LEVEL II SCOUR ANALYSIS FOR BRIDGE 59 (NWPCVT01050059) on STATE ROUTE 105, crossing an UNNAMED MUD CREEK TRIBUTARY, NEWPORT, VERMONT

U.S. Geological Survey
Open-File Report 96-748

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

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By Erick M. Boehmler and Michael A. Ivanoff

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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 59 (NWPCVT01050059) ON STATE ROUTE 105, CROSSING AN UNNAMED MUD CREEK TRIBUTARY, NEWPORT, VERMONT

_By_ Erick M. Boehmler and Michael A. Ivanoff

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure NWPCVT01050059 on state route 105 crossing an unnamed Mud Creek tributary, Newport, 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 New England Upland section of the New England physiographic province of north-central Vermont in the town of Newport. The 9.18-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture while the immediate banks are brush covered with some trees.

In the study area, this unnamed Mud Creek tributary has an incised, sinuous channel with a slope of approximately 0.005 ft/ft, an average channel top width of 42 ft and an average channel depth of 5 ft. The predominant channel bed materials are gravel and cobbles with a median grain size (D_{50}) of 54.1 mm (0.178 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 stable.

The state route 105 crossing of an unnamed Mud Creek tributary is a 33-ft-long, two-lane bridge consisting of one 29-foot concrete-slab span (Vermont Agency of Transportation, written communication, August 5, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 15 degrees to the opening and the opening-skew-to-roadway is 15 degrees.

Scour protection measures at the site were type-2 stone fill (less than 36 inches diameter) on each bank upstream and both upstream wingwalls. The downstream wingwalls are protected by remnant abutment walls from a previous structure. 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, 1993). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 0.2 to 0.5 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 5.2 to 16.6 ft. The worst-case abutment scour also occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled "Scour Results". Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives "excessively conservative estimates of scour depths" (Richardson and 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.

Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

NORTH

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

LEVEL II SUMMARY

Structure Number NWPCVT01050059 ***Stream*** Unnamed Mud Creek Tributary

County Orleans ***Road*** VT 105 ***District*** 09

Description of Bridge

Bridge length 33 ***ft*** ***Bridge width*** 38.0 ***ft*** ***Max span length*** 29 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 10/21/94

Description of stone fill Type-2, on both upstream banks and wingwalls. Remnant concrete abutment walls from a previous structure protect both downstream wingwalls. The abutments are not protected.

Brief description of piers/abutments Abutments and wingwalls are concrete.

Is bridge skewed to flood flow according to Y ***survey?*** Y ***Angle*** 15

There is a moderate channel bend in the upstream reach such that flow impacts the left abutment wall.

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	10/21/94	0	0
Level II	10/21/94	--	--

Potential for debris Low. There are some cut-banks upstream but the channel is laterally stable.

Describe any features near or at the bridge that may affect flow (include observation date) On 10/21/94 there were two remnant abutment walls immediately downstream from this site, which constrict the channel.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley setting with narrow flood plains and moderately sloping valley walls on both sides.

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

Date of inspection 10/21/94

DS left: Moderately steep channel bank to a narrow, gradually sloping flood plain.

DS right: Moderately steep channel bank to a narrow, gradually sloping flood plain

US left: Steep channel bank and valley wall.

US right: Moderately sloping channel bank to narrow overbank then VT105 roadway.

Description of the Channel

Average top width 42 *ft*

Average depth 5 *ft*

Predominant bed material Gravel / Cobbles

Bank material Cobbles / Boulders

Perennial, sinuous but stable with alluvial channel boundaries.

10/21/94

Vegetative co Trees and brush

DS left: Trees and brush

DS right: Trees and brush

US left: Grass and brush with a few trees.

US right:

Do banks appear stable? Y

date of observation.

None evident on 10/21/94.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 9.18 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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

USGS gage description -

USGS gage number -

Gage drainage area - ***mi²***

Is there a lake/p No

-

Calculated Discharges

Q100 1,320 ***ft³/s*** ***Q500*** 1,800 ***ft³/s***

The 100-year discharge was computed as the median value of the range determined from several empirical methods (Benson, 1962; FHWA, 1983; Johnson and Laraway, unpublished draft, 1971; Johnson and Tasker, 1974; Potter, 1957a&b; and Talbot, 1887) including a drainage area relationship with bridge 60 over the main stem of Mud creek (Written communication, VTAOT, May, 1995; (Q100 = 1450*[(9.18/7.9)exp(0.67)]). The 500-year discharge was based on the general slope of the empirical flood frequency curves extrapolated from the 100-year discharge.

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

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

Datum tie between USGS survey and VTAOT plans Add 576.0 feet to USGS survey to obtain VTAOT plans' datum to within 0.25 feet.

Description of reference marks used to determine USGS datum. RM1 is the center point of an engraved triangle in a brass tablet marked "VT Highway Dept., E-50" on top of concrete at DS end of the right abutment (elev. 100.45 feet, arbitrary survey datum). RM2 is the center point of a chiseled "X" in the concrete at the US end of the left abutment (elev. 97.47 feet, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT2	-63	1	Exit section
EXIT1	-29	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	22	1	Road Grade section
APPR1	72	2	Modelled Approach section (Templated from APTEM)
APTEM	98	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 0.045 to 0.065, and overbank "n" values ranged from 0.030 to 0.050.

Normal depth at the downstream-most exit section (EXIT2) 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 0.0049 ft/ft which was estimated from the surveyed channel thalweg points downstream of the EXIT2 section.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0226 ft/ft) to establish the modelled approach section (APPR1), 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.

Bridge Hydraulics Summary

Average bridge embankment elevation 100.2 *ft*
Average low steel elevation 95.7 *ft*

100-year discharge 1,320 *ft*^{3}*/s*
Water-surface elevation in bridge opening 93.4 *ft*
Road overtopping? No *Discharge over road* -- *ft*^{3}*/s*
Area of flow in bridge opening 140 *ft*^{2}
Average velocity in bridge opening 9.4 *ft/s*
Maximum WSPRO tube velocity at bridge 11.3 *ft/s*

Water-surface elevation at Approach section with bridge 95.5
Water-surface elevation at Approach section without bridge 95.0
Amount of backwater caused by bridge 0.5 *ft*

500-year discharge 1,800 *ft*^{3}*/s*
Water-surface elevation in bridge opening 95.8 *ft*
Road overtopping? No *Discharge over road* -- *ft*^{3}*/s*
Area of flow in bridge opening 205 *ft*^{2}
Average velocity in bridge opening 8.8 *ft/s*
Maximum WSPRO tube velocity at bridge 10.1 *ft/s*

Water-surface elevation at Approach section with bridge 97.7
Water-surface elevation at Approach section without bridge 96.1
Amount of backwater caused by bridge 1.6

Incipient overtopping discharge -- *ft*^{3}*/s*
Water-surface elevation in bridge opening -- *ft*
Area of flow in bridge opening -- *ft*^{2}
Average velocity in bridge opening -- *ft/s*
Maximum WSPRO tube velocity at bridge -- *ft/s*

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and 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 clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for the 100-year discharge. The 500-year discharge resulted in unsubmerged 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). Therefore, contraction scour for the 500-year discharge was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146).

