LEVEL II SCOUR ANALYSIS FOR BRIDGE 9 (JAY-VT02420009) ON VERMONT HIGHWAY 242, CROSSING THE JAY BRANCH OF THE MISSISQUOI RIVER, JAY, VERMONT

U.S. Geological Survey
Open-File Report 96-750

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

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By ROBERT H. FLYNN AND MICHAEL A. IVANOFF

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Pembroke, New Hampshire

1996

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 9 (JAY-VT02420009) ON VERMONT HIGHWAY 242, CROSSING THE JAY BRANCH OF THE MISSISQUOI RIVER, JAY, VERMONT

By **Robert H. Flynn and Michael A. Ivanoff**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure JAY-VT02420009 on Vermont highway 242 crossing the the Jay Branch of the Missisquoi River, 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 study provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province of northern Vermont in the town of Jay. The 4.36-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is primarily forest and brush except for the downstream left overbank which is grass.

In the study area, the the Jay Branch of the Missisquoi River has an incised, sinuous channel with a slope of approximately 0.021 ft/ft, an average channel top width of 38 ft and an average channel depth of 5 ft. A Level I visual inspection at the site indicates that the predominant channel bed material is cobble and boulder with gravel. Results of a pebble count indicate that the predominant channnel bed material is a very coarse gravel with a median grain size (D_{50}) of 41.7 mm (0.1369 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 6, 1995, indicated that the reach was stable.

The Vermont highway 242 crossing of the the Jay Branch of the Missisquoi River is a 60-ft-long, two-lane bridge consisting of one 55-foot steel-beam span (Vermont Agency of Transportation, written communication, March 6, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 60 degrees to the opening while the opening-skew-to-roadway is 45 degrees.
The scour protection measures at the site included type-2 stone fill (less than 36 inches diameter) at the upstream right wingwall, the downstream left and right wingwalls and the upstream end of the left abutment. Type-1 stone fill (less than 12 inches) was along the upstream end of the right abutment. Type-4 stone fill (less than 64 inches) was along the upstream left wingwall. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 0.6 ft. The worst-case contraction scour occurred at the 100-year discharge. Abutment scour ranged from 0.8 to 5.6 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

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-VT02420009 ***Stream*** Jay Branch of Missisquoi River

County Orleans ***Road*** VT 242 ***District*** 09

Description of Bridge

Bridge length 60 ***ft*** ***Bridge width*** 33.5 ***ft*** ***Max span length*** 55 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 06/06/95

Description of stone fill Type-2, at the upstream right wingwall, downstream right wingwall, downstream left wingwall and left abutment; type-1, at the right abutment; and type-4, at the upstream left wingwall. Protection is sparse along abutments.

Brief description of piers/abutments Abutments and wingwalls are concrete. No scour holes were observed during the Level I assessment.

Is bridge skewed to flood flow according to survey? Yes ***Angle*** 60 Y

There is a severe channel bend at the upstream channel reach. Channel at approach is parallel to VT 242 and then downstream is nearly perpendicular to the bridge.

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	06/06/95	0	0
Level II	06/06/95	0	0

Potential for debris Low. Stable banks.

Describe any features near or at the bridge that may affect flow (include observation date) Abutments are skewed to flow (06/06/95).

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley setting with a narrow flood plain.

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

Date of inspection 06/06/95

DS left: Steep channel bank to a moderately sloped overbank along Vt 242.

DS right: Moderately sloped bank and overbank.

US left: Steep channel bank and overbank.

US right: Steep channel bank and overbank

Description of the Channel

Average top width 38 ***ft*** ***Average depth*** 5 ***ft***

Predominant bed material Gravel/Cobble ***Bank material*** Cobble/Boulder

Sinuous but stable with semi-alluvial to non-alluvial channel boundaries and a very narrow flood plain.

06/06/95

Vegetative co Cut grass and a few trees

DS left: Trees and brush

DS right: Trees and brush

US left: Grass on bank, Vt 242 (paved road) and then trees along far side of road..

US right: Y

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

The assessment of 06/06/95 noted a point bar with large boulders along the upstream left bank.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 4.36 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/Green Mountain	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None.

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 1,110 ***ft³/s*** ***Q500*** 1,580 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(4.3/4.36)exp 0.7] with bridge number 11 in Jay. Bridge number 11 crosses an unnamed tributary to the Jay Branch of the Missisquoi River downstream of this site and has flood frequency estimates available from the VTAOT database (VTAOT, written communication, May, 1995). The basin characteristics of bridge number 11 are similar to Jay bridge number 9. The drainage area above bridge number 11 is 4.30 square miles.

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

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

Datum tie between USGS survey and VTAOT plans Subtract 396.5 feet from arbitrary survey datum to obtain VTAOT plans datum.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the US end of the right abutment (elev. 502.08 ft, arbitrary survey datum). RM2 is a chiseled X on top of the DS end of the left abutment (elev. 502.70 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	-50	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	26	1	Road Grade section
APPRO	89	2	Modelled Approach section (Templated from APTEM)
APTEM	137	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 0.055 to 0.065, and overbank "n" values ranged from 0.035 to 0.080.

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 0.0210 ft/ft which was determined from surveyed thalweg and water surface points downstream of the bridge.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0279 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 503.5 ***ft***
Average low steel elevation 498.3 ***ft***

100-year discharge 1,110 ***ft³/s***
Water-surface elevation in bridge opening 495.1 ***ft***
Road overtopping? N ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 119 ***ft²***
Average velocity in bridge opening 9.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.3 ***ft/s***

Water-surface elevation at Approach section with bridge 497.9
Water-surface elevation at Approach section without bridge 497.2
Amount of backwater caused by bridge 0.7 ***ft***

500-year discharge 1,580 ***ft³/s***
Water-surface elevation in bridge opening 498.4 ***ft***
Road overtopping? N ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 239 ***ft²***
Average velocity in bridge opening 6.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.0 ***ft/s***

Water-surface elevation at Approach section with bridge 499.4
Water-surface elevation at Approach section without bridge 497.8
Amount of backwater caused by bridge 1.6

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 discharge was computed by use of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The 500-year discharge resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for the 500-year discharge was computed by use of the Chang pressure flow scour equation (Richarson and others, 1995, p. 145-146). The results of Laursen's contraction scour equation for the 500-year event were also computed for comparison and can be found in appendix F.

