LEVEL II SCOUR ANALYSIS FOR BRIDGE 16 (BURKTH00070016) on TOWN HIGHWAY 7, crossing DISH MILL BROOK, BURKE, VERMONT

Open-File Report 97-758

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

U.S. Department of the Interior
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LEVEL II SCOUR ANALYSIS FOR BRIDGE 16 (BURKTH00070016) on TOWN HIGHWAY 7, crossing DISH MILL BROOK, BURKE, VERMONT

By RONDA L. BURNS AND TIM SEVERANCE

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Pembroke, New Hampshire

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U.S. DEPARTMENT OF THE INTERIOR
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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 16 (BURKTH00070016) ON TOWN HIGHWAY 7, CROSSING DISH MILL BROOK, BURKE, VERMONT

By **Ronda L. Burns and Tim Severance**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BURKTH00070016 on Town Highway 7 crossing Dish Mill Brook, Burke, 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 White Mountain section of the New England physiographic province in northeastern Vermont. The 6.0-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest except on the left bank upstream which is brushland.

In the study area, Dish Mill Brook has an incised, sinuous channel with a slope of approximately 0.04 ft/ft, an average channel top width of 40 ft and an average bank height of 6 ft. The channel bed material ranges from sand to boulder with a median grain size (D_{50}) of 94.1 mm (0.309 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 7, 1995, indicated that the reach was stable.

The Town Highway 7 crossing of Dish Mill Brook is a 28-ft-long, two-lane bridge consisting of one 24-foot steel-beam span (Vermont Agency of Transportation, written communication, March 24, 1995). The opening length of the structure parallel to the bridge face is 24.8 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 35 degrees to the opening while the computed opening-skew-to-roadway is 35 degrees.

A scour hole 1.0 ft deeper than the mean thalweg depth was observed along the left and right abutments during the Level I assessment. In front of the upstream and downstream left wingwalls the scour depth was only 0.5 ft, while in front of the downstream right wingwall it was 0.75 ft and in front of the upstream right wingwall it was 0.3 ft. The scour countermeasures at the site include type-1 stone fill (less than 12 inches diameter) at the downstream end of the right abutment and along the downstream right wingwall. Type-2 stone fill (less than 36 inches diameter) is along the upstream left bank, the upstream and downstream left wingwalls, and at the upstream end of the upstream right wingwall. 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 others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge is 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 0.0 to 0.5 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 6.7 to 9.3 ft. The worst-case abutment scour occurred at the 500-year discharge for the left abutment and at the incipient road-overtopping discharge for the right abutment. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

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 BURKTH0070016 ***Stream*** Dish Mill Brook

County Caledonia ***Road*** TH 7 ***District*** 7

Description of Bridge

Bridge length 28 ***ft*** ***Bridge width*** 22.9 ***ft*** ***Max span length*** 24 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** None

Stone fill on abutment? Yes ***Date of inspection*** 8/7/95

Description of stone fill Type-1, at the downstream end of the right abutment and along the downstream right wingwall. Type-2, along the upstream and downstream left wingwalls and at the upstream end of the upstream right wingwall.

Abutments and wingwalls are concrete. There are 1.0 foot deep scour holes in front of the left and right abutments which extend along their wingwalls. The right abutment footing is exposed 2.5 feet while the left abutment footing is exposed 1.5 feet. All four wingwalls also have exposed footings.

Is bridge skewed to flood flow according to Level I survey? Yes ***Angle*** 35

Is bridge located on a bend in channel? Yes ***If so, describe (mild, moderate, severe)***

There is a mild channel bend in the upstream reach which impacts the left bank upstream causing a cut-bank. The flow then impacts the right 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*
	8/7/95	0	0
Level I	8/7/95	0	0
Level II			

Potential for debris Moderate. There is some debris caught on the banks.

None as of 8/7/95.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with steep valley walls on both sides.

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

Date of inspection 8/7/95

DS left: Steep channel bank and irregular overbank to a steep stone pile

DS right: Steep channel bank to a narrow terrace

US left: Steep channel bank to a moderately sloped overbank

US right: Steep valley wall

Description of the Channel

Average top width 40 ***ft*** ***Average depth*** 6 ***ft***

Predominant bed material Gravel/Cobbles ***Bank material*** Gravel/Cobbles

Sinuous but stable with non-alluvial channel boundaries.

8/7/95

Vegetative co

Trees and brush

DS left: Trees and brush

DS right: Shrubs and brush

US left: Trees and brush

US right: Yes

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

A large boulder in the center of the channel at the upstream bridge face diverts ambient flow along the left and right abutment footings as of 8/7/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 6.0 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/White Mountain	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 No

Calculated Discharges

Q100 1,410 ***ft³/s*** ***Q500*** 1,900 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(6.0/6.35)exp 0.67] with Dish Mill Brook at the confluence with the East Branch Passumpsic River in Burke. The drainage area at the confluence is 6.35 square miles and has flood frequency estimates available in the Flood Insurance Study for the town of Burke (Federal Emergency Management Agency, December 1979). The values used were within a range defined by flood frequency curves developed from several empirical methods (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 None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the curb at the upstream left corner of the bridge (elev. 500.72 ft, arbitrary survey datum). RM2 is a chiseled X on top of the curb at the downstream left corner of the bridge (elev. 500.76 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-27	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	14	1	Road Grade section
APPRO	49	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 0.050 to 0.055, and overbank "n" values ranged from 0.050 to 0.070.

Critical depth at the exit section (EXITX) was assumed as the starting water surface. Normal depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990), and resulted in a supercritical solution. Because normal depth was within 0.2 ft of critical depth, the critical water surface was assumed to be a satisfactory starting water surface. The slope used was 0.0356 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1988).

The surveyed approach section (APPRO) was 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 500.8 *ft*
Average low steel elevation 497.7 *ft*

100-year discharge 1,410 *ft^3/s*
Water-surface elevation in bridge opening 497.9 *ft*
Road overtopping? No *Discharge over road* - *ft^3/s*
Area of flow in bridge opening 154 *ft^2*
Average velocity in bridge opening 9.2 *ft/s*
Maximum WSPRO tube velocity at bridge 11.5 *ft/s*

Water-surface elevation at Approach section with bridge 499.9
Water-surface elevation at Approach section without bridge 496.4
Amount of backwater caused by bridge 3.5 *ft*

500-year discharge 1,900 *ft^3/s*
Water-surface elevation in bridge opening 497.7 *ft*
Road overtopping? Yes *Discharge over road* 281 *ft^3/s*
Area of flow in bridge opening 153 *ft^2*
Average velocity in bridge opening 10.6 *ft/s*
Maximum WSPRO tube velocity at bridge 15.0 *ft/s*

Water-surface elevation at Approach section with bridge 501.2
Water-surface elevation at Approach section without bridge 497.4
Amount of backwater caused by bridge 3.8 *ft*

Incipient overtopping discharge 1,480 *ft^3/s*
Water-surface elevation in bridge opening 497.9 *ft*
Area of flow in bridge opening 154 *ft^2*
Average velocity in bridge opening 9.6 *ft/s*
Maximum WSPRO tube velocity at bridge 12.0 *ft/s*

Water-surface elevation at Approach section with bridge 500.2
Water-surface elevation at Approach section without bridge 496.6
Amount of backwater caused by bridge 3.6 *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.

At this site, the 100-year, 500-year and incipient roadway-overtopping discharges resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The computed streambed armoring depths suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the discharges resulting in orifice flow was also computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and presented in Appendix F. Furthermore, for those discharges resulting in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions are provided in Appendix F.

