LEVEL II SCOUR ANALYSIS FOR BRIDGE 15 (GRNVTH00230015) on TOWN HIGHWAY 23, crossing the THIRD BRANCH of the WHITE RIVER, GRANVILLE, VERMONT

U.S. Geological Survey
Open-File Report 96-564

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

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By MICHAEL A. IVANOFF and SCOTT A. OLSON

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Pembroke, New Hampshire

1996

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

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

In this report, the words “right” and “left” refer to directions that would be reported by an observer facing downstream.

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929-- a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

In the appendices, the above abbreviations may be combined. For example, USLB would represent upstream left bank.

LEVEL II SCOUR ANALYSIS FOR BRIDGE 15 (GRNVTH00230015) ON TOWN HIGHWAY 23, CROSSING THE THIRD BRANCH OF THE WHITE RIVER, GRANVILLE, VERMONT

***By* Michael A. Ivanoff and Scott A. Olson**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure GRNVTH00230015 on town highway 23 crossing the Third Branch of the White River, Granville, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). A Level I study is included in Appendix E of this report. A Level I study 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 can be found in Appendix D.

The site is in the Green Mountain physiographic province of central Vermont in the town of Granville. The 23.6-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the banks have woody vegetation coverage except for the downstream banks, which are residential.

In the study area, the Third Branch of the White River has an incised, sinuous channel with a slope of approximately 0.0128 ft/ft, an average channel top width of 42 ft and an average channel depth of 4 ft. The predominant channel bed material is cobble (D_{50} is 108 mm or 0.353 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 21, 1994, indicated that the reach was laterally unstable.

The town highway 23 crossing of the Third Branch of the White River is a 35-ft-long, one-lane bridge consisting of one 31-foot steel beam span (Vermont Agency of Transportation, written communication, August 26, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is 10 degrees.

The only scour protection measures in place at the site were type-1 stone fill (less than 12 inches diameter) along the upstream right bank, upstream right wingwall, and right abutment. Retaining walls are in place along the upstream left bank up to the upstream end of the upstream left wingwall and both downstream banks with the left bank wall extending from the downstream left wingwall. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995).
Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute scour 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 to 0.4 ft. The worst-case contraction scour occurred at the incipient overtopping discharge. Abutment scour ranged from 9.8 to 13.9 ft. The worst-case abutment scour occurred at the 100-year discharge. Additional information on scour depths and depths to armoring are included in the section titled "Scour Results". Scoured-streambed elevations, based on the calculated depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Warren, VT. Quadrangle, 1:24,000, 1970
Photo inspected 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 GRNVTH00230015 ***Stream*** Third Branch of the White River

County Addison ***Road*** TH 23 ***District*** 04

Description of Bridge

Bridge length 35 ***ft*** ***Bridge width*** 12.3 ***ft*** ***Max span length*** 31 ***ft***

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

Abutment type Vertical ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 10/21/94

Description of stone fill Type-1, along US right bank, US right wingwall, and right abutment.

Retaining walls are along US left bank up to the US end of the US left wingwall and both DS banks with the left bank wall extending from the DS left wingwall.

Abutments and wingwalls are concrete.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 10

There is a mild channel bend in the upstream reach.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
	10/21/94	0	0
Level I	10/21/94	0	0
Level II			

Potential for debris Moderate. There is some debris caught on a tree on the left bank upstream. The upstream banks are unstable with trees lining the channel.

Describe any features near or at the bridge that may affect flow (include observation date) A side bar begins under the bridge extending downstream along the left abutment and left bank 10/21/94.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a narrow flood plain and steep valley walls on both sides.

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

Date of inspection 10/21/94

DS left: Gradually sloped channel bank to a narrow gradually sloped flood plain

DS right: Steep channel bank to a narrow gradually sloped flood plain

US left: Moderately sloped channel bank to a narrow gradually sloped flood plain

US right: Moderately sloped bank

Description of the Channel

Average top width 42 ***ft*** ***Average depth*** 4 ***ft***

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

Sinuous and wider at bends with irregular point and lateral bars and semi-alluvial channel boundaries.

10/21/94

Vegetative co[ver] Trees and brush

DS left: Brush and multiple homes on the bank

DS right: Trees and brush on the bank with short grass on the flood plain

US left: Trees and brush on the bank with railroad on bank

US right:

Do banks appear stable? No ***If not, describe location and type of instability and date of observation.***

The banks in the immediate vicinity of the bridge are protected by walls. A cut bank was noted along the upstream left bank 10/21/94.

None -- 10/21/94

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 23.6 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province	***Percent of drainage area***
Green Mountain	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: There are a couple houses on the downstream right overbank area

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

USGS gage description -

USGS gage number -

Gage drainage area - ***mi²***

No

Is there a lake/p -

-

Calculated Discharges

Q100 4,100 ***ft³/s*** ***Q500*** 5,100 ***ft³/s***

The 100- year discharge is based on values from the VTAOT database and those computed by use of several empirical methods (Potter, 1957a&b; Johnson and Tasker, 1974; Benson, 1962; FHWA, 1983; Talbot, 1887; Richardson and others, 1993). The 500-year discharge is based on an extrapolation of the empirical relationship flood frequency curves and that of the VTAOT database values (VTAOT, written communication, May 4, 1995). VTAOT database values were from another site downstream.

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 the center of a chiseled square on top of the DS end of the right abutment (elev. 496.86 ft, arbitrary survey datum). RM2 is a chiseled square on top of the US end of the right abutment (elev. 496.75ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	*Section Reference Distance (SRD) in feet*	*[2]Cross-section development*	*Comments*
EXITX	-29	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPRO	51	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, Jr. and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.035 to 0.046, and overbank "n" values ranged from 0.035 to 0.065.

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 0.0128 ft/ft which was measured from channel thalweg points surveyed at and downstream of the exit section.

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

For the 500-year discharge, WSPRO assumes a critical depth at the exit section. A supercritical model was developed for the discharge. Analyzing both the supercritical and subcritical profiles for the discharge, it can be determined that the water surface profile does pass through critical depth at the exit. Thus, the assumption of critical depth at the exit is a satifactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 498.5 *ft*
Average low steel elevation 497.2 *ft*

100-year discharge 4,100 *ft³/s*
Water-surface elevation in bridge opening 497.5 *ft*
Road overtopping? Yes *Discharge over road* 1756 *ft³/s*
Area of flow in bridge opening 236 *ft²*
Average velocity in bridge opening 9.8 *ft/s*
Maximum WSPRO tube velocity at bridge 11.6 *ft/s*

Water-surface elevation at Approach section with bridge 500.6
Water-surface elevation at Approach section without bridge 499.7
Amount of backwater caused by bridge 0.9 *ft*

500-year discharge 5,100 *ft³/s*
Water-surface elevation in bridge opening 497.5 *ft*
Road overtopping? Yes *Discharge over road* 2960 *ft³/s*
Area of flow in bridge opening 236 *ft²*
Average velocity in bridge opening 9.1 *ft/s*
Maximum WSPRO tube velocity at bridge 10.8 *ft/s*

Water-surface elevation at Approach section with bridge 501.4
Water-surface elevation at Approach section without bridge 500.6
Amount of backwater caused by bridge 0.8

Incipient overtopping discharge 2,220 *ft³/s*
Water-surface elevation in bridge opening 495.0 *ft*
Area of flow in bridge opening 176 *ft²*
Average velocity in bridge opening 12.6 *ft/s*
Maximum WSPRO tube velocity at bridge 15.5 *ft/s*

Water-surface elevation at Approach section with bridge 497.3
Water-surface elevation at Approach section without bridge 496.9
Amount of backwater caused by bridge 0.4 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour was computed by use of the Chang pressure-flow scour equation (Richarson and others, 1995, p. 145-146) for the 100-year and 500-year discharges. For these modelled discharges, there was orifice flow at the bridge. 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). The results of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) were also computed for the 100-year and 500-year discharges and can be found in appendix F. Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for the incipient road-overflow discharge. For contraction scour computations using the Laursen's equation, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. In this case, the incipient road-overflow model resulted in the worst case contraction scour with a scour depth of 0.4 ft. The incipient road-overflow model resulted in the worst case total scour with depths of 10.7 and 13.4, respectively for the left and right abutment. The results of the streambed armoring computations suggest that the depth of contraction scour will not be limited by armoring.

