# LEVEL II SCOUR ANALYSIS FOR BRIDGE 10 (CHESTH00030010) on TOWN HIGHWAY 3 (VT 35), crossing the SOUTH BRANCH WILLIAMS RIVER, CHESTER, VERMONT

U.S. Geological Survey
Open-File Report 97-369

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

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By EMILY C. WILD and ROBERT E. HAMMOND

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**Pembroke, New Hampshire**

**1997**

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

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

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

## OTHER ABBREVIATIONS

| | | | |
|---|---|---|---|
| BF | bank full | LWW | left wingwall |
| cfs | cubic feet per second | 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 10 (CHESTH00030010) ON TOWN HIGHWAY 3 (VT 35), CROSSING THE SOUTH BRANCH WILLIAMS RIVER, CHESTER, VERMONT

*By* **Emily C. Wild and Robert E. Hammond**

## INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure CHESTH00030010 on Town Highway 3 (VT 35) crossing the South Branch Williams River, Chester, 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 New England Upland section of the New England physiographic province in southeastern Vermont. The 9.44-$mi^2$ drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest.

In the study area, the South Branch Williams River has an incised, sinuous channel with a slope of approximately 0.03 ft/ft, an average channel top width of 67 ft and an average bank height of 5 ft. The channel bed material ranges from gravel to boulder with a median grain size ($D_{50}$) of 69.0 mm (0.226 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 26-27, 1996, indicated that the reach was stable.

The Town Highway 3 (VT 35) crossing of the South Branch Williams River is a 69-foot-long, two-lane bridge consisting of one 67-foot steel-stringer span with a concrete deck (Vermont Agency of Transportation, written communication, August 23, 1994). The opening length of the structure parallel to the bridge face is 64.5 ft. The bridge is supported by vertical, concrete abutments with spill-through embankments. The channel is skewed approximately 50 degrees to the opening while the opening-skew-to-roadway is 30 degrees.

The scour protection (spill-through abutments) measured at the site was type-3 stone fill (less than 48 inches diameter) extending the entire base length and around the ends of the left and right abutments. 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). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for modelled flows ranged from 0.8 to 3.8 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge. Left abutment scour ranged from 13.3 to 14.9 ft. The worst-case scour at the left abutment occurred at the 500-year discharge. Right abutment scour ranged from 4.1 to 6.0 ft. The worst-case scour at the right abutment occurred at the incipient roadway-overtopping 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.

**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*** CHESTH00030010 ***Stream*** South Branch Williams River

***County*** Windsor ***Road*** TH3 ***District*** 2

## Description of Bridge

***Bridge length*** 69 ***ft*** ***Bridge width*** 27.3 ***ft*** ***Max span length*** 67 ***ft***

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

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

***Stone fill on abutment?*** No ***Date of inspection*** 8/26/96

***Description of stone fill*** Type-3 on the spill-through slopes of the left and right abutments and the right bank upstream.

Vertical concrete abutments support the bridge structure. In front of the vertical abutments, type-3 stone fill has been placed to create spill-through slopes.

***Is bridge skewed to flood flow according to*** N ***survey?*** Y ***Angle*** 50

Opening skew to roadway is 30 degrees.

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

| | *Date of inspection* | *Percent of channel blocked horizontally* | *Percent of channel blocked vertically* |
|---|---|---|---|
| | 8/26/96 | 0 | 0 |
| ***Level I*** | 8/27/96 | 0 | 0 |

***Level II*** Moderate. There is some debris caught on boulders and trees along the upstream banks.

***Potential for debris***

The assessment of 08/26/96 noted a large bend in the channel, approximately 125 feet downstream from the bridge. Also at 125 feet downstream from the bridge, an ephemeral tributary was noted to enter the South Branch Williams River on the right bank.

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

## Description of the Geomorphic Setting

***General topography*** The channel is located within a steep valley with very narrow, irregular overbanks.

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

***Date of inspection*** 08/26/96

***DS left:*** Steep valley wall with a narrow overbank

***DS right:*** Steep valley wall with a narrow overbank

***US left:*** Steep valley wall

***US right:*** Steep valley wall with a narrow overbank

## Description of the Channel

***Average top width*** 67 ***ft*** ***Average depth*** 5 ***ft***

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

Perennial, sinuous and stable with semi-alluvial channel boundaries and a narrow flood plain.

8/26/96

***Vegetative co***

***DS left:*** Trees and brush

***DS right:*** Trees and brush

***US left:*** Trees

***US right:*** Trees and brush

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

None evident on 8/26/97.

***Describe any obstructions in channel and date of observation.***

## Hydrology

***Drainage area*** 9.44 ***mi²***

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

| ***Physiographic province/section*** | ***Percent of drainage area*** |
| --- | --- |
| New England/ New England Upland | 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*** 2,780 ***ft³/s*** ***Q500*** 4,080 ***ft³/s***

The 100- and 500-year discharges are from the Flood Insurance Study of the Town of Chester (Federal Emergency Management Agency, 1982). These values are within a range defined by several empirical flood frequency curves. (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*** To obtain VTAOT survey, subtract 399.6 feet from USGS arbitrary survey datum.

***Description of reference marks used to determine USGS datum.***

RM1 is a chiseled X on top of the upstream left end of the bridge curb (elev. 503.1 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the right abutment (elev. 500.7 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 | -72 | 1 | Exit section |
| FULLV | 0 | 2 | Downstream Full-valley section (Templated from EXITX) |
| BRIDG | 0 | 1 | Bridge section |
| RDWAY | 17 | 1 | Road Grade section |
| APPRO | 90 | 2 | Modelled Approach section (Templated from APTEM) |
| APTEM | 103 | 1 | Approach section as surveyed (Used as a template) |

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

## Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.060 to 0.065, and overbank "n" values ranged from 0.075 to 0.100.

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 0.031 ft/ft determined from surveyed thalweg points downstream of the structure.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0068 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*** 501.3 ***ft***
***Average low steel elevation*** 496.9 ***ft***

***100-year discharge*** 2,780 ***ft³/s*** 
***Water-surface elevation in bridge opening*** 497.1 ***ft***
***Road overtopping?*** N ***Discharge over road*** -- ***ft³/s***
***Area of flow in bridge opening*** 290 ***ft²***
***Average velocity in bridge opening*** 9.6 ***ft/s***
***Maximum WSPRO tube velocity at bridge*** 11.3 ***ft/s***

***Water-surface elevation at Approach section with bridge*** 500.2
***Water-surface elevation at Approach section without bridge*** 499.1
***Amount of backwater caused by bridge*** 1.1 ***ft***

***500-year discharge*** 4,080 ***ft³/s***
***Water-surface elevation in bridge opening*** 497.1 ***ft***
***Road overtopping?*** Y ***Discharge over road*** 602 ***ft³/s***
***Area of flow in bridge opening*** 290 ***ft²***
***Average velocity in bridge opening*** 11.7 ***ft/s***
***Maximum WSPRO tube velocity at bridge*** 13.8 ***ft/s***

***Water-surface elevation at Approach section with bridge*** 502.8
***Water-surface elevation at Approach section without bridge*** 500.6
***Amount of backwater caused by bridge*** 2.2

***Incipient overtopping discharge*** 3,380 ***ft³/s***
***Water-surface elevation in bridge opening*** 497.1 ***ft***
***Area of flow in bridge opening*** 290 ***ft²***
***Average velocity in bridge opening*** 11.7 ***ft/s***
***Maximum WSPRO tube velocity at bridge*** 13.7 ***ft/s***

***Water-surface elevation at Approach section with bridge*** 502.0
***Water-surface elevation at Approach section without bridge*** 499.9
***Amount of backwater caused by bridge*** 2.1 ***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.

The 100-year, 500-year, and incipient overtopping discharges modelled resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by the use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Therefore, contraction scour for all modelled discharges were computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The results of Laursen's clear-water contraction scour equation were also computed for all discharges and can be found in appendix F. The 500-year discharge model resulted in the worst case contraction scour with a scour depth of 4.1 ft, and it was also the worst case total scour.

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.

Because the influence of scour processes on the spill-through embankment material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, the total scour depths were applied for the entire spill-through embankment below the elevation at the toe of each embankment.

