LEVEL II SCOUR ANALYSIS FOR BRIDGE 22 (JAY-TH00400022) on TOWN HIGHWAY 40, crossing JAY BRANCH TRIBUTARY, JAY, VERMONT

U.S. Geological Survey
Open-File Report 97-591

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

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By MICHAEL A. IVANOFF and DONALD L. SONG

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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 22 (JAY-TH00400022) ON TOWN HIGHWAY 40, CROSSING JAY BRANCH TRIBUTARY, JAY, VERMONT

By **Michael A. Ivanoff and Donald L. Song**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure JAY-TH00400022 on Town Highway 40 crossing Jay Tributary, Jay, 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 in northern Vermont. The 2.15-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is primarily pasture on the upstream and downstream left overbank while the immediate banks have dense woody vegetation. The downstream right overbank of the bridge is forested.

In the study area, Jay Branch Tributary has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 26 ft and an average bank height of 3 ft. The channel bed material ranges from gravel to cobble with a median grain size (D_{50}) of 40.5 mm (0.133 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 7, 1995, indicated that the reach was stable.

The Town Highway 40 crossing of Jay Branch Tributary is a 27-ft-long, two-lane bridge consisting of one 25-foot steel-beam span (Vermont Agency of Transportation, written communication, March 6, 1995). The opening length of the structure parallel to the bridge face is 23.5 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel skew and the opening-skew-to-roadway are zero degrees.

The scour counter-measures at the site included type-2 stone fill (less than 36 inches diameter) at the upstream end of the left and right abutments, at the upstream right wingwall, and at the downstream left wingwall. There was also type-3 stone fill (less than 48 inches diameter) at the upstream left and downstream right wingwall. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.7 to 1.1 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 4.6 to 4.9 ft. The worst-case left abutment scour occurred at the 100-year discharge. Right abutment scour ranged from 4.0 to 5.0 ft. The worst-case right 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.

North Troy, VT. Quadrangle, 1:24,000, 1986

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 JAY-TH00400022 ***Stream*** Jay Branch Tributary

County Orleans ***Road*** TH40 ***District*** 9

Description of Bridge

Bridge length 27 ***ft*** ***Bridge width*** 20.0 ***ft*** ***Max span length*** 25 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 6/7/95

Description of stone fill Type-2 stone fill at the upstream end of the left and right abutments, at the upstream right wingwall, and at the downstream left wingwall. There was also type-3 stone fill at the upstream left and downstream right wingwall.

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

Is bridge skewed to flood flow according to No ***survey?*** No ***Angle*** 0

There is a mild channel bend in the upstream reach.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	6/7/95	0	0
Level II	6/7/95	0	0

Potential for debris Low. There is some debris caught on boulders and trees leaning over the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date) A thick slab of concrete stretches across the channel 10 feet upstream of the bridge forming a minor drop as of 6/7/95.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley.

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

Date of inspection 6/7/95

DS left: Moderately sloped overbank.

DS right: Steep channel bank to a moderately sloped overbank.

US left: Moderately sloped overbank.

US right: Steep channel bank to a moderately sloped overbank and a pond.

Description of the Channel

Average top width 26 ***ft*** ***Average depth*** 3 ***ft***

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

Sinuous but stable

with non-alluvial channel boundaries and no flood plain.

6/7/95

Vegetative co Lawn with a few trees and some brush.

DS left: Trees and brush.

DS right: Trees and brush on the immediate bank with pasture on the overbank

US left: Trees and brush

US right:

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

The assessment of 6/7/95 noted flow conditions up to bank-full level are influenced by a pile of stone fill along the upstream end of the left abutment blocking ten percent of the opening.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 2.15 ***mi***^{2}

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***: None.

Is there a USGS gage on the stream of interest? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi***^{2}

Is there a lake/p No

There is a small pond on the upstream right overbank.

Calculated Discharges

Q100 560 ***ft***^{3}***/s*** ***Q500*** 830 ***ft***^{3}***/s***

Flood frequencies were computed using methods described in "Peak rates of runoff in the New England Hill and Lowland area" (Potter, 1957 b) and graphically extrapolated to the 100-year and 500-year discharge. These results were chosen due to their central tendency among other empirical techniques (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Talbot, 1887). For example, the Q100 result was the median and within 3 per cent of the average.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the left abutment (elev. 499.84 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the right abutment (elev. 499.30 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	-21	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	10	1	Road Grade section
APPRO	44	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.045 to 0.065, and overbank "n" value was 0.075.

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 0.0116 ft/ft which was determined from surveyed points downstream of the bridge.

The approach section (APPRO) was surveyed one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

For the 100-year and 500-year discharges, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. After analyzing both the supercritical and subcritical profiles for each discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge are satisfactory solutions.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.7 ***ft***
Average low steel elevation 497.6 ***ft***

100-year discharge 560 ***ft³/s***
Water-surface elevation in bridge opening 491.2 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 57 ***ft²***
Average velocity in bridge opening 9.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.7 ***ft/s***

Water-surface elevation at Approach section with bridge 493.1
Water-surface elevation at Approach section without bridge 492.3
Amount of backwater caused by bridge 0.8 ***ft***

500-year discharge 830 ***ft³/s***
Water-surface elevation in bridge opening 492.2 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 77 ***ft²***
Average velocity in bridge opening 10.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.5 ***ft/s***

Water-surface elevation at Approach section with bridge 494.4
Water-surface elevation at Approach section without bridge 493.3
Amount of backwater caused by bridge 1.1 ***ft***

Incipient overtopping discharge -- ***ft³/s***
Water-surface elevation in bridge opening -- ***ft***
Area of flow in bridge opening -- ***ft²***
Average velocity in bridge opening -- ***ft/s***
Maximum WSPRO tube velocity at bridge -- ***ft/s***

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the 100-year and 500-year discharges were computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction 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.