Abutment scour was computed by use of the Froehlich equation (Richardson and others, 1995, p. 48, equation 28). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0	0	0.4
Depth to armoring	1.7	1.1	20.6
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	9.8	10.4	10.3
Right abutment	13.9	13.6	13.0
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Rock Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	1.9	1.6	2.6
Right abutment	1.9	1.6	2.6
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

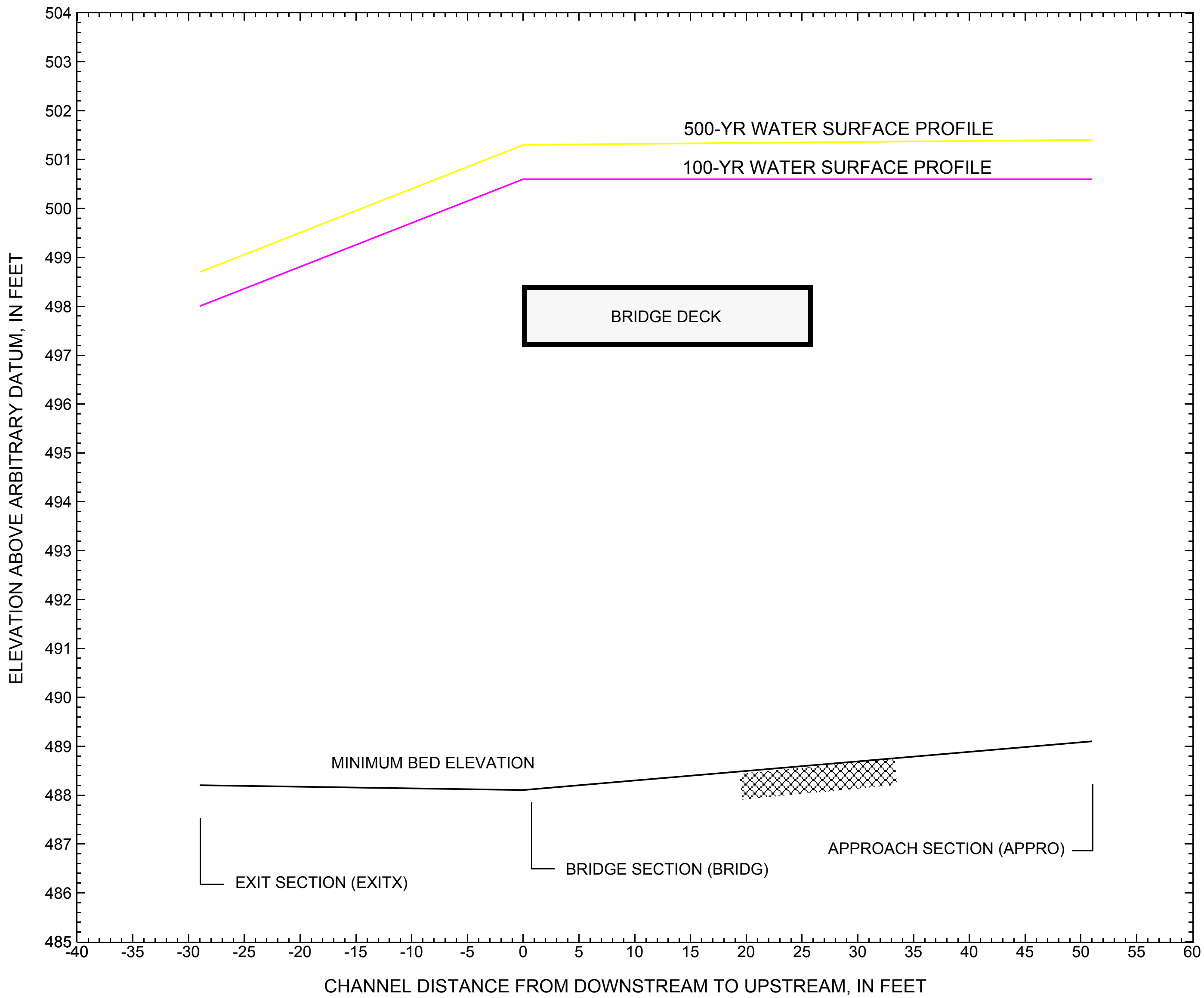

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure GRNVTH00230015 on town highway 23, crossing the Third Branch of the White River, Granville, Vermont.

