Espey, Huston & Associates, Inc.

LEVEL II BRIDGE SCOUR ANALYSIS

FOR STRUCTURE 124000900200 ON ROUTE SC 9 CROSSING TURKEY CREEK IN CHESTER COUNTY, SOUTH CAROLINA

EH&A Project No. 16139.01
EH&A File Number 16139.01 B-2

Prepared in cooperation with

South Carolina Department of Transportation

Columbia, South Carolina
January 1995

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FOR STRUCTURE 124000900200 ON ROUTE SC 9 CROSSING TURKEY CREEK IN CHESTER COUNTY, SOUTH CAROLINA

This report provides the results of the detailed Level II analysis of scour potential at bridge 124000900200 on Route SC 9 crossing Turkey Creek in Chester County, South Carolina. The site is located in the Piedmont physiographic province near Lockhart, South Carolina. The bridge lies at approximately 34° 46' 35" north, 081° 25' 57" west, 1.5 miles east of Lockhart. The contributing watershed area for this bridge is 142.5 mi^2. The watershed is rural, consisting of forest and farmland. In the vicinity of the bridge, the floodplain consists of pasture, woodland, and brush.

The floodplains adjacent to the bridge over Turkey Creek consists of open areas which will provide little resistance to flood flow (refer to photos 8 and 9).

This 315-foot bridge consists of fourteen bents. Bents 1 and 14 are at the abutments, and bents 2, 3, 4, and 9 through 13 consist of seven 1-foot diameter timbers, with cross supports. Bents 5 and 6, and 7 and 8 form tower bents, (refer to the bridge drawings and photos 4, 5, and 6). The western floodplain at the approach is contributing to the abutment scour, (refer to photo 13). This large scour hole is about 50 feet wide and 100 feet long. The abutments are protected by D_{50}= 18 in. riprap. The abutment scour at the western abutment dictates that appropriate abutment scour calculations be 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 downstream face of the bridge ranged from 0 to 46.7 feet. The 500-year total scour depth at the downstream face of the bridge ranged from 0 to 53.05 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 124000900200 *Stream* Turkey Creek
County Chester *Route* SC 9 *District* 4

Description of Bridge

Bridge length 315 *ft* *Bridge width* 34.6 *ft* *Max span length* 64 *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* November 13, 1994

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

Brief description of piers/pile bents Bents 2, 3 and 4 and 9 through 13 consist of seven timbers with cross supports. Bents 5 and 6 and 7 and 8 form tower bents (refer to photos 4, 5 and 6).

Is bridge skewed to floodplain according to USGS quad map? Yes *Angle* 20°

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	November 13, 1994	0	1

Potential for debris Moderate, due to trapping effect of tower bents

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 November 13, 1994

D/S left: Wooded

D/S right: Wooded

U/S left: Pasture

U/S right: Pasture

Description of Channel

Average top width 61 *ft* *Average depth* .5 *ft*

Predominant bed material Sand *Bank material* Sandy clay

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

Vegetative cover on channel banks near bridge: *Date of inspection* November 13, 1994

D/S left: Trees and brush

D/S right: Trees and brush

U/S left: Trees and brush

U/S right: Trees and brush

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 142.5 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 17441 ft^3/s Q500 24000 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	315	4	Full Valley Section
BRDG	315	1	Bridge Section
ROAD	Not Used	3	Road Section
APPR	664	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 "Lockhart, S.C." USGS quad map and from information collected during the field inspection on November 13, 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 377.0 ft

Average low steel elevation 372.50 ft

100-year discharge	17441	ft^3/s
Water-surface elevation at D/S bridge face	369.04	ft
Area of flow at D/S bridge face	4577	ft^2
Average velocity in bridge opening	3.81	ft/s
Maximum WSPRO tube velocity at bridge	5.21	ft/s

Water-surface elevation at Approach section with bridge	369.49	ft
Water-surface elevation at Approach section without bridge	369.56	ft
Amount of backwater caused by bridge	0	ft

500-year discharge	24000	ft^3/s
Water-surface elevation at D/S bridge face	372.16	ft
Area of flow at D/S bridge face	5497	ft^2
Average velocity in bridge opening	4.37	ft/s
Maximum WSPRO tube velocity at bridge	5.97	ft/s

Water-surface elevation at Approach section with bridge	372.75	ft
Water-surface elevation at Approach section without bridge	372.81	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 124000900200 on SC 9 crossing Turkey 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 17441 cubic feet per second							
Abutment	0	0	Abutment-Protected	0	345.69	N/A	N/A
2	25	10.26	Protected	10.26	328.64	354.04	25.40
3	50	10.26	1.93	12.19	329.60	343.71	14.11
4	75	10.26	2.55	12.81	328.51	341.00	12.49
5/6	100	10.26	9.00	19.26	329.51	334.95	5.44
7/8	163	28.88	10.50	39.38	330.79	309.51	-21.28
9	190	25.79	2.49	28.28	331.71	327.12	-4.59
10	214	25.79	20.28	46.07	329.66	308.13	-21.53
11	240	25.79	20.28	46.07	326.51	296.83	-29.68
12	264	25.79	20.28	46.07	330.74	300.83	-29.91
13	290	25.79	20.28	46.07	328.72	317.33	-11.39
Abutment	315	0	20.28	20.28	346.82	354.32	7.5

Notes: Bents 5/6 and 7/8 are "Tower Bents" see SCDOT plans, Sheet 8 and photos 4, 5, and 6.

Due to the history and magnitude of abutment scour at the west abutment, the abutment scour was used as the local scour for piers 10, 11, 12 and 13.

---

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 124000900200 on SC 9 crossing Turkey 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 24000 cubic feet per second							
Abutment	0	0	Abutment-Protected	0	345.69	N/A	N/A
2	25	12.63	Protected	12.63	328.64	351.67	23.03
3	50	12.63	2.02	14.65	329.60	341.25	11.65
4	75	12.63	2.78	15.41	328.51	338.39	9.88
5/6	100	12.63	10.16	22.79	329.51	331.42	1.91
7/8	163	39.50	11.51	51.01	330.79	297.89	-32.90
9	190	30.55	2.78	33.33	331.71	322.07	-9.64
10	214	30.55	22.50	53.05	329.66	301.15	-28.51
11	240	30.55	22.50	53.05	326.51	289.85	-36.66
12	264	30.55	22.50	53.05	330.74	293.85	-36.89
13	290	30.55	22.50	53.05	328.72	310.35	-18.37
Abutment	315	0	22.50	22.50	346.82	352.10	5.28

Notes: Bents 5/6 and 7/8 are "Tower Bents" see SCDOT plans, Sheet 8 and photos 4, 5, and 6.

Due to the history and magnitude of abutment scour at the west abutment, the abutment scour was used as the local scour for piers 10, 11, 12 and 13.

---

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

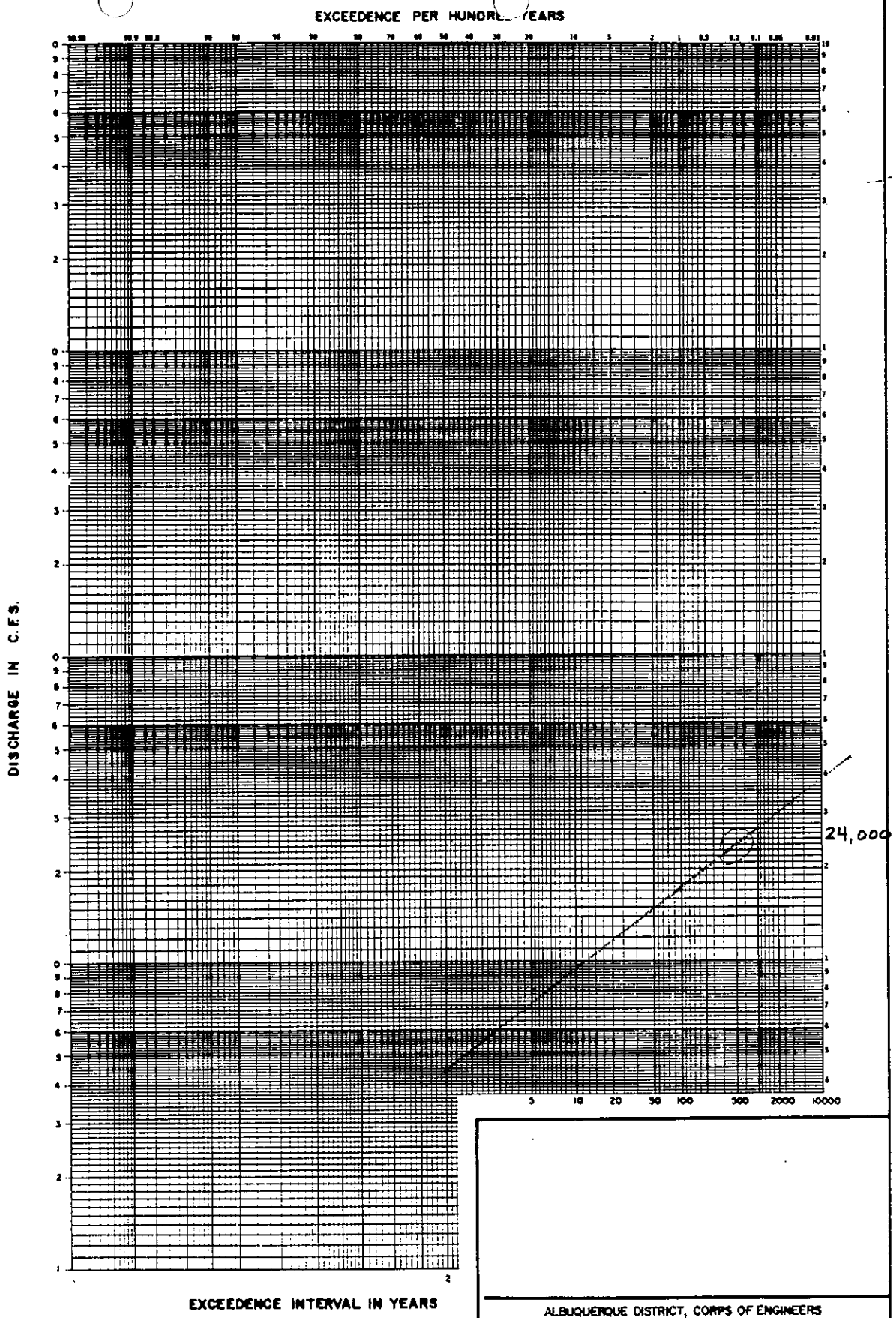
DETERMINING THE FLOOD DISCHARGES FOR VARIOUS RECURRENCE INTERVALS IN THE BLUE RIDGE-PIEDMONT HYDROLOGIC AREA OF NORTH CAROLINA

BRIDGE NUMBER 2 TURKEY CREEK

AREA IN SQUARE FEET = 3971806263.0

AREA IN SQUARE MILES = 142.5

	DISCHARGE (CFS)	RECURRENCE INTERVAL (YEAR)
Q2 = 144*(AREA)^0.691	Q2 = 4432	2
Q5 = 248*(AREA)^0.670	Q5 = 6878	5
Q10 = 334*(AREA)^0.665	Q10 = 9036	10
Q25 = 467*(AREA)^0.655	Q25 = 12023	25
Q50 = 581*(AREA)^0.650	Q50 = 14591	50
Q100 = 719*(AREA)^0.643	Q100 = 17441	100
EXTRAPOLATION:	Q500 = 24000	500



ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS

WSPRO INPUT

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T2        ROUTE 9 OVER TURKEY CREEK
T3        EH&A FILE NO. 16139.01 B-2
*         CHESTER CO., SOUTH CAROLINA
*         FILE NAME: 16139W02.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          17441  24000
SK         .0011  .0011
*         ************************************************************
*         CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
*         SHEET "LOCKHART S.C." AND FROM INFORMATION
*         COLLECTED DURING THE FIELD INSPECTION ON NOVEMBER 13, 1994.
*         ELEVATIONS GIVEN ARE APPROXIMATE.  MANNINGS COEFFICIENTS
*         WERE ESTIMATED FROM FIELD OBSERVATIONS.  THIS BRIDGE FALLS
*         IN THE REGION WHERE THE S.C. REGIONAL REGRESSION EQUATIONS
*         DO NOT APPLY.  SCDOT SUGGESTED
*         THE USE OF THE N.C. REGIONAL REGRESSION EQUATIONS FOR THIS
*         AREA.  THE 100-YEAR DISCHARGE WAS CALCULATED USING THE 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 00
GR         1900,380.0 1950,370.0 2000,360.0
GR         2050,355.6 2075,353.5 2100,353.9 2110,353.0
GR         2116,348.6 2146,348.1 2155,347.6 2163,348.6
GR         2177,348.6 2177,353.6 2190,355.1
GR         2290,355.1 2325,360.0 2500,370.0 2550,380.0
N          .15    .040    .15
SA            2110    2177
*         ************************************************************
XS     FULL  315 00
GR         1750,380.0 1800,370.0 1900,360.0
GR         2050,355.9 2075,353.8 2100,354.2 2110,353.3
GR         2116,348.9 2146,348.4 2155,347.9 2163,348.9
GR         2177,348.9 2177,353.9 2190,355.4
GR         2290,355.4 2500,360.0 2600,370.0 2650,380.0
N          .15    .040    .15
SA            2110    2177
*         ************************************************************
BR     BRDG  315 372.5 00
GR         2001,374.0 2020,367.5 2025,364.3 2043,356.3
GR         2050,355.9 2075,353.8 2100,354.2 2110,353.3
GR         2116,348.9 2146,348.4 2155,347.9 2163,348.9
GR         2177,348.9 2177,353.9 2190,355.4
GR         2214,354.2 2224,350.9 2224,348.4 2240,342.9
GR         2257,343.9 2264,346.9 2282,357.9 2290,363.4
GR         2315,374.6 2001,374.0
N          .043    .040    .043    .040    .043
SA            2110    2177    2216    2268
CD        3  34.6  2  377.0
PW 1      342.9,1 346.9,1 346.9,2 348.9,2  348.9,8 353.8,8
PW 1      353.8,9 354.2,9 354.2,16 355.4,16 355.4,17 355.9,17
PW 1      355.9,18 363.4,18 363.4,19 364.3,19 364.3,20 372.5,20
*         ************************************************************
*         XR    ROAD  222  25  1  *  10
*         GR          1400,370 2000,360 2210,367.5 2300,370
*         N           .015
*         ************************************************************
AS     APPR  664 00
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WSPRO INPUT (Cont.)

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GR          1400,380.0 1450,370.0 1500,360.0 2050,356.3 2075,354.2
GR          2100,354.6 2110,353.7 2116,349.3 2146,348.8
GR          2155,348.3 2163,349.3 2177,349.3 2177,354.3
GR          2190,355.8 2690,360.0 2740,370.0 2790,380.0
N           .15    .042    .040    .042    .15
SA             1500    2110    2177    2690
*          ************************************************************
HP 1  APPR 369.49 * 369.49
HP 1  BRDG 369.04 * 369.04
HP 2  APPR 369.49 * 369.49 17441
HP 2  BRDG 369.04 * 369.04 17441
*
HP 1  APPR 372.75 * 372.75
HP 1  BRDG 372.16 * 372.16
HP 2  APPR 372.75 * 372.75 24000
HP 2  BRDG 372.16 * 372.16 24000
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: 12-02-94  09:07

   T2        ROUTE 9 OVER TURKEY CREEK
   T3        EH&A FILE NO. 16139.01 B-2
   *         CHESTER CO., SOUTH CAROLINA
   *         FILE NAME: 16139W02.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
   *         ************************************************************
   *          Q100    Q500
   Q          17441  24000
 *** Q-DATA FOR SEC-ID, ISEQ =            1
   SK        .0011  .0011
   *         ************************************************************
   *         CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
   *         SHEET "LOCKHART S.C." AND FROM INFORMATION
   *         COLLECTED DURING THE FIELD INSPECTION ON NOVEMBER 13, 1994.
   *         ELEVATIONS GIVEN ARE APPROXIMATE.  MANNINGS COEFFICIENTS
   *         WERE ESTIMATED FROM FIELD OBSERVATIONS.  THIS BRIDGE FALLS
   *         IN THE REGION WHERE THE S.C. REGIONAL REGRESSION EQUATIONS
   *         DO NOT APPLY.  SCDOT SUGGESTED
   *         THE USE OF THE N.C. REGIONAL REGRESSION EQUATIONS FOR THIS
   *         AREA.  THE 100-YEAR DISCHARGE WAS CALCULATED USING THE 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 9 OVER TURKEY CREEK
         EH&A FILE NO. 16139.01 B-2
            *** RUN DATE & TIME: 12-02-94  09:07

 *** START PROCESSING CROSS SECTION - " EXIT"
   XS    EXIT  000 00
   GR         1900,380.0 1950,370.0 2000,360.0
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   GR         2116,348.6 2146,348.1 2155,347.6 2163,348.6
   GR         2177,348.6 2177,353.6 2190,355.1
   GR         2290,355.1 2325,360.0 2500,370.0 2550,380.0
   N          .15    .040    .15
   SA            2110    2177
   *         ************************************************************

 *** FINISH PROCESSING CROSS SECTION - " EXIT"
 *** CROSS SECTION " EXIT" WRITTEN TO DISK, RECORD NO. =  1
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WSPRO OUTPUT (Cont.)

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--- 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 =  18):
       X      Y          X      Y          X      Y          X      Y
   1900.0  380.00    1950.0  370.00    2000.0  360.00    2050.0  355.60
   2075.0  353.50    2100.0  353.90    2110.0  353.00    2116.0  348.60
   2146.0  348.10    2155.0  347.60    2163.0  348.60    2177.0  348.60
   2177.0  353.60    2190.0  355.10    2290.0  355.10    2325.0  360.00
   2500.0  370.00    2550.0  380.00

 X-Y MAX-MIN POINTS:
     XMIN       Y          X    YMIN      XMAX       Y          X    YMAX
   1900.0  380.00    2155.0  347.60    2550.0  380.00    1900.0  380.00

SUBAREA BREAKPOINTS (NSA =  3):
       2110.   2177.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .150    .040    .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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07

*** START PROCESSING CROSS SECTION - " FULL"
  XS    FULL  315 00
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  GR         2050,355.9 2075,353.8 2100,354.2 2110,353.3
  GR         2116,348.9 2146,348.4 2155,347.9 2163,348.9
  GR         2177,348.9 2177,353.9 2190,355.4
  GR         2290,355.4 2500,360.0 2600,370.0 2650,380.0
  N          .15    .040    .15
  SA            2110    2177
  *         ************************************************************

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

--- DATA SUMMARY FOR SECID " FULL" AT SRD =    315.  ERR-CODE =      0

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

X-Y COORDINATE PAIRS  (NGP =  18):
       X      Y          X      Y          X      Y          X      Y
   1750.0  380.00    1800.0  370.00    1900.0  360.00    2050.0  355.90
   2075.0  353.80    2100.0  354.20    2110.0  353.30    2116.0  348.90
   2146.0  348.40    2155.0  347.90    2163.0  348.90    2177.0  348.90
   2177.0  353.90    2190.0  355.40    2290.0  355.40    2500.0  360.00
   2600.0  370.00    2650.0  380.00

 X-Y MAX-MIN POINTS:
     XMIN       Y          X    YMIN      XMAX       Y          X    YMAX
   1750.0  380.00    2155.0  347.90    2650.0  380.00    1750.0  380.00

SUBAREA BREAKPOINTS (NSA =  3):
       2110.   2177.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .150    .040    .150
```

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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07

*** START PROCESSING CROSS SECTION - " BRDG"
  BR    BRDG  315 372.5 00
  GR          2001,374.0 2020,367.5 2025,364.3 2043,356.3
  GR          2050,355.9 2075,353.8 2100,354.2 2110,353.3
  GR          2116,348.9 2146,348.4 2155,347.9 2163,348.9
  GR          2177,348.9 2177,353.9 2190,355.4
  GR          2214,354.2 2224,350.9 2224,348.4 2240,342.9
  GR          2257,343.9 2264,346.9 2282,357.9 2290,363.4
  GR          2315,374.6 2001,374.0
  N           .043    .040    .043    .040    .043
  SA              2110    2177    2216   2268
  CD         3  34.6  2  377.0
  PW 1       342.9,1 346.9,1 346.9,2 348.9,2  348.9,8 353.8,8
  PW 1       353.8,9 354.2,9 354.2,16 355.4,16 355.4,17 355.9,17
  PW 1       355.9,18 363.4,18 363.4,19 364.3,19 364.3,20 372.5,20
  *          ***********************************************************
  *          XR    ROAD  222  25  1  *  10
  *          GR          1400,370 2000,360 2210,367.5 2300,370
  *          N           .015
  *          ***********************************************************

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

--- DATA SUMMARY FOR SECID " BRDG" AT SRD =    315.  ERR-CODE =      0

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

X-Y COORDINATE PAIRS  (NGP =  25):
       X      Y          X      Y          X      Y          X      Y
   2001.0  374.00    2020.0  367.50    2025.0  364.30    2043.0  356.30
   2050.0  355.90    2075.0  353.80    2100.0  354.20    2110.0  353.30
   2116.0  348.90    2146.0  348.40    2155.0  347.90    2163.0  348.90
   2177.0  348.90    2177.0  353.90    2190.0  355.40    2214.0  354.20
   2224.0  350.90    2224.0  348.40    2240.0  342.90    2257.0  343.90
   2264.0  346.90    2282.0  357.90    2290.0  363.40    2315.0  374.60
   2001.0  374.00

 X-Y MAX-MIN POINTS:
     XMIN      Y         X    YMIN      XMAX      Y         X    YMAX
   2001.0  374.00    2240.0  342.90    2315.0  374.60    2315.0  374.60

SUBAREA BREAKPOINTS (NSA =  5):
       2110.   2177.   2216.   2268.

ROUGHNESS COEFFICIENTS (NSA =  5):
         .043    .040    .043    .040    .043

BRIDGE PARAMETERS:
 BRTYPE  BRWDTH     LSEL  USERCD  EMBSS   EMBELV  ABSLPL  ABSLPR
    3      34.6   372.50 *******   2.00   377.00 ******* *******

PIER DATA:  NPW = 18    PPCD = 1.
     PELV  PWDTH      PELV  PWDTH      PELV  PWDTH      PELV  PWDTH
    342.90   1.0     346.90   1.0     346.90   2.0     348.90   2.0
    348.90   8.0     353.80   8.0     353.80   9.0     354.20   9.0
    354.20  16.0     355.40  16.0     355.40  17.0     355.90  17.0
```

WSPRO OUTPUT (Cont.)

```
    355.90  18.0     363.40  18.0     363.40  19.0     364.30  19.0
    364.30  20.0     372.50  20.0
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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07

*** START PROCESSING CROSS SECTION - " APPR"
  AS    APPR  664 00
  GR         1400,380.0 1450,370.0 1500,360.0 2050,356.3 2075,354.2
  GR         2100,354.6 2110,353.7 2116,349.3 2146,348.8
  GR         2155,348.3 2163,349.3 2177,349.3 2177,354.3
  GR         2190,355.8 2690,360.0 2740,370.0 2790,380.0
  N          .15    .042    .040    .042    .15
  SA            1500    2110    2177    2690
  *         ************************************************************
  HP 1  APPR 369.49 * 369.49

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

--- DATA SUMMARY FOR SECID " APPR" AT SRD =    664.  ERR-CODE =      0

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

X-Y COORDINATE PAIRS  (NGP =  17):
       X      Y          X      Y          X      Y          X      Y
   1400.0  380.00    1450.0  370.00    1500.0  360.00    2050.0  356.30
   2075.0  354.20    2100.0  354.60    2110.0  353.70    2116.0  349.30
   2146.0  348.80    2155.0  348.30    2163.0  349.30    2177.0  349.30
   2177.0  354.30    2190.0  355.80    2690.0  360.00    2740.0  370.00
   2790.0  380.00

 X-Y MAX-MIN POINTS:
     XMIN       Y          X    YMIN      XMAX       Y          X    YMAX
   1400.0  380.00    2155.0  348.30    2790.0  380.00    1400.0  380.00

SUBAREA BREAKPOINTS (NSA =  5):
       1500.   2110.   2177.   2690.

ROUGHNESS COEFFICIENTS (NSA =  5):
         .150    .042    .040    .042    .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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07
    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID =  APPR;  SRD =     664.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     225.     6233.    47.    48.                       2783.
             2    7124.  1300627.   610.   610.                     138139.
             3    1358.   353375.    67.    74.                      34684.
             4    5983.  1091351.   513.   513.                     115936.
             5     225.     6233.    47.    48.                       2783.
```

WSPRO OUTPUT (Cont.)

```
   369.49        14914. 2757819.  1285.  1294.  1.10  1453.  2737. 275061.
1
  HP 1  BRDG 369.04 * 369.04
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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID =  BRDG;  SRD =     315.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1151.  206645.    95.    98.                      22786.
             2    1354.  351923.    67.    74.                      34556.
             3     559.  113921.    39.    39.                      12015.
             4    1194.  337200.    52.    57.                      32459.
             5     318.   44067.    35.    40.                       5484.
   369.04         4577. 1053756.   287.   307.  1.13  2015.  2303.  97721.
1
  HP 2  APPR 369.49 * 369.49 17441
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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID =  APPR;  SRD =     664.

         WSEL     LEW     REW    AREA        K        Q    VEL
       369.49  1452.6  2737.4 14914.4 2757819.   17441.   1.17

 X STA.      1452.6     1583.8     1666.3     1739.7     1808.9     1873.1
   A(I)          1044.5      851.4      797.2      784.4      756.1
   V(I)             .83       1.02       1.09       1.11       1.15

 X STA.      1873.1     1932.1     1989.3     2044.3     2089.6     2124.8
   A(I)           719.7      720.3      713.9      652.1      595.4
   V(I)            1.21       1.21       1.22       1.34       1.46

 X STA.      2124.8     2149.0     2173.2     2224.7     2277.0     2333.1
   A(I)           496.8      497.3      734.5      689.3      714.3
   V(I)            1.76       1.75       1.19       1.27       1.22

 X STA.      2333.1     2392.8     2457.8     2526.9     2605.8     2737.4
   A(I)           730.1      761.8      770.6      830.9     1053.7
   V(I)            1.19       1.14       1.13       1.05        .83
1
  HP 2  BRDG 369.04 * 369.04 17441
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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07
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WSPRO OUTPUT (Cont.)

```
     VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID =  BRDG;  SRD =     315.

          WSEL     LEW     REW    AREA        K        Q    VEL
        369.04  2015.5  2302.6  4576.6 1053756.   17441.   3.81

 X STA.      2015.5     2061.0     2078.2     2094.8     2111.6     2122.1
   A(I)           416.5      254.6      250.1      255.4      204.4
   V(I)            2.09       3.42       3.49       3.41       4.27

 X STA.      2122.1     2131.5     2140.8     2150.0     2159.1     2168.7
   A(I)           192.5      190.3      189.0      190.1      195.5
   V(I)            4.53       4.58       4.61       4.59       4.46

 X STA.      2168.7     2183.9     2202.9     2219.5     2230.7     2238.3
   A(I)           268.8      264.5      249.3      222.8      184.4
   V(I)            3.24       3.30       3.50       3.91       4.73

 X STA.      2238.3     2244.8     2251.4     2258.1     2266.2     2302.6
   A(I)           169.7      170.0      167.4      187.4      354.0
   V(I)            5.14       5.13       5.21       4.65       2.46
1
   *
   HP 1  APPR 372.75 * 372.75
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 9 OVER TURKEY CREEK
         EH&A FILE NO. 16139.01 B-2
            *** RUN DATE & TIME: 12-02-94  09:07
     CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID =  APPR;  SRD =     664.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     406.    13699.    64.    65.                      5823.
             2    9112. 1960462.   610.   610.                    199849.
             3    1576.  453112.    67.    74.                     43382.
             4    7655. 1645831.   513.   513.                    167802.
             5     406.    13699.    64.    65.                      5823.
    372.75        19156. 4086803.  1318.  1327.  1.10  1436.  2754. 395505.
1
   HP 1  BRDG 372.16 * 372.16
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 9 OVER TURKEY CREEK
         EH&A FILE NO. 16139.01 B-2
            *** RUN DATE & TIME: 12-02-94  09:07
     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID =  BRDG;  SRD =     315.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1460.  288498.   104.   107.                     31091.
             2    1563.  447029.    67.    74.                     42857.
             3     681.  158167.    39.    39.                     16143.
             4    1356.  416985.    52.    57.                     39296.
             5     437.   66511.    42.    48.                      8049.
    372.16         5497. 1377189.   303.   325.  1.13  2006.  2310. 125188.
1
   HP 2  APPR 372.75 * 372.75 24000
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)
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WSPRO OUTPUT (Cont.)

```
        ROUTE 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID =  APPR;  SRD =     664.

         WSEL     LEW     REW    AREA        K        Q    VEL
       372.75  1436.3  2753.8 19156.4 4086803.   24000.   1.25

 X STA.      1436.3     1575.4     1652.2     1721.8     1790.5     1853.8
   A(I)          1387.1     1037.7      975.6      993.9      944.7
   V(I)             .87       1.16       1.23       1.21       1.27

 X STA.      1853.8     1914.5     1974.3     2029.4     2080.4     2121.4
   A(I)           929.5      941.4      889.6      875.0      798.0
   V(I)            1.29       1.27       1.35       1.37       1.50

 X STA.      2121.4     2149.2     2182.7     2235.1     2288.7     2346.8
   A(I)           660.6      764.9      883.2      876.2      922.9
   V(I)            1.82       1.57       1.36       1.37       1.30

 X STA.      2346.8     2408.5     2471.4     2540.2     2615.4     2753.8
   A(I)           948.5      934.1      982.3     1030.6     1380.7
   V(I)            1.27       1.28       1.22       1.16        .87
1
   HP 2  BRDG 372.16 * 372.16 24000
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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07


    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID =  BRDG;  SRD =     315.

         WSEL     LEW     REW    AREA        K        Q    VEL
       372.16  2006.4  2309.6  5497.4 1377189.   24000.   4.37

 X STA.      2006.4     2058.7     2075.7     2091.5     2107.0     2119.8
   A(I)           533.1      301.5      288.0      280.6      271.0
   V(I)            2.25       3.98       4.17       4.28       4.43

 X STA.      2119.8     2129.3     2138.9     2148.6     2158.0     2167.7
   A(I)           223.2      225.9      229.3      226.3      227.2
   V(I)            5.38       5.31       5.23       5.30       5.28

 X STA.      2167.7     2182.1     2199.6     2216.3     2229.0     2237.2
   A(I)           309.3      298.5      296.0      277.1      218.9
   V(I)            3.88       4.02       4.05       4.33       5.48

 X STA.      2237.2     2244.3     2251.4     2258.5     2267.4     2309.6
   A(I)           208.4      202.5      201.0      229.4      450.4
   V(I)            5.76       5.93       5.97       5.23       2.66
1
   EX

 +++ BEGINNING PROFILE CALCULATIONS --   2
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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07

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

  EXIT:XS   ******  1957.    5467.   .76 *****  369.27  360.55  17441.  368.51
        0. ******  2474.  525390.  4.80 ***** *******     .38    3.19

  FULL:FV     315.  1808.    8767.   .34   .26  369.53 *******  17441.  369.19
      315.    315.  2592.  704748.  5.50   .00     .00     .25    1.99
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            " APPR"     KRATIO =  3.95

  APPR:AS     349.  1452.   15001.   .02   .05  369.58 *******  17441.  369.56
      664.    349.  2738. 2783113.  1.10   .00     .00     .06    1.16
         <<<<<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     315.  2015.    4577.   .42   .19  369.46  357.27  17441.  369.04
      315.    315.  2303. 1053863.  1.84   .00    -.01     .23    3.81

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3.   1.   1.   .736   .071  372.50 ****** ****** ******

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

  APPR:AS     314.  1453.   14916.   .02   .04  369.51  359.82  17441.  369.49
      664.    383.  2737. 2758321.  1.10   .01     .00     .06    1.17

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       .776   .651  962999.  1971.  2258.   369.48

                    <<<<<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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07
  FIRST USER DEFINED TABLE.

    XSID:CODE       Q    WSEL     VEL    CRWS    YMIN
    EXIT:XS     17441.  368.51    3.19  360.55  347.60
    FULL:FV     17441.  369.19    1.99********  347.90
    BRDG:BR     17441.  369.04    3.81  357.27  342.90
    APPR:AS     17441.  369.49    1.17  359.82  348.30
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 9 OVER TURKEY CREEK
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WSPRO OUTPUT (Cont.)

```
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07
  SECOND USER DEFINED TABLE.

     XSID:CODE       Q     AREA    LEW    REW    SRD        K
     EXIT:XS     17441.    5467.  1957.  2474.     0.  525390.
     FULL:FV     17441.    8767.  1808.  2592.   315.  704748.
     BRDG:BR     17441.    4577.  2015.  2303.   315. 1053863.
     APPR:AS     17441.   14916.  1453.  2737.   664. 2758321.

     XSID:CODE    OTEL
     APPR:AS    369.48
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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07
   THIRD USER DEFINED TABLE.

     XSID:CODE     EGL     FR#    WSEL    HF
     EXIT:XS    369.27     .38  368.51******
     FULL:FV    369.53     .25  369.19   .26
     BRDG:BR    369.46     .23  369.04   .19
     APPR:AS    369.51     .06  369.49   .04
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 9 OVER TURKEY CREEK
        EH&A FILE NO. 16139.01 B-2
           *** RUN DATE & TIME: 12-02-94  09:07

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

  EXIT:XS   ******  1942.    7199.   .86 *****  372.54  362.63  24000.  371.68
         0. ******  2508.  723595.  4.98 ***** *******     .37    3.33

  FULL:FV     315.  1788.   11382.   .36   .25  372.79 *******  24000.  372.43
       315.   315.  2612.  991667.  5.24   .00     .00     .23    2.11
           <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              " APPR"     KRATIO =  4.15

  APPR:AS     349.  1436.   19239.   .03   .05  372.84 *******  24000.  372.81
       664.   349.  2754. 4114366.  1.10   .00     .00     .06    1.25
           <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   372.16     372.71     372.75     372.50

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

  ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                        YU/Z,WSIU,WS = 1.03     372.93     372.97

  ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.

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

  XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
```

WSPRO OUTPUT (Cont.)

```
        SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

  BRDG:BR     315.  2006.    5498.   .56   .18  372.72  358.83  24000.  372.16
      315.    315.  2310. 1377270.  1.89   .00     .00     .25    4.37

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        3.   1.   1.   .728   .071  372.50 ****** ****** ******

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

  APPR:AS     314.  1436.   19152.   .03   .04  372.77  360.53  24000.  372.75
      664.    386.  2754. 4085177.  1.10   .01     .00     .06    1.25

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
        .769   .662 1381513.  1960.  2263.   372.74

                    <<<<<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 9 OVER TURKEY CREEK
         EH&A FILE NO. 16139.01 B-2
            *** RUN DATE & TIME: 12-02-94  09:07
   FIRST USER DEFINED TABLE.

     XSID:CODE       Q    WSEL     VEL    CRWS    YMIN
     EXIT:XS    24000.  371.68    3.33  362.63  347.60
     FULL:FV    24000.  372.43    2.11********  347.90
     BRDG:BR    24000.  372.16    4.37  358.83  342.90
     APPR:AS    24000.  372.75    1.25  360.53  348.30
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 9 OVER TURKEY CREEK
         EH&A FILE NO. 16139.01 B-2
            *** RUN DATE & TIME: 12-02-94  09:07
  SECOND USER DEFINED TABLE.

     XSID:CODE       Q     AREA    LEW    REW    SRD        K
     EXIT:XS    24000.    7199.  1942.  2508.     0.  723595.
     FULL:FV    24000.   11382.  1788.  2612.   315.  991667.
     BRDG:BR    24000.    5498.  2006.  2310.   315. 1377270.
     APPR:AS    24000.   19152.  1436.  2754.   664. 4085177.

     XSID:CODE    OTEL
     APPR:AS    372.74
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 9 OVER TURKEY CREEK
         EH&A FILE NO. 16139.01 B-2
            *** RUN DATE & TIME: 12-02-94  09:07
   THIRD USER DEFINED TABLE.

     XSID:CODE     EGL     FR#    WSEL    HF
     EXIT:XS    372.54     .37  371.68******
     FULL:FV    372.79     .23  372.43   .25
     BRDG:BR    372.72     .25  372.16   .18
```

WSPRO OUTPUT (Cont.)

```
  APPR:AS    372.77     .06  372.75    .04
ER

1  NORMAL  END  OF  WSPRO  EXECUTION.
```

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-2
BRIDGE NO. 124000900200
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	1358
TOPW	APPR. MAIN CHANNEL TOP WIDTH (ft)	67
Ym	APPR. MAIN CHANNEL AVG. DEPTH = AREAm/TOPW	20.27
HFa	APPR. HEAD LOSS DUE TO FRICTION	0.05
DIST	DISTANCE FROM BRIDGE TO APPR.	349
Sf	AVG. UNCONSTRICTED ENERGY SLOPE = HFa/DIST	0.00014
Km	APPR. MAIN CHANNEL CONVEYANCE	353375
Vm	APPR. MAIN CHANNEL AVG. VELOCITY (fps)	3.11
	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	7349
TOPW	LEFT OVERBANK TOP WIDTH (ft)	657
Yl	APPR. LEFT OVERBANK AVG. DEPTH (ft)	11.19
Kl	LEFT OVERBANK CONVEYANCE	1306860
Vl	APPR. LEFT OVERBANK AVG. VELOCITY (fps)	2.13
	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	6208
TOPW	RIGHT OVERBANK TOP WIDTH (ft)	560
Yr	APPR. RIGHT OVERBANK AVG. DEPTH (ft)	11.09
Kr	RIGHT OVERBANK CONVEYANCE	1097584
Vr	APPR. RIGHT OVERBANK AVG. VELOCITY (fps)	2.12

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-2
BRIDGE NO. 124000900200
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= 1.39 fps

(2) LEFT OVERBANK CRITICAL VELOCITY (Vcl):
NEILL'S EQ;
Vcl=1.58*((Ssl-1)*g*D50l)^1/2*(Yl/D50l)^1/6
Vcl= 1.26 fps

(3) RIGHT OVERBANK CRITICAL VELOCITY (Vcr):
NEILL'S EQ;
Vcr=1.58*((Ssr-1)*g*D50r)^1/2*(Yr/D50r)^1/6
Vcr= 1.26 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.

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-2
BRIDGE NO. 124000900200
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	17441
Q	TOTAL DISCHARGE(cfs) BRIDGE	17441
Ktot(APP)	APP. TOTAL CONVEYANCE	2757819
Ktot(BR)	BR. TOTAL CONVEYANCE	1053756
Sf	AVG. UNCONSTRICTED ENERGY SLOPE	0.00014
MAIN CHANNEL:		
Km(APP)	APP. MAIN CHANNEL CONVEYANCE	353375
W1m(APP)	APP. MAIN CHANNEL WIDTH(ft)	67
Am(APP)	APP. MAIN CHANNEL AREA	1358
TOPWm(APP)	APP. MAIN CHANNEL TOP WIDTH(ft)	67
Y1m(APP)	AVG. DEPTH IN UPSTR MAIN CHANNEL(ft)	20.27
WETPm(APP)	APP. MAIN CHANNEL WETTED PERIM.(ft)	74
Km(BR)	BR. MAIN CHANNEL CONVEYANCE	351923
W2m(BR)	BR. MAIN CHANNEL WIDTH MINUS PIER WIDTHS(ft)	61
LEFT OVERBANK:		
Kl(APP)	APP. LEFT OVERBANK CONVEYANCE	1306860
W1l(APP)	APP. LEFT OVERBANK WIDTH(ft)	657
Al(APP)	APP. LEFT OVERBANK AREA(ft^2)	7349
TOPWl(APP)	APP. LEFT OVERBANK TOP WIDTH(ft)	657
Y1l(APP)	AVG. DEPTH IN UPSTR LEFT OVERBANK (ft)	11.19
WETPl(APP)	APP. LEFT OVERBANK WETTED PERIM.(ft)	658
Kl(BR)	BR. LEFT OVERBANK CONVEYANCE	206645
W2l(BR)	BR. LEFT OVERBANK WIDTH MINUS PIER5 WIDTHS(ft)	85.5
RIGHT OVERBANK:		
Kr(APP)	APP. RIGHT OVERBANK CONVEYANCE	1097584
W1r(APP)	APP. RIGHT OVERBANK WIDTH(ft)	560
Ar(APP)	APP. RIGHT OVERBANK AREA(ft^2)	6208
TOPWr(APP)	APP. RIGHT OVERBANK TOP WIDTH(ft)	560
Y1r(APP)	AVG. DEPTH IN UPSTR RIGHT OVERBANK ft)	11.09
WETPr(APP)	APP. RIGHT OVERBANK WETTED PERIM.(ft)	561
Kr(BR)	BR. RIGHT OVERBANK CONVEYANCE	495188
W2r(BR)	BR. RIGHT OVERBANK WIDTH(ft)	120.6

SCDOT BRIDGE SCOUR
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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= 18.35 ft

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

SHEARm=Ywater*Rm*Sf
SHEARm= 0.16 lb/sf

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

Vm*=(SHEARm/p)^.5
Vm*= 0.29 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= 9.69
K1= 0.69

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

Q1m=Q*(Km(APP)/Ktot(APP))
Q1m= 2235 cfs

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

Q2m=Q*(Km(BR)/Ktot(BR))
Q2m= 5825 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2m/Y1m=(Q2m/Q1m)^6/7*(W1m/W2m)^K1
Y2m= 49.15 ft

(j) MAIN CONTRACTION SCOUR DEPTH (Ysm):
Ysm=Y2m-Y1m
Ysm= 28.88 ft

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
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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= 11.17 ft

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

SHEARl=Ywater*Rl*Sf
SHEARl= 0.10 lb/sf

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

Vl*=(SHEARl/p)^.5
Vl*= 0.23 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= 7.56
K1= 0.69

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

Q1l=Q*(Kl(APP)/Ktot(APP))
Q1l= 8265 cfs

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

Q2l=Q*(Kl(BR)/Ktot(BR))
Q2l= 3420 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2l/Y1l=(Q2l/Q1l)^6/7*(W1l/W2l)^K1
Y2l= 21.44 ft

(j) LEFT OVERBANK CONTRACTION SCOUR DEPTH (Ysl):
Ysl=Y2l-Y1l
Ysl= 10.26 ft

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
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BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100

3. RIGHT OVERBANK CONTRACTION SCOUR (Ysr):

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

Rr=Ar(APP)/WETPr(APP)
Rr= 11.07 ft

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

SHEARr=Ywater*Rr*Sf
SHEARr= 0.10 lb/sf

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

Vr*=(SHEARr/p)^.5
Vr*= 0.23 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= 7.53
K1= 0.69

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

Q1r=Q*(Kr(APP)/Ktot(APP))
Q1r= 6941 cfs

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

Q2r=Q*(Kr(BR)/Ktot(BR))
Q2r= 8196 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2r/Y1r=(Q2r/Q1r)^6/7*(W1r/W2r)^K1
Y2r= 36.88 ft

(j) RIGHT OVERBANK CONTRACTION SCOUR DEPTH (Ysr):
Ysr=Y2r-Y1r
Ysr= 25.79 ft

SCDOT BRIDGE SCOUR
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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	2025	
	PIER #2 IS PROTECTED BY THE RIPRAP OF THE ABUTMENT NO SCOUR CALCULATIONS ARE PERFORMED		
PIER #3:	WSPRO STA	2050	
A3		AREA OF CONVEYANCE TUBE AT PIER #3 (sf)	416.5
V3		VELOCITY IN CONVEYANCE TUBE AT PIER #3 (fps)	2.09
TOPW3		TOPWIDTH OF CONVEYANCE TUBE AT PIER #3 (ft)	45.5
Y3		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #3 (ft)	9.15
PIER #4:	WPSRO STA	2075	
A4		AREA OF CONVEYANCE TUBE AT PIER #4 (sf)	254.6
V4		VELOCITY IN CONVEYANCE TUBE AT PIER #4 (fps)	3.42
TOPW4		TOPWIDTH OF CONVEYANCE TUBE AT PIER #4 (ft)	17.2
Y4		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #4 (ft)	14.80
PIER #5/6:	WSPRO STA	2100	
A5/6		AREA OF CONVEYANCE TUBE AT PIER #5/6 (sf)	255.4
V5/6		VELOCITY IN CONVEYANCE TUBE AT PIER #5/6 (fps)	3.41
TOPW5/6		TOPWIDTH OF CONVEYANCE TUBE AT PIER #5/6 (ft)	16.8
Y5/6		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #5/6 (ft)	15.20
PIER #7/8:	WSPRO STA	2163	
A7/8		AREA OF CONVEYANCE TUBE AT PIER #7/8 (sf)	195.5
V7/8		VELOCITY IN CONVEYANCE TUBE AT PIER #7/8 (fps)	4.46
TOPW7/8		TOPWIDTH OF CONVEYANCE TUBE AT PIER #7/8 (ft)	9.6
Y7/8		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #7/8 (ft)	20.36
PIER #9:	WSPRO STA	2190	
A9		AREA OF CONVEYANCE TUBE AT PIER #9 (sf)	264.5
V9		VELOCITY IN CONVEYANCE TUBE AT PIER #9 (fps)	3.3
TOPW9		TOPWIDTH OF CONVEYANCE TUBE AT PIER #9 (ft)	19
Y9		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #9 (ft)	13.92

SCDOT BRIDGE SCOUR
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460 McLAWS CIRCLE, SUITE 150
WILLIAMSBURG, VA 23185

STORM EVENT (YR): 100

PIER #10:	WSPRO STA	2214	
A10		AREA OF CONVEYANCE TUBE AT PIER #10 (sf)	249.3
V10		VELOCITY IN CONVEYANCE TUBE AT PIER #10 (fps)	3.5
TOPW10		TOPWIDTH OF CONVEYANCE TUBE AT PIER #10 (ft)	16.6
Y10		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #10 (ft)	15.02
PIER #11:	WSPRO STA	2240	
A11		AREA OF CONVEYANCE TUBE AT PIER #11 (sf)	169.7
V11		VELOCITY IN CONVEYANCE TUBE AT PIER #11 (fps)	5.14
TOPW11		TOPWIDTH OF CONVEYANCE TUBE AT PIER #11 (ft)	6.5
Y11		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #11 (ft)	26.11
PIER #12:	WSPRO STA	2264	
A12		AREA OF CONVEYANCE TUBE AT PIER #12 (sf)	187.4
V12		VELOCITY IN CONVEYANCE TUBE AT PIER #12 (fps)	4.65
TOPW12		TOPWIDTH OF CONVEYANCE TUBE AT PIER #12 (ft)	8.1
Y12		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #12 (ft)	23.14
PIER #13:	WSPRO STA	2290	
A13		AREA OF CONVEYANCE TUBE AT PIER #13 (sf)	354
V13		VELOCITY IN CONVEYANCE TUBE AT PIER #13 (fps)	2.46
TOPW13		TOPWIDTH OF CONVEYANCE TUBE AT PIER #13 (ft)	36.4
Y13		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #13 (ft)	9.73

SCDOT BRIDGE SCOUR
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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):

PIER #2 IS PROTECTED BY THE RIPRAP OF THE ABUTMENT
NO SCOUR CALCULATIONS ARE PERFORMED

PROTECTED

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

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR3=V3/(g*Y3)^.5=	0.12	
(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= 1.93 ft

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

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR4=V4/(g*Y4)^.5=	0.16	
(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#4=Y4*2*K1*K2*K3*(a/Y4)^.65*FR4^.43
Ys#4= 2.55 ft

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

STORM EVENT (YR): 100

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

(a) a=PIER WIDTH (ft)= 6
(b) FROUDE NO.=FR5/6=V5/6/(g*Y5/6)^.5= 0.15
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1.1
(d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)= 1
(e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)= 1.1
(f) CSU EQ. FOR PIER SCOUR;
Ys#5/6=Y5/6*2*K1*K2*K3*(a/Y5/6)^.65*FR5/6^.43
Ys#5/6= 9.00 ft

5. SCOUR DEPTH AT PIER #7/8 (Ys#7/8):

(a) a=PIER WIDTH (ft)= 6
(b) FROUDE NO.=FR7/8=V7/8/(g*Y7/8)^.5= 0.17
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1.1
(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#7/8=Y7/8*2*K1*K2*K3*(a/Y7/8)^.65*FR7/8^.43
Ys#7/8= 10.50 ft

6. SCOUR DEPTH AT PIER #9 (Ys#9):

(a) a=PIER WIDTH (ft)= 1
(b) FROUDE NO.=FR9=V9/(g*Y9)^.5= 0.16
(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#9=Y9*2*K1*K2*K3*(a/Y9)^.65*FR9^.43
Ys#9= 2.49 ft

SCDOT BRIDGE SCOUR
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BY/CHK: ABS/JNP

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WILLIAMSBURG, VA 23185

STORM EVENT (YR): 100

7. SCOUR DEPTH AT PIER #10 (Ys#10):

(a) a=PIER WIDTH (ft)= 1
(b) FROUDE NO.=FR10=V10/(g*Y10)^.5= 0.16
(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#10=Y10*2*K1*K2*K3*(a/Y10)^.65*FR10^.43
Ys#10= 2.58 ft

8. SCOUR DEPTH AT PIER #11 (Ys#11):

(a) a=PIER WIDTH (ft)= 1
(b) FROUDE NO.=FR11=V11/(g*Y11)^.5= 0.18
(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#11=Y11*2*K1*K2*K3*(a/Y11)^.65*FR11^.43
Ys#11= 3.28 ft

9. SCOUR DEPTH AT PIER #12 (Ys#12):

(a) a=PIER WIDTH (ft)= 1
(b) FROUDE NO.=FR12=V12/(g*Y12)^.5= 0.17
(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#12=Y12*2*K1*K2*K3*(a/Y12)^.65*FR12^.43
Ys#12= 3.09 ft

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10. SCOUR DEPTH AT PIER #13 (Ys#13):

(a) a=PIER WIDTH (ft)= 1
(b) FROUDE NO.=FR13=V13/(g*Y13)^.5= 0.14
(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#13=Y13*2*K1*K2*K3*(a/Y13)^.65*FR13^.43
Ys#13= 2.09 ft

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STORM EVENT (YR): 100

IV. ABUTMENT SCOUR - FROELICH'S EQ.

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
Q	TOTAL DISCHARGE INPUT TO WSPRO (cfs)	17441
qtube	DISCHARGE PER EQUAL CONVEYANCE TUBE (cfs)	872.1

LEFT:

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED
THE RIGHT ABUTMENT HAS A HISTORY OF ABUTMENT SCOUR EVEN THOUGH IT IS PROTECTED.

RIGHT:

#Tr	# APP. CONVEYANCE TUBES OBSTR. BY RIGHT ABT.	5.5
Qr	FLOW IN RIGHT OVERBANK OBSTR. BY ABT. (cfs)	4796.3
Ar	AREA OF CONV. TUBES OBSTR. BY RIGHT ABT. (sf)	4535.4
ar	LENGTH OF RIGHT ABT. PROJECTING INTO FLOW(ft)	434.8

(B) CALCULATIONS

1. LEFT ABUTMENT SCOUR (Ysl):

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED

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STORM EVENT (YR): 100

THE RIGHT ABUTMENT HAS A HISTORY OF ABUTMENT SCOUR EVEN THOUGH IT IS PROTECTED.

2. RIGHT ABUTMENT SCOUR (Ysr):

(a) AVG. FLOW DEPTH IN RIGHT OVERBANK AREA (Yr):
Yr=Ar/ar= 10.43 ft Use HIRE Equation!
(b) AVG. VELOCITY IN RIGHT OVERBANK AREA (Vr):
Vr=Qr/Ar= 1.06 fps
(c) FROUDE NO (FRr):
FRr=Vr/(g*Yr)^.5= 0.06
(d) K1=COEFF. OF ABT. SHAPE(TBL4, PG50)= 0.55
(e) K2=COEFF. OF ABT. ANGLE(FIG11,PG51)= 1.0
(f) FROELICH EQ. FOR SCOUR DEPTH (Ysr):
Ysr=Yr*(2.27*K1*K2*(ar/Yr)^.43*FRr^.61+1)
Ysr= 21.80 ft NOT VALID...Use HIRE Equation!

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BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100

V. ABUTMENT SCOUR - HIRE EQ.

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
Q(ABut)	TOTAL DISCHARGE INPUT TO WSPRO (cfs)	17441
qtube	DISCHARGE PER EQUAL CONVEYANCE TUBE (cfs)	872.1

LEFT:

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED

RIGHT:

Ar	AREA OF CONV. TUBE ADJACENT TO RIGHT ABT.(sf)	354
Vr	VEL. OF CONV. TUBE ADJACENT TO RIGHT ABT.(fps)	2.46
TOPWr	TOPWIDTH OF CONV. TUBE ADJ. TO RT.ABT.(ft)	36.4
Yr	AVG. DEPTH OF CONV. TUBE ADJ. TO RT. ABT.(ft)	9.7

(B) CALCULATIONS

1. LEFT ABUTMENT SCOUR DEPTH (Ysl):

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED

2. RIGHT ABUTMENT SCOUR DEPTH (Ysr):

(a) FROUDE NO.=FRr=Vr/(g*Yr)^.5= 0.14
(b) Ysr=Yr*4*FRr^.33

Ysr= 20.28 ft

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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	1576
TOPW	APPR. MAIN CHANNEL TOP WIDTH (ft)	67
Ym	APPR. MAIN CHANNEL AVG. DEPTH = AREAm/TOPW	23.52
HFa	APPR. HEAD LOSS DUE TO FRICTION	0.05
DIST	DISTANCE FROM BRIDGE TO APPR.	349
Sf	AVG. UNCONSTRICTED ENERGY SLOPE = HFa/DIST	0.00014
Km	APPR. MAIN CHANNEL CONVEYANCE	453112
Vm	APPR. MAIN CHANNEL AVG. VELOCITY (fps)	3.44
	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	9518
TOPW	LEFT OVERBANK TOP WIDTH (ft)	674
Yl	APPR. LEFT OVERBANK AVG. DEPTH (ft)	14.12
Kl	LEFT OVERBANK CONVEYANCE	1974161
Vl	APPR. LEFT OVERBANK AVG. VELOCITY (fps)	2.48
	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	8061
TOPW	RIGHT OVERBANK TOP WIDTH (ft)	577
Yr	APPR. RIGHT OVERBANK AVG. DEPTH (ft)	13.97
Kr	RIGHT OVERBANK CONVEYANCE	1659530
Vr	APPR. RIGHT OVERBANK AVG. VELOCITY (fps)	2.46

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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= 1.43 fps

(2) LEFT OVERBANK CRITICAL VELOCITY (Vcl):
NEILL'S EQ;
Vcl=1.58*((Ssl-1)*g*D50l)^1/2*(Yl/D50l)^1/6
Vcl= 1.31 fps

(3) RIGHT OVERBANK CRITICAL VELOCITY (Vcr):
NEILL'S EQ;
Vcr=1.58*((Ssr-1)*g*D50r)^1/2*(Yr/D50r)^1/6
Vcr= 1.31 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	24000
Q	TOTAL DISCHARGE(cfs) BRIDGE	24000
Ktot(APP)	APP. TOTAL CONVEYANCE	4086803
Ktot(BR)	BR. TOTAL CONVEYANCE	1377189
Sf	AVG. UNCONSTRICTED ENERGY SLOPE	0.00014
MAIN CHANNEL:		
Km(APP)	APP. MAIN CHANNEL CONVEYANCE	453112
W1m(APP)	APP. MAIN CHANNEL WIDTH(ft)	67
Am(APP)	APP. MAIN CHANNEL AREA	1576
TOPWm(APP)	APP. MAIN CHANNEL TOP WIDTH(ft)	67
Y1m(APP)	AVG. DEPTH IN UPSTR MAIN CHANNEL(ft)	23.52
WETPm(APP)	APP. MAIN CHANNEL WETTED PERIM.(ft)	74
Km(BR)	BR. MAIN CHANNEL CONVEYANCE	447029
W2m(BR)	BR. MAIN CHANNEL WIDTH MINUS PIER WIDTHS(ft)	61
LEFT OVERBANK:		
Kl(APP)	APP. LEFT OVERBANK CONVEYANCE	1974161
W1l(APP)	APP. LEFT OVERBANK WIDTH(ft)	674
Al(APP)	APP. LEFT OVERBANK AREA(ft^2)	9518
TOPWl(APP)	APP. LEFT OVERBANK TOP WIDTH(ft)	674
Y1l(APP)	AVG. DEPTH IN UPSTR LEFT OVERBANK (ft)	14.12
WETPl(APP)	APP. LEFT OVERBANK WETTED PERIM.(ft)	675
Kl(BR)	BR. LEFT OVERBANK CONVEYANCE	288498
W2l(BR)	BR. LEFT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	94.6
RIGHT OVERBANK:		
Kr(APP)	APP. RIGHT OVERBANK CONVEYANCE	1659530
W1r(APP)	APP. RIGHT OVERBANK WIDTH(ft)	577
Ar(APP)	APP. RIGHT OVERBANK AREA(ft^2)	8061
TOPWr(APP)	APP. RIGHT OVERBANK TOP WIDTH(ft)	577
Y1r(APP)	AVG. DEPTH IN UPSTR RIGHT OVERBANK ft)	13.97
WETPr(APP)	APP. RIGHT OVERBANK WETTED PERIM.(ft)	578
Kr(BR)	BR. RIGHT OVERBANK CONVEYANCE	641663
W2r(BR)	BR. RIGHT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	127.6

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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= 21.30 ft

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

SHEARm=Ywater*Rm*Sf
SHEARm= 0.19 lb/sf

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

Vm*=(SHEARm/p)^.5
Vm*= 0.31 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= 10.44
K1= 0.69

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

Q1m=Q*(Km(APP)/Ktot(APP))
Q1m= 2661 cfs

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

Q2m=Q*(Km(BR)/Ktot(BR))
Q2m= 7790 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2m/Y1m=(Q2m/Q1m)^6/7*(W1m/W2m)^K1
Y2m= 63.02 ft

(j) MAIN CONTRACTION SCOUR DEPTH (Ysm):
Ysm=Y2m-Y1m
Ysm= 39.50 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= 14.10 ft

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

SHEARl=Ywater*Rl*Sf
SHEARl= 0.13 lb/sf

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

Vl*=(SHEARl/p)^.5
Vl*= 0.25 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= 8.50
K1= 0.69

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

Q1l=Q*(Kl(APP)/Ktot(APP))
Q1l= 11593 cfs

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

Q2l=Q*(Kl(BR)/Ktot(BR))
Q2l= 5028 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2l/Y1l=(Q2l/Q1l)^6/7*(W1l/W2l)^K1
Y2l= 26.75 ft

(j) LEFT OVERBANK CONTRACTION SCOUR DEPTH (Ysl):
Ysl=Y2l-Y1l
Ysl= 12.63 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= 13.95 ft

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

SHEARr=Ywater*Rr*Sf
SHEARr= 0.12 lb/sf

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

Vr*=(SHEARr/p)^.5
Vr*= 0.25 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= 8.45
K1= 0.69

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

Q1r=Q*(Kr(APP)/Ktot(APP))
Q1r= 9746 cfs

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

Q2r=Q*(Kr(BR)/Ktot(BR))
Q2r= 11182 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2r/Y1r=(Q2r/Q1r)^6/7*(W1r/W2r)^K1
Y2r= 44.52 ft

(j) RIGHT OVERBANK CONTRACTION SCOUR DEPTH (Ysr):
Ysr=Y2r-Y1r
Ysr= 30.55 ft

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III. LOCAL SCOUR AT PIERS

(A) INPUT FROM WSPRO

VARIABLE		DESCRIPTION	VALUE
PIER #2:	WSPRO STA	2025	
	PIER #2 IS PROTECTED BY THE RIPRAP OF THE ABUTMENT NO SCOUR CALCULATIONS ARE PERFORMED		
PIER #3:	WSPRO STA	2050	
A3		AREA OF CONVEYANCE TUBE AT PIER #3 (sf)	533.1
V3		VELOCITY IN CONVEYANCE TUBE AT PIER #3 (fps)	2.25
TOPW3		TOPWIDTH OF CONVEYANCE TUBE AT PIER #3 (ft)	52.3
Y3		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #3 (ft)	10.19
PIER #4:	WPSRO STA	2075	
A4		AREA OF CONVEYANCE TUBE AT PIER #4 (sf)	301.5
V4		VELOCITY IN CONVEYANCE TUBE AT PIER #4 (fps)	3.98
TOPW4		TOPWIDTH OF CONVEYANCE TUBE AT PIER #4 (ft)	17
Y4		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #4 (ft)	17.74
PIER #5/6:	WSPRO STA	2100	
A5/6		AREA OF CONVEYANCE TUBE AT PIER #5/6 (sf)	280.6
V5/6		VELOCITY IN CONVEYANCE TUBE AT PIER #5/6 (fps)	4.28
TOPW5/6		TOPWIDTH OF CONVEYANCE TUBE AT PIER #5/6 (ft)	15.5
Y5/6		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #5/6 (ft)	18.10
PIER #7/8:	WSPRO STA	2163	
A7/8		AREA OF CONVEYANCE TUBE AT PIER #7/8 (sf)	227.2
V7/8		VELOCITY IN CONVEYANCE TUBE AT PIER #7/8 (fps)	5.28
TOPW7/8		TOPWIDTH OF CONVEYANCE TUBE AT PIER #7/8 (ft)	9.7
Y7/8		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #7/8 (ft)	23.42
PIER #9:	WSPRO STA	2190	
A9		AREA OF CONVEYANCE TUBE AT PIER #9 (sf)	298.5
V9		VELOCITY IN CONVEYANCE TUBE AT PIER #9 (fps)	4.02
TOPW9		TOPWIDTH OF CONVEYANCE TUBE AT PIER #9 (ft)	17.5
Y9		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #9 (ft)	17.06

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PIER #10:	WSPRO STA	2214	
A10		AREA OF CONVEYANCE TUBE AT PIER #10 (sf)	296
V10		VELOCITY IN CONVEYANCE TUBE AT PIER #10 (fps)	4.05
TOPW10		TOPWIDTH OF CONVEYANCE TUBE AT PIER #10 (ft)	16.7
Y10		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #10 (ft)	17.72
PIER #11:	WSPRO STA	2240	
A11		AREA OF CONVEYANCE TUBE AT PIER #11 (sf)	208.4
V11		VELOCITY IN CONVEYANCE TUBE AT PIER #11 (fps)	5.76
TOPW11		TOPWIDTH OF CONVEYANCE TUBE AT PIER #11 (ft)	7.1
Y11		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #11 (ft)	29.35
PIER #12:	WSPRO STA	2264	
A12		AREA OF CONVEYANCE TUBE AT PIER #12 (sf)	229.4
V12		VELOCITY IN CONVEYANCE TUBE AT PIER #12 (fps)	5.23
TOPW12		TOPWIDTH OF CONVEYANCE TUBE AT PIER #12 (ft)	8.9
Y12		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #12 (ft)	25.78
PIER #13:	WSPRO STA	2290	
A13		AREA OF CONVEYANCE TUBE AT PIER #13 (sf)	450.4
V13		VELOCITY IN CONVEYANCE TUBE AT PIER #13 (fps)	2.66
TOPW13		TOPWIDTH OF CONVEYANCE TUBE AT PIER #13 (ft)	42.2
Y13		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #13 (ft)	10.67

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V. ABUTMENT SCOUR - HIRE EQ.

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
Q(ABut)	TOTAL DISCHARGE INPUT TO WSPRO (cfs)	24000
qtube	DISCHARGE PER EQUAL CONVEYANCE TUBE (cfs)	1200.0

LEFT:

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED
THE RIGHT ABUTMENT HAS A HISTORY OF ABUTMENT SCOUR EVEN THOUGH IT IS PROTECTED.

RIGHT:

Ar	AREA OF CONV. TUBE ADJACENT TO RIGHT ABT.(sf)	450.4
Vr	VEL. OF CONV. TUBE ADJACENT TO RIGHT ABT.(fps)	2.66
TOPWr	TOPWIDTH OF CONV. TUBE ADJ. TO RT.ABT.(ft)	42.2
Yr	AVG. DEPTH OF CONV. TUBE ADJ. TO RT. ABT.(ft)	10.7

(B) CALCULATIONS

1. LEFT ABUTMENT SCOUR DEPTH (Ysl):

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED

2. RIGHT ABUTMENT SCOUR DEPTH (Ysr):

(a) FROUDE NO.=FRr=Vr/(g*Yr)^.5= 0.14
(b) Ysr=Yr*4*FRr^.33

Ysr= 22.50 ft

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-2
BRIDGE NO. 124000900200
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500

IV. ABUTMENT SCOUR - FROELICH'S EQ.

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
Q	TOTAL DISCHARGE INPUT TO WSPRO (cfs)	24000
qtube	DISCHARGE PER EQUAL CONVEYANCE TUBE (cfs)	1200.0

LEFT:

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED
THE RIGHT ABUTMENT HAS A HISTORY OF ABUTMENT SCOUR EVEN THOUGH IT IS PROTECTED.

RIGHT:

#Tr	# APP. CONVEYANCE TUBES OBSTR. BY RIGHT ABT.	5.64
Qr	FLOW IN RIGHT OVERBANK OBSTR. BY ABT. (cfs)	6768.0
Ar	AREA OF CONV. TUBES OBSTR. BY RIGHT ABT. (sf)	5867.1
ar	LENGTH OF RIGHT ABT. PROJECTING INTO FLOW(ft)	444.2

(B) CALCULATIONS

1. LEFT ABUTMENT SCOUR (Ysl):

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-2
BRIDGE NO. 124000900200
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STORM EVENT (YR): 500

THE RIGHT ABUTMENT HAS A HISTORY OF ABUTMENT SCOUR EVEN THOUGH IT IS PROTECTED.

2. RIGHT ABUTMENT SCOUR (Ysr):

(a) AVG. FLOW DEPTH IN RIGHT OVERBANK AREA (Yr):
Yr=Ar/ar= 13.21 ft Use HIRE Equation!

(b) AVG. VELOCITY IN RIGHT OVERBANK AREA (Vr):
Vr=Qr/Ar= 1.15 fps

(c) FROUDE NO (FRr):
FRr=Vr/(g*Yr)^.5= 0.06

(d) K1=COEFF. OF ABT. SHAPE(TBL4, PG50)= 0.55

(e) K2=COEFF. OF ABT. ANGLE(FIG11,PG51)= 1.0

(f) FROELICH EQ. FOR SCOUR DEPTH (Ysr):
Ysr=Yr*(2.27*K1*K2*(ar/Yr)^.43*FRr^.61+1)
Ysr= 26.09 ft NOT VALID...Use HIRE Equation!

Photo 1: ***View facing east.***

Photo 2: ***View facing west.***

Photo 3: ***Southern view, east abutment is at left.***

Photo 4: ***Northwest view of Tower/Bent 5/6.***

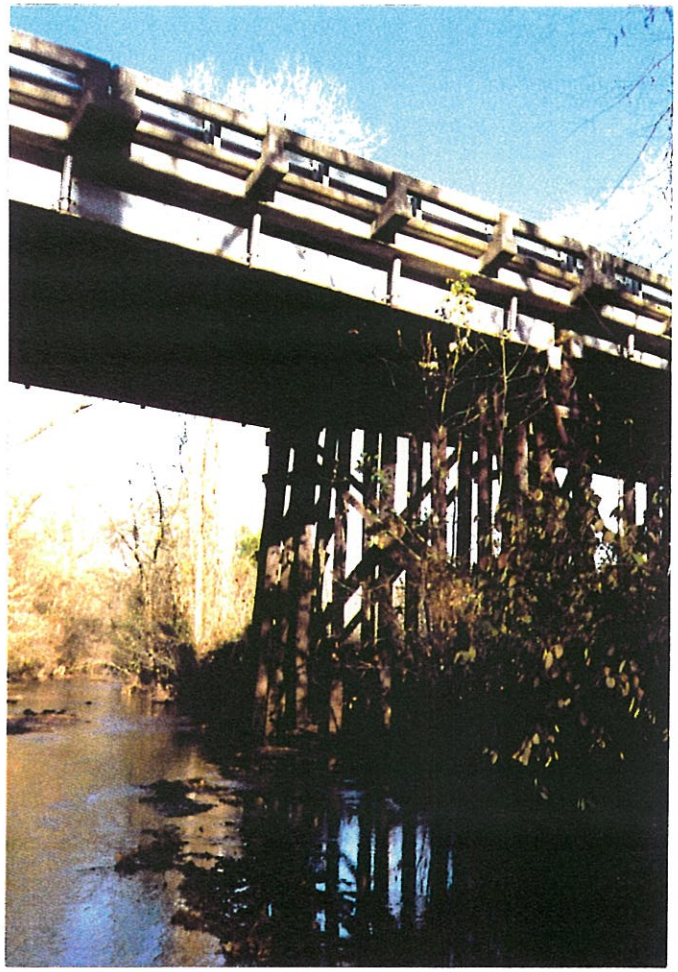

Photo 5: ***Upstream view at Tower Bent 5/6.***

Photo 6: ***Upstream view at Tower Bent 7/8.***

Photo 7: ***Upstream view.***

Photo 8: ***Upstream view at east overbank at approach.***

Photo 9: ***Upstream view at west overbank at approach.***

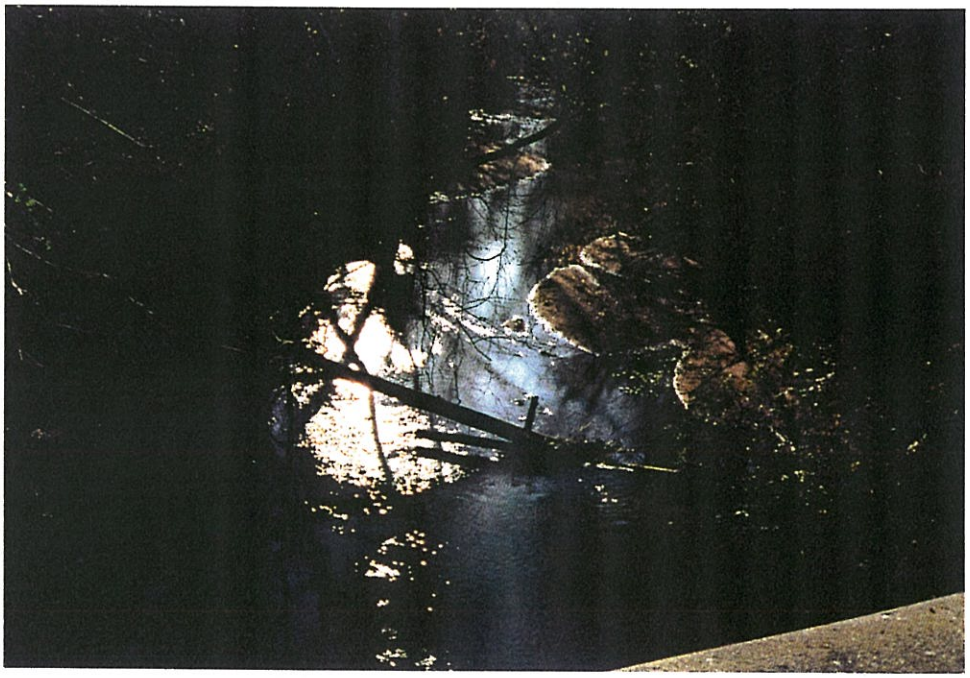

Photo 10: ***Downstream view.***

Photo 11: ***Eastern view of downstream face. Scour hole is in foreground.***

Photo 12: ***View of west abutment.***

Photo 13: ***Viewing downstream side of scour hole at east abutment.***