LEVEL II SCOUR ANALYSIS FOR BRIDGE 13 (PFRDTH00030013) ON TOWN HIGHWAY 3, CROSSING FURNACE BROOK, PITTSFORD, VERMONT

U.S. Geological Survey
Open-File Report 97-110

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

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By ROBERT H. FLYNN AND LAURA MEDALIE

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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Denver, CO 80225-0286

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 13 (PFRDTH00030013) ON TOWN HIGHWAY 3, CROSSING FURNACE BROOK, PITTSFORD, VERMONT

By ROBERT H. FLYNN AND LAURA MEDALIE

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure PFRDTH00030013 on Town Highway 3 crossing Furnace Brook, Pittsford, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Taconic section of the New England physiographic province in western Vermont. The 17.1-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is grass along the downstream right bank while the remaining banks are primarily forested.

In the study area, Furnace Brook has an incised, sinuous channel with a slope of approximately 0.03 ft/ft, an average channel top width of 49 ft and an average channel depth of 4 ft. The predominant channel bed material ranges from gravel to bedrock with a median grain size (D_{50}) of 70.2 mm (0.230 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 20, 1995, indicated that the reach was stable.

The Town Highway 3 crossing of Furnace Brook is a 75-ft-long, two-lane bridge consisting of one 72-ft-long steel stringer span (Vermont Agency of Transportation, written communication, March 14, 1995). The bridge is supported by vertical, concrete abutments with spill-through slopes. The channel is skewed approximately 20 degrees to the opening while the opening-skew-to-roadway is 35 degrees. The opening-skew-to-roadway was determined from surveyed data collected at the bridge although, information provided from the VTAOT files, indicates that the opening-skew-to-roadway is 30 degrees (Appendix D).

The scour protection measures at the site included type-2 stone fill (less than 36 inches diameter) on the spill-through slope along each abutment. Type-2 stone fill scour protection was also found along the upstream left wingwall and downstream right wingwall. Type-1 (less than 12 inches diameter) stone fill scour protection was found along the upstream right wingwall and downstream left wingwall. No bank protection was observed downstream or upstream. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 1.2 to 2.0 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 7.8 to 13.1 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution although, bedrock outcropping is apparent both upstream and downstream of this bridge.

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

Proctor, VT. Quadrangle, 1:24,000, 1944
and Chittenden, VT. Quadrangle, 1:24,000, 1961

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 PFRDTH00030013 ***Stream*** Furnace Brook

County Rutland ***Road*** TH2 ***District*** 3

Description of Bridge

Bridge length 75 ***ft*** ***Bridge width*** 27.0 ***ft*** ***Max span length*** 72 ***ft***

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

Abutment type Spill-through ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 6/20/95

Description of stone fill Type-2, on the spill-through slope along each abutment is in good condition.

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

Is bridge skewed to flood flow according to Y ***survey?*** Y ***Angle*** 20

There is a moderate channel bend in the downstream reach and a mild channel bend in the upstream reach.

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	6/20/95	0	0
Level II	6/20/95	0	0

Potential for debris Low.

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

Description of the Geomorphic Setting

General topography The channel is located within a narrow, slightly irregular flood plain with steep valley walls.

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

Date of inspection 6/20/95

DS left: Steep channel bank to a narrow terrace

DS right: Narrow flood plain

US left: Steep valley wall

US right: Moderately sloped overbank

Description of the Channel

Average top width 49.0 *ft* ***Average depth*** 4.0 *ft*

Predominant bed material Bedrock/Cobbles ***Bank material*** Boulder/Cobbles

Sinuous but stable with non-alluvial channel boundaries and little to no flood plain.

6/20/95

Vegetative co Forested.

DS left: Forested along bank with grass on overbank.

DS right: Forested along bank with Town Highway 3 on the overbank.

US left: Forested along bank with grass on overbank.

US right: Y

Do banks appear stable? 6/20/95 ***If not, describe location and type of instability and date of observation.***

None observed

(6/20/95)

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 17.1 ***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? No

-

USGS gage description -

USGS gage number -

Gage drainage area ***mi²***

Is there a lake/p [illegible] No

-

Calculated Discharges

Q100 2,750 ***ft³/s*** ***Q500*** 3,700 ***ft³/s***

The 100- and 500-year discharges are the median of discharge frequency curves which were developed from empirical relationships and extended to the 500-year discharge (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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 Subtract 387 feet from arbitrary survey datum to obtain VTAOT plans' datum within one foot.

Description of reference marks used to determine USGS datum. RM1 is a chiseled "X" on top of the downstream right end of the concrete curbing (elev. 497.20 ft, arbitrary survey datum). RM2 is a chisled "X" on top of the upstream left end of the concrete curbing (elev. 504.00 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT2	-109	1	Exit section at top of waterfall
EXITX	-48	1	Bridge exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	17	1	Bridge road grade section
APPRO	79	2	Modelled Approach section (Templated from APTEM)
APTEM	92	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. The channel "n" value for the reach was 0.065 for all of the sections, and the overbank "n" values ranged from 0.054 to 0.060.

Critical depth at the exit section (EXIT2) located at the top of the waterfall was assumed as the starting water surface.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0299 ft/ft) to establish the modelled approach section (APPRO) one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

For the 100-and 500-year discharges, WSPRO assumes critical depth at the sections downstream of the bridge and at the bridge section. Supercritical models were developed for these discharges. Analyzing both the supercritical and subcritical profiles for each discharge, it can be determined that the water surface profile passes through critical depth within the bridge constriction and is close to or just below critical depth downstream of the bridge. Thus, the assumptions of critical depth are satisfactory solutions.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.7 *ft*
Average low steel elevation 495.9 *ft*

100-year discharge 2,750 *ft^3/s*
Water-surface elevation in bridge opening 492.1 *ft*
Road overtopping? N *Discharge over road* -- *ft^3/s*
Area of flow in bridge opening 218 *ft^2*
Average velocity in bridge opening 12.6 *ft/s*
Maximum WSPRO tube velocity at bridge 16.3 *ft/s*

Water-surface elevation at Approach section with bridge 496.4
Water-surface elevation at Approach section without bridge 493.4
Amount of backwater caused by bridge 3.0 *ft*

500-year discharge 3,700 *ft^3/s*
Water-surface elevation in bridge opening 493.2 *ft*
Road overtopping? N *Discharge over road* -- *ft^3/s*
Area of flow in bridge opening 267 *ft^2*
Average velocity in bridge opening 13.8 *ft/s*
Maximum WSPRO tube velocity at bridge 18.0 */s*

Water-surface elevation at Approach section with bridge 497.8
Water-surface elevation at Approach section without bridge 494.3
Amount of backwater caused by bridge 3.5

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

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the main channel was computed by use of the clear-water scour equation (Richardson and others, 1995, p.32. equation 20). In this case, the 500-year discharge model resulted in the worst case contraction scour with a scour depth of 2.0 ft. Armoring will not impede potential contraction scour.