### 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* | 0.8 | 3.7 | 3.8 |
| *Depth to armoring* | 3.9 10.0 | 9.7 | -- |
| *Left overbank* | -- | -- | -- |
| *Right overbank* | -- | -- | 13.3 |
| *Local scour:* | | | |
| *Abutment scour* | 14.9 | 14.4 | 5.0 |
| *Left abutment* | 4.1 | 6.0 | --- |
| *Right abutment* | | | |
| *Pier scour* | -- | -- | -- |
| *Pier 1* | -- | -- | -- |
| *Pier 2* | -- | -- | 2.4 |
| *Pier 3* | | | |

### Riprap Sizing

| | *100-yr discharge* | *500-yr discharge* | *Incipient overtopping discharge* |
| --- | --- | --- | --- |
| | | *($D_{50}$ in feet)* | |
| *Abutments:* | 2.6 | 2.6 | 2.4 |
| *Left abutment* | 2.6 | 2.6 | -- |
| *Right abutment* | | | |
| *Piers:* | -- | -- | -- |
| *Pier 1* | -- | -- | -- |
| *Pier 2* | -- | -- | |

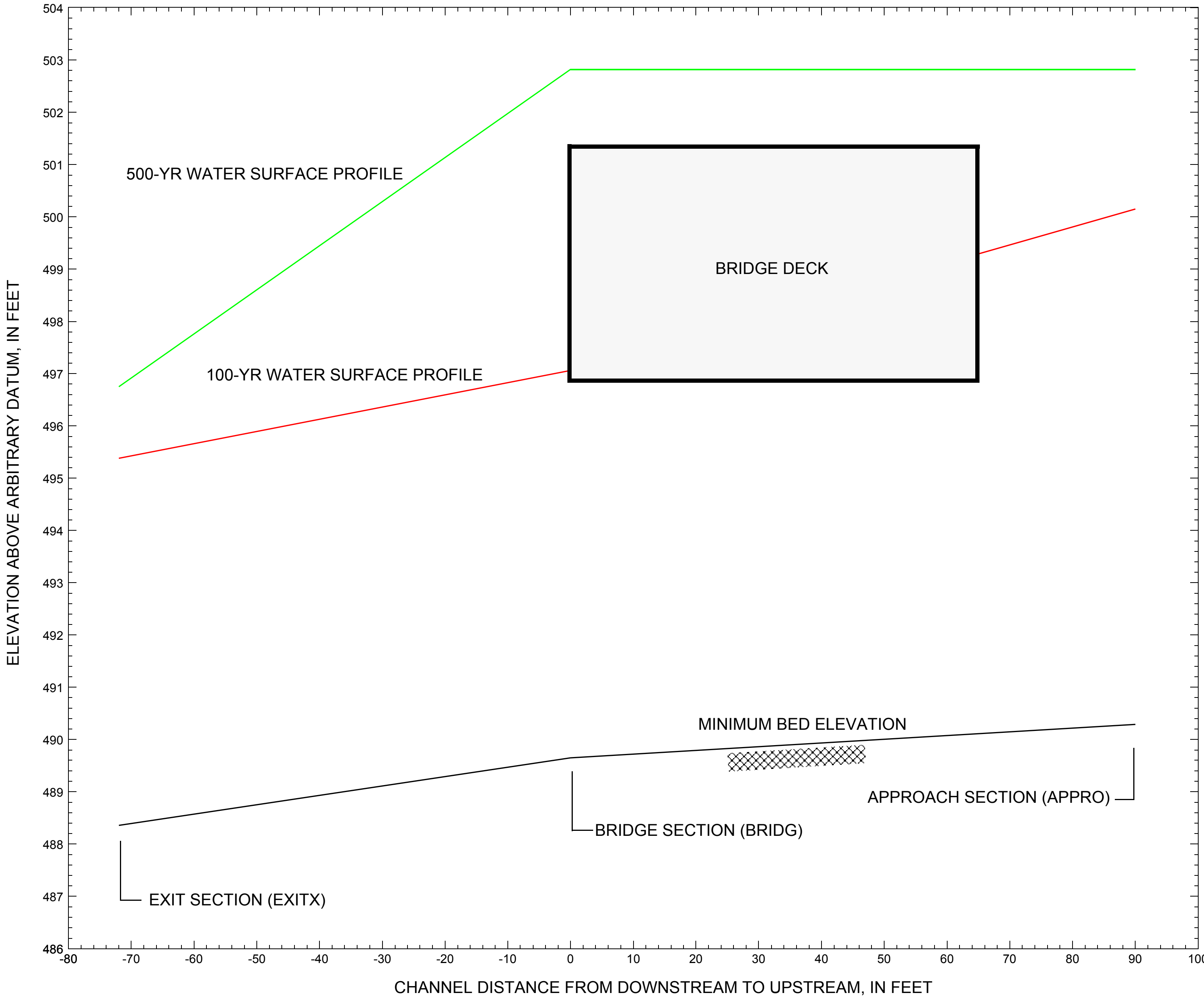


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure CHESTH00030010 on Town Highway 3 (VT 35), crossing the South Branch Williams River, Bridgewater, Vermont.

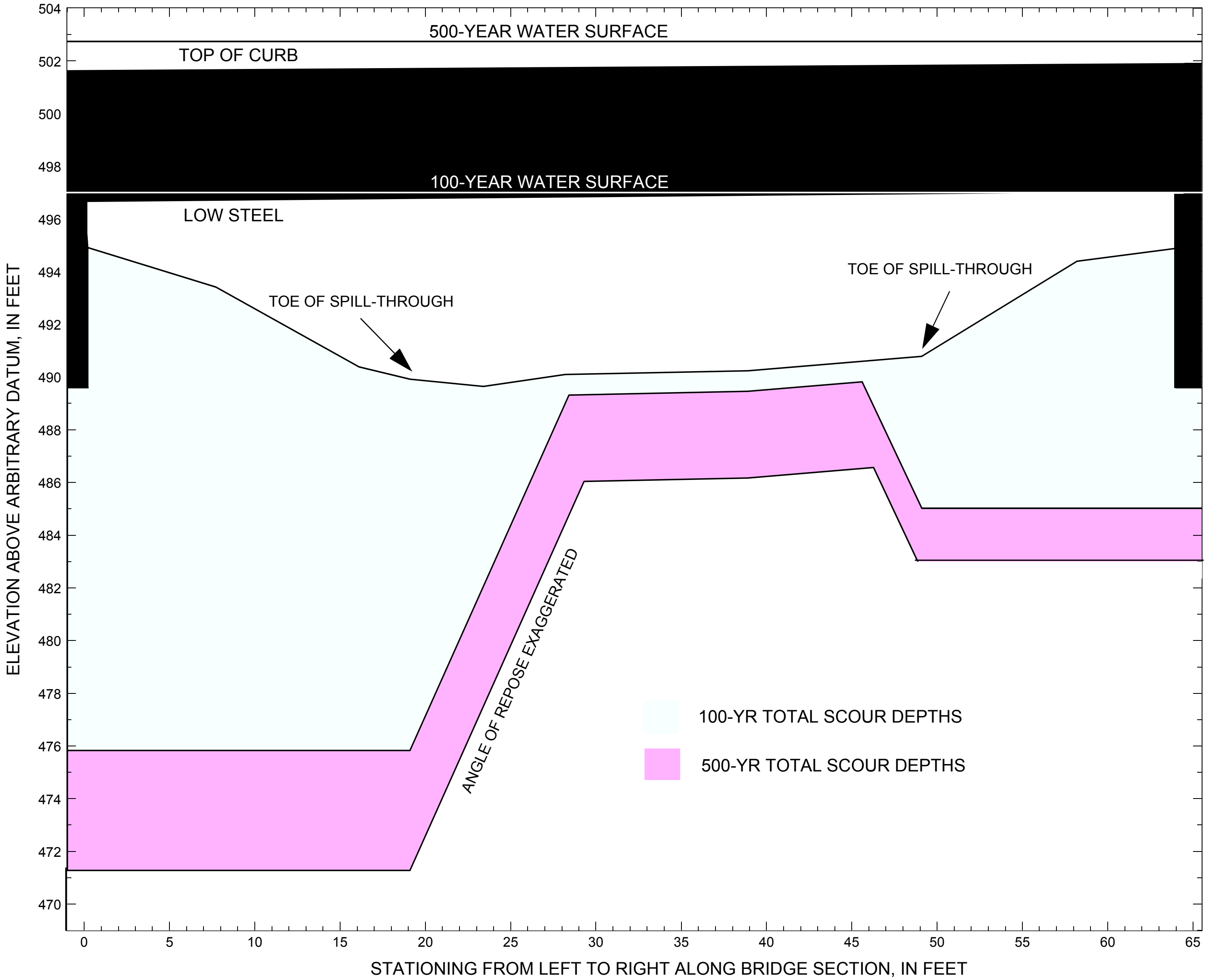


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure CHESTH00030010 on Town Highway 3 (VT 35), crossing the South Branch Williams River, Chester, Vermont.

