LEVEL II SCOUR ANALYSIS FOR BRIDGE 1 (JAY-TH00040001) on TOWN HIGHWAY 4, crossing CROOK BROOK, JAY, VERMONT

U.S. Geological Survey
Open-File Report 97-366

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

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By SCOTT A. OLSON

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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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Box 25286
Denver, CO 80225-0286

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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 1 (JAY-TH00040001) ON TOWN HIGHWAY 4, CROSSING CROOK BROOK, JAY, VERMONT

By **Scott A. Olson**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure JAY-TH00040001 on Town Highway 4 crossing Crook Brook, 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 20.7-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is thick woody vegetation and/or forest except for the upstream right bank and overbank which is pasture.

In the study area, Crook Brook has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 86 ft and an average bank height of 6 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 48.7 mm (0.160 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 5, 1995, indicated that the reach was stable.

The Town Highway 4 crossing of Crook Brook is a 49-ft-long, two-lane bridge consisting of one 45-foot concrete span (Vermont Agency of Transportation, written communication, March 6, 1995). The opening length of the structure parallel to the bridge face is 42 ft.The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 5 degrees to the opening. The opening-skew-to-roadway is also 5 degrees.

Channel scour is present along the left abutment. The scoured area was 1.5 ft deeper than the mean thalweg depth during the Level I assessment. Scour countermeasures include type-2 stone fill (less than 36 inches diameter) on the upstream and downstream sides of the left road embankment and at the upstream end of the left abutment. There is type-3 stone fill (less than 48 inches diameter) along the base of 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 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 2.5 to 3.8 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour at the left abutment ranged from 15.4 to 18.5 ft. Abutment scour at the right abutment ranged from 12.3 to 15.3 ft. The worst-case abutment scour occurred at the 500-year discharge for both abutments. 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-TH00040001 ***Stream*** Crook Brook

County Orleans ***Road*** TH4 ***District*** 9

Description of Bridge

Bridge length 49 ***ft*** ***Bridge width*** 21.3 ***ft*** ***Max span length*** 45 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 6/5/95

Description of stone fill Except for type-2 at the upstream end of the left abutment, the abutments are unprotected.

Abutments and wingwalls are concrete. The left abutment is in a channel impact zone and has a subfooter along its toe.

Y 5

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

There is a slight to moderate channel bend through the reach resulting in an impact zone along the left abutment. There is scour along the left abutment in this impact zone.

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	6/5/95	0	0
Level II	6/5/95	0	0

Potential for debris Low.

Describe any features near or at the bridge that may affect flow (include observation date) June 5, 1995. There is a island 150 feet downstream of the bridge. The island is approximately one-third the channel width. Flow on either side of the island is roughly the same.

Description of the Geomorphic Setting

General topography The channel is located within a narrow upland valley with no flood plains.

6/5/95

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

Date of inspection Moderately

DS left: sloped overbank.

DS right: Moderately sloped overbank.

US left: Moderately sloped overbank.

US right: Moderately sloped overbank.

Description of the Channel

Average top width 86 *ft* ***Average depth*** 6 *ft*

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

Sinuous but stable.

Incised with non-alluvial channel boundaries and a no flood plains.

6/5/95

Vegetative co Forest.

DS left: Forest.

DS right: Brush and forest.

US left: Pasture with a few trees.

US right: Y

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

June 5, 1995. There is an island 150 feet downstream of the bridge. The island is approximately one-third the channel width. Flow on either side of the island is roughly the same.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 20.7 ***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 3,230 ***ft³/s*** ***Q500*** 4,550 ***ft³/s***

The 100- and 500-year discharges 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 500-year discharge. These results were chosen due to their central tendency (within 10 per cent of the average) among other empirical techniques applicable to a drainage with basin characteristics similar to the ones at this site (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the left abutment (elev. 513.08 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the right abutment (elev. 513.34 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	*Section Reference Distance (SRD) in feet*	*[2]Cross-section development*	*Comments*
EXIT1	-144	1	Downstream section at island.
EXITX	-32	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	12	1	Road Grade section
APPRO	69	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 0.055, and overbank "n" values ranged from 0.040 to 0.090.

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 0.022 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1986).

The surveyed 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-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 514.1 ***ft***
Average low steel elevation 509.8 ***ft***

100-year discharge 3,230 ***ft³/s***
Water-surface elevation in bridge opening 502.9 ***ft***
Road overtopping? N ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 238 ***ft²***
Average velocity in bridge opening 13.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 16.7 ***ft/s***

Water-surface elevation at Approach section with bridge 506.4
Water-surface elevation at Approach section without bridge 504.1
Amount of backwater caused by bridge 2.3 ***t***

500-year discharge 4,550 ***ft³/s***
Water-surface elevation in bridge opening 504.4 ***ft***
Road overtopping? N ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 300 ***ft²***
Average velocity in bridge opening 15.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 18.8 ***/s***

Water-surface elevation at Approach section with bridge 508.5
Water-surface elevation at Approach section without bridge 505.2
Amount of backwater caused by bridge 3.3 ***t***

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 -- ***t***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). Results of this analysis are presented in figure 8 and tables 1 and 2. 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	2.5	3.8	--
Depth to armoring	30.1	34.7	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	15.4	18.5	--
Right abutment	12.3	15.3	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	2.4	3.0	--
Right abutment	2.4	3.0	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

