LEVEL II SCOUR ANALYSIS FOR BRIDGE 30 (MNTGTH00410030) on TOWN HIGHWAY 41, crossing the TROUT RIVER, MONTGOMERY, VERMONT

U.S. Geological Survey
Open-File Report 97-396

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

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By MICHAEL A. IVANOFF AND LAURA MEDALIE

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

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 30 (MNTGTH00410030) ON TOWN HIGHWAY 41, CROSSING THE TROUT RIVER, MONTGOMERY, VERMONT

By **Michael A. Ivanoff and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure MNTGTH00410030 on Town Highway 41 crossing the Trout River, Montgomery, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province in northern Vermont. The 46.1-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover on the left bank is pasture upstream and downstream of the bridge with dense woody vegetation along the immediate banks. The upstream and downstream right bank surface cover is brush.

In the study area, the Trout River has an incised, meandering channel with a slope of approximately 0.005 ft/ft, an average channel top width of 130 ft and an average bank height of 6 ft. The channel bed material ranges from sand to cobble with a median grain size (D_{50}) of 68.3 mm (0.224 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 27, 1995, indicated that the reach was laterally unstable. At this site there is visible lateral channel movement upstream and downstream of the bridge with meanders and cut banks.

The Town Highway 41 crossing of the Trout River is a 90-ft-long, one-lane bridge consisting of one 87-foot steel-beam span (Vermont Agency of Transportation, written communication, August 3, 1994). The opening length of the structure parallel to the bridge face is 86.7 ft.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 0 degrees.

A scour hole 4.5 ft deeper than the mean thalweg depth, was observed 35 ft downstream of the bridge during the Level I assessment. The scour counter-measures at the site included type-1 stone fill (less than 12 inches diameter) at the upstream left wingwall, at the left abutment, along the upstream right bank, and at the upstream end of the downstream left wingwall. There was also type-2 stone fill (less than 36 inches diameter) along the downstream right bank. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows was 0.0 ft. Abutment scour ranged from 2.5 to 8.9 ft. The worst-case abutment scour occurred at the 500-year discharge. The computed scour depths are well above the pile depths set in bedrock. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Richford, VT. Quadrangle, 1:24,000, 1986

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 MNTGTH00410030 ***Stream*** Trout River

County Franklin ***Road*** TH 41 ***District*** 8

Description of Bridge

Bridge length 90 ***ft*** ***Bridge width*** 16.3 ***ft*** ***Max span length*** 87 ***ft***

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

Abutment type Spill-through/Vertical ***Embankment type*** Sloping

Stone fill on abutment? Yes, left ***Date of inspection*** 6/27/95

Description of stone fill Type-1, along the upstream left wingwall, upstream right bank, the spill-through embankment of the left abutment, and the upstream end of the downstream left wingwall. Type-2, along the downstream right bank.

Abutments and wingwalls are concrete. There are spill-through embankments in front of each vertical abutment wall.

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

There is a severe channel bend in the upstream reach.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	6/27/95	0	0
Level II	6/27/95	0	0

Potential for debris Moderate. There is some trees leaning over the channel upstream. The channel is laterally unstable with cut banks.

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

There was a large point bar upstream along the left bank as of 6/27/95.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with flat to slightly irregular flood plain.

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

Date of inspection 6/27/95

DS left: Steep channel bank to the narrow flood plain.

DS right: Narrow flood plain.

US left: Steep channel bank to the narrow flood plain.

US right: Steep channel bank to the narrow flood plain.

Description of the Channel

Average top width 130 *ft* ***Average depth*** 6 *ft*

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

Meandering with alluvial channel boundaries and a narrow flood plain.

6/27/95

Vegetative co

Trees and brush with pasture beyond.

DS left: Brush.

DS right: Brush and pasture.

US left: Some trees and brush on the immediate bank with row crops beyond.

US right:

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

There is visible lateral movement of the channel upstream and downstream of the bridge with cut banks and large point bars as of 6/27/95.

None noted 6/27/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 46.1 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None.

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 6,000 ***ft³/s*** ***Q500*** 8,200 ***ft³/s***

The 100- and 500-year discharges are taken from the downstream covered bridge in Montgomery. The covered bridge has flood frequency estimates available from the VTAOT database. The drainage area above the covered bridge is 47.7 square miles. The final calculated discharges for bridge 30 in Montgomery are within a range defined by several empirical flood frequency curves (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans VTAOT plans' datum and arbitrary survey datum are the same. Subtract 20.6 ft. to obtain NGVD29.

Description of reference marks used to determine USGS datum. RM1 is a Vermont State brass tablet on the upstream road curb above the left abutment (elev. 503.51 ft, arbitrary survey datum). RM2 is a spike in a telephone pole on the upstream left bank 50 ft west on TH 41 then 50 ft south of the edge of road (elev. 500.00 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	-62	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	10	1	Road Grade section
APPRO	107	2	Modelled Approach section (Templated from APTEM)
APTEM	140	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.035 to 0.046, and overbank "n" values ranged from 0.036 to 0.076.

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 0.00073 ft/ft which was measured from the 100-year water-surface profile downstream of the bridge in the Flood Insurance Study for the Town of Montgomery (Federal Emergency Management Agency, 1980).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.010 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 502.7 ***ft***
Average low steel elevation 498.9 ***ft***

100-year discharge 6,000 ***ft^3/s***
Water-surface elevation in bridge opening 498.9 ***ft***
Road overtopping? Yes ***Discharge over road*** 4,300 ***ft^3/s***
Area of flow in bridge opening 796 ***ft^2***
Average velocity in bridge opening 2.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 2.6 ***ft/s***

Water-surface elevation at Approach section with bridge 499.8
Water-surface elevation at Approach section without bridge 499.8
Amount of backwater caused by bridge 0.0 ***ft***

500-year discharge 8,200 ***ft^3/s***
Water-surface elevation in bridge opening 498.9 ***ft***
Road overtopping? Yes ***Discharge over road*** 6,510 ***ft^3/s***
Area of flow in bridge opening 796 ***ft^2***
Average velocity in bridge opening 2.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 2.4 ***/s***

Water-surface elevation at Approach section with bridge 500.6
Water-surface elevation at Approach section without bridge 500.7
Amount of backwater caused by bridge 0.0 ***ft***

Incipient overtopping discharge 2,090 ***ft^3/s***
Water-surface elevation in bridge opening 496.7 ***ft***
Area of flow in bridge opening 608 ***ft^2***
Average velocity in bridge opening 3.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 4.3 ***ft/s***

Water-surface elevation at Approach section with bridge 497.0
Water-surface elevation at Approach section without bridge 496.9
Amount of backwater caused by bridge 0.1 ***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 for the incipient roadway-overtopping discharge was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 100-year and 500-year discharges resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). In addition, for the discharges resulting in orifice flow, estimates of contraction scour were also computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) for comparison and presented in Appendix F.

Abutment scour for the left abutment with a spill-through embankment 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 at the right abutment with a spill-through embankment was computed by use of the HIRE equation (Richardson and others, 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.

