LEVEL II SCOUR ANALYSIS FOR BRIDGE 27 (WSTOTH00070027) on TOWN HIGHWAY 7, crossing JENNY COOLIDGE BROOK, WESTON, VERMONT

Open-File Report 98-156

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior
U.S. Geological Survey

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 27 (WSTOTH00070027) on TOWN HIGHWAY 7, crossing JENNY COOLIDGE BROOK, WESTON, VERMONT

By EMILY C. WILD

U.S. Geological Survey
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Pembroke, New Hampshire

1998

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

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

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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 27 (WSTOTH00070027) ON TOWN HIGHWAY 7, CROSSING JENNY COOLIDGE BROOK, WESTON, VERMONT

By **Emily C. Wild**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure WSTOTH00070027 on Town Highway 7 crossing Jenny Coolidge Brook, Weston, 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 (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Green Mountain section of the New England physiographic province in southwestern Vermont. The 2.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture downstream of the bridge while upstream of the bridge is forested.

In the study area, the Jenny Coolidge Brook has an incised, sinuous channel with a slope of approximately 0.04 ft/ft, an average channel top width of 51 ft and an average bank height of 6 ft. The channel bed material ranges from sand to boulders with a median grain size (D_{50}) of 122 mm (0.339 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 20, 1996, indicated that the reach was stable.

The Town Highway 7 crossing of the Jenny Coolidge Brook is a 52-ft-long, two-lane bridge consisting of a 50-foot steel-beam span (Vermont Agency of Transportation, written communication, April 7, 1995). The opening length of the structure parallel to the bridge face is 49.2 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 5 degrees to the opening while the computed opening-skew-to-roadway is 15 degrees.

The legs of the skeleton-type right abutment were exposed approximately 2 feet (vertically) and approximately 2 feet (horizontally) during the Level I assessment. Scour protection measures at the site include type-1 stone fill (less than 12 inches diameter) along the downstream right wingwall, and type-2 stone fill (less than 36 inches diameter) along the upstream banks, upstream left wingwall, left abutment, downstream left wingwall and downstream left bank. A stone wall levee extends along the downstream 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 Davis, 1995) for the 100- and 500-year discharges. 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 was zero ft. Abutment scour ranged from 3.0 to 4.1 ft. The worst-case left abutment scour occurred at the 100-year discharge. The worst-case right 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 Davis, 1995, p. 46). 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.

Plymouth, 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 WSTOTH00070027 ***Stream*** Jenny Coolidge Brook

County Windsor ***Road*** TH 7 ***District*** 2

Description of Bridge

Bridge length 52 ***ft*** ***Bridge width*** 22 ***ft*** ***Max span length*** 50 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 8/20/96

Description of stone fill Type-1, along the downstream right wingwall. Type-2, along the left abutment, the upstream left wingwall and the downstream left wingwall.

Abutments and wingwalls are concrete.

Yes 5

Is bridge skewed to flood flow according to No ***Level I survey?*** ***Angle***

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	8/20/96	0	0
Level II	8/20/96	0	0

Potential for debris Moderate. Debris has accumulated along the banks upstream.

Describe any features near or at the bridge that may affect flow (include observation date) No features near or at the bridge that may affect flow were observed on 8/20/96.

Description of the Geomorphic Setting

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

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

Date of inspection 8/20/96

DS left: Steep channel bank to a narrow flood plain

DS right: Steep channel bank to a narrow flood plain

US left: Steep valley wall

US right: Steep channel bank to a moderately sloped overbank

Description of the Channel

Average top width 51 ***ft*** ***Average depth*** 6 ***ft***

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

Perennial and straight with non-alluvial channel boundaries and a narrow flood plain.

8/20/96

Vegetative co… Pasture with some trees

DS left: Pasture with some trees

DS right: Trees

US left: Trees

US right:

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

None, 8/20/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 2.9 ***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

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 640 ***ft³/s*** ***Q500*** 1,020 ***ft³/s***

The 100- and 500-year discharges are the median curve values from a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve was extended graphically to the 500-year discharge.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream left bridge curb corner (elev. 500.98 ft, arbitrary survey datum). RM2 is a chiseled corner of the upstream right bridge curb (elev. 500.95 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	-49	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	11	1	Road Grade section
APPRO	70	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.055 to 0.060, and overbank "n" values were 0.055.

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 0.0444 ft/ft, which was calculated from thalweg points surveyed downstream.

The surveyed approach section (APPRO) was modelled 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 discharge, 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 was 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 500.2 ***ft***
Average low steel elevation 496.8 ***ft***

100-year discharge 640 ***ft^3/s***
Water-surface elevation in bridge opening 489.7 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft^3/s***
Area of flow in bridge opening 74 ***ft^2***
Average velocity in bridge opening 8.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 14.0 ***ft/s***

Water-surface elevation at Approach section with bridge 492.2
Water-surface elevation at Approach section without bridge 491.5
Amount of backwater caused by bridge 0.7 ***ft***

500-year discharge 1,020 ***ft^3/s***
Water-surface elevation in bridge opening 490.6 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft^3/s***
Area of flow in bridge opening 104 ***ft^2***
Average velocity in bridge opening 9.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 14.1 ***ft/s***

Water-surface elevation at Approach section with bridge 493.0
Water-surface elevation at Approach section without bridge 492.6
Amount of backwater caused by bridge 0.4 ***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 Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analyses for the 100- and 500-year discharges are presented in tables 1 and 2 and the scour depths are shown graphically in figure 8.

Contraction scour for the 100-year and 500-year discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). 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 Davis, 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.

The influence of scour processes on the stone fill and embankment material along the concrete abutments is unknown. Therefore, the total scour depth computed at the toe of the embankment was applied to the entire embankment area.

Scour Results

Contraction scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	--
Depth to armoring	3.2	4.5	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
Abutment scour	3.1	3.0	--
Left abutment	3.3	4.1	--
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-year discharge	500-year discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:	1.3	1.7	--
Left abutment	1.3	1.7	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

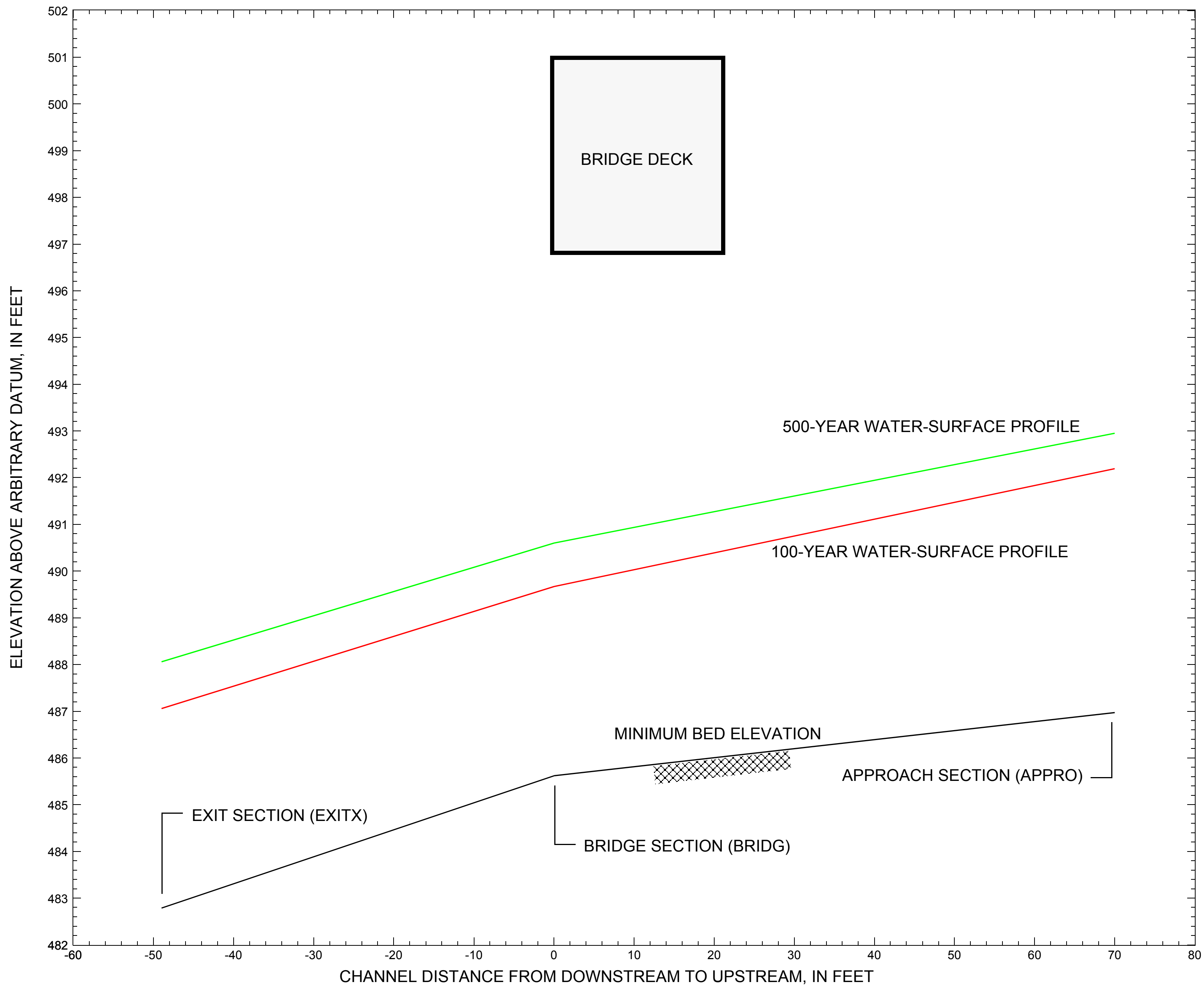

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure WSTOTH00070027 on Town Highway 7, crossing Jenny Coolidge Brook, Weston, Vermont.

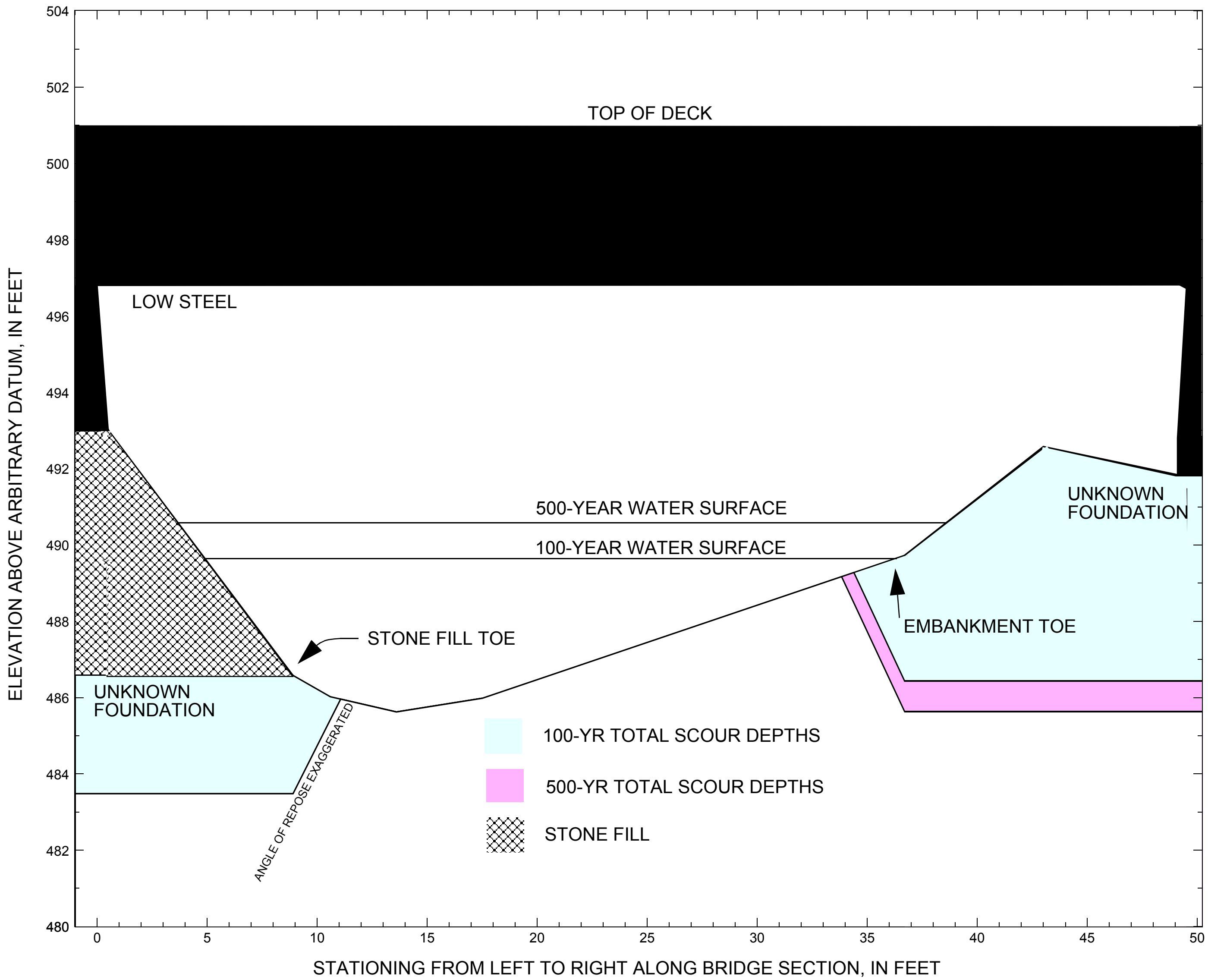

Figure 8. Scour elevations for the 100- and 500-year discharges at structure WSTOTH00070027 on Town Highway 7, crossing Jenny Coolidge Brook, Weston, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure WSTOTH00070027 on Town Highway 7, crossing Jenny Coolidge Brook, Weston, 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/pile 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-year discharge is 640 cubic-feet per second											
Left abutment	0.0	--	496.8	--	493.0	--	--	--	--	--	--
Stone Fill Toe	8.9	--	--	--	486.6	0.0	3.1	--	3.1	483.5	--
Embankment Toe	36.7	--	--	--	489.7	0.0	3.3	--	3.3	486.4	--
Right abutment	49.2	--	496.8	--	492.8	--	--	--	--	--	--

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 WSTOTH00070027 on Town Highway 7, crossing Jenny Coolidge Brook, Weston, 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/pile 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-year discharge is 1,020 cubic-feet per second											
Left abutment	0.0	--	496.8	--	493.0	--	--	--	--	--	--
Stone Fill Toe	8.9	--	--	--	486.6	0.0	3.0	--	3.0	483.6	--
Embankment Toe	36.7	--	--	--	489.7	0.0	4.1	--	4.1	485.6	--
Right abutment	49.2	--	496.8	--	492.8	--	--	--	--	--	--

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, 1986, Weston, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File wsto027.wsp
T2        Hydraulic analysis for structure WSTOTH00070027   Date: 01-OCT-97
T3        TH7 CROSSING JENNY COOLIDGE BROOK, WESTON, VERMONT              ECW
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q            640.0   1020.0
SK          0.0444   0.0444
*
XS   EXITX    -49           0.
GR         -208.9, 505.73   -168.2, 497.70   -143.0, 497.33    -27.3, 490.16
GR          -15.7, 487.75     -3.5, 483.58      0.0, 482.79      3.5, 483.66
GR           11.1, 484.18     19.8, 492.85     24.5, 491.01    120.4, 489.81
GR          156.5, 492.93    261.2, 494.26    387.5, 514.41
*
*  GR   -128.8, 489.51    -103.5, 487.93   -46.7, 489.29   -38.4, 489.95
*
N           0.055        0.065        0.055
SA                 -27.3         19.8
*
*
XS   FULLV      0  * * *   0.0347
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    496.81       0.0
GR            0.0, 496.80      0.5, 493.02      8.9, 486.58     10.6, 486.02
GR           13.6, 485.62     17.5, 485.98     36.7, 489.73     43.0, 492.58
GR           49.1, 491.84     49.1, 492.80     49.2, 496.82      0.0, 496.80
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      28.3 * *     88.3      0.2
N           0.055
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     11      22.0     2
GR         -152.1, 505.27    -82.3, 497.57    -31.8, 499.87     -1.5, 500.14
GR           -1.2, 501.03      0.0, 500.98     49.4, 500.96     50.7, 500.95
GR           50.7, 500.29     74.3, 499.61    139.4, 497.76    238.2, 496.18
GR          304.0, 501.23    378.6, 514.41
*
*
AS   APPRO     70           0.
GR          -68.7, 504.12    -49.3, 499.32    -16.5, 498.76      0.0, 497.20
GR           11.3, 487.64     12.1, 487.13     15.2, 486.97     18.1, 487.15
GR           20.2, 487.63     22.6, 488.20     29.0, 490.84     34.5, 492.13
GR           36.4, 493.58     40.5, 493.50    181.2, 495.64    261.1, 503.42
GR          299.7, 514.33
*
N           0.060        0.055
SA                  36.4
*
HP 1 BRIDG 489.67 1 489.67
HP 2 BRIDG 489.67 * * 640
HP 1 APPRO 492.19 1 492.19
HP 2 APPRO 492.19 * * 640
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File wsto027.wsp
       Hydraulic analysis for structure WSTOTH00070027   Date: 01-OCT-97
       TH7 CROSSING JENNY COOLIDGE BROOK, WESTON, VERMONT              ECW
          *** RUN DATE & TIME: 02-13-98  10:40
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
            1      73.    3388.    32.    33.                         636.
  489.67           73.    3388.    32.    33.  1.00     5.    36.    636.

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      489.67     4.9    36.4    73.5    3388.     640.   8.71

X STA.         4.9         9.2        10.1        10.9        11.7        12.4
  A(I)             7.1         3.0         2.9         2.9         2.9
  V(I)            4.52       10.61       10.99       11.00       11.20

X STA.        12.4        13.1        13.8        14.6        15.3        16.0
  A(I)             2.8         2.9         2.9         2.9         2.6
  V(I)           11.38       11.08       11.08       10.89       12.17

X STA.        16.0        16.6        17.3        18.1        18.9        19.7
  A(I)             2.3         2.7         2.7         2.8         2.8
  V(I)           13.97       11.77       11.75       11.26       11.33

X STA.        19.7        20.7        21.7        22.9        24.2        36.4
  A(I)             2.9         3.0         3.3         3.5        14.4
  V(I)           10.89       10.53        9.83        9.21        2.22

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      70.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
            1      88.    4370.    29.    31.                         878.
  492.19           88.    4370.    29.    31.  1.00     6.    35.    878.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      70.

        WSEL     LEW     REW    AREA        K        Q    VEL
      492.19     5.9    34.6    88.2    4370.     640.   7.26

X STA.         5.9        10.8        11.7        12.4        13.0        13.7
  A(I)            10.1         3.9         3.5         3.3         3.3
  V(I)            3.15        8.31        9.23        9.83        9.74

X STA.        13.7        14.3        15.0        15.6        16.3        16.9
  A(I)             3.4         3.4         3.3         3.5         3.3
  V(I)            9.35        9.47        9.59        9.15        9.81

X STA.        16.9        17.5        18.1        18.8        19.5        20.2
  A(I)             3.0         3.2         3.3         3.3         3.3
  V(I)           10.63       10.06        9.76        9.79        9.61

X STA.        20.2        21.0        21.7        22.6        23.6        34.6
  A(I)             3.4         3.4         3.5         3.8        17.1
  V(I)            9.46        9.42        9.02        8.53        1.87
```

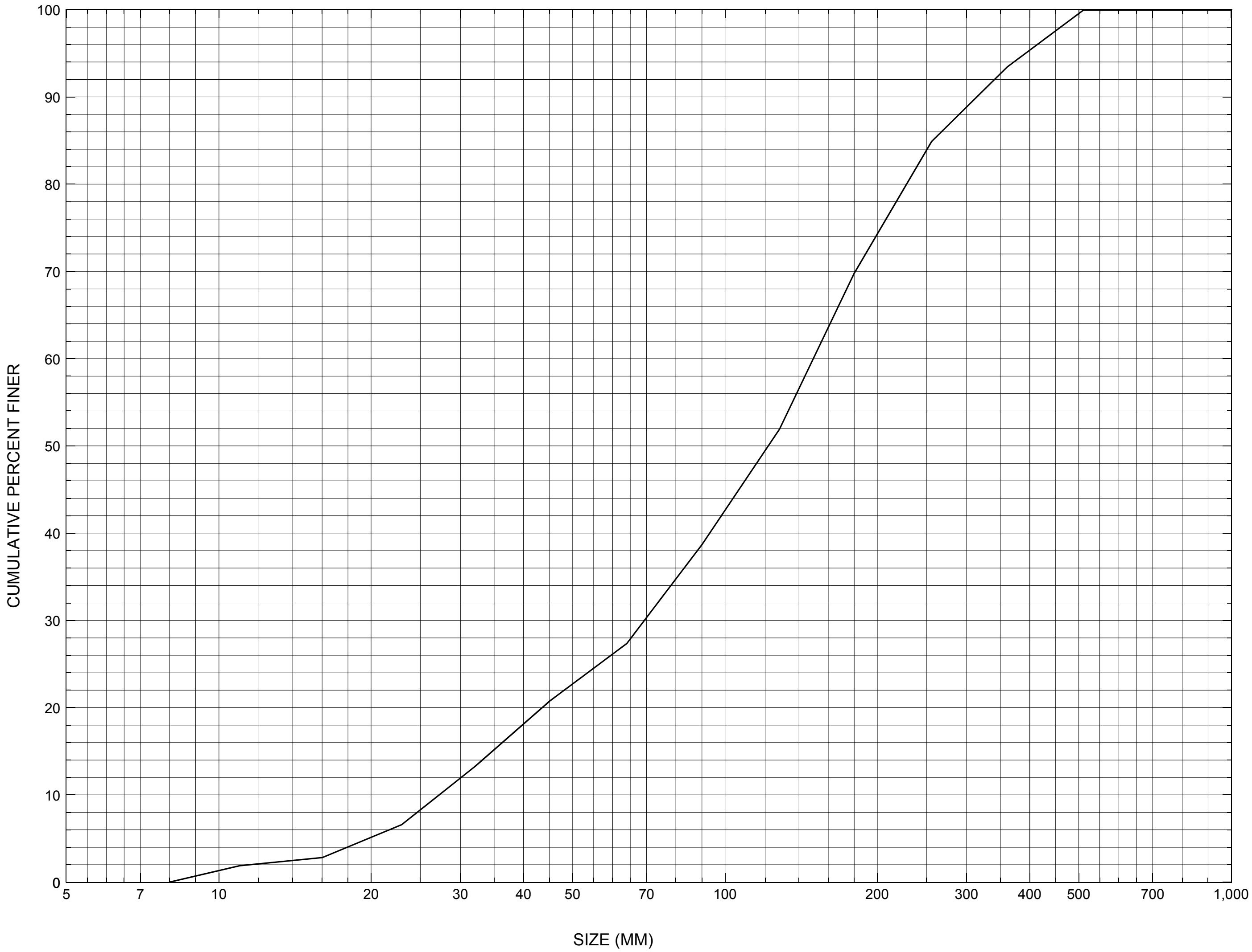
```
        U.S. Geological Survey WSPRO Input File wsto027.wsp
        Hydraulic analysis for structure WSTOTH00070027   Date: 01-OCT-97
        TH7 CROSSING JENNY COOLIDGE BROOK, WESTON, VERMONT              ECW
           *** RUN DATE & TIME: 02-13-98  10:40
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     104.    5651.    35.    37.                        1024.
   490.60          104.    5651.    35.    37.  1.00     4.    39.   1024.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       490.60     3.7    38.6   104.5    5651.    1020.   9.77

X STA.         3.7         9.0        10.0        10.9        11.8        12.6
  A(I)             11.0         4.3         4.1         4.1         4.0
  V(I)             4.64       11.96       12.43       12.40       12.87

X STA.        12.6        13.5        14.3        15.1        16.0        16.8
  A(I)              4.1         4.0         4.2         4.2         3.9
  V(I)            12.39       12.61       12.18       12.15       13.15

X STA.        16.8        17.6        18.5        19.4        20.4        21.5
  A(I)              3.6         4.0         4.0         4.1         4.2
  V(I)            14.06       12.78       12.60       12.33       12.01

X STA.        21.5        22.7        24.0        25.6        27.5        38.6
  A(I)              4.4         4.6         4.9         5.5        17.2
  V(I)            11.51       11.13       10.41        9.34        2.97

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      70.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     111.    6072.    31.    34.                        1196.
   492.95          111.    6072.    31.    34.  1.00     5.    36.   1196.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      70.

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.95     5.0    35.6   110.7    6072.    1020.   9.21

X STA.         5.0        10.7        11.6        12.4        13.1        13.8
  A(I)             13.4         4.9         4.4         4.1         4.1
  V(I)             3.79       10.50       11.66       12.41       12.31

X STA.        13.8        14.5        15.2        15.9        16.6        17.4
  A(I)              4.1         4.3         4.2         4.3         4.3
  V(I)            12.29       11.86       12.05       11.86       11.95

X STA.        17.4        18.0        18.8        19.5        20.3        21.1
  A(I)              3.9         4.1         4.2         4.2         4.3
  V(I)            12.97       12.38       12.13       12.17       11.96

X STA.        21.1        22.0        22.9        24.0        25.3        35.6
  A(I)              4.3         4.5         4.8         5.2        19.0
  V(I)            11.79       11.46       10.65        9.77        2.68
```

```
        U.S. Geological Survey WSPRO Input File wsto027.wsp
        Hydraulic analysis for structure WSTOTH00070027   Date: 01-OCT-97
        TH7 CROSSING JENNY COOLIDGE BROOK, WESTON, VERMONT              ECW
           *** RUN DATE & TIME: 02-13-98  10:40
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******   -14.      73.  1.20 *****  488.26  486.97    640.  487.06
      -49. ******    14.    3034.  1.00 ***** *******    0.96    8.80

FULLV:FV      49.   -15.      84.  0.91  1.79  490.06 *******    640.  489.15
        0.    49.    14.    3700.  1.00  0.00    0.01    0.79    7.63
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.01     491.41     491.45
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   488.65     514.33    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   488.65     514.33     491.45
 ===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 =   491.45     514.33     491.45
APPRO:AS      70.     7.      68.  1.37 *****  492.81  491.45    640.  491.45
       70.    70.    32.    3143.  1.00 ***** *******    1.00    9.37
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =     640.     489.67
            <<<<<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      49.     5.      74.  1.18 *****  490.85  489.67    640.  489.67
        0.    49.    36.    3396.  1.00 ***** *******    1.00    8.70

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  496.81 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.        <<<<<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      42.     6.      88.  0.82  1.15  493.01  491.45    640.  492.19
       70.    42.    35.    4366.  1.00  1.01    0.00    0.73    7.26

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.000  0.000    4369.     6.    37.   491.16
                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -49.   -14.    14.    640.    3034.      73.    8.80  487.06
   FULLV:FV       0.   -15.    14.    640.    3700.      84.    7.63  489.15
   BRIDG:BR       0.     5.    36.    640.    3396.      74.    8.70  489.67
   RDWAY:RG      11.**************      0.*****************    2.00********
   APPRO:AS      70.     6.    35.    640.    4366.      88.    7.26  492.19

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       6.    37.    4369.
 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    486.97    0.96  482.79  514.41************  1.20  488.26  487.06
   FULLV:FV  ********    0.79  484.49  516.11  1.79  0.00  0.91  490.06  489.15
   BRIDG:BR    489.67    1.00  485.62  496.82************  1.18  490.85  489.67
   RDWAY:RG  ****************  496.18  514.41**********************************
   APPRO:AS    491.45    0.73  486.97  514.33  1.15  1.01  0.82  493.01  492.19
```

```
        U.S. Geological Survey WSPRO Input File wsto027.wsp
        Hydraulic analysis for structure WSTOTH00070027   Date: 01-OCT-97
        TH7 CROSSING JENNY COOLIDGE BROOK, WESTON, VERMONT              ECW
           *** RUN DATE & TIME: 02-13-98  10:40
  XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
        SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
 EXITX:XS   ******   -17.     103.  1.54 *****  489.60  488.01   1020.  488.06
      -49. ******    15.    4837.  1.00 ***** *******    0.98    9.95
  ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.81     490.27     489.71
  ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   487.56     516.11    0.50
  ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   487.56     516.11     489.71
 FULLV:FV      49.   -20.     119.  1.14  1.80  491.40  489.71   1020.  490.26
        0.    49.    15.    5867.  1.00  0.00    0.00    0.82    8.56
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
  ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.03     492.47     492.55
  ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   489.76     514.33    0.50
  ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   489.76     514.33     492.55
  ===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 =   492.55     514.33     492.55
 APPRO:AS      70.     5.      99.  1.66 *****  494.21  492.55   1020.  492.55
       70.    70.    35.    5151.  1.00 ***** *******    1.00   10.33
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
  ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    1020.     490.60
            <<<<<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      49.     4.     105.  1.48 *****  492.08  490.60   1020.  490.60
        0.    49.    39.    5655.  1.00 ***** *******    1.00    9.76
     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  496.81 ****** ****** ******
    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.        <<<<<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      42.     5.     111.  1.32  1.26  494.27  492.55   1020.  492.95
       70.    42.    36.    6072.  1.00  0.92   -0.02    0.85    9.21
       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.000  0.000    6109.     4.    39.   491.61
                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
   FIRST USER DEFINED TABLE.
     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXITX:XS     -49.   -17.    15.   1020.    4837.     103.    9.95  488.06
    FULLV:FV       0.   -20.    15.   1020.    5867.     119.    8.56  490.26
    BRIDG:BR       0.     4.    39.   1020.    5655.     105.    9.76  490.60
    RDWAY:RG      11.**************      0.******************    2.00********
    APPRO:AS      70.     5.    36.   1020.    6072.     111.    9.21  492.95
     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS       4.    39.    6109.
  SECOND USER DEFINED TABLE.
     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXITX:XS    488.01    0.98  482.79  514.41************  1.54  489.60  488.06
    FULLV:FV    489.71    0.82  484.49  516.11  1.80  0.00  1.14  491.40  490.26
    BRIDG:BR    490.60    1.00  485.62  496.82************  1.48  492.08  490.60
    RDWAY:RG  ****************  496.18  514.41**********************************
    APPRO:AS    492.55    0.85  486.97  514.33  1.26  0.92  1.32  494.27  492.95
   ER
NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure WSTOTH00070027, in Weston, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number WSTOTH00070027

General Location Descriptive

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

Date (MM/DD/YY) 04 / 07 / 95

Highway District Number (I - 2; nn) 02

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

Town (FIPS place code; I - 4; nnnnn) 82000

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

Waterway (I - 6) JENNY COOLIDGE BROOK

Road Name (I - 7): -

Route Number TH007

Vicinity (I - 9) @ JCT W CL3 TH16

Topographic Map Weston

Hydrologic Unit Code: 01080107

Latitude (I - 16; nnnn.n) 43204

Longitude (i - 17; nnnnn.n) 72487

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10142100271421

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0050

Year built (I - 27; YYYY) 1935

Structure length (I - 49; nnnnnn) 000052

Average daily traffic, ADT (I - 29; nnnnnn) 000015

Deck Width (I - 52; nn.n) 220

Year of ADT (I - 30; YY) 91

Channel & Protection (I - 61; n) 4

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) 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) 009.0

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

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

Comments:

The structural inspection report of 09/16/93 indicates the structure is a single span, steel beam type bridge with a concrete deck and an asphalt roadway surface. Both abutments are concrete skeleton type. The caps and wingwalls have minor stains noted. The legs are only in view for roughly 18 inches at the right abutment. On the left abutment the legs are in view 4.5 feet. The stone fill material around the legs is somewhat eroded upstream from the left abutment. There are some trees cantilevered out over the channel area. The waterway has a slight turn into the structure. The streambed consists of stone and boulders, with some gravel deposits. A gravel point bar exists near the right abutment side of the channel.

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area (*mi²*): -

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

Ice conditions (*Heavy, Moderate, Light*) : - Debris (*Heavy, Moderate, Light*): -

The stage increases to maximum highwater elevation (*Rapidly, Not rapidly*): -

The stream response is (*Flashy, Not flashy*): -

Describe any significant site conditions upstream or downstream that may influence the stream's stage: -

Watershed storage area (*in percent*): - %

The watershed storage area is: - (*1-mainly at the headwaters; 2- uniformly distributed; 3-immediatly upstream oi the site*)

Water Surface Elevation Estimates for Existing Structure:

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*)	-	-	-	-	-
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

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

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft³/ sec*): -

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

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

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

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (*ft²*): -

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

Comments:
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 2.93 mi^2
Lake/pond/swamp area 0.01 mi^2
Watershed storage *(ST)* 0.3 %
Bridge site elevation 1620.7 ft
Headwater elevation 2808.4 ft
Main channel length 3.52 mi
10% channel length elevation 1732 ft
85% channel length elevation 2461 ft
Main channel slope *(S)* 275.96 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 chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

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

Comments: **NO CROSS SECTION INFORMATION**

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	
Feature	-	-	-	-	-	-	-	-	-	-	
Low chord elevation	-	-	-	-	-	-	-	-	-	-	
Bed elevation	-	-	-	-	-	-	-	-	-	-	
Low chord to bed	-	-	-	-	-	-	-	-	-	-	

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: RB Date: 10/07/96
Computerized by: RB Date: 10/08/96
Reviewd by: EW Date: 2/20/98

Structure Number WSTOTH00070027

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* E. WILD Date *(MM/DD/YY)* 08 / 20 / 1996

2. Highway District Number 02 Mile marker 0000

County WINDSOR (027) Town WESTON (82000)

Waterway *(I - 6)* JENNY COOLIDGE BROOK Road Name -

Route Number TH007 Hydrologic Unit Code: 01080107

3. Descriptive comments:

Located at the junction with CL3 TH16. The bridge is a single span steel beam type with a concrete deck and an asphalt roadway surface. Both of the abutments are characterized as concrete skeleton.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 4 RBDS 4 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 52 *(feet)* Span length 50 *(feet)* Bridge width 22 *(feet)*

Road approach to bridge:

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

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

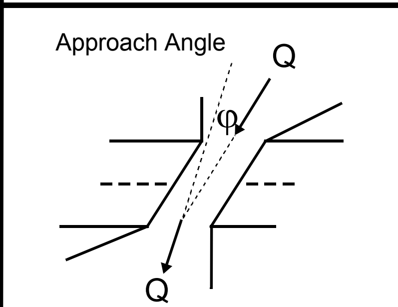
10. Embankment slope (*run / rise in feet / foot*):
US left 2.1:1 US right 2.6:1

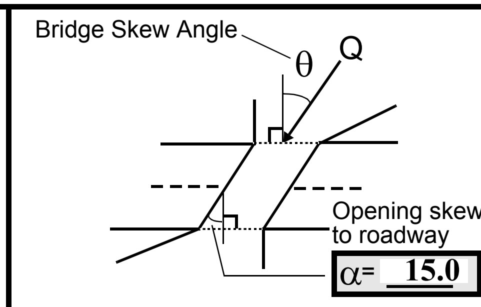
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	0	-	2	1
RBDS	2	1	0	-
LBDS	1	1	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: 0 16. Bridge skew: 3





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 2
Range? 104 feet US *(US, UB, DS)* to 76 feet US

Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 10 feet DS *(US, UB, DS)* to 100 feet DS

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

18. Bridge Type: **2**

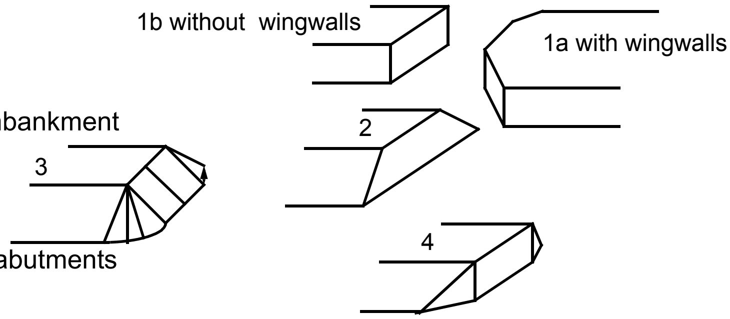
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4. TH16 runs along the US left bank. A house and grass area are beyond the forest along the stream on the right bank US. There are houses and lawns on both the left and right banks DS of the bridge.
7. Values are from the VT AOT files. Measured bridge length is 51.5 ft between the backs of the abutments, bridge span is 46.2 ft between the insides of the abutments and bridge width is 21.9 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
34.0	**8.0**			**7.0**	**3**	**3**	**234**	**54**	**1**	**1**

23. Bank width **15.0** 24. Channel width **35.0** 25. Thalweg depth **52.5** 29. Bed Material **543**

30 .Bank protection type: LB **2** RB **5** 31. Bank protection condition: LB **1** 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.):

30. The right bank protection is a stone wall extending from the end of the US right wingwall at 7 ft US to 13 ft US. The left bank protection is stone fill which extends from 71 ft US to 23 ft DS continuously.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **3** 35. Mid-bar width: **32**

36. Point bar extent: **103** feet **US** (US, UB) to **22** feet **DS** (US, UB, DS) positioned **35** %LB to **100** %RB

37. Material: **5432**

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

Point bar is boulder with cobble and gravel between. Under the bridge the point bar is mainly gravel with cobble and sand. Refer to the sketch for a clearer understanding of the stream morphology at this point near the bridge.

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: **96** 42. Cut bank extent: **156** feet **US** (US, UB) to **25** feet **US** (US, UB, DS)

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

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

Bank has been under cut and is slipping into the channel. Blocks of concrete and boulders have been placed where the cut bank is the worst.

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) 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
18.5		1.0		2	7	7	-

58. Bank width (BF) **-** 59. Channel width **-** 60. Thalweg depth **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.):

4352

55. The natural bank is protected on the left extensively under the left abutment. There is a point bar in front of the right bank and abutment.

61. The right and left abutments rest on the top of both banks, so the banks are seen during low flows.

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

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

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

70. Debris and Ice Comments:

2

Debris is accumulated along the left and right banks US.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	0	1	0	0	90.0
RABUT	1	0	90			0	1	28.5

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.):

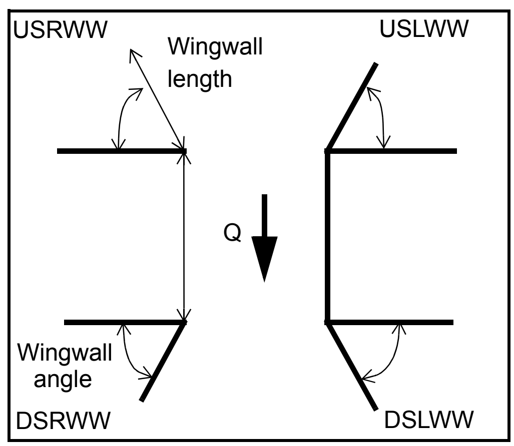
0
0
1

74. On the right abutment a range pole can be penetrated 2 ft. There are stacked cobbles in the void under the abutment from the bottom of the abutment to the bank underneath it. There is a 2 ft vertical void. On the left abutment, though protection is extensive, the left abutment can be penetrated about 1 ft. There is a 0.4 ft vertical void underneath the abutment.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						28.5	
USRWW:	Y		1		0	1.0	
DSLWW:	-		-		Y	29.0	
DSRWW:	1		1		0	29.5	

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



82. **Bank / Bridge Protection**:

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

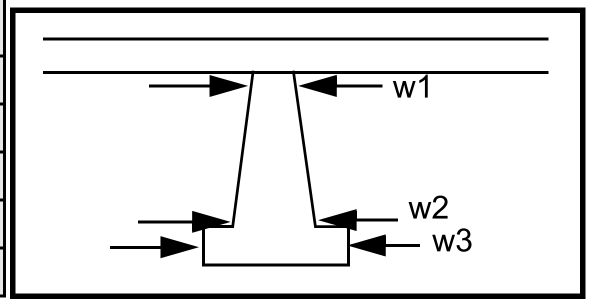
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				**30.0**	**30.0**	**60.0**
Pier 2				**14.0**	**60.0**	**11.0**
Pier 3			-	**30.0**	**25.0**	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**The**	**end 2**	**at the**		*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**US**	**ft.**	**DS**		*1- Solid pier, 2- column, 3- bent*
88. Material	**right**	**Ther**	**end**		*1- Wood; 2- concrete; 3- metal; 4- stone*
89. Shape	**wing**	**e is a**	**of**		*1- Round; 2- Square; 3- Pointed*
90. Inclined?	**wall**	**ver-**	**the**	**N**	*Y- yes; N- no*
91. Attack ∠ (BF)	**can**	**tical**	**wing**	-	
92. Pushed	**be**	**void**	**wall.**	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**pen-**	**of 1**		-	
95. Cross-members	**etrat**	**ft at**		-	*0- none; 1- laterals; 2- diagonals; 3- both*
96. Scour Condition	**ed at**	**this**		-	*0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed*
97. Scour depth	**the**	**loca-**		-	
98. Exposure depth	**DS**	**tion**		-	

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

E. Downstream Channel Assessment

100.

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

Bank width (BF) - Channel width - Thalweg depth - 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):
-
-
-
NO PIERS

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

Point bar extent: ______ feet ____ *(US, UB, DS)* to ______ feet ____ *(US, UB, DS)* positioned **1** %LB to **1** %RB

Material: **345**

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

345
1
1
543

Is a cut-bank present? **2** *(Y or if N type ctrl-n cb)* Where? **5** *(LB or RB)* Mid-bank distance: **1**

Cut bank extent: **1** feet **Th** *(US, UB, DS)* to **e left** feet **ba** *(US, UB, DS)*

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

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

protection extends from the DS bridge face to 23 ft DS. Also, there is type 2 protection on the left bank from 120 ft DS to 200 ft DS in good condition. The right bank protection is a stone levee extending from the DS end of the DS right wingwall to 120 ft DS. A foot bridge made of logs crosses the channel at 250 ft DS.

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

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

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

N

Are there major confluences? **-** *(Y or if N type ctrl-n mc)* How many? **NO**

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

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

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

Y
45
9.5
14
DS
107
DS
0
55
435
An additional point bar is from 101 ft. DS to 200 ft. DS. It is comprised of cobble, gravel and small brush.

109. G. Plan View Sketch

- It

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: WSTOTH00070027 Town: WESTON
Road Number: TH7 County: WINDSOR
Stream: JENNY COOLIDGE BROOK

Initials ECW Date: 2-13-98 Checked: MAI

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 Davis, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	640	1020	0
Main Channel Area, ft2	88	111	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	29	31	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.399	0.399	0.399
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	3.0	3.6	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	4370	6072	0
Conveyance, main channel	4370	6072	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	640.0	1020.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	7.3	9.2	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	10.2	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	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/(131*Dm^(2/3)*W2^2))^(3/7)   Converted to English Units
ys=y2-y_bridge
(Richardson and Davis, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	640	1020	0
(Q) discharge thru bridge, cfs	640	1020	0
Main channel conveyance	3388	5651	0
Total conveyance	3388	5651	0
Q2, bridge MC discharge,cfs	640	1020	ERR
Main channel area, ft2	73	104	0
Main channel width (normal), ft	20.1	22.8	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	20.1	22.8	0
y_bridge (avg. depth at br.), ft	3.63	4.56	ERR
Dm, median (1.25*D50), ft	0.49875	0.49875	0.49875
y2, depth in contraction,ft	2.93	3.92	ERR
ys, scour depth (y2-ybridge), ft	-0.70	-0.64	N/A

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)
(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	640	1020	N/A
Main channel area (DS), ft2	73	104	0
Main channel width (normal), ft	20.1	22.8	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	20.1	22.8	0.0
D90, ft	1.0305	1.0305	0.0000
D95, ft	1.2870	1.2870	0.0000
Dc, critical grain size, ft	0.5475	0.6092	ERR
Pc, Decimal percent coarser than Dc	0.342	0.289	0.000
Depth to armoring, ft	3.16	4.50	ERR

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and Davis, 1995, p. 48, eq. 28)

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	640	1020	0	640	1020	0
a', abut.length blocking flow, ft	1	0.2	0	7.6	7.6	0
Ae, area of blocked flow ft2	2.06	0.47	0	11.81	14.02	0
Qe, discharge blocked abut.,cfs	6.53	1.79	0	22.11	37.63	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.17	3.81	ERR	1.87	2.68	ERR
ya, depth of f/p flow, ft	2.06	2.35	ERR	1.55	1.84	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	0.389	0.438	ERR	0.265	0.348	ERR
ys, scour depth, ft	3.12	2.96	N/A	3.26	4.07	N/A

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and Davis, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	1	0.2	0	7.6	7.6	0
y1 (depth f/p flow, ft)	2.06	2.35	ERR	1.55	1.84	ERR
a'/y1	0.49	0.09	ERR	4.89	4.12	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.39	0.44	N/A	0.26	0.35	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 Davis, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	1	0	1	1	0
y, depth of flow in bridge, ft	3.63	4.56	0.00	3.63	4.56	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.)	1.52	1.91	ERR	1.52	1.91	ERR
Fr<=0.8 (spillthrough abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (spillthrough abut.)	1.34	1.69	ERR	1.34	1.69	ERR