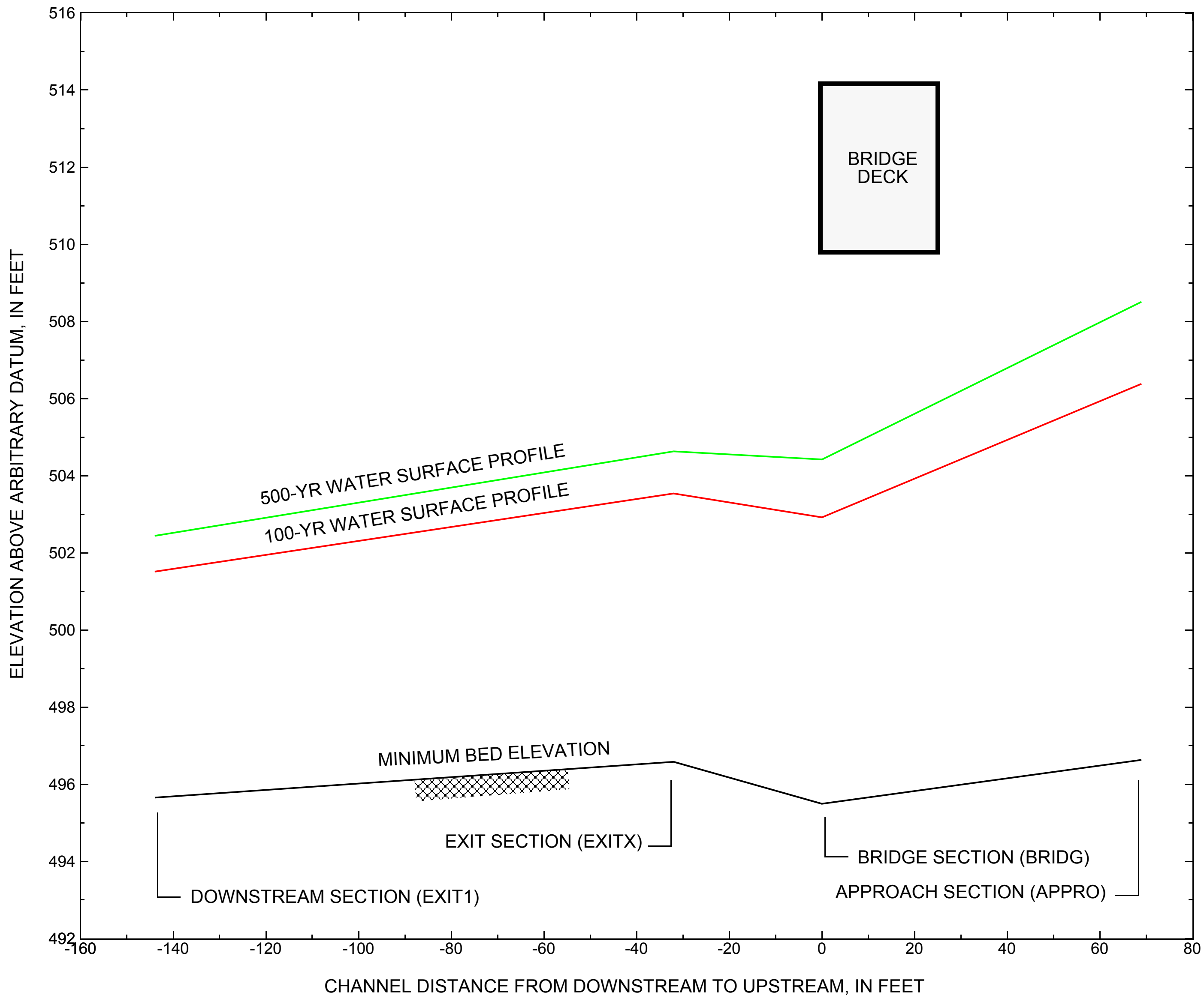

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure JAY-TH00040001 on Town Highway 4, crossing Crook Brook, Jay, Vermont.

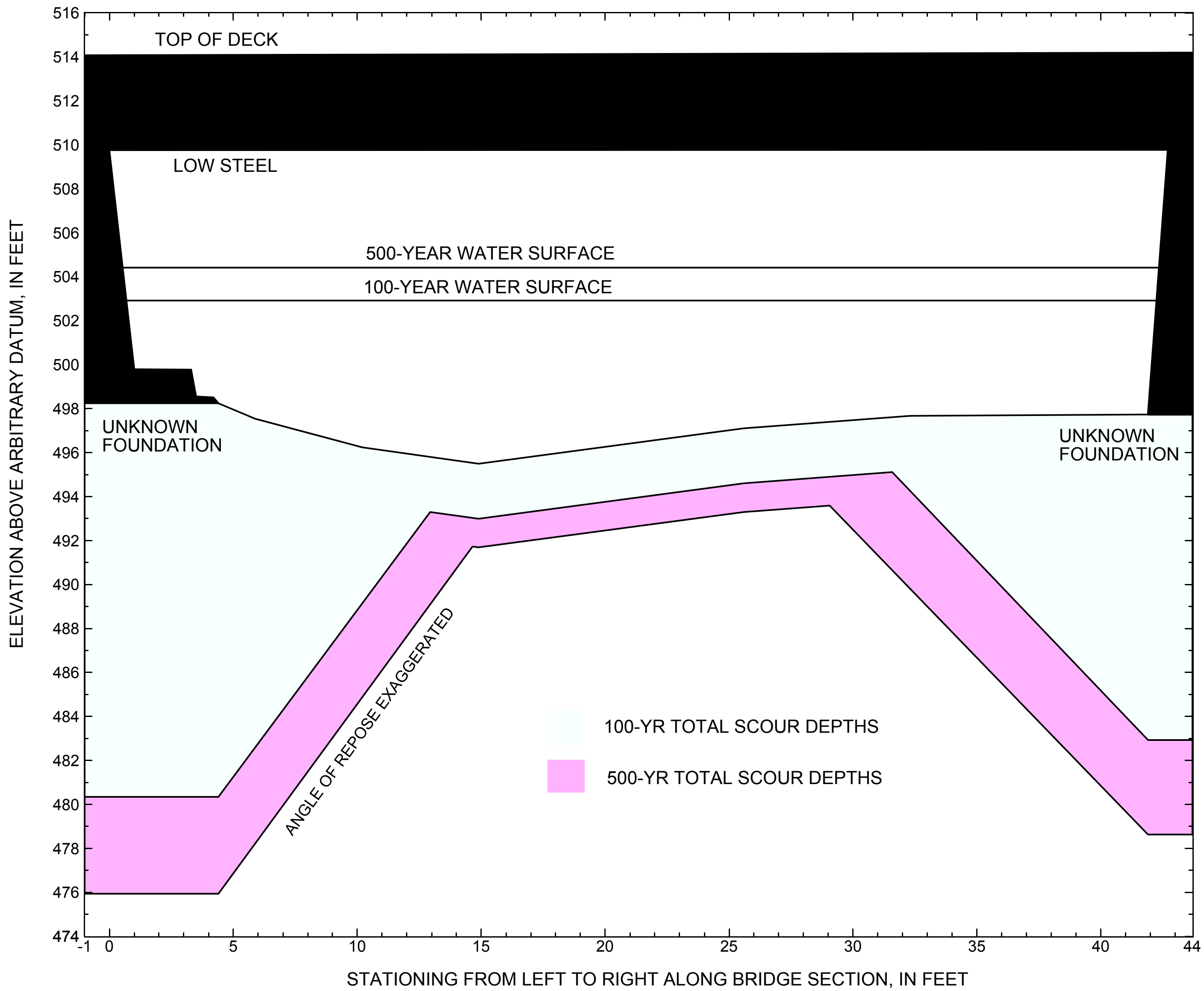

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure JAY-TH00040001 on Town Highway 4, crossing Crook Brook, Jay, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure JAY-TH00040001 on Town Highway 4, crossing Crook Brook, 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 3,230 cubic-feet per second											
Left abutment	0.0	--	509.8	--	498.2	2.5	15.4	--	17.9	480.3	--
Right abutment	42.0	--	509.8	--	497.7	2.5	12.3	--	14.8	482.9	--

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-TH00040001 on Town Highway 4, crossing Crook Brook, 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 4,550 cubic-feet per second											
Left abutment	0.0	--	509.8	--	498.2	3.8	18.5	--	22.3	475.9	--
Right abutment	42.0	--	509.8	--	497.7	3.8	15.3	--	19.1	478.6	--

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-001.wsp
T2        Hydraulic analysis for structure jay-th00040001   Date: 09-APR-97
T3        Jay bridge 1 over Crook Brook.
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3230   4550
SK          0.022  0.022
*
XS   EXIT1    -144
GR          -74.2, 507.53    -20.8, 500.11    -18.0, 497.33    -11.0, 495.79
GR            0.0, 496.13      7.5, 497.35     12.1, 498.89     29.8, 500.33
GR           43.9, 499.34     48.0, 496.89     56.1, 495.65     62.1, 495.90
GR           62.2, 496.43     65.3, 496.86     73.2, 500.04    102.5, 518.88
N           0.085        0.055        0.090            0.055
SA                -20.8          12.1          43.9
*
XS   EXITX    -32
GR          -55.6, 515.51    -40.6, 506.69    -19.9, 502.96    -18.0, 499.88
GR          -14.1, 497.73    -10.3, 496.71      0.0, 497.16     10.4, 496.61
GR           17.3, 496.60     25.8, 496.70     32.3, 497.64     39.5, 496.58
GR           45.5, 497.93     50.0, 499.60     62.8, 502.30     87.0, 508.62
GR          108.5, 518.43
N           0.090        0.045
SA                 -19.9
*
XS   FULLV     0
*
BR   BRIDG     0 509.75 5
GR            0.0, 509.75      1.0, 499.79      3.3, 499.77      3.5, 498.55
GR            4.2, 498.51      4.4, 498.24      5.9, 497.53     10.2, 496.24
GR           14.9, 495.49     25.6, 497.10     32.3, 497.67     41.9, 497.73
GR           42.0, 498.19     42.7, 509.75      0.0, 509.75
N             0.045
CD           1 32 * * 27.5 12.7
*
XR   RDWAY     12 21 2
GR          -80.8, 519.94    -45.8, 517.28    -23.5, 514.98    -11.1, 513.98
GR            0.0, 514.07     20.2, 514.21     22.0, 514.23     43.1, 514.19
GR           61.8, 513.94     93.6, 515.14    125.9, 516.74    189.6, 519.90
*
AS   APPRO     69
GR          -45.3, 517.13    -24.6, 503.28     -8.6, 499.85      0.0, 498.17
GR            2.1, 497.55     10.8, 497.20     16.4, 497.07     24.4, 496.63
GR           34.2, 498.30     42.0, 498.83     55.6, 502.55     64.3, 505.71
GR           82.0, 507.62     98.5, 509.82    128.4, 511.93    171.5, 519.10
N             0.055        0.040
SA                  64.3
*
HP 1 BRIDG     502.92 1 502.92
HP 2 BRIDG     502.92 * * 3230
HP 1 APPRO     506.38 1 506.38
HP 2 APPRO     506.38 * * 3230
*
HP 1 BRIDG     504.42 1 504.42
HP 2 BRIDG     504.42 * * 4550
HP 1 APPRO     508.51 1 508.51
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File jay-001.wsp
        Hydraulic analysis for structure jay-th00040001   Date: 09-APR-97
        Jay bridge 1 over Crook Brook.