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	0.7	1.1	--
Depth to armoring	13.0	17.9	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	4.9	4.6	--
Right abutment	4.0	5.0	--
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	1.6	1.8	--
Right abutment	1.6	1.8	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

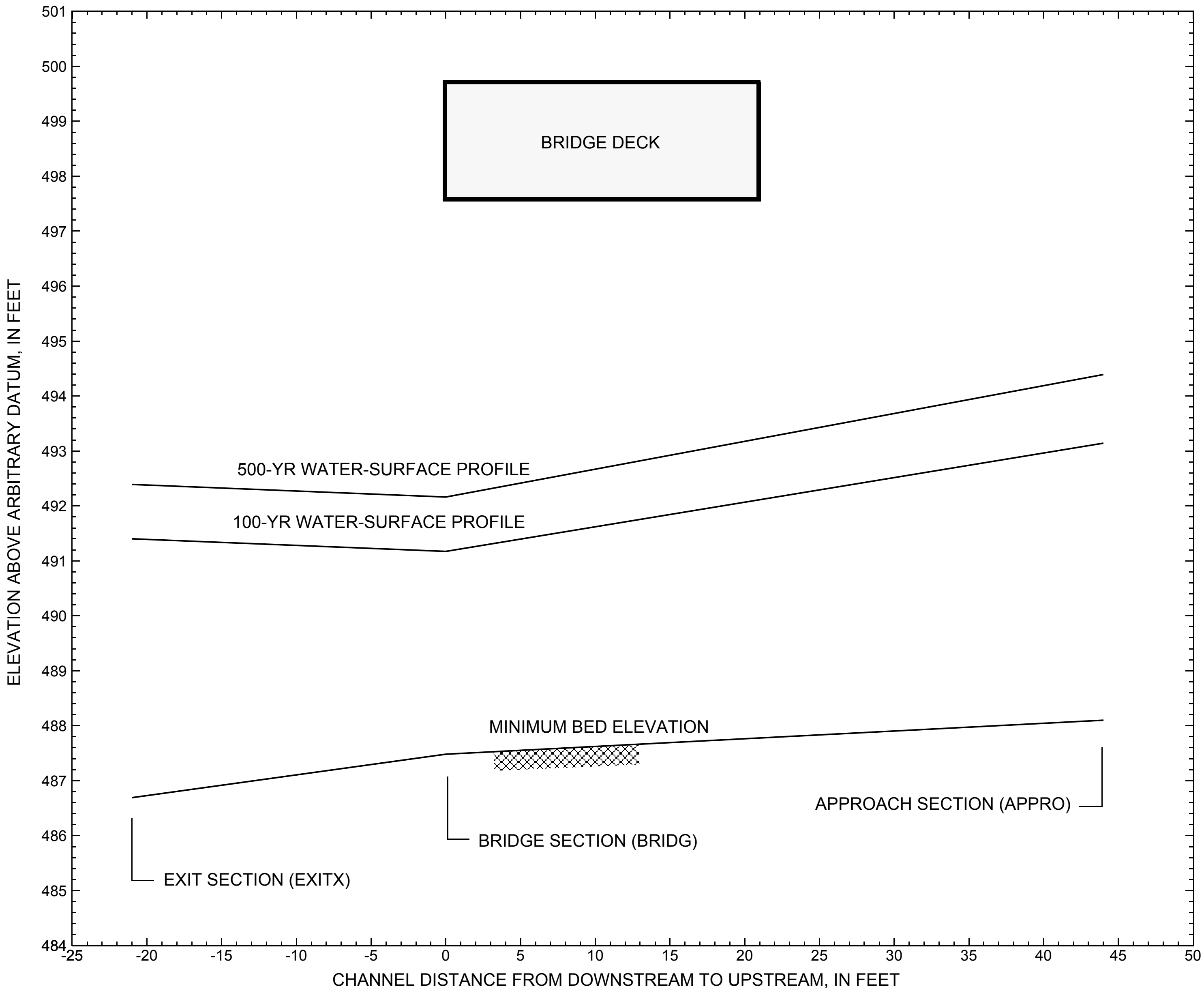

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure JAY-TH00400022 on Town Highway 40, crossing Jay Branch Tributary, Jay, Vermont.