Abutment scour for all modelled discharges 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	0.2	0.5	--
Depth to armoring	7.0	2.3	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	15.0	16.6	--
Right abutment	5.2	8.9	--
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	1.7	1.5	--
Right abutment	1.7	1.5	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

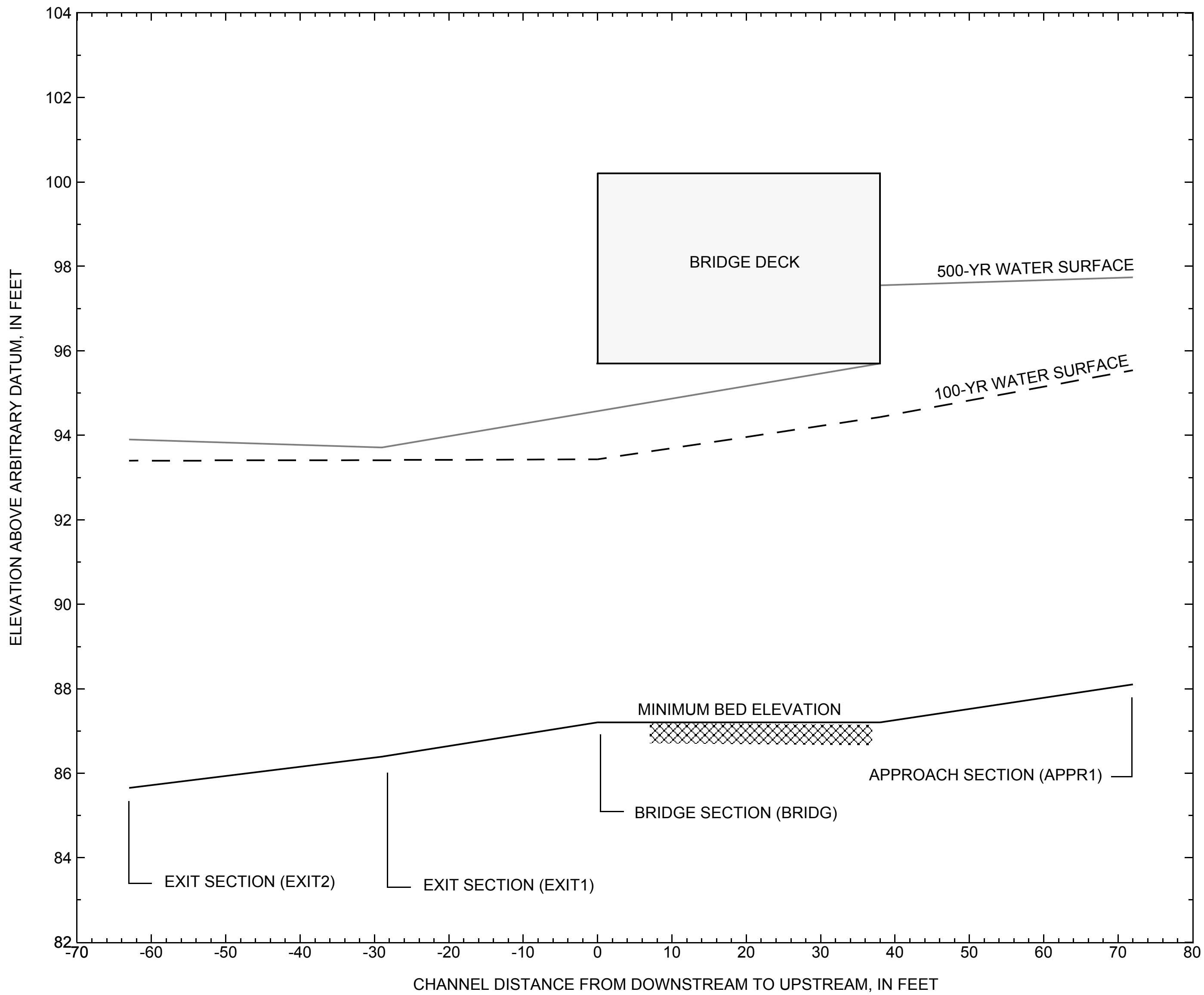

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure NWPCVT01050059 on state route 105, crossing Unnamed Mud Creek Tributary, Newport, Vermont.

