**1**	**-**
Condition	**-**	**1**		**0**	**2**	**2**	**0**	**0**
Extent		**0**	**Y**	**-**	**2**	**1**	**-**	**-**

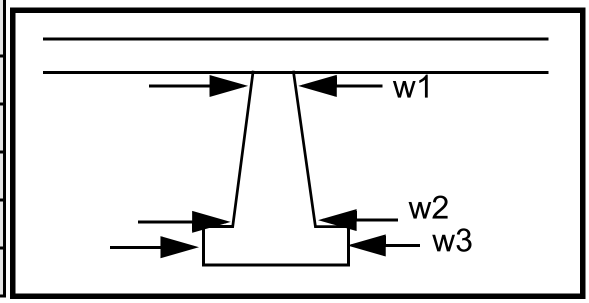
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
-
-
2
1
3
3

Piers:

84. Are there piers? 1 (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		7.5		70.0	10.0	15.5
Pier 2				25.0	17.0	70.0
Pier 3	6.0	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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? ____ *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

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

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

2
2
4
4

106. Point/Side bar present? 0 (Y or N. if N type ctrl-n pb) Mid-bar distance: 0 Mid-bar width: 3

Point bar extent: 0 feet 0 (US, UB, DS) to - feet - (US, UB, DS) positioned Th %LB to e %RB

Material: ba

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

nk material again is organics overlying cobbles and boulders. The bed material ranges from mostly coarse gravel to some cobbles and boulders.

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 0 (LB or RB) Type 10.0 (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance 10 Enters on UB (LB or RB) Type 25 (**1**- perennial; **2**- ephemeral)

Confluence comments (eg. confluence name):

DS
70

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)*:

4

Point bar material ranges from sand to boulder size. The boulders appear remnants of riprap protection.

N

-

-

-

-

-

-

-

109. G. Plan View Sketch

- N

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: BRNATH00470030   Town: Barnard
Road Number: TH 47   County: Windsor
Stream: Locust Creek

Initials EMB   Date: 1/4/96   Checked: SAO   1/5/96

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	1150	1540	989
Main Channel Area, ft2	214	230	185
Left overbank area, ft2	23	30	9
Right overbank area, ft2	0	7	0
Top width main channel, ft	33	33	32
Top width L overbank, ft	16	16	15
Top width R overbank, ft	0	33	0
D50 of channel, ft	0.1623	0.1623	0.1623
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.5	7.0	5.8
y1, average depth, LOB, ft	1.4	1.9	0.6
y1, average depth, ROB, ft	ERR	0.2	ERR
Total conveyance, approach	15591	17838	12156
Conveyance, main channel	15036	16907	12026
Conveyance, LOB	555	885	130
Conveyance, ROB	0	46	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1109.1	1459.6	978.4
Ql, discharge, LOB, cfs	40.9	76.4	10.6
Qr, discharge, ROB, cfs	0.0	4.0	0.0
Vm, mean velocity MC, ft/s	5.2	6.3	5.3
Vl, mean velocity, LOB, ft/s	1.8	2.5	1.2
Vr, mean velocity, ROB, ft/s	ERR	0.6	ERR
Vc-m, crit. velocity, MC, ft/s	8.4	8.5	8.2
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

ARMORING			
D90	0.5419	0.5419	0.5419
D95	0.7302	0.7302	0.7302
Critical grain size,Dc, ft	0.2447	0.3052	0.6739
Decimal-percent coarser than Dc	0.3152	0.23	0.0627
Depth to armoring,ft	1.59	3.07	30.22

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	214	230	185
Main channel width, ft	33	33	32
y1, main channel depth, ft	6.48	6.97	5.78

Bridge Section			
(Q) total discharge, cfs	1150	1540	989
(Q) discharge thru bridge, cfs	1071	1194	989
Main channel conveyance	6911	8292	4685
Total conveyance	6911	8292	4685
Q2, bridge MC discharge,cfs	1071	1194	989
Main channel area, ft2	135	135	83
Main channel width (skewed), ft	19.0	19.0	19.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	19	19	19
y_bridge (avg. depth at br.), ft	7.13	7.12	4.38
Dm, median (1.25*D50), ft	0.202875	0.202875	0.202875
y2, depth in contraction,ft	6.19	6.79	5.78
ys, scour depth (y2-ybridge), ft	-0.94	-0.33	1.39

