# LEVEL II SCOUR ANALYSIS FOR BRIDGE 6 (BRISVT01160006) on STATE ROUTE 116, crossing LITTLE NOTCH BROOK, BRISTOL, VERMONT

U.S. Geological Survey
Open-File Report 97-4

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

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By Erick M. Boehmler and Ronda L. Burns

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**Pembroke, New Hampshire**

**1997**

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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.

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## INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BRISVT01160006 on State Route 116 crossing the Little Notch Brook, Bristol, 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 Green Mountain section of the New England physiographic province of West-central Vermont in the town of Bristol. The 8.59-$mi^2$ drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is dense forest except for the downstream left side, which is row crops.

In the study area, Little Notch Brook has a sinuous channel with a slope of approximately 0.005 ft/ft, an average channel top width of 32 ft and an average channel depth of 4 ft. The predominant channel bed material is sand and gravel with a median grain size ($D_{50}$) of 17.4 mm (0.0570 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 13, 1996, indicated that the reach was laterally unstable. The sinuous configuration of the channel with fine bed and bank material, a sharp channel bend upstream, and point bars and cut-banks upstream and downstream of this site are among the primary characteristics, which suggest lateral instability.

In addition, there is evidence of streambed degradation at this site. A large eddy was noted at the location where Little Notch Brook enters the New Haven River about 100 feet downstream. There was a large scour hole noted at the location of the eddy, which is likely to remove streambed material at least as quickly as supplied from upstream on Little Notch Brook. Hence, channel degradation may be significant during a flood event.

The state route 116 crossing of Little Notch Brook is a 24-ft-long, two-lane bridge consisting of one 21-foot concrete span (Vermont Agency of Transportation, written communication, December 14, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 15 degrees to the opening while the opening-skew-to-roadway is 25 degrees.

There was one foot of scour evident along the downstream half of the left abutment footing and some separation of the left abutment wall from the deck above due to settling. The left abutment footing was undermined up to a foot at the downstream end. The scour protection measures at the site were type-1 stone fill (less than 12 inches diameter) on the upstream left bank and type-2 stone fill (less than 36 inches diameter) on the right banks and right wingwalls upstream and downstream of the structure. 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 3.2 to 4.3 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 6.0 to 10.0 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.

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.

**South Mountain, VT. Quadrangle, 1:24,000, 1963**
**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*** BRISVT01160006 ***Stream*** Little Notch Brook

***County*** Addison ***Road*** VT 116 ***District*** 5

## Description of Bridge

***Bridge length*** 24 ***ft*** ***Bridge width*** 28.6 ***ft*** ***Max span length*** 21 ***ft***

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

***Abutment type*** Vertical ***Embankment type*** Sloping

***Stone fill on abutment?*** No ***Date of inspection*** 6/13/96

***Description of stone fill*** Type-2 on the right wingwalls and right banks upstream and downstream of the bridge. Type-1 on the left bank upstream.

***Brief description of piers/abutments*** Abutments and wingwalls are concrete. There is a one foot deep scour hole along the downstream half of the left abutment footing. The footings of both abutments are exposed.

***Is bridge skewed to flood flow according to*** Y ***survey?*** Y ***Angle*** 15

There is a sharp channel bend in the upstream reach. The scour along the left abutment has developed where the greatest impact of flow occurs.

***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 | 6/13/96 | 0 | 0 |
| Level II | 6/13/96 | 0 | 0 |

***Potential for debris*** High. There is greater than 50% tree coverage on unstable banks upstream.

***Describe any features near or at the bridge that may affect flow (include observation date)*** There is a large point bar noted on 6/13/96 immediately upstream of the bridge opening, which blocks up to 50% of the channel width.

## Description of the Geomorphic Setting

***General topography*** The channel at this site crosses the flood plain of the New Haven River valley, which has moderate relief and moderately sloping valley walls.

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

***Date of inspection*** 6/13/96

***DS left:*** Steep channel bank to a wide, irregular overbank.

***DS right:*** Steep channel bank to a wide irregular overbank.

***US left:*** Moderately sloping channel bank.

***US right:*** Moderately sloping channel bank to a narrow, very irregular overbank.

## Description of the Channel

***Average top width*** 32 ft ***Average depth*** 4 ft

***Predominant bed material*** Gravel / Sand ***Bank material*** Silt&Clay / Sand

Sinuous and laterally unstable with alluvial channel boundaries.

6/13/96

***Vegetative co*** Trees with row crops on the overbank.

***DS left:*** Trees, vines, shrubs, and brush.

***DS right:*** Trees and shrubs.

***US left:*** Trees, shrubs, and brush.

***US right:*** No

***Do banks appear stable?*** ***If not, describe location and type of instability and date of observation.*** On 6/13/96, there were cut-banks, point bars and localized scour evident in the channel upstream and downstream of this site. Particularly downstream the banks are noted as oversteepend with block failure slumping of bank material at the cut-bank. Some minor channel braiding also is evident downstream.

***Describe any obstructions in channel and date of observation.*** The assessment of 6/13/96 noted flow conditions up to bank-full level are influenced by a large point bar on the left bank immediately upstream of the bridge opening, which occupies about 50% of the channel width.

## Hydrology

***Drainage area*** 8.59 ***mi²***

***Percentage of drainage area in physiographic provinces: (approximate)***

| ***Physiographic province/section*** | ***Percent of drainage area*** |
| --- | --- |
| New England / Green 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*** 1,690 ***ft³/s*** ***Q500*** 2,350 ***ft³/s***

The 100- and 500-year discharges are based on discharge frequency curves computed by use of several empirical equations (Benson, 1962; FHWA, 1983; Johnson and Laraway, unpublished draft, 1972; Johnson and Tasker, 1974; Potter, 1957a&b; and Talbot, 1887) and a drainage area relationship [(8.59/8.3)exp 0.67] with VTAOT database values for the 100- and 500- year discharges (1400 and 1650 cfs respectively) at bridge number 21 in Bristol on Little Notch Brook. The 100- and 500-year discharges selected for the hydraulic analyses herein were those resulting from the drainage area relationship due to their central tendency with the empirical estimates.

## 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 399 feet from the USGS survey to obtain VTAOT plans' datum to the nearest foot.

***Description of reference marks used to determine USGS datum.*** RM1 is the center point of a chiseled "X" in the asphalt roadway surface at the upstream end of the right abut-ment (elev. 502.73 ft, arbitrary survey datum). RM2 is the head of a nail in one of a clump of five trees located about 15 feet toward the right bank from the right abutment and 50 feet upstream perpendicular to roadway (elev. 504.88 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 | -24 | 1 | Exit section |
| FULLV | 0 | 2 | Downstream Full-valley section (Templated from EXITX) |
| BRIDG | 0 | 1 | Bridge section |
| RDWAY | 15 | 1 | Road Grade section |
| APPRO | 48 | 2 | Modelled Approach sec-tion (Templated from (APTEM) |
| APTEM | 53 | 1 | Approach section as sur-veyed (Used as a tem-plate) |

[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.

Field observations on 6/13/96 indicate that flow will cross the drainage divide into a swamp on the upstream right overbank area when the stage exceeds the top of the right bank upstream of this site. Since the quantity of flow loss is uncertain and the maximum scour potential is desired, a vertical wall was drawn near the divide on the right overbank of each section for modeling the hydraulics at this site. Therefore, all of the discharge for each modeled event was assumed to remain within the watershed and contribute to scour.

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 0.035 to 0.050, and overbank "n" values ranged from 0.040 to 0.10.

Although Little Notch Brook enters the New Haven River about 300 feet downstream of this site, the differences in watershed area and characteristics suggest that the peak discharges on each reach are not contemporaneous. Therefore, no backwater effects were assumed and normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0046 ft/ft, which was estimated by use of surveyed water surface points between the BRIDG and EXITX sections.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.00445 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.