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

Scour Results

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

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	7.6	8.9	8.6
Right abutment	4.5	5.2	1.7
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	0.1	0.1	0.3
Right abutment	0.1	0.1	0.3
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

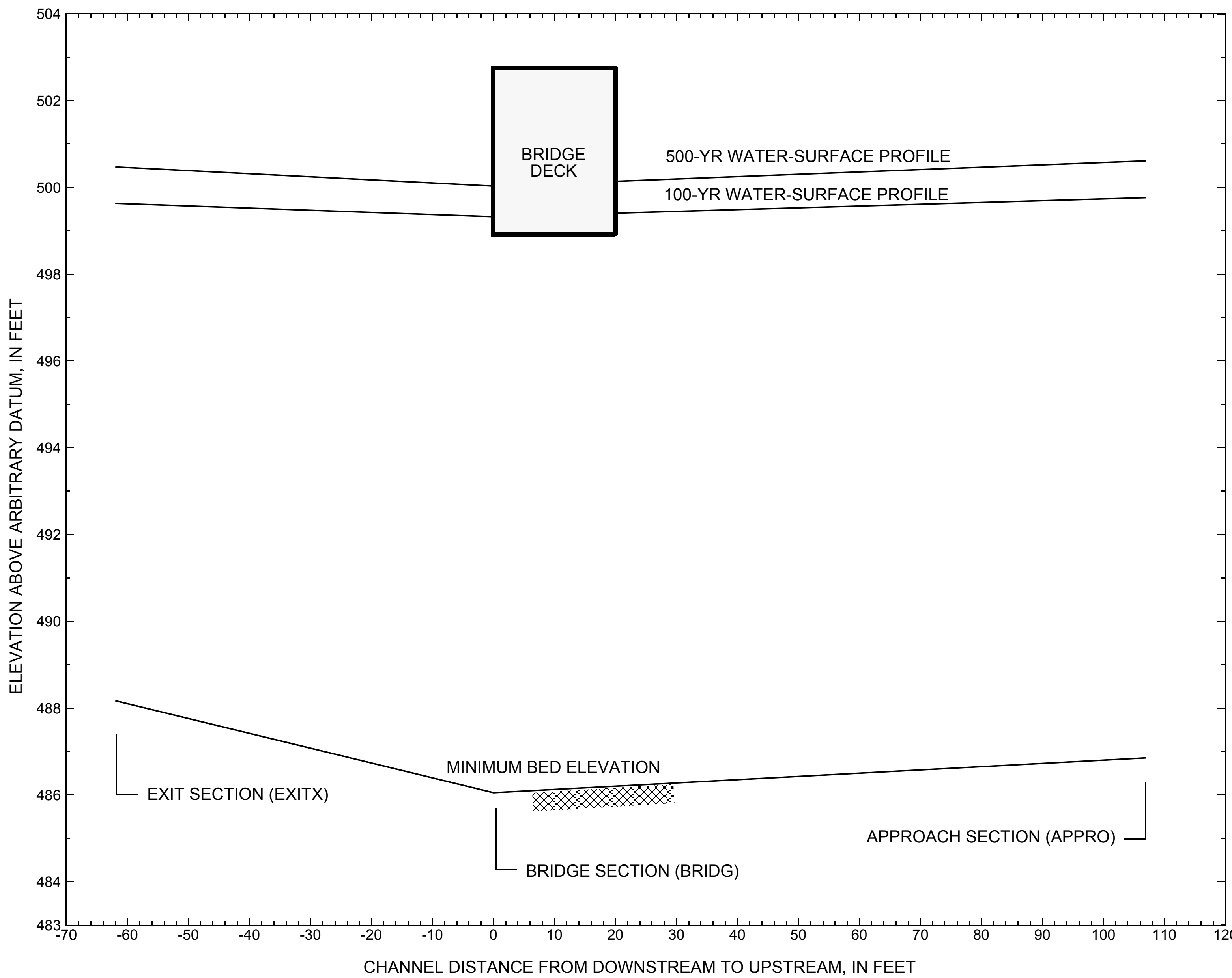

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure MNTGTH00410030 on Town Highway 41, crossing the Trout River, Montgomery, Vermont.

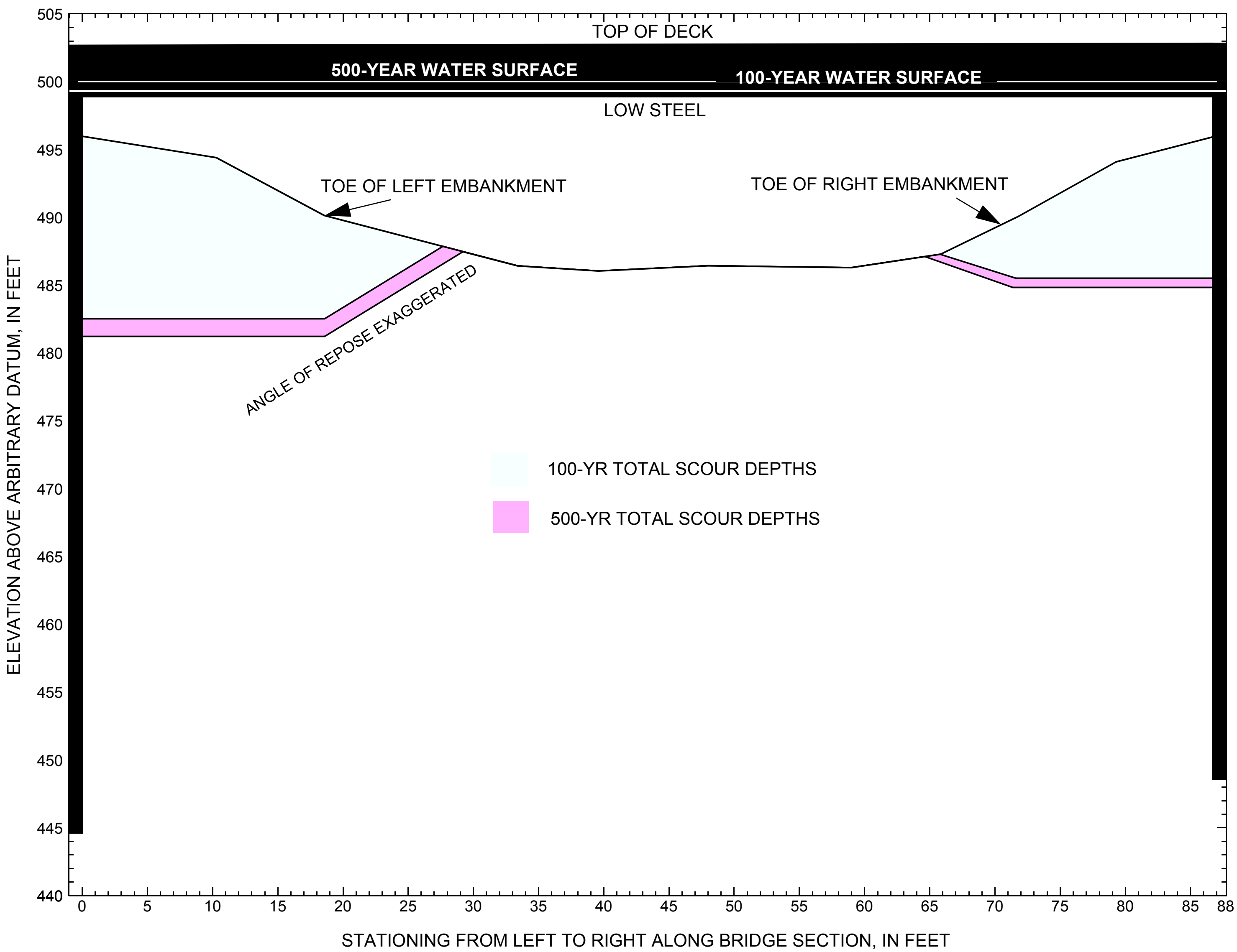

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure MNTGTH00410030 on Town Highway 41, crossing the Trout River, Montgomery, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure MNTGTH00410030 on Town Highway 41, crossing the Trout River, Montgomery, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 6,000 cubic-feet per second											
Left abutment	0.0	498.6	498.9	444.6	496.0	0.0	--	--	--	--	37.9
Toe of left embankment	18.6	--	--	--	490.1	0.0	7.6	--	7.6	482.5	--
Toe of right embankment	71.9	--	--	--	490.1	0.0	4.5	--	4.5	485.6	--
Right abutment	86.7	498.6	498.9	448.6	495.9	0.0	--	--	--	--	37.0

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 MNTGTH00410030 on Town Highway 41, crossing the Trout River, Montgomery, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 8,200 cubic-feet per second											
Left abutment	0.0	498.6	498.9	444.6	496.0	0.0	--	--	--	--	36.6
Toe of left embankment	18.6	--	--	--	490.1	0.0	8.9	--	8.9	481.2	--
Toe of right embankment	71.9	--	--	--	490.1	0.0	5.2	--	5.2	484.9	--
Right abutment	86.7	498.6	498.9	448.6	495.9	0.0	--	--	--	--	36.3

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

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U.S. Geological Survey, 1986, Richford, 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 mntg030.wsp
T2        Hydraulic analysis for structure MNTGTH00410030   Date: 14-APR-97
T3        Bridge # 30 on Town Highway 41 over the Trout River, Montgomery, VT
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           6000.0   8200.0   2090.0
WS          496      496      496.74
SK          0.00073  0.00073  0.00073
*
XS   EXITX    -62
GR         -597.8, 504.08   -453.3, 502.36   -401.2, 498.73   -332.7, 497.50
GR          -75.7, 497.87    -15.1, 496.50      0.0, 494.95      6.4, 489.72
GR           18.9, 488.17     33.7, 488.50     40.1, 488.71     60.6, 489.15
GR           82.1, 489.84     89.9, 495.46    131.4, 497.93    290.1, 496.78
GR          401.4, 496.81    517.6, 498.70
N           0.058        0.046        0.049
SA                  0.0          89.9
*
XS   FULLV     0 * * * 0.004
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    498.92       0.0
GR            0.0, 498.90      0.9, 495.98     10.3, 494.40     18.6, 490.13
GR           33.4, 486.42     39.6, 486.05     48.0, 486.43     59.0, 486.30
GR           65.8, 487.28     71.9, 490.13     79.3, 494.10     86.5, 495.93
GR           86.7, 498.94      0.0, 498.90
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV
CD           2      20.3      4.1    502.8
N           0.035
*
*             SRD    EMBWID   IPAVE
XR   RDWAY    10      16.3     2
GR         -597.8, 504.08   -453.3, 502.36   -401.2, 498.73
GR         -333.0, 497.02   -253.2, 496.90   -111.8, 498.57    -41.3, 502.02
GR            0.0, 502.68      0.2, 503.45     89.5, 503.56     89.5, 502.83
GR          148.8, 501.66    193.7, 498.02    436.1, 497.18    595.4, 503.69
*
XT   APTEM    140
GR         -597.8, 504.08   -453.3, 502.36   -401.2, 498.73   -187.8, 498.58
GR          -73.5, 498.91    -59.5, 496.29    -47.5, 496.04    -23.0, 493.94
GR            0.0, 491.30     12.1, 492.72     31.0, 493.13     62.5, 491.03
GR           65.9, 489.92     77.7, 487.51     81.1, 487.18     89.9, 487.95
GR           92.2, 489.89     96.4, 494.69    117.6, 497.83    541.3, 495.82
GR          595.4, 503.69
*
AS   APPRO     107 * * * 0.010
GT
N           0.036        0.046        0.076
SA                -73.5         96.4
*
HP 1 BRIDG   498.94 1 498.94
HP 2 BRIDG   498.94 * * 1713
HP 2 RDWAY   499.32 * * 4304
HP 1 APPRO   499.76 1 499.76
HP 2 APPRO   499.76 * * 6000
*
HP 1 BRIDG   498.94 1 498.94
HP 2 BRIDG   498.94 * * 1577
HP 2 RDWAY   500.03 * * 6507
HP 1 APPRO   500.61 1 500.61
HP 2 APPRO   500.61 * * 8200
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File mntg030.wsp
        Hydraulic analysis for structure MNTGTH00410030   Date: 14-APR-97
        Bridge # 30 on Town Highway 41 over the Trout River, Montgomery, VT
           *** RUN DATE & TIME: 05-22-97  07:42
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     796.   90646.     0.   182.                           0.
   498.94          796.   90646.     0.   182.  1.00     0.    87.      0.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.94     0.0    86.7   796.0   90646.    1713.   2.15

 X STA.        0.0       16.1       21.5       25.8       29.4       32.4
  A(I)            70.8       47.2       42.7       39.5       36.4
  V(I)            1.21       1.81       2.00       2.17       2.35

 X STA.       32.4       35.2       37.9       40.5       43.1       45.7
  A(I)            35.0       34.3       33.6       33.0       32.7
  V(I)            2.45       2.50       2.55       2.59       2.62

 X STA.       45.7       48.4       51.0       53.7       56.4       59.1
  A(I)            33.2       33.1       33.6       33.4       34.2
  V(I)            2.58       2.58       2.55       2.56       2.51

 X STA.       59.1       61.9       65.0       68.6       73.6       86.7
  A(I)            35.3       37.0       39.8       45.9       65.0
  V(I)            2.42       2.31       2.15       1.87       1.32

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.32  -409.7   488.5  1002.6   38410.    4304.   4.29

 X STA.     -409.7     -347.5     -324.9     -305.4     -286.5     -267.9
  A(I)            70.4       49.3       45.5       44.4       44.4
  V(I)            3.06       4.36       4.72       4.85       4.85

 X STA.     -267.9     -249.5     -229.6     -205.2     -170.1      202.5
  A(I)            44.2       44.9       48.9       57.7       91.6
  V(I)            4.87       4.80       4.40       3.73       2.35

 X STA.      202.5      239.5      272.1      300.4      326.0      350.2
  A(I)            51.6       49.4       45.9       43.8       43.6
  V(I)            4.17       4.35       4.69       4.91       4.93

 X STA.      350.2      372.8      393.7      414.0      434.9      488.5
  A(I)            42.6       40.9       41.0       43.8       58.7
  V(I)            5.06       5.26       5.24       4.91       3.67

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     107.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     473.   24075.   347.   347.                        3135.
             2    1243.  149427.   170.   174.                       19081.
             3    1527.   65246.   474.   475.                       15552.
   499.76         3244.  238747.   991.   996.  1.81  -421.   571.  24751.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     107.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.76  -420.7   570.7  3243.6  238747.    6000.   1.85

 X STA.     -420.7     -242.8      -80.0      -30.6      -12.2        0.3
  A(I)           237.5      228.1      170.4      117.5      100.9
  V(I)            1.26       1.32       1.76       2.55       2.97

 X STA.        0.3       12.7       27.0       41.4       53.4       63.7
  A(I)            99.5      103.4      103.5       97.0       90.8
  V(I)            3.01       2.90       2.90       3.09       3.30

 X STA.       63.7       71.6       78.0       83.8       89.9      141.7
  A(I)            83.0       76.1       74.0       76.2      195.4
  V(I)            3.62       3.94       4.05       3.94       1.54

 X STA.      141.7      263.3      354.0      428.0      491.4      570.7
  A(I)           323.8      287.2      263.2      246.5      269.7
  V(I)            0.93       1.04       1.14       1.22       1.11
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File mntg030.wsp
        Hydraulic analysis for structure MNTGTH00410030   Date: 14-APR-97
        Bridge # 30 on Town Highway 41 over the Trout River, Montgomery, VT
           *** RUN DATE & TIME: 05-22-97  07:42
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     796.   90646.     0.   182.                           0.
   498.94          796.   90646.     0.   182.  1.00     0.    87.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.94     0.0    86.7   796.0   90646.    1577.   1.98

