LEVEL II SCOUR ANALYSIS FOR BRIDGE 13 (IRA-VT01330013) on STATE ROUTE 133, crossing an IRA BROOK TRIBUTARY, IRA, VERMONT

U.S. Geological Survey
Open-File Report 96-749

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

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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 13 (IRA-VT01330013) ON STATE ROUTE 133, CROSSING AN IRA BROOK TRIBUTARY, IRA, 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 IRA-VT01330013 on State Route 133 crossing an Ira Brook Tributary, Ira, 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 Taconic section of the New England physiographic province in west-central Vermont. The 2.88-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 have dense tree cover.

In the study area, this Ira Brook Tributary has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 40 ft and an average channel depth of 7 ft. The predominant channel bed material is cobble with a median grain size (D_{50}) of 71.9 mm (0.236 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 14, 1995, indicated that the reach was stable.

The State Route 133 crossing of this Ira Brook Tributary is a 28-ft-long, two-lane bridge consisting of one 26-foot concrete span (Vermont Agency of Transportation, written communication, March 13, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 20 degrees to the opening while the opening-skew-to-roadway is 5 degrees.

A scour hole, approximately 0.5 ft deeper than the mean thalweg depth, was observed at the downstream end of the left abutment wall during the Level I assessment. The scour protection measures at the site were type-1 stone fill (less than 12 inches diameter) on the upstream left bank and upstream left wingwall and type-2 stone fill (less than 36 inches diameter) on the upstream right bank, upstream right wingwall, the downstream wingwalls and downstream banks. 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.

There was no computed contraction scour for any of the modelled flows. Abutment scour ranged from 3.6 to 4.7 ft. The worst-case abutment scour 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.

West Rutland, VT. Quadrangle, 1:24,000, 1964

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 IRA-VT01330013 ***Stream*** Ira Brook Tributary

County Rutland ***Road*** VT 133 ***District*** 3

Description of Bridge

Bridge length 28 ***ft*** ***Bridge width*** 31.2 ***ft*** ***Max span length*** 26 ***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*** 6/14/95

Description of stone fill Type-1 on the upstream left wingwall and upstream left bank. Type-2 on the remaining wingwalls and banks.

Abutments and wingwalls are concrete. There is a scour hole approximately 0.5 ft deep at the downstream end of the left abutment.

Y 20

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

There is a mild channel bend in the reach. The scour hole has developed in the location where the bend impacts the downstream end of the left abutment.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
	6/14/95	0	0
Level I	6/14/95	0	0
Level II			

Potential for debris Moderate. Trees leaning over the channel upstream and many dead trees on the banks were noted.

Describe any features near or at the bridge that may affect flow (include observation date) None noted on 6/14/95.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with an irregular flood plain and no valley walls.

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

Date of inspection 6/14/95

DS left: Steep channel bank to flood plain.

DS right: Steep channel bank to flood plain

US left: Moderately sloping channel bank to flood plain.

US right: Steep channel bank to flood plain.

Description of the Channel

Average top width 40 ***ft*** ***Average depth*** 7 ***ft***

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

Perennial but flashy and straight with non-alluvial channel boundaries.

6/14/95

Vegetative co Trees.

DS left: Trees

DS right: Trees

US left: Trees.

US right: Y

Do banks appear stable? -

If not, describe location and type of instability and

date of observation.

None evident on 6/14/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 2.88 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England / Taconic	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 -- ***mi***^{2}

Is there a lake/p No

-

-

Calculated Discharges

Q100 700 ***ft***^{3}***/s*** ***Q500*** 950 ***ft***^{3}***/s***

The 100- and 500-year discharges are based on discharge frequency curves computed by use of several empirical equations (Benson, 1962; FHWA, 1983; Johnson and Laraway, unpublished draft, 1972; Johnson and Tasker, 1974; Potter, 1957a&b; and Talbot, 1887) and values available from the VTAOT database (written communication, May, 1995). The 100- and 500-year discharges selected and noted above for this hydraulic analysis are from the VTAOT database due to the central tendency of the VTAOT curve with the others.

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 point of a chiseled "X" on top of the concrete left abutment, downstream end (elev. 500.52 ft, arbitrary survey datum). RM2 is the center point of a chiseled "X" on top of concrete right abutment, upstream end (elev. 501.20 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	-22	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APPRO	48	2	Modelled Approach section (Templated from APTEM)
APTEM	52	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 0.070 to 0.080.

This tributary enters Ira Brook approximately 900 feet downstream. Because of the similar basin characteristics of this tributary and Ira Brook, peak flows could occur simultaneously. If peaks were concurrent, backwater from Ira Brook may influence the hydraulics at this site. However, for this hydraulic analysis, normal depth (no backwater) 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 0.0220 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1964).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0245 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 method also provides a consistent approach for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.2 *ft*
Average low steel elevation 499.0 *ft*

100-year discharge 700 *ft³/s*
Water-surface elevation in bridge opening 495.1 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 94.9 *ft²*
Average velocity in bridge opening 7.4 *ft/s*
Maximum WSPRO tube velocity at bridge 9.5 *ft/s*

Water-surface elevation at Approach section with bridge 495.5
Water-surface elevation at Approach section without bridge 496.4
Amount of backwater caused by bridge 0 *ft*

500-year discharge 950 *ft³/s*
Water-surface elevation in bridge opening 495.5 *ft*
Road overtopping? No *Discharge over road* -- */s*
Area of flow in bridge opening 104 *ft²*
Average velocity in bridge opening 9.1 *ft/s*
Maximum WSPRO tube velocity at bridge 11.6 */s*

Water-surface elevation at Approach section with bridge 496.3
Water-surface elevation at Approach section without bridge 497.2
Amount of backwater caused by bridge 0

Incipient overtopping discharge -- *ft³/s*
Water-surface elevation in bridge opening -- *ft*
Area of flow in bridge opening -- *ft²*
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 -- *t*

