LEVEL II SCOUR ANALYSIS FOR BRIDGE 14 (FFIETH00010014) on TOWN HIGHWAY 1, crossing the FAIRFIELD RIVER, FAIRFIELD, VERMONT

U.S. Geological Survey
Open-File Report 96-742

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

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By SCOTT A. OLSON

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Pembroke, New Hampshire

1996

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

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information
write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275-3718

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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 14 (FFIETH00010014) ON TOWN HIGHWAY 1, CROSSING THE FAIRFIELD RIVER, FAIRFIELD, VERMONT

By **Scott A. Olson**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure FFIETH00010014 on Town Highway 1 crossing the Fairfield River, Fairfield, 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 northwestern Vermont. The 7.84-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover on the upstream left and downstream right is row crops. The surface cover on the upstream right and downstream left is pasture.

In the study area, the Fairfield River has a sinuous channel with a slope of approximately 0.006 ft/ft, an average channel top width of 33 ft and an average channel depth of 3 ft. The channel bed material ranges from silt to gravel with a median grain size (D_{50}) of 15.4 mm (0.0505 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 11, 1995, indicated that the reach was laterally unstable.

The Town Highway 1 crossing of the Fairfield River is a 26-ft-long, two-lane bridge consisting of one 23-foot concrete span (Vermont Agency of Transportation, written communication, March 9, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 27 degrees to the opening while there is no opening-skew-to-roadway.

The bridge is located on a sharp channel bend. The left abutment is impacted due to this bend. A scour hole 1.5 ft deeper than the mean thalweg depth was observed along the left abutment during the Level I assessment. Scour protection measures at the site include type-3 stone fill (less than 48 inches diameter) along the immediate upstream banks and along the base of the upstream left wingwall. Type-2 stone fill (less than 36 inches diameter) was present along the downstream left wingwall. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 5.4 to 8.0 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 3.0 to 8.3 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.

Fairfield, 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 FFIETH00010014 ***Stream*** Fairfield River

County Franklin ***Road*** TH1 ***District*** 8

Description of Bridge

Bridge length 26 ***ft*** ***Bridge width*** 27.4 ***ft*** ***Max span length*** 23 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 7/11/95

Description of stone fill Type-3, along upstream banks and the upstream left wingwall. Type-2 along the downstream right wingwall.

Abutments and wingwalls are concrete. There is a 1.5 ft deep scour hole in front of the left abutment. There is minor settlement noted along a vertical crack in the left abutment.

Y 27

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

There is a sharp channel bend immediately upstream of the bridge.

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*
	7/11/95	0	0
Level I	7/11/95	0	0
Level II			

Potential for debris Moderate.

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

Depending upon season and agricultural activities, the roughness of the upstream left overbank and the downstream right overbank in respect to flow resistance could change dramatically. On 7/11/95, these overbanks were covered by mature corn stalks.

Description of the Geomorphic Setting

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

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

Date of inspection 7/11/95

DS left: Flood plain.

DS right: Flood plain.

US left: Flood plain.

US right: Flood plain.

Description of the Channel

Average top width 33 ***ft*** ***Average depth*** 3 ***ft***

Predominant bed material Gravel ***Bank material*** Gravel

Meandering

7/11/95

Vegetative co Pasture.

DS left: Row crops.

DS right: Row crops.

US left: Pasture.

US right: N

Do banks appear stable? July 11, 1995. There are cut banks with block failures of the bank in the reach.

date of observation.

None. July 11, 1995.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 7.84 ***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 1,190 ***ft³/s*** ***Q500*** 1,780 ***ft³/s***

Discharges at Bridge 14 in Fairfield were determined from a drainage area relationship [(7.84/7.37) to the 0.7 power] with discharges taken from the Level II Scour Analysis for Bridge 12 on Town Highway 3 Crossing the Fairfield River, Fairfield, Vermont (Boehmler, 1996).

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is the center of a chiseled X on top of the downstream end of the right abutment (elev. 499.92 ft, arbitrary survey datum). RM2 is the center of a chiseled X on the top of the upstream concrete curb near the upstream right corner of the bridge deck (elev. 500.30 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	-33	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	14	1	Road Grade section
APPRO	50	2	Modelled Approach section (Templated from APTEM)
APTEM	60	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 0.040 to 0.065.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0062 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1986).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0 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 approach also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.9 ***ft***
Average low steel elevation 498.2 ***ft***

100-year discharge 1,190 ***ft^3/s***
Water-surface elevation in bridge opening 498.2 ***ft***
Road overtopping? Y ***Discharge over road*** 104 ***ft^3/s***
Area of flow in bridge opening 139 ***ft^2***
Average velocity in bridge opening 7.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.1 ***ft/s***

Water-surface elevation at Approach section with bridge 499.6
Water-surface elevation at Approach section without bridge 497.6
Amount of backwater caused by bridge 2.0 ***ft***

500-year discharge 1,780 ***ft^3/s***
Water-surface elevation in bridge opening 498.2 ***ft***
Road overtopping? Y ***Discharge over road*** 600 ***ft^3/s***
Area of flow in bridge opening 139 ***ft^2***
Average velocity in bridge opening 8.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.0 ***ft/s***

Water-surface elevation at Approach section with bridge 500.0
Water-surface elevation at Approach section without bridge 498.2
Amount of backwater caused by bridge 1.8

Incipient overtopping discharge 950 ***ft^3/s***
Water-surface elevation in bridge opening 498.2 ***ft***
Area of flow in bridge opening 139 ***ft^2***
Average velocity in bridge opening 6.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 8.2 ***ft/s***

Water-surface elevation at Approach section with bridge 499.1
Water-surface elevation at Approach section without bridge 496.8
Amount of backwater caused by bridge 2.3 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of the Chang pressure-flow scour equation (Richardson and others, 1995, p. 145-146). For each of the modelled discharges, there was orifice flow at the bridge. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). The results of Laursen's clear-water contraction scour equation were also computed and can be found in appendix F.

Abutment scour 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. Variables for the 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	6.8	8.0	5.4
Depth to armoring	--	--	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	4.0	5.3	3.0
Right abutment	6.9	8.3	6.0
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	1.1	1.3	0.9
Right abutment	1.1	1.3	0.9
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

