LEVEL II SCOUR ANALYSIS FOR BRIDGE 8 (DANVTH00020008) on TOWN HIGHWAY 2, crossing MORRILL BROOK, DANVILLE, VERMONT

U.S. Geological Survey
Open-File Report 97-104

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

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By MICHAEL A. IVANOFF

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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Box 25286
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 8 (DANVTH00020008) ON TOWN HIGHWAY 2, CROSSING MORRILL BROOK, DANVILLE, VERMONT

By **Michael A. Ivanoff**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure DANVTH00020008 on Town Highway 2 crossing Morrill Brook, Danville, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the New England Upland section of the New England physiographic province in North-East Vermont. The 4.74-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest with a residence on the upstream right bank.

In the study area, Morrill Brook has an incised, sinuous channel with a slope of approximately 0.03 ft/ft, an average channel top width of 60 ft and an average channel depth of 8 ft. The predominant channel bed material is cobble with a median grain size (D_{50}) of 67.0 mm (0.220 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 9, 1995, indicated that the reach was stable.

The Town Highway 2 crossing of Morrill Brook is a 59-ft-long, two-lane bridge consisting of one 57-foot steel-beam span (Vermont Agency of Transportation, written communication, March 24, 1995). The bridge is supported by vertical, concrete abutments. The channel is skewed approximately 5 degrees to the opening while the opening-skew-to-roadway is 0 degrees.

The scour protection measure at the site included type-2 stone fill (less than 36 inches diameter) along the base of the left abutment. There was type-1 stone fill (less than 12 inches diameter) along the base of the right abutment. There was also type-3 stone fill (less than 48 inches diameter) along both upstream banks at the location of previous bridge abutments. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for modelled flows ranged from 0.1 to 0.4 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 4.0 to 8.7 ft. The worst-case abutment scour occurred at the 100-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.

St. Johnsbury, VT. Quadrangle, 1:25,000, 1983

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 DANVTH00020008 ***Stream*** Morrill Brook

County Caledonia ***Road*** TH 2 ***District*** 7

Description of Bridge

Bridge length 59 ***ft*** ***Bridge width*** 23.4 ***ft*** ***Max span length*** 57 ***ft***

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

Abutment type Spill-through, stone fill ***Embankment type*** Sloping

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

Description of stone fill Type-2, along the base of the left abutment. Type-1, along the base of the right abutment. Type-3, along both upstream banks at location of previous bridge abutments.

Vertical abutment walls are concrete. The stone fill along the bank forms the spill-through abutments.

Brief description of piers/abutments

Yes

Is bridge skewed to flood flow according to There ***survey?*** 5 ***Angle*** Yes

is a mild channel bend into the bridge and a severe channel bend in the upstream reach 150 feet from the bridge.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	09/09/95	0	0
Level II	09/09/95	0	0

Potential for debris Moderate. There is some small debris caught on boulders. There are trees along the left bank leaning over the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date) Stacked granite blocks used for abutments at a previous bridge constrict the channel upstream of the bridge. 09/09/95.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a narrow overbank.

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

Date of inspection 09/09/95

DS left: Moderately sloped channel bank to a narrow overbank

DS right: Steep channel bank to Town Highway 38

US left: Steep valley wall

US right: Moderately sloped channel bank to a narrow overbank

Description of the Channel

Average top width 60.0 *ft* ***Average depth*** 8.0 *ft*

Predominant bed material Cobbles ***Bank material*** Cobbles

Sinuous but stable with non-alluvial channel boundaries and no flood plain.

09/09/95

Vegetative co Trees and brush

DS left: Trees and brush

DS right: Trees

US left: Short grass and brush with a few trees.

US right:

Do banks appear stable? Yes ***If not, describe location and type of instability and date of observation.*** Cut banks noted on the upstream left bank at bend in channel and both downstream banks. 9/9/95.

Describe any obstructions in channel and date of observation. The assessment of 09/09/95 noted flow conditions up to bank-full level are influenced by stacked stone blocks (old bridge abutments) on both sides of the channel upstream. In addition, some debris is caught on boulders in the channel upstream.

Hydrology

Drainage area 4.74 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: There is a house on the upstream right overbank area

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 950 ***ft³/s*** ***Q500*** 1,350 ***ft³/s***

The 100- and 500-year discharges are the median values of flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; 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 None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the left abutment (elev. 495.33 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the right abutment (elev. 495.49 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT1	-41	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
APPR1	60	2	Approach section (Templated from APTEM)
APTEM	81	1	Approach section as surveyed

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.053 to 0.060, and overbank "n" values ranged from 0.080 to 0.125.

Normal depth at the exit section (EXIT1) 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 0.027 ft/ft which was determined from surveyed downstream thalweg points.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.04 ft/ft) to establish the modelled approach section (APPR1), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

For the 100-year and 500-year discharge, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. Analyzing both the supercritical and subcritical profiles for each discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge are satisfactory solutions.

Bridge Hydraulics Summary

Average bridge embankment elevation 496.0 *ft*
Average low steel elevation 491.2 *ft*

100-year discharge 950 *ft³/s*
Water-surface elevation in bridge opening 484.5 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 98 *ft²*
Average velocity in bridge opening 9.7 *ft/s*
Maximum WSPRO tube velocity at bridge 12.3 *ft/s*

Water-surface elevation at Approach section with bridge 487.4
Water-surface elevation at Approach section without bridge 486.4
Amount of backwater caused by bridge 1.0 *ft*

500-year discharge 1,350 *ft³/s*
Water-surface elevation in bridge opening 485.4 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 127 *ft²*
Average velocity in bridge opening 10.6 *ft/s*
Maximum WSPRO tube velocity at bridge 13.5 *ft/s*

Water-surface elevation at Approach section with bridge 488.2
Water-surface elevation at Approach section without bridge 487.3
Amount of backwater caused by bridge 0.9

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

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The worst case contraction scour occurred at the 500-year discharge.