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 live-bed contraction scour equation (Richardson and others, 1995, p. 30, equation 17). For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. For this case, the computations resulted in no contraction scour.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	0.0	0.0	--
Clear-water scour	--	--	--
Depth to armoring	1.0	3.7	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	3.6	4.7	--
Right abutment	3.6	4.7	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	1.0	1.6	--
Right abutment	1.0	1.6	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

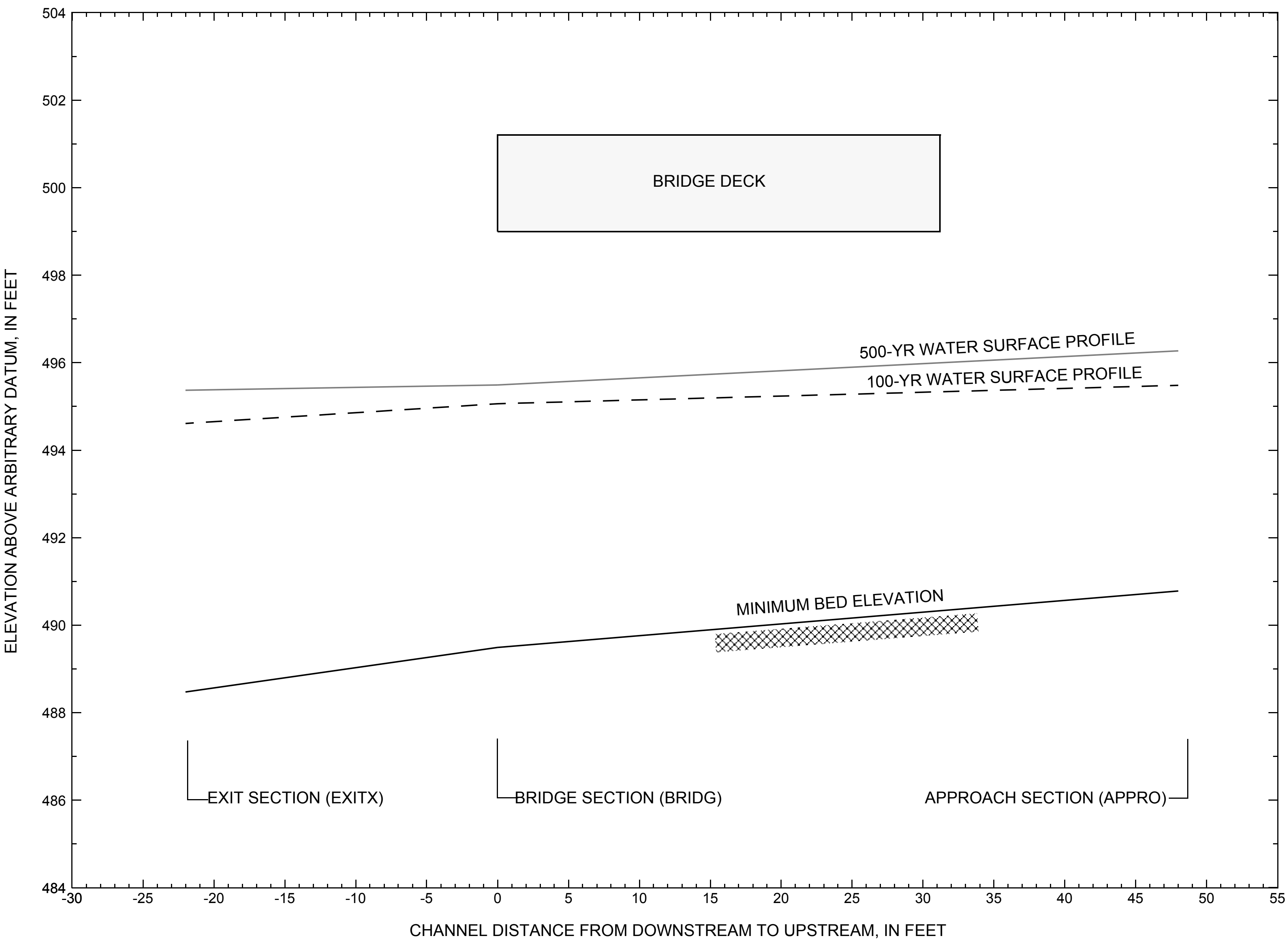


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure IRA-VT01330013 on State Route 133, crossing an Ira Brook Tributary, Ira, Vermont.