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1     237.   21973.   41.    51.                        3225.
   502.92          237.   21973.   41.    51.  1.00     1.    42.   3225.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       502.92     0.7    42.3   237.5   21973.    3230.  13.60
X STA.         0.7         6.0         8.3        10.2        11.8        13.2
  A(I)            20.6        13.4        11.8        10.9        10.1
  V(I)            7.86       12.08       13.69       14.88       15.94

X STA.        13.2        14.6        16.0        17.3        18.7        20.2
  A(I)            10.0         9.9         9.6         9.8         9.8
  V(I)           16.09       16.34       16.74       16.51       16.51

X STA.        20.2        21.7        23.4        25.2        27.0        29.0
  A(I)            10.1        10.4        10.5        10.8        11.0
  V(I)           15.93       15.55       15.41       14.99       14.73

X STA.        29.0        31.1        33.3        35.8        38.3        42.3
  A(I)            11.6        11.6        12.7        13.3        19.7
  V(I)           13.95       13.92       12.72       12.18        8.18

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      69.
     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1     617.   57671.   94.    96.                        8995.
             2       2.      37.    6.     6.                           7.
   506.38          619.   57709.  100.   103.  1.00   -29.    71.   8734.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      69.
         WSEL     LEW     REW    AREA        K        Q    VEL
       506.38   -29.2    70.5   619.2   57709.    3230.   5.22
X STA.       -29.2       -14.1        -8.0        -3.4         0.4         3.6
  A(I)            51.5        36.9        32.4        30.4        28.1
  V(I)            3.14        4.38        4.99        5.31        5.76

X STA.         3.6         6.7         9.6        12.5        15.2        18.0
  A(I)            27.0        26.4        26.5        25.4        25.7
  V(I)            5.97        6.11        6.10        6.35        6.29

X STA.        18.0        20.6        23.3        25.9        28.8        31.9
  A(I)            25.3        25.7        25.2        26.6        27.1
  V(I)            6.39        6.29        6.41        6.08        5.96

X STA.        31.9        35.4        39.2        43.3        49.2        70.5
  A(I)            29.1        29.3        31.4        37.4        52.0
  V(I)            5.55        5.51        5.14        4.32        3.11
```

```
         U.S. Geological Survey WSPRO Input File jay-001.wsp
         Hydraulic analysis for structure jay-th00040001   Date: 09-APR-97
         Jay bridge 1 over Crook Brook.

     CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.
      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     300.   31187.    42.    54.                       4563.
    504.42          300.   31187.    42.    54.  1.00     1.    42.   4563.

     VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.
          WSEL     LEW     REW    AREA        K        Q    VEL
        504.42     0.5    42.4   299.8   31187.    4550.  15.18
 X STA.        0.5         5.7         8.1        10.0        11.7        13.2
   A(I)            26.8        16.9        15.1        13.4        13.1
   V(I)            8.50       13.49       15.11       16.95       17.33

 X STA.       13.2        14.6        16.0        17.4        18.9        20.4
   A(I)            12.6        12.4        12.1        12.4        12.4
   V(I)           18.05       18.36       18.75       18.42       18.34

 X STA.       20.4        22.0        23.7        25.4        27.3        29.2
   A(I)            12.4        12.8        13.1        13.6        13.6
   V(I)           18.28       17.72       17.43       16.78       16.76

 X STA.       29.2        31.2        33.4        35.7        38.3        42.4
   A(I)            14.0        14.7        15.2        17.3        26.1
   V(I)           16.27       15.46       14.98       13.19        8.72

     CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      69.
      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     820.   90193.    97.   100.                      13543.
              2      36.    1702.    24.    25.                        244.
    508.51          855.   91895.   121.   125.  1.03   -32.    89.  12692.

     VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      69.
          WSEL     LEW     REW    AREA        K        Q    VEL
        508.51   -32.4    88.7   855.4   91895.    4550.   5.32
 X STA.      -32.4       -16.3       -10.0        -4.9        -0.6         3.1
   A(I)            70.9        48.8        45.3        42.1        39.3
   V(I)            3.21        4.66        5.02        5.40        5.79

 X STA.        3.1         6.4         9.7        12.8        15.9        19.0
   A(I)            37.2        36.3        35.5        35.3        35.6
   V(I)            6.11        6.27        6.41        6.44        6.38

 X STA.       19.0        22.0        24.9        28.0        31.3        34.9
   A(I)            34.5        35.0        35.7        35.8        37.4
   V(I)            6.59        6.51        6.37        6.35        6.08