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

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.5	0.0
Depth to armoring	22.6	25.1	23.0
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	7.8	9.3	8.3
Right abutment	7.6	6.7	7.7
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	2.2	2.4	2.3
Right abutment	2.2	2.4	2.3
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

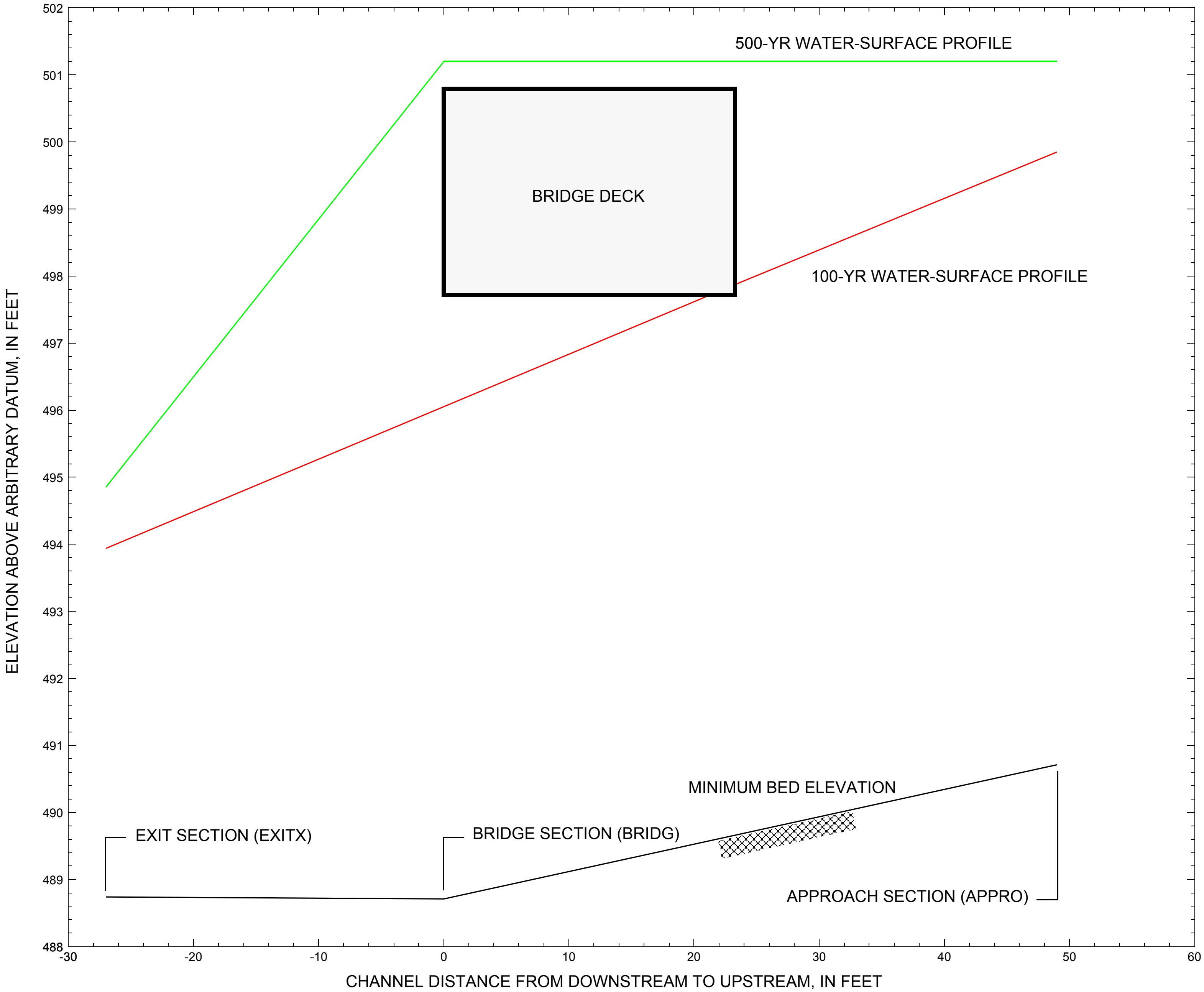

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BURKTH00070016 on Town Highway 7, crossing Dish Mill Brook, Burke, Vermont.

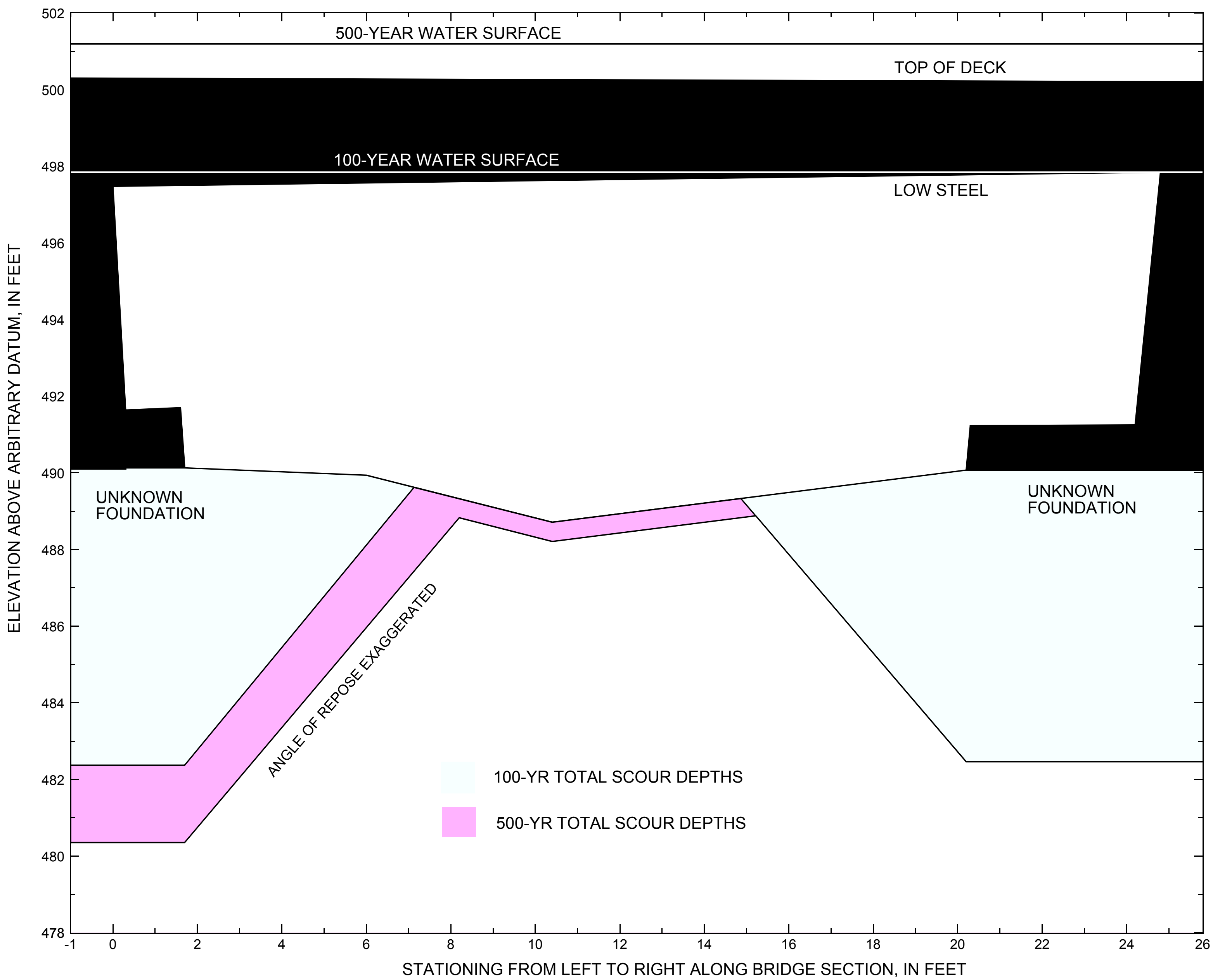

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BURKTH00070016 on Town Highway 7, crossing Dish Mill Brook, Burke, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BURKTH00070016 on Town Highway 7, crossing Dish Mill Brook, Burke, 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-yr. discharge is 1,410 cubic-feet per second											
Left abutment	0.0	--	497.5	--	490.1	0.0	7.8	--	7.8	482.3	--
Right abutment	24.8	--	497.9	--	490.1	0.0	7.6	--	7.6	482.5	--