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	1150	1540	989
Q, thru bridge, cfs	1071	1194	989
Total Conveyance, bridge	6911	8292	4685
Main channel(MC) conveyance, bridge	6911	8292	4685
Q, thru bridge MC, cfs	1071	1194	989
Vc, critical velocity, ft/s	8.35	8.45	8.19
Vc, critical velocity, m/s	2.55	2.58	2.50
Main channel width (skewed), ft	19.0	19.0	19.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	19.0	19.0	19.0
qbr, unit discharge, ft2/s	56.4	62.8	52.1
qbr, unit discharge, m2/s	5.2	5.8	4.8
Area of full opening, ft2	135.0	135.0	83.3
Hb, depth of full opening, ft	7.11	7.11	4.38
Hb, depth of full opening, m	2.17	2.17	1.34
Fr, Froude number, bridge MC	0.58	0.65	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
Elevation of Low Steel, ft	498.2	498.2	0
Elevation of Bed, ft	491.09	491.09	-4.38
Elevation of Approach, ft	499.78	500.27	0
Friction loss, approach, ft	0.23	0.25	0
Elevation of WS immediately US, ft	499.55	500.02	0.00
ya, depth immediately US, ft	8.46	8.93	4.38
ya, depth immediately US, m	2.58	2.72	1.34
Mean elevation of deck, ft	499.7	499.7	0
w, depth of overflow, ft (>=0)	0.00	0.32	0.00
Cc, vert contrac correction (<=1.0)	0.96	0.95	1.00
Ys, depth of scour, ft	-0.05	0.70	N/A

Comparison of Chang and Laursen results (for unsubmerged orifice flow)			
y2, from Laursen's equation, ft	6.186152	6.790324	5.777891
Full valley WSEL, ft	495.91	496.43	0
Full valley depth, ft	4.815263	5.335263	4.384211
Ys, depth of scour (y2-yfullv), ft	1.370889	1.455061	N/A

Abutment Scour

Froehlich's Abutment Scour

$$Ys/Y1 = 2.27*K1*K2*(a'/Y1)^{0.43}*Fr1^{0.61}+1$$

(Richardson and others, 1995, p. 48, eq. 28)

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	1150	1540	989	1150	1540	989
a', abut.length blocking flow, ft	24.8	25.4	23.5	3.2	5.3	4.3
Ae, area of blocked flow ft2	46.1	26.8	43.3	16.8	2.5	13.1
Qe, discharge blocked abut.,cfs	--	--	134.2	--	--	38
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.13	3.86	3.10	2.78	2.71	2.90
ya, depth of f/p flow, ft	1.86	1.06	1.84	5.25	0.47	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	55	55	55	125	125	125
K2	0.94	0.94	0.94	1.04	1.04	1.04
Fr, froude number f/p flow	0.341	0.391	0.402	0.268	0.558	0.293
ys, scour depth, ft	6.99	5.13	7.36	8.94	2.29	6.29

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)	24.8	25.4	23.5	3.2	5.3	4.3
y1 (depth f/p flow, ft)	1.86	1.06	1.84	5.25	0.47	3.05
a'/y1	13.34	24.07	12.75	0.61	11.24	1.41
Skew correction (p. 49, fig. 16)	0.87	0.87	0.87	1.08	1.08	1.08
Froude no. f/p flow	0.34	0.39	0.40	0.27	0.56	0.29
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

$$D50=y*K*Fr^2/(Ss-1) \text{ and } D50=y*K*(Fr^2)^{0.14}/(Ss-1)$$

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.58	0.65	1	0.58	0.65	1
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	7.13	7.12	4.38	7.13	7.12	4.38
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.48	1.86	ERR	1.48	1.86	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	1.83	ERR	ERR	1.83