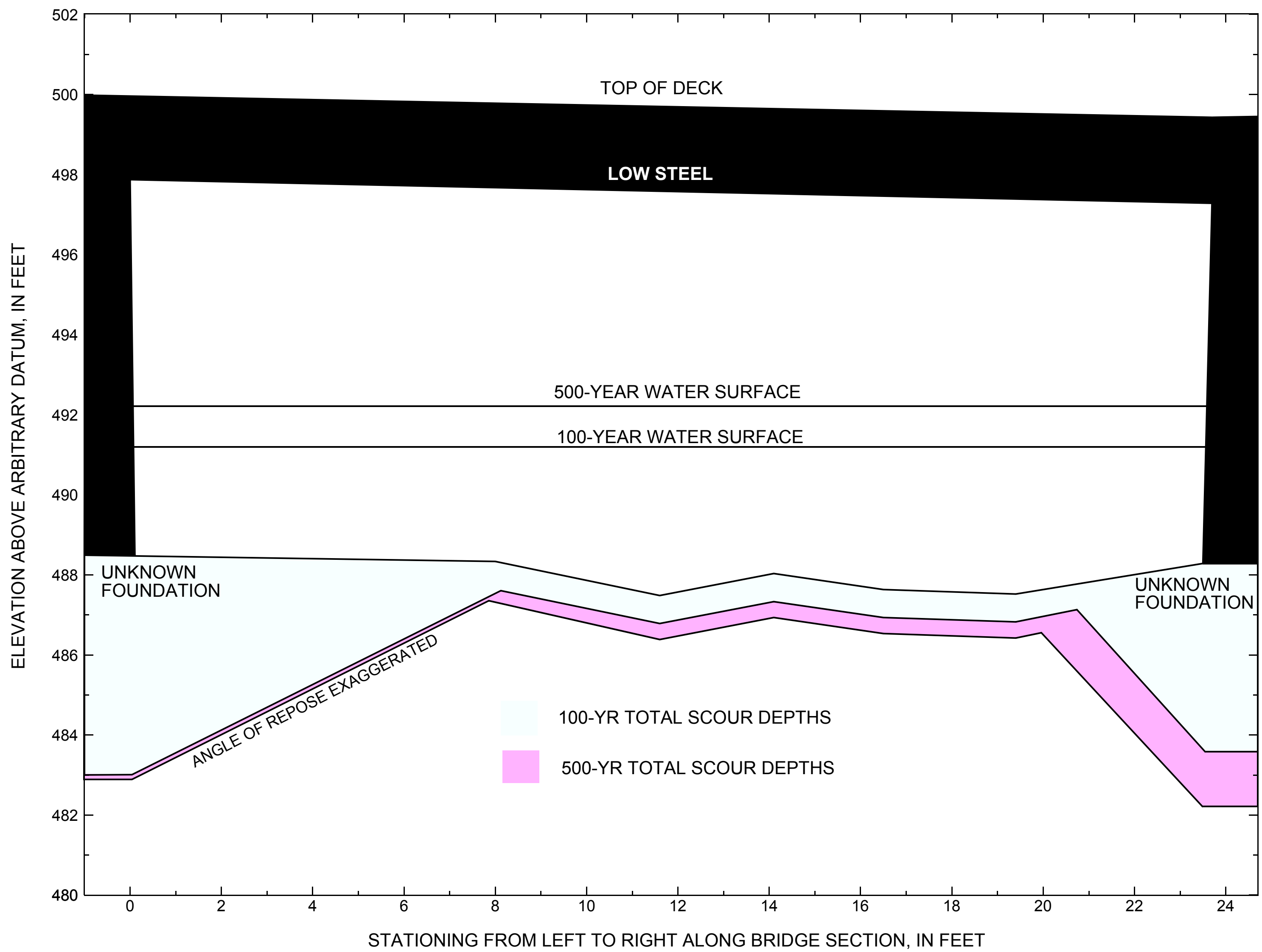

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure JAY-TH00400022 on Town Highway 40, crossing Jay Branch Tributary, Jay, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure JAY-TH00400022 on Town Highway 40, crossing Jay Branch Tributary, Jay, 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 540 cubic-feet per second											
Left abutment	0.0	--	497.9	--	488.6	0.7	4.9	--	5.6	483.0	--
Right abutment	23.5	--	497.3	--	488.3	0.7	4.0	--	4.7	483.6	--

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 JAY-TH00400022 on Town Highway 40, crossing Jay Branch Tributary, Jay, 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 840 cubic-feet per second											
Left abutment	0.0	--	497.9	--	488.6	1.1	4.6	--	5.7	482.9	--
Right abutment	23.5	--	497.3	--	488.3	1.1	5.0	--	6.1	482.2	--

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

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U.S. Geological Survey, 1986, North Troy, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File jay-022.wsp
T2        Hydraulic analysis for structure JAY-TH00400022   Date: 14-APR-97
T3        Bridge # 22 on Town Highway 40 over Jay Branch Tributary in Jay, VT by MAI
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q            560.0    830.0
SK          0.0116   0.0116
*
XS   EXITX    -21
GR         -145.4, 509.00   -137.2, 504.62   -100.4, 503.80    -28.1, 499.65
GR            0.0, 489.64      5.9, 487.36     14.0, 486.69     17.8, 486.83
GR           22.3, 487.33     28.5, 490.87     31.5, 494.48     50.4, 495.33
GR           82.6, 495.46    139.9, 503.46    220.8, 510.12
*
N            0.065        0.075
SA                  31.5
*
*
XS   FULLV      0 * * *   0.0225
*
*              SRD     LSEL    XSSKEW
BR   BRIDG      0    497.58       0.0
GR            0.0, 497.87      0.0, 491.93      2.7, 492.56      5.3, 490.45
GR            8.0, 488.33     11.6, 487.48     14.1, 488.03     16.5, 487.63
GR           19.4, 487.52     23.5, 488.26     23.5, 488.48     23.7, 497.28
GR            0.0, 497.87
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      28.0 * *     38.8      8.8
N           0.045
*
The model includes stone fill along the left abutment at the upstream end, scour was
applied to the base of footing apparent at the downstream bridge face.
*
*              SRD    EMBWID   IPAVE
XR   RDWAY      10      20.0     2
GR         -137.8, 510.63   -132.5, 506.04    -95.1, 505.28    -38.0, 501.47
GR            0.0, 499.96     24.0, 499.43     40.0, 499.38     65.2, 499.75
GR          100.7, 501.07    202.0, 510.34
*
AS   APPRO     44
GR         -125.1, 512.80   -119.8, 508.13    -87.2, 506.80     -9.6, 495.87
GR           -3.5, 493.37      0.0, 493.00      3.5, 489.88      6.9, 489.24
GR           11.8, 488.63     15.3, 488.10     19.9, 488.62     22.2, 489.20
GR           23.0, 491.75     28.1, 494.74     37.7, 495.86     71.2, 507.73
GR          197.9, 510.43
*
N           0.065
*
HP 1 BRIDG   491.17 1 491.17
HP 2 BRIDG   491.17 * * 560
HP 1 APPRO   493.14 1 493.14
HP 2 APPRO   493.14 * * 560
*
HP 1 BRIDG   492.16 1 492.16
HP 2 BRIDG   492.16 * * 830
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File jay-022.wsp
        Hydraulic analysis for structure JAY-TH00400022   Date: 14-APR-97
        Bridge # 22 on Town Highway 40 over Jay Branch Tributary in Jay, VT  by MAI
           *** RUN DATE & TIME: 06-18-97  10:31
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1       57      3471    19     23                          564
   491.17            57      3471    19     23  1.00      4     24      564