Since the approach channel is narrower than the bridge section, the abutments do not block flow. This makes computation of abutment scour impossible. Thus, as per the Froehlich equation factor of safety (Richardson and others, 1995, p. 48, equation 28), abutment scour (Ys) was computed as the flow depth (Ya) at the abutment (toe).

Scouring of the streambed along the right abutment footing was reported during a structural inspection conducted by the VTAOT on 10/19/93. The scour was reported to be approximately "three feet below the top of the original footing and roughly a foot below the newer upstream section footing". This scour was not observed during the level II scour analysis of 06/06/95.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	0.0	--
Clear-water scour	0.6	--	--
Depth to armoring	11.7	1.1	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	2.2	5.6	--
Right abutment	0.8	4.2	--
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	1.3	1.2	--
Right abutment	1.3	1.2	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

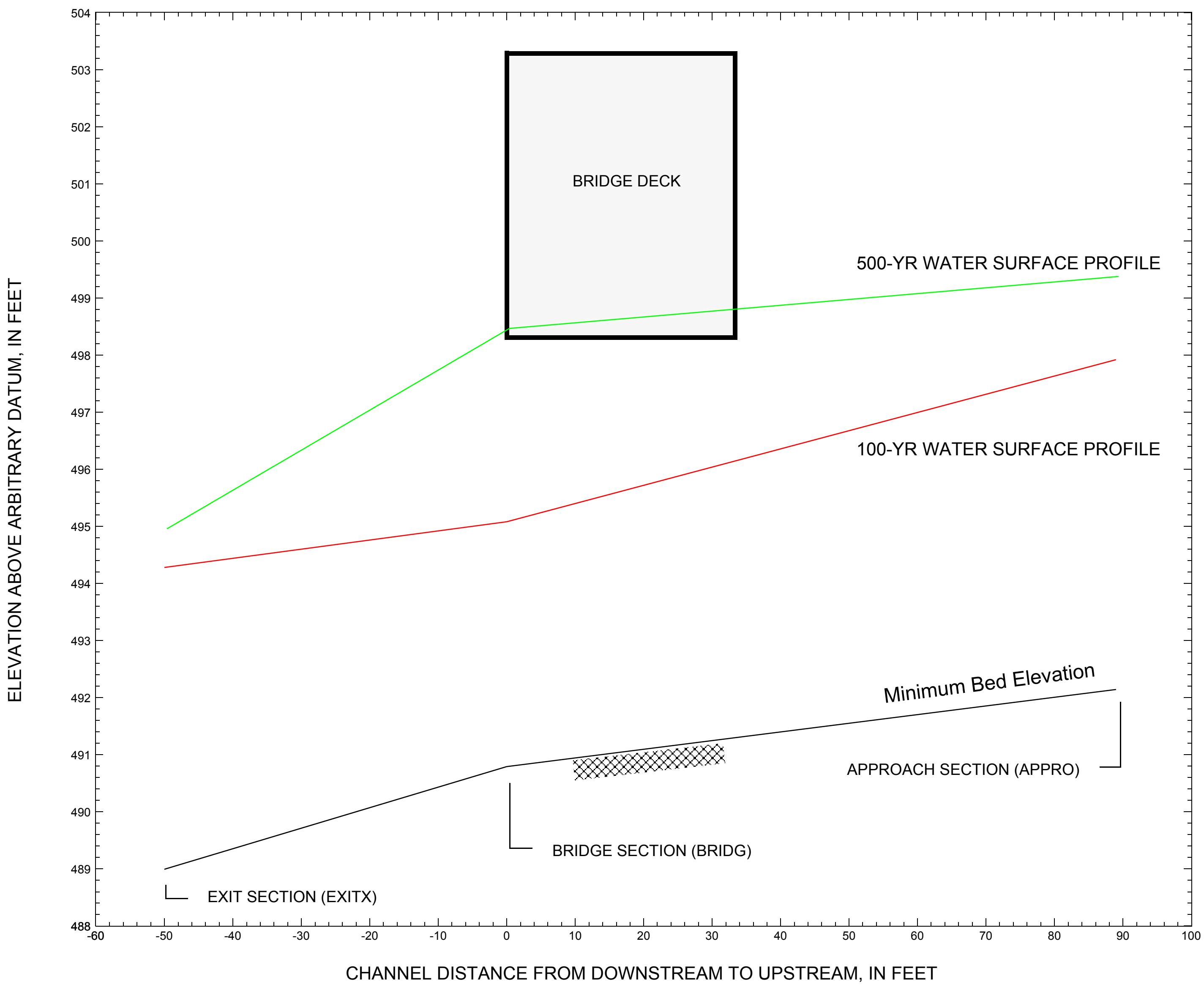

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure JAY-VT02420009 on Vermont highway 242, crossing the Jay Branch of the Missisquoi River, Jay, Vermont.