X STA.         0.0       16.1       21.5       25.8       29.4       32.4
  A(I)            70.8       47.2       42.7       39.5       36.4
  V(I)            1.11       1.67       1.84       1.99       2.17

X STA.        32.4       35.2       37.9       40.5       43.1       45.7
  A(I)            35.0       34.3       33.6       33.0       32.7
  V(I)            2.25       2.30       2.35       2.39       2.41

X STA.        45.7       48.4       51.0       53.7       56.4       59.1
  A(I)            33.2       33.1       33.6       33.4       34.2
  V(I)            2.38       2.38       2.35       2.36       2.31

X STA.        59.1       61.9       65.0       68.6       73.6       86.7
  A(I)            35.3       37.0       39.8       45.9       65.0
  V(I)            2.23       2.13       1.98       1.72       1.21

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.03  -419.9   505.8  1463.7   68560.    6507.   4.45

X STA.      -419.9     -354.1     -327.9     -305.1     -283.7     -262.7
  A(I)           101.2       73.2       69.4       65.6       64.9
  V(I)            3.21       4.45       4.69       4.96       5.01

X STA.      -262.7     -241.3     -217.0     -188.2     -148.4      203.9
  A(I)            66.1       69.3       72.9       84.7      128.7
  V(I)            4.92       4.70       4.47       3.84       2.53

X STA.       203.9      237.8      267.6      295.6      322.4      347.0
  A(I)            71.2       66.1       64.6       64.7       61.5
  V(I)            4.57       4.92       5.03       5.03       5.29

X STA.       347.0      370.4      393.4      415.7      438.6      505.8
  A(I)            60.5       61.1       61.2       64.5       92.4
  V(I)            5.38       5.33       5.31       5.05       3.52

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     107.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     774.   53362.   359.   359.                        6440.
             2    1388.  179463.   170.   174.                       22501.
             3    1933.   95818.   480.   481.                       22007.
   500.61         4094.  328644.  1009.  1014.  1.65  -433.   576.  36437.


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     107.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.61  -432.9   576.5  4093.9  328644.    8200.   2.00

X STA.      -432.9     -302.3     -206.4     -102.8      -37.2      -15.1
  A(I)           257.0      221.8      233.9      219.8      149.7
  V(I)            1.60       1.85       1.75       1.86       2.74

X STA.       -15.1       -0.1       13.9       30.4       45.9       58.7
  A(I)           131.5      123.9      131.7      128.5      118.6
  V(I)            3.12       3.31       3.11       3.19       3.46

X STA.        58.7       69.4       77.4       84.4       92.8      178.3
  A(I)           112.0      100.7       95.5      106.6      326.4
  V(I)            3.66       4.07       4.29       3.84       1.26

X STA.       178.3      277.3      359.6      429.0      491.5      576.5
  A(I)           359.8      334.2      307.0      296.2      339.0
  V(I)            1.14       1.23       1.34       1.38       1.21
```

```
        U.S. Geological Survey WSPRO Input File mntg030.wsp
        Hydraulic analysis for structure MNTGTH00410030   Date: 14-APR-97
        Bridge # 30 on Town Highway 41 over the Trout River, Montgomery, VT
           *** RUN DATE & TIME: 05-22-97  07:42

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     608.   91936.    86.    91.                       9177.
   496.74          608.   91936.    86.    91.  1.00     1.    87.   9177.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.74     0.7    86.6   607.9   91936.    2090.   3.44

X STA.         0.7       19.4       24.4       28.2       31.3       34.1
  A(I)            57.4       37.1       32.4       29.4       27.9
  V(I)            1.82       2.82       3.22       3.55       3.75

X STA.        34.1       36.6       39.0       41.3       43.7       46.0
  A(I)            26.2       24.9       25.2       24.7       24.5
  V(I)            3.98       4.20       4.14       4.23       4.27

X STA.        46.0       48.4       50.8       53.2       55.6       58.0
  A(I)            24.7       24.7       25.0       24.9       25.4
  V(I)            4.23       4.24       4.18       4.20       4.11

X STA.        58.0       60.6       63.3       66.5       70.9       86.6
  A(I)            26.6       27.1       30.6       35.5       53.7
  V(I)            3.93       3.86       3.41       2.95       1.95

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     107.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     784.   71670.   162.   165.                       9802.
             3     279.    4681.   351.   351.                       1409.
   497.02         1063.   76351.   513.   517.  1.52   -65.   552.   7037.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     107.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.02   -65.2   551.8  1062.8   76351.    2090.   1.97

X STA.       -65.2      -20.5       -7.8        0.5        8.6       18.8
  A(I)            83.8       56.4       46.8       44.5       47.6
  V(I)            1.25       1.85       2.23       2.35       2.20

X STA.        18.8       29.9       40.8       49.4       56.7       63.2
  A(I)            48.4       49.3       44.1       41.7       39.8
  V(I)            2.16       2.12       2.37       2.51       2.63

X STA.        63.2       68.1       72.1       75.4       78.5       81.3
  A(I)            36.0       32.9       30.3       29.5       28.5
  V(I)            2.90       3.18       3.45       3.54       3.66

X STA.        81.3       84.1       87.1       90.4      399.1      551.8
  A(I)            27.9       29.2       31.2      137.0      177.6
  V(I)            3.75       3.57       3.35       0.76       0.59
```

```
        U.S. Geological Survey WSPRO Input File mntg030.wsp
        Hydraulic analysis for structure MNTGTH00410030   Date: 14-APR-97
        Bridge # 30 on Town Highway 41 over the Trout River, Montgomery, VT
           *** RUN DATE & TIME: 05-22-97  07:42

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

EXITX:XS   ******  -414.    2742.  0.16 *****  499.79  494.65   6000.  499.63
      -62. ******   518.  222000.  2.15 ***** *******    0.33    2.19

 ===140 AT SECID "FULLV":  END OF CROSS SECTION EXTENDED VERTICALLY.
                           WSEL,YLT,YRT =   499.66     504.33     498.95

FULLV:FV      62.  -411.    2541.  0.19  0.05  499.85 *******   6000.  499.66
        0.    62.   518.  203499.  2.21  0.02    0.00    0.37    2.36
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS     107.  -422.    3316.  0.09  0.08  499.92 *******   6000.  499.83
      107.   107.   571.  245794.  1.79  0.00   -0.01    0.23    1.81
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                      WS3N,LSEL =   499.66     498.92

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                 QRD,QRDMAX,RATIO =     4304.      4176.    1.03

            <<<<<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      62.     0.     796.  0.07 *****  499.01  490.38   1713.  498.94
        0. ******    87.   90646.  1.00 ***** *******    0.13    2.15

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       2. ****   6.  0.800  0.000  498.92 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    91.  0.06  0.10  499.80    0.00   4304.  499.32

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   2214.   313.  -410.   -96.   2.4   1.7   5.0   4.3   2.1   2.3
   RT:   2090.   311.   178.   488.   2.1   1.6   4.9   4.3   2.0   2.3

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

APPRO:AS      87.  -421.    3248.  0.10  0.09  499.86  495.47   6000.  499.76
      107.   128.   571.  239204.  1.81  0.00    0.00    0.24    1.85

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -62.  -414.   518.   6000.  222000.    2742.    2.19  499.63
   FULLV:FV       0.  -411.   518.   6000.  203499.    2541.    2.36  499.66
   BRIDG:BR       0.     0.    87.   1713.   90646.     796.    2.15  498.94
   RDWAY:RG      10.******* 2214.   4304.******************    2.00  499.32
   APPRO:AS     107.  -421.   571.   6000.  239204.    3248.    1.85  499.76

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    494.65    0.33  488.17  504.08************  0.16  499.79  499.63
   FULLV:FV   ********   0.37  488.42  504.33  0.05  0.02  0.19  499.85  499.66
   BRIDG:BR    490.38    0.13  486.05  498.94************  0.07  499.01  498.94
   RDWAY:RG   ****************  496.90  504.08  0.06******  0.10  499.80  499.32
   APPRO:AS    495.47    0.24  486.85  503.75  0.09  0.00  0.10  499.86  499.76
```

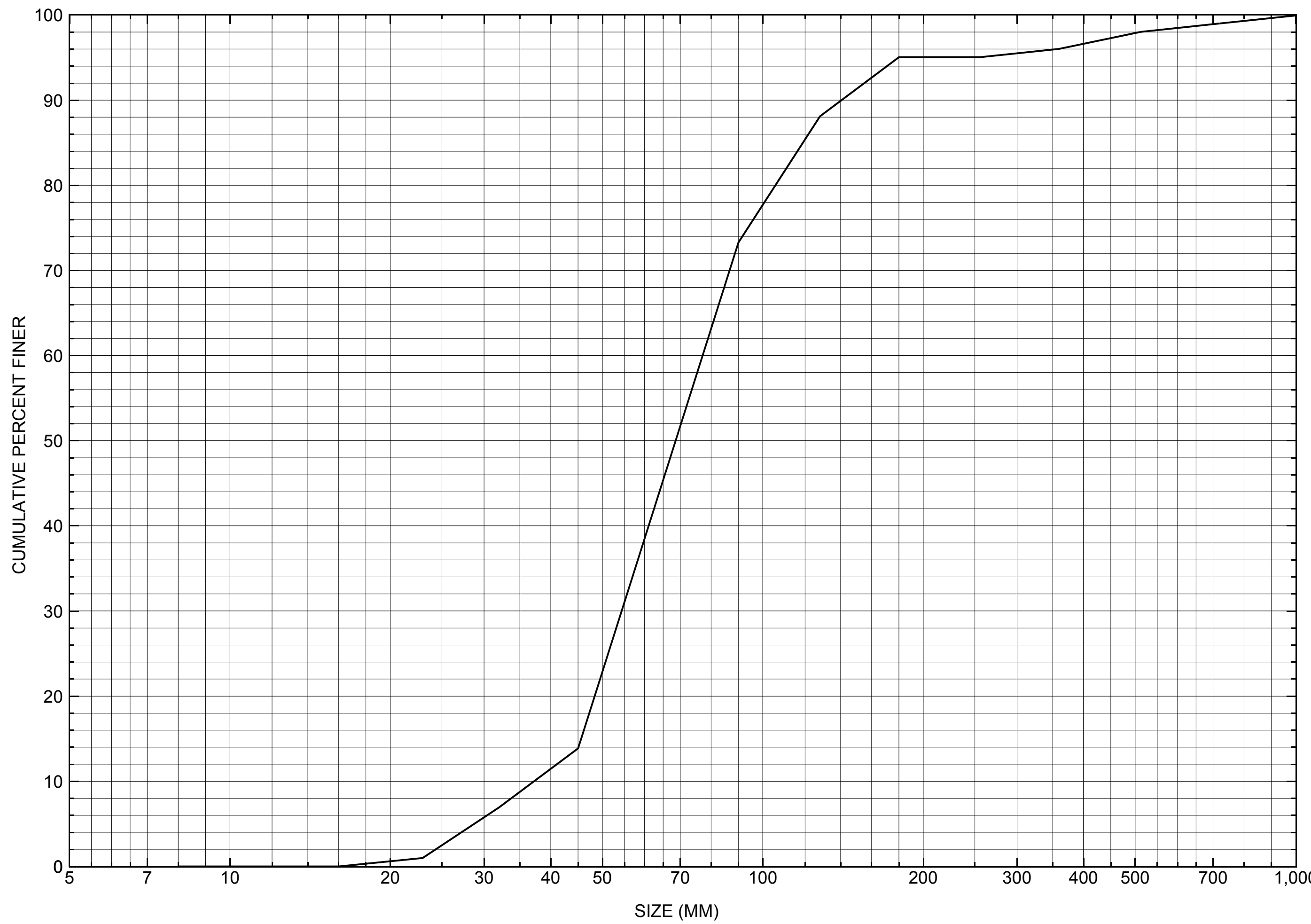
```
        U.S. Geological Survey WSPRO Input File mntg030.wsp
        Hydraulic analysis for structure MNTGTH00410030   Date: 14-APR-97
        Bridge # 30 on Town Highway 41 over the Trout River, Montgomery, VT
           *** RUN DATE & TIME: 05-22-97  07:42

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

EXITX:XS   ******  -426.    3535.  0.16 *****  500.63  495.99   8200.  500.47
      -62. ******   518.  303412.  1.90 ***** *******    0.29    2.32

 ===140 AT SECID "FULLV":  END OF CROSS SECTION EXTENDED VERTICALLY.
                           WSEL,YLT,YRT =   500.51     504.33     498.95

FULLV:FV      62.  -423.    3335.  0.18  0.05  500.70 *******   8200.  500.51
        0.    62.   518.  281617.  1.96  0.01    0.00    0.32    2.46
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS     107.  -434.    4152.  0.10  0.08  500.77 *******   8200.  500.67
      107.   107.   577.  335289.  1.64  0.00    0.00    0.22    1.98
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                      WS3N,LSEL =   500.51     498.92

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                 QRD,QRDMAX,RATIO =    6507.      6387.    1.02

           <<<<<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      62.     0.     796.  0.06 *****  499.00  490.19   1577.  498.94
        0. ******    87.   90646.  1.00 ***** *******    0.12    1.98

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       2. ****   6.  0.800  0.000  498.92 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       10.    91.  0.06  0.10  500.66   -0.01   6507.  500.03

             Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   3327.   338.  -420.   -82.   3.1   2.2   5.2   4.4   2.8   2.0
   RT:   3181.   337.   169.   506.   2.9   2.1   5.2   4.5   2.7   2.1

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

APPRO:AS      87.  -433.    4096.  0.10  0.11  500.71  496.88   8200.  500.61
      107.   133.   577.  328858.  1.65  0.00   -0.01    0.22    2.00


  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -62.  -426.   518.   8200.  303412.    3535.    2.32  500.47
   FULLV:FV       0.  -423.   518.   8200.  281617.    3335.    2.46  500.51
   BRIDG:BR       0.     0.    87.   1577.   90646.     796.    1.98  498.94
   RDWAY:RG      10.*******  3327.   6507.******************    2.00  500.03
   APPRO:AS     107.  -433.   577.   8200.  328858.    4096.    2.00  500.61


 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS     495.99    0.29  488.17  504.08************  0.16  500.63  500.47
   FULLV:FV   ********    0.32  488.42  504.33  0.05  0.01  0.18  500.70  500.51
   BRIDG:BR     490.19    0.12  486.05  498.94************  0.06  499.00  498.94
   RDWAY:RG   ****************  496.90  504.08  0.06******  0.10  500.66  500.03
   APPRO:AS     496.88    0.22  486.85  503.75  0.11  0.00  0.10  500.71  500.61
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File mntg030.wsp
        Hydraulic analysis for structure MNTGTH00410030   Date: 14-APR-97
        Bridge # 30 on Town Highway 41 over the Trout River, Montgomery, VT
           *** RUN DATE & TIME: 05-22-97  07:42

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

EXITX:XS   ******   -26.     681.  0.16 *****  496.90  491.83   2090.  496.75
      -62. ******   111.   77284.  1.07 ***** *******    0.25    3.07

