Espey, Huston & Associates, Inc.

LEVEL II BRIDGE SCOUR ANALYSIS

FOR STRUCTURE 124000900500 ON ROUTE SC 9 CROSSING SEELEY CREEK IN CHESTER COUNTY, SOUTH CAROLINA

EH&A Project No. 16139.01
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Prepared in cooperation with

South Carolina Department of Transportation

Columbia, South Carolina
January 1995

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FOR STRUCTURE 124000900500 ON ROUTE SC 9
CROSSING SEELEY CREEK
IN CHESTER COUNTY, SOUTH CAROLINA

This report provides the results of the detailed Level II analysis of scour potential at bridge 124000900500 on Route SC 9 crossing Seeley Creek in Chester County, South Carolina. The site is located in the Piedmont physiographic province near Chester, South Carolina. The bridge lies at approximately 34° 42' 55" north, 081° 16' 54" west, 4 miles west of Chester, South Carolina. The contributing watershed area for this bridge is 10.2 mi^2. The watershed is rural, consisting of forest and farmland. In the vicinity of the bridge, the floodplain consists of residential lawn and tall grass.

During low to moderate flow conditions, the flow is skewed approximately 30 degrees. This skew has produced some minimal debris accumulation, (refer to photo 6). During flood conditions the skew will be zero; therefore, a zero skew was used in the WSPRO and scour calculations.

This 150-foot bridge consists of seven bents. Bents 1 and 7 are at the abutments. Bents 2 through 6 consist of seven timber piles with cross supports for each bent, (refer to the bridge sketch and photos 3, 5, and 6). The spill-through abutments are protected by D_{50}= 12 in. riprap that is in good condition, (refer to photos 4 and 5). Note: that the riprap is covered by thick vegetation, (kudzu). Since the abutments are protected by riprap, abutment scour calculations were not performed.

Scour calculations were performed using engineering judgement and according to the FHWA Hydraulic Engineering Circular No. 18, (Revised April 1993). The calculations were performed assuming a uniform fine-sand streambed particle with a D_{50} of 0.12 mm. The 100-year total scour depth at the downstream face of the bridge ranged from 0 to 5.19 feet. The 500-year total scour depth at the downstream face of the bridge ranged from 0 to 8.36 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 124000900500 Stream Seeley Creek
County Chester Route SC 9 District 4

Description of Bridge

Bridge length 150 ft Bridge width 34.7 ft Max span length 25 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 15, 1994

Description of riprap D_{50} = 12 inches in good condition

Brief description of piers/pile bents Seven timber piles per bent with cross supports.

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	November 15, 1994	1	1

Potential for debris Low

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

None

Description of Floodplain

General topography Gently rolling

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

Date of inspection November 15, 1994

D/S left: Open woods (no underbrush)

D/S right: Dense woods and brush

U/S left: Tall grass

U/S right: Residential lawn

Description of Channel

Average top width 10 *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 15, 1994

D/S left: Kudzu, grass, trees

D/S right: Kudzu, grass, trees

U/S left: Trees and brush

U/S right: Trees and brush

Do banks appear stable? No *If not, describe location and type of instability and date of observation.* November 15, 1994. Minor sloughing of banks.

Describe any obstructions in channel and date of observation. None

Hydrology

Drainage area 10.2 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 3200 ft^3/s *Q500* 4400 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	*150*	*4*	*Full Valley Section*
BRDG	*150*	*1*	*Bridge Section*
ROAD	*Not Used*	*3*	*Road Section*
APPR	*335*	*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 "Baton Rouge, S.C." USGS quad map and from information collected during the field inspection on November 15, 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 449.6 ft

Average low steel elevation 447.4 ft

100-year discharge	3200	ft^3/s
Water-surface elevation at D/S bridge face	439.27	ft
Area of flow at D/S bridge face	767	ft^2
Average velocity in bridge opening	4.17	ft/s
Maximum WSPRO tube velocity at bridge	5.46	ft/s

Water-surface elevation at Approach section with bridge	440.36	ft
Water-surface elevation at Approach section without bridge	440.15	ft
Amount of backwater caused by bridge	0.21	ft

500-year discharge	4400	ft^3/s
Water-surface elevation at D/S bridge face	439.90	ft
Area of flow at D/S bridge face	841	ft^2
Average velocity in bridge opening	5.23	ft/s
Maximum WSPRO tube velocity at bridge	6.76	ft/s

Water-surface elevation at Approach section with bridge	441.30	ft
Water-surface elevation at Approach section without bridge	440.85	ft
Amount of backwater caused by bridge	0.45	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 124000900500 on SC 9 crossing Seeley 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 3200 cubic feet per second							
Abutment	0	0	Abutment-Protected	0	417.63	N/A	N/A
2	25	0	1.74	1.74	414.96	434.96	20
3	50	2.31	2.73	5.04	415.48	426.05	10.57
4	75	2.31	2.88	5.19	415.46	424.41	8.95
5	100	2.31	2.01	4.32	415.02	430.98	15.96
6	125	2.88	1.85	4.73	414.59	428.07	13.48
Abutment	150	0	Abutment-Protected	0	417.03	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 124000900500 on SC 9 crossing Seeley Creek in Chester County, South Carolina.

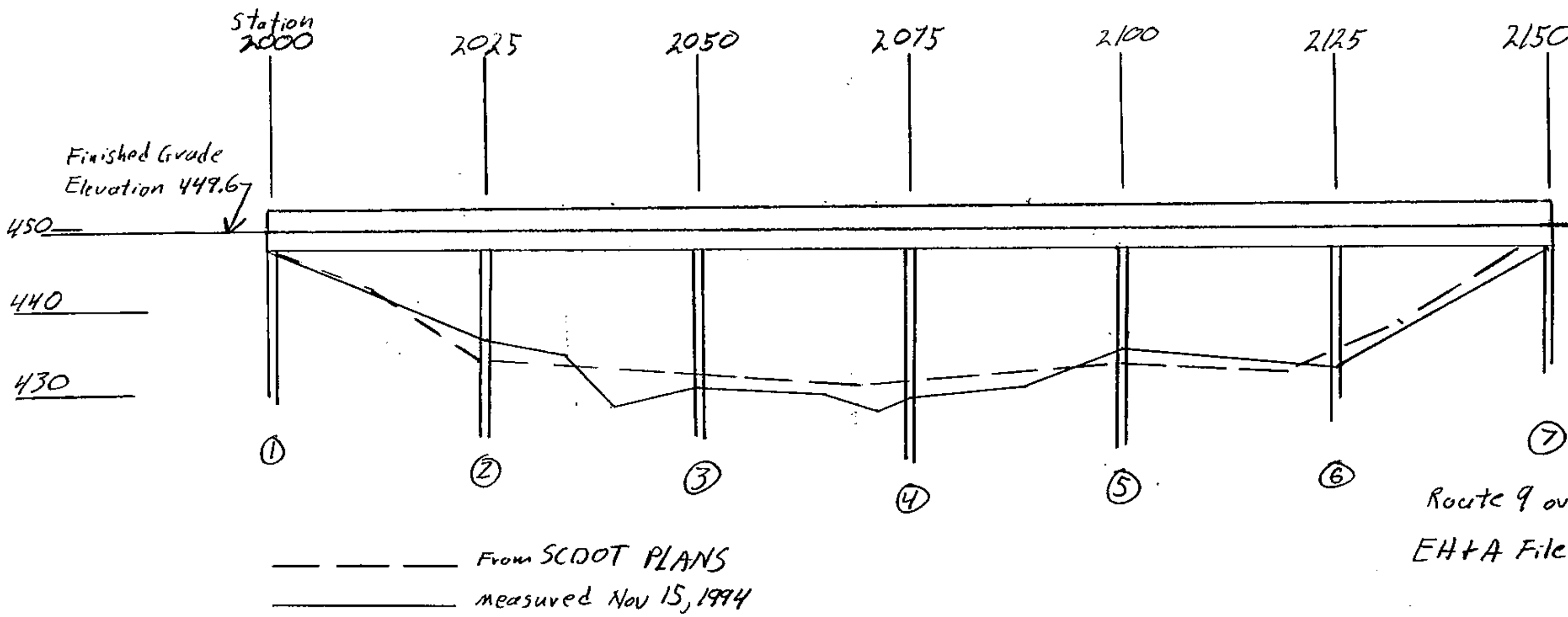
Pier/bent Number[1]	Distance[2] from left end of bridge (feet)	Contraction scour depth (feet)	Local scour depth without debris (feet)	Total scour[3] depth without debris (feet)	Elevation of Highest Pile Tip (feet)	Elevation of Bottom of Scour Hole (feet)	Remaining[4] Embedment (feet)
500-year discharge is 4400 cubic feet per second							
Abutment	0	0	Abutment-Protected	0	417.63	N/A	N/A
2	25	0	1.92	1.92	414.96	434.78	19.82
3	50	5.15	3.05	8.20	415.48	422.91	7.43
4	75	5.15	3.21	8.36	415.46	421.24	5.78
5	100	5.15	2.36	7.51	415.02	427.79	12.77
6	125	3.59	2.04	5.63	414.59	427.17	12.58
Abutment	150	0	Abutment-Protected	0	417.03	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.



Route 9 over Seeley Creek

EH+A File no. 16139.01 B-3

Looking Downstream

PROJECT 16139.01

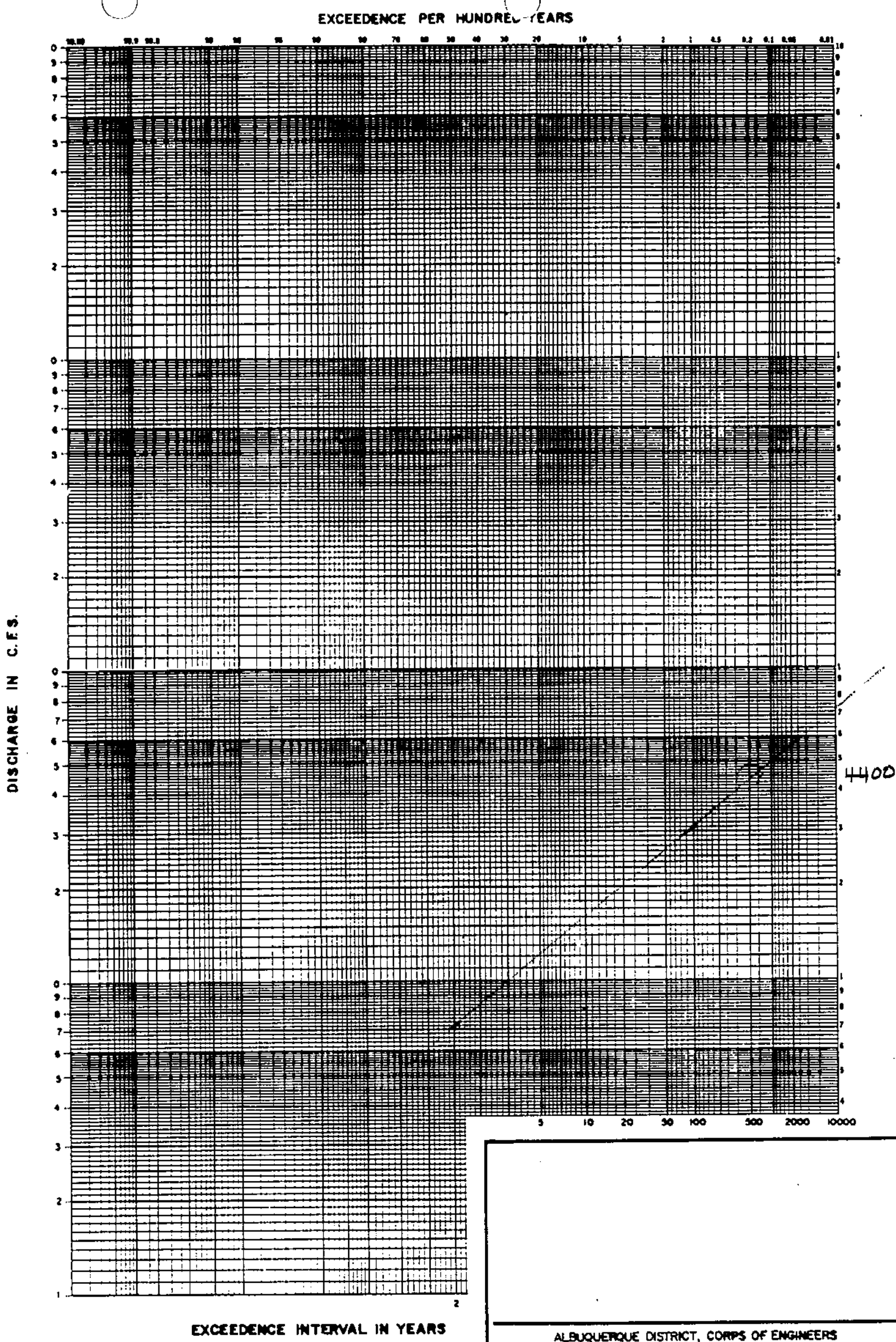
DETERMINING THE FLOOD DISCHARGES FOR VARIOUS RECURRENCE INTERVALS IN THE BLUE RIDGE-PIEDMONT HYDROLOGIC AREA OF NORTH CAROLINA

BRIDGE NUMBER 3 SEELEY CREEK

AREA IN SQUARE FEET = 284255534.0

AREA IN SQUARE MILES = 10.2

	DISCHARGE (CFS)	RECURRENCE INTERVAL (YEAR)
Q2 = 144*(AREA)^0.691	Q2 = 716	2
Q5 = 248*(AREA)^0.670	Q5 = 1175	5
Q10 = 334*(AREA)^0.665	Q10 = 1564	10
Q25 = 467*(AREA)^0.655	Q25 = 2187	25
Q50 = 581*(AREA)^0.650	Q50 = 2628	50
Q100 = 719*(AREA)^0.643	Q100 = 3200	100
EXTRAPOLATION:	Q500 = 4400	500



ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS

WSPRO INPUT

```
T2         ROUTE 9 OVER SEELEY CREEK
T3         EH&A FILE NO. 16139.01 B-3
*          CHESTER CO., SOUTH CAROLINA
*          FILE NAME: 16139W03.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           3200   4400
SK         .0044  .0044
*          ***********************************************************
*          CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
*          SHEET "BATON ROUGHE S.C." AND FROM INFORMATION
*          COLLECTED DURING THE FIELD INSPECTION ON NOVEMBER 15, 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
*          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 EXTRAPOLATEING 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          1500,450.0 1700,440.0
GR          2034,434.4 2060,434.4
GR          2065,429.5 2071,427.3 2075,428.9
GR          2080,434.3 2100,434.6
GR          2700,440.0 2800,450.0
N             .11  .07  .11
SA             2060  2080
*          ***********************************************************
XS     FULL  150 00
GR          1650,450.0 1750,440.0
GR          2034,435.1 2060,434.4
GR          2065,430.2 2071,428.0 2075,429.6
GR          2080,434.3 2100,435.3
GR          2400,440.0 2500,450.0
N             .11  .07  .11
SA             2060  2080
*          ***********************************************************
BR     BRDG  150 447.4 00
GR          2001,446.9 2025,436.7
GR          2034,435.1 2040,428.9 2050,431.1
GR          2065,430.2 2071,428.0 2075,429.6
GR          2089,431.0 2100,435.3
GR          2125,432.8
GR          2150,447.1 2001,446.9
N           .05  .045 .05
SA            2034  2100
CD          3  34.7  2  449.6
PW 1        429.6,1 431.1,1 431.1,2 432.8,2 432.8,3 435.3,3 435.3,4
PW 1        436.7,4 436.7,5 447.4,5
*          ***********************************************************
AS     APPR  335 00
GR          1700,450.0 1800,440.0
GR          2034,435.1 2060,435.1
GR          2065,430.2 2071,428.0 2075,429.6
GR          2080,434.3 2100,435.3
GR          2400,440.0 2500,450.0
N             .11  .07  .11
```

WSPRO INPUT (Cont.)

```
SA          2060  2080
*       *************************************************************
HP 1  APPR 440.36 * 440.36
HP 1  BRDG 439.27 * 439.27
HP 2  APPR 440.36 * 440.36  3200
HP 2  BRDG 439.27 * 439.27  3200
*
HP 1  APPR 441.30 * 441.30
HP 1  BRDG 439.90 * 439.90
HP 2  APPR 441.30 * 441.30  4400
HP 2  BRDG 439.90 * 439.90  4400
EX
ER
```

WSPRO OUTPUT

```
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  12:54

   T2        ROUTE 9 OVER SEELEY CREEK
   T3        EH&A FILE NO. 16139.01 B-3
   *         CHESTER CO., SOUTH CAROLINA
   *         FILE NAME: 16139W03.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          3200   4400
 *** Q-DATA FOR SEC-ID, ISEQ =            1
   SK        .0044  .0044
   *         ***********************************************************
   *         CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
   *         SHEET "BATON ROUGHE S.C." AND FROM INFORMATION
   *         COLLECTED DURING THE FIELD INSPECTION ON NOVEMBER 15, 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
   *         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 EXTRAPOLATEING 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 SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54

 *** START PROCESSING CROSS SECTION - " EXIT"
   XS    EXIT  000 00
   GR         1500,450.0 1700,440.0
   GR         2034,434.4 2060,434.4
   GR         2065,429.5 2071,427.3 2075,428.9
   GR         2080,434.3 2100,434.6
   GR         2700,440.0 2800,450.0
   N            .11  .07  .11
   SA            2060  2080
   *         ***********************************************************

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

WSPRO OUTPUT (Cont.)

```
--- 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 =  11):
       X      Y         X      Y         X      Y         X      Y
   1500.0  450.00    1700.0  440.00    2034.0  434.40    2060.0  434.40
   2065.0  429.50    2071.0  427.30    2075.0  428.90    2080.0  434.30
   2100.0  434.60    2700.0  440.00    2800.0  450.00

 X-Y MAX-MIN POINTS:
     XMIN      Y         X     YMIN      XMAX       Y         X    YMAX
   1500.0  450.00    2071.0  427.30    2800.0  450.00    1500.0  450.00

SUBAREA BREAKPOINTS (NSA =  3):
      2060.   2080.

ROUGHNESS COEFFICIENTS (NSA =  3):
        .110    .070    .110
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 SEELEY CREEK
        EH&A FILE NO. 16139.01 8-3
           *** RUN DATE & TIME: 12-21-94  12:54

*** START PROCESSING CROSS SECTION - " FULL"
  XS    FULL  150 00
  GR         1650,450.0 1750,440.0
  GR         2034,435.1 2060,434.4
  GR         2065,430.2 2071,428.0 2075,429.6
  GR         2080,434.3 2100,435.3
  GR         2400,440.0 2500,450.0
  N            .11  .07  .11
  SA            2060  2080
  *         ***********************************************************

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

--- DATA SUMMARY FOR SECID " FULL" AT SRD =    150.  ERR-CODE =      0

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

X-Y COORDINATE PAIRS  (NGP =  11):
       X      Y         X      Y         X      Y         X      Y
   1650.0  450.00    1750.0  440.00    2034.0  435.10    2060.0  434.40
   2065.0  430.20    2071.0  428.00    2075.0  429.60    2080.0  434.30
   2100.0  435.30    2400.0  440.00    2500.0  450.00

 X-Y MAX-MIN POINTS:
     XMIN      Y         X     YMIN      XMAX       Y         X    YMAX
   1650.0  450.00    2071.0  428.00    2500.0  450.00    1650.0  450.00

SUBAREA BREAKPOINTS (NSA =  3):
      2060.   2080.

ROUGHNESS COEFFICIENTS (NSA =  3):
        .110    .070    .110
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 SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54

*** START PROCESSING CROSS SECTION - " BRDG"
  BR    BRDG  150 447.4 00
  GR         2001,446.9 2025,436.7
  GR         2034,435.1 2040,428.9 2050,431.1
  GR         2065,430.2 2071,428.0 2075,429.6
  GR         2089,431.0 2100,435.3
  GR         2125,432.8
  GR         2150,447.1 2001,446.9
  N          .05  .045 .05
  SA           2034  2100
  CD         3  34.7  2  449.6
  PW 1       429.6,1 431.1,1 431.1,2 432.8,2 432.8,3 435.3,3 435.3,4
  PW 1       436.7,4 436.7,5 447.4,5
  *         **********************************************************

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

--- DATA SUMMARY FOR SECID " BRDG" AT SRD =     150.  ERR-CODE =      0

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

X-Y COORDINATE PAIRS  (NGP =  13):
      X       Y          X       Y          X       Y          X       Y
   2001.0  446.90     2025.0  436.70     2034.0  435.10     2040.0  428.90
   2050.0  431.10     2065.0  430.20     2071.0  428.00     2075.0  429.60
   2089.0  431.00     2100.0  435.30     2125.0  432.80     2150.0  447.10
   2001.0  446.90

 X-Y MAX-MIN POINTS:
     XMIN       Y          X    YMIN      XMAX       Y          X    YMAX
   2001.0  446.90     2071.0  428.00     2150.0  447.10     2150.0  447.10

SUBAREA BREAKPOINTS (NSA =  3):
       2034.   2100.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .050    .045    .050

BRIDGE PARAMETERS:
 BRTYPE  BRWDTH     LSEL  USERCD  EMBSS   EMBELV  ABSLPL  ABSLPR
    3      34.7   447.40 *******   2.00   449.60 ******* *******

PIER DATA:  NPW = 10    PPCD = 1.
     PELV  PWDTH       PELV  PWDTH       PELV  PWDTH       PELV  PWDTH
    429.60   1.0      431.10   1.0      431.10   2.0      432.80   2.0
    432.80   3.0      435.30   3.0      435.30   4.0      436.70   4.0
    436.70   5.0      447.40   5.0
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 SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54

*** START PROCESSING CROSS SECTION - " APPR"
  AS    APPR  335 00
  GR         1700,450.0 1800,440.0
  GR         2034,435.1 2060,435.1
```

WSPRO OUTPUT (Cont.)

```
 GR        2065,430.2 2071,428.0 2075,429.6
 GR        2080,434.3 2100,435.3
 GR        2400,440.0 2500,450.0
 N           .11  .07  .11
 SA           2060  2080
 *       ************************************************************
 HP 1  APPR 440.36 * 440.36

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

--- DATA SUMMARY FOR SECID " APPR" AT SRD =    335.  ERR-CODE =      0

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

X-Y COORDINATE PAIRS  (NGP =  11):
      X       Y          X       Y          X       Y          X       Y
   1700.0  450.00    1800.0  440.00    2034.0  435.10    2060.0  435.10
   2065.0  430.20    2071.0  428.00    2075.0  429.60    2080.0  434.30
   2100.0  435.30    2400.0  440.00    2500.0  450.00

 X-Y MAX-MIN POINTS:
     XMIN       Y          X    YMIN      XMAX       Y          X    YMAX
   1700.0  450.00    2071.0  428.00    2500.0  450.00    1700.0  450.00

SUBAREA BREAKPOINTS (NSA =  3):
       2060.   2080.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .110    .070    .110

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 SEELEY CREEK
       EH&A FILE NO. 16139.01 B-3
          *** RUN DATE & TIME: 12-21-94  12:54
   CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID =  APPR;  SRD =     335.

     WSEL  SA#      AREA         K   TOPW   WETP  ALPH    LEW     REW     QCR
             1      795.    22472.   264.   264.                        7834.
           — 2      194.    16434.    20.    25.                        3439.
             3      925.    25225.   324.   324.                        8872.
   440.36          1914.    64131.   607.   612.  2.14  1796.  2404.  13178.
1
  HP 1  BRDG 439.27 * 439.27
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 SEELEY CREEK
       EH&A FILE NO. 16139.01 B-3
          *** RUN DATE & TIME: 12-21-94  12:54
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID =  BRDG;  SRD =     150.

     WSEL  SA#      AREA         K   TOPW   WETP  ALPH    LEW     REW     QCR
             1       38.     2049.    15.    16.                         344.
             2      561.    74149.    66.    70.                        9292.
             3      167.    13328.    36.    38.                        2034.
   439.27           767.    89526.   117.   124.  1.13  2019.  2136.  10442.
```

WSPRO OUTPUT (Cont.)

```
1
  HP 2  APPR 440.36 * 440.36  3200
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 SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID =  APPR;  SRD =      335.

         WSEL     LEW     REW    AREA         K         Q    VEL
       440.36  1796.4  2403.6  1914.2    64131.    3200.   1.67

X STA.      1796.4     1945.8     1973.8     1995.5     2013.9     2030.1
  A(I)           275.6      103.7       92.0       85.5       81.1
  V(I)             .58       1.54       1.74       1.87       1.97

X STA.      2030.1     2045.0     2059.9     2066.0     2068.9     2071.5
  A(I)            78.1       78.4       49.1       32.5       31.2
  V(I)            2.05       2.04       3.26       4.93       5.13

X STA.      2071.5     2074.2     2078.7     2091.1     2106.3     2123.8
  A(I)            31.9       41.4       72.7       78.6       84.8
  V(I)            5.01       3.86       2.20       2.03       1.89

X STA.      2123.8     2142.8     2164.6     2190.1     2223.3     2403.6
  A(I)            85.9       92.1       98.0      112.5      308.9
  V(I)            1.86       1.74       1.63       1.42        .52
1
  HP 2  BRDG 439.27 * 439.27  3200
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 SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID =  BRDG;  SRD =      150.

         WSEL     LEW     REW    AREA         K         Q    VEL
       439.27  2019.0  2136.3   766.6    89526.    3200.   4.17

X STA.      2019.0     2039.1     2042.3     2045.5     2049.2     2053.2
  A(I)            72.6       32.1       30.4       32.5       33.0
  V(I)            2.20       4.99       5.26       4.92       4.85

X STA.      2053.2     2057.1     2060.7     2064.2     2067.6     2070.5
  A(I)            33.2       31.9       31.2       32.2       29.8
  V(I)            4.81       5.02       5.13       4.97       5.37

X STA.      2070.5     2073.2     2076.3     2079.6     2083.0     2086.7
  A(I)            29.3       31.0       30.7       31.0       32.6
  V(I)            5.46       5.16       5.22       5.17       4.91

X STA.      2086.7     2090.9     2099.5     2111.8     2120.4     2136.3
  A(I)            33.9       50.4       55.7       47.8       65.5
  V(I)            4.72       3.18       2.87       3.34       2.44
```

```
1
  *
  HP 1  APPR 441.30 * 441.30
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 SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54
    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID =  APPR;  SRD =     335.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     1047.   34746.   273.   273.                       11637.
             2      213.   19167.    20.    25.                        3950.
             3     1233.   39987.   333.   333.                       13471.
   441.30          2494.   93901.   626.   631.  1.77  1787.  2413.  21250.
1
  HP 1  BRDG 439.90 * 439.90
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 SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID =  BRDG;  SRD =     150.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1       48.    2827.    17.    17.                         465.
             2      603.   83526.    66.    70.                       10343.
             3      190.   16199.    37.    39.                        2436.
   439.90           841.  102551.   120.   127.  1.14  2017.  2137.  11867.
1
  HP 2  APPR 441.30 * 441.30  4400
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 SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID =  APPR;  SRD =     335.

          WSEL     LEW     REW    AREA        K        Q     VEL
        441.30  1787.0  2413.0  2493.8   93901.    4400.   1.76

X STA.      1787.0      1918.5      1952.1      1978.4      2000.4      2019.5
  A(I)           309.5       139.0       125.1       115.8       108.7
  V(I)             .71        1.58        1.76        1.90        2.02

X STA.      2019.5      2036.8      2053.4      2065.1      2068.9      2072.3
  A(I)           105.2       103.0        84.6        45.3        43.8
  V(I)            2.09        2.14        2.60        4.86        5.02

X STA.      2072.3      2076.2      2087.5      2103.7      2122.5      2142.9
  A(I)            46.7        84.5       100.9       109.2       112.1
  V(I)            4.71        2.60        2.18        2.02        1.96
```

WSPRO OUTPUT (Cont.)

```
X STA.      2142.9     2165.5     2191.6     2222.7     2263.9     2413.0
  A(I)            116.3      124.5      134.6      154.6      330.4
  V(I)             1.89       1.77       1.63       1.42        .67
1
  HP 2  BRDG 439.90 * 439.90  4400
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 SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54



   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID =  BRDG;  SRD =      150.

         WSEL     LEW     REW    AREA        K        Q     VEL
       439.90  2017.5  2137.4   841.4  102551.   4400.   5.23

X STA.      2017.5     2038.6     2042.0     2045.3     2049.1     2053.2
  A(I)             80.8       35.8       34.3       35.4       36.0
  V(I)             2.72       6.14       6.41       6.21       6.11

X STA.      2053.2     2057.0     2060.8     2064.4     2067.8     2070.7
  A(I)             35.0       35.5       34.8       34.2       32.6
  V(I)             6.29       6.20       6.33       6.43       6.76

X STA.      2070.7     2073.6     2076.8     2080.2     2083.8     2087.6
  A(I)             32.7       33.6       34.0       34.4       35.4
  V(I)             6.73       6.55       6.47       6.40       6.22

X STA.      2087.6     2092.3     2102.1     2112.5     2120.7     2137.4
  A(I)             39.2       57.0       55.7       51.4       73.4
  V(I)             5.61       3.86       3.95       4.28       3.00
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 9 OVER SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54

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

 EXIT:XS   ******  1787.    1734.   .13 *****  438.67  437.14   3200.  438.54
        0. ******  2538.   48202.  2.51 ***** *******     .34    1.85

 FULL:FV     150.  1793.    1381.   .22   .76  439.48 *******   3200.  439.26
      150.   150.  2353.   41841.  2.68   .05     .00     .43    2.32
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPR:AS     185.  1799.    1787.   .11   .78  440.26 *******   3200.  440.15
      335.   185.  2401.   58191.  2.27   .00     .00     .28    1.79
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

           <<<<<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      150.  2019.     767.   .39    .88  439.66  435.15    3200.  439.27
       150.   150.  2136.   89573.  1.44    .11     .00     .35     4.17

      TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
        3.   1.   1.   .832   .040  447.40 ****** ****** ******

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

 APPR:AS      150.  1796.    1912.   .09    .72  440.45  438.05    3200.  440.36
       335.   162.  2404.   64012.  2.14    .07     .01     .24     1.67

        M(G)   M(K)      KQ   XLKQ   XRKQ    OTEL
        .805   .430  36269.  2020.  2137.  439.98

                      <<<<<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 SEELEY CREEK
         EH&A FILE NO. 16139.01 B-3
            *** RUN DATE & TIME: 12-21-94  12:54
   FIRST USER DEFINED TABLE.

     XSID:CODE       Q     WSEL      VEL    CRWS     YMIN
     EXIT:XS      3200.  438.54     1.85  437.14   427.30
     FULL:FV      3200.  439.26     2.32********   428.00
     BRDG:BR      3200.  439.27     4.17  435.15   428.00
     APPR:AS      3200.  440.36     1.67  438.05   428.00
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 SEELEY CREEK
         EH&A FILE NO. 16139.01 B-3
            *** RUN DATE & TIME: 12-21-94  12:54
  SECOND USER DEFINED TABLE.

     XSID:CODE       Q      AREA    LEW    REW     SRD        K
     EXIT:XS      3200.    1734.  1787.  2538.      0.   48202.
     FULL:FV      3200.    1381.  1793.  2353.    150.   41841.
     BRDG:BR      3200.     767.  2019.  2136.    150.   89573.
     APPR:AS      3200.    1912.  1796.  2404.    335.   64012.

     XSID:CODE    OTEL
     APPR:AS    439.98
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 SEELEY CREEK
         EH&A FILE NO. 16139.01 B-3
            *** RUN DATE & TIME: 12-21-94  12:54
   THIRD USER DEFINED TABLE.

     XSID:CODE     EGL      FR#    WSEL     HF
     EXIT:XS    438.67     .34  438.54******
     FULL:FV    439.48     .43  439.26    .76
     BRDG:BR    439.66     .35  439.27    .88
```

WSPRO OUTPUT (Cont.)

```
   APPR:AS    440.45     .24  440.36   .72
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 SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54

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

  EXIT:XS   ******  1748.    2265.   .13 *****  439.33  437.58   4400.  439.20
         0. ******  2611.   66282.  2.23 ***** *******     .32    1.94

  FULL:FV     150.  1754.    1784.   .23   .78  440.16 *******   4400.  439.93
       150.   150.  2395.   56280.  2.43   .05     .00     .41    2.47
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              " APPR"     KRATIO =  1.40

  APPR:AS     185.  1792.    2214.   .12   .81  440.97 *******   4400.  440.85
       335.   185.  2408.   78978.  1.92   .00     .00     .26    1.99
         <<<<<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     150.  2017.     841.   .66   .94  440.56  436.10   4400.  439.90
       150.   150.  2137.  102530.  1.55   .28     .00     .43    5.23

      TYPE PPCD FLOW       C     P/A     LSEL    BLEN    XLAB    XRAB
        3.   1.   1.    .803    .040   447.40 ****** ****** ******

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

  APPR:AS     150.  1787.    2492.   .09   .73  441.38  438.58   4400.  441.30
       335.   165.  2413.   93807.  1.77   .09    -.01     .21    1.77

        M(G)   M(K)        KQ   XLKQ   XRKQ    OTEL
        .805   .508    46421.  2019.  2139.   440.97

                      <<<<<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 SEELEY CREEK
        EH&A FILE NO. 16139.01 B-3
           *** RUN DATE & TIME: 12-21-94  12:54
  FIRST USER DEFINED TABLE.

    XSID:CODE        Q    WSEL      VEL    CRWS    YMIN
    EXIT:XS      4400.  439.20     1.94  437.58  427.30
    FULL:FV      4400.  439.93     2.47********  428.00
    BRDG:BR      4400.  439.90     5.23  436.10  428.00
    APPR:AS      4400.  441.30     1.77  438.58  428.00
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 SEELEY CREEK
EH&A FILE NO. 16139.01 B-3
*** RUN DATE & TIME: 12-21-94 12:54
SECOND USER DEFINED TABLE.

XSID:CODE	Q	AREA	LEW	REW	SRD	K
EXIT:XS	4400.	2265.	1748.	2611.	0.	66282.
FULL:FV	4400.	1784.	1754.	2395.	150.	56280.
BRDG:BR	4400.	841.	2017.	2137.	150.	102530.
APPR:AS	4400.	2492.	1787.	2413.	335.	93807.

XSID:CODE	OTEL
APPR:AS	440.97

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 SEELEY CREEK
EH&A FILE NO. 16139.01 B-3
*** RUN DATE & TIME: 12-21-94 12:54
THIRD USER DEFINED TABLE.

XSID:CODE	EGL	FR#	WSEL	HF
EXIT:XS	439.33	.32	439.20	******
FULL:FV	440.16	.41	439.93	.78
BRDG:BR	440.56	.43	439.90	.94
APPR:AS	441.38	.21	441.30	.73

ER

1 NORMAL END OF WSPRO EXECUTION.

SCDOT BRIDGE SCOUR
Saved As: 16139A03.WQ1
JOB NO. 16139.01 B-3
BRIDGE NO. 124000900500
BY/CHK: RAS/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	194
TOPW	APPR. MAIN CHANNEL TOP WIDTH (ft)	20
Ym	APPR. MAIN CHANNEL AVG. DEPTH = AREAm/TOPW	9.70
HFa	APPR. HEAD LOSS DUE TO FRICTION	0.78
DIST	DISTANCE FROM BRIDGE TO APPR.	185
Sf	AVG. UNCONSTRICTED ENERGY SLOPE = HFa/DIST	0.00422
Km	APPR. MAIN CHANNEL CONVEYANCE	16434
Vm	APPR. MAIN CHANNEL AVG. VELOCITY (fps)	5.50
	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	795
TOPW	LEFT OVERBANK TOP WIDTH (ft)	264
Yl	APPR. LEFT OVERBANK AVG. DEPTH (ft)	3.01
Kl	LEFT OVERBANK CONVEYANCE	22472
Vl	APPR. LEFT OVERBANK AVG. VELOCITY (fps)	1.84
	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	925
TOPW	RIGHT OVERBANK TOP WIDTH (ft)	324
Yr	APPR. RIGHT OVERBANK AVG. DEPTH (ft)	2.85
Kr	RIGHT OVERBANK CONVEYANCE	25225
Vr	APPR. RIGHT OVERBANK AVG. VELOCITY (fps)	1.77

SCDOT BRIDGE SCOUR
Saved As: 16139A03.WQ1
JOB NO. 16139.01 B-3
BRIDGE NO. 124000900500
BY/CHK: RAS/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= 1.01 fps

(3) RIGHT OVERBANK CRITICAL VELOCITY (Vcr):
NEILL'S EQ;
Vcr=1.58*((Ssr-1)*g*D50r)^1/2*(Yr/D50r)^1/6
Vcr= 1.01 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	ESPEY, HUSTON & ASSOC., INC
Saved As: 16139A03.WQ1	460 McLAWS CIRCLE, SUITE 150
JOB NO. 16139.01 B-3	WILLIAMSBURG, VA 23185
BRIDGE NO. 124000900500	
BY/CHK: RAS/JNP	STORM EVENT (YR): 100

SCOUR CALCULATIONS

I. LIVE BED CONTRACTION SCOUR

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
Q	TOTAL DISCHARGE(cfs) APPROACH	3200
Q	TOTAL DISCHARGE(cfs) BRIDGE	3200
Ktot(APP)	APP. TOTAL CONVEYANCE	64131
Ktot(BR)	BR. TOTAL CONVEYANCE	89526
Sf	AVG. UNCONSTRICTED ENERGY SLOPE	0.00422
MAIN CHANNEL:		
Km(APP)	APP. MAIN CHANNEL CONVEYANCE	16434
W1m(APP)	APP. MAIN CHANNEL WIDTH(ft)	20
Am(APP)	APP. MAIN CHANNEL AREA	194
TOPWm(APP)	APP. MAIN CHANNEL TOP WIDTH(ft)	20
Y1m(APP)	AVG. DEPTH IN UPSTR MAIN CHANNEL(ft)	9.70
WETPm(APP)	APP. MAIN CHANNEL WETTED PERIM.(ft)	25
Km(BR)	BR. MAIN CHANNEL CONVEYANCE	74149
W2m(BR)	BR. MAIN CHANNEL WIDTH MINUS PIER WIDTHS(ft)	63
LEFT OVERBANK:		
Kl(APP)	APP. LEFT OVERBANK CONVEYANCE	22472
W1l(APP)	APP. LEFT OVERBANK WIDTH(ft)	264
Al(APP)	APP. LEFT OVERBANK AREA(ft^2)	795
TOPWl(APP)	APP. LEFT OVERBANK TOP WIDTH(ft)	264
Y1l(APP)	AVG. DEPTH IN UPSTR LEFT OVERBANK (ft)	3.01
WETPl(APP)	APP. LEFT OVERBANK WETTED PERIM.(ft)	264
Kl(BR)	BR. LEFT OVERBANK CONVEYANCE	2049
W2l(BR)	BR. LEFT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	14
RIGHT OVERBANK:		
Kr(APP)	APP. RIGHT OVERBANK CONVEYANCE	25225
W1r(APP)	APP. RIGHT OVERBANK WIDTH(ft)	324
Ar(APP)	APP. RIGHT OVERBANK AREA(ft^2)	925
TOPWr(APP)	APP. RIGHT OVERBANK TOP WIDTH(ft)	324
Y1r(APP)	AVG. DEPTH IN UPSTR RIGHT OVERBANK ft)	2.85
WETPr(APP)	APP. RIGHT OVERBANK WETTED PERIM.(ft)	324
Kr(BR)	BR. RIGHT OVERBANK CONVEYANCE	13328
W2r(BR)	BR. RIGHT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	35.3

SCDOT BRIDGE SCOUR
Saved As: 16139A03.WQ1
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BRIDGE NO. 124000900500
BY/CHK: RAS/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= 7.76 ft

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

SHEARm=Ywater*Rm*Sf
SHEARm= 2.04 lb/sf

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

Vm*=(SHEARm/p)^.5
Vm*= 1.03 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= 34.19
K1= 0.69

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

Q1m=Q*(Km(APP)/Ktot(APP))
Q1m= 820 cfs

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

Q2m=Q*(Km(BR)/Ktot(BR))
Q2m= 2650 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2m/Y1m=(Q2m/Q1m)^6/7*(W1m/W2m)^K1
Y2m= 12.01 ft

(j) MAIN CONTRACTION SCOUR DEPTH (Ysm):
Ysm=Y2m-Y1m
Ysm= 2.31 ft

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460 McLAWS CIRCLE, SUITE 150
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STORM EVENT (YR): 100

2. LEFT OVERBANK CONTRACTION SCOUR (Ysl):

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

Rl=Al(APP)/WETPl(APP)
Rl= 3.01 ft

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

SHEARl=Ywater*Rl*Sf
SHEARl= 0.79 lb/sf

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

Vl*=(SHEARl/p)^.5
Vl*= 0.64 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= 21.30
K1= 0.69

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

Q1l=Q*(Kl(APP)/Ktot(APP))
Q1l= 1121 cfs

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

Q2l=Q*(Kl(BR)/Ktot(BR))
Q2l= 73 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2l/Y1l=(Q2l/Q1l)^6/7*(W1l/W2l)^K1
Y2l= 2.20 ft

(j) LEFT OVERBANK CONTRACTION SCOUR DEPTH (Ysl):
Ysl=Y2l-Y1l
Ysl= -0.81 ft

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BRIDGE NO. 124000900500	
BY/CHK: RAS/JNP	STORM EVENT (YR): 100

3. RIGHT OVERBANK CONTRACTION SCOUR (Ysr):

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

Rr=Ar(APP)/WETPr(APP)
Rr= 2.85 ft

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

SHEARr=Ywater*Rr*Sf
SHEARr= 0.75 lb/sf

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

Vr*=(SHEARr/p)^.5
Vr*= 0.62 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= 20.74
K1= 0.69

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

Q1r=Q*(Kr(APP)/Ktot(APP))
Q1r= 1259 cfs

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

Q2r=Q*(Kr(BR)/Ktot(BR))
Q2r= 476 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2r/Y1r=(Q2r/Q1r)^6/7*(W1r/W2r)^K1
Y2r= 5.73 ft

(j) RIGHT OVERBANK CONTRACTION SCOUR DEPTH (Ysr):
Ysr=Y2r-Y1r
Ysr= 2.88 ft

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STORM EVENT (YR): 100

III. LOCAL SCOUR AT PIERS

(A) INPUT FROM WSPRO

VARIABLE		DESCRIPTION	VALUE
PIER #2:	WSPRO STA	2025	
A2		AREA OF CONVEYANCE TUBE AT PIER #2 (sf)	72.6
V2		VELOCITY IN CONVEYANCE TUBE AT PIER #2 (fps)	2.2
TOPW2		TOPWIDTH OF CONVEYANCE TUBE AT PIER #2 (ft)	20.1
Y2		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #2 (ft)	3.61
PIER #3:	WSPRO STA	2050	
A3		AREA OF CONVEYANCE TUBE AT PIER #3 (sf)	33
V3		VELOCITY IN CONVEYANCE TUBE AT PIER #3 (fps)	4.85
TOPW3		TOPWIDTH OF CONVEYANCE TUBE AT PIER #3 (ft)	4
Y3		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #3 (ft)	8.25
PIER #4:	WPSRO STA	2075	
A4		AREA OF CONVEYANCE TUBE AT PIER #4 (sf)	31
V4		VELOCITY IN CONVEYANCE TUBE AT PIER #4 (fps)	5.16
TOPW4		TOPWIDTH OF CONVEYANCE TUBE AT PIER #4 (ft)	3.1
Y4		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #4 (ft)	10.00
PIER #5:	WSPRO STA	2100	
A5		AREA OF CONVEYANCE TUBE AT PIER #5 (sf)	55.7
V5		VELOCITY IN CONVEYANCE TUBE AT PIER #5 (fps)	2.87
TOPW5		TOPWIDTH OF CONVEYANCE TUBE AT PIER #5 (ft)	12.3
Y5		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #5 (ft)	4.53
PIER #6:	WSPRO STA	2125	
A6		AREA OF CONVEYANCE TUBE AT PIER #6 (sf)	65.5
V6		VELOCITY IN CONVEYANCE TUBE AT PIER #6 (fps)	2.44
TOPW6		TOPWIDTH OF CONVEYANCE TUBE AT PIER #6 (ft)	15.9
Y6		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #6 (ft)	4.12

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ESPEY, HUSTON & ASSOC., INC
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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=	0.20	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.0
(e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1

(f) CSU EQ. FOR PIER SCOUR;
Ys#2=Y2*2*K1*K2*K3*(a/Y2)^.65*FR2^.43
Ys#2= 1.74 ft

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

(a) a=PIER WIDTH (ft)=		1
(b) FROUDE NO.=FR3=V3/(g*Y3)^.5=	0.30	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.0
(e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1

(f) CSU EQ. FOR PIER SCOUR;
Ys#3=Y3*2*K1*K2*K3*(a/Y3)^.65*FR3^.43
Ys#3= 2.73 ft

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

(a) a=PIER WIDTH (ft)=		1
(b) FROUDE NO.=FR4=V4/(g*Y4)^.5=	0.29	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.0
(e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1

(f) CSU EQ. FOR PIER SCOUR;
Ys#4=Y4*2*K1*K2*K3*(a/Y4)^.65*FR4^.43
Ys#4= 2.88 ft

SCDOT BRIDGE SCOUR	ESPEY, HUSTON & ASSOC., INC
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BY/CHK: RAS/JNP	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=	0.24	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		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=Y5*2*K1*K2*K3*(a/Y5)^.65*FR5^.43

Ys#5= 2.01 ft

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

(a)	a=PIER WIDTH (ft)=		1
(b)	FROUDE NO.=FR6=V6/(g*Y6)^.5=	0.21	
(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#6=Y6*2*K1*K2*K3*(a/Y6)^.65*FR6^.43

Ys#6= 1.85 ft

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STORM EVENT (YR): 100

IV. ABUTMENT SCOUR :

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED

SCDOT BRIDGE SCOUR
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BY/CHK: RAS/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	213
TOPW	APPR. MAIN CHANNEL TOP WIDTH (ft)	20
Ym	APPR. MAIN CHANNEL AVG. DEPTH = AREAm/TOPW	10.65
HFa	APPR. HEAD LOSS DUE TO FRICTION	0.81
DIST	DISTANCE FROM BRIDGE TO APPR.	185
Sf	AVG. UNCONSTRICTED ENERGY SLOPE = HFa/DIST	0.00438
Km	APPR. MAIN CHANNEL CONVEYANCE	19167
Vm	APPR. MAIN CHANNEL AVG. VELOCITY (fps)	5.95
	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	1047
TOPW	LEFT OVERBANK TOP WIDTH (ft)	273
Yl	APPR. LEFT OVERBANK AVG. DEPTH (ft)	3.84
Kl	LEFT OVERBANK CONVEYANCE	34746
Vl	APPR. LEFT OVERBANK AVG. VELOCITY (fps)	2.20
	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	1233
TOPW	RIGHT OVERBANK TOP WIDTH (ft)	333
Yr	APPR. RIGHT OVERBANK AVG. DEPTH (ft)	3.70
Kr	RIGHT OVERBANK CONVEYANCE	39987
Vr	APPR. RIGHT OVERBANK AVG. VELOCITY (fps)	2.15

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BY/CHK: RAS/JNP

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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= 1.25 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):
NEILL'S EQ;
Vcr=1.58*((Ssr-1)*g*D50r)^1/2*(Yr/D50r)^1/6
Vcr= 1.05 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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WILLIAMSBURG, VA 23185

STORM EVENT (YR): 500

SCOUR CALCULATIONS

I. LIVE BED CONTRACTION SCOUR

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
Q	TOTAL DISCHARGE(cfs) APPROACH	4400
Q	TOTAL DISCHARGE(cfs) BRIDGE	4400
Ktot(APP)	APP. TOTAL CONVEYANCE	93900
Ktot(BR)	BR. TOTAL CONVEYANCE	102551
Sf	AVG. UNCONSTRICTED ENERGY SLOPE	0.00438
MAIN CHANNEL:		
Km(APP)	APP. MAIN CHANNEL CONVEYANCE	19167
W1m(APP)	APP. MAIN CHANNEL WIDTH(ft)	20
Am(APP)	APP. MAIN CHANNEL AREA	213
TOPWm(APP)	APP. MAIN CHANNEL TOP WIDTH(ft)	20
Y1m(APP)	AVG. DEPTH IN UPSTR MAIN CHANNEL(ft)	10.65
WETPm(APP)	APP. MAIN CHANNEL WETTED PERIM.(ft)	25
Km(BR)	BR. MAIN CHANNEL CONVEYANCE	83526
W2m(BR)	BR. MAIN CHANNEL WIDTH MINUS PIER WIDTHS(ft)	63
LEFT OVERBANK:		
Kl(APP)	APP. LEFT OVERBANK CONVEYANCE	34746
W1l(APP)	APP. LEFT OVERBANK WIDTH(ft)	273
Al(APP)	APP. LEFT OVERBANK AREA(ft^2)	1047
TOPWl(APP)	APP. LEFT OVERBANK TOP WIDTH(ft)	273
Y1l(APP)	AVG. DEPTH IN UPSTR LEFT OVERBANK (ft)	3.84
WETPl(APP)	APP. LEFT OVERBANK WETTED PERIM.(ft)	273
Kl(BR)	BR. LEFT OVERBANK CONVEYANCE	2827
W2l(BR)	BR. LEFT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	15.5
RIGHT OVERBANK:		
Kr(APP)	APP. RIGHT OVERBANK CONVEYANCE	39987
W1r(APP)	APP. RIGHT OVERBANK WIDTH(ft)	333
Ar(APP)	APP. RIGHT OVERBANK AREA(ft^2)	1233
TOPWr(APP)	APP. RIGHT OVERBANK TOP WIDTH(ft)	333
Y1r(APP)	AVG. DEPTH IN UPSTR RIGHT OVERBANK ft)	3.70
WETPr(APP)	APP. RIGHT OVERBANK WETTED PERIM.(ft)	333
Kr(BR)	BR. RIGHT OVERBANK CONVEYANCE	16199
W2r(BR)	BR. RIGHT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	36.4

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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= 8.52 ft

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

SHEARm=Ywater*Rm*Sf
SHEARm= 2.33 lb/sf

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

Vm*=(SHEARm/p)^.5
Vm*= 1.10 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= 36.51
K1= 0.69

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

Q1m=Q*(Km(APP)/Ktot(APP))
Q1m= 898 cfs

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

Q2m=Q*(Km(BR)/Ktot(BR))
Q2m= 3584 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2m/Y1m=(Q2m/Q1m)^6/7*(W1m/W2m)^K1
Y2m= 15.80 ft

(j) MAIN CONTRACTION SCOUR DEPTH (Ysm):
Ysm=Y2m-Y1m
Ysm= 5.15 ft

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WILLIAMSBURG, VA 23185

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2. LEFT OVERBANK CONTRACTION SCOUR (Ysl):

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

Rl=Al(APP)/WETPl(APP)
Rl= 3.84 ft

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

SHEARl=Ywater*Rl*Sf
SHEARl= 1.05 lb/sf

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

Vl*=(SHEARl/p)^.5
Vl*= 0.73 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= 24.50
K1= 0.69

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

Q1l=Q*(Kl(APP)/Ktot(APP))
Q1l= 1628 cfs

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

Q2l=Q*(Kl(BR)/Ktot(BR))
Q2l= 121 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2l/Y1l=(Q2l/Q1l)^6/7*(W1l/W2l)^K1
Y2l= 3.00 ft

(j) LEFT OVERBANK CONTRACTION SCOUR DEPTH (Ysl):
Ysl=Y2l-Y1l
Ysl= -0.84 ft

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3. RIGHT OVERBANK CONTRACTION SCOUR (Ysr):

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

Rr=Ar(APP)/WETPr(APP)
Rr= 3.70 ft

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

SHEARr=Ywater*Rr*Sf
SHEARr= 1.01 lb/sf

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

Vr*=(SHEARr/p)^.5
Vr*= 0.72 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= 24.07
K1= 0.69

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

Q1r=Q*(Kr(APP)/Ktot(APP))
Q1r= 1874 cfs

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

Q2r=Q*(Kr(BR)/Ktot(BR))
Q2r= 695 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2r/Y1r=(Q2r/Q1r)^6/7*(W1r/W2r)^K1
Y2r= 7.29 ft

(j) RIGHT OVERBANK CONTRACTION SCOUR DEPTH (Ysr):
Ysr=Y2r-Y1r
Ysr= 3.59 ft

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III. LOCAL SCOUR AT PIERS

(A) INPUT FROM WSPRO

VARIABLE		DESCRIPTION	VALUE
PIER #2:	WSPRO STA	2025	
A2		AREA OF CONVEYANCE TUBE AT PIER #2 (sf)	80.8
V2		VELOCITY IN CONVEYANCE TUBE AT PIER #2 (fps)	2.72
TOPW2		TOPWIDTH OF CONVEYANCE TUBE AT PIER #2 (ft)	21.1
Y2		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #2 (ft)	3.83
PIER #3:	WSPRO STA	2050	
A3		AREA OF CONVEYANCE TUBE AT PIER #3 (sf)	36
V3		VELOCITY IN CONVEYANCE TUBE AT PIER #3 (fps)	6.11
TOPW3		TOPWIDTH OF CONVEYANCE TUBE AT PIER #3 (ft)	4.1
Y3		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #3 (ft)	8.78
PIER #4:	WPSRO STA	2075	
A4		AREA OF CONVEYANCE TUBE AT PIER #4 (sf)	33.6
V4		VELOCITY IN CONVEYANCE TUBE AT PIER #4 (fps)	6.55
TOPW4		TOPWIDTH OF CONVEYANCE TUBE AT PIER #4 (ft)	3.2
Y4		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #4 (ft)	10.50
PIER #5:	WSPRO STA	2100	
A5		AREA OF CONVEYANCE TUBE AT PIER #5 (sf)	57
V5		VELOCITY IN CONVEYANCE TUBE AT PIER #5 (fps)	3.86
TOPW5		TOPWIDTH OF CONVEYANCE TUBE AT PIER #5 (ft)	9.8
Y5		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #5 (ft)	5.82
PIER #6:	WSPRO STA	2125	
A6		AREA OF CONVEYANCE TUBE AT PIER #6 (sf)	73.4
V6		VELOCITY IN CONVEYANCE TUBE AT PIER #6 (fps)	3
TOPW6		TOPWIDTH OF CONVEYANCE TUBE AT PIER #6 (ft)	16.7
Y6		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #6 (ft)	4.40

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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=	0.24	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.0
(e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1

(f) CSU EQ. FOR PIER SCOUR;
Ys#2=Y2*2*K1*K2*K3*(a/Y2)^.65*FR2^.43
Ys#2= 1.92 ft

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

(a) a=PIER WIDTH (ft)=		1
(b) FROUDE NO.=FR3=V3/(g*Y3)^.5=	0.36	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1
(d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)=		1.0
(e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)=		1.1

(f) CSU EQ. FOR PIER SCOUR;
Ys#3=Y3*2*K1*K2*K3*(a/Y3)^.65*FR3^.43
Ys#3= 3.05 ft

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

(a) a=PIER WIDTH (ft)=		1
(b) FROUDE NO.=FR4=V4/(g*Y4)^.5=	0.36	
(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= 3.21 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= 0.28
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 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=Y5*2*K1*K2*K3*(a/Y5)^.65*FR5^.43
Ys#5= 2.36 ft

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

(a) a=PIER WIDTH (ft)= 1
(b) FROUDE NO.=FR6=V6/(g*Y6)^.5= 0.25
(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#6=Y6*2*K1*K2*K3*(a/Y6)^.65*FR6^.43
Ys#6= 2.04 ft

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

ABUTMENT

PROTECTED

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IV. ABUTMENT SCOUR :

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED

Photo 1: ***View facing north.***

Photo 2: ***View facing south.***

Photo 3: *Downstream face view (northward).*

Photo 4: *View of the southern abutment.*

Photo 5: *View of the northern abutment.*

Photo 6: *View looking downstream.*

Photo 7: *Downstream view at exit section.*

Photo 8: *Upstream view at approach section.*

Photo 9: *View of southern floodplain downstream of bridge. The stream is out of frame to the right.*

Photo 10: *Downstream view (from roadway).*

Photo 11: *Upstream view of northern floodplain. The stream is out of frame to the right.*

Photo 12: *Upstream view of southern floodplain.*