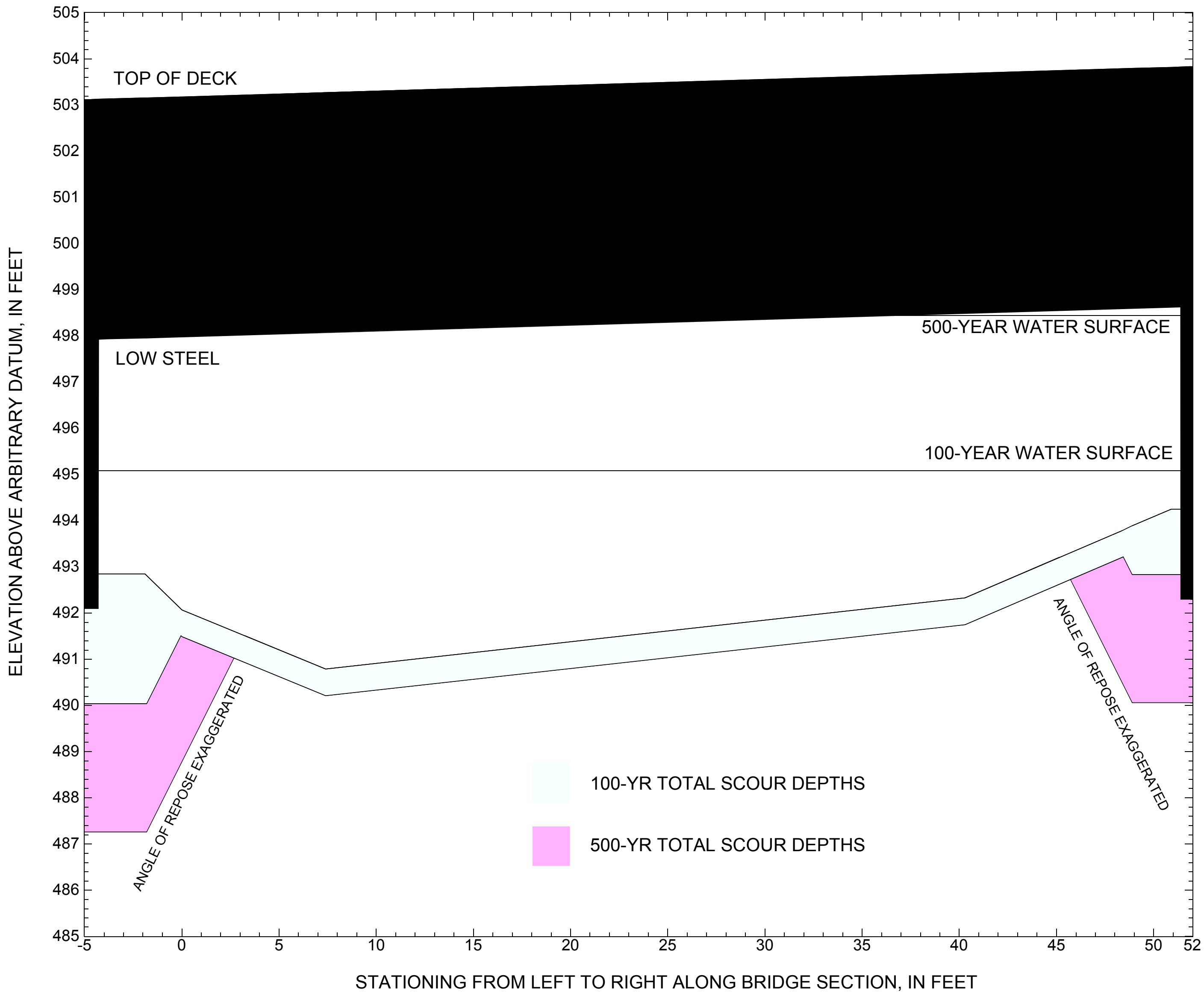

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure JAY-VT02420009 on Vermont highway 242, crossing the Jay Branch of the Missisquoi River, Jay, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure JAY-VT02420009 on Vermont highway 242, crossing the Jay Branch of the Missisquoi River, Jay, Vermont.

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

Description	Station[1]	VTAOT 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 1,110 cubic-feet per second											
Left abutment	-3.8	101.70	497.74	492.1	492.9	0.6	2.2	--	2.8	490.1	-2.0
Right abutment	50.9	101.88	498.87	492.3	494.3	0.6	0.8	--	1.4	492.9	0.6

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-VT02420009 on Vermont highway 242, crossing the Jay Branch of the Missisquoi River, Jay, Vermont.

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

Description	Station[1]	VTAOT 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 1,580 cubic-feet per second											
Left abutment	-3.8	101.70	497.74	492.1	492.9	0.0	5.6	--	5.6	487.3	-4.8
Right abutment	50.9	101.88	498.87	492.3	494.3	0.0	4.2	--	4.2	490.1	-2.2

