LEVEL II SCOUR ANALYSIS FOR BRIDGE 25 (ROCHTH00400025) on TOWN HIGHWAY 40, crossing CORPORATION BROOK, ROCHESTER, VERMONT

Open-File Report 98-160

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 25 (ROCHTH00400025) on TOWN HIGHWAY 40, crossing CORPORATION BROOK, ROCHESTER, VERMONT

By EMILY C. WILD and MATTHEW A. WEBER

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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

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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	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 25 (ROCHTH00400025) ON TOWN HIGHWAY 40, CROSSING CORPORATION BROOK, ROCHESTER, VERMONT

By **Emily C. Wild and Matthew A. Weber**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure ROCHTH00400025 on Town Highway 40 crossing Corporation Brook, Rochester, 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, from Vermont Agency of Transportation files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Green Mountain section of the New England physiographic province in central Vermont. The 4.97-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest on the upstream left and right overbanks, and the downstream left overbank. On the downstream right overbank, the surface cover is predominately brushland.

In the study area, Corporation Brook has an incised, sinuous channel with a slope of approximately 0.04 ft/ft, an average channel top width of 37 ft and an average bank height of 6 ft. The channel bed material ranges from gravel to boulders with a median grain size (D_{50}) of 101 mm (0.332 ft). The geomorphic assessment at the time of the Level I site visit on April 12, 1995 and Level I and II site visit on July 8, 1996, indicated that the reach was stable.

The Town Highway 40 crossing of Corporation Brook is a 31-ft-long, one-lane bridge consisting of a 26-foot steel stringer span (Vermont Agency of Transportation, written communication, March 22, 1995). The opening length of the structure parallel to the bridge face is 24 ft. The bridge is supported by vertical, concrete abutments. The channel is skewed approximately 15 degrees to the opening while the opening-skew-to-roadway is 15 degrees.

A scour hole 1.0 ft deeper than the mean thalweg depth was observed in the channel at the downstream bridge face during the Level I assessment. Additionally, it was observed that the left abutment footing was exposed 1.0 ft and the right abutment footing was exposed 2.0 ft. Scour countermeasures at the site included type-1 stone fill (less than 12 inches diameter) along the upstream left and right banks and the downstream left bank. Type-2 stone fill (less than 36 inches diameter) scour protection extended along the downstream right bank and the upstream and downstream ends of the abutments. 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. In addition, the incipient roadway-overtopping discharge was determined and analyzed as another potential worst-case scour scenario. 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 0.1 to 1.5 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 6.5 to 7.0 ft. The worst-case left abutment scour occurred at the 500-year discharge. Right abutment scour ranged from 5.6 to 6.0 ft. The worst-case right abutment scour occurred at the incipient roadway-overtopping 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 ROCHTH00400025 ***Stream*** Corporation Brook

County Windsor ***Road*** TH 40 ***District*** 4

Description of Bridge

Bridge length 31 ***ft*** ***Bridge width*** 16.0 ***ft*** ***Max span length*** 26 ***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*** 4/12/95

Description of stone fill Type-2, along the upstream and downstream ends of the abutments.

Abutments are laid-up stone and faced with concrete. There is a one foot deep scour hole in the

channel at the downstream bridge face.

Yes

15

No

Is bridge skewed to flood flow according to Level I survey? ***Angle***

4/12/95

0

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***
	0	7/8/96	0
Level I	0	Moderat	e. There
Level II			

is some debris caught on the banks upstream and downstream of the

bridge.

Potential for debris

None, 4/12/95.

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

Description of the Geomorphic Setting

General topography The channel is located within a high relief valley with a narrow floodplain.

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

Date of inspection 4/12/95

DS left: Moderately sloped overbank

DS right: Steep valley wall

US left: Moderately sloped overbank

US right: Steep valley wall

Description of the Channel

Average top width 37 ***ft***   ***Average depth*** 6 ***ft***

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

The stream is perennial and sinuous with semi-alluvial, stable channel boundaries.

4/12/95

Vegetative co Trees

DS left: Brush and shrubs with a few trees

DS right: Trees

US left: Trees

US right: Yes

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

None, 4/12/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 4.97 ***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***:

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 1,680 ***ft³/s*** ***Q500*** 2,400 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(5.0/6.0)exp 0.67] with flood frequency estimates available from the VTAOT database (written communication, May 1995) for bridge number 16 in Rochester. The drainage area above bridge number 16 is 6.0 square miles. These area adjusted values were within 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 end of the right abutment (elev. 497.92 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the left abutment (elev. 499.27 ft, arbitrary survey datum). RM3 is a National Forest Service Land Survey Marker (elev. 506.83, arbitrary survey datum), located 150 feet upstream on the right bank.

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-26	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	10	1	Road Grade section
APPRO	44	2	Modelled Approach section (Templated from APTEM)
APTEM	48	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.055 to 0.065, and overbank "n" values ranged from 0.065 to 0.075.

Critical depth at the exit section (EXITX) was assumed as the starting water surface for each modelled discharge. Normal depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990) which resulted in a supercritical solution, but within 0.3 feet of critical depth. The slope used was 0.0400 ft/ft, which was calculated from thalweg points surveyed downstream.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0579 ft/ft) to establish the modelled approach section (APPRO), 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 incipient roadway-overtopping discharge, WSPRO assumed critical depth at the bridge section. A supercritical model was developed for this discharge. After analyzing the supercritical and subcritical profiles for the incipient-overtopping discharge, it was assumed that the water surface profile passes through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.5 ***ft***
Average low steel elevation 498.0 ***ft***

100-year discharge 1,680 ***ft^3/s***
Water-surface elevation in bridge opening 498.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 297 ***ft^3/s***
Area of flow in bridge opening 141 ***ft^2***
Average velocity in bridge opening 9.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 20.4 ***ft/s***

Water-surface elevation at Approach section with bridge 500.9
Water-surface elevation at Approach section without bridge 498.8
Amount of backwater caused by bridge 2.1 ***ft***

500-year discharge 2,400 ***ft^3/s***
Water-surface elevation in bridge opening 498.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 673 ***ft^3/s***
Area of flow in bridge opening 142 ***ft^2***
Average velocity in bridge opening 12.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 14.7 ***ft/s***

Water-surface elevation at Approach section with bridge 501.6
Water-surface elevation at Approach section without bridge 500.1
Amount of backwater caused by bridge 1.5 ***ft***

Incipient overtopping discharge 1,150 ***ft^3/s***
Water-surface elevation in bridge opening 496.1 ***ft***
Area of flow in bridge opening 98 ***ft^2***
Average velocity in bridge opening 11.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 14.9 ***ft/s***

Water-surface elevation at Approach section with bridge 499.0
Water-surface elevation at Approach section without bridge 497.7
Amount of backwater caused by bridge 1.3 ***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 incipient roadway-overtopping discharge was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). At this site, the 100-year discharge resulted in unsubmerged orifice flow and the 500-year discharge resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for these discharges was computed by use of the Chang equation (Richardson and Davis, 1995, p. 145-146). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the 100-year and 500-year discharges was computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). Contraction scour for the 100-year discharge was computed by substituting an estimate for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these computations are presented in appendix F.

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.