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.

Because the influence of scour processes on the spill-through embankment material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, the total scour depth computed at the toe of each abutment was applied to the entire area of the embankment, as shown in figure 8.

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	0.1	0.4	--
Depth to armoring	10.4	8.3	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
Abutment scour			
Left abutment	8.7	7.1	--
Right abutment	4.0	4.6	--
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	1.6	1.7	--
Right abutment	1.6	1.7	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

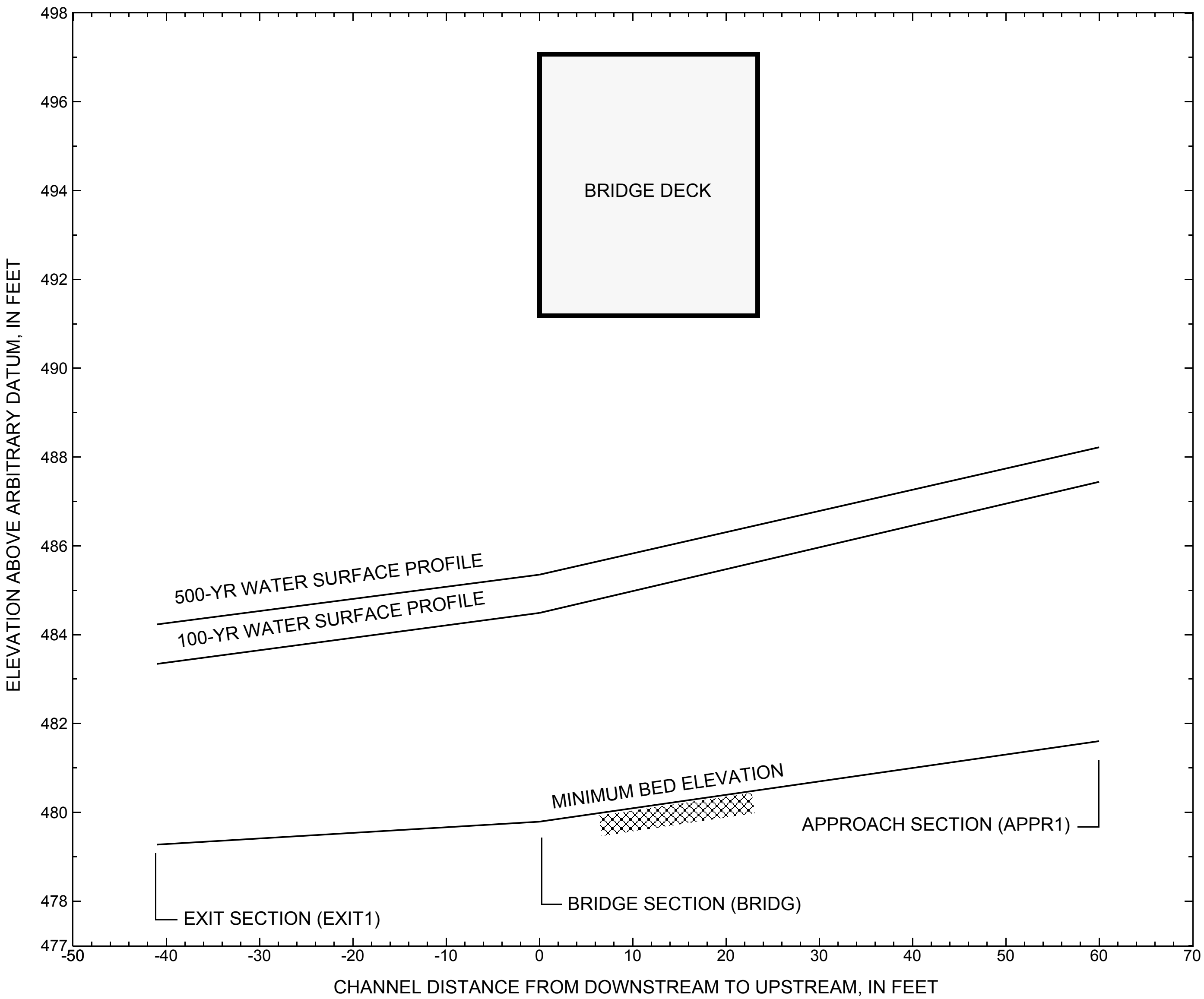

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure DANVTH00020008 on Town Highway 2, crossing Morrill Brook, Danville, Vermont.

