LEVEL II SCOUR ANALYSIS FOR BRIDGE 20 (BURKTH00560020) on TOWN HIGHWAY 56, crossing the EAST BRANCH PASSUMPSIC RIVER, BURKE, VERMONT

Open-File Report 98-555

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior

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By MICHELLE M. SERRA AND TIMOTHY SEVERANCE

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Pembroke, New Hampshire

1998

U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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 20 (BURKTH00560020) ON TOWN HIGHWAY 56, CROSSING THE EAST BRANCH PASSUMPSIC RIVER, BURKE, VERMONT

By **Michelle M. Serra and Timothy Severance**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BURKTH00560020 on Town Highway 56 crossing the East Branch Passumpsic River, Burke, 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 White Mountain section of the New England physiographic province in northeastern Vermont. The 51.0-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forested except for the left bank upstream and downstream of the bridge which also has some sections of lawn.

In the study area, the East Branch Passumpsic River has an incised, sinuous channel with a slope of approximately 0.004 ft/ft, an average channel top width of 53 ft and an average bank height of 3 ft. The channel bed material ranges from gravel to boulders with a median grain size (D_{50}) of 99.6 mm (0.327 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 15, 1995, indicated that the reach was stable.

The Town Highway 56 crossing of the East Branch Passumpsic River is a 46-ft-long, one-lane bridge consisting of one 44-foot steel-beam span (Vermont Agency of Transportation, written communication, March 24, 1995). The opening length of the structure parallel to the bridge face is 40.8 ft. The bridge is supported by vertical, concrete and laid-up stone abutments with wingwalls. The channel is skewed approximately 30 degrees to the opening while the computed opening-skew-to-roadway is 5 degrees.

During the Level I assessment, a scour hole 1.5 ft deeper than the mean thalweg depth was observed along the right side of the channel upstream. A scour hole 1.0 ft deeper than the mean thalweg depth was observed along the upstream end of the left abutment. A scour hole up to 3 ft deeper than the mean thalweg was observed close to the right bank, extending from under, to downstream of the bridge. Scour protection measures at the site consisted of type-3 stone fill (less than 48 inches diameter) at the upstream and downstream right wingwalls, the right abutment, and the right bank upstream and downstream. Type-2 stone fill (less than 36 inches diameter) had been placed at the upstream and downstream left wingwalls and along the upstream left bank. The downstream right bank has type-1 stone-fill (less than 12 inches diameter), as well as type-2 and type-3 stone-fill. 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 was 0 ft. Abutment scour ranged from 5.8 to 7.5 ft for the left abutment and from 10.7 to 14.5 ft for the right abutment. The worst-case abutment scour occurred at the 500-year discharge for the right abutment and at the 100-year discharge for the left abutment. 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.

West Burke, VT. Quadrangle, 1:24,000, 1988

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 BURKTH00560020 ***Stream*** East Branch Passumpsic River

County Caledonia ***Road*** TH 56 ***District*** 7

Description of Bridge

Bridge length 46 ***ft*** ***Bridge width*** 13.6 ***ft*** ***Max span length*** 44 ***ft***

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

Abutment type Concrete and laid-up stone ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 8/15/95

Description of stone fill There is type-3 protection on the upstream and downstream right wingwalls and right abutment, and type-2 protection on the upstream and downstream left wingwalls

Brief description of piers/abutments The right abutment and wingwalls are made of concrete, while the left abutment and wingwalls are stone masonry. There are scour holes at the upstream end of the left abutment and along the channel in front of the Rabut.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 30

There is a moderate channel bend in the upstream reach. A scour hole has developed in the location where the bend impacts the right bank and abutment.

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	8/15/95	0	0
Level II	8/15/95	0	0

Potential for debris The potential for debris is moderate. There is some debris both upstream and downstream of the bridge.

Describe any features near or at the bridge that may affect flow (include observation date) None as of 8/15/95.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley with narrow flood plains on the left bank and moderate to steeply sloping valley walls on the right bank.

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

Date of inspection 8/15/95

DS left: Moderately sloped channel bank to narrow flood plain

DS right: Steeply sloping channel bank to steep valley wall

US left: Mildly sloping channel bank to narrow flood plain

US right: Moderately sloping channel bank to steep valley wall

Description of the Channel

Average top width 53 ft ***Average depth*** 3 ft

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

Perennial but flashy

and sinuous with semi-alluvial channel boundaries and narrow point bars.

8/15/95

Vegetative co Trees and shrubs

DS left: Trees and some grass

DS right: Trees and brush

US left: Trees and shrubs

US right:

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

None as of 8/15/95

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 51.0 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

Is there a USGS gage on the stream of interest? Yes

USGS gage description East Branch Passumpsic River near East Haven, VT

USGS gage number 01133000

Gage drainage area 53.8 ***mi²***

Is there a lake/p No

-

Calculated Discharges

Q100 3,920 ***ft³/s*** ***Q500*** 5,430 ***ft³/s***

The 100- and 500-year discharges are based on the gaged discharges at the East Haven USGS gage. A log-Pearson Type III analysis of the peak discharges recorded at the East Haven gage was conducted for the period of record from 1948 - 1979 in accordance with the guidelines documented by the Interagency Advisory Committee on Water Data (1982). These 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 event.

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. 956.17 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the right abutment (elev. 956.29 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	-53	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPRO	58	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.060 to 0.065, and overbank "n" values ranged from 0.036 to 0.037.

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 0.0039 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1988).

Bridge Hydraulics Summary

Average bridge embankment elevation 955.9 ***ft***
Average low steel elevation 954.3 ***ft***

100-year discharge 3,920 ***ft³/s***
Water-surface elevation in bridge opening 951.6 ***ft***
Road overtopping? Yes ***Discharge over road*** 845 ***ft³/s***
Area of flow in bridge opening 323 ***ft²***
Average velocity in bridge opening 9.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.0 ***ft/s***

Water-surface elevation at Approach section with bridge 953.5
Water-surface elevation at Approach section without bridge 952.1
Amount of backwater caused by bridge 1.4 ***ft***

500-year discharge 5,430 ***ft³/s***
Water-surface elevation in bridge opening 953.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 2,200 ***ft³/s***
Area of flow in bridge opening 377 ***ft²***
Average velocity in bridge opening 8.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.8 ***ft/s***

Water-surface elevation at Approach section with bridge 954.5
Water-surface elevation at Approach section without bridge 952.9
Amount of backwater caused by bridge 1.6 ***ft***

Incipient overtopping discharge 2,260 ***ft³/s***
Water-surface elevation in bridge opening 950.3 ***ft***
Area of flow in bridge opening 270 ***ft²***
Average velocity in bridge opening 8.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.5 ***ft/s***

Water-surface elevation at Approach section with bridge 951.7
Water-surface elevation at Approach section without bridge 950.9
Amount of backwater caused by bridge 0.8 ***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, 500-year, and incipient roadway-overtopping discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). Variables for the live-bed contraction scour equation include the bottom width, depth, and discharge in the bridge opening and in the approach main channel, the shear velocity in the approach channel, and the fall velocity of the median-sized particles of the bed material.

Abutment scour for the right abutment 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.

Because the influence of scour processes on the stone-fill embankment material on the right abutment is uncertain, the scour depth at the vertical concrete abutment wall is unknown. Therefore, the total scour depths were applied for the entire embankment area below the elevation at the toe of each embankment, as shown in figure 8.