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-009.wsp
T2        Hydraulic analysis for structure jay-vt02420009   Date: 27-JUN-96
T3
Q           1110 1580
SK          0.0210 0.0210
WS          494.28 494.93
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EXITX    -50           0.
GR          -56.7, 494.61    -13.7, 493.86      0.0, 489.77      3.4, 489.24
GR            9.1, 489.05     13.0, 488.99     18.2, 489.99     26.8, 493.59
GR           31.0, 497.13     51.6, 498.43     69.8, 498.34
N           0.035        0.065        0.080
SA                 -13.7         31.0
*
XS   FULLV      0  * * *   0.0210
*
BR   BRIDG     0    498.30      45.0
GR           -3.8, 497.74     -1.9, 492.85      0.0, 492.07      7.4, 490.79
GR           40.3, 492.33     50.9, 494.25     50.9, 498.87     -3.8, 497.74
N             0.055
CD           1      58.1 * *     54.1      8.5
*
XR   RDWAY     26      33.5     1
GR         -102.9, 500.56    -13.0, 502.70      0.0, 503.01     32.6, 503.65
GR           40.6, 503.95    129.0, 503.17
*
* Left most RDWAY PT. was -102.9, 494.61 (same as left most EXIT PT.)
* Changed to -102.9, 500.56  based on same slope between -13 and 0 and photos
*
XT   APTEM    137
GR          -24.2, 502.81     -1.0, 501.15      0.0, 493.81      7.7, 493.48
GR           12.2, 493.52     17.3, 494.08     25.0, 494.75     33.6, 500.55
GR           41.3, 503.17
*
AS   APPRO    89 * * * 0.0279
GT
N           0.080        0.060
SA                  -1.0
*
HP 1 BRIDG    495.08 1 495.08
HP 2 BRIDG    495.08 * * 1110
HP 1 APPRO    497.92 1 497.92
HP 2 APPRO    497.92 * * 1110
*
HP 1 BRIDG    498.44 1 498.44
HP 2 BRIDG    498.44 * * 1580
HP 1 APPRO    499.35 1 499.35
HP 2 APPRO    499.35 * * 1580
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

```
      U.S. Geological Survey WSPRO Input File jay-009.wsp
      Hydraulic analysis for structure jay-vt02420009   Date: 27-JUN-96

         *** RUN DATE & TIME: 08-06-96  11:39
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     119.    6509.    38.    41.                        1190.
  495.08          119.    6509.    38.    41.  1.00    -3.    51.   1190.

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      495.08    -2.8    50.9   118.6    6509.    1110.   9.36

X STA.        -2.8        2.0        4.4        6.4        8.1        9.8
  A(I)             8.7        6.1        5.4        5.2        4.9
  V(I)            6.36       9.13      10.20      10.71      11.25

X STA.         9.8       11.4       13.2       15.0       16.8       18.7
  A(I)             4.9        5.0        5.0        5.1        5.1
  V(I)           11.32      11.00      11.20      10.96      10.86

X STA.        18.7       20.7       22.7       24.9       27.3       29.7
  A(I)             5.2        5.3        5.5        5.7        5.6
  V(I)           10.60      10.54      10.15       9.78       9.87

X STA.        29.7       32.4       35.3       38.4       42.2       50.9
  A(I)             6.0        6.3        6.3        7.3        9.9
  V(I)            9.23       8.81       8.77       7.57       5.60

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      89.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            2     151.    9344.    32.    39.                        1856.
  497.92          151.    9344.    32.    39.  1.00    -1.    32.   1856.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      89.

        WSEL     LEW     REW    AREA        K        Q    VEL
      497.92    -0.7    31.7   151.4    9344.    1110.   7.33

X STA.        -0.7        2.1        3.5        4.8        6.1        7.2
  A(I)            13.5        8.1        7.2        7.0        6.5
  V(I)            4.11       6.88       7.67       7.95       8.49

X STA.         7.2        8.3        9.4       10.5       11.6       12.7
  A(I)             6.4        6.3        6.4        6.3        6.2
  V(I)            8.62       8.79       8.74       8.86       8.89

X STA.        12.7       13.8       15.0       16.2       17.5       18.8
  A(I)             6.3        6.4        6.6        6.7        6.9
  V(I)            8.78       8.71       8.35       8.33       8.10

X STA.        18.8       20.2       21.8       23.4       25.4       31.7
  A(I)             7.1        7.4        7.9        8.8       13.4
  V(I)            7.86       7.49       7.00       6.32       4.14
```

```
        U.S. Geological Survey WSPRO Input File jay-009.wsp
        Hydraulic analysis for structure jay-vt02420009   Date: 27-JUN-96

           *** RUN DATE & TIME: 08-06-96  11:39
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     239.   14533.    15.    71.                         5472.
   498.44          239.   14533.    15.    71.  1.00    -4.    51.   5472.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.44    -3.8    50.9   239.2   14533.    1580.   6.61

 X STA.        -3.8        2.3        5.5        8.0       10.5       13.0
   A(I)             20.1       14.6       12.9       12.4       12.3
   V(I)             3.94       5.41       6.13       6.37       6.41

 X STA.        13.0       15.4       17.9       20.4       23.0       25.5
   A(I)             12.2       12.0       12.2       12.4       12.3
   V(I)             6.50       6.58       6.46       6.38       6.44

 X STA.        25.5       28.2       30.6       32.6       34.5       36.5
   A(I)             12.4       11.6        8.9        8.8        8.8
   V(I)             6.35       6.83       8.91       9.02       8.98

 X STA.        36.5       38.5       40.6       43.0       45.8       50.9
   A(I)              8.9        9.2        9.9       10.8       16.6
   V(I)             8.84       8.58       8.01       7.29       4.76

        U.S. Geological Survey WSPRO Input File jay-009.wsp
        Hydraulic analysis for structure jay-vt02420009   Date: 27-JUN-96

           *** RUN DATE & TIME: 08-06-96  11:39
    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      89.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     199.   13813.    35.    43.                         2703.
   499.35          199.   13813.    35.    43.  1.00    -1.    34.   2703.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      89.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.35    -0.9    34.0   199.4   13813.    1580.   7.92

 X STA.        -0.9        2.2        3.7        5.1        6.4        7.6
   A(I)             18.3       11.0        9.8        9.1        8.5
   V(I)             4.32       7.21       8.09       8.68       9.28

 X STA.         7.6        8.7        9.9       11.0       12.1       13.3
   A(I)              8.4        8.2        8.2        8.0        8.2
   V(I)             9.45       9.65       9.59       9.87       9.65

 X STA.        13.3       14.5       15.7       16.9       18.2       19.6
   A(I)              8.1        8.4        8.4        8.7        8.8
   V(I)             9.78       9.36       9.40       9.12       9.01

 X STA.        19.6       21.1       22.6       24.3       26.4       34.0
   A(I)              9.2        9.5       10.4       11.8       18.5
   V(I)             8.55       8.34       7.56       6.68       4.27
```

```
        U.S. Geological Survey WSPRO Input File jay-009.wsp
        Hydraulic analysis for structure jay-vt02420009   Date: 27-JUN-96

           *** RUN DATE & TIME: 08-06-96  11:39

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

EXITX:XS   ******   -38.     151.  0.87 *****  495.15  493.49   1110.  494.28
      -50. ******    28.    7667.  1.04 ***** *******    0.87    7.33

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.86     495.35     494.54

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   493.78     499.48    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   493.78     499.48     494.54

FULLV:FV      50.   -38.     152.  0.86  1.04  496.20  494.54   1110.  495.34
        0.    50.    28.    7697.  1.04  0.00    0.01    0.86    7.30
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      89.    -1.     127.  1.19  1.97  498.34 *******   1110.  497.15
       89.    89.    31.    7224.  1.00  0.16    0.00    0.77    8.76
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

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

BRIDG:BR      50.    -3.     119.  1.36  1.23  496.44  494.93   1110.  495.08
        0.    50.    51.    6510.  1.00  0.06    0.00    0.93    9.36

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  498.30 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      26.        <<<<<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      31.    -1.     151.  0.84  0.63  498.76  496.43   1110.  497.92
       89.    31.    32.    9342.  1.00  1.69    0.01    0.60    7.33

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.000  0.000    9316.   -12.    41.   497.13

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

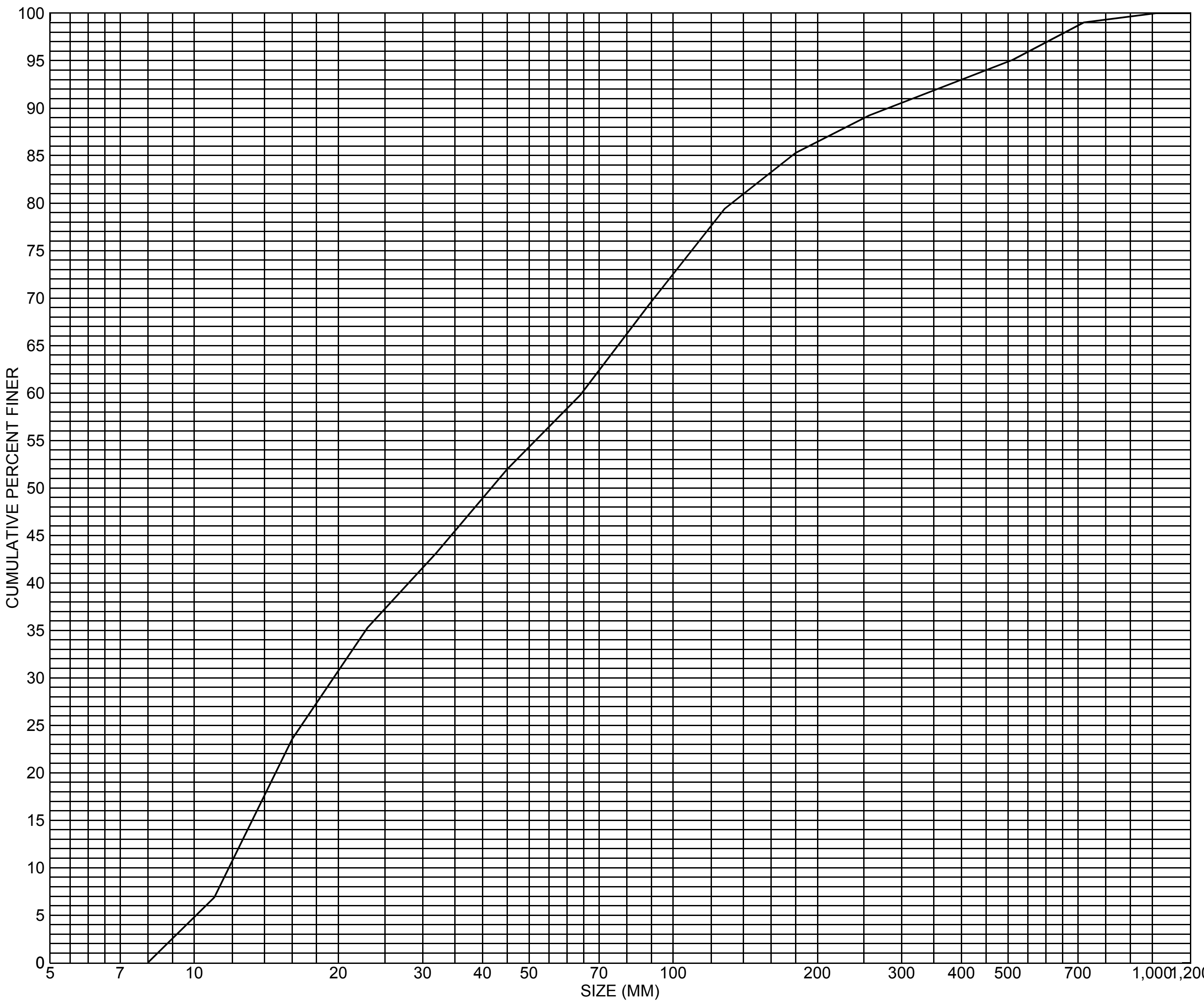
WSPRO OUTPUT FILE (continued)