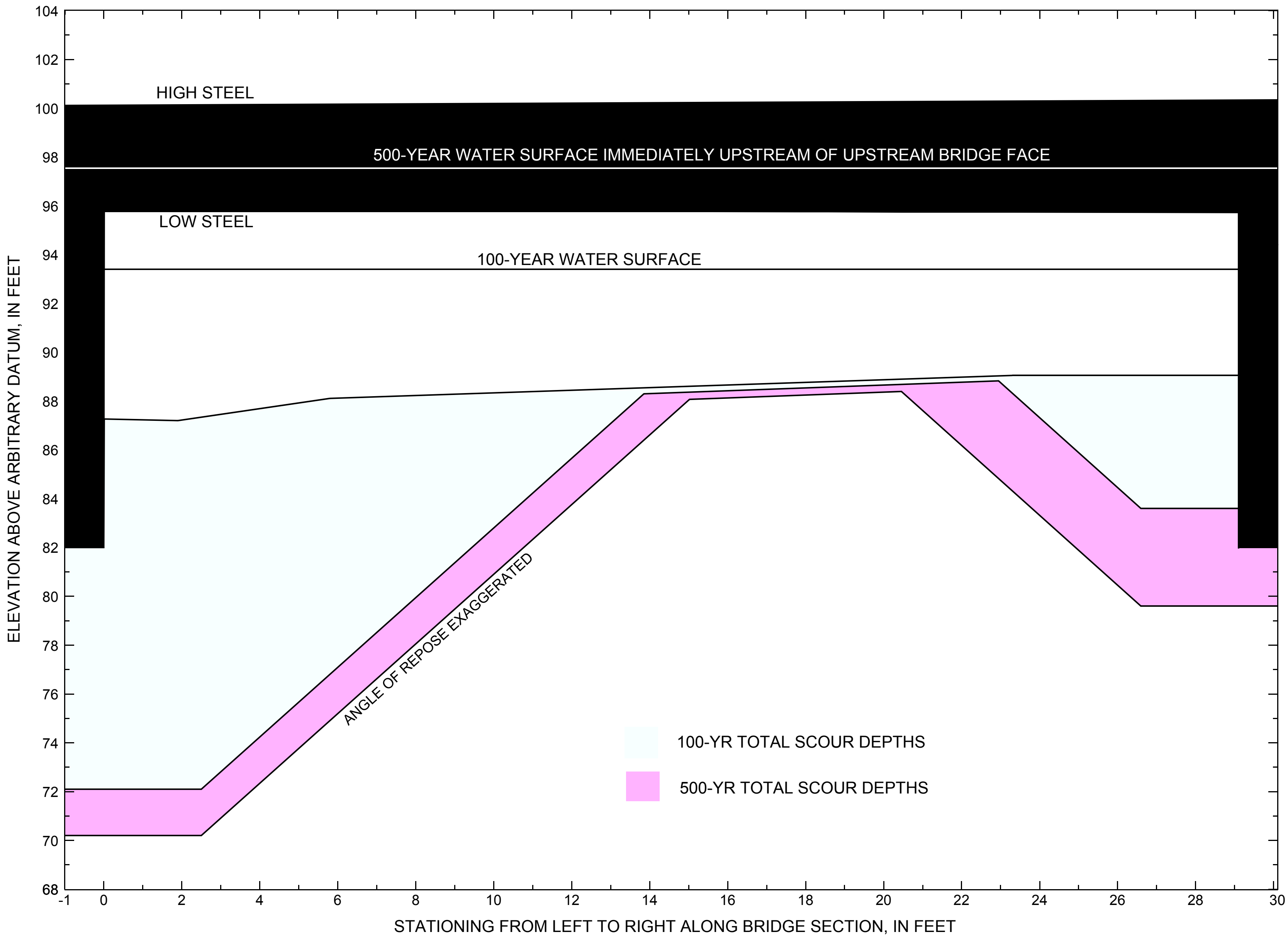

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure NWPCVT01050059 on state route 105, crossing Unnamed Mud Creek Tributary, Newport, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure NWPCVT01050059 on State Route 105, crossing Unnamed Mud Creek Tributary, Newport, 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 1,320 cubic-feet per second											
Left abutment	0.0	671.7	95.8	82.0	87.3	0.2	15.0	--	15.2	72.1	-9.9
Right abutment	29.1	671.9	95.7	82.0	89.0	0.2	5.2	--	5.4	83.6	1.6

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 NWPCVT01050059 on State Route 105, crossing Unnamed Mud Creek Tributary, Newport, 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 1,800 cubic-feet per second											
Left abutment	0.0	671.7	95.8	82.0	87.3	0.5	16.6	--	17.1	70.2	-11.8
Right abutment	29.1	671.9	95.7	82.0	89.0	0.5	8.9	--	9.4	79.6	-2.4

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. Department of Transportation, 1993, Stream stability and scour at highway bridges, Participant Workbook: Federal Highway Administration Publication FHWA HI-91-011.

U.S. Geological Survey, 1986, Newport Center, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Aerial photographs, 1981, Contour interval, 6 meters, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File nwpc059.wsp
T2        Hydraulic analysis for structure NWPCVT01050059   Date: 01-AUG-96
T3        State Route 105 Crossing an Unnamed Mud Creek Trib., Newport, VT   EMB
*
J1         *  *  0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1320.0,  1800.0
SK          0.0049,  0.0049
*
XS   EXIT2    -63
GR         -215.7,  99.07   -130.1,  96.36    -65.7,  91.98    -16.3,  92.51
GR          -10.2,  89.24     -4.2,  88.23      0.0,  86.68      2.8,  85.91
GR            8.0,  85.65     10.2,  86.01     11.9,  86.68     17.3,  89.38
GR           28.7,  92.12     44.3,  93.21     79.2,  92.23    157.2, 100.44
GR          181.6, 100.44    251.7, 100.87    361.5, 102.00    465.7, 104.29
*
N           0.035        0.060        0.045
SA                 -16.3         28.7
*
XS   EXIT1    -29
GR         -201.6,  99.07   -119.3,  96.36     -0.6,  94.35      0.0,  86.90
GR            3.7,  86.39      9.7,  87.50     18.3,  89.00     26.0,  88.86
GR           33.9,  90.20     34.1,  94.31     40.4,  95.80    141.1, 100.44
GR          165.6, 100.44    235.7, 100.87    345.4, 102.00    449.6, 104.29
*
N           0.030        0.065        0.050
SA                  -0.6         34.1
*
XS   FULLV      0  * * *   0.0117
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0      95.74      15.0
GR            0.0,  95.78      0.0,  87.29      1.9,  87.20      5.8,  88.11
GR           10.5,  88.31     23.3,  89.05     29.1,  89.01     29.1,  95.70
GR            0.0,  95.78
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV   WWANGL
CD           4      43.9      2.5    100.2     59
N           0.045
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     22       38.0     1
GR         -200.1,  99.07      0.0, 100.11     32.7, 100.34    121.2, 100.75
GR          127.5, 100.82    222.1, 100.87    330.4, 102.00    431.8, 104.29
*
XT   APTEM     98
GR          -45.2, 106.57    -19.4,  92.02     -7.3,  89.46      0.0,  90.43
GR            4.9,  89.58     10.8,  88.67     15.2,  89.57     20.0,  93.35
GR           32.9,  94.13     39.3,  95.18     79.2,  98.03    119.4, 100.44
GR          189.7, 100.87    299.4, 102.00    403.5, 104.29
*
AS   APPR1     72  *  *  *  0.0226
GT
N           0.060        0.050        0.030
SA                  20.0         79.2
*
HP 1 BRIDG    93.43 1  93.43
HP 2 BRIDG    93.43 * * 1320
HP 1 APPR1    95.54 1  95.54
HP 2 APPR1    95.54 * * 1320
*
HP 1 BRIDG    95.78 1  95.78
HP 2 BRIDG    95.78 * * 1800
HP 1 APPR1    97.74 1  97.74
HP 2 APPR1    97.74 * * 1800
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File nwpc059.wsp
        Hydraulic analysis for structure NWPCVT01050059   Date: 01-AUG-96
        State Route 105 Crossing an Unnamed Mud Creek Trib., Newport, VT   EMB
           *** RUN DATE & TIME: 08-21-96  07:46
    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      140     10928     28     39                         1776
    93.43           140     10928     28     39  1.00      0     29     1776