Scour at the left abutment was computed by use of the HIRE equation (Richardson and Davis, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

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	0.0
Depth to armoring	2.6 0.9	1.4	--
Left overbank	--	--	--
Right overbank	--	--	7.5 6.7

Local scour:			
Abutment scour	5.8	13.0	14.5
Left abutment	10.7–	---	---
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	2.0	1.7
Pier 3			

Riprap Sizing

	100-year discharge	*500-year discharge (D$_{50}$ in feet)*	*Incipient overtopping discharge*
Abutments:	1.4	2.0	1.7
Left abutment	1.4	--	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--		
Pier 2			

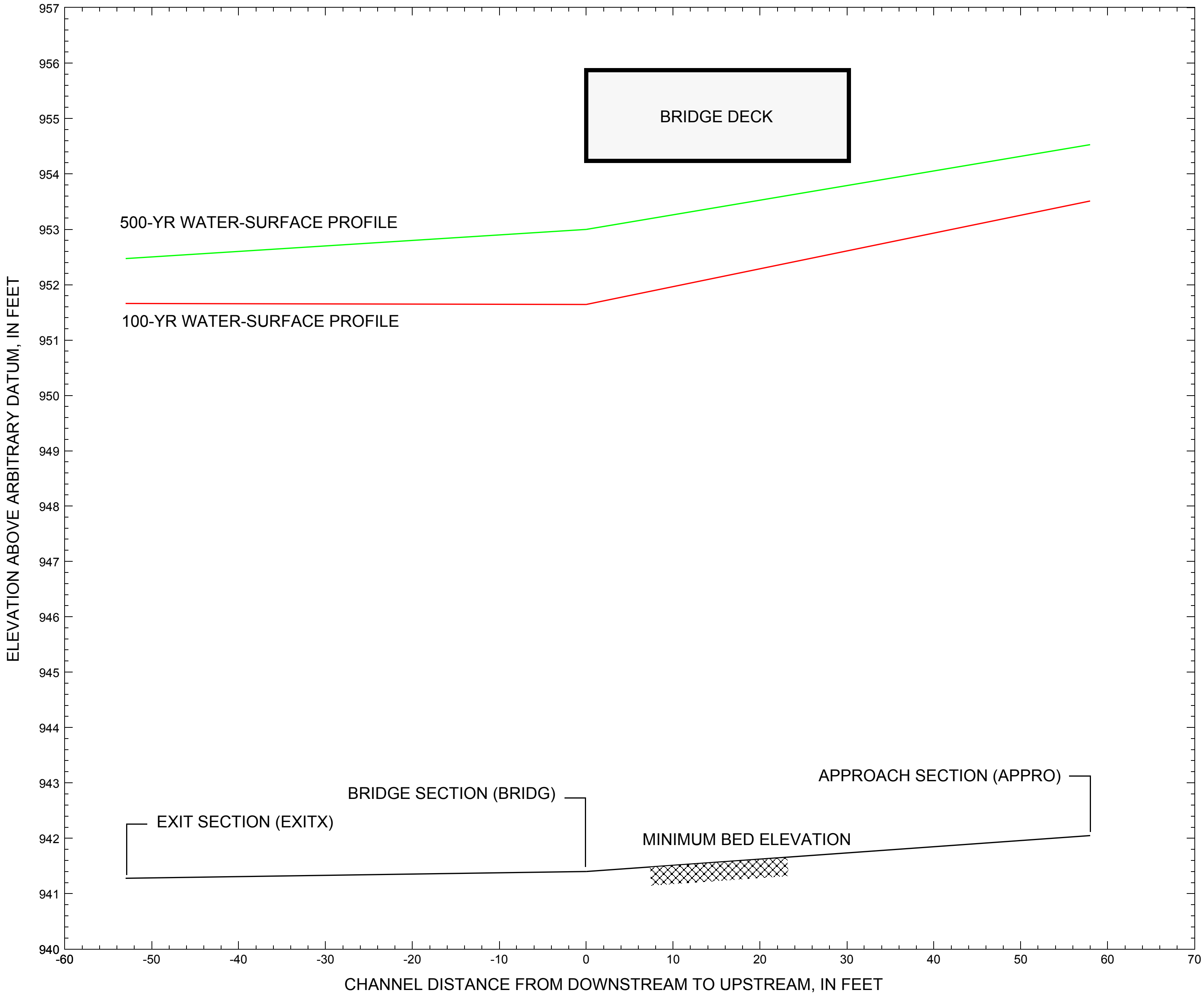

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure BURKTH00560020 on Town Highway 56, crossing the East Branch Passumpsic River, Burke, Vermont.