Abutment scour for the left and right abutments was computed by use of the Froehlich equation (Richardson and others, 1995, p. 48, equation 28). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping. Because scour processes on the spill-through embankment material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, the total scour depths were applied for the entire spill-through embankment below the elevation at the toe of each embankment and extended to the vertical concrete abutment wall as shown in figure 8.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.2	2.0	--
Depth to armoring	19.3	23.4	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	11.8	13.1	--
Right abutment	7.8	9.7	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:			
Left abutment	2.4	2.9	--
Right abutment	2.4	2.9	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

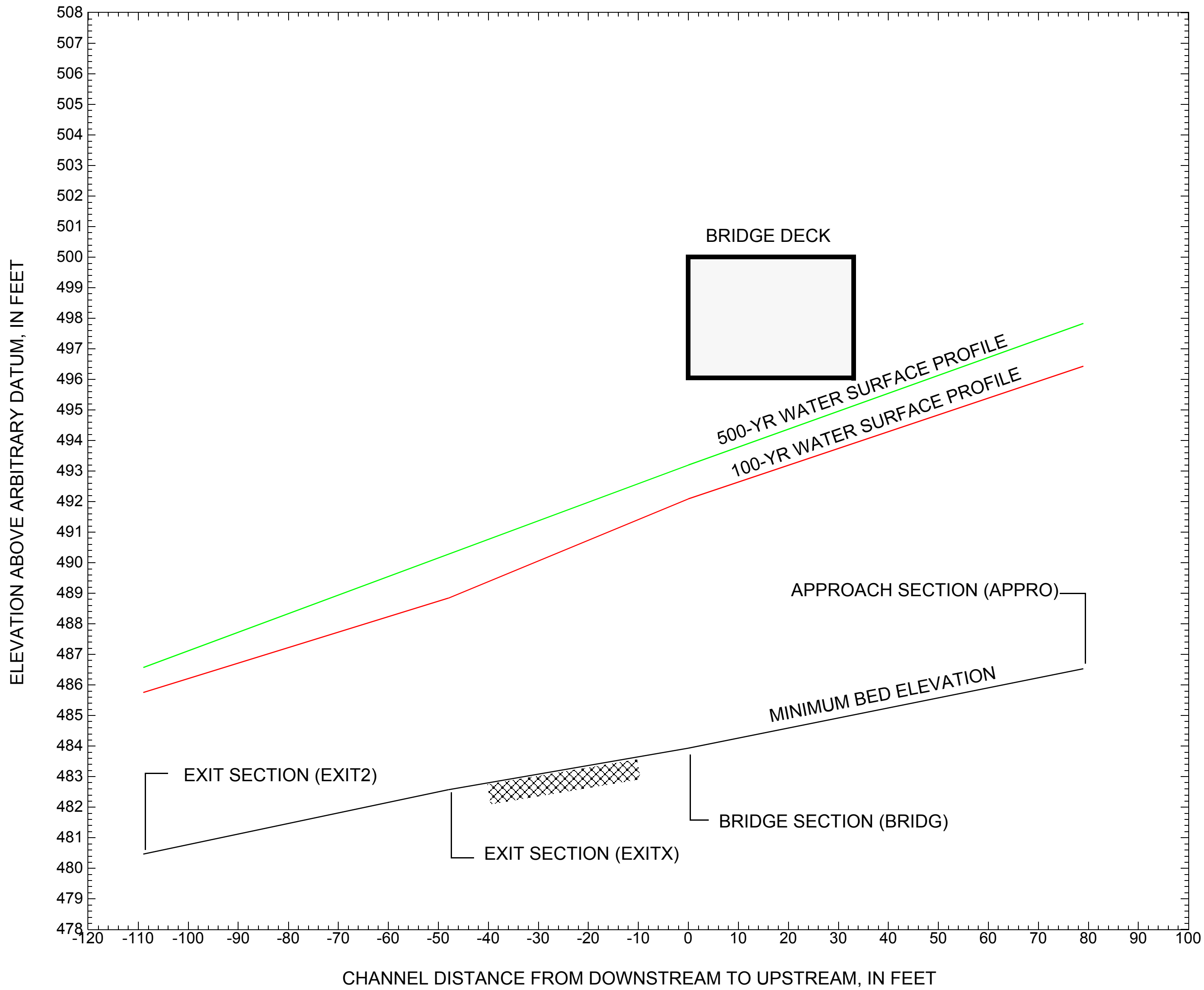

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure PFRDTH00030013 on Town Highway 3, crossing Furnace Brook, Pittsford, Vermont.

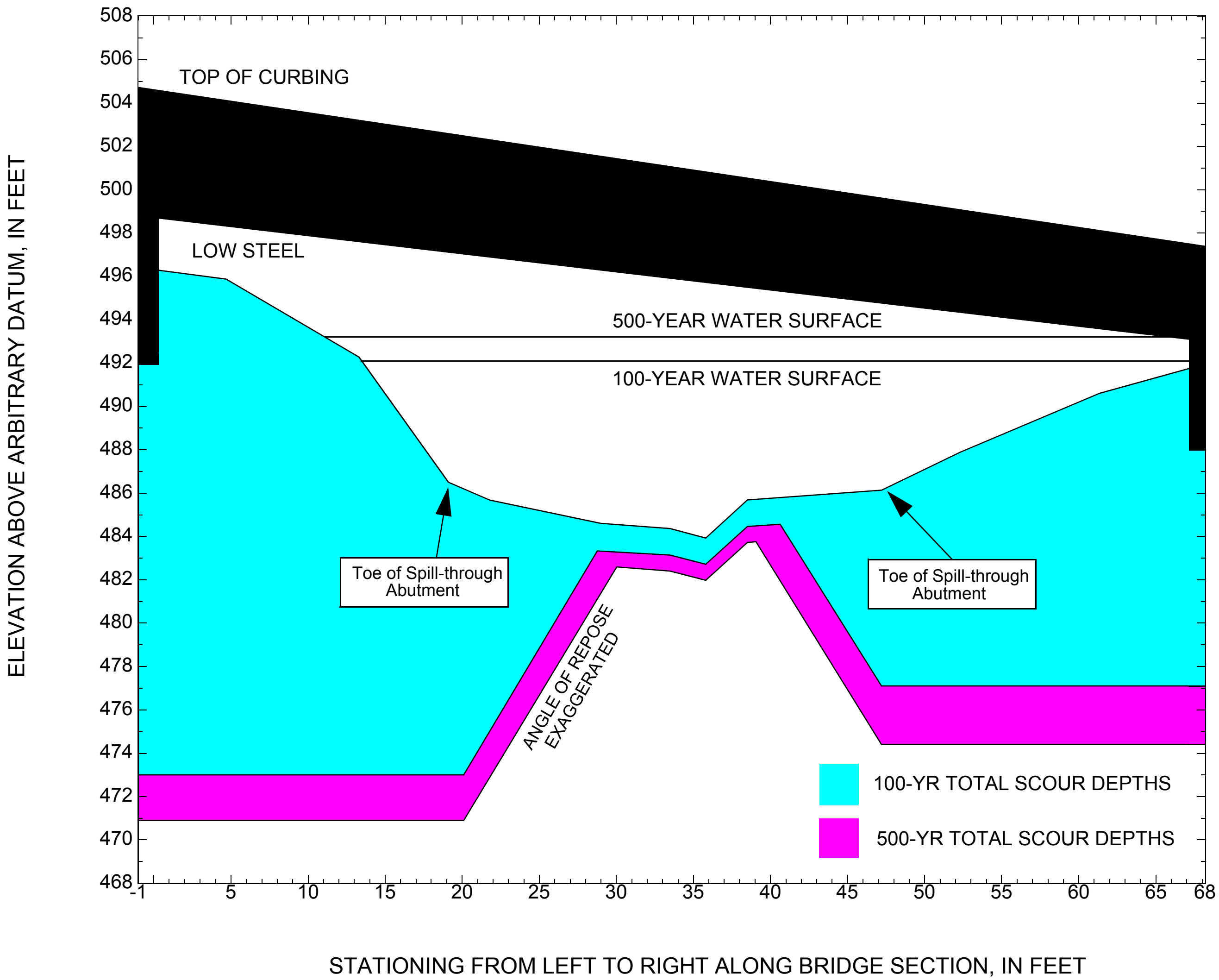

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure PFRDTH00030013 on Town Highway 3, crossing Furnace Brook, Pittsford, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure PFRDTH00030013 on Town Highway 3, crossing Furnace Brook, Pittsford, Vermont.(VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT minimum bridge seat 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-yr. discharge is 2,750 cubic-feet per second											
Left abutment	0.0	112.7	498.7	492	496.3	--	--	--	--	--	-19
Toe of LABUT	19.6	--	--	--	486.0	1.2	11.8	--	13.0	473.0	--
Toe of RABUT	47.7	--	--	--	486.1	1.2	7.8	--	9.0	477.1	--
Right abutment	67.2	105.7	493.1	488	491.7	--	--	--	--	--	-11

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 PFRDTH00030013 on Town Highway 3, crossing Furnace Brook, Pittsford, Vermont. (VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum bridge seat 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-yr. discharge is 3,700 cubic-feet per second											
Left abutment	0.0	112.7	498.7	492	496.3	--	--	--	--	--	-21
Toe of LABUT	19.6	--	--	--	486.0	2.0	13.1	--	15.1	470.9	--
Toe of RABUT	47.7	--	--	--	486.1	2.0	9.7	--	11.7	474.4	--
Right abutment	67.2	105.7	493.1	488	491.7	--	--	--	--	--	-14

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

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APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File pfrd013.wsp
T2        Hydraulic analysis for structure PFRDTH00030013   Date: 30-SEP-96
T3
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2750.0   3700.0
SK          0.0833   0.0833
*
XS   EXIT2    -109          0.
GR          -18.2, 499.66      0.0, 482.20      4.1, 481.15      8.6, 481.56
GR           11.3, 480.46     16.0, 482.70     25.2, 482.00     34.7, 481.53
GR           36.9, 483.06     39.2, 482.57     41.0, 481.00     44.7, 482.09
GR           47.1, 481.09     50.1, 481.96     54.0, 481.14     57.9, 482.01
GR           60.2, 482.51     71.1, 487.59
*
N           0.065
*
XS   EXITX    -48          0.
GR          -57.0, 500.23    -18.2, 499.66      0.0, 497.18     11.0, 489.06
GR           13.2, 485.97     19.6, 484.24     21.9, 483.35     28.3, 483.67
GR           32.3, 483.30     37.9, 482.57     41.5, 482.96     42.1, 482.97
GR           43.7, 484.08     48.4, 484.23     60.3, 486.22     61.3, 489.80
GR           84.5, 489.35
*
N           0.065        0.060
SA                  61.3
*
XS   FULLV      0  * * *   0.0306
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.89      35.0
GR            0.0, 498.69      0.3, 496.28      4.7, 495.87     13.3, 492.28
GR           19.6, 486.00     21.8, 485.67     29.0, 484.60     33.5, 484.36
GR           35.8, 483.93     38.5, 485.68     47.7, 486.13     52.3, 487.88
GR           61.3, 490.59     67.1, 491.75     67.2, 493.09      0.0, 498.69
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV
CD           3      33.6     2.35    499.3
N           0.065
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     17      27.0     1
GR          -63.9, 512.20     -3.0, 503.27     -1.8, 504.71      0.0, 504.61
GR           37.6, 501.48     71.0, 497.49     71.6, 498.16     73.0, 496.19
GR          145.0, 491.97    269.9, 486.86    440.1, 481.89
*
*
XT   APTEM     92           0.
GR          -21.8, 501.73    -13.0, 498.84      0.0, 493.68      5.6, 489.79
GR           20.2, 488.21     27.3, 487.46     30.1, 486.92     36.1, 487.53
GR           42.0, 488.38     47.9, 491.84     56.1, 492.17     67.8, 499.69
GR           89.6, 500.54    100.7, 500.11
*
AS   APPRO     79 * * * 0.0299
GT
N           0.065        0.054
SA                  67.8
*
HP 1 BRIDG     492.09 1 492.09
HP 2 BRIDG     492.09 * * 2750
HP 1 APPRO     496.43 1 496.43
HP 2 APPRO     496.43 * * 2750
*
HP 1 BRIDG     493.20 1 493.20
HP 2 BRIDG     493.20 * * 3700
HP 1 APPRO     497.83 1 497.83
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File pfrd013.wsp
        Hydraulic analysis for structure PFRDTH00030013   Date: 30-SEP-96