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
        93.43     0.0    29.1   140.2   10928.    1320.   9.42

X STA.         0.0        2.1        3.5        4.7        5.9        7.1
  A(I)            12.8        7.7        6.6        6.4        6.2
  V(I)            5.15       8.58       9.94      10.34      10.69

X STA.         7.1        8.3        9.5       10.6       11.9       13.1
  A(I)             6.0        5.9        5.9        5.9        5.9
  V(I)           10.94      11.17      11.22      11.09      11.25

X STA.        13.1       14.3       15.6       16.9       18.3       19.7
  A(I)             6.0        5.9        6.1        6.3        6.3
  V(I)           10.99      11.15      10.81      10.44      10.56

X STA.        19.7       21.2       22.7       24.4       26.3       29.1
  A(I)             6.5        6.7        7.1        7.9       12.0
  V(I)           10.09       9.90       9.24       8.37       5.50

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPR1;  SRD =      72.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      250     18222     47     50                         3280
             2       47      1753     33     33                          315
    95.54           296     19974     79     82  1.10    -26     53     3107

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPR1;  SRD =      72.

         WSEL     LEW     REW    AREA        K        Q    VEL
        95.54   -26.7    52.6   296.3   19974.    1320.   4.45

X STA.       -26.7      -17.3      -13.9      -11.2       -9.0       -6.9
  A(I)            24.2       16.7       15.0       13.5       13.2
  V(I)            2.73       3.95       4.39       4.88       4.99

X STA.        -6.9       -5.0       -2.9       -0.8        1.4        3.4
  A(I)            12.6       12.7       12.7       12.6       12.5
  V(I)            5.24       5.21       5.19       5.22       5.27

X STA.         3.4        5.3        7.0        8.7       10.2       11.8
  A(I)            12.0       11.8       11.5       11.2       11.6
  V(I)            5.48       5.59       5.73       5.91       5.70

X STA.        11.8       13.5       15.4       18.5       26.1       52.6
  A(I)            12.0       12.5       16.2       20.9       30.8
  V(I)            5.51       5.27       4.07       3.15       2.15
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File nwpc059.wsp
        Hydraulic analysis for structure NWPCVT01050059   Date: 01-AUG-96
        State Route 105 Crossing an Unnamed Mud Creek Trib., Newport, VT   EMB
           *** RUN DATE & TIME: 08-21-96  07:46

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      205     13707      0     72                     12069906
    95.78           205     13707      0     72  1.00      0     29 12069906

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA         K        Q    VEL
        95.78     0.0    29.1   205.1   13707.    1800.   8.78

X STA.         0.0        2.1        3.4        4.7        5.9        7.2
  A(I)            17.3       10.7        9.7        9.5        9.0
  V(I)            5.21       8.39       9.25       9.49       9.97

X STA.         7.2        8.4        9.6       10.9       12.1       13.4
  A(I)             9.1        8.9        8.9        8.9        9.1
  V(I)            9.89      10.07      10.10      10.11       9.91

X STA.        13.4       14.7       16.0       17.4       18.8       20.2
  A(I)             8.9        9.1        9.3        9.3        9.5
  V(I)           10.08       9.88       9.68       9.70       9.47

X STA.        20.2       21.7       23.2       24.8       26.5       29.1
  A(I)             9.7        9.9       10.3       11.2       16.6
  V(I)            9.23       9.08       8.74       8.01       5.42

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPR1;  SRD =      72.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      357     31159     51     54                         5378
             2      151      8419     59     59                         1374
             3        1        10      5      5                            2
    97.74           509     39589    115    119  1.10    -30     84     5798

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPR1;  SRD =      72.

         WSEL     LEW     REW    AREA         K        Q    VEL
        97.74   -30.6    84.2   509.0   39589.    1800.   3.54

X STA.       -30.6      -18.6      -14.6      -11.5       -8.8       -6.4
  A(I)            40.3       27.7       23.9       22.4       21.0
  V(I)            2.23       3.24       3.77       4.01       4.28

X STA.        -6.4       -3.9       -1.4        1.2        3.6        5.9
  A(I)            20.9       20.9       20.9       20.0       19.7
  V(I)            4.30       4.31       4.30       4.50       4.57

X STA.         5.9        8.0       10.0       12.0       14.1       16.7
  A(I)            19.4       18.9       18.7       19.5       21.4
  V(I)            4.63       4.76       4.80       4.61       4.21

X STA.        16.7       21.4       27.2       34.0       45.0       84.2
  A(I)            27.8       27.5       29.5       35.8       52.6
  V(I)            3.23       3.27       3.05       2.52       1.71

  EX
```

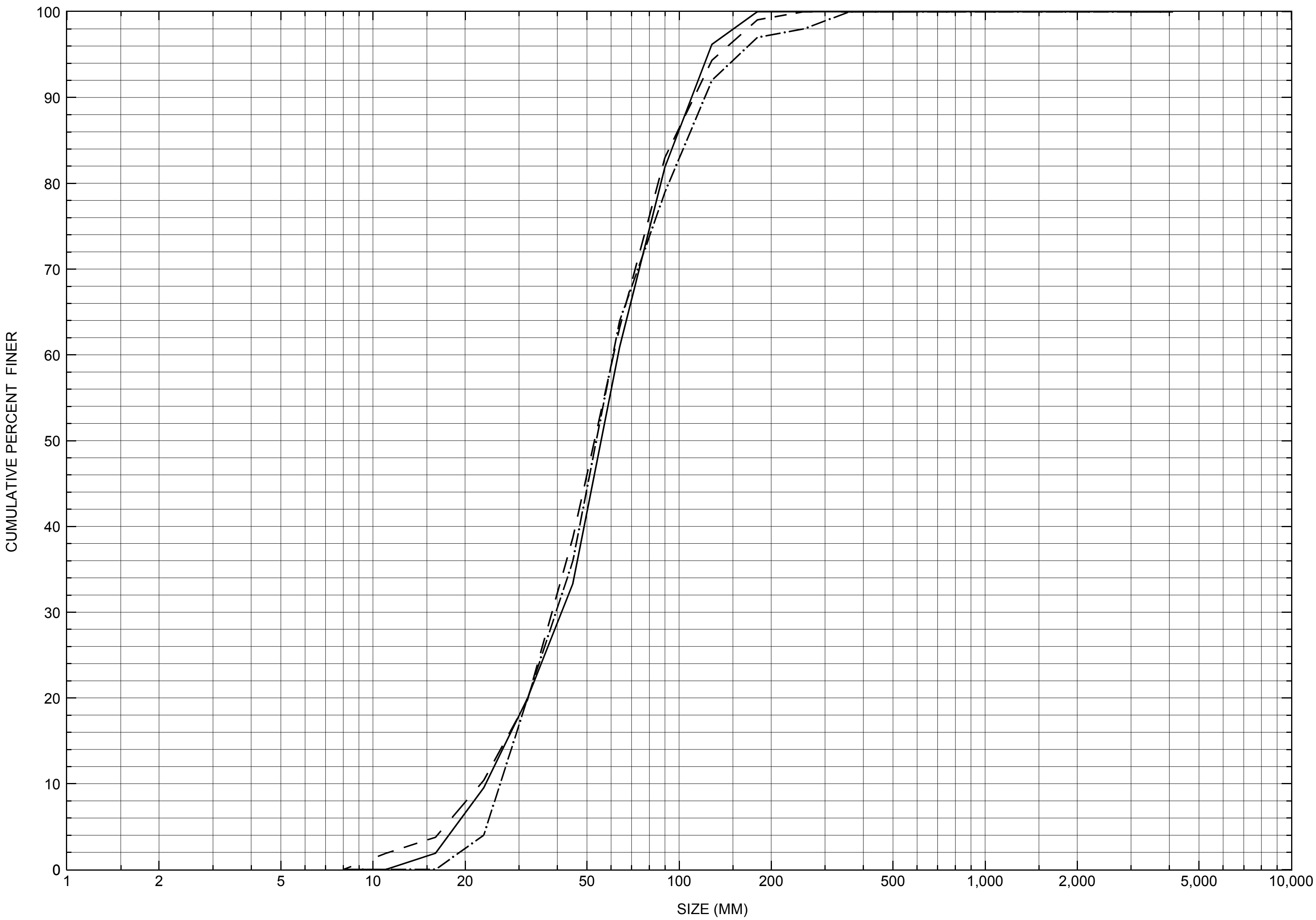
WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File nwpc059.wsp
        Hydraulic analysis for structure NWPCVT01050059   Date: 01-AUG-96
        State Route 105 Crossing an Unnamed Mud Creek Trib., Newport, VT   EMB
           *** RUN DATE & TIME: 08-21-96  07:46

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

 EXIT2:XS   ******    -86      329  0.30 *****   93.70   91.44    1320   93.40
       -62 ******     90    18851  1.21 ***** *******    0.57    4.01

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "EXIT1"     KRATIO =  0.54

 EXIT1:XS       34      0      175  0.88  0.31   94.29 *******    1320   93.41
       -28      34     34    10103  1.00  0.29   -0.01    0.59    7.53

 FULLV:FV       29      0      182  0.82  0.47   94.76 *******    1320   93.94
         0      29     34    10681  1.00  0.00    0.00    0.56    7.25
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPR1"     KRATIO =  1.56

 APPR1:AS       72    -25      257  0.44  0.70   95.46 *******    1320   95.02
        72      72     45    16694  1.08  0.00    0.00    0.49    5.13
          <<<<<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      140  1.38  0.46   94.81   92.53    1320   93.43
         0      29     29    10921  1.00  0.06    0.00    0.74    9.42

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        4. ****   1.  1.000 ******   95.74 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      22.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

 APPR1:AS       28    -26      296  0.34  0.26   95.87   92.88    1320   95.54
        72      32     53    19946  1.10  0.81    0.01    0.43    4.46

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.590  0.238   15145.   -10.    19.    95.39

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

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT2:XS     -63.   -87.    90.   1320.   18851.     329.    4.01   93.40
   EXIT1:XS     -29.    -1.    34.   1320.   10103.     175.    7.53   93.41
   FULLV:FV      0.    -1.    34.   1320.   10681.     182.    7.25   93.94
   BRIDG:BR      0.     0.    29.   1320.   10921.     140.    9.42   93.43
   RDWAY:RG     22.**************      0.*****************    1.00********
   APPR1:AS     72.   -27.    53.   1320.   19946.     296.    4.46   95.54

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS     -10.    19.   15145.

  SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXIT2:XS     91.44    0.57   85.65  104.29************  0.30    93.70   93.40
   EXIT1:XS  ********    0.59   86.39  104.29  0.31  0.29  0.88    94.29   93.41
   FULLV:FV  ********    0.56   86.73  104.63  0.47  0.00  0.82    94.76   93.94
   BRIDG:BR     92.53    0.74   87.20   95.78  0.46  0.06  1.38    94.81   93.43
   RDWAY:RG  ***************    99.07  104.29********************************
   APPR1:AS     92.88    0.43   88.08  105.98  0.26  0.81  0.34    95.87   95.54
```

```
       U.S. Geological Survey WSPRO Input File nwpc059.wsp
       Hydraulic analysis for structure NWPCVT01050059   Date: 01-AUG-96
       State Route 105 Crossing an Unnamed Mud Creek Trib., Newport, VT   EMB
          *** RUN DATE & TIME: 08-21-96  07:46
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXIT2:XS   ******    -93      420  0.33 *****   94.23   93.00    1800   93.90
       -62 ******     95    25713  1.16 ***** *******    0.55    4.29

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "EXIT1"     KRATIO =  0.43
EXIT1:XS       34      0      186  1.46  0.39   95.17 *******    1800   93.71
       -28     34     34    11010  1.00  0.57   -0.01    0.74    9.69

FULLV:FV       29      0      206  1.19  0.66   95.83 *******    1800   94.64
         0     29     34    12881  1.00  0.00   -0.01    0.63    8.73
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPR1"     KRATIO =  1.87
APPR1:AS       72    -27      344  0.47  0.75   96.58 *******    1800   96.11
        72     72     60    24051  1.11  0.00    0.00    0.49    5.24
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =    93.67      96.93      97.19      95.74

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

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

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

BRIDG:BR       29      0      205  1.20 *****   96.98   93.47    1800   95.78
         0 ******     29    13707  1.00 ***** *******    0.58    8.78

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   2.  0.465 ******   95.74 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      22.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPR1:AS       28    -30      509  0.21  0.19   97.95   93.80    1800   97.74
        72     32     84    39594  1.10  1.21    0.00    0.31    3.54

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******    97.67
                  <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT2:XS     -63.   -94.    95.   1800.   25713.     420.    4.29   93.90
   EXIT1:XS     -29.    -1.    34.   1800.   11010.     186.    9.69   93.71
   FULLV:FV       0.    -1.    34.   1800.   12881.     206.    8.73   94.64
   BRIDG:BR       0.     0.    29.   1800.   13707.     205.    8.78   95.78
   RDWAY:RG      22.**************      0.*****************     1.00********
   APPR1:AS      72.   -31.    84.   1800.   39594.     509.    3.54   97.74

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS  ***********************

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT2:XS     93.00    0.55   85.65  104.29************  0.33   94.23   93.90
   EXIT1:XS  ********    0.74   86.39  104.29  0.39  0.57  1.46   95.17   93.71
   FULLV:FV  ********    0.63   86.73  104.63  0.66  0.00  1.19   95.83   94.64
   BRIDG:BR     93.47    0.58   87.20   95.78************  1.20   96.98   95.78
   RDWAY:RG  ****************   99.07  104.29************  0.05  100.90********
   APPR1:AS     93.80    0.31   88.08  105.98  0.19  1.21  0.21   97.95   97.74
  ER
 NORMAL  END  OF  WSPRO  EXECUTION.
```