FULLV:FV      62.   -17.     654.  0.17  0.05  496.96 *******   2090.  496.79
        0.    62.   108.   73561.  1.05  0.01    0.00    0.25    3.19
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS     107.   -65.    1025.  0.10  0.09  497.04 *******   2090.  496.94
      107.   107.   551.   74066.  1.49  0.00    0.00    0.30    2.04
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   497.02       0.00     496.74     496.90

 ===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      62.     1.     608.  0.23  0.06  496.97  490.85   2090.  496.74
        0.    62.    87.   91961.  1.26  0.01    0.00    0.26    3.44

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       2. ****   4.  0.890 ******  498.92 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS      87.   -65.    1063.  0.09  0.10  497.11  493.16   2090.  497.02
      107.   102.   552.   76381.  1.52  0.04    0.00    0.30    1.97

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.861  0.263   56272.    18.   104. ********


  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW      Q        K     AREA     VEL   WSEL
   EXITX:XS     -62.   -26.   111.   2090.   77284.     681.    3.07  496.75
   FULLV:FV       0.   -17.   108.   2090.   73561.     654.    3.19  496.79
   BRIDG:BR       0.     1.    87.   2090.   91961.     608.    3.44  496.74
   RDWAY:RG      10.**************      0.       0.       0.    2.00********
   APPRO:AS     107.   -65.   552.   2090.   76381.    1063.    1.97  497.02

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      18.   104.   56272.


 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    491.83    0.25  488.17  504.08************  0.16  496.90  496.75
   FULLV:FV   ********   0.25  488.42  504.33  0.05  0.01  0.17  496.96  496.79
   BRIDG:BR    490.85    0.26  486.05  498.94  0.06  0.01  0.23  496.97  496.74
   RDWAY:RG   ***************  496.90  504.08  0.07******  0.09  497.03********
   APPRO:AS    493.16    0.30  486.85  503.75  0.10  0.04  0.09  497.11  497.02
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure MNTGTH00410030, in Montgomery, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number MTNGTH00410030

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 03 / 94

Highway District Number *(I - 2; nn)* 08

County *(FIPS county code; I - 3; nnn)* 011

Town *(FIPS place code; I - 4; nnnnn)* 45850

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

Waterway *(I - 6)* TROUT RIVER

Road Name *(I - 7):* -

Route Number TH041

Vicinity *(I - 9)* 0.05 MI TO JCT W VT118

Topographic Map Richford

Hydrologic Unit Code: 02010007

Latitude *(I - 16; nnnn.n)* 44539

Longitude *(i - 17; nnnnn.n)* 72380

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10061000300610

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

Maximum span length *(I - 48; nnnn)* 0087

Year built *(I - 27; YYYY)* 1974

Structure length *(I - 49; nnnnnn)* 000090

Average daily traffic, ADT *(I - 29; nnnnnn)* 000010

Deck Width *(I - 52; nn.n)* 163

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

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

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*) 016.0

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

Vertical clearance from streambed (*nnn.n ft*) 031.4

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

Waterway of full opening (*nnn.n* ft^2) 380.0

Comments:

Structural inspection report of 9/14/92 indicates only minor cracks in the abutments and wingwalls. No undermining or settlement of the footings is noted. A six foot deep scour hole was noted along half of the left abutment but no footing exposure was detected. Stone fill is noted as present in good condition, partially covered with vegetation and silt. A large point bar is noted as having developed from upstream to downstream of the bridge on the right bank.

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **47.7**

Terrain character: **Mountainous**

Stream character & type: -

Streambed material: **Gravel with some silt**

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} **3300** Q_{25} **4300**

Q_{50} **5200** Q_{100} - Q_{500} -

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

Estimated Discharge *(cfs)*: - Velocity at Q **50** *(ft/s)*: **10.5**

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

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

The stream response is (*Flashy, Not flashy*): **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: **2** (*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*)	-	-	-	**497.8**	-
Velocity (*ft / sec*)	-	-	-	**10.5**	-

Long term stream bed changes: -

Is the roadway overtopped below the Q_{100}? (*Yes, No, Unknown*): **Y** Frequency: **Q50**

Relief Elevation (*ft*): **496.2** Discharge over roadway at Q_{100} (*ft³/ sec*): -

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

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

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

Clear span (*ft*): **50.0** Clear Height (*ft*): **11.0** Full Waterway (*ft²*): **500.0**

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

Highway No. : -　Structure No. : -　Structure Type: **Covered bridge**

Clear span (*ft*): **55.0**　Clear Height (*ft*): **20.0**　Full Waterway (ft^2): **1100**

Comments:

Design discharge was the Q50. Hydraulic report available was prepared prior to 9/5/73.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **46.15** mi^2　Lake/pond/swamp area **0.07** mi^2

Watershed storage *(ST)* **0.2** %

Bridge site elevation **472** ft　Headwater elevation **2953** ft

Main channel length **10.63** mi

10% channel length elevation **489** ft　85% channel length elevation **1663** ft

Main channel slope *(S)* **147.25** ft / mi

Watershed Precipitation Data

Average site precipitation ____ in　Average headwater precipitation ____ in

Maximum 2yr-24hr precipitation event *(I24,2)* ____ in

Average seasonal snowfall *(Sn)* ____ ft

Bridge Plan Data

Are plans available? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: 10 / 1973

Project Number TF 7309 Minimum channel bed elevation: 485.0

Low superstructure elevation: USLAB 498.62* DSLAB ________ USRAB _______ DSRAB _______

Benchmark location description:

BM#1, pole elevation 500.00, 50 feet west on TH 41 off left bank then 50 feet off on left side of road on the edge of a meadow near brush. BM#2, six inch elm, elevation 499.27, 60 feet east on TH 41 from right bank and 20 feet off right side of road on the edge of woods.

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

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

If 1: Footing Thickness _______ Footing bottom elevation: ______

If 2: Pile Type: 2 (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: 46

If 3: Footing bottom elevation: ______

Is boring information available? Y *If no, type ctrl-n bi* Number of borings taken: 2

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

Briefly describe material at foundation bottom elevation or around piles:

Piles driven to or counter sunk into bedrock. Bedrock is a quartz-sericite, chlorite, albite schist from the boring logs, all other shallower units are sand, silt, or gravel. The piles of the left abutment were driven about 50 feet through silt and sand into ledge. The piles of the right abutment were driven about 46 feet through silt and sand into ledge.

Comments:

***Typical low superstructure elevation for the bridge abutments. Other elevation points are the typical top of the wingwalls at 502.75. The footing bottom elevation of both abutments is 494.62. Bridge was built at previous bridge location. Hydraulic information on plans was the same as that noted above.**

Cross-sectional Data

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

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

Comments: **Upstream bridge cross section at stationing 5 + 20. The channel base line runs parallel to the stream along the right bank 39.5 feet from the right abutment streamward face. Stationing increases in an upstream direction. *Top of the stone rip rap along the abutment face.**

Station	-124.5	-103.0	-97.0	-85.0	-57.5	-39.5					
Feature	LCL	BLB	TD		BRB	LCR					
Low cord elevation	498.8					498.8					
Bed elevation	497.4*	484.0	482.9	485.0	486.0	498.0*					
Low cord to bed length	1.4	14.8			12.8	.8					

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

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

Comments: **Downstream bridge cross section at stationing 5 + 10. *Top of the stone rip rap along the abutment face.**

Station	-124.5	-103.0	-91.0	-85.0	-70.0	-63.0	-39.5				
Feature	LCL	BLB		TD		BRB	LCR				
Low cord elevation	499.0						498.8				
Bed elevation	497.5*	483.0	482.6	481.8	481.8	482.0	498.0				
Low cord to bed length	2.5						0.8				

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: RB Date: 3/6/96
Computerized by: RB Date: 3/6/96
Reviewd by: MAI Date: 6/5/97

Structure Number MNTGTH00410030

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* L. MEDALIE Date *(MM/DD/YY)* 6/ / 27/ / 1995
2. Highway District Number 08 Mile marker 000
   County FRANKLIN (011) Town MONTGOMERY (45850)
   Waterway *(I - 6)* TROUT RIVER Road Name -
   Route Number TH041 Hydrologic Unit Code: 02010007
3. Descriptive comments:

The site is located 0.05 miles from junction with VT 118.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 RBUS 3 LBDS 4 RBDS 5 Overall 4
*(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 1 UB 1 DS 1 *(**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 90 *(feet)* Span length 87 *(feet)* Bridge width 16.3 *(feet)*

Road approach to bridge:

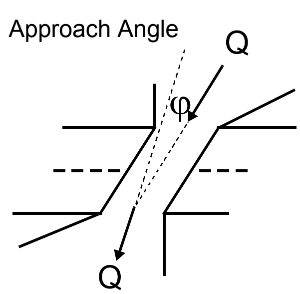
8. LB 1 RB 1 *(**0** even, **1**- lower, **2**- higher)*
9. LB 2 RB 2 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left 3.3:1 US right 4.9:1

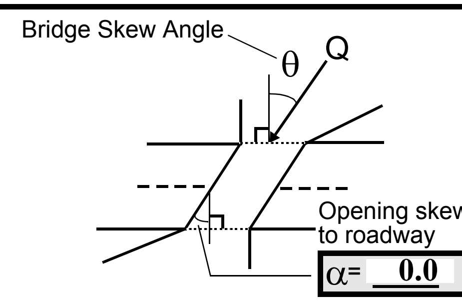
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	2	1

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

Channel approach to bridge (BF):

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





α= 0.0

17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 20 feet DS *(US, UB, DS)* to 68 feet DS
Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 38 feet US *(US, UB, DS)* to 65 feet US

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

18. Bridge Type: 2

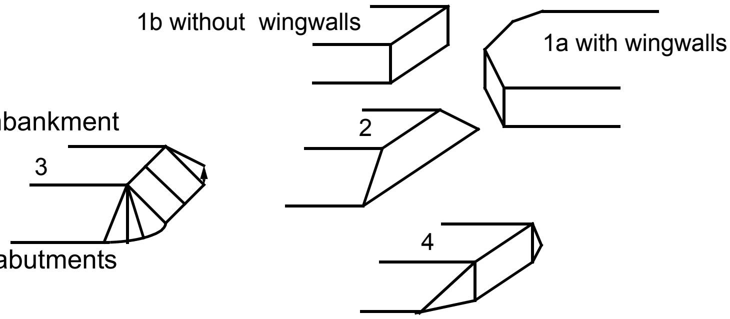
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls 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. On the US right bank there is a 10 foot wide strip of trees along the bank widening to 40 feet at the bridge. On the US left bank there is also a 10 foot wide strip of trees along the bank with shrubs between the trees and along the point bar. On the left bank downstream there are shrubs, then a 60 foot wide strip of trees, and pasture on the flood plain.

7. The bridge dimensions are from the VT AOT files.

8. The left and right bank are even with the bridge for 50 feet and then lower. Road width is 12 feet.

13. On the DS left bank there is a 2 foot wide strip of slightly eroded material next to the wingwall.

17. Impact zone 2 along the upstream right bank is moderate because high flows would hit that area almost head on before being deflected towards left bank and the straight section of the channel under the bridge.

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
118.0	7.5			5.0	2	2	23	2	1	2

23. Bank width **5.0** 24. Channel width **50.0** 25. Thalweg depth **170.0** 29. Bed Material **432**

30 .Bank protection type: LB **0** RB **1** 31. Bank protection condition: LB **-** RB **1**

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

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

26. The left and right bank tree cover is sparse.

28. The left bank erosion refers to the low bank along the DS end of the point bar. The bank is protected by the large point bar that averages 4 feet high and is vegetated with brush.

29. There are some boulders along the streambed within 40 feet upstream of the bridge.

30. The right bank has placed stone protection, type 1 and 2, from about 170 feet to 350 feet US on the outside edge of the large channel bend. The type-1 protection referred to above, extends from 10 feet US to 50 feet US at the impact zone.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **90** 35. Mid-bar width: **62**

36. Point bar extent: **20** feet **US** (US, UB) to **165** feet **US** (US, UB, DS) positioned **40** %LB to **95** %RB

37. Material: **32**

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

There is another point bar further US in the same broad curve of the stream. The point bar begins about 250 feet US of bridge and is comprised of sand and gravel.

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

41. Mid-bank distance: **132** 42. Cut bank extent: **38** feet **US** (US, UB) to **170** 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.):

The cut bank would continue further US except some placed protection prevents erosion. There are large trees 65 feet US growing out of the right bank at a 30 degree angle.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **31**

47. Scour dimensions: Length **26** Width **6** Depth : **3** Position **80** %LB to **83** %RB

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

The scour appears to be due to the major channel constriction which the stream width decreases to about 20 feet next to the point bar.

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
92.0		**2.5**		**2**	**7**	**7**	**0**

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

5412

63. There is placed stone fill along the left abutment forming a spill-through embankment.

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

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

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

70. Debris and Ice Comments:

2

Trees are growing with branches extending across the entire channel width at 65 feet US which can potentially block the channel. The channel is laterally unstable with cutbanks.

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		10	90	0	0	-	-	90.0
RABUT	1	-	90			0	0	86.5

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.):

-

-

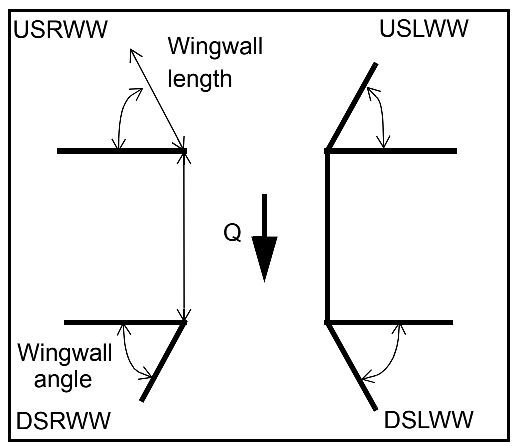
1

The embankments at each of the abutments are at a 45 degree angle. There is 2.5 feet of the left and right vertical abutment wall exposed.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						86.5	
USRWW:	Y		1		0	4.0	
DSLWW:	-		-		Y	20.5	
DSRWW:	1		0		-	20.5	

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



82. **Bank / Bridge Protection**:

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

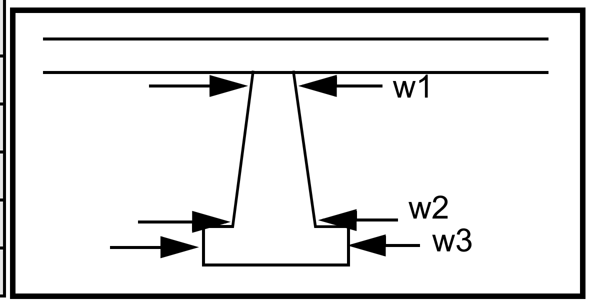
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
0
-
-
1
1
2
0
-
-

Piers:

84. Are there piers? **82.** *(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		**4.5**	**4.0**	**90.0**	**85.0**	**90.0**
Pier 2	**4.0**	**4.0**	-	**90.0**	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**On the**	**and 24**	**The**	**bot-**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**left**	**inch**	**US**	**tom**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**abut**	**es**	**left**	**of**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**ment**	**form**	**wing**	**the**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**there**	**ing a**	**wall**	**bank**	*Y- yes; N- no*
91. Attack ∠ (BF)	**are**	**spill-**	**pro-**	**and**	
92. Pushed	**some**	**thro**	**tec-**	**does**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**stone**	**ugh**	**tion**	**not**	
95. Cross-members	**s,**	**emb**	**is**	**exte**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**betw**	**ank-**	**only**	**nd**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**een**	**ment**	**at**	**up to**	
98. Exposure depth	**12**	**.**	**the**	**the**	

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

wingwall. There are some native stones along the right bank from 80 feet US to under the bridge.