**Table 1.** Remaining footing/pile depth at abutments for the 100-year discharge at structure CHESTH00030010 on Town Highway 3 (VT 35), crossing the South Branch Williams River, Chester, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

| Description | Station[1] | VTAOT minimum bridge seat elevation (feet) | Surveyed minimum low-chord elevation[2] (feet) | Bottom of footing elevation[2] (feet) | Channel elevation at abutment/ pier[2] (feet) | Contraction scour depth (feet) | Abutment scour depth (feet) | Pier scour depth (feet) | Depth of total scour (feet) | Elevation of scour[2] (feet) | Remaining footing/pile depth (feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100-yr. discharge is 2,780 cubic-feet per second | | | | | | | | | | | |
| Left abutment | 0.0 | 496.3 | 496.7 | 489.6 | 494.9 | -- | -- | -- | -- | -- | -13.8 |
| Spill-through toe | 19.1 | -- | -- | -- | 489.9 | 0.8 | 13.3 | -- | 14.1 | 475.8 | -- |
| Spill-through toe | 49.1 | -- | -- | -- | 490.8 | 0.8 | 5.0 | -- | 5.8 | 485.0 | -- |
| Right abutment | 64.5 | 496.8 | 497.1 | 489.6 | 494.9 | -- | -- | -- | -- | -- | -4.6 |

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

**Table 2.** Remaining footing/pile depth at abutments for the 500-year discharge at structure CHESTH00030010 on Town Highway 3 (VT 35), crossing South Branch Williams River, Chester, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

| Description | Station[1] | VTAOT minimum bridge seat elevation (feet) | Surveyed minimum low-chord elevation[2] (feet) | Bottom of footing 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 4,080 cubic-feet per second | | | | | | | | | | | |
| Left abutment | 0.0 | 496.3 | 496.7 | 489.6 | 494.9 | -- | -- | -- | -- | -- | -18.3 |
| Spill-through toe | 19.1 | -- | -- | -- | 489.9 | 3.7 | 14.9 | -- | 18.6 | 471.3 | -- |
| Spill-through toe | 49.1 | -- | -- | -- | 490.8 | 3.7 | 4.1 | -- | 7.8 | 483.0 | -- |
| Right abutment | 64.5 | 496.8 | 497.1 | 489.6 | 494.9 | -- | -- | -- | -- | -- | -6.6 |

1.Measured along the face of the most constricting side of the bridge.

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U.S. Geological Survey, 1957, Saxtons River, Vermont 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:62,500.

