LEVEL II SCOUR ANALYSIS FOR BRIDGE 14 (CLARTH00010014) on TOWN HIGHWAY 1, crossing COLD RIVER, CLARENDON, VERMONT

U.S. Geological Survey
Open-File Report 96-389

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

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By SCOTT A. OLSON

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Pembroke, New Hampshire

1996

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 14 (CLARTH00010014) ON TOWN HIGHWAY 1, CROSSING COLD RIVER, CLARENDON, VERMONT

By **Scott A. Olson**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure CLARTH00010014 on town highway 1 crossing the Cold 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). A Level I study is included in Appendix E of this report. A Level I study provides a qualitative geomorphic characterization of the study site. Information on the bridge available from VTAOT files was compiled prior to conducting Level I and Level II analyses and can be found in Appendix D.

The site is in the Taconic Section of the New England physiographic province in west-central Vermont in the town of Clarendon. The 36.2-mi^2 drainage area is in a predominantly rural basin. In the vicinity of the study site, the surface cover is primarily pasture, except for the right bank upstream which is forested.

In the study area, the Cold River has a sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 104 ft and an average channel depth of 3 ft. The predominant channel bed material is cobble with a median grain size (D_{50}) of 103 mm (0.339 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. This assessment was due to the cut-banks and the local anabranching occurring upstream of the bridge.

The town highway 1 crossing of the Cold River is a 80-ft-long, two-lane bridge consisting of one 77-foot span (Vermont Agency of Transportation, written communication, March 13, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The left abutment and upstream wingwalls are protected by type-2 stone fill (less than 36 inches diameter). The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is 15 degrees. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1993). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for modelled flows ranged from 0.0 to 0.6 ft. Abutment scour ranged from 17.4 to 23.3 ft. The worst-case contraction and 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, 1993, p. 48). 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.

Rutland, VT. Quadrangle, 1:24,000, 1966

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 CLARTH00010014 ***Stream*** Cold River

County Rutland ***Road*** TH 1 ***District*** 03

Description of Bridge

Bridge length 80 ***ft*** ***Bridge width*** 19.3 ***ft*** ***Max span length*** 77 ***ft***

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

Abutment type Concrete, vertical ***Embankment type*** sloping

Stone fill on abutment? on left ***Date of inspection*** 04/27/95

Description of stone fill Type-II around upstream wingwalls. Stone fill is in good condition on wing-walls. Some stone fill is also on left abutment. Stone fill extends from the upstream wingwalls to two hundred feet upstream.

Brief description of piers/abutments Toes of abutments protrude into the channel.

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

There is a mild bend to the channel. The skew angle of the stream to the bridge is 10 degrees. Opening skew to roadway is 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	04/27/95	0	0

Potential for debris Moderate due to bridge constricting a relatively wide anabranching channel. Some fallen trees were noted upstream of the bridge site.

Describe any features near or at the bridge that may affect flow (include observation date) On 04/27/95 anabranching was noted in the immediate approach.

Description of the Geomorphic Setting

General topography Moderate relief valley with a narrow flood plain. Just downstream of the site, Cold River changes from a 0.02 gradient to the flood plain of Otter Creek.

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

Date of inspection 04/27/95

DS left: flood plain

DS right: high bank to flat-topped land surface

US left: flood plain

US right: high bank to flat-topped land surface

Description of the Channel

Average top width 104 ***ft*** ***Average depth*** 3 ***ft***

Predominant bed material cobble ***Bank material*** cobble & gravel

Boundaries are alluvial. Channel is sinuous and anabranching occurs upstream of the bridge.

04/27/95

Vegetative co Pasture

DS left: Pasture

DS right: Pasture

US left: Forest

US right: N

Do banks appear stable? 04/27/95--Upstream of the bridge the channel has anabranched. Banks are reported to be steep and eroded and cut-banks exist both up- and downstream. However, both upstream banks are well protected with stone fill from the upstream bridge face to beyond 200 feet upstream.

If not, describe location and type of instability and date of observation.

4/27/95--None

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 36.2 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province	***Percent of drainage area***
New England	100

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

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p -- No

Calculated Discharges

Q100 5,590 ***ft³/s*** ***Q500*** 9,500 ***ft³/s***

Final Q100 based upon the design Q100 from Vermont Agency of Transportation files of a bridge just upstream with a drainage area of 35.4 square miles (Vermont Agency of Transportation, written commun., March 13, 1995). Q500 determined by multiplying Q100 by 1.7 (Richardson and others, 1983)

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. RM2 is a spike in the base of a 20 inch diameter tree 100 feet north of the right bank of Cold River and on west side of town highway 1 about level with the road surface. Arbitrary survey elevation is 502.18 feet

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	Section Reference Distance (SRD) in feet	[2]Cross-section development	Comments
RREX	-860	2	Railroad bridge exit section (templated from RRTEM)
RRFV	-799	2	Railroad bridge full valley section (templated from RRTEM)
RRBRI	-799	1	Railroad bridge section
RRRDW	-791	1	Railroad grade section
RRAPP/RRTEM	-726	1	Railroad bridge approach section and template for RREX and RRFV
XS1	-600	2	Templated from RRAPP
XS2	-400	2	Templated from EXITX
XS3	-200	2	Templated from EXITX
EXITX/SURVX	-136	1	Exit section and template for XS2, XS3, and FULLV
FV	0	2	Full valley section (templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	14	1	Roadway section
APPR	111	1	Approach section
APPR2	174	1	Additional upstream 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 analysis reported herein reflects 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. A railroad bridge about 800 feet downstream of the site was included in the model. It was determined that backwater from the railroad bridge did not affect the hydraulics of the study bridge. 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 0.050 to 0.060, and overbank "n" values ranged from 0.045 to 0.060.

Normal depth at the exit section of the railroad bridge (RREX) 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 0.014 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1966).

For the 500-year discharge, WSPRO assumes critical depth at sections XS3 and EXITX in subcritical model runs. Further analysis showed that localized supercritical flow could occur between the two bridges. However, because the flow regime was not stable in this reach the default to critical was allowed.

Other assumptions also had to be made. Due to the topography of the reach, flow that overtops the roadway does not actually return to the modelled exit section. However, it is necessary to assume that the flow does return to the exit when modelling with WSPRO. In addition, once the left approach overbank is overtopped, the gradient of the overbank would carry flow *away* from the main channel. To compensate for this, a vertical wall was assumed at the left end of the approach section. Since, all the roadway overflow occurs left of the structure, this wall was placed so that the conveyance weighted left overbank flow was roughly equal to the roadway overflow. None of these assumptions were necessary in the incipient overbank model, thus it is likely the most reliable of the three models.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.2 *ft*
Average low steel elevation 497.15 *ft*

100-year discharge 5,590 *ft³/s*
Water-surface elevation in bridge opening 493.1 *ft*
Road overtopping? yes *Discharge over road* 646 *s*
Area of flow in bridge opening 414 *ft²*
Average velocity in bridge opening 12.0 *ft/s*
Maximum WSPRO tube velocity at bridge 14.7 *ft/s*

Water-surface elevation at Approach section with bridge 496.3
Water-surface elevation at Approach section without bridge 494.7
Amount of backwater caused by bridge 1.6 *t*

500-year discharge 9,500 *ft³/s*
Water-surface elevation in bridge opening 497.2 *ft*
Road overtopping? yes *Discharge over road* 3,125 */s*
Area of flow in bridge opening 706 *ft²*
Average velocity in bridge opening 9.0 *ft/s*
Maximum WSPRO tube velocity at bridge 10.6 */s*

Water-surface elevation at Approach section with bridge 499.2
Water-surface elevation at Approach section without bridge 496.4
Amount of backwater caused by bridge 2.8

Incipient overtopping discharge 4,310 *ft³/s*
Water-surface elevation in bridge opening 492.2 *ft*
Area of flow in bridge opening 353 *ft²*
Average velocity in bridge opening 12.2 *ft/s*
Maximum WSPRO tube velocity at bridge 15.2 *ft/s*

Water-surface elevation at Approach section with bridge 495.8
Water-surface elevation at Approach section without bridge 493.8
Amount of backwater caused by bridge 2.0 *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 clear-water contraction scour equation (Richardson and others, 1993, p. 35, equation 18) for the 100-year and incipient road-overflow discharges. 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. The 500-year discharge resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1995). Therefore, contraction scour for the 500-year discharge was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The results of Laursen's clear-water contraction scour for the 500-year event were also computed and can be found in appendix F.