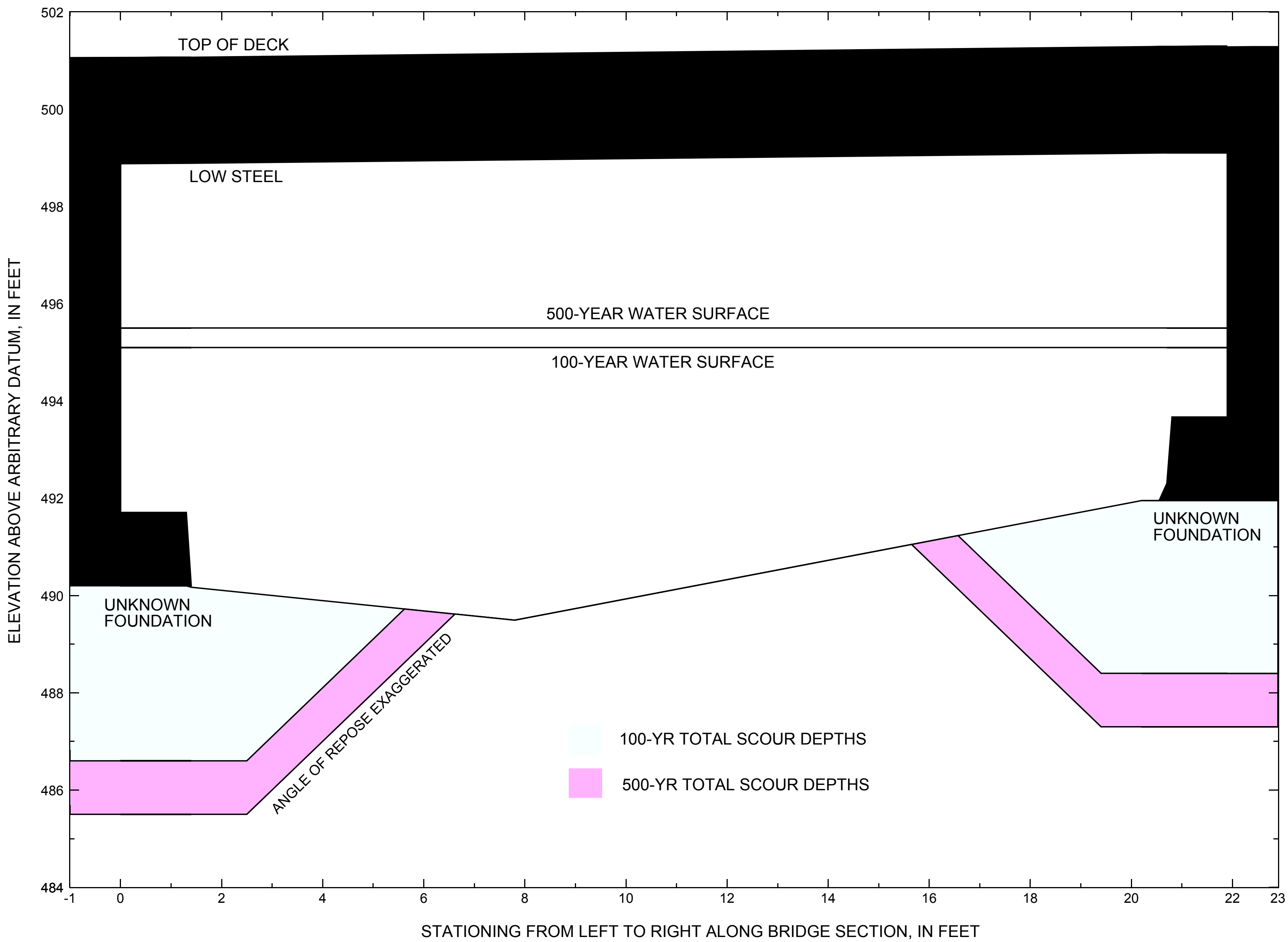


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure IRA-VT01330013 on State Route 133, crossing an Ira Brook Tributary, Ira, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure IRA-VT01330013 on State Route 133, crossing an Ira Brook Tributary, Ira, 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 700 cubic-feet per second											
Left abutment	0.0	--	498.9	--	490.2	0.0	3.6	--	3.6	486.6	--
Right abutment	21.9	--	499.1	--	492.0	0.0	3.6	--	3.6	488.4	--

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 IRA-VT01330013 on State Route 133, crossing an Ira Brook Tributary, Ira, 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 950 cubic-feet per second											
Left abutment	0.0	--	498.9	--	490.2	0.0	4.7	--	4.7	485.5	--
Right abutment	21.9	--	499.1	--	492.0	0.0	4.7	--	4.7	487.3	--

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

SELECTED REFERENCES

Arcement, G.J., Jr., and Schneider, V.R., 1989, Guide for selecting Manning's roughness coefficients for natural channels and flood plains: U.S. Geological Survey Water-Supply Paper 2339, 38 p.

Barnes, H.H., Jr., 1967, Roughness characteristics of natural channels: U.S. Geological Survey Water-Supply Paper 1849, 213 p.

Benson, M. A., 1962, Factors Influencing the Occurrence of Floods in a Humid Region of Diverse Terrain: U.S. Geological Survey Water-Supply Paper 1580-B, 64 p.

Brown, S.A. and Clyde, E.S., 1989, Design of riprap revetment: Federal Highway Administration Hydraulic Engineering Circular No. 11, Publication FHWA-IP-89-016, 156 p.

Federal Highway Administration, 1983, Runoff estimates for small watersheds and development of sound design: Federal Highway Administration Report FHWA-RD-77-158

Froehlich, D.C., 1989, Local scour at bridge abutments *in* Ports, M.A., ed., Hydraulic Engineering--Proceedings of the 1989 National Conference on Hydraulic Engineering: New York, American Society of Civil Engineers, p. 13-18.

Hayes, D.C.,1993, Site selection and collection of bridge-scour data in Delaware, Maryland, and Virginia: U.S. Geological Survey Water-Resources Investigation Report 93-4017, 23 p.

Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency: U.S. Geological Survey, Bulletin 17B of the Hydrology Subcommittee, 190 p.

Johnson, C.G. and Tasker, G.D.,1974, Progress report on flood magnitude and frequency of Vermont streams: U.S. Geological Survey Open-File Report 74-130, 37 p.

Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., Chang, F., 1995, Stream Stability at Highway Structures: Federal Highway Administration Hydraulic Engineering Circular No. 20, Publication FHWA-IP-90-014, 144 p.

Laursen, E.M., 1960, Scour at bridge crossings: Journal of the Hydraulics Division, American Society of Civil Engineers, v. 86, no. HY2, p. 39-53.

Potter, W. D., 1957a, Peak rates of runoff in the Adirondack, White Mountains, and Maine woods area, Bureau of Public Roads

Potter, W. D., 1957b, Peak rates of runoff in the New England Hill and Lowland area, Bureau of Public Roads

Richardson, E.V. and Davis, S.R., 1995, Evaluating scour at bridges: Federal Highway Administration Hydraulic Engineering Circular No. 18, Publication FHWA-IP-90-017, 204 p.

Richardson, E.V., Simons, D.B., and Julien, P.Y., 1990, Highways in the river environment: Federal Highway Administration Publication FHWA-HI-90-016.

Ritter, D.F., 1984, Process Geomorphology: W.C. Brown Co., Debuque, Iowa, 603 p.