# APPENDIX A:

# WSPRO INPUT FILE

# WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File ches010.wsp
T2        Hydraulic analysis for structure CHESTH00030010   Date: 11-FEB-97
T3        VERMONT 35, SOUTH BRANCH WILLIAMS RIVER, CHESTER, VERMONT     ECW
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q            2780.0   4080.0   3380.0
SK           0.0311   0.0311   0.0311
*
XS   EXITX    -72
GR         -137.1, 517.10    -94.1, 499.63    -82.7, 499.54    -51.1, 500.05
GR          -23.3, 498.31      0.0, 494.22      6.1, 491.38     19.3, 489.15
GR           23.2, 488.72     27.4, 488.82     31.1, 488.36     35.2, 488.85
GR           36.8, 489.16     44.9, 491.41     49.3, 492.98     58.5, 498.49
GR          128.5, 499.60    284.5, 507.75
*
N           0.080        0.065        0.080
SA                -23.2         58.5
*
*
XS   FULLV      0  * * *   0.0184
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    496.86      30.0
GR            0.0, 496.67      0.2, 494.92      7.7, 493.42     16.1, 490.39
GR           19.1, 489.92     23.4, 489.65     28.2, 490.10     38.9, 490.24
GR           49.1, 490.79     58.2, 494.40     64.0, 494.89     64.5, 497.06
GR            0.0, 496.67
*
*         BRTYPE  BRWDTH    EMBSS    EMBELV
CD           3      34.2     1.83     501.26
N           0.060
*
*
*
XR   RDWAY     17      27.3     1
GR          -98.4, 513.25    -53.1, 505.12      0.0, 501.62     64.0, 501.89
GR          134.3, 502.66    284.5, 510.81
*
*
XT   APTEM    103
GR          -27.3, 515.39      0.0, 496.87      4.5, 492.80      7.4, 492.30
GR            8.9, 491.39     11.2, 490.62     16.7, 490.38     20.0, 490.70
GR           29.4, 491.57     31.4, 491.67     39.8, 493.06     45.6, 494.86
GR           50.8, 498.10     61.5, 499.52     74.3, 502.50    112.4, 502.56
GR          247.3, 509.81
*
AS   APPRO     90  *  *  *  0.0068
GT
N           0.060        0.075
SA                  61.5
*
HP 1 BRIDG 497.06 1 497.06
HP 2 BRIDG 497.06 * * 2780
HP 1 APPRO 500.15 1 500.15
HP 2 APPRO 500.15 * * 2780
*
HP 1 BRIDG 497.06 1 497.06
HP 2 BRIDG 497.06 * * 3400
HP 2 RDWAY 502.82 * * 602
HP 1 APPRO 502.82 1 502.82
HP 2 APPRO 502.82 * * 4080
```

APPENDIX B:

# WSPRO OUTPUT FILE

# WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File ches010.wsp
        Hydraulic analysis for structure CHESTH00030010   Date: 11-FEB-97
        VERMONT 35, SOUTH BRANCH WILLIAMS RIVER, CHESTER, VERMONT     ECW
           *** RUN DATE & TIME: 06-10-97  10:12
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      290     13203     0    117                            0
   497.06           290     13203     0    117  1.00      0     65        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.06     0.0    64.5   289.9   13203.    2780.   9.59

X STA.         0.0        9.9       14.0       16.8       19.1       21.3
  A(I)            23.5       17.1       14.9       13.4       12.9
  V(I)            5.91       8.13       9.31      10.37      10.75

X STA.        21.3       23.3       25.3       27.4       29.5       31.6
  A(I)            12.4       12.4       12.4       12.4       12.4
  V(I)           11.19      11.22      11.21      11.20      11.24

X STA.        31.6       33.7       35.9       38.0       40.2       42.5
  A(I)            12.4       12.3       12.4       12.8       12.8
  V(I)           11.25      11.28      11.17      10.86      10.88

X STA.        42.5       44.9       47.5       50.3       54.2       64.5
  A(I)            13.3       14.2       14.6       17.0       24.2
  V(I)           10.46       9.76       9.51       8.16       5.75


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      90.

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      415     33393    66     71                         5875
             2        1        11     3      3                            4
   500.15           416     33404    70     74  1.00     -4     65     5754


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      90.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.15    -5.0    64.6   415.7   33404.    2780.   6.69

X STA.        -5.0        4.8        7.6       10.0       11.9       13.6
  A(I)            34.8       22.1       20.3       18.1       17.1
  V(I)            3.99       6.30       6.85       7.68       8.11

X STA.        13.6       15.4       17.0       18.7       20.4       22.2
  A(I)            16.9       16.2       16.5       16.3       16.5
  V(I)            8.22       8.59       8.44       8.52       8.40

X STA.        22.2       24.0       25.9       27.9       29.9       32.1
  A(I)            16.8       17.0       17.8       17.9       18.6
  V(I)            8.28       8.17       7.81       7.75       7.48

X STA.        32.1       34.4       37.1       40.2       44.4       64.6
  A(I)            19.4       21.1       22.8       26.7       42.8
  V(I)            7.17       6.60       6.09       5.21       3.25
```

```
     U.S. Geological Survey WSPRO Input File ches010.wsp
     Hydraulic analysis for structure CHESTH00030010   Date: 11-FEB-97
     VERMONT 35, SOUTH BRANCH WILLIAMS RIVER, CHESTER, VERMONT     ECW
        *** RUN DATE & TIME: 06-10-97  10:12

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

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      290     13203      0    117                            0
497.06           290     13203      0    117  1.00      0     65        0


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

      WSEL     LEW     REW    AREA        K        Q    VEL
    497.06     0.0    64.5   289.9   13203.    3400.  11.73

X STA.        0.0        9.9       14.0       16.8       19.1       21.3
  A(I)            23.5       17.1       14.9       13.4       12.9
  V(I)            7.23       9.94      11.39      12.68      13.15

X STA.       21.3       23.3       25.3       27.4       29.5       31.6
  A(I)            12.4       12.4       12.4       12.4       12.4
  V(I)           13.69      13.72      13.71      13.69      13.75

X STA.       31.6       33.7       35.9       38.0       40.2       42.5
  A(I)            12.4       12.3       12.4       12.8       12.8
  V(I)           13.76      13.79      13.66      13.28      13.31

X STA.       42.5       44.9       47.5       50.3       54.2       64.5
  A(I)            13.3       14.2       14.6       17.0       24.2
  V(I)           12.80      11.94      11.62       9.98       7.03

 VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      17.

      WSEL     LEW     REW    AREA        K        Q    VEL
    502.82   -18.2   137.2   117.6    2202.     602.   5.12

X STA.      -18.2       -2.9        1.8        5.7        9.8       13.7
  A(I)             7.7        5.3        4.7        4.7        4.5
  V(I)            3.92       5.63       6.39       6.35       6.75

X STA.       13.7       17.8       21.9       25.9       30.2       34.6
  A(I)             4.6        4.6        4.5        4.6        4.7
  V(I)            6.49       6.61       6.69       6.51       6.42

X STA.       34.6       39.1       43.7       48.4       53.4       58.4
  A(I)             4.7        4.7        4.8        4.9        4.8
  V(I)            6.47       6.39       6.31       6.13       6.22

X STA.       58.4       65.7       74.0       84.5       99.2      137.2
  A(I)             6.8        7.2        8.0        9.1       12.6
  V(I)            4.41       4.18       3.75       3.29       2.39

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      90.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      597     58775     70     76                         9872
          2       40       618     57     58                          188
502.82           637     59393    128    133  1.10     -8    119     7687


 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      90.

      WSEL     LEW     REW    AREA        K        Q    VEL
    502.82    -8.9   118.9   637.1   59393.    4080.   6.40

X STA.       -8.9        3.6        7.0        9.7       12.1       14.2
  A(I)            54.1       35.4       30.2       28.4       26.0
  V(I)            3.77       5.76       6.75       7.19       7.84

X STA.       14.2       16.2       18.2       20.2       22.3       24.3
  A(I)            25.2       24.9       24.7       24.9       24.5
  V(I)            8.10       8.19       8.27       8.20       8.33

X STA.       24.3       26.4       28.6       30.9       33.2       35.7
  A(I)            24.8       25.1       25.5       26.4       26.8
  V(I)            8.23       8.11       7.99       7.74       7.61

X STA.       35.7       38.5       41.5       45.3       52.0      118.9
  A(I)            27.8       30.2       32.9       41.5       77.9
  V(I)            7.33       6.77       6.20       4.91       2.62
```

```
        U.S. Geological Survey WSPRO Input File ches010.wsp
        Hydraulic analysis for structure CHESTH00030010   Date: 11-FEB-97
        VERMONT 35, SOUTH BRANCH WILLIAMS RIVER, CHESTER, VERMONT     ECW
           *** RUN DATE & TIME: 06-10-97  10:12
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      290     13203      0    117                            0
   497.06           290     13203      0    117  1.00      0     65        0


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.06     0.0    64.5   289.9   13203.    3380.  11.66

X STA.         0.0         9.9        14.0        16.8        19.1        21.3
  A(I)            23.5        17.1        14.9        13.4        12.9
  V(I)            7.18        9.88       11.32       12.61       13.07

X STA.        21.3        23.3        25.3        27.4        29.5        31.6
  A(I)            12.4        12.4        12.4        12.4        12.4
  V(I)           13.61       13.64       13.63       13.61       13.67

X STA.        31.6        33.7        35.9        38.0        40.2        42.5
  A(I)            12.4        12.3        12.4        12.8        12.8
  V(I)           13.68       13.71       13.58       13.20       13.23

X STA.        42.5        44.9        47.5        50.3        54.2        64.5
  A(I)            13.3        14.2        14.6        17.0        24.2
  V(I)           12.72       11.87       11.56        9.92        6.99


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      90.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      538     50043     69     74                         8515
             2       14       317     11     11                           88
   501.97           552     50359     80     85  1.03     -7     72     8089


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      90.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.97    -7.6    72.4   551.8   50359.    3380.   6.13

X STA.        -7.6         4.0         7.2         9.9        12.0        14.1
  A(I)            47.8        30.5        27.5        24.5        23.2
  V(I)            3.53        5.54        6.14        6.90        7.30

X STA.        14.1        16.0        17.9        19.8        21.7        23.7
  A(I)            22.4        22.2        22.0        21.8        22.1
  V(I)            7.55        7.61        7.68        7.75        7.63

X STA.        23.7        25.7        27.9        30.0        32.3        34.7
  A(I)            21.8        22.8        22.7        23.6        24.0
  V(I)            7.76        7.42        7.44        7.17        7.03

X STA.        34.7        37.3        40.2        43.8        49.2        72.4
  A(I)            25.6        26.6        30.0        35.1        55.7
  V(I)            6.61        6.36        5.63        4.82        3.04
```

```
       U.S. Geological Survey WSPRO Input File ches010.wsp
       Hydraulic analysis for structure CHESTH00030010   Date: 11-FEB-97
       VERMONT 35, SOUTH BRANCH WILLIAMS RIVER, CHESTER, VERMONT     ECW
          *** RUN DATE & TIME: 06-10-97  10:12

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

EXITX:XS   ******     -6      263  1.74 *****  497.11  494.97    2780  495.38
       -71 ******     53    15762  1.00 ***** *******    0.89   10.57

FULLV:FV       72    -11      324  1.14  1.70  498.81 *******    2780  497.67
         0     72     55    20726  1.00  0.00   -0.01    0.69    8.57
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       90     -2      347  1.00  1.30  500.11 *******    2780  499.11
        90     90     59    25853  1.00  0.00    0.00    0.60    8.02
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   497.67     496.86

            <<<<<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       72      0      290  1.40 *****  498.46  495.88    2747  497.06
         0 ******     65    13203  1.00 ***** *******    0.79    9.47

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   3.  0.800  0.000  496.86 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS       56     -4      415  0.70  1.00  500.85  496.91    2780  500.15
        90     57     65    33376  1.00  0.00   -0.01    0.48    6.69

       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     -72.    -7.    53.   2780.   15762.     263.   10.57  495.38
   FULLV:FV       0.   -12.    55.   2780.   20726.     324.    8.57  497.67
   BRIDG:BR       0.     0.    65.   2747.   13203.     290.    9.47  497.06
   RDWAY:RG      17.**************       0.*****************    1.00********
   APPRO:AS      90.    -5.    65.   2780.   33376.     415.    6.69  500.15

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    494.97    0.89  488.36  517.10************  1.74  497.11  495.38
   FULLV:FV  ********    0.69  489.68  518.42  1.70  0.00  1.14  498.81  497.67
   BRIDG:BR    495.88    0.79  489.65  497.06************  1.40  498.46  497.06
   RDWAY:RG  ***************  501.62  513.25************  0.40  502.29********
   APPRO:AS    496.91    0.48  490.29  515.30  1.00  0.00  0.70  500.85  500.15
```

