Espey, Huston & Associates, Inc.

Level II Bridge Scour Analysis

for Structure 137004700100 on Route S-47 Crossing Deep Creek in Chesterfield County, South Carolina

EH&A Project No. 16139.01
EH&A File Number 16139.01 B-6

Prepared in cooperation with

South Carolina Department of Transportation

Columbia, South Carolina
January 1995

LEVEL II BRIDGE SCOUR ANALYSIS

FOR STRUCTURE 137004700100 ON ROUTE S-47 CROSSING DEEP CREEK IN CHESTERFIELD COUNTY, SOUTH CAROLINA

This report provides the results of the detailed Level II analysis of scour potential at bridge 137004700100 on Route S-47 crossing Deep Creek in Chesterfield County, South Carolina. The site is located in the Piedmont physiographic province near Mt. Croghan, South Carolina. The bridge lies at approximately 34° 45' 45" north, 080° 09' 50" west, 3.5 miles east of Mt. Croghan, South Carolina. The contributing watershed area for this bridge is 23.9 mi^2. The watershed is rural, consisting of forest and farmland. In the vicinity of the bridge the floodplain consists of woodland and brush.

The watershed for this bridge lies near the North Carolina line in the Piedmont physiographic province near the border with the Upper Coastal Plain physiographic province according to the U.S.G.S. WRIR, 91-4157, "Techniques for Estimating Magnitude and Frequency of Floods in South Carolina, 1988", Guimaraes and Bowman. According to the geotechnical data on the bridge plans, the soil in the vicinity of the bridge ranges from sandy to silty clay. This soil more closely matches that of the Upper Coastal Plain than the Piedmont. However, a more extensive study of the watershed would be required to declare this watershed part of the Upper Coastal Plain physiographic province. The higher discharges attained with the Piedmont regression equations have been used in this report since the higher discharge presents the worst case scenario.

This 130-foot reinforced concrete structure consists of four bents. Bents 1 and 4 are at the abutments and bents 2 and 3 are each supported by a pair of 3-foot diameter concrete columns. The abutments and channel banks are well protected by riprap (refer to photo 7). Abutment scour calculations were not performed.

Scour calculations were performed using engineering judgement and according to the FHWA Hydraulic Engineering Circular No. 18, (Revised April 1993). The calculations were performed assuming a uniform fine-sand streambed particle with a D_{50} of 0.12 mm. The 100-year total scour depth at the upstream face of the bridge ranged from 0 to 19.91 feet. The 500-year total scour depth at the upstream face of the bridge ranged from 0 to 24.53 feet. It is assumed that scour activity will be arrested at the solid rock line.

This study was conducted using limited available data. Stream surveys and geotechnical assessments were not available. For hydraulic modeling purposes, stream cross sections were estimated using measurements taken at the upstream face of the bridge, due to superelevation, combined with contour data from the USGS quad map and field observations. Scour computations are dependent upon, and sensitive to, cross-sectional geometry. A sand grain size was assumed for scour calculations. For these reasons, the results of this study should be considered approximate.

SCOUR REPORT SUMMARY

Structure Number 137004700100 Stream Deep Creek
County Chesterfield Route S-47 District 4

Description of Bridge

Bridge length 130 ft Bridge width 35.3 ft Max span length 70 ft

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

Abutment type Spill-through Embankment type Sloping

Riprap on abutment? Yes Date of inspection October 26, 1994

Description of riprap D_{50} = 10 inches in good condition.

Brief description of piers/pile bents Bents 2 and 3 consist of two 3-foot diameter concrete columns.

Is bridge skewed to floodplain according to USGS quad map? No Angle

Is bridge located on a bend in channel? No If so, describe (mild, moderate, severe)

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			
Level II	October 26, 1994	0	0

Potential for debris Low

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

None

Description of Floodplain

General topography Gently rolling

Floodplain conditions at bridge site; downstream (D/S), upstream (U/S)

Date of inspection October 26, 1994

D/S left: Dense woodland

D/S right: Tall grass (refer to photo 8)

U/S left: Dense woodland

U/S right: Dense woodland

Description of Channel

Average top width 19 *ft* *Average depth* 1 *ft*

Predominant bed material Rock, cobbles, gravel and sand *Bank material* Clay with rock outcroppings

Stream type (straight, meandering, braided, swampy, channelized) Straight

Vegetative cover on channel banks near bridge: *Date of inspection* October 26, 1994

D/S left: Dense woodland

D/S right: Dense woodland

U/S left: Woodland and residential lawn

U/S right: Brush and tall grass

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

Describe any obstructions in channel and date of observation. None

Hydrology

Drainage area 23.9 mi^2

Percentage of drainage area in physiographic provinces:

Physiographic province	Percent of drainage area
Piedmont	100%

Is drainage area considered rural or urban? Rural Describe any significant urbanization and potential for development. Potential for development is low.

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

USGS gage description _____

USGS gage number _____

Gage drainage area _____ mi^2

Is there a lake/pond that will significantly affect hydrology/hydraulics? No

If so, describe _____

Calculated Discharges

Q100 3502 ft^3/s Q500 4544 ft^3/s

Method used to determine discharges Regression equations for 100- and 500-year flood discharges (Ref. USGS WRIR 91-4157, "Techniques for Estimating Magnitude and Frequency of Floods in South Carolina, 1988" Guimarares and Bowman).

(Guimarares & Bohman, 1991)

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

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

Datum tie, if available Bridge elevations taken from the SCDOT bridge plans match the quad map.

Briefly describe the survey used to develop WSPRO model. No survey was available. Due to superelevation the cross section at the upstream face of the bridge was measured during the inspection. This cross section was then combined with data from the USGS quad map to produce other cross sections. Field observations were used to supplement and modify the sections.

Cross-Sections Used in WSPRO Analysis

Cross-section ID[1]	Section Reference Distance (SRD) in feet	How cross-section was developed[2]	Comments
EXIT	000	2,3	Exit Section
FULL	130	4	Full Valley Section
BRDG	130	1	Bridge Section
ROAD	136	3	Road Section
APPR	296	2,3	Approach Section

[1] For more detail on how cross-sections were developed, see WSPRO input file.

[2] Cross-section development: 1) survey at SRD; 2) shift of survey data to SRD; 3) modification of survey data based on topographic map; 4) synthesized by combining channel survey data and topographic contours; and 5) other

Starting water-surface elevation for WSPRO analysis (place ✓ on the appropriate line):

✓ *used slope/conveyance and confirmed by testing for convergence when reasonably possible*

__ *used known water-surface elevations. Describe* _____

Describe any special assumptions or considerations made in developing WSPRO model.

No survey was available. Cross section information was taken from the "Mt. Croghan, S.C." USGS quad map and from information collected during the field inspection on October 26, 1994. Elevations given are approximate. Manning's roughness coefficients were estimated from field observations. The 100- and 500-year discharges were obtained using procedures described in USGS WRIR 91-4157, "Techniques for Estimating Magnitude and Frequency of Floods in South Carolina, 1988" Guimarares and Bowman). Bridge elevations were estimated from the USGS quad map and the SCDOT bridge plans using field measurements. There is no discharge data associated with high water marks available for model calibration. The cross section data is coded left to right facing downstream.

Bridge Hydraulics

Average embankment elevation 251.7 ft

Average low steel elevation 247.8 ft

100-year discharge	3502	ft^3/s
Water-surface elevation at D/S bridge face	243.46	ft
Area of flow at D/S bridge face	471	ft^2
Average velocity in bridge opening	7.44	ft/s
Maximum WSPRO tube velocity at bridge	12.92	ft/s

Water-surface elevation at Approach section with bridge	245.23	ft
Water-surface elevation at Approach section without bridge	243.81	ft
Amount of backwater caused by bridge	1.42	ft

500-year discharge	4544	ft^3/s
Water-surface elevation at D/S bridge face	244.07	ft
Area of flow at D/S bridge face	531	ft^2
Average velocity in bridge opening	8.56	ft/s
Maximum WSPRO tube velocity at bridge	15.19	ft/s

Water-surface elevation at Approach section with bridge	246.31	ft
Water-surface elevation at Approach section without bridge	244.50	ft
Amount of backwater caused by bridge	1.81	ft

Scour

Describe any special assumptions or considerations made in bridge scour analysis.

Scour calculations were performed using engineering judgement according to FHWA Hydraulic Circular No. 18, "Evaluating Scour at Bridges" (Richardson et al., 1993). Because gradation information is unavailable for this site, the streambed was assumed to be comprised of fine sand having a D_{50} of 0.12 mm. It was further assumed that the streambed is composed of homogeneous, erosive fine sand down to the solid rock line, at which elevation all scour would be arrested. The results of the scour analysis are summarized in Tables 1 and 2 on the following pages.

Table 1

Cumulative scour depths at piers/bents for the 100-year discharge at structure 137004700100 on S-47 crossing Deep Creek in Chesterfield County, South Carolina.

Pier/bent Number[1]	Distance[2] from left end of bridge (feet)	Contraction scour depth (feet)	Local scour depth without debris (feet)	Total scour[3] depth without debris (feet)	Elevation of Highest Pile Tip (feet)	Elevation of Bottom of Scour Hole (feet)	Remaining[4] Embedment (feet)
100-year discharge is 3502 cubic feet per second							
Abutment	0	0	Abutment-Protected	0	236.45	N/A	N/A
3	30	16.00	3.91	19.91	228.96	219.99	-8.97
2	100	1.51	3.25	4.76	232.94	236.84	3.90
Abutment	130	0	Abutment-Protected	0	234.07	N/A	N/A

1 Piers/bent number corresponds to South Carolina Department of Transportation bridge plans.

2 Distances are determined from left to right looking downstream.

3 Total scour depth is the sum of the contraction and local scour depths.

4 Elevation of bottom of scour hole minus elevation of highest pile tip. A negative number indicates computed scour is below the bottom of the pile tip.