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	0.1	1.5	0.3
Depth to armoring	13.2	12.6	19.4
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	6.5 7.0	6.6 5.6	5.7
Left abutment	6.0–	---	---
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	2.1	2.5
Pier 3			

Riprap Sizing

	100-year discharge	*500-year discharge* *(D_{50} in feet)*	*Incipient overtopping discharge*
Abutments:	1.8	2.1	2.5
Left abutment	1.8	--	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--		
Pier 2			

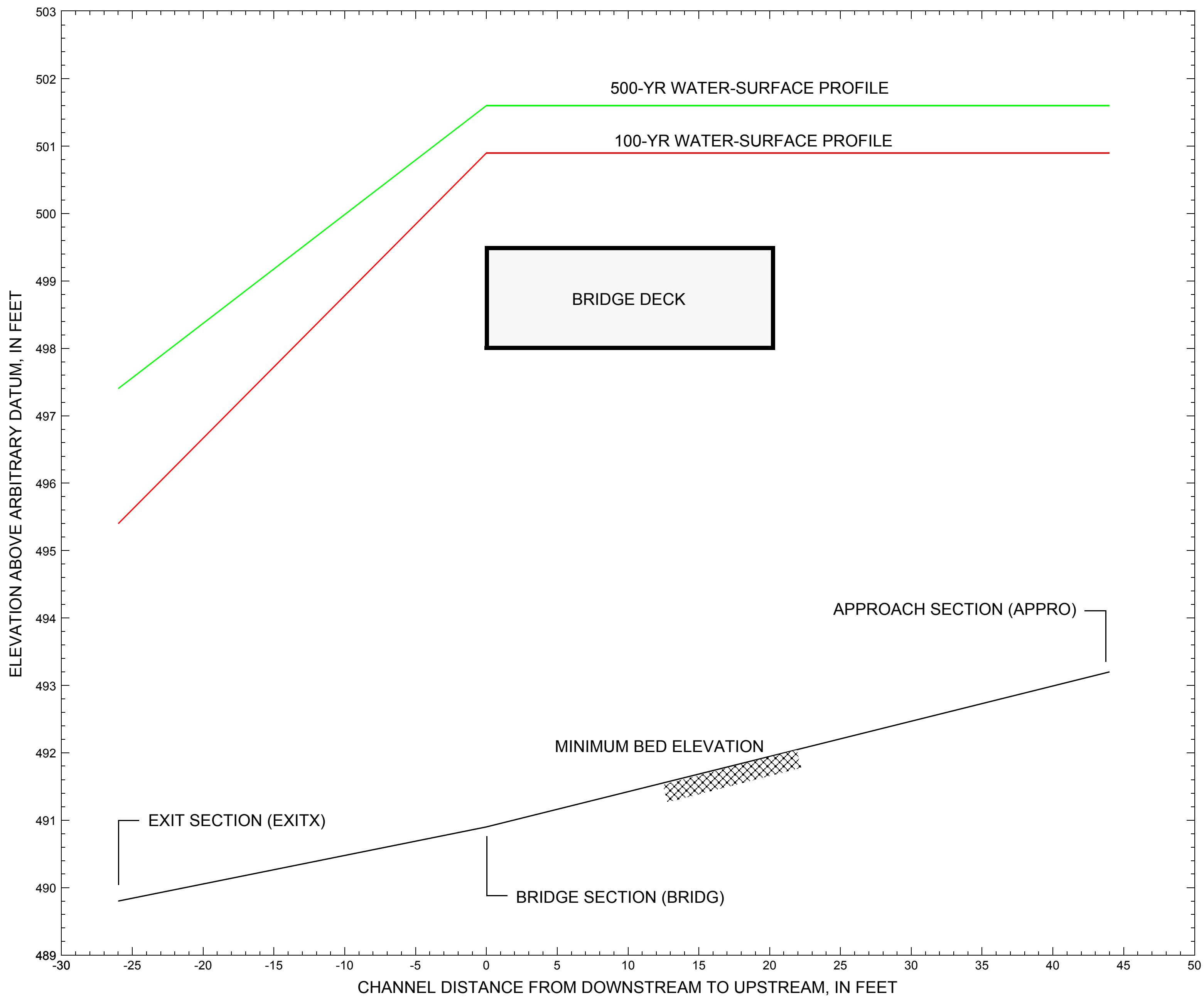

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure ROCHTH00400025 on Town Highway 40, crossing Corporation Brook, Rochester, Vermont.