**Bridge Hydraulics Summary**

*Average bridge embankment elevation* 503.1 *ft*
*Average low steel elevation* 500.8 *ft*

*100-year discharge* 1,690 $ft^3/s$
*Water-surface elevation in bridge opening* 501.0 *ft*
*Road overtopping?* Yes *Discharge over road* 569 $ft^3/s$
*Area of flow in bridge opening* 135 $ft^2$
*Average velocity in bridge opening* 8.2 *ft/s*
*Maximum WSPRO tube velocity at bridge* 10.4 *ft/s*

*Water-surface elevation at Approach section with bridge* 502.4
*Water-surface elevation at Approach section without bridge* 499.5
*Amount of backwater caused by bridge* 2.9 *ft*

*500-year discharge* 2,350 $ft^3/s$
*Water-surface elevation in bridge opening* 501.0 *ft*
*Road overtopping?* Yes *Discharge over road* 1130 $ft^3/s$
*Area of flow in bridge opening* 136 $ft^2$
*Average velocity in bridge opening* 9.1 *ft/s*
*Maximum WSPRO tube velocity at bridge* 11.4 *ft/s*

*Water-surface elevation at Approach section with bridge* 502.9
*Water-surface elevation at Approach section without bridge* 500.4
*Amount of backwater caused by bridge* 2.5

*Incipient overtopping discharge* 1,050 $ft^3/s$
*Water-surface elevation in bridge opening* 498.3 *ft*
*Area of flow in bridge opening* 91 $ft^2$
*Average velocity in bridge opening* 11.5 *ft/s*
*Maximum WSPRO tube velocity at bridge* 15.2 *ft/s*

*Water-surface elevation at Approach section with bridge* 500.9
*Water-surface elevation at Approach section without bridge* 499.0
*Amount of backwater caused by bridge* 1.9 *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 was computed by use of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for the incipient road overtopping discharge. The 100- and 500-year 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). Therefore, contraction scour for the 100- and 500-year discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). Results of Laursen's equation for the 100- and 500- year discharge models also are provided in Appendix F. Streambed armoring depths computed suggest that armoring will not impede contraction scour.

Abutment scour for the left abutment at all modelled discharges 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 at the right abutment for the modeled discharges was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

## 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* | 3.2 | 4.3 | 3.6 |
| *Depth to armoring* | 24.1 | 43.7 | N/A |
| ***Left overbank*** | -- | -- | -- |
| ***Right overbank*** | -- | -- | -- |
| ***Local scour:*** | | | |
| ***Abutment scour*** | | | |
| *Left abutment* | 9.0 | 10.0 | 9.1 |
| *Right abutment* | 8.4 | 8.9 | 6.0 |
| ***Pier scour*** | | | |
| *Pier 1* | -- | -- | -- |
| *Pier 2* | -- | -- | -- |
| *Pier 3* | -- | -- | -- |

## Riprap Sizing

| | *100-yr discharge* | *500-yr discharge* | *Incipient overtopping discharge* |
|---|---|---|---|
| | *($D_{50}$ in feet)* | | |
| ***Abutments:*** | | | |
| *Left abutment* | 1.4 | 1.8 | 2.1 |
| *Right abutment* | 1.4 | 1.8 | 2.1 |
| ***Piers:*** | | | |
| *Pier 1* | -- | -- | -- |
| *Pier 2* | -- | -- | -- |

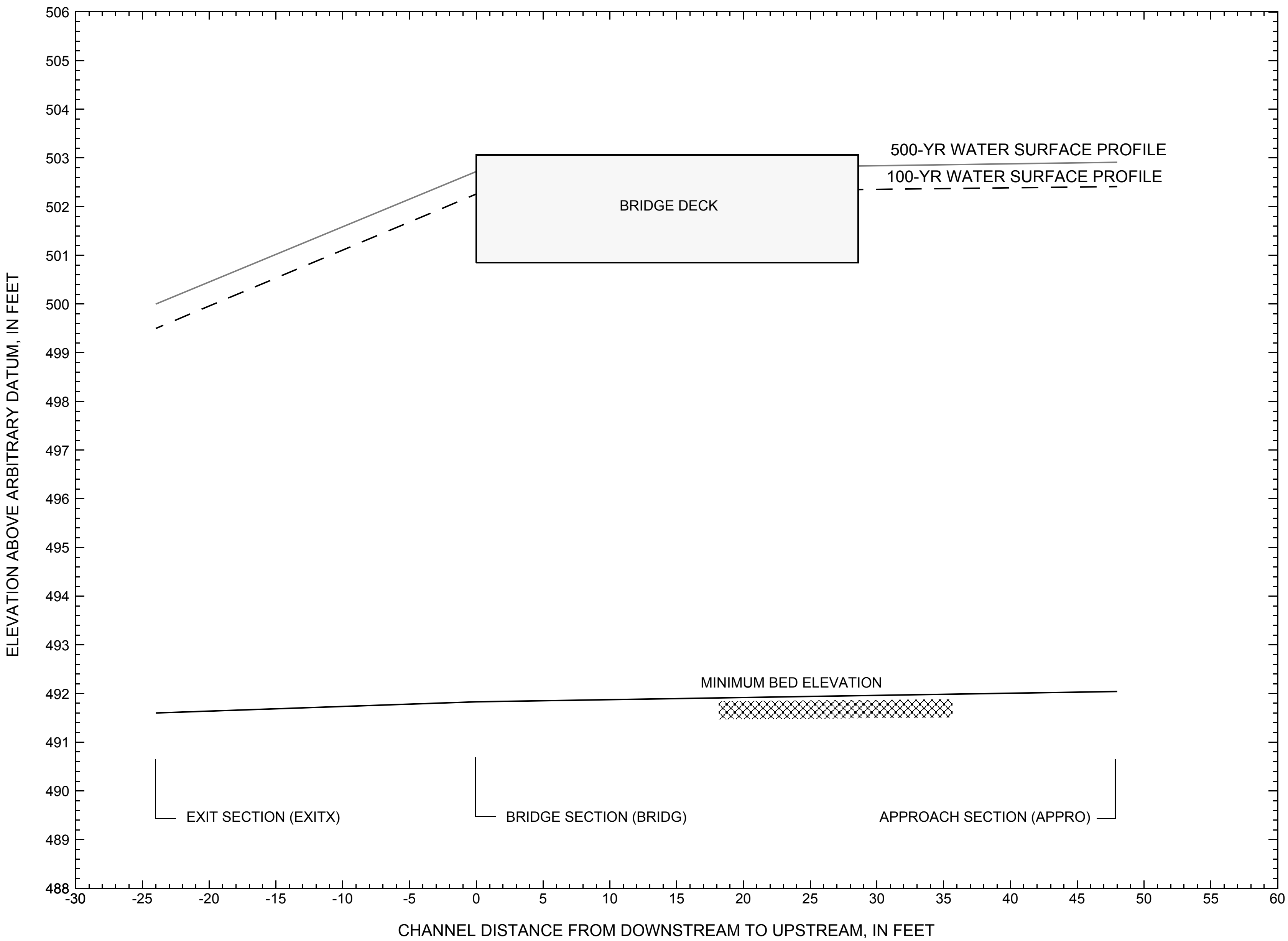


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BRISVT01160006 on state route 116, crossing Little Notch Brook, Bristol, Vermont.