Shearman, J.O., 1990, User's manual for WSPRO--a computer model for water surface profile computations: Federal Highway Administration Publication FHWA-IP-89-027, 187 p.

Shearman, J.O., Kirby, W.H., Schneider, V.R., and Flippo, H.N., 1986, Bridge waterways analysis model; research report: Federal Highway Administration Publication FHWA-RD-86-108, 112 p.

Talbot, A.N., 1887, The determination of water-way for bridges and culverts.

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, 1964, West Rutland, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Aerial photographs, 1962, Contour interval, 20 feet, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File ira-013.wsp
T2        Hydraulic analysis for structure IRA-VT01330013   Date: 26-SEP-96
T3        State Route 133 over an Ira Brook Tributary, Ira, VT               EMB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q            700.0    950.0
SK          0.022    0.022
*
XS   EXITX    -22
GR          -79.2, 498.71    -35.0, 498.09    -12.8, 495.96     -2.1, 493.92
GR            0.0, 491.23      7.1, 489.18     10.8, 488.47     14.0, 489.17
GR           17.6, 492.21     31.6, 495.10     43.0, 496.12     61.4, 495.96
GR           82.3, 495.74    101.7, 496.28
*
N           0.080        0.065        0.080
SA                 -12.8         31.6
*
XS   FULLV      0  * * *   0.045
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    498.99       5.0
GR            0.0, 498.88      0.0, 491.72      1.3, 491.71      1.4, 490.17
GR            7.8, 489.49     10.7, 490.07     20.2, 491.95     20.7, 492.28
GR           20.8, 493.67     21.9, 493.67     21.9, 499.11      0.0, 498.88
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      31.7 * *     51.4      4.9
N           0.045
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      31.2     1
GR          -77.9, 499.43      0.0, 501.06     14.7, 501.30    160.0, 503.00
BP          3.6
*           -195.4, 496.51
*
XT   APTEM     52
GR         -125.4, 498.34    -60.3, 498.48    -13.2, 498.52     -7.2, 498.43
GR            7.0, 491.30     11.3, 490.88     16.6, 491.34     21.8, 494.81
GR           28.3, 498.96    104.9, 502.17
*
AS   APPRO     48  *  *  *  0.0245
GT
BP          0.0
N           0.070        0.060        0.070
SA                 -7.2         28.3
*
HP 1 BRIDG 495.06 1 495.06
HP 2 BRIDG 495.06 * *  700
HP 1 APPRO 495.48 1 495.48
HP 2 APPRO 495.48 * *  700
*
HP 1 BRIDG 495.49 1 495.49
HP 2 BRIDG 495.49 * *  950
HP 1 APPRO 496.27 1 496.27
HP 2 APPRO 496.27 * *  950
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File ira-013.wsp
       Hydraulic analysis for structure IRA-VT01330013   Date: 26-SEP-96
       State Route 133 over an Ira Brook Tributary, Ira, VT               EMB
          *** RUN DATE & TIME: 10-18-96  14:24

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1       95      6819     22     30                         1123
  495.06            95      6819     22     30  1.00      0     22     1123

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      495.06     0.0    21.9    94.9    6819.     700.   7.38

X STA.         0.0         2.3         3.4         4.3         5.1         5.9
  A(I)            9.2         5.3         4.7         4.4         4.1
  V(I)           3.80        6.63        7.43        8.00        8.60

X STA.         5.9         6.6         7.3         8.0         8.7         9.4
  A(I)            3.8         3.9         3.8         3.7         3.8
  V(I)           9.13        9.04        9.27        9.48        9.14

X STA.         9.4        10.1        10.9        11.7        12.6        13.5
  A(I)            3.8         3.9         4.0         4.1         4.2
  V(I)           9.29        8.99        8.83        8.54        8.29

X STA.        13.5        14.5        15.7        17.0        18.5        21.9
  A(I)            4.3         4.6         5.0         5.6         8.7
  V(I)           8.08        7.57        6.96        6.22        4.04

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      48.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            2       75      3668     25     27                          740
  495.48            75      3668     25     27  1.00     -1     23      740

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      48.

        WSEL     LEW     REW    AREA        K        Q    VEL
      495.48    -1.5    23.0    74.7    3668.     700.   9.37

X STA.        -1.5         3.7         5.3         6.4         7.2         8.0
  A(I)            6.9         4.7         4.0         3.6         3.4
  V(I)           5.07        7.43        8.64        9.75       10.37

X STA.         8.0         8.7         9.4        10.1        10.8        11.4
  A(I)            3.2         3.2         3.0         3.0         3.0
  V(I)          10.95       11.11       11.78       11.58       11.79

X STA.        11.4        12.0        12.7        13.3        14.0        14.7
  A(I)            2.9         3.0         3.0         3.1         3.1
  V(I)          12.04       11.81       11.59       11.39       11.30