```
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW      Q        K     AREA     VEL    WSEL
   EXITX:XS     -50.   -38.    28.   1110.    7667.     151.    7.33  494.28
   FULLV:FV       0.   -38.    28.   1110.    7697.     152.    7.30  495.34
   BRIDG:BR       0.    -3.    51.   1110.    6510.     119.    9.36  495.08
   RDWAY:RG      26.**************      0.*****************     1.00********
   APPRO:AS      89.    -1.    32.   1110.    9342.     151.    7.33  497.92

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     -12.    41.    9316.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN     YMAX     HF    HO  VHD      EGL    WSEL
   EXITX:XS    493.49    0.87  488.99  498.43************  0.87  495.15  494.28
   FULLV:FV    494.54    0.86  490.04  499.48  1.04  0.00  0.86  496.20  495.34
   BRIDG:BR    494.93    0.93  490.79  498.87  1.23  0.06  1.36  496.44  495.08
   RDWAY:RG  ****************  500.56  503.95**********************************
   APPRO:AS    496.43    0.60  492.14  501.83  0.63  1.69  0.84  498.76  497.92
```

```
        U.S. Geological Survey WSPRO Input File jay-009.wsp
        Hydraulic analysis for structure jay-vt02420009   Date: 27-JUN-96
            *** RUN DATE & TIME: 08-06-96  11:39
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******   -57.     203.  1.00 *****  495.93  494.85   1580.  494.93
      -50. ******    28.   10903.  1.07 ***** *******    0.92    7.77

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.90     496.00     495.90

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   494.43     499.48    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   494.43     499.48     495.90

 ===140 AT SECID "FULLV":  END OF CROSS SECTION EXTENDED VERTICALLY.
                           WSEL,YLT,YRT =   496.00     495.66     499.39

FULLV:FV      50.   -57.     205.  0.98  1.04  496.98  495.90   1580.  496.00
        0.    50.    28.   11057.  1.07  0.00    0.02    0.90    7.69
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.87     497.83     497.42

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   495.50     501.83    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   495.50     501.83     497.42

APPRO:AS      89.    -1.     148.  1.76  2.21  499.59  497.42   1580.  497.83
       89.    89.    32.    9079.  1.00  0.39    0.00    0.88   10.65
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
         WS3,WSIU,WS1,LSEL =   495.74     498.44     499.12     498.30

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

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for one pebble count transect at the approach cross-section for structure JAY-VT02420009 in Jay, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number JAY-VT02420009

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 06 / 96

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)* 002220

Waterway *(I - 6)* JAY BRANCH OF MISSISQUOI R.

Road Name *(I - 7)*:

Route Number VT242

Vicinity *(I - 9)* ML3.3 MI W JCT 101

Topographic Map North Troy

Hydrologic Unit Code: 02010007

Latitude *(I - 16; nnnn.n)* 44565

Longitude *(i - 17; nnnnn.n)* 72281

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20027800091012

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

Maximum span length *(I - 48; nnnn)* 0055

Year built *(I - 27; YYYY)* 1934

Structure length *(I - 49; nnnnnn)* 000060

Average daily traffic, ADT *(I - 29; nnnnnn)* 000900

Deck Width *(I - 52; nn.n)* 335

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

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

Opening skew to Roadway *(I - 34; nn)* 45

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)* 1966

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

Clear span (*nnn.n ft*)

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

Vertical clearance from streambed (*nnn.n ft*) 5.0

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

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

Comments:

The structural inspection report of 10/19/93 indicates the structure is a single span steel stringer type bridge. The downstream end of left abutment and the mid-section of the right abutment consists of older concrete. The right upstream wingwall has a small crack with minor spalling reported. The right abutment footing is not exposed. The left abutment footing, however, is exposed but is not undermined. The waterway takes a moderate turn into the structure. The streambed consists of cobbles and boulders with gravel deposits. There is streambed scour reported along the right abutment footing. The scour is about 3 feet below the top of the original footing and roughly a foot below the newer **(Continued, page 31)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

-

Streambed material: Boulders and coarse gravel

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:

upstream section footing. There is large boulder riprap reported at all 4 corners of the structure. The structure has a history of overtopping but is reported in fairly good condition. The inspection report states that the channel scour is 3 to 4 feet deep along right abutment, but there has been no undermining. There is some apparent cobble aggradation on the left abutment side noted. No apparent settlement.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **4.36** mi^2

Lake and pond area **0** mi^2

Watershed storage *(ST)* **0** %

Bridge site elevation **1266** ft

Headwater elevation **3409** ft

Main channel length **3.61** mi

10% channel length elevation **1319** ft

85% channel length elevation **2185** ft

Main channel slope *(S)* **320.33** 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)*: **08** / **1934**

Project Number **BP 1283-6613** Minimum channel bed elevation: **95.0**

Low superstructure elevation: USLAB **101.7** DSLAB **101.7** USRAB **101.88** DSRAB **101.88**

Benchmark location description:

BM #1, spot on 10 foot boulder located about 150 feet left bankward from the left abutment on the roadway and 60 feet perpendicular to the roadway centerline, downstream (campground?), elevation 100.00

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 **2.0** Footing bottom elevation: **95.71**

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

If 3: Footing bottom elevation: **-**

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

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

Briefly describe material at foundation bottom elevation or around piles:

Comments:

The bottom of footing elevation noted is an average of the bottom of left abutment. The minimum footing elevation indicated on the left is 95.60 and that on the right is 95.82. There is no hydraulic data on plans. The bridge was reconstructed in 1966 according to inventory codes, but no plans can be found. Plan data above refers to original structure design of 1934. Other elevation points: 1. the top streamward edge of the upstream end left abutment where the slope begins to decline, elevation 105.03; 2. at the same location described above on the upstream end of the right abutment, elevation 105.25.

Cross-sectional Data

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

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

Comments: **There are several channel cross sections. No reproducible bridge cross sections.**

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: 04/05/96
Computerized by: EW Date: 04/09/96
Reviewd by: RF Date: 06/27/96

Structure Number JAY-VT02420009

A. General Location Descriptive

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

2. Highway District Number 09
County 019 ORLEANS
Waterway *(I - 6)* JAY BRANCH OF MISSISQUOI R.
Route Number VT242
Mile marker 002220
Town JAY 36325
Road Name ROUTE 242
Hydrologic Unit Code: 02010007

3. Descriptive comments:
3.3 MILES WEST OF JUNCTION WITH VT 101.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 5 LBDS 4 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 60 *(feet)* Span length 55 *(feet)* Bridge width 33.5 *(feet)*

Road approach to bridge:

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

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

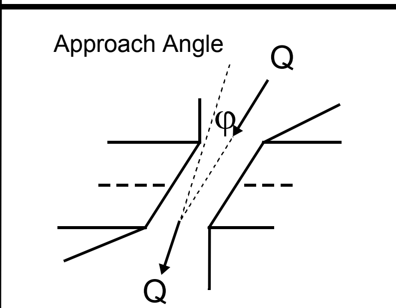
10. Embankment slope (*run / rise in feet / foot*):
US left 3.1:1 US right 1.8:1

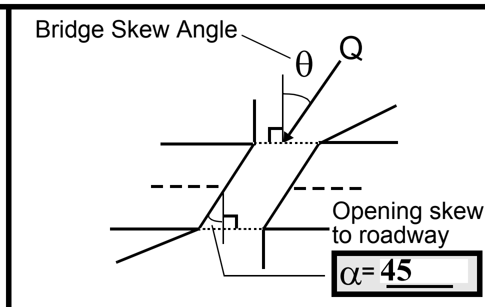
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	4	1	0	-
RBUS	3	1	0	-
RBDS	2	1	0	-
LBDS	2	1	0	-