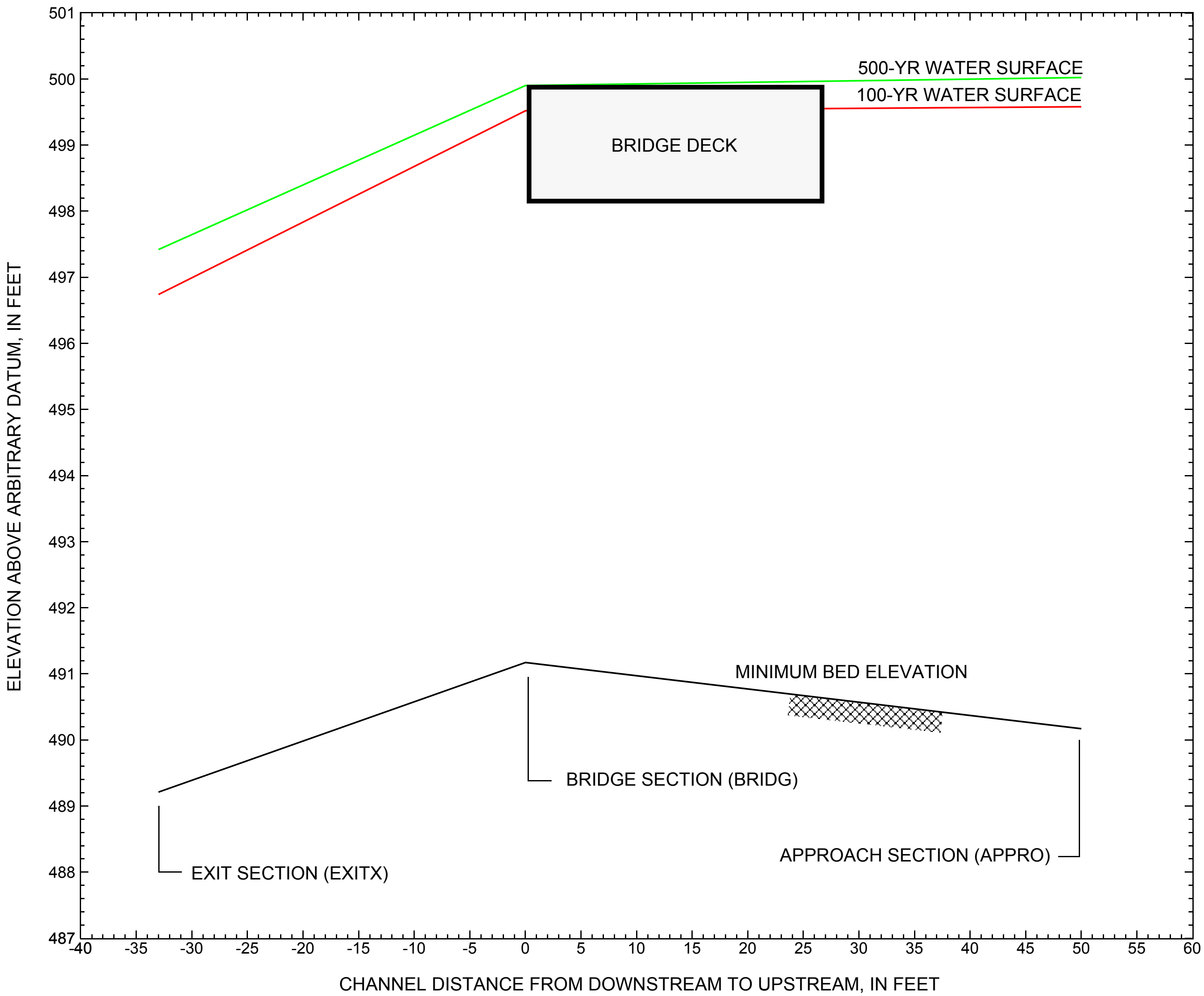

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure FFIETH00010014 on Town Highway 1, crossing the Fairfield River, Fairfield, Vermont.

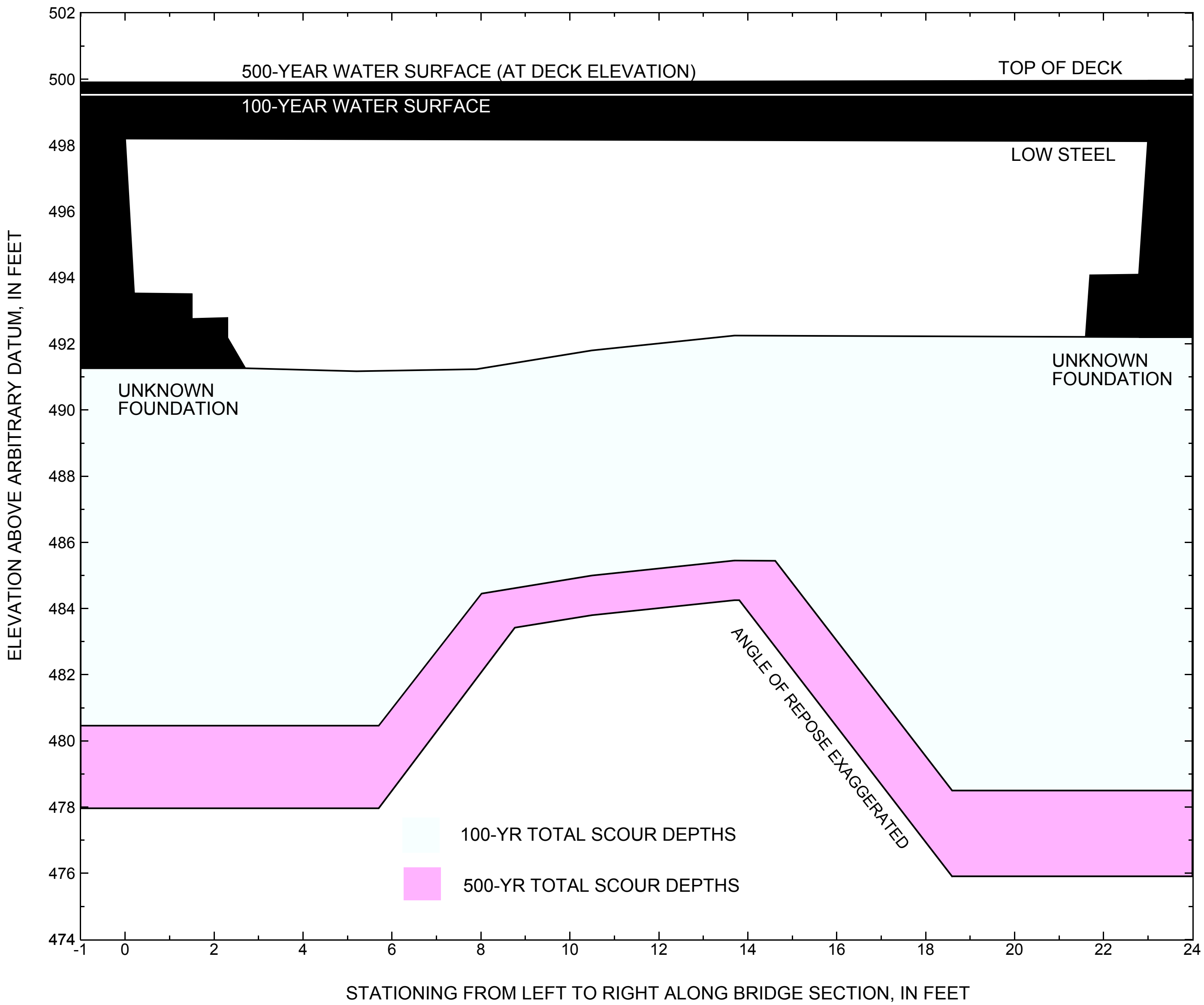

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure FFIETH00010014 on Town Highway 1, crossing the Fairfield River, Fairfield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure FFIETH00010014 on Town Highway 1, crossing the Fairfield River, Fairfield, 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 1,190 cubic-feet per second											
Left abutment	0.0	--	498.2	--	491.3	6.8	4.0	--	10.8	480.5	--
Right abutment	23.0	--	498.1	--	492.2	6.8	6.9	--	13.7	478.5	--

