LEVEL II SCOUR ANALYSIS FOR BRIDGE 25 (CLARTH00100025) on TOWN HIGHWAY 10, crossing the CLARENDON RIVER, CLARENDON, VERMONT

U.S. Geological Survey
Open-File Report 96-636

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

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By JOSEPH D. AYOTTE

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Pembroke, New Hampshire

1996

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

U.S. GEOLOGICAL SURVEY
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CONTENTS

FIGURES

TABLES

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 25 (CLARTH00100025) ON TOWN HIGHWAY 10, CROSSING THE CLARENDON RIVER, CLARENDON, VERMONT

By **Joseph D. Ayotte**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure CLARTH00100025 on town highway 10 crossing the Clarendon River, Clarendon, 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). Resultsof a Level I scour investigation also are included in Appendix E of this report. A Level I study provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Taconic Section of the New England physiographic province in west-central Vermont. The 19.3-mi^2 drainage area is in a predominantly rural basin. In the vicinity of the study site, the left and right banks are covered by pasture and (or) fields. The right bank of Clarendon River is eroded due to stream-flow attack immediately upstream of the bridge.

In the study area, the Clarendon River has a sinuous channel with a slope of approximately 0.007 ft/ft, an average channel top width of 44 ft and an average channel depth of 3 ft. There are large meanders approximately 100 feet upstream and downstream of the bridge. The predominant channel bed materials are gravel and cobbles with a median grain size (D_{50}) of 42.4 mm (0.139 ft). The geomorphic assessment at the time of the Level I and Level II site visit on April 27, 1995, indicated that the reach was laterally unstable.

The town highway 10 crossing of the Clarendon River was a 27-ft-long, two-lane bridge consisting of one 24-foot steel stringer with a timber deck (Vermont Agency of Transportation, written communication, March 13, 1995). The deck was removed at the time of the survey but the analysis was done as if the old deck was in place. The bridge is supported on the left by a vertical stone abutment and on the right by a vertical, concrete abutment with an upstream wingwall. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is 0 degrees.

A scour hole 3 ft deeper than the mean thalweg depth was observed along the right bank extending from 24 to 60 feet upstream of the bridge. No scour prevention measures were observed at this site at the time of the site visit. 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 0.0 to 0.8 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 5.7 to 10.6 ft. The worst-case abutment scour also occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

West Rutland, VT. Quadrangle, 1:24,000, 1964
Photorevised 1972

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 CLARTH00100025 ***Stream*** Clarendon River

County Rutland ***Road*** TH10 ***District*** 3

Description of Bridge

Bridge length 27 ***ft*** ***Bridge width*** 12.2 ***ft*** ***Max span length*** 24 ***ft***

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

Abutment type vertical ***Embankment type*** sloping

Stone fill on abutment? no ***Date of inspection*** 4/27/95

Description of stone fill None

Left abutment is stone. Right abutment is concrete with one wing wall on the upstream right bank

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

Moderate. The skew angle of the stream to the bridge is up to 10 degrees. Opening skew to roadway is 0 degrees and the left abutment is attacked at approx. 15 degrees

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	04/27/95	0	0
Level II	same	-	-

Potential for debris Low, due to lack of woody vegetation upstream of the structure

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

Bank-full flow at this site goes through a strong meander just upstream of the bridge and attacks the right bank at the upstream face of the bridge; flow then attacks the left abutment within the bridge opening.

Description of the Geomorphic Setting

General topography The bridge is in a 2000 ft-wide, flat valley approx. 1000 ft DS of a major constriction. The roadway is the highest land feature in the bridge vicinity.

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

Date of inspection 04/27/95

DS left: mostly flat, wide overbank vegetated with field grasses.

DS right: mostly flat, wide overbank vegetated with field grasses.

US left: mostly flat, wide overbank vegetated with field grasses.

US right: mostly flat, wide overbank vegetated with field grasses.

Description of the Channel

Average top width 44 ***ft*** ***Average depth*** 3 ***ft***

Predominant bed material gravel and cobbles ***Bank material*** sand

sinuous, with large flood plains. It is alluvial and laterally unstable

4/27/95

Vegetative co

DS left: field grasses

DS right: field grasses

US left: field grasses

US right: field grasses

Do banks appear stable? N ***If not, describe location and type of instability and date of observation.***

07/27/95--Banks are reported to be eroded by means of moderate to heavy fluvial processes. The USRB is eroded heavily due to flow impact; the USRB more stable but is eroded in places; the DSLB has moderate fluvial erosion and DSRB has light fluvial erosion.

Describe any obstructions in channel and date of observation.

04/27/95--No large obstructions; a shallow riffle-dam is several feet upstream of bridge face

Hydrology

Drainage area 19.3 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England Province/Taconic Section	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 Yes

There are several major swamp areas in the drainage area. Each is controlled by a natural constriction in the channel. These account for up to 13 percent of the area; areas that are not swamp or lowland are steep uplands, which rise out of the low areas.

1,440

Calculated Discharges

Q100 2,450 ***ft³/s*** ***Q500*** Q100 ***ft³/s***

from DuBois and King report "Evaluation of the Bridge No. 25 on Town Highway #10 Village of Chippenhook, Clarendon, Vermont; Alignment and Bridge Type Study -- approved by VTAOT (DuBois and King, Inc, 1995); Q500 determined by multiplying Q100 by 1.7 (Richardson and others, 1983). These values were considered reasonable compared to values from empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887) which ranged from 335 to > 4000 cfs for the 100-yr flood.

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 N/A

Description of reference marks used to determine USGS datum. RM1 is a spike in a pole at the intersection of TH5 and TH10. The pole is in the DS right-bank corner of the intersection; the arbitrary elevation is 507.910 feet.

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-25	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	6	1	Road Grade section
APPRO	43	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement, Jr. and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.035 to 0.043, and overbank "n" values ranged from 0.032 to 0.033.

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 0.00653 ft/ft which was calculated from water surface points downstream of the bridge.

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

The roadway was overtopped in both the 100- and 500-year models. The incipient roadway overtopping discharge was 556 cfs.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.5 *ft*
Average low steel elevation 497.8 *ft*

100-year discharge 1,440 *ft^3/s*
Water-surface elevation in bridge opening 497.8 *ft*
Road overtopping? Y *Discharge over road* 605 *s*
Area of flow in bridge opening 103 *ft^2*
Average velocity in bridge opening 8.1 *ft/s*
Maximum WSPRO tube velocity at bridge 9.7 *ft/s*

Water-surface elevation at Approach section with bridge 499.8
Water-surface elevation at Approach section without bridge 496.8
Amount of backwater caused by bridge 3.0 *t*

500-year discharge 2,450 *ft^3/s*
Water-surface elevation in bridge opening 497.8 *ft*
Road overtopping? Y *Discharge over road* 1,570
Area of flow in bridge opening 103 *ft^2*
Average velocity in bridge opening 8.7 *ft/s*
Maximum WSPRO tube velocity at bridge 10.4 */s*

Water-surface elevation at Approach section with bridge 500.4
Water-surface elevation at Approach section without bridge 497.3
Amount of backwater caused by bridge 3.1

Incipient overtopping discharge 556 *ft^3/s*
Water-surface elevation in bridge opening 497.8 *ft*
Area of flow in bridge opening 103 *ft^2*
Average velocity in bridge opening 5.3 *ft/s*
Maximum WSPRO tube velocity at bridge 6.5 *ft/s*

Water-surface elevation at Approach section with bridge 498.4
Water-surface elevation at Approach section without bridge 496.2
Amount of backwater caused by bridge 2.2 *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, 1993). 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 (Richardson and others, 1995, p. 32, equation 20) were also computed and can be found in appendix F.