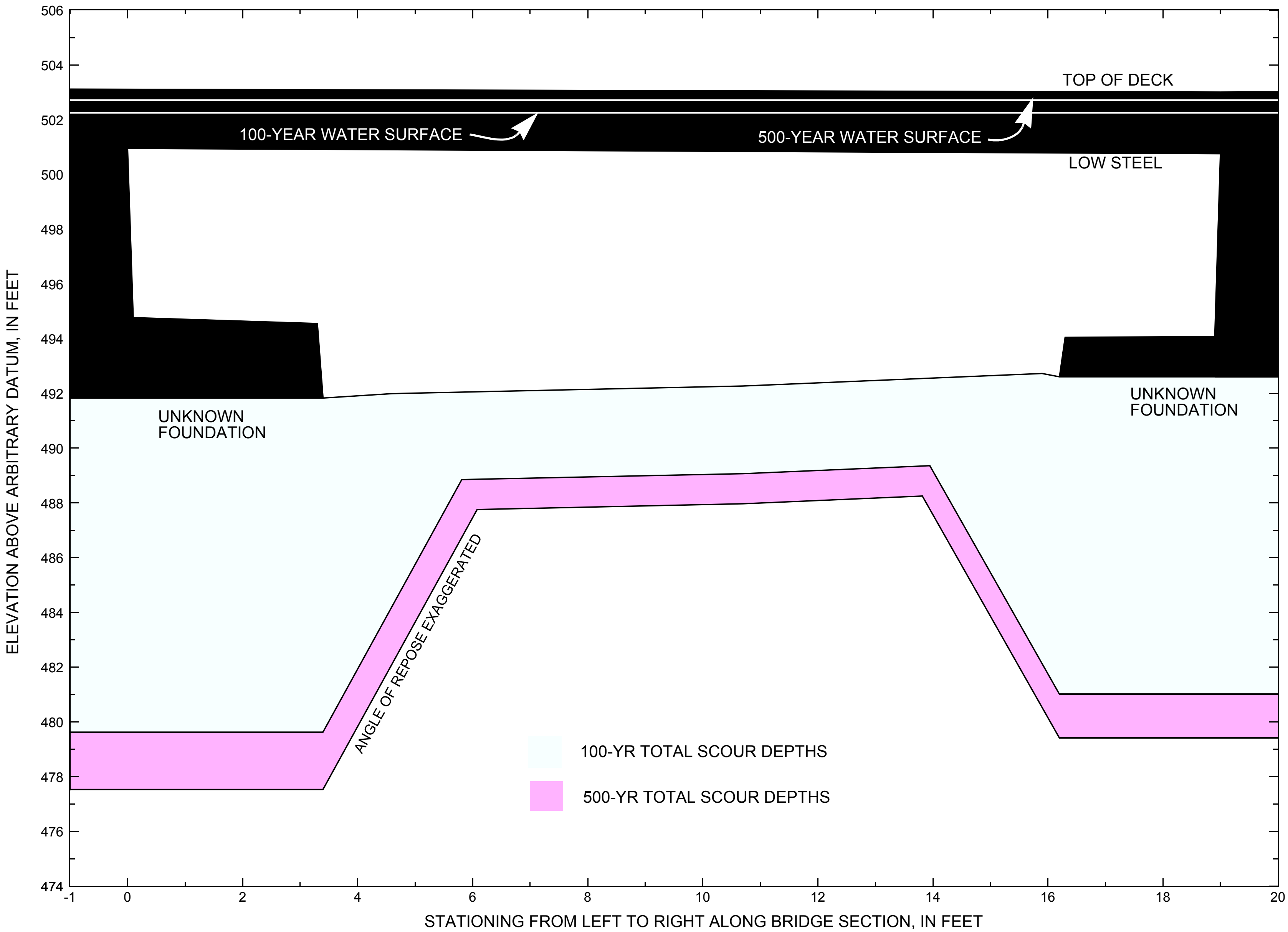


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BRISVT01160006 on state route 116, crossing Little Notch Brook, Bristol, Vermont.

**Table 1.** Remaining footing/pile depth at abutments for the 100-year discharge at structure BRISVT01160006 on State Route 116, crossing Little Notch Brook, Bristol, Vermont.

[VTAOT, Vermont Agency of Transportation; --,no data]

| Description | Station[1] | VTAOT minimum low-chord elevation (feet) | Surveyed minimum low-chord elevation[2] (feet) | Bottom of footing elevation[2] (feet) | Channel elevation at abutment/ pier[2] (feet) | Contraction scour depth (feet) | Abutment scour depth (feet) | Pier scour depth (feet) | Depth of total scour (feet) | Elevation of scour[2] (feet) | Remaining footing/pile depth (feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100-yr. discharge is 1,690 cubic-feet per second | | | | | | | | | | | |
| Left abutment | 0.0 | 102.0 | 501.0 | -- | 491.8 | 3.2 | 9.0 | -- | 12.2 | 479.6 | -- |
| Right abutment | 19.0 | 101.8 | 500.8 | -- | 492.6 | 3.2 | 8.4 | -- | 11.6 | 481.0 | -- |

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



**Table 2.** Remaining footing/pile depth at abutments for the 500-year discharge at structure BRISVT01160006 on State Route 116, crossing Little Notch Brook, Bristol, Vermont.

[VTAOT, Vermont Agency of Transportation; --, no data]

| Description | Station[1] | VTAOT minimum low-chord elevation (feet) | Surveyed minimum low-chord elevation[2] (feet) | Bottom of footing elevation[2] (feet) | Channel elevation at abutment/ pier[2] (feet) | Contraction scour depth (feet) | Abutment scour depth (feet) | Pier scour depth (feet) | Depth of total scour (feet) | Elevation of scour[2] (feet) | Remaining footing/pile depth (feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 500-yr. discharge is 2,350 cubic-feet per second | | | | | | | | | | | |
| Left abutment | 0.0 | 102.0 | 501.0 | -- | 491.8 | 4.3 | 10.0 | -- | 14.3 | 477.5 | -- |
| Right abutment | 19.0 | 101.8 | 500.8 | -- | 492.6 | 4.3 | 8.9 | -- | 13.2 | 479.4 | -- |

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 bris006.wsp
T2        Hydraulic analysis for structure BRISVT01160006   Date: 02-AUG-96
T3        State Route 116 Crossing Little Notch Brook, Bristol, VT           EMB
*
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           1690.0,   2350.0,   1050.0
SK          0.0046,   0.0046,   0.0046
WS          499.48,   500.00,   498.72
*
XS   EXITX    -24
GR         -557.8, 507.28   -555.6, 505.71   -553.9, 503.05   -540.2, 502.14
GR           -4.4, 498.72      0.0, 493.82      2.0, 491.61      6.1, 492.17
GR            9.3, 492.89     19.2, 493.23     20.6, 493.86     23.6, 494.46
GR           28.7, 497.59    249.5, 498.00    249.5, 504.00
*
*           Replaced: 33.4, 501.04    128.1, 501.69    249.5, 500.91 with
*                    249.5, 498.00 to more closely represent right overbank
*                    along the toe of the road embankment on the downstream
*                    side. Most road overflow occurs here.
*
*           Notice: A vertical wall was drawn at station 249.5 on the EXITX
*                   section, at station 263.2 on the RDWAY section, and at
*                   station 126.6 on the APPRO section, in order
*                   to prevent excessive roadway overflow and keep flow left
*                   of a localized drainage divide. Right of this station
*                   on the approach, flow would enter a swamp, which is
*                   another drainage according to field observations
*                   for which the modeled discharges do not include.
*
N           0.040        0.050        0.10
SA                 -4.4        28.7
*
XS   FULLV      0 *  *  *  0.0046
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    500.85      25.0
GR            0.0, 500.95      0.1, 494.77      3.3, 494.56      3.4, 491.83
GR            4.6, 491.99     10.7, 492.27     15.9, 492.73     16.2, 492.61
GR           16.3, 494.05     18.9, 494.08     19.0, 500.76      0.0, 500.95
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      40.4 * *     60       5.0
N          0.035
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     15      28.6     1
GR         -556.4, 508.93   -415.0, 504.99   -252.5, 503.07    -95.5, 503.14
GR            0.0, 503.11     16.3, 503.01    141.8, 501.69    263.2, 500.91
GR          263.2, 504.00
*           374.1, 500.38    374.6, 504.00
*
XT   APTEM     53
GR         -540.3, 508.93   -399.1, 504.99   -236.6, 503.07    -79.5, 503.14
GR          -17.3, 501.95     -9.3, 498.23     -5.8, 496.74     -1.1, 494.96
GR            0.0, 493.92      2.9, 493.43      9.9, 493.34     16.0, 492.64
GR           18.5, 492.06     22.1, 493.91     24.7, 496.17     29.3, 498.52
GR           68.3, 499.48     96.7, 499.84    126.5, 499.22    200.0, 499.22
GR          200.0, 504.00
*
*          Notice: The right overbank was extended from station 126.5 to 200.0
*                  to be more comparable to the length of the roadway right
*                  overbank and the location of the divide between the brook
*                  and the swamp.
*
*
*
```