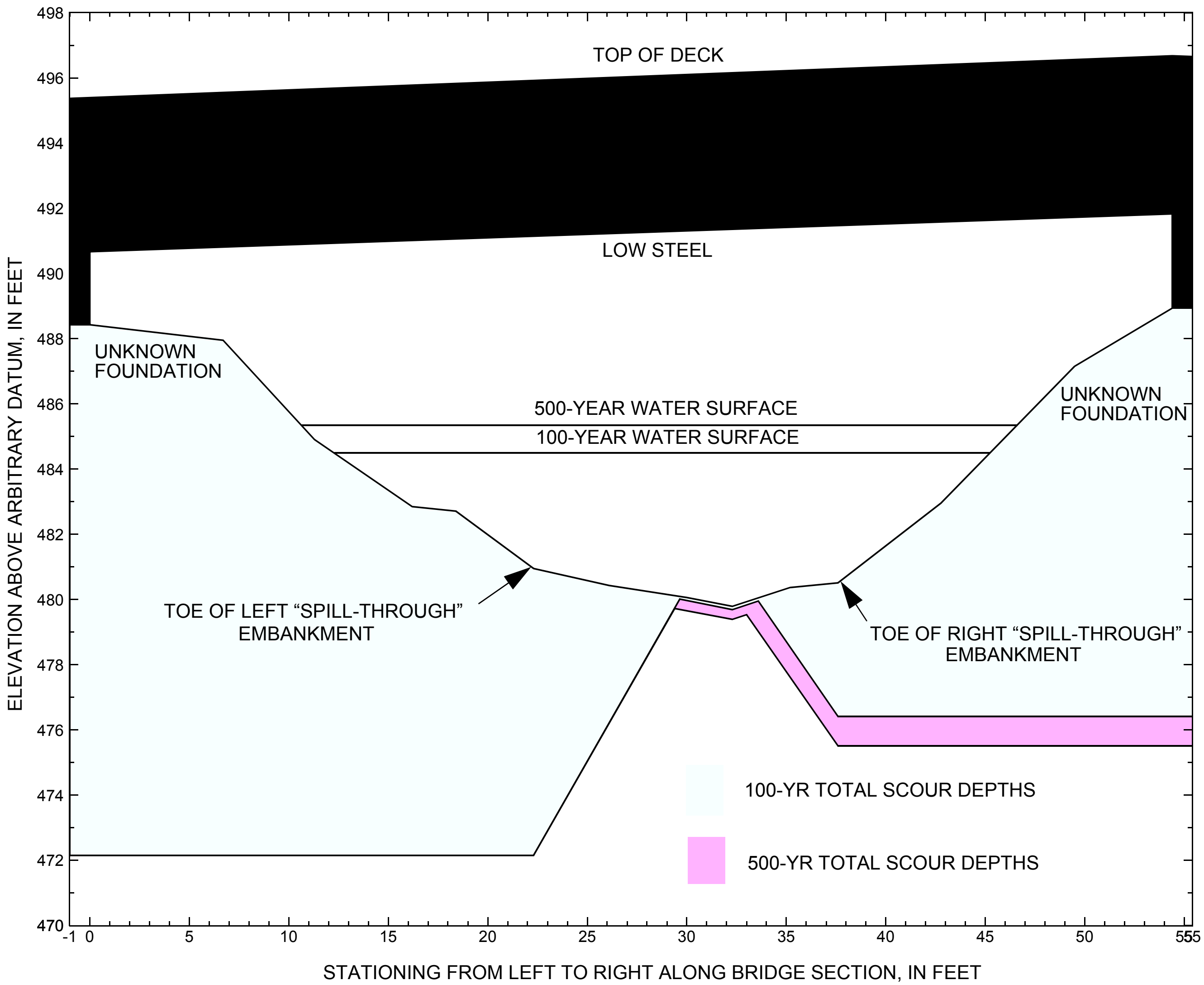

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure DANVTH00020008 on Town Highway 2, crossing Morrill Brook, Danville, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure DANVTH00020008 on Town Highway 2, crossing Morrill Brook, Danville, 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 950 cubic-feet per second											
Left abutment	0.0	--	490.7	--	488.4	--	--	--	--	472.1	--
Toe of left “spill-through” embankment	22.3	--	--	--	481.0	0.1	8.7	--	8.8	--	--
Toe of right “spill-through” embankment	37.6	--	--	--	480.5	0.1	4.0	--	4.1	--	--
Right abutment	54.4	--	491.8	--	488.9	--	--	--	--	476.4	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure DANVTH00020008 on Town Highway 2, crossing Morrill Brook, Danville, 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 1,350 cubic-feet per second											
Left abutment	0.0	--	490.7	--	488.4	--	--	--	--	473.4	--
Toe of left “spill-through” embankment	22.3	--	--	--	480.9	0.4	7.1	--	7.5	--	--
Toe of right “spill-through” embankment	37.6	--	--	--	480.5	0.4	4.6	--	5.0	--	--
Right abutment	54.4	--	491.8	--	488.9	--	--	--	--	475.5	--

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, 1983, St. Johnsbury, 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

```
T1        U.S. Geological Survey WSPRO Input File danv008.wsp
T2        Hydraulic analysis for structure DANVTH00020008   Date: 18-SEP-96
T3        Bridge #8 over Morrill Brook in Danville, VT by MAI
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q            950.0  1350.0
SK          0.0270  0.0270
*
XS   EXIT1    -41
GR         -226.6, 505.81   -137.0, 496.37    -32.0, 493.00    -22.3, 487.27
GR            0.0, 485.73      8.0, 483.69     10.3, 482.08     10.8, 481.15
GR           21.2, 479.97     23.7, 479.54     30.6, 479.32     33.5, 479.27
GR           39.8, 479.97     43.7, 481.27     44.9, 483.61     52.0, 485.82
GR           71.4, 496.91     88.2, 496.60    118.9, 497.85    132.5, 497.61
GR          150.7, 508.34
N           0.080        0.060        0.110
SA                    0.0        71.4
*
XS   FULLV      0  * * *   0.0120
*
*               SRD  LSEL     SKEW
BR   BRIDG      0  491.25    0.0
GR            0.0, 490.67      0.0, 488.43      6.7, 487.95     11.3, 484.91
GR           16.2, 482.85     18.4, 482.71     22.3, 480.95     26.1, 480.43
GR           30.0, 480.06     32.3, 479.79     35.2, 480.37     37.6, 480.51
GR           42.8, 482.97     49.5, 487.16     54.4, 488.94     54.4, 491.83
GR            0.0, 490.67
*           BRTYPE   BRWDTH   EMBSS   EMBELV
CD            3      24.3       2.65  495.92
N           0.053
*    RDWAY section omitted because minimum elevation 494.9, well above 500-yr discharge
*
XT   APTEM     81
GR         -155.7, 504.69    -93.7, 493.26      2.3, 493.12      2.5, 490.25
GR           11.0, 487.38     12.8, 483.82     15.1, 482.44     18.4, 483.11
GR           23.3, 483.48     27.1, 484.11     32.3, 484.91     37.5, 484.27
GR           44.2, 487.17     51.8, 490.97    132.0, 493.99    169.3, 499.76
GR          267.0, 510.52
*
AS   APPR1     60  * * *  0.04
GT
N           0.125        0.060        0.080
SA                   2.3          51.8
*
HP 1 BRIDG   484.49 1 484.49
HP 2 BRIDG   484.49 * * 950
HP 1 APPR1   487.44 1 487.44
HP 2 APPR1   487.44 * * 950
*
HP 1 BRIDG   485.35 1 485.35
HP 2 BRIDG   485.35 * * 1350
HP 1 APPR1   488.22 1 488.22
HP 2 APPR1   488.22 * * 1350
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File danv008.wsp
        Hydraulic analysis for structure DANVTH00020008   Date: 18-SEP-96
        Bridge #8 over Morrill Brook in Danville, VT by MAI
           *** RUN DATE & TIME: 02-10-97  16:23
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       97      5450     33     35                          952
   484.49            97      5450     33     35  1.00     12     45      952

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       484.49    12.3    45.2    97.5    5450.     950.   9.75

X STA.        12.3       19.4       21.7       23.2       24.5       25.7
  A(I)             9.0        6.5        5.2        4.8        4.6
  V(I)            5.29       7.36       9.16       9.90      10.35

X STA.        25.7       26.7       27.7       28.7       29.6       30.5
  A(I)             4.3        4.2        4.1        4.0        3.9
  V(I)           11.07      11.39      11.46      11.98      12.12

X STA.        30.5       31.4       32.2       33.0       33.9       34.9
  A(I)             3.9        3.9        3.9        4.0        4.1
  V(I)           12.09      12.21      12.30      11.83      11.53

X STA.        34.9       35.9       37.0       38.2       39.9       45.2
  A(I)             4.2        4.4        4.9        5.6        8.2
  V(I)           11.37      10.74       9.78       8.54       5.83


    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = APPR1;  SRD =      60.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      135      7284     38     42                         1437
   487.44           135      7284     38     42  1.00      8     46     1437

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = APPR1;  SRD =      60.

         WSEL     LEW     REW    AREA        K        Q    VEL
       487.44     8.3    46.4   134.7    7284.     950.   7.05

X STA.         8.3       14.0       15.3       16.4       17.5       18.5
  A(I)            11.8        7.2        6.3        5.9        5.6
  V(I)            4.02       6.56       7.59       8.03       8.54

X STA.        18.5       19.6       20.7       21.8       22.9       24.1
  A(I)             5.6        5.5        5.5        5.4        5.6
  V(I)            8.55       8.71       8.62       8.84       8.50

X STA.        24.1       25.4       26.7       28.2       29.8       31.6
  A(I)             5.8        5.8        6.0        6.3        6.6
  V(I)            8.26       8.14       7.90       7.55       7.23

X STA.        31.6       33.6       35.5       37.2       39.4       46.4
  A(I)             6.9        6.8        6.7        7.8       11.7
  V(I)            6.89       6.99       7.05       6.05       4.07
```

```
        U.S. Geological Survey WSPRO Input File danv008.wsp
        Hydraulic analysis for structure DANVTH00020008   Date: 18-SEP-96
        Bridge #8 over Morrill Brook in Danville, VT by MAI
           *** RUN DATE & TIME: 02-10-97  16:23
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      127      7964     36     38                         1357
   485.35           127      7964     36     38  1.00     11     47     1357

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       485.35    10.6    46.6   127.2    7964.    1350.  10.61

X STA.        10.6       17.8       20.5       22.3       23.7       25.0
  A(I)             11.5        8.2        7.0        6.3        6.0
  V(I)             5.87       8.26       9.71      10.76      11.29

X STA.        25.0       26.1       27.2       28.2       29.2       30.2
  A(I)              5.6        5.4        5.3        5.2        5.1
  V(I)            12.10      12.42      12.81      12.96      13.13

X STA.        30.2       31.2       32.1       33.0       34.0       35.0
  A(I)              5.1        5.0        5.2        5.2        5.4
  V(I)            13.31      13.46      13.04      13.05      12.49

X STA.        35.0       36.2       37.3       38.7       40.6       46.6
  A(I)              5.5        5.7        6.5        7.2       10.9
  V(I)            12.22      11.83      10.45       9.37       6.16


    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = APPR1;  SRD =      60.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      166      9677     42     46                         1872
   488.22           166      9677     42     46  1.00      6     48     1872


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = APPR1;  SRD =      60.

         WSEL     LEW     REW    AREA        K        Q    VEL
       488.22     6.0    48.0   165.9    9677.    1350.   8.14

X STA.         6.0       13.8       15.2       16.5       17.6       18.8
  A(I)             15.8        9.1        7.9        7.3        7.0
  V(I)             4.27       7.40       8.51       9.30       9.63

X STA.        18.8       20.0       21.1       22.3       23.5       24.7
  A(I)              6.8        6.7        6.8        6.7        6.7
  V(I)             9.88      10.05       9.94      10.03      10.01

X STA.        24.7       26.1       27.5       29.0       30.7       32.5
  A(I)              6.9        7.1        7.3        7.6        7.8
  V(I)             9.71       9.54       9.19       8.90       8.69

X STA.        32.5       34.4       36.2       37.9       40.3       48.0
  A(I)              7.9        8.0        8.2        9.7       14.4
  V(I)             8.54       8.39       8.21       6.96       4.70
```