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 BURKTH00070016 on Town Highway 7, crossing Dish Mill Brook, Burke, 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-yr. discharge is 1,900 cubic-feet per second											
Left abutment	0.0	--	497.5	--	490.1	0.5	9.3	--	9.8	480.3	--
Right abutment	24.8	--	497.9	--	490.1	0.5	6.7	--	7.2	482.9	--

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

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U.S. Geological Survey, 1988, Burke Mountain, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File burk016.wsp
T2        Hydraulic analysis for structure BURKTH00070016   Date: 24-JUL-97
T3        TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                   RLB
*
J1         * * 0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1410.0   1900.0   1480.0
SK          0.0356   0.0356   0.0356
*
XS   EXITX    -27           0.
GR         -135.6, 505.39   -128.2, 508.80    -87.8, 509.07    -60.1, 510.61
GR          -41.9, 498.43    -31.8, 495.55     -7.4, 494.82     -2.7, 493.00
GR            0.0, 490.53      2.8, 490.13      5.9, 489.00     13.5, 489.26
GR           15.6, 488.74     19.6, 489.08     21.7, 490.07     26.7, 490.90
GR           31.2, 495.11     33.7, 497.54     43.0, 499.39     60.1, 499.40
GR           74.6, 499.17     82.1, 498.08
*
N           0.070        0.055      0.070
SA                  -7.4       43.0
*
XS   FULLV      0  * * *   0.0256
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.67      35.0
GR            0.0, 497.48      0.3, 491.64      1.6, 491.70      1.6, 490.13
GR            6.0, 489.94     10.4, 488.71     13.5, 489.14     20.3, 490.07
GR           20.3, 491.23     24.2, 491.25     24.8, 497.85      0.0, 497.48
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      36.2 * *     55.9      7.1
N           0.050
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     14      22.9     1
GR         -229.8, 517.01   -201.9, 509.40   -189.6, 508.19   -154.2, 507.25
GR         -138.2, 508.21    -89.0, 504.73    -88.9, 504.72    -41.2, 502.25
GR           -2.1, 500.30     -1.7, 500.73     26.4, 500.82     26.6, 500.21
GR           42.4, 500.11     49.8, 500.11     58.8, 503.26     69.1, 510.16
*             5.5, 500.44     26.2, 500.23     49.8, 498.93
*
AS   APPRO     49           0.
GR          -78.3, 504.46    -40.8, 502.42     -1.8, 497.45      0.0, 493.50
GR            5.7, 492.16      6.8, 491.29      9.8, 490.71     13.9, 491.24
GR           18.2, 490.95     20.7, 491.84     24.4, 492.97     26.5, 497.86
GR           28.5, 499.25     50.4, 503.26     58.4, 503.35     68.8, 505.99
GR           74.8, 510.05
*
N           0.050        0.055       0.070
SA                  -1.8        28.5
*
HP 1 BRIDG  497.85 1 497.85
HP 2 BRIDG  497.85 * * 1410
HP 1 BRIDG  495.36 1 495.36
HP 1 APPRO  499.85 1 499.85
HP 2 APPRO  499.85 * * 1410
*
HP 1 BRIDG  497.67 1 497.67
HP 2 BRIDG  497.67 * * 1621
HP 1 BRIDG  495.89 1 495.89
HP 2 RDWAY  501.20 * * 281
HP 1 APPRO  501.20 1 501.20
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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        U.S. Geological Survey WSPRO Input File burk016.wsp
        Hydraulic analysis for structure BURKTH00070016   Date: 24-JUL-97
        TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                   RLB
           *** RUN DATE & TIME: 08-05-97  13:25

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      154      9057      0     55                            0
   497.85           154      9057      0     55  1.00      0     25        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.85     0.0    24.8   153.9    9057.    1410.   9.16

X STA.         0.0         2.8         4.2         5.4         6.6         7.7
  A(I)            14.2         8.5         7.7         7.3         6.9
  V(I)            4.96        8.28        9.14        9.72       10.15

X STA.         7.7         8.6         9.6        10.4        11.3        12.2
  A(I)             6.7         6.5         6.3         6.2         6.2
  V(I)           10.58       10.78       11.26       11.32       11.46

X STA.        12.2        13.0        13.9        14.9        15.8        16.8
  A(I)             6.3         6.2         6.4         6.5         6.7
  V(I)           11.21       11.36       10.98       10.80       10.48

X STA.        16.8        17.8        19.0        20.2        22.0        24.8
  A(I)             6.8         7.3         7.8         9.8        13.6
  V(I)           10.43        9.71        9.03        7.19        5.20

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      107      7406     20     30                         1410
   495.36           107      7406     20     30  1.00      0     25     1410

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      49.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       23       756     19     19                          140
             2      218     19135     30     37                         3318
             3        1         9      3      3                            3
   499.85           242     19901     52     60  1.10    -20     32     2809

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      49.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.85   -20.6    31.8   241.6   19901.    1410.   5.84

X STA.       -20.6        -0.1         2.1         3.7         5.2         6.6
  A(I)            30.0        14.1        11.5        10.8        11.1
  V(I)            2.35        5.00        6.11        6.52        6.35

X STA.         6.6         7.7         8.8         9.8        10.8        11.8
  A(I)             9.7         9.4         9.3         9.2         9.1
  V(I)            7.23        7.48        7.56        7.62        7.74

X STA.        11.8        12.9        14.0        15.1        16.2        17.3
  A(I)             9.4         9.3         9.7         9.5        10.0
  V(I)            7.47        7.59        7.26        7.42        7.05

X STA.        17.3        18.5        19.8        21.2        23.0        31.8
  A(I)            10.1        11.2        11.9        13.2        23.0
  V(I)            6.98        6.32        5.94        5.35        3.07
```

```
       U.S. Geological Survey WSPRO Input File burk016.wsp
       Hydraulic analysis for structure BURKTH00070016   Date: 24-JUL-97
       TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                   RLB
          *** RUN DATE & TIME: 08-05-97  13:25

     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      153     10253     10     45                          3417
    497.67           153     10253     10     45  1.00      0     25     3417

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.67     0.0    24.8   153.0   10253.    1621.  10.60

 X STA.        0.0        3.0        4.6        6.1        7.3        8.5
   A(I)            15.6        9.9        8.9        8.2        7.9
   V(I)            5.21       8.17       9.12       9.86      10.30

 X STA.        8.5        9.6       10.6       11.6       12.5       13.3
   A(I)             7.4        7.2        7.1        7.0        5.7
   V(I)           10.98      11.19      11.49      11.55      14.12

 X STA.       13.3       14.1       14.9       15.7       16.5       17.4
   A(I)             5.5        5.4        5.4        5.5        5.6
   V(I)           14.83      15.02      15.04      14.75      14.42

 X STA.       17.4       18.3       19.2       20.6       22.0       24.8
   A(I)             5.7        6.2        8.1        7.7       13.0
   V(I)           14.10      13.11      10.06      10.56       6.22

     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      118      8474     20     32                          1622
    495.89           118      8474     20     32  1.00      0     25     1622

     VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      14.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.20   -20.1    52.9    46.7     907.     281.   6.02

 X STA.      -20.1       -7.0       -4.1       -1.8        5.1       12.1
   A(I)             4.3        2.1        2.0        3.2        3.1
   V(I)            3.25       6.81       7.18       4.45       4.55

 X STA.       12.1       20.9       27.8       29.7       31.6       33.4
   A(I)             3.6        3.4        2.0        1.9        1.8
   V(I)            3.88       4.09       7.13       7.52       7.67

 X STA.       33.4       35.1       36.8       38.4       40.0       41.5
   A(I)             1.8        1.7        1.7        1.7        1.6
   V(I)            7.70       8.11       8.26       8.20       8.53

 X STA.       41.5       43.0       44.9       46.8       48.7       52.9
   A(I)             1.6        2.1        2.1        2.1        2.9
   V(I)            8.82       6.84       6.64       6.72       4.88

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      49.
      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1       55      2487     29     30                           429
              2      259     25486     30     37                          4295
              3       10       215     11     11                            58
    501.20           324     28188     70     78  1.19    -30     39     3632

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      49.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.20   -31.2    39.1   324.5   28188.    1900.   5.86

 X STA.      -31.2       -7.2       -0.2        2.0        3.7        5.3
   A(I)            36.7       27.0       18.0       14.1       13.7
   V(I)            2.59       3.52       5.29       6.73       6.94

 X STA.        5.3        6.8        8.0        9.2       10.3       11.4
   A(I)            13.9       12.2       12.1       11.8       11.7
   V(I)            6.85       7.79       7.85       8.08       8.15

 X STA.       11.4       12.6       13.8       15.0       16.2       17.4
   A(I)            11.8       12.0       11.9       12.4       12.4
   V(I)            8.02       7.89       7.97       7.64       7.67

 X STA.       17.4       18.7       20.1       21.7       23.7       39.1
   A(I)            12.7       14.0       14.9       17.2       34.0
   V(I)            7.47       6.79       6.36       5.53       2.79
```

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       U.S. Geological Survey WSPRO Input File burk016.wsp
       Hydraulic analysis for structure BURKTH00070016   Date: 24-JUL-97
       TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                   RLB
          *** RUN DATE & TIME: 08-05-97  13:25

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      154      9057      0     55                            0
  497.85           154      9057      0     55  1.00      0     25        0

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      497.85     0.0    24.8   153.9    9057.    1480.   9.62

X STA.        0.0        2.8        4.2        5.4        6.6        7.7
  A(I)           14.2        8.5        7.7        7.3        6.9
  V(I)           5.21       8.69       9.60      10.20      10.65

X STA.        7.7        8.6        9.6       10.4       11.3       12.2
  A(I)            6.7        6.5        6.3        6.2        6.2
  V(I)          11.10      11.32      11.82      11.88      12.03

X STA.       12.2       13.0       13.9       14.9       15.8       16.8
  A(I)            6.3        6.2        6.4        6.5        6.7
  V(I)          11.77      11.92      11.53      11.33      11.00

X STA.       16.8       17.8       19.0       20.2       22.0       24.8
  A(I)            6.8        7.3        7.8        9.8       13.6
  V(I)          10.95      10.19       9.47       7.54       5.46

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      111      7745     20     31                         1477
  495.53           111      7745     20     31  1.00      0     25     1477

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      49.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1       29      1067     21     22                          194
            2      228     20620     30     37                         3549
            3        2        30      5      5                            9
  500.18           260     21717     57     64  1.12    -22     34     2977

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      49.

        WSEL     LEW     REW    AREA        K        Q    VEL
      500.18   -23.2    33.6   259.6   21717.    1480.   5.70

X STA.      -23.2       -1.4        1.6        3.4        4.9        6.3
  A(I)           30.7       18.1       12.7       11.5       11.3
  V(I)           2.41       4.08       5.84       6.41       6.56

X STA.        6.3        7.5        8.6        9.7       10.7       11.8
  A(I)           11.0       10.0        9.9        9.9        9.7
  V(I)           6.72       7.40       7.48       7.51       7.61

X STA.       11.8       12.8       14.0       15.1       16.2       17.3
  A(I)            9.9       10.0       10.0       10.4       10.4
  V(I)           7.50       7.38       7.43       7.13       7.15

X STA.       17.3       18.5       19.8       21.3       23.1       33.6
  A(I)           10.9       11.5       12.5       14.3       24.9
  V(I)           6.76       6.45       5.91       5.16       2.97
```

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       U.S. Geological Survey WSPRO Input File burk016.wsp
       Hydraulic analysis for structure BURKTH00070016   Date: 24-JUL-97
       TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                   RLB
          *** RUN DATE & TIME: 08-05-97  13:25

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                             WSI,CRWS =   493.79     493.94

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

EXITX:XS   ******     -4      129  1.85 *****  495.79  493.94    1410  493.94
       -26 ******     30     7916  1.00 ***** *******    1.00   10.91

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.88     495.02     494.64
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   493.44     511.30    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   493.44     511.30     494.64

FULLV:FV       27     -5      143  1.51  0.75  496.53  494.64    1410  495.02
         0     27     30     9100  1.00  0.00   -0.01    0.88    9.87
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.14     496.04     496.42
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.52     510.05    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.52     510.05     496.42
 ===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 "APPRO"
                  WSBEG,WSEND,CRWS =   496.42     510.05     496.42

APPRO:AS       49      0      119  2.18 *****  498.60  496.42    1410  496.42
        49     49     26     7699  1.00 ***** *******    1.00   11.85
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   495.36     498.47     498.74     497.67
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

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

BRIDG:BR       27      0      154  1.31 *****  499.16  495.36    1409  497.85
         0 ******     25     9057  1.00 ***** *******    0.65    9.16

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.479  0.000  497.67 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.        <<<<<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       13    -20      241  0.58  0.17  500.43  496.42    1410  499.85
        49     15     32    19881  1.10  1.31    0.00    0.50    5.84

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   499.71
                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -27.    -5.    30.   1410.    7916.     129.   10.91  493.94
   FULLV:FV       0.    -6.    30.   1410.    9100.     143.    9.87  495.02
   BRIDG:BR       0.     0.    25.   1409.    9057.     154.    9.16  497.85
   RDWAY:RG      14.**************      0.******************    1.00********
   APPRO:AS      49.   -21.    32.   1410.   19881.     241.    5.84  499.85

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

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    493.94    1.00  488.74  510.61************  1.85  495.79  493.94
   FULLV:FV    494.64    0.88  489.43  511.30  0.75  0.00  1.51  496.53  495.02
   BRIDG:BR    495.36    0.65  488.71  497.85************  1.31  499.16  497.85
   RDWAY:RG  ***************  500.11  517.01************  0.41  501.09********
   APPRO:AS    496.42    0.50  490.71  510.05  0.17  1.31  0.58  500.43  499.85
```

```
        U.S. Geological Survey WSPRO Input File burk016.wsp
        Hydraulic analysis for structure BURKTH00070016   Date: 24-JUL-97
        TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                   RLB
           *** RUN DATE & TIME: 08-05-97  13:25

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                          WSI,CRWS =   494.61     494.85

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

EXITX:XS   ******     -8      163  2.12 *****  496.97  494.85    1900  494.85
       -26 ******     31    10909  1.00 ***** *******    1.01   11.68

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.02     495.92     495.55
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.35     511.30    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.35     511.30     495.55

FULLV:FV       27    -19      178  1.82  0.73  497.69  495.55    1900  495.88
         0     27     31    12301  1.02  0.00   -0.01    1.02   10.69
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.22     496.73     497.42
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.38     510.05    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.38     510.05     497.42
 ===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 "APPRO"
                  WSBEG,WSEND,CRWS =   497.42     510.05     497.42

APPRO:AS       49     -1      147  2.61 *****  500.03  497.42    1900  497.42
        49     49     26    10436  1.00 ***** *******    1.00   12.96
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   500.57       0.00     496.56     500.11
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   503.95          0.      1900.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

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

BRIDG:BR       27      0      153  1.75 *****  499.42  495.89    1621  497.67
         0 ******     25    10253  1.00 ***** *******    0.75   10.60

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.496  0.000  497.67 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD      EGL      ERR       Q    WSEL
   RDWAY:RG      14.    26.  0.12  0.63  501.71     0.00    281.  501.20

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     93.    32.   -20.    12.   0.9   0.5   4.5   6.4   1.0   3.0
   RT:    188.    41.    12.    53.   1.1   0.8   5.3   5.9   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       13    -30      324  0.63  0.16  501.83  497.42    1900  501.20
        49     15     39    28190  1.19  0.00    0.00    0.52    5.86
                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.
    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -27.     -9.    31.   1900.   10909.     163.   11.68  494.85
   FULLV:FV       0.    -20.    31.   1900.   12301.     178.   10.69  495.88
   BRIDG:BR       0.      0.    25.   1621.   10253.     153.   10.60  497.67
   RDWAY:RG      14.*******    93.    281.******************     1.00  501.20
   APPRO:AS      49.    -31.    39.   1900.   28190.     324.    5.86  501.20

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL     WSEL
   EXITX:XS     494.85    1.01  488.74  510.61************  2.12  496.97  494.85
   FULLV:FV     495.55    1.02  489.43  511.30  0.73  0.00  1.82  497.69  495.88
   BRIDG:BR     495.89    0.75  488.71  497.85************  1.75  499.42  497.67
   RDWAY:RG   ****************  500.11  517.01  0.12******  0.63  501.71  501.20
   APPRO:AS     497.42    0.52  490.71  510.05  0.16  0.00  0.63  501.83  501.20
```

```
        U.S. Geological Survey WSPRO Input File burk016.wsp
        Hydraulic analysis for structure BURKTH00070016   Date: 24-JUL-97
        TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                   RLB
           *** RUN DATE & TIME: 08-05-97  13:25

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                         WSI,CRWS =   493.92     494.10

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

EXITX:XS   ******     -5      135  1.87 *****  495.98  494.10    1480  494.10
       -26 ******     30     8403  1.00 ***** *******    0.99   10.97

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.88     495.15     494.80
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   493.60     511.30    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   493.60     511.30     494.80

FULLV:FV       27     -5      147  1.57  0.74  496.71  494.80    1480  495.14
         0     27     30     9489  1.00  0.00   -0.01    0.89   10.05
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    1.15     496.15     496.58
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   494.64     510.05    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   494.64     510.05     496.58
 ===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 "APPRO"
                 WSBEG,WSEND,CRWS =   496.58     510.05     496.58

APPRO:AS       49      0      123  2.24 *****  498.82  496.58    1480  496.58
        49     49     26     8108  1.00 ***** *******    1.00   12.01
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   495.54     498.74     499.01     497.67
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
           <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

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

BRIDG:BR       27      0      154  1.43 *****  499.28  495.53    1473  497.85
         0 ******     25     9057  1.00 ***** *******    0.68    9.57

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.487  0.000  497.67 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.        <<<<<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       13    -22      260  0.56  0.17  500.75  496.58    1480  500.18
        49     15     34    21743  1.12  1.32    0.00    0.50    5.70

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   500.06
                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>

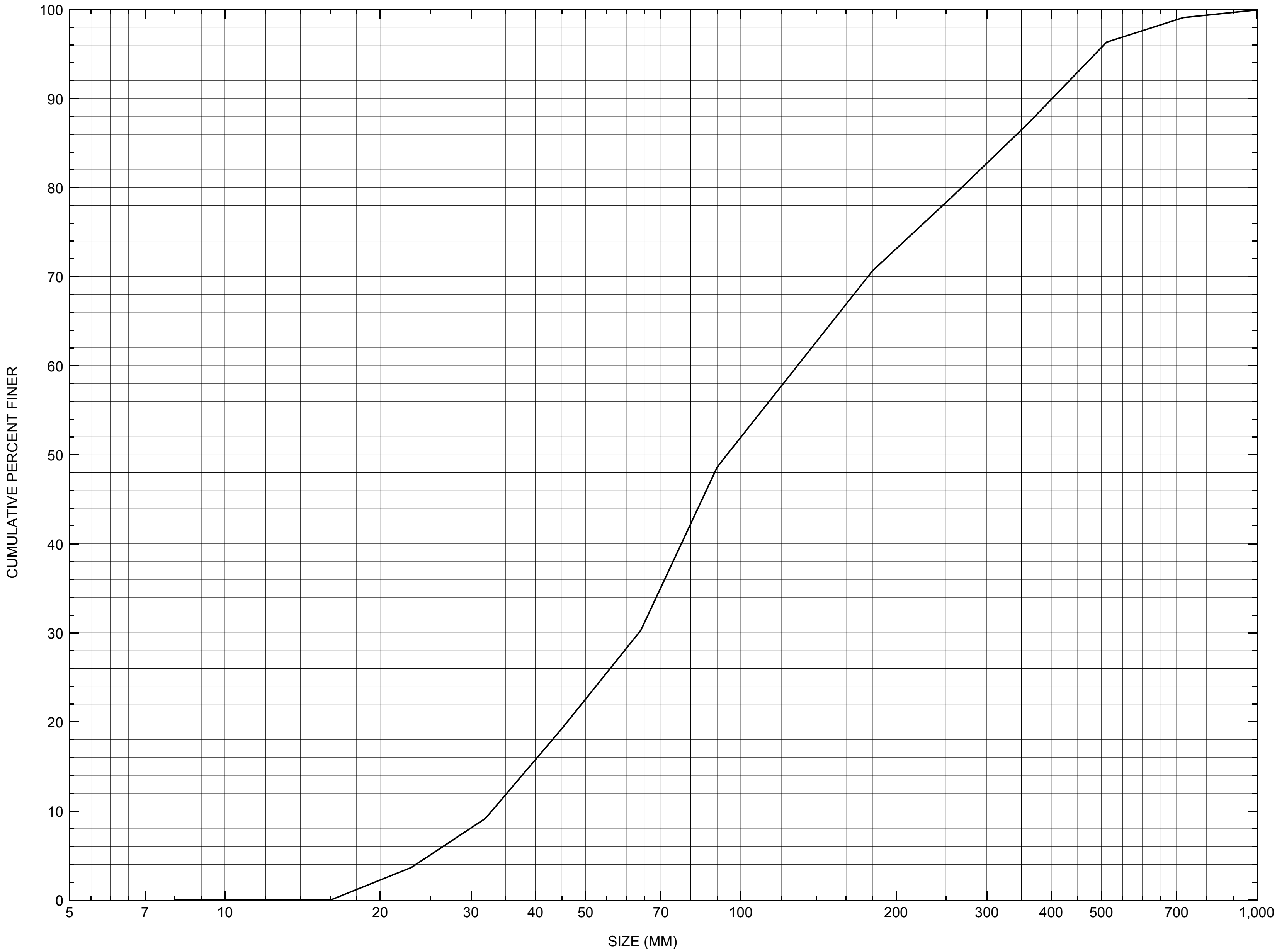
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q       K     AREA     VEL    WSEL
   EXITX:XS     -27.    -6.    30.   1480.    8403.     135.   10.97  494.10
   FULLV:FV       0.    -6.    30.   1480.    9489.     147.   10.05  495.14
   BRIDG:BR       0.     0.    25.   1473.    9057.     154.    9.57  497.85
   RDWAY:RG      14.**************      0.       0.       0.    1.00********
   APPRO:AS      49.   -23.    34.   1480.   21743.     260.    5.70  500.18

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

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    494.10    0.99  488.74  510.61************  1.87  495.98  494.10
   FULLV:FV    494.80    0.89  489.43  511.30  0.74  0.00  1.57  496.71  495.14
   BRIDG:BR    495.53    0.68  488.71  497.85************  1.43  499.28  497.85
   RDWAY:RG  ***************  500.11  517.01************  0.56  500.63********
   APPRO:AS    496.58    0.50  490.71  510.05  0.17  1.32  0.56  500.75  500.18
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure BURKTH00070016, in Burke, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BURKTH00070016

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 24 / 95

Highway District Number *(I - 2; nn)* 07

County *(FIPS county code; I - 3; nnn)* 005

Town *(FIPS place code; I - 4; nnnnn)* 10450

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

Waterway *(I - 6)* DISH MILL BROOK

Road Name *(I - 7):* -

Route Number TH007

Vicinity *(I - 9)* 0.5 MI JCT TH 7 + VT 114

Topographic Map Burke Mountain

Hydrologic Unit Code: 01080102

Latitude *(I - 16; nnnn.n)* 44354

Longitude *(i - 17; nnnnn.n)* 71559

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10030200160302

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

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

Year built *(I - 27; YYYY)* 1929

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

Average daily traffic, ADT *(I - 29; nnnnnn)* 000800

Deck Width *(I - 52; nn.n)* 229

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

Channel & Protection *(I - 61; n)* 5

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

Waterway adequacy *(I - 71; n)* 6

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*) 020.0

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) 140.0

Comments:

The structural inspection report of 10/31/94 indicates the structure is a steel stringer type bridge with a concrete deck and an asphalt roadway surface. The abutment walls and wingwalls are concrete, which have a few fine cracks, leaks, and areas of surface spalling noted overall. In addition, a random vertical crack and leak is reported on the left abutment wall. Similarly, a settlement crack is noted in the right abutment wall which extends down through the footing. The report gives the impression that both concrete footings are exposed. The right abutment is reported undermined in a 8 foot section centered on the centerline of the roadway by up to 30 inches horizontally. **(Continued, page 33)**

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: **6.0**

Terrain character: -

Stream character & type: -

Streambed material: **Small stones and boulders**

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} **800** Q_{25} **1100**

Q_{50} **1400** Q_{100} **1700** Q_{500} -

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

Estimated Discharge *(cfs)*: - Velocity at Q **50** *(ft/s)*: **14.7**

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: **There is a current proposal to straighten the channel and riprap the channel edges in some locations in an effort to eliminate 2 other bridges over the same waterway further upstream. The VTAOT is currently procuring the Corp. of engineers for a permit to do this work.**

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*)	-	2.7	3.2	3.6	4.1
Velocity (*ft / sec*)	-	-	-	14.7	-

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*): **Y** *If No or Unknown, type ctrl-n os*

Upstream distance (*miles*): **0.3** Town: **Burke** Year Built: **1929**

Highway No. : **TH07** Structure No. : **17** Structure Type: **Concrete, steel beam**

Clear span (*ft*): **23.2** Clear Height (*ft*): **7.0** Full Waterway (ft^2): **162.4**

Downstream distance (*miles*): 0.5 Town: Burke Year Built: 1928

Highway No. : - Structure No. : 13 Structure Type: Concrete, Steel beam

Clear span (*ft*): 29.0 Clear Height (*ft*): 11.0 Full Waterway (ft^2): 319.0

Comments:

A few boulders are present at the ends of each wingwall and along the banks upstream and downstream of the bridge. Bank erosion upstream and downstream is evident from previous flooding.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 6.03 mi^2

Lake/pond/swamp area 0 mi^2

Watershed storage *(ST)* 0 %

Bridge site elevation 964 ft

Headwater elevation 2474 ft

Main channel length 4.33 mi

10% channel length elevation 1060 ft

85% channel length elevation 1900 ft

Main channel slope *(S)* 258.65 ft / mi

Watershed Precipitation Data

Average site precipitation - in

Average headwater precipitation - in

Maximum 2yr-24hr precipitation event *(I24,2)* - in

Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

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

Project Number - Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB -

Benchmark location description:

NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness - Footing bottom elevation: -

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS.

Cross-sectional Data

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

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

Comments: **This cross section is the downstream face. The low chord elevations are from the survey log done for this report on 8/7/95. The low chord to bed length data is from the sketch attached to a bridge inspection report dated 10/31/94. The sketch was done on 10/27/92.**

Station	0	3	6.3	12.5	15.8	17.6	19.2	-	-	-	-
Feature	RAB	-	-	-	-	-	LAB	-	-	-	-
Low chord elevation	497.9	497.8	497.8	497.7	497.6	497.5	497.5	-	-	-	-
Bed elevation	491.5	489.5	488.8	489.1	489.9	489.9	491.3	-	-	-	-
Low chord-bed	6.4	8.3	9.0	8.6	7.8	7.6	6.2	-	-	-	-

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

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

Comments:

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **2/28/96**
Computerized by: **RB** Date: **2/28/96**
Reviewd by: **RB** Date: **8/8/97**

Structure Number **BURKTH00070016**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **T. SEVERANCE** Date *(MM/DD/YY)* **08** / **07** / 19**95**

2. Highway District Number **07** Mile marker **0000**
County **CALEDONIA 005** Town **BURKE 10450**
Waterway *(I - 6)* **DISH MILL BROOK** Road Name **-**
Route Number **TH07** Hydrologic Unit Code: **01080102**

3. Descriptive comments:
Located about 0.5 miles east of the intersection of TH07 with VT114.

B. Bridge Deck Observations

4. Surface cover... LBUS **5** RBUS **6** 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 **2** UB **1** DS **1** *(**1**- pool; **2**- riffle)*

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

7. Bridge length **28** *(feet)* Span length **24** *(feet)* Bridge width **22.9** *(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)*

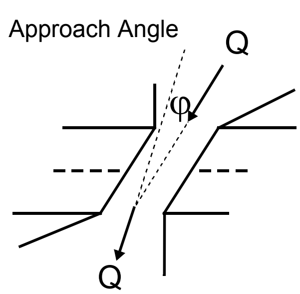
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

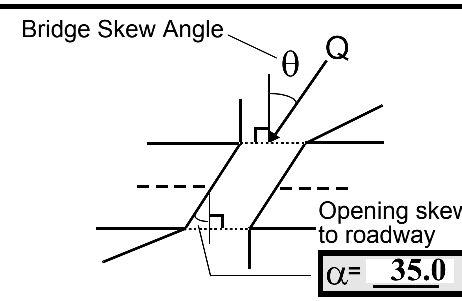
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	3	1
RBUS	0	-	2	1
RBDS	0	-	3	1
LBDS	0	-	3	1

*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: **15** 16. Bridge skew: **35**





α= **35.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **3** feet **US** *(US, UB, DS)* to **0** feet **DS**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **15** feet **DS** *(US, UB, DS)* to **50** feet **DS**

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

18. Bridge Type: **1a**

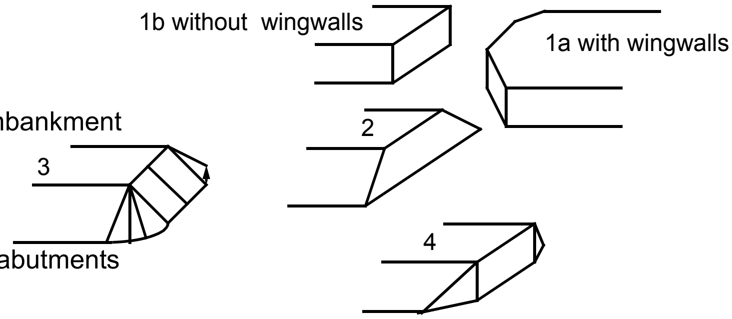
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls 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.)

Three vertical concrete posts are along both bridge faces, each with two steel braided cables. The cable extends 15 feet up hill on the US left bank and 5 feet beyond bridge on the US right bank. The left bank DS cables extend up hill but the anchors to the ground are damaged (pulled out of the wood post) and the right bank DS cables have been ripped out of the post. The left bank US concrete post reads "1928."

7. Values are from VT AOT files. Measured bridge length = 29.2 feet, span length = 24.3 feet, and bridge width = 22.2 feet. Paved roadway width perpendicular to the road is 19.7 feet.

4. Immediate banks are densely vegetated with shrubs and brush.

13. Some channel erosion is evident. Abundant rock fill has been placed along the channel edge on the left bank US from the wingwall to 75 ft US.

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
33.0	4.0			6.5	2	4	34	34	1	1

23. Bank width **65.0** 24. Channel width **55.0** 25. Thalweg depth **30.5** 29. Bed Material **432**

30 .Bank protection type: LB **2** RB **0** 31. Bank protection condition: LB **1** 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.):

27. Bank material is composed of small to large cobbles and a few small boulders.

30. Boulders have been used as back fill for both US wingwalls but only extends US on the left bank. Bank protection extends from 0 feet US to 40 feet US on the left bank.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **125** 35. Mid-bar width: **13**

36. Point bar extent: **100** feet **US** (US, UB) to **150** feet **US** (US, UB, DS) positioned **0** %LB to **50** %RB

37. Material: **4**

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

This side bar is beyond 2 bridge lengths.

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: **40** 42. Cut bank extent: **0** feet **US** (US, UB) to **46** 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.):

The fines have been washed from much of this section leaving cobbles and boulders exposed. Some have fallen into the river bed and lie at the edgeof the channel. Some slumping of the bank at the US left wingwall has occurred. Debris from high flow has accumulated here. Another cut bank exists from 40 feet US to 90 feet US on the left bank.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **1UB**

47. Scour dimensions: Length **3** Width **3** Depth : **1.75** Position **45** %LB to **55** %RB

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

Mid scour distance is 1 foot DS from the US bridge face in the middle of the channel. There are four adjacent pooled areas starting at the US bridge face. The first is the channel scour described above. Just after this pool is a large rock in the center of the channel, 1/3 of the channel width. Consequently, most of the flow is forced quickly left and right along the footing walls to the DS bridge face. Another small scour hole is at the DS bridge face from 50% LB to 60% RB; 6 feet long, 4 feet wide, and 1 foot deep.

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
24.5		1.5		2	7	7	-

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

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

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

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

435

-

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 **2**____ *(**1**- Low; **2**- Moderate; **3**- High)*

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

70. Debris and Ice Comments:

2

Various examples of debris, grass, branches, and small logs, have accumulated on the banks.

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		**-**	**90**	**2**	**1**	**1**	**1.5**	**90.0**
RABUT	**1**	**10**	**90**			**2**	**1**	**20.5**

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*

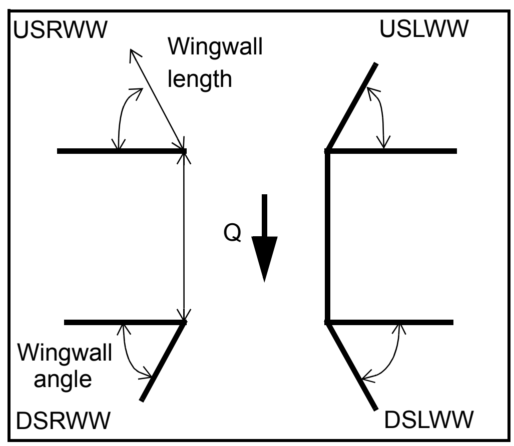
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

1
2.5
1

At the middle of the left abutment it is possible to penetrate beneath the footing 0.25 ft. At the middle of the right abutment it is possible to penetrate beneath the footing 1.75 ft. Some scarring of both abutments and footing faces is evident. The left footing vertical height above the bed is 1.5 ft. The right footing is 2.5 ft. from the top of footing to the bed at the same point above where the penetration measurement was made. On the US left wingwall and left abutment there is a crack starting at the top and going down 1 foot. There is a large crack 0.25 inches wide running from the bridge seat to the base of the footing on the DS right abutment. Along the right abutment there is a concrete slab lining the channel from the footing, down 1.5 feet, around to

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:	**the**		**bank**		**alon**	**20.5**	
USRWW:	**g the**		**wing**		**wall**	**2.0**	
DSLWW:	**foot-**		**ing,**		**14**	**29.0**	
DSRWW:	**feet**		**DS**		**to 24**	**29.0**	



*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	**feet**	**lweg**	**US**	**-1**	**=**	**DS**	**-1 ft.**	**1**
Condition	**DS.**	**dept**	**=**	**ft.,**	**1.5-**	**=**		**2**
Extent	**Tha**	**hs:**	**0.75**	**UB**	**2 ft.,**	**0.75**	**Y**	**0.5**

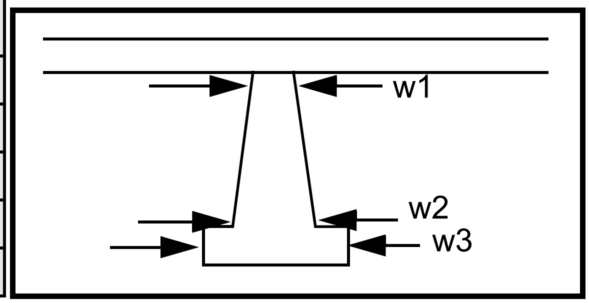
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
1.5
Y
1
2
0.33
1.33
Y
1
2
0.5
1.5

Piers:

84. Are there piers? **Y** (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				20.0	15.0	90.0
Pier 2	9.5	8.0		35.0	15.0	15.0
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	1	-	1	with	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	2	1	1	cob-	1- Solid pier, 2- column, 3- bent
88. Material	0.75	1	1	bles	1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	1.75	3	1	and	1- Round; 2- Square; 3- Pointed
90. Inclined?	2	0	All	smal	Y- yes; N- no
91. Attack ∠ (BF)	1	-	four	l	
92. Pushed	1	-	wing	boul-	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	2	0	walls	ders.	
95. Cross-members	2	-	have	It is	0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	2	-	been	most	0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	0	2	back	evi-	
98. Exposure depth	-	2	filled	dent	

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

at the US wingwalls. There is damage to the US left wingwall and concrete face above the steel. The edge of the concrete above the steel is chopped and scarred. The wingwall has a large scarred area approximately 1 ft. by 3 ft. wide just below the girder level. Similar damage is observed on the downstream left wingwall. It is possible to penetrate the US left wingwall approximately 3 inches where the wingwall and abutment meet.

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
-	-			-	N	-	-	-	-	-

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):
-
-
-
-
-
-

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

Point bar extent: _-____ feet _-___ *(US, UB, DS)* to _-____ feet _-___ *(US, UB, DS)* positioned _-___ %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? _NO__ *(LB or RB)* Mid-bank distance: _PIE_

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

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

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

Is channel scour present? _____ *(Y or if N type ctrl-n cs)* Mid-scour distance: _3_____

Scour dimensions: Length _3____ Width _34____ Depth: _34__ Positioned _1__ %LB to _1__ %RB

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

543
0
0
-

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

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: BURKTH00070016 Town: BURKE
Road Number: TH 7 County: CALEDONIA
Stream: DISH MILL BROOK

Initials RLB Date: 8/5/97 Checked: LKS

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	1410	1900	1480
Main Channel Area, ft2	218	259	228
Left overbank area, ft2	23	55	29
Right overbank area, ft2	1	10	2
Top width main channel, ft	30	30	30
Top width L overbank, ft	19	29	21
Top width R overbank, ft	3	11	5
D50 of channel, ft	0.3086	0.3086	0.3086
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.3	8.6	7.6
y1, average depth, LOB, ft	1.2	1.9	1.4
y1, average depth, ROB, ft	0.3	0.9	0.4
Total conveyance, approach	19901	28188	21717
Conveyance, main channel	19135	25486	20620
Conveyance, LOB	756	2487	1067
Conveyance, ROB	9	215	30
Percent discrepancy, conveyance	0.0050	0.0000	0.0000
Qm, discharge, MC, cfs	1355.7	1717.9	1405.2
Ql, discharge, LOB, cfs	53.6	167.6	72.7
Qr, discharge, ROB, cfs	0.6	14.5	2.0
Vm, mean velocity MC, ft/s	6.2	6.6	6.2
Vl, mean velocity, LOB, ft/s	2.3	3.0	2.5
Vr, mean velocity, ROB, ft/s	0.6	1.4	1.0
Vc-m, crit. velocity, MC, ft/s	10.5	10.9	10.6
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	1410	1900	1480
(Q) discharge thru bridge, cfs	1410	1621	1480
Main channel conveyance	9057	10253	9057
Total conveyance	9057	10253	9057
Q2, bridge MC discharge,cfs	1410	1621	1480
Main channel area, ft2	154	153	154
Main channel width (normal), ft	20.3	20.3	20.3
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	20.3	20.3	20.3
y_bridge (avg. depth at br.), ft	7.59	7.54	7.59
Dm, median (1.25*D50), ft	0.38575	0.38575	0.38575
y2, depth in contraction,ft	6.16	6.94	6.42
ys, scour depth (y2-ybridge), ft	-1.43	-0.60	-1.17

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 other, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	1410	1900	1480
Q, thru bridge MC, cfs	1410	1621	1480
Vc, critical velocity, ft/s	10.54	10.85	10.62
Va, velocity MC approach, ft/s	6.22	6.63	6.16
Main channel width (normal), ft	20.3	20.3	20.3
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	20.3	20.3	20.3
qbr, unit discharge, ft2/s	69.5	79.9	72.9
Area of full opening, ft2	154.0	153.0	154.0
Hb, depth of full opening, ft	7.59	7.54	7.59
Fr, Froude number, bridge MC	0.65	0.75	0.68
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	107	118	111
**Hb, depth at downstream face, ft	5.27	5.81	5.47
**Fr, Froude number at DS face	1.01	1.00	1.00
**Cf, for downstream face (<=1.0)	1.00	1.00	1.00
Elevation of Low Steel, ft	497.67	497.67	497.67

Elevation of Bed, ft	490.08	490.13	490.08
Elevation of Approach, ft	499.85	501.2	500.18
Friction loss, approach, ft	0.17	0.16	0.17
Elevation of WS immediately US, ft	499.68	501.04	500.01
ya, depth immediately US, ft	9.60	10.91	9.93
Mean elevation of deck, ft	500.78	500.78	500.78
w, depth of overflow, ft (>=0)	0.00	0.26	0.00
Cc, vert contrac correction (<=1.0)	0.94	0.91	0.93
**Cc, for downstream face (<=1.0)	0.79	0.79	0.79
Ys, scour w/Chang equation, ft	-0.59	0.54	-0.23
Ys, scour w/Umbrell equation, ft	0.11	1.27	0.29

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

**Ys, scour w/Chang equation, ft	3.07	3.50	3.22
**Ys, scour w/Umbrell equation, ft	2.42	2.99	2.41

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	6.16	6.94	6.42
WSEL at downstream face, ft	495.36	495.89	495.53
Depth at downstream face, ft	5.27	5.81	5.47
Ys, depth of scour (Laursen), ft	0.89	1.13	0.95

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)
(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	1410	1621	1480
Main channel area (DS), ft2	107	118	111
Main channel width (normal), ft	20.3	20.3	20.3
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	20.3	20.3	20.3
D90, ft	1.3174	1.3174	1.3174
D95, ft	1.5962	1.5962	1.5962
Dc, critical grain size, ft	1.1576	1.1971	1.1631
Pc, Decimal percent coarser than Dc	0.133	0.125	0.132
Depth to armoring, ft	22.64	25.14	22.95

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	1410	1900	1480	1410	1900	1480
a', abut.length blocking flow, ft	22.9	33.5	25.5	9.2	16.5	11
Ae, area of blocked flow ft2	45.54	73.89	53.74	25.93	29.26	28.87

Qe, discharge blocked abut.,cfs	149.81	--	176.78	86.17	--	94.56
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.29	3.58	3.29	3.32	3.39	3.28
ya, depth of f/p flow, ft	1.99	2.21	2.11	2.82	1.77	2.62
--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	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	0.411	0.398	0.399	0.349	0.368	0.356
ys, scour depth, ft	7.76	9.28	8.25	7.61	6.66	7.66

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)	22.9	33.5	25.5	9.2	16.5	11
y1 (depth f/p flow, ft)	1.99	2.21	2.11	2.82	1.77	2.62
a'/y1	11.52	15.19	12.10	3.26	9.30	4.19
Skew correction (p. 49, fig. 16)	0.87	0.87	0.87	1.08	1.08	1.08
Froude no. f/p flow	0.41	0.40	0.40	0.35	0.37	0.36
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	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1.01	1	1	1.01	1	1
y, depth of flow in bridge, ft	5.27	5.81	5.47	5.27	5.81	5.47
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	2.21	2.43	2.29	2.21	2.43	2.29