```
AS   APPRO     48  *  *  *  0.00445
GT
N           0.060        0.050        0.090
SA                 -9.3         24.7
*
HP 1 BRIDG  500.95 1 500.95
HP 2 BRIDG  500.95 * * 1116
HP 2 RDWAY  502.26 * *  569
HP 1 APPRO  502.41 1 502.41
HP 2 APPRO  502.41 * * 1690
*
HP 1 BRIDG  500.95 1 500.95
HP 2 BRIDG  500.95 * * 1227
HP 2 RDWAY  502.72 * * 1126
HP 1 APPRO  502.91 * 502.91
HP 2 APPRO  502.91 * * 2350
*
HP 1 BRIDG  498.28 1 498.28
HP 2 BRIDG  498.28 * * 1050
HP 1 APPRO  500.86 1 500.86
HP 2 APPRO  500.86 * * 1050
*
EX
ER
```

APPENDIX B:

# WSPRO OUTPUT FILE

# WSPRO OUTPUT FILE

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      135     11035      0     51                            0
   500.95           135     11035      0     51  1.00      0     19        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.95     0.0    19.0   135.5   11035.    1116.   8.24

X STA.         0.0        2.2        3.7        4.6        5.3        6.1
  A(I)             11.9        9.8        6.8        6.3        5.8
  V(I)             4.68       5.68       8.15       8.90       9.63

X STA.         6.1        6.8        7.5        8.2        8.9        9.5
  A(I)              5.6        5.7        5.5        5.4        5.4
  V(I)             9.89       9.82      10.20      10.36      10.41

X STA.         9.5       10.2       10.9       11.6       12.4       13.1
  A(I)              5.4        5.4        5.4        5.6        5.7
  V(I)            10.28      10.32      10.28      10.02       9.75

X STA.        13.1       13.9       14.8       15.7       16.9       19.0
  A(I)              5.9        6.4        6.7        8.5       12.3
  V(I)             9.48       8.76       8.33       6.57       4.55

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      15.

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.26    87.6   263.2   132.0    1618.     569.   4.31

X STA.        87.6      139.6      155.4      168.2      178.4      187.3
  A(I)             14.2        9.6        8.9        7.9        7.4
  V(I)             2.00       2.96       3.20       3.59       3.83

X STA.       187.3      195.4      202.5      209.0      215.0      220.7
  A(I)              7.2        6.7        6.4        6.1        6.0
  V(I)             3.97       4.27       4.44       4.64       4.77

X STA.       220.7      225.9      230.9      235.5      239.9      244.1
  A(I)              5.8        5.6        5.4        5.2        5.1
  V(I)             4.93       5.10       5.29       5.50       5.56

X STA.       244.1      248.1      251.8      255.5      259.1      263.2
  A(I)              4.9        4.8        4.7        4.7        5.4
  V(I)             5.79       5.96       6.01       6.01       5.23

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      48.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       25       499     33     34                          122
             2      282     32814     34     36                         4604
             3      559     19740    175    179                         5658
   502.41           865     53053    243    250  2.35    -42    200     6043

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      48.

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.41   -42.5   200.0   865.2   53053.    1690.   1.95

X STA.       -42.5       -4.4       -0.5        2.2        4.6        7.0
  A(I)             50.2       27.3       23.5       22.0       21.0
  V(I)             1.68       3.10       3.60       3.85       4.03

X STA.         7.0        9.2       11.5       13.7       15.8       17.8
  A(I)             20.8       20.9       20.8       20.0       20.1
  V(I)             4.06       4.05       4.06       4.22       4.21

X STA.        17.8       19.9       22.4       30.5       48.9       73.1
  A(I)             20.7       22.9       44.5       67.6       75.9
  V(I)             4.09       3.68       1.90       1.25       1.11

X STA.        73.1      103.1      129.3      151.7      175.1      200.0
  A(I)             81.7       78.2       72.3       75.0       80.0
  V(I)             1.03       1.08       1.17       1.13       1.06
```

# WSPRO OUTPUT FILE (continued)

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      135     11035      0     51                            0
   500.95           135     11035      0     51  1.00      0     19        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.95     0.0    19.0   135.5   11035.    1227.   9.06

X STA.         0.0        2.2        3.7        4.6        5.3        6.1
  A(I)             11.9        9.8        6.8        6.3        5.8
  V(I)             5.14       6.24       8.96       9.78      10.59

X STA.         6.1        6.8        7.5        8.2        8.9        9.5
  A(I)              5.6        5.7        5.5        5.4        5.4
  V(I)            10.87      10.80      11.21      11.39      11.44

X STA.         9.5       10.2       10.9       11.6       12.4       13.1
  A(I)              5.4        5.4        5.4        5.6        5.7
  V(I)            11.30      11.35      11.30      11.02      10.72

X STA.        13.1       13.9       14.8       15.7       16.9       19.0
  A(I)              5.9        6.4        6.7        8.5       12.3
  V(I)            10.42       9.63       9.16       7.23       5.00

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      15.

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.72    43.9   263.2   222.8    3337.    1126.   5.05

X STA.        43.9      112.7      132.5      147.0      159.1      169.7
  A(I)             24.9       16.4       14.6       13.3       12.4
  V(I)             2.26       3.44       3.85       4.23       4.54

X STA.       169.7      179.1      187.8      195.8      203.2      210.1
  A(I)             11.7       11.3       10.8       10.3       10.0
  V(I)             4.79       4.98       5.21       5.47       5.64

X STA.       210.1      216.6      222.6      228.4      233.8      239.0
  A(I)              9.7        9.3        9.0        8.8        8.5
  V(I)             5.83       6.05       6.29       6.41       6.61

X STA.       239.0      244.1      248.9      253.5      258.0      263.2
  A(I)              8.4        8.3        7.9        7.9        9.3
  V(I)             6.68       6.81       7.09       7.11       6.05

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      48.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       48      1024     59     60                          245
             2      299     36179     34     36                         5027
             3      646     25122    175    180                         7041
   502.91           993     62324    269    276  2.32    -68    200     7117

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      48.

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.91   -68.6   200.0   993.0   62324.    2350.   2.37

X STA.       -68.6       -5.1       -0.9        2.1        4.7        7.2
  A(I)             71.3       30.5       27.0       24.8       24.2
  V(I)             1.65       3.86       4.35       4.75       4.86

X STA.         7.2        9.7       12.1       14.4       16.7       18.8
  A(I)             23.3       23.5       23.0       23.2       22.7
  V(I)             5.03       5.00       5.12       5.06       5.17

X STA.        18.8       21.2       25.3       40.7       60.6       84.9
  A(I)             24.6       32.5       70.4       77.5       82.8
  V(I)             4.77       3.62       1.67       1.52       1.42

X STA.        84.9      111.7      134.3      155.7      176.6      200.0
  A(I)             86.3       81.5       79.4       77.8       86.7
  V(I)             1.36       1.44       1.48       1.51       1.35
```

# WSPRO OUTPUT FILE (continued)

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       91      8374     17     29                         1194
   498.28            91      8374     17     29  1.00      0     19     1194

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.28     0.0    19.0    91.2    8374.    1050.  11.51

X STA.         0.0        2.6        4.2        5.0        5.7        6.4
  A(I)            8.2        7.4        4.6        4.2        3.9
  V(I)           6.40       7.10      11.37      12.47      13.60

X STA.         6.4        7.1        7.7        8.4        9.0        9.6
  A(I)            3.7        3.7        3.5        3.5        3.5
  V(I)          14.08      14.33      14.88      15.13      15.20

X STA.         9.6       10.3       10.9       11.6       12.2       12.9
  A(I)            3.5        3.5        3.5        3.7        3.7
  V(I)          14.98      15.05      15.01      14.36      14.21

X STA.        12.9       13.7       14.5       15.4       16.7       19.0
  A(I)            3.9        4.1        4.6        6.2        8.5
  V(I)          13.47      12.75      11.45       8.52       6.17

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      48.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1        8       212      6      6                           49
             2      229     23238     34     36                         3375
             3      287      6539    175    178                         2082
   500.86           524     29989    215    220  2.47    -14    200     2952

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      48.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.86   -15.0   200.0   523.5   29989.    1050.   2.01

X STA.       -15.0       -4.1       -0.8        1.5        3.5        5.4
  A(I)           27.2       17.8       16.2       14.5       14.3
  V(I)           1.93       2.95       3.25       3.61       3.67

X STA.         5.4        7.2        9.0       10.8       12.5       14.2
  A(I)           13.5       13.4       13.7       13.1       13.0
  V(I)           3.87       3.91       3.84       4.01       4.03

X STA.        14.2       15.7       17.3       18.8       20.4       22.5
  A(I)           12.9       12.9       12.8       13.8       15.2
  V(I)           4.07       4.07       4.09       3.82       3.45

X STA.        22.5       29.9       59.9      120.7      160.8      200.0
  A(I)           30.0       59.4       78.3       66.3       65.2
  V(I)           1.75       0.88       0.67       0.79       0.81
```

# WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File bris006.wsp
       Hydraulic analysis for structure BRISVT01160006   Date: 02-AUG-96
       State Route 116 Crossing Little Notch Brook, Bristol, VT           EMB
          *** RUN DATE & TIME: 11-20-96  11:50

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

EXITX:XS   ******   -122      604  0.36 *****  499.84  498.81    1690  499.48
       -23 ******    250    24896  2.98 ***** *******    0.67    2.80

FULLV:FV       24   -125      610  0.35  0.11  499.96 *******    1690  499.61
         0     24    250    25174  2.97  0.00    0.01    0.66    2.77
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.30     499.52     498.41

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   499.11     508.91    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   499.11     508.91     498.41

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.66

APPRO:AS       48    -11      242  1.19  0.33  500.71  498.41    1690  499.52
        48     48    200    16594  1.58  0.42    0.00    1.31    6.98
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   503.85       0.00     499.68     500.91

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   499.64     502.08     502.13     500.85

 ===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       24      0      135  1.06 *****  502.01  498.06    1116  500.95
         0 ******     19    11035  1.00 ***** *******    0.54    8.24

    TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
      1. ****   5.  0.450  0.000  500.85 ****** ****** ******

   XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
  RDWAY:RG      15.    19.  0.02  0.14  502.53    0.00    569.  502.26

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
  LT:      0.   361.  -351.    10.   1.2   1.0   5.9   6.6   1.6   3.1
  RT:    569.   175.    88.   263.   1.3   0.8   4.8   4.3   1.0   3.1

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

APPRO:AS        8    -41      865  0.14  0.04  502.55  498.41    1690  502.41
        48     12    200    53020  2.36  0.53    0.00    0.28    1.95