X STA.        14.7        15.4        16.2        17.2        18.5        23.0
  A(I)            3.3         3.4         3.8         4.5         6.7
  V(I)          10.75       10.21        9.16        7.86        5.20
```

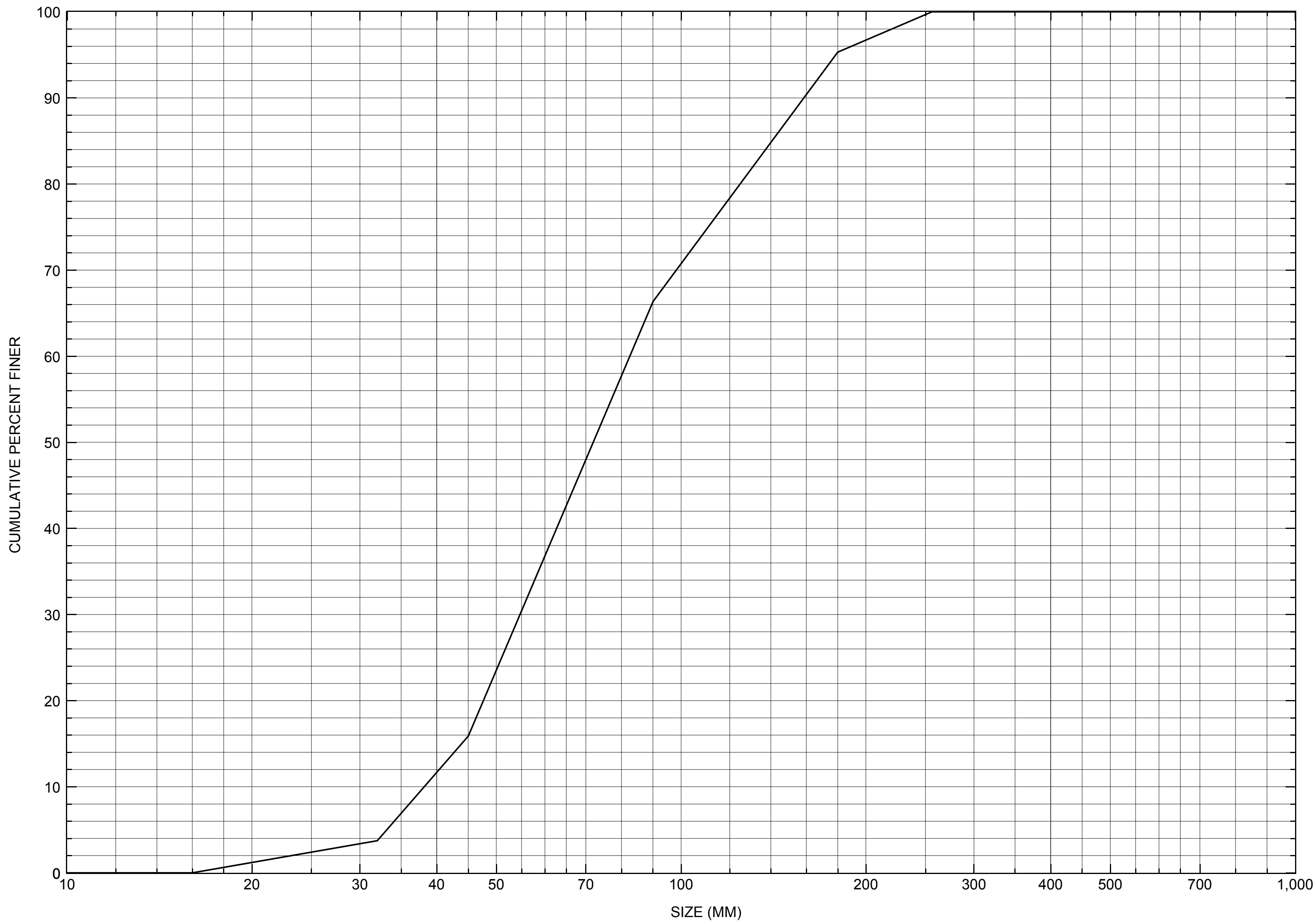
```
        U.S. Geological Survey WSPRO Input File ira-013.wsp
        Hydraulic analysis for structure IRA-VT01330013   Date: 26-SEP-96
        State Route 133 over an Ira Brook Tributary, Ira, VT               EMB
           *** RUN DATE & TIME: 10-18-96  14:24

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      104      7828     22     31                         1293
   495.49           104      7828     22     31  1.00      0     22     1293

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.49     0.0    21.9   104.2    7828.     950.   9.11

X STA.         0.0         2.3         3.4         4.3         5.2         6.0
  A(I)             10.2         6.0         5.2         4.7         4.5
  V(I)             4.66        7.92        9.16       10.11       10.57

X STA.         6.0         6.7         7.4         8.1         8.8         9.5
  A(I)              4.3         4.2         4.2         4.1         4.1
  V(I)            11.03       11.37       11.44       11.56       11.48

X STA.         9.5        10.3        11.1        11.9        12.8        13.7
  A(I)              4.1         4.3         4.4         4.4         4.6
  V(I)            11.48       11.09       10.86       10.91       10.25

X STA.        13.7        14.7        15.9        17.1        18.7        21.9
  A(I)              4.8         5.1         5.4         6.1         9.6
  V(I)             9.96        9.30        8.74        7.78        4.96

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      48.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2       95      5093     27     30                         1008
   496.27            95      5093     27     30  1.00     -2     24     1008

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      48.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.27    -3.1    24.2    95.2    5093.     950.   9.98

X STA.        -3.1         2.9         4.6         5.8         6.8         7.7
  A(I)              8.9         6.0         5.1         4.6         4.3
  V(I)             5.32        7.92        9.25       10.22       11.12

X STA.         7.7         8.5         9.2         9.9        10.6        11.3
  A(I)              4.1         3.8         3.9         3.8         3.7
  V(I)            11.53       12.35       12.31       12.53       12.77

X STA.        11.3        12.0        12.7        13.4        14.1        14.9
  A(I)              3.7         3.7         3.8         3.8         4.0
  V(I)            12.68       12.82       12.38       12.40       11.82

X STA.        14.9        15.7        16.5        17.6        19.1        24.2
  A(I)              4.0         4.4         5.0         5.8         8.6
  V(I)            11.75       10.91        9.54        8.25        5.53
```

```
        U.S. Geological Survey WSPRO Input File ira-013.wsp
        Hydraulic analysis for structure IRA-VT01330013   Date: 26-SEP-96
        State Route 133 over an Ira Brook Tributary, Ira, VT               EMB
           *** RUN DATE & TIME: 10-18-96  14:24

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

EXITX:XS   ******     -5      105  0.69 *****  495.30  493.57     700  494.61
      -21 ******     29     4715  1.00 ***** *******    0.68    6.68

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.83     495.04     494.56

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.11     499.70    0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.11     499.70     494.56

FULLV:FV       22     -2       87  1.00  0.59  496.06  494.56     700  495.06
         0     22     27     3869  1.00  0.15    0.01    0.82    8.01
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       48     -2       99  0.77  1.12  497.20 *******     700  496.43
        48     48     24     5405  1.00  0.00    0.01    0.66    7.04
         <<<<<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       22      0       95  0.85  0.60  495.91  493.88     700  495.06
         0     22     22     6817  1.00  0.01    0.01    0.62    7.38

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  498.99 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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       16     -1       75  1.37  0.59  496.85  495.36     700  495.48
        48     17     23     3669  1.00  0.34   -0.01    0.95    9.37

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.215  0.000    3816.     2.    24.   494.87

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS    -22.    -6.    29.    700.    4715.     105.    6.68  494.61
   FULLV:FV      0.    -3.    27.    700.    3869.      87.    8.01  495.06
   BRIDG:BR      0.     0.    22.    700.    6817.      95.    7.38  495.06
   RDWAY:RG     13.**************      0.******************    1.00********
   APPRO:AS     48.    -2.    23.    700.    3669.      75.    9.37  495.48

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      2.    24.    3816.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF     HO   VHD      EGL    WSEL
   EXITX:XS    493.57    0.68  488.47  498.71************  0.69  495.30  494.61
   FULLV:FV    494.56    0.82  489.46  499.70  0.59  0.15  1.00  496.06  495.06
   BRIDG:BR    493.88    0.62  489.49  499.11  0.60  0.01  0.85  495.91  495.06
   RDWAY:RG  ****************  499.43  503.00**********************************
   APPRO:AS    495.36    0.95  490.78  502.07  0.59  0.34  1.37  496.85  495.48
```

```
       U.S. Geological Survey WSPRO Input File ira-013.wsp
       Hydraulic analysis for structure IRA-VT01330013   Date: 26-SEP-96
       State Route 133 over an Ira Brook Tributary, Ira, VT               EMB
          *** RUN DATE & TIME: 10-18-96  14:24

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

EXITX:XS   ******     -9      134  0.78 *****  496.15  494.39     950  495.37
      -21 ******     35     6399  1.01 ***** *******    0.72    7.07

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.86     495.80     495.38

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.87     499.70    0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.87     499.70     495.38

FULLV:FV       22     -6      112  1.11  0.61  496.92  495.38     950  495.81
         0     22     30     5097  1.00  0.17    0.00    0.86    8.47
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       48     -4      122  0.95  1.20  498.13 *******     950  497.19
        48     48     26     7099  1.00  0.00    0.02    0.69    7.80
         <<<<<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       22      0      104  1.29  0.58  496.78  494.61     950  495.49
         0     22     22     7838  1.00  0.07    0.02    0.73    9.11

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  498.99 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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       16     -2       95  1.55  0.55  497.82  496.11     950  496.27
        48     17     24     5094  1.00  0.47   -0.01    0.94    9.98

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.284  0.000    5380.     2.    24.   495.69

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW      Q        K      AREA     VEL    WSEL
   EXITX:XS     -22.   -10.    35.    950.    6399.     134.    7.07  495.37
   FULLV:FV       0.    -7.    30.    950.    5097.     112.    8.47  495.81
   BRIDG:BR       0.     0.    22.    950.    7838.     104.    9.11  495.49
   RDWAY:RG      13.**************      0.******************    1.00********
   APPRO:AS      48.    -3.    24.    950.    5094.      95.    9.98  496.27

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       2.    24.    5380.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    494.39    0.72  488.47  498.71************  0.78  496.15  495.37
   FULLV:FV    495.38    0.86  489.46  499.70  0.61  0.17  1.11  496.92  495.81
   BRIDG:BR    494.61    0.73  489.49  499.11  0.58  0.07  1.29  496.78  495.49
   RDWAY:RG  ****************  499.43  503.00**********************************
   APPRO:AS    496.11    0.94  490.78  502.07  0.55  0.47  1.55  497.82  496.27
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for one pebble count transect in the channel approach of structure IRA-VT01330013, in Ira, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number IRA-VT01330013

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 13 / 95

Highway District Number *(I - 2; nn)* 03

County *(FIPS county code; I - 3; nnn)* 021

Town *(FIPS place code; I - 4; nnnnn)* 35425

Mile marker *(I - 11; nnn.nnn)* 003120

Waterway *(I - 6)* Ira Brook Tributary

Road Name *(I - 7):* -

Route Number VT133

Vicinity *(I - 9)* 4.8 MI S JCT. VT.4A

Topographic Map West Rutland

Hydrologic Unit Code: 02010002

Latitude *(I - 16; nnnn.n)* 43322

Longitude *(i - 17; nnnnn.n)* 73036

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 200141001311092

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

Maximum span length *(I - 48; nnnn)* 0026

Year built *(I - 27; YYYY)* 1948

Structure length *(I - 49; nnnnnn)* 000028

Average daily traffic, ADT *(I - 29; nnnnnn)* 001420

Deck Width *(I - 52; nn.n)* 3126

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

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

Opening skew to Roadway *(I - 34; nn)* 05

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

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

Underwater Inspection Frequency *(I - 92B; XYY)* 0000

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

Year Reconstructed *(I - 106)* -

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

Clear span (*nnn.n ft*) 7.5

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

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

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

Waterway of full opening (*nnn.n ft²*) The

Comments:

structural inspection of 9/10/93 indicates the structure is a concrete slab type bridge. The right abutment wall is reported having areas of cracking and scaling with leakage. A concrete facing is reported to have been poured at the base of the right abutment and has areas of light to moderate scaling. The right abutment footing is exposed but not undermined. The right wingwalls are reported as having light scaling generally. The left abutment also has areas of minor cracking and scaling. The left footing is exposed and has moderate to heavy concrete scaling noted. There is an area of undermining at the downstream end about 8 feet long, up to 8" deep and penetration reaches 1 foot in places. (Continued, page 31)

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:

The channel is reported to make a slight turn into the structure. There is some minor streambank erosion noted downstream. The wingwalls generally are protected with light stone fill. There is vegetation noted growing on the banks both up- and downstream.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **2.88** mi^2 Lake and pond area **0** mi^2

Watershed storage *(ST)* **0** %

Bridge site elevation **840** ft Headwater elevation **2726** ft

Main channel length **3.489** mi

10% channel length elevation **880** ft 85% channel length elevation **1680** ft

Main channel slope *(S)* **229.29** 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:

***Plans marked TF 30 -1962 only show deck details with no elevations.**

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: CG Date: 01/22/96
Computerized by: CG Date: 01/25/96
Reviewd by: EMB Date: 10/22/96

Structure Number IRA-VT01330013

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* M. Ivanoff Date *(MM/DD/YY)* 6 / 14 / 1995

2. Highway District Number 03 Mile marker 003120

County Rutland (021) Town Ira (35425)

Waterway *(I - 6)* Ira Brook Road Name VT 133

Route Number VT 133 Hydrologic Unit Code: 02010002

3. Descriptive comments:

Located 4.8 mi south from the junction of VT 133 with VT 4A.

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 2 DS 2 *(**1**- pool; **2**- riffle)*

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

7. Bridge length 28.0 *(feet)* Span length 26.0 *(feet)* Bridge width 31.2 *(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 ________ US right ________

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

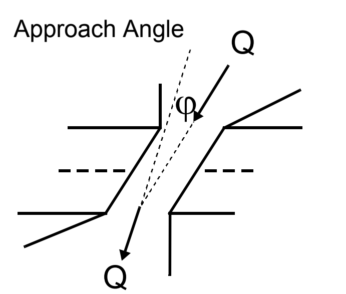
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

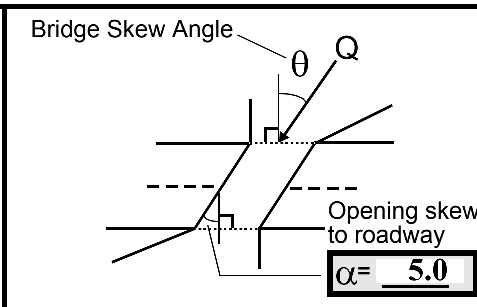
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

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

Channel approach to bridge (BF):

15. Angle of approach: 15 16. Bridge skew: 20





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

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

Range? 12 feet UB *(US, UB, DS)* to 0 feet DS

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

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

Range? - feet - *(US, UB, DS)* to - feet -

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

18. Bridge Type: **1a**

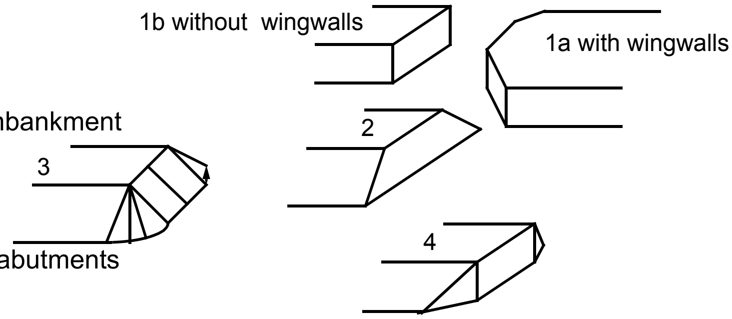
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls 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. Within two bridge lengths the vegetation is pasture with dense tree cover on the immediate banks. Approach overflow width left road approach 23.0 feet, 170 feet from upstream left abutment.

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
24.0	**7.0**			**7.5**	**4**	**4**	**453**	**453**	**0**	**0**

23. Bank width **25.0** 24. Channel width **35.0** 25. Thalweg depth **35.5** 29. Bed Material **453**

30 .Bank protection type: LB **1** 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 consists of cobbles, boulders and gravel.
29. Bed material consists of cobbles, boulders and gravel.
30. Right bank protection "stone fill" extends 20 feet from the bridge.
30. Left bank protection "stone fill" extends 18 feet from the bridge.

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

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
10.0		0.5		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.):

453

63. Bed Material consists of cobbles, boulders and gravel.

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

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

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

70. Debris and Ice Comments:

1

67. There are some trees leaning over channel and some dead trees on the banks.

68. The span is 80% of the bank width skewed to the flow.

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		15	90	2	3	0.5	2.5	90.0
RABUT	1	0	90			2	2	22.0

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

2.0

1

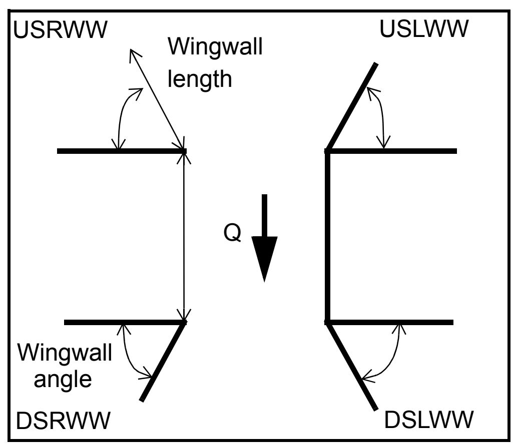
75. For 8 feet from the downstream face, the left abutment is undermined up to 8" deep with about 1 foot of horizontal penetration under the footing.