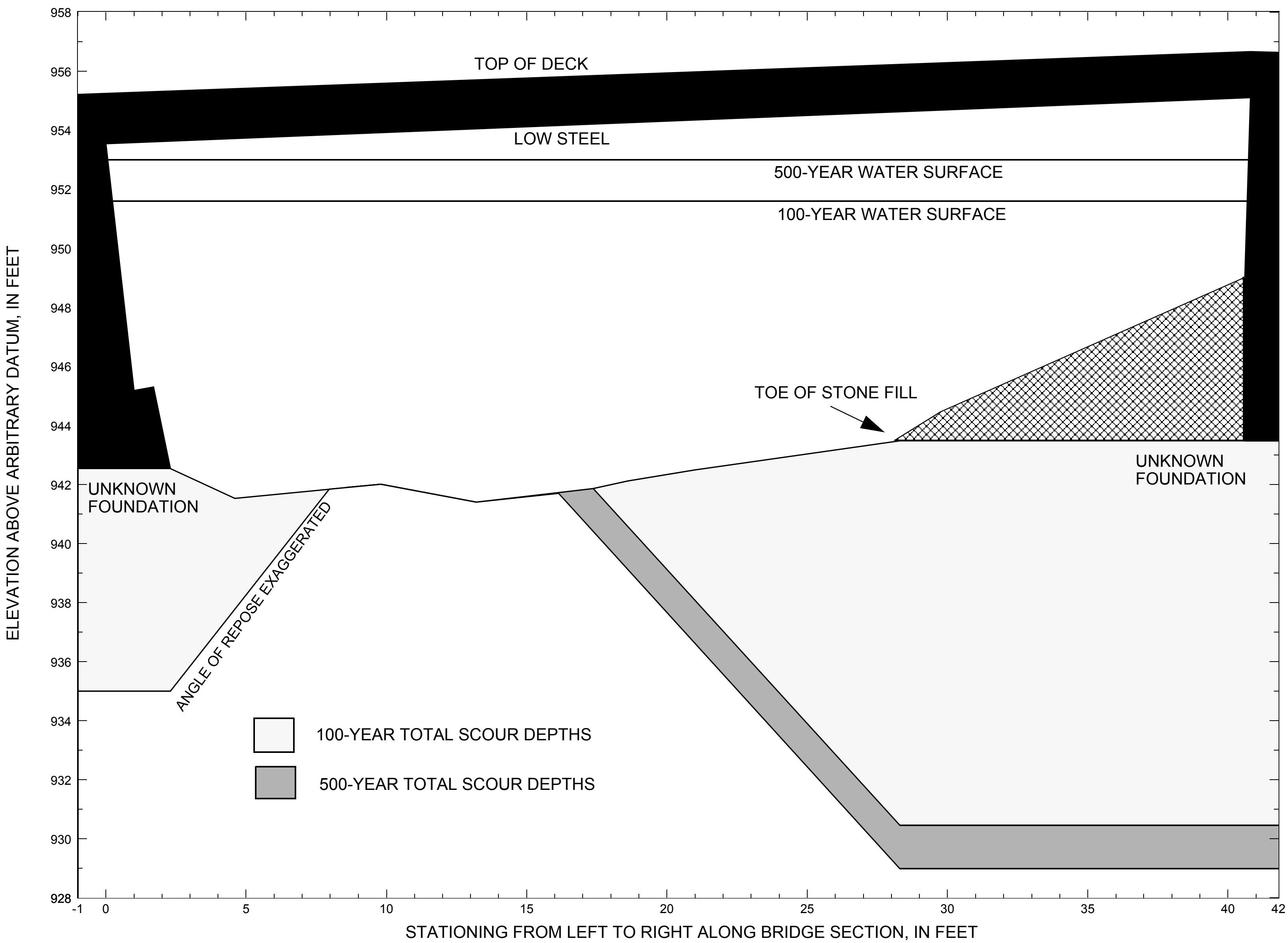

Figure 8. Scour elevations for the 100- and 500-year discharges at structure BURKTH00560020 on Town Highway 56, crossing the East Branch Passumpsic River, Burke, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BURKTH00560020 on Town Highway 56, crossing the East Branch Passumpsic River, Burke, 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[3] (feet)	Elevation of scour[2,3] (feet)	Remaining footing/pile depth (feet)
100-year discharge is 3,920 cubic-feet per second											
Left abutment	0.0	--	953.5	--	942.5	0.0	7.5	--	7.5	935.0	--
Toe of stone fill	28.3	--	--	--	943.5	0.0	13.0	--	13.0	--	--
Right abutment	40.8	--	955.1	--	949.0	--	--	--	--	930.5	--

1.Measured along the face of the most constricting side of the bridge.
2.Arbitrary datum for this study.
3.Depth of total scour is computed at the toe of stone-fill and elevation of scour pertains to the area between the toe of stone-fill and the right abutment

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure BURKTH00560020 on Town Highway 56, crossing the East Branch Passumpsic River, Burke, 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[3] (feet)	Elevation of scour[2,3] (feet)	Remaining footing/pile depth (feet)
500-year discharge is 5,430 cubic-feet per second											
Left abutment	0.0	--	953.5	--	942.5	0.0	6.7	--	6.7	935.8	--
Toe of stone fill	28.3	--	--	--	943.5	0.0	14.5	--	14.5	--	--
Right abutment	40.8	--	955.1	--	949.0	--	--	--	--	929.0	--

1.Measured along the face of the most constricting side of the bridge.
2.Arbitrary datum for this study.
3.Depth of total scour is computed at the toe of stone-fill and elevation of scour pertains to the area between the toe of stone-fill and the right abutment

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U.S. Geological Survey, 1988, West Burke, 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 burk020.wsp
T2        Hydraulic analysis for structure BURKTH00560020   Date: 19-AUG-97
T3        Hydraulic analysis of Bridge 20 in Burke over E. Br. of Passumpsic R.
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3920.0   5430.0   2260.0
SK          0.0039   0.0039   0.0039
*
XS   EXITX    -53           0.
GR         -330.7, 961.98   -317.3, 959.21   -285.6, 959.29   -254.2, 959.22
GR         -244.2, 957.69   -181.3, 950.51   -158.1, 950.40   -135.7, 949.20
GR          -97.6, 950.25    -53.6, 949.29    -11.6, 947.90     -5.2, 944.91
GR            0.0, 944.19      3.6, 943.73      9.8, 942.94     16.4, 942.17
GR           19.3, 941.65     21.9, 941.28     25.8, 942.20     31.7, 942.74
GR           34.1, 944.24     41.4, 947.52     75.0, 966.17
*
N           0.036        0.060
SA                 -11.6
*
XS   FULLV      0  * * *   0.0018
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    954.32       5.0
GR            0.0, 953.54      1.0, 945.18      1.7, 945.30      1.9, 944.40
GR            2.3, 942.54      4.6, 941.53      9.8, 942.01     13.2, 941.40
GR           16.2, 941.62     18.6, 942.12     21.0, 942.49     28.3, 943.48
GR           30.1, 944.42     40.6, 949.00     40.8, 955.10      0.0, 953.54
*
         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      24.1 * *     37.9     11.5
N          0.060
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      8      13.6     2
GR         -287.5, 959.09   -261.7, 955.22   -225.3, 953.56   -118.8, 951.78
GR          -90.9, 951.73    -73.6, 951.75    -34.1, 952.81      0.0, 955.24
GR           40.7, 956.66     48.0, 956.72     89.7, 958.05    124.6, 961.29
GR          137.0, 961.81
*
AS   APPRO     58           0.
GR         -287.5, 959.09   -276.0, 957.06
GR         -200.7, 954.54   -161.9, 953.23   -140.7, 951.42    -78.2, 951.19
GR          -51.7, 949.69    -13.5, 950.05     -8.8, 948.52     -3.4, 945.03
GR            0.0, 944.50      2.2, 944.03      6.1, 943.80     12.2, 943.39
GR           21.2, 942.85     22.9, 942.21     26.0, 942.07     28.8, 942.05
GR           34.0, 943.44     37.5, 944.42     42.5, 945.95     57.7, 948.71
GR           61.9, 953.01     72.8, 957.84     86.2, 960.23     93.8, 962.32
GR           98.6, 962.91    110.1, 963.22
*
N           0.037        0.065
SA                 -13.5
*
HP 1 BRIDG  951.64 1 951.64
HP 2 BRIDG  951.64 * * 3075
HP 2 RDWAY  953.33 * *  845
HP 1 APPRO  953.51 1 953.51
HP 2 APPRO  953.51 * * 3920
*
HP 1 BRIDG  952.97 1 952.97
HP 2 BRIDG  952.97 * * 3230
HP 2 RDWAY  954.24 * * 2200
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File burk020.wsp
        Hydraulic analysis for structure BURKTH00560020   Date: 19-AUG-97
        Hydraulic analysis of Bridge 20 in Burke over E. Br. of Passumpsic R.
           *** RUN DATE & TIME: 01-20-98  16:19
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      323     26902     40     52                         5182
   951.64           323     26902     40     52  1.00      0     41     5182

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       951.64     0.2    40.7   322.7   26902.    3075.   9.53

X STA.         0.2         4.3         6.2         7.8         9.2        10.7
  A(I)            31.0        18.1        15.8        14.4        14.2
  V(I)            4.96        8.48        9.74       10.69       10.85

X STA.        10.7        12.1        13.4        14.6        15.9        17.2
  A(I)            13.6        13.0        12.9        13.0        12.8
  V(I)           11.30       11.81       11.96       11.79       11.97

X STA.        17.2        18.6        20.0        21.5        23.0        24.7
  A(I)            13.0        13.5        13.4        13.8        14.2
  V(I)           11.79       11.37       11.47       11.15       10.84

X STA.        24.7        26.4        28.3        30.6        33.7        40.7
  A(I)            14.9        15.3        17.7        19.4        28.5
  V(I)           10.28       10.04        8.67        7.91        5.40

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.