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

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

```
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -24.  -123.   250.   1690.   24896.     604.    2.80  499.48
   FULLV:FV       0.  -126.   250.   1690.   25174.     610.    2.77  499.61
   BRIDG:BR       0.     0.    19.   1116.   11035.     135.    8.24  500.95
   RDWAY:RG      15.*******     0.    569.       0.*********    1.00  502.26
   APPRO:AS      48.   -42.   200.   1690.   53020.     865.    1.95  502.41

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    498.81    0.67  491.61  507.28************  0.36  499.84  499.48
   FULLV:FV  ********    0.66  491.72  507.39  0.11  0.00  0.35  499.96  499.61
   BRIDG:BR    498.06    0.54  491.83  500.95************  1.06  502.01  500.95
   RDWAY:RG  ****************  500.91  508.93  0.02******  0.14  502.53  502.26
   APPRO:AS    498.41    0.28  492.04  508.91  0.04  0.53  0.14  502.55  502.41

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

EXITX:XS   ******   -205      821  0.35 *****  500.36  499.40    2350  500.00
      -23 ******    250    34618  2.76 ***** *******    0.62    2.86

FULLV:FV       24   -206      825  0.35  0.11  500.47 *******    2350  500.12
        0     24    250    34824  2.76  0.00    0.01    0.62    2.85
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.70     499.70     500.36

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   499.62     508.91    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   499.62     508.91     500.36

 ===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 =   500.36     508.91     500.36

APPRO:AS       48    -13      416  1.17 *****  501.53  500.36    2350  500.36
       48     48    200    24115  2.36 ***** *******    1.10    5.65
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   506.81       0.00     500.80     500.91

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   500.32     502.63     502.70     500.85

 ===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       24      0      135  1.28 *****  502.23  498.37    1227  500.95
        0 ******     19    11035  1.00 ***** *******    0.60    9.06

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    5.  0.470  0.000  500.85 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.    19.  0.03  0.20  503.09    0.00   1126.  502.72

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.     5.  -253.    10.   0.0   0.0   3.0 125.8   0.4   3.0
   RT:  1126.   220.    44.   263.   1.8   1.0   5.6   5.0   1.4   3.2
```

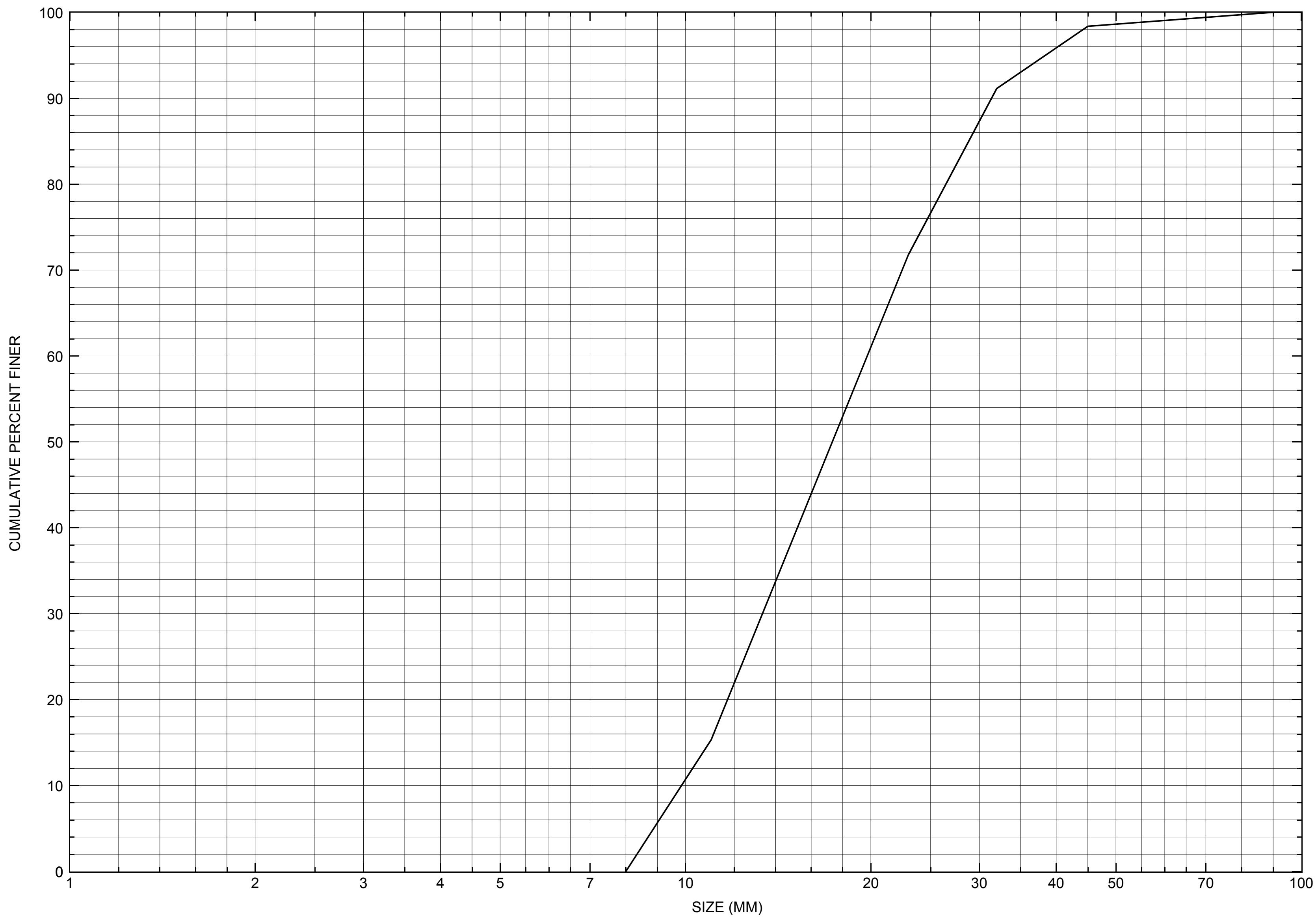
# WSPRO OUTPUT FILE (continued)

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

APPRO:AS        8    -68      993  0.20  0.06  503.11  500.36    2350  502.91
        48     14    200    62357  2.32  0.49    0.00    0.33    2.37

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

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -24.  -206.   250.   2350.   34618.     821.    2.86  500.00
   FULLV:FV       0.  -207.   250.   2350.   34824.     825.    2.85  500.12
   BRIDG:BR       0.     0.    19.   1227.   11035.     135.    9.06  500.95
   RDWAY:RG      15.*******     0.   1126.       0.*********    1.00  502.72
   APPRO:AS      48.   -69.   200.   2350.   62357.     993.    2.37  502.91

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    499.40    0.62  491.61  507.28************  0.35  500.36  500.00
   FULLV:FV  ********    0.62  491.72  507.39  0.11  0.00  0.35  500.47  500.12
   BRIDG:BR    498.37    0.60  491.83  500.95************  1.28  502.23  500.95
   RDWAY:RG  ****************  500.91  508.93  0.03******  0.20  503.09  502.72
   APPRO:AS    500.36    0.33  492.04  508.91  0.06  0.49  0.20  503.11  502.91

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

EXITX:XS   ******     -3      362  0.37 *****  499.07  496.83    1050  498.71
       -23 ******    250    15480  2.80 ***** *******    0.72    2.90

FULLV:FV       24     -4      366  0.36  0.11  499.19 *******    1050  498.83
         0     24    250    15624  2.80  0.00    0.01    0.71    2.87
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       48    -10      177  0.62  0.25  499.57 *******    1050  498.95
        48     48     48    13471  1.12  0.13    0.00    0.64    5.95
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

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

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

BRIDG:BR       24      0       91  2.06  0.20  500.34  497.84    1050  498.28
         0     24     19     8380  1.00  1.06    0.00    0.88   11.50

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  500.85 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.        <<<<<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        8    -14      523  0.15  0.04  501.01  497.10    1050  500.86
        48      9    200    29932  2.47  0.63    0.02    0.36    2.01

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.677  0.424   17132.     2.    21.   500.83

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

```
 FIRST USER DEFINED TABLE.

   XSID:CODE    SRD    LEW    REW      Q        K     AREA     VEL    WSEL
  EXITX:XS     -24.    -4.   250.   1050.   15480.     362.    2.90  498.71
  FULLV:FV       0.    -5.   250.   1050.   15624.     366.    2.87  498.83
  BRIDG:BR       0.     0.    19.   1050.    8380.      91.   11.50  498.28
  RDWAY:RG      15.**************      0.******************    1.00********
  APPRO:AS      48.   -15.   200.   1050.   29932.     523.    2.01  500.86

   XSID:CODE   XLKQ   XRKQ      KQ
  APPRO:AS       2.    21.  17132.

 SECOND USER DEFINED TABLE.

   XSID:CODE    CRWS    FR#   YMIN    YMAX    HF    HO  VHD     EGL    WSEL
  EXITX:XS    496.83   0.72  491.61  507.28************  0.37  499.07  498.71
  FULLV:FV  ********   0.71  491.72  507.39  0.11  0.00  0.36  499.19  498.83
  BRIDG:BR    497.84   0.88  491.83  500.95  0.20  1.06  2.06  500.34  498.28
  RDWAY:RG  ****************  500.91  508.93**********************************
  APPRO:AS    497.10   0.36  492.04  508.91  0.04  0.63  0.15  501.01  500.86
 ER

1  NORMAL  END  OF  WSPRO  EXECUTION.
```

# APPENDIX C:

# BED-MATERIAL PARTICAL-SIZE DISTRIBUTION




Appendix C. Bed material particle-size distribution for one pebble count transect at the approach cross-section for structure BRISVT01160006, in Bristol, Vermont.

# APPENDIX D:

# HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BRISVT01160006

## General Location Descriptive

Data collected by *(First Initial, Full last name)* L. Medalie

Date *(MM/DD/YY)* 12 / 14 / 95

Highway District Number *(I - 2; nn)* 05

County *(FIPS county code; I - 3; nnn)* 001

Town *(FIPS place code; I - 4; nnnnn)* 09025

Mile marker *(I - 11; nnn.nnn)* 002830

Waterway *(I - 6)* Little Notch Brook

Road Name *(I - 7):* -

Route Number VT 116

Vicinity *(I - 9)* 2.7 MI S JCT. VT.17 W

Topographic Map South.Mountain

Hydrologic Unit Code: 2010002

Latitude *(I - 16; nnnn.n)* 44057

Longitude *(i - 17; nnnnn.n)* 73055

## Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20002100060103

Maintenance responsibility *(I - 21; nn)* 01

Maximum span length *(I - 48; nnnn)* 0021

Year built *(I - 27; YYYY)* 1931

Structure length *(I - 49; nnnnnn)* 000024

Average daily traffic, ADT *(I - 29; nnnnnn)* 002080

Deck Width *(I - 52; nn.n)* 286

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

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

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

Waterway adequacy *(I - 71; n)* 4

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

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

Structure type *(I - 43; nnn)* 101

Year Reconstructed *(I - 106)* 1970

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

Clear span (*nnn.n ft*) 20

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

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

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

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

Comments:

**According to the structural inspection report dated 9/13/93, structure is a concrete slab bridge. The downstream half of the left abutment is undermined up to 1.5 feet vertically with horizontal penetration up to 5 feet underneath the footing. This undermining extends underneath the footing for the downstream left wingwall. It appears that the left abutment has settled up to 4 inches on the left end. The stem of the left abutment has some minor cracking and heavy scaling along the bottom of the wall. The exposed portion of this footing and of the footing at the left wingwall has heavy scaling and some spalled areas on the top. The left wingwall has areas of staining and scaling particularly at the bottom.** **(Continued, page 35)**

## Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

$Q_{50}$ - $Q_{100}$ - $Q_{500}$ -

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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:

**There is a spalled area at the top near the fascia line. The concrete facing on the right half of the abutment is undermined at its left end. The stem of the right abutment has areas of general scaling near the bottom and areas of diagonal cracking at the top near the fascia lines. The footing is exposed and has heavy scaling both in the top and in the face. There is some scour along this footing, but no undermining noted. The upstream wingwall has areas of cracking and general scaling. The exposed footing has heavy scaling, with some spalling. The downstream wingwall is similar. The channel takes a moderate turn into and a slight turn out of the structure. The majority of the flow is toward the undermined area at the left abutment.**

## USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **8.59** $mi^2$  Lake and pond area **0.025** $mi^2$

Watershed storage *(ST)* **0.29** %

Bridge site elevation **330** ft  Headwater elevation **1840** ft

Main channel length **5.2** mi

10% channel length elevation **370** ft  85% channel length elevation **1660** ft

Main channel slope *(S)* **330.77** 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)*: **-** / **-**

Project Number **-** Minimum channel bed elevation: **93.5**

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

Benchmark location description:

**BM #1, 16" elm, elev. 100', 20' up the right bank of the new channel, and 50 ' downstream of the road.**

Reference Point (*MSL, Arbitrary, Other*): **Arbitrary** 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: ______ (*1-regolith, 2-bedrock, 3-unknown*)

Briefly describe material at foundation bottom elevation or around piles:

-

Comments:

**Few elevations are provided on the plans. A rough cross-section plot of the bridge section is provided on the plans and shows a left low steel elevation of ~102.0 feet and right low steel elevation of ~101.8. It is not clear where the section was taken within the bridge.**

## Cross-sectional Data

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

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

Comments: **Channel x-sections available.**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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: EW Date: 12/3/96
Computerized by: EW Date: 12/3/96
Reviewd by: EMB Date: 12/4/96

Structure Number BRISVT01160006

## A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. BURNS Date *(MM/DD/YY)* 06 / 13 / 1996
2. Highway District Number 05 Mile marker 002830
County ADDISON (001) Town BRISTOL (09025)
Waterway *(I - 6)* Little Notch Brook Road Name -
Route Number VT 116 Hydrologic Unit Code: 02010002
3. Descriptive comments:
**Located about 2.7 miles south from the junction of VT 116 with VT 17.**

## B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 3 RBDS 6 Overall 6
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US 1 UB 1 DS 1 *(**1**- pool; **2**- riffle)*
6. Bridge structure type 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 24 *(feet)* Span length 21 *(feet)* Bridge width 28.6 *(feet)*

### Road approach to bridge:

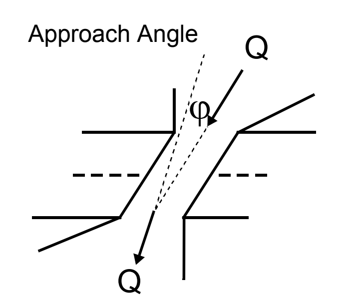
8. LB 0 RB 0 *( **0** even, **1**- lower, **2**- higher)*
9. LB 1 RB 1 *( **1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

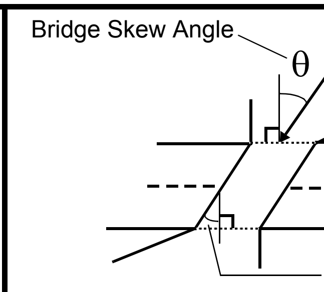
| | Protection | | 13.Erosion | 14.Severity |
|---|---|---|---|---|
| | 11.Type | 12.Cond. | | |
| LBUS | 0 | - | 0 | - |
| RBUS | 0 | - | 0 | - |
| RBDS | 0 | - | 2 | 1 |
| LBDS | 0 | - | 3 | 1 |

*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: 20 16. Bridge skew: 15



α= 25.0

17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 61 feet US *(US, UB, DS)* to 46 feet US
Channel impact zone 2: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 2
Range? 21 feet DS *(US, UB, DS)* to 38 feet DS

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

18. Level II Bridge Type: **1a**

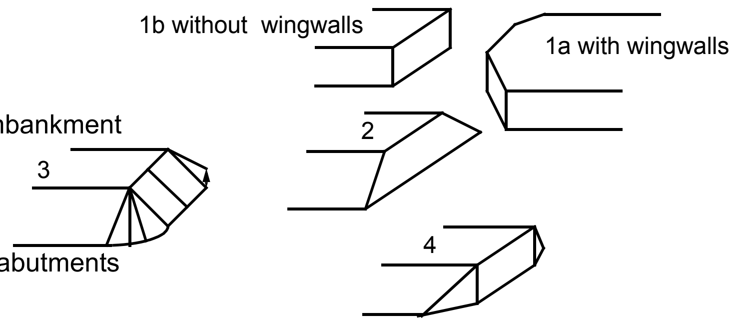
1a- Vertical abutments with wingwalls

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.)

**4: The downstream left bank surface cover is a plowed field with trees and shrubs along the immediate bank. The other three banks are shrubs and brush with some trees and some wetlands beyond two bridge lengths.**

**7: Measured bridge length = 25 feet; bridge span = 21 feet; and bridge width = 28.7 feet.**

## C. Upstream Channel Assessment

| 20. SRD | 21. Bank height (BF) LB | 21. Bank height (BF) RB | 22. Bank angle (BF) LB | 22. Bank angle (BF) RB | 26. % Veg. cover (BF) LB | 26. % Veg. cover (BF) RB | 27. Bank material (BF) LB | 27. Bank material (BF) RB | 28. Bank erosion (BF) LB | 28. Bank erosion (BF) RB |
|---|---|---|---|---|---|---|---|---|---|---|
| **21.0** | **3.0** | | | **2.5** | **3** | **3** | **21** | **21** | **1** | **1** |

| 23. Bank width | 24. Channel width | 25. Thalweg depth | 29. Bed Material |
|---|---|---|---|
| **25.0** | **40.0** | **30.5** | **32** |

30 .Bank protection type: LB **1** RB **2**

31. Bank protection condition: LB **2** RB **2**

*SRD - Section ref. dist. to US face* *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*

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

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

*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*

*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

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

**The right bank protection extends from the upstream right wingwall to 48 feet upstream.**

**The left bank protection extends from the upstream left wingwall to 18 feet upstream.**

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **49** 35. Mid-bar width: **12**

36. Point bar extent: **92** feet **US** *(US, UB)* to **29** feet **US** *(US, UB, DS)* positioned **0** %LB to **50** %RB

37. Material: **23**

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

**Point bar is sand with gravel on top.**

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: **54** 42. Cut bank extent: **61** feet **US** *(US, UB)* to **48** 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 cut-bank begins where the protection ends. At the top of the cut-bank is a path that leads to a pull out off of VT 116.**

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

47. Scour dimensions: Length **30** Width **4** Depth : **0.25** Position **80** %LB to **90** %RB

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

**Scour is along the right bank protection and at the bend in the stream.**

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 |
|---|---|---|---|---|---|---|---|
| 22.0 | | 2.0 | | 2 | 7 | 7 | - |

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

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

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

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

**32**

**At the upstream left corner of the left abutment, the bed material is mostly fines.**

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

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

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

70. Debris and Ice Comments:

**2**

**Debris potential is high because of all the shrubs and small trees on the banks and the debris collection both upstream and downstream.**

**Capture efficiency and ice blockage potential are moderate because of the angle of flow through the bridge and its low clearance.**

| Abutments | 71. Attack ∠(BF) | 72. Slope ∠ (Qmax) | 73. Toe loc. (BF) | 74. Scour Condition | 75. Scour depth | 76. Exposure depth | 77. Material | 78. Length |
|---|---|---|---|---|---|---|---|---|
| LABUT | | 15 | 90 | 2 | 3 | 1 | 4 | 90.0 |
| RABUT | 1 | - | 90 | | | 2 | 2 | 17.0 |

*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**
**1**

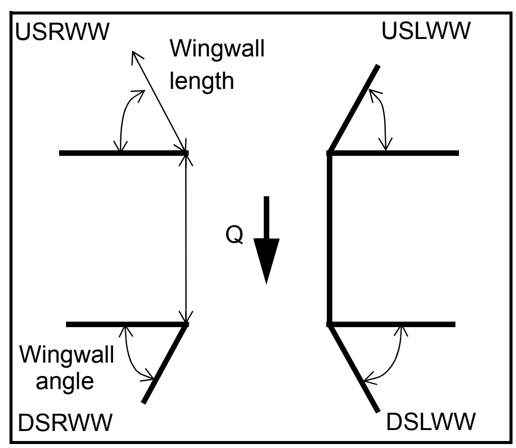
**The left abutment footing on the upstream half has an additional section of footing for which the bottom is a foot lower than the rest and is not undermined. Its top is 4 feet above the stream bed. There are a few large rocks in front of the footing. The downstream half of the left abutment is undermined 1 foot and the footing is 3 feet thick. There is about 2 horizontal feet of penetration underneath the footing into very loose material.**

**The right abutment is not exposed at the upstream end, but it is exposed 1 foot at the downstream end.**

80. **Wingwalls**:

| | Exist? | Material? | Scour Condition? | Scour depth? | Exposure depth? | 81. Angle? | Length? |
|---|---|---|---|---|---|---|---|
| USLWW: | | | | | | 17.0 | |
| USRWW: | Y | | 1 | | 2 | 2.0 | |
| DSLWW: | 0 | | 2.5 | | Y | 31.0 | |
| DSRWW: | 1 | | 0 | | - | 31.0 | |

*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 | - | 3 | Y | 0 | - | 1 | - | - |
| Condition | Y | 0 | 1 | 1 | - | 2 | - | - |
| Extent | 1 | 3 | 2 | 0 | 2 | 0 | 0 | - |

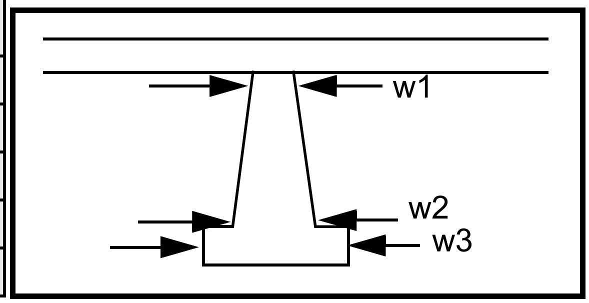
*Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee*
*Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed*
*Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other*

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
0
-
-
2
1
3

## Piers:

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

| 85. Pier no. | width (w) feet | | | elevation (e) feet | | |
|---|---|---|---|---|---|---|
| | w1 | w2 | w3 | e@w1 | e@w2 | e@w3 |
| Pier 1 | | | | 30.0 | 12.0 | 90.0 |
| Pier 2 | | | 9.0 | 13.0 | 85.0 | 25.0 |
| Pier 3 | 9.5 | - | - | - | - | - |
| Pier 4 | - | - | - | - | - | - |




| Level 1 Pier Descr. | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| 86. Location (BF) | e | WW | WW | e it | LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP |
| 87. Type | wing | is the | is | joins | **1**- Solid pier, **2**- column, **3**- bent |
| 88. Material | wall | same | unde | the | **1**- Wood; **2**- concrete; **3**- metal; **4**- stone |
| 89. Shape | pro- | as | rmin | LAB | **1**- Round; **2**- Square; **3**- Pointed |
| 90. Inclined? | tec- | the | ed | UT. | Y- yes; N- no |
| 91. Attack ∠ (BF) | tion | bank | 0.2 | | |
| 92. Pushed | for | pro- | feet | The | LB or RB |
| 93. Length (feet) | - | - | - | - | |
| 94. # of piles | the | tec- | at | USL | |
| 95. Cross-members | USR | tion. | the | WW | **0**- none; **1**- laterals; **2**- diagonals; **3**- both |
| 96. Scour Condition | WW | | cor- | pro- | **0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed |
| 97. Scour depth | and | The | ner | tec- | |
| 98. Exposure depth | DSR | DSL | wher | tion | |

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

**is the same for the upstream left bank because the bank is in front of the wingwall, 4 feet upstream from the upstream bridge face. The other 4 feet have an exposed footing.**

**N**
-
-

## 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.):
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

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.):

**-**
**-**
**NO PIERS**

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

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

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

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

**3**
**3**
**12**
**12**

Is channel scour present? **3** (Y or if N type ctrl-n cs) Mid-scour distance: **3**

Scour dimensions: Length **23** Width **0** Depth: **2** Positioned - %LB to **2** %RB

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

**The confluence with the New Haven River is about 300 feet downstream.**

**The right bank protection extends from the downstream right wingwall to 35 feet downstream.**

Are there major confluences? **Th** (Y or if N type ctrl-n mc) How many? **e left**

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

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

Confluence comments (eg. confluence name):

**rely eroded with large trees falling into the stream.**

## F. Geomorphic Channel Assessment

107. Stage of reach evolution **Th**

***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)*:

**e right bank downstream is steep from erosion and there are a lot of exposed roots and trees leaning into the stream.**

**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: | BRISVT01160006 | Town: | Bristol |
| Road Number: | VT 116 | County: | Addison |
| Stream: | Little Notch Brook | | |

Initials EMB Date: 11/26/96 Checked: SAO

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

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

Approach Section

| Characteristic | 100 yr | 500 yr | other Q |
|---|---|---|---|
| Total discharge, cfs | 1690 | 2350 | 1050 |
| Main Channel Area, ft2 | 282 | 299 | 229 |
| Left overbank area, ft2 | 25 | 48 | 8 |
| Right overbank area, ft2 | 559 | 646 | 287 |
| Top width main channel, ft | 34 | 34 | 34 |
| Top width L overbank, ft | 33 | 59 | 6 |
| Top width R overbank, ft | 175 | 175 | 175 |
| D50 of channel, ft | 0.057 | 0.057 | 0.057 |
| D50 left overbank, ft | -- | -- | -- |
| D50 right overbank, ft | -- | -- | -- |
| y1, average depth, MC, ft | 8.3 | 8.8 | 6.7 |
| y1, average depth, LOB, ft | 0.8 | 0.8 | 1.3 |
| y1, average depth, ROB, ft | 3.2 | 3.7 | 1.6 |
| Total conveyance, approach | 53053 | 62324 | 29989 |
| Conveyance, main channel | 32814 | 36179 | 23238 |
| Conveyance, LOB | 499 | 1024 | 212 |
| Conveyance, ROB | 19740 | 25122 | 6539 |
| Percent discrepancy, conveyance | 0.0000 | -0.0016 | 0.0000 |
| Qm, discharge, MC, cfs | 1045.3 | 1364.2 | 813.6 |
| Ql, discharge, LOB, cfs | 15.9 | 38.6 | 7.4 |
| Qr, discharge, ROB, cfs | 628.8 | 947.3 | 228.9 |
| Vm, mean velocity MC, ft/s | 3.7 | 4.6 | 3.6 |
| Vl, mean velocity, LOB, ft/s | 0.6 | 0.8 | 0.9 |
| Vr, mean velocity, ROB, ft/s | 1.1 | 1.5 | 0.8 |
| Vc-m, crit. velocity, MC, ft/s | 6.1 | 6.2 | 5.9 |
| 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 |

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 | 282 | 299 | 229 |
| Main channel width, ft | 34 | 34 | 34 |
| y1, main channel depth, ft | 8.29 | 8.79 | 6.74 |

| Bridge Section | | | |
|---|---|---|---|
| (Q) total discharge, cfs | 1690 | 2350 | 1050 |
| (Q) discharge thru bridge, cfs | 1116 | 1227 | 1050 |
| Main channel conveyance | 11035 | 11035 | 8374 |
| Total conveyance | 11035 | 11035 | 8374 |
| Q2, bridge MC discharge,cfs | 1116 | 1227 | 1050 |
| Main channel area, ft2 | 136 | 136 | 91 |
| Main channel width (skewed), ft | 17.2 | 17.2 | 17.2 |
| Cum. width of piers in MC, ft | 0.0 | 0.0 | 0.0 |
| W, adjusted width, ft | 17.2 | 17.2 | 17.2 |
| y_bridge (avg. depth at br.), ft | 7.88 | 7.88 | 5.30 |
| Dm, median (1.25*D50), ft | 0.07125 | 0.07125 | 0.07125 |
| y2, depth in contraction,ft | 9.41 | 10.21 | 8.93 |
| ys, scour depth (y2-ybridge), ft | 1.53 | 2.33 | 3.63 |

Comparison of Chang and Laursen results (for unsubmerged orifice flow)

| | | | |
|---|---|---|---|
| y2, from Laursen's equation, ft | 9.410939 | 10.20776 | 8.931825 |
| Full valley WSEL, ft | 499.61 | 500.12 | 0 |
| Full valley depth, ft | 6.637907 | 7.147907 | 5.302326 |
| Ys, depth of scour (y2-yfullv), ft | 2.773032 | 3.059853 | N/A |

| ARMORING | | | |
|---|---|---|---|
| D90 | 0.103 | 0.103 | 0.103 |
| D95 | 0.1259 | 0.1259 | 0.1259 |
| Critical grain size,Dc, ft | 0.1464 | 0.1769 | 0.3222 |
| Decimal-percent coarser than Dc | 0.0179 | 0.012 | N/A |
| Depth to armoring,ft | 24.09 | 43.70 | ERR |

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

| | Q100 | Q500 | OtherQ |
|---|---|---|---|
| Q, total, cfs | 1690 | 2350 | 1050 |
| Q, thru bridge, cfs | 1116 | 1227 | 1050 |
| Total Conveyance, bridge | 11035 | 11035 | 8374 |
| Main channel(MC) conveyance, bridge | 11035 | 11035 | 8374 |
| Q, thru bridge MC, cfs | 1116 | 1227 | 1050 |
| Vc, critical velocity, ft/s | 6.14 | 6.20 | 5.93 |
| Vc, critical velocity, m/s | 1.87 | 1.89 | 1.81 |
| Main channel width (skewed), ft | 17.2 | 17.2 | 17.2 |
| Cum. width of piers in MC, ft | 0.0 | 0.0 | 0.0 |
| W, adjusted width, ft | 17.2 | 17.2 | 17.2 |
| qbr, unit discharge, ft^2/s | 64.9 | 71.3 | 61.0 |
| qbr, unit discharge, m^2/s | 6.0 | 6.6 | 5.7 |
| Area of full opening, ft^2 | 135.5 | 135.5 | 91.2 |
| Hb, depth of full opening, ft | 7.88 | 7.88 | 5.30 |
| Hb, depth of full opening, m | 2.40 | 2.40 | 1.62 |
| Fr, Froude number, bridge MC | 0.54 | 0.6 | 0 |
| Cf, Fr correction factor (<=1.0) | 1.00 | 1.00 | 0.00 |
| Elevation of Low Steel, ft | 500.85 | 500.85 | 0 |
| Elevation of Bed, ft | 492.97 | 492.97 | -5.30 |
| Elevation of Approach, ft | 502.41 | 502.91 | 0 |
| Friction loss, approach, ft | 0.04 | 0.06 | 0 |
| Elevation of WS immediately US, ft | 502.37 | 502.85 | 0.00 |
| ya, depth immediately US, ft | 9.40 | 9.88 | 5.30 |
| ya, depth immediately US, m | 2.86 | 3.01 | 1.62 |
| Mean elevation of deck, ft | 503.06 | 503.06 | 0 |
| w, depth of overflow, ft (>=0) | 0.00 | 0.00 | 0.00 |
| Cc, vert contrac correction (<=1.0) | 0.96 | 0.94 | 1.00 |
| | | | |
| Ys, depth of scour, ft | 3.17 | 4.31 | N/A |

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)

| Characteristic | Left Abutment 100 yr Q | 500 yr Q | Other Q | Right Abutment 100 yr Q | 500 yr Q | Other Q |
|---|---|---|---|---|---|---|
| (Qt), total discharge, cfs | 1690 | 2350 | 1050 | 1690 | 2350 | 1050 |
| a', abut.length blocking flow, ft | 44.3 | 70.4 | 16.8 | 181 | 181 | 181 |
| Ae, area of blocked flow ft2 | 97.5 | 126.1 | 63.4 | 475 | 474.6 | 326.5 |
| Qe, discharge blocked abut.,cfs | 241 | 340.8 | 165.4 | -- | -- | 360.9 |
| (If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually) | | | | | | |
| Ve, (Qe/Ae), ft/s | 2.47 | 2.70 | 2.61 | 1.31 | 1.67 | 1.11 |
| ya, depth of f/p flow, ft | 2.20 | 1.79 | 3.77 | 2.62 | 2.62 | 1.80 |
| --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 | 65 | 65 | 65 | 115 | 115 | 115 |
| K2 | 0.96 | 0.96 | 0.96 | 1.03 | 1.03 | 1.03 |
| Fr, froude number f/p flow | 0.294 | 0.356 | 0.237 | 0.126 | 0.150 | 0.145 |
| ys, scour depth, ft | 8.96 | 10.04 | 9.09 | 11.43 | 12.41 | 9.55 |

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) | 44.3 | 70.4 | 16.8 | 181 | 181 | 181 |
| y1 (depth f/p flow, ft) | 2.20 | 1.79 | 3.77 | 2.62 | 2.62 | 1.80 |
| a'/y1 | 20.13 | 39.30 | 4.45 | 68.97 | 69.03 | 100.34 |
| Skew correction (p. 49, fig. 16) | 0.92 | 0.92 | 0.92 | 1.06 | 1.06 | 1.06 |
| Froude no. f/p flow | 0.29 | 0.36 | 0.24 | 0.13 | 0.15 | 0.15 |
| Ys w/ corr. factor K1/0.55: | | | | | | |
| vertical | ERR | 8.52 | ERR | 10.21 | 10.81 | 7.35 |
| vertical w/ ww's | ERR | 6.99 | ERR | 8.37 | 8.86 | 6.03 |
| spill-through | ERR | 4.69 | ERR | 5.62 | 5.94 | 4.04 |

Abutment riprap Sizing

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

| Characteristic | Q100 | Q500 | Qother | | | |
|---|---|---|---|---|---|---|
| Fr, Froude Number | 0.54 | 0.6 | 0.88 | 0.54 | 0.6 | 0.88 |
| (Fr from the characteristic V and y in contracted section--mc, bridge section) | | | | | | |
| y, depth of flow in bridge, ft | 7.88 | 7.88 | 5.30 | 7.88 | 7.88 | 5.30 |
| Median Stone Diameter for riprap at: | left abutment | | | right abutment, ft | | |
| Fr<=0.8 (vertical abut.) | 1.42 | 1.75 | ERR | 1.42 | 1.75 | ERR |
| Fr>0.8 (vertical abut.) | ERR | ERR | 2.14 | ERR | ERR | 2.14 |