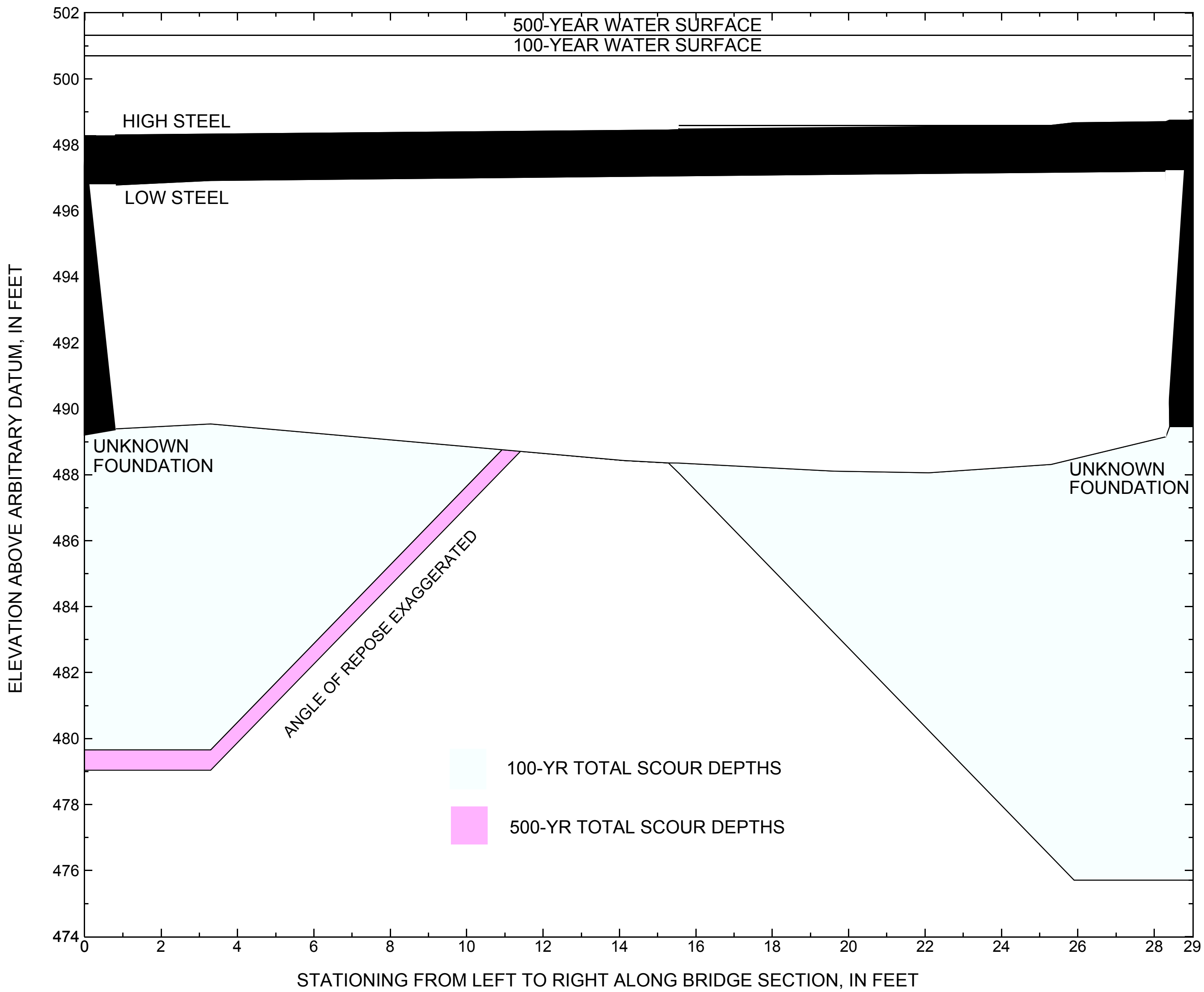

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure GRNVTH00230015 on town highway 23, crossing the Third Branch of the White River, Granville, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure GRNVTH00230015 on Town Highway 23, crossing the Third Branch of the White River, Granville, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 4,100 cubic-feet per second											
Left abutment	0.0	--	496.8	--	489.4	0.0	9.8	--	9.8	479.6	--
Right abutment	29.0	--	497.5	--	489.5	0.0	13.9	--	13.9	475.6	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure GRNVTH00230015 on Town Highway 23, crossing the Third Branch of the White River, Granville, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 5,100 cubic-feet per second											
Left abutment	0.0	--	496.8	--	489.4	0.0	10.4	--	10.4	479.0	--
Right abutment	29.0	--	497.5	--	489.5	0.0	13.6	--	13.6	475.9	--

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

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File grnv015.wsp
T2        Hydraulic analysis for structure GRNVTH00230015   Date: 19-APR-96
T3        Town Highway 23 Bridge Over the 3rd Branch White River, Granville MAI
Q           4100.0   5100.0  2220.0
SK          0.0128   0.0128  0.0128
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EXITX   -29
GR         -137.5, 507.00   -130.8, 498.89   -117.6, 498.90    -66.2, 498.89
GR          -30.2, 497.68    -15.0, 495.40     -5.9, 493.13     -0.7, 492.14
GR            0.0, 490.81     12.1, 489.20     18.4, 488.45     22.9, 488.17
GR           24.7, 488.39     29.7, 489.29     31.2, 490.14     31.2, 493.31
GR           31.6, 495.72     34.8, 497.66     52.6, 498.06     60.4, 499.46
GR           70.1, 502.62     99.0, 505.07
N           0.035        0.045        0.035
SA                  -30.2        34.8
*
XS   FULLV      0  * * *   0.007
*
BR   BRIDG      0   497.15      10.0
GR            0.0, 496.78      0.8, 489.36      3.3, 489.54     14.1, 488.43
GR           19.6, 488.11     22.1, 488.06     25.3, 488.31     28.3, 489.15
GR           28.4, 489.46     29.0, 496.89     29.0, 497.52      0.0, 496.78
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      26.0 * *     64.0      3.9
N           0.035
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      9      12.0     2
GR         -137.6, 507.00   -128.4, 498.89   -114.8, 498.90    -63.2, 498.89
GR          -20.9, 498.68      0.0, 498.27     28.7, 498.82     61.8, 501.12
GR           90.0, 505.07    108.6, 504.28    140.8, 509.04
*
AS   APPRO   51             0.
GR         -143.5, 507.00   -125.7, 498.89   -112.3, 498.90    -64.7, 498.89
GR          -60.0, 498.26     -7.5, 495.61     -6.8, 492.92     -3.2, 490.84
GR            3.1, 490.32      7.9, 489.25     12.1, 489.11     12.6, 489.14
GR           14.8, 490.27     16.4, 489.29     24.5, 490.05     31.4, 490.31
GR           39.7, 494.22     45.8, 498.18     51.7, 498.27     61.6, 503.24
GR           69.4, 504.92     80.2, 504.11     88.7, 502.61    106.7, 510.15
N           0.041        0.046        0.065        0.025
SA                 -7.5          39.7         61.6
*
HP 1 BRIDG   497.52 1 497.52
HP 2 BRIDG   497.52 * * 2317
HP 2 RDWAY   500.59 * * 1756
HP 1 APPRO   500.62 1 500.62
HP 2 APPRO   500.62 * * 4100
*
HP 1 BRIDG   497.52 1 497.52
HP 2 BRIDG   497.52 * * 2140
HP 2 RDWAY   501.31 * * 2960
HP 1 APPRO   501.45 1 501.45
HP 2 APPRO   501.45 * * 5100
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
     U.S. Geological Survey WSPRO Input File grnv015.wsp
     Hydraulic analysis for structure GRNVTH00230015   Date: 19-APR-96
     Town Highway 23 Bridge Over the 3rd Branch White River, Granville MAI
        *** RUN DATE & TIME: 05-22-96  09:46
 CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      236     22176      0     72                            0
497.52           236     22176      0     72  1.00      0     29        0

 VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
      WSEL     LEW     REW    AREA        K        Q    VEL
    497.52     0.0    29.0   235.7   22176.    2317.   9.83

X STA.         0.0        3.2        4.9        6.6        8.1        9.5
  A(I)            20.3       12.9       12.3       11.5       11.1
  V(I)            5.70       9.00       9.40      10.03      10.47

X STA.         9.5       10.8       12.1       13.3       14.5       15.7
  A(I)            10.8       10.7       10.4       10.1       10.2
  V(I)           10.73      10.83      11.18      11.51      11.36

X STA.        15.7       16.8       18.0       19.1       20.2       21.3
  A(I)            10.0       10.1       10.0       10.0       10.2
  V(I)           11.61      11.48      11.64      11.59      11.39

X STA.        21.3       22.5       23.6       24.9       26.3       29.0
  A(I)            10.4       10.7       11.3       12.5       20.3
  V(I)           11.19      10.82      10.21       9.26       5.70

 VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.
      WSEL     LEW     REW    AREA        K        Q    VEL
    500.59  -130.3    54.2   313.9   17604.    1756.   5.59

X STA.      -130.3     -119.8     -111.2     -102.4      -93.9      -85.3
  A(I)            16.2       14.6       14.8       14.4       14.7
  V(I)            5.42       6.00       5.95       6.09       5.98

X STA.       -85.3      -76.8      -68.2      -59.7      -51.5      -43.5
  A(I)            14.4       14.6       14.5       14.3       14.2
  V(I)            6.10       6.03       6.07       6.14       6.19

X STA.       -43.5      -35.8      -27.9      -18.9      -10.7       -3.3
  A(I)            13.9       14.7       17.2       16.7       16.1
  V(I)            6.30       5.98       5.11       5.27       5.45

X STA.        -3.3        3.3       10.7       18.7       28.2       54.2
  A(I)            15.0       16.2       16.3       17.8       23.4
  V(I)            5.83       5.42       5.37       4.93       3.76

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      51.
  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      312     21101    122    122                         2826
          2      476     68050     47     51                         8589
          3       47      1983     17     18                          442
500.62           835     91134    186    192  1.37   -128     56     8573

 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      51.

      WSEL     LEW     REW    AREA        K        Q    VEL
    500.62  -129.5    56.4   834.6   91134.    4100.   4.91

X STA.      -129.5      -74.9      -42.9      -26.3      -14.0       -4.5
  A(I)            90.9       74.9       60.6       53.8       54.5
  V(I)            2.25       2.74       3.38       3.81       3.76

X STA.        -4.5       -0.9        2.2        5.2        7.8       10.4
  A(I)            35.0       32.1       30.5       29.7       28.8
  V(I)            5.86       6.39       6.72       6.91       7.13

X STA.        10.4       12.8       15.8       18.3       21.0       23.7
  A(I)            28.2       31.9       28.6       29.3       29.2
  V(I)            7.28       6.42       7.17       7.00       7.03

X STA.        23.7       26.5       29.4       32.5       36.4       56.4
  A(I)            30.0       30.3       31.0       35.2       70.0
  V(I)            6.84       6.76       6.62       5.82       2.93
```

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       U.S. Geological Survey WSPRO Input File grnv015.wsp
       Hydraulic analysis for structure GRNVTH00230015   Date: 19-APR-96
       Town Highway 23 Bridge Over the 3rd Branch White River, Granville MAI
          *** RUN DATE & TIME: 05-22-96  09:46
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      236     22176      0     72                            0
  497.52           236     22176      0     72  1.00      0     29        0

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
       WSEL     LEW     REW    AREA        K        Q    VEL
     497.52     0.0    29.0   235.7   22176.    2140.   9.08

X STA.         0.0        3.2        4.9        6.6        8.1        9.5
  A(I)            20.3       12.9       12.3       11.5       11.1
  V(I)            5.27       8.32       8.68       9.26       9.67

X STA.         9.5       10.8       12.1       13.3       14.5       15.7
  A(I)            10.8       10.7       10.4       10.1       10.2
  V(I)            9.91      10.00      10.32      10.63      10.50

X STA.        15.7       16.8       18.0       19.1       20.2       21.3
  A(I)            10.0       10.1       10.0       10.0       10.2
  V(I)           10.72      10.61      10.75      10.70      10.52

X STA.        21.3       22.5       23.6       24.9       26.3       29.0
  A(I)            10.4       10.7       11.3       12.5       20.3
  V(I)           10.33       9.99       9.43       8.55       5.26

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.
       WSEL     LEW     REW    AREA        K        Q    VEL
     501.31  -131.1    63.2   450.7   31278.    2960.   6.57

X STA.      -131.1     -120.0     -111.4     -103.0      -94.3      -86.0
  A(I)            23.7       20.6       20.2       21.0       20.2
  V(I)            6.24       7.17       7.33       7.05       7.31

X STA.       -86.0      -77.5      -69.1      -60.6      -52.4      -44.4
  A(I)            20.4       20.3       20.6       20.2       19.9
  V(I)            7.26       7.28       7.20       7.33       7.44

X STA.       -44.4      -36.5      -28.6      -19.1      -10.3       -2.5
  A(I)            20.0       20.3       24.8       24.2       22.9
  V(I)            7.39       7.27       5.96       6.12       6.45

X STA.        -2.5        5.3       13.5       22.6       32.9       63.2
  A(I)            23.3       23.3       24.7       25.3       34.6
  V(I)            6.35       6.36       5.99       5.85       4.27

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      51.
    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      414     33468    124    124                         4289
            2      516     77630     47     51                         9669
            3       61      2925     18     20                          633
  501.45           990    114023    189    196  1.31   -130     58    11212

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      51.

       WSEL     LEW     REW    AREA        K        Q    VEL
     501.45  -131.3    58.0   990.3  114023.    5100.   5.15

X STA.      -131.3      -93.2      -60.7      -41.3      -27.0      -16.0
  A(I)            90.3       84.1       70.6       64.3       56.5
  V(I)            2.83       3.03       3.61       3.96       4.52

X STA.       -16.0       -5.6       -1.4        2.1        5.3        8.2
  A(I)            63.5       43.1       37.6       36.9       34.4
  V(I)            4.02       5.92       6.78       6.92       7.41

X STA.         8.2       11.0       13.9       17.0       19.9       22.8
  A(I)            34.1       35.0       37.1       33.8       34.8
  V(I)            7.47       7.29       6.87       7.55       7.34

X STA.        22.8       26.0       29.0       32.5       36.8       58.0
  A(I)            35.7       34.9       37.8       41.9       83.9
  V(I)            7.15       7.30       6.74       6.08       3.04
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        U.S. Geological Survey WSPRO Input File grnv015.wsp
        Hydraulic analysis for structure GRNVTH00230015   Date: 19-APR-96
        Town Highway 23 Bridge Over the 3rd Branch White River, Granville MAI
           *** RUN DATE & TIME: 05-22-96  09:46
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      176     20435     28     39                         2488
   495.04           176     20435     28     39  1.00      0     29     2488

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.04     0.2    28.9   175.7   20435.    2220.  12.63

X STA.         0.2        3.4        5.3        6.8        8.3        9.7
  A(I)            16.2       10.2        8.9        8.6        8.1
  V(I)            6.86      10.88      12.45      12.97      13.63

X STA.         9.7       10.9       12.2       13.3       14.4       15.6
  A(I)             7.8        7.7        7.4        7.2        7.3
  V(I)           14.32      14.46      14.92      15.36      15.18

X STA.        15.6       16.6       17.7       18.8       19.8       20.9
  A(I)             7.2        7.3        7.2        7.2        7.5
  V(I)           15.42      15.27      15.50      15.44      14.84

X STA.        20.9       22.1       23.2       24.5       25.9       28.9
  A(I)             7.7        8.0        8.5        9.7       16.2
  V(I)           14.47      13.90      13.12      11.50       6.83

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      51.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       29       933     34     34                          150
             2      320     35089     47     51                         4732
             3        7       200      5      6                           52
   497.31           356     36222     86     91  1.13    -40     44     3881

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      51.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.31   -41.2    44.5   356.2   36222.    2220.   6.23

X STA.       -41.2       -4.4       -1.3        1.3        3.6        5.8
  A(I)            43.2       19.6       17.4       16.3       16.0
  V(I)            2.57       5.66       6.37       6.81       6.92

X STA.         5.8        7.7        9.6       11.3       13.1       15.3
  A(I)            15.0       14.7       14.2       14.6       16.1
  V(I)            7.41       7.53       7.84       7.58       6.90

X STA.        15.3       17.2       19.1       21.0       23.0       25.1
  A(I)            15.3       14.5       14.8       14.9       15.1
  V(I)            7.24       7.66       7.50       7.43       7.35

X STA.        25.1       27.2       29.4       31.8       34.9       44.5
  A(I)            15.4       15.7       16.8       18.6       27.7
  V(I)            7.19       7.05       6.62       5.96       4.01
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        U.S. Geological Survey WSPRO Input File grnv015.wsp
        Hydraulic analysis for structure GRNVTH00230015   Date: 19-APR-96
        Town Highway 23 Bridge Over the 3rd Branch White River, Granville MAI
           *** RUN DATE & TIME: 05-22-96  09:46

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

EXITX:XS   ******    -39      374  1.91 *****  499.93  497.20    4100  498.02
       -28 ******     51    36213  1.02 ***** *******    0.96   10.97

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.91     498.64     497.40

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   497.52     507.20    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   497.52     507.20     497.40

FULLV:FV       29    -52      416  1.60  0.33  500.25  497.40    4100  498.64
         0     29     55    41253  1.06  0.00   -0.01    0.91    9.86
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  1.69

APPRO:AS       51   -126      667  0.83  0.30  500.54 *******    4100  499.71
        51     51     55    69617  1.42  0.00    0.00    0.67    6.15
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   498.64     497.15

            <<<<<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       29      0      236  1.50 *****  499.02  494.75    2317  497.52
         0 ******     29    22176  1.00 ***** *******    0.61    9.83

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.15 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    39.  0.08  0.51  501.06   -0.01   1756.  500.59

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1501.   146.  -130.    16.   2.3   1.8   6.7   5.6   2.3   3.0
   RT:    255.    38.    16.    54.   2.0   1.2   5.9   5.4   1.7   3.0

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

APPRO:AS       25   -128      835  0.51  0.15  501.13  497.12    4100  500.62
        51     29     56    91156  1.37  0.00   -0.01    0.48    4.91

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -29.   -40.    51.   4100.   36213.     374.   10.97  498.02
   FULLV:FV       0.   -53.    55.   4100.   41253.     416.    9.86  498.64
   BRIDG:BR       0.     0.    29.   2317.   22176.     236.    9.83  497.52
   RDWAY:RG       9.******* 1501.   1756.*****************    2.00  500.59
   APPRO:AS      51.  -129.    56.   4100.   91156.     835.    4.91  500.62
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    497.20    0.96  488.17  507.00************  1.91  499.93  498.02
   FULLV:FV    497.40    0.91  488.37  507.20  0.33  0.00  1.60  500.25  498.64
   BRIDG:BR    494.75    0.61  488.06  497.52************  1.50  499.02  497.52
   RDWAY:RG  ****************  498.27  509.04  0.08******  0.51  501.06  500.59
   APPRO:AS    497.12    0.48  489.11  510.15  0.15  0.00  0.51  501.13  500.62
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WSPRO OUTPUT FILE (continued)

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       U.S. Geological Survey WSPRO Input File grnv015.wsp
       Hydraulic analysis for structure GRNVTH00230015   Date: 19-APR-96
       Town Highway 23 Bridge Over the 3rd Branch White River, Granville MAI
          *** RUN DATE & TIME: 05-22-96  09:46

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

EXITX:XS   ******    -60      448  2.19 *****  500.92  498.63    5100  498.73
       -28 ******     56    45041  1.09 ***** *******    1.07   11.38

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.91     499.85     498.84

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   498.23     507.20    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   498.23     507.20     498.84

FULLV:FV       29   -130      609  1.34  0.27  501.17  498.84    5100  499.84
         0     29     61    60971  1.23  0.00   -0.02    0.92    8.37
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  1.48

APPRO:AS       51   -128      828  0.81  0.24  501.39 *******    5100  500.58
        51     51     56    90205  1.37  0.00   -0.02    0.60    6.16
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   499.84     497.15

            <<<<<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       29      0      236  1.28 *****  498.80  494.44    2140  497.52
         0 ******     29    22176  1.00 ***** *******    0.56    9.08

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.15 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    39.  0.08  0.54  501.91    0.00   2960.  501.31

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   2469.   147.  -131.    16.   3.0   2.5   8.0   6.6   3.1   3.0
   RT:    490.    47.    16.    63.   2.7   1.6   6.9   6.3   2.3   3.0

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

APPRO:AS       25   -130      990  0.54  0.15  501.99  498.17    5100  501.45
        51     30     58   113969  1.31  0.00    0.00    0.46    5.15

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS     -29.   -61.    56.   5100.   45041.     448.   11.38  498.73
   FULLV:FV       0.  -131.    61.   5100.   60971.     609.    8.37  499.84
   BRIDG:BR       0.     0.    29.   2140.   22176.     236.    9.08  497.52
   RDWAY:RG       9.******* 2469.   2960.******************    2.00  501.31
   APPRO:AS      51.  -131.    58.   5100.  113969.     990.    5.15  501.45

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    498.63    1.07  488.17  507.00************  2.19  500.92  498.73
   FULLV:FV    498.84    0.92  488.37  507.20  0.27  0.00  1.34  501.17  499.84
   BRIDG:BR    494.44    0.56  488.06  497.52************  1.28  498.80  497.52
   RDWAY:RG  ****************  498.27  509.04  0.08******  0.54  501.91  501.31
   APPRO:AS    498.17    0.46  489.11  510.15  0.15  0.00  0.54  501.99  501.45
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        U.S. Geological Survey WSPRO Input File grnv015.wsp
        Hydraulic analysis for structure GRNVTH00230015   Date: 19-APR-96
        Town Highway 23 Bridge Over the 3rd Branch White River, Granville MAI
           *** RUN DATE & TIME: 05-22-96  09:46

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

EXITX:XS   ******    -15      228  1.48 *****  497.03  494.68    2220  495.55
       -28 ******     32    19616  1.00 ***** *******    0.79    9.74

FULLV:FV       29    -17      242  1.31  0.35  497.36 *******    2220  496.05
         0     29     32    21110  1.00  0.00   -0.02    0.73    9.16
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  1.54

APPRO:AS       51    -33      325  0.80  0.37  497.72 *******    2220  496.92
        51     51     44    32430  1.09  0.00   -0.01    0.62    6.84
         <<<<<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       29      0      176  2.48  0.36  497.52  494.58    2220  495.04
         0     29     29    20431  1.00  0.13   -0.01    0.89   12.64

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.15 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
   RDWAY:RG       9.        <<<<<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       25    -40      356  0.68  0.17  497.99  494.62    2220  497.31
        51     26     44    36238  1.13  0.31    0.01    0.57    6.23

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.627  0.268   26445.     0.    29.   497.16

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -29.   -16.    32.   2220.   19616.     228.    9.74  495.55
   FULLV:FV       0.   -18.    32.   2220.   21110.     242.    9.16  496.05
   BRIDG:BR       0.     0.    29.   2220.   20431.     176.   12.64  495.04
   RDWAY:RG       9.**************      0.******************    2.00********
   APPRO:AS      51.   -41.    44.   2220.   36238.     356.    6.23  497.31

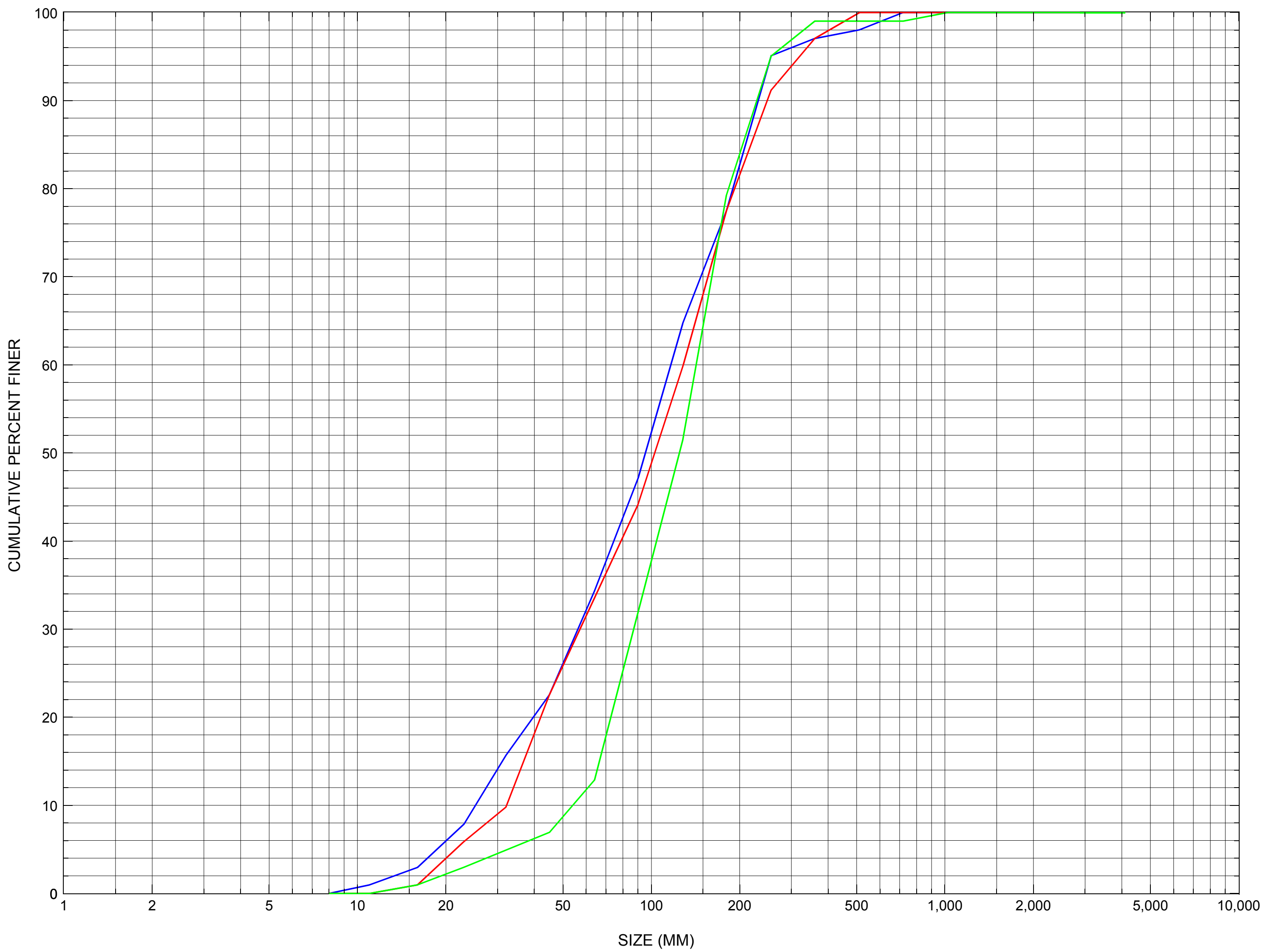
    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       0.    29.   26445.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    494.68    0.79  488.17  507.00************  1.48  497.03  495.55
   FULLV:FV  ********    0.73  488.37  507.20  0.35  0.00  1.31  497.36  496.05
   BRIDG:BR    494.58    0.89  488.06  497.52  0.36  0.13  2.48  497.52  495.04
   RDWAY:RG  ****************  498.27  509.04**********************************
   APPRO:AS    494.62    0.57  489.11  510.15  0.17  0.31  0.68  497.99  497.31
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for three pebble count transects at the approach cross-section for structure GRNVTH00230015, in Granville, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number GRNVTH00230015

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 26 / 94

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

County *(FIPS county code; I - 3; nnn)* 001

Town *(FIPS place code; I - 4; nnnnn)* 29575

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

Waterway *(I - 6)* THIRD BRANCH WHITE R

Road Name *(I - 7)*: -

Route Number TH023

Vicinity *(I - 9)* AT JCT TH 23 + VT 12A

Topographic Map Warren

Hydrologic Unit Code: 01080105

Latitude *(I - 16; nnnn.n)* 44008

Longitude *(i - 17; nnnnn.n)* 72452

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10010700150107

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

Maximum span length *(I - 48; nnnn)* 0031

Year built *(I - 27; YYYY)* 1919

Structure length *(I - 49; nnnnnn)* 000035

Average daily traffic, ADT *(I - 29; nnnnnn)* 000070

Deck Width *(I - 52; nn.n)* 123

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

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

Opening skew to Roadway *(I - 34; nn)* 12

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

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

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

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

Year Reconstructed *(I - 106)* 1955

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*) 008.5

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

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

Comments:

Structural report of 4/21/93 indicates a steel beam and timber deck type bridge with a narrow gravel roadway approach. The bridge has concrete abutment walls and wingwalls. The right abutment has some areas where it has eroded away leaving some deep pockets, one foot deep, at the streambed level. No settlement was reported. The channel makes a moderate turn into bridge with most of the flow along right abutment. The banks are well protected with no embankment erosion. No drift/vegetation build up near bridge.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

-

Streambed material: **Stone and gravel**

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

Q_{50} - Q_{100} - Q_{500} -

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -
-

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

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

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

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

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

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

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

Comments:
--
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **23.57** mi^2
Lake and pond area **0.02** mi^2
Watershed storage *(ST)* **0.1** %
Bridge site elevation **820** ft
Headwater elevation **2823** ft
Main channel length **8.44** mi
10% channel length elevation **850** ft
85% channel length elevation **1700** ft
Main channel slope *(S)* **134.28** ft / mi

Watershed Precipitation Data

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

Bridge Plan Data

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

Project Number ________________________ Minimum channel bed elevation: ________

Low superstructure elevation: USLAB _______ DSLAB ________ USRAB _______ DSRAB _______

Benchmark location description:

NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness _______ Footing bottom elevation: ______

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

If 3: Footing bottom elevation: ______

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS.

Cross-sectional Data

Is cross-sectional data available? N *If no, type ctrl-n xs*

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

Comments: **NO CROSS SECTION INFORMATION**

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

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

Comments: **NO CROSS SECTION INFORMATION**

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **MAW** Date: **02/10/95**

Computerized by: **MAI** Date: **03/15/95**

Reviewd by: **MAI** Date: **05/13/95**

Structure Number **GRNVTH00230015**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **S. OLSON** Date *(MM/DD/YY)* **10** / **21** / 19**94**

2. Highway District Number **04** Mile marker **0**

County **ADDISON (001)** Town **GRANVILLE (29575)**

Waterway *(I - 6)* **THIRD BRANCH WHITE RIVER** Road Name **-**

Route Number **TH023** Hydrologic Unit Code: **01080105**

3. Descriptive comments:

Near junction of TH 23 and VT 12A.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **5** LBDS **2** RBDS **2** Overall **2**

*(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 **35** *(feet)* Span length **31** *(feet)* Bridge width **12.3** *(feet)*

Road approach to bridge:

8. LB **0** 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	0
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	0	-	0	0

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

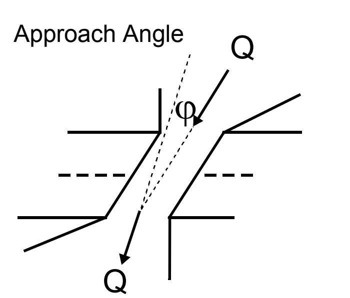
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

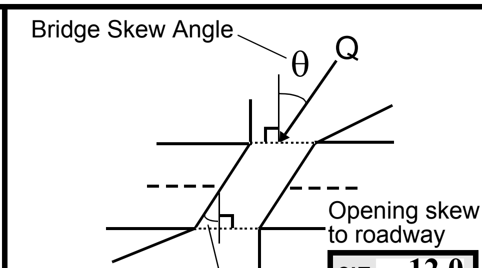
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

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

Channel approach to bridge (BF):

15. Angle of approach: **5** 16. Bridge skew: **10**





α= **12.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*

Where? **RB** *(LB, RB)* Severity **2**

Range? **9** feet **US** *(US, UB, DS)* to **25** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*

Where? **RB** *(LB, RB)* Severity **2**

Range? **6** feet **UB** *(US, UB, DS)* to **30** feet **DS**

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

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

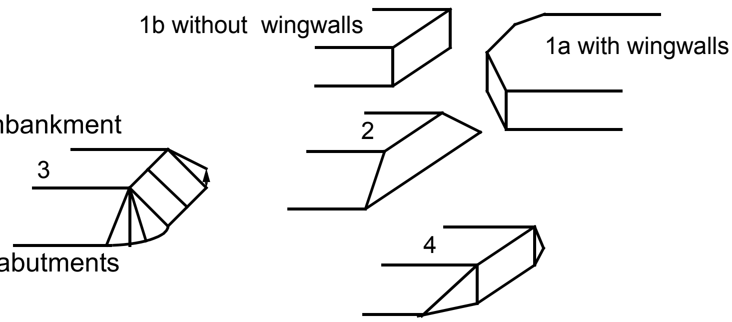
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4. LBUS: shrubs and brush with some trees on the immediate bank then pasture. RBUS is shrubs/brush. At two bridge lengths landward there is railroad tracks and VT 12. LBDS is suburban for a short distance downstream; becomes forest about 70 ft. RBDS: there is a large house surrounded by brush type vegetation.
7. Values from VTAOT database (VTAOT, written communication, August 26, 1994). Measured bridge length: 35, span: 29, and width: 12 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
50.8	**5.0**			**4.0**	**3**	**2**	**4**	**4**	**1**	**1**

23. Bank width **50.0** 24. Channel width **25.0** 25. Thalweg depth **47.0** 29. Bed Material **46**

30 .Bank protection type: LB **5** 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.):

29. Bed material is bedrock from about 30 to 105 feet upstream and cobbles.
30. LB: some protection from a cinder block wall extending 45 ft. upstream. RB: stone fill extends 40 ft. from the bridge.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **95** 35. Mid-bar width: **6**

36. Point bar extent: **85** feet **US** (US, UB) to **120** feet **US** (US, UB, DS) positioned **0** %LB to **15** %RB

37. Material: **4**

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

There are a few boulders on point bar as well. Its a small point bar on the inside of a bend. A much larger point bar exist on the right bank opposite of the described cut bank.

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

41. Mid-bank distance: **200** 42. Cut bank extent: **120** feet **US** (US, UB) to **220** feet **US** (US, UB, DS)

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

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

Beyond the two bridge length range.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **60**

47. Scour dimensions: Length **20** Width **8** Depth : **2** Position **5** %LB to **40** %RB

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

It is a scour hole completely bounded by bedrock.

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
28.5		1.0		2	7	7	-

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

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

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

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

4

The right abutment is cracked and a few pieces of the abutment are missing, exposing a part of a stone abutment wall. Further weathering of the concrete is visible at an impact point near the downstream face on the right abutment. The concrete of the abutment is cut into 4 to 5 inches horizontally exposing drywall.

There is some slight channel deepening under the bridge (about 0.5 feet determined from survey data), however length and width of 'scour' is not clearly visible; it is either long term or contraction scour.

63. There are some boulders and native material in the channel.

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. Some slight debris caught on a tree on the left bank just upstream of the bridge.

67. Upstream is laterally stable, has few cut banks, and consists of cobble and boulder type material.

68. Moderate channel gradient and the span length is 60% of the upstream bank width.

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		-	83	2	0	-	-	90.0
RABUT	1	5	90			2	0	29.0

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.):

-

-

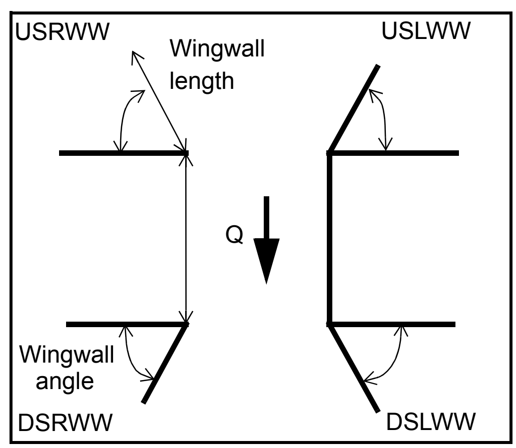
1

See previous comments in 64.

75. RABUT: There is no footing along the abutment. Apparently the concrete covers part of an old stonewall abutment. Some of the concrete is eroded away especially along the base of the abutment exposing the stone drywall. In one spot there is nearly a foot between the streambed and the concrete; a hole has formed 0.5 ft. deep into the abutment. However, the stone drywall exposed at the base does not appear to be undermined.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						25.0	
USRWW:	Y		1		0	1.5	
DSLWW:	-		-		Y	12.5	
DSRWW:	1		0		-	23.0	



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	-	0	N	-	1	1	-	2
Condition	Y	-	-	-	2	1	-	1
Extent	1	-	-	5	1	0	1	-

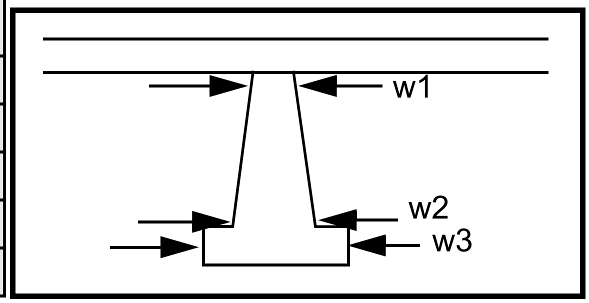
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
--
-
-
-
5
1
3
-
-
-

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				**70.0**	**10.5**	**55.0**
Pier 2	**8.0**	**5.0**	-	**60.0**	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**US**	**82.**	**nstre**	**g the**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**Left**	**RAB**	**am**	**right**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**and**	**UT:**	**end**	**abut**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**Righ**	**Ther**	**of**	**ment**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**t**	**e is a**	**the**	**base**	*Y- yes; N- no*
91. Attack ∠ (BF)	**wing**	**woo**	**right**	**is**	
92. Pushed	**wall:**	**den/**	**abut**	**dow**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**see**	**log**	**ment**	**ngra**	
95. Cross-members	**com-**	**wall**	**. The**	**ded**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**ment**	**at**	**stone**	**to**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**s in**	**the**	**fill**	**slum**	
98. Exposure depth	**79.**	**dow**	**alon**	**ped**	

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

because if it was placed along the abutment it has now slid into the channel and is only protecting the bed at the abutment toe. Furthermore, the protection is quite sparse. Abutment damage has occurred.

N

-

E. Downstream Channel Assessment

100.

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

Bank width (BF) - Channel width (Amb) - Thalweg depth (Amb) - Bed Material -

Bank protection type (Qmax): LB - RB - Bank protection condition: LB - RB -

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*
*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*
*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

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

-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

101. Is a drop structure present? - (*Y or N, if N type ctrl-n ds*) 102. Distance: - feet

103. Drop: - feet 104. Structure material: - (***1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other*)

105. Drop structure comments (eg. downstream scour depth):

-
-
-
-
-
-

106. 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.):

-
-
-

NO 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 _____ (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.):

1
1
4

Is channel scour present? **7** (Y or if N type ctrl-n cs) Mid-scour distance: **1**

Scour dimensions: Length **0** Width **4** Depth: **5** Positioned **5** %LB to **1** %RB

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

1

Bank protection LB: protection by a masonry wall extending from the end of the DS wingwall to 10 ft. Additional stone fill extends another 20 feet. RB: protected by a log crib wall about five feet tall and extending from the right abutment to 105 ft. downstream; extensive stone fill extends beyond the crib-work another 50 -

Are there major confluences? **75** (Y or if N type ctrl-n mc) How many? **feet.**

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

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

Confluence comments (eg. confluence name):

g the right bank shows signs of undermining but in general is in good shape; undermined a foot in some locations.

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

109. G. Plan View Sketch

-

point bar	pb	debris		flow	Q	stone wall	
cut-bank	cb	rip rap or stone fill		cross-section		other wall	
scour hole				ambient channel			

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: GRNVTH00230015 Town: Granville
Road Number: TH 23 County: Addison
Stream: Third Branch White River

Initials MAI Date: 04/23/96 Checked: EMB

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	4100	5100	2220
Main Channel Area, ft2	476	516	320
Left overbank area, ft2	312	414	29
Right overbank area, ft2	47	61	7
Top width main channel, ft	47	47	47
Top width L overbank, ft	122	124	34
Top width R overbank, ft	17	18	5
D50 of channel, ft	0.353	0.353	0.353
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	10.1	11.0	6.8
y1, average depth, LOB, ft	2.6	3.3	0.9
y1, average depth, ROB, ft	2.8	3.4	1.4
Total conveyance, approach	91134	114023	36222
Conveyance, main channel	68050	77630	35089
Conveyance, LOB	21101	33468	933
Conveyance, ROB	1983	2925	200
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	3061.5	3472.2	2150.6
Ql, discharge, LOB, cfs	949.3	1497.0	57.2
Qr, discharge, ROB, cfs	89.2	130.8	12.3
Vm, mean velocity MC, ft/s	6.4	6.7	6.7
Vl, mean velocity, LOB, ft/s	3.0	3.6	2.0
Vr, mean velocity, ROB, ft/s	1.9	2.1	1.8
Vc-m, crit. velocity, MC, ft/s	11.7	11.8	10.9
Vc-l, crit. velocity, LOB, ft/s	0.0	0.0	0.0
Vc-r, crit. velocity, ROB, ft/s	0.0	0.0	0.0

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	0
Left Overbank	1	1	1
Right Overbank	1	1	1

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)

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	476	516	320
Main channel width, ft	47	47	47
y1, main channel depth, ft	10.13	10.98	6.81
Bridge Section			
(Q) total discharge, cfs	4100	5100	2220
(Q) discharge thru bridge, cfs	2317	2140	2220
Main channel conveyance	22176	22176	20435
Total conveyance	22176	22176	20435
Q2, bridge MC discharge,cfs	2317	2140	2220
Main channel area, ft2	236	236	176
Main channel width (skewed), ft	29.0	29.0	28.7
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	29	29	28.7
y_bridge (avg. depth at br.), ft	8.13	8.13	6.12
Dm, median (1.25*D50), ft	0.44125	0.44125	0.44125
y2, depth in contraction,ft	6.68	6.24	6.50
ys, scour depth (y2-ybridge), ft	-1.45	-1.89	0.38
ys, scour depth (y2-y1), ft	-3.45	-4.74	-0.31

ARMORING			
D90	0.772	0.772	0.772
D95	0.934	0.934	0.934
Critical grain size,Dc, ft	0.4133	0.3526	0.7700
Decimal-percent coarser than Dc	0.421	0.501	0.101
Depth to armoring,ft	1.71	1.05	20.56

PRESSURE FLOW SCOUR COMPUTATION

Structure Number: GRNVTH00230015 Town: Granville
Road Number: TH 23 County: Addison
Stream: Third Branch White River
Initial: EMB Date: 10/10/96 Checked: MAI
Pressure Flow Scour (contraction scour for orifice flow conditions)

Hb+Ys=Cq*qbr/Vc Cq=1/Cf*Cc Cf=1.5*Fr^0.43 (<=1)
Chang Equation Cc=SQRT[0.10*(Hb/(ya-w)-0.56)]+0.79 (<=1)
(Richardson and others, 1995, p. 145-146)

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	2317	2140	0
Vc, critical velocity, ft/s	11.7	11.8	0
Vc, critical velocity, m/s	3.565986	3.596464	0
Main channel width (skewed), ft	28.6	28.6	0
Cum. width of piers, ft	0	0	0
W, adjusted width, ft	28.6	28.6	0
qbr, unit discharge, ft^2/s	81.01399	74.82517	ERR
qbr, unit discharge, m^2/s	7.525711	6.950808	N/A
Area of full opening, ft^2	235.7	235.7	0
Hb, depth of full opening, ft	8.241259	8.241259	ERR
Hb, depth of full opening, m	2.511813	2.511813	N/A
Fr, Froude number MC	0.61	0.56	1
Cf, Fr correction factor (<=1.0)	1	1	1.5
Elevation of Low Steel, ft	497.15	497.15	0
Elevation of Bed, ft	488.9087	488.9087	N/A
Elevation of approach WS, ft	500.62	501.45	0
HF, bridge to approach, ft	0.15	0.15	0
Elevation of WS immediately US, ft	500.47	501.3	0
ya, depth immediately US, ft	11.56126	12.39126	N/A
ya, depth immediately US, m	3.592685	3.850609	N/A
Mean elev. of deck, ft	498.54	498.54	0
w, depth of overflow, ft (>=0)	1.93	2.76	0
Cc, vert contrac correction (<=1.0)	0.961953	0.961953	ERR
Ys, depth of scour (chang), ft	-1.04312	-1.64934	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)

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	4100	5100	2220	4100	5100	2220
a', abut.length blocking flow, ft	129.5	131.3	41.2	27.8	29.4	15.9
Ae, area of blocked flow ft2	146.2	160.7	71.5	121.9	124.1	68.8
Qe, discharge blocked abut.,cfs	--	--	277.5	--	--	373.4
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve manually)						
Ve, (Qe/Ae), ft/s	3.40	3.87	3.88	4.65	4.75	5.43
ya, depth of f/p flow, ft	1.13	1.22	1.74	4.38	4.22	4.33
--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	100	100	100	80	80	80
K2	1.01	1.01	1.01	0.98	0.98	0.98
Fr, froude number f/p flow	0.350	0.354	0.519	0.359	0.350	0.460
ys, scour depth, ft	9.76	10.38	10.31	13.91	13.62	12.97

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)	129.5	131.3	41.2	27.8	29.4	15.9
y1 (depth f/p flow, ft)	1.13	1.22	1.74	4.38	4.22	4.33
a'/y1	114.71	107.28	23.74	6.34	6.97	3.67
Skew correction (p. 49, fig. 16)	1.04	1.04	1.04	0.97	0.97	0.97
Froude no. f/p flow	0.35	0.35	0.52	0.36	0.35	0.46
Ys w/ corr. factor K1/0.55:						
vertical	6.06	6.60	ERR	ERR	ERR	ERR
vertical w/ ww's	4.97	5.41	ERR	ERR	ERR	ERR
spill-through	3.33	3.63	ERR	ERR	ERR	ERR

Abutment riprap Sizing

Isbash Relationship
D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)
(Richardson and others, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.61	0.56	0.89	0.61	0.56	0.89
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	8.34	8.34	6.38	8.34	8.34	6.38
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.92	1.62	ERR	1.92	1.62	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	2.58	ERR	ERR	2.54
Fr<=0.8 (spillthrough abut.)	1.67	1.41	ERR	1.67	1.41	ERR
Fr>0.8 (spillthrough abut.)	ERR	ERR	2.28	ERR	ERR	2.24