         WSEL     LEW     REW    AREA        K        Q    VEL
       953.33  -211.5   -26.8   186.7    7780.     845.   4.53

X STA.      -211.5      -164.1      -150.1      -140.4      -132.5      -125.9
  A(I)            18.8        12.7        10.8         9.9         9.0
  V(I)            2.25        3.32        3.91        4.28        4.67

X STA.      -125.9      -120.2      -114.9      -109.9      -105.0      -100.1
  A(I)             8.5         8.1         7.9         7.6         7.7
  V(I)            4.98        5.20        5.32        5.54        5.51

X STA.      -100.1       -95.4       -90.7       -86.1       -81.4       -76.6
  A(I)             7.5         7.5         7.4         7.5         7.6
  V(I)            5.63        5.60        5.73        5.66        5.57

X STA.       -76.6       -71.7       -66.1       -59.2       -50.3       -26.8
  A(I)             7.7         8.1         8.8         9.6        13.8
  V(I)            5.50        5.21        4.78        4.39        3.05

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      385     28154    157    157                         3418
             2      620     55334     77     81                        10018
   953.51          1005     83488    233    238  1.03   -169     63    11682

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

         WSEL     LEW     REW    AREA        K        Q    VEL
       953.51  -170.2    63.0  1004.7   83488.    3920.   3.90

X STA.      -170.2      -114.5       -85.8       -63.1       -49.3       -36.3
  A(I)            82.2        64.3        59.0        49.3        48.4
  V(I)            2.38        3.05        3.32        3.98        4.05

X STA.       -36.3       -23.5        -8.3        -1.2         3.6         7.9
  A(I)            46.2        57.6        52.8        44.1        42.1
  V(I)            4.24        3.40        3.72        4.44        4.65

X STA.         7.9        12.0        15.9        19.8        23.4        26.9
  A(I)            40.9        39.4        40.6        39.4        39.6
  V(I)            4.79        4.97        4.82        4.97        4.94

X STA.        26.9        30.4        34.5        39.7        47.1        63.0
  A(I)            39.9        43.6        47.9        54.8        72.5
  V(I)            4.92        4.50        4.09        3.58        2.70
```

```
      U.S. Geological Survey WSPRO Input File burk020.wsp
      Hydraulic analysis for structure BURKTH00560020   Date: 19-AUG-97
      Hydraulic analysis of Bridge 20 in Burke over E. Br. of Passumpsic R.
         *** RUN DATE & TIME: 01-20-98  16:19
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      376     33644     41     55                         6512
 952.97           376     33644     41     55  1.00      0     41     6512

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     952.97     0.1    40.7   376.4   33644.    3230.   8.58

X STA.        0.1        4.4        6.3        7.9        9.5       11.0
  A(I)            37.3       21.2       18.5       17.3       16.6
  V(I)            4.33       7.62       8.75       9.36       9.73

X STA.       11.0       12.4       13.7       15.0       16.4       17.7
  A(I)            15.6       15.3       15.0       15.2       14.9
  V(I)           10.33      10.58      10.79      10.63      10.83

X STA.       17.7       19.1       20.6       22.1       23.6       25.3
  A(I)            15.2       15.4       15.5       16.0       16.5
  V(I)           10.61      10.51      10.40      10.09       9.78

X STA.       25.3       27.0       29.0       31.3       34.4       40.7
  A(I)            17.0       18.3       19.9       22.9       32.9
  V(I)            9.49       8.84       8.11       7.04       4.91

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.

       WSEL     LEW     REW    AREA        K        Q    VEL
     954.24  -240.2   -14.0   376.6   21892.    2200.   5.84

X STA.     -240.2     -194.4     -175.9     -162.4     -151.5     -142.1
  A(I)            34.1       25.0       21.8       19.8       18.8
  V(I)            3.22       4.41       5.04       5.56       5.85

X STA.     -142.1     -133.8     -126.3     -119.5     -113.1     -106.8
  A(I)            17.7       17.0       16.4       15.6       15.7
  V(I)            6.21       6.46       6.70       7.05       7.02

X STA.     -106.8     -100.6      -94.4      -88.3      -82.2      -75.9
  A(I)            15.4       15.5       15.2       15.4       15.7
  V(I)            7.13       7.10       7.24       7.14       7.02

X STA.      -75.9      -69.5      -62.2      -53.7      -42.7      -14.0
  A(I)            15.7       16.7       17.6       19.9       27.6
  V(I)            6.99       6.59       6.25       5.52       3.99

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      560     46809    187    187                         5497
           2      699     66242     79     83                        11821
 954.53          1259    113050    266    270  1.01   -199     65    15466

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

       WSEL     LEW     REW    AREA        K        Q    VEL
     954.53  -200.4    65.3  1259.1  113050.    5430.   4.31

X STA.     -200.4     -128.6     -105.2      -83.5      -64.9      -51.9
  A(I)           109.7       74.8       71.2       67.2       57.9
  V(I)            2.47       3.63       3.81       4.04       4.69

X STA.      -51.9      -40.2      -28.8      -16.9       -4.2        1.6
  A(I)            56.0       53.5       54.2       74.7       56.8
  V(I)            4.85       5.08       5.01       3.63       4.78

X STA.        1.6        6.6       11.4       15.9       20.4       24.5
  A(I)            53.3       51.5       51.5       51.5       49.8
  V(I)            5.10       5.27       5.27       5.27       5.46

X STA.       24.5       28.7       33.2       38.9       46.7       65.3
  A(I)            51.3       54.4       59.7       66.8       93.3
  V(I)            5.29       4.99       4.55       4.06       2.91
```

```
        U.S. Geological Survey WSPRO Input File burk020.wsp
        Hydraulic analysis for structure BURKTH00560020   Date: 19-AUG-97
        Hydraulic analysis of Bridge 20 in Burke over E. Br. of Passumpsic R.
           *** RUN DATE & TIME: 01-20-98  16:19
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      270     20733    40     50                         3985
   950.34           270     20733    40     50  1.00      0     41     3985

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       950.34     0.4    40.6   270.4   20733.    2260.   8.36

X STA.         0.4         4.3         6.0         7.5         8.9        10.3
  A(I)             25.0        15.2        12.8        12.1        11.8
  V(I)             4.52        7.46        8.81        9.37        9.57

X STA.        10.3        11.7        12.9        14.1        15.4        16.6
  A(I)             11.3        11.2        10.7        10.9        10.8
  V(I)            10.00       10.10       10.53       10.38       10.50

X STA.        16.6        17.9        19.3        20.7        22.2        23.8
  A(I)             11.0        11.3        11.2        11.9        11.9
  V(I)            10.27        9.97       10.09        9.47        9.51

X STA.        23.8        25.6        27.4        29.6        32.8        40.6
  A(I)             12.8        13.1        14.5        17.1        23.8
  V(I)             8.83        8.60        7.79        6.60        4.74

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      132      5370   131    131                          755
             2      486     37869    74     78                         7071
   951.73           619     43239   205    209  1.13   -143     61     5742

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

         WSEL     LEW     REW    AREA        K        Q    VEL
       951.73  -144.3    60.6   618.8   43239.    2260.   3.65

X STA.      -144.3       -48.0       -25.3        -5.4        -0.5         3.1
  A(I)             68.9        43.0        46.8        31.7        27.0
  V(I)             1.64        2.63        2.41        3.56        4.18