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 FFIETH00010014 on Town Highway 1, crossing the Fairfield River, Fairfield, 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 1,780 cubic-feet per second											
Left abutment	0.0	--	498.2	--	491.3	8.0	5.3	--	13.3	478.0	--
Right abutment	23.0	--	498.1	--	492.2	8.0	8.3	--	16.3	475.9	--

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

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U.S. Geological Survey, 1986, Fairfield, 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 ffie014.wsp
T2        Hydraulic analysis for structure FFIETH00010014   Date: 20-JUN-96
T3        Hydraulic analysis of FFIE014 over Fairfield River    SAO
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1190 1780 950
WS          496.90 498 496.15
SK          0.0062 0.0062 0.0062
*
XS   EXITX    -33
GR         -486.5, 502.66   -486.5, 498.00   -303.3, 497.64   -226.6, 497.14
GR          -58.2, 495.99    -34.8, 496.44    -11.9, 496.40     -6.3, 494.39
GR           -1.9, 494.65      0.0, 492.65      7.0, 490.25     13.2, 489.21
GR           20.7, 490.58     23.4, 492.21     25.1, 495.29     31.8, 496.91
GR           95.8, 496.91    181.2, 503.33    224.7, 510.18
N           0.065        0.046        0.040
SA                  -1.9         31.8
*
XS   FULLV      0 * * * 0.0062
*
BR   BRIDG     0 498.16
GR            0.0, 498.20      0.2, 493.52      1.5, 493.50      1.5, 492.75
GR            2.3, 492.78      2.3, 492.18      2.7, 491.26      5.2, 491.17
GR            7.9, 491.23     10.5, 491.80     13.7, 492.25     21.6, 492.20
GR           21.7, 494.07     22.8, 494.09     23.0, 498.12      0.0, 498.20
N             0.035
CD           4 27.3 3 499.9 75
*
XR   RDWAY     14 27
GR         -492.5, 499.99   -492.5, 499.21   -297.0, 499.38      0.0, 499.89
GR            0.0, 501.10     22.5, 501.11     22.6, 499.95    194.4, 500.88
GR          256.3, 500.81    294.6, 512.69
*
XT   APTEM     60
GR         -479.9, 500.15   -459.0, 499.04   -428.5, 497.89    -72.2, 497.89
GR            0.0, 497.76      5.2, 493.58     11.1, 492.95     13.4, 492.22
GR           13.9, 492.00     15.7, 490.52     18.0, 490.17     23.5, 491.03
GR           32.9, 492.29     36.6, 496.87    172.4, 495.93    310.9, 497.86
GR          365.3, 501.22    374.4, 509.50
*
AS   APPRO    50
GT            0
N           0.050        0.040        0.050
SA                   0.0         36.6
*
HP 1 BRIDG   498.20 1 498.20
HP 2 BRIDG   498.20 * * 1063
HP 2 RDWAY   499.52 * * 104
HP 1 APPRO   499.58 1 499.58
HP 2 APPRO   499.58 * * 1190
*
HP 1 BRIDG   498.20 1 498.20
HP 2 BRIDG   498.20 * * 1159
HP 2 RDWAY   499.90 * * 600
HP 1 APPRO   500.02 1 500.02
HP 2 APPRO   500.02 * * 1780
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File ffie014.wsp
        Hydraulic analysis for structure FFIETH00010014   Date: 20-JUN-96
        Hydraulic analysis of FFIE014 over Fairfield River    SAO

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     139.  10548.     0.    58.                            0.
   498.20          139.  10548.     0.    58.  1.00     0.    23.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.20     0.0    23.0   138.7   10548.    1063.   7.66
X STA.        0.0         2.5         3.6         4.6         5.5         6.3
  A(I)             12.2         7.7         6.5         6.4         6.0
  V(I)             4.36        6.88        8.12        8.34        8.88

X STA.        6.3         7.2         8.0         8.9         9.8        10.7
  A(I)              5.9         5.8         5.8         5.8         6.0
  V(I)             8.95        9.14        9.10        9.11        8.83

X STA.       10.7        11.6        12.6        13.7        14.7        15.8
  A(I)              5.9         6.2         6.1         6.3         6.4
  V(I)             8.97        8.62        8.70        8.37        8.31

X STA.       15.8        16.9        18.0        19.2        20.5        23.0
  A(I)              6.3         6.8         6.9         7.7        11.9
  V(I)             8.45        7.83        7.73        6.89        4.48

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      14.
         WSEL     LEW     REW    AREA        K        Q    VEL
       499.52  -492.5  -215.5    49.7     362.     104.   2.09
X STA.     -492.5      -486.6      -480.7      -474.6      -468.3      -461.5
  A(I)              1.8         1.8         1.8         1.8         1.9
  V(I)             2.88        2.92        2.85        2.83        2.68

X STA.     -461.5      -454.5      -447.2      -439.5      -431.3      -422.6
  A(I)              2.0         2.0         2.1         2.1         2.2
  V(I)             2.65        2.58        2.53        2.44        2.36

X STA.     -422.6      -413.3      -403.3      -392.6      -380.8      -368.0
  A(I)              2.3         2.3         2.5         2.6         2.6
  V(I)             2.28        2.22        2.12        2.03        1.96

X STA.     -368.0      -353.8      -337.5      -317.9      -293.1      -215.5
  A(I)              2.8         3.0         3.3         3.6         5.2
  V(I)             1.87        1.75        1.59        1.43        1.00

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      50.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     766.  31621.   469.   469.                         5550.
             2     256.  32244.    37.    41.                         3841.
             3     828.  48279.   302.   302.                         7773.
   499.58         1849. 112144.   808.   813.  1.77  -469.   339.  11934.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      50.
         WSEL     LEW     REW    AREA        K        Q    VEL
       499.58  -469.2   338.7  1849.2  112144.    1190.   0.64
X STA.     -469.2      -360.7      -282.1      -202.5      -123.8       -46.3
  A(I)            151.3       132.9       134.5       133.0       131.6
  V(I)             0.39        0.45        0.44        0.45        0.45

X STA.      -46.3         6.3        13.3        17.9        22.0        26.5
  A(I)            109.4        45.5        40.2        37.3        38.0
  V(I)             0.54        1.31        1.48        1.60        1.56

X STA.       26.5        31.8        57.3        88.1       116.1       142.3
  A(I)             41.2        84.2        91.1        88.5        87.9
  V(I)             1.44        0.71        0.65        0.67        0.68