Table 2

Cumulative scour depths at piers/bents for the 500-year discharge at structure 137004700100 on S-47 crossing Deep Creek in Chesterfield County, South Carolina.

Pier/bent Number[1]	Distance[2] from left end of bridge (feet)	Contraction scour depth (feet)	Local scour depth without debris (feet)	Total scour[3] depth without debris (feet)	Elevation of Highest Pile Tip (feet)	Elevation of Bottom of Scour Hole (feet)	Remaining[4] Embedment (feet)
500-year discharge is 4544 cubic feet per second							
Abutment	0	0	Abutment-Protected	0	236.45	N/A	N/A
3	30	20.24	4.29	24.53	228.96	215.37	-13.59
2	100	2.67	3.67	6.34	232.94	235.26	2.32
Abutment	130	0	Abutment-Protected	0	234.07	N/A	N/A

1 Piers/bent number corresponds to South Carolina Department of Transportation bridge plans.

2 Distances are determined from left to right looking downstream.

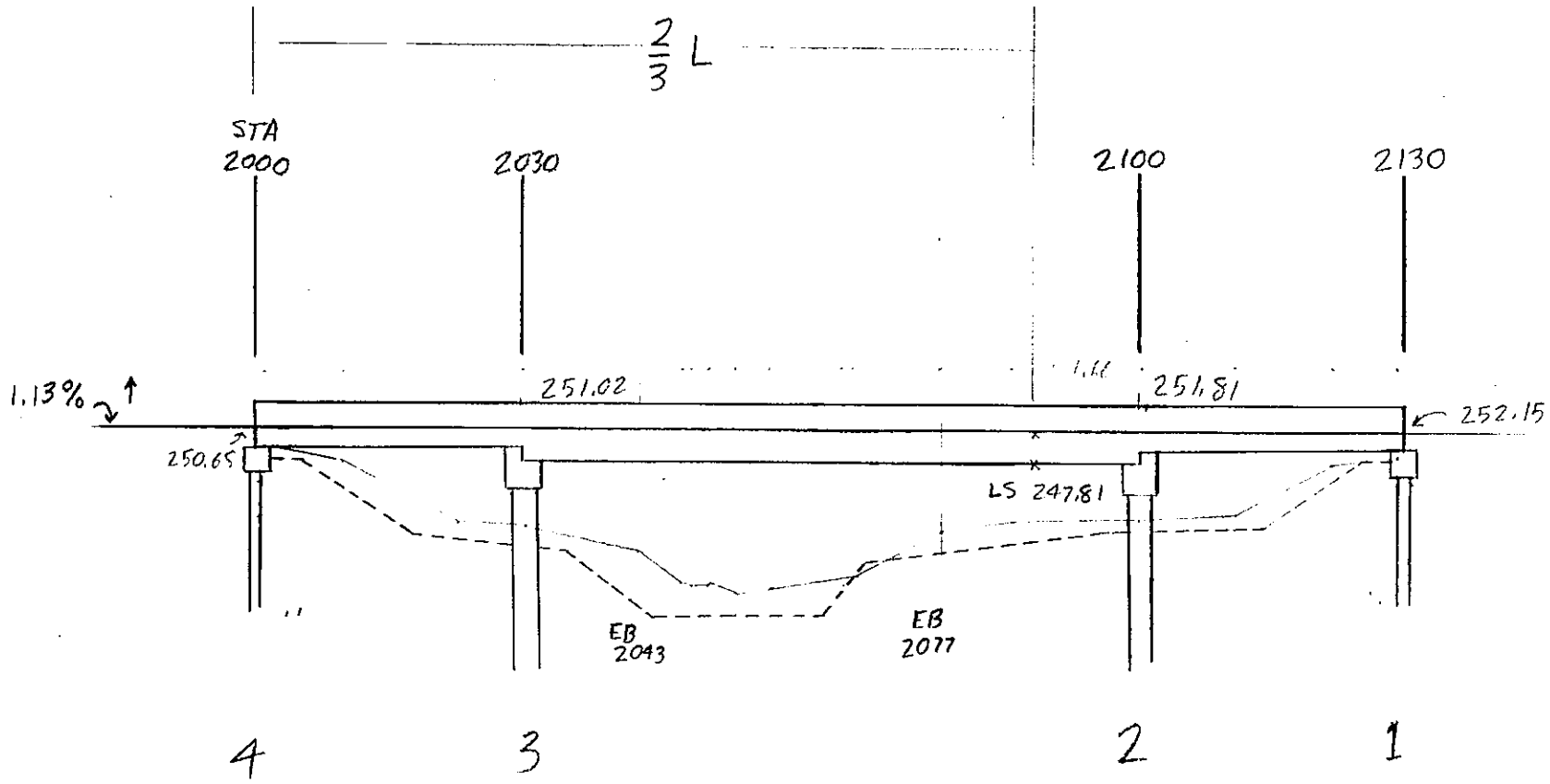
3 Total scour depth is the sum of the contraction and local scour depths.

4 Elevation of bottom of scour hole minus elevation of highest pile tip. A negative number indicates computed scour is below the bottom of the pile tip.

MEASURED ON 10/26/94

SCDOT PLANS

ROUTE S-41 OVER
DEEP CREEK
CHESTERFIELD COUNTY
EHA FILE NO. 16139.01



LOOKING DOWNSTREAM

WSPRO INPUT

```
T2        ROUTE 47 OVER DEEP CREEK
T3        EH&A FILE NO. 16139.01 B-6
*         MT. CROGHAN, SOUTH CAROLINA
*         FILE NAME: 16139W06.DAT
*         ************************************************************
J1         .02 .005 .005 .95
J3        5 3 13 15 23 430 446 448 * 5 17 29 30 6 16 555 * 7 14 3 11
*         ************************************************************
*          Q100   Q500
Q          3502   4544
SK         .002   .002
*         ************************************************************
*         CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
*         SHEET "MT. CROGHAN, S.C." AND FROM INFORMATION
*         COLLECTED DURING THE FIELD INSPECTION ON OCTOBER 26, 1994.
*         ELEVATIONS GIVEN ARE APPROXIMATE.  MANNINGS COEFFICIENTS
*         WERE ESTIMATED FROM FIELD OBSERVATIONS.  THE 100 AND
*         500-YEAR DISCHARGES WERE CALCULATED USING REGRESSION
*         EQUATIONS.
*         BRIDGE STRUCTURAL ELEVATIONS WERE TAKEN FROM BRIDGE
*         DRAWINGS PROVIDED BY SCDOT WHICH MATCHED THE QUAD SHEET.
*         THERE ARE NO
*         HIGH WATER MARKS KNOWN TO CALIBRATE THE MODEL.  THE CROSS
*         SECTION DATA IS CODED LEFT TO RIGHT FACING DOWNSTREAM.
*         ************************************************************
XS     EXIT  000 00
GR          1600,260.0 1900,240.0 2043,236.9 2048,233.2
GR          2049,232.9 2051,233.1 2054,232.6 2058,232.9 2066,233.4
GR          2067,234.3 2077,239.3 2200,240.0 3000,250.0
N            .15    .045    .15    .07
SA             2048    2067   2127
*         ************************************************************
XS     FULL 130  00
GR          1800,260.0 2000,250.0 2043,237.2 2048,233.5 2049,233.2
GR          2051,233.4 2054,232.8 2058,233.2 2066,233.7 2067,234.6
GR          2077,239.6 2300,240.0 3000,250.0
N           .15    .045    .15    .07
SA             2048    2067   2127
*         ************************************************************
BR     BRDG 130  247.8  00
GR          2001,248.4 2010,246.7 2023,239.9 2030,239.9 2043,237.2
GR          2048,233.5 2049,233.2 2051,233.4 2054,232.8 2058,233.2
GR          2066,233.7 2067,234.6 2077,239.6 2085,241.0 2100,241.6
GR          2110,242.4 2121,247.9 2129,249.2 2001,248.4
N           .07    .045    .07
SA             2048    2067
CD          3  35.3  .5  251.66
PW 1        239.9,3 241.6,3 241.6,6 247.8,6
*         ************************************************************
XR     ROAD  136  37  1  *  00
GR          1850,420.0 2001,415.2 2049,415.4 2300,420.0
N           .015
*         ************************************************************
AS     APPR  296  00
GR          2000,250.0 2033,237.5 2043,237.5 2048,233.8
GR          2049,233.5 2051,233.7 2054,233.2 2058,233.5 2066,234.0
GR          2067,234.9 2077,239.9 2300,240.0 2800,250.0
N           .15    .045    .07    .15
SA             2048    2067   2300
*         ************************************************************
HP 1   APPR 245.23 * 245.23
HP 1   BRDG 243.46 * 243.46
HP 2   APPR 245.23 * 245.23  3502
HP 2   BRDG 243.46 * 243.46  3502
*
HP 1   APPR 246.31 * 246.31
HP 1   BRDG 244.07 * 244.07
HP 2   APPR 246.31 * 246.31  4544
```

WSPRO INPUT (Cont.)

```
HP 2  BRDG 244.07 * 244.07  4544
EX
ER
```

WSPRO OUTPUT

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1
 WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                      (Input modified to free format by GKY&A 01/92)

            *** RUN DATE & TIME: 12-22-94  11:44

   T2         ROUTE 47 OVER DEEP CREEK
   T3         EH&A FILE NO. 16139.01 B-6
   *          MT. CROGHAN, SOUTH CAROLINA
   *          FILE NAME: 16139W06.DAT
   *          ************************************************************
   J1          .02 .005 .005 .95

 J1 RECORD PARAMETERS:
 DELTAY =  .02   YTOL =  .00   QTOL =  .00   FNTEST =  .95   IHFNOJ = -1

   J3         5 3 13 15 23 430 446 448 * 5 17 29 30 6 16 555 * 7 14 3 11
   *          ************************************************************
   *           Q100   Q500
   Q           3502   4544
 *** Q-DATA FOR SEC-ID, ISEQ =            1
   SK          .002   .002
   *          ************************************************************
   *          CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
   *          SHEET "MT. CROGHAN, S.C." AND FROM INFORMATION
   *          COLLECTED DURING THE FIELD INSPECTION ON OCTOBER 26, 1994.
   *          ELEVATIONS GIVEN ARE APPROXIMATE.  MANNINGS COEFFICIENTS
   *          WERE ESTIMATED FROM FIELD OBSERVATIONS.  THE 100 AND
   *          500-YEAR DISCHARGES WERE CALCULATED USING REGRESSION
   *          EQUATIONS.
   *          BRIDGE STRUCTURAL ELEVATIONS WERE TAKEN FROM BRIDGE
   *          DRAWINGS PROVIDED BY SCDOT WHICH MATCHED THE QUAD SHEET.
   *          THERE ARE NO
   *          HIGH WATER MARKS KNOWN TO CALIBRATE THE MODEL.  THE CROSS
   *          SECTION DATA IS CODED LEFT TO RIGHT FACING DOWNSTREAM.
   *          ************************************************************
1
 WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                      (Input modified to free format by GKY&A 01/92)


         ROUTE 47 OVER DEEP CREEK
         EH&A FILE NO. 16139.01 B-6
            *** RUN DATE & TIME: 12-22-94  11:44

 *** START PROCESSING CROSS SECTION - " EXIT"
   XS    EXIT  000 00
   GR          1600,260.0 1900,240.0 2043,236.9 2048,233.2
   GR          2049,232.9 2051,233.1 2054,232.6 2058,232.9 2066,233.4
   GR          2067,234.3 2077,239.3 2200,240.0 3000,250.0
   N            .15    .045    .15    .07
   SA              2048    2067   2127
   *          ************************************************************

 *** FINISH PROCESSING CROSS SECTION - " EXIT"
 *** CROSS SECTION " EXIT" WRITTEN TO DISK, RECORD NO. =  1

 --- DATA SUMMARY FOR SECID " EXIT" AT SRD =      0.  ERR-CODE =      0

      SKEW      IHFNO     VSLOPE         EK         CK
        .0         0. *********        .50        .00

 X-Y COORDINATE PAIRS  (NGP =  13):
       X      Y          X      Y          X      Y          X      Y
```

WSPRO OUTPUT (Cont.)

```
   1600.0  260.00    1900.0  240.00    2043.0  236.90    2048.0  233.20
   2049.0  232.90    2051.0  233.10    2054.0  232.60    2058.0  232.90
   2066.0  233.40    2067.0  234.30    2077.0  239.30    2200.0  240.00
   3000.0  250.00

 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   1600.0  260.00    2054.0  232.60    3000.0  250.00    1600.0  260.00

SUBAREA BREAKPOINTS (NSA =  4):
       2048.   2067.   2127.

ROUGHNESS COEFFICIENTS (NSA =  4):
        .150    .045    .150    .070
1
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
P060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                   (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
           *** RUN DATE & TIME: 12-22-94  11:44

*** START PROCESSING CROSS SECTION - " FULL"
  XS    FULL 130  00
  GR         1800,260.0 2000,250.0 2043,237.2 2048,233.5 2049,233.2
  GR         2051,233.4 2054,232.8 2058,233.2 2066,233.7 2067,234.6
  GR         2077,239.6 2300,240.0 3000,250.0
  N          .15    .045    .15    .07
  SA            2048    2067   2127
  *        ************************************************************

*** FINISH PROCESSING CROSS SECTION - " FULL"
*** CROSS SECTION " FULL" WRITTEN TO DISK, RECORD NO. =  2

--- DATA SUMMARY FOR SECID " FULL" AT SRD =    130.  ERR-CODE =      0

     SKEW      IHFNO     VSLOPE         EK         CK
       .0         0. *********        .50        .00

X-Y COORDINATE PAIRS  (NGP =  13):
       X       Y         X       Y         X       Y         X       Y
   1800.0  260.00    2000.0  250.00    2043.0  237.20    2048.0  233.50
   2049.0  233.20    2051.0  233.40    2054.0  232.80    2058.0  233.20
   2066.0  233.70    2067.0  234.60    2077.0  239.60    2300.0  240.00
   3000.0  250.00

 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   1800.0  260.00    2054.0  232.80    3000.0  250.00    1800.0  260.00

SUBAREA BREAKPOINTS (NSA =  4):
       2048.   2067.   2127.

ROUGHNESS COEFFICIENTS (NSA =  4):
        .150    .045    .150    .070
1
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
P060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                   (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
           *** RUN DATE & TIME: 12-22-94  11:44

*** START PROCESSING CROSS SECTION - " BRDG"
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WSPRO OUTPUT (Cont.)

```
  BR    BRDG 130  247.8  00
  GR         2001,248.4 2010,246.7 2023,239.9 2030,239.9 2043,237.2
  GR         2048,233.5 2049,233.2 2051,233.4 2054,232.8 2058,233.2
  GR         2066,233.7 2067,234.6 2077,239.6 2085,241.0 2100,241.6
  GR         2110,242.4 2121,247.9 2129,249.2 2001,248.4
  N          .07    .045    .07
  SA            2048    2067
  CD         3  35.3  .5  251.66
  PW 1       239.9,3 241.6,3 241.6,6 247.8,6
  *         ************************************************************

*** FINISH PROCESSING CROSS SECTION - " BRDG"
*** CROSS SECTION " BRDG" WRITTEN TO DISK, RECORD NO. =  3

--- DATA SUMMARY FOR SECID " BRDG" AT SRD =    130.  ERR-CODE =      0

     SKEW      IHFNO     VSLOPE         EK         CK
       .0         0. *********        .50        .00

X-Y COORDINATE PAIRS  (NGP =  19):
       X      Y          X      Y          X      Y          X      Y
   2001.0  248.40    2010.0  246.70    2023.0  239.90    2030.0  239.90
   2043.0  237.20    2048.0  233.50    2049.0  233.20    2051.0  233.40
   2054.0  232.80    2058.0  233.20    2066.0  233.70    2067.0  234.60
   2077.0  239.60    2085.0  241.00    2100.0  241.60    2110.0  242.40
   2121.0  247.90    2129.0  249.20    2001.0  248.40

 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   2001.0  248.40    2054.0  232.80    2129.0  249.20    2129.0  249.20

SUBAREA BREAKPOINTS (NSA =  3):
       2048.   2067.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .070    .045    .070

BRIDGE PARAMETERS:
 BRTYPE  BRWDTH     LSEL  USERCD  EMBSS   EMBELV  ABSLPL  ABSLPR
    3      35.3   247.80 *******    .50   251.66 ******* *******

PIER DATA:  NPW =  4    PPCD = 1.
     PELV  PWDTH      PELV  PWDTH      PELV  PWDTH      PELV  PWDTH
    239.90   3.0     241.60   3.0     241.60   6.0     247.80   6.0
1
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
P060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                   (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
           *** RUN DATE & TIME: 12-22-94  11:44

*** START PROCESSING CROSS SECTION - " ROAD"
  XR    ROAD  136  37  1  *  00
  GR         1850,420.0 2001,415.2 2049,415.4 2300,420.0
  N          .015
  *         ************************************************************

*** FINISH PROCESSING CROSS SECTION - " ROAD"
*** CROSS SECTION " ROAD" WRITTEN TO DISK, RECORD NO. =  4

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     SKEW      IHFNO     VSLOPE         EK         CK
       .0         0. *********        .50        .00
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WSPRO OUTPUT (Cont.)

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X-Y COORDINATE PAIRS  (NGP =   4):
      X      Y          X      Y          X      Y          X      Y
   1850.0  420.00    2001.0  415.20    2049.0  415.40    2300.0  420.00

 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   1850.0  420.00    2001.0  415.20    2300.0  420.00    1850.0  420.00

ROUGHNESS COEFFICIENTS (NSA =  1):
        .015

ROAD GRADE DATA:  IPAVE  RDWID  USERCF
                     1.   37.0 *******

BRIDGE PROJECTION DATA:  XREFLT  XREFRT  FDSTLT  FDSTRT
                        ******* ******* ******* *******
1
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
P060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
           *** RUN DATE & TIME: 12-22-94  11:44

*** START PROCESSING CROSS SECTION - " APPR"
  AS    APPR  296  00
  GR          2000,250.0 2033,237.5 2043,237.5 2048,233.8
  GR          2049,233.5 2051,233.7 2054,233.2 2058,233.5 2066,234.0
  GR          2067,234.9 2077,239.9 2300,240.0 2800,250.0
  N           .15    .045    .07    .15
  SA             2048    2067   2300
  *          ************************************************************
  HP 1  APPR 245.23 * 245.23

*** FINISH PROCESSING CROSS SECTION - " APPR"
*** CROSS SECTION " APPR" WRITTEN TO DISK, RECORD NO. =  5

--- DATA SUMMARY FOR SECID " APPR" AT SRD =    296.  ERR-CODE =      0

     SKEW      IHFNO    VSLOPE        EK        CK
       .0         0. *********       .50       .00

X-Y COORDINATE PAIRS  (NGP =  13):
      X      Y          X      Y          X      Y          X      Y
   2000.0  250.00    2033.0  237.50    2043.0  237.50    2048.0  233.80
   2049.0  233.50    2051.0  233.70    2054.0  233.20    2058.0  233.50
   2066.0  234.00    2067.0  234.90    2077.0  239.90    2300.0  240.00
   2800.0  250.00

 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   2000.0  250.00    2054.0  233.20    2800.0  250.00    2000.0  250.00

SUBAREA BREAKPOINTS (NSA =  4):
       2048.   2067.   2300.

ROUGHNESS COEFFICIENTS (NSA =  4):
        .150    .045    .070    .150

BRIDGE PROJECTION DATA:  XREFLT  XREFRT  FDSTLT  FDSTRT
                        ******* ******* ******* *******
1
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
P060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)
```