X STA.         3.1         6.4         9.5        12.4        15.2        18.0
  A(I)             26.0        24.7        24.1        23.9        23.6
  V(I)             4.34        4.57        4.69        4.73        4.79

X STA.        18.0        20.6        23.2        25.5        28.0        30.4
  A(I)             23.5        23.1        22.7        23.4        23.7
  V(I)             4.80        4.89        4.98        4.83        4.77

X STA.        30.4        33.3        36.7        41.1        47.3        60.6
  A(I)             25.5        26.9        30.5        34.0        45.6
  V(I)             4.43        4.19        3.71        3.33        2.48
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File burk020.wsp
        Hydraulic analysis for structure BURKTH00560020   Date: 19-AUG-97
        Hydraulic analysis of Bridge 20 in Burke over E. Br. of Passumpsic R.
           *** RUN DATE & TIME: 01-20-98  16:19

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

EXITX:XS   ******   -190      797  0.40 *****  952.06  950.39    3920  951.66
       -52 ******     49    62714  1.07 ***** *******    0.49    4.92

FULLV:FV       53   -192      831  0.36  0.19  952.27 *******    3920  951.90
         0     53     49    66651  1.05  0.00    0.01    0.46    4.72
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       58   -147      687  0.56  0.27  952.62 *******    3920  952.06
        58     58     61    49421  1.10  0.10   -0.01    0.58    5.70
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   954.43       0.00     950.95     951.73

 ===260 ATTEMPTING FLOW CLASS 4 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       53      0      323  1.59  0.38  953.22  949.27    3075  951.64
         0     53     41    26896  1.12  0.78    0.00    0.63    9.53

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.944 ******  954.32 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    44.  0.10  0.24  953.65    0.00    845.  953.33

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    845.   185.  -211.   -27.   1.6   1.0   5.2   4.5   1.3   3.0
   RT:      0.    20.    17.    38.   0.7   0.4   5.0  12.4   1.3   2.9

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

APPRO:AS       34   -169     1004  0.24  0.21  953.75  949.48    3920  953.51
        58     38     63    83367  1.03  0.32    0.00    0.34    3.91

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.806  0.471   44085.    -1.    40. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -53.  -191.    49.   3920.   62714.     797.    4.92  951.66
   FULLV:FV       0.  -193.    49.   3920.   66651.     831.    4.72  951.90
   BRIDG:BR       0.     0.    41.   3075.   26896.     323.    9.53  951.64
   RDWAY:RG       8.*******   845.    845.*********       0.    2.00  953.33
   APPRO:AS      58.  -170.    63.   3920.   83367.    1004.    3.91  953.51

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -1.    40.   44085.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    950.39    0.49  941.28  966.17************  0.40  952.06  951.66
   FULLV:FV  ********    0.46  941.38  966.27  0.19  0.00  0.36  952.27  951.90
   BRIDG:BR    949.27    0.63  941.40  955.10  0.38  0.78  1.59  953.22  951.64
   RDWAY:RG  ****************  951.73  961.81  0.10******  0.24  953.65  953.33
   APPRO:AS    949.48    0.34  942.05  963.22  0.21  0.32  0.24  953.75  953.51
```

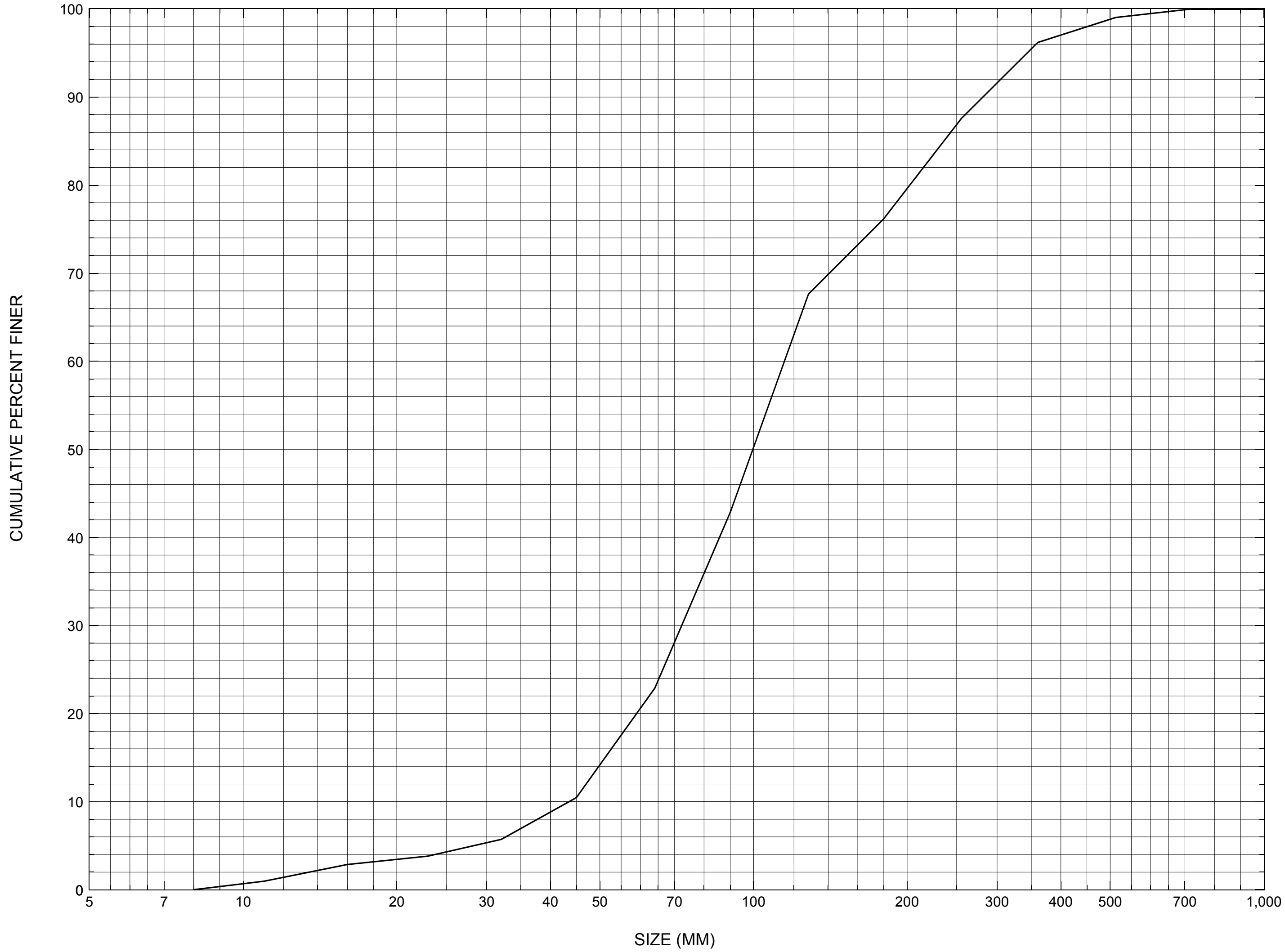
WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File burk020.wsp
        Hydraulic analysis for structure BURKTH00560020   Date: 19-AUG-97
        Hydraulic analysis of Bridge 20 in Burke over E. Br. of Passumpsic R.
           *** RUN DATE & TIME: 01-20-98  16:19

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

EXITX:XS   ******   -197      994  0.47 *****  952.94  951.08    5430  952.47
       -52 ******     50    86869  1.02 ***** *******    0.49    5.46

FULLV:FV       53   -199     1030  0.44  0.20  953.15 *******    5430  952.71
         0     53     51    91645  1.01  0.00    0.01    0.46    5.27
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       58   -157      860  0.65  0.28  953.52 *******    5430  952.87
        58     58     62    67352  1.05  0.11   -0.01    0.58    6.31
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   957.01       0.00     951.90     951.73

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   952.97     954.34     954.54     954.32

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

 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                       YU/Z,WSIU,WS = 1.06     954.94     955.08

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

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

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

BRIDG:BR       53      0      377  1.43  0.34  954.41  949.46    3230  952.97
         0     53     41    33664  1.25  1.12    0.00    0.55    8.58

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.894 ******  954.32 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG       8.    44.  0.10  0.29  954.75    0.00   2200.  954.24

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   2200.   226.  -240.   -14.   2.5   1.7   6.7   5.8   2.2   3.0
   RT:      0.    59.    18.    77.   1.8   0.9   6.5  10.1   2.1   3.0

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

APPRO:AS       34   -200     1260  0.29  0.20  954.83  951.18    5430  954.53
        58     40     65   113165  1.01  0.22    0.00    0.35    4.31

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.815  0.551   50877.    -6.    35. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS     -53.  -198.    50.   5430.   86869.     994.    5.46  952.47
   FULLV:FV       0.  -200.    51.   5430.   91645.    1030.    5.27  952.71
   BRIDG:BR       0.     0.    41.   3230.   33664.     377.    8.58  952.97
   RDWAY:RG       8.******* 2200.   2200.*********       0.    2.00  954.24
   APPRO:AS      58.  -201.    65.   5430.  113165.    1260.    4.31  954.53

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -6.    35.   50877.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    951.08    0.49  941.28  966.17************  0.47  952.94  952.47
   FULLV:FV  ********    0.46  941.38  966.27  0.20  0.00  0.44  953.15  952.71
   BRIDG:BR    949.46    0.55  941.40  955.10  0.34  1.12  1.43  954.41  952.97
   RDWAY:RG  ****************  951.73  961.81  0.10******  0.29  954.75  954.24
   APPRO:AS    951.18    0.35  942.05  963.22  0.20  0.22  0.29  954.83  954.53
```

```
       U.S. Geological Survey WSPRO Input File burk020.wsp
       Hydraulic analysis for structure BURKTH00560020   Date: 19-AUG-97
       Hydraulic analysis of Bridge 20 in Burke over E. Br. of Passumpsic R.
          *** RUN DATE & TIME: 01-20-98  16:19

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

EXITX:XS   ******   -177      524  0.35 *****  950.85  947.57    2260  950.50
       -52 ******     47    36175  1.21 ***** *******    0.55    4.32

FULLV:FV       53   -182      559  0.30  0.19  951.05 *******    2260  950.75
         0     53     47    39020  1.20  0.00    0.01    0.50    4.04
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       58    -73      483  0.36  0.23  951.31 *******    2260  950.94
        58     58     60    33008  1.07  0.03    0.00    0.45    4.68
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

            <<<<<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       53      0      270  1.13  0.36  951.47  948.09    2260  950.34
         0     53     41    20716  1.04  0.26    0.00    0.58    8.36

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  0.980 ******  954.32 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<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       34   -143      618  0.23  0.21  951.96  947.81    2260  951.73
        58     37     61    43207  1.13  0.29    0.01    0.39    3.65

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.698  0.281   30974.     3.    44.   951.61

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -53.  -178.    47.   2260.   36175.     524.    4.32  950.50
   FULLV:FV       0.  -183.    47.   2260.   39020.     559.    4.04  950.75
   BRIDG:BR       0.     0.    41.   2260.   20716.     270.    8.36  950.34
   RDWAY:RG       8.**************       0.******************    2.00********
   APPRO:AS      58.  -144.    61.   2260.   43207.     618.    3.65  951.73

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       3.    44.   30974.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF     HO   VHD      EGL    WSEL
   EXITX:XS    947.57    0.55  941.28  966.17************  0.35  950.85  950.50
   FULLV:FV  ********    0.50  941.38  966.27  0.19  0.00  0.30  951.05  950.75
   BRIDG:BR    948.09    0.58  941.40  955.10  0.36  0.26  1.13  951.47  950.34
   RDWAY:RG  ****************  951.73  961.81**********************************
   APPRO:AS    947.81    0.39  942.05  963.22  0.21  0.29  0.23  951.96  951.73
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel 30 feet upstream of the approach of structure BURKTH00560020, in Burke, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BURKTH00560020

General Location Descriptive

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

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

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

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

Town *(FIPS place code; I - 4; nnnnn)* 10450

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

Waterway *(I - 6)* EAST BR. PASSUMPSIC RIVER

Road Name *(I - 7):* -

Route Number TH056

Vicinity *(I - 9)* 0.1 MI JCT TH 56 + VT114

Topographic Map West Burke

Hydrologic Unit Code: 01080102

Latitude *(I - 16; nnnn.n)* 44381

Longitude *(i - 17; nnnnn.n)* 71538

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10030200200302

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

Maximum span length *(I - 48; nnnn)* 0044

Year built *(I - 27; YYYY)* 1955

Structure length *(I - 49; nnnnnn)* 000046

Average daily traffic, ADT *(I - 29; nnnnnn)* 000020

Deck Width *(I - 52; nn.n)* 136

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

Channel & Protection *(I - 61; n)* 5

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*) 010.2

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

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

Comments:

The structural inspection report of 9/19/94 indicates that the structure is a steel, stringer-type bridge with a wooden plank deck. The right abutment and its wingwalls are constructed with concrete, while the left abutment and wingwalls are "laid-up" stone blocks. The stone blocks of the left abutment are capped with concrete. The cap has a few fine cracks and leaks, and a vertical settlement crack at the center-line of the roadway. Small areas of the stone chinking are missing on the abutment face. The report mentions that "boulder fill" has been piled in front of the right abutment and its wingwalls. Similarly, the same stone fill is evident on the stream banks upstream and downstream. The report indicates **(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:

there is no undermining but there may have been settling problems that have been stabilized. Channel scour is reported to be "normal", and debris accumulation and point bars are noted as minor.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **51.05** mi^2 Lake/pond/swamp area **0.41** mi^2
Watershed storage *(ST)* **0.8** %
Bridge site elevation **960** ft Headwater elevation **3300** ft
Main channel length **12.30** mi
10% channel length elevation **980** ft 85% channel length elevation **1810** ft
Main channel slope *(S)* **89.96** 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? **Y** *If no, type ctrl-n xs*

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

Comments: **This cross section is the upstream face. The low chord and bed elevations are from the cross sections done by the U.S. Department of Housing and Urban Development.**

Station	192	193	193	193	202	209	218	227	236	-	-
Feature	LB								RB	-	-
Low chord elevation	955.6	955.6	955.6	955.6	955.9	956.1	956.4	956.7	957.0	-	-
Bed elevation	947.0	947.0	946.2	946.0	945.0	943.1	943.8	946.2	951.3	-	-
Low chord to bed	8.6	8.6	9.4	9.6	10.9	13.0	12.6	10.5	5.7	-	-
Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

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

Comments:

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: **2/29/96**

Computerized by: **RB** Date: **2/29/96**

Reviewd by: **MS** Date: **5/20/98**

Structure Number **BURKTH00560020**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **T**. **SEVERANCE** Date *(MM/DD/YY)* **08** / **15** / 19**95**

2. Highway District Number **07** Mile marker **0000**

County **CALEDONIA (005)** Town **BURKE (10450)**

Waterway *(I - 6)* **EAST BR. PASSUMPSIC RIVER** Road Name **-**

Route Number **TH056** Hydrologic Unit Code: **01080102**

3. Descriptive comments:

The structure is located 0.75 miles south of Hartwellville off of VT 114, 100 feet east of the intersection of VT 114 and TH056. There is a USGS gaging station just DS on the right bank. The structure is located in Caledonia County, 0.3 miles from the Caledonia/Essex County border.

B. Bridge Deck Observations

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

5. Ambient water surface... US **2** UB **1** DS **2** *(**1**- pool; **2**- riffle)*

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

7. Bridge length **46** *(feet)* Span length **44** *(feet)* Bridge width **13.6** *(feet)*

Road approach to bridge:

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

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

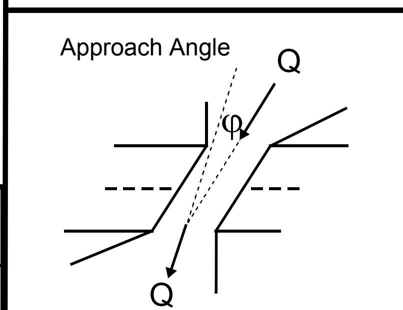
10. Embankment slope (*run / rise in feet / foot*):
US left **0.0:1** US right **0.0:1**

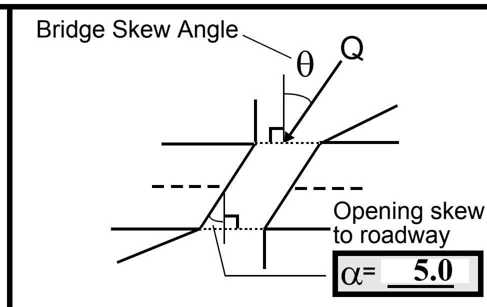
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	2	1
RBDS	0	-	2	2
LBDS	0	-	0	-

*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: **60** 16. Bridge skew: **30**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **100** feet **US** *(US, UB, DS)* to **50** feet **DS**

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: **1a**

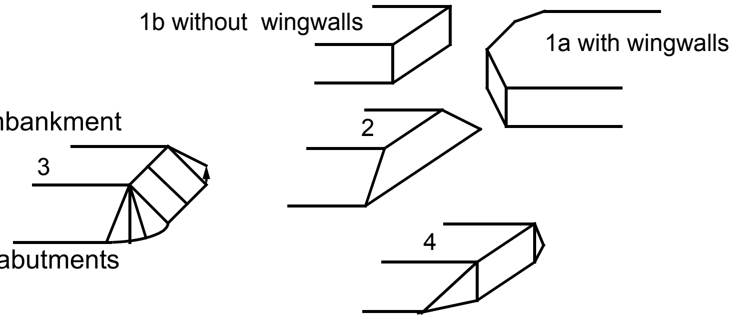
1a- Vertical abutments with wingwalls

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. The surface cover is predominantly forest except for the road, VT 114, to the west, and the US and DS sections of lawn on the left bank. The immediate banks are wooded with shrubs. The road on the left bank will overflow well before the bridge will overflow.

7. The values are from the VTAOT files. Measured bridge length = 45.2 feet, span length = 44.0 feet, and bridge width = 13.0 feet.

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
45.0	**3.5**			**1.5**	**2**	**2**	**135**	**135**	**1**	**1**

23. Bank width **35.0** 24. Channel width **15.0** 25. Thalweg depth **51.5** 29. Bed Material **345**

30 .Bank protection type: LB **2** RB **3** 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. The bank material is predominantly silts and clays with some gravel and boulders. The right bank is lined with boulders (cut granite slabs) over the range of channel impact zone 1.

29. Beyond two bridge lengths the bed is made up of more gravel and cobble. Within two bridge lengths, there are a significant number of boulders.

The US thalweg depth is 1 foot, average thalweg depth for the stream upstream and downstream of the bridge is 1.5 feet.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **90** 35. Mid-bar width: **10**

36. Point bar extent: **80** feet **US** *(US, UB)* to **110** feet **US** *(US, UB, DS)* positioned **0** %LB to **20** %RB

37. Material: **3**

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

At lower flows this side bar would be more visible and flow would be positioned just right of the center of the channel.

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? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **35**

47. Scour dimensions: Length **40** Width **6** Depth : **1.5** Position **40** %LB to **65** %RB

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

This scour continues under the bridge. There are a lot of boulders scattered in the hole along its length.

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
41.5		**2.5**		**2**	**7**	**7**	**0**

58. Bank width (BF) **-** 59. Channel width **-** 60. Thalweg depth **90.0** 63. Bed Material **0**

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

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

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

245

The left abutment and wingwalls are laid-up granite sections with a one-foot high cast concrete slab on top of the abutment. The footing is exposed. Some stone and boulder fill is at the US left wingwall.

The right abutment and right wingwalls are concrete. Stones are dumped at the base of the abutment and wingwalls. At bank-full conditions, the protection is covered.

63. The left channel is sand and the right channel is cobble and boulder.

The thalweg depth is 3 feet.

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

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

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

70. Debris and Ice Comments:

1

Both the left and right banks US are gradual slopes. The right bank becomes steeper approaching VT 114. At bank full there is evidence of some capture amongst shrubs and saplings and there is a section of flattened long grass. On the US left bank, there is a 16-inch diameter tree with obvious ice damage.

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		-	85	2	3	1.0	2.5	90.0
RABUT	2	30	90			2	0	40.5

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.):

-

-

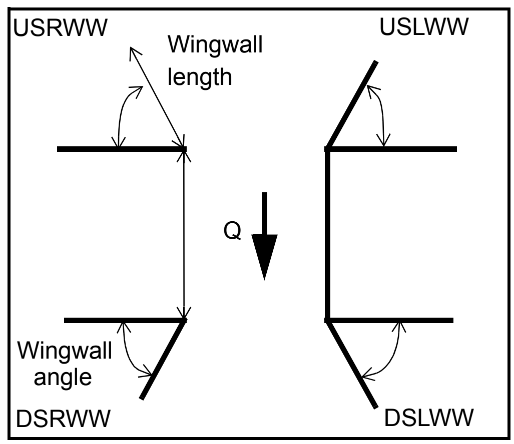
1

74. The US left abutment footing is undermined with penetration of 2 feet with a range pole. This condition continues from the US bridge face to six feet downstream. From that point on, the footing is exposed but not undermined.

75,76 Because of the boulders piled in front of the footing, the exposure depth approaches 4 feet at 2 feet away from the abutment into the channel. This condition extends from the US bridge face for 4 feet DS under the bridge. Scour depth is 1.5 feet at this point. The right abutment footing is beneath 0.5 foot of sand and silt at the US end and 1 foot of sand and silt at the DS end. There is air space between the stone protection on the