           *** RUN DATE & TIME: 11-06-96  08:29
        CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     218.   13513.    44.    49.                         2753.
   492.09          218.   13513.    44.    49.  1.00    13.    67.   2753.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.09    13.5    67.1   217.9   13513.    2750.  12.62

X STA.        13.5       20.2       22.4       24.3       25.9       27.5
  A(I)            18.1       11.5       10.2        9.4        9.1
  V(I)            7.58      11.94      13.50      14.66      15.15

X STA.        27.5       28.9       30.3       31.7       33.0       34.4
  A(I)             8.8        8.6        8.4        8.4        8.5
  V(I)           15.66      15.91      16.29      16.33      16.10

X STA.        34.4       35.7       37.1       38.9       40.8       42.8
  A(I)             8.6        9.4        9.9        9.7       10.1
  V(I)           16.03      14.61      13.94      14.23      13.64

X STA.        42.8       44.8       47.0       49.7       53.6       67.1
  A(I)            10.3       11.0       12.2       14.3       21.3
  V(I)           13.38      12.47      11.23       9.59       6.46


    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      79.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     451.   34057.    71.    76.                         6450.
   496.43          451.   34057.    71.    76.  1.00    -8.    63.   6450.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      79.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.43    -7.9    63.3   451.5   34057.    2750.   6.09

X STA.        -7.9        5.6        9.1       12.2       14.9       17.4
  A(I)            40.7       25.3       23.6       21.5       20.1
  V(I)            3.37       5.42       5.83       6.39       6.83

X STA.        17.4       19.8       22.0       24.1       26.1       28.1
  A(I)            20.0       19.1       18.6       18.8       18.1
  V(I)            6.86       7.19       7.37       7.31       7.60

X STA.        28.1       29.9       31.8       33.7       35.7       37.8
  A(I)            18.0       18.3       18.1       18.8       19.6
  V(I)            7.62       7.52       7.58       7.33       7.03

X STA.        37.8       40.0       42.5       46.0       51.8       63.3
  A(I)            19.9       21.2       24.9       29.3       37.4
  V(I)            6.90       6.50       5.51       4.69       3.68
```

```
        U.S. Geological Survey WSPRO Input File pfrd013.wsp
        Hydraulic analysis for structure PFRDTH00030013   Date: 30-SEP-96

           *** RUN DATE & TIME: 11-06-96  08:29
    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     268.   17984.    45.    53.                         3708.
   493.20          268.   17984.    45.    53.  1.00    11.    67.   3708.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.20    11.1    67.2   267.6   17984.    3700.  13.83

X STA.        11.1       19.9       22.3       24.3       26.1       27.8
  A(I)            23.6       14.4       12.7       11.7       11.5
  V(I)            7.84      12.82      14.56      15.86      16.08

X STA.        27.8       29.3       30.8       32.2       33.7       35.1
  A(I)            10.8       10.6       10.3       10.3       10.5
  V(I)           17.10      17.47      17.90      17.95      17.57

X STA.        35.1       36.5       38.3       40.2       42.1       44.1
  A(I)            10.8       11.8       11.4       11.5       12.2
  V(I)           17.08      15.69      16.23      16.04      15.17

X STA.        44.1       46.2       48.5       51.5       55.7       67.2
  A(I)            12.2       13.3       15.3       16.9       25.6
  V(I)           15.11      13.94      12.10      10.94       7.22


    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      79.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     555.   45545.    77.    82.                         8463.
   497.83          555.   45545.    77.    82.  1.00   -11.    66.   8463.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      79.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.83   -11.4    65.5   555.2   45545.    3700.   6.66

X STA.       -11.4        4.2        8.1       11.3       14.2       16.8
  A(I)            51.1       32.8       28.5       26.6       24.8
  V(I)            3.62       5.64       6.49       6.95       7.45

X STA.        16.8       19.3       21.7       23.9       26.1       28.2
  A(I)            24.2       23.6       23.0       22.8       22.6
  V(I)            7.64       7.84       8.06       8.13       8.20

X STA.        28.2       30.1       32.1       34.2       36.3       38.5
  A(I)            21.9       22.1       22.7       22.5       23.8
  V(I)            8.44       8.38       8.15       8.22       7.77

X STA.        38.5       41.0       43.8       47.8       53.3       65.5
```

```
 A(I)            24.9       26.8       30.4       34.4       45.8
 V(I)            7.42       6.91       6.09       5.37       4.04
```

```
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File pfrd013.wsp
        Hydraulic analysis for structure PFRDTH00030013   Date: 30-SEP-96

           *** RUN DATE & TIME: 11-06-96  08:29

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXIT2":  USED WSI = CRWS.
                            WSI,CRWS =   485.05     485.75

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

EXIT2:XS   ******    -4.     256.  1.79 *****  487.54  485.75   2750.  485.75
     -109. ******    67.   13226.  1.00 ***** *******    1.00   10.74

 ===125 FR# EXCEEDS FNTEST AT SECID "EXITX":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.20     488.32     488.84

 ===110 WSEL NOT FOUND AT SECID "EXITX":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   485.25     500.23    0.50

 ===115 WSEL NOT FOUND AT SECID "EXITX":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   485.25     500.23     488.84

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "EXITX"
                  WSBEG,WSEND,CRWS =   488.84     500.23     488.84

EXITX:XS      61.    11.     227.  2.29 *****  491.12  488.84   2750.  488.84
      -48.    61.    61.   13469.  1.00 ***** *******    1.00   12.13

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.89     491.01     490.30

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   488.34     501.70    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   488.34     501.70     490.30

 ===140 AT SECID "FULLV":  END OF CROSS SECTION EXTENDED VERTICALLY.
                            WSEL,YLT,YRT =   491.02     501.70     490.82

FULLV:FV      48.    10.     264.  1.70  1.60  492.72  490.30   2750.  491.02
```

```
        0.    48.    85.   16846.  1.01  0.00    0.00    0.89   10.43
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.93     493.36     493.14

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   490.52     501.34    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   490.52     501.34     493.14

APPRO:AS      79.     0.     251.  1.86  2.41  495.21  493.14   2750.  493.35
       79.    79.    59.   14721.  1.00  0.08    0.00    0.93   10.94
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   496.43       0.00     492.09     481.89

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   492.17         6.      2744.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

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

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   495.89         0.     28502.

 ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR      48.    13.     218.  2.48  2.00  494.57  484.64   2750.  492.09
        0.    48.    67.   13501.  1.00  0.00    0.00    1.00   12.63

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  1.000 ******  495.89 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.       <<<<<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      45.    -8.     452.  0.58  0.77  497.01  493.14   2750.  496.43
       79.    47.    63.   34076.  1.00  1.67    0.00    0.43    6.09

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.167  0.005   33911.     7.    61.   496.09

                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
WSPRO        FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V090192          MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File pfrd013.wsp
        Hydraulic analysis for structure PFRDTH00030013   Date: 30-SEP-96

           *** RUN DATE & TIME: 11-06-96  08:29
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
```

```
   EXIT2:XS    -109.    -4.    67.   2750.   13226.     256.   10.74  485.75
   EXITX:XS     -48.    11.    61.   2750.   13469.     227.   12.13  488.84
   FULLV:FV       0.    10.    85.   2750.   16846.     264.   10.43  491.02
   BRIDG:BR       0.    13.    67.   2750.   13501.     218.   12.63  492.09
   RDWAY:RG      17.**************      0.       0.       0.    1.00********
   APPRO:AS      79.    -8.    63.   2750.   34076.     452.    6.09  496.43

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       7.    61.   33911.
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File pfrd013.wsp
        Hydraulic analysis for structure PFRDTH00030013   Date: 30-SEP-96

           *** RUN DATE & TIME: 11-06-96  08:29
  SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT2:XS    485.75    1.00  480.46  499.66************  1.79  487.54  485.75
   EXITX:XS    488.84    1.00  482.57  500.23************  2.29  491.12  488.84
   FULLV:FV    490.30    0.89  484.04  501.70  1.60  0.00  1.70  492.72  491.02
   BRIDG:BR    484.64    1.00  483.93  498.69  2.00  0.00  2.48  494.57  492.09
   RDWAY:RG  ****************  481.89  512.20************  0.69  496.14********
   APPRO:AS    493.14    0.43  486.53  501.34  0.77  1.67  0.58  497.01  496.43
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File pfrd013.wsp
        Hydraulic analysis for structure PFRDTH00030013   Date: 30-SEP-96

           *** RUN DATE & TIME: 11-06-96  08:29

  ===015 WSI IN WRONG FLOW REGIME AT SECID “EXIT2”:  USED WSI = CRWS.
                            WSI,CRWS =   485.67     486.57

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

 EXIT2:XS   ******    -5.     315.  2.14 *****  488.71  486.57   3700.  486.57
      -109. ******    69.   18204.  1.00 ***** *******    1.00   11.74

  ===125 FR# EXCEEDS FNTEST AT SECID “EXITX”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.30     488.95     490.23

  ===110 WSEL NOT FOUND AT SECID “EXITX”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   486.07     500.23    0.50

  ===115 WSEL NOT FOUND AT SECID “EXITX”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   486.07     500.23     490.23

  ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID “EXITX”
                  WSBEG,WSEND,CRWS =   490.23     500.23     490.23

  ===140 AT SECID “EXITX”:  END OF CROSS SECTION EXTENDED VERTICALLY.
                            WSEL,YLT,YRT =   490.23     500.23     489.35

 EXITX:XS       61.     9.     313.  2.31 *****  492.54  490.23   3700.  490.23
       -48.     61.    85.   20689.  1.06 ***** *******    1.05   11.82

  ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.01     491.82     491.70

  ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   489.73     501.70    0.50
```

```
 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   489.73     501.70     491.70

 ===140 AT SECID “FULLV”:  END OF CROSS SECTION EXTENDED VERTICALLY.
                            WSEL,YLT,YRT =   491.83     501.70     490.82

FULLV:FV      48.     9.     322.  2.19  1.48  494.01  491.70   3700.  491.83
        0.    48.    85.   21481.  1.07  0.00   -0.01    1.01   11.47
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID “APPRO”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.94     494.33     494.12

 ===110 WSEL NOT FOUND AT SECID “APPRO”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   491.33     501.34    0.50

 ===115 WSEL NOT FOUND AT SECID “APPRO”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   491.33     501.34     494.12

APPRO:AS      79.    -3.     312.  2.19  2.51  496.53  494.12   3700.  494.34
       79.    79.    60.   20081.  1.00  0.00    0.01    0.94   11.87
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   497.83       0.00     493.20     481.89

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   492.63         4.      3696.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

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

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   495.89         0.     29447.

 ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR      48.    11.     267.  2.98  1.77  496.17  484.86   3700.  493.20
        0.    48.    67.   17973.  1.00  0.05    0.00    1.00   13.84

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  1.000 ******  495.89 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.        <<<<<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      45.   -11.     555.  0.69  0.77  498.52  494.12   3700.  497.83
       79.    46.    66.   45513.  1.00  1.57    0.00    0.44    6.67

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.150  0.000   46895.     5.    61.   497.48

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
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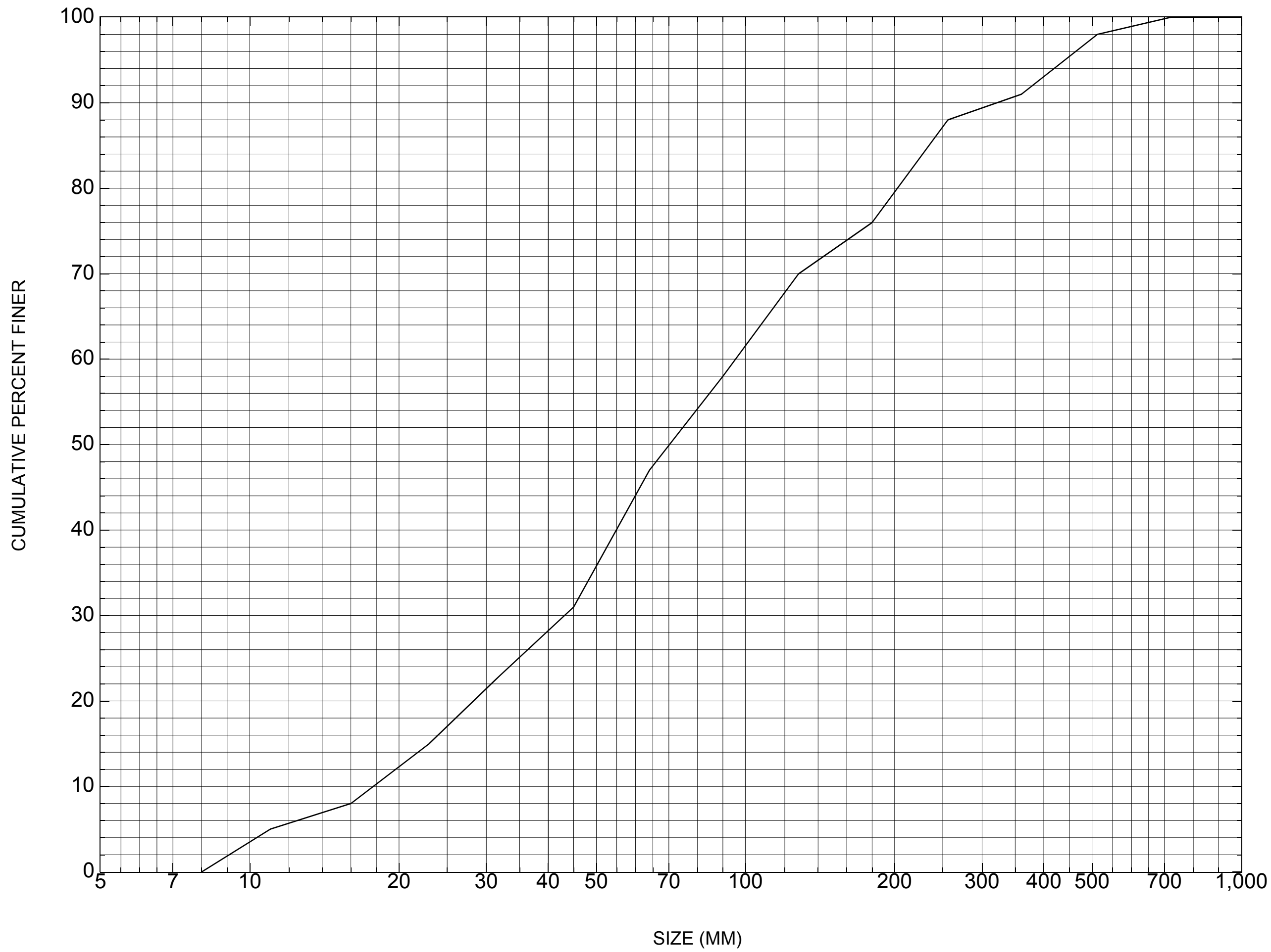
APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure PFRDTH00030013, in Pittsford, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number PFRDTH00030013

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)* 55600

Mile marker *(I - 11; nnn.nnn)* 001760

Waterway *(I - 6)* FURNACE BROOK

Road Name *(I - 7)*: -

Route Number TH003

Vicinity *(I - 9)* 1.6 MI E JCT US 7

Topographic Map Proctor

Hydrologic Unit Code: 02010002

Latitude *(I - 16; nnnn.n)* 43433

Longitude *(i - 17; nnnnn.n)* 73000

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20016500131116

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

Maximum span length *(I - 48; nnnn)* 0072

Year built *(I - 27; YYYY)* 1947

Structure length *(I - 49; nnnnnn)* 000075

Average daily traffic, ADT *(I - 29; nnnnnn)* 000700

Deck Width *(I - 52; nn.n)* 270

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

Channel & Protection *(I - 61; n)* 8

Opening skew to Roadway *(I - 34; nn)* 30

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

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 069.2

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

Vertical clearance from streambed (*nnn.n ft*) 007.0

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

Waterway of full opening (*nnn.n ft^2*) 250.0

Comments:

The structural inspection report of 8/17/94 indicates the structure is a single span steel stringer type bridge. This bridge is part of the Federal Aid System and is listed under the route number, FAS 165. The right abutment wall has areas of cracking and concrete scaling reported. Both of its wingwalls also have areas of concrete cracking and scaling noted. The left abutment has some concrete cracking visible with light to moderate scaling reported. The same condition applies to its wingwalls. Both abutment walls are reported as protected with heavy stone fill. The channel makes a slight bend into the crossing and a moderate bend just downstream. Vegetation is noted as evident on both banks up- and **(Continued, page 33)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: Large boulders and bedrock

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)* : Light Debris *(Heavy, Moderate, Light)*: Light

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

Comments:
downstream. A large tree is reported having broken off and fallen into the channel about 40 feet down stream from the bridge. The channel is noted as being composed of large boulders and bedrock primarily.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **17.10** mi^2 Lake and pond area **0** mi^2
Watershed storage *(ST)* **0** %
Bridge site elevation **550** ft Headwater elevation **3522** ft
Main channel length **10.19** mi
10% channel length elevation **780** ft 85% channel length elevation **1940** ft
Main channel slope *(S)* **151.79** 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)*: 06 / 1946

Project Number SA 14-1945 Minimum channel bed elevation: 101.0

Low superstructure elevation: USLAB 113.46 DSLAB 112.73 USRAB 107.09 DSRAB 105.73

Benchmark location description:

The original project benchmarks are not shown on the plans. However, a couple of points shown with elevations are: 1) On the top of the concrete post at the upstream end of the right abutment, where the top slope changes from horizontal to sloping on the bankward and upstream corner, elevation 110.58, and 2) the point at the same location as in (1) but on the post at the upstream end of the left abutment,

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

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

If 1: Footing Thickness - Footing bottom elevation: 101.55 (R)

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

If 3: Footing bottom elevation: ______

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

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

Briefly describe material at foundation bottom elevation or around piles:

-

Comments:

elevation 117.27. The footing bottom elevation of the left abutment is 105.73 and right abutment is 101.55. The plans show stone fill embankments on the abutments, which resemble flow through type abutments. The low superstructure elevation given above is actually the minimum low steel elevation shown on the plans. These plans are listed under the last project number which is SA14-1945.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: CG Date: 02/12/96
Computerized by: CG Date: 02/12/96
Reviewd by: RF Date: 12/27/96

Structure Number PFRDTH00030013

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* L. Medalie   Date *(MM/DD/YY)* 06 / 20 / 1995

2. Highway District Number 03   Mile marker 1.76

County Rutland (021)   Town Pittsford (55600)

Waterway *(I - 6)* Furnace Brook   Road Name -

Route Number TH 03   Hydrologic Unit Code: 02010002

3. Descriptive comments:

1.6 miles East of the junction with US 7.

B. Bridge Deck Observations

4. Surface cover... LBUS 6   RBUS 6   LBDS 6   RBDS 4   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 2   UB 1   DS 2   *(**1**- pool; **2**- riffle)*

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

7. Bridge length 75 *(feet)*   Span length 72 *(feet)*   Bridge width 27 *(feet)*

Road approach to bridge:

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

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

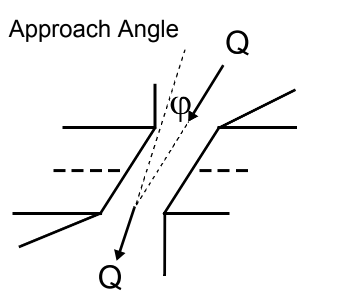
10. Embankment slope (*run / rise in feet / foot*):
US left 1.0:1   US right 3.5:1

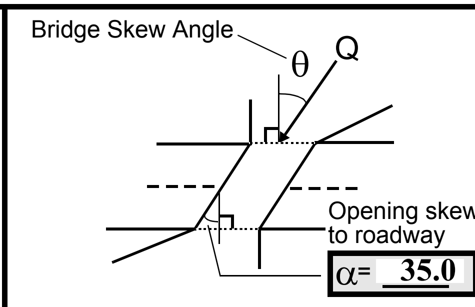
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	3	1

*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: 10   16. Bridge skew: 20





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)*   Severity 0
Range? 10 feet US *(US, UB, DS)* to 50 feet US

Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)*   Severity 0
Range? 5 feet DS *(US, UB, DS)* to 38 feet DS

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

18. Bridge Type: 3

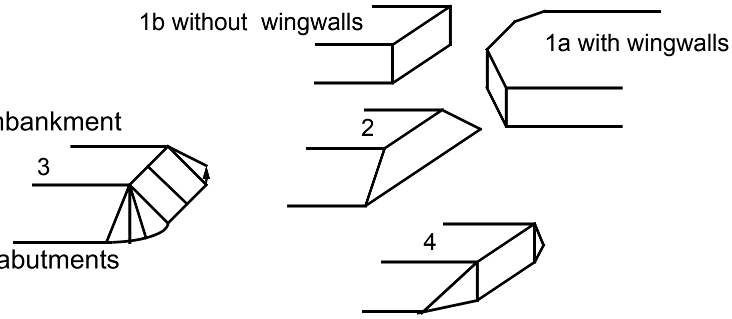
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

Measured structure length = 73.8 feet

4. The left bank upstream is forested on either side of a paved road. The right bank upstream has some houses with lawns and trees. The left bank downstream has a single house with a small lawn, but is mostly forest. The right bank downstream has a 40 - 50 foot strip of forest between the stream and a meadow.

8. The road width by the right bank is 22 feet.

17. The impact zones are very slight due to the moderate approach angle.

18. The vertical concrete abutments extend 2 feet below the bridge deck, below which there is heavy stone fill protection on each spill-through slope.

The downstream culvert on the left bank (at the road approach) leads to a small erosional channel and then down to a stream about 10 feet from the bridge.

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
66.0	4.0			3.5	4	3	534	453	1	1

23. Bank width 35.0 24. Channel width 30.0 25. Thalweg depth 48.0 29. Bed Material 543

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

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

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

31. On the right and left bank there is ample natural protection (i.e. there are large boulders and cobbles).

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

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

37. Material: -

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

NO POINT BARS

There is some minor accumulation of cobbles/boulders along left side of the channel from about 70 to 90 feet upstream.

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: 60 42. Cut bank extent: 30 feet US (US, UB) to 80 feet US (US, UB, DS)

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

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

There is another major cutbank to bedrock with almost vertical walls beginning about 150 feet upstream on both right and left banks and continuing another 250 feet to a pool in stream upstream of which there are 2 huge boulders (10 feet high) which form a waterfall, slip failure damage to both sides.

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 27

47. Scour dimensions: Length 4 Width 3 Depth : 0.5 Position 40 %LB to 60 %RB

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

The scour is local and formed downstream of a series of boulders that form a "V" in the channel.

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)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
36.5		1.5		2	7	7	0

58. Bank width (BF) - 59. Channel width (Amb) - 60. Thalweg depth (Amb) 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.):

543

61. The restraint material is vertical abutment walls protected by large 1-2+ foot stone fill.

63. There is variable bed material.

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

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

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

70. Debris and Ice Comments:

1

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		**0**	**90**	**(45)**	**0**	**0**	**-**	**90.0**
RABUT	**-**	**1**	**0**			**90**	**(60)**	**55.0**

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

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

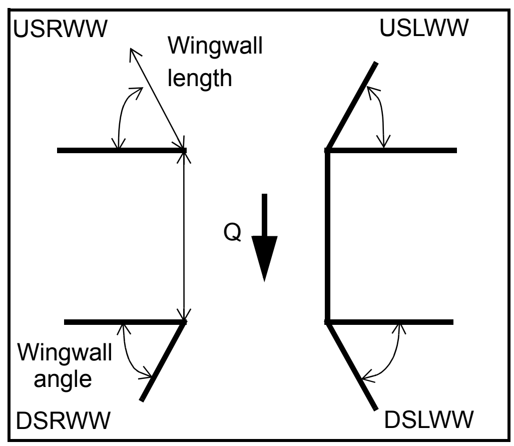
0
1
0.5
-
1

72. The numbers in parenthesis indicate the general slope of the stone fill.

74. The under bridge local scour hole is 3 feet long by 2 feet wide by 0.5 feet deep at the bottom of the right abutment stone fill.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**55.0**	
USRWW:					**Y**	**1.5**	
DSLWW:	**1**		**0**		**-**	**36.5**	
DSRWW:	**-**		**Y**		**1**	**30.5**	



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

82. **Bank / Bridge Protection**:

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

*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*

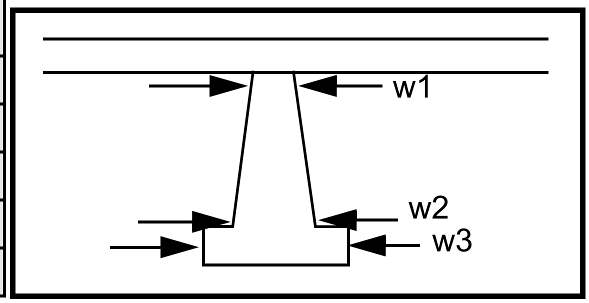
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

1
-
-
-
-
-
-
1
1
-
2

Piers:

84. Are there piers? **1** (*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	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-	-	-	-	-	-	-

Bank width (BF) -_____ Channel width (Amb) -_____ Thalweg depth (Amb) -_____ Bed Material -_____

Bank protection type (Qmax): LB -_____ RB -_____ Bank protection condition: LB -_____ RB -_____

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

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

NO PIERS

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

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

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

3
2

106. Point/Side bar present? **54** (Y or N. if N type ctrl-n pb) Mid-bar distance: **543** Mid-bar width: **1**

Point bar extent: **0** feet **54** (US, UB, DS) to **0** feet **0** (US, UB, DS) positioned **-** %LB to **-** %RB

Material: **Be**

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

drock outcrops from 30 to 66 feet downstream. There is significant natural bank protection.
On the right bank at 30 to 46 feet downstream, there are two 3 foot high concrete structures (4 feet triangular) that provide an opening to the path that follows parallel to the stream.
At about 80 feet downstream on the left bank, a 20 foot long stone wall is placed behind a large (7') boulder.

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

Cut bank extent: **e** feet **wal** (US, UB, DS) to **l was** feet **pla** (US, UB, DS)

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

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

to protect the bank. There is a house above the stone wall.
Twelve feet downstream, there is a large tree on the right bank which has broken and fallen across the channel. This may effect debris accumulation.
The bedrock crops up in the streambed 100 feet downstream from the bridge and forces all of the flow to the

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

Scour dimensions: Length **the** Width **chan** Depth: **nel** Positioned **ove** %LB to **r** %RB

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

an 8 feet high water fall.

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

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

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

Confluence comments (eg. confluence name):

STRUCTURE

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

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

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

N
-
-
-
-
-
-
-
-
-

109. G. Plan View Sketch

N

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: PFRDTH00030013 Town: Pittsford
Road Number: TH3 County: Rutland
Stream: Furnace Brook

Initials RF Date: 12/13/96 Checked: SAO

Analysis of contraction scour, live-bed or clear water?

Critical Velocity of Bed Material (converted to English units)
Vc=11.21*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and others, 1995, p. 28, eq. 16)

Approach Section Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	2750	3700	0
Main Channel Area, ft2	451.5	555.2	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	71.2	76.9	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.2304	0.2304	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.3	7.2	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	34057	45545	0
Conveyance, main channel	34057	45545	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	2750.0	3700.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	6.1	6.7	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	9.3	9.6	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

y2 = (Q2^2/(131*Dm^(2/3)*W2^2))^(3/7)   Converted to English Units
ys=y2-y_bridge
(Richardson and others, 1995, p. 32, eq. 20, 20a)

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	451.5	555.2	0
Main channel width, ft	71.2	76.9	0
y1, main channel depth, ft	6.34	7.22	ERR

Bridge Section			
(Q) total discharge, cfs	2750	3700	0
(Q) discharge thru bridge, cfs	2750	3700	0
Main channel conveyance	13513	17984	0
Total conveyance	13513	17984	0
Q2, bridge MC discharge,cfs	2750	3700	ERR
Main channel area, ft2	218	268	0
Main channel width (skewed), ft	33.5	34.5	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	33.5	34.5	0
y_bridge (avg. depth at br.), ft	6.50	7.76	ERR
Dm, median (1.25*D50), ft	0.288	0.288	0
y2, depth in contraction,ft	7.72	9.71	ERR
ys, scour depth (y2-ybridge), ft	1.22	1.96	N/A

ARMORING			
D90	1.054	1.054	0
D95	1.444	1.444	0
Critical grain size,Dc, ft	0.8598	0.9529	ERR
Decimal-percent coarser than Dc	0.1179	0.109	0
Depth to armoring,ft	19.30	23.37	ERR

Abutment Scour

Froehlich's Abutment Scour

Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1

(Richardson and others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	2750	3700	0	2750	3700	0
a', abut.length blocking flow, ft	24.5	26.8	0	13.2	15.6	0
Ae, area of blocked flow ft2	124.77	150.45	0	45.99	67.07	0
Qe, discharge blocked abut.,cfs	643.5	825.38	0	177.8	299.36	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	5.16	5.49	ERR	3.87	4.46	ERR
ya, depth of f/p flow, ft	5.09	5.61	ERR	3.48	4.30	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0.55	0.55	0.55	0.55
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	55	55	55	125	125	125
K2	0.94	0.94	0.94	1.04	1.04	1.04
Fr, froude number f/p flow	0.403	0.408	ERR	0.365	0.379	ERR
ys, scour depth, ft	11.82	13.07	N/A	7.84	9.70	N/A

HIRE equation (a'/ya > 25)

ys = 4*Fr^0.33*y1*K/0.55

(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	24.5	26.8	0	13.2	15.6	0
y1 (depth f/p flow, ft)	5.09	5.61	ERR	3.48	4.30	ERR
a'/y1	4.81	4.77	ERR	3.79	3.63	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.40	0.41	N/A	0.37	0.38	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother	Q100	Q500	Qother
Fr, Froude Number	1	1	0	1	1	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	6.50	7.76	0.00	6.50	7.76	0.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	2.72	3.24	ERR	2.72	3.24	ERR
Fr<=0.8 (spillthrough abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (spillthrough abut.)	2.40	2.87	ERR	2.40	2.87	ERR