*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: 15 16. Bridge skew: 60





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 0 feet US *(US, UB, DS)* to 38 feet UB

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. Level II Bridge Type: **4,1A**

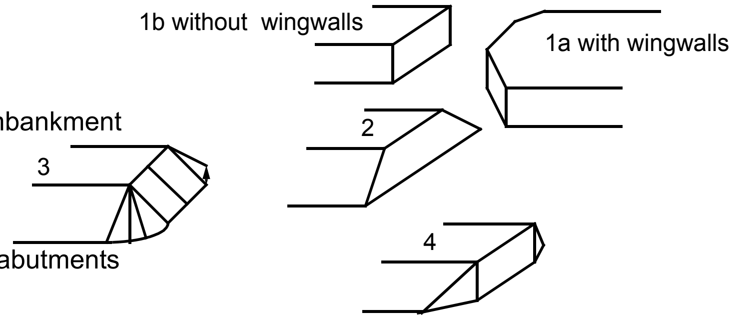
1a- Vertical abutments with wingwalls

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: RBUS road embankment for VT242 has a few trees and brush.

#16: Abutments are skewed to the flow.

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
82.5	**7.5**			**6.0**	**3**	**1**	**453**	**453**	**1**	**1**

23. Bank width **55.0** 24. Channel width **35.0** 25. Thalweg depth **34.5** 29. Bed Material **453**

30 .Bank protection type: LB **3** RB **3** 31. Bank protection condition: LB **1** 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.):

#27/ #29: Bank and bed material consists of cobble and boulder with gravel.

#31: Left bank protection extends 100 feet from left abutment.
Right bank protection extends >250 feet from right wingwall and road embankment

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **200** 35. Mid-bar width: **12**

36. Point bar extent: **160** feet **US** *(US, UB)* to **280** feet **US** *(US, UB, DS)* positioned **0** %LB to **50** %RB

37. Material: **453**

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

Point bar

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

41. Mid-bank distance: **125** 42. Cut bank extent: **100** feet **US** *(US, UB)* to **160** 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.):

Steep bank with exposure of cobble.

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)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
23.5		**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.):

4352

UB point bar described in DS section.

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? 2___ *(Y or N)* Ice Blockage Potential N____ *(**1**- Low; **2**- Moderate; **3**- High)*

70. Debris and Ice Comments:

1

#67: The banks consist of large material with small trees on immediate bank.

#68: Skewed bridge face with a low clearance (six feet).

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		20	90	2	2	0	2.5	90.0
RABUT	1	-	90			2	2	37.0

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

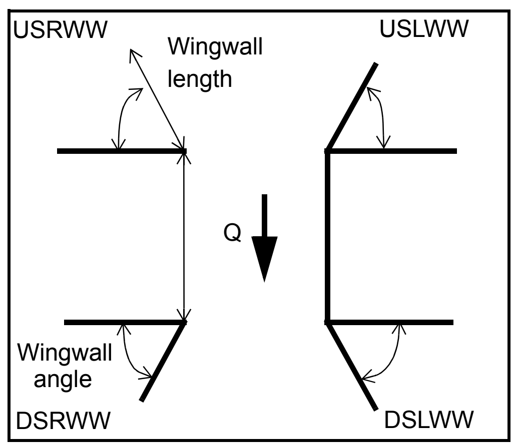
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0
1.5
1

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						37.0	
USRWW:	Y		1		0	1.5	
DSLWW:	-		-		Y	51.0	
DSRWW:	1		0		-	52.5	

*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	2	4	2
Extent	1	-	0	4	2	2	1	-

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

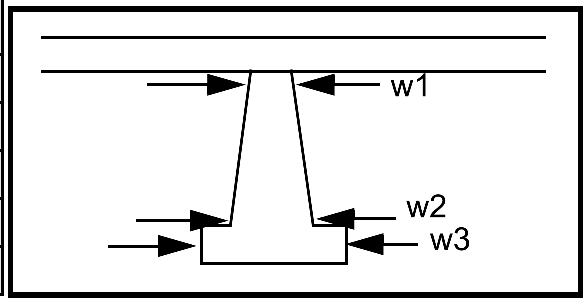
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
2
1
1
2
1
1

Piers:

84. Are there piers? **#82** *(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	**85.0**	**20.0**	**45.0**	**6.0**	**18.0**	**7.0**
Pier 2	**135.0**	-	-	**6.0**	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**:**	**s at**	**foot-**	**N**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**Spar**	**the**	**ing.**	**-**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**se**	**US**		**-**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**pro-**	**and**		**-**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**tec-**	**DS**		**-**	*Y- yes; N- no*
91. Attack ∠ (BF)	**tion**	**ends**		**-**	
92. Pushed	**alon**	**with**		**-**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**g left**	**none**		**-**	
95. Cross-members	**and**	**alon**		**-**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**right**	**g**		**-**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**abut**	**expo**		**-**	
98. Exposure depth	**ment**	**sed**		**-**	

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: **NO** *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

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

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 **1** *(US, UB, DS)* to **4** feet **543** *(US, UB, DS)* positioned **453** %LB to **0** %RB

Material: **1**

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

453
2
2
1

Is a cut-bank present? **1** *(Y or if N type ctrl-n cb)* Where? **RB** *(LB or RB)* Mid-bank distance: **pro-**

Cut bank extent: **tec-** feet **tio** *(US, UB, DS)* to **n** feet **ext** *(US, UB, DS)*

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

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

s 70 feet from wingwall.
LB protection extends 70 feet from wingwall.

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 _____

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)*:

Y
0 DS
10
0
US
30 DS
70 100
34
Point bar starts beneath bridge at US end of right abutment and extends 80 feet.

109. G. Plan View Sketch

55.

point bar (pb)
cut-bank (cb)
scour hole
debris
rip rap or stone fill
flow Q
cross-section
ambient channel
stone wall
other wall

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number:	JAYVT02420009	Town:	36325
Road Number:	VT242	County:	019 (Orleans)
Stream:	Jay Branch		

Initials RF Date: 11/15/96 Checked: SAO

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	1110	1580	0
Main Channel Area, ft2	151.4	199.4	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	32.4	34.9	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.1369	0.1369	0
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	4.7	5.7	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	9344	13813	0
Conveyance, main channel	9344	13813	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	1110.0	1580.0	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	7.3	7.9	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	7.5	7.7	N/A
Vc-l, crit. velocity, LOB, ft/s	N/A	N/A	N/A
Vc-r, crit. velocity, ROB, ft/s	N/A	N/A	N/A

Results

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

Live-Bed Contraction Scour

Laursen’s Live Bed Contraction Scour
y2/y1 = (Q2/Q1)^(6/7)*(W1/W2)^(k1)
ys=y2-y_bridge
(Richardson and others, 1995, p. 30, eq. 17 and 18)

Characteristic	Approach 100 yr	Approach 500 yr	Approach Other Q	Bridge 100 yr	Bridge 500 yr	Bridge Other Q
Q1, discharge, cfs	1110	1580	0	1110	1580	0
Total conveyance	9344	13813	0	6509	14533	0
Main channel conveyance	9344	13813	0	6509	14533	0
Main channel discharge	1110	1580	ERR	1110	1580	ERR
Area - main channel, ft2	151.4	199.4	0	119	239	0
(W1) channel width, ft	32.4	34.9	0	38	38.7	0
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	32.4	34.9	0	38	38.7	0
D50, ft	0.1369	0.1369	0.1369			
w, fall velocity, ft/s (p. 32)	>2	>2	0			
y, ave. depth flow, ft	4.67	5.71	N/A	3.13	6.18	ERR
S1, slope EGL	0.02404	0.02932	0			
P, wetted perimeter, MC, ft	39	43	0			
R, hydraulic Radius, ft	3.882	4.637	ERR			
V*, shear velocity, ft/s	1.734	2.092	N/A			
V*/w	ERR	ERR	ERR			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0.64	0.64	0			
y2,depth in contraction, ft	4.22	5.35	ERR			
ys, scour depth, ft (y2-y_bridge)	1.09	-0.83	N/A			
ys, scour depth, ft (y2-yfullv)	N/A	1.48	N/A			

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	151.4	199.4	0
Main channel width, ft	32.4	34.9	0
y1, main channel depth, ft	4.67	5.71	ERR
Bridge Section			
(Q) total discharge, cfs	1110	1580	0
(Q) discharge thru bridge, cfs	1110	1580	
Main channel conveyance	6509	14533	

Total conveyance	6509	14533	
Q2, bridge MC discharge,cfs	1110	1580	ERR
Main channel area, ft2	119	239	0
Main channel width (skewed), ft	38.0	38.7	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	38	38.7	0
y_bridge (avg. depth at br.), ft	3.13	6.18	ERR
Dm, median (1.25*D50), ft	0.171125	0.171125	0
y2, depth in contraction,ft	3.70	4.93	ERR
ys, scour depth (y2-ybridge), ft	0.57	-1.25	N/A

ARMORING

D90	0.9198	0.9198	0
D95	1.6602	1.6602	0
Critical grain size,Dc, ft	0.6313	0.2270	ERR
Decimal-percent coarser than Dc	0.13963	0.37954	0
depth to armoring, ft	11.67	1.11	ERR

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	1110	1580	0
Q, thru bridge, cfs	1110	1580	0
Total Conveyance, bridge	6509	14533	0
Main channel(MC) conveyance, bridge	6509	14533	0
Q, thru bridge MC, cfs	1110	1580	ERR
Vc, critical velocity, ft/s	7.47	7.72	N/A
Vc, critical velocity, m/s	2.28	2.35	N/A
Main channel width (skewed), ft	38.0	38.7	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	38.0	38.7	0.0
qbr, unit discharge, ft^2/s	29.2	40.8	ERR
qbr, unit discharge, m^2/s	2.7	3.8	N/A
Area of full opening, ft^2	119.0	239.0	0.0
Hb, depth of full opening, ft	3.13	6.18	ERR
Hb, depth of full opening, m	0.95	1.88	N/A
Fr, Froude number, bridge MC	0.93	0.56	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
Elevation of Low Steel, ft	0	498.301	0
Elevation of Bed, ft	-3.13	492.13	N/A
Elevation of Approach, ft	0	499.35	0
Friction loss, approach, ft	0	0.38	0
Elevation of WS immediately US, ft	0.00	498.97	0.00
ya, depth immediately US, ft	3.13	6.84	N/A
ya, depth immediately US, m	0.95	2.09	N/A
Mean elevation of deck, ft	0	503.478	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.98	ERR
Ys, depth of scour, ft	0.00	-0.76	0.00

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	1110	1580	0	1110	1580	0
a', abut.length blocking flow, ft	0	0	0	0	0	0
Ae, area of blocked flow ft2	0	0	0	0	0	0
Qe, discharge blocked abut.,cfs	0	0	0	0	0	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	ERR	ERR	ERR	ERR	ERR	ERR
ya, depth of f/p flow, ft	2.23	5.59	ERR	0.83	4.19	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	135	135	135	45	45	45
K2	1.05	1.05	1.05	0.91	0.91	0.91
Fr, froude number f/p flow	0.000	0.000	ERR	0.000	0.000	ERR
ys, scour depth, ft	2.23	5.59	N/A	0.83	4.19	N/A

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	0.93	0.56	0	0.93	0.56	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	3.13	6.18	0.00	3.13	6.18	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	1.20	0.00	ERR	1.20	0.00
Fr>0.8 (vertical abut.)	1.28	ERR	ERR	1.28	ERR	ERR