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 NWPCVT01050059, in Newport, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number NWPCVT01050059

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 05 / 94

Highway District Number *(I - 2; nn)* 09

County *(FIPS county code; I - 3; nnn)* 019

Town *(FIPS place code; I - 4; nnnnn)* 48925

Mile marker *(I - 11; nnn.nnn)* 001220

Waterway *(I - 6)* Unnamed Mud Creek Tributary

Road Name *(I - 7):* -

Route Number VT105

Vicinity *(I - 9)* 3.0 MI W JCT. VT.100

Topographic Map Newport.Center

Hydrologic Unit Code: 01110000

Latitude *(I - 16; nnnn.n)* 44581

Longitude *(i - 17; nnnnn.n)* 72188

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20003400591016

Maintenance responsibility *(I - 21; nn)* 01

Maximum span length *(I - 48; nnnn)* 0029

Year built *(I - 27; YYYY)* 1961

Structure length *(I - 49; nnnnnn)* 000033

Average daily traffic, ADT *(I - 29; nnnnnn)* 002520

Deck Width *(I - 52; nn.n)* 380

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

Channel & Protection *(I - 61; n)* 8

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

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

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

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

Structure type *(I - 43; nnn)* 101

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 007.0

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

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

Comments:

Structural inspection report of 5/21/91 indicates bridge is a concrete slab type structure. The report notes moderate settlement of road approaches behind both abutments, especially in the eastbound lane. The left abutment is reported as having shrinkage cracks and the right abutment has possibly settled near the upstream end. There is a point bar developed along the upstream right wingwall and channel makes a sharp bend into the bridge crossing. No embankment erosion or channel scour are noted.

Bridge Hydrologic Data

Is there hydrologic data available? **N** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **8.8**

Terrain character: -

Stream character & type: -

Streambed material: **Coarse sand, gravel, and cobbles**

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} **930** Q_{25} -

Q_{50} **1440** Q_{100} **1850** 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)* : **Light** Debris *(Heavy, Moderate, Light)*: **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)* 9.18 mi^2 Lake and pond area 0.03 mi^2
Watershed storage *(ST)* 0.3 %
Bridge site elevation 676 ft Headwater elevation 1437 ft
Main channel length 7.77 mi
10% channel length elevation 728 ft 85% channel length elevation 1004 ft
Main channel slope *(S)* 47.31 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)*: 07 / 1958

Project Number F 034 - 2(2) Minimum channel bed elevation: 664.0

Low superstructure elevation: USLAB 671.69 DSLAB 674.61 USRAB 671.86 DSRAB 674.76

Benchmark location description:

BM#5, spot on right downstream rail, elevation 676.90.

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

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

If 1: Footing Thickness 2.5 Footing bottom elevation: 658.0

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? Y *If no, type ctrl-n bi* Number of borings taken: 4

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

Briefly describe material at foundation bottom elevation or around piles:

They drilled through gravel, clay, and sand until hitting "hard pan" in all borings taken, in which the spread footings were set.

Comments:

There was an earlier structure which they removed. In some places this bridge is numbered as bridge 46, but has been replaced with bridge 59. The plans do not show a stamp indicating built as designed. This current bridge was put in as a part of a larger road improvement project. Plans show a recommended clear span of 33 feet, with a full waterway of 231 square feet. The terrain is hilly. The extreme high water elevation = 668.6 feet.

Cross-sectional Data

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

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

Comments: NO CROSS SECTIONAL 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: -

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: **DLS** Date: **2/15/95**
Computerized by: **MAI** Date: **2/24/95**
Reviewd by: **EMB** Date: **8/1/96**

Structure Number **NWPCVT01050059**

A. General Location Descriptive

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

2. Highway District Number **9**
   Mile marker **001220**
   County **ORLEANS (019)**
   Town **NEWPORT (48925)**
   Waterway *(I - 6)* **MUD CREEK**
   Road Name **VT 105**
   Route Number **VT105**
   Hydrologic Unit Code: **01110000**

3. Descriptive comments:
Located 3.0 miles west of junction with VT 100.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **4** LBDS **4** RBDS **4** 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 **2** UB **1** DS **2** *(**1**- pool; **2**- riffle)*

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

7. Bridge length **33** *(feet)* Span length **29** *(feet)* Bridge width **38** *(feet)*

Road approach to bridge:

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

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

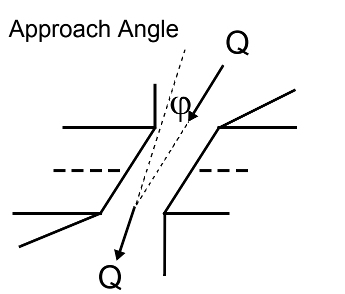
10. Embankment slope (*run / rise in feet / foot*):
US left **2.9:1** US right **2.0:1**