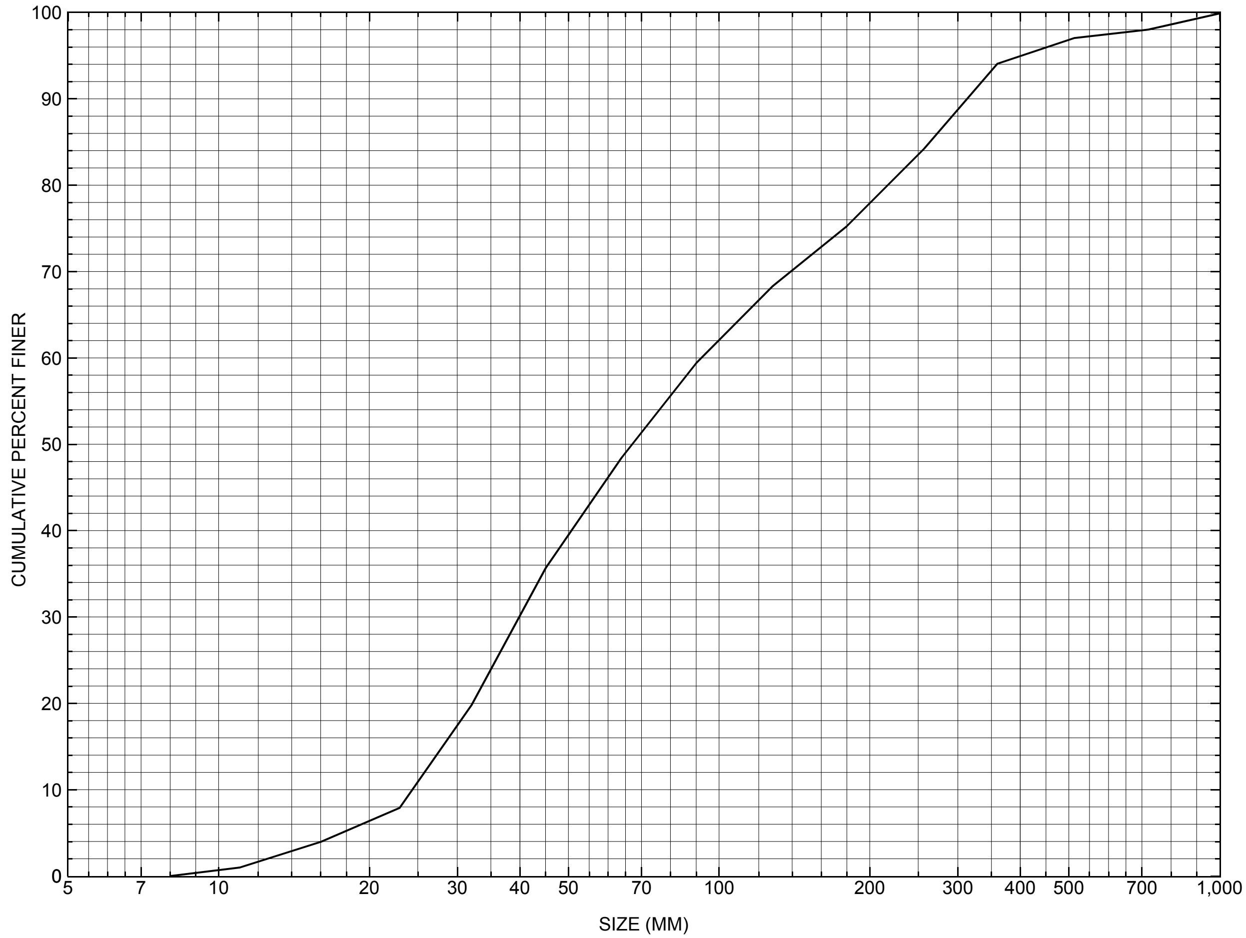
```
        U.S. Geological Survey WSPRO Input File danv008.wsp
        Hydraulic analysis for structure DANVTH00020008   Date: 18-SEP-96
        Bridge #8 over Morrill Brook in Danville, VT by MAI
           *** RUN DATE & TIME: 02-10-97  16:23

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

 EXIT1:XS   ******      9      114  1.09 *****  484.42  482.95     950  483.34
        -40 ******     45     5778  1.00 ***** *******    0.83    8.36

 FULLV:FV       41      7      140  0.72  0.83  485.25 *******     950  484.53
          0     41     46     7684  1.00  0.00   -0.01    0.64    6.79
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===125 FR# EXCEEDS FNTEST AT SECID "APPR1":  TRIALS CONTINUED.
               FNTEST,FR#,WSEL,CRWS =  0.80    1.33     485.84     486.39

  ===110 WSEL NOT FOUND AT SECID "APPR1":  REDUCED DELTAY.
                    WSLIM1,WSLIM2,DELTAY =   484.03     509.68    0.50

  ===115 WSEL NOT FOUND AT SECID "APPR1":  USED WSMIN = CRWS.
                    WSLIM1,WSLIM2,CRWS =   484.03     509.68     486.39

  ===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 "APPR1"
                    WSBEG,WSEND,CRWS =   486.39     509.68     486.39

 APPR1:AS       60     11       97  1.48 *****  487.87  486.39     950  486.39
         60     60     44     4653  1.00 ***** *******    1.00    9.75
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                    SECID "BRIDG"     Q,CRWS =      950.      484.49

             <<<<<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       41     12       98  1.47 *****  485.97  484.49     950  484.49
          0     41     45     5458  1.00 ***** *******    1.00    9.74

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        3. ****   1.  1.000 ******  491.25 ****** ****** ******

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

 APPR1:AS       36      8      135  0.77  0.83  488.21  486.39     950  487.44
         60     37     46     7288  1.00  1.42    0.00    0.66    7.05

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.004  0.064    6808.     5.    38.   486.83

   FIRST USER DEFINED TABLE.

     XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXIT1:XS      -41.     9.    45.    950.    5778.     114.    8.36  483.34
    FULLV:FV        0.     7.    46.    950.    7684.     140.    6.79  484.53
    BRIDG:BR        0.    12.    45.    950.    5458.      98.    9.74  484.49
    APPR1:AS       60.     8.    46.    950.    7288.     135.    7.05  487.44

     XSID:CODE   XLKQ   XRKQ       KQ
    APPR1:AS       5.    38.    6808.

  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
    EXIT1:XS    482.95    0.83  479.27  508.34************  1.09  484.42  483.34
    FULLV:FV  ********    0.64  479.76  508.83  0.83  0.00  0.72  485.25  484.53
    BRIDG:BR    484.49    1.00  479.79  491.83************  1.47  485.97  484.49
    APPR1:AS    486.39    0.66  481.60  509.68  0.83  1.42  0.77  488.21  487.44
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File danv008.wsp
        Hydraulic analysis for structure DANVTH00020008   Date: 18-SEP-96
        Bridge #8 over Morrill Brook in Danville, VT by MAI
           *** RUN DATE & TIME: 02-10-97  16:23

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

EXIT1:XS   ******      6      148  1.30 *****  485.53  483.74    1350  484.23
       -40 ******     47     8213  1.00 ***** *******    0.85    9.15

FULLV:FV       41      3      182  0.86  0.85  486.36 *******    1350  485.51
         0     41     49    10723  1.00  0.00   -0.02    0.66    7.42
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPR1":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     1.29     486.62     487.26

 ===110 WSEL NOT FOUND AT SECID "APPR1":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   485.01     509.68    0.50

 ===115 WSEL NOT FOUND AT SECID "APPR1":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   485.01     509.68     487.26

 ===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 "APPR1"
                   WSBEG,WSEND,CRWS =   487.26     509.68     487.26

APPR1:AS       60      9      128  1.73 *****  488.99  487.26    1350  487.26
        60     60     46     6801  1.00 ***** *******    1.00   10.54
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    1350.     485.35

            <<<<<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       41     11      127  1.76 *****  487.10  485.35    1350  485.35
         0     41     47     7950  1.00 ***** *******    1.00   10.63

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  1.000 ******  491.25 ****** ****** ******

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

APPR1:AS       36      6      166  1.03  0.86  489.25  487.26    1350  488.22
        60     36     48     9682  1.00  1.29    0.01    0.72    8.13

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.020  0.013    9525.     4.    40.   487.52


  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD     LEW     REW       Q        K      AREA     VEL    WSEL
   EXIT1:XS      -41.      6.     47.   1350.    8213.     148.     9.15  484.23
   FULLV:FV        0.      3.     49.   1350.   10723.     182.     7.42  485.51
   BRIDG:BR        0.     11.     47.   1350.    7950.     127.    10.63  485.35
   APPR1:AS       60.      6.     48.   1350.    9682.     166.     8.13  488.22

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS       4.    40.    9525.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT1:XS    483.74    0.85  479.27  508.34************  1.30  485.53  484.23
   FULLV:FV  ********    0.66  479.76  508.83  0.85  0.00  0.86  486.36  485.51