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.):

-
-
-
-

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

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

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

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

Is channel scour present? _____ (Y or if N type ctrl-n cs) Mid-scour distance: 4

Scour dimensions: Length 1 Width 2 Depth: 24 Positioned 1 %LB to 1 %RB

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

423
0
2
-

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

Confluence 1: Distance ough Enters on the (LB or RB) Type left (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance bank Enters on veg- (LB or RB) Type eta- (**1**- perennial; **2**- ephemeral)

Confluence comments (eg. confluence name):

tion cover is 4, the tree cover does not extend far beyond the top of the bank. Beyond 70 feet from the bridge the left bank is naturally protected by an extended lower bank, up to 50 feet wide. The bed material is

F. Geomorphic Channel Assessment

107. Stage of reach evolution agg

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)*:

raded downstream of the bridge forming a right bank side bar and a 60 foot stretch of constricted flow with a riffle area. The right bank protection begins at about 75 feet DS and continues along the bank at least to 250 feet. The right bank protection consists of varying sizes of stone fill.

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: MNTGTH00410030   Town: Montgomery
Road Number: TH 41   County: Franklin
Stream: Trout River

Initials MAI   Date: 05/21/97 Checked: SAO

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	6000	8200	2090
Main Channel Area, ft2	1243	1388	784
Left overbank area, ft2	473	774	0
Right overbank area, ft2	1527	1933	279
Top width main channel, ft	170	170	162
Top width L overbank, ft	347	359	0
Top width R overbank, ft	474	480	351
D50 of channel, ft	0.224	0.224	0.224
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.3	8.2	4.8
y1, average depth, LOB, ft	1.4	2.2	ERR
y1, average depth, ROB, ft	3.2	4.0	0.8
Total conveyance, approach	238747	328644	76351
Conveyance, main channel	149427	179463	71670
Conveyance, LOB	24075	53362	0
Conveyance, ROB	65246	95818	4681
Percent discrepancy, conveyance	-0.0004	0.0003	0.0000
Qm, discharge, MC, cfs	3755.3	4477.8	1961.9
Ql, discharge, LOB, cfs	605.0	1331.4	0.0
Qr, discharge, ROB, cfs	1639.7	2390.8	128.1
Vm, mean velocity MC, ft/s	3.0	3.2	2.5
Vl, mean velocity, LOB, ft/s	1.3	1.7	ERR
Vr, mean velocity, ROB, ft/s	1.1	1.2	0.5
Vc-m, crit. velocity, MC, ft/s	9.5	9.7	8.9
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

y2 = (Q2^2/(131*Dm^(2/3)*W2^2))^(3/7)   Converted to English Units
ys=y2-y_bridge
(Richardson and others, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	6000	8200	2090
(Q) discharge thru bridge, cfs	1713	1577	2090
Main channel conveyance	90646	90646	91936
Total conveyance	90646	90646	91936
Q2, bridge MC discharge,cfs	1713	1577	2090
Main channel area, ft2	796	796	608
Main channel width (normal), ft	86.7	86.7	85.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	86.7	86.7	85.9
y_bridge (avg. depth at br.), ft	9.18	9.18	7.08
Dm, median (1.25*D50), ft	0.28	0.28	0.28
y2, depth in contraction,ft	2.30	2.14	2.75
ys, scour depth (y2-ybridge), ft	-6.88	-7.04	-4.33

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	6000	8200	2090
Q, thru bridge MC, cfs	1713	1577	2090
Vc, critical velocity, ft/s	9.48	9.66	8.85
Va, velocity MC approach, ft/s	3.02	3.23	2.50
Main channel width (normal), ft	86.7	86.7	85.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	86.7	86.7	85.9
qbr, unit discharge, ft2/s	19.8	18.2	24.3
Area of full opening, ft2	796.0	796.0	607.9
Hb, depth of full opening, ft	9.18	9.18	7.08
Fr, Froude number, bridge MC	0.13	0.12	0
Cf, Fr correction factor (<=1.0)	0.62	0.60	0.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	498.92	498.92	0
Elevation of Bed, ft	489.74	489.74	-7.08

Elevation of Approach, ft	499.76	500.61	0
Friction loss, approach, ft	0.09	0.11	0
Elevation of WS immediately US, ft	499.67	500.50	0.00
ya, depth immediately US, ft	9.93	10.76	7.08
Mean elevation of deck, ft	503.5	503.5	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.98	0.96	1.00
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	-5.78	-5.93	N/A
Ys, scour w/Umbrell equation, ft	-3.69	-3.06	N/A

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]

Depth to Armoring=3*(1/Pc-1)

(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	1713	1577	2090
Main channel area (DS), ft2	796	796	607.9
Main channel width (normal), ft	86.7	86.7	85.9
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	86.7	86.7	85.9
D90, ft	0.4607	0.4607	0.4607
D95, ft	0.5891	0.5891	0.5891
Dc, critical grain size, ft	0.0155	0.0131	0.0435
Pc, Decimal percent coarser than Dc	1.000	1.000	1.000
Depth to armoring, ft	0.00	0.00	0.00

Abutment Scour

Froehlich's Abutment Scour

Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1

(Richardson and others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	6000	8200	2090	6000	8200	2090
a', abut.length blocking flow, ft	429.5	441.7	74	484	489.8	465.3
Ae, area of blocked flow ft2	404.2	540.3	232.4	1141.6	1328.4	351.6
Qe, discharge blocked abut.,cfs	--	--	420	--	--	334.4
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.85	2.11	1.81	1.20	1.35	0.95
ya, depth of f/p flow, ft	0.94	1.22	3.14	2.36	2.71	0.76
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0.55	0.55	0.55	0.55
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	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	0.222	0.217	0.180	0.116	0.117	0.193
ys, scour depth, ft	7.56	8.89	8.57	10.05	11.13	6.14

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)	429.5	441.7	74	484	489.8	465.3
y1 (depth f/p flow, ft)	0.94	1.22	3.14	2.36	2.71	0.76
a'/y1	456.38	361.09	23.56	205.20	180.60	615.77
Skew correction (p. 49, fig. 16)	1.02	1.02	1.02	0.97	0.97	0.97
Froude no. f/p flow	0.22	0.22	0.18	0.12	0.12	0.19
Ys w/ corr. factor K1/0.55:						
vertical	4.26	5.49	ERR	8.15	9.40	3.09
vertical w/ ww's	3.49	4.50	ERR	6.68	7.70	2.53
spill-through	2.34	3.02	ERR	4.48	5.17	1.70

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)

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.13	0.12	0.26	0.13	0.12	0.26
y, depth of flow in bridge, ft	9.18	9.18	7.08	9.18	9.18	7.08
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	0.10	0.08	0.30	0.10	0.08	0.30
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr<=0.8 (spillthrough abut.)	0.08	0.07	0.26	0.08	0.07	0.26
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR