SCOUR EVALUATION

FOR

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

ON

STRUCTURE # 132005200500
US-52 OVER WESTFIELD CREEK
CHESTERFIELD COUNTY, SC

Prepared by:

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SOUTH CAROLINA
REGISTERED PROFESSIONAL ENGINEER
No. 13362
1-30-95
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SCOUR EVALUATION FOR US-52 OVER WESTFIELD CREEK

1.0 STREAM STABILITY

1.1 Stream Characteristics

A field investigation recorded the stream characteristics on Figure 1 and on forms contained in Appendix 1. The investigation found that the overbank areas are well vegetated and the channel area is free from vegetation. The stream is described as a small perennial stream. A portion of the USGS Quad map is presented as Figure 2 for location purposes.

1.2 Land Use Changes

The bridge site is approximately 5.4 miles north of Cheraw, South Carolina. The land use in the drainage basin is rural and no major land use changes are expected for the life of the structure.

1.3 Overall Stream Stability

The overall stream stability appears to be relatively stable except for some evidence of minor bed degradation. The 2-Year discharge and the stream slope have been plotted in the transitional zone on Figure 3 (Figure 8 in HEC-20[1]). This shows that a sand bed stream at this site would be in transition between a meandering and braided pattern. The actual stream conditions include dense vegetation which will influence the behavior of the stream.

1.4 Lateral Stability

The stream alignment is currently approximately 45° upstream and 90° downstream to the bridge opening. An abandoned railroad alignment exists immediately upstream from the site. Massive concrete vertical abutments and a center pier still exist on the railroad alignment. These abandoned concrete works restrict the potential for lateral movement of the stream. Photographs of the site (Appendix 2) show that the stream banks are well vegetated and stable during average flow conditions.

1.5 Vertical Stability

The stream bed profile is currently approximately 1.5 feet lower than it was in 1936. This is evidenced by shallower channel depths for the 1936 construction plans than the channel depths measured for this report.

1.6 Channel Response to Change

The channel may still be responding to the change resulting from the construction of the bridge. No site changes are anticipated at this time which would further influence the stream behavior.

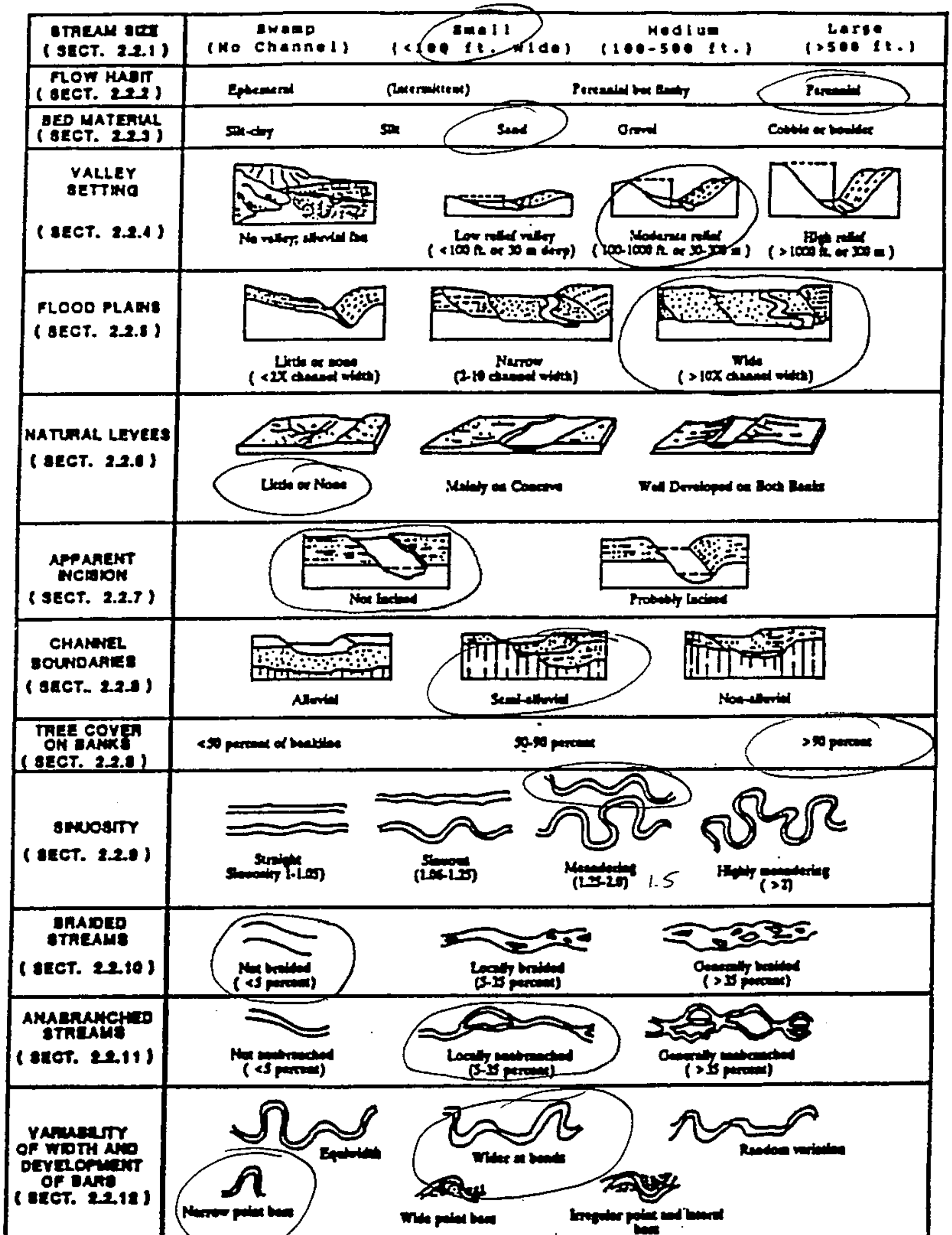


Figure 1. Geomorphic factors that affect stream stability (From HEC-20)

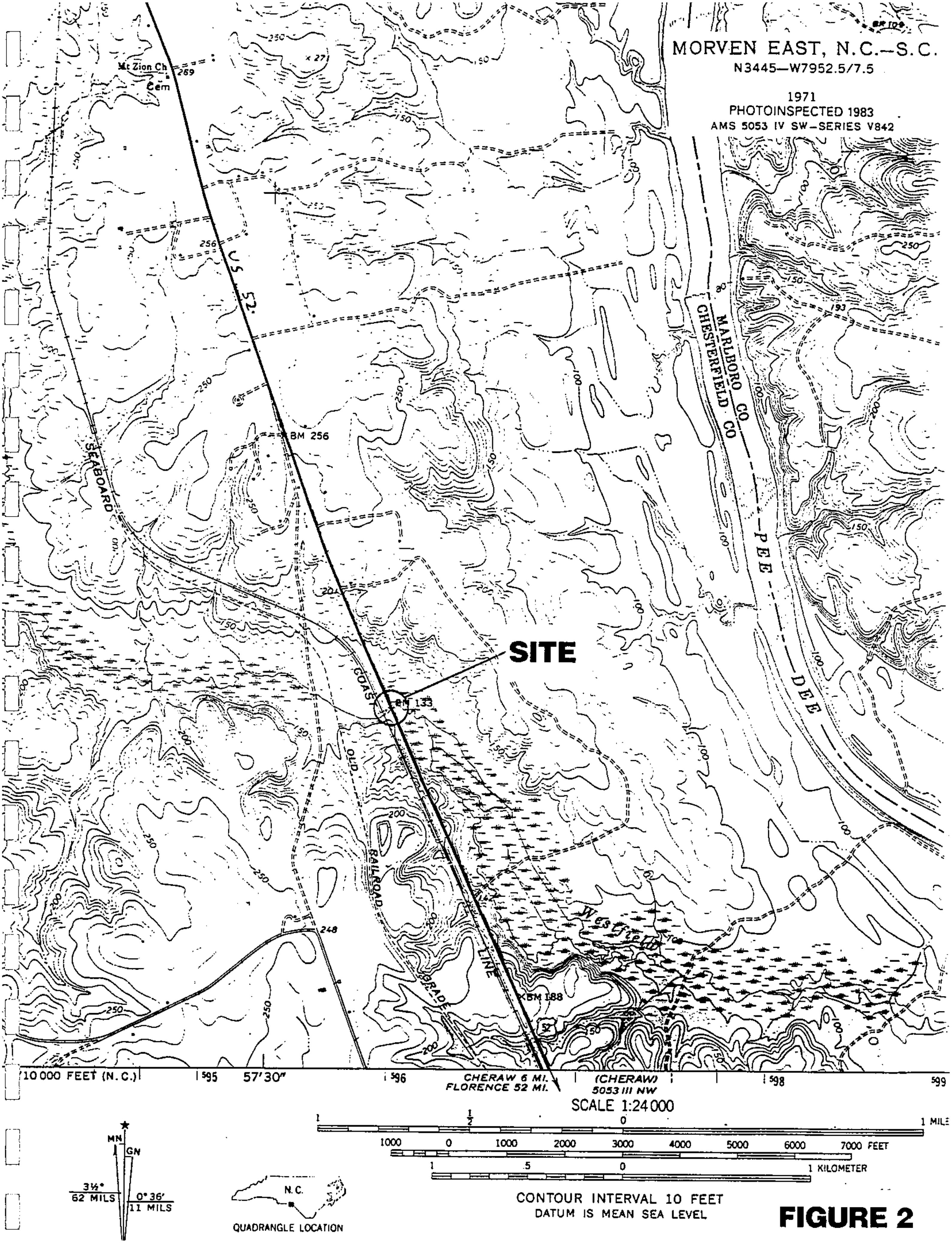

MORVEN EAST, N.C.–S.C.
N3445—W7952.5/7.5
1971
PHOTOINSPECTED 1983
AMS 5053 IV SW–SERIES V842
Mt Zion Ch
Cem
US 52
BM 256
SEABOARD
COAST
LINE
OLD
RAILROAD
GRADE
SITE
BM 133
BM 188
MARLBORO CO
CHESTERFIELD CO
PEE DEE
10 000 FEET (N.C.)
57'30"
CHERAW 6 MI.
FLORENCE 52 MI.
(CHERAW)
5053 III NW
SCALE 1:24 000
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER
MN
GN
3½°
62 MILS
0° 36'
11 MILS
N.C.
QUADRANGLE LOCATION
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

FIGURE 2

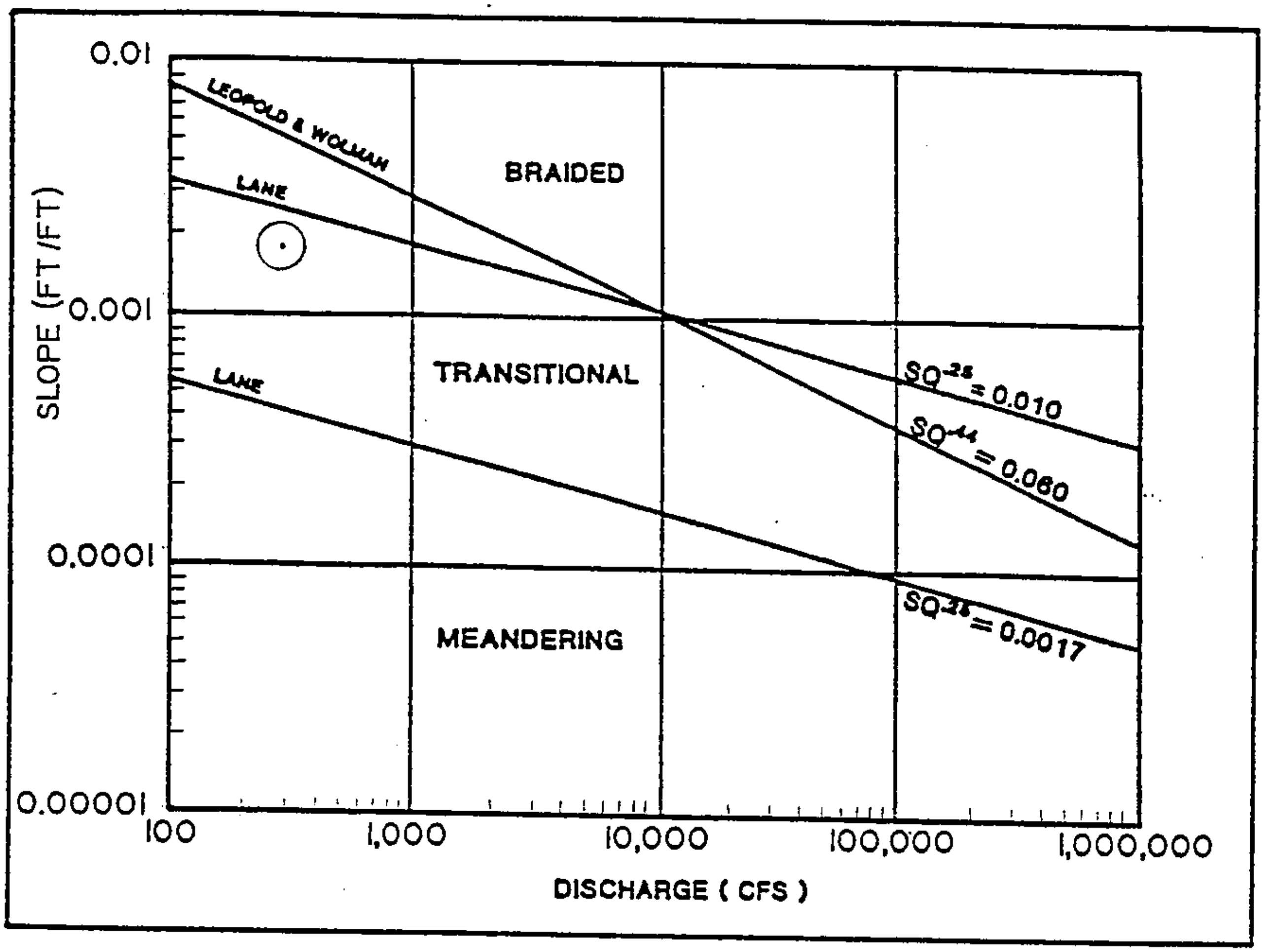


Figure 3. Slope-discharge relationship for braiding or meandering in sand bed streams (Figure 8 in HEC-20)

2.0 SCOUR ANALYSES

2.1 Flood History and Rainfall-Runoff Relations

The 1936 construction plans show a 1928 H.W. El. = 126.0 FT MSL. This water surface elevation is considerably above the elevation that was calculated for the 500-year storm (117.59 FT MSL) by the WSPRO computer program. This discrepancy is believed to be due to backwater from the Pee Dee River. The backwater likely influenced the 1928 H.W. elevation while the WSPRO model was run assuming no backwater at the time of the Westfield Creek peak flow.

The rainfall-runoff relations for the 23 sq. mi. drainage basin were obtained using the USGS Report 91-4157[2] titled "Techniques for Estimating Magnitude and Frequency of Floods in South Carolina, 1988". The results of the regression equations for the Upper Coastal Plain are listed below:

Frequency (years)	Regression Equation Flowrate (cfs)
2	254
10	547
25	718
50	871
100	1009
500	1418

2.2 Hydraulic Conditions

The hydraulic conditions were investigated using the WSPRO[3] computer program and the bridge geometry measured in the field. The approach and exit cross sections were developed by combining the channel geometry from the bridge soundings and the flood plain geometry from the 1936 centerline profile. The soundings were taken from the upstream face of the bridge which is also representative of the downstream face of the bridge.

The results of the computer analysis show that the bridge opening is within the limits that would be allowed for a new bridge at this site. The existing bridge creates 0.12 ft. of backwater and has a velocity of 3.67 fps in the bridge opening. Standard design practice for South Carolina is 1.0 ft. backwater and 5 fps maximum velocity for the 100-year event.

2.3 Bed and Bank Material Analysis

The field investigation visually identified the bed and bank materials as a medium sand.

2.4 Watershed Sediment Yield Evaluation

The sediment yield for the watershed appears to be not stable as evidenced by the apparent stream bed degradation. A rural, well vegetated drainage basin such as this one is generally characterized by relatively low sediment yields and discharge rates. Changed farming practices may have reduced the sediment yield or the stream may have always been in an erosive condition.

2.5 Rating Curve Shifts

Rating curve shifts have not been investigated at this time at the direction of SCDOT.

2.6 Scour Condition Evaluation

The bridge at this site was built in 1936 and widened in 1971. This current bridge replaced an old bridge 0.2 miles west this site. The 1936 bridge consists of concrete girders and deck supported on spread footings with spill-thru abutments. The 1971 widening was constructed with a flat slab deck supported on concrete piles.

Scour conditions were evaluated using the WSPRO computer program and the scour equations presented in HEC-18[4]. The WSPRO computer output and the scour calculations are presented in Appendix 3. The results of the scour calculations have been summarized in Table 1.

The scour calculations resulted in maximum depths (100 year) of 0 and 8.9 feet for contraction and pier scour, respectively.

The abutment scour was not considered at this site since the upstream railroad abutments block the flood plain flow (Section 1.4).

This bridge has evidence of scour as shown on the photographs of Bent 3. Minor scour holes can be observed around the piles.

The thalweg for this stream could easily shift in the channel area during the life of the structure. For this reason, the ground elevation at Bents 3, 4 and 5 were assumed to be the thalweg elevation.

The results of the scour calculations show that scour could undermine the spread footings of the 1936 bridge and could undermine the pile tips of the 1971 bridge. The bottom of footing and pile tip elevations were from SCDOT Plan/Profile Sheets. The average bottom of footing and pile tip elevations were listed in Table 1. A geotechnical and structural review of the information will be needed to determine if the foundations are stable.

2.7 Recommendations

The scour calculations for the bridge show critical scour depths. We recommend a structural engineer and a geotechnical engineer review the scour conditions at this site and decide if the stability of the bridge can be determined with the currently available information. The geotechnical engineer will need to determine if the calculated scour depths can be reduced due to erosion resistant material. The recommendations of the geotechnical engineer should then be given to a structural engineer for a structural stability analysis. The structural engineer should review the pile length data to determine the individual pile lengths.

SCDOT should monitor the ground line beneath the bridge. Lateral shifts of 5 feet or more for the channel area and vertical changes of 2 feet or more should be immediately reported to the SCDOT Hydraulics Unit. The sounding data presented in Appendix 1 of this report should be used as the reference for determining significant ground line changes. A new scour study will be necessary if significant ground line changes are observed in the future.

The northern abutment is protected with D_{50} = 10" stone only beneath the 1936 bridge deck. The northern fill slopes beneath the widening and the fill cones do not have any slope protection. The southern abutment also does not have any slope protection; however, the southern abutment is not as critical since the abutment is on the inside of a curve in the stream and the abutment may have been excavated into rock. The quantity of stone on the abutments may not be adequate to protect the bridge. SCDOT should review this data and the field conditions to determine if additional riprap is necessary to protect this bridge.

Table 1 - Remaining pile/footing penetration at piers/bents for Structure #132005200500 on Route US-52, crossing Westfield Creek in Chesterfield County, South Carolina

Pier/bent[1] number	Station[1] (feet)	Bottom Footing[2] elevation (feet)	Ground[3] elevation at pier/bent (feet)	Total[4] scour depth (feet)	Elevation of scour (feet)	Remaining[5] footing penetration (feet)
100-year discharge is 1009 cfs - 500-year discharge is 1418 cfs						
Scour Information for 100-Year Storm (1936 Bridge):						
1	32857	114.55	128.6	0	128.6	14.0
2	32887	104.59	116.5	5.4	111.1	6.5
3	32917	104.62	109.5	8.9	100.6	-4.0
4	32947	104.62	109.5	8.9	100.6	-4.0
5	32977	104.59	109.5	8.9	100.6	-4.0
6	33007	104.55	128.6	0	128.6	24.0
Scour Information for 500-Year Storm (1936 Bridge):						
1	32857	114.55	128.6	0	128.6	14.0
2	32887	104.59	116.5	6.8	109.7	5.1
3	32917	104.62	109.5	9.4	100.1	-4.5
4	32947	104.62	109.5	9.4	100.1	-4.5
5	32977	104.59	109.5	9.4	100.1	-4.5
6	33007	104.55	128.6	0	128.6	24.0

Pier/bent[1] number	Station[1] (feet)	Pile Tip[2] elevation (feet)	Ground[3] elevation at pier/bent (feet)	Total[4] scour depth (feet)	Elevation of scour (feet)	Remaining[5] pile penetration (feet)
100-year discharge is 1009 cfs - 500-year discharge is 1418 cfs						
Scour Information for 100-Year Storm (1971 Bridge):						
1	32857	128.60	128.6	0	128.6	0.0
2	32887	109.99	116.5	5.4	111.1	1.1
3	32917	108.14	109.5	8.9	100.6	-7.5
4	32947	106.93	109.5	8.9	100.6	-6.3
5	32977	107.89	109.5	8.9	100.6	-7.3
6	33007	109.27	128.6	0	128.6	19.3
Scour Information for 500-Year Storm (1971 Bridge):						
1	32857	128.60	128.6	0	128.6	0.0
2	32887	109.99	116.5	6.8	109.7	-0.3
3	32917	108.14	109.5	9.4	100.1	-8.0
4	32947	106.93	109.5	9.4	100.1	-6.8
5	32977	107.89	109.5	9.4	100.1	-7.8
6	33007	109.27	128.6	0	128.6	19.3

[1]Pier/bent number and station corresponds to South Carolina Department of Transportation bridge plans.
[2]Bottom footing and pile tip elevations obtained from SCDOT bridge plans. Average pile length listed.
[3]Thalweg elevation used in some areas since thalweg may shift during life of structure.
[4]Total scour depth is the sum of the contraction, pier/bent and abutment scour depths.
[5]A negative number signifies undermining of pile tip/footing.

APPENDIX 1

FIELD INFORMATION

HYDRAULIC DESIGN
AND
RISK ASSESSMENT FOR
BRIDGE/BRIDGE REPLACEMENT OVER Westfield Creek

ROUTE/ROAD NUMBER US 52
FILE NO. 13.439 PROJECT NO. A-439
CHESTERFIELD COUNTY, SOUTH CAROLINA

#132005200500

6-13-94
DATE

Prepared By THS
Checked By DYN

Signed and Sealed

PROJECT DESCRIPTION

County CHESTERFIELD Rt./Rd. No. US 52
Stream WESTFIELD CK File No. 13.439 Project No. A-439
PIN____ Charge Code____
Project Engineer Doug Nichols Road Squad____
#132005200500

COMPARATIVE DATA

By THS Date 6-13-94 Checked DYN Date 1-5-95

ROUTE/ROAD NO.	US 52	S-61		
DIST. FROM NEW BR. (MI.)	0.0	0.3		
DRAINAGE AREA (SQ. MI.)	23	10		
ZONE	UPPER COASTAL			
Q_{10}	547	303		
Q_{25}	718	401		
Q_{50}	871	486		
Q_{100}	1009	568		
Q_{500}	1418	818		
BRIDGE LENGTH (FT.)	150	90		
AVG. F. G. (FT.)	131.9 *	—		
OPENING FURN. (SQ.FT.)	1820	1017		
VELOCITY (FT./SEC.)	0.55	0.55		
HIGH-WATER ELEV. (FT.)	126.0 *	—		
HIGH-WATER DATE	1928	—		
HIGH-WATER DEPTH	14 ±	—		
NORMAL-WATER ELEV. (FT.)	111.9	—		
NORMAL-WATER DATE	6-13-94	6-13-94		
NORMAL-WATER DEPTH	2.4	0.7		
FILE/DOCKET/PROJ. NO.	13.439/A-439	—		
LOCATION OF PLANS	SCDOT	—		
DATUM/DATUM TIE	ASSUMED	—		
FLOODWAY MAP	NONE (ZONE A)	—		

* Elevation: from 1936 Plans

SITE INSPECTION

County CHESTERFIELD Rt/Rd No. US 52 Date 6-14-94
Stream WESTFIELD CR PIN ____
By ____

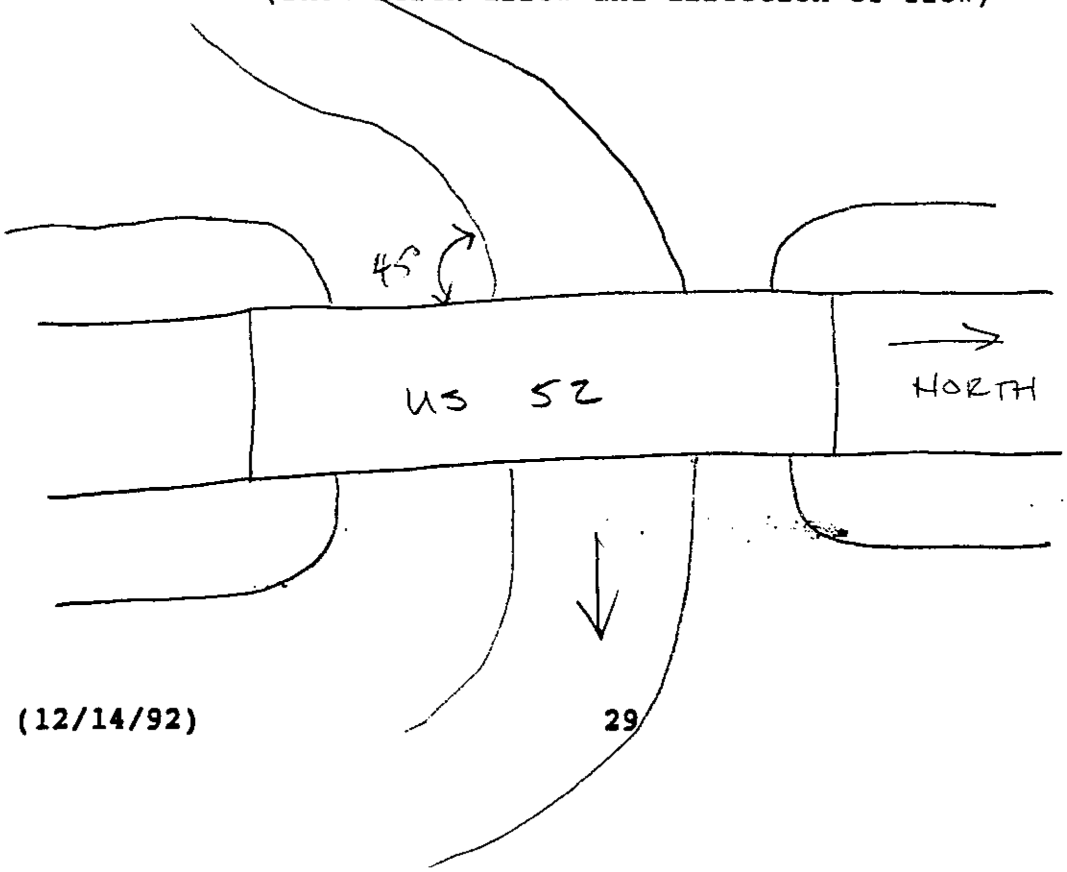
Note: All references to left and right are looking in the direction of flow.

EXISTING BRIDGE

Length 150 Ft. Width 47'-6" Ft. Max. Span Length 30' FT.
Alignment Tangent/Curved Bridge skewed Yes/No Angle ____
End Abutment Type SPILL THRU
Riprap on Fills? Yes/No Condition ONLY N. FILL SLOPE OLD BRIDGE
Superstructure Type REIN. CONC GIRDERS (OLD) FLAT SLABS (WIDENING)
Substructure Type SPREAD FTGS (OLD) PILES (WIDENING)
Utilities Present Yes/No Describe ____

Debris accumulations on bridge, percent channel blocked horizontal 10% Percent channel blocked vertical 1%
Hydraulic Problems? Yes/No Describe ____

Draw Sketch of Bridge and Stream Below
(Show north arrow and direction of flow)



Site Characteristics

General Topography HILLY
Stream Type (circle one) Straight, Braided, or Meandering
Are Channel banks Stable? Yes/No If No, Describe

Are there any Hydraulic Controls Upstream or Downstream? Yes/No
Describe Old railroad track immediately upstream of bridge

Soil type SAND (MEDIUM) Exposed Rock Yes/No If so, give description and location SHALE ON SOUTHERN END BENT
Describe potential for drift MODERATE TO HIGH

Give description and location of any structures or other property that could be damaged by backwater NONE

Describe any other features that might affect or be affected by the hydraulic performance of the proposed bridge Massive concrete retaining walls and center bent from old railroad track still exist immediately upstream from bridge.

Mannings "n" Values

Channel

$$n = (n_b + n_1 + n_2 + n_3 \; n_4) \; m$$

n_b	-- Base n for soil	Earth	.020
		Rock Cut	.025
		Fine Gravel	.024
		Course Gravel	.028
n_1	-- Degree of Irregularity	Smooth	.000
		Minor	.001-.005
		Moderate	.006-.010
		Severe	.011-.020
n_2	-- Variations of Channel Cross Sections	Gradual	.000
		Alternating occasionally	.001-.005
		Frequently	.010-.015
n_3	-- Relative Effect of Obstructions	Negligible	.000-.004
		Minor	.010-.015
		Appreciable	.020-.030
		Severe	.040-.060

n_4 --	Vegetation	Low	.002-.010
		Medium	.010-.025
		High	.025-.050
		Very High	.050-.100
m --	Degree of Meandering	Minor	1.00
		Appreciable	1.15
		Severe	1.30

Field Observations
for Channel

Channel Depth	n_b	n_1	n_2	n_3	n_4	m	Computed n
	.02	.01	0	0	0.005	1.0	0.035

Mannings "n"
For Over Bank Areas

$$n = n_b + n_1 + n_3 + n_4$$

n_b --	Base n for soil	Earth	.020
		Rock Cut	.025
		Fine Gravel	.024
		Course Gravel	.028
n_1 --	Degree of Irregularity	Smooth	.000
		Minor	.001-.005
		Moderate	.006-.010
		Severe	.011-.020
n_3 --	Effect of Obstructions	Negligible	.000-.004
		Minor	.005-.019
		Appreciable	.020-.030
n_4 --	Amount of Vegetation	Small	.001-.010
		Medium	.011-.025
		Large	.025-.Very Large

Field Observations
For Over Bank Areas

Location	Depth	n_b	n_1	n_3	n_4	Computed n
115 ft D.S		0.02	0.01	0.01	0.14	0.18
At Site		0.02	0.0	0.01	0.01	0.04

STREAM BED SOUNDINGS

BRIDGE NO. B7005200500 COUNTY CHESTERFIELD DATE 6-13-94 BY THS/PYN

RECORD SOUNDINGS FROM TOP OF RAIL. OTHER LOCATION IF NEEDED: ______________________

DISTANCE H. W. MARK TO TOP OF RAIL 18.2 LOCATION H. W. MARK BENT 3

DOWNSTREAM | SOUTH END PGL to Top of Rail = 3.0' | UPSTREAM | PGL 299 ±

STATION	SOUNDING	DESCRIPTION	STATION	SOUNDING	DESCRIPTION	
				5.6	South Lower Chord	OLD
				4.9	LOWERCHORD	NEW
			1.4	6.2		
			8.4	8.3		
			15.3	11.9		
			23.2	16.5		
			31.1	17.7	BENT 1	N.S.
			39.3	16.9		
			46.9	18.8		
			52.0	20.0		
			58.4	20.5	BENT 2	SS
			60.9	21.5	BENT 2	HS
			66.3	21.5		
			71.3	22.3	EDGE W.S.	
			75.5	23.1		
			80.6	24.5		
94.5	24.9	LOW PT		BENT 3	DEBRI AR[illegible]	
			92.5	24.7		
			100.5	22.5	BANK BOT	
			104.3	19.2	TOP BANK	
			111.0	19.1		
			118.6	18.7	BENT 4	SS

SHEET 1 OF 2

STREAM BED SOUNDINGS

BRIDGE NO. 13200520050O COUNTY CHESTERFIELD DATE 6-13-94 BY THS/DYN

RECORD SOUNDINGS FROM TOP OF RAIL. OTHER LOCATION IF NEEDED: ______

DISTANCE H. W. MARK TO TOP OF RAIL ______ LOCATION H. W. MARK ______

DOWNSTREAM PGL to Top of Rail = UPSTREAM

STATION	SOUNDING	DESCRIPTION	STATION	SOUNDING	DESCRIPTION
					~~Lower Chord~~
			121.1	18.3	BENT 4 N.S.
			124.2	17.1	
			129.6	16.1	BANK TOE
			133.9	13.7	
			140.5	8.9	
			144.7	7.6	
			147.9	6.9	
			149.9		North FILL FACE

SHEET 2 OF 2

COMPARATIVE BRIDGE SITE INSPECTION FORM

County CHESTERFIELD Rt/Rd No. S-61
Stream WESTFIELD CK Measured bridge length 90

Maximum span length 30' Superstructure type CORED SLAB

Substructure type STEEL "H" PILES End Abutment type VERTICAL

Rip-rap present? Yes No Condition GOOD

Stream type (circle one) ~~Straight~~, Braided, Meander, or Anabranched. Alluvial or Rock. (circle)

Any visible signs of scour problems (describe)
MODERATE SCOUR @ "H" PILES

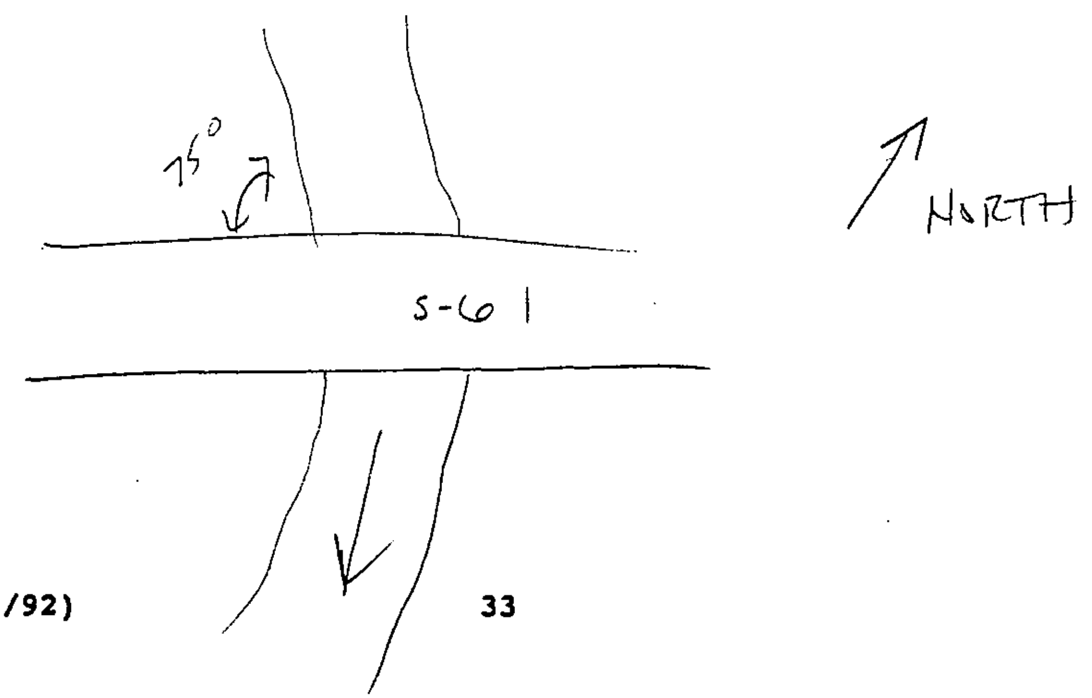
Are banks stable (describe) YES

Debris blockage; Percent of channel blocked horizontally 5%

vertically 0%. Describe other signs of debris
NONE

Any other problems NONE

Draw sketch and indicate problem areas. On sketch indicate location of woods, fields and other land uses in the vicinity of bridge. Show north arrow and direction of flow.



STREAM BED SOUNDINGS

BRIDGE NO. 5-61 Upstream COUNTY Chesterfield DATE 6-13-94 BY Tina S. / Doug N.

RECORD SOUNDINGS FROM TOP OF RAIL. OTHER LOCATION IF NEEDED: ____________

DISTANCE H. W. MARK TO TOP OF RAIL 10.0 LOCATION H. W. MARK Bent 2

PGL to Top of Rail =

DOWNSTREAM STATION	DOWNSTREAM SOUNDING	DOWNSTREAM DESCRIPTION	UPSTREAM STATION	UPSTREAM SOUNDING	UPSTREAM DESCRIPTION
			—	4.3	South west Lower Chord
			1.4	6.0	
			5.1	7.4	
			15.0	8.2	
			24.2	10.6	TB
			26.5	13.6	Edge H_2O
			30.0	14.2	B-2
			35.5	14.2	
			41.6	14.3	
			48.3	13.6	Edge H_2O
			50.0	10.0	TB
			60.0	9.7	B-3
			72.9	9.1	
			78.6	8.5	
			88.6	5.8	
			90.0	—	FF North-East

SHEET ____ OF ____

APPENDIX 2

PHOTOGRAPHS

US-52 OVER WESTFIELD CREEK
CHESTERFIELD COUNTY

(1) Looking Upstream

US-52 OVER WESTFIELD CREEK
CHESTERFIELD COUNTY

(2) Looking Downstream

US-52 OVER WESTFIELD CREEK
CHESTERFIELD COUNTY

(3) Downstream Face Looking South

US-52 OVER WESTFIELD CREEK
CHESTERFIELD COUNTY

(4) Upstream Face Looking South

US-52 OVER WESTFIELD CREEK
CHESTERFIELD COUNTY

(5) Riprap at North Fill Slope

(6) Looking Upstream from North Fill Slope

US-52 OVER WESTFIELD CREEK
CHESTERFIELD COUNTY

(7) Looking at South Fill Slope Upstream Side

(8) Looking at South Fill Slope Downstream Side

US-52 OVER WESTFIELD CREEK
CHESTERFIELD COUNTY

(9) South Fill Slope

(10) Looking Upstream at Bents 3 and 4

US-52 OVER WESTFIELD CREEK
CHESTERFIELD COUNTY

(11) Looking at North Fill Slope

(12) Looking Downstream at Bents 3 and 4

US-52 OVER WESTFIELD CREEK
CHESTERFIELD COUNTY

(13) Looking Downstream

(14) Looking South on US-52

APPENDIX 3

WSPRO COMPUTER DATA
and
SCOUR CALCULATIONS

```
T1          STR. NO. 132005200500 CHESTERFIELD CO.
T2          US-52 OVER WESTFIELD CREEK
*F
Q           1009.3         1417.7
SK          0.0018         0.0018
XT        1   1000
GR      Rt   850.0 134.0   862.0 130.0   867.0 128.0   880.2 117.7
GR           888.1 116.5   896.3 117.3   903.9 115.4   909.0 114.2
GR           915.4 113.7   917.9 112.7   923.3 112.7   928.3 111.9
GR           932.5 111.1   937.6 109.7   949.5 109.5   957.5 111.7
GR           961.3 115.0   968.0 115.1   975.6 115.5   978.1 115.9
GR           983.2 117.1  1000.0 117.6  1020.0 116.0  1035.0 116.8
GR          1100.0 115.4  1108.0 114.6  1124.0 116.2  1200.0 116.0
GR          1215.0 117.0  1300.0 117.9  1400.0 120.3  1440.0 120.0
GR          1468.0 121.6  1480.0 123.8  1600.0 128.5  1621.0 128.3
GR          1645.0 130.0  1740.0 134.5 Lt
XS     EXIT    850     0       *      * 0.0018
GT
N             0.18 0.035    0.18
SA           928.3 957.5
XS     FULLV  1000     0       *      * 0.0018
GT
N             0.18 0.035    0.18
SA           928.3 957.5
BR     BRID   1000 129.3       0
GR   Rt. End→857.0 128.6   858.4 128.0   865.4 125.9   872.3 122.3
GR           880.2 117.7   888.1 116.5   896.3 117.3   903.9 115.4
GR           909.0 114.2   915.4 113.7   917.9 112.7   923.3 112.7
GR           928.3 111.9   932.5 111.1   937.6 109.7   949.5 109.5
GR           957.5 111.7   961.3 115.0   968.0 115.1   975.6 115.5
GR           978.1 115.9   983.2 117.1   986.6 118.1   990.9 120.5
GR           997.5 125.3  1001.7 126.6  1004.9 127.3  1006.9 128.6
GR           857.0 128.6                                 ←Lt. End
N             0.04  0.03    0.04
SA           928.3 957.5
CD               3    48   2.000 131.9       0       0       0
PW 1           110   1.8     114   1.8     114     3.6     116     3.6     116     5.4
               117   5.4     117   7.2   129.3     7.2   129.3       0
HP               1 BRID   116.29      * 116.29
HP               1 BRID   117.42      * 117.42
HP               2 BRID   116.29      * 116.29 1009.
HP               2 BRID   117.42      * 117.42 1417.
AS     APPR   1198     0
GR      Rt   720.0 134.4   732.0 130.4   737.0 128.4   750.2 118.1
GR           758.1 116.9   766.3 117.7   773.9 115.8   779.0 114.6
GR           785.4 114.1   787.9 113.1   793.3 113.1   798.3 112.3
GR           802.5 111.5   807.6 110.1   819.5 109.9   827.5 112.1
GR           831.3 115.4   838.0 115.5   845.6 115.9   848.1 116.3
GR           853.2 117.5   870.0 118.0   890.0 116.4   905.0 117.2
GR           970.0 115.8   978.0 115.0   994.0 116.6  1070.0 116.4
GR          1085.0 117.4  1170.0 118.3  1270.0 120.7  1310.0 120.4
GR          1338.0 122.0  1350.0 124.2  1470.0 128.9  1491.0 128.7 Lt
N             0.18 0.035    0.18
SA           798.3 827.5
HP               1 APPR   116.52      * 116.52
HP               1 APPR   117.59      * 117.59
HP               2 APPR   116.52      * 116.52 1009.
HP               2 APPR   117.59      * 117.59 1417.
XS       US   1488     0       *      * 0.0018
GT
N             0.18 0.035    0.18
SA           928.3 957.5
EX
```

```
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: 01-06-95  09:29

  T1         STR. NO. 132005200500 CHESTERFIELD CO.

  T2         US-52 OVER WESTFIELD CREEK

  *F

  Q          1009.3        1417.7

*** Q-DATA FOR SEC-ID, ISEQ =             1
  SK         0.0018        0.0018
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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)

        STR. NO. 132005200500 CHESTERFIELD CO.
        US-52 OVER WESTFIELD CREEK
           *** RUN DATE & TIME: 01-06-95  09:29

*** START PROCESSING CROSS SECTION - "1     "
  XT   1        1000

  GR          850.0 134.0  862.0 130.0  867.0 128.0  880.2 117.7

  GR          888.1 116.5  896.3 117.3  903.9 115.4  909.0 114.2

  GR          915.4 113.7  917.9 112.7  923.3 112.7  928.3 111.9

  GR          932.5 111.1  937.6 109.7  949.5 109.5  957.5 111.7

  GR          961.3 115.0  968.0 115.1  975.6 115.5  978.1 115.9

  GR          983.2 117.1 1000.0 117.6 1020.0 116.0 1035.0 116.8

  GR         1100.0 115.4 1108.0 114.6 1124.0 116.2 1200.0 116.0

  GR         1215.0 117.0 1300.0 117.9 1400.0 120.3 1440.0 120.0

  GR         1468.0 121.6 1480.0 123.8 1600.0 128.5 1621.0 128.3

  GR         1645.0 130.0 1740.0 134.5

*** FINISH PROCESSING CROSS SECTION - "1     "
*** TEMPLATE CROSS SECTION "1     " SAVED INTERNALLY.
```

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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)

        STR. NO. 132005200500 CHESTERFIELD CO.
        US-52 OVER WESTFIELD CREEK
           *** RUN DATE & TIME: 01-06-95  09:29

*** START PROCESSING CROSS SECTION - "EXIT "
  XS   EXIT     850      0       *      * 0.0018

  GT

  N           0.18 0.035   0.18

  SA         928.3 957.5


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

--- DATA SUMMARY FOR SECID "EXIT " AT SRD =     850.  ERR-CODE =      0

     SKEW     IHFNO    VSLOPE        EK        CK
       .0        0.     .0018        .50       .00

X-Y COORDINATE PAIRS  (NGP =  38):
       X      Y              X      Y              X      Y              X      Y
    850.0  133.73        862.0  129.73        867.0  127.73        880.2  117.43
    888.1  116.23        896.3  117.03        903.9  115.13        909.0  113.93
    915.4  113.43        917.9  112.43        923.3  112.43        928.3  111.63
    932.5  110.83        937.6  109.43        949.5  109.23        957.5  111.43
    961.3  114.73        968.0  114.83        975.6  115.23        978.1  115.63
    983.2  116.83       1000.0  117.33       1020.0  115.73       1035.0  116.53
   1100.0  115.13       1108.0  114.33       1124.0  115.93       1200.0  115.73
   1215.0  116.73       1300.0  117.63       1400.0  120.03       1440.0  119.73
   1468.0  121.33       1480.0  123.53       1600.0  128.23       1621.0  128.03
   1645.0  129.73       1740.0  134.23

 X-Y MAX-MIN POINTS:
     XMIN      Y              X    YMIN         XMAX       Y              X    YMAX
    850.0  133.73        949.5  109.23       1740.0  134.23       1740.0  134.23

SUBAREA BREAKPOINTS (NSA =  3):
        928.   958.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .180    .035    .180
```

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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)

        STR. NO. 132005200500 CHESTERFIELD CO.
        US-52 OVER WESTFIELD CREEK
           *** RUN DATE & TIME: 01-06-95  09:29

*** START PROCESSING CROSS SECTION - "FULLV"
  XS   FULLV  1000    0      *     * 0.0018

  GT

  N           0.18 0.035   0.18

  SA         928.3 957.5


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

--- DATA SUMMARY FOR SECID "FULLV" AT SRD =   1000.  ERR-CODE =      0

     SKEW      IHFNO    VSLOPE       EK        CK
       .0         0.     .0018      .50       .00

X-Y COORDINATE PAIRS  (NGP =  38):
       X      Y             X      Y             X      Y             X      Y
     850.0  134.00       862.0  130.00       867.0  128.00       880.2  117.70
     888.1  116.50       896.3  117.30       903.9  115.40       909.0  114.20
     915.4  113.70       917.9  112.70       923.3  112.70       928.3  111.90
     932.5  111.10       937.6  109.70       949.5  109.50       957.5  111.70
     961.3  115.00       968.0  115.10       975.6  115.50       978.1  115.90
     983.2  117.10      1000.0  117.60      1020.0  116.00      1035.0  116.80
    1100.0  115.40      1108.0  114.60      1124.0  116.20      1200.0  116.00
    1215.0  117.00      1300.0  117.90      1400.0  120.30      1440.0  120.00
    1468.0  121.60      1480.0  123.80      1600.0  128.50      1621.0  128.30
    1645.0  130.00      1740.0  134.50

 X-Y MAX-MIN POINTS:
     XMIN        Y             X    YMIN        XMAX       Y             X    YMAX
     850.0  134.00       949.5  109.50      1740.0  134.50      1740.0  134.50

SUBAREA BREAKPOINTS (NSA =  3):
        928.    958.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .180    .035    .180
```

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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)

        STR. NO. 132005200500 CHESTERFIELD CO.
        US-52 OVER WESTFIELD CREEK
           *** RUN DATE & TIME: 01-06-95  09:29

*** START PROCESSING CROSS SECTION - "BRID "
 BR   BRID     1000 129.3      0

 GR          857.0 128.6  858.4 128.0  865.4 125.9  872.3 122.3

 GR          880.2 117.7  888.1 116.5  896.3 117.3  903.9 115.4

 GR          909.0 114.2  915.4 113.7  917.9 112.7  923.3 112.7

 GR          928.3 111.9  932.5 111.1  937.6 109.7  949.5 109.5

 GR          957.5 111.7  961.3 115.0  968.0 115.1  975.6 115.5

 GR          978.1 115.9  983.2 117.1  986.6 118.1  990.9 120.5

 GR          997.5 125.3 1001.7 126.6 1004.9 127.3 1006.9 128.6

 GR          857.0 128.6

 N            0.04  0.03   0.04

 SA          928.3 957.5

 CD              3    48  2.000 131.9      0      0      0

 PW 1          110   1.8    114   1.8    114   3.6    116   3.6    116   5.4

               117   5.4    117   7.2  129.3   7.2  129.3     0

 HP              1 BRID  116.29     * 116.29

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

--- DATA SUMMARY FOR SECID "BRID " AT SRD =   1000.  ERR-CODE =      0

     SKEW      IHFNO    VSLOPE        EK        CK
       .0         0.     .0018       .50       .00

X-Y COORDINATE PAIRS  (NGP =  29):
       X      Y            X      Y             X      Y            X      Y
    857.0  128.60       858.4  128.00       865.4  125.90       872.3  122.30
    880.2  117.70       888.1  116.50       896.3  117.30       903.9  115.40
    909.0  114.20       915.4  113.70       917.9  112.70       923.3  112.70
    928.3  111.90       932.5  111.10       937.6  109.70       949.5  109.50
    957.5  111.70       961.3  115.00       968.0  115.10       975.6  115.50
    978.1  115.90       983.2  117.10       986.6  118.10       990.9  120.50
    997.5  125.30      1001.7  126.60      1004.9  127.30      1006.9  128.60
    857.0  128.60

 X-Y MAX-MIN POINTS:
     XMIN       Y            X    YMIN       XMAX       Y            X    YMAX
    857.0  128.60       949.5  109.50      1006.9  128.60       857.0  128.60
```

ROUGHNESS COEFFICIENTS (NSA = 3):

.040	.030	.040

BRIDGE PARAMETERS:

BRTYPE	BRWDTH	LSEL	USERCD	EMBSS	EMBELV	ABSLPL	ABSLPR
3	48.0	129.30	*******	2.00	131.90	*******	*******

PIER DATA: NPW = 9 PPCD = 1.

PELV	PWDTH	PELV	PWDTH	PELV	PWDTH	PELV	PWDTH
110.00	1.8	114.00	1.8	114.00	3.6	116.00	3.6
116.00	5.4	117.00	5.4	117.00	7.2	129.30	7.2
129.30	.0						

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)

STR. NO. 132005200500 CHESTERFIELD CO.
US-52 OVER WESTFIELD CREEK
*** RUN DATE & TIME: 01-06-95 09:29
CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	~~LEW~~ REW	~~REW~~ LEW	QCR
	1	71.	4887.	28.	28.				645.
	2	175.	28392.	29.	30.				2437.
	3	29.	1226.	22.	24.				186.
116.29		275.	34506.	79.	82.	1.42	900.	980.	2440.

HP	1 BRID	117.42	* 117.42

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)

STR. NO. 132005200500 CHESTERFIELD CO.
US-52 OVER WESTFIELD CREEK
*** RUN DATE & TIME: 01-06-95 09:29
CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	112.	7485.	46.	47.				994.
	2	208.	37848.	29.	30.				3157.
	3	57.	3353.	27.	28.				467.
117.42		377.	48686.	102.	105.	1.60	882.	984.	3254.

HP 2 BRID 116.29 * 116.29 1009.

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)

STR. NO. 132005200500 CHESTERFIELD CO.
US-52 OVER WESTFIELD CREEK
*** RUN DATE & TIME: 01-06-95 09:29

VELOCITY DISTRIBUTION: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	LEW	REW	AREA	K	Q	VEL
116.29	900.3	979.8	275.3	34506.	1009.	3.66

X STA.	900.3		919.2		924.7		928.8		931.6		933.8
A(I)		36.4		19.9		17.3		13.1		11.8	
V(I)		1.39		2.54		2.92		3.86		4.26	
X STA.	933.8		935.7		937.4		938.9		940.4		941.9
A(I)		11.0		10.6		9.9		9.8		9.9	
V(I)		4.61		4.76		5.09		5.13		5.11	
X STA.	941.9		943.3		944.8		946.3		947.7		949.2
A(I)		9.9		9.9		9.7		9.9		9.6	
V(I)		5.11		5.09		5.19		5.09		5.23	
X STA.	949.2		950.7		952.4		954.3		956.7		979.8
A(I)		10.1		10.5		11.1		12.2		32.7	
V(I)		5.00		4.81		4.53		4.14		1.54	

HP 2 BRID 117.42 * 117.42 1417.

WSPRO
P060188

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

STR. NO. 132005200500 CHESTERFIELD CO.
US-52 OVER WESTFIELD CREEK
*** RUN DATE & TIME: 01-06-95 09:29

VELOCITY DISTRIBUTION: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	LEW	REW	AREA	K	Q	VEL
117.42	882.0	984.3	377.3	48686.	1417.	3.76

X STA.	882.0		918.8		923.7		928.0		930.8		933.3
A(I)		65.6		23.1		22.0		16.3		15.2	
V(I)		1.08		3.07		3.22		4.35		4.65	
X STA.	933.3		935.3		937.1		938.8		940.4		942.0
A(I)		13.9		13.4		12.6		12.5		12.5	
V(I)		5.09		5.29		5.64		5.67		5.65	
X STA.	942.0		943.6		945.2		946.8		948.4		949.9
A(I)		12.5		12.6		12.3		12.6		12.5	
V(I)		5.66		5.64		5.75		5.64		5.66	
X STA.	949.9		951.7		953.6		955.9		959.8		984.3
A(I)		13.2		13.4		14.8		20.7		45.6	
V(I)		5.38		5.28		4.80		3.42		1.55	

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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)

        STR. NO. 132005200500 CHESTERFIELD CO.
        US-52 OVER WESTFIELD CREEK
           *** RUN DATE & TIME: 01-06-95  09:29

 *** START PROCESSING CROSS SECTION - "APPR "
   AS   APPR    1198     0

   GR         720.0 134.4  732.0 130.4  737.0 128.4  750.2 118.1

   GR         758.1 116.9  766.3 117.7  773.9 115.8  779.0 114.6

   GR         785.4 114.1  787.9 113.1  793.3 113.1  798.3 112.3

   GR         802.5 111.5  807.6 110.1  819.5 109.9  827.5 112.1

   GR         831.3 115.4  838.0 115.5  845.6 115.9  848.1 116.3

   GR         853.2 117.5  870.0 118.0  890.0 116.4  905.0 117.2

   GR         970.0 115.8  978.0 115.0  994.0 116.6 1070.0 116.4

   GR        1085.0 117.4 1170.0 118.3 1270.0 120.7 1310.0 120.4

   GR        1338.0 122.0 1350.0 124.2 1470.0 128.9 1491.0 128.7

   N           0.18 0.035   0.18

   SA         798.3 827.5

   HP             1 APPR  116.52     * 116.52

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

 --- DATA SUMMARY FOR SECID "APPR " AT SRD =   1198.  ERR-CODE =      0

      SKEW      IHFNO     VSLOPE        EK        CK
        .0         0.      .0018       .50       .00

 X-Y COORDINATE PAIRS  (NGP =  36):
        X        Y            X        Y            X        Y            X        Y
     720.0   134.40       732.0   130.40       737.0   128.40       750.2   118.10
     758.1   116.90       766.3   117.70       773.9   115.80       779.0   114.60
     785.4   114.10       787.9   113.10       793.3   113.10       798.3   112.30
     802.5   111.50       807.6   110.10       819.5   109.90       827.5   112.10
     831.3   115.40       838.0   115.50       845.6   115.90       848.1   116.30
     853.2   117.50       870.0   118.00       890.0   116.40       905.0   117.20
     970.0   115.80       978.0   115.00       994.0   116.60      1070.0   116.40
    1085.0   117.40      1170.0   118.30      1270.0   120.70      1310.0   120.40
    1338.0   122.00      1350.0   124.20      1470.0   128.90      1491.0   128.70

 X-Y MAX-MIN POINTS:
      XMIN        Y           X     YMIN       XMAX         Y            X     YMAX
     720.0   134.40       819.5   109.90     1491.0    128.70       720.0   134.40

 SUBAREA BREAKPOINTS (NSA =  3):
        798.    828.

 ROUGHNESS COEFFICIENTS (NSA =  3):
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```
         .180    .035    .180

BRIDGE PROJECTION DATA:  XREFLT  XREFRT  FDSTLT  FDSTRT
                        ******* ******* ******* *******
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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)

STR. NO. 132005200500 CHESTERFIELD CO.
US-52 OVER WESTFIELD CREEK
*** RUN DATE & TIME: 01-06-95 09:29
CROSS-SECTION PROPERTIES: ISEQ = 4; SECID = APPR ; SRD = 1198.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCF
	1	67.	986.	27.	28.		REW	LEW	589.
	2	170.	23199.	29.	30.				2334.
	3	61.	301.	129.	131.				236.
116.52		298.	24485.	186.	188.	2.60	771.	1072.	1326.

HP 1 APPR 117.59 * 117.59

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)

STR. NO. 132005200500 CHESTERFIELD CO.
US-52 OVER WESTFIELD CREEK
*** RUN DATE & TIME: 01-06-95 09:29
CROSS-SECTION PROPERTIES: ISEQ = 4; SECID = APPR ; SRD = 1198.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	102.	1482.	43.	44.				890.
	2	202.	30716.	29.	30.				3005.
	3	283.	2494.	257.	258.				1689.
117.59		587.	34692.	329.	332.	5.89	754.	1103.	1833.

HP 2 APPR 116.52 * 116.52 1009.

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)

STR. NO. 132005200500 CHESTERFIELD CO.
US-52 OVER WESTFIELD CREEK
*** RUN DATE & TIME: 01-06-95 09:29

VELOCITY DISTRIBUTION: ISEQ = 4; SECID = APPR ; SRD = 1198.

WSEL	LEW	REW	AREA	K	Q	VEL
116.52	771.0	1071.8	297.5	24485.	1009.	3.39

X STA.	771.0		798.8		801.2		803.3		805.1		806.6
A(I)		68.6		11.2		10.4		9.6		8.9	
V(I)		.74		4.51		4.85		5.24		5.66	
X STA.	806.6		808.0		809.2		810.5		811.8		813.1
A(I)		8.7		8.3		8.4		8.3		8.3	
V(I)		5.82		6.11		6.04		6.09		6.07	
X STA.	813.1		814.4		815.6		816.9		818.1		819.4
A(I)		8.3		8.3		8.2		8.3		8.3	
V(I)		6.07		6.05		6.18		6.06		6.07	
X STA.	819.4		820.7		822.1		823.8		825.7		1071.8
A(I)		8.5		8.6		9.5		10.0		69.0	
V(I)		5.96		5.87		5.32		5.07		.73	

HP 2 APPR 117.59 * 117.59 1417.

```
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)

        STR. NO. 132005200500 CHESTERFIELD CO.
        US-52 OVER WESTFIELD CREEK
           *** RUN DATE & TIME: 01-06-95  09:29

*** START PROCESSING CROSS SECTION - "US    "
  XS   US       1488     0      *     * 0.0018

  GT

  N           0.18 0.035   0.18

  SA         928.3 957.5

  EX


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

--- DATA SUMMARY FOR SECID "US    " AT SRD =   1488.  ERR-CODE =      0

     SKEW     IHFNO    VSLOPE        EK        CK
       .0        0.     .0018       .50       .00

X-Y COORDINATE PAIRS  (NGP =  38):
       X      Y            X      Y            X      Y            X      Y
    850.0  134.88      862.0  130.88      867.0  128.88      880.2  118.58
    888.1  117.38      896.3  118.18      903.9  116.28      909.0  115.08
    915.4  114.58      917.9  113.58      923.3  113.58      928.3  112.78
    932.5  111.98      937.6  110.58      949.5  110.38      957.5  112.58
    961.3  115.88      968.0  115.98      975.6  116.38      978.1  116.78
    983.2  117.98     1000.0  118.48     1020.0  116.88     1035.0  117.68
   1100.0  116.28     1108.0  115.48     1124.0  117.08     1200.0  116.88
   1215.0  117.88     1300.0  118.78     1400.0  121.18     1440.0  120.88
   1468.0  122.48     1480.0  124.68     1600.0  129.38     1621.0  129.18
   1645.0  130.88     1740.0  135.38

 X-Y MAX-MIN POINTS:
     XMIN      Y            X   YMIN        XMAX      Y            X   YMAX
    850.0  134.88      949.5  110.38     1740.0  135.38     1740.0  135.38

SUBAREA BREAKPOINTS (NSA =  3):
        928.    958.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .180    .035    .180

+++ BEGINNING PROFILE CALCULATIONS --   2
```

```
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)

        STR. NO. 132005200500 CHESTERFIELD CO.
        US-52 OVER WESTFIELD CREEK
           *** RUN DATE & TIME: 01-06-95  09:29

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

EXIT :XS    ******     901.      282.    .48  *****  116.23  113.37    1009.  115.75
      850.  ******    1200.    23773.   2.41  ***** *******     .69     3.59

FULLV:FV      150.     901.      284.    .48    .27  116.52 *******    1009.  116.04
     1000.    150.    1201.    23886.   2.44    .00     .01     .70     3.56
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR :AS      198.     772.      279.    .49    .36  116.88 *******    1009.  116.40
     1198.    198.     992.    23624.   2.38    .00     .01     .66     3.62
          <<<<<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

BRID :BR      150.     900.      275.    .21    .26  116.50  113.74    1009.  116.29
     1000.    150.     980.    34469.   1.00    .00     .01     .35     3.67

     TYPE PPCD FLOW      C     P/A     LSEL    BLEN    XLAB    XRAB
       3.   1.   1.  1.000    .058   129.30  ******  ******  ******

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

APPR :AS      150.     771.      297.    .47    .42  116.98  114.06    1009.  116.52
     1198.    244.    1072.    24456.   2.59    .07     .00     .76     3.40

       M(G)   M(K)        KQ   XLKQ   XRKQ    OTEL
       .649   .003    24354.   772.   851.  116.26

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

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

US   :XS      290.     901.      301.    .46    .49  117.48 *******    1009.  117.02
     1488.    290.    1202.    24620.   2.64    .00     .01     .77     3.35
```

```
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)

        STR. NO. 132005200500 CHESTERFIELD CO.
        US-52 OVER WESTFIELD CREEK
           *** RUN DATE & TIME: 01-06-95  09:29

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

EXIT :XS   ******   884.     548.   .57 *****  117.37  114.24   1418.  116.80
      850. ******  1221.   33393.  5.46 ***** *******     .80    2.59

FULLV:FV     150.   884.     555.   .56   .27  117.65 *******   1418.  117.09
     1000.   150.  1224.   33631.  5.53   .00     .02     .80    2.55
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPR ":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =   .80     .81    117.45    114.93

 ===110 WSEL NOT FOUND AT SECID "APPR ":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   116.59    134.40     .50

 ===115 WSEL NOT FOUND AT SECID "APPR ":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   116.59    134.40    114.93

APPR :AS     198.   755.     536.   .58   .36  118.01  114.93   1418.  117.43
     1198.   198.  1088.   32975.  5.32   .01    -.01     .81    2.65
         <<<<<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

BRID :BR     150.   882.     377.   .22   .28  117.64  114.65   1418.  117.42
     1000.   150.   984.   48713.  1.00   .00     .00     .34    3.76

     TYPE PPCD FLOW      C    P/A     LSEL   BLEN   XLAB   XRAB
       3.   1.   1.  1.000   .060  129.30 ****** ****** ******

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

APPR :AS     150.   754.     586.   .53   .42  118.12  114.93   1418.  117.59
     1198.   236.  1103.   34679.  5.88   .07     .00     .77    2.42

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       .703   .055   32788.   754.   856.  117.34

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

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

US   :XS     290.   883.     594.   .53   .48  118.62 *******   1418.  118.09
     1488.   290.  1235.   34914.  5.96   .00     .01     .77    2.39
  ER
```

NORMAL END OF WSPRO EXECUTION.

US-52 WESTFIELD CREEK CHESTERFIELD CO. #132005200500
100 YEAR CHANNEL CONTRACTION SCOUR

Y1=	6.6	ft
Wc1=	30	ft
Wc2=	30	ft
Qmc1=	956	cfs
Qmc2=	830	cfs
K1=	0.64	

Y2= Y1*(Qmc2/Qmc1)^(6/7)*(Wc1/Wc2)^K1)
Y2= 5.9 ft
Ys=Y2-Y1= -0.8 ft

500 YEAR CHANNEL CONTRACTION SCOUR

Y1=	7.7	ft
Wc1=	30	ft
Wc2=	30	ft
Qmc1=	1255	cfs
Qmc2=	1102	cfs
K1=	0.64	

Y2= Y1*(Qmc2/Qmc1)^(6/7)*(Wc1/Wc2)^K1)
Y2= 6.9 ft
Ys=Y2-Y1= -0.8 ft

100 YEAR CHANNEL PIER SCOUR

Y1=	6.79	
K1=	1.1	
K2=	2.0	
K3=	1.1	
a=	1.8	ft
V1=	5.2	
Fr1=	0.354	

Ys= Y1*2*K1*K2*K3*(a/Y1)^0.65*Fr1^0.43
Ys= 8.9

500 YEAR CHANNEL PIER SCOUR

Y1=	7.9	
K1=	1.1	
K2=	2.0	
K3=	1.1	
a=	1.8	ft
V1=	5.75	
Fr1=	0.360	

Ys= Y1*2*K1*K2*K3*(a/Y1)^0.65*Fr1^0.43
Ys= 9.4

US-52 WESTFIELD CREEK CHESTERFIELD CO. #132005200500

100 YEAR FLOODPLAIN CLEAR WATER CONTRACTION SCOUR

Y1=	2.02
Q=	50.596
Dm=	0.000820
W2=	19
Ys=	Y1*.13*[(Q/(Dm^.333*Y1^1.167*W)^.857-1]
Ys=	0.3

500 YEAR FLOODPLAIN CLEAR WATER CONTRACTION SCOUR

Y1=	3.09
Q=	70.848
Dm=	0.000820
W2=	25
Ys=	Y1*.13*[(Q/(Dm^.333*Y1^1.167*W)^.857-1]
Ys=	-0.7

100 YEAR FLOODPLAIN PIER SCOUR

GROUND=	116.5
Y1=	0.02
K1=	1.1
K2=	2.0
K3=	1.1
a=	1.8 ft
V1=	1.4
Fr1=	1.732
Ys=	Y1*2*K1*K2*K3*(a/Y1)^0.65*Fr1^0.43
Ys=	2.3

500 YEAR FLOODPLAIN PIER SCOUR

GROUND=	116.5
Y1=	1.1
K1=	1.1
K2=	2.0
K3=	1.1
a=	1.8 ft
V1=	1.39
Fr1=	0.235
Ys=	Y1*2*K1*K2*K3*(a/Y1)^0.65*Fr1^0.43
Ys=	3.9

APPENDIX 5

Selected References

1. HEC-20, Stream Stability at Highway Structures, Publication No. FHWA-IP-90-014. FHWA, U.S. Department of Transportation, February 1991

2. Techniques for Estimating Magnitude and Frequency of Floods in South Carolina, 1988, U.S. Geological Survey Water-Resources Investigations Report 91-4157.

3. The WSPRO computer program and manual, prepared by the U.S. Geological Survey for The Federal Highway Administration.

4. HEC-18, Evaluating Scour at Bridges (Second Edition), Publication No. FHWA-IP-90-017. FHWA, U.S. Department of Transportation, Revised April 1993.

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SCDOT Hydraulics Unit

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