 X STA.       34.9        38.7        43.0        47.9        54.9        88.7
   A(I)            38.6        41.0        43.4        49.8        77.7
   V(I)            5.89        5.55        5.24        4.57        2.93
```

WSPRO OUTPUT FILE (continued)

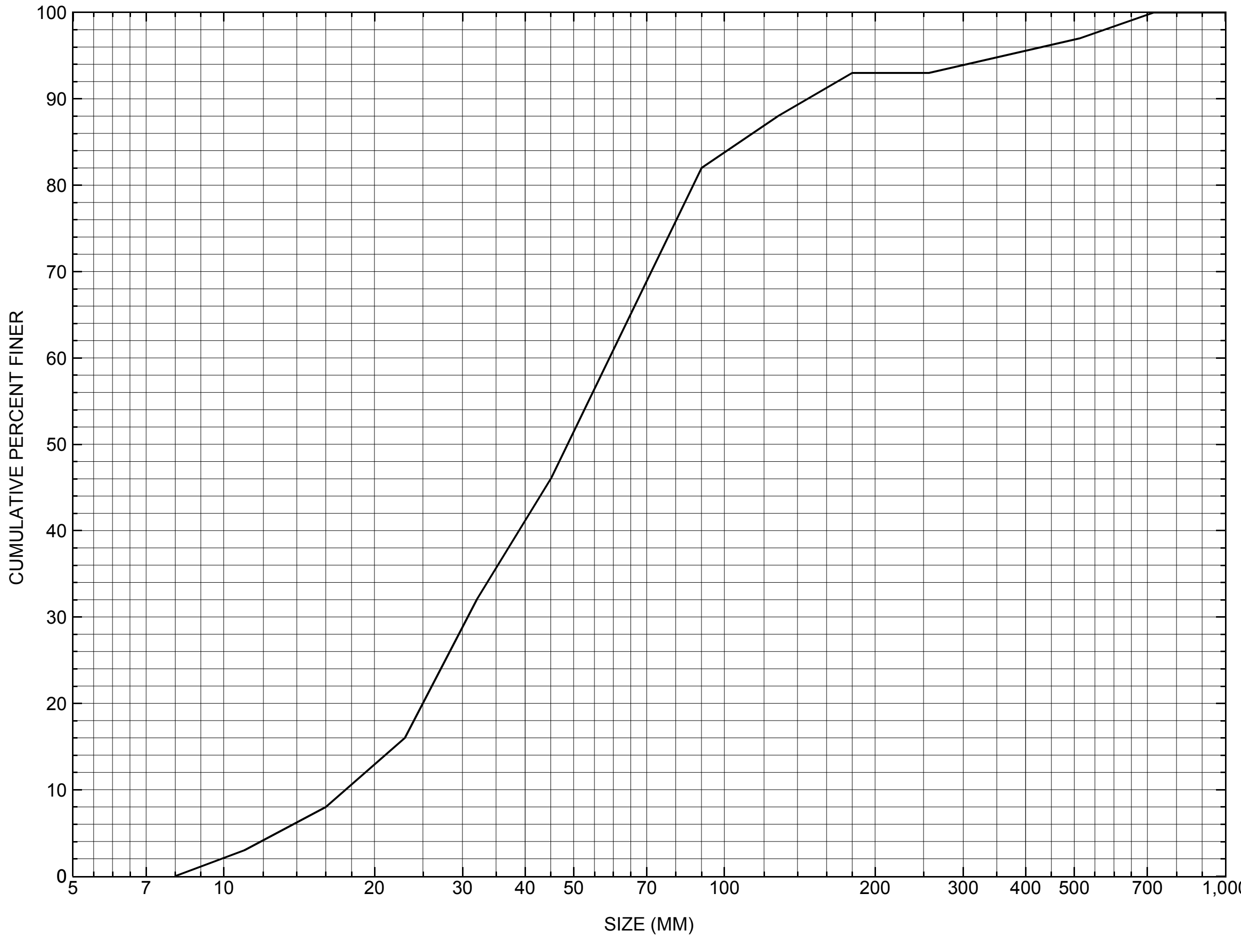
```
        U.S. Geological Survey WSPRO Input File jay-001.wsp
        Hydraulic analysis for structure jay-th00040001   Date: 09-APR-97
        Jay bridge 1 over Crook Brook.

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

 EXIT1:XS   ******   -31.     351.  1.62 *****  503.12  501.40   3230.  501.51
      -144. ******    75.   21758.  1.23 ***** *******    0.99    9.20

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "EXITX"     KRATIO =  2.16

 EXITX:XS     112.   -23.     474.  0.72  1.14  504.26 *******   3230.  503.54
       -32.   112.    68.   47054.  1.00  0.00    0.00    0.53    6.81

 FULLV:FV      32.   -24.     493.  0.67  0.14  504.42 *******   3230.  503.75
         0.    32.    68.   49803.  1.01  0.00    0.01    0.50    6.55
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  0.62

 APPRO:AS      69.   -26.     408.  0.98  0.47  505.03 *******   3230.  504.06
        69.    69.    60.   30855.  1.00  0.15    0.00    0.64    7.92
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =     3230.     502.92

             <<<<<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      32.     1.     238.  2.87 *****  505.80  502.92   3230.  502.92
         0.    32.    42.   22000.  1.00 ***** *******    1.00   13.59

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   1.  1.000 ******  509.75 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      12.        <<<<<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      37.   -29.     619.  0.43  0.32  506.80  502.66   3230.  506.38
        69.    39.    70.   57685.  1.00  0.69    0.00    0.37    5.22

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.512  0.257   42843.    -1.    40.   506.23

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

   FIRST USER DEFINED TABLE.
     XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
    EXIT1:XS    -144.   -31.    75.   3230.   21758.      351.    9.20  501.51
    EXITX:XS     -32.   -23.    68.   3230.   47054.      474.    6.81  503.54
    FULLV:FV       0.   -24.    68.   3230.   49803.      493.    6.55  503.75
    BRIDG:BR       0.     1.    42.   3230.   22000.      238.   13.59  502.92
    RDWAY:RG      12.**************      0.******************    2.00********
    APPRO:AS      69.   -29.    70.   3230.   57685.      619.    5.22  506.38

     XSID:CODE   XLKQ   XRKQ        KQ
    APPRO:AS      -1.    40.   42843.