   BRIDG:BR    485.35    1.00  479.79  491.83************  1.76  487.10  485.35
   APPR1:AS    487.26    0.72  481.60  509.68  0.86  1.29  1.03  489.25  488.22
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure DANVTH00020008, in Danville, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number DANVTH00020008

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 24 / 95

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

County *(FIPS county code; I - 3; nnn)* 005

Town *(FIPS place code; I - 4; nnnnn)* 17125

Mile marker *(I - 11; nnn.nnn)* 006720

Waterway *(I - 6)* MORRILL BROOK

Road Name *(I - 7):* TH002

Route Number FAS215

Vicinity *(I - 9)* 3.6 MI N JCT. U.S.2 W

Topographic Map St.Johnsbury

Hydrologic Unit Code: 01080102

Latitude *(I - 16; nnnn.n)* 44274

Longitude *(i - 17; nnnnn.n)* 72074

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20021500080303

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

Maximum span length *(I - 48; nnnn)* 0057

Year built *(I - 27; YYYY)* 1935

Structure length *(I - 49; nnnnnn)* 000059

Average daily traffic, ADT *(I - 29; nnnnnn)* 000400

Deck Width *(I - 52; nn.n)* 234

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

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

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

Waterway adequacy *(I - 71; n)* 3

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 008.0

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

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

Comments:

The structural inspection report of 6/10/94 indicates the structure is a steel stringer type bridge with a concrete deck. The abutment walls are concrete. The right abutment wall has some shrinkage cracks and light scaling reported. The left abutment wall has a full-height settlement crack noted, which extends down into but not through the exposed concrete footing. The wingwalls are concrete and have some minor spalling and shrinkage cracks reported overall. The footings on both abutments are exposed partially. The footings appear to be in good condition. Both abutment walls are protected with stone fill. The waterway is noted as making a moderate bend into the crossing. **(Continued, page 31)**

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:

The channel consists of mainly stone and gravel. The old abutments for the original crossing remain approximately 30 feet upstream from this bridge. No apparent channel scour problems are reported. Bank erosion and debris accumulation problems are noted as not evident.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **4.735** mi^2

Lake and pond area **0** mi^2

Watershed storage *(ST)* **0** %

Bridge site elevation **1168** ft

Headwater elevation **2068** ft

Main channel length **3.308** mi

10% channel length elevation **1237** ft

85% channel length elevation **1795** ft

Main channel slope *(S)* **224.9** 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:

NO BENCHMARK INFORMATION

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:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 02/26/96
Computerized by: EW Date: 02/26/96
Reviewd by: MAL Date: 12/5/96

Structure Number DANVTH00020008

A. General Location Descriptive

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

2. Highway District Number 7 Mile marker 006720

County CALEDONIA (005) Town DANVILLE (17125)

Waterway *(I - 6)* MORRILL BROOK Road Name FAS 215

Route Number TH2 Hydrologic Unit Code: 01080102

3. Descriptive comments:

ON FAS 215, 3.6 MILES NORTH OF JUNCTION WITH US 2 WEST

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 4 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 2 UB 2 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 69.0 *(feet)* Span length 57.0 *(feet)* Bridge width 23.4 *(feet)*

Road approach to bridge:

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

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

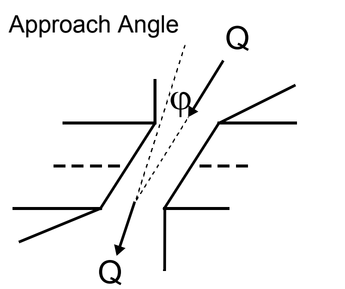
10. Embankment slope (*run / rise in feet / foot*):
US left 2.9:1 US right 2.4:1

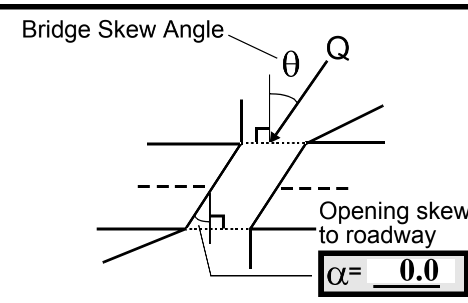
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	0			
RBUS	0			
RBDS	2	1	0	-
LBDS	2	1	0	-

*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: 10 16. Bridge skew: 5





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 3
Range? 150 feet US *(US, UB, DS)* to 20 feet US

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: 3

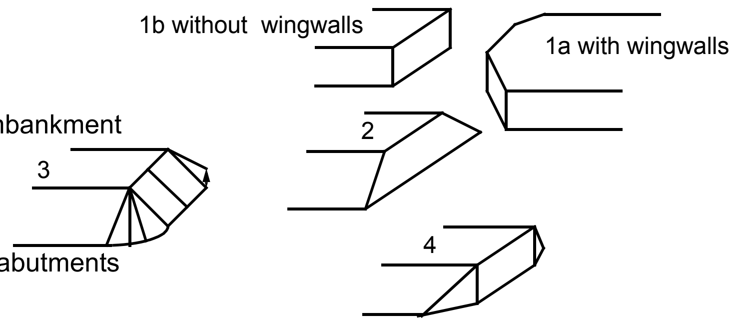
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

#4:There is a residence on the upstream right bank at the inside bend of the channel. On the left downstream overbank is a cleared access area/parking area leading to house set in woods.
#7: The values are from the Vermont Agency of Transportation (VTAOT). The measured span length was 55 feet.
#8: The left bank road approach is level for 20 feet then rises higher than bridge
#11: There was no protection alongside the road. However, where runoff goes over the bank, there are large boulders (<36 inches) protecting the bank from road wash (runoff).
#17: The stream makes a severe bend at least 150 feet US from bridge, impact zone and cut-bank extend beyond 150 feet US
#18: The concrete abutments are set back with sloping banks composed of cobbles and boulders which have been placed.

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
60.5	6.5			6.5	4	2	5	5	2	1

23. Bank width 30.0 24. Channel width 25.0 25. Thalweg depth 49.5 29. Bed Material 435

30 .Bank protection type: LB 3 RB 3 31. Bank protection condition: LB 2 RB 1

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.):