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

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.17     4.4    23.6    57.4    3471.     560.   9.76

X STA.         4.4        8.0        9.1       10.0       10.8       11.5
  A(I)             5.1        3.2        2.9        2.8        2.5
  V(I)            5.46       8.81       9.58      10.05      11.04

X STA.        11.5       12.2       12.9       13.7       14.5       15.2
  A(I)             2.5        2.5        2.5        2.5        2.5
  V(I)           11.32      11.33      11.08      11.13      11.19

X STA.        15.2       15.9       16.6       17.3       18.0       18.7
  A(I)             2.5        2.4        2.4        2.4        2.5
  V(I)           11.41      11.74      11.47      11.69      11.30

X STA.        18.7       19.3       20.1       20.9       21.9       23.6
  A(I)             2.5        2.7        2.8        3.2        5.1
  V(I)           11.39      10.52       9.87       8.86       5.52

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1       91      4337    27     30                          954
   493.14            91      4337    27     30  1.00      0     25      954



    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.14    -1.3    25.4    91.0    4337.     560.   6.15

X STA.        -1.3        4.2        5.8        7.0        8.2        9.2
  A(I)             8.5        5.5        4.8        4.4        4.2
  V(I)            3.31       5.08       5.82       6.35       6.66

X STA.         9.2       10.1       11.0       11.9       12.7       13.5
  A(I)             4.0        4.0        3.8        3.8        3.7
  V(I)            7.00       6.98       7.45       7.38       7.65

X STA.        13.5       14.2       15.0       15.7       16.4       17.2
  A(I)             3.6        3.6        3.7        3.7        3.8
  V(I)            7.67       7.74       7.67       7.65       7.45

X STA.        17.2       18.0       18.9       19.9       21.1       25.4
  A(I)             3.9        4.2        4.5        5.0        8.5
  V(I)            7.17       6.70       6.26       5.55       3.31
```

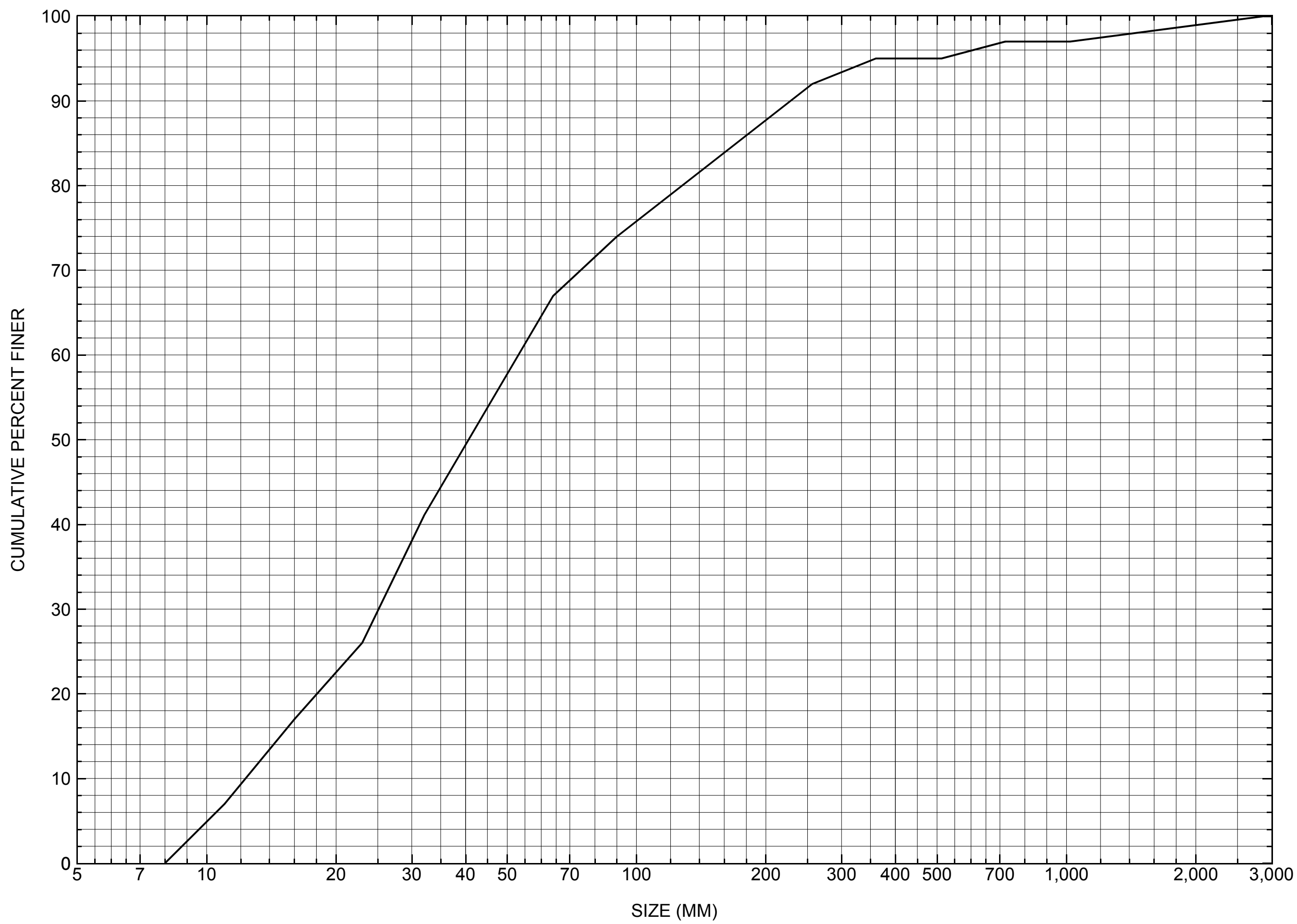
```
     U.S. Geological Survey WSPRO Input File jay-022.wsp
     Hydraulic analysis for structure JAY-TH00400022   Date: 14-APR-97
     Bridge # 22 on Town Highway 40 over Jay Branch Tributary in Jay, VT  by MAI
        *** RUN DATE & TIME: 06-18-97  10:31
 CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1       77      5129     21     27                          830
492.16            77      5129     21     27  1.00      0     24      830




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

      WSEL     LEW     REW    AREA         K        Q    VEL
    492.16     0.0    23.6    77.1     5129.     830.  10.77

X STA.         0.0        7.5        8.8        9.8       10.6       11.4
  A(I)            7.7        4.7        4.1        3.6        3.5
  V(I)           5.40       8.80      10.22      11.52      11.89

X STA.        11.4       12.1       12.8       13.5       14.3       15.1
  A(I)            3.4        3.3        3.2        3.2        3.2
  V(I)          12.35      12.76      12.89      12.86      13.11

X STA.        15.1       15.8       16.5       17.2       17.9       18.5
  A(I)            3.2        3.1        3.2        3.1        3.2
  V(I)          13.01      13.48      13.16      13.43      13.00

X STA.        18.5       19.3       20.0       20.8       21.8       23.6
  A(I)            3.3        3.5        3.6        4.3        7.0
  V(I)          12.76      11.99      11.51       9.64       5.96


 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      129      6752     33     38                         1444
494.39           129      6752     33     38  1.00     -5     28     1444




 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

      WSEL     LEW     REW    AREA         K        Q    VEL
    494.39    -6.0    27.5   129.5     6752.     830.   6.41

X STA.        -6.0        2.9        4.7        6.1        7.4        8.5
  A(I)           13.1        8.4        6.8        6.4        5.9
  V(I)           3.16       4.96       6.11       6.50       7.02

X STA.         8.5        9.5       10.5       11.5       12.4       13.2
  A(I)            5.6        5.5        5.3        5.3        5.1
  V(I)           7.40       7.52       7.90       7.86       8.18

X STA.        13.2       14.0       14.9       15.7       16.5       17.3
  A(I)            5.0        5.1        5.0        5.1        5.2
  V(I)           8.35       8.18       8.24       8.19       7.96

X STA.        17.3       18.3       19.2       20.3       21.6       27.5
  A(I)            5.4        5.7        6.2        7.2       12.3
  V(I)           7.65       7.34       6.68       5.76       3.38
```

```
        U.S. Geological Survey WSPRO Input File jay-022.wsp
        Hydraulic analysis for structure JAY-TH00400022   Date: 14-APR-97
        Bridge # 22 on Town Highway 40 over Jay Branch Tributary in Jay, VT  by MAI
           *** RUN DATE & TIME: 06-18-97  10:31

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

EXITX:XS   ******     -4      108  0.42 *****  491.82  490.00     560  491.40
       -20 ******     29     5195  1.00 ***** *******    0.51    5.17

FULLV:FV       21     -3      100  0.48  0.27  492.12 *******     560  491.63
         0     21     29     4660  1.00  0.03    0.00    0.56    5.58
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  0.68

APPRO:AS       44      1       71  0.96  0.93  493.29 *******     560  492.34
        44     44     24     3169  1.00  0.24    0.01    0.79    7.85
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =      560.      491.17

            <<<<<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       21      4       57  1.49 *****  492.65  491.17     560  491.17
         0     21     24     3464  1.00 ***** *******    1.00    9.77

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.58 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<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       16      0       91  0.59  0.35  493.73  491.82     560  493.14
        44     17     25     4335  1.00  0.73    0.02    0.59    6.15

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.152  0.000    4896.     3.    22.   492.73


  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -21.    -5.    29.    560.    5195.     108.    5.17  491.40
   FULLV:FV       0.    -4.    29.    560.    4660.     100.    5.58  491.63
   BRIDG:BR       0.     4.    24.    560.    3464.      57.    9.77  491.17
   RDWAY:RG      10.**************       0.******************    2.00********
   APPRO:AS      44.    -1.    25.    560.    4335.      91.    6.15  493.14

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       3.    22.    4896.