WSPRO OUTPUT (Cont.)

```
        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
          *** RUN DATE & TIME: 12-22-94  11:44
    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID =  APPR;  SRD =     296.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     204.     6212.   35.   38.                        2780.
             2     220.    36772.   19.   19.                        4257.
             3    1256.    81888.  233.  234.                       16542.
             4     684.    12891.  261.  262.                        6275.
   245.23         2364.   137764.  549.  553.  2.96  2013.  2561.  16192.
1
  HP 1  BRDG 243.46 * 243.46
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
          *** RUN DATE & TIME: 12-22-94  11:44
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID =  BRDG;  SRD =     130.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     141.     7758.   32.   34.                        1692.
             2     193.    29398.   19.   19.                        3483.
             3     137.     5975.   45.   47.                        1355.
   243.46           471.    43131.   96.  100.  1.99  2016.  2112.   4202.
1
  HP 2  APPR 245.23 * 245.23  3502
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
          *** RUN DATE & TIME: 12-22-94  11:44


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID =  APPR;  SRD =     296.

        WSEL     LEW     REW    AREA        K        Q    VEL
      245.23  2012.6  2561.5  2364.0   137764.   3502.   1.48

X STA.      2012.6     2048.3     2051.9     2055.3     2058.7     2062.2
  A(I)           207.7       41.3       40.6       40.4       40.5
  V(I)             .84       4.24       4.32       4.33       4.32

X STA.      2062.2     2065.9     2075.1     2095.2     2115.1     2134.9
  A(I)            41.9       79.0      108.1      105.7      105.5
  V(I)            4.18       2.22       1.62       1.66       1.66

X STA.      2134.9     2155.0     2175.1     2195.4     2215.5     2236.1
  A(I)           106.4      106.2      107.2      106.2      108.1
  V(I)            1.65       1.65       1.63       1.65       1.62

X STA.      2236.1     2256.5     2277.0     2297.3     2344.9     2561.5
  A(I)           107.3      107.7      106.3      228.6      469.2
  V(I)            1.63       1.63       1.65        .77        .37
1
  HP 2  BRDG 243.46 * 243.46  3502
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
```

WSPRO OUTPUT (Cont.)

```
P060188          MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                   (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
           *** RUN DATE & TIME: 12-22-94  11:44


    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID =  BRDG;  SRD =     130.

         WSEL     LEW     REW    AREA        K        Q    VEL
       243.46  2016.2  2112.1   471.2   43131.    3502.   7.43

 X STA.      2016.2     2035.8     2041.9     2046.3     2048.6     2050.0
   A(I)            61.0       33.4       31.1       21.8       14.0
   V(I)            2.87       5.24       5.63       8.03      12.47

 X STA.      2050.0     2051.3     2052.7     2054.0     2055.3     2056.6
   A(I)            13.9       13.9       13.8       13.7       13.6
   V(I)           12.62      12.59      12.69      12.76      12.92

 X STA.      2056.6     2057.9     2059.3     2060.6     2062.1     2063.5
   A(I)            13.7       14.0       13.8       14.2       13.9
   V(I)           12.78      12.52      12.68      12.36      12.62

 X STA.      2063.5     2064.9     2066.5     2069.5     2074.6     2112.1
   A(I)            14.1       15.8       25.4       32.0       84.1
   V(I)           12.46      11.09       6.90       5.46       2.08
1
   *
   HP 1  APPR 246.31 * 246.31
1
 WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188          MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
           *** RUN DATE & TIME: 12-22-94  11:44
    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID =  APPR;  SRD =     296.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW     REW     QCR
             1     244.     7940.   38.    41.                        3493.
             2     241.    42656.   19.    19.                        4866.
             3    1507.   111026.  233.   234.                       21756.
             4     995.    21267.  315.   316.                       10033.
   246.31         2987.   182889.  606.   610.  2.86  2010.   2616.  22271.
1
   HP 1  BRDG 244.07 * 244.07
1
 WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188          MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
           *** RUN DATE & TIME: 12-22-94  11:44
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID =  BRDG;  SRD =     130.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW     REW     QCR
             1     161.     9407.   33.    35.                        2022.
             2     204.    32403.   19.    19.                        3802.
             3     165.     7983.   46.    48.                        1765.
   244.07           530.    49793.   98.   103.  1.97  2015.   2113.   4977.
```

WSPRO OUTPUT (Cont.)

```
1
  HP 2  APPR 246.31 * 246.31  4544
1
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
P060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                     (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
           *** RUN DATE & TIME: 12-22-94  11:44


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID =  APPR;  SRD =     296.

         WSEL     LEW     REW    AREA        K        Q    VEL
       246.31  2009.7  2615.5  2987.5  182889.    4544.   1.52

X STA.     2009.7     2048.5     2052.6     2056.5     2060.4     2064.5
  A(I)          250.6       52.0       49.8       50.4       51.6
  V(I)            .91       4.37       4.57       4.51       4.41

X STA.     2064.5     2071.7     2089.6     2109.3     2128.7     2148.2
  A(I)           78.4      121.9      125.9      124.2      124.1
  V(I)           2.90       1.86       1.80       1.83       1.83

X STA.     2148.2     2167.8     2187.5     2207.4     2227.1     2246.7
  A(I)          125.3      125.1      126.4      125.2      124.5
  V(I)           1.81       1.82       1.80       1.81       1.83

X STA.     2246.7     2266.6     2286.7     2313.8     2369.1     2615.5
  A(I)          126.0      126.5      169.6      302.7      607.4
  V(I)           1.80       1.80       1.34        .75        .37
1
  HP 2  BRDG 244.07 * 244.07  4544
1
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
P060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                     (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
           *** RUN DATE & TIME: 12-22-94  11:44


    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID =  BRDG;  SRD =     130.

         WSEL     LEW     REW    AREA        K        Q    VEL
       244.07  2015.0  2113.3   530.4   49793.    4544.   8.57

X STA.     2015.0     2034.3     2040.9     2045.6     2048.3     2049.8
  A(I)           65.5       38.4       34.4       26.4       15.6
  V(I)           3.47       5.92       6.61       8.60      14.52

X STA.     2049.8     2051.2     2052.7     2054.0     2055.4     2056.8
  A(I)           15.8       15.4       15.3       15.0       15.2
  V(I)          14.39      14.73      14.85      15.19      14.90

X STA.     2056.8     2058.2     2059.6     2061.0     2062.5     2064.0
  A(I)           15.4       15.3       15.3       15.7       15.8
  V(I)          14.72      14.87      14.82      14.45      14.40

X STA.     2064.0     2065.5     2067.6     2071.4     2079.3     2113.3
  A(I)           15.7       20.9       31.0       42.9       85.4
  V(I)          14.49      10.87       7.33       5.30       2.66
```

WSPRO OUTPUT (Cont.)

```
1
  EX

 +++ BEGINNING PROFILE CALCULATIONS --   2
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
           *** RUN DATE & TIME: 12-22-94  11:44

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

  EXIT:XS   ******  1852.    1899.   .29 *****  243.49  241.71   3502.  243.20
         0. ******  2456.   78242.  5.52 ***** *******     .43    1.84

  FULL:FV     130.  2022.    1599.   .28   .26  243.75 *******   3502.  243.46
       130.   130.  2542.   79666.  3.81   .00     .00     .43    2.19
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  APPR:AS     166.  2016.    1635.   .23   .29  244.04 *******   3502.  243.81
       296.   166.  2490.   88452.  3.22   .00     .00     .36    2.14
          <<<<<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

  BRDG:BR     130.  2016.     471.  1.23   .57  244.68  242.91   3502.  243.46
       130.   130.  2112.   43110.  1.43   .62     .00     .71    7.44

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        3.   1.   1.   .837   .034  247.80 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
     ROAD:RG     136.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

  APPR:AS     131.  2013.    2362.   .10   .39  245.33  242.02   3502.  245.23
       296.   154.  2561.  137603.  2.96   .25     .00     .22    1.48

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
        .798   .742    35499.  2067.  2163.   245.14

                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
           *** RUN DATE & TIME: 12-22-94  11:44
  FIRST USER DEFINED TABLE.

     XSID:CODE       Q     WSEL      VEL     CRWS    YMIN
     EXIT:XS      3502.  243.20     1.84   241.71  232.60
     FULL:FV      3502.  243.46    2.19********  232.80
     BRDG:BR      3502.  243.46     7.44   242.91  232.80
     ROAD:RG         0.********    1.00********  415.20
```

WSPRO OUTPUT (Cont.)

```
    XSID:CODE       Q  VMAX  VAVG
    ROAD:RG  ********************
    ROAD:RG  ********************

    XSID:CODE       Q    WSEL     VEL    CRWS    YMIN
    APPR:AS      3502.  245.23    1.48  242.02  233.20
1
 WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
          *** RUN DATE & TIME: 12-22-94  11:44
  SECOND USER DEFINED TABLE.

    XSID:CODE       Q     AREA    LEW    REW    SRD        K
    EXIT:XS      3502.    1899.  1852.  2456.     0.   78242.
    FULL:FV      3502.    1599.  2022.  2542.   130.   79666.
    BRDG:BR      3502.     471.  2016.  2112.   130.   43110.
    ROAD:RG        0.**********************   136.*********
    APPR:AS      3502.    2362.  2013.  2561.   296.  137603.

    XSID:CODE    OTEL
    APPR:AS    245.14
1
 WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
          *** RUN DATE & TIME: 12-22-94  11:44
   THIRD USER DEFINED TABLE.

    XSID:CODE      EGL     FR#    WSEL    HF
    EXIT:XS     243.49     .43  243.20******
    FULL:FV     243.75     .43  243.46   .26
    BRDG:BR     244.68     .71  243.46   .57
    ROAD:RG  ******************************
    APPR:AS     245.33     .22  245.23   .39
1
 WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)


        ROUTE 47 OVER DEEP CREEK
        EH&A FILE NO. 16139.01 B-6
          *** RUN DATE & TIME: 12-22-94  11:44

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

  EXIT:XS   ******  1841.    2357.   .28 *****  244.20  242.23   4544.  243.92
         0. ******  2513.  101572.  4.89 ***** *******     .40    1.93

  FULL:FV      130.  2020.    1990.   .28   .25  244.45 *******   4544.  244.18
       130.   130.  2592.  103823.  3.40   .00     .00     .40    2.28
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  APPR:AS      166.  2015.    1976.   .25   .30  244.75 *******   4544.  244.50
       296.   166.  2525.  111004.  3.07   .00     .00     .36    2.30
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

WSPRO OUTPUT (Cont.)

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

 BRDG:BR      130.  2015.      531.  1.64    .57   245.71   243.90    4544.  244.07
      130.    130.  2113.    49840.  1.44    .94      .00      .78     8.56

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       3.   1.   1.    .834    .038  247.80 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF    VHD     EGL     ERR       Q    WSEL
    ROAD:RG      136.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

 APPR:AS      131.  2010.     2988.   .10    .38   246.41   242.45    4544.  246.31
      296.    156.  2616.   182920.  2.86    .32      .00      .20     1.52

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       .807   .748    45982.  2081.  2179.   246.23

                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
 WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                     (Input modified to free format by GKY&A 01/92)


         ROUTE 47 OVER DEEP CREEK
         EH&A FILE NO. 16139.01 B-6
            *** RUN DATE & TIME: 12-22-94  11:44
   FIRST USER DEFINED TABLE.

     XSID:CODE       Q    WSEL     VEL    CRWS    YMIN
     EXIT:XS      4544.  243.92    1.93  242.23  232.60
     FULL:FV      4544.  244.18    2.28********  232.80
     BRDG:BR      4544.  244.07    8.56  243.90  232.80
     ROAD:RG         0.********    1.00********  415.20

     XSID:CODE       Q  VMAX  VAVG
     ROAD:RG  ********************
     ROAD:RG  ********************

     XSID:CODE       Q    WSEL     VEL    CRWS    YMIN
     APPR:AS      4544.  246.31    1.52  242.45  233.20
1
 WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                     (Input modified to free format by GKY&A 01/92)


         ROUTE 47 OVER DEEP CREEK
         EH&A FILE NO. 16139.01 B-6
            *** RUN DATE & TIME: 12-22-94  11:44
   SECOND USER DEFINED TABLE.

     XSID:CODE       Q     AREA    LEW    REW    SRD        K
     EXIT:XS      4544.    2357.  1841.  2513.     0.  101572.
     FULL:FV      4544.    1990.  2020.  2592.   130.  103823.
     BRDG:BR      4544.     531.  2015.  2113.   130.   49840.
     ROAD:RG         0.************************   136.*********
     APPR:AS      4544.    2988.  2010.  2616.   296.  182920.

     XSID:CODE    OTEL
     APPR:AS    246.23
1
 WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
```

WSPRO OUTPUT (Cont.)

(Input modified to free format by GKY&A 01/92)

```
      ROUTE 47 OVER DEEP CREEK
      EH&A FILE NO. 16139.01 B-6
         *** RUN DATE & TIME: 12-22-94  11:44
 THIRD USER DEFINED TABLE.

   XSID:CODE      EGL      FR#    WSEL     HF
   EXIT:XS     244.20      .40  243.92******
   FULL:FV     244.45      .40  244.18   .25
   BRDG:BR     245.71      .78  244.07   .57
   ROAD:RG   ********************************
   APPR:AS     246.41      .20  246.31   .38
 ER

1  NORMAL  END  OF  WSPRO  EXECUTION.
```

SCDOT BRIDGE SCOUR
Saved As: 16139A06.WQ1
JOB NO. 16139.01 B-6
BRIDGE NO. 137004700100
BY/CHK: ABS/JNP

ESPEY, HUSTON & ASSOC., INC
460 McLAWS CIRCLE, SUITE 150
WILLIAMSBURG, VA 23185

STORM EVENT (YR): 100

DETERMINATION OF CRITICAL SCOUR VELOCITY

(A) INPUT

VARIABLES	DESCRIPTION	VALUE
MAIN CHANNEL:		
Ssm	SPECIFIC GRAVITY OF MAIN CHANNEL BED MATERIAL	2.65
D50m	MEAN DIAM. OF MAIN CHANNEL BED MATERAIL (mm)	0.12
AREAm	APPR. MAIN CHANNEL AREA (ft)^2	220
TOPW	APPR. MAIN CHANNEL TOP WIDTH (ft)	19
Ym	APPR. MAIN CHANNEL AVG. DEPTH = AREAm/TOPW	11.58
HFa	APPR. HEAD LOSS DUE TO FRICTION	0.29
DIST	DISTANCE FROM BRIDGE TO APPR.	166
Sf	AVG. UNCONSTRICTED ENERGY SLOPE = HFa/DIST	0.00175
Km	APPR. MAIN CHANNEL CONVEYANCE	36772
Vm	APPR. MAIN CHANNEL AVG. VELOCITY (fps)	6.99
	Vm = (Km*(Sf)^.5)/AREAm	
LEFT OVERBANK:		
Ssl	SPECIFIC GRAVITY OF LT. OVERBANK BED MATERIAL	2.65
D50l	MEAN DIAM. OF LT. OVERBANK BED MATL. (mm)	0.12
AREAl	LEFT OVERBANK AREA (ft)^2	204
TOPW	LEFT OVERBANK TOP WIDTH (ft)	35
Yl	APPR. LEFT OVERBANK AVG. DEPTH (ft)	5.83
Kl	LEFT OVERBANK CONVEYANCE	6212
Vl	APPR. LEFT OVERBANK AVG. VELOCITY (fps)	1.27
	Vl = (Kl*(Sf)^.5)/AREAl	
RIGHT OVERBANK:		
Ssr	SPECIFIC GRAVITY OF RT.OVERBANK BED MATERIAL	2.65
D50r	MEAN DIAM. OF RT. OVERBANK BED MATL. (mm)	0.12
AREAr	RIGHT OVERBANK AREA (ft)^2	1940
TOPW	RIGHT OVERBANK TOP WIDTH (ft)	494
Yr	APPR. RIGHT OVERBANK AVG. DEPTH (ft)	3.93
Kr	RIGHT OVERBANK CONVEYANCE	94779
Vr	APPR. RIGHT OVERBANK AVG. VELOCITY (fps)	2.04

SCDOT BRIDGE SCOUR
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BY/CHK: ABS/JNP

ESPEY, HUSTON & ASSOC., INC
460 McLAWS CIRCLE, SUITE 150
WILLIAMSBURG, VA 23185

STORM EVENT (YR): 100

(1) MAIN CHANNEL CRITICAL VELOCITY (Vcm):
NEILL'S EQ;
Vcm=1.58*((Ssm-1)*g*D50m)^1/2*(Ym/D50m)^1/6
Vcm= 1.27 fps

(2) LEFT OVERBANK CRITICAL VELOCITY (Vcl):
NEILL'S EQ;
Vcl=1.58*((Ssl-1)*g*D50l)^1/2*(Yl/D50l)^1/6
Vcl= 1.13 fps

(3) RIGHT OVERBANK CRITICAL VELOCITY (Vcr):
NEILL'S EQ;
Vcr=1.58*((Ssr-1)*g*D50r)^1/2*(Yr/D50r)^1/6
Vcr= 1.06 fps

NOTES: LIVE-BED SCOUR WILL BE COMPUTED FOR THE MAIN CHANNEL.
LIVE-BED SCOUR WILL BE COMPUTED FOR THE LEFT OVERBANK.
LIVE-BED SCOUR WILL BE COMPUTED FOR THE RIGHT OVERBANK.

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460 McLAWS CIRCLE, SUITE 150
WILLIAMSBURG, VA 23185

STORM EVENT (YR): 100

SCOUR CALCULATIONS

I. LIVE BED CONTRACTION SCOUR

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
Q	TOTAL DISCHARGE(cfs) APPROACH	3502
Q	TOTAL DISCHARGE(cfs) BRIDGE	3502
Ktot(APP)	APP. TOTAL CONVEYANCE	137763
Ktot(BR)	BR. TOTAL CONVEYANCE	43131
Sf	AVG. UNCONSTRICTED ENERGY SLOPE	0.00175
MAIN CHANNEL:		
Km(APP)	APP. MAIN CHANNEL CONVEYANCE	36772
W1m(APP)	APP. MAIN CHANNEL WIDTH(ft)	19
Am(APP)	APP. MAIN CHANNEL AREA	220
TOPWm(APP)	APP. MAIN CHANNEL TOP WIDTH(ft)	19
Y1m(APP)	AVG. DEPTH IN UPSTR MAIN CHANNEL(ft)	11.58
WETPm(APP)	APP. MAIN CHANNEL WETTED PERIM.(ft)	19
Km(BR)	BR. MAIN CHANNEL CONVEYANCE	29398
W2m(BR)	BR. MAIN CHANNEL WIDTH MINUS PIER WIDTHS(ft)	19
LEFT OVERBANK:		
Kl(APP)	APP. LEFT OVERBANK CONVEYANCE	6212
W1l(APP)	APP. LEFT OVERBANK WIDTH(ft)	35
Al(APP)	APP. LEFT OVERBANK AREA(ft^2)	204
TOPWl(APP)	APP. LEFT OVERBANK TOP WIDTH(ft)	35
Y1l(APP)	AVG. DEPTH IN UPSTR LEFT OVERBANK (ft)	5.83
WETPl(APP)	APP. LEFT OVERBANK WETTED PERIM.(ft)	38
Kl(BR)	BR. LEFT OVERBANK CONVEYANCE	7758
W2l(BR)	BR. LEFT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	28.8
RIGHT OVERBANK:		
Kr(APP)	APP. RIGHT OVERBANK CONVEYANCE	94779
W1r(APP)	APP. RIGHT OVERBANK WIDTH(ft)	494
Ar(APP)	APP. RIGHT OVERBANK AREA(ft^2)	1940
TOPWr(APP)	APP. RIGHT OVERBANK TOP WIDTH(ft)	494
Y1r(APP)	AVG. DEPTH IN UPSTR RIGHT OVERBANK ft)	3.93
WETPr(APP)	APP. RIGHT OVERBANK WETTED PERIM.(ft)	496
Kr(BR)	BR. RIGHT OVERBANK CONVEYANCE	5975
W2r(BR)	BR. RIGHT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	42.1

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STORM EVENT (YR): 100

(B) CALCULATIONS (CONTRACTION SCOUR)

1. MAIN CHANNEL CONTRACTION SCOUR (Ysm):

(a) APP. MAIN CHAN. HYD. RADIUS (Rm):

Rm=Am(APP)/WETPm(APP)
Rm= 11.58 ft

(b) AVG. MAIN CHANNEL SHEAR STRESS (SHEARm):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARm=Ywater*Rm*Sf
SHEARm= 1.26 lb/sf

(c) SHEAR VELOCITY IN APP. MAIN CHANNEL (Vm*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vm*=(SHEARm/p)^.5
Vm*= 0.81 fps

(d) MAIN CHANNEL BED MATL. D50m:

D50m= 0.12 mm
D50m= 0.0004 ft

(e) FALL VELOCITY (wm):
FROM FIG. 3, PAGE 34

wm= 0.03 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vm*/wm= 26.89
K1= 0.69

(g) DISCHARGE IN MAIN CHANNEL OF APP (Q1m):

Q1m=Q*(Km(APP)/Ktot(APP))
Q1m= 935 cfs

(h) DISCHARGE IN MAIN CHANNEL OF BR (Q2m):

Q2m=Q*(Km(BR)/Ktot(BR))
Q2m= 2387 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2m/Y1m=(Q2m/Q1m)^6/7*(W1m/W2m)^K1
Y2m= 25.86 ft

(j) MAIN CONTRACTION SCOUR DEPTH (Ysm):
Ysm=Y2m-Y1m
Ysm= 14.28 ft

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STORM EVENT (YR): 100

2. LEFT OVERBANK CONTRACTION SCOUR (Ysl):

(a) APP. LEFT OVERBANK HYD. RADIUS (Rl):

Rl=Al(APP)/WETPl(APP)
Rl= 5.37 ft

(b) AVG. LEFT OVERBANK SHEAR STRESS (SHEARl):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARl=Ywater*Rl*Sf
SHEARl= 0.59 lb/sf

(c) SHEAR VELOCITY IN APP. LEFT OVERBANK (Vl*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vl*=(SHEARl/p)^.5
Vl*= 0.55 fps

(d) LEFT OVERBANK BED MATL.(D50l):

D50l= 0.12 mm
D50l= 0.0004 ft

(e) FALL VELOCITY (wl):
FROM FIG. 3, PAGE 34

wl= 0.03 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vl*/wl= 18.31
K1= 0.69

(g) DISCHARGE IN LEFT OVERBANK OF APP (Q1l):

Q1l=Q*(Kl(APP)/Ktot(APP))
Q1l= 158 cfs

(h) DISCHARGE IN LEFT OVERBANK OF BR (Q2l):

Q2l=Q*(Kl(BR)/Ktot(BR))
Q2l= 630 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2l/Y1l=(Q2l/Q1l)^6/7*(W1l/W2l)^K1
Y2l= 21.83 ft

(j) LEFT OVERBANK CONTRACTION SCOUR DEPTH (Ysl):
Ysl=Y2l-Y1l
Ysl= 16.00 ft

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STORM EVENT (YR): 100

3. RIGHT OVERBANK CONTRACTION SCOUR (Ysr):

(a) APP. RIGHT OVERBANK HYD. RADIUS(Rr):

Rr=Ar(APP)/WETPr(APP)
Rr= 3.91 ft

(b) AVG. RIGHT OVERBANK SHEAR STRESS (SHEARr):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARr=Ywater*Rr*Sf
SHEARr= 0.43 lb/sf

(c) SHEAR VELOCITY IN APP. RIGHT OVERBANK (Vr*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vr*=(SHEARr/p)^.5
Vr*= 0.47 fps

(d) RIGHT OVERBANK BED MATL. (D50r):

D50r= 0.12 mm
D50r= 0.0004 ft

(e) FALL VELOCITY (wr):
FROM FIG. 3, PAGE 34

wr= 0.03 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vr*/wr= 15.63
K1= 0.69

(g) DISCHARGE IN RIGHT OVERBANK OF APP (Q1r):

Q1r=Q*(Kr(APP)/Ktot(APP))
Q1r= 2409 cfs

(h) DISCHARGE IN RIGHT OVERBANK OF BR (Q2r):

Q2r=Q*(Kr(BR)/Ktot(BR))
Q2r= 485 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2r/Y1r=(Q2r/Q1r)^6/7*(W1r/W2r)^K1
Y2r= 5.44 ft

(j) RIGHT OVERBANK CONTRACTION SCOUR DEPTH (Ysr):
Ysr=Y2r-Y1r
Ysr= 1.51 ft

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STORM EVENT (YR): 100

III. LOCAL SCOUR AT PIERS

(A) INPUT FROM WSPRO

VARIABLE		DESCRIPTION	VALUE
PIER #2:	WSPRO STA	2100	
A2		AREA OF CONVEYANCE TUBE AT PIER #2 (sf)	84.1
V2		VELOCITY IN CONVEYANCE TUBE AT PIER #2 (fps)	2.08
TOPW2		TOPWIDTH OF CONVEYANCE TUBE AT PIER #2 (ft)	37.5
Y2		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #2 (ft)	2.24
PIER #3:	WSPRO STA	2030	
A3		AREA OF CONVEYANCE TUBE AT PIER #3 (sf)	61
V3		VELOCITY IN CONVEYANCE TUBE AT PIER #3 (fps)	2.87
TOPW3		TOPWIDTH OF CONVEYANCE TUBE AT PIER #3 (ft)	19.6
Y3		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #3 (ft)	3.11

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BY/CHK: ABS/JNP

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STORM EVENT (YR): 100

(B) CALCULATIONS (LOCAL SCOUR AT PIERS)

1. SCOUR DEPTH AT PIER #2 (Ys#2):

(a) a=PIER WIDTH (ft)= 3
(b) FROUDE NO.=FR2=V2/(g*Y2)^.5= 0.24
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1
(d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)= 1.0
(e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)= 1.1
(f) CSU EQ. FOR PIER SCOUR;
Ys#2=Y2*2*K1*K2*K3*(a/Y2)^.65*FR2^.43
Ys#2= 3.25 ft

2. SCOUR DEPTH AT PIER #3 (Ys#3):

(a) a=PIER WIDTH (ft)= 3
(b) FROUDE NO.=FR3=V3/(g*Y3)^.5= 0.29
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1
(d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)= 1.0
(e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)= 1.1
(f) CSU EQ. FOR PIER SCOUR;
Ys#3=Y3*2*K1*K2*K3*(a/Y3)^.65*FR3^.43
Ys#3= 3.91 ft

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STORM EVENT (YR): 100

IV. ABUTMENT SCOUR :

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED

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STORM EVENT (YR): 500

DETERMINATION OF CRITICAL SCOUR VELOCITY

(A) INPUT

VARIABLES	DESCRIPTION	VALUE
MAIN CHANNEL:		
Ssm	SPECIFIC GRAVITY OF MAIN CHANNEL BED MATERIAL	2.65
D50m	MEAN DIAM. OF MAIN CHANNEL BED MATERAIL (mm)	0.12
AREAm	APPR. MAIN CHANNEL AREA (ft)^2	241
TOPW	APPR. MAIN CHANNEL TOP WIDTH (ft)	19
Ym	APPR. MAIN CHANNEL AVG. DEPTH = AREAm/TOPW	12.68
HFa	APPR. HEAD LOSS DUE TO FRICTION	0.3
DIST	DISTANCE FROM BRIDGE TO APPR.	166
Sf	AVG. UNCONSTRICTED ENERGY SLOPE = HFa/DIST	0.00181
Km	APPR. MAIN CHANNEL CONVEYANCE	42656
Vm	APPR. MAIN CHANNEL AVG. VELOCITY (fps)	7.52
	Vm = (Km*(Sf)^.5)/AREAm	
LEFT OVERBANK:		
Ssl	SPECIFIC GRAVITY OF LT. OVERBANK BED MATERIAL	2.65
D50l	MEAN DIAM. OF LT. OVERBANK BED MATL. (mm)	0.12
AREAl	LEFT OVERBANK AREA (ft)^2	244
TOPW	LEFT OVERBANK TOP WIDTH (ft)	38
Yl	APPR. LEFT OVERBANK AVG. DEPTH (ft)	6.42
Kl	LEFT OVERBANK CONVEYANCE	7940
Vl	APPR. LEFT OVERBANK AVG. VELOCITY (fps)	1.38
	Vl = (Kl*(Sf)^.5)/AREAl	
RIGHT OVERBANK:		
Ssr	SPECIFIC GRAVITY OF RT.OVERBANK BED MATERIAL	2.65
D50r	MEAN DIAM. OF RT. OVERBANK BED MATL. (mm)	0.12
AREAr	RIGHT OVERBANK AREA (ft)^2	2502
TOPW	RIGHT OVERBANK TOP WIDTH (ft)	548
Yr	APPR. RIGHT OVERBANK AVG. DEPTH (ft)	4.57
Kr	RIGHT OVERBANK CONVEYANCE	132293
Vr	APPR. RIGHT OVERBANK AVG. VELOCITY (fps)	2.25

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STORM EVENT (YR): 500

(1) MAIN CHANNEL CRITICAL VELOCITY (Vcm):
NEILL'S EQ;
Vcm=1.58*((Ssm-1)*g*D50m)^1/2*(Ym/D50m)^1/6
Vcm= 1.29 fps

(2) LEFT OVERBANK CRITICAL VELOCITY (Vcl):
NEILL'S EQ;
Vcl=1.58*((Ssl-1)*g*D50l)^1/2*(Yl/D50l)^1/6
Vcl= 1.15 fps

(3) RIGHT OVERBANK CRITICAL VELOCITY (Vcr):
NEILL'S EQ;
Vcr=1.58*((Ssr-1)*g*D50r)^1/2*(Yr/D50r)^1/6
Vcr= 1.09 fps

NOTES: LIVE-BED SCOUR WILL BE COMPUTED FOR THE MAIN CHANNEL.
LIVE-BED SCOUR WILL BE COMPUTED FOR THE LEFT OVERBANK.
LIVE-BED SCOUR WILL BE COMPUTED FOR THE RIGHT OVERBANK.

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STORM EVENT (YR): 500

SCOUR CALCULATIONS

I. LIVE BED CONTRACTION SCOUR

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
Q	TOTAL DISCHARGE(cfs) APPROACH	4544
Q	TOTAL DISCHARGE(cfs) BRIDGE	4544
Ktot(APP)	APP. TOTAL CONVEYANCE	182889
Ktot(BR)	BR. TOTAL CONVEYANCE	49793
Sf	AVG. UNCONSTRICTED ENERGY SLOPE	0.00181
MAIN CHANNEL:		
Km(APP)	APP. MAIN CHANNEL CONVEYANCE	42656
W1m(APP)	APP. MAIN CHANNEL WIDTH(ft)	19
Am(APP)	APP. MAIN CHANNEL AREA	241
TOPWm(APP)	APP. MAIN CHANNEL TOP WIDTH(ft)	19
Y1m(APP)	AVG. DEPTH IN UPSTR MAIN CHANNEL(ft)	12.68
WETPm(APP)	APP. MAIN CHANNEL WETTED PERIM.(ft)	19
Km(BR)	BR. MAIN CHANNEL CONVEYANCE	32403
W2m(BR)	BR. MAIN CHANNEL WIDTH MINUS PIER WIDTHS(ft)	19
LEFT OVERBANK:		
Kl(APP)	APP. LEFT OVERBANK CONVEYANCE	7940
W1l(APP)	APP. LEFT OVERBANK WIDTH(ft)	38
Al(APP)	APP. LEFT OVERBANK AREA(ft^2)	244
TOPWl(APP)	APP. LEFT OVERBANK TOP WIDTH(ft)	38
Y1l(APP)	AVG. DEPTH IN UPSTR LEFT OVERBANK (ft)	6.42
WETPl(APP)	APP. LEFT OVERBANK WETTED PERIM.(ft)	41
Kl(BR)	BR. LEFT OVERBANK CONVEYANCE	9407
W2l(BR)	BR. LEFT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	30
RIGHT OVERBANK:		
Kr(APP)	APP. RIGHT OVERBANK CONVEYANCE	132293
W1r(APP)	APP. RIGHT OVERBANK WIDTH(ft)	548
Ar(APP)	APP. RIGHT OVERBANK AREA(ft^2)	2502
TOPWr(APP)	APP. RIGHT OVERBANK TOP WIDTH(ft)	548
Y1r(APP)	AVG. DEPTH IN UPSTR RIGHT OVERBANK ft)	4.57
WETPr(APP)	APP. RIGHT OVERBANK WETTED PERIM.(ft)	550
Kr(BR)	BR. RIGHT OVERBANK CONVEYANCE	7983
W2r(BR)	BR. RIGHT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	43.3

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STORM EVENT (YR): 500

(B) CALCULATIONS (CONTRACTION SCOUR)

1. MAIN CHANNEL CONTRACTION SCOUR (Ysm):

(a) APP. MAIN CHAN. HYD. RADIUS (Rm):

Rm=Am(APP)/WETPm(APP)
Rm= 12.68 ft

(b) AVG. MAIN CHANNEL SHEAR STRESS (SHEARm):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARm=Ywater*Rm*Sf
SHEARm= 1.43 lb/sf

(c) SHEAR VELOCITY IN APP. MAIN CHANNEL (Vm*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vm*=(SHEARm/p)^.5
Vm*= 0.86 fps

(d) MAIN CHANNEL BED MATL. D50m:

D50m= 0.12 mm
D50m= 0.00039 ft

(e) FALL VELOCITY (wm):
FROM FIG. 3, PAGE 34

wm= 0.03 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vm*/wm= 28.62
K1= 0.69

(g) DISCHARGE IN MAIN CHANNEL OF APP (Q1m):

Q1m=Q*(Km(APP)/Ktot(APP))
Q1m= 1060 cfs

(h) DISCHARGE IN MAIN CHANNEL OF BR (Q2m):

Q2m=Q*(Km(BR)/Ktot(BR))
Q2m= 2957 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2m/Y1m=(Q2m/Q1m)^6/7*(W1m/W2m)^K1
Y2m= 30.57 ft

(j) MAIN CONTRACTION SCOUR DEPTH (Ysm):
Ysm=Y2m-Y1m
Ysm= 17.88 ft

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STORM EVENT (YR): 500

2. LEFT OVERBANK CONTRACTION SCOUR (Ysl):

(a) APP. LEFT OVERBANK HYD. RADIUS (Rl):

Rl=Al(APP)/WETPl(APP)
Rl= 5.95 ft

(b) AVG. LEFT OVERBANK SHEAR STRESS (SHEARl):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARl=Ywater*Rl*Sf
SHEARl= 0.67 lb/sf

(c) SHEAR VELOCITY IN APP. LEFT OVERBANK (Vl*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vl*=(SHEARl/p)^.5
Vl*= 0.59 fps

(d) LEFT OVERBANK BED MATL.(D50l):

D50l= 0.12 mm
D50l= 0.00039 ft

(e) FALL VELOCITY (wl):
FROM FIG. 3, PAGE 34

wl= 0.03 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vl*/wl= 19.61
K1= 0.69

(g) DISCHARGE IN LEFT OVERBANK OF APP (Q1l):

Q1l=Q*(Kl(APP)/Ktot(APP))
Q1l= 197 cfs

(h) DISCHARGE IN LEFT OVERBANK OF BR (Q2l):

Q2l=Q*(Kl(BR)/Ktot(BR))
Q2l= 858 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2l/Y1l=(Q2l/Q1l)^6/7*(W1l/W2l)^K1
Y2l= 26.66 ft

(j) LEFT OVERBANK CONTRACTION SCOUR DEPTH (Ysl):
Ysl=Y2l-Y1l
Ysl= 20.24 ft

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STORM EVENT (YR): 500

3. RIGHT OVERBANK CONTRACTION SCOUR (Ysr):

(a) APP. RIGHT OVERBANK HYD. RADIUS(Rr):

Rr=Ar(APP)/WETPr(APP)
Rr= 4.55 ft

(b) AVG. RIGHT OVERBANK SHEAR STRESS (SHEARr):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARr=Ywater*Rr*Sf
SHEARr= 0.51 lb/sf

(c) SHEAR VELOCITY IN APP. RIGHT OVERBANK (Vr*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vr*=(SHEARr/p)^.5
Vr*= 0.51 fps

(d) RIGHT OVERBANK BED MATL. (D50r):

D50r= 0.12 mm
D50r= 0.00039 ft

(e) FALL VELOCITY (wr):
FROM FIG. 3, PAGE 34

wr= 0.03 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vr*/wr= 17.14
K1= 0.69

(g) DISCHARGE IN RIGHT OVERBANK OF APP (Q1r):

Q1r=Q*(Kr(APP)/Ktot(APP))
Q1r= 3287 cfs

(h) DISCHARGE IN RIGHT OVERBANK OF BR (Q2r):

Q2r=Q*(Kr(BR)/Ktot(BR))
Q2r= 729 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2r/Y1r=(Q2r/Q1r)^6/7*(W1r/W2r)^K1
Y2r= 7.23 ft

(j) RIGHT OVERBANK CONTRACTION SCOUR DEPTH (Ysr):
Ysr=Y2r-Y1r
Ysr= 2.67 ft

SCDOT BRIDGE SCOUR
Saved As: 16139B06.WQ1
JOB NO. 16139.01 B-6
BRIDGE NO. 137004700100
BY/CHK: ABS/JNP

ESPEY, HUSTON & ASSOC., INC
460 McLAWS CIRCLE, SUITE 150
WILLIAMSBURG, VA 23185

STORM EVENT (YR): 500

III. LOCAL SCOUR AT PIERS

(A) INPUT FROM WSPRO

VARIABLE		DESCRIPTION	VALUE
PIER #2:	WSPRO STA	2100	
A2		AREA OF CONVEYANCE TUBE AT PIER #2 (sf)	85.4
V2		VELOCITY IN CONVEYANCE TUBE AT PIER #2 (fps)	2.66
TOPW2		TOPWIDTH OF CONVEYANCE TUBE AT PIER #2 (ft)	34
Y2		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #2 (ft)	2.51
PIER #3:	WSPRO STA	2030	
A3		AREA OF CONVEYANCE TUBE AT PIER #3 (sf)	65.5
V3		VELOCITY IN CONVEYANCE TUBE AT PIER #3 (fps)	3.47
TOPW3		TOPWIDTH OF CONVEYANCE TUBE AT PIER #3 (ft)	19.3
Y3		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #3 (ft)	3.39

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STORM EVENT (YR): 500

(B) CALCULATIONS (LOCAL SCOUR AT PIERS)

1. SCOUR DEPTH AT PIER #2 (Ys#2):

(a)	a=PIER WIDTH (ft)=	3
(b)	FROUDE NO.=FR2=V2/(g*Y2)^.5=	0.30
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=	1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=	1.0
(e)	K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=	1.1

(f) CSU EQ. FOR PIER SCOUR;
Ys#2=Y2*2*K1*K2*K3*(a/Y2)^.65*FR2^.43
Ys#2= 3.67 ft

2. SCOUR DEPTH AT PIER #3 (Ys#3):

(a)	a=PIER WIDTH (ft)=	3
(b)	FROUDE NO.=FR3=V3/(g*Y3)^.5=	0.33
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=	1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=	1.0
(e)	K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=	1.1

(f) CSU EQ. FOR PIER SCOUR;
Ys#3=Y3*2*K1*K2*K3*(a/Y3)^.65*FR3^.43
Ys#3= 4.29 ft

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Saved As: 16139B06.WQ1
JOB NO. 16139.01 B-6
BRIDGE NO. 137004700100
BY/CHK: ABS/JNP

ESPEY, HUSTON & ASSOC., INC
460 McLAWS CIRCLE, SUITE 150
WILLIAMSBURG, VA 23185

STORM EVENT (YR): 500

IV. ABUTMENT SCOUR :

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED

Photo 1: *View looking north. Note superelevation.*

Photo 2: *View looking south.*

Photo 3: *View looking upstream at rock outcropping (center) and left bend in creek.*

Photo 4: *View looking downstream at bridge from rock outcropping in Photo 3.*

Photo 5: *View looking upstream from near exit section.*

Photo 6: *View looking downstream toward exit section.*

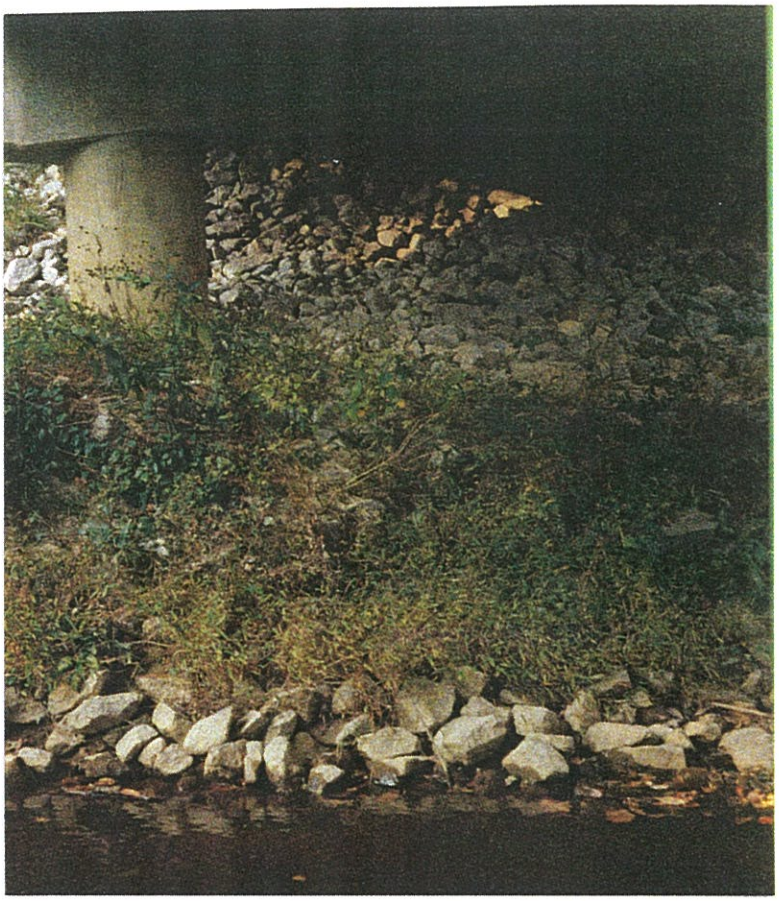

Photo 7: *View of good riprap on abutment and creek bank and 3 foot diameter column.*

Photo 8: *View of floodplain on downstream right (southern) overbank.*

Photo 9: ***View looking upstream at residential area..***

Photo 10: View looking downstream.

Photo 11: *Erosion from surface runoff on upstream side of north abutment.*

Consultant Scour Study Checklist

County Chesterfield Crossing Deep Creek

Road/Route S-47

Consultant E H + A

Structure No. 13700470010 0

Mark whether each item is completed correctly or incorrectly and make a comment as to what needs to be changed.

Check List	Correct	Incorrect	Comments
County	✓		
Structure#	✓		
Stream Name	✓		
Physiographic Province	✓		
Description of Location	✓		
Bridge Length and Width	✓		
Max Span Length # of Spans	✓		
D_{50}	✓		Rpt says D_{15} = 0.12 mm, OK
Skew	✓		
Q_{100}	✓		
Q_{500}	✓		
Discharge Method and Applicability	✓		
WSPRO Cross section Locations			
WSPRO Setup			
Inputs for scour against WSPRO			
Equations for Scour			

Model may be suspect w/ apx. of 100yr backwater = 1.42

Usual design ④ 1' backwater

Bridge Built 1990

OK,

WBG

DATE: 3/18/85

MEMORANDUM TO ROAD DESIGN SQUAD LEADER ~~G. Hall~~ CMS

FROM: Hydraulic Engineer Hulbert

SUBJECT: Hydrology Data for Bridge Over Deep Creek
Pt/Rd S-47, Chesterfield County

Bridge Length 130' Ft. Bridge Roadway Width 32 Ft.

Beg. Sta. 90+65 End Sta. 91+95

Skew Angle N/A Minimum F.G. Elev. 251.4 @ Sta 91+30

End Fill Slope 1½:1 Riprap Req'd ✓ Yes ___ No

To Elev. 246.5

Comments: Maintain full Super-elev throughout Bridge

High Water Data:

25 year H.W. Elev. = 244.5 including 1.1 ft. backwater
100 year H.W. Elev. = 246.5 including 1.0 ft. backwater
Highwater Elev. =
Highwater Elev. =

Hydrology Data:

D.A. = 24.0 sq.mi.
Q25 = 3560 cfs.
Area furnished under
Elev. 244.3 = 754 sq.ft.
Vel. = 4.72 ft/sec.
Q100 = 4930 cfs.
Area furnished under
Elev. 246 = 870 sq.ft.
Vel. = 5.67 ft/sec.

S-47 over Deep Creek
Hy 152 = Box 10'
Performed 1985
Catalog # 13006

Overtopping Flood:

Q = 8000 cfs.
Probability is outside range of data

William H. Hulbert

Used Eqn. Publish in 1982 $Q_{100} = 709A^{.61}$ (Piedmont)