Old bridge abutments (granite blocks) form bank protection US. Blocks on the LB protect the old LB abutment. Pieces of the old abutment are missing or moved, as is the old abutment protection.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 55 35. Mid-bar width: 15

36. Point bar extent: 100 feet US (US, UB) to 20 feet US (US, UB, DS) positioned 30 %LB to 100 %RB

37. Material: 45

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

Inside of major bend in stream.

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: 70 42. Cut bank extent: 150 feet US (US, UB) to 20 feet US (US, UB, DS)

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

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

#43: There are many roots exposed and trees leaning over channel. However, no large trees or bank material lie in the channel from the August 5/6, 1995 peak (which was up to the base of larger trees). Evidence of slumping prior to August 1995 does exist, therefore the 1/2 rating.

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 140 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):

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
25.5		1.5		2	7	7	0

58. Bank width (BF) 7.0 59. Channel width (Amb) 6.5 60. Thalweg depth (Amb) 25.0 63. Bed Material 0

*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.):

453

#55: There is an abundance of cobbles and boulders that exist in the area between the abutment and stream channel.

#61: The abutment wall material is concrete and the steep bank sides under the bridge are cobble and boulder.

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

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

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

70. Debris and Ice Comments:

1

There was small debris caught in the rock/ boulders.

There were large piles of debris about 140 feet DS.

There was no evidence of debris capture at the bridge or US of the old abutments.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	1	0	-	-	30.0
RABUT	1	0	90			1	0	43.0

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

#72: The spill-through abutment protection slopes are 20 degrees on the left abutment and 30 degrees on the right abutment.

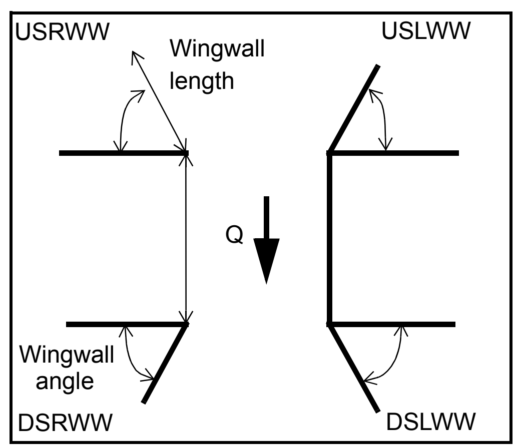
#75 and #76: The footing of the vertical concrete abutments on the left and right banks are visible. The left bank top of footing is visible. The right bank footing is exposed a depth of 1.5 feet.

#77: The abutments are concrete, however cobble and boulder material forms the spill-through abutments.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						15.5	
USRWW:	N		-		-	0.5	
DSLWW:	-		-		N	24.0	
DSRWW:	-		-		-	24.5	

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



82. Bank / Bridge Protection:

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

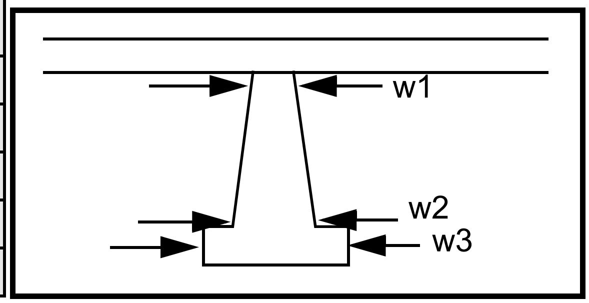
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? #80 *(Y or if N type ctrl-n pr)*

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



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	: The	clas-	ever	mod-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	wing	sifies	the	eling	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	walls	the	exte	pur-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	were	abut	nt of	pose	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	sur-	ment	the	s the	*Y- yes; N- no*
91. Attack ∠ (BF)	veye	as	“win	abut	
92. Pushed	d	one	gwal	ment	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	and	with	ls” is	s	
95. Cross-members	his-	wing	abou	have	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	tori-	walls	t two	been	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	cal	,	feet-	clas-	
98. Exposure depth	form	how-	for	sifie	

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

d as a type 3 with no wingwalls

#82: There is some left and right bank abutment protection on the US and DS ends.

N

E. Downstream Channel Assessment

100.

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

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

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

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

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

-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

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

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

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

-
-
-
-
-
-

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

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

Material: -____

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

-
-
-
-

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

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

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

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

Is channel scour present? _____ (Y or if N type ctrl-n cs) Mid-scour distance: 3______

Scour dimensions: Length 3_____ Width 45_____ Depth: 45____ Positioned 1____ %LB to 1____ %RB

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

453
0
0
-

Are there major confluences? -____ (Y or if N type ctrl-n mc) How many? #100

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

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

Confluence comments (eg. confluence name):

tion is a buried rock wall approximately 80 feet DS

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

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

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

N

109. G. Plan View Sketch

-

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