 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    490.00    0.51  486.69  510.12************  0.42  491.82  491.40
   FULLV:FV  ********    0.56  487.16  510.59  0.27  0.03  0.48  492.12  491.63
   BRIDG:BR    491.17    1.00  487.48  497.87************  1.49  492.65  491.17
   RDWAY:RG ****************  499.38  510.63**********************************
   APPRO:AS    491.82    0.59  488.10  512.80  0.35  0.73  0.59  493.73  493.14
```

```
        U.S. Geological Survey WSPRO Input File jay-022.wsp
        Hydraulic analysis for structure JAY-TH00400022   Date: 14-APR-97
        Bridge # 22 on Town Highway 40 over Jay Branch Tributary in Jay, VT  by MAI
           *** RUN DATE & TIME: 06-18-97  10:31

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

EXITX:XS   ******     -7      144  0.52 *****  492.91  490.77     830  492.39
       -20 ******     30     7705  1.00 ***** *******    0.52    5.78

FULLV:FV       21     -6      134  0.59  0.27  493.21 *******     830  492.61
         0     21     30     7031  1.00  0.04    0.00    0.57    6.17
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.85     493.25     492.73

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   492.11     512.80    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   492.11     512.80     492.73

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  0.64

APPRO:AS       44     -2       95  1.20  0.96  494.47  492.73     830  493.27
        44     44     26     4477  1.00  0.30    0.00    0.84    8.78
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =     830.     492.16

            <<<<<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       21      0       77  1.80 *****  493.96  492.16     830  492.16
         0     21     24     5135  1.00 ***** *******    1.00   10.76

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.58 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<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       16     -5      129  0.64  0.34  495.03  492.73     830  494.39
        44     17     27     6744  1.00  0.73    0.01    0.58    6.42

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.162  0.000    7375.    -2.    22.  494.02


  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -21.    -8.    30.    830.    7705.     144.    5.78  492.39
   FULLV:FV       0.    -7.    30.    830.    7031.     134.    6.17  492.61
   BRIDG:BR       0.     0.    24.    830.    5135.      77.   10.76  492.16
   RDWAY:RG      10.**************      0.*****************    2.00********
   APPRO:AS      44.    -6.    27.    830.    6744.     129.    6.42  494.39

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -2.    22.    7375.


 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    490.77    0.52  486.69  510.12************  0.52  492.91  492.39
   FULLV:FV   ********   0.57  487.16  510.59  0.27  0.04  0.59  493.21  492.61
   BRIDG:BR    492.16    1.00  487.48  497.87************  1.80  493.96  492.16
   RDWAY:RG   ****************  499.38  510.63**********************************
   APPRO:AS    492.73    0.58  488.10  512.80  0.34  0.73  0.64  495.03  494.39
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure JAY-TH00400022, in Jay, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number JAY-TH00400022

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 06 / 95

Highway District Number *(I - 2; nn)* 09

County *(FIPS county code; I - 3; nnn)* 019

Town *(FIPS place code; I - 4; nnnnn)* 36325

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

Waterway *(I - 6)* JAY BRANCH TRIBUTARY

Road Name *(I - 7):* -

Route Number TH040

Vicinity *(I - 9)* 0.02 MI TO JCT W VT.242

Topographic Map North Troy

Hydrologic Unit Code: 02010007

Latitude *(I - 16; nnnn.n)* 44564

Longitude *(i - 17; nnnnn.n)* 72275

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10101200221012

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

Maximum span length *(I - 48; nnnn)* 0025

Year built *(I - 27; YYYY)* 1960

Structure length *(I - 49; nnnnnn)* 000027

Average daily traffic, ADT *(I - 29; nnnnnn)* 000075

Deck Width *(I - 52; nn.n)* 200

Year of ADT *(I - 30; YY)* 94

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

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

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*) 024.0

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

Vertical clearance from streambed (*nnn.n ft*) 009.0

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

Waterway of full opening (*nnn.n ft*^{2}) 216.0

Comments:

The structural inspection report of 5/27/93 indicates the structure is a single span steel stringer type bridge. Both abutment walls and all wings are in good condition. The right abutment footing is exposed. In a few locations, the streambed is up to 9 inches below the top of the footing. No undermining is reported. The waterway proceeds straight through the bridge. The streambed material is composed of stone and gravel, with several medium sized boulders. There is a section of concrete along the bottom of the streambed about 10 feet upstream from the bridge. Streambank erosion and debris accumulation are noted as not evident.

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: **Stone and gravel, with some random medium boulders**

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:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 2.15 mi^2

Lake/pond/swamp area 0 mi^2

Watershed storage *(ST)* 0 %

Bridge site elevation 1402 ft

Headwater elevation 3858 ft

Main channel length 2.80 mi

10% channel length elevation 1497 ft

85% channel length elevation 2756 ft

Main channel slope *(S)* 600.47 ft / mi

Watershed Precipitation Data

Average site precipitation ______ in

Average headwater precipitation ______ in

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

Average seasonal snowfall *(Sn)* ______ ft

Bridge Plan Data

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

Project Number -

Minimum channel bed elevation: -

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

Benchmark location description:

NO BENCHMARK INFORMATION

Reference Point (*MSL, Arbitrary, Other*): -

Datum (*NAD27, NAD83, Other*): -

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

If 1: Footing Thickness ______ Footing bottom elevation: ______

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

If 3: Footing bottom elevation: ______

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

-

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 04/10/96
Computerized by: EW Date: 04/10/96
Reviewd by: MAI Date: 6/4/97

Structure Number JAY-TH00400022

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* D. SONG Date *(MM/DD/YY)* 06 / 07 / 1995
2. Highway District Number 09
   County Orleans (019)
   Waterway *(I - 6)* JAY BRANCH TRIBUTARY
   Route Number TH040
   Mile marker 000000
   Town JAY (36325)
   Road Name -
   Hydrologic Unit Code: 02010007
3. Descriptive comments:

Located 0.02 miles to junction with State Route 242.
There is a pond on the upstream right bank.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 RBUS 4 LBDS 4 RBDS 6 Overall 4
*(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 27 *(feet)* Span length 25 *(feet)* Bridge width 20 *(feet)*

Road approach to bridge:

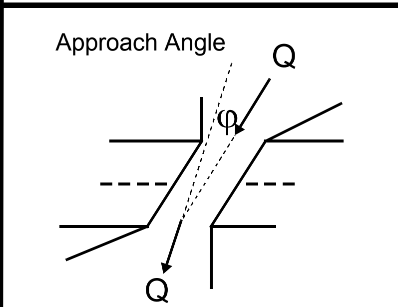
8. LB 2 RB 0 *(**0** even, **1**- lower, **2**- higher)*
9. LB 2 RB 2 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
    US left --:1 US right --:1

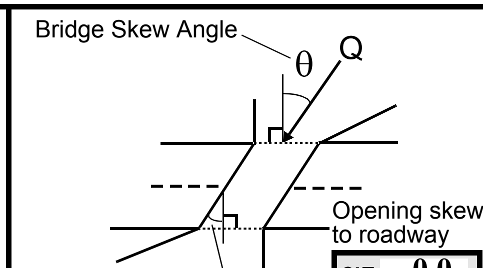
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: 5 16. Bridge skew: 0





α= 0.0

17. Channel impact zone 1: Exist? Y *(Y or N)*
    Where? RB *(LB, RB)* Severity 0
    Range? 20 feet DS *(US, UB, DS)* to 40 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: 1a

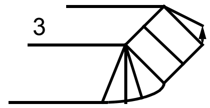
1a- Vertical abutments with wingwalls

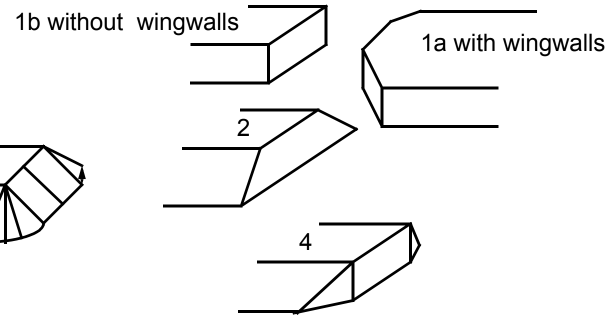
1b- Vertical abutments without wingwalls

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 upstream right overbank cover is comprised of low-lying vegetation surrounding a pond.
The downstream left overbank cover is comprised of a lawn surrounding a house.**

#18: The wingwalls are a combination of bridge types 1a and 4, the ends are approximately 2 feet below low chord.

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
23.0	**4.0**			**2.5**	**3**	**4**	**524**	**524**	**1**	**0**

23. Bank width **30.0** 24. Channel width **75.0** 25. Thalweg depth **23.0** 29. Bed Material **354**

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

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

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

#29: The bed material consists mainly of boulders with fines settled in pools often behind boulders.

#30: Boulders line the banks.

A thick slab of concrete stretches across channel 10 feet US of bridge forming a minor drop.

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

39. Is a cut-bank present? N (Y or if N type ctrl-n cb) 40. Where? - (LB or RB)

41. Mid-bank distance: - 42. Cut bank extent: - feet - (US, UB) to - feet - (US, UB, DS)

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

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

NO CUT BANKS

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

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

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

NO CHANNEL SCOUR

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
15.5		1.0		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.):

54

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

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

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

70. Debris and Ice Comments:

1

This is a high gradient stream with little bridge constriction of the waterway and the banks appear stable.

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	-	0	90.0
RABUT	1	0	90			2	2	23.5

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

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

-

0.5

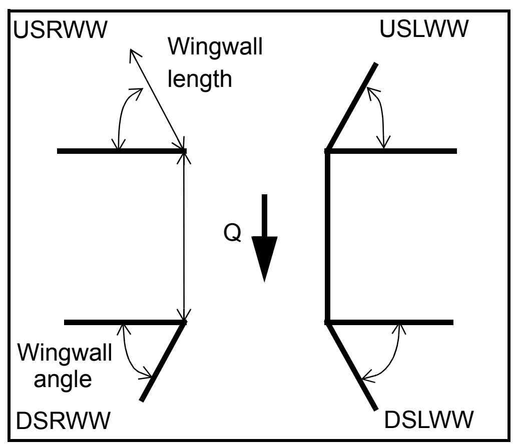
1

The right abutment is exposed in some areas.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						23.5	
USRWW:	Y		1		0	1.0	
DSLWW:	-		0		Y	21.0	
DSRWW:	1		0		-	21.0	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	0	0	Y	-	1	1	1	1
Condition	Y	-	1	0	1	1	2	2
Extent	1	0	0	3	2	2	2	-

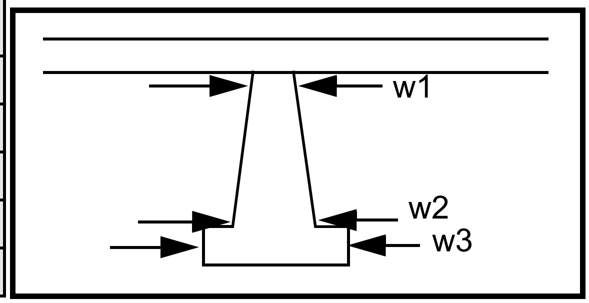
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

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				40.0	11.5	40.0
Pier 2				11.5	35.0	11.0
Pier 3			-	40.0	10.0	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e pro-	down-	sec-		LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	tec-	strea	tion		1- Solid pier, 2- column, 3- bent
88. Material	tion	m	of		1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	is	left	pour		1- Round; 2- Square; 3- Pointed
90. Inclined?	com-	wing	ed		Y- yes; N- no
91. Attack ∠ (BF)	prise	wall	con-	N	
92. Pushed	d of	pro-	crete	-	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	nativ	tec-	.	-	
95. Cross-members	e	tion		-	0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	boul-	con-		-	0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	ders.	sists		-	
98. Exposure depth	The	of a		-	

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

E. Downstream Channel Assessment

100.

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

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

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

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

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

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):
-
-
-
-

NO PIERS

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 **2** %RB

Material: **3**

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

452
452
0
0

Is a cut-bank present? **45** *(Y or if N type ctrl-n cb)* Where? **3** *(LB or RB)* Mid-bank distance: **0**

Cut bank extent: **0** feet **-** *(US, UB, DS)* to **-** feet **Th** *(US, UB, DS)*

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

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

bank material consists of fines overlying boulders and cobbles. There are less boulders within 40 ft. DS of the bridge.

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

Scour dimensions: Length ______ Width ______ Depth: _____ Positioned ____ %LB to ____ %RB

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

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

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

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

Confluence comments (eg. confluence name):

RE

F. Geomorphic Channel Assessment

107. Stage of reach evolution **Ap**

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)*:

proximately 100 feet DS there is a 4 feet drop in the streambed formed by wedged boulders.

N

-

-

-

-

-

-

-

-

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: JAY-TH00400022 Town: Jay
Road Number: TH 40 County: Orleans
Stream: Jay Branch Tributary

Initials MAI Date: 04/25/97 Checked: ECW

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	560	830	0
Main Channel Area, ft2	91	129.5	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	26.7	33.5	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.1329	0.1329	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	3.4	3.9	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	4337	6752	0
Conveyance, main channel	4337	6752	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	560.0	830.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	6.2	6.4	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	7.0	7.2	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?

	100 yr	500 yr	other Q
Main Channel	0	0	N/A
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	560	830	0
(Q) discharge thru bridge, cfs	560	830	0
Main channel conveyance	3471	5129	0
Total conveyance	3471	5129	0
Q2, bridge MC discharge,cfs	560	830	ERR
Main channel area, ft2	57	78	0
Main channel width (normal), ft	19.2	23.6	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	19.2	23.6	0
y_bridge (avg. depth at br.), ft	2.99	3.31	ERR
Dm, median (1.25*D50), ft	0.166125	0.166125	0
y2, depth in contraction,ft	3.72	4.37	ERR
ys, scour depth (y2-ybridge), ft	0.73	1.06	N/A

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

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	560	830	N/A
Main channel area (DS), ft2	57.4	78.1	0
Main channel width (normal), ft	19.2	23.6	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	19.2	23.6	0.0
D90, ft	0.7469	0.7469	0.0000
D95, ft	1.1810	1.1810	0.0000
Dc, critical grain size, ft	0.6344	0.7150	ERR
Pc, Decimal percent coarser than Dc	0.128	0.107	0.000
Depth to armoring, ft	12.97	17.90	ERR

Abutment Scour

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

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	560	830	0	560	830	0
a', abut.length blocking flow, ft	5.7	6	0	1.8	3.9	0
Ae, area of blocked flow ft2	9.2	8.8	0	3.6	8.1	0
Qe, discharge blocked abut.,cfs	31.5	28	0	11.7	27.4	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.42	3.18	ERR	3.25	3.38	ERR
ya, depth of f/p flow, ft	1.61	1.47	ERR	2.00	2.08	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.475	0.463	ERR	0.405	0.414	ERR
ys, scour depth, ft	4.90	4.59	N/A	4.05	5.04	N/A

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

a'(abut length blocked, ft)	5.7	6	0	1.8	3.9	0
y1 (depth f/p flow, ft)	1.61	1.47	ERR	2.00	2.08	ERR
a'/y1	3.53	4.09	ERR	0.90	1.88	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.47	0.46	N/A	0.40	0.41	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	1	0	1	1	0
y, depth of flow in bridge, ft	3.72	4.37	0.00	3.72	4.37	0.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	1.56	1.83	ERR	1.56	1.83	ERR