Abutment scour at all modelled discharges was computed by use of the Froehlich equation (Richardson and others, 1993, p. 49, equation 24). The Froehlich equation gives "excessively conservative estimates of scour depths" (Richardson and others, 1993, p. 48). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the depth of flow approaching the embankment less any roadway overtopping, and the length of the embankment blocking flow. At this site the approach is gradually constricted by the natural channel boundaries near the upstream face and the length of abutment blocking flow is difficult to define. Therefore the a' derived from the approach data is probably inaccurate. Abutment scour was largest during the 500-year discharge.

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	0.4	0.0	0.6
Depth to armoring	13.1	1.3	18.7
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	19.7	23.3	17.4
Right abutment	19.7	21.8	18.5
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Rock Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	2.4	1.7	2.0
Right abutment	2.4	1.7	2.0
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

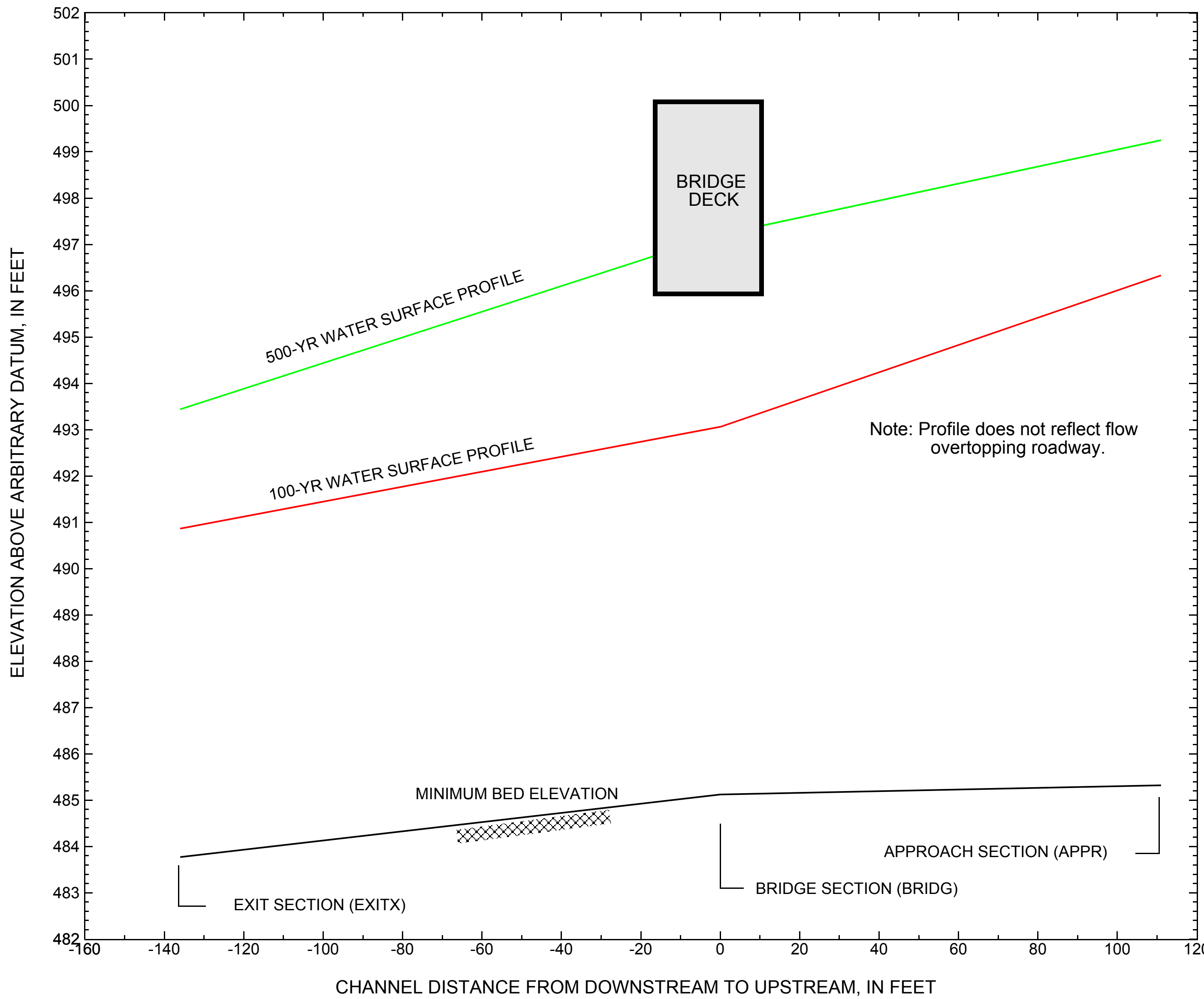

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure CLARTH00010014 on town highway 1, crossing Cold River, Clarendon, Vermont.

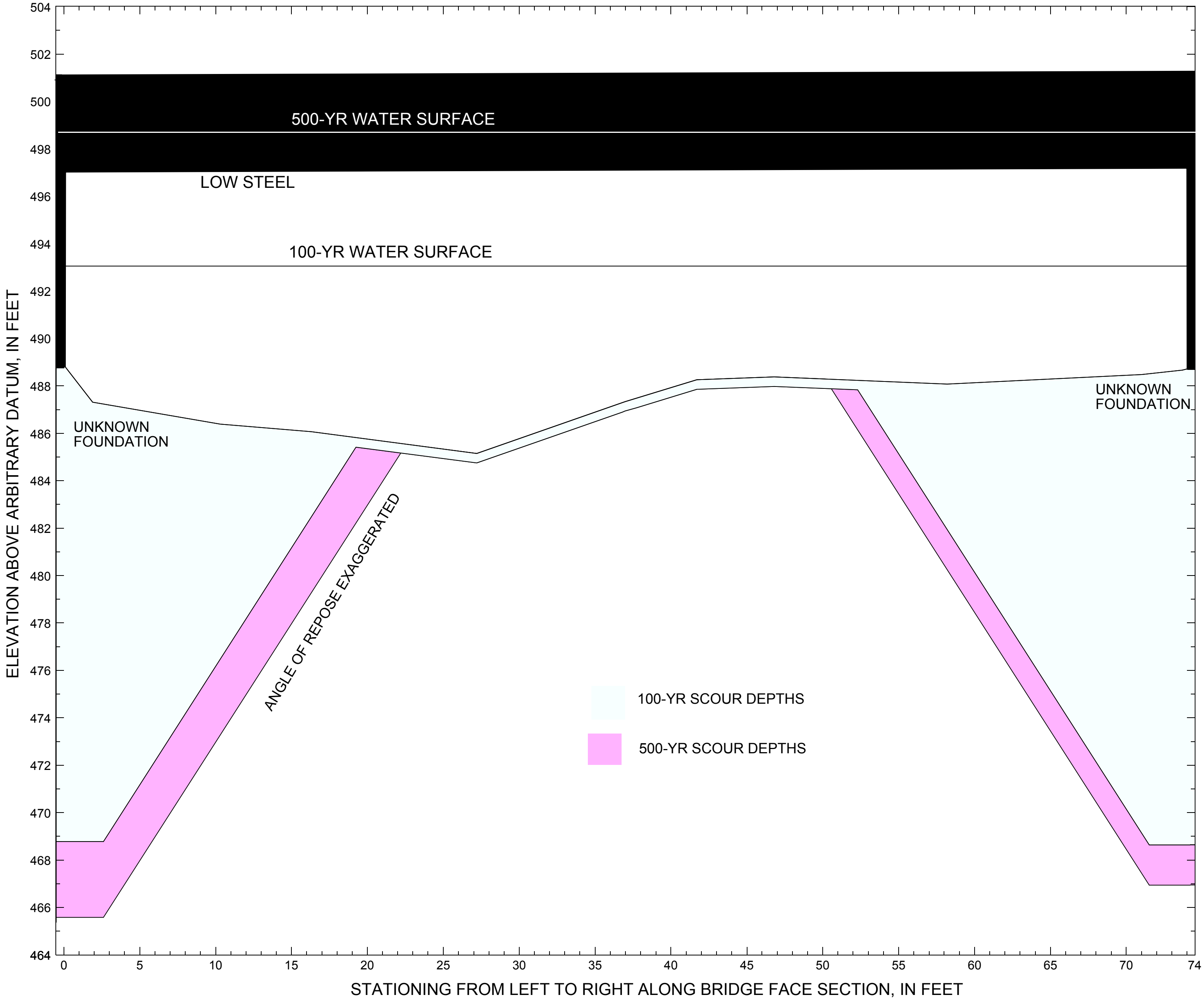

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure CLARTH00010014 on town highway 1, crossing Cold River, Clarendon, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure CLARTH00010014 on Town Highway 1, crossing Cold 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 5,590 cubic-feet per second											
Left abutment	0.0	--	497.1	--	488.9	0.4	19.7	--	20.1	468.8	--
Right abutment	74	--	497.2	--	488.7	0.4	19.7	--	20.1	468.6	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure CLARTH00010014 on Town Highway 1, crossing Cold 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 9,500 cubic-feet per second											
Left abutment	0.0	--	497.1	--	488.9	0.0	23.3	--	23.3	465.6	--
Right abutment	74	--	497.2	--	488.7	0.0	21.8	--	21.8	466.9	--

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.

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.

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., Richardson, J.R., Chang, F., 1991, Stream Stability at Highway Structures: Federal Highway Administration Hydraulic Engineering Circular No. 20, Publication FHWA-IP-90-014, 195 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.

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., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges: Federal Highway Administration Hydraulic Engineering Circular No. 18, Publication FHWA-IP-90-017, 131 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.

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, 1966, Rutland, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1          U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar014.wsp
T2          CREATED ON 19-JUN-95 FOR BRIDGE CLARTH00010014
T3          HYDRAULIC ANALYSIS OF CLAR014 OVER THE COLD RIVER IN CLARENDON, VT
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*            Q100,Q500,incipient overflow Q
Q            5590 9500 4310
SK           0.014 0.014 0.014
*
*            In this model there is road overflow. The road overflow was limited
*            by cutting off the flood plain with a vertical wall in an
*            appropriate location. Note that the amount of road overflow in each
*            model run is nearly equal to the conveyance weighted discharge on
*            the left overbank of the approach. This is appropriate since the only
*            discharge that can cross the road is the is the discharge that goes
*            over the left bank of the approach.
*
*            The incipient overflow discharge of 4310 was found by trial and
*            error. Flow which overtops the left overbank is not likely to return
*            to the river before the exit section. Thus, this discharge may be
*            more realistic than the Q100 or the Q500 model.

*            Section RRTEM is the actual approach surveyed for the
*            railroad bridge. It is being used as a template for the
*            exit, full valley, approach (for the Railroad bridge)
             and a section at SRD=-600.
*            The template section was propagated based on a slope of
*            0.014, which was measured from the topo map.
*
XT   RRTEM     -726
GR          -150., 500       -150., 484
GR           -84., 483.84     -42., 482.26     -26., 485.36     -14., 485.45
GR             0., 483.43      10., 476.59      19., 474.99      32., 473.13
GR            38., 473.40      51., 474.78      69., 476.41      85., 475.29
GR            93., 476.63     100., 480.49     110., 479.85     148., 483.49
GR           200., 484        200., 500
*
XS   RREX      -860
GT             -1.88
N             0.050 0.050 0.050
SA            0      100
*
XS   RRFV      -799
GT             -1.02
N             0.050 0.050 0.050
SA            0      100
*
*             RRBRI is the railroad bridge downstream of site CLAR014
*
BR   RRBRI     -799 483.39
GR             0., 483.39       0., 481.16       1., 475.80       3., 475.80
GR             7., 474.40      21., 473.20      34., 473.14      51., 474.27
```

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GR              74., 474.90      79., 475.66      99., 477.69      99., 483.39
GR               0., 483.39
N                0.05
CD              1 15
*
XR   RRRDW       -791 15 2
GR             -52., 485.44       0., 485.71       0., 491.69     108., 492.06
GR             108., 485.65     140., 485.50
BP              0
AS   RRAPP       -726
GT               0
N               0.050 0.050 0.050
SA              0      100
BP              10
*
XS   XS1        -600
GT              1.76
N              0.045 0.055  0.050
SA              0    100
*
XT   SURVX    -136
GR            -210., 500
GR            -210., 492.48    -74.3, 492.48    -29.6, 490.69      0.0, 488.54
GR              6.8, 485.47     13.1, 484.86     30.4, 484.92     43.7, 484.18
GR             51.4, 484.02     60.7, 483.77     69.1, 485.36     79.5, 485.73
GR             83.7, 487.47     97.0, 500.77    106.3, 502.75    123.2, 502.06
*
XS   XS2       -400
GT             -5.28
N              0.045 0.060
SA              0
*
XS   XS3       -200
GT             -1.28
N              0.045 0.060
SA              0
*
XS   EXITX    -136
GT             0
N              0.045        0.060
SA                      0.
*
XS   FULLV      0
GT              1.22
N              0.045        0.060
SA                      0.
*                                 The following bridge section is CLAR014
BR   BRIDG    0 497.15 15.0
GR              0.0, 497.09      0.0, 488.88      1.9, 487.31     10.3, 486.39
GR             16.3, 486.07     27.2, 485.15     36.8, 487.30     41.7, 488.26
GR             46.8, 488.38     58.2, 488.08     71.0, 488.48     73.7, 488.67
GR             74.1, 496.74     74.1, 497.21      0.0, 497.09
N              0.050
```

```
*             In the incipient overflow model the APPR section ended at the left
*             bank high point: -100.1,495.77. Points left of this station were not
*             considered as it was assumed that the channel would contain the flow.
*
AS   APPR     111
GR          -235., 500       -235., 494.9    -137.8, 494.81
GR         -100.1, 495.77    -60.3, 494.77    -23.8, 495.06
GR          -16.2, 493.54     -6.6, 490.29     -2.7, 488.10      0.0, 486.03
GR            2.6, 485.32      7.3, 487.31     17.0, 488.05     26.7, 488.95
GR           31.7, 490.12     51.9, 490.52     76.6, 489.58     92.0, 488.94
GR          100.9, 488.34    114.7, 489.12    121.2, 491.45    134.3, 496.77
GR          151.8, 499.90    178.2, 500.97    210.1, 502.98
N            0.045        0.060        0.045
SA                -23.8          134.3
BP              0
*
*             In the incipient overflow model the APPR2 section ended at the high
*             point on the top of the left bank: -24, 496.30
*
XS   APPR2          174.
GR          -212., 500       -212., 496.13    -201., 494.43
GR          -184., 494.17    -175., 492.81    -153., 494.42    -120., 494.37
GR           -89., 493.98     -81., 496.25     -59., 495.64     -24., 496.30
GR           -19., 495.75      -4., 495.93       0., 494.89      14., 489.85
GR            18., 488.42      28., 489.27      43., 488.89      51., 490.11
GR            96., 490.69     116., 490.12     135., 489.18     141., 488.38
GR           143., 488.55     162., 497.78     179., 500.57
N            0.050       0.060    0.060
SA                 0          162
*
HP 1 BRIDG   493.06 1 493.06
HP 2 BRIDG   493.06 * * 4944
HP 2 RDWAY   495.87 * * 646
HP 1 APPR    496.33 1 496.33
HP 2 APPR    496.33 * * 5590
*
HP 1 BRIDG   497.21 1 497.21
HP 2 BRIDG   497.21 * * 6369
HP 2 RDWAY   498.38 * * 3125
HP 1 APPR    499.25 1 499.25
HP 2 APPR    499.25 * * 9500
*

HP 1 BRIDG   492.21 1 492.21
HP 2 BRIDG   492.21 * * 4310
HP 1 APPR    495.76 1 495.76
HP 2 APPR    495.76 * * 4310
*
EX
ER
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APPENDIX B:

WSPRO OUTPUT FILE

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         U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar014.wsp
         CREATED ON 19-JUN-95 FOR BRIDGE CLARTH00010014
         HYDRAULIC ANALYSIS OF CLAR014 OVER THE COLD RIVER IN CLARENDON, VT
          *** RUN DATE & TIME: 06-21-95  15:19
   CROSS-SECTION PROPERTIES:  ISEQ = 11;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     414.   36619.    71.    81.                       5650.
  493.06          414.   36619.    71.    81.  1.00     0.    74.   5650.

   VELOCITY DISTRIBUTION:  ISEQ = 11;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
      493.06     0.0    73.9   413.7   36619.    4944.  11.95
X STA.         0.0         5.6         9.0        12.0        14.7        17.3
 A(I)             30.2        20.8        19.2        18.1        17.8
 V(I)             8.19       11.88       12.86       13.65       13.87
X STA.        17.3        19.9        22.2        24.5        26.8        29.1
 A(I)             17.5        17.0        16.9        17.1        17.0
 V(I)            14.11       14.56       14.66       14.47       14.56
X STA.        29.1        31.6        34.6        38.1        42.5        47.3
 A(I)             17.6        18.8        19.9        21.6        22.1
 V(I)            14.04       13.13       12.39       11.44       11.17
X STA.        47.3        52.2        56.9        61.6        66.7        73.9
 A(I)             22.4        22.0        22.4        23.8        31.3
 V(I)            11.02       11.22       11.04       10.37        7.90

   VELOCITY DISTRIBUTION:  ISEQ = 12;  SECID = RDWAY;  SRD =      14.
        WSEL     LEW     REW    AREA        K        Q    VEL
      495.87  -210.0  -134.2   111.0    4638.     646.   5.82
X STA.      -210.0      -207.4      -205.5      -203.7      -201.8      -199.8
 A(I)              6.0         4.6         4.2         4.3         4.3
 V(I)             5.35        7.07        7.76        7.54        7.48
X STA.      -199.8      -197.9      -195.9      -193.8      -191.7      -189.5
 A(I)              4.3         4.3         4.5         4.6         4.7
 V(I)             7.47        7.45        7.21        7.00        6.88
X STA.      -189.5      -187.1      -184.7      -182.1      -179.3      -176.3
 A(I)              4.8         5.0         5.1         5.4         5.5
 V(I)             6.76        6.50        6.35        5.99        5.86
X STA.      -176.3      -173.0      -169.2      -164.2      -157.5      -134.2
 A(I)              5.8         6.4         7.1         8.0        12.1
 V(I)             5.55        5.07        4.54        4.04        2.67

   CROSS-SECTION PROPERTIES:  ISEQ = 13;  SECID = APPR ;  SRD =     111.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     276.   10901.   211.   213.                       1794.
            2    1007.   84793.   157.   161.                      14462.
  496.33         1283.   95694.   368.   374.  1.16  -235.   133.  12606.

   VELOCITY DISTRIBUTION:  ISEQ = 13;  SECID = APPR ;  SRD =     111.
        WSEL     LEW     REW    AREA        K        Q    VEL
      496.33  -235.0   133.2  1283.0   95694.    5590.   4.36
X STA.      -235.0      -157.7       -46.7        -5.5         1.2         5.9
 A(I)            113.3       132.0        95.9        58.6        48.8
 V(I)             2.47        2.12        2.91        4.77        5.73
X STA.         5.9        11.2        17.0        23.2        30.4        39.7
 A(I)             47.6        49.3        49.7        52.3        57.3
 V(I)             5.88        5.67        5.62        5.34        4.88
X STA.        39.7        49.6        59.5        68.5        77.0        84.7
 A(I)             58.9        58.7        56.4        55.7        53.5
 V(I)             4.74        4.76        4.95        5.02        5.22
X STA.        84.7        92.0        98.7       105.4       113.1       133.2
 A(I)             53.3        50.9        52.6        58.2        80.0
 V(I)             5.25        5.49        5.32        4.80        3.49
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          U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar014.wsp
          CREATED ON 19-JUN-95 FOR BRIDGE CLARTH00010014
          HYDRAULIC ANALYSIS OF CLAR014 OVER THE COLD RIVER IN CLARENDON, VT
           *** RUN DATE & TIME: 06-21-95  15:19
    CROSS-SECTION PROPERTIES:  ISEQ = 11;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#    AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     706.   56480.     0.   161.                   ********
   497.21          706.   56480.     0.   161.  1.00     0.    74.********

    VELOCITY DISTRIBUTION:  ISEQ = 11;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA         K        Q    VEL
       497.21     0.0    74.1   706.1   56480.    6369.   9.02
 X STA.         0.0         5.5         9.0        12.2        15.3        18.2
   A(I)            51.1        35.2        33.4        32.4        31.3
   V(I)            6.23        9.05        9.54        9.82       10.18
 X STA.        18.2        21.0        23.7        26.4        29.0        31.9
   A(I)            30.4        30.5        30.6        30.0        31.3
   V(I)           10.46       10.45       10.40       10.63       10.17
 X STA.        31.9        35.0        38.6        42.6        46.7        50.9
   A(I)            31.9        33.7        35.2        35.5        35.4
   V(I)            9.98        9.46        9.04        8.96        8.99
 X STA.        50.9        55.0        59.0        63.3        67.8        74.1
   A(I)            35.9        35.3        37.4        38.5        51.0
   V(I)            8.86        9.03        8.51        8.26        6.24

    VELOCITY DISTRIBUTION:  ISEQ = 12;  SECID = RDWAY;  SRD =      14.
         WSEL     LEW     REW    AREA         K        Q    VEL
       498.38  -210.0   -78.0   372.1   23985.    3125.   8.40
 X STA.      -210.0      -205.7      -202.7      -199.7      -196.8      -193.9
   A(I)            20.8        14.7        13.9        13.8        13.9
   V(I)            7.53       10.65       11.26       11.34       11.22
 X STA.      -193.9      -190.8      -187.8      -184.6      -181.3      -177.8
   A(I)            14.0        14.1        14.5        14.7        15.4
   V(I)           11.17       11.10       10.74       10.61       10.14
 X STA.      -177.8      -174.2      -170.3      -166.1      -161.4      -156.2
   A(I)            15.6        16.2        16.8        18.1        18.9
   V(I)           10.00        9.67        9.28        8.63        8.28
 X STA.      -156.2      -150.1      -142.7      -133.8      -120.9       -78.0
   A(I)            20.3        22.6        24.1        28.4        41.3
   V(I)            7.70        6.92        6.50        5.50        3.78

    CROSS-SECTION PROPERTIES:  ISEQ = 13;  SECID = APPR ;  SRD =     111.
     WSEL  SA#    AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     893.   76282.   211.   216.                     10422.
             2    1468.  158268.   158.   162.                     25384.
             3      17.     650.    14.    14.                       109.
   499.25         2378.  235200.   383.   392.  1.04  -235.   148.  32938.

    VELOCITY DISTRIBUTION:  ISEQ = 13;  SECID = APPR ;  SRD =     111.
         WSEL     LEW     REW    AREA         K        Q    VEL
       499.25  -235.0   148.2  2378.3  235200.    9500.   3.99
 X STA.      -235.0      -201.6      -171.7      -142.2      -107.4       -69.6
   A(I)           146.0       131.2       130.3       142.8       144.2
   V(I)            3.25        3.62        3.65        3.33        3.30
 X STA.       -69.6       -39.2        -9.4         1.0         8.4        16.8
   A(I)           133.2       149.5       109.9        95.8        96.8
   V(I)            3.56        3.18        4.32        4.96        4.91
 X STA.        16.8        25.9        37.1        49.7        62.1        73.6
   A(I)            97.6       106.4       112.0       110.0       107.7
   V(I)            4.87        4.46        4.24        4.32        4.41
 X STA.        73.6        84.1        94.1       103.6       113.8       148.2
   A(I)           102.7       101.5       101.7       107.1       152.0
   V(I)            4.63        4.68        4.67        4.44        3.12
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         U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar014.wsp
         CREATED ON 19-JUN-95 FOR BRIDGE CLARTH00010014
         HYDRAULIC ANALYSIS OF CLAR014 OVER THE COLD RIVER IN CLARENDON, VT
          *** RUN DATE & TIME: 06-21-95  15:19
   CROSS-SECTION PROPERTIES:  ISEQ = 11;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     353.   28514.    71.    79.                        4455.
  492.21          353.   28514.    71.    79.  1.00     0.    74.   4455.

   VELOCITY DISTRIBUTION:  ISEQ = 11;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       492.21     0.0    73.9   353.0   28514.    4310.  12.21
X STA.         0.0        5.4        8.8       11.6       14.3       16.9
  A(I)            24.7       17.8       16.1       15.6       14.9
  V(I)            8.73      12.08      13.40      13.82      14.43
X STA.        16.9       19.3       21.6       23.9       26.0       28.1
  A(I)            15.0       14.2       14.5       14.2       14.5
  V(I)           14.40      15.15      14.88      15.16      14.91
X STA.        28.1       30.5       33.1       36.3       40.5       45.7
  A(I)            14.9       15.5       16.6       18.4       19.9
  V(I)           14.45      13.93      12.96      11.70      10.85
X STA.        45.7       51.1       56.1       61.1       66.4       73.9
  A(I)            20.1       19.5       19.9       20.0       26.8
  V(I)           10.70      11.07      10.84      10.79       8.05

   CROSS-SECTION PROPERTIES:  ISEQ = 12;  SECID = APPR ;  SRD =     111.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1      50.    1141.    76.    76.                         233.
            2     917.   73116.   156.   160.                       12642.
  495.76          968.   74257.   232.   236.  1.06  -100.   132.  10888.

   VELOCITY DISTRIBUTION:  ISEQ = 12;  SECID = APPR ;  SRD =     111.
         WSEL     LEW     REW    AREA        K        Q    VEL
       495.76   -99.7   131.8   967.8   74257.    4310.   4.45
X STA.       -99.7       -5.7        0.6        4.7        9.3       14.2
  A(I)           103.4       49.6       41.6       39.9       39.8
  V(I)            2.08       4.35       5.18       5.39       5.42
X STA.        14.2       19.5       25.1       32.1       40.6       49.7
  A(I)            40.7       41.0       43.9       47.5       49.0
  V(I)            5.29       5.26       4.91       4.53       4.40
X STA.        49.7       59.0       67.2       74.9       81.9       88.6
  A(I)            49.6       46.4       45.7       44.0       43.6
  V(I)            4.34       4.65       4.72       4.90       4.94
X STA.        88.6       94.9      100.7      106.6      113.5      131.8
  A(I)            43.4       41.6       42.7       48.2       66.2
  V(I)            4.97       5.18       5.04       4.47       3.26

         U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar014.wsp
         CREATED ON 19-JUN-95 FOR BRIDGE CLARTH00010014
         HYDRAULIC ANALYSIS OF CLAR014 OVER THE COLD RIVER IN CLARENDON, VT
          *** RUN DATE & TIME: 06-21-95  15:19
 XSID:CODE   SRDL    LEW     AREA    VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
RREX :XS   ******     4.     535.  1.75 *****  480.84  478.40   5590.  479.08
     -860. ******   122.   47197.  1.03 ***** *******    0.88   10.44

 ===125 FR# EXCEEDS FNTEST AT SECID “RRFV “:  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.87     479.96     479.26

 ===110 WSEL NOT FOUND AT SECID “RRFV “:  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   478.58     498.98    0.50

 ===115 WSEL NOT FOUND AT SECID “RRFV “:  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   478.58     498.98     479.26

RRFV :FV      61.     4.     537.  1.75  0.85  481.70  479.26   5590.  479.95
     -799.    61.   122.   47342.  1.04  0.00    0.01    0.88   10.42
        <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID “RRAPP”:  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.87     481.00     480.28

 ===110 WSEL NOT FOUND AT SECID “RRAPP”:  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   479.45     500.00    0.50

 ===115 WSEL NOT FOUND AT SECID “RRAPP”:  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   479.45     500.00     480.28

RRAPP:AS      73.     4.     538.  1.74  1.01  482.72  480.28   5590.  480.98
     -726.    73.   122.   47520.  1.04  0.00    0.01    0.87   10.39
        <<<<<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
```

```
RRBRI:BR      61.     0.     521.  1.79  0.89  481.73  479.31   5590.  479.94
     -799.    61.    99.   45174.  1.00  0.00    0.00    0.82   10.73

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  483.39 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RRRDW:RG    -791.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

RRAPP:AS      58.     3.     558.  1.62  0.82  482.78  480.28   5590.  481.15
     -726.    59.   124.   50048.  1.04  0.23    0.01    0.84   10.01

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.165  0.000   50170.     6.   104.   480.43

                       <<<<<END OF BRIDGE COMPUTATIONS>>>>>
 ===125 FR# EXCEEDS FNTEST AT SECID "XS1  ":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.84     482.90     482.04

 ===110 WSEL NOT FOUND AT SECID "XS1  ":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   480.65     501.76    0.50

 ===115 WSEL NOT FOUND AT SECID "XS1  ":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   480.65     501.76     482.04

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

XS1  :XS     126.     3.     555.  1.63  1.74  484.53  482.04   5590.  482.89
     -600.   126.   123.   45228.  1.04  0.01    0.00    0.84   10.06

 ===125 FR# EXCEEDS FNTEST AT SECID "XS2  ":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.81     486.06     485.06

 ===110 WSEL NOT FOUND AT SECID "XS2  ":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   482.39     497.47    0.50

 ===115 WSEL NOT FOUND AT SECID "XS2  ":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   482.39     497.47     485.06

XS2  :XS     200.   -46.     596.  1.46  2.99  487.52  485.06   5590.  486.06
     -400.   200.    88.   46202.  1.07  0.00    0.00    0.81    9.39

 ===125 FR# EXCEEDS FNTEST AT SECID "XS3  ":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.93     489.40     489.06

 ===110 WSEL NOT FOUND AT SECID "XS3  ":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   485.56     501.47    0.50

 ===115 WSEL NOT FOUND AT SECID "XS3  ":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   485.56     501.47     489.06
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS      64.   -34.     535.  1.79  1.32  492.65  490.36   5590.  490.86
     -136.    64.    87.   40013.  1.05  0.00    0.00    0.90   10.46

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "FULLV"     KRATIO =  1.48
FULLV:FV     136.   -67.     720.  1.02  1.80  494.44 *******   5590.  493.42
        0.   136.    88.   59088.  1.09  0.00    0.00    0.67    7.76

APPR :AS     111.   -22.     754.  0.86  1.09  495.55 *******   5590.  494.70
      111.   111.   129.   53731.  1.00  0.00    0.02    0.59    7.42
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   497.10       0.00     493.03     493.50

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===225 NO ENERGY BALANCE IN 15 ITERATIONS.
                   FLOW,Q =    4      3615.
             WS1,WSSD,WS3 =   495.47       0.00     493.76

 ===235 CONTINUE FLOW CLASS 4 COMPUTATIONS.
                   ITER,QRD =    1      1975.
             WS,WSMIN,WSMAX =   498.24     493.50     502.98
```

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           <<<<<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     136.     0.     414.  2.29  2.57  495.35  492.57   4944.  493.06
        0.   136.    74.   36603.  1.03  0.13    0.00    0.89   11.96

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.984 ******  497.15 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.    92.  0.32  0.35  496.34    0.00    646.  495.87

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    646.    76.  -210.  -134.   2.4   1.5   6.6   5.8   1.9   3.2
   RT:      0. ****** ****** ****** ***** ***** ***** ***** ***** *****

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

APPR :AS      77.  -235.    1282.  0.34  0.70  496.67  493.04   5590.  496.33
      111.    88.   133.   95554.  1.16  0.62   -0.01    0.44    4.36

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.511  0.561   42195.    21.    95. ********
                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>

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

APPR2:XS      63.  -212.    1356.  0.31  0.21  496.89 *******   5590.  496.58
      174.    63.   160.   98113.  1.17  0.00    0.01    0.41    4.12

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   RREX :XS    -860.     4.   122.   5590.   47197.     535.   10.44  479.08
   RRFV :FV    -799.     4.   122.   5590.   47342.     537.   10.42  479.95
   RRBRI:BR    -799.     0.    99.   5590.   45174.     521.   10.73  479.94
   RRRDW:RG    -791.**************       0.*****************    2.00********
   RRAPP:AS    -726.     3.   124.   5590.   50048.     558.   10.01  481.15
   XS1  :XS    -600.     3.   123.   5590.   45228.     555.   10.06  482.89
   XS2  :XS    -400.   -46.    88.   5590.   46202.     596.    9.39  486.06
   XS3  :XS    -200.   -29.    87.   5590.   37921.     514.   10.88  489.40
   EXITX:XS    -136.   -34.    87.   5590.   40013.     535.   10.46  490.86
   FULLV:FV       0.   -67.    88.   5590.   59088.     720.    7.76  493.42
   BRIDG:BR       0.     0.    74.   4944.   36603.     414.   11.96  493.06
   RDWAY:RG      14.*******   646.    646.********        0.    1.00  495.87
   APPR :AS     111.  -235.   133.   5590.   95554.    1282.    4.36  496.33
   APPR2:XS     174.  -212.   160.   5590.   98113.    1356.    4.12  496.58

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF    HO   VHD      EGL    WSEL
   RREX :XS     478.40    0.88  471.25  498.12************  1.75  480.84  479.08
   RRFV :FV     479.26    0.88  472.11  498.98  0.85  0.00  1.75  481.70  479.95
   RRBRI:BR     479.31    0.82  473.14  483.39  0.89  0.00  1.79  481.73  479.94
   RRRDW:RG   ****************  485.44  492.06*********************************
   RRAPP:AS     480.28    0.84  473.13  500.00  0.82  0.23  1.62  482.78  481.15
   XS1  :XS     482.04    0.84  474.89  501.76  1.74  0.01  1.63  484.53  482.89
   XS2  :XS     485.06    0.81  478.49  497.47  2.99  0.00  1.46  487.52  486.06
   XS3  :XS     489.06    0.93  482.49  501.47  3.57  0.23  1.93  491.33  489.40
   EXITX:XS     490.36    0.90  483.77  502.75  1.32  0.00  1.79  492.65  490.86
   FULLV:FV   ********    0.67  484.99  503.97  1.80  0.00  1.02  494.44  493.42
   BRIDG:BR     492.57    0.89  485.15  497.21  2.57  0.13  2.29  495.35  493.06
   RDWAY:RG   ****************  493.50  501.81  0.32******  0.35  496.34  495.87
   APPR :AS     493.04    0.44  485.32  502.98  0.70  0.62  0.34  496.67  496.33
   APPR2:XS   ********    0.41  488.38  500.57  0.21  0.00  0.31  496.89  496.58

          U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar014.wsp
          CREATED ON 19-JUN-95 FOR BRIDGE CLARTH00010014
          HYDRAULIC ANALYSIS OF CLAR014 OVER THE COLD RIVER IN CLARENDON, VT
           *** RUN DATE & TIME: 06-21-95  15:19

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

RREX :XS   ******   -59.     793.  2.46 *****  483.48  480.64   9500.  481.02
     -860. ******   142.   80285.  1.10 ***** *******    1.00   11.98

 ===125 FR# EXCEEDS FNTEST AT SECID "RRFV ":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80     1.00     481.90     481.50

 ===110 WSEL NOT FOUND AT SECID "RRFV ":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   480.52     498.98     0.50

 ===115 WSEL NOT FOUND AT SECID "RRFV ":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   480.52     498.98     481.50
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RRFV :FV      61.   -59.     795.  2.44  0.85  484.34  481.50   9500.  481.90
     -799.    61.   142.   80610.  1.10  0.00    0.01    1.00   11.94

 ===125 FR# EXCEEDS FNTEST AT SECID "RRAPP":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.99     482.93     482.52

 ===110 WSEL NOT FOUND AT SECID "RRAPP":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   481.40     500.00    0.50

 ===115 WSEL NOT FOUND AT SECID "RRAPP":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   481.40     500.00     482.52

RRAPP:AS      73.   -60.     797.  2.43  1.01  485.36  482.52   9500.  482.93
     -726.    73.   142.   80838.  1.10  0.00    0.01    1.00   11.92
         <<<<<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

RRBRI:BR      61.     0.     660.  3.22  1.04  484.57  481.28   9500.  481.35
     -799.    61.    99.   65832.  1.00  0.05    0.00    0.98   14.39

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  483.39 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RRRDW:RG    -791.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

RRAPP:AS      58.   -99.     979.  1.81  0.81  485.68  482.52   9500.  483.88
     -726.    59.   187.  100489.  1.23  0.31    0.01    0.97    9.71

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.510  0.029   97353.     6.   105.   483.36

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

 ===125 FR# EXCEEDS FNTEST AT SECID "XS1  ":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.93     485.12     484.28

 ===110 WSEL NOT FOUND AT SECID "XS1  ":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   483.38     501.76    0.50

 ===115 WSEL NOT FOUND AT SECID "XS1  ":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   483.38     501.76     484.28

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

XS1  :XS     126.   -71.     873.  2.05  1.38  487.18  484.28   9500.  485.12
     -600.   126.   147.   82287.  1.11  0.12    0.00    0.92   10.89

 ===125 FR# EXCEEDS FNTEST AT SECID "XS2  ":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.95     488.16     488.16

 ===110 WSEL NOT FOUND AT SECID "XS2  ":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   484.62     497.47    0.50

 ===115 WSEL NOT FOUND AT SECID "XS2  ":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   484.62     497.47     488.16

XS2  :XS     200.  -210.    1051.  1.59  2.58  489.75  488.16   9500.  488.16
     -400.   200.    90.   85066.  1.25  0.00   -0.01    0.95    9.04

 ===125 FR# EXCEEDS FNTEST AT SECID "XS3  ":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.10     491.04     492.16

 ===110 WSEL NOT FOUND AT SECID "XS3  ":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   487.66     501.47    0.50

 ===115 WSEL NOT FOUND AT SECID "XS3  ":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   487.66     501.47     492.16

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "XS3  "
                   WSBEG,WSEND,CRWS =   492.16     501.47     492.16

XS3  :XS     200.  -210.    1051.  1.59 *****  493.75  492.16   9500.  492.16
     -200.   200.    90.   85066.  1.25 ***** *******    0.95    9.04

 ===125 FR# EXCEEDS FNTEST AT SECID "EXITX":  TRIALS CONTINUED.
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               FNTEST,FR#,WSEL,CRWS =  0.80    1.36     492.69     493.44

  ===110 WSEL NOT FOUND AT SECID "EXITX":  REDUCED DELTAY.
                    WSLIM1,WSLIM2,DELTAY =   491.66     502.75    0.50

  ===115 WSEL NOT FOUND AT SECID "EXITX":  USED WSMIN = CRWS.
                    WSLIM1,WSLIM2,CRWS =   491.66     502.75     493.44

  ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
               ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "EXITX"
                    WSBEG,WSEND,CRWS =   493.44     502.75     493.44

 EXITX:XS      64.  -210.    1051.  1.59 *****  495.03  493.44   9500.  493.44
      -136.    64.    90.   85066.  1.25 ***** *******    0.95    9.04

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

 FULLV:FV     136.  -210.    1247.  1.08  1.36  496.39 *******   9500.  495.31
         0.   136.    90.  105816.  1.20  0.00    0.00    0.72    7.62

 APPR :AS     111.  -235.    1313.  0.94  0.96  497.35 *******   9500.  496.41
       111.   111.   133.   98566.  1.16  0.00    0.00    0.73    7.24
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
            WS1,WSSD,WS3,RGMIN =   500.58       0.00     495.46     493.50

  ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

  ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
            WS3,WSIU,WS1,LSEL =   495.01     498.04     498.59     497.15

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

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

 BRIDG:BR     136.     0.     706.  1.27 *****  498.48  493.54   6369.  497.21
         0. ******    74.   56480.  1.00 ***** *******    0.52    9.02

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****    5.  0.435 ******  497.15 ****** ****** ******

     XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      14.    92.  0.15  0.26  499.35    0.00   3125.  498.38

              Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
    LT:   3125.   132.  -210.   -78.   4.9   2.8   9.4   8.4   3.8   3.2
    RT:      0. ****** ****** ****** ***** ***** ***** ***** ***** *****

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

 APPR :AS      77.  -235.    2376.  0.26  0.43  499.50  495.43   9500.  499.25
       111.    91.   148.  234914.  1.04  0.52    0.00    0.29    4.00

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

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

 APPR2:XS      63.  -212.    2402.  0.26  0.11  499.62 *******   9500.  499.36
       174.    63.   172.  228372.  1.06  0.00    0.01    0.29    3.95

   FIRST USER DEFINED TABLE.
     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    RREX :XS    -860.   -59.   142.   9500.   80285.     793.   11.98  481.02
    RRFV :FV    -799.   -59.   142.   9500.   80610.     795.   11.94  481.90
    RRBRI:BR    -799.     0.    99.   9500.   65832.     660.   14.39  481.35
    RRRDW:RG    -791.**************       0.******************    2.00********
    RRAPP:AS    -726.   -99.   187.   9500.  100489.     979.    9.71  483.88
    XS1  :XS    -600.   -71.   147.   9500.   82287.     873.   10.89  485.12
    XS2  :XS    -400.  -210.    90.   9500.   85066.    1051.    9.04  488.16
    XS3  :XS    -200.  -210.    90.   9500.   85066.    1051.    9.04  492.16
    EXITX:XS    -136.  -210.    90.   9500.   85066.    1051.    9.04  493.44
    FULLV:FV       0.  -210.    90.   9500.  105816.    1247.    7.62  495.31
    BRIDG:BR       0.     0.    74.   6369.   56480.     706.    9.02  497.21
    RDWAY:RG      14.******* 3125.   3125.*********       0.    1.00  498.38
    APPR :AS     111.  -235.   148.   9500.  234914.    2376.    4.00  499.25
    APPR2:XS     174.  -212.   172.   9500.  228372.    2402.    3.95  499.36
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WSPRO OUTPUT FILE (continued)

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 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   RREX :XS    480.64    1.00  471.25  498.12************  2.46  483.48  481.02
   RRFV :FV    481.50    1.00  472.11  498.98  0.85  0.00  2.44  484.34  481.90
   RRBRI:BR    481.28    0.98  473.14  483.39  1.04  0.05  3.22  484.57  481.35
   RRRDW:RG  ****************  485.44  492.06**********************************
   RRAPP:AS    482.52    0.97  473.13  500.00  0.81  0.31  1.81  485.68  483.88
   XS1  :XS    484.28    0.92  474.89  501.76  1.38  0.12  2.05  487.18  485.12
   XS2  :XS    488.16    0.95  478.49  497.47  2.58  0.00  1.59  489.75  488.16
   XS3  :XS    492.16    0.95  482.49  501.47************  1.59  493.75  492.16
   EXITX:XS    493.44    0.95  483.77  502.75************  1.59  495.03  493.44
   FULLV:FV  ********    0.72  484.99  503.97  1.36  0.00  1.08  496.39  495.31
   BRIDG:BR    493.54    0.52  485.15  497.21************  1.27  498.48  497.21
   RDWAY:RG  ****************  493.50  501.81  0.15******  0.26  499.35  498.38
   APPR :AS    495.43    0.29  485.32  502.98  0.43  0.52  0.26  499.50  499.25
   APPR2:XS  ********    0.29  488.38  500.57  0.11  0.00  0.26  499.62  499.36

          U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE clar014.wsp
          CREATED ON 19-JUN-95 FOR BRIDGE CLARTH00010014
          HYDRAULIC ANALYSIS OF CLAR014 OVER THE COLD RIVER IN CLARENDON, VT
           *** RUN DATE & TIME: 06-21-95  15:20

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

RREX :XS   ******     5.     445.  1.47 *****  479.74  477.56   4310.  478.27
     -860. ******   113.   36403.  1.00 ***** *******    0.82    9.69

 ===125 FR# EXCEEDS FNTEST AT SECID “RRFV “:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.82     479.15     478.42

 ===110 WSEL NOT FOUND AT SECID “RRFV “:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   477.77     498.98    0.50

 ===115 WSEL NOT FOUND AT SECID “RRFV “:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   477.77     498.98     478.42

RRFV :FV      61.     5.     446.  1.46  0.85  480.60  478.42   4310.  479.14
     -799.    61.   113.   36471.  1.00  0.00    0.01    0.82    9.67

 ===125 FR# EXCEEDS FNTEST AT SECID “RRAPP”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.82     480.18     479.44

 ===110 WSEL NOT FOUND AT SECID “RRAPP”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   478.64     500.00    0.50

 ===115 WSEL NOT FOUND AT SECID “RRAPP”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   478.64     500.00     479.44

RRAPP:AS      73.     5.     447.  1.46  1.02  481.63  479.44   4310.  480.17
     -726.    73.   113.   36602.  1.01  0.00    0.01    0.82    9.65
         <<<<<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

RRBRI:BR      61.     0.     445.  1.46  0.89  480.63  478.57   4310.  479.17
     -799.    61.    99.   35044.  1.00  0.00    0.00    0.80    9.69

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  483.39 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RRRDW:RG    -791.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

RRAPP:AS      58.     5.     462.  1.37  0.83  481.68  479.44   4310.  480.31
     -726.    60.   115.   38338.  1.01  0.23    0.00    0.80    9.34

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.092  0.000   38576.     6.   104.   479.58

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

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

XS1  :XS     126.     5.     462.  1.37  1.75  483.44 *******   4310.  482.08
     -600.   126.   115.   34886.  1.01  0.00    0.01    0.80    9.33
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WSPRO OUTPUT FILE (continued)

```
XS2  :XS     200.   -27.     491.  1.25  3.00  486.45 *******   4310.  485.20
     -400.   200.    87.   35547.  1.04  0.00    0.01    0.76    8.78

 ===125 FR# EXCEEDS FNTEST AT SECID "XS3  ":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     0.90     488.61     488.16

 ===110 WSEL NOT FOUND AT SECID "XS3  ":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   484.70     501.47    0.50

 ===115 WSEL NOT FOUND AT SECID "XS3  ":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   484.70     501.47     488.16

XS3  :XS     200.   -19.     426.  1.64  3.60  490.24  488.16   4310.  488.61
     -200.   200.    86.   29071.  1.03  0.19    0.01    0.90   10.11

 ===125 FR# EXCEEDS FNTEST AT SECID "EXITX":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     0.85     490.07     489.42

 ===110 WSEL NOT FOUND AT SECID "EXITX":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   488.11     502.75    0.50

 ===115 WSEL NOT FOUND AT SECID "EXITX":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   488.11     502.75     489.42

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

EXITX:XS      64.   -21.     444.  1.52  1.33  491.57  489.42   4310.  490.05
     -136.    64.    86.   30790.  1.03  0.00    0.00    0.86    9.72

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "FULLV"     KRATIO =  1.47

FULLV:FV     136.   -44.     586.  0.90  1.81  493.38 *******   4310.  492.49
        0.   136.    87.   45259.  1.07  0.00    0.00    0.63    7.35
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR :AS     111.   -17.     617.  0.76  1.15  494.53 *******   4310.  493.77
      111.   111.   127.   39755.  1.00  0.00    0.00    0.60    6.98
         <<<<<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     136.     0.     353.  2.31  2.87  494.53  492.11   4310.  492.21
        0.   136.    74.   28556.  1.00  0.09    0.00    0.97   12.20

     TYPE PPCD FLOW       C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.15 ****** ****** ******

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

APPR :AS      77.  -100.     967.  0.33  0.78  496.08  492.43   4310.  495.76
      111.    88.   132.   74171.  1.06  0.78    0.01    0.40    4.46

       M(G)   M(K)        KQ   XLKQ   XRKQ    OTEL
      0.488  0.512   36047.    20.    94.   495.43

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

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

APPR2:XS      63.   -71.     910.  0.35  0.22  496.33 *******   4310.  495.97
      174.    63.   158.   70534.  1.02  0.01    0.00    0.40    4.73

  FIRST USER DEFINED TABLE.

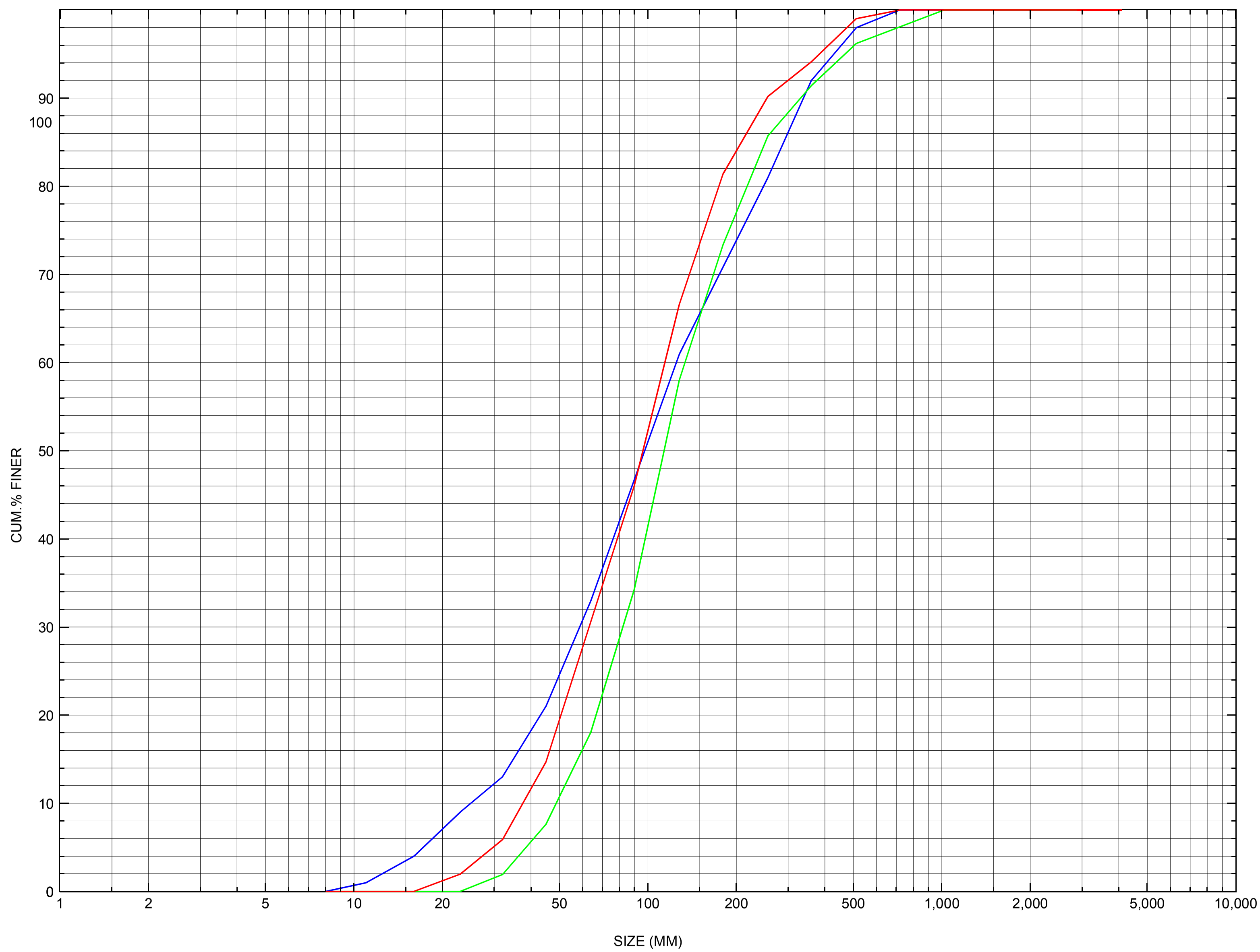
    XSID:CODE    SRD     LEW     REW       Q        K      AREA      VEL    WSEL
   RREX :XS    -860.      5.    113.   4310.   36403.     445.     9.69  478.27
   RRFV :FV    -799.      5.    113.   4310.   36471.     446.     9.67  479.14
   RRBRI:BR    -799.      0.     99.   4310.   35044.     445.     9.69  479.17
   RRRDW:RG    -791.**************      0.******************     2.00********
   RRAPP:AS    -726.      5.    115.   4310.   38338.     462.     9.34  480.31
   XS1  :XS    -600.      5.    115.   4310.   34886.     462.     9.33  482.08
   XS2  :XS    -400.    -27.     87.   4310.   35547.     491.     8.78  485.20
   XS3  :XS    -200.    -19.     86.   4310.   29071.     426.    10.11  488.61
   EXITX:XS    -136.    -21.     86.   4310.   30790.     444.     9.72  490.05
   FULLV:FV       0.    -44.     87.   4310.   45259.     586.     7.35  492.49
   BRIDG:BR       0.      0.     74.   4310.   28556.     353.    12.20  492.21
   APPR :AS     111.   -100.    132.   4310.   74171.     967.     4.46  495.76
   APPR2:XS     174.    -71.    158.   4310.   70534.     910.     4.73  495.97
```

SECOND USER DEFINED TABLE.

XSID:CODE	CRWS	FR#	YMIN	YMAX	HF	HO	VHD	EGL	WSEL
RREX :XS	477.56	0.82	471.25	498.12	******	******	1.47	479.74	478.27
RRFV :FV	478.42	0.82	472.11	498.98	0.85	0.00	1.46	480.60	479.14
RRBRI:BR	478.57	0.80	473.14	483.39	0.89	0.00	1.46	480.63	479.17
RRRDW:RG	********	********	485.44	492.06	******	******	******	********	********
RRAPP:AS	479.44	0.80	473.13	500.00	0.83	0.23	1.37	481.68	480.31
XS1 :XS	********	0.80	474.89	501.76	1.75	0.00	1.37	483.44	482.08
XS2 :XS	********	0.76	478.49	497.47	3.00	0.00	1.25	486.45	485.20
XS3 :XS	488.16	0.90	482.49	501.47	3.60	0.19	1.64	490.24	488.61
EXITX:XS	489.42	0.86	483.77	502.75	1.33	0.00	1.52	491.57	490.05
FULLV:FV	********	0.63	484.99	503.97	1.81	0.00	0.90	493.38	492.49
BRIDG:BR	492.11	0.97	485.15	497.21	2.87	0.09	2.31	494.53	492.21
APPR :AS	492.43	0.40	485.32	502.98	0.78	0.78	0.33	496.08	495.76
APPR2:XS	********	0.40	488.38	500.57	0.22	0.01	0.35	496.33	495.97

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 CLARTH00010014, in Clarendon, Vermont.

APPENDIX D:

HISTORICAL DATA FORM