76. The exposure is measured from the top of the footing to the streambed.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						22.0	
USRWW:	Y		1		2	0.5	
DSLWW:	0		0.4		Y	26.5	
DSRWW:	1		2		0	25.5	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	0.5	2	Y	0	1	1	-	-
Condition	Y	0	1	1.8	1	1	-	-
Extent	1	2.0	2	1	2	0	0	0

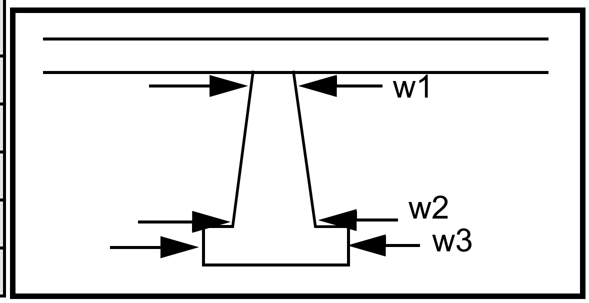
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				**45.0**	**10.0**	**55.0**
Pier 2	**5.0**			**45.0**	**11.0**	**50.0**
Pier 3	**6.0**	**-**	**-**	**-**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**All**	**sure**	**ment**	**-**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**wing**	**dept**	**s.**	**-**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**walls**	**hs of**		**-**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**have**	**foot-**		**-**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**been**	**ings**		**-**	*Y- yes; N- no*
91. Attack ∠ (BF)	**pro-**	**are**		**-**	
92. Pushed	**tecte**	**at**		**-**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**d**	**the**		**-**	
95. Cross-members	**with**	**junc-**		**-**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**stone**	**tions**		**-**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**fill.**	**with**		**-**	
98. Exposure depth	**Expo**	**abut**	**N**	**-**	

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

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? N (*Y or N, if N type ctrl-n ds*) 102. Distance: - feet

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

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

PIERS

106. Point/Side bar present? _____ *(Y or N. if N type ctrl-n pb)* Mid-bar distance: ______ Mid-bar width: ______

Point bar extent: ______ feet **4** (*US, UB, DS*) to **4** feet **453** (*US, UB, DS*) positioned **1** %LB to **453** %RB

Material: **1**

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

2
2
453
2

Is a cut-bank present? **2** *(Y or if N type ctrl-n cb)* Where? **1** *(LB or RB)* Mid-bank distance: **1**

Cut bank extent: **Ban** feet **k** *(US, UB, DS)* to **mate** feet **rial** *(US, UB, DS)*

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

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

sists of cobbles, boulders, gravel and silt/clay.
Bed material consists of cobbles, boulders and gravel.
Bank protection extends 18 feet along both banks from the bridge face.

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

Scour dimensions: Length ______ Width ______ Depth: _____ Positioned ____ %LB to ____ %RB

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

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

Confluence 1: Distance **NO** Enters on **DR** *(LB or RB)* Type **OP** *(**1**- perennial; **2**- ephemeral)*

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

Confluence comments (eg. confluence name):

RE

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)*:

Y
35
4
30
DS
45
DS
0
45
34

109. G. Plan View Sketch

- Si

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: IRA-VT01330013 Town: Ira
Road Number: VT 133 County: Rutland
Stream: Ira Brook Tributary

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	700	950	0
Main Channel Area, ft2	75	95	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	25	27	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.237	0.237	0
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	3.0	3.5	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	3668	5093	0
Conveyance, main channel	3668	5093	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	700.0	950.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	9.3	10.0	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	8.3	8.6	N/A
Vc-l, crit. velocity, LOB, ft/s	N/A	N/A	N/A
Vc-r, crit. velocity, ROB, ft/s	N/A	N/A	N/A

Results

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

Live-Bed Contraction Scour

Laursen's Live Bed Contraction Scour
y2/y1 = (Q2/Q1)^(6/7)*(W1/W2)^(k1)
ys=y2-y_bridge
(Richardson and others, 1995, p. 30, eq. 17 and 18)

Characteristic	Approach 100 yr	500 yr	Other Q	Bridge 100 yr	500 yr	Other Q
Q1, discharge, cfs	700	950	0	700	950	0
Total conveyance	3668	5093	0	6818	7828	0
Main channel conveyance	3668	5093	0	6818	7828	0
Main channel discharge	700	950	ERR	700	950	ERR
Area - main channel, ft2	75	95	0	94.9	104.2	0
(W1) channel width, ft	25	27	0	21.8	21.8	0
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	25	27	0	21.8	21.8	0
D50, ft	0.237	0.237	0.237	<-- D50:	72.2 mm	
w, fall velocity, ft/s (p. 32)	2	2	0			
y, ave. depth flow, ft	3.00	3.52	N/A	4.35	4.78	ERR
S1, slope EGL	0.024	0.025	0			
P, wetted perimeter, MC, ft	27	30	0			
R, hydraulic Radius, ft	2.778	3.167	ERR			
V*, shear velocity, ft/s	1.465	1.597	N/A			
V*/w	0.733	0.798	ERR			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0.64	0.64	0			
y2,depth in contraction, ft	3.27	4.03	ERR			
ys, scour depth, ft (y2-y_bridge)	-1.08	-0.75	N/A			
ARMORING						
D90	0.519	0.519	0			
D95	0.586	0.586	0			
Critical grain size,Dc, ft	0.2561	0.3759	ERR			
Decimal-percent coarser than Dc	0.442	0.234	0			
depth to armoring, ft	0.97	3.69	ERR			

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	700	950	0	700	950	0
a', abut.length blocking flow, ft	1.5	3.1	0	1.2	2.4	0
Ae, area of blocked flow ft2	2	4.6	0	1.8	4.1	0
Qe, discharge blocked abut.,cfs	10.1	24.5	0	9.3	22.4	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	5.05	5.33	ERR	5.17	5.46	ERR
ya, depth of f/p flow, ft	1.33	1.48	ERR	1.50	1.71	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	95	95	95	85	85	85
K2	1.01	1.01	1.01	0.99	0.99	0.99
Fr, froude number f/p flow	0.771	0.771	ERR	0.743	0.737	ERR
ys, scour depth, ft	3.58	4.74	N/A	3.60	4.74	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)	1.5	3.1	0	1.2	2.4	0
y1 (depth f/p flow, ft)	1.33	1.48	ERR	1.50	1.71	ERR
a'/y1	1.13	2.09	ERR	0.80	1.40	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.77	0.77	N/A	0.74	0.74	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.62	0.73	0	0.62	0.73	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	4.35	4.78	0.00	4.35	4.78	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	1.03	1.57	0.00	1.03	1.57	0.00
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR