Espey, Huston & Associates, Inc.

LEVEL II BRIDGE SCOUR ANALYSIS

FOR STRUCTURE 124090100100 ON ROUTE SC 901 CROSSING LITTLE ROCKY CREEK IN CHESTER COUNTY, SOUTH CAROLINA

EH&A Project No. 16139.01
EH&A File Number 16139.01 B-5

Prepared in cooperation with

South Carolina Department of Transportation

Columbia, South Carolina
January 1995

Consultant Scour Study Check List

County Chester Crossing Little Rocky CK
Road/Route SC901
Consultant Espey Huston

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	✓		
D50	✓		.3 from soil book
Skew	✓		
Q100	✓		
Q500	✓		
Discharge Method and applicability	✓		
WSPRO Cross section Locations	✓		
WSPRO Setup	✓		
Equations for Scour	✓		

LEVEL II BRIDGE SCOUR ANALYSIS

FOR STRUCTURE 124090100100 ON ROUTE SC 901 CROSSING LITTLE ROCKY CREEK IN CHESTER COUNTY, SOUTH CAROLINA

This report provides the results of the detailed Level II analysis of scour potential at bridge 124090100100 on Route SC 901 crossing Little Rocky Creek in Chester County, South Carolina. The site is located in the Piedmont physiographic province near Great Falls, South Carolina. The bridge lies at approximately 34° 35' 35" north, 080° 59' 50" west, 6 miles west of Great Falls. The contributing watershed area for this bridge is 50.0 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 right-of-way immediately upstream of the Route 901 bridge over Little Rocky Creek is strewn with cut trees and brush (refer to photo 4). During low flows these cut trees do not present a threat to the bridge. During a flood flow condition, the debris could become lodged against the bridge. During the bridge inspection, a local resident reported that a flood had occurred about two years after the bridge had been completed. The estimated year of this event is 1950. The resident stated that the water depth came to within three feet of the bridge low steel elevation.

This 210-foot reinforced concrete bridge consists of eight bents. Bents 2 through 7 consist of four steel H-piles and cross bracing (refer to photo 3). The spill-through abutments are well protected with riprap; therefore abutment scour calculations were not performed. No scour was noted during the field observations other than some erosion and sloughing of the south bank near the south abutment (refer to photo 5).

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 downstream face of the bridge ranged from 0 to 12.32 feet. The 500-year total scour depth at the downstream face of the bridge ranged from 0 to 14.98 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 downstream face of the bridge, 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 124090100100 Stream Little Rocky Creek
County Chester Route SC 901 District 4

Description of Bridge

Bridge length 210 ft Bridge width 24 ft Max span length 30 ft

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

Abutment type Spill-through Embankment type Sloping

Riprap on abutment? Yes Date of inspection October 25, 1994

Description of riprap D_{50} = 18 inches in good condition

Brief description of piers/pile bents Bents 2 through 7 consist of four steel H-piles

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 25, 1994	5	5

Potential for debris High, due to the cutting of trees in the upstream right-of-way (refer to Photo 4)

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 25, 1994

D/S left: Dense woodland

D/S right: Dense woodland

U/S left: Dense woodland

U/S right: Dense woodland

Description of Channel

Average top width 13 *ft* *Average depth* .5 *ft*

Predominant bed material Sand and pea size gravel *Bank material* Sand and clay

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

Vegetative cover on channel banks near bridge: *Date of inspection* October 25, 1994

D/S left: Dense woodland

D/S right: Dense woodland

U/S left: Dense woodland with numerous cut trees (refer to photo 4)

U/S right: Dense woodland with numerous cut trees (refer to photo 4)

Do banks appear stable? No *If not, describe location and type of instability and date of observation.* Bank is sloughing and eroding near south abutment (refer to photo 5). Banks are predominantly loose sand at upstream recreational area (refer to photo 6).

Describe any obstructions in channel and date of observation. None

Hydrology

Drainage area 50.0 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. Low potential for development

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 8900 ft^3/s Q500 12500 ft^3/s

Method used to determine discharges Regression equation for 100-year flood discharge (Ref. USGS WRIR 87-4096, "Magnitude and Frequency of Floods in Rural and Urban Basins of North Carolina", Gunter, Mason, and Stamey). SCDOT recommends using the North Carolina regression equations for bridges located in this portion of the state where the South Carolina regression equations do not apply. The 500-year discharge for this site was obtained by plotting the 2- through 100-year North Carolina regression equation results on log-probability paper, and extrapolating to obtain the 500-year discharge.

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 from the SCDOT bridge plans match the USGS quad map.

Briefly describe the survey used to develop WSPRO model. No survey was available. The stream cross section at the downstream 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	210	4	Full Valley Section
BRDG	210	1	Bridge Section
ROAD	Not Used	3	Road Section
APPR	444	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 "Great Falls, S.C." USGS quad map and from information collected during the field inspection on October 25, 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 87-4096, "Magnitude and Frequency of Floods in Rural and Urban Basins of North Carolina", Gunter, Mason, and Stamey. SCDOT recommends using the North Carolina regression equations for bridges located in this portion of the state where the South Carolina regression equations do not apply. The 500-year discharge for this site was obtained by plotting the 2- through 100-year North Carolina regression equation results on log-probability paper, and extrapolating to obtain the 500-year discharge. 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 360.30 ft

Average low steel elevation 362.00 ft

100-year discharge	8900	ft^3/s
Water-surface elevation at D/S bridge face	349.81	ft
Area of flow at D/S bridge face	1222	ft^2
Average velocity in bridge opening	7.28	ft/s
Maximum WSPRO tube velocity at bridge	10.00	ft/s

Water-surface elevation at Approach section with bridge	349.95	ft
Water-surface elevation at Approach section without bridge	350.26	ft
Amount of backwater caused by bridge	0	ft

500-year discharge	12500	ft^3/s
Water-surface elevation at D/S bridge face	351.59	ft
Area of flow at D/S bridge face	1524	ft^2
Average velocity in bridge opening	8.20	ft/s
Maximum WSPRO tube velocity at bridge	11.21	ft/s

Water-surface elevation at Approach section with bridge	351.73	ft
Water-surface elevation at Approach section without bridge	352.00	ft
Amount of backwater caused by bridge	0	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 124090100100 on SC 901 crossing Little Rocky Creek in Chester 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 8900 cubic feet per second							
Abutment	0	0	Abutment-Protected	0	325.83	N/A	N/A
2	30	8.66	3.57	12.23	325.12	331.06	5.94
3	60	8.66	3.65	12.31	324.16	332.78	8.62
4	90	8.66	3.55	12.21	323.52	331.19	7.67
5	120	0	5.64	5.64	320.87	333.26	12.39
6	150	0	5.50	5.50	323.28	334.70	11.42
7	180	4.70	3.89	8.59	321.30	337.91	16.61
Abutment	210	0	Abutment-Protected	0	334.07	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 124090100100 on SC 901 crossing Little Rocky Creek in Chester 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 12500 cubic feet per second							
Abutment	0	0	Abutment-Protected	0	325.83	N/A	N/A
2	30	10.41	3.79	14.20	325.12	329.10	3.98
3	60	10.41	4.42	14.83	324.16	330.26	6.10
4	90	10.41	4.57	14.98	323.52	328.42	4.90
5	120	0	6.15	6.15	320.87	332.75	11.88
6	150	0	5.90	5.90	323.28	334.30	11.02
7	180	6.28	4.10	10.38	321.30	336.12	14.82
Abutment	210	0	Abutment-Protected	0	334.07	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.

PROJECT 16139.01

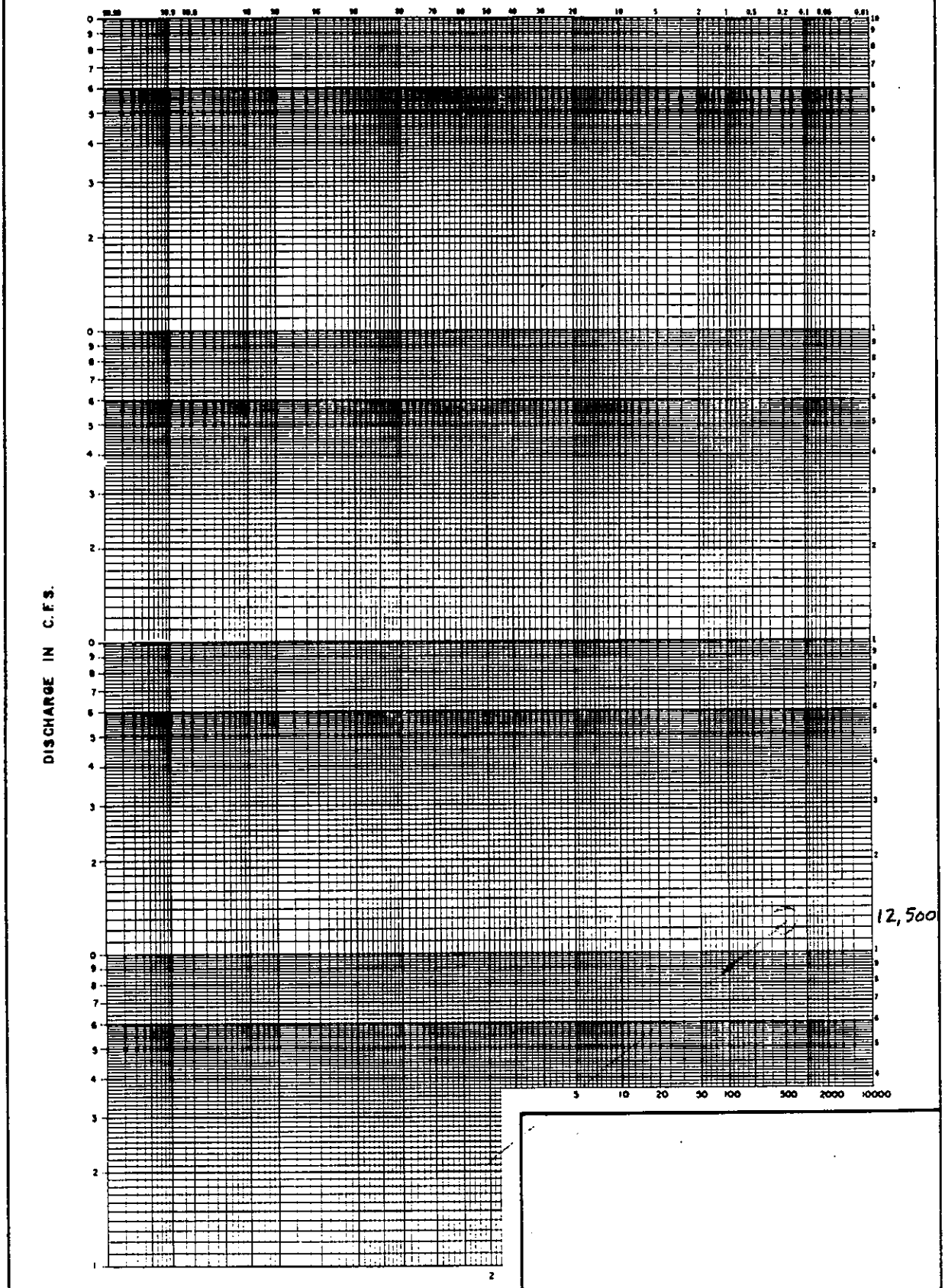
DETERMINING THE FLOOD DISCHARGES FOR VARIOUS RECURRENCE INTERVALS IN THE BLUE RIDGE-PIEDMONT HYDROLOGIC AREA OF NORTH CAROLINA

BRIDGE NUMBER 5 LITTLE ROCKY CREEK

AREA IN SQUARE FEET = 1395143390

AREA IN SQUARE MILES = 50.0

	DISCHARGE (CFS)	RECURRENCE INTERVAL (YEAR)
Q2 = 144*(AREA)^0.691	Q2 = 2151	2
Q5 = 248*(AREA)^0.670	Q5 = 3412	5
Q10 = 334*(AREA)^0.665	Q10 = 4506	10
Q25 = 467*(AREA)^0.655	Q25 = 6059	25
Q50 = 581*(AREA)^0.650	Q50 = 7392	50
Q100 = 719*(AREA)^0.643	Q100 = 8900	100
EXTRAPOLATION:	Q500 = 12500	500



ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS

WSPRO INPUT

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T2        ROUTE 901 OVER LITTLE ROCKY CREEK
T3        EH&A FILE NO. 16139.01 B-5
*         FAIRFIELD CO., SOUTH CAROLINA
*         FILE NAME: 16139W05.DAT
*         ************************************************************
J1         .5  *  *  .95
J3        5 3 13 15 23 430 446 448 * 5 17 29 30 6 16 555 * 7 14 3 11
*         ************************************************************
*          Q100   Q500
Q          8900   12500
SK        .0017  .0017
*         ************************************************************
*         CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
*         SHEET "GREAT FALLS S.C." AND FROM INFORMATION
*         COLLECTED DURING THE FIELD INSPECTION ON OCTOBER 25, 1994.
*         ELEVATIONS GIVEN ARE APPROXIMATE.  MANNINGS COEFFICIENTS
*         WERE ESTIMATED FROM FIELD OBSERVATIONS.  THIS BRIDGE FALLS
*         IN THE REGION WHERE S.C. REGIONAL REGRESSION EQUATIONS DO
*         NOT APPLY.  SCDOT SUGGESTED
*         USE OF THE N.C. REGIONAL REGRESSION EQUATIONS FOR THIS
*         AREA.  THE 100-YEAR DISCHARGE WAS CALCULATED USING N.C.
*         EQUATIONS.  THE 500-YEAR DISCHARGE WAS OBTAINED BY PLOTTING
*         THE 2- THROUGH 100-YEAR DISCHARGES ON LOG-PROBABILITY
*         PAPER, AND EXTRAPOLATING TO OBTAIN THE 500-YEAR DISCHARGE.
*         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 10
GR          1650,370.0 1700,360.0 1750,350.0 1800,342.8
GR          2028,342.8 2030,342.9
GR          2040,342.4 2046,341.8 2050,342.7 2060,344.7
GR          2070,346.0 2080,345.5 2090,343.0
GR          2099,341.5 2107,338.7 2115,337.6 2120,338.5
GR          2123,339.2 2135,339.6 2150,339.8 2160,339.1
GR          2160,339.2 2171,338.8 2175,344.3
GR          2250,350.0 2400,360.0 2550,370
N           .15       .035       .15
SA              2099       2175
*         ************************************************************
XS     FULL  210 10
GR          1400,370.0 1650,360.0 1850,350.0
GR          2028,343.2 2030,343.3
GR          2040,342.8 2046,342.2 2050,343.1 2060,345.1
GR          2070,346.4 2080,345.9 2090,343.4
GR          2099,341.9 2107,339.1 2115,337.9 2120,338.9
GR          2123,339.5 2135,340.0 2150,340.2 2160,339.5
GR          2160,339.5 2171,339.1 2175,344.7
GR          2400,360.0 2550,370
N           .15       .035       .15
SA              2099       2175
*         ************************************************************
BR     BRDG  210 362  10
GR          2001,357.6
GR          2028,343.2 2030,343.3
GR          2040,342.8 2046,342.2 2050,343.1 2060,345.1
GR          2070,346.4 2080,345.9 2090,343.4
GR          2099,341.9 2107,339.1 2115,337.9 2120,338.9
GR          2123,339.5 2135,340.0 2150,340.2 2160,339.5
GR          2160,339.5 2171,339.1 2175,344.7 2180,346.5
GR          2190,353.1 2209,363.6 2001,357.6
N           .045       .035       .045
SA              2099       2175
CD          3  24  2  360.3
PW 1        338.9,1 340.2,1 340.2,2 343.4,2 343.4,4 345.1,4 345.1,5
PW 1        346.5,5 346.5,6 362,6
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WSPRO INPUT (Cont.)

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*         ************************************************************
XR    ROAD  222  25  1  *  10
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N           .015
*         ************************************************************
AS    APPR  444  10
GR          1700,370.0 1775,360.0 1875,350
GR          2028,343.6 2030,343.7
GR          2040,343.2 2046,342.6 2050,343.5 2060,345.5
GR          2070,346.8 2080,346.3 2090,343.8
GR          2099,342.3 2107,339.5 2115,338.3 2120,339.3
GR          2123,339.9 2135,340.4 2150,340.6 2160,339.9
GR          2160,339.9 2171,339.5 2175,345.1 2180,346.9
GR          2225,360.0 2300,370
N           .15       .035       .15
SA              2099       2175
*         ************************************************************
HP 1  APPR 349.95 * 349.95
HP 1  BRDG 349.81 * 349.81
HP 2  APPR 349.95 * 349.95  8900
HP 2  BRDG 349.81 * 349.81  8900
*
HP 1  APPR 351.73 * 351.73
HP 1  BRDG 351.59 * 351.59
HP 2  APPR 351.73 * 351.73  12500
HP 2  BRDG 351.59 * 351.59  12500
EX
ER
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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: 12-21-94  13:15

   T2        ROUTE 901 OVER LITTLE ROCKY CREEK
   T3        EH&A FILE NO. 16139.01 B-5
   *         FAIRFIELD CO., SOUTH CAROLINA
   *         FILE NAME: 16139W05.DAT
   *         ************************************************************
   J1         .5  *  *  .95

 J1 RECORD PARAMETERS:
 DELTAY =  .50   YTOL =  .02   QTOL =  .02   FNTEST =  .95   IHFNOJ = -1

   J3        5 3 13 15 23 430 446 448 * 5 17 29 30 6 16 555 * 7 14 3 11
   *         ************************************************************
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   Q          8900   12500
 *** Q-DATA FOR SEC-ID, ISEQ =           1
   SK        .0017  .0017
   *         ************************************************************
   *         CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
   *         SHEET "GREAT FALLS S.C." AND FROM INFORMATION
   *         COLLECTED DURING THE FIELD INSPECTION ON OCTOBER 25, 1994.
   *         ELEVATIONS GIVEN ARE APPROXIMATE.  MANNINGS COEFFICIENTS
   *         WERE ESTIMATED FROM FIELD OBSERVATIONS.  THIS BRIDGE FALLS
   *         IN THE REGION WHERE S.C. REGIONAL REGRESSION EQUATIONS DO
   *         NOT APPLY.  SCDOT SUGGESTED
   *         USE OF THE N.C. REGIONAL REGRESSION EQUATIONS FOR THIS
   *         AREA.  THE 100-YEAR DISCHARGE WAS CALCULATED USING N.C.
   *         EQUATIONS.  THE 500-YEAR DISCHARGE WAS OBTAINED BY PLOTTING
   *         THE 2- THROUGH 100-YEAR DISCHARGES ON LOG-PROBABILITY
   *         PAPER, AND EXTRAPOLATING TO OBTAIN THE 500-YEAR DISCHARGE.
   *         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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
           *** RUN DATE & TIME: 12-21-94  13:15

 *** START PROCESSING CROSS SECTION - " EXIT"
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   GR          1650,370.0 1700,360.0 1750,350.0 1800,342.8
   GR          2028,342.8 2030,342.9
   GR          2040,342.4 2046,341.8 2050,342.7 2060,344.7
   GR          2070,346.0 2080,345.5 2090,343.0
   GR          2099,341.5 2107,338.7 2115,337.6 2120,338.5
   GR          2123,339.2 2135,339.6 2150,339.8 2160,339.1
   GR          2160,339.2 2171,338.8 2175,344.3
   GR          2250,350.0 2400,360.0 2550,370
   N           .15       .035       .15
   SA              2099       2175
   *         ************************************************************
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WSPRO OUTPUT (Cont.)

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*** 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
     10.0         0. *********       .50       .00

X-Y COORDINATE PAIRS  (NGP =  27):
       X      Y          X      Y          X      Y          X      Y
   1650.0  370.00    1700.0  360.00    1750.0  350.00    1800.0  342.80
   2028.0  342.80    2030.0  342.90    2040.0  342.40    2046.0  341.80
   2050.0  342.70    2060.0  344.70    2070.0  346.00    2080.0  345.50
   2090.0  343.00    2099.0  341.50    2107.0  338.70    2115.0  337.60
   2120.0  338.50    2123.0  339.20    2135.0  339.60    2150.0  339.80
   2160.0  339.10    2160.0  339.20    2171.0  338.80    2175.0  344.30
   2250.0  350.00    2400.0  360.00    2550.0  370.00

 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   1650.0  370.00    2115.0  337.60    2550.0  370.00    1650.0  370.00

SUBAREA BREAKPOINTS (NSA =  3):
       2099.   2175.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .150    .035    .150
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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
           *** RUN DATE & TIME: 12-21-94  13:15

*** START PROCESSING CROSS SECTION - " FULL"
  XS    FULL  210 10
  GR          1400,370.0 1650,360.0 1850,350.0
  GR          2028,343.2 2030,343.3
  GR          2040,342.8 2046,342.2 2050,343.1 2060,345.1
  GR          2070,346.4 2080,345.9 2090,343.4
  GR          2099,341.9 2107,339.1 2115,337.9 2120,338.9
  GR          2123,339.5 2135,340.0 2150,340.2 2160,339.5
  GR          2160,339.5 2171,339.1 2175,344.7
  GR          2400,360.0 2550,370
  N           .15      .035      .15
  SA              2099      2175
  *         ************************************************************

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

--- DATA SUMMARY FOR SECID " FULL" AT SRD =    210.  ERR-CODE =      0

     SKEW      IHFNO    VSLOPE        EK        CK
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X-Y COORDINATE PAIRS  (NGP =  25):
       X      Y          X      Y          X      Y          X      Y
   1400.0  370.00    1650.0  360.00    1850.0  350.00    2028.0  343.20
   2030.0  343.30    2040.0  342.80    2046.0  342.20    2050.0  343.10
   2060.0  345.10    2070.0  346.40    2080.0  345.90    2090.0  343.40
   2099.0  341.90    2107.0  339.10    2115.0  337.90    2120.0  338.90
   2123.0  339.50    2135.0  340.00    2150.0  340.20    2160.0  339.50
   2160.0  339.50    2171.0  339.10    2175.0  344.70    2400.0  360.00
   2550.0  370.00
```

WSPRO OUTPUT (Cont.)

```
 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   1400.0  370.00    2115.0  337.90    2550.0  370.00    1400.0  370.00

SUBAREA BREAKPOINTS (NSA =  3):
       2099.   2175.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .150    .035    .150
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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
           *** RUN DATE & TIME: 12-21-94  13:15

*** START PROCESSING CROSS SECTION - " BRDG"
  BR    BRDG  210 362  10
  GR          2001,357.6
  GR          2028,343.2 2030,343.3
  GR          2040,342.8 2046,342.2 2050,343.1 2060,345.1
  GR          2070,346.4 2080,345.9 2090,343.4
  GR          2099,341.9 2107,339.1 2115,337.9 2120,338.9
  GR          2123,339.5 2135,340.0 2150,340.2 2160,339.5
  GR          2160,339.5 2171,339.1 2175,344.7 2180,346.5
  GR          2190,353.1 2209,363.6 2001,357.6
  N           .045      .035      .045
  SA               2099      2175
  CD          3  24  2  360.3
  PW 1        338.9,1 340.2,1 340.2,2 343.4,2 343.4,4 345.1,4 345.1,5
  PW 1        346.5,5 346.5,6 362,6
  *          ************************************************************

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

--- DATA SUMMARY FOR SECID " BRDG" AT SRD =    210.  ERR-CODE =      0

     SKEW      IHFNO    VSLOPE        EK        CK
     10.0        0. *********       .50       .00

X-Y COORDINATE PAIRS  (NGP =  25):
       X      Y          X      Y          X      Y          X      Y
   2001.0  357.60    2028.0  343.20    2030.0  343.30    2040.0  342.80
   2046.0  342.20    2050.0  343.10    2060.0  345.10    2070.0  346.40
   2080.0  345.90    2090.0  343.40    2099.0  341.90    2107.0  339.10
   2115.0  337.90    2120.0  338.90    2123.0  339.50    2135.0  340.00
   2150.0  340.20    2160.0  339.50    2160.0  339.50    2171.0  339.10
   2175.0  344.70    2180.0  346.50    2190.0  353.10    2209.0  363.60
   2001.0  357.60

 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   2001.0  357.60    2115.0  337.90    2209.0  363.60    2209.0  363.60

SUBAREA BREAKPOINTS (NSA =  3):
       2099.   2175.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .045    .035    .045

BRIDGE PARAMETERS:
 BRTYPE  BRWDTH     LSEL  USERCD  EMBSS   EMBELV  ABSLPL  ABSLPR
    3      24.0   362.00 *******   2.00   360.30 ******* *******
```

WSPRO OUTPUT (Cont.)

```
PIER DATA:  NPW = 10    PPCD = 1.
     PELV  PWDTH      PELV  PWDTH      PELV  PWDTH      PELV  PWDTH
    338.90   1.0     340.20   1.0     340.20   2.0     343.40   2.0
    343.40   4.0     345.10   4.0     345.10   5.0     346.50   5.0
    346.50   6.0     362.00   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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
           *** RUN DATE & TIME: 12-21-94  13:15

*** START PROCESSING CROSS SECTION - " ROAD"
  XR    ROAD  222  25  1  *  10
  GR          1400,370 2000,360 2210,367.5 2300,370
  N           .015
  *          ************************************************************

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

--- DATA SUMMARY FOR SECID " ROAD" AT SRD =    222.  ERR-CODE =      0

     SKEW      IHFNO    VSLOPE        EK        CK
     10.0        0. *********       .50       .00

X-Y COORDINATE PAIRS  (NGP =   4):
       X      Y          X      Y          X      Y          X      Y
   1400.0  370.00    2000.0  360.00    2210.0  367.50    2300.0  370.00

 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   1400.0  370.00    2000.0  360.00    2300.0  370.00    1400.0  370.00

ROUGHNESS COEFFICIENTS (NSA =  1):
         .015

ROAD GRADE DATA:  IPAVE  RDWID  USERCF
                     1.   25.0 *******

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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
           *** RUN DATE & TIME: 12-21-94  13:15

*** START PROCESSING CROSS SECTION - " APPR"
  AS    APPR  444  10
  GR          1700,370.0 1775,360.0 1875,350
  GR          2028,343.6 2030,343.7
  GR          2040,343.2 2046,342.6 2050,343.5 2060,345.5
  GR          2070,346.8 2080,346.3 2090,343.8
  GR          2099,342.3 2107,339.5 2115,338.3 2120,339.3
  GR          2123,339.9 2135,340.4 2150,340.6 2160,339.9
  GR          2160,339.9 2171,339.5 2175,345.1 2180,346.9
  GR          2225,360.0 2300,370
  N           .15      .035      .15
  SA             2099      2175
  *          ************************************************************
```

WSPRO OUTPUT (Cont.)

```
  HP 1  APPR 349.95 * 349.95

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

--- DATA SUMMARY FOR SECID " APPR" AT SRD =    444.  ERR-CODE =      0

     SKEW     IHFNO    VSLOPE        EK        CK
     10.0        0. *********       .50       .00

X-Y COORDINATE PAIRS  (NGP =  26):
       X      Y          X      Y          X      Y          X      Y
   1700.0  370.00    1775.0  360.00    1875.0  350.00    2028.0  343.60
   2030.0  343.70    2040.0  343.20    2046.0  342.60    2050.0  343.50
   2060.0  345.50    2070.0  346.80    2080.0  346.30    2090.0  343.80
   2099.0  342.30    2107.0  339.50    2115.0  338.30    2120.0  339.30
   2123.0  339.90    2135.0  340.40    2150.0  340.60    2160.0  339.90
   2160.0  339.90    2171.0  339.50    2175.0  345.10    2180.0  346.90
   2225.0  360.00    2300.0  370.00

 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   1700.0  370.00    2115.0  338.30    2300.0  370.00    1700.0  370.00

SUBAREA BREAKPOINTS (NSA =  3):
       2099.   2175.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .150    .035    .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)


        ROUTE 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
          *** RUN DATE & TIME: 12-21-94  13:15
    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID =  APPR;  SRD =     444.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     854.    20921.   219.   220.                     9559.
             2     736.   139263.    75.    79.                    13095.
             3      35.      591.    15.    16.                      303.
   349.95         1625.   160775.   310.   315.  3.18  1876.  2190.  11855.
1
  HP 1  BRDG 349.81 * 349.81
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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
          *** RUN DATE & TIME: 12-21-94  13:15
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID =  BRDG;  SRD =     210.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     438.    43335.    82.    85.                     5735.
             2     755.   145453.    75.    79.                    13618.
             3      29.     1802.    10.    11.                      281.
   349.81         1222.   190590.   167.   174.  1.26  2016.  2185.  16744.
1
  HP 2  APPR 349.95 * 349.95  8900
```

WSPRO OUTPUT (Cont.)

```
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 901 OVER LITTLE ROCKY CREEK
         EH&A FILE NO. 16139.01 B-5
            *** RUN DATE & TIME: 12-21-94  13:15


     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID =  APPR;  SRD =     444.

          WSEL     LEW     REW    AREA        K        Q    VEL
        349.95  1876.2  2190.5  1625.0   160775.    8900.   5.48

  X STA.      1876.2     2021.3     2061.7     2101.6     2106.3     2110.2
    A(I)           433.7      247.0      193.9       43.4       40.7
    V(I)            1.03       1.80       2.30      10.26      10.94

  X STA.      2110.2     2113.6     2117.0     2120.7     2124.7     2128.9
    A(I)           37.9       37.9       40.0       40.5       40.6
    V(I)          11.75      11.75      11.12      10.99      10.95

  X STA.      2128.9     2133.2     2137.6     2142.2     2146.8     2151.4
    A(I)           41.1       41.7       42.7       42.8       42.2
    V(I)          10.84      10.68      10.43      10.39      10.55

  X STA.      2151.4     2155.8     2160.0     2164.0     2168.0     2190.5
    A(I)           41.7       41.5       39.7       40.1       96.2
    V(I)          10.67      10.72      11.22      11.09       4.63
1
    HP 2  BRDG 349.81 * 349.81  8900
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 901 OVER LITTLE ROCKY CREEK
         EH&A FILE NO. 16139.01 B-5
            *** RUN DATE & TIME: 12-21-94  13:15


     VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID =  BRDG;  SRD =     210.

          WSEL     LEW     REW    AREA        K        Q    VEL
        349.81  2015.6  2185.0  1222.1   190590.    8900.   7.28

  X STA.      2015.6     2038.0     2049.4     2070.4     2093.4     2102.2
    A(I)           106.3       81.1      101.3      107.8       67.9
    V(I)            4.19       5.49       4.39       4.13       6.56

  X STA.      2102.2     2107.3     2111.5     2115.4     2119.4     2123.9
    A(I)           49.7       46.0       44.5       45.0       47.3
    V(I)           8.96       9.68      10.00       9.89       9.42

  X STA.      2123.9     2128.5     2133.5     2138.6     2143.7     2148.9
    A(I)           46.7       48.8       48.7       48.8       50.3
    V(I)           9.52       9.12       9.14       9.11       8.85

  X STA.      2148.9     2154.0     2158.9     2163.6     2168.1     2185.0
    A(I)           48.4       48.8       47.4       46.5       90.9
    V(I)           9.19       9.11       9.39       9.57       4.90
1
    *
```

WSPRO OUTPUT (Cont.)

```
   HP 1  APPR 351.73 * 351.73
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 901 OVER LITTLE ROCKY CREEK
         EH&A FILE NO. 16139.01 B-5
            *** RUN DATE & TIME: 12-21-94  13:15
     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID =  APPR;  SRD =     444.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1    1261.   38004.   238.   239.                      16489.
              2     869.  183766.    75.    79.                      16808.
              3      68.    1410.    21.    22.                        685.
    351.73         2198.  223180.   334.   340.  3.59  1858.  2197.  16905.
1
   HP 1  BRDG 351.59 * 351.59
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 901 OVER LITTLE ROCKY CREEK
         EH&A FILE NO. 16139.01 B-5
            *** RUN DATE & TIME: 12-21-94  13:15
     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID =  BRDG;  SRD =     210.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     587.   68629.    85.    88.                       8729.
              2     889.  190674.    75.    79.                      17375.
              3      49.    3651.    13.    14.                        547.
    351.59         1524.  262954.   173.   181.  1.24  2012.  2188.  23031.
1
   HP 2  APPR 351.73 * 351.73  12500
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 901 OVER LITTLE ROCKY CREEK
         EH&A FILE NO. 16139.01 B-5
            *** RUN DATE & TIME: 12-21-94  13:15


     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID =  APPR;  SRD =     444.

         WSEL     LEW     REW    AREA        K        Q    VEL
       351.73  1857.7  2196.6  2198.1  223180.   12500.   5.69

 X STA.      1857.7     1998.8     2037.0     2085.0     2102.5     2107.3
   A(I)           541.5      288.3      318.3      147.7       54.9
   V(I)            1.15       2.17       1.96       4.23      11.39

 X STA.      2107.3     2111.2     2115.0     2118.7     2122.9     2127.3
   A(I)            48.3       48.8       48.2       50.0       51.0
   V(I)           12.94      12.82      12.97      12.49      12.25

 X STA.      2127.3     2131.7     2136.3     2141.1     2145.9     2150.6
   A(I)            50.6       51.4       52.6       52.8       52.0
   V(I)           12.34      12.16      11.88      11.83      12.03

 X STA.      2150.6     2155.3     2159.7     2164.0     2168.2     2196.6
   A(I)            52.5       50.9       50.4       49.3      138.8
```

WSPRO OUTPUT (Cont.)

```
   V(I)           11.91      12.29      12.40      12.69      4.50
1
   HP 2  BRDG 351.59 * 351.59  12500
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 901 OVER LITTLE ROCKY CREEK
         EH&A FILE NO. 16139.01 B-5
            *** RUN DATE & TIME: 12-21-94  13:15


     VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID =  BRDG;  SRD =     210.

         WSEL     LEW     REW    AREA        K        Q    VEL
       351.59  2012.3  2187.7  1524.3  262954.   12500.   8.20

 X STA.      2012.3     2036.7     2047.4     2061.4     2084.7     2097.0
   A(I)           137.6       94.6      105.1      131.0       99.8
   V(I)            4.54       6.61       5.95       4.77       6.27

 X STA.      2097.0     2104.1     2109.0     2113.3     2117.6     2122.2
   A(I)            71.7       59.7       55.8       56.8       57.0
   V(I)            8.72      10.47      11.21      11.00      10.96

 X STA.      2122.2     2127.1     2132.3     2137.6     2142.9     2148.2
   A(I)            58.0       60.6       60.5       60.7       59.6
   V(I)           10.77      10.31      10.32      10.30      10.48

 X STA.      2148.2     2153.6     2158.8     2163.6     2168.5     2187.7
   A(I)            61.1       59.9       58.0       59.2      117.5
   V(I)           10.23      10.43      10.77      10.55       5.32
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 901 OVER LITTLE ROCKY CREEK
         EH&A FILE NO. 16139.01 B-5
            *** RUN DATE & TIME: 12-21-94  13:15

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

  EXIT:XS   ******  1754.    2972.   .67 *****  350.12  346.34   8900.  349.45
         0. ******  2243.  215776.  4.81 ***** *******     .47    2.99

  FULL:FV     210.  1862.    1809.  1.39   .47  350.95 *******   8900.  349.56
       210.   210.  2246.  164492.  3.69   .36     .00     .76    4.92
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  APPR:AS     234.  1872.    1721.  1.36   .66  351.61 *******   8900.  350.26
       444.   234.  2192.  170848.  3.26   .00     .01     .70    5.17
          <<<<<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
```

WSPRO OUTPUT (Cont.)

```
 BRDG:BR     210.  2016.    1221.   .84   .50  350.65  347.30   8900.  349.81
      210.   210.  2185.  190434.  1.02   .03     .01     .48    7.29

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3.   1.   1.   .990   .034  362.00 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    ROAD:RG     222.        <<<<<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     210.  1876.    1626.  1.48   .68  351.43  347.78   8900.  349.95
      444.   213.  2190.  160890.  3.18   .10    -.01     .75    5.47

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       .472   .048  153461.  2020.  2189.   349.32

                  <<<<<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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
          *** RUN DATE & TIME: 12-21-94  13:15
  FIRST USER DEFINED TABLE.

    XSID:CODE       Q    WSEL     VEL    CRWS    YMIN
    EXIT:XS      8900.  349.45    2.99  346.34  337.60
    FULL:FV      8900.  349.56    4.92******** 337.90
    BRDG:BR      8900.  349.81    7.29  347.30  337.90
    ROAD:RG         0.********    1.00******** 360.00

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

    XSID:CODE       Q    WSEL     VEL    CRWS    YMIN
    APPR:AS      8900.  349.95    5.47  347.78  338.30
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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
          *** RUN DATE & TIME: 12-21-94  13:15
  SECOND USER DEFINED TABLE.

    XSID:CODE       Q     AREA    LEW    REW    SRD        K
    EXIT:XS      8900.    2972.  1754.  2243.     0.  215776.
    FULL:FV      8900.    1809.  1862.  2246.   210.  164492.
    BRDG:BR      8900.    1221.  2016.  2185.   210.  190434.
    ROAD:RG         0.**********************   222.*********
    APPR:AS      8900.    1626.  1876.  2190.   444.  160890.

    XSID:CODE    OTEL
    APPR:AS    349.32
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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
           *** RUN DATE & TIME: 12-21-94  13:15
  THIRD USER DEFINED TABLE.

    XSID:CODE     EGL     FR#    WSEL    HF
    EXIT:XS     350.12     .47  349.45******
    FULL:FV     350.95     .76  349.56   .47
    BRDG:BR     350.65     .48  349.81   .50
    ROAD:RG  ******************************
    APPR:AS     351.43     .75  349.95   .68
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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
           *** RUN DATE & TIME: 12-21-94  13:15

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

 EXIT:XS    ******  1744.    3895.   .79 *****  352.09  347.52  12500.  351.30
        0. ******  2269.  303042.  4.96 ***** *******     .46    3.21

 FULL:FV     210.   1823.    2542.  1.65   .47  352.99 *******  12500.  351.34
      210.   210.   2273.  230121.  4.38   .43     .00     .76    4.92
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPR:AS     234.   1855.    2288.  1.69   .68  353.69 *******  12500.  352.00
      444.   234.   2198.  233471.  3.64   .02     .00     .71    5.46
          <<<<<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     210.   2012.    1524.  1.12   .52  352.71  348.65  12500.  351.59
      210.   210.   2188.  262893.  1.08   .10     .01     .50    8.20

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       3.   1.   1.    .964   .034  362.00 ****** ****** ******

    XSID:CODE     SRD   FLEN     HF    VHD     EGL     ERR       Q    WSEL
    ROAD:RG      222.         <<<<<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     210.   1858.    2198.  1.80   .72  353.53  349.42  12500.  351.73
      444.   213.   2197.  223115.  3.59   .09    -.02     .74    5.69

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       .490   .072  207683.  2017.  2192.   351.08

                   <<<<<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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
           *** RUN DATE & TIME: 12-21-94  13:15
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WSPRO OUTPUT (Cont.)

```
 FIRST USER DEFINED TABLE.

   XSID:CODE       Q    WSEL     VEL    CRWS    YMIN
   EXIT:XS     12500.  351.30    3.21  347.52  337.60
   FULL:FV     12500.  351.34    4.92******** 337.90
   BRDG:BR     12500.  351.59    8.20  348.65  337.90
   ROAD:RG         0.********    1.00******** 360.00

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

   XSID:CODE       Q    WSEL     VEL    CRWS    YMIN
   APPR:AS     12500.  351.73    5.69  349.42  338.30
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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
           *** RUN DATE & TIME: 12-21-94  13:15
  SECOND USER DEFINED TABLE.

   XSID:CODE       Q     AREA    LEW    REW    SRD        K
   EXIT:XS     12500.    3895.  1744.  2269.    0.  303042.
   FULL:FV     12500.    2542.  1823.  2273.  210.  230121.
   BRDG:BR     12500.    1524.  2012.  2188.  210.  262893.
   ROAD:RG         0.************************  222.*********
   APPR:AS     12500.    2198.  1858.  2197.  444.  223115.

   XSID:CODE    OTEL
   APPR:AS    351.08
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 901 OVER LITTLE ROCKY CREEK
        EH&A FILE NO. 16139.01 B-5
           *** RUN DATE & TIME: 12-21-94  13:15
   THIRD USER DEFINED TABLE.

   XSID:CODE     EGL     FR#    WSEL    HF
   EXIT:XS     352.09     .46  351.30******
   FULL:FV     352.99     .76  351.34   .47
   BRDG:BR     352.71     .50  351.59   .52
   ROAD:RG  ******************************
   APPR:AS     353.53     .74  351.73   .72
  ER

1  NORMAL  END  OF  WSPRO  EXECUTION.
```

SCDOT BRIDGE SCOUR
Saved As: 16139A05.WQ1
JOB NO. 16139.01 B-5
BRIDGE NO. 124090100100
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	736
TOPW	APPR. MAIN CHANNEL TOP WIDTH (ft)	75
Ym	APPR. MAIN CHANNEL AVG. DEPTH = AREAm/TOPW	9.81
HFa	APPR. HEAD LOSS DUE TO FRICTION	0.66
DIST	DISTANCE FROM BRIDGE TO APPR.	234
Sf	AVG. UNCONSTRICTED ENERGY SLOPE = HFa/DIST	0.00282
Km	APPR. MAIN CHANNEL CONVEYANCE	139263
Vm	APPR. MAIN CHANNEL AVG. VELOCITY (fps)	10.05
	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	854
TOPW	LEFT OVERBANK TOP WIDTH (ft)	219
Yl	APPR. LEFT OVERBANK AVG. DEPTH (ft)	3.90
Kl	LEFT OVERBANK CONVEYANCE	20921
Vl	APPR. LEFT OVERBANK AVG. VELOCITY (fps)	1.30
	Vl = (Kl*(Sf)^.5)/AREAl	

RIGHT OVERBANK:

THERE IS NO RIGHT OVERBANK AT THE BRIDGE

SCDOT BRIDGE SCOUR
Saved As: 16139A05.WQ1
JOB NO. 16139.01 B-5
BRIDGE NO. 124090100100
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= 1.23 fps

(2) LEFT OVERBANK CRITICAL VELOCITY (Vcl):
NEILL'S EQ;
Vcl=1.58*((Ssl-1)*g*D50l)^1/2*(Yl/D50l)^1/6
Vcl= 1.06 fps

(3) RIGHT OVERBANK CRITICAL VELOCITY (Vcr):

THERE IS NO RIGHT OVERBANK AT THE BRIDGE

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

SCDOT BRIDGE SCOUR
Saved As: 16139A05.WQ1
JOB NO. 16139.01 B-5
BRIDGE NO. 124090100100
BY/CHK: ABS/JNP

ESPEY, HUSTON & ASSOC., INC
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	8900
Q	TOTAL DISCHARGE(cfs) BRIDGE	8900
Ktot(APP)	APP. TOTAL CONVEYANCE	160775
Ktot(BR)	BR. TOTAL CONVEYANCE	190590
Sf	AVG. UNCONSTRICTED ENERGY SLOPE	0.00282
MAIN CHANNEL:		
Km(APP)	APP. MAIN CHANNEL CONVEYANCE	139263
W1m(APP)	APP. MAIN CHANNEL WIDTH(ft)	75
Am(APP)	APP. MAIN CHANNEL AREA	736
TOPWm(APP)	APP. MAIN CHANNEL TOP WIDTH(ft)	75
Y1m(APP)	AVG. DEPTH IN UPSTR MAIN CHANNEL(ft)	9.81
WETPm(APP)	APP. MAIN CHANNEL WETTED PERIM.(ft)	79
Km(BR)	BR. MAIN CHANNEL CONVEYANCE	145453
W2m(BR)	BR. MAIN CHANNEL WIDTH MINUS PIER WIDTHS(ft)	74
LEFT OVERBANK:		
Kl(APP)	APP. LEFT OVERBANK CONVEYANCE	20921
W1l(APP)	APP. LEFT OVERBANK WIDTH(ft)	219
Al(APP)	APP. LEFT OVERBANK AREA(ft^2)	854
TOPWl(APP)	APP. LEFT OVERBANK TOP WIDTH(ft)	219
Y1l(APP)	AVG. DEPTH IN UPSTR LEFT OVERBANK (ft)	3.90
WETPl(APP)	APP. LEFT OVERBANK WETTED PERIM.(ft)	220
Kl(BR)	BR. LEFT OVERBANK CONVEYANCE	43335
W2l(BR)	BR. LEFT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	80.4

SCDOT BRIDGE SCOUR
Saved As: 16139A05.WQ1
JOB NO. 16139.01 B-5
BRIDGE NO. 124090100100
BY/CHK: ABS/JNP

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

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= 9.32 ft

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

SHEARm=Ywater*Rm*Sf
SHEARm= 1.64 lb/sf

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

Vm*=(SHEARm/p)^.5
Vm*= 0.92 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= 30.64
K1= 0.69

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

Q1m=Q*(Km(APP)/Ktot(APP))
Q1m= 7709 cfs

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

Q2m=Q*(Km(BR)/Ktot(BR))
Q2m= 6792 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2m/Y1m=(Q2m/Q1m)^6/7*(W1m/W2m)^K1
Y2m= 8.89 ft

(j) MAIN CONTRACTION SCOUR DEPTH (Ysm):
Ysm=Y2m-Y1m
Ysm= -0.93 ft

SCDOT BRIDGE SCOUR
Saved As: 16139A05.WQ1
JOB NO. 16139.01 B-5
BRIDGE NO. 124090100100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100

2. LEFT OVERBANK CONTRACTION SCOUR (Ysl):

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

Rl=Al(APP)/WETPl(APP)
Rl= 3.88 ft

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

SHEARl=Ywater*Rl*Sf
SHEARl= 0.68 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= 19.78
K1= 0.69

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

Q1l=Q*(Kl(APP)/Ktot(APP))
Q1l= 1158 cfs

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

Q2l=Q*(Kl(BR)/Ktot(BR))
Q2l= 2024 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2l/Y1l=(Q2l/Q1l)^6/7*(W1l/W2l)^K1
Y2l= 12.56 ft

(j) LEFT OVERBANK CONTRACTION SCOUR DEPTH (Ysl):
Ysl=Y2l-Y1l
Ysl= 8.66 ft

SCDOT BRIDGE SCOUR
Saved As: 16139A05.WQ1
JOB NO. 16139.01 B-5
BRIDGE NO. 124090100100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100

III. LOCAL SCOUR AT PIERS

(A) INPUT FROM WSPRO

VARIABLE		DESCRIPTION	VALUE
PIER #2:	WSPRO STA	2030	
A2		AREA OF CONVEYANCE TUBE AT PIER #2 (sf)	106.3
V2		VELOCITY IN CONVEYANCE TUBE AT PIER #2 (fps)	4.19
TOPW2		TOPWIDTH OF CONVEYANCE TUBE AT PIER #2 (ft)	22.4
Y2		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #2 (ft)	4.75
PIER #3:	WSPRO STA	2060	
A3		AREA OF CONVEYANCE TUBE AT PIER #3 (sf)	101.3
V3		VELOCITY IN CONVEYANCE TUBE AT PIER #3 (fps)	4.39
TOPW3		TOPWIDTH OF CONVEYANCE TUBE AT PIER #3 (ft)	21
Y3		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #3 (ft)	4.82
PIER #4:	WPSRO STA	2090	
A4		AREA OF CONVEYANCE TUBE AT PIER #4 (sf)	107.8
V4		VELOCITY IN CONVEYANCE TUBE AT PIER #4 (fps)	4.13
TOPW4		TOPWIDTH OF CONVEYANCE TUBE AT PIER #4 (ft)	23
Y4		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #4 (ft)	4.69
PIER #5:	WSPRO STA	2120	
A5		AREA OF CONVEYANCE TUBE AT PIER #5 (sf)	47.3
V5		VELOCITY IN CONVEYANCE TUBE AT PIER #5 (fps)	9.42
TOPW5		TOPWIDTH OF CONVEYANCE TUBE AT PIER #5 (ft)	4.5
Y5		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #5 (ft)	10.51
PIER #6:	WSPRO STA	2150	
A6		AREA OF CONVEYANCE TUBE AT PIER #6 (sf)	48.4
V6		VELOCITY IN CONVEYANCE TUBE AT PIER #6 (fps)	9.19
TOPW6		TOPWIDTH OF CONVEYANCE TUBE AT PIER #6 (ft)	5.1
Y6		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #6 (ft)	9.49
PIER #7:	WSPRO STA	2180	
A7		AREA OF CONVEYANCE TUBE AT PIER #7 (sf)	90.9
V7		VELOCITY IN CONVEYANCE TUBE AT PIER #7 (fps)	4.9
TOPW7		TOPWIDTH OF CONVEYANCE TUBE AT PIER #7 (ft)	16.9
Y7		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #7 (ft)	5.38

SCDOT BRIDGE SCOUR
Saved As: 16139A05.WQ1
JOB NO. 16139.01 B-5
BRIDGE NO. 124090100100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100

(B) CALCULATIONS (LOCAL SCOUR AT PIERS)

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

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR2=V2/(g*Y2)^.5=	0.34	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(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=	3.57 ft	

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

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR3=V3/(g*Y3)^.5=	0.35	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(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=	3.65 ft	

3. SCOUR DEPTH AT PIER #4 (Ys#4):

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR4=V4/(g*Y4)^.5=	0.34	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(e)	K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1
(f)	CSU EQ. FOR PIER SCOUR;		
	Ys#4=Y4*2*K1*K2*K3*(a/Y4)^.65*FR4^.43		
	Ys#4=	3.55 ft	

SCDOT BRIDGE SCOUR
Saved As: 16139A05.WQ1
JOB NO. 16139.01 B-5
BRIDGE NO. 124090100100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100

4. SCOUR DEPTH AT PIER #5 (Ys#5):

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR5=V5/(g*Y5)^.5=	0.51	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(e)	K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1
(f)	CSU EQ. FOR PIER SCOUR;		
	Ys#5=Y5*2*K1*K2*K3*(a/Y5)^.65*FR5^.43		
	Ys#5=	5.64 ft	

5. SCOUR DEPTH AT PIER #6 (Ys#6):

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR6=V6/(g*Y6)^.5=	0.53	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(e)	K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1
(f)	CSU EQ. FOR PIER SCOUR;		
	Ys#6=Y6*2*K1*K2*K3*(a/Y6)^.65*FR6^.43		
	Ys#6=	5.50 ft	

6. SCOUR DEPTH AT PIER #7 (Ys#7):

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR7=V7/(g*Y7)^.5=	0.37	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7,TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(e)	K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1
(f)	CSU EQ. FOR PIER SCOUR;		
	Ys#7=Y7*2*K1*K2*K3*(a/Y7)^.65*FR7^.43		
	Ys#7=	3.89 ft	

SCDOT BRIDGE SCOUR
Saved As: 16139A05.WQ1
JOB NO. 16139.01 B-5
BRIDGE NO. 124090100100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100

IV. ABUTMENT SCOUR :

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED

SCDOT BRIDGE SCOUR
Saved As: 16139B05.WQ1
JOB NO. 16139.01 B-5
BRIDGE NO. 124090100100
BY/CHK: ABS/JNP

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

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	869
TOPW	APPR. MAIN CHANNEL TOP WIDTH (ft)	75
Ym	APPR. MAIN CHANNEL AVG. DEPTH = AREAm/TOPW	11.59
HFa	APPR. HEAD LOSS DUE TO FRICTION	0.68
DIST	DISTANCE FROM BRIDGE TO APPR.	234
Sf	AVG. UNCONSTRICTED ENERGY SLOPE = HFa/DIST	0.00291
Km	APPR. MAIN CHANNEL CONVEYANCE	183766
Vm	APPR. MAIN CHANNEL AVG. VELOCITY (fps)	11.40
	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	1261
TOPW	LEFT OVERBANK TOP WIDTH (ft)	238
Yl	APPR. LEFT OVERBANK AVG. DEPTH (ft)	5.30
Kl	LEFT OVERBANK CONVEYANCE	38004
Vl	APPR. LEFT OVERBANK AVG. VELOCITY (fps)	1.62
	Vl = (Kl*(Sf)^.5)/AREAl	

RIGHT OVERBANK:

THERE IS NO RIGHT OVERBANK AT THE BRIDGE

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460 McLAWS CIRCLE, SUITE 150
WILLIAMSBURG, VA 23185

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= 1.27 fps

(2) LEFT OVERBANK CRITICAL VELOCITY (Vcl):
NEILL'S EQ;
Vcl=1.58*((Ssl-1)*g*D50l)^1/2*(Yl/D50l)^1/6
Vcl= 1.11 fps

(3) RIGHT OVERBANK CRITICAL VELOCITY (Vcr):

THERE IS NO RIGHT OVERBANK AT THE BRIDGE

NOTES: LIVE-BED SCOUR WILL BE COMPUTED FOR THE MAIN CHANNEL.
LIVE-BED SCOUR WILL BE COMPUTED FOR THE LEFT 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	12500
Q	TOTAL DISCHARGE(cfs) BRIDGE	12500
Ktot(APP)	APP. TOTAL CONVEYANCE	223180
Ktot(BR)	BR. TOTAL CONVEYANCE	262954
Sf	AVG. UNCONSTRICTED ENERGY SLOPE	0.00291
MAIN CHANNEL:		
Km(APP)	APP. MAIN CHANNEL CONVEYANCE	183766
W1m(APP)	APP. MAIN CHANNEL WIDTH(ft)	75
Am(APP)	APP. MAIN CHANNEL AREA	869
TOPWm(APP)	APP. MAIN CHANNEL TOP WIDTH(ft)	75
Y1m(APP)	AVG. DEPTH IN UPSTR MAIN CHANNEL(ft)	11.59
WETPm(APP)	APP. MAIN CHANNEL WETTED PERIM.(ft)	79
Km(BR)	BR. MAIN CHANNEL CONVEYANCE	190674
W2m(BR)	BR. MAIN CHANNEL WIDTH MINUS PIER WIDTHS(ft)	74
LEFT OVERBANK:		
Kl(APP)	APP. LEFT OVERBANK CONVEYANCE	38004
W1l(APP)	APP. LEFT OVERBANK WIDTH(ft)	238
Al(APP)	APP. LEFT OVERBANK AREA(ft^2)	1261
TOPWl(APP)	APP. LEFT OVERBANK TOP WIDTH(ft)	238
Y1l(APP)	AVG. DEPTH IN UPSTR LEFT OVERBANK (ft)	5.30
WETPl(APP)	APP. LEFT OVERBANK WETTED PERIM.(ft)	239
Kl(BR)	BR. LEFT OVERBANK CONVEYANCE	68629
W2l(BR)	BR. LEFT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	83.7

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(B) CALCULATIONS (CONTRACTION SCOUR)

1. MAIN CHANNEL CONTRACTION SCOUR (Ysm):

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

Rm=Am(APP)/WETPm(APP)
Rm= 11.00 ft

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

SHEARm=Ywater*Rm*Sf
SHEARm= 1.99 lb/sf

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

Vm*=(SHEARm/p)^.5
Vm*= 1.01 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= 33.80
K1= 0.69

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

Q1m=Q*(Km(APP)/Ktot(APP))
Q1m= 10292 cfs

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

Q2m=Q*(Km(BR)/Ktot(BR))
Q2m= 9064 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2m/Y1m=(Q2m/Q1m)^6/7*(W1m/W2m)^K1
Y2m= 10.49 ft

(j) MAIN CONTRACTION SCOUR DEPTH (Ysm):
Ysm=Y2m-Y1m
Ysm= -1.10 ft

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2. LEFT OVERBANK CONTRACTION SCOUR (Ysl):

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

Rl=Al(APP)/WETPl(APP)
Rl= 5.28 ft

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

SHEARl=Ywater*Rl*Sf
SHEARl= 0.96 lb/sf

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

Vl*=(SHEARl/p)^.5
Vl*= 0.70 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= 23.41
K1= 0.69

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

Q1l=Q*(Kl(APP)/Ktot(APP))
Q1l= 2129 cfs

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

Q2l=Q*(Kl(BR)/Ktot(BR))
Q2l= 3262 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2l/Y1l=(Q2l/Q1l)^6/7*(W1l/W2l)^K1
Y2l= 15.71 ft

(j) LEFT OVERBANK CONTRACTION SCOUR DEPTH (Ysl):
Ysl=Y2l-Y1l
Ysl= 10.41 ft

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III. LOCAL SCOUR AT PIERS

(A) INPUT FROM WSPRO

VARIABLE		DESCRIPTION	VALUE
PIER #2:	WSPRO STA	2030	
A2		AREA OF CONVEYANCE TUBE AT PIER #2 (sf)	137.6
V2		VELOCITY IN CONVEYANCE TUBE AT PIER #2 (fps)	4.54
TOPW2		TOPWIDTH OF CONVEYANCE TUBE AT PIER #2 (ft)	24.4
Y2		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #2 (ft)	5.64
PIER #3:	WSPRO STA	2060	
A3		AREA OF CONVEYANCE TUBE AT PIER #3 (sf)	105.1
V3		VELOCITY IN CONVEYANCE TUBE AT PIER #3 (fps)	5.95
TOPW3		TOPWIDTH OF CONVEYANCE TUBE AT PIER #3 (ft)	14
Y3		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #3 (ft)	7.51
PIER #4:	WPSRO STA	2090	
A4		AREA OF CONVEYANCE TUBE AT PIER #4 (sf)	99.8
V4		VELOCITY IN CONVEYANCE TUBE AT PIER #4 (fps)	6.27
TOPW4		TOPWIDTH OF CONVEYANCE TUBE AT PIER #4 (ft)	12.3
Y4		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #4 (ft)	8.11
PIER #5:	WSPRO STA	2120	
A5		AREA OF CONVEYANCE TUBE AT PIER #5 (sf)	57
V5		VELOCITY IN CONVEYANCE TUBE AT PIER #5 (fps)	10.96
TOPW5		TOPWIDTH OF CONVEYANCE TUBE AT PIER #5 (ft)	4.6
Y5		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #5 (ft)	12.39
PIER #6:	WSPRO STA	2150	
A6		AREA OF CONVEYANCE TUBE AT PIER #6 (sf)	61.1
V6		VELOCITY IN CONVEYANCE TUBE AT PIER #6 (fps)	10.23
TOPW6		TOPWIDTH OF CONVEYANCE TUBE AT PIER #6 (ft)	5.4
Y6		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #6 (ft)	11.31
PIER #7:	WSPRO STA	2180	
A7		AREA OF CONVEYANCE TUBE AT PIER #7 (sf)	117.5
V7		VELOCITY IN CONVEYANCE TUBE AT PIER #7 (fps)	5.32
TOPW7		TOPWIDTH OF CONVEYANCE TUBE AT PIER #7 (ft)	19.2
Y7		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #7 (ft)	6.12

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(B) CALCULATIONS (LOCAL SCOUR AT PIERS)

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

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR2=V2/(g*Y2)^.5=	0.34	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(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= 3.79 ft		

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

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR3=V3/(g*Y3)^.5=	0.38	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(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= 4.42 ft		

3. SCOUR DEPTH AT PIER #4 (Ys#4):

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR4=V4/(g*Y4)^.5=	0.39	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(e)	K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1
(f)	CSU EQ. FOR PIER SCOUR;		
	Ys#4=Y4*2*K1*K2*K3*(a/Y4)^.65*FR4^.43		
	Ys#4= 4.57 ft		

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4. SCOUR DEPTH AT PIER #5 (Ys#5):

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR5=V5/(g*Y5)^.5=	0.55	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(e)	K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1
(f)	CSU EQ. FOR PIER SCOUR;		
	Ys#5=Y5*2*K1*K2*K3*(a/Y5)^.65*FR5^.43		
	Ys#5= 6.15 ft		

5. SCOUR DEPTH AT PIER #6 (Ys#6):

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR6=V6/(g*Y6)^.5=	0.54	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(e)	K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1
(f)	CSU EQ. FOR PIER SCOUR;		
	Ys#6=Y6*2*K1*K2*K3*(a/Y6)^.65*FR6^.43		
	Ys#6= 5.90 ft		

6. SCOUR DEPTH AT PIER #7 (Ys#7):

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR7=V7/(g*Y7)^.5=	0.38	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7,TBL2,PG40)=		1
(d)	K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.5
(e)	K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1
(f)	CSU EQ. FOR PIER SCOUR;		
	Ys#7=Y7*2*K1*K2*K3*(a/Y7)^.65*FR7^.43		
	Ys#7= 4.10 ft		

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IV. ABUTMENT SCOUR :

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED

Photo 1: *View Looking north. Downstream is to the right.*

Photo 2: *View looking south. Downstream is to the left.*

Photo 3: ***View of upstream face.***

Photo 4: ***Upstream face showing debris in foreground and background.***

Photo 5: *Erosion and sloughing of bank near south abutment.*

Photo 6: *Loose sandy bank at recreational area upstream of bridge (view from approach section).*

Photo 7: *View looking downstream from approach section.*

Photo 8: *View looking downstream from approach section.*

Photo 9: *Upstream view from near bridge.*

Photo 10: *Debris accumulation at bent 6.*

Photo 11: *Upstream view from exit section.*

Photo 12: *Downstream view from exit section.*