  SECOND USER DEFINED TABLE.
     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
    EXIT1:XS    501.40    0.99  495.65  518.88************  1.62  503.12  501.51
    EXITX:XS  ********    0.53  496.58  518.43  1.14  0.00  0.72  504.26  503.54
    FULLV:FV  ********    0.50  496.58  518.43  0.14  0.00  0.67  504.42  503.75
    BRIDG:BR    502.92    1.00  495.49  509.75************  2.87  505.80  502.92
    RDWAY:RG  ****************  513.94  519.94**********************************
    APPRO:AS    502.66    0.37  496.63  519.10  0.32  0.69  0.43  506.80  506.38
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File jay-001.wsp
        Hydraulic analysis for structure jay-th00040001   Date: 09-APR-97
        Jay bridge 1 over Crook Brook.

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

 EXIT1:XS   ******   -38.     454.  1.97 *****  504.41  502.36   4550.  502.44
      -144. ******    77.   30655.  1.26 ***** *******    1.00   10.02

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "EXITX"     KRATIO =  2.04

 EXITX:XS     112.   -29.     579.  0.98  1.21  505.61 *******   4550.  504.63
       -32.   112.    72.   62497.  1.02  0.00    0.00    0.59    7.86

 FULLV:FV      32.   -31.     604.  0.91  0.16  505.79 *******   4550.  504.88
         0.    32.    73.   66294.  1.03  0.00    0.01    0.56    7.53
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.65

 APPRO:AS      69.   -27.     509.  1.24  0.50  506.45 *******   4550.  505.21
        69.    69.    63.   42894.  1.00  0.17    0.00    0.66    8.94
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =     4550.      504.42

             <<<<<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      32.     1.     300.  3.59 *****  508.00  504.42   4550.  504.42
         0.    32.    42.   31155.  1.00 ***** *******    1.00   15.19

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   1.  1.000 ******  509.75 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD      EGL      ERR       Q    WSEL
    RDWAY:RG      12.         <<<<<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      37.   -32.     855.  0.45  0.28  508.96  503.70   4550.  508.51
        69.    39.    89.   91902.  1.03  0.68    0.01    0.36    5.32

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.536  0.329   61519.    -2.    40.   508.39

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

   FIRST USER DEFINED TABLE.
     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXIT1:XS    -144.   -38.    77.   4550.   30655.     454.   10.02  502.44
    EXITX:XS     -32.   -29.    72.   4550.   62497.     579.    7.86  504.63
    FULLV:FV       0.   -31.    73.   4550.   66294.     604.    7.53  504.88
    BRIDG:BR       0.     1.    42.   4550.   31155.     300.   15.19  504.42
    RDWAY:RG      12.**************      0.******************    2.00********
    APPRO:AS      69.   -32.    89.   4550.   91902.     855.    5.32  508.51

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS      -2.    40.   61519.