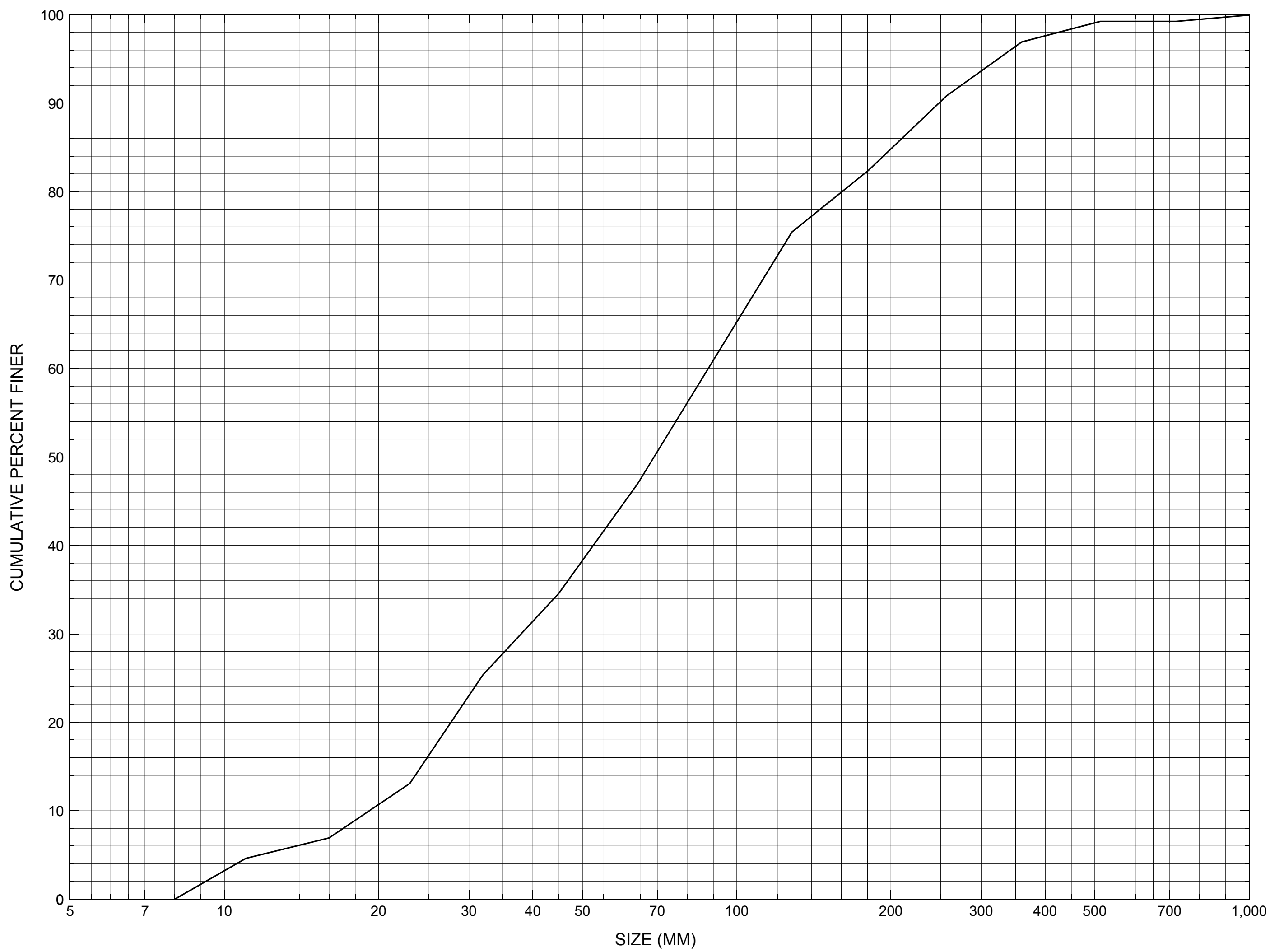
# WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File ches010.wsp
        Hydraulic analysis for structure CHESTH00030010   Date: 11-FEB-97
        VERMONT 35, SOUTH BRANCH WILLIAMS RIVER, CHESTER, VERMONT     ECW
           *** RUN DATE & TIME: 06-10-97  10:12

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

EXITX:XS   ******    -13      352  2.08 *****  498.84  496.38    4080  496.75
       -71 ******     56    23118  1.00 ***** *******    0.91   11.58

FULLV:FV       72    -20      433  1.38  1.71  500.55 *******    4080  499.16
         0     72     57    30271  1.00  0.00    0.00    0.71    9.43
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       90     -5      446  1.31  1.33  501.89 *******    4080  500.58
        90     90     66    37108  1.01  0.00    0.01    0.65    9.15
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   499.16     496.86

            <<<<<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       72      0      290  2.14 *****  499.20  496.53    3400  497.06
         0 ******     65    13203  1.00 ***** *******    0.98   11.73

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   6.  0.800  0.000  496.86 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.    63.  0.30  0.70  503.23   -0.02    602.  502.82

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    240.    50.   -18.    32.   1.2   0.9   5.4   5.1   1.3   3.1
   RT:    362.   103.    32.   134.   1.1   0.7   4.8   5.1   1.1   3.1

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

APPRO:AS       56     -8      637  0.70  1.02  503.52  498.47    4080  502.82
        90     56    119    59392  1.10  0.00   -0.02    0.53    6.40

       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     -72.   -14.    56.   4080.   23118.     352.   11.58  496.75
   FULLV:FV       0.   -21.    57.   4080.   30271.     433.    9.43  499.16
   BRIDG:BR       0.     0.    65.   3400.   13203.     290.   11.73  497.06
   RDWAY:RG      17.*******   240.    602.*********       0.    1.00  502.82
   APPRO:AS      90.    -9.   119.   4080.   59392.     637.    6.40  502.82

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    496.38    0.91  488.36  517.10************  2.08  498.84  496.75
   FULLV:FV  ********    0.71  489.68  518.42  1.71  0.00  1.38  500.55  499.16
   BRIDG:BR    496.53    0.98  489.65  497.06************  2.14  499.20  497.06
   RDWAY:RG  ****************  501.62  513.25  0.30******  0.70  503.23  502.82
   APPRO:AS    498.47    0.53  490.29  515.30  1.02  0.00  0.70  503.52  502.82
```

```
        U.S. Geological Survey WSPRO Input File ches010.wsp
        Hydraulic analysis for structure CHESTH00030010   Date: 11-FEB-97
        VERMONT 35, SOUTH BRANCH WILLIAMS RIVER, CHESTER, VERMONT     ECW
           *** RUN DATE & TIME: 06-10-97  10:12

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

EXITX:XS   ******     -9      305  1.91 *****  497.96  495.67    3380  496.05
       -71 ******     54    19153  1.00 ***** *******    0.90   11.07

FULLV:FV       72    -15      376  1.26  1.71  499.66 *******    3380  498.40
         0     72     56    25132  1.00  0.00   -0.01    0.70    9.00
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       90     -4      395  1.14  1.32  500.99 *******    3380  499.85
        90     90     63    30926  1.00  0.00    0.00    0.63    8.56
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   498.40     496.86

            <<<<<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       72      0      290  2.05 *****  499.11  496.46    3328  497.06
         0 ******     65    13203  1.00 ***** *******    0.95   11.48

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   3.  0.800  0.000  496.86 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.         <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS       56     -7      552  0.60  0.97  502.57  497.63    3380  501.97
        90     57     72    50342  1.03  0.00   -0.02    0.42    6.13

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   501.69

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -72.   -10.    54.   3380.   19153.     305.   11.07  496.05
   FULLV:FV       0.   -16.    56.   3380.   25132.     376.    9.00  498.40
   BRIDG:BR       0.     0.    65.   3328.   13203.     290.   11.48  497.06
   RDWAY:RG      17.**************      0.       0.       0.    1.00********
   APPRO:AS      90.    -8.    72.   3380.   50342.     552.    6.13  501.97

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.67    0.90  488.36  517.10************  1.91  497.96  496.05
   FULLV:FV  ********    0.70  489.68  518.42  1.71  0.00  1.26  499.66  498.40
   BRIDG:BR    496.46    0.95  489.65  497.06************  2.05  499.11  497.06
   RDWAY:RG  ****************  501.62  513.25************  0.60  502.29********
   APPRO:AS    497.63    0.42  490.29  515.30  0.97  0.00  0.60  502.57  501.97
  ER

  NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

# BED-MATERIAL PARTICLE-SIZE DISTRIBUTION




Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure CHESTH00030010, in Bridgewater, Vermont.

