LEVEL II SCOUR ANALYSIS FOR BRIDGE 5 (DUMMVT00300005) on STATE ROUTE 30, crossing STICKNEY BROOK, DUMMERSTON, VERMONT

U.S. Geological Survey
Open-File Report 97-627

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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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 5 (DUMMVT00300005) ON STATE ROUTE 30, CROSSING STICKNEY BROOK, DUMMERSTON, 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 DUMMVT00300005 on State Route 30 crossing Stickney Brook, Dummerston, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the New England Upland section of the New England physiographic province in southeastern Vermont. The 6.31-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest and brush.

In the study area, Stickney Brook has an incised, straight channel with a slope of approximately 0.04 ft/ft, an average channel top width of 80 ft and an average bank height of 7 ft. The channel bed material is predominantly cobble with a median grain size (D_{50}) of 80.3 mm (0.264 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 12, 1996, indicated that the reach was aggrading.

The State Route 30 crossing of Stickney Brook is a 84-ft-long, two-lane bridge consisting of one 82-foot steel-beam span (Vermont Agency of Transportation, written communication, March 30, 1995). The opening length of the structure parallel to the bridge face is 79.7 ft. The bridge is supported by vertical, concrete abutments with spill-through embankments. The channel is skewed approximately 5 degrees to the opening while the opening-skew-to-roadway is 0 degrees.

A scour hole 0.5 ft deeper than the mean thalweg depth was observed along the toe of the right spill-through slope during the Level I assessment. The scour protection measures at the site were type-2 stone fill (less than 36 inches diameter) along the left and right bank under the bridge forming a spill-through slope and type-2 stone fill from approximately 20 ft to 64 ft upstream on the right bank. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 0.2 ft. The worst-case contraction scour occurred at the 100-year discharge. Left abutment scour ranged from 5.5 to 6.3 ft. Right abutment scour ranged from 2.0 to 3.8 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled "Scour Results". Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives "excessively conservative estimates of scour depths" (Richardson and others, 1995, p. 47). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Newfane, VT. Quadrangle, 1:25,000, 1984

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 DUMMVT00300005 ***Stream*** Stickney Brook

County Windham ***Road*** VT 30 ***District*** 2

Description of Bridge

Bridge length 84 ***ft*** ***Bridge width*** 35.2 ***ft*** ***Max span length*** 82 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 8/12/96

Description of stone fill Type-2, along the left and right abutment and from 20 ft to 64 ft upstream on the right bank.

Brief description of piers/abutments Abutments are concrete with spill-through embankments. There is a half-foot deep scour hole at the toe of the right spill-through slope.

Yes

Is bridge skewed to flood flow according to There ***survey?*** 5 ***Angle*** No

If so, describe (mild, moderate, severe) is a mild channel bend in the upstream reach.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	8/12/96	0	0
Level II	8/12/96	0	0

Potential for debris High. There are trees leaning over the channel upstream and tree debris in the channel area near the bridge. Ice build up is evident from scarring on trees. There is a cut bank on the upstream right bank with exposed tree roots.

Describe any features near or at the bridge that may affect flow (include observation date) There was a mid-channel bar under the bridge extending into the downstream channel as of 8/12/96. There was also tree debris in the channel which will affect flow at lower flows.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with steep valley walls on both sides near the confluence with the West River.

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

Date of inspection 8/12/96

DS left: Steep channel bank to a narrow terrace.

DS right: Steep channel bank to a moderately sloped overbank.

US left: Steep valley wall.

US right: Steep channel bank to a moderately sloped overbank.

Description of the Channel

Average top width 80 ***ft*** ***Average depth*** 7.0 ***ft***

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

Straight channel with aggrading bed material, semi-alluvial channel boundaries and no flood plain.

8/12/96

Vegetative co Trees and brush.

DS left: Trees and brush.

DS right: Trees and brush.

US left: Trees and brush.

US right: No

Do banks appear stable? Moderate to heavy fluvial erosion along both banks with a cut bank along the upstream right bank.

date of observation.

The assessment of 8/12/96 noted a mid-channel bar under the bridge extending downstream. There was a tree in the channel under the bridge on 8/12/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 6.31 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: -

Is there a USGS gage on the stream of interest? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi***^{2}

Is there a lake/p ... No

-

-

Calculated Discharges

Q100 1,900 ***ft***^{3}***/s*** ***Q500*** 2,900 ***ft***^{3}***/s***

The 100- and 500-year discharges are based on a drainage area relationship [(6.30/6.31)exp 0.7] with bridge number 39 in Dummerston. Bridge number 39 crosses the Stickney Brook upstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 39 is 6.30 square miles. These values are within a range defined by several empirical flood frequency curves (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 Subtract 1 ft from the USGS arbitrary survey datum to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the right abutment (elev. 500.53 ft, arbitrary survey datum). RM2 is the center of a chiseled square on top of the upstream end of the left abutment (elev. 501.17 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-67	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	19	1	Road Grade section
APPRO	118	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 0.050 to 0.060, and overbank "n" values ranged from 0.065 to 0.080.

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 0.036 ft/ft which was calculated from the surveyed thalweg points downstream of the bridge. Stickney Brook enters the West River 180 feet downstream of the bridge forming a large deltaic deposit at low flows. Due to the steep downstream channel of Stickney Brook the effects of backwater from the West River were ignored.

The approach section (APPRO) was surveyed one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

For the 100-year and 500-year discharges, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. After analyzing both the supercritical and subcritical profiles for each discharge, it 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 500.4 ***ft***
Average low steel elevation 496.0 ***ft***

100-year discharge 1,900 ***ft^3/s***
Water-surface elevation in bridge opening 488.0 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft^3/s***
Area of flow in bridge opening 176 ***ft^2***
Average velocity in bridge opening 10.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.7 ***ft/s***

Water-surface elevation at Approach section with bridge 492.3
Water-surface elevation at Approach section without bridge 491.9
Amount of backwater caused by bridge 0.4 ***ft***

500-year discharge 2,900 ***ft^3/s***
Water-surface elevation in bridge opening 489.2 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft^3/s***
Area of flow in bridge opening 241 ***ft^2***
Average velocity in bridge opening 12.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.9 ***ft/s***

Water-surface elevation at Approach section with bridge 493.4
Water-surface elevation at Approach section without bridge 493.3
Amount of backwater caused by bridge 0.1 ***ft***

Incipient overtopping discharge -- ***ft^3/s***
Water-surface elevation in bridge opening -- ***ft***
Area of flow in bridge opening -- ***ft^2***
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 the live-bed contraction scour equation (Richardson and others, 1995, p. 30, equation 17). Results of this analysis are presented in figure 8 and tables 1 and 2. The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

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 depths were applied for the entire spill-through embankment below the elevation at the toe of each embankment and extended to the vertical concrete abutment wall, 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	0.2	0.0	--
Depth to armoring	15.1	18.6	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	5.5	6.3	--
Right abutment	2.0	3.8	--
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	1.3	1.7	--
Right abutment	1.3	1.7	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

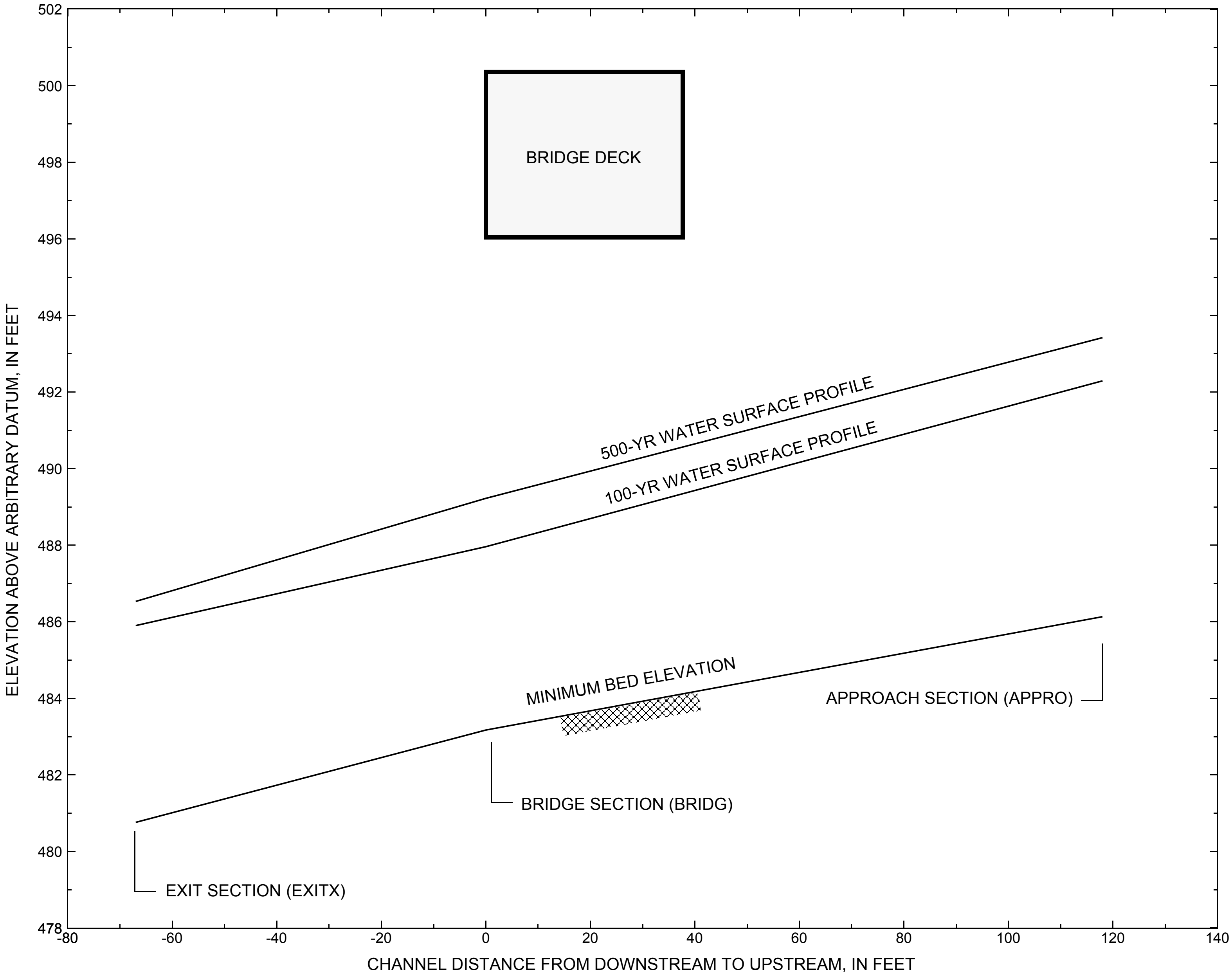

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure DUMMVT00300005 on State Route 30, crossing Stickney Brook, Dummerston, Vermont.

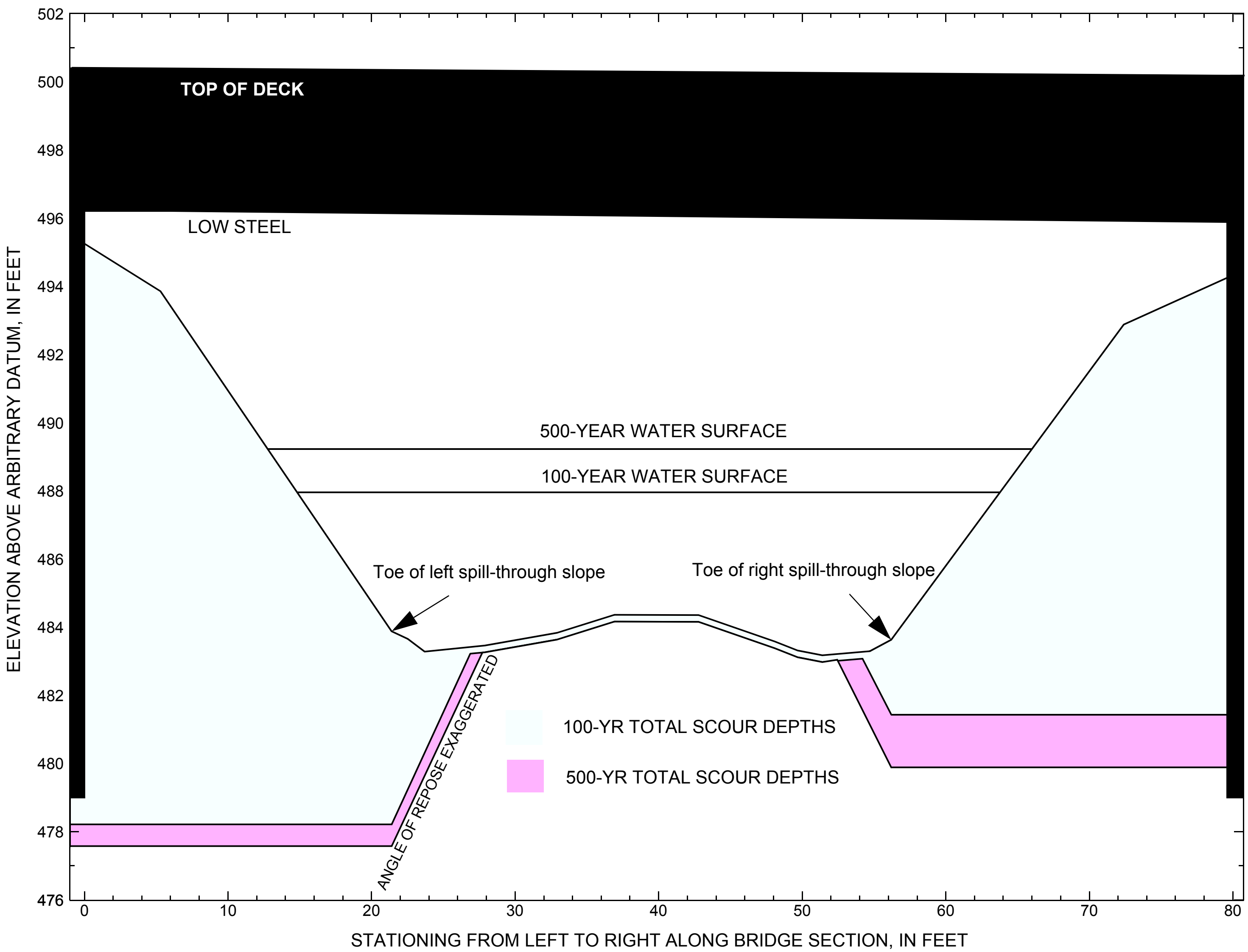

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure DUMMVT00300005 on State Route 30, crossing Stickney Brook, Dummerston, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure DUMMVT00300005 on State Route 30, crossing Stickney Brook, Dummerston, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,900 cubic-feet per second											
Left abutment	0.0	--	496.2	479.0	--	--	--	--	--	--	-0.8
Toe of left spill-through slope	21.4	--	--	--	483.9	0.2	5.5	--	5.7	478.2	--
Toe of right spill-through slope	56.2	--	--	--	483.6	0.2	2.0	--	2.2	481.4	--
Right abutment	79.7	--	495.9	479.0	--	--	--	--	--	--	2.4

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 DUMMVT00300005 on State Route 30, crossing Stickney Brook, Dummerston, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2,900 cubic-feet per second											
Left abutment	0.0	--	496.2	479.0	--	--	--	--	--	--	-1.4
Toe of left spill-through slope	21.4	--	--	--	483.9	0.0	6.3	--	6.3	477.6	--
Toe of right spill-through slope	56.2	--	--	--	483.6	0.0	3.8	--	3.8	479.8	--
Right abutment	79.7	--	495.9	479.0	--	--	--	--	--	--	0.8

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

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U.S. Geological Survey, 1984, Newfane, 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 dumm005.wsp
T2        Hydraulic analysis for structure DUMMVT00300005   Date: 05-FEB-97
T3        Bridge # 5 on VT 30 over Stickney Brook in Dummerston, 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           1900.0  2900.0
SK          0.0360   0.0360
*
XS   EXITX    -67
GR         -258.5, 514.72   -241.7, 502.10   -190.8, 501.61   -110.1, 500.89
GR          -66.2, 499.82    -27.3, 485.87      0.0, 484.24     15.6, 483.84
GR           20.9, 482.17     23.0, 481.82     30.6, 481.87     31.3, 482.00
GR           34.5, 482.43     38.0, 481.50     39.6, 481.25     40.5, 480.94
GR           42.7, 480.76     46.0, 481.20     55.2, 484.19     84.3, 484.89
GR           93.2, 490.47    123.8, 490.81    162.9, 491.92    184.2, 498.63
GR          260.5, 500.01    302.2, 499.67    375.9, 504.84
N           0.075        0.060        0.075
SA                 -27.3          93.2
*
XS   FULLV      0  * * *   0.0360
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    496.04       0.0
GR            0.0, 496.21      0.1, 495.25      5.3, 493.85     21.4, 483.88
GR           22.5, 483.66     23.7, 483.28     27.9, 483.46     32.9, 483.83
GR           36.9, 484.36     42.8, 484.35     48.1, 483.58     49.7, 483.31
GR           51.4, 483.17     54.7, 483.29     56.2, 483.63     72.4, 492.88
GR           79.6, 494.25     79.7, 495.86      0.0, 496.21
*
*        BRTYPE  BRWDTH    EMBSS   EMBELV
CD          3      37.7      5.0    501.3
N           0.05
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     19      35.2     1
GR         -232.2, 514.72   -206.7, 502.10   -152.6, 501.61    -72.0, 500.89
GR           -9.7, 500.56     -9.7, 501.41     -6.7, 501.39      0.0, 501.39
GR           73.2, 501.16     75.2, 501.14     75.4, 500.18    116.4, 499.95
GR          236.1, 500.01    271.5, 499.67    340.8, 504.84
*
AS   APPRO    118
GR         -117.7, 516.72   -100.7, 504.10      0.0, 502.13     11.2, 492.83
GR           17.0, 487.02     20.4, 486.25     26.4, 486.13     28.3, 486.67
GR           31.0, 487.04     34.4, 486.60     37.9, 486.23     41.0, 486.71
GR           52.4, 493.15    116.5, 495.23    130.6, 501.19    161.8, 502.45
GR          174.4, 513.38
N           0.065        0.060        0.080
SA                  11.2          52.4
*
HP 1 BRIDG   487.96 1 487.96
HP 2 BRIDG   487.96 * * 1900
HP 1 APPRO   492.29 1 492.29
HP 2 APPRO   492.29 * * 1900
*
HP 1 BRIDG   489.22 1 489.22
HP 2 BRIDG   489.22 * * 2900
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File dumm005.wsp
       Hydraulic analysis for structure DUMMVT00300005   Date: 05-FEB-97
       Bridge # 5 on VT 30 over Stickney Brook in Dummerston, VT  by MAI
          *** RUN DATE & TIME: 02-27-97  14:27


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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     176.   11918.    49.    52.                         1897.
   487.96          176.   11918.    49.    52.  1.00    15.    64.   1897.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       487.96    14.8    63.8   176.2   11918.    1900.  10.78

 X STA.        14.8        21.6        23.6        25.5        27.2        28.9
   A(I)              14.2         9.0         8.5         7.8         7.8
   V(I)              6.71       10.55       11.22       12.11       12.19

 X STA.        28.9        30.7        32.6        34.6        36.8        39.2
   A(I)               7.9         7.8         8.1         8.4         8.6
   V(I)             12.06       12.14       11.66       11.34       11.11

 X STA.        39.2        41.5        43.8        46.0        47.8        49.6
   A(I)               8.4         8.5         8.3         8.0         7.8
   V(I)             11.35       11.23       11.49       11.94       12.13

 X STA.        49.6        51.2        52.8        54.6        56.8        63.8
   A(I)               7.5         7.9         8.5         9.4        14.0
   V(I)             12.68       12.07       11.16       10.11        6.77


   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     118.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     180.   11633.    39.    43.                         2196.
   492.29          180.   11633.    39.    43.  1.00    12.    51.   2196.


   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     118.

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.29    11.7    50.9   180.3   11633.    1900.  10.54

 X STA.        11.7        17.3        19.0        20.5        21.9        23.2
   A(I)              15.5         9.5         8.7         8.1         7.9
   V(I)              6.12        9.96       10.87       11.67       12.06

 X STA.        23.2        24.4        25.6        26.9        28.2        29.6
   A(I)               7.7         7.4         7.6         7.7         7.8
   V(I)             12.42       12.81       12.55       12.35       12.23

 X STA.        29.6        31.1        32.5        34.0        35.4        36.7
   A(I)               8.0         8.0         7.8         8.0         7.8
   V(I)             11.93       11.91       12.21       11.86       12.14

 X STA.        36.7        38.0        39.5        41.1        43.3        50.9
   A(I)               8.2         8.5         9.2        10.8        16.2
   V(I)             11.66       11.19       10.30        8.81        5.86
```

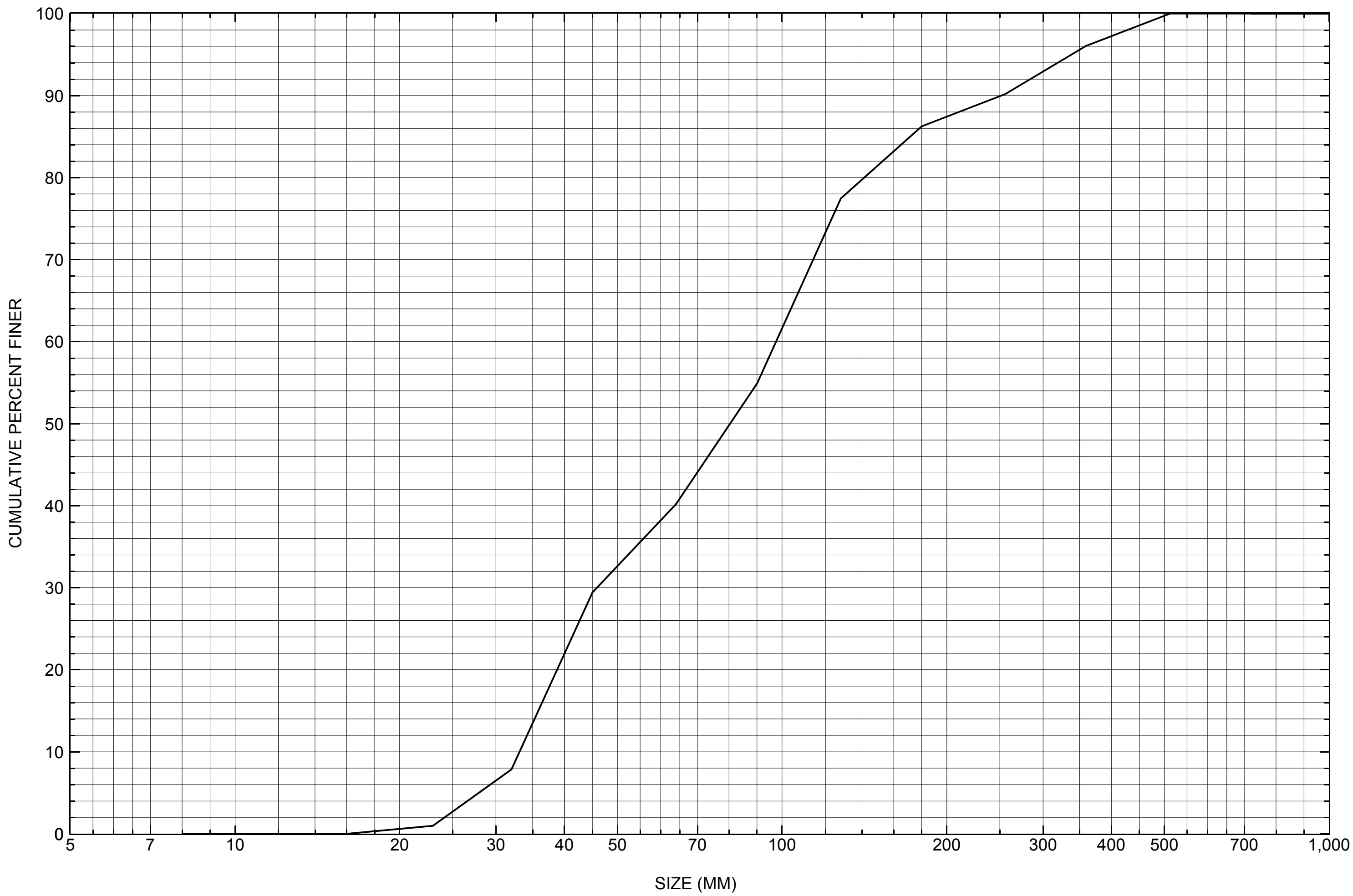
```
 U.S. Geological Survey WSPRO Input File dumm005.wsp
 Hydraulic analysis for structure DUMMVT00300005   Date: 05-FEB-97
 Bridge # 5 on VT 30 over Stickney Brook in Dummerston, VT  by MAI
    *** RUN DATE & TIME: 02-27-97  14:27



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

  WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
          1     241.   18842.    53.    56.                        2903.
489.22          241.   18842.    53.    56.  1.00    13.    66.   2903.



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

     WSEL     LEW     REW    AREA        K        Q    VEL
   489.22    12.8    66.0   240.6   18842.    2900.  12.05

X STA.        12.8        20.8        23.2        25.1        27.0        28.8
  A(I)             20.0        12.9        11.4        10.9        10.7
  V(I)             7.24       11.26       12.70       13.31       13.58

X STA.        28.8        30.7        32.7        34.7        36.9        39.2
  A(I)             10.7        10.5        10.8        11.1        11.1
  V(I)            13.60       13.85       13.45       13.12       13.10

X STA.        39.2        41.5        43.8        45.9        47.8        49.6
  A(I)             11.2        11.2        10.8        10.7        10.6
  V(I)            12.99       12.90       13.47       13.59       13.71

X STA.        49.6        51.4        53.2        55.2        57.6        66.0
  A(I)             10.6        10.9        11.5        13.2        20.0
  V(I)            13.71       13.31       12.61       10.95        7.23



CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     118.

  WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
          1       0.       2.     1.     1.                           1.
          2     226.   16329.    41.    46.                        3005.
          3       1.       6.     8.     8.                           2.
493.42          227.   16336.    50.    55.  1.01    10.    61.   2731.



VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     118.

     WSEL     LEW     REW    AREA        K        Q    VEL
   493.42    10.5    60.7   227.4   16336.    2900.  12.75

X STA.        10.5        16.8        18.6        20.2        21.7        23.0
  A(I)             19.3        11.9        11.2        10.1         9.6
  V(I)             7.51       12.14       12.96       14.29       15.12

X STA.        23.0        24.3        25.6        26.9        28.3        29.8
  A(I)              9.6         9.6         9.4         9.6         9.7
  V(I)            15.14       15.12       15.47       15.17       14.88

X STA.        29.8        31.3        32.8        34.3        35.7        37.1
  A(I)              9.8         9.8         9.9         9.9         9.9
  V(I)            14.86       14.72       14.64       14.65       14.67

X STA.        37.1        38.6        40.1        41.9        44.4        60.7
  A(I)             10.3        10.7        11.9        13.8        21.4
  V(I)            14.08       13.58       12.17       10.48        6.79
```

```
       U.S. Geological Survey WSPRO Input File dumm005.wsp
       Hydraulic analysis for structure DUMMVT00300005   Date: 05-FEB-97
       Bridge # 5 on VT 30 over Stickney Brook in Dummerston, VT  by MAI
          *** RUN DATE & TIME: 02-27-97  14:27

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

EXITX:XS   ******   -27.     244.  0.95 *****  486.85  485.79   1900.  485.90
      -67. ******    86.   10009.  1.00 ***** *******    0.94    7.80

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.93     488.32     488.21

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   485.40     517.13    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   485.40     517.13     488.21

FULLV:FV      67.   -27.     244.  0.94  2.41  489.26  488.21   1900.  488.32
        0.    67.    86.   10041.  1.00  0.00    0.01    0.93    7.78
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.97     491.90     491.82

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   487.82     516.72    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   487.82     516.72     491.82

APPRO:AS     118.    12.     165.  2.06  4.13  493.96  491.82   1900.  491.90
      118.   118.    50.   10266.  1.00  0.56    0.01    0.97   11.50
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                 SECID "BRIDG"     Q,CRWS =    1900.     487.96

            <<<<<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      67.    15.     176.  1.80 *****  489.77  487.96   1900.  487.96
        0.    67.    64.   11935.  1.00 ***** *******    1.00   10.77

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****    1.  1.000 ******  496.04 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      19.        <<<<<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      80.    12.     180.  1.73  2.16  494.02  491.82   1900.  492.29
      118.    80.    51.   11636.  1.00  2.10    0.02    0.87   10.54

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.000  0.000   11580.     5.    54.   490.06

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -67.   -27.    86.   1900.   10009.     244.    7.80  485.90
   FULLV:FV       0.   -27.    86.   1900.   10041.     244.    7.78  488.32
   BRIDG:BR       0.    15.    64.   1900.   11935.     176.   10.77  487.96
   RDWAY:RG      19.**************      0.******************    1.00********
   APPRO:AS     118.    12.    51.   1900.   11636.     180.   10.54  492.29

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       5.    54.   11580.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    485.79    0.94  480.76  514.72************  0.95  486.85  485.90
   FULLV:FV    488.21    0.93  483.17  517.13  2.41  0.00  0.94  489.26  488.32
   BRIDG:BR    487.96    1.00  483.17  496.21************  1.80  489.77  487.96
   RDWAY:RG  ****************  499.67  514.72**********************************
   APPRO:AS    491.82    0.87  486.13  516.72  2.16  2.10  1.73  494.02  492.29
```

```
        U.S. Geological Survey WSPRO Input File dumm005.wsp
        Hydraulic analysis for structure DUMMVT00300005   Date: 05-FEB-97
        Bridge # 5 on VT 30 over Stickney Brook in Dummerston, VT  by MAI
           *** RUN DATE & TIME: 02-27-97  14:27

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

EXITX:XS   ******   -29.     316.  1.31 *****  487.85  486.49   2900.  486.53
      -67. ******    87.   15283.  1.00 ***** *******    0.98    9.18

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.98     488.96     488.90
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   486.03     517.13    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   486.03     517.13     488.90

FULLV:FV      67.   -29.     316.  1.31  2.41  490.26  488.90   2900.  488.95
        0.    67.    87.   15313.  1.00  0.00    0.00    0.98    9.17
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.15     492.78     493.32
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   488.45     516.72    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   488.45     516.72     493.32
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                  WSBEG,WSEND,CRWS =   493.32     516.72     493.32

APPRO:AS     118.    11.     222.  2.65 *****  495.97  493.32   2900.  493.32
      118.   118.    58.   15833.  1.00 ***** *******    1.06   13.03
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    2900.     489.22

            <<<<<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      67.    13.     241.  2.26 *****  491.48  489.22   2900.  489.22
        0.    67.    66.   18853.  1.00 ***** *******    1.00   12.05

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  1.000 ******  496.04 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL

   RDWAY:RG      19.        <<<<<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      80.    10.     228.  2.55  2.66  495.98  493.32   2900.  493.42
      118.    85.    61.   16356.  1.01  1.82   -0.02    1.06   12.74

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.000  0.000   16451.     3.    57.   490.85

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -67.   -29.    87.   2900.   15283.     316.    9.18  486.53
   FULLV:FV       0.   -29.    87.   2900.   15313.     316.    9.17  488.95
   BRIDG:BR       0.    13.    66.   2900.   18853.     241.   12.05  489.22
   RDWAY:RG      19.**************       0.******************    1.00********
   APPRO:AS     118.    10.    61.   2900.   16356.     228.   12.74  493.42

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       3.    57.   16451.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    486.49    0.98  480.76  514.72************  1.31  487.85  486.53
   FULLV:FV    488.90    0.98  483.17  517.13  2.41  0.00  1.31  490.26  488.95
   BRIDG:BR    489.22    1.00  483.17  496.21************  2.26  491.48  489.22
   RDWAY:RG  ****************  499.67  514.72**********************************
   APPRO:AS    493.32    1.06  486.13  516.72  2.66  1.82  2.55  495.98  493.42
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure DUMMVT00300005, in Dummerston, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number DUMMVT00300005

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 30 / 95

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

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

Town *(FIPS place code; I - 4; nnnnn)* 18325

Mile marker *(I - 11; nnn.nnn)* 001500

Waterway *(I - 6)* STICKNEY BROOK

Road Name *(I - 7)*: -

Route Number VT 30

Vicinity *(I - 9)* 5.4 MI N JCT. U.S. 5

Topographic Map Newfane

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 42551

Longitude *(i - 17; nnnnn.n)* 72370

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20001500051305

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

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

Year built *(I - 27; YYYY)* 1952

Structure length *(I - 49; nnnnnn)* 000084

Average daily traffic, ADT *(I - 29; nnnnnn)* 004690

Deck Width *(I - 52; nn.n)* 352

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

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

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

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

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

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

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

Year Reconstructed *(I - 106)* 1972

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*) 12.0

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

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

Comments:

Structural inspection report (11/03/93): Single span steel beam bridge with asphalt surface and approaches. Not very much of the concrete abutment stems are in view. They have very minor hairline cracks and stains. There is riprap in front of them. The waterway has a fairly straight alignment through the structure. The streambed consists of stone and gravel, with numerous large boulders upstream. The West river is roughly 200 ft downstream.

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: -

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*): ____ *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)* **6.31** mi^2 Lake/pond/swamp area **0.15** mi^2
Watershed storage *(ST)* **2.3** %
Bridge site elevation **276** ft Headwater elevation **1673** ft
Main channel length **5.23** mi
10% channel length elevation **453** ft 85% channel length elevation **1378** ft
Main channel slope *(S)* **236.05** ft / mi

Watershed Precipitation Data

Average site precipitation - in Average headwater precipitation - in
Maximum 2yr-24hr precipitation event *(I24,2)* - in
Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? **Y** *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: **12** / **1969**

Project Number **-** Minimum channel bed elevation: **484.5**

Low superstructure elevation: USLAB **-** DSLAB **-** USRAB **-** DSRAB **-**

Benchmark location description:

-

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

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

If 1: Footing Thickness **2.0** Footing bottom elevation: **478.0**

If 2: Pile Type: **-** (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: **-**

If 3: Footing bottom elevation: **-**

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

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

Briefly describe material at foundation bottom elevation or around piles:
NO FOUNDATION MATERIAL INFORMATION

Comments:
Other elevation points: 1) above left abutment end finished grade elevation 499.56. 2) above right abutment end finished grade elevation 499.27. Plans are for reconditioning of the pavement.

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: **RB** Date: **11/1/96**
Computerized by: **RB** Date: **11/4/96**
Reviewd by: **MAI** Date: **5/27/97**

Structure Number **DUMMVT00300005**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **R. FLYNN** Date *(MM/DD/YY)* **08** / **12** / 19**96**

2. Highway District Number **02** Mile marker **001500**

County **Windham (025)** Town **Dummerston (18325)**

Waterway *(I - 6)* **STICKNEY BROOK** Road Name **STICKNEY BROOK ROAD**

Route Number **VT30** Hydrologic Unit Code: **01080107**

3. Descriptive comments:

Located 5.4 miles north of VT 30 intersection with US 5 and 0.05 miles north of TH 47 in Dummerston.

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 **1** DS **2** *(**1**- pool; **2**- riffle)*

6. Bridge structure type **1** *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*

7. Bridge length **84** *(feet)* Span length **82** *(feet)* Bridge width **35.2** *(feet)*

Road approach to bridge:

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

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

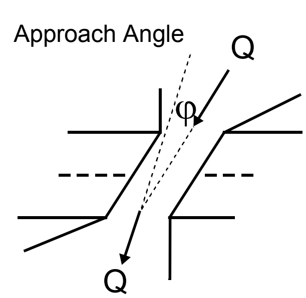
10. Embankment slope (*run / rise in feet / foot*):
US left **6.8:1** US right **3.1:1**

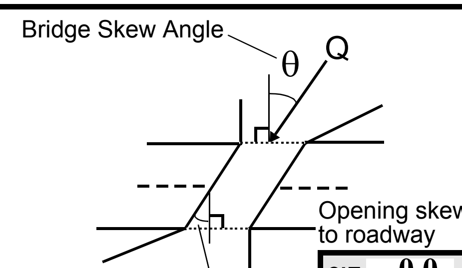
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	0	-	1	1
RBUS	0	-	3	2
RBDS	0	-	2	1
LBDS	0	-	2	1

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*
*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: **5** 16. Bridge skew: **5**





α= **0.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **0** feet **US** *(US, UB, DS)* to **80** feet **DS**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **64** feet **US** *(US, UB, DS)* to **125** feet **US**

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

18. Bridge Type: **3**

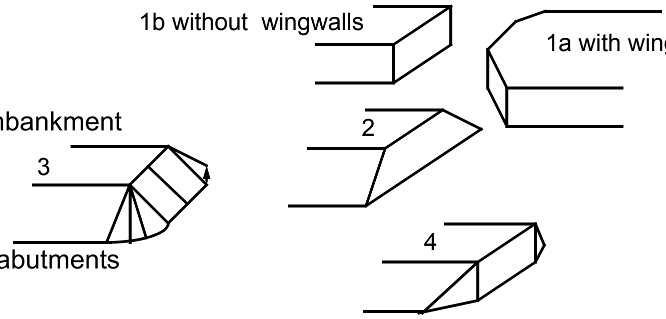
1a- Vertical abutments with wingwalls

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.)

7. Values are from the VT AOT files. Measured bridge length is 84 ft., span length is 82 ft., and the bridge width is 34.9 ft.

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
86.0	**6.0**			**6.5**	**3**	**3**	**453**	**453**	**2**	**3**

23. Bank width **45.0** 24. Channel width **30.0** 25. Thalweg depth **41.0** 29. Bed Material **4532**

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

27. Cobbles and boulders from US are scattered along both banks on both sides.
28. There are exposed tree roots along the right bank and a cut bank at the approach cross section.
30. The right bank protection is from 20 ft US to 64 ft US.

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

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

37. Material: **-**

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

NO POINT BARS

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

41. Mid-bank distance: **95** 42. Cut bank extent: **64** feet **US** (US, UB) to **125** feet **US** (US, UB, DS)

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

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

Exposed tree roots and the scarring of trees is evident.

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? **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)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
24.0		**0.5**		**2**	**7**	**7**	**0**

58. Bank width (BF) **10.0** 59. Channel width (Amb) **9.0** 60. Thalweg depth (Amb) **30.0** 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.):

4532

There is a scour hole along the toe of the right spill-through slope from the US bridge face to 15 ft under the bridge. The scour hole is 5 ft wide and 0.5 ft deep.

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

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

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

70. Debris and Ice Comments:

1

There is scarring on the tree trunks and roots.

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	45	2	0	-	-	30.0
RABUT	2	0	45			2	1	67.0

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.):

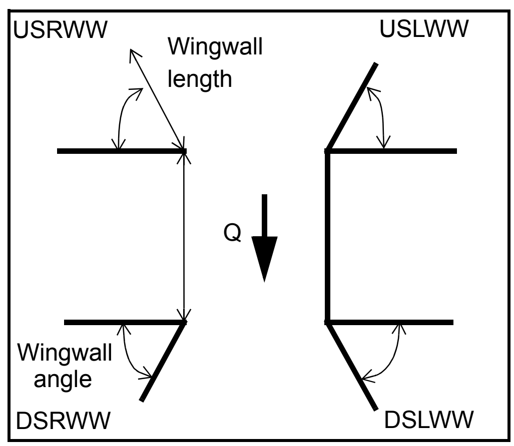
0.5
0
2

Approximately 2 ft. of the top of each concrete abutment is showing. There is type-2 granite placed at an angle in front of the abutments down to the water that acts as a spill through slope. There is a scour hole along the bottom of the right spill through slope.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						35.0	
USRWW:	N		-		-	0.5	
DSLWW:	-		-		N	37.5	
DSRWW:	-		-		-	37.5	

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	2	-

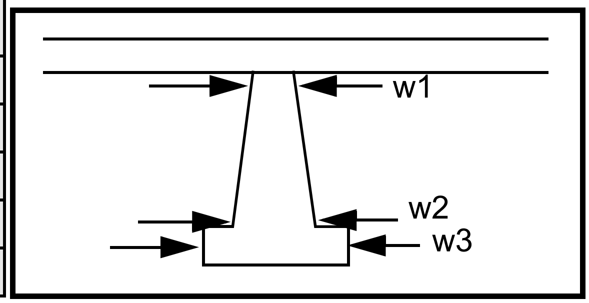
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? **On** (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 US**	**lier**	**cracke**	**A 5 ft**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**right**	**brid**	**d in**	**by 2**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**bank**	**ge.**	**area**	**ft by**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**,**	**The**	**s and**	**2 ft**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**there**	**con-**	**is**	**sec-**	*Y- yes; N- no*
91. Attack ∠ (BF)	**is a**	**crete**	**act-**	**tion**	
92. Pushed	**con-**	**has**	**ing**	**of**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**crete**	**bro-**	**as**	**con-**	
95. Cross-members	**rem-**	**ken**	**bank**	**crete**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**nant**	**away**	**pro-**	**is in**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**of an**	**and**	**tec-**	**the**	
98. Exposure depth	**ear-**	**is**	**tion.**	**river**	

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

.

E. Downstream Channel Assessment

100.

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

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? - (Y or if N type ctrl-n cb) Where? NO (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 430 Depth: 430 Positioned 2 %LB to 2 %RB

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

425
0
0
-

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

Confluence 1: Distance West Enters on Rive (LB or RB) Type r is (*1*- perennial; *2*- ephemeral)

Confluence 2: Distance 180 ft Enters on DS (LB or RB) Type of (*1*- perennial; *2*- ephemeral)

Confluence comments (eg. confluence name):

the DS face of the bridge. The Stickney Brook has formed a delta where it meets the West River. The deposited material has narrowed the West River by half the width that is immediately US. There is natural bank protec-

F. Geomorphic Channel Assessment

107. Stage of reach evolution tio

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, consisting of large rock, along the base of both the left and right banks for approximately 25 ft DS.

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: DUMMVT00300005 Town: Dummerston
Road Number: VT 30 County: Windham
Stream: Stickney Brook

Initials MAI Date: 02/27/97 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	1900	2900	0
Main Channel Area, ft2	180	226	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	1	0
Top width main channel, ft	39	41	0
Top width L overbank, ft	0	1	0
Top width R overbank, ft	0	8	0
D50 of channel, ft	0.264	0.264	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	4.6	5.5	ERR
y1, average depth, LOB, ft	ERR	0.0	ERR
y1, average depth, ROB, ft	ERR	0.1	ERR
Total conveyance, approach	11633	16336	0
Conveyance, main channel	11633	16329	0
Conveyance, LOB	0	2	0
Conveyance, ROB	0	6	0
Percent discrepancy, conveyance	0.0000	-0.0061	ERR
Qm, discharge, MC, cfs	1900.0	2898.8	ERR
Ql, discharge, LOB, cfs	0.0	0.4	ERR
Qr, discharge, ROB, cfs	0.0	1.1	ERR
Vm, mean velocity MC, ft/s	10.6	12.8	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	1.1	ERR
Vc-m, crit. velocity, MC, ft/s	9.3	9.6	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	1	1	N/A

Live-Bed Contraction Scour

Laursen’s Live Bed Contraction Scour
y2/y1 = (Q2/Q1)^(6/7)*(W1/W2)^(k1)
ys=y2-y_bridge
(Richardson and others, 1995, p. 30, eq. 17 and 18)

	Approach			Bridge		
Characteristic	100 yr	500 yr	Other Q	100 yr	500 yr	Other Q
Q1, discharge, cfs	1900	2900	0	1900	2900	0
Total conveyance	11633	16336	0	11918	18842	0
Main channel conveyance	11633	16329	0	11918	18842	0
Main channel discharge	1900	2899	ERR	1900	2900	ERR
Area - main channel, ft2	180	226	0	176.2	240.6	0
(W1) channel width, ft	39	41	0	41.9	44	0
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	39	41	0	41.9	44	0
D50, ft	0.264	0.264	0.264			
w, fall velocity, ft/s (p. 32)	4.2	4.2	0			
y, ave. depth flow, ft	4.62	5.51	N/A	4.21	5.47	ERR
S1, slope EGL	0.0398	0.0484	0			
P, wetted perimeter, MC, ft	43	46	0			
R, hydraulic Radius, ft	4.186	4.913	ERR			
V*, shear velocity, ft/s	2.316	2.767	N/A			
V*/w	0.551	0.659	ERR			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0.64	0.64	0			
y2,depth in contraction, ft	4.41	5.27	ERR			
ys, scour depth, ft (y2-y_bridge)	0.20	-0.20	N/A			

ARMORING

D90	0.825	0.825	0
D95	1.11	1.11	0
Critical grain size,Dc, ft	0.6871	0.7590	ERR
Decimal-percent coarser than Dc	0.12	0.109	0
depth to armoring, ft	15.12	18.61	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)

	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	1900	2900	0	1900	2900	0
a', abut.length blocking flow, ft	2.9	3.1	0	0	3.1	0
Ae, area of blocked flow ft2	8	9.5	0	0	4.1	0
Qe, discharge blocked abut.,cfs	49.2	71.4	0	0	27.6	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	6.15	7.52	ERR	6.77	6.73	ERR
ya, depth of f/p flow, ft	2.76	3.06	ERR	2.00	1.32	ERR

--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)

K1	0.55	0.55	0.55	0.55	0.55	0.55

--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)

theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.653	0.757	ERR	0.844	1.032	ERR
ys, scour depth, ft	5.47	6.31	N/A	2.00	3.75	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)	2.9	3.1	0	0	3.1	0
y1 (depth f/p flow, ft)	2.76	3.06	ERR	ERR	1.32	ERR
a'/y1	1.05	1.01	ERR	ERR	2.34	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.65	0.76	N/A	0.84	1.03	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	0	1	1	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	3.60	4.52	0.00	3.60	4.52	0.00

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.)	1.51	1.89	ERR	1.51	1.89	ERR
Fr<=0.8 (spillthrough abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (spillthrough abut.)	1.33	1.67	ERR	1.33	1.67	ERR