```
Structure Number: DANVTH00020008            Town:    Danville
Road Number:      TH 2                      County:  Calendonia
Stream:           Morrill Brook

Initials MAI      Date:    11/06/96 Checked: RHF

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              950      1350     0
  Main Channel Area, ft2            134.7    165.9    0
  Left overbank area, ft2           0        0        0
  Right overbank area, ft2          0        0        0
  Top width main channel, ft        38       42       0
  Top width L overbank, ft          0        0        0
  Top width R overbank, ft          0        0        0
  D50 of channel, ft                0.220    0.220    0
  D50 left overbank, ft             0        0        0
  D50 right overbank, ft            0        0        0

y1, average depth, MC, ft             3.5      4.0    ERR
y1, average depth, LOB, ft          ERR      ERR      ERR
y1, average depth, ROB, ft          ERR      ERR      ERR

  Total conveyance, approach        7284     9677     0
  Conveyance, main channel          7284     9677     0
  Conveyance, LOB                   0        0        0
  Conveyance, ROB                   0        0        0
  Percent discrepancy, conveyance   0.0000   0.0000   ERR
  Qm, discharge, MC, cfs            950.0    1350.0   ERR
  Ql, discharge, LOB, cfs           0.0      0.0      ERR
  Qr, discharge, ROB, cfs           0.0      0.0      ERR

Vm, mean velocity MC, ft/s          7.1      8.1      ERR
Vl, mean velocity, LOB, ft/s        ERR      ERR      ERR
Vr, mean velocity, ROB, ft/s        ERR      ERR      ERR
Vc-m, crit. velocity, MC, ft/s        8.4      8.5    N/A
Vc-l, crit. velocity, LOB, ft/s     N/A      N/A      N/A
Vc-r, crit. velocity, ROB, ft/s     N/A      N/A      N/A

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?
  Main Channel                      0        0        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	134.7	165.9	0
Main channel width, ft	38	42	0
y1, main channel depth, ft	3.54	3.95	ERR

Bridge Section			
(Q) total discharge, cfs	950	1350	0
(Q) discharge thru bridge, cfs	950	1350	
Main channel conveyance	5450	7964	
Total conveyance	5450	7964	
Q2, bridge MC discharge,cfs	950	1350	ERR
Main channel area, ft2	98	127	0
Main channel width (skewed), ft	23.3	27.2	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	23.3	27.2	0
y_bridge (avg. depth at br.), ft	4.18	4.68	ERR
Dm, median (1.25*D50), ft	0.275	0.275	0
y2, depth in contraction,ft	4.30	5.09	ERR
ys, scour depth (y2-ybridge), ft	0.11	0.41	N/A

ARMORING			
D90	1.027	1.027	
D95	1.32	1.32	
Critical grain size,Dc, ft	0.6270	0.7034	ERR
Decimal-percent coarser than Dc	0.1813	0.203	
Depth to armoring,ft	8.49	8.29	ERR

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	950	1350	0	950	1350	0
a', abut.length blocking flow, ft	10.1	9.5	0	4.7	5.3	0
Ae, area of blocked flow ft2	36.2	26.7	0	7.9	9.9	0
Qe, discharge blocked abut.,cfs	232.8	150.6	0	31.9	46.5	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	6.43	5.64	ERR	4.04	4.70	ERR
ya, depth of f/p flow, ft	3.58	2.81	ERR	1.68	1.87	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0	0.55	0.55	0
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	0	90	90	0
K2	1.00	1.00	0.00	1.00	1.00	0.00
Fr, froude number f/p flow	0.599	0.593	ERR	0.549	0.606	ERR
ys, scour depth, ft	8.69	7.12	N/A	3.95	4.56	N/A

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)	10.1	9.5	0	4.7	5.3	0
y1 (depth f/p flow, ft)	3.58	2.81	ERR	1.68	1.87	ERR
a'/y1	2.82	3.38	ERR	2.80	2.84	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.60	0.59	N/A	0.55	0.61	N/A
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	Q100	Q500	Qother
Fr, Froude Number	1	1		1	1	
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	4.18	4.68		4.18	4.68	
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	1.75	1.96	ERR	1.75	1.96	ERR
Fr<=0.8 (spillthrough abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (spillthrough abut.)	1.55	1.73	ERR	1.55	1.73	ERR