APPENDIX D:

# HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number CHESTH00030010

## General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 30 / 95

Highway District Number *(I - 2; nn)* 02

County *(FIPS county code; I - 3; nnn)* 027

Town *(FIPS place code; I - 4; nnnnn)* 13675

Mile marker *(I - 11; nnn.nnn)* 000950

Waterway *(I - 6)* S BR WILLIAMS RIVER

Road Name *(I - 7):* -

Route Number TH003

Vicinity *(I - 9)* 1.5 MI S JCT. VT.11

Topographic Map Saxtons.River

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 43146

Longitude *(i - 17; nnnnn.n)* 72365

## Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20012500101407

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

Maximum span length *(I - 48; nnnn)* 0067

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

Structure length *(I - 49; nnnnnn)* 000069

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

Deck Width *(I - 52; nn.n)* 273

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

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

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

Waterway adequacy *(I - 71; n)* 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*) 065.0

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* $ft^2$) 330.0

Comments:

**The structural inspection report of 8/23/94 indicates the structure is a steel stringer type bridge with a concrete deck and an asphalt roadway surface. This bridge is part of the Federal Aid System and is listed by the route number FAS 125. The abutment walls are concrete, which are in good condition according to the report. Both abutments are flow through type abutment embankments, which are protected with large riprap. The footings of the concrete abutment walls are reported not in view. The waterway proceeds nearly straight through the structure. The streambed consists of stone and gravel. The report indicates there is no channel scour or bank erosion evident. Additionally, point bar and** **(Continued, page 33)**

## Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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:
**debris accumulation problems are reported as not evident.**

## USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **9.44** $mi^2$  Lake and pond area **0.07** $mi^2$
Watershed storage *(ST)* **0.7** %
Bridge site elevation **843** ft  Headwater elevation **1940** ft
Main channel length **7.59** mi
10% channel length elevation **906** ft  85% channel length elevation **1673** ft
Main channel slope *(S)* **134.93** ft / mi

Watershed Precipitation Data

Average site precipitation ____ in  Average headwater precipitation ____ in

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

Average seasonal snowfall *(Sn)* ____ ft

## Bridge Plan Data

Are plans available? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: 06 / 1947

Project Number SA8-47 1947-8 Minimum channel bed elevation: 90.6

Low superstructure elevation: USLAB 97.84 DSLAB 96.74 USRAB 99.82 DSRAB 97.22

Benchmark location description:

**There is no specific benchmark shown on the plans. A couple points shown on the plans with elevations are: 1) The finished road grade at the center line and the right bankward edge of the right abutment, ele vation 101.54 and 2) the point at the same location as in (1) but on the left abutment side, elevation 101.05.**

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

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

If 1: Footing Thickness 1.5 Footing bottom elevation: 90.0

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:

-

## Cross-sectional Data

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

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

Comments: **Many bridge and stream cross-sections from 1977 are with bridge plans. Orientation of the cross sections is inconsistent with any cross section data surveyed for this study and is not comparable. Data was not retreived.**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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: 9/18/96
Computerized by: EW Date: 9/18/96
Reviewd by: EW Date: 3/31/97

Structure Number CHESTH00030010

## A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. HAMMOND Date *(MM/DD/YY)* 8 / 26 / 1996

2. Highway District Number 02 Mile marker 000950

County 027 WINDSOR Town 13675 CHESTER

Waterway *(I - 6)* SOUTH BR. WILLIAMS RIVER Road Name VERMONT RT. 35 (SOUTH)

Route Number TH003 Hydrologic Unit Code: 01080107

3. Descriptive comments:
**Bridge is located 1.5 miles south of junction with Vermont 11, and at junction with road to Williams River State Forest.**

## B. Bridge Deck Observations

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

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

7. Bridge length 69 *(feet)* Span length 67 *(feet)* Bridge width 27.3 *(feet)*

### Road approach to bridge:

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

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

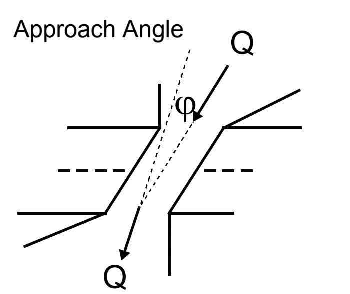
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

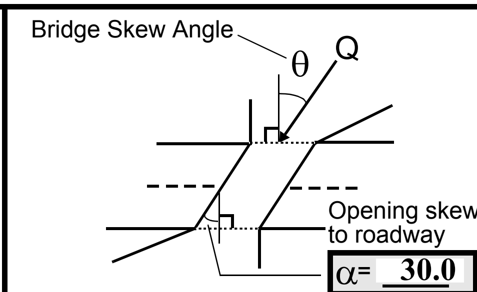
| | Protection | | 13.Erosion | 14.Severity |
|---|---|---|---|---|
| | 11.Type | 12.Cond. | | |
| LBUS | 0 | - | 2 | 1 |
| RBUS | 2 | 1 | 0 | - |
| RBDS | 2 | 1 | 2 | 0 |
| LBDS | *5 | 1 | 2 | 1 |

*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: 0 16. Bridge skew: 50



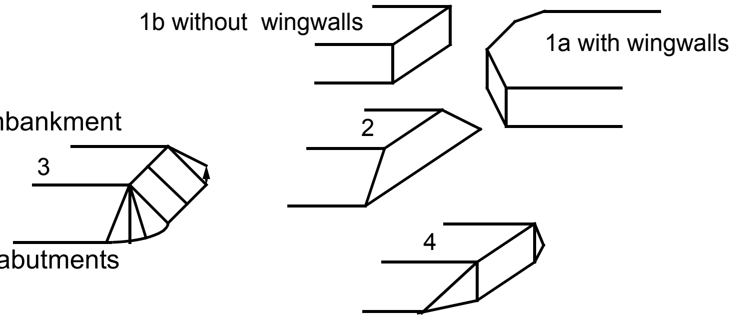

17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 3
Range? 125 feet DS *(US, UB, DS)* to 220 feet DS

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

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

18. Bridge Type: 3/ 1b

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 channel parallels the road along the right bank upstream and left bank downstream.**

**#7: Measured bridge length - upstream bridge face, between the back of abutments = 69.2 feet; downstream face = 70.5 feet. Bridge span, between abutment faces on the upstream end = 64.6 feet; and 64.3 feet on the downstream end. Bridge widths: between the inside of rails = 23.8 feet; and 27.2 feet between the outside of the edges of the deck.**

**#11: *Left bank downstream road protection consists of asphalt which protects the bottom of the road wash channel.**
**#18: The concrete structure the bridge sits on is type 1b. However, approximately two feet below low cord, the placed boulder protection for the abutments acts like a spill through. Additionally, it looks as though flat boulders where placed in channel bed along the left side of channel.**

## 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| 73.5 | 4.0 | | | 5.0 | 4 | 3 | 435 | 435 | 1 | 1 |

23. Bank width 40.0 24. Channel width 30.0 25. Thalweg depth 61.5 29. Bed Material 435

30 .Bank protection type: LB 0 RB 3 31. Bank protection condition: LB - RB 1

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

32. Comments (bank material variation, minor inflows, protection extent, etc.):
**#28: Recent high flows have washed both banks of loose organic material; in some places, scouring of some soil occurred.**

**#30: Right bank protection exists from 35 feet upstream to 0 feet downstream.**

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

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

37. Material: **-**

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

**NO POINT BARS**

**Channel is rather straight. Ambient channel wonders from side to side, however no distinctive bar exists.**

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: **330 US** 42. Cut bank extent: **350** feet **US** (*US, UB*) to **320** 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.):

**Also, refer to #28 explanation.**

45. Is channel scour present? **Y** (*Y or if N type ctrl-n cs*) 46. Mid-scour distance: **70 US**

47. Scour dimensions: Length **28** Width **10** Depth : **0.5** Position **10** %LB to **50** %RB

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

**This could also be considered local scour.**
**An additional scour hole exists beside a large boulder, from 330 feet upstream to 280 feet upstream. It is 3.5 feet (0.5 ft. thalweg) in depth, 15 feet wide and 50 feet long. The mid-scour distance is 370 feet upstream, and it is positioned 40% LB to 80% RB.**

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

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

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

54. Confluence comments (eg. confluence name):

**NO MAJOR CONFLUENCES**

## D. Under Bridge Channel Assessment

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

| 56. Height (BF) | | 57 Angle (BF) | | 61. Material (BF) | | 62. Erosion (BF) | |
|---|---|---|---|---|---|---|---|
| LB | RB | LB | RB | LB | RB | LB | RB |
| **22.5** | | **1.0** | | **2** | **5** | **5** | **0** |

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

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

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

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

**435**
**#55: The channel restraints of laid stone also act like spill through abutments.**

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

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

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

70. Debris and Ice Comments:

**1**

**#65: Recent high waters left debris along banks and under bridge on top of abutment protection (spill through abutment).**

**#69: One tree upstream shows scaring which may be a result of ice accumulation.**

| Abutments | 71. Attack ∠(BF) | 72. Slope ∠ (Qmax) | 73. Toe loc. (BF) | 74. Scour Condition | 75. Scour depth | 76. Exposure depth | 77. Material | 78. Length |
|---|---|---|---|---|---|---|---|---|
| LABUT | | 0 | 90 | 2 | 0 | - | - | 90.0 |
| RABUT | 1/2 | 0 | 90 | | | 2 | 0 | 56.0 |

*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.):

**-**

**-**

**1/2**

**#71: There is no attack angle on either of the abutments at bank full, though bridge is skewed 50 degrees to flow (refer to plan view sketch on page 45).**

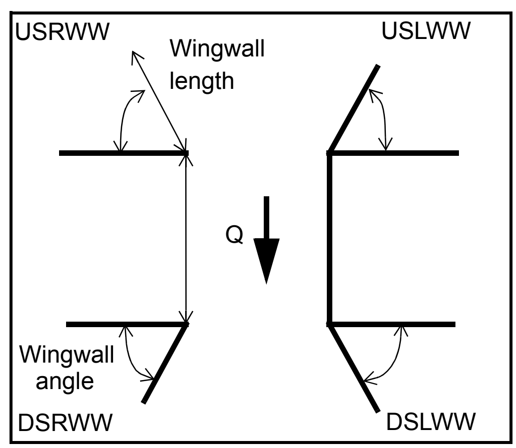
**#73: Protruding toes for both type 1b and type 3.**

**#77: Vertical walls are type 1, and spill-through slopes are type 3.**

80. **Wingwalls**:

| | Exist? | Material? | Scour Condition? | Scour depth? | Exposure depth? | 81. Angle? | Length? |
|---|---|---|---|---|---|---|---|
| USLWW: | | | | | | 33.0 | |
| USRWW: | Y | | 1 | | 0 | 0.5 | |
| DSLWW: | - | | - | | Y | 34.5 | |
| DSRWW: | 1 | | 0 | | - | 33.5 | |

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




82. **Bank / Bridge Protection**:

| Location | USLWW | USRWW | LABUT | RABUT | LB | RB | DSLWW | DSRWW |
|---|---|---|---|---|---|---|---|---|
| Type | - | 0 | Y | - | 1 | 1 | 1 | 1 |
| Condition | Y | - | 1 | - | 1 | 1 | 1 | 1 |
| Extent | 1 | - | 0 | 3 | 3 | 3 | 3 | - |

*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*

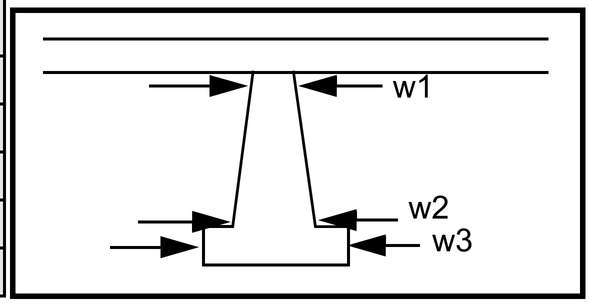
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
**3**
**1**
**1**
**3**
**1**
**1**

## Piers:

84. Are there piers? **#80** *(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 | 120 | | 2.5 | 2.5 | 60.0 | 60.0 |
| Pier 2 | 2.5 | 2.5 | - | 120.0 | - | - |
| Pier 3 | - | - | - | - | - | - |
| Pier 4 | - | - | - | - | - | - |




| Level 1 Pier Descr. | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| 86. Location (BF) | : | from | with | ugh | *LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP* |
| 87. Type | Win | brid | bev- | is | ***1**- Solid pier, **2**- column, **3**- bent* |
| 88. Material | gwal | ge | eled | pro- | ***1**- Wood; **2**- concrete; **3**- metal; **4**- stone* |
| 89. Shape | ls | faces | tops. | tec- | ***1**- Round; **2**- Square; **3**- Pointed* |
| 90. Inclined? | are | ) of | | tion | *Y- yes; N- no* |
| 91. Attack ∠ (BF) | exte | ver- | #82: | for | |
| 92. Pushed | nsio | tical | The | ver- | *LB or RB* |
| 93. Length (feet) | - | - | - | - | |
| 94. # of piles | ns | con- | laid | tical | |
| 95. Cross-members | (abo | crete | stone | abut | ***0**- none; **1**- laterals; **2**- diagonals; **3**- both* |
| 96. Scour Condition | ut | abut | / | ment | ***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed* |
| 97. Scour depth | 2.5 | ment | spill | s. | |
| 98. Exposure depth | feet | s | thro | | |

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

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: **4** ( **1**- eroded and/or creep; **2**- slip failure; **3**- block failure)

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

**3**
**435**
**435**
**1**

Is channel scour present? **1** (Y or if N type ctrl-n cs) Mid-scour distance: **435**

Scour dimensions: Length **3** Width **0** Depth: **1** Positioned **-** %LB to **Ba** %RB

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

**nk material on right bank is bedrock from 125 feet downstream to 210 feet downstream.**

**Right bank erosion is exposed roots from 15 feet downstream to 65 feet downstream. Also, left bank erosion exists from 115 feet downstream to at least 300 feet downstream.**

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

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

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

Confluence comments (eg. confluence name):

**from downstream bridge face to 32 feet downstream.**

## 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: CHESTH00030010 Town: CHESTER
Road Number: VERMONT 35 County: WINDHAM
Stream: SOUTH BRANCH WILLIAMS RIVER

Initials ECW Date: 6/10/97 Checked: SAO

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

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

Approach Section

| Characteristic | 100 yr | 500 yr | other Q |
|---|---|---|---|
| Total discharge, cfs | 2780 | 4080 | 3380 |
| Main Channel Area, ft2 | 415 | 597 | 538 |
| Left overbank area, ft2 | 0 | 0 | 0 |
| Right overbank area, ft2 | 1 | 40 | 14 |
| Top width main channel, ft | 66 | 70 | 69 |
| Top width L overbank, ft | 0 | 0 | 0 |
| Top width R overbank, ft | 3 | 57 | 11 |
| D50 of channel, ft | 0.226 | 0.226 | 0.226 |
| D50 left overbank, ft | -- | -- | -- |
| D50 right overbank, ft | -- | -- | -- |
| | | | |
| y1, average depth, MC, ft | 6.3 | 8.5 | 7.8 |
| y1, average depth, LOB, ft | ERR | ERR | ERR |
| y1, average depth, ROB, ft | 0.3 | 0.7 | 1.3 |
| | | | |
| Total conveyance, approach | 33404 | 59393 | 50359 |
| Conveyance, main channel | 33393 | 58775 | 50043 |
| Conveyance, LOB | 0 | 0 | 0 |
| Conveyance, ROB | 11 | 618 | 317 |
| Percent discrepancy, conveyance | 0.0000 | 0.0000 | -0.0020 |
| Qm, discharge, MC, cfs | 2779.1 | 4037.5 | 3358.8 |
| Ql, discharge, LOB, cfs | 0.0 | 0.0 | 0.0 |
| Qr, discharge, ROB, cfs | 0.9 | 42.5 | 21.3 |
| | | | |
| Vm, mean velocity MC, ft/s | 6.7 | 6.8 | 6.2 |
| Vl, mean velocity, LOB, ft/s | ERR | ERR | ERR |
| Vr, mean velocity, ROB, ft/s | 0.9 | 1.1 | 1.5 |
| Vc-m, crit. velocity, MC, ft/s | 9.3 | 9.8 | 9.6 |
| 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 |

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 | 415 | 597 | 538 |
| Main channel width, ft | 66 | 70 | 69 |
| y1, main channel depth, ft | 6.29 | 8.53 | 7.80 |
| **Bridge Section** | | | |
| (Q) total discharge, cfs | 2780 | 4080 | 3380 |
| (Q) discharge thru bridge, cfs | 2780 | 3400 | 3380 |
| Main channel conveyance | 13203 | 13203 | 13203 |
| Total conveyance | 13203 | 13203 | 13203 |
| Q2, bridge MC discharge,cfs | 2780 | 3400 | 3380 |
| Main channel area, ft2 | 290 | 290 | 290 |
| Main channel width (skewed), ft | 40.6 | 40.6 | 40.6 |
| Cum. width of piers in MC, ft | 0.0 | 0.0 | 0.0 |
| W, adjusted width, ft | 40.6 | 40.6 | 40.6 |
| y_bridge (avg. depth at br.), ft | 7.14 | 7.14 | 7.14 |
| Dm, median (1.25*D50), ft | 0.2825 | 0.2825 | 0.2825 |
| y2, depth in contraction,ft | 6.65 | 7.90 | 7.86 |
| ys, scour depth (y2-ybridge), ft | -0.49 | 0.76 | 0.72 |

| ARMORING | | | |
|---|---|---|---|
| D90 | 0.8134 | 0.8134 | 0.8134 |
| D95 | 1.062 | 1.062 | 1.062 |
| Critical grain size,Dc, ft | 0.4241 | 0.6349 | 0.6269 |
| Decimal-percent coarser than Dc | 0.244 | 0.16 | 0.163 |
| Depth to armoring,ft | 3.94 | 10.00 | 9.66 |

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 | 2780 | 4080 | 3380 |
| Q, thru bridge, cfs | 2780 | 3400 | 3380 |
| Total Conveyance, bridge | 13203 | 13203 | 13203 |
| Main channel(MC) conveyance, bridge | 13203 | 13203 | 13203 |
| Q, thru bridge MC, cfs | 2780 | 3400 | 3380 |
| Vc, critical velocity, ft/s | 9.28 | 9.76 | 9.62 |
| Vc, critical velocity, m/s | 2.83 | 2.97 | 2.93 |
| Main channel width (skewed), ft | 40.6 | 40.6 | 40.6 |
| Cum. width of piers in MC, ft | 0.0 | 0.0 | 0.0 |
| W, adjusted width, ft | 40.6 | 40.6 | 40.6 |
| qbr, unit discharge, ft2/s | 68.5 | 83.7 | 83.3 |
| qbr, unit discharge, m2/s | 6.4 | 7.8 | 7.7 |
| Area of full opening, ft2 | 290.0 | 289.9 | 290.0 |
| Hb, depth of full opening, ft | 7.14 | 7.14 | 7.14 |
| Hb, depth of full opening, m | 2.18 | 2.18 | 2.18 |
| Fr, Froude number, bridge MC | 0.79 | 0.98 | 0.95 |
| Cf, Fr correction factor (<=1.0) | 1.00 | 1.00 | 1.00 |
| Elevation of Low Steel, ft | 496.86 | 496.86 | 496.86 |
| Elevation of Bed, ft | 489.72 | 489.72 | 489.72 |
| Elevation of Approach, ft | 500.15 | 502.82 | 501.97 |
| Friction loss, approach, ft | 1 | 1.02 | 0.97 |
| Elevation of WS immediately US, ft | 499.15 | 501.80 | 501.00 |
| ya, depth immediately US, ft | 9.43 | 12.08 | 11.28 |
| ya, depth immediately US, m | 2.87 | 3.68 | 3.44 |
| Mean elevation of deck, ft | 501.755 | 501.755 | 501.755 |
| w, depth of overflow, ft (>=0) | 0.00 | 0.05 | 0.00 |
| Cc, vert contrac correction (<=1.0) | 0.93 | 0.79 | 0.79 |
| Ys, depth of scour, ft | 0.79 | 3.72 | 3.82 |

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 | 2780 | 4080 | 3380 | 2780 | 4080 | 3380 |
| a', abut.length blocking flow, ft | 17.8 | 21.7 | 20.4 | 11.2 | 65.5 | 19 |
| Ae, area of blocked flow ft2 | 104.4 | 150.5 | 139.1 | 23.7 | 44.3 | 45.6 |
| Qe, discharge blocked abut.,cfs | 629.6 | -- | 740.4 | 77.1 | -- | 138.4 |
| (If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually) | | | | | | |
| Ve, (Qe/Ae), ft/s | 6.03 | 5.64 | 5.32 | 3.25 | 2.62 | 3.04 |
| ya, depth of f/p flow, ft | 5.87 | 6.94 | 6.82 | 2.12 | 0.68 | 2.40 |
| --Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru) | | | | | | |
| K1 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 |
| --Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US) | | | | | | |
| theta | 120 | 120 | 120 | 60 | 60 | 60 |
| K2 | 1.04 | 1.04 | 1.04 | 0.95 | 0.95 | 0.95 |
| Fr, froude number f/p flow | 0.439 | 0.370 | 0.359 | 0.394 | 0.428 | 0.345 |
| ys, scour depth, ft | 13.28 | 14.94 | 14.40 | 5.02 | 4.09 | 6.02 |

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) | 17.8 | 21.7 | 20.4 | 11.2 | 65.5 | 19 |
| y1 (depth f/p flow, ft) | 5.87 | 6.94 | 6.82 | 2.12 | 0.68 | 2.40 |
| a'/y1 | 3.03 | 3.13 | 2.99 | 5.29 | 96.85 | 7.92 |
| Skew correction (p. 49, fig. 16) | 1.07 | 1.07 | 1.07 | 0.90 | 0.90 | 0.90 |
| Froude no. f/p flow | 0.44 | 0.37 | 0.36 | 0.39 | 0.43 | 0.35 |
| Ys w/ corr. factor K1/0.55: | | | | | | |
| vertical | ERR | ERR | ERR | ERR | 3.35 | ERR |
| vertical w/ ww's | ERR | ERR | ERR | ERR | 2.74 | ERR |
| spill-through | ERR | ERR | ERR | ERR | 1.84 | ERR |

Abutment riprap Sizing

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

| Characteristic | Q100 | Q500 | Qother | | | |
|---|---|---|---|---|---|---|
| Fr, Froude Number | 0.79 | 0.98 | 0.95 | 0.79 | 0.98 | 0.95 |
| (Fr from the characteristic V and y in contracted section--mc, bridge section) | | | | | | |
| y, depth of flow in bridge, ft | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 |
| Median Stone Diameter for riprap at: | left abutment | | | right abutment, ft | | |
| Fr<=0.8 (vertical abut.) | 2.76 | ERR | ERR | 2.76 | ERR | ERR |
| Fr>0.8 (vertical abut.) | ERR | 2.97 | 2.94 | ERR | 2.97 | 2.94 |
| Fr<=0.8 (spillthrough abut.) | 2.40 | ERR | ERR | 2.40 | ERR | ERR |
| Fr>0.8 (spillthrough abut.) | ERR | 2.62 | 2.60 | ERR | 2.62 | 2.60 |