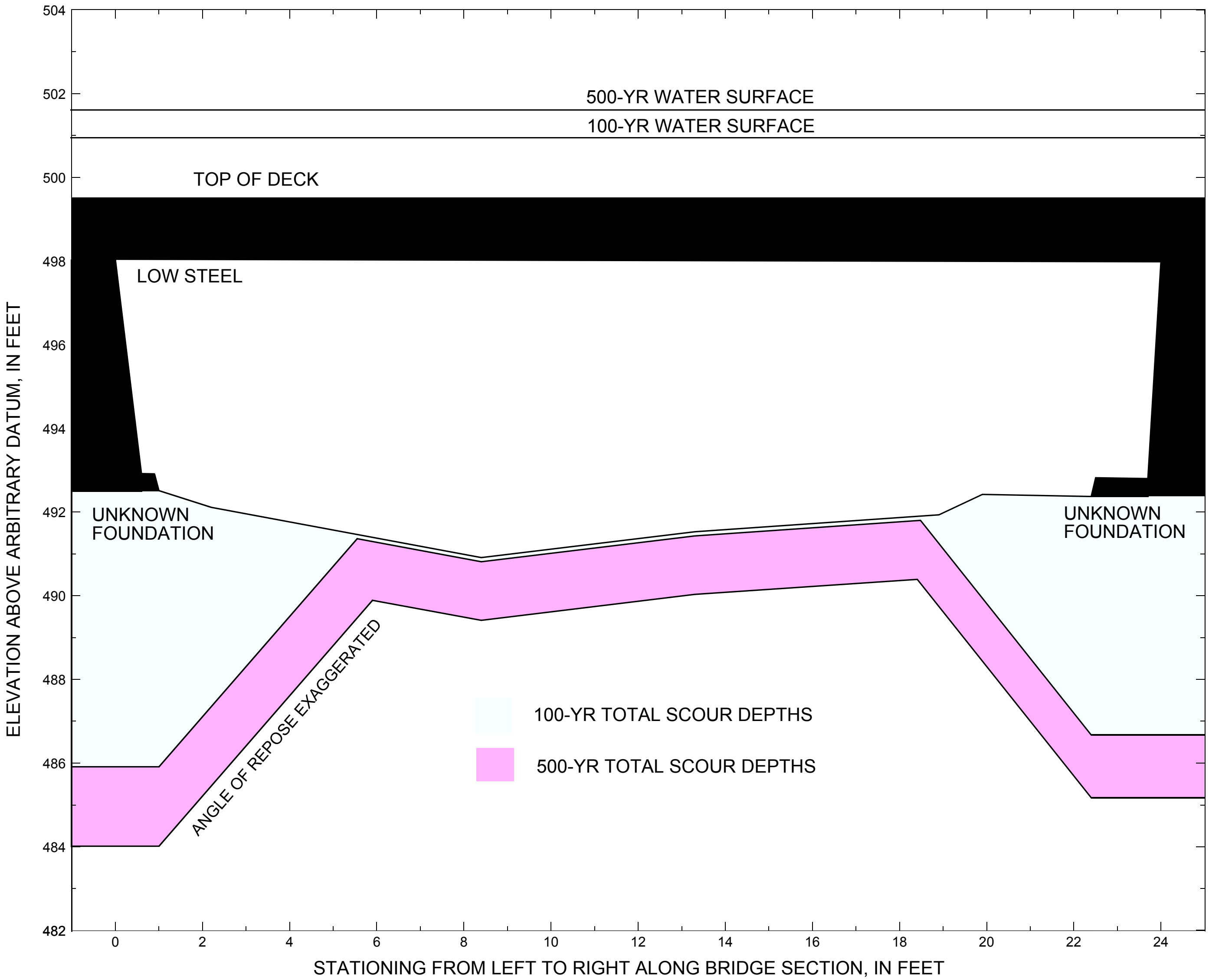

Figure 8. Scour elevations for the 100- and 500-yr discharges at structure ROCHTH00400025 on Town Highway 40, crossing Corporation Brook, Rochester, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-yr discharge at structure ROCHTH00400025 on Town Highway 40, crossing Corporation Brook, Rochester, 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-yr discharge is 1,680 cubic-feet per second											
Left abutment	0.0	--	498.0	--	492.5	0.1	6.5	--	6.6	485.9	--
Right abutment	24.0	--	498.0	--	492.4	0.1	5.6	--	5.7	486.7	--

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-yr discharge at structure ROCHTH00400025 on Town Highway 40, crossing Corporation Brook, Rochester, 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-yr discharge is 2,400 cubic-feet per second											
Left abutment	0.0	--	498.0	--	492.5	1.5	7.0	--	8.5	484.0	--
Right abutment	24.0	--	498.0	--	492.4	1.5	5.7	--	7.2	485.2	--

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, 1970, Rochester, 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 roch025.wsp
T2        Hydraulic analysis for structure ROCHTH00400025   Date: 27-OCT-97
T3        TH 40 CROSSING CORPORATION BROOK, ROCHESTER, VERMONT           ECW
*
J1         * * 0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1680.0   2400.0    1150.0
SK          0.0400   0.0400    0.0400
*
XS   EXITX    -26           0.
GR          -57.9, 502.03    -43.7, 495.79      0.0, 496.86      4.0, 494.08
GR            7.4, 491.31      9.9, 491.12     12.9, 490.06     21.1, 489.98
GR           27.7, 489.84     30.7, 491.17     36.1, 494.82     39.5, 497.44
GR           64.9, 496.81     81.8, 506.67     99.9, 510.92
*
* GR -28.0, 493.76    -10.1, 494.32
*
N           0.072        0.055        0.065
SA                  0.0         39.5
*
XS   FULLV      0  * * *   0.0040
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    498.01      15.0
GR            0.0, 498.04      0.6, 492.92      0.9, 492.91      1.0, 492.51
GR            2.2, 492.11      8.4, 490.91     13.3, 491.53     18.9, 491.93
GR           19.9, 492.42     22.4, 492.37     22.5, 492.82     23.7, 492.80
GR           24.0, 497.98      0.0, 498.04
*
*         BRTYPE  BRWDTH
CD           1      20.6
N           0.060
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     10      16.0     2
GR         -134.1, 508.35   -108.3, 506.86    -43.1, 502.11     -7.9, 500.27
GR            0.0, 499.50     23.8, 499.48     81.8, 506.67     99.9, 510.92
*
*   GR   83.6, 496.78
*
XT   APTEM     48
GR         -134.1, 508.35   -108.3, 506.86    -43.1, 502.11     -7.9, 500.27
GR           -4.3, 497.66      0.0, 494.12      8.9, 493.92     15.0, 493.54
GR           19.5, 493.44     22.4, 494.33     28.8, 498.88     42.9, 502.95
GR           81.8, 508.31     99.9, 516.55
*
AS   APPRO     44 * * * 0.0579
GT
N           0.075       0.065
SA                 -7.9
*
HP 1 BRIDG 498.01 1 498.01
HP 2 BRIDG 498.01 * * 1384
HP 1 BRIDG 496.99 1 496.99
HP 2 RDWAY 500.94 * * 297
HP 1 APPRO 500.94 1 500.94
HP 2 APPRO 500.94 * * 1680
*
HP 1 BRIDG 498.04 1 498.04
HP 2 BRIDG 498.04 * * 1728
HP 2 RDWAY 501.63 * * 673
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File roch025.wsp
        Hydraulic analysis for structure ROCHTH00400025   Date: 27-OCT-97
        TH 40 CROSSING CORPORATION BROOK, ROCHESTER, VERMONT            ECW
           *** RUN DATE & TIME: 01-30-98  11:10
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     141.    7507.    12.    45.                       2804.
   498.01          141.    7507.    12.    45.  1.00     0.    24.   2804.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.01     0.0    24.0   141.4    7507.    1384.   9.79

 X STA.         0.0         2.9         3.8         4.6         5.5         6.3
   A(I)             14.3         5.2         5.1         5.4         5.1
   V(I)             4.84       13.39       13.53       12.92       13.59

 X STA.         6.3         7.1         7.9         8.7         9.5        10.1
   A(I)              5.3         5.4         5.3         5.4         4.3
   V(I)            13.06       12.85       12.97       12.77       16.11

 X STA.        10.1        10.7        11.4        12.1        13.3        14.4
   A(I)              3.4         4.6         4.9         7.2         7.3
   V(I)            20.42       15.07       14.24        9.57        9.51

 X STA.        14.4        15.6        16.9        18.1        19.4        24.0
   A(I)              7.4         7.4         7.4         7.6        23.5
   V(I)             9.41        9.29        9.35        9.12        2.94

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     118.    7051.    23.    32.                       1517.
   496.99          118.    7051.    23.    32.  1.00     0.    24.   1517.
1
    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.94   -20.7    35.6    55.7    1513.     297.   5.33

 X STA.       -20.7        -3.7        -1.0         0.8         2.4         3.9
   A(I)              7.9         3.3         2.6         2.2         2.2
   V(I)             1.87        4.49        5.82        6.67        6.70

 X STA.         3.9         5.4         7.0         8.5        10.1        11.5
   A(I)              2.2         2.3         2.2         2.2         2.1
   V(I)             6.66        6.58        6.64        6.74        7.17

 X STA.        11.5        12.9        14.4        15.9        17.4        18.9
   A(I)              2.0         2.1         2.2         2.2         2.2
   V(I)             7.39        6.94        6.82        6.75        6.82

 X STA.        18.9        20.4        21.9        23.3        24.9        35.6
   A(I)              2.2         2.2         2.2         2.2         7.1
   V(I)             6.85        6.81        6.88        6.70        2.10

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1       8.      91.    17.    17.                         30.
             2     234.   15247.    45.    49.                       3035.
   500.94          241.   15338.    62.    66.  1.05   -25.    37.   2643.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.94   -25.1    36.7   241.5   15338.    1680.   6.96

 X STA.       -25.1        -1.2         0.5         1.8         3.1         4.5
   A(I)             30.8        10.9         9.4         9.5         9.5
   V(I)             2.73        7.71        8.95        8.81        8.82

 X STA.         4.5         5.8         7.1         8.4         9.8        11.1
   A(I)              9.6         9.5         9.6         9.8         9.3
   V(I)             8.73        8.86        8.76        8.54        9.00

 X STA.        11.1        12.3        13.5        14.7        15.9        17.1
   A(I)              9.1         9.1         9.0         9.0         9.0
   V(I)             9.28        9.18        9.31        9.28        9.38

 X STA.        17.1        18.2        19.4        20.5        21.8        36.7
   A(I)              8.8         9.0         9.0         9.4        42.1
   V(I)             9.57        9.34        9.34        8.92        1.99
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        U.S. Geological Survey WSPRO Input File roch025.wsp
        Hydraulic analysis for structure ROCHTH00400025   Date: 27-OCT-97
        TH 40 CROSSING CORPORATION BROOK, ROCHESTER, VERMONT             ECW
           *** RUN DATE & TIME: 01-30-98  11:10
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     142.    6460.     0.    57.                    6923261.
   498.04          142.    6460.     0.    57.  1.00     0.   24.6923261.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.04     0.0    24.0   141.6    6460.    1728.  12.20

X STA.         0.0         3.2         4.2         5.2         6.1         7.0
  A(I)             15.7         6.2         6.1         5.9         6.0
  V(I)             5.51       13.88       14.07       14.59       14.41

X STA.         7.0         7.9         8.8         9.7        10.5        11.5
  A(I)              5.9         5.9         6.0         5.9         6.0
  V(I)            14.64       14.74       14.50       14.62       14.42

X STA.        11.5        12.4        13.4        14.3        15.3        16.4
  A(I)              6.1         6.0         6.2         6.0         6.3
  V(I)            14.23       14.50       14.04       14.34       13.79

X STA.        16.4        17.4        18.4        19.5        20.8        24.0
  A(I)              6.1         6.1         6.6         6.7        16.1
  V(I)            14.18       14.16       13.17       12.92        5.37

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.63   -33.9    41.1   101.1    3352.     673.   6.66

X STA.       -33.9       -9.1        -4.7        -1.7         0.6         2.3
  A(I)             16.1         6.5         5.4         4.7         3.8
  V(I)             2.09        5.18        6.23        7.20        8.87

X STA.         2.3         4.1         5.9         7.7         9.5        11.2
  A(I)              3.8         3.8         3.8         3.8         3.5
  V(I)             8.81        8.84        8.75        8.75        9.60

X STA.        11.2        12.8        14.5        16.2        18.0        19.7
  A(I)              3.5         3.7         3.7         3.7         3.7
  V(I)             9.73        9.14        8.99        9.07        9.03

X STA.        19.7        21.4        23.2        25.0        27.2        41.1
  A(I)              3.7         3.7         3.7         4.2        12.0
  V(I)             9.08        9.02        9.00        7.99        2.80

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      24.     413.    30.    30.                        123.
             2     265.   18223.    47.    51.                       3576.
   501.63          290.   18636.    77.    82.  1.12   -38.    39.   3008.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.63   -38.3    39.1   289.6   18636.    2400.   8.29

X STA.       -38.3       -2.7        -0.5         1.0         2.4         3.8
  A(I)             42.6        14.2        11.5        10.7        11.2
  V(I)             2.81        8.44       10.46       11.27       10.68

X STA.         3.8         5.2         6.6         8.0         9.4        10.8
  A(I)             10.8        11.1        11.3        11.1        10.5
  V(I)            11.08       10.82       10.67       10.79       11.38

X STA.        10.8        12.0        13.3        14.5        15.8        17.0
  A(I)              9.9        10.7        10.2        10.5        10.2
  V(I)            12.08       11.24       11.76       11.48       11.78

X STA.        17.0        18.2        19.4        20.7        22.1        39.1
  A(I)             10.0        10.2        10.6        10.7        51.6
  V(I)            12.03       11.73       11.36       11.18        2.33
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        U.S. Geological Survey WSPRO Input File roch025.wsp
        Hydraulic analysis for structure ROCHTH00400025   Date: 27-OCT-97
        TH 40 CROSSING CORPORATION BROOK, ROCHESTER, VERMONT           ECW
           *** RUN DATE & TIME: 01-30-98  11:10
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW     REW     QCR
             1      98.    5360.    23.    30.                        1149.
   496.11           98.    5360.    23.    30.  1.00     0.     24.   1149.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.11     0.2    23.9    97.9    5360.    1150.  11.75

X STA.         0.2        3.6        4.6        5.5        6.4        7.2
  A(I)             11.8        4.2        4.1        3.9        4.0
  V(I)             4.87      13.75      13.87      14.73      14.44

X STA.         7.2        8.0        8.8        9.6       10.4       11.3
  A(I)              3.9        4.0        3.9        4.0        4.0
  V(I)            14.86      14.55      14.72      14.39      14.25

X STA.        11.3       12.1       13.0       14.0       14.9       15.8
  A(I)              3.9        4.1        4.1        4.0        4.0
  V(I)            14.66      14.10      14.19      14.25      14.29

X STA.        15.8       16.8       17.8       18.8       20.1       23.9
  A(I)              4.2        4.1        4.1        4.7       12.9
  V(I)            13.72      13.94      14.10      12.32       4.46

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW     REW     QCR
             2     155.    8773.    37.    40.                        1812.
   499.02          155.    8773.    37.    40.  1.00    -6.     30.   1812.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.02    -6.5    30.1   155.1    8773.    1150.   7.41

X STA.        -6.5        0.5        1.8        3.1        4.3        5.5
  A(I)             19.0        6.5        6.6        6.4        6.6
  V(I)             3.03       8.90       8.77       8.93       8.73

X STA.         5.5        6.8        8.0        9.2       10.4       11.6
  A(I)              6.5        6.4        6.5        6.5        6.6
  V(I)             8.87       9.00       8.88       8.89       8.76

X STA.        11.6       12.8       13.9       15.0       16.1       17.2
  A(I)              6.4        6.3        6.3        6.2        6.3
  V(I)             8.96       9.13       9.09       9.25       9.19

X STA.        17.2       18.2       19.3       20.4       21.6       30.1
  A(I)              6.1        6.3        6.3        6.5       21.0
  V(I)             9.38       9.14       9.16       8.85       2.74
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        U.S. Geological Survey WSPRO Input File roch025.wsp
        Hydraulic analysis for structure ROCHTH00400025   Date: 27-OCT-97
        TH 40 CROSSING CORPORATION BROOK, ROCHESTER, VERMONT            ECW
           *** RUN DATE & TIME: 01-30-98  11:10

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                          WSI,CRWS =   495.07     495.43
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******     2.     145.  2.10 *****  497.53  495.43   1680.  495.43
      -26. ******    37.    9546.  1.00 ***** *******    1.00   11.61

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80     0.90     496.99      495.53
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.93     511.02    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.93     511.02     495.53
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                          "FULLV"     KRATIO =  1.60

FULLV:FV      26.    -46.     225.  1.04  0.50  498.03  495.53   1680.  496.99
        0.    26.    65.   15273.  1.19  0.00    0.00    0.90    7.48
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.49     516.32    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.49     516.32     498.77
 ===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 =   498.77     516.32     498.77

APPRO:AS      44.     -6.     146.  2.06 *****  500.83  498.77   1680.  498.77
       44.    44.    29.    8120.  1.00 ***** *******    1.00   11.50
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
            WS1,WSSD,WS3,RGMIN =   500.81       0.00     497.36     499.48
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   503.67         0.      1680.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

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

BRIDG:BR      26.      0.     141.  1.49 *****  499.50  496.68   1384.  498.01
        0. ******    24.    7507.  1.00 ***** *******    0.71    9.79
     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    5.  0.491  0.000  498.01 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    28.  0.34  0.79  501.40    0.00    297.  500.94
             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    156.    32.   -21.    11.   1.5   0.9   5.4   5.4   1.4   3.1
   RT:    141.    24.    11.    36.   1.5   1.1   5.6   5.3   1.6   3.0

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

APPRO:AS      23.    -25.     242.  0.79  0.48  501.73  498.77   1680.  500.94
       44.    24.    37.   15348.  1.05  0.00    0.00    0.64    6.95
       M(G)   M(K)        KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ****** ********
                       <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -26.     2.    37.   1680.    9546.     145.   11.61  495.43
   FULLV:FV       0.   -46.    65.   1680.   15273.     225.    7.48  496.99
   BRIDG:BR       0.     0.    24.   1384.    7507.     141.    9.79  498.01
   RDWAY:RG      10.*******   156.    297.*****************    2.00  500.94
   APPRO:AS      44.   -25.    37.   1680.   15348.     242.    6.95  500.94

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

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS     495.43    1.00  489.84  510.92************  2.10  497.53  495.43
   FULLV:FV     495.53    0.90  489.94  511.02  0.50  0.00  1.04  498.03  496.99
   BRIDG:BR     496.68    0.71  490.91  498.04************  1.49  499.50  498.01
   RDWAY:RG  ***************  499.48  510.92  0.34******  0.79  501.40  500.94
   APPRO:AS     498.77    0.64  493.21  516.32  0.48  0.00  0.79  501.73  500.94
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        U.S. Geological Survey WSPRO Input File roch025.wsp
        Hydraulic analysis for structure ROCHTH00400025   Date: 27-OCT-97
        TH 40 CROSSING CORPORATION BROOK, ROCHESTER, VERMONT            ECW
           *** RUN DATE & TIME: 01-30-98  11:10

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                             WSI,CRWS =   496.13     497.35
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******   -47.     270.  1.61 *****  498.96  497.35   2400.  497.35
      -26. ******    66.   18059.  1.31 ***** *******    1.14    8.89
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "FULLV"     KRATIO =  1.42

FULLV:FV      26.   -49.     375.  0.91  0.32  499.28 *******   2400.  498.37
        0.    26.    67.   25560.  1.43  0.00   -0.01    0.75    6.40
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   497.87     516.32    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   497.87     516.32     500.05
 ===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 =   500.05     516.32     500.05

APPRO:AS      44.    -8.     195.  2.35 *****  502.40  500.05   2400.  500.05
       44.    44.    34.   11843.  1.00 ***** *******    1.00   12.28
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   498.37     498.01

            <<<<<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      26.     0.     142.  2.32 *****  500.36  497.47   1728.  498.04
        0. ******    24.    6460.  1.00 ***** *******    0.89   12.20

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  498.01 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    28.  0.46  1.19  502.36    0.00    673.  501.63

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    375.    45.   -34.    11.   2.1   1.2   6.3   6.7   2.0   3.0
   RT:    298.    30.    11.    41.   2.1   1.5   6.7   6.6   2.2   3.0

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

APPRO:AS      23.   -38.     289.  1.19  0.84  502.82  500.05   2400.  501.63
       44.    24.    39.   18624.  1.11  0.00    0.00    0.80    8.29

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ****** ********

                      <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -26.   -47.    66.   2400.   18059.     270.    8.89  497.35
   FULLV:FV       0.   -49.    67.   2400.   25560.     375.    6.40  498.37
   BRIDG:BR       0.     0.    24.   1728.    6460.     142.   12.20  498.04
   RDWAY:RG      10.*******   375.    673.*****************    2.00  501.63
   APPRO:AS      44.   -38.    39.   2400.   18624.     289.    8.29  501.63

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    497.35    1.14  489.84  510.92************  1.61  498.96  497.35
   FULLV:FV  ********    0.75  489.94  511.02  0.32  0.00  0.91  499.28  498.37
   BRIDG:BR    497.47    0.89  490.91  498.04************  2.32  500.36  498.04
   RDWAY:RG  ***************  499.48  510.92  0.46******  1.19  502.36  501.63
   APPRO:AS    500.05    0.80  493.21  516.32  0.84  0.00  1.19  502.82  501.63
```
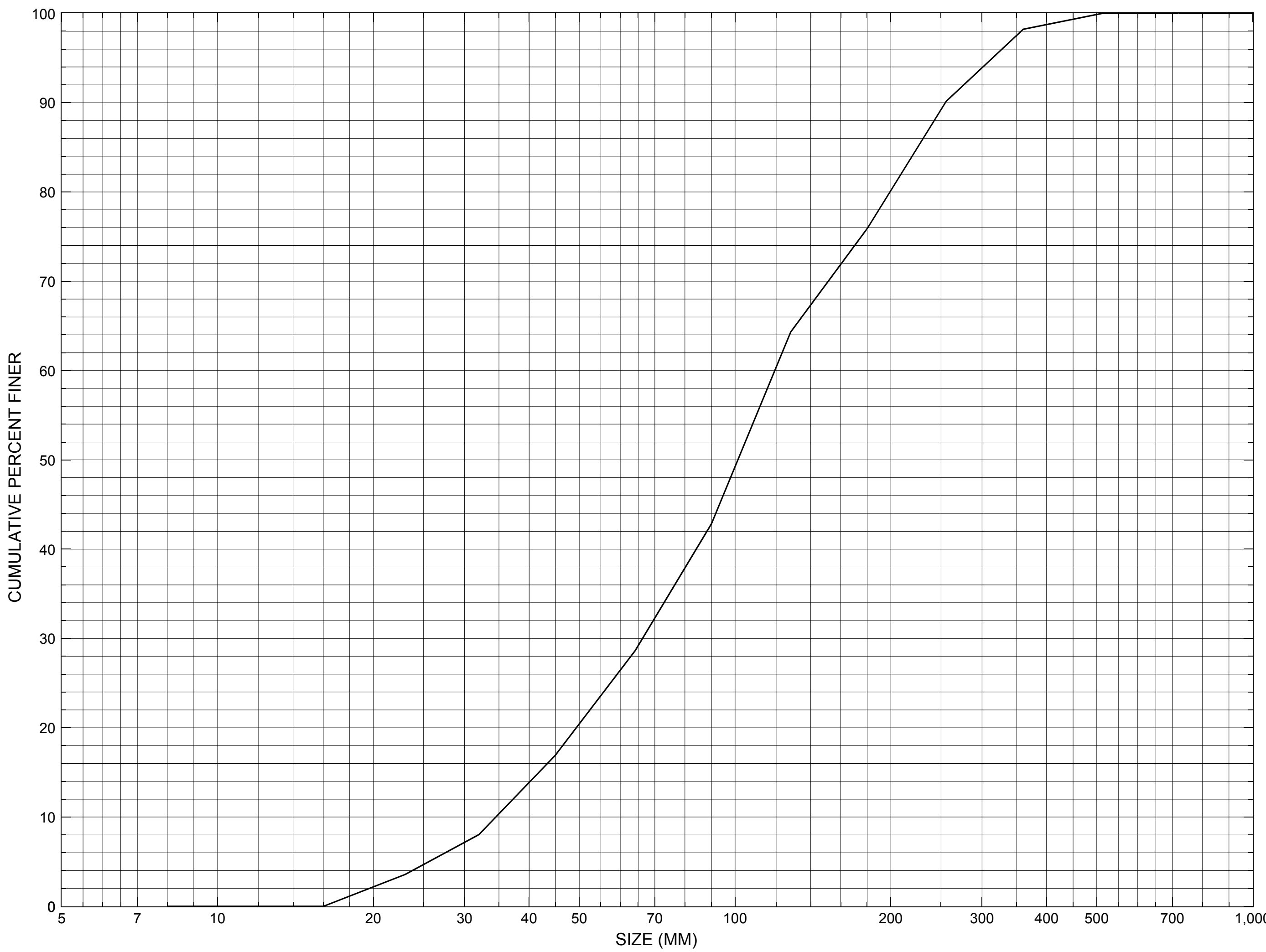