   SECOND USER DEFINED TABLE.
     XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXIT1:XS    502.36    1.00  495.65  518.88************  1.97  504.41  502.44
    EXITX:XS  ********    0.59  496.58  518.43  1.21  0.00  0.98  505.61  504.63
    FULLV:FV  ********    0.56  496.58  518.43  0.16  0.00  0.91  505.79  504.88
    BRIDG:BR    504.42    1.00  495.49  509.75************  3.59  508.00  504.42
    RDWAY:RG  ****************  513.94  519.94**********************************
    APPRO:AS    503.70    0.36  496.63  519.10  0.28  0.68  0.45  508.96  508.51
```

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-TH00040001, in Jay, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number JAY-TH00040001

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)* CROOK BROOK

Road Name *(I - 7):* -

Route Number TH004

Vicinity *(I - 9)* 0.18 MI TO JCT W VT105

Topographic Map North Troy

Hydrologic Unit Code: 02010007

Latitude *(I - 16; nnnn.n)* 44578

Longitude *(i - 17; nnnnn.n)* 72260

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10101200011012

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

Maximum span length *(I - 48; nnnn)* 0045

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

Structure length *(I - 49; nnnnnn)* 000049

Average daily traffic, ADT *(I - 29; nnnnnn)* 000070

Deck Width *(I - 52; nn.n)* 213

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

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)* 104

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 42

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

Vertical clearance from streambed (*nnn.n ft*) 12.0

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

Waterway of full opening (*nnn.n ft*^{2}) 504

Comments:

The structural inspection report of 5/27/93 indicates the structure is a single span concrete T-beam type bridge. The footing is not exposed along right abutment, but is exposed along left abutment. There is a newer concrete subfooting directly in front of the left abutment. There are some random boulders in front of the subfooting. The waterway makes a moderate turn just upstream, and has a relatively straight alignment through the structure. There is a large boulder and gravel bar in the middle of the channel, roughly 150 feet downstream. The streambed consists of boulders and gravel. There are some medium sized boulders along with some random larger boulders.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

-

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft³/ 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 (*ft²*): -

Downstream distance (*miles*): - Town: - Year Built: -

Highway No. : - Structure No. : - Structure Type: -

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (ft^2): -

Comments:

Inspection report states that there is minor streambank erosion with little stone fill present. The report indicates settling is not evident.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **20.74** mi^2 Lake and pond area **0.05** mi^2

Watershed storage *(ST)* **0.2** %

Bridge site elevation **866** ft Headwater elevation **3386** ft

Main channel length **7.11** mi

10% channel length elevation **965** ft 85% channel length elevation **2038** ft

Main channel slope *(S)* **202.47** 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*)? NO

Comments: 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: 04/04/96
Computerized by: EW Date: 04/05/96
Reviewd by: SAO Date: 5/5/97

Structure Number JAY-TH00040001

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* D. SONG Date *(MM/DD/YY)* 06 / 05 / 1995

2. Highway District Number 09 Mile marker -
County ORLEANS (019) Town JAY (36325)
Waterway *(I - 6)* CROOK BROOK Road Name REVOIR FLATS ROAD
Route Number TH4 Hydrologic Unit Code: 02010007

3. Descriptive comments:
LOCATED 0.18 MILES TO JUNCTION WITH VT105. SLIGHT BEND IN WATERWAY UPSTREAM. CONCRETE T-BEAM BRIDGE.

B. Bridge Deck Observations

4. Surface cover... LBUS 5 RBUS 4 LBDS 6 RBDS 6 Overall 6
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

5. Ambient water surface... US 2 UB 1 DS 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 49 *(feet)* Span length 45 *(feet)* Bridge width 21.3 *(feet)*

Road approach to bridge:

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

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

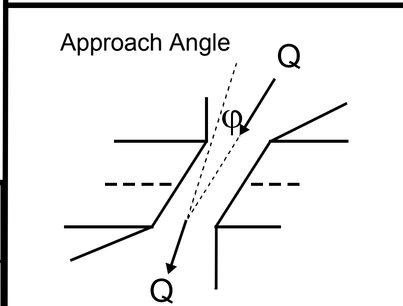
10. Embankment slope (*run / rise in feet / foot*):
US left 2.1:1 US right 1.5:1

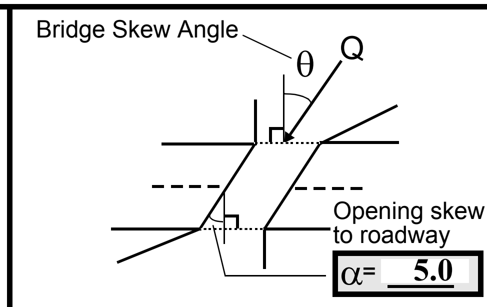
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	1	2	1
RBUS	5	1	0	-
RBDS	0	-	0	-
LBDS	2	1	0	-

*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: 5 16. Bridge skew: 5





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 15 feet US *(US, UB, DS)* to 5 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. Bridge Type: **4/ 1a**

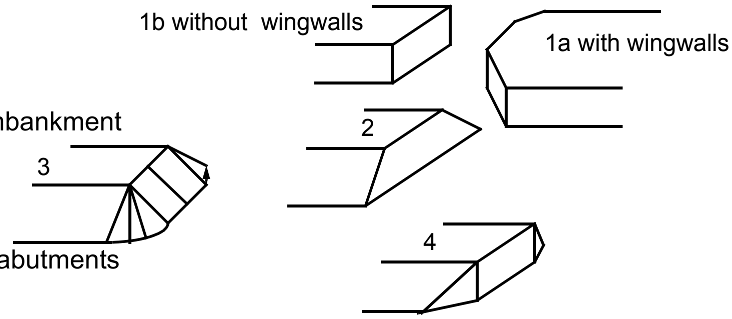
1a- Vertical abutments with wingwalls

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.)

#11: RBUS protection extends to drywall behind right abutment.
#17: Wingwall protection exists at impact zone.
#18: Left abutment has sloping wingwalls.
Right wingwalls extend straight back to drywall.

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
42.5	**5.0**			**7.5**	**4**	**1**	**452**	**452**	**0**	**0**

23. Bank width **10.0** 24. Channel width **15.0** 25. Thalweg depth **89.0** 29. Bed Material **4**

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.):

#27: Fine-grained material overlying cobble and boulder.
#29: Ranges from boulder to gravel.
#30: Large boulders line both banks but appear natural.

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

A well vegetated bar is present >100 feet US on LB, just US of minor tributary. Bar is well developed and indicates slight shifting of stream.

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? Y *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **-8 ft. UB**

47. Scour dimensions: Length **40** Width **15** Depth : **1.5** Position **5** %LB to **50** %RB

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

Local scour caused by impact zone at left abutment.

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

Minor tributary enters approximately 90 feet US on LB: 2 feet wide and 0.5 feet deep (at time of survey).

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
34.0		**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.):

4

#63: Ranges from sand to cobble.

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

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

Minor pile of small trees and twigs on LB upstream. Stream is moderate gradient with little bank constriction.

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		5	90	2	2	1.5	3.25	90.0
RABUT	1	-	90			2	0	42.5

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

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

-

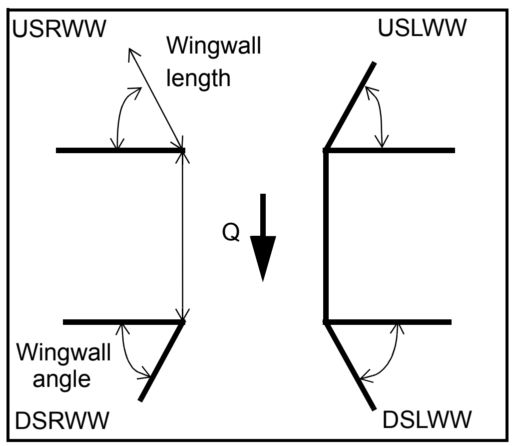
-

1

Left abutment - footing is raised and a subfooting exists beneath the original.
#75: 1.5 feet scour depth = 2.5 feet scour (surface of water) - 1.0 foot thalweg
#76: 3.25 exposure depth - footing + subfooting depths 3.0 feet and 3.5 feet

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						42.5	
USRWW:	Y		1		0	2.5	
DSLWW:	-		-		Y	24.5	
DSRWW:	1		0		-	24.5	



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

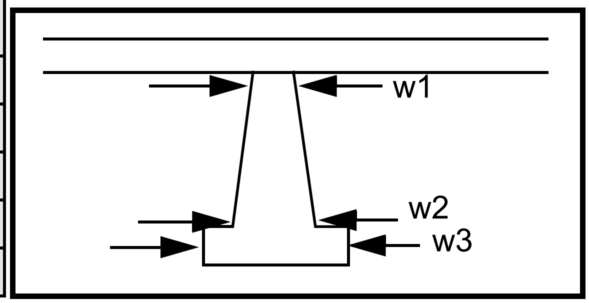
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? **Pr** *(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			**5.0**	**50.0**	**18.5**	**13.5**
Pier 2				**20.0**	**16.5**	**25.0**
Pier 3		-	-	**17.0**	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**otec-**	**gside**		-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**tion**	**of**		-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**con-**	**left**		-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**sists**	**abut**		-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**of**	**ment**	**N**	-	*Y- yes; N- no*
91. Attack ∠ (BF)	**large**	**.**	-	-	
92. Pushed	**boul-**		-	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**ders**		-	-	
95. Cross-members	**upst**		-	-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**ream**		-	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**and**		-	-	
98. Exposure depth	**alon**		-	-	

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.):
-
-
-
-
-
-
-
-
NO PIERS

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):

4
4
452
452
2

106. Point/Side bar present? - (Y or N. if N type ctrl-n pb) Mid-bar distance: 4 Mid-bar width: 0

Point bar extent: 0 feet - (US, UB, DS) to - feet Ba (US, UB, DS) positioned nk %LB to ero %RB

Material: sio

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

n on left bank possibly a result of eddying.
Bank material ranges from boulder to gravel.

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

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

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

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

N

Is channel scour present? - (Y or if N type ctrl-n cs) Mid-scour distance: NO

Scour dimensions: Length DRO Width P Depth: STR Positioned UC %LB to TU %RB

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

RE

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

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

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

Confluence comments (eg. confluence name):

-
-

F. Geomorphic Channel Assessment

107. Stage of reach evolution -

1- *Constructed*
2- *Stable*
3- *Aggraded*
4- *Degraded*
5- *Laterally unstable*
6- *Vertically and laterally unstable*

108. Evolution comments *(Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors)*:

-

NO POINT BARS

Large anabranched island exists about 150 ft downstream in middle of stream.

Y
LB
20
10
DS
30
DS
1

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-001TH00040001 Town: JAY
Road Number: TH4 County: ORLEANS
Stream: CROOK BROOK

Initials SAO Date: 4/15/97 Checked: MAI

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	3230	4550	0
Main Channel Area, ft2	617	820	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	2	36	0
Top width main channel, ft	94	97	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	6	24	0
D50 of channel, ft	0.160	0.160	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.6	8.5	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	0.3	1.5	ERR
Total conveyance, approach	57709	91895	0
Conveyance, main channel	57671	90193	0
Conveyance, LOB	0	0	0
Conveyance, ROB	37	1702	0
Percent discrepancy, conveyance	0.0017	0.0000	ERR
Qm, discharge, MC, cfs	3227.9	4465.7	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	2.1	84.3	ERR
Vm, mean velocity MC, ft/s	5.2	5.4	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	1.0	2.3	ERR
Vc-m, crit. velocity, MC, ft/s	8.3	8.7	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?			
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	3230	4550	0
(Q) discharge thru bridge, cfs	3230	4550	0
Main channel conveyance	21973	31187	0
Total conveyance	21973	31187	0
Q2, bridge MC discharge,cfs	3230	4550	ERR
Main channel area, ft2	237	300	0
Main channel width (normal), ft	41.4	41.7	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	41.4	41.7	0
y_bridge (avg. depth at br.), ft	5.72	7.19	ERR
Dm, median (1.25*D50), ft	0.2	0.2	0
y2, depth in contraction,ft	8.21	10.94	ERR
ys, scour depth (y2-ybridge), ft	2.48	3.75	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	3230	4550	N/A
Main channel area (DS), ft2	237	300	0
Main channel width (normal), ft	41.4	41.7	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	41.4	41.7	0.0
D90, ft	0.4813	0.4813	0.0000
D95, ft	1.1811	1.1811	0.0000
Dc, critical grain size, ft	0.7560	0.8560	ERR
Pc, Decimal percent coarser than Dc	0.070	0.069	0.000
Depth to armoring, ft	30.13	34.70	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)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	3230	4550	0	3230	4550	0
a', abut.length blocking flow, ft	29.2	32.4	0	29.1	47.0	0
Ae, area of blocked flow ft2	148.0	213.5	0	104.0	183.3	0
Qe, discharge blocked abut.,cfs	629.0	946.9	0	397.8	751.3	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.25	4.44	ERR	3.83	4.10	ERR
ya, depth of f/p flow, ft	5.07	6.59	ERR	3.57	3.90	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	95	95	95	85	85	85
K2	1.01	1.01	1.01	0.99	0.99	0.99
Fr, froude number f/p flow	0.333	0.304	ERR	0.357	0.366	ERR
ys, scour depth, ft	15.38	18.45	N/A	12.25	15.28	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)	29.2	32.4	0	29.1	47	0
y1 (depth f/p flow, ft)	5.07	6.59	ERR	3.57	3.90	ERR
a'/y1	5.76	4.92	ERR	8.14	12.05	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.33	0.30	N/A	0.36	0.37	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	5.72	7.19	0.00	5.72	7.19	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.)	2.39	3.01	ERR	2.39	3.01	ERR