X STA.      142.3       166.3       190.7       219.3       258.2       338.7
  A(I)             84.7        86.5        91.5       106.1       133.8
  V(I)             0.70        0.69        0.65        0.56        0.44
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        U.S. Geological Survey WSPRO Input File ffie014.wsp
        Hydraulic analysis for structure FFIETH00010014   Date: 20-JUN-96
        Hydraulic analysis of FFIE014 over Fairfield River    SAO

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     139.  10548.     0.    58.                            0.
   498.20          139.  10548.     0.    58.  1.00     0.    23.       0.
1
    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.20     0.0    23.0   138.7   10548.    1159.   8.35
 X STA.        0.0         2.5         3.6         4.6         5.5         6.3
  A(I)              12.2         7.7         6.5         6.4         6.0
  V(I)              4.75        7.50        8.85        9.10        9.68

 X STA.        6.3         7.2         8.0         8.9         9.8        10.7
  A(I)               5.9         5.8         5.8         5.8         6.0
  V(I)              9.76        9.97        9.92        9.93        9.62

 X STA.       10.7        11.6        12.6        13.7        14.7        15.8
  A(I)               5.9         6.2         6.1         6.3         6.4
  V(I)              9.78        9.40        9.48        9.13        9.07

 X STA.       15.8        16.9        18.0        19.2        20.5        23.0
  A(I)               6.3         6.8         6.9         7.7        11.9
  V(I)              9.21        8.54        8.42        7.51        4.88

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      14.
         WSEL     LEW     REW    AREA        K        Q    VEL
       499.90  -492.5     0.0   197.0    2455.     600.   3.05
 X STA.     -492.5      -482.1      -471.4      -460.9      -449.5      -438.0
  A(I)               7.1         7.3         7.0         7.5         7.4
  V(I)              4.23        4.12        4.29        3.98        4.03

 X STA.     -438.0      -425.9      -413.2      -400.0      -386.5      -372.0
  A(I)               7.7         7.9         8.1         8.2         8.5
  V(I)              3.89        3.79        3.69        3.66        3.51

 X STA.     -372.0      -356.7      -340.8      -323.4      -305.0      -285.4
  A(I)               8.9         8.9         9.6         9.8        10.1
  V(I)              3.38        3.35        3.12        3.06        2.97

 X STA.     -285.4      -262.8      -235.0      -201.7      -154.0         0.0
  A(I)              10.9        12.2        12.8        15.0        21.9
  V(I)              2.76        2.46        2.34        1.99        1.37

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      50.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     974.  46672.   477.   477.                         7892.
             2     272.  35696.    37.    41.                         4209.
             3     962.  61095.   309.   309.                         9630.
   500.02         2208. 143462.   823.   828.  1.60  -477.   346.  16231.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      50.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.02  -477.5   345.9  2208.1  143462.    1780.   0.81
 X STA.     -477.5      -375.4      -305.0      -235.4      -168.2       -98.8
  A(I)             169.6       149.9       148.3       143.0       148.0
  V(I)              0.52        0.59        0.60        0.62        0.60

 X STA.      -98.8       -33.0         7.6        15.1        19.9        25.1
  A(I)             141.5       112.0        55.4        46.5        47.0
  V(I)              0.63        0.79        1.61        1.92        1.89

 X STA.       25.1        30.8        54.7        86.1       114.9       141.8
  A(I)              48.5        94.3       106.6       103.4       101.9
  V(I)              1.84        0.94        0.84        0.86        0.87

 X STA.      141.8       166.8       193.0       223.2       263.2       345.9
  A(I)              98.7       104.3       108.4       124.1       156.8
  V(I)              0.90        0.85        0.82        0.72        0.57
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        U.S. Geological Survey WSPRO Input File ffie014.wsp
        Hydraulic analysis for structure FFIETH00010014   Date: 20-JUN-96
        Hydraulic analysis of FFIE014 over Fairfield River    SAO

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     139.  10548.     0.    58.                           0.
   498.20          139.  10548.     0.    58.  1.00     0.    23.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.20     0.0    23.0   138.7   10548.     950.   6.85
X STA.         0.0         2.5         3.6         4.6         5.5         6.3
  A(I)            12.2         7.7         6.5         6.4         6.0
  V(I)            3.90        6.15        7.26        7.46        7.93

X STA.         6.3         7.2         8.0         8.9         9.8        10.7
  A(I)             5.9         5.8         5.8         5.8         6.0
  V(I)            8.00        8.17        8.13        8.14        7.89

X STA.        10.7        11.6        12.6        13.7        14.7        15.8
  A(I)             5.9         6.2         6.1         6.3         6.4
  V(I)            8.02        7.71        7.77        7.48        7.43

X STA.        15.8        16.9        18.0        19.2        20.5        23.0
  A(I)             6.3         6.8         6.9         7.7        11.9
  V(I)            7.55        7.00        6.90        6.16        4.00

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      50.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     556.  18803.   461.   461.                        3470.
             2     239.  28861.    37.    41.                        3476.
             3     693.  36531.   295.   295.                        6033.
   499.13         1489.  84195.   792.   797.  2.01  -461.   331.   8165.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      50.
         WSEL     LEW     REW    AREA        K        Q    VEL
       499.13  -460.7   331.5  1489.2   84195.     950.   0.64
X STA.      -460.7      -338.6      -238.4      -138.6       -39.8         7.2
  A(I)           131.9       124.2       123.8       123.4        82.6
  V(I)            0.36        0.38        0.38        0.38        0.58

X STA.         7.2        13.0        17.1        20.4        24.0        27.8
  A(I)            35.6        32.7        28.7        29.9        29.8
  V(I)            1.33        1.45        1.66        1.59        1.59

X STA.        27.8        32.4        59.8        89.8       116.9       141.3
  A(I)            32.9        74.6        75.8        73.9        70.7
  V(I)            1.45        0.64        0.63        0.64        0.67

X STA.       141.3       164.2       187.3       214.2       250.8       331.5
  A(I)            70.2        72.0        75.6        86.4       114.5
  V(I)            0.68        0.66        0.63        0.55        0.41
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        U.S. Geological Survey WSPRO Input File ffie014.wsp
        Hydraulic analysis for structure FFIETH00010014   Date: 20-JUN-96
        Hydraulic analysis of FFIE014 over Fairfield River    SAO
           *** RUN DATE & TIME: 11-12-96  07:30

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

EXITX:XS   ******  -168.     240.  0.67 *****  497.42  494.91   1190.  496.74
      -33. ******    31.   15100.  1.77 ***** *******    1.06    4.96

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.04     496.99     495.12

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.24     510.38    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.24     510.38     495.12

FULLV:FV      33.  -171.     244.  0.66  0.20  497.63  495.12   1190.  496.97
        0.    33.    31.   15243.  1.79  0.00    0.01    1.05    4.87
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

APPRO:AS      50.     0.     432.  0.25  0.18  497.80 *******   1190.  497.55
       50.    50.   289.   25755.  2.11  0.00   -0.01    0.58    2.75
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   499.21       0.00     496.48     499.21

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   496.48     499.15     499.21     498.16

 ===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      33.     0.     139.  0.91 *****  499.11  496.16   1063.  498.20
        0. ******    23.   10548.  1.00 ***** *******    0.55    7.66

     TYPE PPCD FLOW       C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   5.  0.455  0.000  498.16 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.    23.  0.00  0.01  499.59   -0.02    104.  499.52

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   104.   279.  -493.  -213.   0.3   0.2   2.3   2.1   0.2   3.1
   RT:     0.   139.    23.   161.   0.7   0.4   3.7   4.5   0.7   3.0

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

APPRO:AS      23.  -469.    1847.  0.01  0.04  499.59  495.57   1190.  499.58
       50.    36.   339.  111979.  1.77  0.49   -0.02    0.10    0.64

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -33.  -168.    31.   1190.   15100.     240.    4.96  496.74
   FULLV:FV       0.  -171.    31.   1190.   15243.     244.    4.87  496.97
   BRIDG:BR       0.     0.    23.   1063.   10548.     139.    7.66  498.20
   RDWAY:RG      14.*******   104.    104.*********       0.    1.00  499.52
   APPRO:AS      50.  -469.   339.   1190.  111979.    1847.    0.64  499.58

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    494.91    1.06  489.21  510.18************  0.67  497.42  496.74
   FULLV:FV    495.12    1.05  489.41  510.38  0.20  0.00  0.66  497.63  496.97
   BRIDG:BR    496.16    0.55  491.17  498.20************  0.91  499.11  498.20
   RDWAY:RG  ****************  499.21  512.69  0.00******  0.01  499.59  499.52
   APPRO:AS    495.57    0.10  490.17  509.50  0.04  0.49  0.01  499.59  499.58
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File ffie014.wsp
        Hydraulic analysis for structure FFIETH00010014   Date: 20-JUN-96
        Hydraulic analysis of FFIE014 over Fairfield River    SAO
           *** RUN DATE & TIME: 11-12-96  07:30

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

EXITX:XS   ******  -269.     443.  0.65 *****  498.07  497.36   1780.  497.42
      -33. ******   103.   22584.  2.60 ***** *******    1.05    4.02

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.00     497.67     497.57

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.92     510.38    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.92     510.38     497.57

FULLV:FV      33.  -272.     450.  0.64  0.20  498.28  497.57   1780.  497.64
        0.    33.   103.   22865.  2.61  0.00    0.00    1.03    3.96
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "APPRO"     KRATIO =  1.84

APPRO:AS      50.  -438.     794.  0.20  0.16  498.43 *******   1780.  498.23
       50.    50.   317.   42172.  2.50  0.00   -0.01    0.61    2.24
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   501.20       0.00     497.84     499.21

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   497.60     499.80     499.87     498.16

 ===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      33.     0.     139.  1.09 *****  499.29  496.41   1159.  498.20
        0. ******    23.   10548.  1.00 ***** *******    0.60    8.35

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****    5.  0.474  0.000  498.16 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.    23.  0.00  0.02  500.03   -0.01    600.  499.90

            Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    600.   493.  -493.     0.   0.7   0.4   3.4   3.1   0.5   3.1
   RT:      0.     3.    23.    26.   0.0   0.0   1.8  20.3   0.2   3.0

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

APPRO:AS      23.  -477.    2209.  0.02  0.07  500.04  497.37   1780.  500.02
       50.    48.   346.  143499.  1.60  0.32   -0.01    0.11    0.81

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -33.  -269.   103.   1780.   22584.     443.    4.02  497.42
   FULLV:FV       0.  -272.   103.   1780.   22865.     450.    3.96  497.64
   BRIDG:BR       0.     0.    23.   1159.   10548.     139.    8.35  498.20
   RDWAY:RG      14.*******   600.    600.*********       0.    1.00  499.90
   APPRO:AS      50.  -477.   346.   1780.  143499.    2209.    0.81  500.02

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    497.36    1.05  489.21  510.18************  0.65  498.07  497.42
   FULLV:FV    497.57    1.03  489.41  510.38  0.20  0.00  0.64  498.28  497.64
   BRIDG:BR    496.41    0.60  491.17  498.20************  1.09  499.29  498.20
   RDWAY:RG  ****************  499.21  512.69  0.00******  0.02  500.03  499.90
   APPRO:AS    497.37    0.11  490.17  509.50  0.07  0.32  0.02  500.04  500.02
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        U.S. Geological Survey WSPRO Input File ffie014.wsp
        Hydraulic analysis for structure FFIETH00010014   Date: 20-JUN-96
        Hydraulic analysis of FFIE014 over Fairfield River    SAO
           *** RUN DATE & TIME: 11-12-96  07:30

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

EXITX:XS   ******   -80.     156.  0.67 *****  496.80  494.25    950.  496.14
      -33. ******    29.   12065.  1.15 ***** *******    0.77    6.09

FULLV:FV      33.   -81.     156.  0.66  0.20  497.01 *******    950.  496.35
        0.    33.    29.   12088.  1.16  0.00    0.01    0.77    6.07
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.91     496.82     495.06

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   495.85     509.50    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   495.85     509.50     495.06

APPRO:AS      50.     1.     237.  0.44  0.24  497.24  495.06    950.  496.80
       50.    50.   235.   15736.  1.77  0.00   -0.01    0.92    4.01
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.86     498.25     498.33     498.16

 ===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      33.     0.     139.  0.73 *****  498.93  495.86    948.  498.20
        0. ******    23.   10548.  1.00 ***** *******    0.49    6.83

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   2.  0.428  0.000  498.16 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS      23.  -461.    1493.  0.01  0.03  499.15  495.06    950.  499.13
       50.    31.   332.   84456.  2.01  0.54    0.00    0.12    0.64

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   499.13

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -33.   -80.    29.    950.   12065.     156.    6.09  496.14
   FULLV:FV       0.   -81.    29.    950.   12088.     156.    6.07  496.35
   BRIDG:BR       0.     0.    23.    948.   10548.     139.    6.83  498.20
   RDWAY:RG      14.**************      0.*********       0.    1.00********
   APPRO:AS      50.  -461.   332.    950.   84456.    1493.    0.64  499.13

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    494.25    0.77  489.21  510.18************  0.67  496.80  496.14
   FULLV:FV  ********    0.77  489.41  510.38  0.20  0.00  0.66  497.01  496.35
   BRIDG:BR    495.86    0.49  491.17  498.20************  0.73  498.93  498.20
   RDWAY:RG  ****************  499.21  512.69************  0.01  499.23********
   APPRO:AS    495.06    0.12  490.17  509.50  0.03  0.54  0.01  499.15  499.13
```
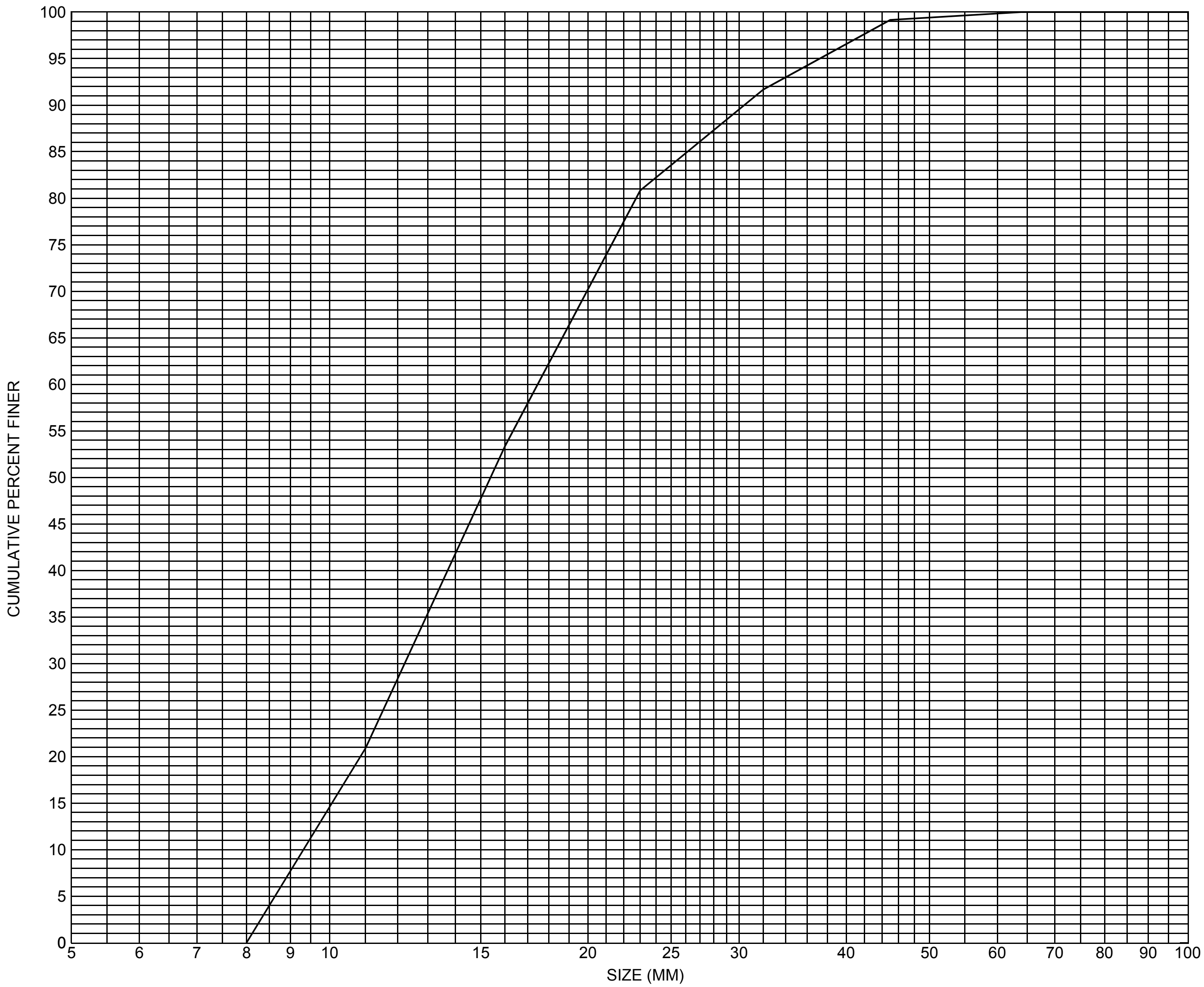

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure FFIETH00010014, in Fairfield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number FFIETH00010014

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 09 / 95

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

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

Town *(FIPS place code; I - 4; nnnnn)* 25225

Mile marker *(I - 11; nnn.nnn)* 001090

Waterway *(I - 6)* FAIRFIELD RIVER

Road Name *(I - 7):* -

Route Number TH001

Vicinity *(I - 9)* 2.5 MI S JCT. VT 36

Topographic Map Fairfield

Hydrologic Unit Code: 02010007

Latitude *(I - 16; nnnn.n)* 44461

Longitude *(i - 17; nnnnn.n)* 72575

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20028100140605

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

Maximum span length *(I - 48; nnnn)* 0023

Year built *(I - 27; YYYY)* 1949

Structure length *(I - 49; nnnnnn)* 000026

Average daily traffic, ADT *(I - 29; nnnnnn)* 000340

Deck Width *(I - 52; nn.n)* 274

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

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

Opening skew to Roadway *(I - 34; nn)* 00

Waterway adequacy *(I - 71; n)* 5

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)* 01

Vertical clearance from streambed (*nnn.n ft*) 6.0

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

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

Comments:

The structural inspection report of 7/26/94 indicates the structure is a single span concrete slab type bridge. This bridge is a part of the Federal Aid System filed under the route number, FAS281. The left abutment has a full height vertical crack near the centerline of the roadway with some minor settling evident along the crack. The footing is exposed, possibly undermined. The right abutment and footing are noted as in good condition. There is a small area of undermining at its upstream end and extends along the upstream right wingwall. The channel is noted as making a sharp turn into the structure with some minor stream bank erosion noted on the downstream side. There is vegetation (Continued, page 33)

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: -

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft^3/ sec*): -

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

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

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

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

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

Comments:

growing along both banks up- and downstream. There is stone fill protection on the banks upstream reported. There is a large gravel point bar deposited along the right abutment under the bridge and downstream in photos of the site. The channel flows along the left abutment.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **7.84** mi^2 Lake and pond area **0.03** mi^2
Watershed storage *(ST)* **0.4** %
Bridge site elevation **591** ft Headwater elevation **1920** ft
Main channel length **4.80** mi
10% channel length elevation **604** ft 85% channel length elevation **1100** ft
Main channel slope *(S)* **137.78** ft / mi

Watershed Precipitation Data

Average site precipitation ______ in Average headwater precipitation ______ in

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

Average seasonal snowfall *(Sn)* ______ ft

Bridge Plan Data

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

Project Number - Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB -

Benchmark location description:

NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness ____ Footing bottom elevation: ____

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

If 3: Footing bottom elevation: ____

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: RB Date: 3/12/96
Computerized by: RB Date: 3/12/96
Reviewd by: SAO Date: 11/20/96

Structure Number FFIETH00010014

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN Date *(MM/DD/YY)* 7 / 11 / 1995
2. Highway District Number 08 Mile marker 001090
   County 011 Town 25225
   Waterway *(I - 6)* FAIRFIELD RIVER Road Name -
   Route Number TH001 Hydrologic Unit Code: 02010007
3. Descriptive comments:
2.5 miles south of the junction with VT 36. This is a concrete slab type bridge with concrete curbings and guard rail posts. The left footing has a vertical crack where some settling has occurred to the US half. Since then another footing has been added below the original.

B. Bridge Deck Observations

4. Surface cover... LBUS 3 RBUS 4 LBDS 4 RBDS 3 Overall 3
*(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 26 *(feet)* Span length 23 *(feet)* Bridge width 27.4 *(feet)*

Road approach to bridge:

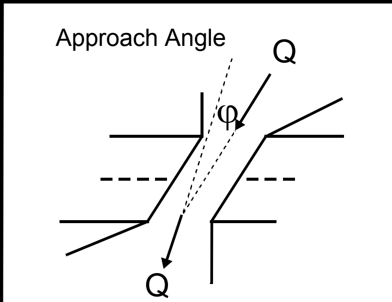
8. LB 0 RB 0 *(**0** even, **1**- lower, **2**- higher)*
9. LB 1 RB 1 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left 4.1:1 US right 1.8:1

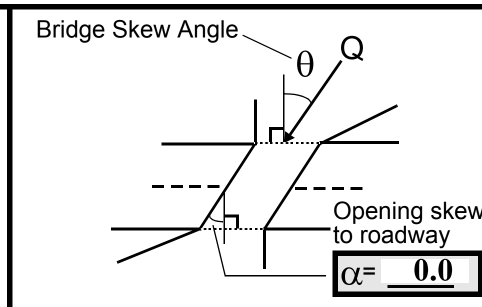
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	3	1	3	1
RBDS	0	-	2	1
LBDS	2	1	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: 30 16. Bridge skew: 27



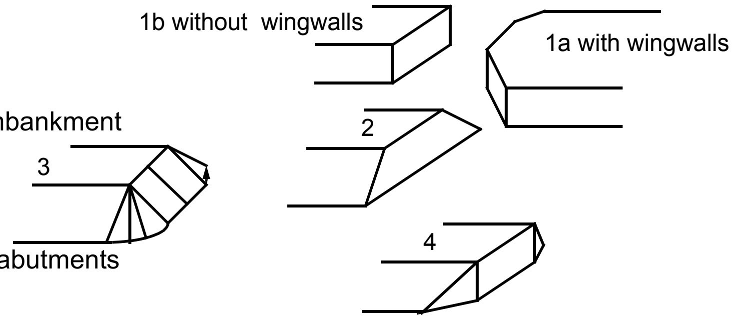


17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 60 feet US *(US, UB, DS)* to 20 feet US
Channel impact zone 2: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 3
Range? 0 feet UB *(US, UB, DS)* to 22 feet US

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

18. 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.)

4. The surface cover on the DS right bank is pasture for 2 bridge lengths and then it is row crops.
7. Values are from the VT AOT files.
11. The right bank US road approach protection also serves as stream bank protection.
18. The US left wingwall is a type 2.

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
33.5	**4.0**			**4.5**	**1**	**1**	**321**	**321**	**2**	**2**

23. Bank width **30.0** 24. Channel width **50.0** 25. Thalweg depth **36.5** 29. Bed Material **32**

30 .Bank protection type: LB **3** RB **3** 31. Bank protection condition: LB **2** 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.):

The right bank protection stretches from the end of the wingwall to 75 feet US almost parallel to the road. The left bank protection extends from the US end of the abutment in front of the wingwall to 30 feet US.

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

36. Point bar extent: - feet - (US, UB) to - feet - (US, UB, DS) positioned - %LB to - %RB

37. Material: -

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

NO POINT BARS

There are some channel bars beginning at 70 feet US but that is out of the 2 bridge length range. They are made up of gravel.

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

The bank protection prevents cut banks.

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 5

47. Scour dimensions: Length 50 Width 19 Depth : 3 Position 10 %LB to 85 %RB

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

The scour starts at the DS bridge face and ends at 23 feet US. As it enters the US bridge opening it shifts to the left bank along the left abutment (see sketch).

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
27.5		2.0		2	7	7	-

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

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

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

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

123

The bed has some large boulders visible in the scour hole along the left abutment.

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 2____ (1- Low; 2- Moderate; 3- High)

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

70. Debris and Ice Comments:

1

The low clearance of the bridge increases the capture efficiency.

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		**27**	**90**	**2**	**5**	**1.5**	**3.5**	**90.0**
RABUT	**1**	**-**	**90**			**2**	**2**	**23.0**

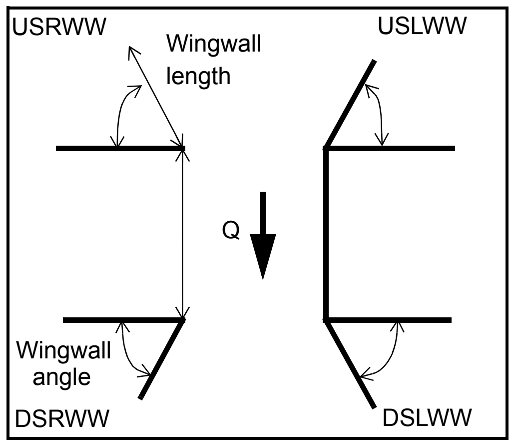
Pushed: LB or RB   *Toe Location (Loc.): 0- even, 1- set back, 2- protrudes*
Scour cond.: 0- not evident; 1- evident (comment); 2- footing exposed; 3-undermined footing; 4- piling exposed; 5- settled; 6- failed
Materials: 1- Concrete; 2- Stone masonry or drywall; 3- steel or metal; 4- wood

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

0
1.5
1
There is a silt and sand bar stretching from the US bridge face to the DS bridge face positioned 60% LB to 100% RB against the right wingwall.
76. The exposure depth for the right abutment ranges from 1.5 feet to 2 feet.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**23.0**	
USRWW:	**Y**		**1**		**2**	**1.0**	
DSLWW:	**1.5**		**3**		**Y**	**27.5**	
DSRWW:	**1**		**3**		**1**	**27.0**	



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	**3**	**2**	**Y**	**0**	**2**	**-**	**-**	**-**
Condition	**Y**	**0**	**1**	**1.5**	**1**	**-**	**-**	**-**
Extent	**1**	**2**	**2**	**3**	**0**	**0**	**0**	**-**

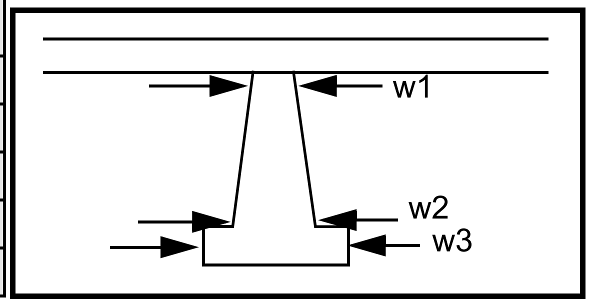
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
2
3
1
0
-
-

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1		8.5		90.0	60.0	11.5
Pier 2				55.0	11.0	65.0
Pier 3		-	-	11.5	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e US	tion	rmin	only	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	right	unde	ed	expo	1- Solid pier, 2- column, 3- bent
88. Material	wing	r the	US	sed	1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	wall	foot-	alon	at	1- Round; 2- Square; 3- Pointed
90. Inclined?	has 4	ing.	g the	the	Y- yes; N- no
91. Attack ∠ (BF)	feet	The	wall.	foot-	
92. Pushed	of	wing	The	ing	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	hori-	wall	US	wher	
95. Cross-members	zon-	beco	left	e it	0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	tal	mes	wing	joins	0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	pen-	more	wall	the	
98. Exposure depth	etra-	unde	is	abut	

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

ment. The rest is protected with stone fill. There seems to be stone fill on the bed on the right abutment under the soft sediment about 1 foot underneath. The DS right wingwall is buried in sediment at the DS end of the footing hiding any protection.

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: 1______

Scour dimensions: Length 1______ Width 321_____ Depth: 321_____ Positioned 2____ %LB to 3____ %RB

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

321
0
0
-

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

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

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

Confluence comments (eg. confluence name):

one bridge length but DS it turns back to 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: FFIETH00010014 Town: FAIRFIELD
Road Number: TH1 County: FRANKLIN
Stream: FAIRFIELD RIVER

Initials SAO Date: 11/12/96 Checked: MAI

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	1190	1780	950
Main Channel Area, ft2	256	272	239
Left overbank area, ft2	766	974	556
Right overbank area, ft2	828	962	693
Top width main channel, ft	36.6	36.6	36.6
Top width L overbank, ft	469.2	477.5	460.7
Top width R overbank, ft	302.1	309.3	294.9
D50 of channel, ft	0.0146	0.0146	0.0146
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.0	7.4	6.5
y1, average depth, LOB, ft	1.6	2.0	1.2
y1, average depth, ROB, ft	2.7	3.1	2.3
Total conveyance, approach	112114	143462	84195
Conveyance, main channel	32244	35696	28861
Conveyance, LOB	31621	46672	18803
Conveyance, ROB	48279	61095	36531
Percent discrepancy, conveyance	-0.0268	-0.0007	0.0000
Qm, discharge, MC, cfs	342.2	442.9	325.6
Ql, discharge, LOB, cfs	335.6	579.1	212.2
Qr, discharge, ROB, cfs	512.4	758.0	412.2
Vm, mean velocity MC, ft/s	1.3	1.6	1.4
Vl, mean velocity, LOB, ft/s	0.4	0.6	0.4
Vr, mean velocity, ROB, ft/s	0.6	0.8	0.6
Vc-m, crit. velocity, MC, ft/s	3.8	3.8	3.7
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

```
ARMORING
 D90                                 0.0725   0.0725   0.0725
 D95                                 0.0873   0.0873   0.0873
 Critical grain size,Dc, ft          0.1231   0.1463   0.0983
 Decimal-percent coarser than Dc     Critical grain size > D95. NO ARMORING
 Depth to armoring,ft                ERR      ERR      ERR


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            256      272      239
   Main channel width, ft            36.6     36.6     36.6
 y1, main channel depth, ft            6.99     7.43     6.53

 Bridge Section
   (Q) total discharge, cfs          1190     1780     950
   (Q) discharge thru bridge, cfs    1063     1159     950
   Main channel conveyance           10548    10548    10548
   Total conveyance                  10548    10548    10548
 Q2, bridge MC discharge,cfs         1063     1159     950
   Main channel area, ft2            139      139      139
   Main channel width (skewed), ft   23.0     23.0     23.0
   Cum. width of piers in MC, ft     0.0      0.0      0.0
 W, adjusted width, ft               23       23       23
 y_bridge (avg. depth at br.), ft    6.04     6.04     6.04
 Dm, median (1.25*D50), ft           0.01825  0.01825  0.01825
 y2, depth in contraction,ft          10.38    11.18     9.43

 ys, scour depth (y2-ybridge), ft    4.34     5.14     3.39

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                       1190     1780     950
 Q, thru bridge, cfs                 1063     1159     950
 Total Conveyance, bridge            10548    10548    10548
 Main channel(MC) conveyance, bridge 10548    10548    10548
 Q, thru bridge MC, cfs              1063     1159     950
 Vc, critical velocity, ft/s         3.79     3.83     3.75
 Vc, critical velocity, m/s          1.15     1.17     1.14
 Main channel width (skewed), ft     23.0     23.0     23.0
 Cum. width of piers in MC, ft       0.0      0.0      0.0
 W, adjusted width, ft               23.0     23.0     23.0
 qbr, unit discharge, ft^2/s         46.2     50.4     41.3
 qbr, unit discharge, m^2/s          4.3      4.7      3.8
 Area of full opening, ft^2          139.0    139.0    139.0
 Hb, depth of full opening, ft       6.04     6.04     6.04
 Hb, depth of full opening, m        1.84     1.84     1.84
 Fr, Froude number, bridge MC        0.55     0.6      0.49
 Cf, Fr correction factor (<=1.0)    1.00     1.00     1.00
```

Elevation of Low Steel, ft	498.16	498.16	498.16
Elevation of Bed, ft	492.12	492.12	492.12
Elevation of Approach, ft	499.58	500.02	499.13
Friction loss, approach, ft	0.04	0.07	0.03
Elevation of WS immediately US, ft	499.54	499.95	499.10
ya, depth immediately US, ft	7.42	7.83	6.98
ya, depth immediately US, m	2.26	2.39	2.13
Mean elevation of deck, ft	499.92	499.92	499.92
w, depth of overflow, ft (>=0)	0.00	0.03	0.00
Cc, vert contrac correction (<=1.0)	0.95	0.94	0.96
Ys, depth of scour, ft	6.80	8.02	5.39

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

y2, from Laursen's equation, ft	10.3838	11.18258	9.430165
Full valley WSEL, ft	496.97	497.64	496.35
Full valley depth, ft	4.853478	5.523478	4.233478
Ys, depth of scour (y2-yfullv), ft	5.530317	5.659101	5.196687

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	1190	1780	950	1190	1780	950
a', abut.length blocking flow, ft	476.0	484.3	467.5	308.9	316.1	301.7
Ae, area of blocked flow ft2	791.0	1004.5	585.2	869.9	1007.0	732.3
Qe, discharge blocked abut.,cfs	--	--	237.1	558.0	816.6	454.4
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	0.45	0.62	0.41	0.64	0.81	0.62
ya, depth of f/p flow, ft	1.66	2.07	1.25	2.82	3.19	2.43
--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	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.062	0.075	0.064	0.067	0.080	0.070
ys, scour depth, ft	8.12	10.37	6.80	10.44	12.36	9.54

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)	476	484.3	467.5	308.9	316.1	301.7
y1 (depth f/p flow, ft)	1.66	2.07	1.25	2.82	3.19	2.43
a'/y1	286.44	233.50	373.47	109.69	99.22	124.30
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.06	0.08	0.06	0.07	0.08	0.07
Ys w/ corr. factor K1/0.55:						
vertical	4.83	6.42	3.67	8.41	10.07	7.35
vertical w/ ww's	3.96	5.26	3.01	6.90	8.26	6.02
spill-through	2.66	3.53	2.02	4.62	5.54	4.04

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	0.55	0.6	0.49	0.55	0.6	0.49
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	6.04	6.04	6.04	6.04	6.04	6.04
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	1.13	1.34	0.90	1.13	1.34	0.90
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR