LEVEL II SCOUR ANALYSIS FOR BRIDGE 2 (RTLCCYRIVR0002) on RIVER STREET, crossing OTTER CREEK, RUTLAND, VERMONT

Open-File Report 98-568

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior
U.S. Geological Survey

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By ERICK M. BOEHMLER

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Pembroke, New Hampshire

1998

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

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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 2 (RTLCCYRIVR0002) ON RIVER STREET, CROSSING OTTER CREEK, RUTLAND, VERMONT

By **Erick M. Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure RTLCCYRIVR0002 on River Street crossing Otter Creek in the City of Rutland, 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 (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Taconic section of the New England physiographic province in central Vermont. The 244.0-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover consists of forest downstream, pasture on the left bank upstream, and suburban on the upstream right bank.

In the study area, Otter Creek has a sinuous channel with a slope of approximately 0.001 ft/ft, an average channel top width of 134 ft and an average bank height of 6 ft. The channel bed material ranges from silt/clay to gravel with a median grain size (D_{50}) of 0.799 mm (0.00262 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 17, 1995, indicated that the reach was laterally unstable. This designation was based on a severe bend in the channel immediately upstream of the bridge, a cut-bank upstream and a point bar downstream.

The River Street crossing of Otter Creek is a 210-ft-long, two-lane bridge consisting of two steel-beam spans 127- and 83-feet long (Vermont Agency of Transportation, written communication, March 14, 1995). The opening length of the structure parallel to the bridge face is 207 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 1.5 feet deeper than the mean thalweg depth was observed along the left abutment during the Level I assessment. The only scour protection measure at the site was type-1 stone fill (less than 12 inches diameter) along the right bank upstream. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge was determined and analyzed as another potential worst-case scour scenario. 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 3.1 to 6.1 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 23.1 to 25.8 ft at the left abutment and from 9.7 to 12.1 ft at the right abutment. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results.” Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and Davis, 1995, p. 46). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

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

NORTH

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

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

LEVEL II SUMMARY

Structure Number RTLCCYRIVR0002 ***Stream*** Otter Creek

County Rutland ***Road*** River Street ***District*** 3

Description of Bridge

Bridge length 210 ***ft*** ***Bridge width*** 28.0 ***ft*** ***Max span length*** 127 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** Steeply sloped

Stone fill on abutment? No ***Date of inspection*** 10/17/95

Description of stone fill Type-1 along the upstream right bank.

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

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

There is a severe channel bend in the upstream reach. Scour is evident at the location where the flow impacts the upstream left bank and left abutment.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	10/17/95	0	0
Level II	10/17/95	0	0

Potential for debris High. Debris was observed in the channel upstream and under the bridge along the right bank side of the pier.

Describe any features near or at the bridge that may affect flow (include observation date) A severe bend in the channel was observed immediately upstream of the bridge on 10/17/95.

Description of the Geomorphic Setting

General topography The channel is located in a low relief valley setting with flat to slightly irregular flood plains and mildly to moderately sloped valley walls.

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

Date of inspection 10/17/95

DS left: Steep channel bank to a narrow overbank (River Street roadway)

DS right: Moderately sloped channel bank and overbank

US left: Steep channel bank to flood plain

US right: Steep channel bank to flood plain.

Description of the Channel

Average top width 134 ***ft***   ***Average depth*** 6 ***ft***

Predominant bed material Sand   ***Bank material*** Sand, Silt / Clay

Perennial and meandering, with semi-alluvial to alluvial channel boundaries and narrow point bars.

10/17/95

Vegetative co Brush and grass with a few trees

DS left: Trees and brush

DS right: Trees and grass

US left: Brush and grass with a few trees

US right: No

Do banks appear stable? The channel is designated as laterally unstable. Block failure of the left bank material at a cut-bank on the severe channel bend immediately upstream of the bridge and another cut-bank along the right bank upstream were observed on 10/17/95.

date of observation.

None were observed on 10/17/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 244 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

Is there a USGS gage on the stream of interest? Yes

USGS gage description Otter Creek at Center Rutland, VT

USGS gage number 04282000

Gage drainage area 307 ***mi²***

Is there a lake/ [illegible] No

-

Calculated Discharges

Q100 13,300 ***ft³/s*** ***Q500*** 16,300 ***ft³/s***

The 100- and 500-year discharges are based on a log-Pearson Type III analysis of the peak discharges recorded at the Center Rutland gage for the continuous period from 1929 - 1996 (68 years) in accordance with the guidelines documented by the Interagency Advisory Committee on Water Data (1982). These values were consistent with a range of values derived from flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve was extended graphically to the 500-year event. Peak discharges were reduced by 2,900 cfs and 4,300 cfs to account for flow contributions from East Creek, which enters Otter Creek between the gage and this site.

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

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

Datum tie between USGS survey and VTAOT plans Add 36.4 feet to the USGS datum to obtain the VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a VTAOT metal survey disk set in the right bank end of the concrete curb on the downstream side of the bridge deck (elev. 500.31 ft, arbitrary survey datum). RM2 is a chiseled "X" on top of the downstream end of the left wingwall (elev. 498.02 ft, arbitrary survey datum). RM5 is a chiseled "X" on top of the right abutment of Ripley Dam about 1500 feet downstream (elev. 492.21 feet, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
SEC-A	0	1	Valley section below Ripley Dam
WEIR	44	1	Crest of Ripley Dam
SEC-B	205	1	Valley section above Dam
SEC-C	1169	2	Valley section (Templated from SEC-B)
EXITX	1484	1	Exit section
FULLV	1644	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	1644	1	Bridge section
RDWAY	1658	1	Road Grade section
APPRO	1885	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 and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.030 to 0.052, and overbank "n" values ranged from 0.035 to 0.070.

Normal depth at the section below Ripley Dam (SEC-A) 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 0.0025 ft/ft, which was computed as the average of the 100- and 500-year water-surface-profile slopes between sections B and C (downstream of Ripley Dam) as shown in the Flood Insurance Study for the City of Rutland (U.S. Dept. of Housing and Urban Development, 1977).

A submerged weir analysis was conducted for Ripley Dam in accordance with the methods documented by Hulsing (1967) for computation of the water surface upstream of the dam to resume flow computations. Modeled discharges were reduced at the exit section (EXITX) to account for the inflow from East Creek. Differences in the discharges for Otter Creek above and below the confluence of East Creek (U.S. Dept. of Housing and Urban Development, 1977) were used to adjust the discharges modeled at this site.

The surveyed approach section was moved without an elevation adjustment to establish the modelled approach section (APPRO) one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.0 ***ft***
Average low steel elevation 495.0 ***ft***

100-year discharge 10,400 ***ft^3/s***
Water-surface elevation in bridge opening 496.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 70 ***ft^3/s***
Area of flow in bridge opening 2780 ***ft^2***
Average velocity in bridge opening 3.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 4.6 ***ft/s***

Water-surface elevation at Approach section with bridge 496.6
Water-surface elevation at Approach section without bridge 496.6
Amount of backwater caused by bridge 0.0 ***ft***

500-year discharge 12,000 ***ft^3/s***
Water-surface elevation in bridge opening 496.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,400 ***ft^3/s***
Area of flow in bridge opening 2780 ***ft^2***
Average velocity in bridge opening 3.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 4.7 ***/s***

Water-surface elevation at Approach section with bridge 498.0
Water-surface elevation at Approach section without bridge 497.9
Amount of backwater caused by bridge 0.1 ***ft***

Incipient overtopping discharge 9,770 ***ft^3/s***
Water-surface elevation in bridge opening 495.7 ***ft***
Area of flow in bridge opening 2770 ***ft^2***
Average velocity in bridge opening 3.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 4.7 ***ft/s***

Water-surface elevation at Approach section with bridge 496.0
Water-surface elevation at Approach section without bridge 496.1
Amount of backwater caused by bridge N/A ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analyses for the 100- and 500-year discharges are presented in tables 1 and 2 and the scour depths are shown graphically in figure 8.

At this site, all of the modeled discharges resulted in an orifice flow solution. Although the Chang equation is usually applicable when orifice flow conditions exist, the equation was derived solely with data for clear-water scour. It is not currently understood how well the Chang equation would predict contraction scour in live-bed conditions. Therefore, contraction scour for all of the modeled discharges was computed by use of the Laursen live-bed contraction scour equation (Richardson and Davis, 1995, p. 30, equation 17).

For comparison, contraction scour also was computed by use of the Laursen clear-water contraction scour equation because the incipient motion velocity was nearly the same as the average channel velocity upstream. Furthermore, contraction scour was computed by use of the Chang equation (Richardson and Davis, 1995, p. 145-146) and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). Results from these alternative computations are provided in appendix F.

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

The length to depth ratio of the embankment blocking flow exceeded 25 for modeled discharges at both abutments. Although the HIRE equation (Richardson and others, 1993, p. 50, equation 25) generally is applicable when this ratio exceeds 25, the results from the HIRE equation were not reported in the tables and figure 8. However, results from the HIRE equation are provided in appendix F. Hydraulic Engineering Circular 18 recommends that the field conditions be similar to those from which the HIRE equation was derived (Richardson and others, 1993).

Pier scour was computed by use of an equation developed at Colorado State University (Richardson and others, 1995, p. 36, equation 21) for all discharges modeled. Variables for the pier scour equation include pier length, pier width, average depth and maximum velocity (for the froude number) immediately upstream of the bridge, and four correction factors for pier shape, flow attack angle, streambed-form, and streambed armoring.

Scour Results

Contraction scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	4.3	6.1	3.1
Clear-water scour	--	--	--
Depth to armoring	N/A	N/A	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	23.9	25.8	23.1
Right abutment	10.0	12.1	9.7
Pier scour			
Pier 1	20.8	20.9	21.8
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	500-year discharge *(D50 in feet)*	Incipient overtopping discharge
Abutments:			
Left abutment	0.3	0.3	0.2
Right abutment	0.3	0.3	0.2
Piers:			
Pier 1	0.3	0.3	0.2
Pier 2	--	--	--
	--	--	--

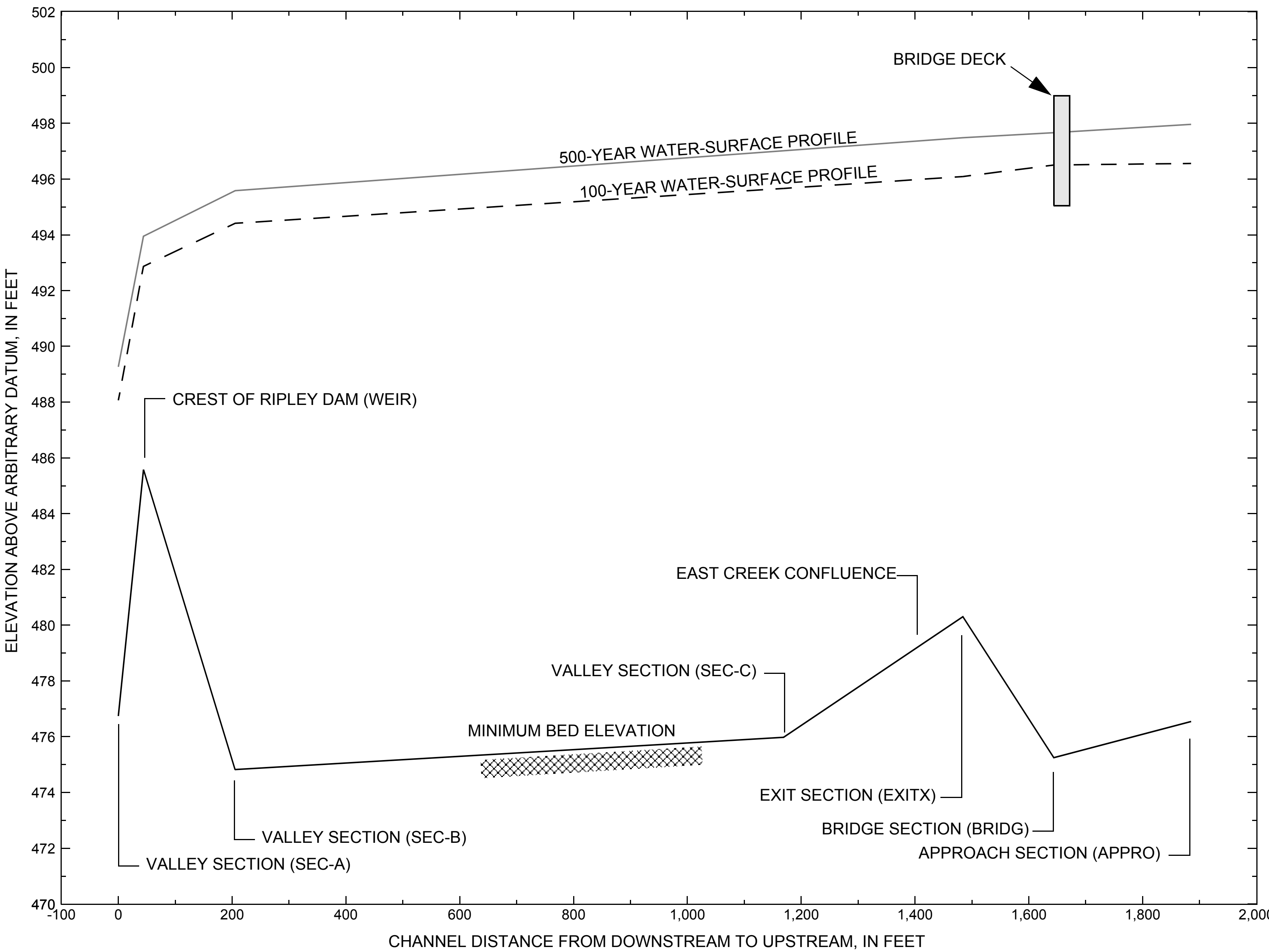

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure RTLCCYRIVR0002 on River Street, crossing Otter Creek, Rutland City, Vermont.

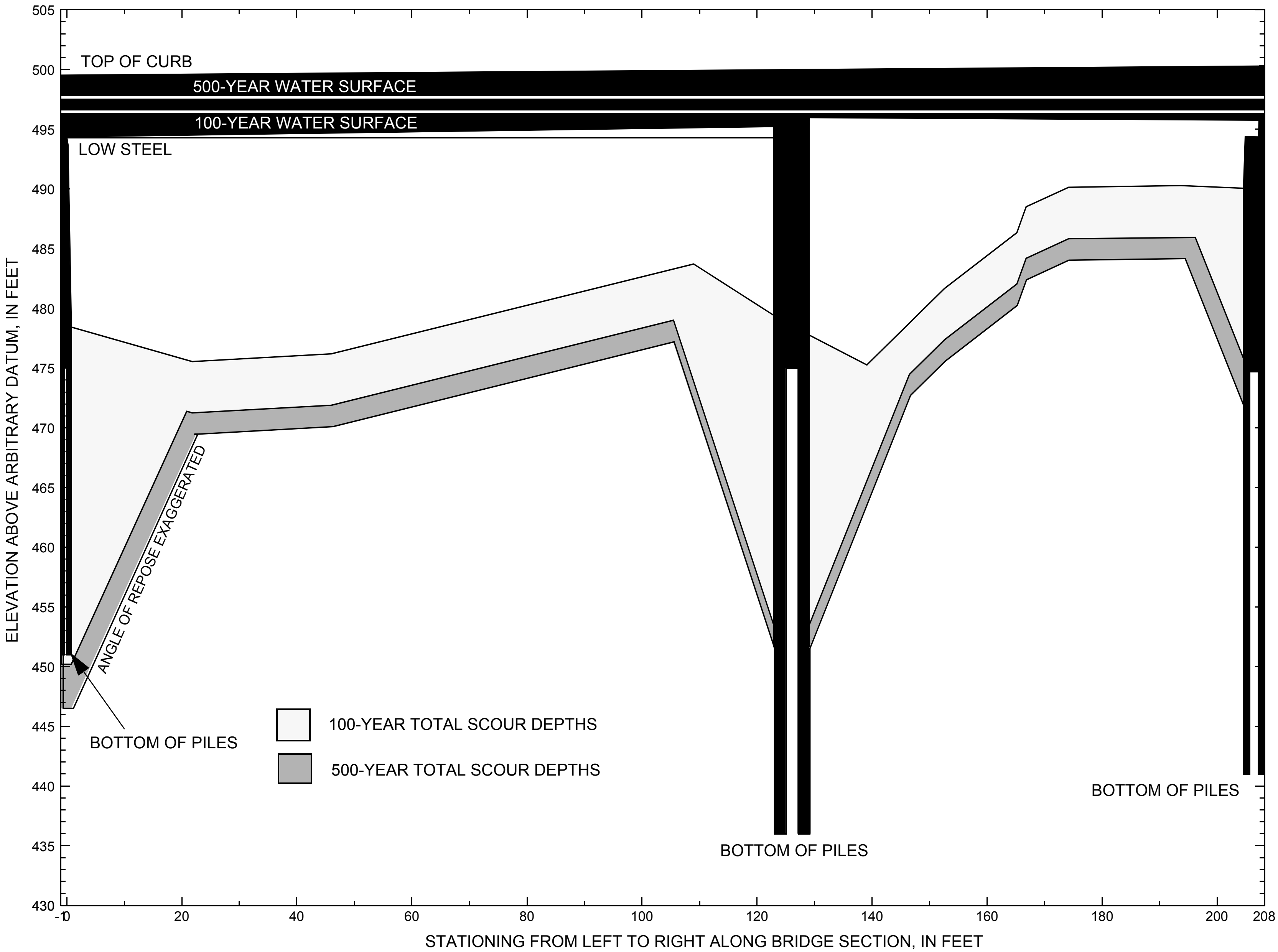

Figure 8. Scour elevations for the 100- and 500-year discharges at structure RTLCCYRIVR0002 on River Street, crossing Otter Creek, Rutland City, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure RTLCCYRIVR0002 on River Street, crossing Otter Creek, Rutland City, 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/pile 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-year discharge is 10,400 cubic-feet per second											
Left abutment	0.0	531.0	494.3	451	478.4	4.3	23.9	--	28.2	450.2	-1
Pier	126.0	532.0	495.7	436	478.5	4.3	--	20.8	25.1	453.4	17
Right abutment	207.3	531.6	495.8	441	490.1	4.3	10.0	--	14.3	475.8	35

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 RTLCCYRIVR0002 on River Street, crossing Otter Creek, Rutland City, 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/pile 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-year discharge is 12,000 cubic-feet per second											
Left abutment	0.0	531.0	494.3	451	478.4	6.1	25.8	--	31.9	446.5	-5
Pier	126.0	532.0	495.7	436	478.5	6.1	--	20.9	27.0	451.5	16
Right abutment	207.3	531.6	495.8	441	490.1	6.1	12.1	--	18.2	471.9	31

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

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———————, 1964, West Rutland, Vermont 7.5 Minute Series Quadrangle Map: U.S. Geological Survey Topographic Maps, Photorevised 1972, Contour Interval 20 feet, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File wsi.wsp
T2        Hydraulic analysis for structure RTLCCYRIVR0002   Date: 19-MAY-98
T3        River Street Bridge Crossing Otter Creek, Rutland City, VT        EMB
*         * * This file was generated by AWISPP v3.0.5 * *
*
*          6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           13300.0  16300.0   12300.0   12310.0
SK          0.00250  0.00250   0.00250   0.00250
*
XS    SEC-A       0
GR          -68.5, 498.27    -56.5, 491.35    -28.0, 491.30    -20.0, 490.18
GR           -5.0, 481.62      0.0, 479.44      8.0, 478.74     28.0, 478.41
GR           45.0, 477.98     58.0, 477.72     69.0, 477.06     80.0, 476.74
GR           91.0, 476.76    102.0, 477.08    118.0, 477.05    142.0, 477.10
GR          164.0, 477.28    172.0, 478.79    176.0, 481.73    192.0, 485.84
GR          220.0, 485.94    246.0, 485.94    270.0, 499.09
*
N           0.045        0.050        0.070
SA                 -20.0        192.0
*
EX
ER
```

```
T1        U.S. Geological Survey WSPRO Input File rtlc002.wsp
T2        Hydraulic analysis for structure RTLCCYRIVR0002   Date: 28-OCT-96
T3        River Street Bridge Over Otter Creek in Rutland City, VT       EMB
*
J1         * * 0.002
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          13300.0  16300.0  12300.0  12310.0
WS         492.87   493.95   492.49   492.49
*
XS   WEIR    44
GR          -77.3, 515.48    -55.3, 502.33    -38.0, 495.66     -25.2, 494.96
GR          -13.4, 491.91      0.0, 491.51      0.4, 490.22       8.7, 489.68
GR            9.4, 485.58    184.8, 485.70    185.6, 492.33     210.6, 492.69
GR          278.7, 495.69    300.7, 508.44
*           210.6, 483.69    235.0, 483.69
N             0.06      0.03     0.07
SA                 8.7     185.6
*
XS   SEC-B    205
GR         -143.3, 510.04   -116.0, 498.75    -82.9, 498.14    -63.7, 491.40
GR           -6.8, 490.28     -3.5, 488.95      0.0, 485.94      7.0, 483.94
GR           26.6, 483.46     43.7, 481.42     66.7, 479.18     95.5, 476.92
GR          114.2, 474.82    131.3, 477.50    141.4, 480.76    150.5, 485.98
GR          151.6, 488.06    173.0, 490.42    227.2, 515.44
*
N           0.065        0.052
SA                 -3.5
*
XS   SEC-C   1169  * * *   0.00120
*
*            Confluence of East Creek is just below the EXITX section
*
XS   EXITX   1484           0.
GR          -77.3, 510.48    -55.3, 502.33    -38.0, 495.66    -12.9, 495.29
GR           -1.5, 489.63     -0.7, 486.38      0.0, 482.87     13.5, 480.92
GR           39.7, 480.34     67.9, 480.30     87.3, 482.21    105.1, 485.39
GR          117.7, 486.23    127.8, 490.07    161.6, 492.30    213.1, 494.05
GR          282.3, 493.18    325.7, 492.58    417.6, 491.27    425.8, 498.85
GR          434.6, 499.67
*
N           0.035      0.045        0.07
SA               -12.9        127.8
*
Q           10400.0   12000.0   9770.0   9880.0
*
XS   FULLV   1644  * * *   0.0
*
*             SRD     LSEL    XSSKEW
BR   BRIDG   1644   495.04       0.0
GR            0.0, 494.31      0.2, 493.68      0.4, 486.35      0.8, 478.44
GR           21.8, 475.55     46.0, 476.19     77.0, 479.93    109.0, 483.72
GR          125.0, 478.78    139.1, 475.25    152.7, 481.71    165.2, 486.36
GR          166.8, 488.50    174.2, 490.14    193.7, 490.29    204.6, 490.06
GR          204.9, 494.39    207.2, 494.36    207.3, 495.77    129.1, 495.99
GR          123.0, 495.33      0.0, 494.31
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      40.7 * *     32.6     14.9
N           0.040
PW 0       478.78, 6.1   495.66, 6.1
*
*             SRD    EMBWID   IPAVE
XR   RDWAY   1658      28.0     1
GR         -125.6, 512.89   -110.7, 504.72   -100.0, 504.52    -99.1, 499.85
GR          -85.4, 496.71    -59.8, 497.16     -3.2, 498.62     -3.0, 499.53
GR            0.0, 499.59    123.0, 500.65    126.8, 500.62    203.8, 500.27
GR          207.5, 500.29    207.6, 499.35    340.1, 497.13    490.6, 496.46
GR          570.8, 495.92    610.8, 505.00
*           718.2, 496.61    903.3, 498.88   1111.4, 501.31
*          1366.0, 503.76   1460.5, 504.80
*
*           The section below was surveyed about 290 feet upstream but
*           was modeled at 241 feet upstream with no elevation adjustments
*           due to little or no bed slope between the section and the
*           bridge...
```

```
*
AS   APPRO    1885
GR         -369.3, 512.01   -356.3, 506.68   -356.1, 501.53   -341.2, 496.63
GR         -309.1, 496.21   -295.0, 491.52   -230.3, 489.74   -221.3, 489.48
GR         -141.8, 489.62    -78.0, 488.86    -40.4, 489.63     40.0, 489.89
GR          103.6, 490.98    106.3, 486.34    117.4, 481.30    144.6, 479.83
GR          158.6, 479.00    169.9, 476.54    186.2, 477.51    206.6, 486.18
GR          212.6, 490.73    220.5, 492.65    228.8, 497.35    247.6, 497.35
GR          380.1, 495.13    530.6, 494.46    610.8, 493.92    623.0, 505.00
*
N           0.035        0.045        0.040        0.050
SA                -309.1        103.6        228.8
*
HP 1 BRIDG 495.99 1 495.99
HP 2 BRIDG 495.99 * * 10331
HP 2 RDWAY 496.50 * * 69
HP 1 APPRO 496.56 1 496.56
HP 2 APPRO 496.56 * * 10400
*
HP 1 BRIDG 495.99 1 495.99
HP 2 BRIDG 495.99 * * 10577
HP 2 RDWAY 497.66 * * 1401
HP 1 APPRO 497.96 1 497.96
HP 2 APPRO 497.96 * * 12000
*
HP 1 BRIDG 495.74 1 495.74
HP 2 BRIDG 495.74 * * 9770
HP 1 APPRO 496.02 1 496.02
HP 2 APPRO 496.02 * * 9770
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

         U.S. Geological Survey WSPRO Input File wsi.wsp
         Hydraulic analysis for structure RTLCCYRIVR0002   Date: 19-MAY-98
         River Street Bridge Crossing Otter Creek, Rutland City, VT        EMB
            *** RUN DATE & TIME: 05-21-98  12:57

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

 SEC-A:XS   ******   -16.    2100.  0.67 *****  488.73  483.27  13300.  488.06
         0. ******   250.  265823.  1.07 ***** *******    0.41    6.33
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

         U.S. Geological Survey WSPRO Input File wsi.wsp
         Hydraulic analysis for structure RTLCCYRIVR0002   Date: 19-MAY-98
         River Street Bridge Crossing Otter Creek, Rutland City, VT        EMB
            *** RUN DATE & TIME: 05-21-98  12:57

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

 SEC-A:XS   ******   -18.    2423.  0.77 *****  490.03  484.07  16300.  489.26
         0. ******   252.  325796.  1.09 ***** *******    0.41    6.73
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

         U.S. Geological Survey WSPRO Input File wsi.wsp
         Hydraulic analysis for structure RTLCCYRIVR0002   Date: 19-MAY-98
         River Street Bridge Crossing Otter Creek, Rutland City, VT        EMB
            *** RUN DATE & TIME: 05-21-98  12:57

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

 SEC-A:XS   ******   -16.    1987.  0.64 *****  488.27  482.96  12300.  487.63
         0. ******   249.  245995.  1.07 ***** *******    0.41    6.19
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

         U.S. Geological Survey WSPRO Input File wsi.wsp
         Hydraulic analysis for structure RTLCCYRIVR0002   Date: 19-MAY-98
         River Street Bridge Crossing Otter Creek, Rutland City, VT        EMB
            *** RUN DATE & TIME: 05-21-98  12:57

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

 SEC-A:XS   ******   -16.    1989.  0.64 *****  488.27  482.96  12310.  487.63
         0. ******   249.  246195.  1.07 ***** *******    0.41    6.19
   ER

1  NORMAL  END  OF  WSPRO  EXECUTION.
```

WSPRO OUTPUT FILE (continued)

Ripley dam analysis (sharp crested rectangular weir)

Initial water surface, Q100:	488.06 ft
Initial water surface, Q500:	489.26 ft
Average dam crest elevation:	485.64 ft
Average channel elevation upstream:	479.75 ft
Height of dam, P:	5.89 ft
Tailwater height above dam at Q100, h(t):	2.42 ft
Tailwater height above dam at Q500, h(t):	3.62 ft
Dam crest length, b	185.6 ft
Trial WSI for incipient	487.63 ft
Tailwater height above dam at incipient Q	1.99 ft

Q100 Initial water surface at SEC-B = 492.87

assumed U/S Head h	h/P	C	Q	h(t)/h	k(t)1	k(t)2	k(t)	adjusted Q
5	0.848896	3.59	7440.381	0.484	0.9322	0.8922	0.920112	6845.981
5.1	0.865874	3.59	7677.77	0.47451	0.936471	0.896471	0.925741	7107.623
5.2	0.882852	3.60	7918.141	0.465385	0.940577	0.900577	0.931205	7373.414
5.3	0.89983	3.60	8161.485	0.456604	0.944528	0.904528	0.936515	7643.351
5.4	0.916808	3.61	8407.792	0.448148	0.948333	0.908333	0.941678	7917.432
5.5	0.933786	3.62	8657.052	0.44	0.952	0.912	0.946703	8195.656
5.6	0.950764	3.62	8909.256	0.432143	0.955536	0.915536	0.951597	8478.02
5.7	0.967742	3.63	9164.396	0.424561	0.958947	0.918947	0.956367	8764.524
5.8	0.98472	3.63	9422.465	0.417241	0.962241	0.922241	0.961019	9055.168
5.9	1.001698	3.64	9683.454	0.410169	0.996949	0.965932	0.965985	9354.07
6	1.018676	3.65	9947.356	0.403333	0.999	0.968667	0.969233	9641.307
6.1	1.035654	3.65	10214.16	0.396721	0.980984	0.97082	0.971182	9919.813
6.2	1.052632	3.66	10483.87	0.390323	0.982903	0.972419	0.972971	10200.5
6.3	1.06961	3.67	10756.47	0.384127	0.984762	0.973968	0.97472	10484.54
6.4	1.086587	3.67	11031.96	0.378125	0.986562	0.975469	0.976429	10771.93
6.5	1.103565	3.68	11310.33	0.372308	0.988308	0.976923	0.978102	11062.65
6.6	1.120543	3.68	11591.57	0.366667	0.99	0.978333	0.97974	11356.72
6.7	1.137521	3.69	11875.68	0.361194	0.991642	0.979701	0.981344	11654.12
6.8	1.154499	3.70	12162.66	0.355882	0.993235	0.981029	0.982915	11954.86
6.9	1.171477	3.70	12452.5	0.350725	0.994783	0.982319	0.984456	12258.94
7	1.188455	3.71	12745.19	0.345714	0.996286	0.983571	0.985967	12566.35
7.1	1.205433	3.71	13040.74	0.340845	0.997746	0.984789	0.987451	12877.09
7.2	1.222411	3.72	13339.13	0.336111	0.999167	0.985972	0.988907	13191.16
7.21	1.224109	3.72	13369.13	0.335645	0.999307	0.986089	0.989051	13222.75
7.22	1.225806	3.72	13399.15	0.33518	0.999446	0.986205	0.989195	13254.37
7.23	1.227504	3.72	13429.2	0.334716	0.999585	0.986321	0.989339	13286.03
7.24	1.229202	3.72	13459.29	0.334254	0.999724	0.986436	0.989482	13317.72

Q500 Initial water surface at SEC-B = 493.95

assumed U/S Head h	h/P	C	Q	h(t)/h	k(t)1	k(t)2	k(t)	adjusted Q
7	1.188455	3.71	12745.19	0.517143	0.962286	0.920571	0.928433	11833.06
7.1	1.205433	3.71	13040.74	0.509859	0.965563	0.924577	0.932997	12166.98
7.2	1.222411	3.72	13339.13	0.502778	0.96875	0.928472	0.93743	12504.51
7.3	1.239389	3.73	13640.37	0.49589	0.971233	0.931644	0.941121	12837.24
7.4	1.256367	3.73	13943.49	0.489189	0.973243	0.934324	0.944302	13166.86
7.5	1.273345	3.74	14247.79	0.482667	0.9752	0.936933	0.947393	13498.26
7.6	1.290323	3.74	14554.82	0.476316	0.977105	0.939474	0.950399	13832.89
7.7	1.307301	3.75	14864.58	0.47013	0.978961	0.941948	0.953322	14170.73
7.8	1.324278	3.75	15177.05	0.464103	0.980769	0.944359	0.956166	14511.78
7.9	1.341256	3.76	15492.24	0.458228	0.982532	0.946709	0.958934	14856.03
8	1.358234	3.76	15810.14	0.4525	0.98425	0.949	0.961628	15203.47
8.1	1.375212	3.77	16130.75	0.446914	0.985926	0.951235	0.964251	15554.1
8.2	1.39219	3.78	16454.07	0.441463	0.987561	0.953415	0.966806	15907.9
8.3	1.409168	3.78	16780.09	0.436145	0.989157	0.955542	0.969296	16264.87
8.31	1.410866	3.78	16812.84	0.43562	0.989314	0.955752	0.969542	16300.74

Qio Initial water surface at SEC-B = 492.491

assumed U/S Head h	h/P	C	Q	h(t)/h	k(t)1	k(t)2	k(t)	adjusted Q
6.85	1.162988	3.70	12307.22	0.290511	1.027372	0.997372	1.002262	12335.06
6.847	1.162479	3.70	12298.53	0.290638	1.026872	0.99734	1.002139	12324.83
6.848	1.162649	3.70	12301.43	0.290596	1.026881	0.997351	1.002154	12327.92
6.849	1.162818	3.70	12304.33	0.290553	1.026889	0.997362	1.002169	12331.02
6.85	1.162988	3.70	12307.22	0.290511	1.026898	0.997372	1.002185	12334.11
6.851	1.163158	3.70	12310.12	0.290469	1.026906	0.997383	1.0022	12337.2
6.852	1.163328	3.70	12313.02	0.290426	1.026915	0.997393	1.002215	12340.3
6.853	1.163497	3.70	12315.92	0.290384	1.026923	0.997404	1.00223	12343.39

WSPRO OUTPUT FILE (continued)

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File rtlc002.wsp
        Hydraulic analysis for structure RTLCCYRIVR0002   Date: 28-OCT-96
        River Street Bridge Over Otter Creek in Rutland City, VT       EMB
           *** RUN DATE & TIME: 05-21-98  13:01

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = BRIDG;  SRD =    1644.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     2882.  375621.     0.   440.                           0.
   495.99          2882.  375621.     0.   440.  1.00     0.   207.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = BRIDG;  SRD =    1644.

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.99     0.0   207.3  2882.4  375621.   10331.   3.58

X STA.         0.0       11.7       18.4       24.9       31.3       37.8
  A(I)            187.8      120.7      120.6      120.8      122.5
  V(I)             2.75       4.28       4.28       4.27       4.22

X STA.        37.8       44.3       51.1       58.2       65.9       73.2
  A(I)            120.7      123.8      124.1      129.4      115.4
  V(I)             4.28       4.17       4.16       3.99       4.48

X STA.        73.2       80.6       90.5      102.0      115.0      124.2
  A(I)            111.8      138.9      147.9      158.8      136.3
  V(I)             4.62       3.72       3.49       3.25       3.79

X STA.       124.2      131.0      136.8      142.5      149.7      207.3
  A(I)            119.6      113.5      114.4      124.6      430.8
  V(I)             4.32       4.55       4.52       4.15       1.20

    VELOCITY DISTRIBUTION:  ISEQ =  7;  SECID = RDWAY;  SRD =    1658.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.50   481.6   573.4    25.8     235.      69.   2.68

X STA.       481.6      532.0      535.7      538.9      541.8      544.5
  A(I)              7.6        1.2        1.1        1.1        1.1
  V(I)             0.45       2.80       3.02       3.20       3.26

X STA.       544.5      546.9      549.3      551.4      553.5      553.7
  A(I)              1.0        1.0        1.0        0.9        0.1
  V(I)             3.45       3.49       3.59       3.72      35.38

X STA.       553.7      554.3      556.6      558.8      560.9      562.9
  A(I)              0.3        1.1        1.1        1.1        1.0
  V(I)            11.37       3.12       3.23       3.26       3.35

X STA.       562.9      564.8      566.6      568.4      570.1      573.4
  A(I)              1.0        1.0        1.0        1.0        1.1
  V(I)             3.39       3.47       3.47       3.49       3.05

    CROSS-SECTION PROPERTIES:  ISEQ =  8;  SECID = APPRO;  SRD =    1885.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1        5.      62.    27.    27.                          11.
             2     2720.  316148.   413.   414.                       39621.
             3     1769.  371019.   124.   132.                       37957.
             4      521.   21458.   319.   320.                        3774.
   496.56          5014.  708687.   882.   893.  1.46  -336.   614.  56205.

    VELOCITY DISTRIBUTION:  ISEQ =  8;  SECID = APPRO;  SRD =    1885.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.56  -335.8   613.7  5014.5  708687.   10400.   2.07

X STA.      -335.8     -237.7     -195.6     -153.5     -112.7      -74.4
  A(I)            376.9      293.3      294.4      288.2      288.2
  V(I)             1.38       1.77       1.77       1.80       1.80

X STA.       -74.4      -34.6        8.0       54.0      109.4      121.2
  A(I)            287.0      291.6      306.8      353.0      166.1
  V(I)             1.81       1.78       1.69       1.47       3.13

X STA.       121.2      131.0      140.5      149.3      157.8      165.6
  A(I)            154.6      154.8      147.4      145.5      142.3
  V(I)             3.36       3.36       3.53       3.57       3.66

X STA.       165.6      172.6      179.4      186.3      195.3      613.7
  A(I)            138.5      134.1      132.2      153.4      766.2
  V(I)             3.76       3.88       3.93       3.39       0.68
```

WSPRO OUTPUT FILE (continued)

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File rtlc002.wsp
        Hydraulic analysis for structure RTLCCYRIVR0002   Date: 28-OCT-96
        River Street Bridge Over Otter Creek in Rutland City, VT       EMB
           *** RUN DATE & TIME: 05-21-98  13:01

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = BRIDG;  SRD =    1644.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     2882.  375621.     0.   440.                          0.
   495.99          2882.  375621.     0.   440.  1.00     0.   207.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = BRIDG;  SRD =    1644.

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.99     0.0   207.3  2882.4  375621.   10577.   3.67

X STA.         0.0       11.7       18.4       24.9       31.3       37.8
  A(I)           187.8      120.7      120.6      120.8      122.5
  V(I)            2.82       4.38       4.39       4.38       4.32

X STA.        37.8       44.3       51.1       58.2       65.9       73.2
  A(I)           120.7      123.8      124.1      129.4      115.4
  V(I)            4.38       4.27       4.26       4.09       4.58

X STA.        73.2       80.6       90.5      102.0      115.0      124.2
  A(I)           111.8      138.9      147.9      158.8      136.3
  V(I)            4.73       3.81       3.58       3.33       3.88

X STA.       124.2      131.0      136.8      142.5      149.7      207.3
  A(I)           119.6      113.5      114.4      124.6      430.8
  V(I)            4.42       4.66       4.62       4.24       1.23

    VELOCITY DISTRIBUTION:  ISEQ =  7;  SECID = RDWAY;  SRD =    1658.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.66   -89.5   578.5   288.5    6197.    1401.   4.86

X STA.       -89.5      -76.4      -58.6      392.3      416.0      434.2
  A(I)             9.8       11.3       46.4       19.4       16.5
  V(I)            7.17       6.19       1.51       3.62       4.24

X STA.       434.2      450.0      464.0      476.7      488.1      493.7
  A(I)            15.5       14.7       14.1       13.2        6.7
  V(I)            4.51       4.77       4.95       5.30      10.49

X STA.       493.7      499.9      510.3      520.0      528.8      537.3
  A(I)             7.8       13.5       13.2       12.5       12.7
  V(I)            9.03       5.18       5.31       5.59       5.53

X STA.       537.3      545.1      552.8      560.0      566.9      578.5
  A(I)            12.1       12.1       11.9       11.6       13.5
  V(I)            5.80       5.77       5.88       6.04       5.21

    CROSS-SECTION PROPERTIES:  ISEQ =  8;  SECID = APPRO;  SRD =    1885.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1       52.    2821.    36.    36.                        355.
             2     3298.  435831.   413.   414.                      52895.
             3     1944.  430605.   125.   134.                      43471.
             4     1027.   58562.   386.   388.                       9501.
   497.96          6321.  927819.   960.   972.  1.45  -345.   615.  76479.

    VELOCITY DISTRIBUTION:  ISEQ =  8;  SECID = APPRO;  SRD =    1885.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.96  -345.2   615.2  6320.9  927819.   12000.   1.90

X STA.      -345.2     -246.2     -205.2     -165.1     -124.5      -86.9
  A(I)           456.9      338.7      337.7      340.8      329.2
  V(I)            1.31       1.77       1.78       1.76       1.82

X STA.       -86.9      -49.7       -8.3       33.3       79.7      115.8
  A(I)           330.0      343.9      340.2      360.7      327.2
  V(I)            1.82       1.74       1.76       1.66       1.83

X STA.       115.8      127.4      138.4      148.6      158.3      167.1
  A(I)           196.2      191.5      185.7      179.6      175.1
  V(I)            3.06       3.13       3.23       3.34       3.43

X STA.       167.1      175.2      183.1      192.0      396.7      615.2
  A(I)           172.4      164.7      175.8      634.6      740.0
  V(I)            3.48       3.64       3.41       0.95       0.81
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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File rtlc002.wsp
        Hydraulic analysis for structure RTLCCYRIVR0002   Date: 28-OCT-96
        River Street Bridge Over Otter Creek in Rutland City, VT       EMB
           *** RUN DATE & TIME: 05-21-98  13:01

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = BRIDG;  SRD =    1644.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    2871.  426969.    81.   360.                      97294.
   495.74         2871.  426969.    81.   360.  1.00     0.   207.  97294.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = BRIDG;  SRD =    1644.

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.74     0.0   207.3  2871.1  426969.    9770.   3.40

X STA.         0.0       13.8       20.9       27.9       34.9       41.8
  A(I)           224.4       130.6       130.5       132.0       129.0
  V(I)            2.18        3.74        3.74        3.70        3.79

X STA.        41.8       48.9       56.6       64.8       73.8       84.1
  A(I)           131.2       136.6       137.6       144.0       152.1
  V(I)            3.72        3.58        3.55        3.39        3.21

X STA.        84.1       96.1      110.9      122.3      129.8      135.4
  A(I)           162.2       180.9       157.5       127.6       105.7
  V(I)            3.01        2.70        3.10        3.83        4.62

X STA.       135.4      140.6      146.3      153.4      163.5      207.3
  A(I)           103.9       105.2       110.4       119.8       249.8
  V(I)            4.70        4.64        4.42        4.08        1.96

    CROSS-SECTION PROPERTIES:  ISEQ =  8;  SECID = APPRO;  SRD =    1885.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2    2497.  274440.   412.   413.                      34878.
             3    1703.  349970.   123.   131.                      35973.
             4     357.   12317.   286.   287.                       2265.
   496.02         4557.  636727.   821.   831.  1.46  -309.   613.  50466.

    VELOCITY DISTRIBUTION:  ISEQ =  8;  SECID = APPRO;  SRD =    1885.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.02  -308.5   613.1  4557.0  636727.    9770.   2.14

X STA.      -308.5     -234.2     -190.9     -147.8     -106.5      -68.7
  A(I)           354.8       280.3       277.4       272.3       264.8
  V(I)            1.38        1.74        1.76        1.79        1.84

X STA.       -68.7      -26.6       19.3       66.6      114.0      123.8
  A(I)           277.0       287.4       285.1       305.8       143.2
  V(I)            1.76        1.70        1.71        1.60        3.41

X STA.       123.8      133.1      142.0      150.3      158.4      165.5
  A(I)           141.4       141.4       134.5       135.7       127.2
  V(I)            3.46        3.45        3.63        3.60        3.84

X STA.       165.5      172.1      178.5      185.3      193.1      613.1
  A(I)           126.4       122.8       126.1       135.2       618.2
  V(I)            3.86        3.98        3.87        3.61        0.79
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WSPRO OUTPUT FILE (continued)

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File rtlc002.wsp
        Hydraulic analysis for structure RTLCCYRIVR0002   Date: 28-OCT-96
        River Street Bridge Over Otter Creek in Rutland City, VT       EMB
           *** RUN DATE & TIME: 05-21-98  13:01

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

WEIR :XS   ******   -17.    1327.  1.66 ***** 494.53  491.28  13300.  492.87
       44. ******   215.  229801.  1.06 ***** *******    0.76   10.03

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "SEC-B"     KRATIO =  1.61

SEC-B:XS     161.   -72.    2583.  0.45  0.33  494.86 *******  13300.  494.41
      205.   161.   182.  370464.  1.10  0.00    0.00    0.30    5.15

SEC-C:XS     964.   -73.    2605.  0.45  1.23  496.10 *******  13300.  495.66
     1169.   964.   182.  374821.  1.10  0.00    0.01    0.29    5.11

EXITX:XS     315.   -39.    2849.  0.33  0.32  496.42 *******  10400.  496.09
     1484.   315.   423.  367964.  1.61  0.00    0.00    0.33    3.65

FULLV:FV     160.   -39.    2917.  0.32  0.12  496.55 *******  10400.  496.23
     1644.   160.   423.  377632.  1.62  0.00    0.01    0.32    3.57
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "APPRO"     KRATIO =  1.87

APPRO:AS     241.  -335.    5006.  0.10  0.10  496.65 *******  10400.  496.55
     1885.   241.   614.  707406.  1.46  0.00    0.00    0.19    2.08
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                         WS3N,LSEL =   496.23      495.04

            <<<<<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     160.     0.    2777.  0.22 ***** 496.21  484.04  10331.  495.99
     1644. ******   207.  375621.  1.00 ***** *******    0.18    3.72

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1.   0.   6.  0.800  0.036  495.04 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG    1658.   213.  0.05  0.10  496.61    0.00     69.  496.50

           Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.    20.   -87.   -67.   0.3   0.2   2.8   4.4   0.4   3.0
   RT:    69.    91.   482.   573.   0.6   0.3   2.9   2.7   0.4   3.1

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

APPRO:AS     200.  -336.    5015.  0.10  0.09  496.66  487.12  10400.  496.56
     1885.   226.   614.  708827.  1.46  0.00    0.00    0.19    2.07

       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
   WEIR :XS      44.    -17.   215.  13300.  229801.     1327.   10.03  492.87
   SEC-B:XS     205.    -72.   182.  13300.  370464.     2583.    5.15  494.41
   SEC-C:XS    1169.    -73.   182.  13300.  374821.     2605.    5.11  495.66
   EXITX:XS    1484.    -39.   423.  10400.  367964.     2849.    3.65  496.09
   FULLV:FV    1644.    -39.   423.  10400.  377632.     2917.    3.57  496.23
   BRIDG:BR    1644.      0.   207.  10331.  375621.     2777.    3.72  495.99
   RDWAY:RG    1658.*******     0.     69.        0.*********    1.00  496.50
   APPRO:AS    1885.   -336.   614.  10400.  708827.     5015.    2.07  496.56

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS      FR#    YMIN    YMAX     HF     HO   VHD      EGL     WSEL
   WEIR :XS     491.28     0.76  485.58  515.48************  1.66   494.53   492.87
   SEC-B:XS   ********     0.30  474.82  515.44  0.33  0.00  0.45   494.86   494.41
   SEC-C:XS   ********     0.29  475.98  516.60  1.23  0.00  0.45   496.10   495.66
   EXITX:XS   ********     0.33  480.30  510.48  0.32  0.00  0.33   496.42   496.09
   FULLV:FV   ********     0.32  480.30  510.48  0.12  0.00  0.32   496.55   496.23
   BRIDG:BR     484.04     0.18  475.25  495.99************  0.22   496.21   495.99
   RDWAY:RG   ***************    495.92  512.89  0.05******  0.10   496.61   496.50
   APPRO:AS     487.12     0.19  476.54  512.01  0.09  0.00  0.10   496.66   496.56
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WSPRO OUTPUT FILE (continued)

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File rtlc002.wsp
        Hydraulic analysis for structure RTLCCYRIVR0002   Date: 28-OCT-96
        River Street Bridge Over Otter Creek in Rutland City, VT        EMB
           *** RUN DATE & TIME: 05-21-98  13:01

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

WEIR :XS   ******   -21.    1592.  1.84 *****  495.79  492.14  16300.  493.95
       44. ******   239.  292417.  1.13 ***** *******    0.78   10.24

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "SEC-B"     KRATIO =  1.47

SEC-B:XS     161.   -76.    2882.  0.55  0.34  496.13 ******* 16300.  495.58
      205.   161.   184.  430684.  1.11  0.00    0.00    0.31    5.65

SEC-C:XS     964.   -76.    2938.  0.53  1.34  497.48 ******* 16300.  496.95
     1169.   964.   185.  442171.  1.11  0.00    0.01    0.31    5.55

EXITX:XS     315.   -43.    3499.  0.30  0.30  497.78 ******* 12000.  497.48
     1484.   315.   424.  467877.  1.63  0.00    0.00    0.28    3.43

FULLV:FV     160.   -43.    3554.  0.29  0.10  497.89 ******* 12000.  497.60
     1644.   160.   424.  476983.  1.63  0.00    0.01    0.28    3.38
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  1.92

APPRO:AS     241.  -345.    6252.  0.08  0.08  497.97 ******* 12000.  497.89
     1885.   241.   615.  915165.  1.45  0.00    0.00    0.16    1.92
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   497.60      495.04

            <<<<<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     160.     0.    2777.  0.23 *****  496.22  484.12  10577.  495.99
     1644. ******   207.  375621.  1.00 ***** *******    0.18    3.81

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1.   0.   6.  0.800  0.036  495.04 ****** ****** ******

   XSID:CODE     SRD   FLEN    HF    VHD     EGL      ERR       Q    WSEL
  RDWAY:RG     1658.   213.  0.04  0.08  498.00     0.00    1401.  497.66

             Q    WLEN    LEW     REW   DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
  LT:     122.    49.    -90.    -41.    0.9   0.5   4.3   4.8   0.9   3.1
  RT:    1279.   270.    309.    578.    1.7   1.0   5.4   4.9   1.3   3.1

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

APPRO:AS     200.  -345.    6319.  0.08  0.08  498.04  487.82  12000.  497.96
     1885.   231.   615.  927512.  1.45  0.00    0.00    0.16    1.90

       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
  WEIR :XS       44.   -21.   239.  16300.  292417.     1592.   10.24  493.95
  SEC-B:XS      205.   -76.   184.  16300.  430684.     2882.    5.65  495.58
  SEC-C:XS     1169.   -76.   185.  16300.  442171.     2938.    5.55  496.95
  EXITX:XS     1484.   -43.   424.  12000.  467877.     3499.    3.43  497.48
  FULLV:FV     1644.   -43.   424.  12000.  476983.     3554.    3.38  497.60
  BRIDG:BR     1644.     0.   207.  10577.  375621.     2777.    3.81  495.99
  RDWAY:RG     1658.*******   122.   1401.******************    1.00  497.66
  APPRO:AS     1885.  -345.   615.  12000.  927512.     6319.    1.90  497.96

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

 SECOND USER DEFINED TABLE.

   XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
  WEIR :XS     492.14    0.78  485.58  515.48************  1.84  495.79  493.95
  SEC-B:XS   ********    0.31  474.82  515.44  0.34  0.00  0.55  496.13  495.58
  SEC-C:XS   ********    0.31  475.98  516.60  1.34  0.00  0.53  497.48  496.95
  EXITX:XS   ********    0.28  480.30  510.48  0.30  0.00  0.30  497.78  497.48
  FULLV:FV   ********    0.28  480.30  510.48  0.10  0.00  0.29  497.89  497.60
  BRIDG:BR     484.12    0.18  475.25  495.99************  0.23  496.22  495.99
  RDWAY:RG   ***************  495.92  512.89  0.04******  0.08  498.00  497.66
  APPRO:AS     487.82    0.16  476.54  512.01  0.08  0.00  0.08  498.04  497.96
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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File rtlc002.wsp
        Hydraulic analysis for structure RTLCCYRIVR0002   Date: 28-OCT-96
        River Street Bridge Over Otter Creek in Rutland City, VT       EMB
           *** RUN DATE & TIME: 05-21-98  13:01

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

WEIR :XS   ******   -16.    1241.  1.59 *****  494.08  491.01  12300.  492.49
       44. ******   197.  209548.  1.04 ***** *******    0.74    9.91

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "SEC-B"     KRATIO =  1.67

SEC-B:XS     161.   -71.    2476.  0.42  0.33  494.41 *******  12300.  493.99
      205.   161.   181.  349892.  1.09  0.00    0.00    0.29    4.97

SEC-C:XS     964.   -71.    2487.  0.42  1.18  495.60 *******  12300.  495.19
     1169.   964.   181.  351881.  1.09  0.00    0.01    0.29    4.95

EXITX:XS     315.   -33.    2619.  0.34  0.32  495.93 *******   9770.  495.59
     1484.   315.   422.  335980.  1.58  0.00    0.00    0.35    3.73

FULLV:FV     160.   -38.    2690.  0.33  0.13  496.07 *******   9770.  495.74
     1644.   160.   422.  345575.  1.60  0.00    0.01    0.33    3.63
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  1.86

APPRO:AS     241.  -309.    4596.  0.10  0.10  496.17 *******   9770.  496.07
     1885.   241.   613.  642857.  1.46  0.00    0.00    0.19    2.13
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    495.74     495.04

            <<<<<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     160.     0.    2768.  0.19 *****  495.93  483.83   9779.  495.74
     1644. ******   207.  426972.  1.00 ***** *******    0.17    3.53

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1.   0.   3.  0.800  0.036  495.04 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL    ERR       Q    WSEL
   RDWAY:RG    1658.        <<<<<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     200.  -309.    4556.  0.10  0.08  496.12  486.82   9770.  496.02
     1885.   226.   613.  636513.  1.46  0.00    0.00    0.19    2.14

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   495.97

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   WEIR :XS      44.   -16.   197.  12300.  209548.     1241.    9.91  492.49
   SEC-B:XS     205.   -71.   181.  12300.  349892.     2476.    4.97  493.99
   SEC-C:XS    1169.   -71.   181.  12300.  351881.     2487.    4.95  495.19
   EXITX:XS    1484.   -33.   422.   9770.  335980.     2619.    3.73  495.59
   FULLV:FV    1644.   -38.   422.   9770.  345575.     2690.    3.63  495.74
   BRIDG:BR    1644.     0.   207.   9779.  426972.     2768.    3.53  495.74
   RDWAY:RG    1658.**************      0.        0.        0.    1.00********
   APPRO:AS    1885.  -309.   613.   9770.  636513.     4556.    2.14  496.02

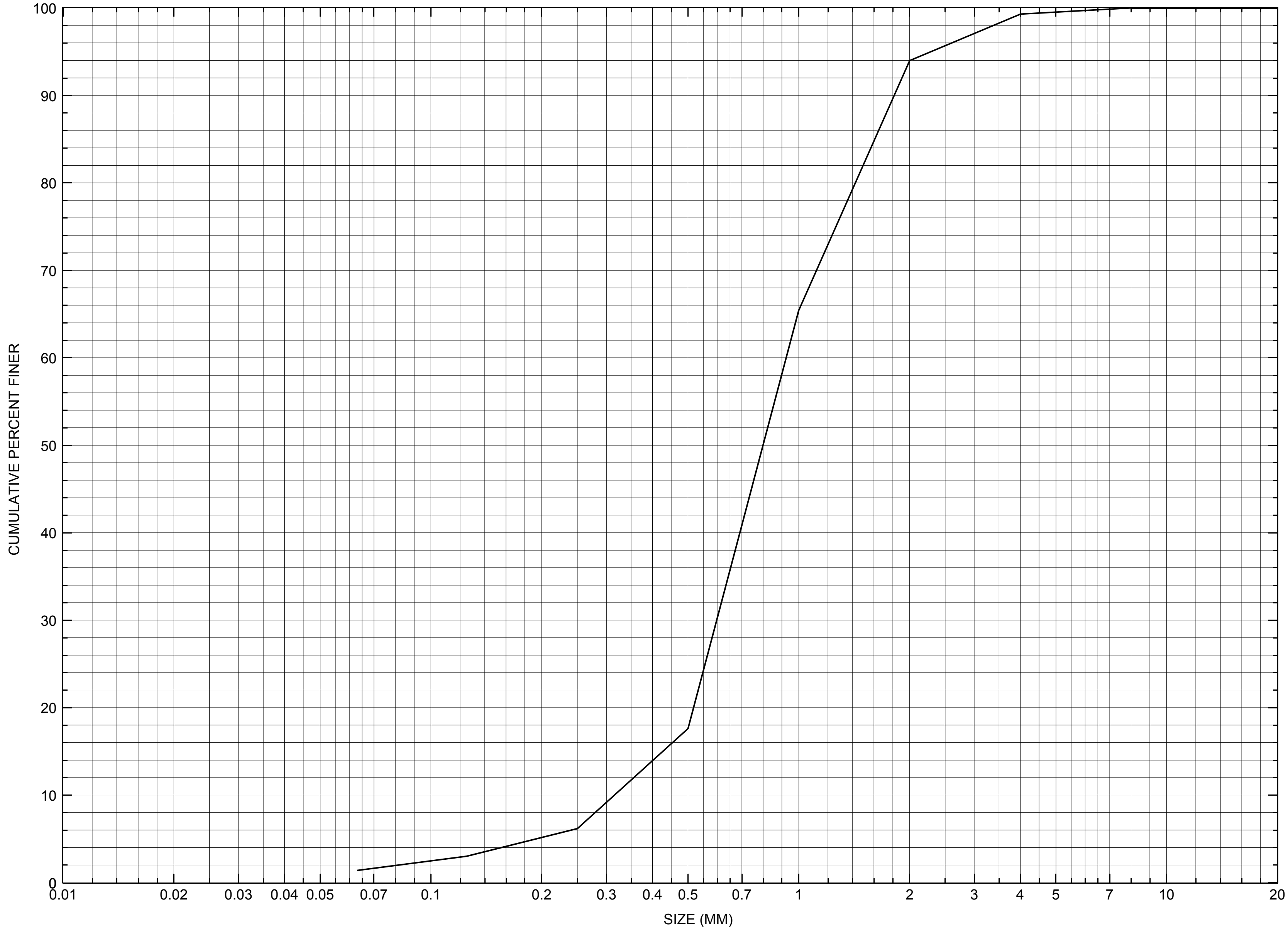
    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS  **********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX     HF     HO   VHD      EGL    WSEL
   WEIR :XS    491.01    0.74  485.58  515.48************  1.59  494.08  492.49
   SEC-B:XS  ********    0.29  474.82  515.44  0.33  0.00  0.42  494.41  493.99
   SEC-C:XS  ********    0.29  475.98  516.60  1.18  0.00  0.42  495.60  495.19
   EXITX:XS  ********    0.35  480.30  510.48  0.32  0.00  0.34  495.93  495.59
   FULLV:FV  ********    0.33  480.30  510.48  0.13  0.00  0.33  496.07  495.74
   BRIDG:BR    483.83    0.17  475.25  495.99************  0.19  495.93  495.74
   RDWAY:RG  ****************  495.92  512.89************  0.10  496.07********
   APPRO:AS    486.82    0.19  476.54  512.01  0.08  0.00  0.10  496.12  496.02
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure RTLCCYRIVR0002, in Rutland City, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number RTLCCYRIVR0002

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 14 / 95

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

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

Town *(FIPS place code; I - 4; nnnnn)* 61225

Mile marker *(I - 11; nnn.nnn)* 000030

Waterway *(I - 6)* OTTER CREEK

Road Name *(I - 7)*: RIVER STREET

Route Number -

Vicinity *(I - 9)* -

Topographic Map Rutland

Hydrologic Unit Code: 02010002

Latitude *(I - 16; nnnn.n)* 43360

Longitude *(i - 17; nnnnn.n)* 72595

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20305200021119

Maintenance responsibility *(I - 21; nn)* 04

Maximum span length *(I - 48; nnnn)* 0127

Year built *(I - 27; YYYY)* 1928

Structure length *(I - 49; nnnnnn)* 000210

Average daily traffic, ADT *(I - 29; nnnnnn)* 004190

Deck Width *(I - 52; nn.n)* 280

Year of ADT *(I - 30; YY)* 89

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

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

Waterway adequacy *(I - 71; n)* 8

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

Underwater Inspection Frequency *(I - 92B; XYY)* Y12

Structure type *(I - 43; nnn)* 310

Year Reconstructed *(I - 106)* 1974

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

Clear span (*nnn.n ft*) -

Number of spans *(I - 45; nnn)* 002

Vertical clearance from streambed (*nnn.n ft*) 010.0

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

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

Comments:

The structural inspection report of 9/20/94 indicates the structure is a two span steel thru-truss type bridge. The left abutment wall reportedly has areas of heavy concrete scaling and its wingwalls have areas of cracking, scaling, and spalling on the tops. The solid shaft pier has areas of cracking, heavy scaling and spalling reported, particularly at the upstream side. The scaling is particularly evident at the flow line. As on the left, the right abutment wall and its wingwalls have areas of cracking and heavy scaling reported. The channel makes a sharp bend into the structure opening. A sand bar is noted on the right bank under the bridge and extends partly downstream. Debris build-up, consisting mainly of **(Continued, page 34)**

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:
limbs on and around the pier, is reported. Some scour is noted on the report but it also mentioned that the water was too deep to ascertain if there was any undermining evident at the time of the inspection.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **244.26** mi^2 Lake/pond/swamp area **1.85** mi^2
Watershed storage *(ST)* **0.8** %
Bridge site elevation **520** ft Headwater elevation **3051** ft
Main channel length **35.26** mi
10% channel length elevation **530** ft 85% channel length elevation **711** ft
Main channel slope *(S)* **6.85** ft / mi

Watershed Precipitation Data

Average site precipitation - in Average headwater precipitation - in
Maximum 2yr-24hr precipitation event *(I24,2)* - in
Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? **Y** *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: **-** / **1928**

Project Number **Dorr bridge** Minimum channel bed elevation: **~498.0**

Low superstructure elevation: USLAB **531.0** DSLAB **531.0** USRAB **531.58** DSRAB **531.58**

Benchmark location description:

No bench marks shown on the plans.

-

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

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

If 1: Footing Thickness _______ Footing bottom elevation: ______

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

If 3: Footing bottom elevation: ______

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

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

Briefly describe material at foundation bottom elevation or around piles:

***The right abutment piles are an assumed length of 35 feet.The left abutment piles are an assumed length of 25 feet. The pier piles are an assumed length of 40 feet. Piles are shown as set 1 foot into the base of all footings.**

Borings 2 and 3 were 61 feet behind the upstream end of the right abutment. Boring 1 was nearest the pier with a gravel and coarse sand with clay (hard pan) at elevation 477.7; piles may penetrate 5 feet into this material. Boring 4 was centered below the left abutment footing hitting a difficult to penetrate gravel layer 20 feet below the channel bed at elevation 491.5; piles may penetrate 5 feet into this material.

Comments:

The footing bottom elevations are 511.5 for the left and 511.08 for the right abutment both having a 3 foot thick base. The pier has a footing bottom elevation "at least" 511.35 with a 3 foot thick base. The bridge seat on the pier is at elevation 532.0. The pier footing is 35.5 feet long and 10.5 feet wide. The pier has a tapered design 5 feet longer (32 feet long) at the base with a bridge seat pier length of 27 feet.

The bridge plans marked SSAB - 8406 of 1974 are for proposed improvements to the deck.

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 chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

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

Comments: NO CROSS SECTION INFORMATION

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 4/11/96
Computerized by: EW Date: 4/16/96
Reviewd by: EMB Date: 8/12/98

Structure Number RTLCCYRIUR0002

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* E. BOEHMLER Date *(MM/DD/YY)* 10 / 17 / 1996

2. Highway District Number 03 Mile marker 000030

County RUTLAND (021) Town CITY OF RUTLAND (61225)

Waterway *(I - 6)* OTTER CREEK Road Name RIVER STREET

Route Number - Hydrologic Unit Code: 02010002

3. Descriptive comments:

Located at the intersection of Dorr Street and River Street. Laura Medalie Assisted with this assessment.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 RBUS 2 LBDS 6 RBDS 6 Overall 6
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

5. Ambient water surface... US 1 UB 1 DS 1 *(**1**- pool; **2**- riffle)*

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

7. Bridge length 210 *(feet)* Span length 127 *(feet)* Bridge width 28 *(feet)*

Road approach to bridge:

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

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

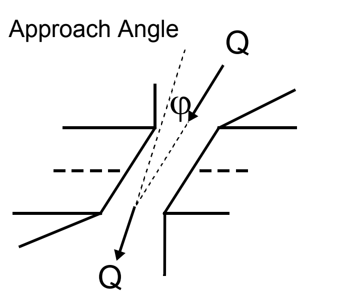
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

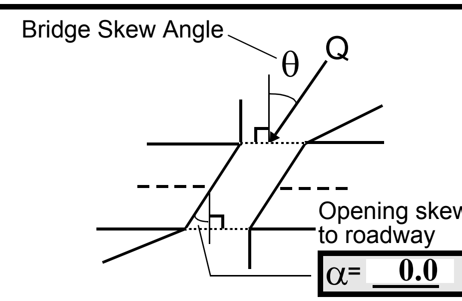
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	1	2
RBUS	0	-	1	2
RBDS	0	-	0	0
LBDS	0	-	0	0

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

Channel approach to bridge (BF):

15. Angle of approach: 50 16. Bridge skew: 10





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 300 feet US *(US, UB, DS)* to 125 feet US

Channel impact zone 2: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 3
Range? 85 feet US *(US, UB, DS)* to 0 feet DS

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

18. Bridge Type: 4/ 1a

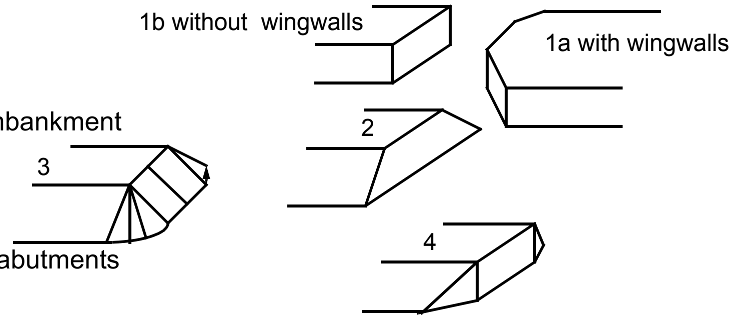
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

#4: USLB - surface cover is pasture except for a narrow (20 feet) strip of trees along the bank edge. This strip of trees widens at the upstream end of tree section. Additionally, Dorr Drive and then forest area exists beyond pasture area.

USRB - surface cover is suburban. This area also has a narrow strip of trees along the bank. There are lawns and houses beyond this strip of trees.

DSRB - surface cover is forest. However, it eventually opens to ball fields and other suburban sprawl coverage.

DSLB - surface cover is shrubs and brush. This area also forms a road embankment for River Street which bisects this area. Beyond River Street is forest, yet one visible house dwells high-up on the hilltop.

#7: values from VTAOT; measured values during survey - bridge length = 210 feet; bridge span = 125 feet; bridge width = 28 feet.

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
276.5	**4.5**			**4.5**	**4**	**3**	**213**	**213**	**2**	**2**

23. Bank width **55.0** 24. Channel width **30.0** 25. Thalweg depth **125.5** 29. Bed Material **213**

30 .Bank protection type: LB **0** RB **1** 31. Bank protection condition: LB **-** RB **1**

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

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

The channel throughout area where bridge is located is pooled, murky, black, deep, and meandering. The channel impacts on the USRB which is the road approach embankment. Then, the channel makes a sharp right bend just US of the bridge and passes through at an angle to the substructure (abutments and pier). The thalweg varies from 4 feet in straight sections to 11 feet at the bends of the channel. The stone fill is present where the channel impacts road approach below the water surface on the USRB.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **410** 35. Mid-bar width: **42**

36. Point bar extent: **490** feet **US** (US, UB) to **375** feet **US** (US, UB, DS) positioned **0** %LB to **40** %RB

37. Material: **213**

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

This point bar is submerged on LBUS due to pooled water by the dam 0.3 mile downstream of 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: **250** 42. Cut bank extent: **455** feet **US** (US, UB) to **85** 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.):

An additional cut-bank is present on LB from 85 feet US to 75 feet DS. The downstream portion is along the road approach embankment.

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

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

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

NO CHANNEL SCOUR

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
114.0		9.5		1	7	213	-

58. Bank width (BF) **-** 59. Channel width **-** 60. Thalweg depth **90.0** 63. Bed Material **0**

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

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

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

213

The native bank material on RBDS extends upstream under the bridge to about the upstream face where the right bank material is only a strip of two feet (width) along the edge of the upstream side of the RABUT. The bridge has one pier situated more to the right bank side of the channel such that the left span is longer than the right. Flow impacts the pier and the LABUT at a relatively large angle.

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

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

2

The angle of this channel to the bridge promotes debris build-up along the right bank face of the pier and the bend in the channel here may result in debris and ice build-up on the left bank just upstream of the bridge and the right bank under the bridge. The channel meanders through the valley.

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		**10**	**90**	**2**	**2**	**1.5**	**2**	**90.0**
RABUT	**1**	**-**	**90**			**0**	**0**	**207.5**

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

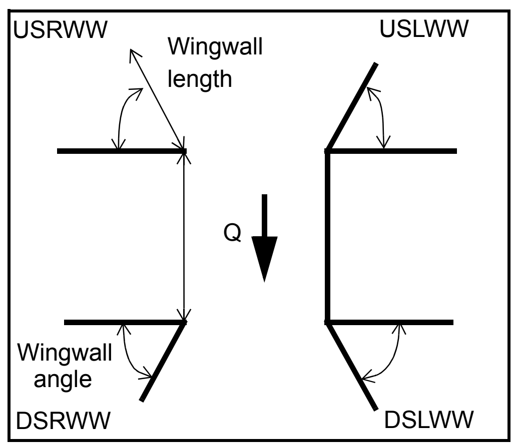
1

The right abutment has a natural bank in front of it with no protection. Probing with a range pole, the streambed is 2-2.5 feet below the top of the footing. It is difficult to detect undermining but it is possible since the streambed material along the edge of the footing is silt with some sand. The footings are about three feet thick according to the historical form. Footings may be undermined during floods.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**207.5**	
USRWW:	**Y**		**1**		**0**	**11.0**	
DSLWW:	**0**		**0**		**Y**	**35.5**	
DSRWW:	**1**		**0**		**0**	**33.0**	

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**	**0**	**Y**	**0**	**-**	**-**	**-**	**-**
Condition	**Y**	**0**	**1**	**0**	**-**	**-**	**-**	**-**
Extent	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**-**

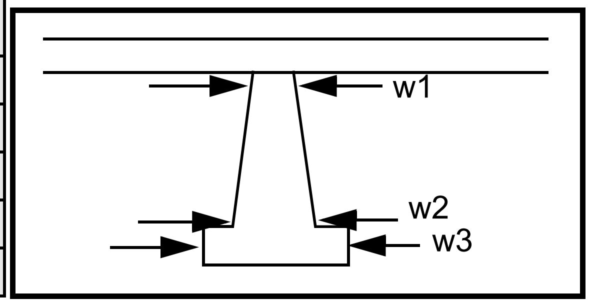
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1		**8.5**		**50.0**	**15.0**	**25.5**
Pier 2				**15.0**	**26.0**	**45.0**
Pier 3		**4.64**	**-**	**11.5**	**497.83**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**e wing-**	**a com-**	**place**		*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**walls**	**bina-**	**arou**		***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**are**	**tion**	**nd**		***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**vir-**	**of**	**all**		***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**tuall**	**nativ**	**wing**	**Y**	*Y- yes; N- no*
91. Attack ∠ (BF)	**y**	**e**	**walls**	**MC**	
92. Pushed	**unpr**	**mate**	**.**	**R**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**otect**	**rial**		**1**	
95. Cross-members	**ed.**	**and**		**2**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**Ther**	**road**		**3**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**e is**	**way**		**N**	
98. Exposure depth	**only**	**fill in**		**40**	

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

LB
1
0
0
0
0

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 - ____ Thalweg depth - ____ Bed Material ____

Bank protection type (Qmax): LB ____ RB ____ Bank protection condition: LB ____ RB ____

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

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

101. Is a drop structure present? ____ *(Y or N, if N type ctrl-n ds)* 102. Distance: - ____ feet

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

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

The pier has stone fill around the base on the right bank side and its nose. A point bar has developed along the downstream half of the left bank side of the pier and is submerged. Debris (whole trees) have lodged on the

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

Point bar extent: side feet of (US, UB, DS) to the feet pie (US, UB, DS) positioned r. %LB to _____ %RB

Material: _____

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

Is a cut-bank present? _____ (Y or if N type ctrl-n cb) Where? 2 (LB or RB) Mid-bank distance: 4

Cut bank extent: 213 feet 213 (US, UB, DS) to 2 feet 2 (US, UB, DS)

Bank damage: 213 (1- eroded and/or creep; 2- slip failure; 3- block failure)

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

0

0

-

-

Is channel scour present? Th (Y or if N type ctrl-n cs) Mid-scour distance: e

Scour dimensions: Length dow Width nstre Depth: am Positioned cha %LB to nne %RB

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

l is straight and then bends left slightly about 300 feet downstream.

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

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

1- Constructed
2- Stable
3- Aggraded
4- Degraded
5- Laterally unstable
6- Vertically and laterally unstable

108. Evolution comments *(Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors)*:

N

-

NO DROP STRUCTURE

Y

35

60

28

DS

109. G. Plan View Sketch

point bar (pb)	debris	flow (Q)	stone wall
cut-bank (cb)	rip rap or stone fill	cross-section	other wall
scour hole		ambient channel	

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: RTLCCYRIVR0002 Town: Rutland City
Road Number: River Street County: Rutland
Stream: Otter Creek

Initials EMB Date: 8/12/98 Checked: RHF

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 Davis, 1995, p. 28, eq. 16)

Approach Section Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	10400	12000	9770
Main Channel Area, ft2	1769	1944	1703
Left overbank area, ft2	2725	3350	2497
Right overbank area, ft2	521	1027	357
Top width main channel, ft	124	125	123
Top width L overbank, ft	440	449	412
Top width R overbank, ft	319	386	286
D50 of channel, ft	0.002622	0.002622	0.002622
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	14.3	15.6	13.8
y1, average depth, LOB, ft	6.2	7.5	6.1
y1, average depth, ROB, ft	1.6	2.7	1.2
Total conveyance, approach	708687	927819	636727
Conveyance, main channel	371019	430605	349970
Conveyance, LOB	316210	438652	274440
Conveyance, ROB	21458	58562	12317
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	5444.7	5569.3	5370.0
Ql, discharge, LOB, cfs	4640.4	5673.3	4211.0
Qr, discharge, ROB, cfs	314.9	757.4	189.0
Vm, mean velocity MC, ft/s	3.1	2.9	3.2
Vl, mean velocity, LOB, ft/s	1.7	1.7	1.7
Vr, mean velocity, ROB, ft/s	0.6	0.7	0.5
Vc-m, crit. velocity, MC, ft/s	2.4	2.4	2.4
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	1	1	1

Live-Bed Contraction Scour

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

Characteristic	Approach 100 yr	Approach 500 yr	Approach Other Q	Bridge 100 yr	Bridge 500 yr	Bridge Other Q
Q1, discharge, cfs	10400	12000	9770	10331	10577	9770
Total conveyance	708687	927819	636727	375621	375621	426969
Main channel conveyance	371019	430605	349970	375621	375621	426969
Main channel discharge	5445	5569	5370	10331	10577	9770
Area - main channel, ft2	1769	1944	1703	2777	2777	2768
(W1) channel width, ft	124	125	123	207.3	207.3	207.3
(Wp) cumulative pier width, ft	0	0	0	6.1	6.1	6.1
W1, adjusted bottom width(ft)	124	125	123	201.2	201.2	201.2
D50, ft	0.002622	0.002622	0.002622			
w, fall velocity, ft/s (p. 32)	0.3872	0.3872	0.3872			
y, ave. depth flow, ft	14.27	15.55	13.85	13.80	13.80	13.76
S1, slope EGL	0.00041	0.00033	0.00041			
P, wetted perimeter, MC, ft	132	134	131			
R, hydraulic Radius, ft	13.402	14.507	13.000			
V*, shear velocity, ft/s	0.421	0.393	0.414			
V*/w	1.086	1.014	1.070			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0.64	0.64	0.64			
y2,depth in contraction, ft	18.12	19.87	16.88			
ys, scour depth, ft (y2-y_bridge)	**4.32**	**6.07**	**3.12**			

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 Davis, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	10400	12000	9770
(Q) discharge thru bridge, cfs	10331	10577	9770
Main channel conveyance	375621	375621	426969
Total conveyance	375621	375621	426969
Q2, bridge MC discharge,cfs	10331	10577	9770
Main channel area, ft2	2777	2777	2768
Main channel width (normal), ft	207.3	207.3	207.3
Cum. width of piers in MC, ft	6.1	6.1	6.1
W, adjusted width, ft	201.2	201.2	201.2
y_bridge (avg. depth at br.), ft	13.80	13.80	13.76
Dm, median (1.25*D50), ft	0.003278	0.003278	0.003278
y2, depth in contraction,ft	18.56	18.94	17.69
ys, scour depth (y2-ybridge), ft	4.76	5.14	3.94

Pressure Flow Scour (contraction scour for orifice flow conditions)

Chang pressure flow equation Hb+Ys=Cq*qbr/Vc
Cq=1/Cf*Cc Cf=1.5*Fr^0.43 (<=1) Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
Umbrell pressure flow equation
(Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031
(Richardson and Davis, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	10400	12000	9770
Q, thru bridge MC, cfs	10331	10577	9770
Vc, critical velocity, ft/s	2.41	2.44	2.40
Va, velocity MC approach, ft/s	3.08	2.86	3.15
Main channel width (normal), ft	207.3	207.3	207.3
Cum. width of piers in MC, ft	6.1	6.1	6.1
W, adjusted width, ft	201.2	201.2	201.2
qbr, unit discharge, ft2/s	51.3	52.6	48.6
Area of full opening, ft2	2777.0	2777.0	2768.0
Hb, depth of full opening, ft	13.80	13.80	13.76
Fr, Froude number, bridge MC	0.18	0.18	0.17
Cf, Fr correction factor (<=1.0)	0.72	0.72	0.70
**Area at downstream face, ft2	0	0	0
**Hb, depth at downstream face, ft	0.00	0.00	0.00
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	495.04	495.04	495.04
Elevation of Bed, ft	481.24	481.24	481.28
Elevation of Approach, ft	496.56	497.96	496.02
Friction loss, approach, ft	0.09	0.08	0.08
Elevation of WS immediately US, ft	496.47	497.88	495.94
ya, depth immediately US, ft	15.23	16.64	14.66
Mean elevation of deck, ft	498.98	498.98	498.98
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.98	0.95	0.98
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	16.65	17.64	15.65
Ys, scour w/Umbrell equation, ft	5.67	6.39	5.31

**=for UNsubmerged orifice flow using estimated downstream bridge face properties.

**Ys, scour w/Chang equation, ft	N/A	N/A	N/A
**Ys, scour w/Umbrell equation, ft	N/A	N/A	N/A

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	18.12	19.87	16.88
WSEL at downstream face, ft	--	--	--
Depth at downstream face, ft	0.00	0.00	0.00
Ys, depth of scour (Laursen), ft	N/A	N/A	N/A

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and Davis, 1995, p. 48, eq. 28)

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	10400	12000	9770	10400	12000	9770
a', abut.length blocking flow, ft	335.8	345.2	308.5	339	407.9	305.2
Ae, area of blocked flow ft2	2064.8	2515.9	1893.2	714.2	1067.9	590.7
Qe, discharge blocked abut.,cfs	3542.4	--	3214.1	--	--	466.7
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.72	1.70	1.70	0.68	0.87	0.79
ya, depth of f/p flow, ft	6.15	7.29	6.14	2.11	2.62	1.94
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.122	0.110	0.121	0.088	0.085	0.100
ys, scour depth, ft	**23.86**	**25.83**	**23.09**	**10.02**	**12.11**	**9.73**

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and Davis, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	335.8	345.2	308.5	339	407.9	305.2
y1 (depth f/p flow, ft)	6.15	7.29	6.14	2.11	2.62	1.94
a'/y1	54.61	47.36	50.27	160.91	155.80	157.69
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.12	0.11	0.12	0.09	0.09	0.10
Ys w/ corr. factor K1/0.55:						
vertical	22.33	25.58	22.22	6.87	8.44	6.59
vertical w/ ww's	18.31	20.98	18.22	5.63	6.92	5.40
spill-through	12.28	14.07	12.22	3.78	4.64	3.62

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.18	0.18	0.17	0.18	0.18	0.17
y, depth of flow in bridge, ft	13.80	13.80	13.76	13.80	13.80	13.76
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	0.28	0.28	0.25	0.28	0.28	0.25
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR

Pier Scour

ys/y1=2.0*K1*K2*K3*K4*(a/y1)^0.65*Fr1^0.43
(Richardson and Davis, 1995, p. 36, eq. 21)

K1, corr. factor for pier nose shape
Sharp nose, 0.9; round nose, cylinder, or cylinder grp., 1.0; square nose, 1.1

K2, corr. factor attack angle (see Table 3, p 37)
K2=[cos(attackangle)+L/a*sin(attackangle)]^0.65

K3, corr. factor for bed condition
Clear-water, plane bed, antidune, 1.1; med. dunes, 1.1-1.2 (see Tab.4,p37)

K4, corr. factor for armoring (the following equations are in Si units)
K4=[1-0.89*(1-Vr)^2]^0.5
Vr=(V1-Vi)/(Vc90-Vi)

V1=0.645*((D50/a)^0.053)*Vc50
Vc=6.19*(y^1/6)*(Dc^1/3)

Note for round nose piers:
ys<=2.4 times the pier width (a) for Fr<=0.8
ys<=3.0 times the pier width (a) for Fr>0.8

Pier 1	Q100	Q500	Qother
Pier stationing, ft	126	126	126
Area of WSPRO flow tube, ft2	111.8	111.8	103.9
Skewed width of flow tube, ft	7.4	7.4	5.2
y1, pier approach depth, ft	15.11	15.11	19.98
y1 in meters	4.605	4.605	6.090
V1, pier approach velocity, ft/s	4.6	4.7	4.7
a, pier width, ft	6.1	6.1	6.1
L, pier length, ft	30.5	30.5	30.5
Fr1, Froude number at pier	0.209	0.213	0.185
Pier attack angle, degrees	40	40	40
K1, shape factor	0.9	0.9	0.9
K2, attack factor	2.45	2.45	2.45
K3, bed condition factor	1.1	1.1	1.1
D50, ft	0.002622	0.002622	0.002622
D50, m	0.000799	0.000799	0.000799
D90, ft	0.005955	0.005955	0.005955
D90, m	0.001815	0.001815	0.001815
Vc50,critical velocity(D50),m/s	0.741	0.741	0.776
Vc90,critical velocity(D90),m/s	0.974	0.974	1.020
Vi,incipient velocity,m/s	0.317	0.317	0.332
Vr, velocity ratio	1.652	1.698	1.599
K4, armor factor	0.00	0.00	0.00
ys, scour depth (K4 applicable) ft	ERR	ERR	ERR
ys, scour depth (K4 not applied)ft	20.75	20.94	21.75

Pier rip-rap sizing
D50=0.692(K*V)^2/(Ss-1)*2*g
(Richardson and Davis, 1995, p.115, eq. 83)

Pier-shape coefficient (K), round nose, 1.5; square nose, 1.7
Characteristic avg. channel velocity, V, (Q/A):
(Mult. by 0.9 for bankward piers in a straight, uniform reach,
up to 1.7 for a pier in main current of flow around a bend)

Pier 1	Q100	Q500	Qother
K, pier shape coeff.	1.5	1.5	1.5
V, velocity on pier, ft/s	4.296	4.404	4.08
Used 1.2 to adjust velocity			
D50, median stone diameter, ft	0.27	0.28	0.24