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:	bank		in		front	40.5	
USRWW:	of		the		right	3.0	
DSLWW:	abut		ment		and	15.0	
DSRWW:	the		abut		ment	16.0	



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

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	itsel	thal	h is	aver	weg	1.5	ing	s is
Condition	f.	weg	3	age	dept	feet.	thic	1.75
Extent	The	dept	feet,	thal	h is	Foot	knes	feet.

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

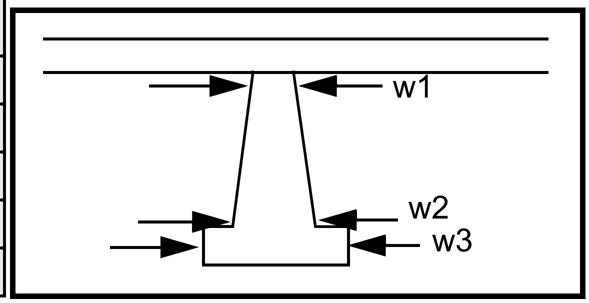
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

Y
2
3
1.0
2.5
Y
1
0
-
-
Y

Piers:

84. Are there piers? __**2**__ *(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				**35.0**	**17.5**	**40.0**
Pier 2			**9.0**	**11.5**	**30.0**	**30.0**
Pier 3		**-**	**-**	**10.5**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**0**	**1**	**-**	**condi-**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**-**	**1**	**-**	**tion**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**-**	**0**	**2**	**for**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**Y**	**-**	**3**	**the**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**1**	**-**	**2**	**US**	*Y- yes; N- no*
91. Attack ∠ (BF)	**0**	**3**	**3**	**left**	
92. Pushed	**-**	**1**	**1**	**wing**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**-**	**1**	**1**	**wall**	
95. Cross-members	**2**	**0**	**80.**	**is the**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**3**	**-**	**The**	**same**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**1**	**-**	**scou**	**as**	
98. Exposure depth	**3**	**0**	**r**	**for**	

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

the left abutment. It is possible to penetrate approximately 4 inches. Note that the footing is made up of granite slabs which are not cut perfectly square, this makes undermining measurement values more pronounced.

82. The protection described for the US and DS left wingwalls consists of small boulders placed at the base of the wingwalls.

Scour holes beneath the bridge are located along the right side of the channel close to the abutment and at the US end of the left abutment-intersection with the wingwall. The bottom of the scour hole located by the upstream section of the left abutment is sandy.

E. Downstream Channel Assessment

100.

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

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

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

-
-
-
-

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

Cut bank extent: PIE_____ feet RS____ *(US, UB, DS)* to _____ feet ____ *(US, UB, DS)*

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

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

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

Scour dimensions: Length 2_____ Width 4_____ Depth: 145_____ Positioned 45____ %LB to 1____ %RB

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

0
345
0
123

Are there major confluences? -____ *(Y or if N type ctrl-n mc)* How many? 1_____

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

Confluence 2: Distance k has_____ Enters on abo_____ *(LB or RB)* Type ut_____ *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

20 ft of trees between the stream and lawn. The right bank is thickly wooded for 40-60 feet from the right bank up to VT 114. The left overbank is fairly flat and then slopes up slightly to a house and TH056. This ter-

F. Geomorphic Channel Assessment

107. Stage of reach evolution rai_____

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 description is similar for the left overbank US.

On the right bank a USGS gage house is within one bridge length of the DS face of the bridge.

Many cobbles and boulders are on the DS right bank from the bridge to beyond 200 feet downstream. At 200 feet DS the channel bends to the right. The left side of the channel cross section is predominantly cobbles and gravel. The right side has larger cobbles to small boulders.

The thalweg depth is 2 feet.

109. G. Plan View Sketch - N

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: BURKTH00560020 Town: Burke
Road Number: TH56 County: Caledonia
Stream: East Branch Passumpsic River

Initials MS Date: 10/14/97 Checked:RF

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	3920	5430	2260
Main Channel Area, ft2	620	699	486
Left overbank area, ft2	385	560	132
Right overbank area, ft2	0	0	0
Top width main channel, ft	77	79	74
Top width L overbank, ft	157	187	131
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.3269	0.3269	0.3269
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	8.1	8.8	6.6
y1, average depth, LOB, ft	2.5	3.0	1.0
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	83488	113050	43239
Conveyance, main channel	55334	66242	37869
Conveyance, LOB	28154	46809	5370
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	-0.0009	0.0000
Qm, discharge, MC, cfs	2598.1	3181.7	1979.3
Ql, discharge, LOB, cfs	1321.9	2248.3	280.7
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	4.2	4.6	4.1
Vl, mean velocity, LOB, ft/s	3.4	4.0	2.1
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	10.9	11.1	10.6
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	3920	5430	2260
(Q) discharge thru bridge, cfs	3075	3230	2260
Main channel conveyance	26902	33644	20733
Total conveyance	26902	33644	20733
Q2, bridge MC discharge,cfs	3075	3230	2260
Main channel area, ft2	323	376	270
Main channel width (normal), ft	40.3	40.4	40
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	40.3	40.4	40
y_bridge (avg. depth at br.), ft	8.01	9.31	6.75
Dm, median (1.25*D50), ft	0.408625	0.408625	0.408625
y2, depth in contraction,ft	6.57	6.83	5.07
ys, scour depth (y2-ybridge), ft	-1.45	-2.47	-1.68

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	3075	3230	2260
Main channel area (DS), ft2	323	376	270
Main channel width (normal), ft	40.3	40.4	40.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	40.3	40.4	40.0
D90, ft	0.9233	0.9233	0.9233
D95, ft	1.1265	1.1265	1.1265
Dc, critical grain size, ft	0.4203	0.3213	0.3502
Pc, Decimal percent coarser than Dc	0.324	0.512	0.421
Depth to armoring, ft	2.63	0.92	1.45

Abutment Scour

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

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	3920	5430	2260	3920	5430	2260
a', abut.length blocking flow, ft	170.5	200.6	144.8	22.4	24.7	20.1
Ae, area of blocked flow ft2	303.46	315.32	197.9	120.64	145.54	83.76
Qe, discharge blocked abut.,cfs	--	--	483.39	368.16	483.83	241.41
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.44	4.00	2.44	3.05	3.32	2.88
ya, depth of f/p flow, ft	1.78	1.57	1.37	5.39	5.89	4.17
--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	85	85	85	95	95	95
K2	0.99	0.99	0.99	1.01	1.01	1.01
Fr, froude number f/p flow	0.364	0.388	0.368	0.232	0.241	0.249
ys, scour depth, ft	14.41	14.69	11.56	**13.02**	**14.49**	**10.74**

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)	170.5	200.6	144.8	22.4	24.7	20.1
y1 (depth f/p flow, ft)	1.78	1.57	1.37	5.39	5.89	4.17
a'/y1	95.80	127.62	105.95	4.16	4.19	4.82
Skew correction (p. 49, fig. 16)	0.98	0.98	0.98	1.01	1.01	1.01
Froude no. f/p flow	0.36	0.39	0.37	0.23	0.24	0.25
Ys w/ corr. factor K1/0.55:						
vertical	9.12	8.22	7.03	ERR	ERR	ERR

vertical w/ ww's	**7.47**	**6.74**	**5.76**	ERR	ERR	ERR
spill-through	5.01	4.52	3.86	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	0.63	0.55	0.58	0.63	0.55	0.58
y, depth of flow in bridge, ft	8.01	9.31	6.75	8.01	9.31	6.75
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	1.97	1.74	1.40	1.97	1.74	1.40