```
        U.S. Geological Survey WSPRO Input File roch025.wsp
        Hydraulic analysis for structure ROCHTH00400025   Date: 27-OCT-97
        TH 40 CROSSING CORPORATION BROOK, ROCHESTER, VERMONT            ECW
           *** RUN DATE & TIME: 01-30-98  11:10

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                            WSI,CRWS =   494.12     494.39

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

EXITX:XS   ******     4.     110.  1.71 *****  496.09  494.39   1150.  494.39
      -26. ******    35.    6442.  1.00 ***** *******    1.00   10.48

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "FULLV"     KRATIO =  1.56

FULLV:FV      26.     2.     150.  0.91  0.53  496.61 *******   1150.  495.69
        0.    26.    37.   10076.  1.00  0.00   -0.02    0.65    7.65
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.19     516.32    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.19     516.32     497.69
 ===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 =   497.69     516.32     497.69

APPRO:AS      44.    -5.     110.  1.71 *****  499.40  497.69   1150.  497.69
       44.    44.    27.    5417.  1.00 ***** *******    1.00   10.48
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   496.11     498.36     499.02     498.01
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   499.79      1142.         0.
 ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.
 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    1150.     496.11

             <<<<<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      26.     0.      98.  2.15 *****  498.26  496.11   1150.  496.11
        0.    26.    24.    5361.  1.00 ***** *******    1.00   11.75
     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  498.01 ****** ****** ******

   XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
  RDWAY:RG      10.        <<<<<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      23.    -6.     155.  0.85  0.67  499.88  497.69   1150.  499.02
       44.    24.    30.    8778.  1.00  0.95    0.00    0.63    7.41

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.265  0.011     8686.     1.    25.   498.54
                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.
   XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
  EXITX:XS     -26.     4.    35.   1150.    6442.     110.   10.48  494.39
  FULLV:FV       0.     2.    37.   1150.   10076.     150.    7.65  495.69
  BRIDG:BR       0.     0.    24.   1150.    5361.      98.   11.75  496.11
  RDWAY:RG      10.**************      0.       0.       0.    2.00********
  APPRO:AS      44.    -6.    30.   1150.    8778.     155.    7.41  499.02

   XSID:CODE   XLKQ   XRKQ       KQ
  APPRO:AS       1.    25.    8686.

 SECOND USER DEFINED TABLE.
   XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
  EXITX:XS    494.39    1.00  489.84  510.92************  1.71  496.09  494.39
  FULLV:FV  ********    0.65  489.94  511.02  0.53  0.00  0.91  496.61  495.69
  BRIDG:BR    496.11    1.00  490.91  498.04************  2.15  498.26  496.11
  RDWAY:RG ****************  499.48  510.92************  0.60  500.09********
  APPRO:AS    497.69    0.63  493.21  516.32  0.67  0.95  0.85  499.88  499.02
  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 ROCHTH00400025, in Rochester, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number **ROCHTH00400025**

General Location Descriptive

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

Date *(MM/DD/YY)* **03** / **22** / **95**

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

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

Town *(FIPS place code; I - 4; nnnnn)* **60100**

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

Waterway *(I - 6)* **CORPORATION BROOK**

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

Route Number **TH040**

Vicinity *(I - 9)* **0.3 MI JCT TH 40 + VT 73**

Topographic Map **Rochester**

Hydrologic Unit Code: **01080105**

Latitude *(I - 16; nnnn.n)* **43507**

Longitude *(i - 17; nnnnn.n)* **72510**

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* **10141500251415**

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

Maximum span length *(I - 48; nnnn)* **0026**

Year built *(I - 27; YYYY)* **1930**

Structure length *(I - 49; nnnnnn)* **000031**

Average daily traffic, ADT *(I - 29; nnnnnn)* **000100**

Deck Width *(I - 52; nn.n)* **160**

Year of ADT *(I - 30; YY)* **94**

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

Opening skew to Roadway *(I - 34; nn)* **15**

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

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

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

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

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

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

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

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

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

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

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

Comments:

The structural inspection report of 7/2/93 indicates the structure is a single span, steel stringer type bridge with a timber deck. The report indicates the abutments apparently are concrete faced, "laid-up" stone walls. There are some voids reported in the concrete facing along the bottom at the upstream end of the right abutment wall. The abutment walls have concrete footings. These footings are noted as not appearing to be undermined or settled. The waterway makes a slight bend into the crossing, reportedly. The report notes that the streambed consists of mainly stone and gravel with some randomly distributed boulders. There is stonefill reported as native cobbles and boulders on the abutments. **(Continued, page 33)**

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*): U *If No or Unknown, type ctrl-n os*

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

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

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

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

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

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

Comments:

Only minor channel scour is noted. Bank erosion is noted as typical for a mountain stream. Debris is noted as not evident.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 4.972 mi^2

Lake/pond/swamp area 0 mi^2

Watershed storage *(ST)* 0 %

Bridge site elevation 1010 ft

Headwater elevation 3342 ft

Main channel length 3.47 mi

10% channel length elevation 1110 ft

85% channel length elevation 2520 ft

Main channel slope *(S)* 541.79 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: 09/30/96
Computerized by: RB Date: 09/30/96
Reviewd by: EW Date: 2/10/98

Structure Number ROCHTH00400025

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* M. WEBER Date *(MM/DD/YY)* 04 / 12 / 1995

2. Highway District Number 04 Mile marker 0000
County WINDSOR (027) Town ROCHESTER (60100)
Waterway *(I - 6)* CORPORATION BROOK Road Name CORPORATION ROAD
Route Number TH040 Hydrologic Unit Code: 01080105

3. Descriptive comments:
Located 0.3 miles from the junction of TH 40 and VT 73.

B. Bridge Deck Observations

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

5. Ambient water surface... US 2 UB 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 31 *(feet)* Span length 26 *(feet)* Bridge width 16 *(feet)*

Road approach to bridge:

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

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

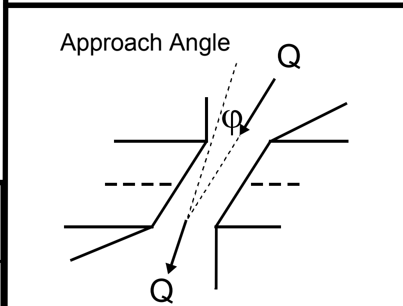
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

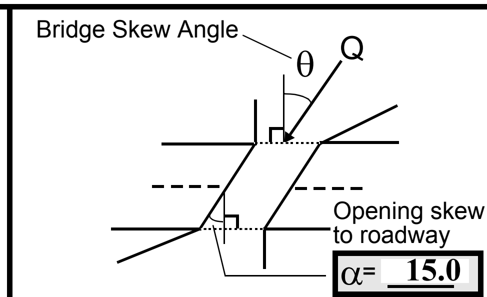
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	1	2	1
RBUS	2	1	0	-
RBDS	3	1	0	-
LBDS	2	1	0	-

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

Channel approach to bridge (BF):

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





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 0
Range? 30 feet US *(US, UB, DS)* to 70 feet US

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

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

18. Bridge Type: **1b**

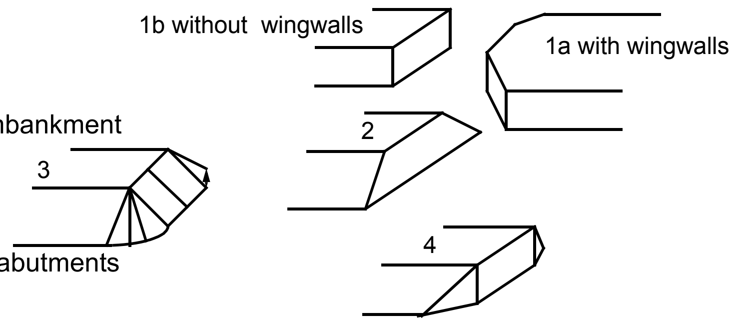
1a- Vertical abutments with wingwalls

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.)

7. Values are from the VTAOT files. Measured bridge length is 32.5 ft, span length is 24.5 ft and the bridge width is 16 ft. Lengths were measured at the downstream bridge face.
4. A few houses are visible from the deck but the predominant surface cover is forest. On the downstream right bank there is a clearing along with a dirt road and trees along the immediate bank.
11. The road approach protection is native channel material.
13. There is a small pool on the upstream left bank from road wash.

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
32.5	6.0			4.5	4	4	3	3	1	1

23. Bank width **35.0** 24. Channel width **30.0** 25. Thalweg depth **37.0** 29. Bed Material **345**

30 .Bank protection type: LB **1** RB **1** 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.):

27. Bank material is gravel, sand, cobbles and boulders.
29. Bed material is gravel, cobbles and boulders.
30. Natural streambed fill is on both banks from 0 ft US to 150 ft US.
The upstream left bank has a wide shelf that is marshy in some places.
There is a National Forest Service survey monument 120 ft US and 25 ft from the right edge of water on the right bank.

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? N (Y or if N type ctrl-n cb) 40. Where? - (LB or RB)

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

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

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

NO CUT BANKS

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
22.5		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.):

34

63. Bed material is mostly gravel and cobbles under the bridge, though there is a boulder riffle at the downstream bridge face.

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:

1

65. There are some branches and logs caught on the banks upstream and downstream.

68. Capture efficiency is moderate because at bank full the channel width under the bridge is about 75% of the width at 100 ft US and there is low deck clearance. There is also a high stream slope.

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		**-**	**90**	**0**	**2**	**0**	**1**	**90.0**
RABUT	**1**	**-**	**90**			**0**	**2**	**23.0**

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

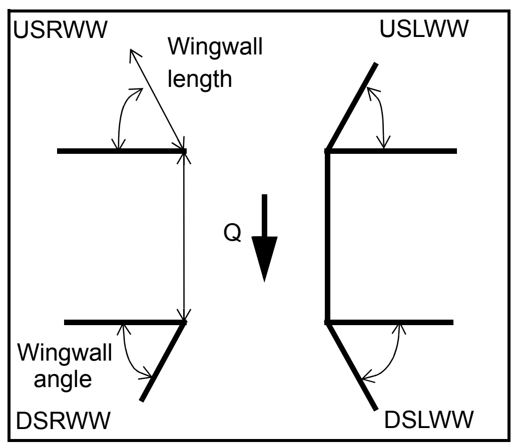
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0
2
1

The abutments are concrete faced, "laid-up" stone walls. At the downstream end of the right abutment footing, a wooden concrete form is visible. The maximum exposure depths are at the downstream end of the right abutment and at the upstream end of the left abutment. The footings are exposed the entire base length of both abutments.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**23.0**	
USRWW:	**N**		**-**		**-**	**1.5**	
DSLWW:	**-**		**-**		**N**	**20.5**	
DSRWW:	**-**		**-**		**-**	**20.5**	



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**	**-**	**-**	**-**	**-**	**-**	**4**	**4**
Extent	**-**	**-**	**-**	**-**	**-**	**2**	**2**	**-**

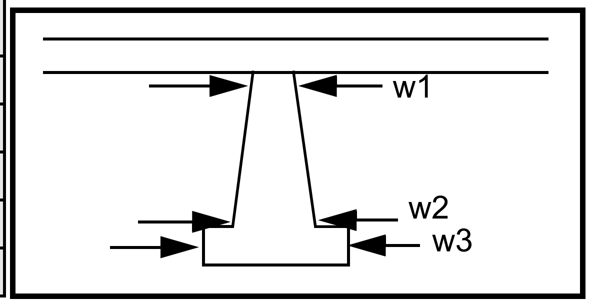
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? Th (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)	e abut-	nstrea	there	am	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	ment	m	are	ends	**1**- Solid pier, **2**- column, **3**- bent
88. Material	s are	ends.	also	of	**1**- Wood; **2**- concrete; **3**- metal; **4**- stone
89. Shape	pro-	In	some	the	**1**- Round; **2**- Square; **3**- Pointed
90. Inclined?	tecte	addi-	type-	abut	Y- yes; N- no
91. Attack ∠ (BF)	d	tion	3	ment	
92. Pushed	alon	to	boul-	s.	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	g the	type-	ders		
95. Cross-members	upst	2	at		**0**- none; **1**- laterals; **2**- diagonals; **3**- both
96. Scour Condition	ream	pro-	the		**0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed
97. Scour depth	and	tec-	dow		
98. Exposure depth	dow	tion,	nstre		

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

N
-
-
-
-
-

E. Downstream Channel Assessment

100.

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

Bank width (BF) -_____ Channel width -_____ 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):
-
-
-
-
-
-

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: NO

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

PIERS

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

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

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

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

3
3
0
0

Is channel scour present? 345 (Y or if N type ctrl-n cs) Mid-scour distance: 1

Scour dimensions: Length 2 Width 1 Depth: 1 Positioned The %LB to ban %RB

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

k material is gravel, sand, cobbles and boulders. The bed material is gravel, cobbles and boulders. The DS banks have been built up with native streambed material. Bank protection on the left bank extends to 60 ft DS and to 50 ft DS on the right bank. The road is parallel to the stream on the DS right bank. At 200 ft DS there is a trailer home on the right bank. The left and right banks are both shelved.

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

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

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

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

N

-

NO DROP STRUCTURE

N

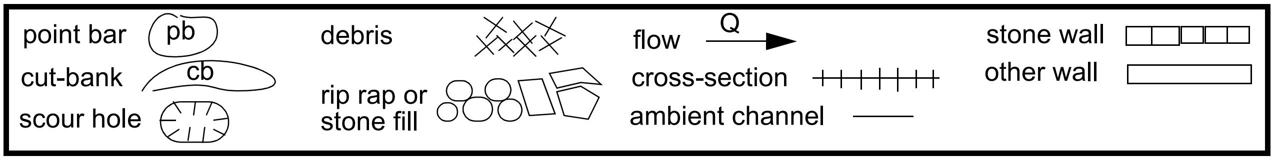
-

-

-

-

109. G. Plan View Sketch



APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: ROCHTH00400025 Town: ROCHESTER
Road Number: TH 40 County: WINDSOR
Stream: CORPORATION BROOK

Initials ECW Date: 1-23-98 Checked: EB

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	1680	2400	1150
Main Channel Area, ft2	234	265	155
Left overbank area, ft2	8	24	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	45	47	37
Top width L overbank, ft	17	30	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.332	0.332	0.332
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.2	5.6	4.2
y1, average depth, LOB, ft	0.5	0.8	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	15338	18636	8773
Conveyance, main channel	15247	18223	8773
Conveyance, LOB	91	413	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1670.0	2346.8	1150.0
Ql, discharge, LOB, cfs	10.0	53.2	0.0
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	7.1	8.9	7.4
Vl, mean velocity, LOB, ft/s	1.2	2.2	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	10.2	10.4	9.9
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	0
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 others, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	1680	2400	1150
(Q) discharge thru bridge, cfs	1384	1728	1150
Main channel conveyance	7507	6460	5360
Total conveyance	7507	6460	5360
Q2, bridge MC discharge,cfs	1384	1728	1150
Main channel area, ft2	141	142	98
Main channel width (normal), ft	23.2	23.2	22.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	23.2	23.2	22.9
y_bridge (avg. depth at br.), ft	6.08	6.12	4.28
Dm, median (1.25*D50), ft	0.415	0.415	0.415
y2, depth in contraction,ft	5.29	6.40	4.57
ys, scour depth (y2-ybridge), ft	-0.78	0.28	0.29

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	1384	1728	1150
Main channel area (DS), ft2	118	142	98
Main channel width (normal), ft	23.2	23.2	22.9
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	23.2	23.2	22.9
D90, ft	0.8362	0.8362	0.8362
D95, ft	1.0305	1.0305	1.0305
Dc, critical grain size, ft	0.7476	0.7399	0.8121
Pc, Decimal percent coarser than Dc	0.145	0.150	0.112
Depth to armoring, ft	13.18	12.62	19.35

Pressure Flow Scour (contraction scour for orifice flow conditions)

```
 Chang pressure flow equation        Hb+Ys=Cq*qbr/Vc
 Cq=1/Cf*Cc   Cf=1.5*Fr^0.43 (<=1)   Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
 Umbrell pressure flow equation
 (Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031
 (Richardson and other, 1995, p. 144-146)
```

	Q100	Q500	OtherQ
Q, total, cfs	1680	2400	1150
Q, thru bridge MC, cfs	1384	1728	1150
Vc, critical velocity, ft/s	10.22	10.36	9.86
Va, velocity MC approach, ft/s	7.14	8.86	7.42
Main channel width (normal), ft	23.2	23.2	22.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	23.2	23.2	22.9
qbr, unit discharge, ft2/s	59.7	74.5	50.2
Area of full opening, ft2	141.0	142.0	98.0
Hb, depth of full opening, ft	6.08	6.12	4.28
Fr, Froude number, bridge MC	0.71	0.89	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	118	N/A	N/A
**Hb, depth at downstream face, ft	5.09	N/A	N/A
**Fr, Froude number at DS face	0.92	ERR	ERR
**Cf, for downstream face (<=1.0)	1.00	N/A	N/A
Elevation of Low Steel, ft	498.01	498.01	0
Elevation of Bed, ft	491.93	491.89	-4.28
Elevation of Approach, ft	500.94	501.63	0
Friction loss, approach, ft	0.48	0.84	0
Elevation of WS immediately US, ft	500.46	500.79	0.00
ya, depth immediately US, ft	8.53	8.90	4.28
Mean elevation of deck, ft	499.5	499.5	0
w, depth of overflow, ft (>=0)	0.96	1.29	0.00
Cc, vert contrac correction (<=1.0)	0.95	0.95	1.00
**Cc, for downstream face (<=1.0)	0.895879	ERR	ERR
Ys, scour w/Chang equation, ft	0.10	1.48	N/A
Ys, scour w/Umbrell equation, ft	0.97	2.00	N/A

**=for UNsubmerged orifice flow using estimated downstream bridge face properties.

**Ys, scour w/Chang equation, ft	1.43	N/A	N/A

**Ys, scour w/Umbrell equation, ft	1.96	N/A	ERR

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	5.29	6.40	4.57
WSEL at downstream face, ft	496.99	--	--
Depth at downstream face, ft	5.09	N/A	N/A
Ys, depth of scour (Laursen), ft	0.21	N/A	N/A

Abutment Scour

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

	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	1680	2400	1150	1680	2400	1150
a', abut.length blocking flow, ft	25.5	38.7	7.1	13.1	15.5	6.6
Ae, area of blocked flow ft2	28.42	32.23	19.5	28.67	30.52	16.31
Qe, discharge blocked abut.,cfs	--	--	61.92	--	--	44.65
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.97	4.90	3.18	2.00	2.33	2.74
ya, depth of f/p flow, ft	1.11	0.83	2.75	2.19	1.97	2.47
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	75	75	75	105	105	105
K2	0.98	0.98	0.98	1.02	1.02	1.02
Fr, froude number f/p flow	0.552	0.673	0.338	0.209	0.235	0.307
ys, scour depth, ft	6.53	7.03	6.62	5.64	5.72	5.95

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)	25.5	38.7	7.1	13.1	15.5	6.6
y1 (depth f/p flow, ft)	1.11	0.83	2.75	2.19	1.97	2.47
a'/y1	22.88	46.47	2.59	5.99	7.87	2.67
Skew correction (p. 49, fig. 16)	0.95	0.95	0.95	1.03	1.03	1.03
Froude no. f/p flow	0.55	0.67	0.34	0.21	0.24	0.31
Ys w/ corr. factor K1/0.55:						
vertical	ERR	5.05	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	4.14	ERR	ERR	ERR	ERR
spill-through	ERR	2.78	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	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.92	0.89	1	0.92	0.89	1
y, depth of flow in bridge, ft	5.09	6.12	4.28	5.09	6.12	4.28
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	2.08	2.48	1.79	2.08	2.48	1.79