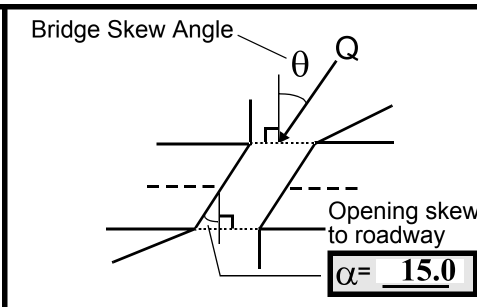
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	0	-	0	0
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	0	-	0	0

*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: **35**
16. Bridge skew: **15**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **0**
Range? **0** feet **US** *(US, UB, DS)* to **6** feet **US**

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

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

18. Level II Bridge Type: **4**

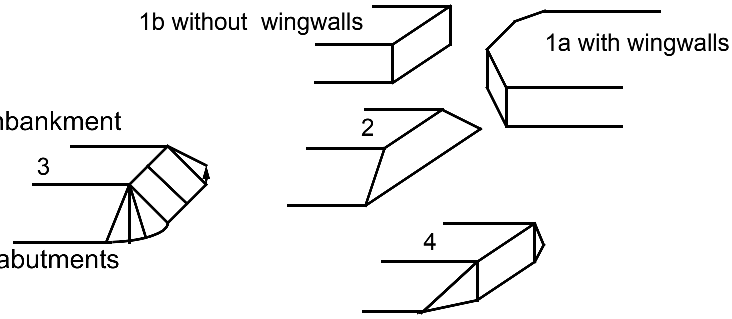
1a- Vertical abutments with wingwalls

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.)

7. Measured bridge length: 33, span: 29, and width: 38.
Road approach overflow width on the left approach is 38 ft.
18. At bank full the stream will see a type 4 bridge. There is a 2 ft. vertical height until the right wingwall slope begins.

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
65.2	**2.5**			**4.0**	**2**	**2**	**514**	**514**	**0**	**0**

23. Bank width **10.0** 24. Channel width **35.0** 25. Thalweg depth **39.5** 29. Bed Material **3**

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

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

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

27. Bank material left and right banks is cobble with silt overlying and some boulders.
29. Bed material is gravel with cobble and some sand.
30. Upstream banks are protected with stones possibly moved from fields.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **6** 35. Mid-bar width: **23**

36. Point bar extent: **32** feet **US** (US, UB) to **10** feet **DS** (US, UB, DS) positioned **20** %LB to **100** %RB

37. Material: **4**

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

The predominant material is cobbles with gravels and sands under the bridge to downstream; silt and organics are deposited on the bar upstream of the bridge face. The mid-bar distance is 6 feet under the bridge from the upstream face.

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

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

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

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

NO CUT BANKS

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

47. Scour dimensions: Length **-** Width **-** Depth : **-** Position **-** %LB to **-** %RB

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

NO CHANNEL SCOUR

49. Are there major confluences? **N** (Y or if N type ctrl-n mc) 50. How many? **-**

51. Confluence 1: Distance **-** 52. Enters on **-** (LB or RB) 53. Type **-** (**1**- perennial; **2**- ephemeral)

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

55. Channel restraint (BF)? LB **2** RB _____ (**1**- natural bank; **2**- abutment; **3**- artificial levee)

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
10.5		1.0		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.):

3

63. Bed material is gravel with cobble and some boulders.

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

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

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

70. Debris and Ice Comments:

1

67. No debris accumulation near the bridge face; upstream channel has few cut banks but is laterally stable.

68. Moderate channel gradient; the span length is approximately 74% of the upstream channel 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		20	90	2	1	0	0	90.0
RABUT	1	0	90			2	5	29.5

Pushed: LB or RB *Toe Location (Loc.): 0- even, 1- set back, 2- protrudes*
Scour cond.: 0- not evident; 1- evident (comment); 2- footing exposed; 3-undermined footing; 4- piling exposed; 5- settled; 6- failed
Materials: *1*- Concrete; *2*- Stone masonry or drywall; *3*- steel or metal; *4*- wood

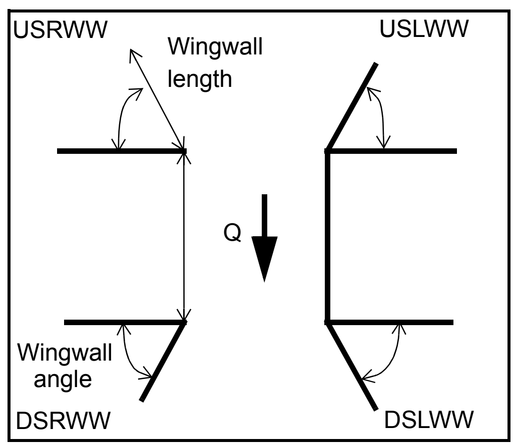
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0
0
1

74. RABUT: Historical form notes settlement from inspection on 5/21/91 of the upstream end of the right abutment. Visual separation of the abutment from the upstream right wingwall and a settlement crack 6 ft. under the bridge from the upstream face with “rebar” showing at the top near the deck.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						10.5	
USRWW:	Y		1		1	1.0	
DSLWW:	0		0		Y	43.0	
DSRWW:	1		0		-	45.0	



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	-	1	Y	-	1	1	-	-
Condition	Y	0	1	-	4	1	-	-
Extent	1	0	0	2	2	0	0	-

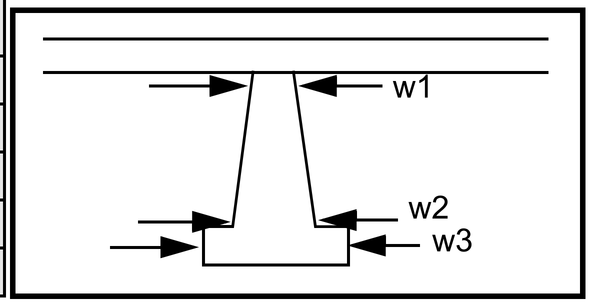
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? __US__ *(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				75.0	10.5	40.0
Pier 2				16.5	50.0	16.0
Pier 3			-	60.0	10.0	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	LW	h,	ment	nstre	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	W:	exce	.	am	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	pro-	pt at	DSL	end	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	tec-	the	WW	with	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	tion	cor-	: has	the	*Y- yes; N- no*
91. Attack ∠ (BF)	exte	ner	been	rem-	
92. Pushed	nt	junc-	rip	nant	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	cov-	tion	rapp	s of	
95. Cross-members	ers	with	ed	the	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	the	the	on	old	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	base	left	the	abut	
98. Exposure depth	lengt	abut	dow	ment	

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

footing mid way along the wingwall base.