Abutment scour was computed by use of the HIRE equation (Richardson and others, 1993, p. 49, equation 29). Variables for the HIRE 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. The HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.5	0.8	0.0
Depth to armoring	2.7	5.2	0.2
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	8.5	8.5	5.7
Right abutment	8.9	10.6	5.8
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	1.3	1.5	0.6
Right abutment	1.3	1.5	0.6
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

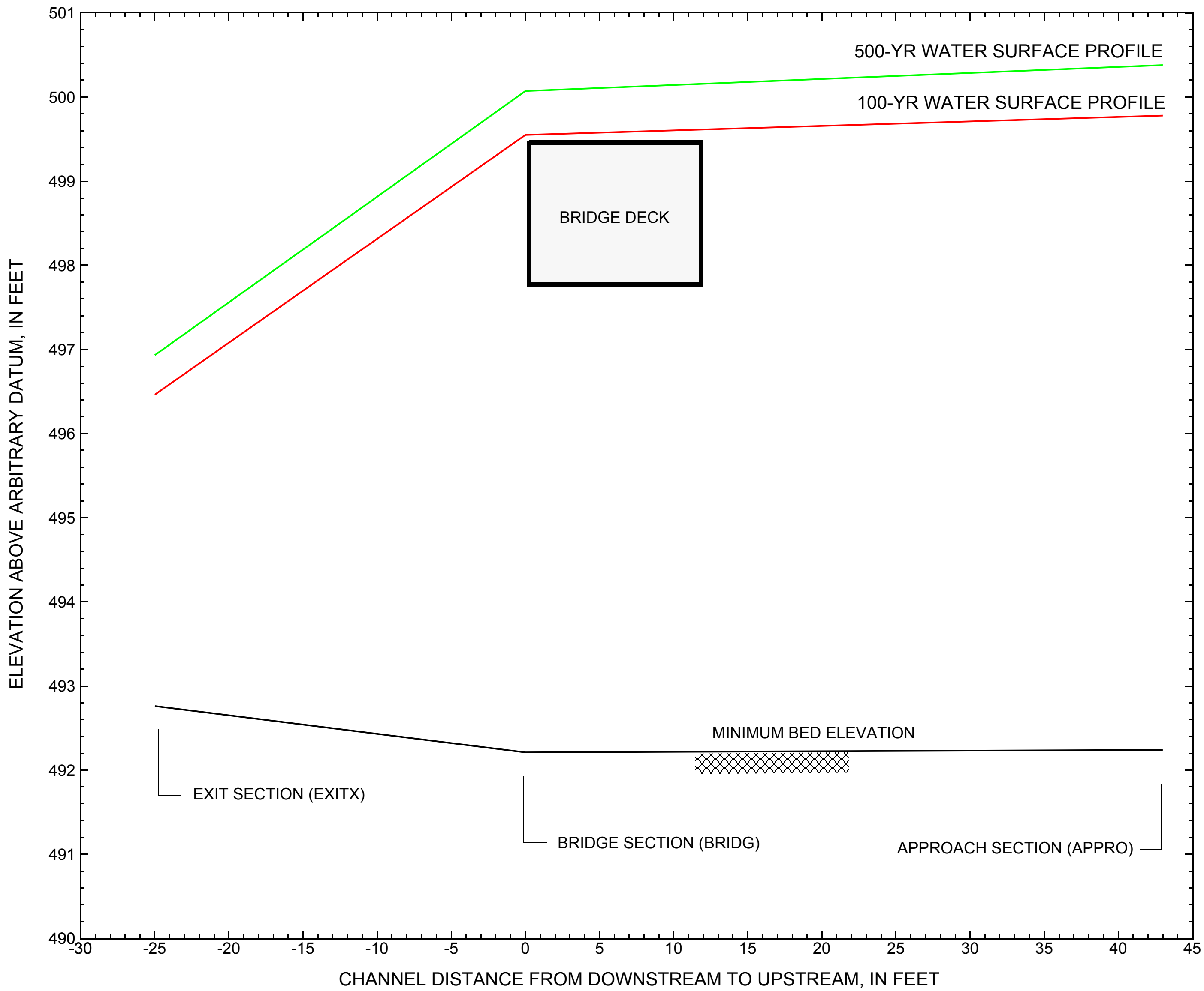

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure CLARTH00100025 on town highway 10, crossing the Clarendon River, Clarendon, Vermont.

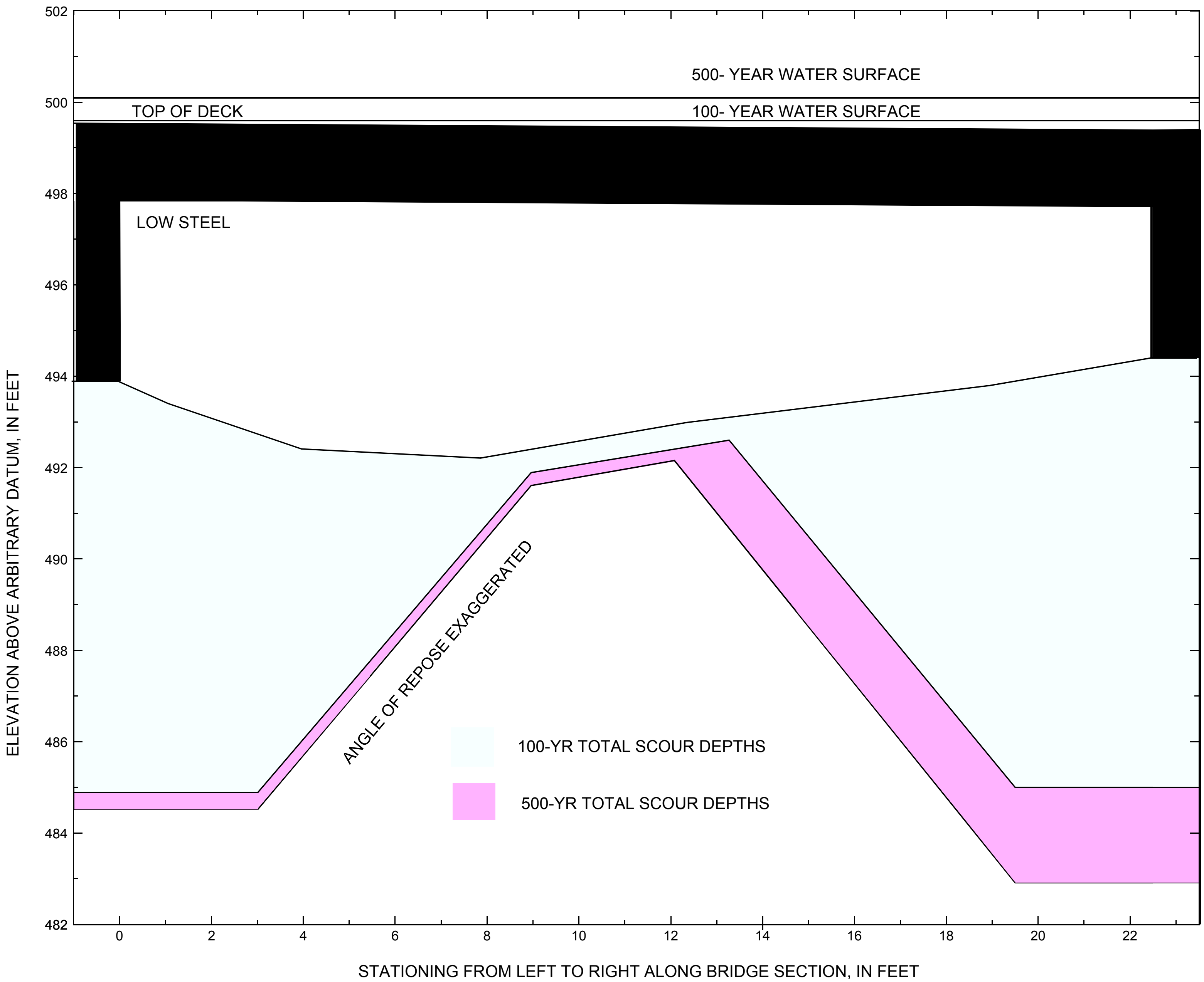

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure CLARTH00100025 on town highway 10, crossing the Clarendon River, Clarendon, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure CLARTH00100025 on Town Highway 10, crossing the Clarendon River, Clarendon, 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 1,440 cubic-feet per second											
Left abutment	-1.1	--	497.8	--	493.9	0.5	8.5	--	9.0	484.9	--
Right abutment	21.4	--	497.7	--	494.4	0.5	8.9	--	9.4	485.0	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure CLARTH00100025 on Town Highway 10, crossing the Clarendon River, Clarendon, 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 2,450 cubic-feet per second											
Left abutment	-1.1	--	497.8	--	493.9	0.8	8.5	--	9.3	484.6	--
Right abutment	21.4	--	497.7	--	494.4	0.8	10.6	--	11.4	483.0	--

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, 1964, West Rutland, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photorevised 1972, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

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T1        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar025.wsp
T2        CREATED ON 17-MAY-95 FOR BRIDGE clarth00010025 USING FILE clar025.dca
T3        bridge clar025, West Rutland, VT quadrangle
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1440      2450       556
SK          0.00653   0.00653   0.00653
*
XS   EXITX    -25
GR         -689.6, 514.03   -632.8, 505.71   -488.8, 504.77   -394.9, 500.65
GR         -372.9, 500.49   -229.9, 499.47   -161.0, 495.51    -28.8, 495.80
GR          -13.4, 495.20     -8.3, 494.95     -5.2, 493.80     -3.9, 493.36
GR            0.0, 492.90      5.3, 492.76     15.2, 493.46     22.1, 493.25
GR           25.2, 493.51     36.8, 496.00    122.3, 495.18    135.8, 496.07
GR          145.5, 500.79    158.3, 506.14
N           0.032        0.043        0.032
SA                  -8.3        36.8
*
XS   FULLV     0
*
BR   BRIDG     0 497.8
GR           -1.1, 497.84     -0.3, 493.89      0.0, 493.40      2.8, 492.41
GR            6.7, 492.21     11.2, 492.99     17.8, 493.80     21.3, 494.40
GR           21.4, 497.70     -1.1, 497.84
N            0.035
CD           2 12 2.3 498.3 * 0.0
*
XR   RDWAY      6      12.2   2
GR         -661.9, 510.77   -584.2, 506.74   -459.0, 504.24   -298.4, 501.85
GR         -188.3, 499.75    -56.9, 498.39     -2.4, 499.53      0.0, 499.53
GR           29.0, 499.53     31.7, 499.39     46.2, 499.13     75.0, 498.83
GR          118.3, 498.70    168.1, 499.95    257.0, 504.95
*
AS   APPRO      43
GR         -597.5, 512.46   -558.2, 507.25   -525.8, 505.19   -429.6, 502.83
GR         -318.6, 501.53   -207.0, 499.76   -162.9, 496.74    -38.2, 496.20
GR            0.0, 495.77      2.2, 495.90      2.3, 494.35      3.7, 493.79
GR            7.9, 493.50     25.6, 492.24     36.0, 492.47     40.3, 492.40
GR           40.7, 494.23     42.1, 495.62     59.6, 495.70    130.3, 495.85
GR          198.1, 497.78    217.5, 498.43    232.4, 504.51
N           0.033        0.043        0.033
SA                   2.2        42.1
*
HP 1 BRIDG    497.84 1 497.84
HP 2 BRIDG    497.84 * * 833
HP 2 RDWAY    499.55 * * 605
HP 1 APPRO    499.78 1 499.78
HP 2 APPRO    499.78 * * 1440
*
HP 1 BRIDG    497.84 1 497.84
HP 2 BRIDG    497.84 * * 897
HP 2 RDWAY    500.07 * * 1572
HP 1 APPRO    500.38 1 500.38
HP 2 APPRO    500.38 * * 2450
*
HP 1 BRIDG    497.84 1 497.84
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar025.wsp
        CREATED ON 17-MAY-95 FOR BRIDGE clarth00010025 USING FILE clar025.dca
        bridge clar025, West Rutland, VT quadrangle
           *** RUN DATE & TIME: 07-11-96  12:20
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     103.    6893.     0.    52.                          0.
   497.84          103.    6893.     0.    52.  1.00    -1.    21.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       497.84    -1.1    21.4   102.8    6893.     833.   8.10
X STA.        -1.1         1.1         2.2         3.2         4.0         4.8
  A(I)             8.2         5.4         5.0         4.6         4.5
  V(I)            5.11        7.69        8.40        9.10        9.17

X STA.         4.8         5.6         6.4         7.2         8.0         8.8
  A(I)             4.4         4.3         4.3         4.4         4.4
  V(I)            9.49        9.68        9.66        9.47        9.43

X STA.         8.8         9.7        10.6        11.6        12.6        13.7
  A(I)             4.5         4.6         4.7         4.9         4.8
  V(I)            9.32        9.04        8.89        8.56        8.61

X STA.        13.7        14.9        16.1        17.5        19.0        21.4
  A(I)             5.1         5.3         5.5         6.0         8.1
  V(I)            8.22        7.86        7.60        6.97        5.16

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       6.
         WSEL     LEW     REW    AREA        K        Q    VEL
       499.55  -169.0   152.2   167.0    5443.     605.   3.62
X STA.      -169.0      -116.0      -100.5       -89.6       -80.7       -73.2
  A(I)            14.5         9.8         8.4         7.7         7.1
  V(I)            2.08        3.09        3.62        3.93        4.23

X STA.       -73.2       -66.8       -60.9       -55.5       -49.5       -42.3
  A(I)             6.6         6.5         6.1         6.4         6.7
  V(I)            4.61        4.68        4.94        4.73        4.51

X STA.       -42.3       -32.1        45.0        63.6        75.6        85.5
  A(I)             7.6        14.4         9.4         7.9         7.4
  V(I)            3.96        2.11        3.23        3.81        4.11

X STA.        85.5        94.9       104.1       112.8       122.2       152.2
  A(I)             7.2         7.3         7.2         7.7        11.3
  V(I)            4.21        4.17        4.20        3.94        2.68

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     634.   59671.   210.   211.                       6243.
             2     275.   32492.    40.    44.                       4091.
             3     591.   59166.   179.   179.                       6099.
   499.78         1500.  151329.   429.   433.  1.02  -208.   221.  15730.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
         WSEL     LEW     REW    AREA        K        Q    VEL
       499.78  -208.3   220.8  1499.6  151329.    1440.   0.96
X STA.      -208.3      -148.6      -121.8       -97.5       -74.4       -53.1
  A(I)           111.3        84.8        79.6        77.8        74.0
  V(I)            0.65        0.85        0.90        0.93        0.97

X STA.       -53.1       -32.3       -13.3         4.3        14.6        23.0
  A(I)            74.2        71.4        73.1        65.4        59.8
  V(I)            0.97        1.01        0.99        1.10        1.20

X STA.        23.0        30.8        39.0        55.0        71.8        88.8
  A(I)            57.9        60.7        72.1        68.3        68.4
  V(I)            1.24        1.19        1.00        1.05        1.05

X STA.        88.8       105.5       123.6       142.7       168.3       220.8
  A(I)            67.0        71.6        73.2        82.0       107.0
  V(I)            1.07        1.01        0.98        0.88        0.67
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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar025.wsp
        CREATED ON 17-MAY-95 FOR BRIDGE clarth00010025 USING FILE clar025.dca
        bridge clar025, West Rutland, VT quadrangle
           *** RUN DATE & TIME: 07-11-96  12:20
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     103.    6893.     0.    52.                          0.
   497.84          103.    6893.     0.    52.  1.00    -1.    21.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       497.84    -1.1    21.4   102.8    6893.     897.   8.72
X STA.        -1.1         1.1         2.2         3.2         4.0         4.8
  A(I)             8.2         5.4         5.0         4.6         4.5
  V(I)            5.50        8.28        9.05        9.80        9.87

X STA.         4.8         5.6         6.4         7.2         8.0         8.8
  A(I)             4.4         4.3         4.3         4.4         4.4
  V(I)           10.22       10.43       10.40       10.19       10.16

X STA.         8.8         9.7        10.6        11.6        12.6        13.7
  A(I)             4.5         4.6         4.7         4.9         4.8
  V(I)           10.03        9.73        9.58        9.21        9.27

X STA.        13.7        14.9        16.1        17.5        19.0        21.4
  A(I)             5.1         5.3         5.5         6.0         8.1
  V(I)            8.85        8.46        8.18        7.50        5.56

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       6.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.07  -205.1   170.2   350.1   15530.    1572.   4.49
X STA.      -205.1      -141.6      -118.5      -102.9       -89.9       -79.1
  A(I)            28.9        21.3        17.4        16.5        15.1
  V(I)            2.72        3.69        4.51        4.75        5.20

X STA.       -79.1       -69.5       -60.8       -52.7       -43.7       -32.1
  A(I)            14.3        14.0        13.3        13.5        14.9
  V(I)            5.49        5.61        5.92        5.82        5.29

X STA.       -32.1       -15.0        36.2        55.3        69.6        81.6
  A(I)            16.8        30.3        17.5        15.9        14.8
  V(I)            4.69        2.59        4.49        4.95        5.32

X STA.        81.6        93.1       104.3       115.6       128.7       170.2
  A(I)            14.7        14.7        15.1        16.7        24.3
  V(I)            5.35        5.36        5.20        4.71        3.24

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     772.   74155.   248.   248.                       7717.
             2     299.   37347.    40.    44.                       4637.
             3     699.   77741.   180.   181.                       7807.
   500.38         1769.  189243.   468.   473.  1.03  -246.   222.  19218.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.38  -246.1   222.3  1768.9  189243.    2450.   1.39
X STA.      -246.1      -148.7      -120.9       -96.4       -73.7       -52.1
  A(I)           158.2       104.6        94.9        90.5        87.8
  V(I)            0.77        1.17        1.29        1.35        1.39

X STA.       -52.1       -31.6       -12.6         5.3        15.9        24.9
  A(I)            85.3        82.8        87.1        74.9        70.4
  V(I)            1.44        1.48        1.41        1.64        1.74

X STA.        24.9        33.5        45.7        61.8        77.9        94.9
  A(I)            69.2        81.3        75.9        75.3        78.3
  V(I)            1.77        1.51        1.61        1.63        1.56

X STA.        94.9       111.9       129.4       148.8       174.5       222.3
  A(I)            77.9        79.9        82.8        93.5       118.1
  V(I)            1.57        1.53        1.48        1.31        1.04
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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar025.wsp
        CREATED ON 17-MAY-95 FOR BRIDGE clarth00010025 USING FILE clar025.dca
        bridge clar025, West Rutland, VT quadrangle
           *** RUN DATE & TIME: 07-11-96  12:20
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     103.    6893.     0.    52.                          0.
   497.84          103.    6893.     0.    52.  1.00    -1.    21.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       497.84    -1.1    21.4   102.8    6893.     556.   5.41
X STA.        -1.1        1.1        2.2        3.2        4.0        4.8
  A(I)             8.2        5.4        5.0        4.6        4.5
  V(I)            3.41       5.13       5.61       6.07       6.12

X STA.         4.8        5.6        6.4        7.2        8.0        8.8
  A(I)             4.4        4.3        4.3        4.4        4.4
  V(I)            6.33       6.46       6.45       6.32       6.30

X STA.         8.8        9.7       10.6       11.6       12.6       13.7
  A(I)             4.5        4.6        4.7        4.9        4.8
  V(I)            6.22       6.03       5.94       5.71       5.75

X STA.        13.7       14.9       16.1       17.5       19.0       21.4
  A(I)             5.1        5.3        5.5        6.0        8.1
  V(I)            5.48       5.24       5.07       4.65       3.44

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     353.   24177.   189.   189.                       2738.
             2     218.   22178.    40.    44.                       2901.
             3     342.   24205.   174.   174.                       2718.
   498.37          913.   70560.   402.   406.  1.10  -187.   216.   7441.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.37  -186.7   215.7   913.0   70560.     556.   0.61
X STA.      -186.7     -134.9     -105.2      -78.0      -54.1      -31.6
  A(I)            66.7       54.0       52.7       48.9       48.5
  V(I)            0.42       0.51       0.53       0.57       0.57

X STA.       -31.6      -12.6        4.4       12.0       18.2       23.7
  A(I)            44.7       47.2       36.9       33.6       32.0
  V(I)            0.62       0.59       0.75       0.83       0.87

X STA.        23.7       28.8       34.1       39.7       55.4       71.4
  A(I)            31.0       31.5       33.2       46.6       42.6
  V(I)            0.90       0.88       0.84       0.60       0.65

X STA.        71.4       87.9      105.1      123.4      145.2      215.7
  A(I)            43.5       44.5       46.7       51.9       76.2
  V(I)            0.64       0.63       0.59       0.54       0.36
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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar025.wsp
        CREATED ON 17-MAY-95 FOR BRIDGE clarth00010025 USING FILE clar025.dca
        bridge clar025, West Rutland, VT quadrangle
           *** RUN DATE & TIME: 07-11-96  12:20

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

EXITX:XS   ******  -178.     350.  0.32 *****  496.78  496.35   1440.  496.46
      -25. ******   137.   17810.  1.21 ***** *******    0.76    4.12

FULLV:FV      25.  -182.     422.  0.20  0.12  496.90 *******   1440.  496.69
        0.    25.   137.   23507.  1.13  0.00   -0.01    0.56    3.41
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.97     496.75     496.76

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   496.19     512.46    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   496.19     512.46     496.76

APPRO:AS      43.  -163.     327.  0.46  0.21  497.22  496.76   1440.  496.76
       43.    43.   162.   18410.  1.52  0.13   -0.01    0.96    4.41
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   504.02       0.00     497.74     498.39

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   497.00     499.76     499.80     497.80

 ===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      25.    -1.     103.  1.02 *****  498.86  496.67    833.  497.84
        0. ******    21.    6893.  1.00 ***** *******    0.67    8.10

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       2. ****   5.  0.491  0.000  497.80 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       6.    31.  0.00  0.01  499.79    0.00    605.  499.55

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    348.   178.  -169.     9.   1.2   0.6   3.7   3.5   0.8   2.8
   RT:    258.   144.     9.   152.   0.9   0.5   3.7   3.7   0.7   2.9

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

APPRO:AS      31.  -208.    1498.  0.01  0.05  499.79  496.76   1440.  499.78
       43.    40.   221.  151079.  1.02  0.17    0.00    0.09    0.96

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

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -25.  -178.   137.   1440.   17810.     350.    4.12  496.46
   FULLV:FV       0.  -182.   137.   1440.   23507.     422.    3.41  496.69
   BRIDG:BR       0.    -1.    21.    833.    6893.     103.    8.10  497.84
   RDWAY:RG       6.*******   348.    605.******************    2.00  499.55
   APPRO:AS      43.  -208.   221.   1440.  151079.    1498.    0.96  499.78

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    496.35    0.76  492.76  514.03************  0.32  496.78  496.46
   FULLV:FV  ********    0.56  492.76  514.03  0.12  0.00  0.20  496.90  496.69
   BRIDG:BR    496.67    0.67  492.21  497.84************  1.02  498.86  497.84
   RDWAY:RG  ****************  498.39  510.77  0.00******  0.01  499.79  499.55
   APPRO:AS    496.76    0.09  492.24  512.46  0.05  0.17  0.01  499.79  499.78
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WSPRO OUTPUT FILE (continued)

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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar025.wsp
        CREATED ON 17-MAY-95 FOR BRIDGE clarth00010025 USING FILE clar025.dca
        bridge clar025, West Rutland, VT quadrangle
           *** RUN DATE & TIME: 07-11-96  12:20

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

EXITX:XS   ******  -186.     499.  0.41 *****  497.34  496.71   2450.  496.93
      -25. ******   138.   30318.  1.08 ***** *******    0.72    4.91

FULLV:FV      25.  -190.     577.  0.30  0.13  497.47 *******   2450.  497.17
        0.    25.   138.   37875.  1.05  0.00    0.00    0.58    4.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.83     497.28     497.20

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   496.67     512.46    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   496.67     512.46     497.20

APPRO:AS      43.  -171.     506.  0.48  0.22  497.77  497.20   2450.  497.29
       43.    43.   181.   31092.  1.32  0.09   -0.01    0.82    4.84
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===230 REJECTED FLOW CLASS 1 SOLUTION.
              WS1,WSSD,WS3 =   512.46       0.00     497.81
                      CRWS =   497.20   ********     497.81
                      YMAX =   512.46   ********     497.84

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   497.56     500.28     500.35     497.80

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

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                   QRD,QRDMAX,RATIO =    1572.      1524.    1.03

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

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

BRIDG:BR      25.    -1.     103.  1.18 *****  499.02  496.85    897.  497.84
        0. ******    21.    6893.  1.00 ***** *******    0.72    8.72

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       2. ****    5.  0.496  0.000  497.80 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       6.    31.  0.01  0.03  500.40    0.01   1572.  500.07

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    900.   214.  -205.     9.   1.7   0.9   5.0   4.5   1.3   2.9
   RT:    672.   161.     9.   170.   1.4   0.9   5.0   4.5   1.3   2.9

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

APPRO:AS      31.  -246.    1767.  0.03  0.09  500.41  497.20   2450.  500.38
       43.    43.   222.  189035.  1.03  0.13    0.01    0.13    1.39

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -25.  -186.   138.   2450.   30318.     499.    4.91  496.93
   FULLV:FV       0.  -190.   138.   2450.   37875.     577.    4.25  497.17
   BRIDG:BR       0.    -1.    21.    897.    6893.     103.    8.72  497.84
   RDWAY:RG       6.*******   900.   1572.******************    2.00  500.07
   APPRO:AS      43.  -246.   222.   2450.  189035.    1767.    1.39  500.38

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX     HF    HO  VHD     EGL    WSEL
   EXITX:XS    496.71    0.72  492.76  514.03************  0.41  497.34  496.93
   FULLV:FV  ********    0.58  492.76  514.03  0.13  0.00  0.30  497.47  497.17
   BRIDG:BR    496.85    0.72  492.21  497.84************  1.18  499.02  497.84
   RDWAY:RG  ****************  498.39  510.77  0.01******  0.03  500.40  500.07
   APPRO:AS    497.20    0.13  492.24  512.46  0.09  0.13  0.03  500.41  500.38
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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar025.wsp
        CREATED ON 17-MAY-95 FOR BRIDGE clarth00010025 USING FILE clar025.dca
        bridge clar025, West Rutland, VT quadrangle
           *** RUN DATE & TIME: 07-11-96  12:20

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

EXITX:XS   ******  -167.     158.  0.30 *****  496.13  495.49    556.  495.84
      -25. ******   132.    6874.  1.54 ***** *******    1.03    3.52

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

FULLV:FV      25.  -172.     241.  0.12  0.10  496.23 *******    556.  496.11
        0.    25.   136.   10729.  1.43  0.00    0.00    0.55    2.31
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      43.   -37.     180.  0.20  0.12  496.39 *******    556.  496.19
       43.    43.   142.   10647.  1.36  0.04    0.00    0.63    3.08
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   498.57       0.00     495.84     498.39

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.82     498.54     498.57     497.80

 ===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      25.    -1.     103.  0.44 *****  498.28  495.80    545.  497.84
        0. ******    21.    6893.  1.00 ***** *******    0.44    5.30

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       2. ****    2.  0.392  0.000  497.80 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       6.        <<<<<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      31.  -187.     914.  0.01  0.02  498.38  494.68    556.  498.37
       43.    36.   216.   70679.  1.10  0.28   -0.02    0.07    0.61

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   498.37

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -25.  -167.   132.    556.    6874.     158.    3.52  495.84
   FULLV:FV       0.  -172.   136.    556.   10729.     241.    2.31  496.11
   BRIDG:BR       0.    -1.    21.    545.    6893.     103.    5.30  497.84
   RDWAY:RG       6.**************       0.*********       0.    2.00********
   APPRO:AS      43.  -187.   216.    556.   70679.     914.    0.61  498.37

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS      FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.49    1.03  492.76  514.03************  0.30  496.13  495.84
   FULLV:FV  ********    0.55  492.76  514.03  0.10  0.00  0.12  496.23  496.11
   BRIDG:BR    495.80    0.44  492.21  497.84************  0.44  498.28  497.84
   RDWAY:RG  ****************  498.39  510.77************  0.01  498.49********
   APPRO:AS    494.68    0.07  492.24  512.46  0.02  0.28  0.01  498.38  498.37
```
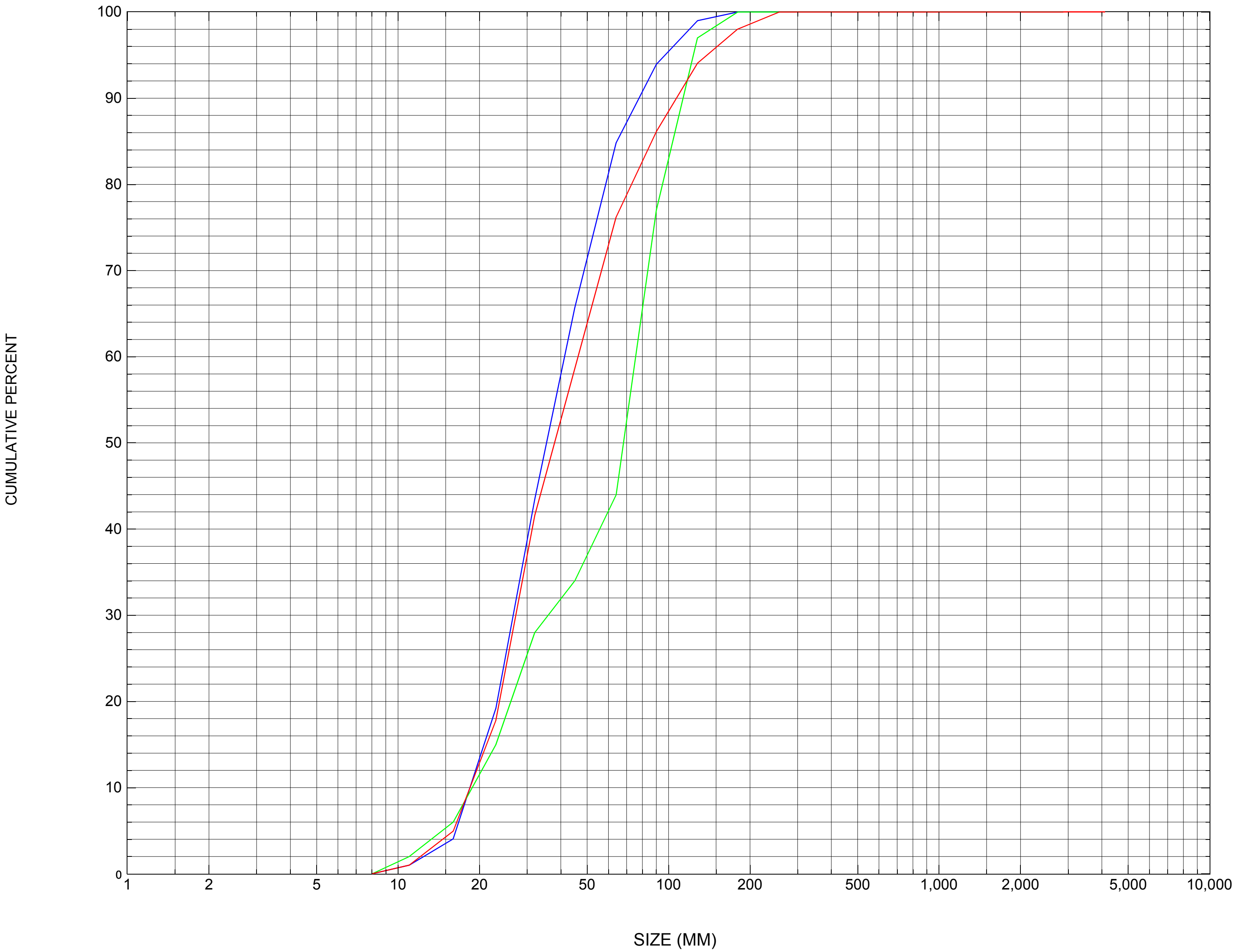

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for three pebble count transects at the approach cross-section for structure CLARTH00100025, in Clarendon, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number CLARTH00100025

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)* 14500

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

Waterway *(I - 6)* CLARENDON RIVER

Road Name *(I - 7):* -

Route Number TH010

Vicinity *(I - 9)* 0.15 MI TO JCT W CL2 TH3

Topographic Map West.Rutland

Hydrologic Unit Code: 02010002

Latitude *(I - 16; nnnn.n)* 43314

Longitude *(i - 17; nnnnn.n)* 73007

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10110500251105

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

Maximum span length *(I - 48; nnnn)* 0024

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

Structure length *(I - 49; nnnnnn)* 000027

Average daily traffic, ADT *(I - 29; nnnnnn)* 000290

Deck Width *(I - 52; nn.n)* 122

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

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)* K

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 4.1

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

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

Comments:

The structural inspection report of 12/8/94 indicates the structure is a steel stringer type bridge with a wood deck. The report indicates this bridge is currently closed to traffic with barricades blocking each end of the bridge. Hence a full substructural description of condition was not performed. This bridge has been closed since July of 1990 roughly as per office memorandum.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} - Q_{25} -
Q_{50} - Q_{100} - Q_{500} -

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

Comments:
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 19.3 mi^2
Lake and pond area 1.26 mi^2
Watershed storage *(ST)* 6.5 %
Bridge site elevation 830 ft
Headwater elevation 1607 ft
Main channel length 12.89 mi
10% channel length elevation 950 ft
85% channel length elevation 1140 ft
Main channel slope *(S)* 19.65 ft / mi

Watershed Precipitation Data

Average site precipitation -- in
Average headwater precipitation -- in
Maximum 2yr-24hr precipitation event *(I24,2)* 5.5 in
Average seasonal snowfall *(Sn)* 5.8 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: **DS** Date: **05/05/95**

Computerized by: **MI** Date: **05/05/95**

Reviewd by: **SAO** Date: **7/11/96**

Structure Number **CLARTH00100025**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M. IVANOFF** Date *(MM/DD/YY)* **04** / **27** / 19**95**

2. Highway District Number **03** Mile marker **0**

County **Rutland (021)** Town **Clarendon (14500)**

Waterway *(I - 6)* **Clarendon River** Road Name **-**

Route Number **TH 10** Hydrologic Unit Code: **02010002**

3. Descriptive comments:

0.15 miles to the junction of TH 3 and TH 1.
Bridge deck and steel stringers were removed prior to the inspection.

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 **27.0** *(feet)* Span length **24.0** *(feet)* Bridge width **12.2** *(feet)*

Road approach to bridge:

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

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

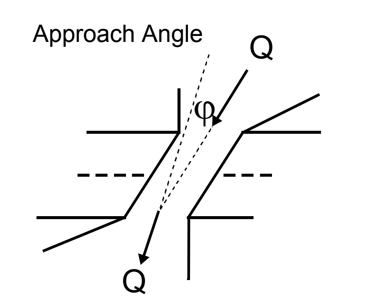
10. Embankment slope (*run / rise in feet / foot*):
US left **2.1:1** US right **2.6:1**

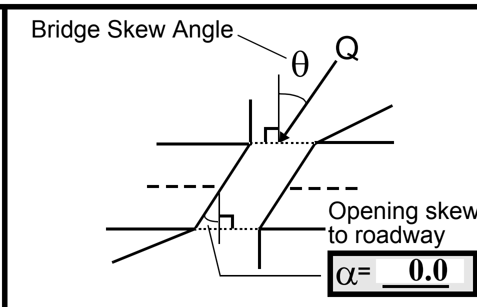
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	0	0	0
RBUS	3	2	1	3
RBDS	0	0	0	0
LBDS	0	0	1	2

*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: **10**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **3**
Range? **42** feet **US** *(US, UB, DS)* to **4** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **6** feet **UB** *(US, UB, DS)* to **32** feet **DS**

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

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

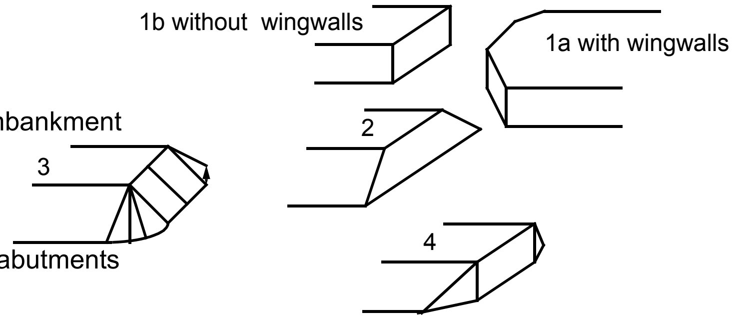
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

7. Measured bridge length: 28.5 feet, span: 24 feet, and width: 15.5. The timber deck was resting on the right road approach.
11. RBUS: protection consists of concrete blocks possibly from an old abutment.
13. LBDS: erosion by an apparent 'eddy' current at the downstream end of the left abutment.
17. Impact zone 1: causing severe erosion to the upstream right bank and road embankment.
18. Impact zone 2: 'eddy' current is also impacting the downstream side of the left road approach embankment.

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
-	**2.0**			**3.0**	**1**	**1**	**321**	**321**	**2**	**3**

23. Bank width **25.0** 24. Channel width **60.0** 25. Thalweg depth **42.0** 29. Bed Material **321**

30 .Bank protection type: LB **0** RB **0** 31. 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*

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

26. Pasture; tall grasses.
27. Coarse gravel material set in a sandy silt clay; fairly cohesive.
29. Fine to coarse gravel in a sandy silt.
Upstream right bank has a minor road drainage entering the stream. The banks are generally low. The channel makes two 90 degree turns just before entering the bridge opening.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **165** 35. Mid-bar width: **11**

36. Point bar extent: **125** feet **US** (US, UB) to **180** feet **US** (US, UB, DS) positioned **40** %LB to **100** %RB

37. Material: **23**

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

37. Medium to fine gravel and some sand. No bars closer to the bridge.

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

41. Mid-bank distance: **26** 42. Cut bank extent: **10** feet **US** (US, UB) to **42** feet **US** (US, UB, DS)

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

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

Numerous locations of block failure. Additional cut-banks are on the right bank 80 to 100 feet upstream and on the left bank 105 to 185 feet upstream; both consist of block failure.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **48**

47. Scour dimensions: Length **36** Width **22** Depth : **3.0** Position **10** %LB to **90** %RB

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

Eddy pool 24 to 60 feet upstream from the bridge.

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
38.5		**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.):

321

63. Medium to coarse gravel imbedded in sand and silty clay.

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

67. No debris accumulation near the bridge. The channel is laterally unstable with cut-banks and few trees or vegetation along the banks.

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

69. The flow angle can increase the ice build up on the right over bank upstream.

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	1	0	0	90.0
RABUT	2	0	90			2	0	22.5

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

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

0

0

1

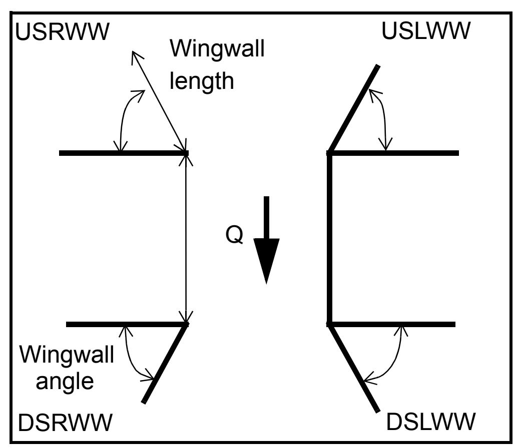
77. LABUT: material consist of cut stone blocks.

74. LABUT: Some of the stone blocks have fallen out of the downstream end of the abutment wall to 6 feet under the bridge. Also the stone below the bridge seat are missing. There is a 2 foot gap (height) between the remaining stones and older concrete.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						18.0	
USRWW:	N		-		-	1.5	
DSLWW:	-		-		Y	13.0	
DSRWW:	1		1		1	11.0	

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



82. **Bank / Bridge Protection**:

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

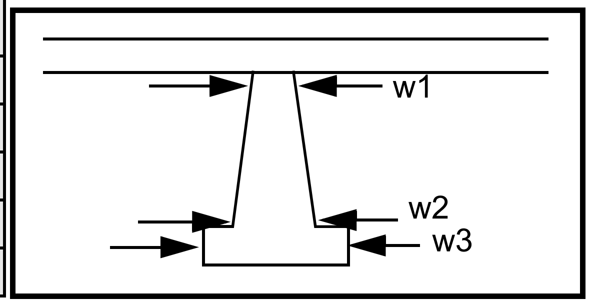
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

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

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	-		9.0	-	80.0	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	USR	of		-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	WW	the		-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	:	wing	N	-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	Scou	wall.	-	-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	r		-	-	*Y- yes; N- no*
91. Attack ∠ (BF)	dept		-	-	
92. Pushed	h is		-	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	at		-	-	
95. Cross-members	the		-	-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	upst		-	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	ream		-	-	
98. Exposure depth	end		-	-	

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.):
-
-
-
-
-
-
NO PIERS

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 *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

105. Drop structure comments (eg. downstream scour depth):
1
321
321
2
1
3214

106. Point/Side bar present? 0 (Y or N. if N type ctrl-n pb) Mid-bar distance: 0 Mid-bar width: -

Point bar extent: - feet Ba (US, UB, DS) to nk feet ma (US, UB, DS) positioned teri %LB to al %RB

Material: con

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

sists of gravels with sand, silt, and clay.
Bed material consists of fine to coarse gravel embedded in sand, silt/ clay with random cobbles.
Uniform channel slope.

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

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

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

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

N

Is channel scour present? - (Y or if N type ctrl-n cs) Mid-scour distance: NO

Scour dimensions: Length DRO Width P Depth: STR Positioned UC %LB to TU %RB

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

RE

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

Confluence 1: Distance Y Enters on 60 (LB or RB) Type 8 (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance 6 Enters on UB (LB or RB) Type 76 (**1**- perennial; **2**- ephemeral)

Confluence comments (eg. confluence name):

DS
50

F. Geomorphic Channel Assessment

107. Stage of reach evolution 80

__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)*:

3

Material is fine to medium gravel with some sand and silt. Apparently eroded by the channel along the right bank; slight anabranching. The bar is slightly vegetated.

Y
LB
32
10
DS
61
DS
3

109. G. Plan View Sketch

- A

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: CLARTH00100025   Town: Clarendon
Road Number: TH10   County: Rutland
Stream: Clarendon River

Initials JDA   Date: 6/13/95   Checked: SAO

I. 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	1440	2450	556
Main Channel Area, ft2	275	299	218
Left overbank area, ft2	634	772	353
Right overbank area, ft2	591	699	342
Top width main channel, ft	40	40	40
Top width L overbank, ft	210	248	189
Top width R overbank, ft	179	180	174
D50 of channel, ft	0.139	0.139	0.139
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.9	7.5	5.5
y1, average depth, LOB, ft	3.0	3.1	1.9
y1, average depth, ROB, ft	3.3	3.9	2.0
Total conveyance, approach	151329	189243	70560
Conveyance, main channel	32492	37347	22178
Conveyance, LOB	59671	74155	24177
Conveyance, ROB	59166	77741	24205
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	309.2	483.5	174.8
Ql, discharge, LOB, cfs	567.8	960.0	190.5
Qr, discharge, ROB, cfs	563.0	1006.5	190.7
Vm, mean velocity MC, ft/s	1.1	1.6	0.8
Vl, mean velocity, LOB, ft/s	0.9	1.2	0.5
Vr, mean velocity, ROB, ft/s	1.0	1.4	0.6
Vc-m, crit. velocity, MC, ft/s	8.0	8.1	7.7
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

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	275	299	218
Main channel width, ft	40	40	40
y1, main channel depth, ft	6.88	7.48	5.45
Bridge Section			
(Q) total discharge, cfs	1440	2450	556
(Q) discharge thru bridge, cfs	833	897	556
Main channel conveyance	6893	6893	6893
Total conveyance	6893	6893	6893
Q2, bridge MC discharge,cfs	833	897	556
Main channel area, ft2	103	103	103
Main channel width (skewed), ft	22.5	22.5	22.5
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	22.5	22.5	22.5
y_bridge (avg. depth at br.), ft	4.58	4.58	4.58
Dm, median (1.25*D50), ft	0.17375	0.17375	0.17375
y2, depth in contraction,ft	4.51	4.81	3.19
ys, scour depth (y2-ybridge), ft	-0.07	0.23	-1.39
ys, scour depth (y2- yfullv), ft	1.05	0.87	0.31

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	833	897	556
Vc, critical velocity, ft/s	8	8.1	7.7
Vc, critical velocity, m/s	2.438281	2.46876	2.346845
Main channel width (skewed), ft	22.5	22.5	22.5
Cum. width of piers, ft	0	0	0
W, adjusted width, ft	22.5	22.5	22.5
qbr, unit discharge, ft^2/s	37.02222	39.86667	24.71111
qbr, unit discharge, m^2/s	3.439141	3.703373	2.295513
Area of full opening, ft^2	102.8	102.8	102.8
Hb, depth of full opening, ft	4.568889	4.568889	4.568889
Hb, depth of full opening, m	1.392529	1.392529	1.392529
Fr, Froude number MC	0.67	0.72	0.44
Cf, Fr correction factor (<=1.0)	1	1	1

Elevation of Low Steel, ft	497.8	497.8	497.8
Elevation of Bed, ft	493.2311	493.2311	493.2311
Elevation of approach WS, ft	499.78	500.38	498.37
HF, bridge to approach, ft	0.05	0.09	0.02
Elevation of WS immediately US, ft	499.73	500.29	498.35
ya, depth immediately US, ft	6.498889	7.058889	5.118889
ya, depth immediately US, m	2.019543	2.193564	1.590705
Mean elev. of deck, ft	499.53	499.53	499.53
w, depth of overflow, ft (>=0)	0.2	0.76	0
Cc, vert contrac correction (<=1.0)	0.918588	0.918588	0.972361
Ys, depth of scour (chang), ft	0.469037	0.78913	-1.26843

ARMORING

D90	0.339	0.339	0.339
D95	0.398	0.398	0.398
Critical grain size,Dc, ft	0.2532	0.2935	0.1128
Decimal-percent coarser than Dc	0.221	0.146	0.592
Depth to armoring,ft	2.68	5.15	0.23

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	1440	2450	556	1440	2450	556
a’, abut.length blocking flow, ft	210.5	248.3	188.9	196.1	197.6	191
Ae, area of blocked flow ft2	543.5	579.3	356.6	646.6	693.9	441.6
Qe, discharge blocked abut.,cfs	--	--	191	--	--	272.6
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	0.89	1.24	0.54	0.98	1.47	0.62
ya, depth of f/p flow, ft	2.58	2.33	1.89	3.30	3.51	2.31
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	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	0.090	0.123	0.069	0.091	0.126	0.072
ys, scour depth, ft	11.53	13.31	7.95	11.54	13.96	8.06

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)	210.5	248.3	188.9	196.1	197.6	191
y1 (depth f/p flow, ft)	2.58	2.33	1.89	3.30	3.51	2.31
a’/y1	81.53	106.43	100.07	59.47	56.27	82.61
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.09	0.12	0.07	0.09	0.13	0.07
Ys w/ corr. factor K1/0.55:						
vertical	8.48	8.50	5.67	10.87	12.89	7.04
vertical w/ ww’s	6.96	6.97	4.65	8.92	10.57	5.77

spill-through	4.67	4.67	3.12	5.98	7.09	3.87

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	0.67	0.72	0.44	0.67	0.72	0.44
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	4.58	4.58	4.58	4.58	4.58	4.58
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.27	1.47	0.55	1.27	1.47	0.55
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr<=0.8 (spillthrough abut.)	1.11	1.28	0.48	1.11	1.28	0.48
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR