LEVEL II SCOUR ANALYSIS FOR BRIDGE 15 (BRIDTH00220015) on TOWN HIGHWAY 22, crossing DAILEY HOLLOW BRANCH, BRIDGEWATER, VERMONT

U.S. Geological Survey
Open-File Report 96-403

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

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By SCOTT A. OLSON

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Pembroke, New Hampshire

1996

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

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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 15 (BRIDTH00220015) ON TOWN HIGHWAY 22, CROSSING DAILEY HOLLOW BRANCH, BRIDGEWATER, VERMONT

***By* Scott A. Olson**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BRIDTH00220015 on town highway 22 crossing Dailey Hollow Branch, Bridgewater, 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 of central Vermont in the town of Bridgewater. The 1.73-mi^2 drainage area is a predominantly rural and forested basin. In the vicinity of the study site, the left and right banks have dense tree cover. The upstream right bank of Dailey Hollow Branch is adjacent to town highway 22.

In the study area, Dailey Hollow Branch has a sinuous channel with a slope of approximately 0.035 ft/ft, an average channel top width of 30 ft and an average channel depth of 4 ft. The predominant channel bed material is cobble with a median grain size (D_{50}) of 108 mm (0.354 ft). The geomorphic assessment at the time of the Level I and Level II site visit on November 1 and 2, 1994, indicates that the reach is stable.

The town highway 22 crossing of Dailey Hollow Branch is a 22-ft-long, one-lane bridge consisting of one 22-ft. steel-beam span (Vermont Agency of Transportation, written communication, August 24, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. Type-1 stone fill (less than 12 inches diameter) protects the left abutment, but it’s condition was reported as eroded. Type-2 stone fill (less than 36 inches diameter) protects the upstream left wingwall; it’s condition was reported as slumping.The channel is skewed approximately 40 degrees to the opening while the opening-skew-to-roadway is 0 degrees. 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, 1993). 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 0.2 ft. with the worst-case contraction scour occurring at the 500-year discharge. Abutment scour ranged from 4.2 to 6.4 ft. The worst-case abutment scour also occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and others, 1993, 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, 1966
Photoinspected 1983

NORTH

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

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

LEVEL II SUMMARY

Structure Number BRIDTH00220015 ***Stream*** Dailey Hollow Branch

County Windsor ***Road*** TH22 ***District*** 4

Description of Bridge

Bridge length 26 ***ft*** ***Bridge width*** 15 ***ft*** ***Max span length*** 22 ***ft***

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

Abutment type vertical and concrete ***Embankment type*** sloping

Stone fill on abutment? yes, left ***Date of inspection*** 11/1-2/94

Description of stone fill Type-2, in slumped condition at the upstream left wingwall, eroded condition along the left bank upstream. Type-1, in eroded condition at the left abutment.

Abutments are concrete and the left abutment is noted as having an exposed footing with approximately 1 foot of scour.

Y

Is bridge skewed to flood flow according to Bridg ***survey?*** 40 ***Angle*** Y

e is located on a moderate bend in the channel. The left bank and abutment are impacted by flood flows.

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***
	11/1-2/94	0	0
Level I	11/1-2/94	-	-
Level II	Moderate		

Potential for debris

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

The bridge is located on a channel bend and a point bar exists on the right side of the bridge near the downstream face. November 1 and 2, 1994.

Description of the Geomorphic Setting

General topography The bridge is in a moderate relief valley with narrow flood plains.

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

Date of inspection 11/1-2/94

DS left: narrow flood plain to valley wall

DS right: steep valley wall

US left: narrow flood plain to valley wall

US right: narrow flood plain to valley wall

Description of the Channel

Average top width 30 ***ft*** ***Average depth*** 4 ***ft***

Predominant bed material cobble ***Bank material*** cobble

Narrow channel with slight sinuosity.

11/1-2/94

Vegetative co forested

DS left: forested

DS right: forested

US left: forested with town highway 22 adjacent to channel

US right: N

Do banks appear stable? November 1 and 2, 1994--The upstream left bank is experiencing heavy fluvial erosion and a cut bank has formed. Downstream left bank is eroded heavily near the downstream left wingwall. The downstream right bank is reported to have heavy fluvial erosion 40 ft. downstream from the bridge.

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

Describe any obstructions in channel and date of observation. November 1 and 2, 1994--Point bars upstream and downstream of the bridge may obstruct flow to a small degree.

Hydrology

Drainage area 1.73 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None. Area is mostly forested high-elevation headwater drainage.

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 670 ***ft³/s*** ***Q500*** 880 ***ft³/s***

Q100 and Q500 determined by drainage area relationship with Bridgewater bridge 30 [(1.7/7.5)to the 0.7 power]. The drainage area of bridge 30 is 7.5 square miles. The 100-year discharge at bridge 30 (1,900 cubic feet per second) was from the VTAOT database (written communication, 5/4/95). The 500-year discharge at bridge 30 (2,500 cubic feet per second) was estimated from applicable empirical methods (Talbot, 1887; Potter, 1957a; Potter, 1957b; Johnson and Laraway, 1971,written communication; Johnson and Tasker, 1974; Federal Highway Administration, 1983).

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" at the upstream left bridge seat (elev. 499.66 feet, arbitrary survey datum). RM2 is a chiseled "X" on the downstream end of the right abutment (elev. 500.60 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	-33	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	7	1	Road Grade section
APPRO	45	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 0.060 to 0.065, and overbank "n" values ranged from 0.055 to 0.100.

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 0.035 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1966).

The approach section was surveyed approximately 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 500-year discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for the 500-year discharge. Analyzing both the supercritical and subcritical profiles, it can be determined that the water surface does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge is a satifactory solution. In addition, the 500-year discharge model had a froude number of 1.00 at the exit section. It was determined that normal depth was equal to critical depth and thus the critical water surface was allowed.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.0 *ft*
Average low steel elevation 499.6 *ft*

100-year discharge 670 *ft³/s*
Water-surface elevation in bridge opening 496.4 *ft*
Road overtopping? N *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 69.2 *ft²*
Average velocity in bridge opening 9.7 *ft/s*
Maximum WSPRO tube velocity at bridge 11.8 *ft/s*

Water-surface elevation at Approach section with bridge 498.7
Water-surface elevation at Approach section without bridge 498.1
Amount of backwater caused by bridge 0.6 *ft*

500-year discharge 880 *ft³/s*
Water-surface elevation in bridge opening 496.9 *ft*
Road overtopping? N *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 79.7 *ft²*
Average velocity in bridge opening 11.1 *ft/s*
Maximum WSPRO tube velocity at bridge 13.7 *ft/s*

Water-surface elevation at Approach section with bridge 499.8
Water-surface elevation at Approach section without bridge 498.6
Amount of backwater caused by bridge 1.2

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, 1993). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1993, p. 35, equation 18). For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. Streambed armoring depths computed suggest that contraction scour will not be limited by armoring.

Abutment scour was computed by use of the Froehlich equation (Richardson and others, 1993, p. 49, equation 24). 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	0.2	--
Depth to armoring	8.0	16.0	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	6.1	6.4	--
Right abutment	4.2	5.2	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	1.4	1.6	--
Right abutment	1.4	1.6	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

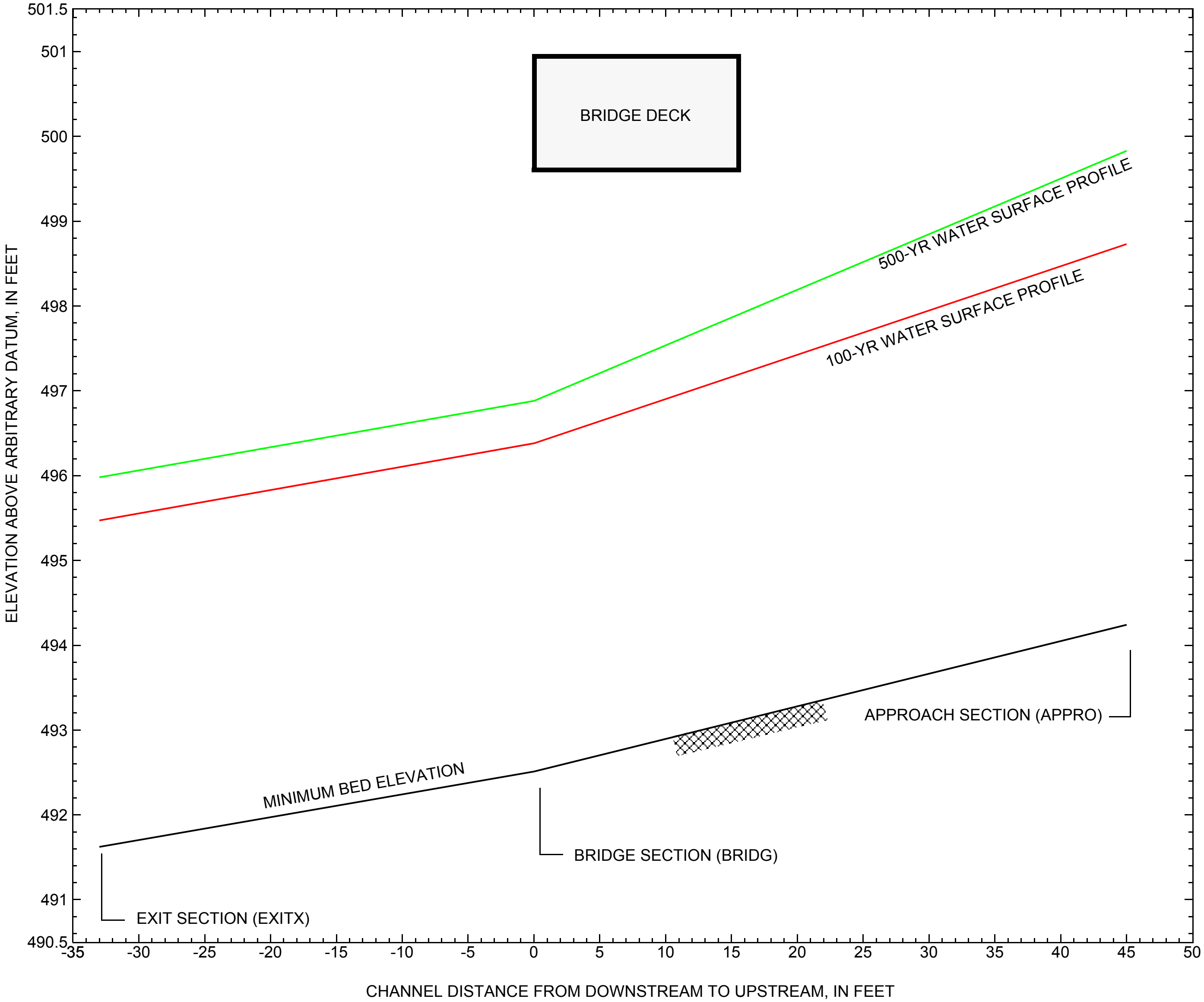

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BRIDTH00220015 on town highway 22, crossing Dailey Hollow Branch, Bridgewater, Vermont.

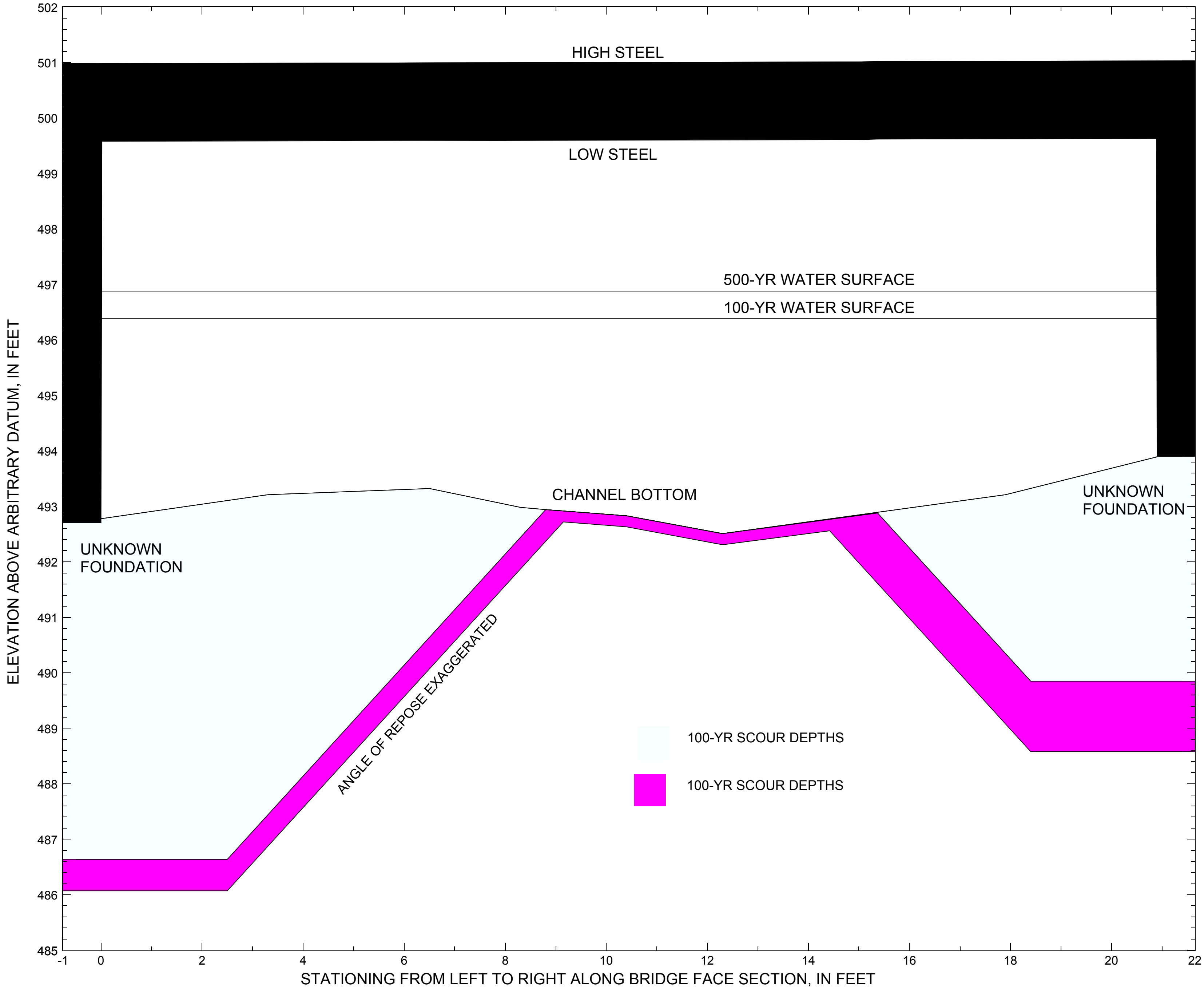

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BRIDTH00220015 on town highway 22, crossing Dailey Hollow Branch, Bridgewater, Vermont.

0.2

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BRIDTH00220015 on Town Highway 22, crossing Dailey Hollow Branch, Bridgewater, 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 670 cubic-feet per second											
Left abutment	0.0	--	499.6	--	492.7	0.0	6.1	--	6.1	486.6	--
Right abutment	20.9	--	499.6	--	494.0	0.0	4.2	--	4.2	489.8	--

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 BRIDTH00220015 on Town Highway 22, crossing Dailey Hollow Branch, Bridgewater, 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 880 cubic-feet per second											
Left abutment	0.0	--	499.6	--	492.7	0.2	6.4	--	6.6	486.1	--
Right abutment	20.9	--	499.6	--	494.0	0.2	5.2	--	5.4	488.6	--

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, Plymouth, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1983, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid015.wsp
T2        CREATED ON 02-MAY-95 FOR BRIDGE BRIDTH00220015 USING FILE brid015.dca
T3        Dailey Hollow Branch, Town Highway 22, Town of Bridgewater
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           670 880
SK          0.035 0.035
*
XS   EXITX    -33
GR         -131.3, 504.94   -121.7, 499.48    -86.1, 499.10    -73.5, 499.09
GR          -48.8, 498.36    -27.1, 497.45    -18.0, 496.06     -6.5, 495.11
GR            0.0, 492.39      2.7, 492.37      4.1, 491.62      6.3, 491.79
GR            9.7, 492.09     16.2, 492.01     19.2, 492.27     23.3, 496.73
GR           37.0, 505.55
N            0.100       0.065
SA                 -6.5
*
XS   FULLV      0 * * * 0.030
*
BR   BRIDG   0 499.6
GR            0.0, 499.58      0.1, 492.71      3.3, 493.21      6.5, 493.32
GR            8.3, 492.98     10.4, 492.83     12.3, 492.51     15.0, 492.83
GR           17.9, 493.21     20.9, 494.01     20.9, 499.60      0.0, 499.58
N            0.06
CD           1 21.4 * * 50 5.4
*
XR   RDWAY   7 15 2
GR         -124.0, 504.94   -114.4, 499.48    -78.8, 499.10    -66.2, 499.09
GR          -41.5, 498.36    -10.4, 500.81      0.0, 500.96     24.2, 501.05
GR           40.5, 500.52     54.5, 499.76     77.7, 506.
*
AS   APPRO     45
GR          -40.9, 506.39    -31.5, 502.86    -25.4, 502.50     -5.0, 498.90
GR            0.0, 494.61      5.6, 494.24     12.4, 494.67     14.9, 495.05
GR           20.5, 496.79     25.4, 499.84     53.9, 500.01     70.4, 500.67
GR           79.8, 502.67     95.6, 512.04
N             0.065       0.055
SA                    25.4
*
HP 1 APPRO  498.73 1 498.73
HP 2 APPRO  498.73 * * 670
HP 1 BRIDG  496.38 1 496.38
HP 2 BRIDG  496.38 * * 670
*
HP 1 APPRO  499.83 1 499.83
HP 2 APPRO  499.83 * * 880
HP 1 BRIDG  496.88 1 496.88
HP 2 BRIDG  496.88 * * 880
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid015.wsp
        CREATED ON 02-MAY-95 FOR BRIDGE BRIDTH00220015 USING FILE brid015.dca
        Dailey Hollow Branch, Town Highway 22, Town of Bridgewater
           *** RUN DATE & TIME: 01-13-96  10:41
    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      45.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      92.    4333.    28.    31.                         932.
   498.73           92.    4333.    28.    31.  1.00    -5.    24.    932.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      45.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.73    -4.8    23.6    91.5    4333.     670.   7.32
X STA.        -4.8         -0.5        0.7         1.8         2.8         3.7
  A(I)            7.9         5.1         4.4         4.1         4.1
  V(I)           4.25        6.58        7.64        8.13        8.26

X STA.         3.7         4.6         5.4         6.2         7.1         8.0
  A(I)            3.8         3.8         3.7         3.8         3.7
  V(I)           8.78        8.84        8.94        8.83        8.94

X STA.         8.0         8.9         9.7        10.7        11.7        12.6
  A(I)            3.8         3.8         3.9         4.1         4.0
  V(I)           8.73        8.85        8.56        8.26        8.33

X STA.        12.6        13.7        14.9        16.4        18.3        23.6
  A(I)            4.3         4.5         5.0         5.7         8.1
  V(I)           7.87        7.44        6.73        5.91        4.16

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      69.    3214.    21.    27.                         716.
   496.38           69.    3214.    21.    27.  1.00     0.    21.    716.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       496.38     0.0    20.9    69.2    3214.     670.   9.68
X STA.         0.0         1.8         3.0         4.1         5.2         6.2
  A(I)            6.1         4.0         3.5         3.4         3.2
  V(I)           5.45        8.48        9.65        9.76       10.34

X STA.         6.2         7.3         8.2         9.1        10.0        10.8
  A(I)            3.3         3.1         3.0         3.0         2.9
  V(I)          10.25       10.76       11.12       11.27       11.40

X STA.        10.8        11.6        12.3        13.1        13.9        14.7
  A(I)            2.9         2.8         2.9         2.9         3.0
  V(I)          11.52       11.85       11.72       11.57       11.28

X STA.        14.7        15.5        16.5        17.5        18.7        20.9
  A(I)            3.1         3.2         3.5         3.7         5.8
  V(I)          10.88       10.53        9.70        8.94        5.80

        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid015.wsp
        CREATED ON 02-MAY-95 FOR BRIDGE BRIDTH00220015 USING FILE brid015.dca
        Dailey Hollow Branch, Town Highway 22, Town of Bridgewater
           *** RUN DATE & TIME: 01-13-96  10:41

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      45.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     126.    6398.    36.    39.                        1350.
   499.83          126.    6398.    36.    39.  1.00   -10.    25.   1350.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      45.
         WSEL     LEW     REW    AREA        K        Q    VEL
       499.83   -10.3    25.4   126.4    6398.     880.   6.96
X STA.       -10.3         -0.9        0.6         1.9         3.0         4.0
  A(I)           13.3         7.9         6.5         6.0         5.6
  V(I)           3.32        5.59        6.77        7.31        7.89

X STA.         4.0         5.0         5.9         6.8         7.8         8.7
  A(I)            5.4         5.1         5.1         5.0         5.0
  V(I)           8.09        8.56        8.55        8.74        8.83

X STA.         8.7         9.6        10.6        11.5        12.5        13.6
  A(I)            5.1         5.0         5.2         5.2         5.2
  V(I)           8.70        8.80        8.49        8.51        8.40

X STA.        13.6        14.7        16.0        17.5        19.5        25.4
  A(I)            5.5         5.8         6.4         7.4        10.6
  V(I)           7.94        7.56        6.90        5.91        4.15
```

```
     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
      WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
              1      80.    3964.   21.    28.                        884.
    496.88           80.    3964.   21.    28.  1.00     0.    21.    884.

     VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
          WSEL     LEW     REW    AREA        K        Q    VEL
        496.88     0.0    20.9    79.7    3964.     880.  11.05
 X STA.         0.0        1.9        3.1        4.2        5.3        6.3
   A(I)            7.3        4.5        4.1        3.9        3.7
   V(I)            6.01       9.81      10.78      11.23      11.87

 X STA.         6.3        7.3        8.2        9.1       10.0       10.8
   A(I)            3.7        3.5        3.4        3.4        3.3
   V(I)           11.97      12.58      12.81      13.01      13.20

 X STA.        10.8       11.6       12.3       13.1       13.9       14.7
   A(I)            3.3        3.2        3.3        3.4        3.4
   V(I)           13.24      13.67      13.52      13.05      12.87

 X STA.        14.7       15.6       16.5       17.5       18.8       20.9
   A(I)            3.5        3.7        3.9        4.5        6.7
   V(I)           12.71      11.98      11.31       9.80       6.53

        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid015.wsp
         CREATED ON 02-MAY-95 FOR BRIDGE BRIDTH00220015 USING FILE brid015.dca
         Dailey Hollow Branch, Town Highway 22, Town of Bridgewater
            *** RUN DATE & TIME: 01-13-96  10:41
 +++ BEGINNING PROFILE CALCULATIONS --   2
  XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS      Q    WSEL
        SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

 EXITX:XS   ******   -11.      82.  1.05 *****  496.51  495.20    670.  495.47
       -33. ******    22.    3580.  1.02 ***** *******    0.92    8.14

  ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.85     496.65     496.19

  ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   494.97     506.54    0.50

  ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   494.97     506.54     496.19

 FULLV:FV      33.   -13.      89.  0.91  1.04  497.56  496.19    670.  496.65
         0.    33.    22.    3977.  1.03  0.00    0.01    0.85    7.54
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.97     498.08     498.01

  ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   496.15     512.04    0.50

  ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   496.15     512.04     498.01
APPRO:AS      45.    -4.      73.  1.30  1.61  499.37  498.01    670.  498.07
        45.    45.    23.    3155.  1.00  0.19    0.00    0.97    9.13
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   498.73       0.00     496.38     498.36

  ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

  ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   500.76         0.       670.

  ===280 REJECTED FLOW CLASS 4 SOLUTION.

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

  ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                        YU/Z,WSIU,WS = 1.03     499.78     499.95

  ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.

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

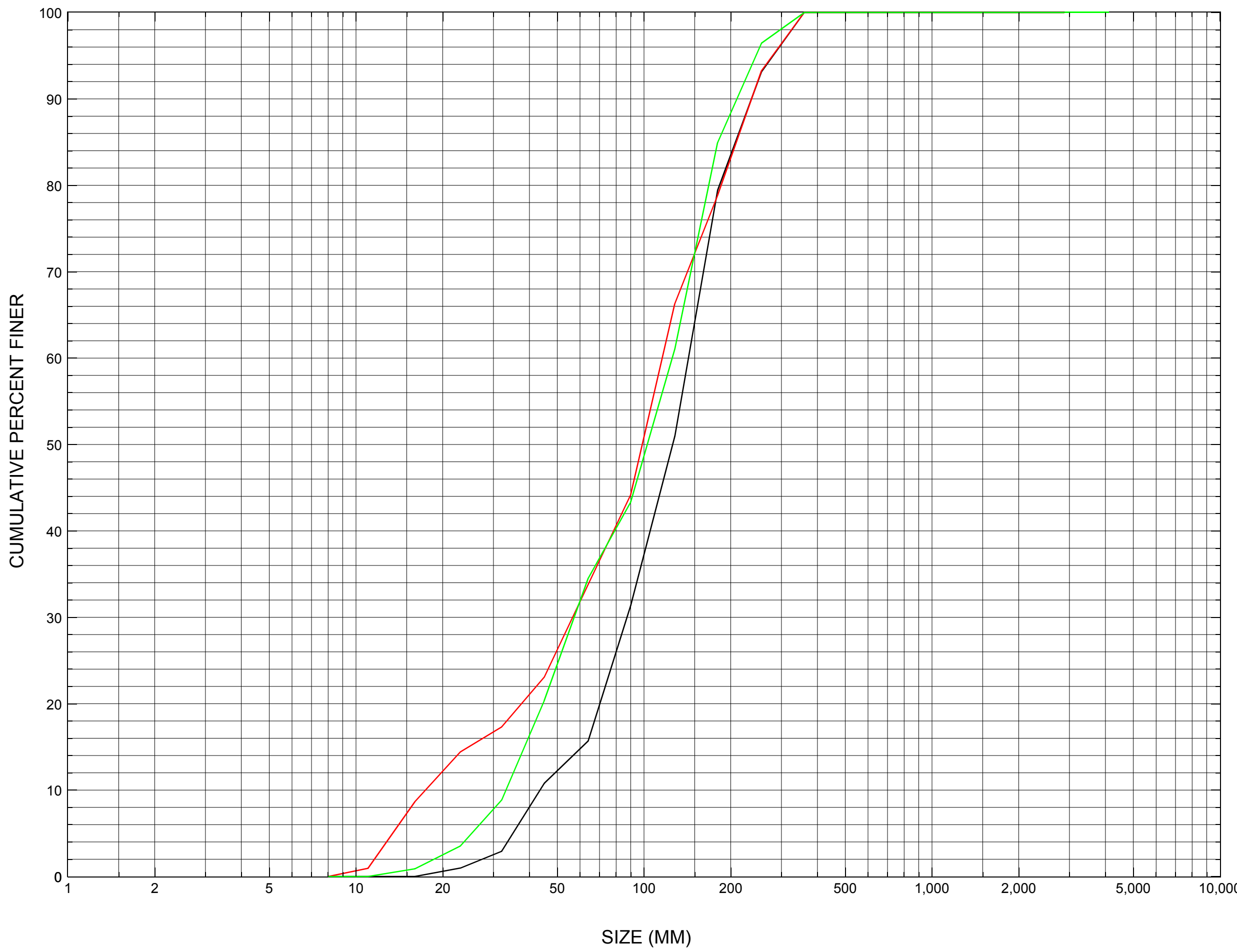
WSPRO OUTPUT FILE (continued)

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

BRIDG:BR      33.     0.      69.  1.45  1.29  497.84  492.71    670.  496.38
        0.    33.    21.    3217.  1.00  0.04    0.00    0.94    9.67

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  499.60 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
   RDWAY:RG       7.        <<<<<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      24.    -5.      92.  0.83  0.80  499.56  498.01    670.  498.73
       45.    25.    24.    4333.  1.00  0.93    0.00    0.72    7.32

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.216  0.000    4412.    -3.    18.   498.01

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

FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -33.   -11.    22.    670.    3580.      82.    8.14  495.47
   FULLV:FV       0.   -13.    22.    670.    3977.      89.    7.54  496.65
   BRIDG:BR       0.     0.    21.    670.    3217.      69.    9.67  496.38
   RDWAY:RG       7.**************      0.*********       0.    2.00********
   APPRO:AS      45.    -5.    24.    670.    4333.      92.    7.32  498.73

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -3.    18.    4412.

SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.20    0.92  491.62  505.55************  1.05  496.51  495.47
   FULLV:FV    496.19    0.85  492.61  506.54  1.04  0.00  0.91  497.56  496.65
   BRIDG:BR    492.71    0.94  492.51  499.60  1.29  0.04  1.45  497.84  496.38
   RDWAY:RG  ****************  498.36  506.00************  0.41  500.06********
   APPRO:AS    498.01    0.72  494.24  512.04  0.80  0.93  0.83  499.56  498.73

         U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid015.wsp
         CREATED ON 02-MAY-95 FOR BRIDGE BRIDTH00220015 USING FILE brid015.dca
         Dailey Hollow Branch, Town Highway 22, Town of Bridgewater
            *** RUN DATE & TIME: 01-13-96  10:41
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******   -17.     101.  1.26 *****  497.25  495.78    880.  495.98
      -33. ******    23.    4701.  1.07 ***** *******    1.00    8.71

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.90     497.21     496.77

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.48     506.54    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.48     506.54     496.77
FULLV:FV      33.   -19.     111.  1.08  1.03  498.29  496.77    880.  497.21
        0.    33.    23.    5261.  1.10  0.00    0.01    0.90    7.96
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.00     498.59     498.59

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.71     512.04    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.71     512.04     498.59
APPRO:AS      45.    -5.      88.  1.57  1.63  500.16  498.59    880.  498.59
       45.    45.    23.    4075.  1.00  0.24    0.00    1.00   10.04
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
```

```
 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   499.83       0.00     496.88     498.36

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   501.03         0.        880.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

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

 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                       YU/Z,WSIU,WS = 1.04     499.85     500.12

 ===270 REJECTED 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      33.     0.      80.  1.90  1.37  498.78  492.71    880.  496.88
        0.    33.    21.    3957.  1.00  0.08    0.00    1.00   11.06

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  499.60 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       7.        <<<<<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      24.   -10.     127.  0.75  0.75  500.59  498.59    880.  499.83
       45.    25.    25.    6406.  1.00  1.06    0.00    0.65    6.96

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.256  0.000    6733.    -3.    18.   499.27

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

FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -33.   -17.    23.    880.    4701.     101.    8.71  495.98
   FULLV:FV       0.   -19.    23.    880.    5261.     111.    7.96  497.21
   BRIDG:BR       0.     0.    21.    880.    3957.      80.   11.06  496.88
   RDWAY:RG       7.**************      0.*********       0.    2.00********
   APPRO:AS      45.   -10.    25.    880.    6406.     127.    6.96  499.83

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -3.    18.    6733.

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS     495.78    1.00  491.62  505.55************  1.26  497.25  495.98
   FULLV:FV     496.77    0.90  492.61  506.54  1.03  0.00  1.08  498.29  497.21
   BRIDG:BR     492.71    1.00  492.51  499.60  1.37  0.08  1.90  498.78  496.88
   RDWAY:RG  ****************  498.36  506.00************  0.63  500.30********
   APPRO:AS     498.59    0.65  494.24  512.04  0.75  1.06  0.75  500.59  499.83
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for three pebble count transects at the approach cross-section for structure BRIDTH00220015, in Bridgewater, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BRIDTH00220015

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 24 / 94

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

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

Town *(FIPS place code; I - 4; nnnnn)* 08275

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

Waterway *(I - 6)* DAILEY HOLLOW BRANCH

Road Name *(I - 7):* -

Route Number TH022

Vicinity *(I - 9)* 0.1 MI JCT TH 21 + TH 22

Topographic Map Delectable.Mtn

Hydrologic Unit Code: 01080106

Latitude *(I - 16; nnnn.n)* 43384

Longitude *(i - 17; nnnnn.n)* 72433

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10140500151405

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

Maximum span length *(I - 48; nnnn)* 0022

Year built *(I - 27; YYYY)* 1974

Structure length *(I - 49; nnnnnn)* 000026

Average daily traffic, ADT *(I - 29; nnnnnn)* 000001

Deck Width *(I - 52; nn.n)* 150

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

Channel & Protection *(I - 61; n)* 6

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

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

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 006.0

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

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

Comments:

Structural inspection report of 10/18/93 indicates a steel I-beam and timber deck type bridge with a gravel road approach surface. The abutments and wingwalls are reported in like new condition. The downstream end of the left abutment is exposed up to 1 foot above the tip of the streambed. The report indicates no undermining or settlement is apparent. Channel scour is localized at the downstream end of the left abutment. No embankment erosion or drift/vegetation buildup near the bridge. The channel was noted as making a moderate bend into bridge. Stone fill is reported as natural stone in fair condition. The report recommended additional riprap for along the left abutment.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: Coarse gravel and a few boulders

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} (*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)* **1.73** mi^2 Lake and pond area **0** mi^2

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

Bridge site elevation **1560** ft Headwater elevation **2580** ft

Main channel length **2.314** mi

10% channel length elevation **1600** ft 85% channel length elevation **2240** ft

Main channel slope *(S)* **368.77** 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: **DLS** Date: **02/02/95**
Computerized by: **MAW** Date: **03/09/95**
Reviewd by: **JDA** Date: **1/13/96**

Structure Number **BRIDTH00220015**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **J**. **AYOTTE** Date *(MM/DD/YY)* **11** / **01** / 19**94**

2. Highway District Number **04** Mile marker **000000**

County **027** Town **BRIDGEWATER**

Waterway *(I - 6)* **DAILEY HOLLOW BRANCH** Road Name **-**

Route Number **TH022** Hydrologic Unit Code: **01080106**

3. Descriptive comments:

The bridge is 0.1 miles from the junction of TH021 and TH022.

B. Bridge Deck Observations

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

5. Ambient water surface... US **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 **26** *(feet)* Span length **22** *(feet)* Bridge width **15** *(feet)*

Road approach to bridge:

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

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

10. Embankment slope (*run / rise in feet / foot*):
US left **0.0:1** US right **0.0:1**

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

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

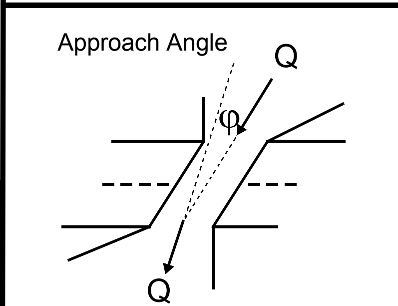
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

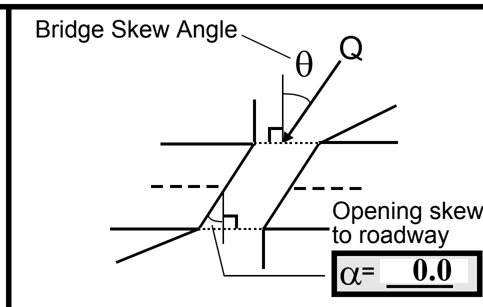
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

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

Channel approach to bridge (BF):

15. Angle of approach: **30** 16. Bridge skew: **40**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **3**
Range? **35** feet **US** *(US, UB, DS)* to **5** feet **DS**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **30** feet **DS** *(US, UB, DS)* to **50** feet **DS**

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

18. Level II Bridge Type: **1a**

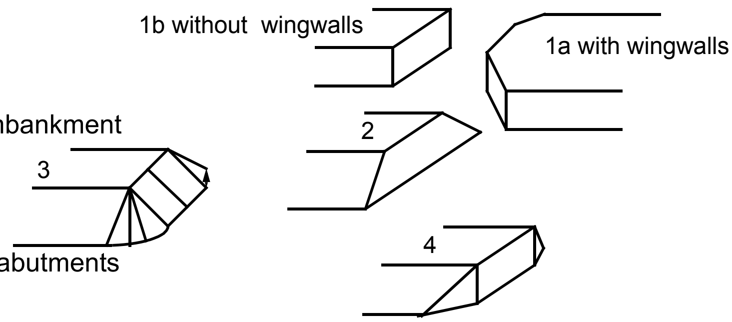
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

Measured bridge dimensions: bridge length=27 ft.; span length=21 ft.; roadway width=15 ft. The surface cover is all forest but the upstream right bank has a dirt road which parallels the stream. The left bank approach to the bridge is severely eroded and some protective measures have been taken (for lower regime high flows). Deck has recently been replaced, some rails and posts are missing.

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
44.8	**4.5**			**5.0**	**4**	**4**	**4**	**4**	**3**	**0**

23. Bank width **40.0** 24. Channel width **25.0** 25. Thalweg depth **30.5** 29. Bed Material **4**

30 .Bank protection type: LB **2** RB **0** 31. Bank protection condition: LB **3** 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.):

The left bank is protected only for low flows. The upstream left channel has a 20 ft. dry wall at the annual flood level which starts 30 ft. upstream of the bridge. The left bank near the bridge is severely eroded, even behind the upstream left wingwall and has, in the past, impacted the left road approach. The channel is not protected and flood flows would utilize the eroded channel. Small woody vegetation (birch) is present on the eroded area (5 year old growth). Natural material is piled in the channel at the upstream left abutment and upstream left wingwall (mostly cobbles). It looks like a point bar but appears to be placed.

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

36. Point bar extent: 10 feet US (US, UB) to 50 feet US (US, UB, DS) positioned 60 %LB to 100 %RB

37. Material: 4

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

Another feature close to the upstream left wingwall and left abutment looks like a point bar but historical records and visual inspection indicate that it is very likely placed material.

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: 15 42. Cut bank extent: 0 feet US (US, UB) to 40 feet US (US, UB, DS)

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

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

The cut-bank is extensive along the left bank and is also double tiered. There is an active cut-bank at the annual flood level and an older cut-bank at a higher flood level. The older cut-bank would convey flood flows over the left road approach and erode behind the left abutment.

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 30

47. Scour dimensions: Length 5 Width 5 Depth : 0.5 Position 10 %LB to 20 %RB

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

Scour is minimal but present along the cut-bank area.

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
12.5		0.5		2	7	7	-

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

Bed and bank Material: 0- organics; 1- silt / clay, < 1/16mm; 2- sand, 1/16 - 2mm; 3- gravel, 2 - 64mm; 4- cobble, 64 - 256mm; 5- boulder, > 256mm; 6- bedrock; 7- manmade

Bank Erosion: 0- not evident; 1- light fluvial; 2- moderate fluvial; 3- heavy fluvial / mass wasting

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

4

Bank is not protected but the upstream left wingwall and left abutment are partially protected by placed material.

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

One log is in downstream bank area; still not significant.

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		**40**	**90**	**2**	**2**	**0**	**1.0**	**90.0**
RABUT	**1**	**-**	**90**			**2**	**0**	**21.0**

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.):

0

-

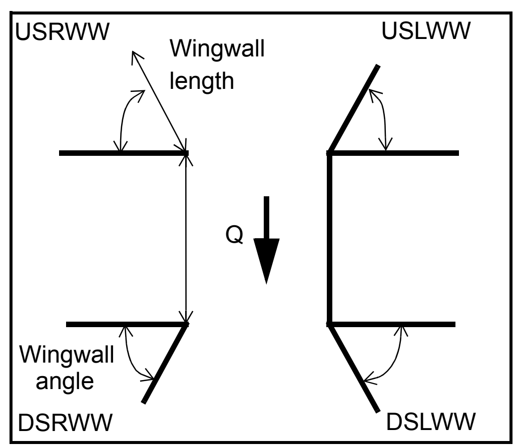
1

The downstream end of the left abutment and the downstream left wingwall are have footings exposed to a depth of about 1.0 ft. The upstream left wingwall has slight footing exposure. Ambient flow attacks the left abutment and downstream left wingwall junction.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**9.5**	
USRWW:	**Y**		**1**		**2**	**0.5**	
DSLWW:	**0**		**0**		**Y**	**14.0**	
DSRWW:	**1**		**0**		**0**	**15.0**	

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	**-**	**2**	**Y**	**0**	**2**	**-**	**3**	**-**
Condition	**Y**	**0**	**1**	**-**	**1**	**-**	**4**	**-**
Extent	**1**	**1.0**	**0**	**2**	**0**	**1**	**0**	**0**

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

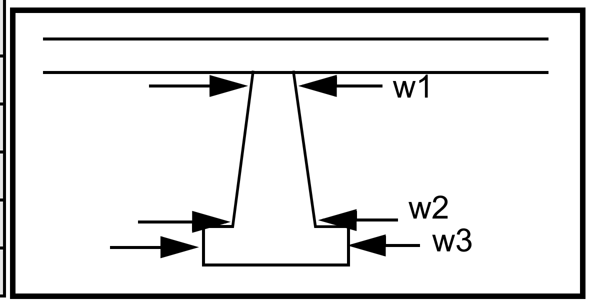
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
0
-
-
0
-
-
0
-
-

Piers:

84. Are there piers? **Un** (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				**55.0**	**12.0**	**45.0**
Pier 2	**5.5**	**6.0**	**5.5**	**50.0**	**45.0**	**-**
Pier 3	**-**	**-**	**-**	**-**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**der**	**cob-**	**left**	**the**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**brid**	**bles**	**abut**	**upst**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**ge,**	**whic**	**ment**	**ream**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**the**	**h**	**, but**	**brid**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**left**	**pro-**	**most**	**ge**	*Y- yes; N- no*
91. Attack ∠ (BF)	**abut**	**vide**	**ly**	**face.**	
92. Pushed	**ment**	**some**	**con-**		*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**has**	**pro-**	**strict**		
95. Cross-members	**“pla**	**tec-**	**s the**		***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**ced”**	**tion**	**flow**		***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**nat-**	**to**	**thro**		
98. Exposure depth	**ural**	**the**	**ugh**		

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

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. <u>Point/Side bar present?</u> - (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 NO %RB

Material: PI

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

ERS

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

Cut bank extent: _____ feet _____ (US, UB, DS) to _____ feet 4 (US, UB, DS)

Bank damage: 4 (**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)

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

4
4
3
3

<u>Is channel scour present?</u> 4 (Y or if N type ctrl-n cs) Mid-scour distance: 0

Scour dimensions: Length 0 Width - Depth: - Positioned The %LB to left %RB

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

bank is heavily eroded at the downstream left wingwall; material has slumped. The same condition exists locally along the left bank downstream; the right bank is severely eroded at the impact point about 40 ft. downstream. The bank is nearly vertical with large boulders and cobbles slumping into the channel near the toe of the slope.

<u>Are there major confluences?</u> _____ (Y or if N type ctrl-n mc) How many? _____

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. <u>Stage of reach evolution</u> _____

__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

-

NO DROP STRUCTURE

Y

10

5

0

DS

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 ANALYSIS

Structure Number: BRIDTH00220015		Town:	Bridgewater
Road Number: TH0022		County:	Windsor
Stream: Dailey Hollow Branch			
Initials SAO	Date: 9/21/95	Checked:	

Analysis of contraction scour, live-bed or clear water?

Neills Equation
Vc=11.52*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and others, 1993, p. 31, eq. 14)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	670	880	0
Main Channel Area, ft2	92	126	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	28	36	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.354	0.354	0
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	3.3	3.5	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	4333	6398	0
Conveyance, main channel	4333	6398	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyeance	0	0	ERR
Qm, discharge, MC, cfs	670	880	ERR
Ql, discharge, LOB, cfs	0	0	ERR
Qr, discharge, ROB, cfs	0	0	ERR
Vm, mean velocity MC, ft/s	7.3	7.0	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	9.9	10.0	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
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Clear Water Contraction Scour in MAIN CHANNEL

y2 = (Q2^2/(120*Dm^(2/3)*W2^2))^(3/7)
ys=y2-y_bridge or ys=y2-y1
(Richardson and others, 1993, p. 35, eq. 18, 19)

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	92	126	0
Main channel width, ft	28	36	0
y1, main channel depth, ft	3.285714	3.5	ERR

Bridge Section	Q100	Q500	Qother
(Q) total discharge, cfs	670	880	0
(Q) discharge thru bridge, cfs	670	880	0
Main channel conveyance	3214	3964	0
Total conveyance	3214	3964	0
Q2, bridge MC discharge,cfs	670	880	ERR
Main channel area, ft2	69	80	0
Main channel width (skewed), ft	20.9	20.9	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	20.9	20.9	0
y_bridge (avg. depth at br.), ft	3.301435	3.827751	ERR
Dm, median (1.25*D50), ft	0.4425	0.4425	0
y2, depth in contraction,ft	3.168734	4.002933	ERR
ys, scour depth (y2-ybridge), ft	-0.13	0.18	N/A
ys, scour depth (y2-y1), ft	-0.12	0.50	N/A

ARMORING	Q100	Q500	Qother
D90	0.747	0.747	
D95	0.873	0.873	
Critical grain size,Dc, ft	0.5976	0.7131	ERR
Percent coarser than Dc	0.184	0.118	
Depth to armoring,ft	7.95	15.99	ERR

Abutment Scour

Froehlich's Abutment Scour

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

(Richardson and others, 1993, p. 49, eq. 24)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	670	880	0	670	880	0
a', abut.length blocking flow, ft	4.8	10.3	0	2.7	4.5	0
Ae, area of blocked flow ft2	10	18	0	4.1	8.1	0
Qe, discharge blocked abut.,cfs	47.5	70.4	0	17.1	33.6	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve manually)						
Ve, (Qe/Ae), ft/s	4.75	3.911111	ERR	4.170732	4.148148	ERR
ya, depth of f/p flow, ft	2.08	1.75	ERR	1.52	1.80	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0	0.82	0.82	0
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	0	90	90	0
K2	1	1	0	1	1	0
Fr, froude number f/p flow	0.58	0.52	ERR	0.60	0.54	ERR
ys, scour depth, ft	6.07	6.44	N/A	4.16	5.23	N/A

HIRE equation (a'/ya > 25)

ys = 4*Fr^0.33*y1*K/0.55

(Richardson and others, 1993, p. 50, eq. 25)

a'(abut length blocked, ft)	4.8	10.3	0	2.7	4.5	0
y1 (depth fp flow, ft)	2.08	1.75	ERR	1.52	1.80	ERR
a'/y1	2.30	5.89	ERR	1.78	2.50	ERR
Froude no. f/p flow	0.58	0.52	N/A	0.60	0.54	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, 1993, p118-119, eq. 93,94)

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.94	1		0.94	1	
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	3.3	3.8		3.3	3.8	
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0
Fr>0.8 (vertical abut.)	1.36	1.59	ERR	1.36	1.59	ERR