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: __2__

Scour dimensions: Length __1__ Width __345__ Depth: __345__ Positioned __0__ %LB to __0__ %RB

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

4
0
0
-

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

Confluence 1: Distance __k__ Enters on __mat__ *(LB or RB)* Type __erial__ *(**1**- perennial; **2**- ephemeral)*

Confluence 2: Distance __on__ Enters on __both__ *(LB or RB)* Type __ban__ *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

ks is boulders with cobbles and some gravel.
Bed material is cobbles with boulders and some gravel.

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

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:	NWPCVT01050059	Town:	Newport City
Road Number:	VT 105	County:	Orleans
Stream:	Unnamed Mud Creek Trib.		

Initials EMB   Date: 11/8/96 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	1320	1800	0
Main Channel Area, ft2	250	357	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	47	152	0
Top width main channel, ft	47	51	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	33	64	0
D50 of channel, ft	0.178	0.178	0
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	5.3	7.0	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	1.4	2.4	ERR
Total conveyance, approach	19974	39589	0
Conveyance, main channel	18222	31159	0
Conveyance, LOB	0	0	0
Conveyance, ROB	1753	8429	0
Percent discrepancy, conveyance	-0.0050	0.0025	ERR
Qm, discharge, MC, cfs	1204.2	1416.7	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	115.8	383.2	ERR
Vm, mean velocity MC, ft/s	4.8	4.0	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	2.5	2.5	ERR
Vc-m, crit. velocity, MC, ft/s	8.3	8.7	N/A
Vc-l, crit. velocity, LOB, ft/s	N/A	N/A	N/A
Vc-r, crit. velocity, ROB, ft/s	0.0	0.0	N/A

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	250	357	0
Main channel width, ft	47	51	0
y1, main channel depth, ft	5.32	7.00	ERR
Bridge Section			
(Q) total discharge, cfs	1320	1800	0
(Q) discharge thru bridge, cfs	1320	1800	
Main channel conveyance	10928	13707	
Total conveyance	10928	13707	
Q2, bridge MC discharge,cfs	1320	1800	ERR
Main channel area, ft2	140	205	0
Main channel width (skewed), ft	28.1	28.1	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	28.1	28.1	0
y_bridge (avg. depth at br.), ft	4.98	7.30	ERR
Dm, median (1.25*D50), ft	0.2225	0.2225	0
y2, depth in contraction,ft	5.15	6.72	ERR
ys, scour depth (y2-ybridge), ft	0.17	-0.57	N/A

ARMORING			
D90	0.374	0.374	0.374
D95	0.446	0.446	0.446
Critical grain size,Dc, ft	0.3459	0.2597	ERR
Decimal-percent coarser than Dc	0.129	0.257	
Depth to armoring,ft	7.01	2.25	ERR

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)
(Richarson and others, 1995, p. 145-146)
```

	Q100	Q500	OtherQ
Q, total, cfs	1320	1800	0
Q, thru bridge, cfs	1320	1800	0
Total Conveyance, bridge	10928	13707	0
Main channel(MC) conveyance, bridge	10928	13707	0
Q, thru bridge MC, cfs	1320	1800	ERR
Vc, critical velocity, ft/s	8.33	8.72	N/A
Vc, critical velocity, m/s	2.54	2.66	N/A
Main channel width (skewed), ft	28.1	28.1	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	28.1	28.1	0.0
qbr, unit discharge, ft^2/s	47.0	64.1	ERR
qbr, unit discharge, m^2/s	4.4	6.0	N/A
Area of full opening, ft^2	140.0	205.0	0.0
Hb, depth of full opening, ft	4.98	7.30	ERR
Hb, depth of full opening, m	1.52	2.22	N/A
Fr, Froude number, bridge MC	0	0.58	0
Cf, Fr correction factor (<=1.0)	0.00	1.00	0.00
Elevation of Low Steel, ft	0	95.74	0
Elevation of Bed, ft	-4.98	88.44	N/A
Elevation of Approach, ft	0	97.74	0
Friction loss, approach, ft	0	0.19	0
Elevation of WS immediately US, ft	0.00	97.55	0.00
ya, depth immediately US, ft	4.98	9.11	N/A
ya, depth immediately US, m	1.52	2.78	N/A
Mean elevation of deck, ft	0	100.22	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.95	ERR
Ys, depth of scour, ft	N/A	0.47	N/A

Comparison of Chang and Laursen results (for unsubmerged orifice flow)

y2, from Laursen's equation, ft	5.153527	6.722959	0
Full valley WSEL, ft	0	94.64	0
Full valley depth, ft	4.982206	6.195374	N/A
Ys, depth of scour (y2-yfullv), ft	N/A	0.527585	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	1320	1800	0	1320	1800	0
a', abut.length blocking flow, ft	27.7	31.6	0	23.5	55.1	0
Ae, area of blocked flow ft2	130.9	196.4	0	27.3	109.66	0
Qe, discharge blocked abut.,cfs	582	713.1	0	58.5	244.8	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.45	3.63	ERR	2.14	2.23	ERR
ya, depth of f/p flow, ft	4.73	6.22	ERR	1.16	1.99	ERR
--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	105	105	105	75	75	75
K2	1.02	1.02	1.02	0.98	0.98	0.98
Fr, froude number f/p flow	0.360	0.257	ERR	0.350	0.279	ERR
ys, scour depth, ft	15.03	16.58	N/A	5.22	8.91	N/A

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)	27.7	31.6	0	23.5	55.1	0
y1 (depth f/p flow, ft)	4.73	6.22	ERR	1.16	1.99	ERR
a'/y1	5.86	5.08	ERR	20.23	27.69	ERR
Skew correction (p. 49, fig. 16)	1.03	1.03	1.03	0.95	0.95	0.95
Froude no. f/p flow	0.36	0.26	N/A	0.35	0.28	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	9.02	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	7.40	ERR
spill-through	ERR	ERR	ERR	ERR	4.96	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	0.74	0.58	0	0.74	0.58	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	4.98	7.30	0.00	4.98	7.30	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	1.69	1.52	0.00	1.69	1.52	0.00
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR