SCOUR EVALUATION

FOR

SOUTH CAROLINA DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

ON

STRUCTURE #132000100400
US-1 OVER BLACK CREEK
CHESTERFIELD COUNTY, SC

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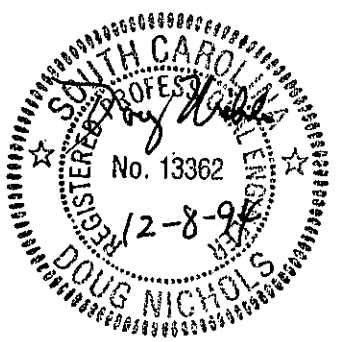


SCOUR EVALUATION FOR US-1 OVER BLACK CREEK

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 heavily vegetated and the channel area is free of vegetation. The stream is described as a small perennial stream through a swamp. 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 9 miles southwest of Patrick in Chesterfield County. The land use in the drainage basin is rural and no land use changes are expected for the life of the structure.

1.3 Overall Stream Stability

The overall stream stability appears to be stable. 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 braided and a meandering pattern. The actual stream conditions include dense vegetation which will influence the behavior of the stream.

1.4 Lateral Stability

The stream alignment is skewed approximately 48° to the bridge opening. Photographs of the site are presented in Appendix 2. Photographs show that the stream banks are well vegetated and generally stable during average flow conditions.

1.5 Vertical Stability

The stream bed profile is currently 2 feet lower at the bridge site that it was when the bridge was built. This is evidenced by shallower channel depths for the 1931 construction plans than for the channel depths measured for this report. The lower bed level could be due to overall stream bed degradation or local degradation due to scour.

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.

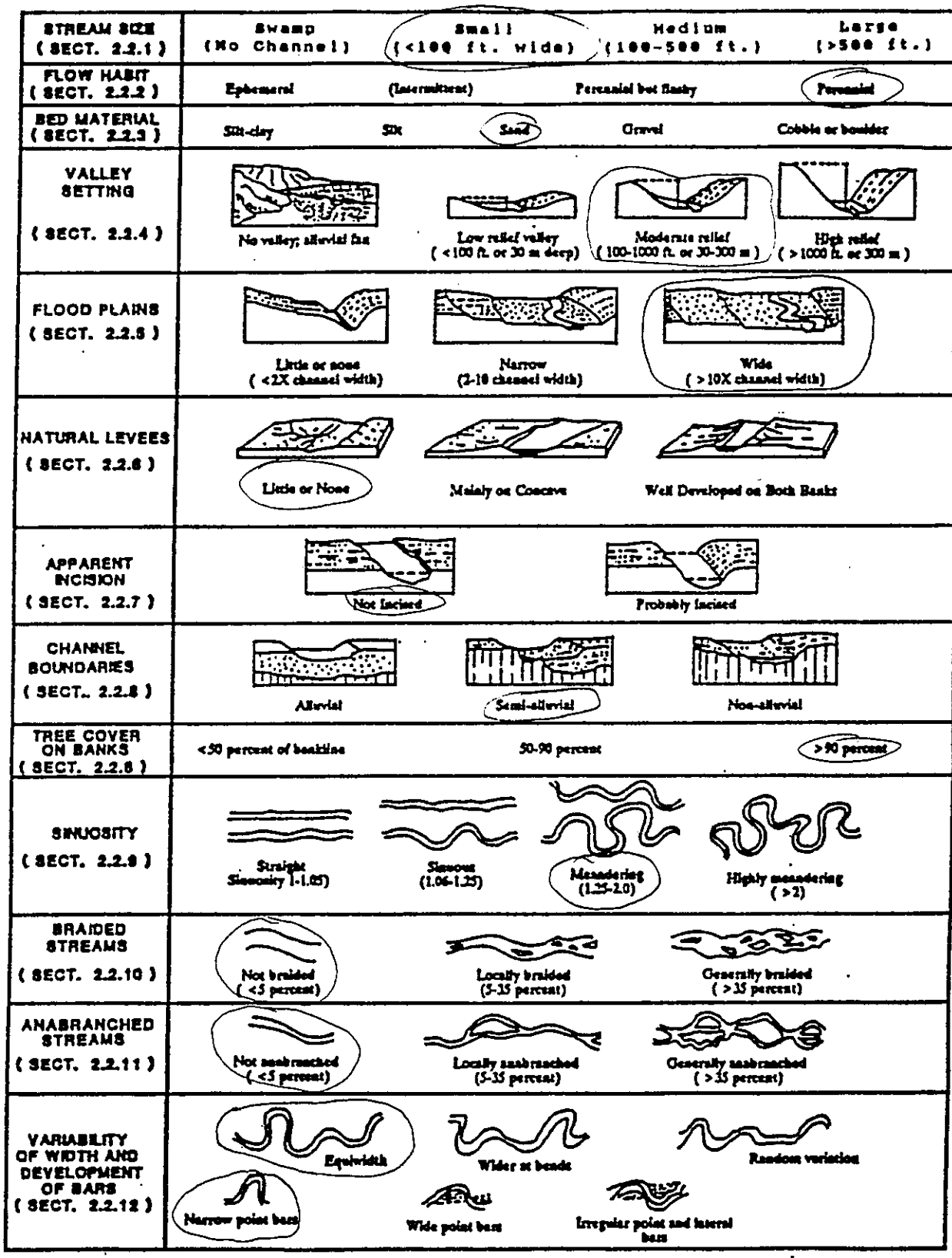
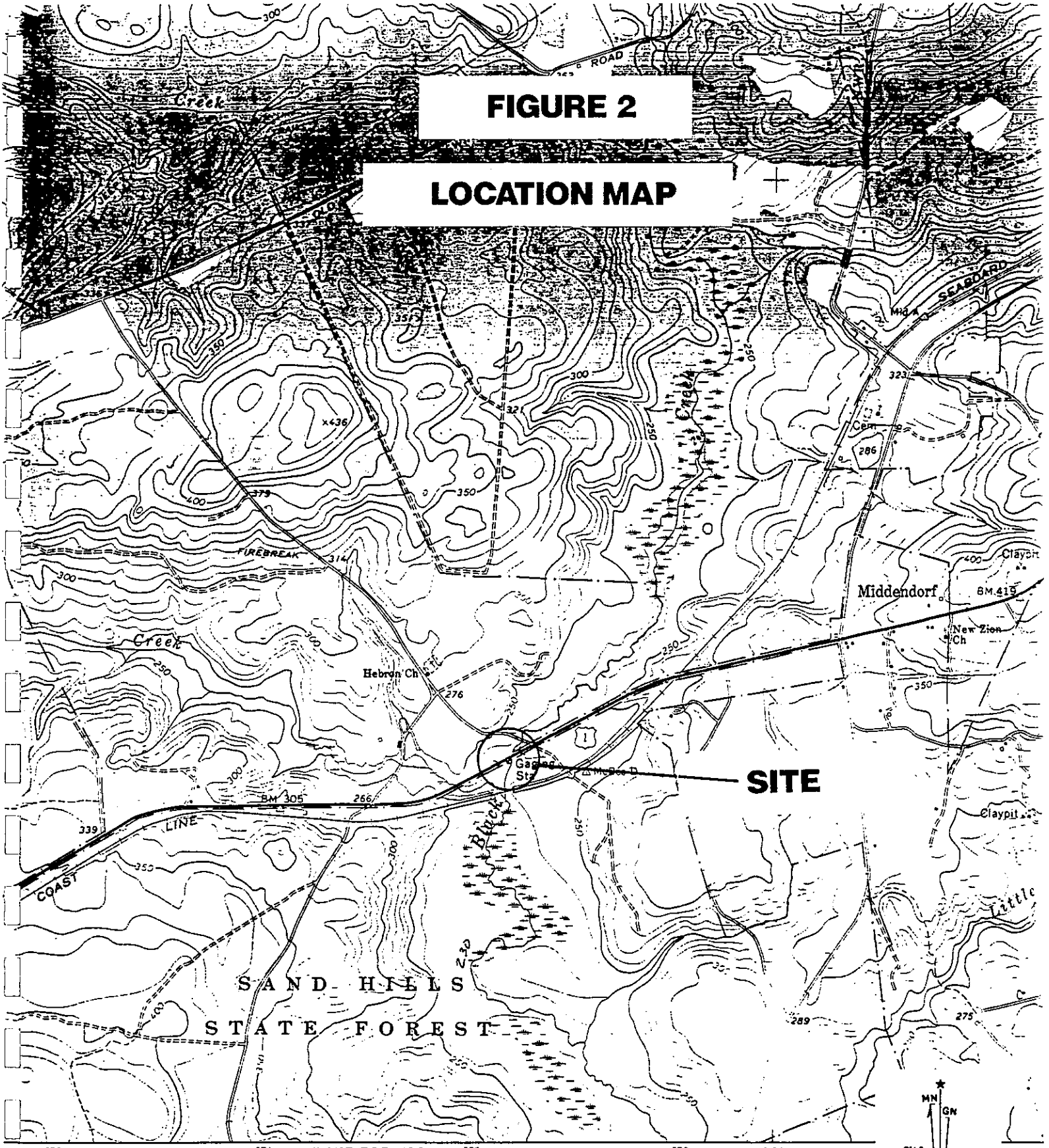


Figure 1. Geomorphic factors that affect stream stability (From HEC-20)

FIGURE 2

LOCATION MAP



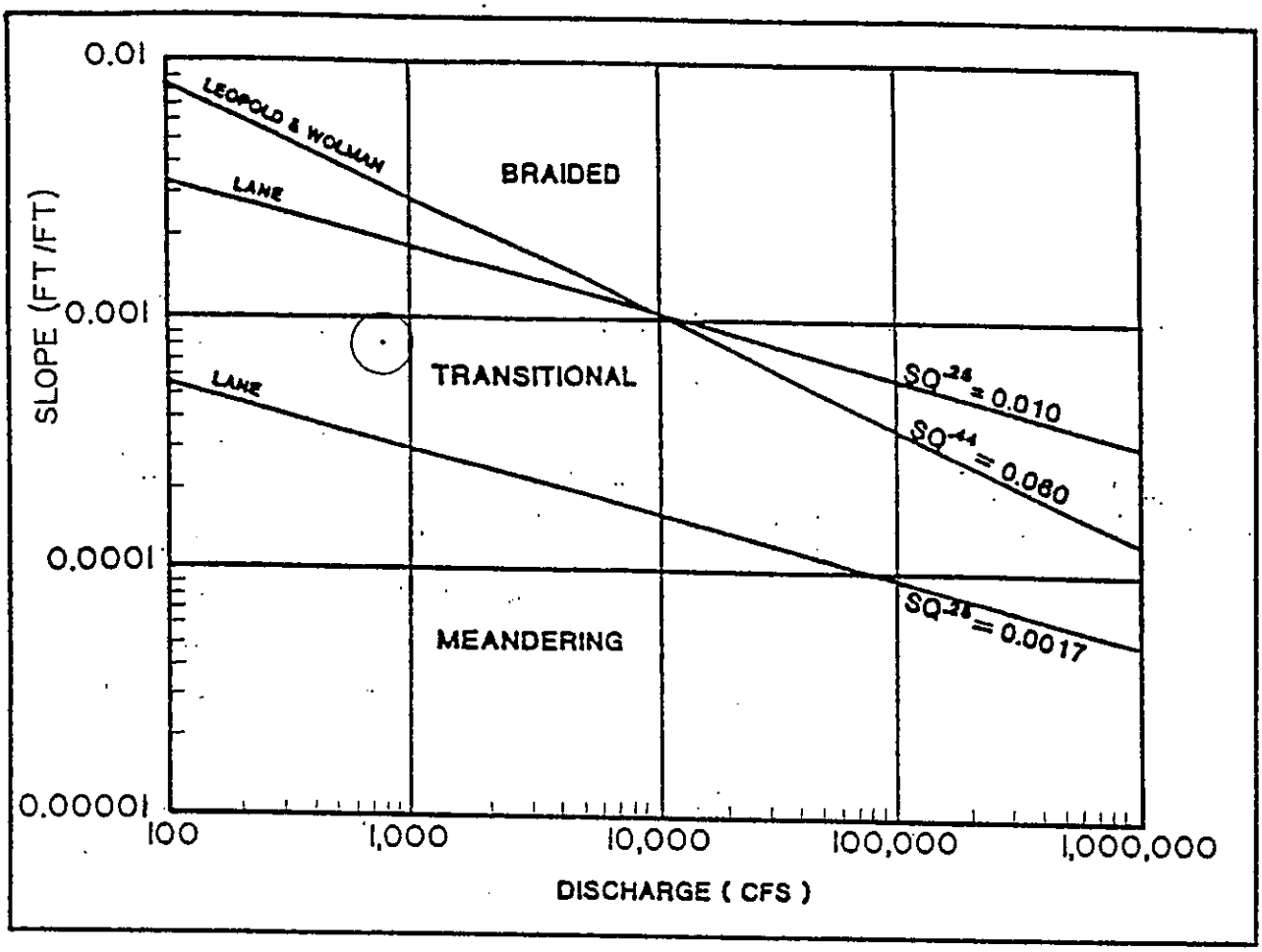


Figure 3. Slope-discharge relationship for braiding or meandering in sand bed streams (Figure 8 in HEC-20)

2.0 SCOUR ANALYSES

2.1 Flood History and Rainfall-Runoff Relations

The 1931 construction plans show a H.W. El. = 566.4 FT MSL. This water surface elevation is well above the elevation that was calculated for the 500-year storm (563.90 FT MSL) by the WSPRO computer program. The reason for this discrepancy is unknown. To verify the computer model, a calibration run was performed with historical data. The historical data was obtained from the USGS gaging station located at the site. A maximum discharge of 1770 cfs and water surface elevation 236.01 ft. MSL are listed in the gage records. The gage elevation was converted to the bridge datum and resulted in an elevation of 562.61 for the WSPRO model calibration target. The WSPRO model was adjusted until the output (562.52) approached the target.

The rainfall-runoff relations for the 108 sq. mi. drainage basin were obtained from USGS gage #02130900. Information for the 500-year storm was not listed in the gage record so it was estimated based on the data tend. Comparison flowrate data was determined 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 in the comparative data section of the field forms.

Flowrate data used in the WSPRO and scour analyses are listed below:

Frequency (years)	USGS Gage Flowrate (cfs)
2	722
10	1210
25	1430
50	1590
100	1760
500	2460*

* Based on data trend

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 1931 centerline profile. The soundings were taken from the upstream and downstream face of the bridge. The downstream face of the bridge was found to be more representative of the bridge opening and adjacent areas. Adjustments to the downstream soundings were made in the field to obtain a representative bridge opening cross section. These adjustments were made by estimating the level of the adjacent floodplain in the area of Bents 8 to 11.

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 0.1 ft. of backwater and has a velocity of 2.1 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 medium sand.

2.4 Watershed Sediment Yield Evaluation

The sediment yield for the watershed appears to be relatively stable as evidenced by the consistent stream bed geometry A rural well vegetated drainage basin such as this one is generally characterized by relatively low sediment yields and discharge rates.

2.5 Rating Curve Shifts

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

2.6 Scour Condition Evaluation

The bridge at this site was built in 1931 and widened in 1961. A different elevation datum was used for the 1961 bridge plans and this datum has been adjusted to correspond to the 1931 plans. This current bridge replaced an old bridge that is still located just upstream of this site. The current bridge consists of concrete deck and girders supported on concrete caps and piles with riprapped spill thru abutments.

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 significant pier scour depths due to the severely skewed flow and insignificant contraction scour depths. The pier and contraction scour depths were calculated to be 11.5 and 0.0 feet, respectively, for the 100-year storm.

The abutment scour at this site is moderate. Only a minor length of the roadway fill (160'±) obstructs flow in the floodplain. This blockage creates abutment scour depths of 4.6 feet or less for the 100-year storm.

There was some evidence of pier scour observed during the field inspection. The photographs in Appendix 2 show the remnant of a scour hole at Bent 3.

The thalweg for this stream could easily shift to any of the interior bents during the life of the structure. The thalweg currently flows directly beneath the bridge from Bent 5 to 15. Also, the construction plans show that a channel change was planned and may have been built in the area downstream of Bent 8. This channel change area is currently not the main flood path but the thalweg could shift to this location. For these reasons, the ground elevation at all the interior bents was assumed to be the thalweg elevation.

The results of the scour calculations show that scour could expose a significant length of most piles and could undermine the tips at Bents 2, 11, 15 & 16 for the 1961 widening. Undermining at Bents 2 and 16 is unlikely since the thalweg would have to shift to these bent locations in order to create the calculated scour. The pile tips listed in Tale 1 are from the 1961 bridge widening since the 1931 bridge pile tips are slightly deeper (533.0). The bridge widening pile tip elevations were listed on a SCDOT Pile Record Sheet. Only the shortest pile lengths 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 severe scour depths. We recommend a structural engineer and a geotechnical engineer review the scour conditions at this site to determine 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.

The abutments are protected with 18" D_{50} stone beneath the 1931 bridge deck. It appears there is no stone beneath the 1961 widening and no stone on the bridge cones. The quantity of stone may not be adequate to protect the bridge from the calculated abutment scour depths of 4± feet and from the possible thalweg shift. We recommend that the abutments be repaired to meet the current SCDOT standards for new construction by adding 18" D_{50} stone beneath the widening and on the bridge cones, particularly for the western abutment.

Table 1 - Remaining pile/footing penetration at piers/bents for Structure #132000100400 on Route US-1, crossing Black Creek in Chesterfield County, South Carolina

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 1760 cfs - 500-year discharge is 2460 cfs						
Scour Information for 100-Year Storm:						
2	109487	535.81	548.8	13.9	534.9	-0.91
3	109512	535.81	548.8	11.5	537.3	1.49
4	109537	535.81	548.8	11.5	537.3	1.49
5	109562	535.81	548.8	11.5	537.3	1.49
6	109587	535.81	548.8	11.5	537.3	1.49
7	109612	535.81	548.8	11.5	537.3	1.49
8	109637	535.81	548.8	11.5	537.3	1.49
9	109662	535.81	548.8	11.5	537.3	1.49
10	109687	535.81	548.8	11.5	537.3	1.49
11	109712	537.98	548.8	11.5	537.3	-0.68
12	109737	535.81	548.8	11.5	537.3	1.49
13	109762	535.81	548.8	11.5	537.3	1.49
14	109787	535.81	548.8	11.5	537.3	1.49
15	109812	535.81	548.8	16.1	532.7	-3.11
16	109837	535.81	548.8	16.1	532.7	-3.11
Scour Information for 500-Year Storm:						
2	109487	535.81	548.8	14.6	534.2	-1.61
3	109512	535.81	548.8	11.7	537.1	1.29
4	109537	535.81	548.8	11.7	537.1	1.29
5	109562	535.81	548.8	11.7	537.1	1.29
6	109587	535.81	548.8	11.7	537.1	1.29
7	109612	535.81	548.8	11.7	537.1	1.29
8	109637	535.81	548.8	11.7	537.1	1.29
9	109662	535.81	548.8	11.7	537.1	1.29
10	109687	535.81	548.8	11.7	537.1	1.29
11	109712	537.98	548.8	11.7	537.1	-0.88
12	109737	535.81	548.8	11.7	537.1	1.29
13	109762	535.81	548.8	11.7	537.1	1.29
14	109787	535.81	548.8	11.7	537.1	1.29
15	109812	535.81	548.8	16.7	532.1	-3.71
16	109837	535.81	548.8	16.7	532.1	-3.71

[1]Pier/bent number and station corresponds to South Carolina Department of Transportation bridge plans.
[2]Pile tip elevations obtained from SCDOT bridge plans for 1961 widening (w/adjusted datum). Shortest pile length listed. Pile tips for 1931 bridge are 533.0.
[3]Thalweg elevation used 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

Draft (9/22/92)

HYDRAULIC DESIGN
AND
RISK ASSESSMENT FOR
BRIDGE/BRIDGE REPLACEMENT OVER Black Creek
~~stream name~~
ROUTE/ROAD NUMBER US-1
FILE NO._____ PROJECT NO._____
Chesterfield COUNTY, SOUTH CAROLINA

DATE
12-1-94

Prepared By DMH/DYN
Checked By DYN
Reviewed By _____

Draft (9/22/92)

SITE INSPECTION

County CHESTERFIELD Rt/Rd No. US-1 Date 10-12-94
Stream BLACK CRK PIN
By Darcy Hammock
Doug Nichols

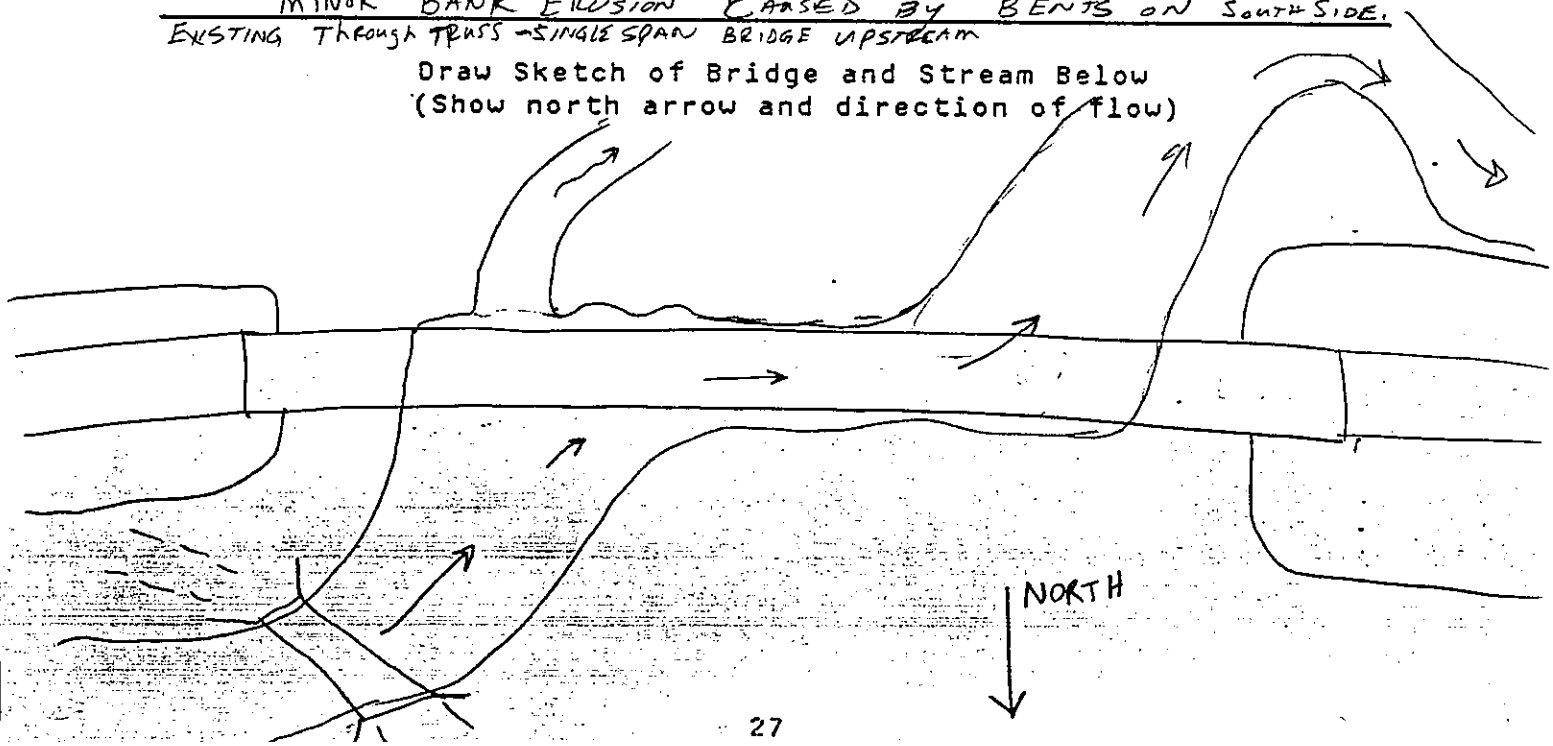
Note: All references to left and right are looking in the direction of flow.

EXISTING BRIDGE

Length 400 Ft. Width 34.7 OUT TO OUT Ft. Max. Span Length 25' FT.
Alignment (Tangent) Curved Bridge skewed Yes (No) Angle
End Abutment Type SPILL THROUGH
Riprap on Fills? (Yes)/No Condition FAIR $D_{50} = 18"$ Only - beneath deck
Superstructure Type R.C. GIRDERS
Substructure Type R.C. PILES - 16" □
Utilities Present (Yes)/No Describe 2" TELEPHONE D.S. FACE · FIBER OPTIC 2" U.S. FACE POWER to GUAGING STA at BENT 2 - OVERHEAD

Debris accumulations on bridge, percent channel blocked horizontal 5% Percent channel blocked vertical 5%
Hydraulic Problems? (Yes)/No Describe ~~HEA~~ RIVER FLOW LINE IS PARALLEL TO BRIDGE, NEARLY EVERY BENT IS SUBMERGED IN CHANNEL
DECK DRAINAGE FROM WIDENING RESULTS IN EROSION AT E.B. #2
MINOR BANK EROSION CAUSED BY BENTS ON SOUTH SIDE.
EXISTING THROUGH TRUSS - SINGLE SPAN BRIDGE UPSTREAM

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



Draft (9/22/92)

Site Characteristics

General Topography SLIGHTLY ROLLING HILLS
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 DOWNSTREAM DAM FORMS LAKE ROBINSON

Soil type MEDIUM SAND Exposed Rock Yes/(No) If so, give description and location _____

Describe potential for drift MODERATE

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 *An existing bridge upstream of the site may channelize some of the floodplain flow before it reaches the site.*

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
	Alternating Frequently	.010-.015
n_3 -- Relative Effect of Obstructions	Negligible	.000-.004
	Minor	.010-.015
	Appreciable	.020-.030
	severe	.040-.060

Draft (9/22/92)

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
U.S. / Flood Plain Width	0.02	0	0	0.01	0.01	1.0	0.04
At Bridge	0.02	0	0	0.01	0.01	1.0	0.04
O.S. / Flood Plain Width	0.02	0	0	0.01	0.01	1.0	0.04

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

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Field Observations For Over Bank Areas

Location	Depth	n_b	n_1	n_3	n_4	Computed n
U.S.1 Flood Plain Width		0.02	0	0.01	0.15	0.18 *
At. Bridge		0.02	0	0.01	0.01	0.04
D.S.1 Flood Plain Width		0.02	0	0.01	0.15	0.18 *

* The "n" values were increased to 0.20 when the WSPRO model was calibrated with the USGS gage data.

Width from TLB-TRB 285.9

STREAM BED SOUNDINGS

US-1 (UPSTREAM)

BRIDGE NO. 132000100400 COUNTY Chesterfield DATE 10-12-94 BY DMH/DYN

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

DISTANCE H. W. MARK TO TOP OF RAIL 12.3 LOCATION H. W. MARK Bent 11

~~DOWNSTREAM~~ PGL to Top of Rail = ~~2.2~~ (metal) 2.0 (conc) UPSTREAM

STATION	SOUNDING	DESCRIPTION	STATION	SOUNDING	DESCRIPTION
75	19.5	BENT 7	0.8	5.0	Lower Chord
87.9	18.2		3.9	5.1	Top of Slope
200.0	18.6	BENT 8	10.1	6.4	
212.2	20.6		17.2	9.9	
25.0	22.0	BENT 9	25.0	14.2	BENT 1
37.6	23.0		29.4	15.5	EDGE OF H_2O
50.0	21.5	BENT 10	32.6	17.0	
62.4	19.6		43.5	19.4	
69.1	18.2		50.0	19.5	BENT 2
75	17.1	BENT 11	59.0	21.4	
87.7	18.0		67.0	22.2	
300.0	18.4	BENT 12	75.0	21.4	BENT 3
308.5	15.5	EDGE H_2O	84.5	21.2	
310.9	14.6	TOP OF BANK	92.0	22.8	
15.8	14.4		100.0	22.0	BENT 4
25	14.1	BENT 13	109.1	19.6	
37.9	13.3		17.1	19.2	
50	14.1	BENT 14	25.0	19.8	BENT 5
61.8	14.1		38.2	20.3	
75.0	13.9	BENT 15	50.0	20.5	BENT 6
80.1	13.2	BOT OF SLOPE	62.4	19.5	
386.8	10.5				
397.8	5.6	TOP of slope			
400.0		EE EAST			

West E

SHEET ___ OF ___

TLB-TRB 12.5.

STREAM BED SOUNDINGS

US-1 (DOWNSTREAM SIDE)

BRIDGE NO. 132000100400 COUNTY Chesterfield DATE 10-12-94 BY DMH/DYN

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

DISTANCE H. W. MARK TO TOP OF RAIL same as upstream LOCATION H. W. MARK _____

DOWNSTREAM P&L to Top of Rail = same as upstream ~~UPSTREAM~~ Downstream

STATION	SOUNDING	DESCRIPTION	STATION	SOUNDING	DESCRIPTION	
211.0	12.8	Assumed Top of Bank	60	5.0	~~Lower Chord~~	WEST EI
212.2	15.6	Assumed Edge of H_2O	3.3	4.9	~~Top~~	
15.5	18.7	CHL	9.6	6.0	Top of Slope	
20.1	19.1	CHL	19.0	9.9		
23.5	15.6	Assumed Edge of H_2O	25	~~13.6~~ 13.6	BENT 1	
25.0	15.1	BENT 9 Ass. Top of Bank	29.5	15.6	Edge H_2O	
50.0	14.1	BENT 10	34.6	19.6		
65.7	13.6		43.0	22.7		
75	13.6	BENT 11	50	24.9	BENT 2	@ GAGE STATION
89.5	14.1		57.6	23.6		
300.0	14.4	BENT 12	64.5	21.8		
315.8	14.0		75.0	21.2	BENT 3	
25	14.1	BENT 13	83.0	15.6	Edge H_2O	
38.3	13.7		85.5	13.5	Top of Bank	
50.0	14.7	BENT 14	100.0	13.2	BENT 4	
63.5	14.3		112.1	12.7		
75.0	13.5	BENT 15	25.0	12.7	BENT 5	
81.2	12.6	Bot. of Slope	39.2	13.9		
88.9	10.3		50.0	12.9	BENT 6	
95.7	6.0	Top of Slope	57.7	12.8	Bank Pavement	
400		FF East		(Rt 8/200)	ROAD	

Note: These soundings were made in an opposite direction from the Roadway Stationing

SHEET ___ OF ___

STREAM BED SOUNDINGS

BRIDGE NO. upstream & Downstream Bridges COUNTY Chesterfield DATE 10-12-94 BY DMH/DYN

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

DISTANCE H. W. MARK TO TOP OF RAIL 12.6 (7.2' (UPSTREAM BRIDGE) (DWN. BR.) LOCATION H. W. MARK BENT 2 (UPST BR.) Bent #7 (DN.

LAKE ROBINSON DOWNSTREAM BRIDGE - UPSTREAM SIDE P&L to Top of Rail = UPSTREAM BRIDGE - UPSTREAM SIDE

STATION	SOUNDING	DESCRIPTION	STATION	SOUNDING	DESCRIPTION	
0.9	4.8	SOUTH WEST END Lower Ch.	1.0	1.2	Lower Chord	SOUTH WEST
2.3	4.3	TOP OF SLOPE	1.1	7.2	TOP of SLOPE	
14.7	9.7	~~BENT~~ 1	7.5	9.7	TOP OF BANK	
30.0	13.0	BENT 1	9.9	11.0	EDGE H_2O	
37.5	14.4 (OK)	EDGE WATER	15.6	13.4	BENT 1	
52.1	18.7		22.6	16.7		
60.0	22.0	BENT 2	30.5	16.8	BENT 2	
75.0	27.0		38.1	18.3		
90.0	29.0	BENT 3	45.5	20.9	BENT 4	
106.7	31.4		53.5	22.3		
120.0	32.4	BENT 4	60.6	22.5	BENT 5	
134.6	30.7		66.6	16.0		
150	30.6	BENT 5	73.8	11.0	EDGE H_2O	
166.7	28.0		75.5	9.8	~~TOP OF~~ BANK	
180.0	24.6	BENT 6	76.3	—	END BENT	FF
195.0	21.6				76.3' LONG	
210.0	17.4	BENT 7				
217.3	15.1 (OK)	EDGE H_2O				
226.3	11.8	SLOPE				
237.6	6.0	TOP of SLOPE				
240.0		FF.				

SHEET ___ OF ___

Draft (9/22/92)

COMPARATIVE BRIDGE SITE INSPECTION FORM

NE END of BLACK CRK. UPSTREAM BRIDGE

County Chesterfield Rt/RdNo. DIRT RD

Stream BLACK CREEK Measured Bridge length 76.3

Maximum Span length 15' Superstructure Type WOOD DECK

Substructure type WOOD PILES End Abutment type VERTICAL

Rip-rap present? Yes/(No) Condition _____

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

Any visible signs of scour problems (describe) EDGE OF STREAM Approaches Vertical Abutment on NE END of BRIDGE

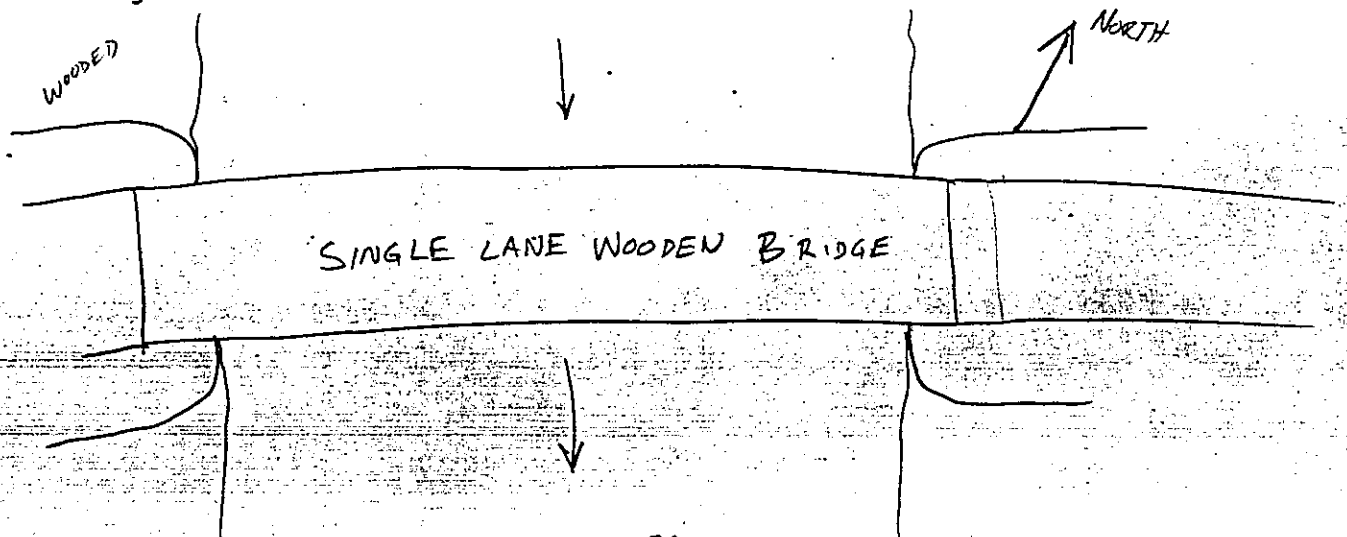
Are banks stable (describe) Yes. Well vegetated. No EXPOSED SOIL

Debris blockage; Percent of channel blocked horizontally 0%

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.



Draft (9/22/92)

COMPARATIVE BRIDGE SITE INSPECTION FORM

DOWNSTREAM BRIDGE

County CHESTERFIELD Rt/RdNo. S-346
Stream BLACK CRK. Measured Bridge length 240'

Maximum Span length 30' Superstructure Type R.C. GIRDERS

Substructure type R.C. PILES End Abutment type SPILL THROUGH

Rip-rap present? (Yes) No Condition FAIR

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

Any visible signs of scour problems (describe) NONE

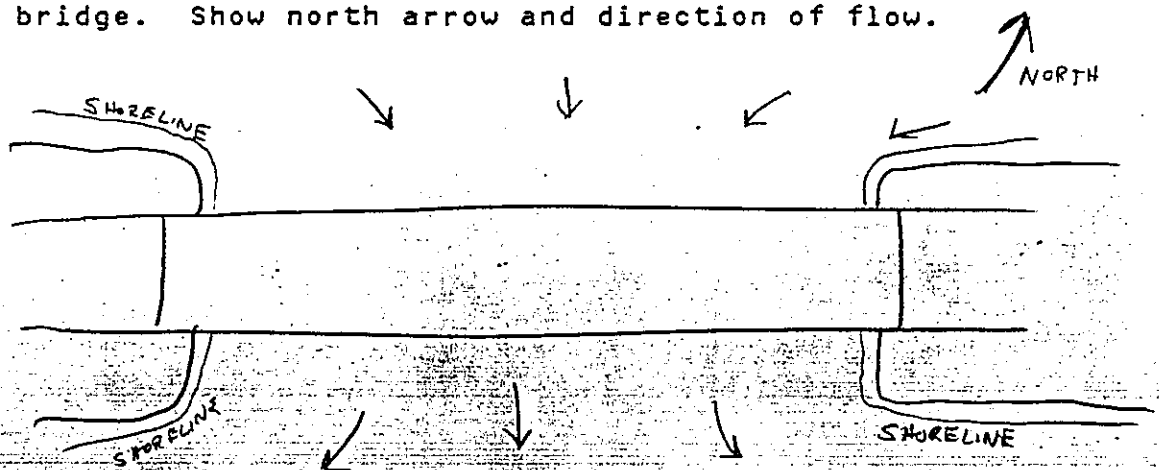
Are banks stable (describe) YES

Debris blockage; Percent of channel blocked horizontally 0%

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.



Flood History

Local resident's name : EARL QUICK QUICK GRO. HWY 1.
address:
Phone # : 335-8327
Period of knowledge: 31 YRS
High water mark location: (COVERED OLD steel BRidge) 1-2 ft. Below guders
Date of occurrence : 4 yrs Ago (1990)
Frequency of flooding : 1/10 yrs.

HIGH WATER EVENT SUBMERGED EXISTING STEEL TRUSS BRIDGE UPSTREAM of HWY 1 BRIDGE.

APPENDIX 2

PHOTOGRAPHS

US-1 OVER BLACK CREEK
Chesterfield County

(1) Looking East

(2) Looking Upstream between Bents 16 & 17

US-1 OVER BLACK CREEK
Chesterfield County

(3) Looking East from Bent 16

(4) Looking Downstream from Bent 16

US-1 OVER BLACK CREEK
Chesterfield County

(5) Looking Upstream near Bent 6

(6) Scour Hole at Bent 3

US-1 OVER BLACK CREEK
Chesterfield County

(7) Bent 1 and Bent 2

(8) Looking West along Upstream Face of Bridge

US-1 OVER BLACK CREEK
Chesterfield County

(9) Looking West along Downstream Face of Bridge

(10) Looking West along Downstream Face of Bridge at Main Channel

US-1 OVER BLACK CREEK
Chesterfield County

(11) Looking Downstream in Area of Planned Channel Change

APPENDIX 3

WSPRO COMPUTER DATA
and
SCOUR CALCULATIONS

```
T1          STR. NO. 132000100400 CHESTERFIELD CO.
T2          US-1 OVER BLACK CREEK
*F
Q             1770          1760          2460
SK          0.0008        0.0008        0.0008
XT       1    1000
GR          7725.0 576.0  7750.0 573.0  7800.0 570.5  7900.0 568.0
GR          8000.0 568.0  8200.0 565.5  8360.0 566.7  8400.0 566.0
GR          8800.0 566.0  8900.0 566.5  9090.0 566.5  9100.0 567.0
GR          9235.0 566.0  9245.0 564.0  9270.0 563.5  9280.0 565.5
GR          9300.0 564.0  9360.0 562.0  9365.0 564.0  9450.0 562.0
GR          9480.8 561.1  9487.0 560.2  9498.5 559.4  9512.0 559.0
GR          9523.7 560.0  9537.0 559.6  9546.2 559.7  9562.0 559.3
GR          9572.5 559.6  9587.0 560.1  9596.3 560.1  9612.0 559.6
GR          9637.0 558.6  9638.5 558.1  9641.9 554.6  9646.5 555.0
GR          9649.8 558.1  9651.0 560.9  9704.3 560.9  9712.0 560.8
GR          9723.8 559.8  9737.0 561.0  9749.9 561.0  9762.0 560.5
GR          9776.5 560.2  9779.0 558.1  9787.0 552.5  9797.5 551.9
GR          9804.4 550.1  9812.0 548.8  9819.0 551.0  9827.4 554.1
GR          9832.5 558.1  9835.0 559.0  9850.0 559.2  9900.0 559.2
GR          9960.0 556.5   10010 559.0   10222 576.0
XS    EXIT     600    48       *      *  0.0008
GT
N             0.2   0.05     0.2   0.05     0.2
SA          9638.5          9649.8   9779  9832.5
XS    FULLV  1000    48       *      *  0.0008
GT
N             0.2   0.04     0.2   0.04     0.2
SA          9638.5          9649.8   9779  9832.5
BR    BRID    1000 568.7       48
GR          9462.0 568.7  9466.3 567.7  9473.1 563.4  9480.8 561.1
GR          9487.0 560.2  9498.5 559.4  9512.0 559.0  9523.7 560.0
GR          9537.0 559.6  9546.2 559.7  9562.0 559.3  9572.5 559.6
GR          9587.0 560.1  9596.3 560.1  9612.0 559.6  9637.0 558.6
GR          9638.5 558.1  9641.9 554.6  9646.5 555.0  9649.8 558.1
GR          9651.0 560.9  9704.3 560.9  9712.0 560.8  9723.8 559.8
GR          9737.0 561.0  9749.9 561.0  9762.0 560.5  9776.5 560.2
GR          9779.0 558.1  9787.0 552.5  9797.5 551.9  9804.4 550.1
GR          9812.0 548.8  9819.0 551.0  9827.4 554.1  9832.5 558.1
GR          9837.0 560.1  9843.0 563.8  9852.4 567.7  9858.7 568.8
GR          9861.0 568.7  9862.0 568.7  9462.0 568.7
N            0.05   0.04    0.05   0.04    0.05
SA          9638.5          9649.8   9779  9832.5
CD               3   34.7   2.000  571.7       0      0      0
PW 1         548.8  1.333     553  1.333     553  2.666    559  2.666   559  6.666
               560  6.666     560     12     561     12    561     20 568.7    20
             568.73      0
HP               1 BRID   562.29      *  562.29
HP               1 BRID   563.71      *  563.71
HP               2 BRID   562.29      *  562.29   1760
HP               2 BRID   563.71      *  563.71   2460
AS    APPR  1434.7    48       *      *  0.0008
GT
N             0.2   0.04     0.2   0.04     0.2
SA          9638.5          9649.8   9779  9832.5
HP               1 APPR   562.49      *  562.49
HP               1 APPR    563.9      *   563.9
HP               2 APPR   562.49      *  562.49   1760
HP               2 APPR    563.9      *   563.9   2460
EX
ER
```

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)

*** RUN DATE & TIME: 12-07-94 07:54

```
  T1         STR. NO. 132000100400 CHESTERFIELD CO.

  T2         US-1 OVER BLACK CREEK

  *F

  Q            1770          1760          2460

*** Q-DATA FOR SEC-ID, ISEQ =              1
  SK         0.0008        0.0008        0.0008
```

```
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. 132000100400 CHESTERFIELD CO.
         US-1 OVER BLACK CREEK
            *** RUN DATE & TIME: 12-07-94  07:54

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

  GR        7725.0 576.0 7750.0 573.0 7800.0 570.5 7900.0 568.0

  GR        8000.0 568.0 8200.0 565.5 8360.0 566.7 8400.0 566.0

  GR        8800.0 566.0 8900.0 566.5 9090.0 566.5 9100.0 567.0

  GR        9235.0 566.0 9245.0 564.0 9270.0 563.5 9280.0 565.5

  GR        9300.0 564.0 9360.0 562.0 9365.0 564.0 9450.0 562.0

  GR        9480.8 561.1 9487.0 560.2 9498.5 559.4 9512.0 559.0

  GR        9523.7 560.0 9537.0 559.6 9546.2 559.7 9562.0 559.3

  GR        9572.5 559.6 9587.0 560.1 9596.3 560.1 9612.0 559.6

  GR        9637.0 558.6 9638.5 558.1 9641.9 554.6 9646.5 555.0

  GR        9649.8 558.1 9651.0 560.9 9704.3 560.9 9712.0 560.8

  GR        9723.8 559.8 9737.0 561.0 9749.9 561.0 9762.0 560.5

  GR        9776.5 560.2 9779.0 558.1 9787.0 552.5 9797.5 551.9

  GR        9804.4 550.1 9812.0 548.8 9819.0 551.0 9827.4 554.1

  GR        9832.5 558.1 9835.0 559.0 9850.0 559.2 9900.0 559.2

  GR        9960.0 556.5  10010 559.0  10222 576.0

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

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. 132000100400 CHESTERFIELD CO.
US-1 OVER BLACK CREEK
*** RUN DATE & TIME: 12-07-94 07:54

*** START PROCESSING CROSS SECTION - "EXIT "
XS EXIT 600 48 * * 0.0008

GT

N 0.2 0.05 0.2 0.05 0.2

SA 9638.5 9649.8 9779 9832.5

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

--- DATA SUMMARY FOR SECID "EXIT " AT SRD = 600. ERR-CODE = 0

SKEW	IHFNO	VSLOPE	EK	CK
48.0	0.	.0008	.50	.00

X-Y COORDINATE PAIRS (NGP = 59):

X	Y	X	Y	X	Y	X	Y
7725.0	575.68	7750.0	572.68	7800.0	570.18	7900.0	567.68
8000.0	567.68	8200.0	565.18	8360.0	566.38	8400.0	565.68
8800.0	565.68	8900.0	566.18	9090.0	566.18	9100.0	566.68
9235.0	565.68	9245.0	563.68	9270.0	563.18	9280.0	565.18
9300.0	563.68	9360.0	561.68	9365.0	563.68	9450.0	561.68
9480.8	560.78	9487.0	559.88	9498.5	559.08	9512.0	558.68
9523.7	559.68	9537.0	559.28	9546.2	559.38	9562.0	558.98
9572.5	559.28	9587.0	559.78	9596.3	559.78	9612.0	559.28
9637.0	558.28	9638.5	557.78	9641.9	554.28	9646.5	554.68
9649.8	557.78	9651.0	560.58	9704.3	560.58	9712.0	560.48
9723.8	559.48	9737.0	560.68	9749.9	560.68	9762.0	560.18
9776.5	559.88	9779.0	557.78	9787.0	552.18	9797.5	551.58
9804.4	549.78	9812.0	548.48	9819.0	550.68	9827.4	553.78
9832.5	557.78	9835.0	558.68	9850.0	558.88	9900.0	558.88
9960.0	556.18	10010.0	558.68	10222.0	575.68		

X-Y MAX-MIN POINTS:

XMIN	Y	X	YMIN	XMAX	Y	X	YMAX
7725.0	575.68	9812.0	548.48	10222.0	575.68	7725.0	575.68

SUBAREA BREAKPOINTS (NSA = 5):
9639. 9650. 9779. 9833.

ROUGHNESS COEFFICIENTS (NSA = 5):
.200 .050 .200 .050 .200

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. 132000100400 CHESTERFIELD CO.
US-1 OVER BLACK CREEK
*** RUN DATE & TIME: 12-07-94 07:54

*** START PROCESSING CROSS SECTION - "FULLV"
XS FULLV 1000 48 * * 0.0008

GT

N 0.2 0.04 0.2 0.04 0.2

SA 9638.5 9649.8 9779 9832.5

*** 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
48.0	0.	.0008	.50	.00

X-Y COORDINATE PAIRS (NGP = 59):

X	Y	X	Y	X	Y	X	Y
7725.0	576.00	7750.0	573.00	7800.0	570.50	7900.0	568.00
8000.0	568.00	8200.0	565.50	8360.0	566.70	8400.0	566.00
8800.0	566.00	8900.0	566.50	9090.0	566.50	9100.0	567.00
9235.0	566.00	9245.0	564.00	9270.0	563.50	9280.0	565.50
9300.0	564.00	9360.0	562.00	9365.0	564.00	9450.0	562.00
9480.8	561.10	9487.0	560.20	9498.5	559.40	9512.0	559.00
9523.7	560.00	9537.0	559.60	9546.2	559.70	9562.0	559.30
9572.5	559.60	9587.0	560.10	9596.3	560.10	9612.0	559.60
9637.0	558.60	9638.5	558.10	9641.9	554.60	9646.5	555.00
9649.8	558.10	9651.0	560.90	9704.3	560.90	9712.0	560.80
9723.8	559.80	9737.0	561.00	9749.9	561.00	9762.0	560.50
9776.5	560.20	9779.0	558.10	9787.0	552.50	9797.5	551.90
9804.4	550.10	9812.0	548.80	9819.0	551.00	9827.4	554.10
9832.5	558.10	9835.0	559.00	9850.0	559.20	9900.0	559.20
9960.0	556.50	10010.0	559.00	10222.0	576.00		

X-Y MAX-MIN POINTS:

XMIN	Y	X	YMIN	XMAX	Y	X	YMAX
7725.0	576.00	9812.0	548.80	10222.0	576.00	7725.0	576.00

SUBAREA BREAKPOINTS (NSA = 5):
9639. 9650. 9779. 9833.

ROUGHNESS COEFFICIENTS (NSA = 5):
.200 .040 .200 .040 .200

```
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. 132000100400 CHESTERFIELD CO.
         US-1 OVER BLACK CREEK
            *** RUN DATE & TIME: 12-07-94  07:54

*** START PROCESSING CROSS SECTION - "BRID "
  BR   BRID    1000 568.7     48

  GR         9462.0 568.7 9466.3 567.7 9473.1 563.4 9480.8 561.1

  GR         9487.0 560.2 9498.5 559.4 9512.0 559.0 9523.7 560.0

  GR         9537.0 559.6 9546.2 559.7 9562.0 559.3 9572.5 559.6

  GR         9587.0 560.1 9596.3 560.1 9612.0 559.6 9637.0 558.6

  GR         9638.5 558.1 9641.9 554.6 9646.5 555.0 9649.8 558.1

  GR         9651.0 560.9 9704.3 560.9 9712.0 560.8 9723.8 559.8

  GR         9737.0 561.0 9749.9 561.0 9762.0 560.5 9776.5 560.2

  GR         9779.0 558.1 9787.0 552.5 9797.5 551.9 9804.4 550.1

  GR         9812.0 548.8 9819.0 551.0 9827.4 554.1 9832.5 558.1

  GR         9837.0 560.1 9843.0 563.8 9852.4 567.7 9858.7 568.8

  GR         9861.0 568.7 9862.0 568.7 9462.0 568.7

  N            0.05  0.04   0.05  0.04   0.05

  SA         9638.5       9649.8  9779 9832.5

  CD               3  34.7  2.000 571.7      0     0      0

  PW 1        548.8 1.333    553 1.333    553 2.666    559 2.666   559 6.666

                560 6.666    560    12    561    12    561    20 568.7    20

              568.73     0

  HP               1 BRID  562.29     * 562.29


*** 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
     48.0        0.      .0008        .50        .00

X-Y COORDINATE PAIRS  (NGP =  43):
       X       Y          X       Y          X       Y          X       Y
   9462.0  568.70     9466.3  567.70     9473.1  563.40     9480.8  561.10
   9487.0  560.20     9498.5  559.40     9512.0  559.00     9523.7  560.00
   9537.0  559.60     9546.2  559.70     9562.0  559.30     9572.5  559.60
   9587.0  560.10     9596.3  560.10     9612.0  559.60     9637.0  558.60
   9638.5  558.10     9641.9  554.60     9646.5  555.00     9649.8  558.10
   9651.0  560.90     9704.3  560.90     9712.0  560.80     9723.8  559.80
```

9812.0	548.80	9819.0	551.00	9827.4	554.10	9832.5	558.10
9837.0	560.10	9843.0	563.80	9852.4	567.70	9858.7	568.80
9861.0	568.70	9862.0	568.70	9462.0	568.70		

X-Y MAX-MIN POINTS:

XMIN	Y	X	YMIN	XMAX	Y	X	YMAX
9462.0	568.70	9812.0	548.80	9862.0	568.70	9858.7	568.80

SUBAREA BREAKPOINTS (NSA = 5):

9639. 9650. 9779. 9833.

ROUGHNESS COEFFICIENTS (NSA = 5):

.050 .040 .050 .040 .050

BRIDGE PARAMETERS:

BRTYPE	BRWDTH	LSEL	USERCD	EMBSS	EMBELV	ABSLPL	ABSLPR
3	34.7	568.70	*******	2.00	571.70	*******	*******

PIER DATA: NPW = 11 PPCD = 1.

PELV	PWDTH	PELV	PWDTH	PELV	PWDTH	PELV	PWDTH
548.80	1.3	553.00	1.3	553.00	2.7	559.00	2.7
559.00	6.7	560.00	6.7	560.00	12.0	561.00	12.0
561.00	20.0	568.70	20.0	568.73	.0		

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. 132000100400 CHESTERFIELD CO.
US-1 OVER BLACK CREEK
*** RUN DATE & TIME: 12-07-94 07:54
CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	285.	16174.	108.	109.				2631.
	2	49.	4957.	8.	11.				713.
	3	139.	5566.	86.	90.				1004.
	4	360.	56200.	36.	42.				6468.
	5	12.	535.	5.	7.				104.
562.29		846.	83431.	243.	258.	1.83	9477.	9841.	6616.

HP	1	BRID	563.71	* 563.71

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. 132000100400 CHESTERFIELD CO.
US-1 OVER BLACK CREEK
*** RUN DATE & TIME: 12-07-94 07:54
CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	441.	32796.	111.	112.				4992.
	2	60.	6886.	8.	11.				959.
	3	262.	15957.	86.	90.				2589.
	4	410.	70054.	36.	42.				7887.
	5	21.	1101.	7.	9.				207.
563.71		1195.	126795.	248.	264.	1.66	9473.	9843.	11546.

HP	2	BRID	562.29	*	562.29	1760

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. 132000100400 CHESTERFIELD CO.
US-1 OVER BLACK CREEK
*** RUN DATE & TIME: 12-07-94 07:54

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

WSEL	LEW	REW	AREA	K	Q	VEL
562.29	9476.8	9840.6	845.8	83431.	1760.	2.08

X STA.	9476.8	9524.4	9564.9	9612.2	9640.8	9648.7
A(I)		78.4	72.6	77.4	65.1	37.7
V(I)		1.12	1.21	1.14	1.35	2.33

X STA.	9648.7	9746.3	9786.9	9790.6	9794.2	9797.5
A(I)		103.1	76.4	24.6	24.3	22.5
V(I)		.85	1.15	3.57	3.63	3.90

X STA.	9797.5	9800.8	9803.8	9806.6	9809.3	9811.7
A(I)		23.7	24.0	23.0	22.4	21.6
V(I)		3.71	3.67	3.83	3.92	4.07

X STA.	9811.7	9814.2	9816.9	9820.0	9823.9	9840.6
A(I)		21.9	22.6	23.6	26.8	54.0
V(I)		4.03	3.89	3.73	3.29	1.63

HP	2	BRID	563.71	* 563.71	2460

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. 132000100400 CHESTERFIELD CO.
US-1 OVER BLACK CREEK
*** RUN DATE & TIME: 12-07-94 07:54

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

WSEL	LEW	REW	AREA	K	Q	VEL
563.71	9472.6	9842.9	1194.7	126795.	2460.	2.06

X STA.	9472.6	9513.4	9544.7	9573.3	9608.8	9634.9
A(I)		95.6	84.2	80.8	89.4	78.6
V(I)		1.29	1.46	1.52	1.38	1.56
X STA.	9634.9	9646.3	9693.2	9741.3	9783.9	9789.3
A(I)		55.8	99.6	99.4	103.6	38.6
V(I)		2.20	1.23	1.24	1.19	3.19
X STA.	9789.3	9793.7	9798.2	9802.2	9805.8	9809.2
A(I)		33.5	35.4	33.8	32.6	31.6
V(I)		3.67	3.47	3.64	3.77	3.89
X STA.	9809.2	9812.2	9815.5	9819.2	9823.8	9842.9
A(I)		29.9	31.4	33.1	36.1	71.6
V(I)		4.11	3.92	3.71	3.40	1.72

```
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. 132000100400 CHESTERFIELD CO.
        US-1 OVER BLACK CREEK
           *** RUN DATE & TIME: 12-07-94  07:54

*** START PROCESSING CROSS SECTION - "APPR "
  AS   APPR  1434.7    48       *      * 0.0008

  GT

  N             0.2  0.04    0.2  0.04    0.2

  SA         9638.5        9649.8  9779 9832.5

  HP              1 APPR  562.49      * 562.49


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

--- DATA SUMMARY FOR SECID "APPR " AT SRD =   1435.  ERR-CODE =      0

    SKEW      IHFNO     VSLOPE         EK         CK
    48.0        0.      .0008        .50        .00

X-Y COORDINATE PAIRS  (NGP =  59):
       X       Y           X       Y           X       Y           X       Y
  7725.0  576.35     7750.0  573.35     7800.0  570.85     7900.0  568.35
  8000.0  568.35     8200.0  565.85     8360.0  567.05     8400.0  566.35
  8800.0  566.35     8900.0  566.85     9090.0  566.85     9100.0  567.35
  9235.0  566.35     9245.0  564.35     9270.0  563.85     9280.0  565.85
  9300.0  564.35     9360.0  562.35     9365.0  564.35     9450.0  562.35
  9480.8  561.45     9487.0  560.55     9498.5  559.75     9512.0  559.35
  9523.7  560.35     9537.0  559.95     9546.2  560.05     9562.0  559.65
  9572.5  559.95     9587.0  560.45     9596.3  560.45     9612.0  559.95
  9637.0  558.95     9638.5  558.45     9641.9  554.95     9646.5  555.35
  9649.8  558.45     9651.0  561.25     9704.3  561.25     9712.0  561.15
  9723.8  560.15     9737.0  561.35     9749.9  561.35     9762.0  560.85
  9776.5  560.55     9779.0  558.45     9787.0  552.85     9797.5  552.25
  9804.4  550.45     9812.0  549.15     9819.0  551.35     9827.4  554.45
  9832.5  558.45     9835.0  559.35     9850.0  559.55     9900.0  559.55
  9960.0  556.85    10010.0  559.35    10222.0  576.35

 X-Y MAX-MIN POINTS:
    XMIN       Y          X    YMIN      XMAX       Y          X    YMAX
  7725.0  576.35     9812.0  549.15    10222.0  576.35     7725.0  576.35

SUBAREA BREAKPOINTS (NSA =  5):
       9639.   9650.   9779.   9833.

ROUGHNESS COEFFICIENTS (NSA =  5):
         .200    .040    .200    .040    .200

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

WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
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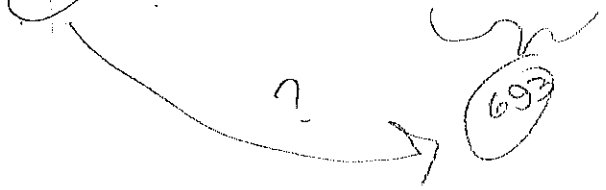
CROSS-SECTION PROPERTIES: ISEQ = 4; SECID = APPR ; SRD = 1435.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	281.	3433.	133.	134.				2315.
	2	48.	4771.	8.	11.				689.
	3	127.	1185.	86.	90.				869.
	4	354.	54829.	36.	42.				6326.
	5	495.	8351.	145.	146.				5197.
562.49		1305.	72569.	408.	422.	6.08	9356.	10049.	5375.



HP	1 APPR	563.9	*	563.9	

WSPRO
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WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	519.	7134.	206.	207.				4672.
	2	59.	6660.	8.	11.				930.
	3	248.	3649.	86.	90.				2390.
	4	405.	68455.	36.	42.				7725.
	5	708.	14376.	157.	157.				8541.
563.90		1939.	100274.	493.	507.	7.65	9267.	10067.	7894.

HP	2 APPR	562.49	*	562.49	1760

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STR. NO. 132000100400 CHESTERFIELD CO.
US-1 OVER BLACK CREEK
*** RUN DATE & TIME: 12-07-94 07:54

VELOCITY DISTRIBUTION: ISEQ = 4; SECID = APPR ; SRD = 1435.

WSEL	LEW	REW	AREA	K	Q	VEL
562.49	9355.7	10049.2	1305.4	72569.	1760.	1.35

X STA.	9355.7	9639.8	9646.6	9785.7	9789.5	9792.7
A(I)		284.9	32.3	167.1	24.0	21.3
V(I)		.31	2.72	.53	3.66	4.13
X STA.	9792.7	9795.8	9798.8	9801.7	9804.3	9806.7
A(I)		20.5	21.1	21.1	20.0	19.6
V(I)		4.28	4.17	4.17	4.40	4.48
X STA.	9806.7	9809.0	9811.2	9813.4	9815.7	9818.3
A(I)		19.6	19.0	19.4	19.5	20.4
V(I)		4.48	4.64	4.54	4.50	4.32
X STA.	9818.3	9821.2	9825.0	9865.9	9952.6	10049.2
A(I)		21.5	23.9	102.4	212.1	215.4
V(I)		4.09	3.67	.86	.41	.41

HP	2	APPR	563.9	*	563.9	2460

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US-1 OVER BLACK CREEK
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VELOCITY DISTRIBUTION: ISEQ = 4; SECID = APPR ; SRD = 1435.

WSEL	LEW	REW	AREA	K	Q	VEL
563.90	9267.4	10066.8	1939.0	100274.	2460.	1.27

X STA.	9267.4	9599.8	9643.7	9699.5	9785.8	9789.9
A(I)		408.5	137.5	120.9	194.4	30.3
V(I)		.30	.89	1.02	.63	4.06
X STA.	9789.9	9793.4	9796.9	9800.2	9803.3	9806.0
A(I)		26.8	26.6	26.3	26.6	24.8
V(I)		4.59	4.62	4.67	4.62	4.95
X STA.	9806.0	9808.7	9811.2	9813.8	9816.6	9819.6
A(I)		25.0	24.2	24.7	25.7	26.5
V(I)		4.92	5.08	4.99	4.78	4.65
X STA.	9819.6	9823.4	9828.7	9907.6	9960.8	10066.8
A(I)		29.0	35.1	239.7	209.8	276.6
V(I)		4.25	3.50	.51	.59	.44

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FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
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STR. NO. 132000100400 CHESTERFIELD CO.
US-1 OVER BLACK CREEK
*** RUN DATE & TIME: 12-07-94 07:54

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
EXIT :XS	******	9352.	1356.	.14	*****	562.09	555.99	1770.	561.95
600.	******	10051.	62575.	5.46	*****	*******	.30	1.30	
FULLV:FV	400.	9354.	1332.	.17	.27	562.38	*******	1770.	562.21
1000.	400.	10050.	73688.	6.16	.01	.00	.32	1.33	

<<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR :AS	435.	9357.	1294.	.18	.26	562.64	*******	1770.	562.46
1435.	435.	10049.	72103.	6.04	.00	.00	.33	1.37	

<<<<<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	400.	9477.	852.	.08	.31	562.40	556.68	1770.	562.32
1000.	400.	9841.	84126.	1.20	.00	.00	.21	2.08	

TYPE	PPCD	FLOW	C	P/A	LSEL	BLEN	XLAB	XRAB
3.	1.	1.	.915	.078	568.70	******	******	******

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
APPR :AS	400.	9355.	1316.	.17	.27	562.69	556.66	1770.	562.52
1435.	411.	10050.	73039.	6.11	.02	-.01	.33	1.34	

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.475	.104	65558.	9485.	9849.	562.28

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

WSPRO
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STR. NO. 132000100400 CHESTERFIELD CO.
US-1 OVER BLACK CREEK
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XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
EXIT :XS	******	9263.	1982.	.15	*****	563.47	557.25	2460.	563.32
600.	******	10068.	86912.	6.46	*****	*******	.28	1.24	
FULLV:FV	400.	9266.	1952.	.19	.28	563.77	*******	2460.	563.58
1000.	400.	10067.	100830.	7.68	.02	.00	.31	1.26	
<<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>									
APPR :AS	435.	9315.	1911.	.20	.26	564.04	*******	2460.	563.84
1435.	435.	10066.	99067.	7.58	.00	.00	.32	1.29	
<<<<<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	400.	9473.	1195.	.08	.32	563.79	557.87	2460.	563.71
1000.	400.	9843.	126776.	1.23	.00	.00	.18	2.06	

TYPE	PPCD	FLOW	C	P/A	LSEL	BLEN	XLAB	XRAB
3.	1.	1.	.901	.079	568.70	******	******	******

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
APPR :AS	400.	9267.	1940.	.19	.28	564.09	557.90	2460.	563.90
1435.	412.	10067.	100295.	7.65	.02	-.01	.31	1.27	

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.507	.124	88036.	9489.	9859.	563.66

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

ER

NORMAL END OF WSPRO EXECUTION.

==========

STR. # 132000100400 US-1 OVER BLACK CREEK CHESTERFIELD CO.

100 YEAR CHANNEL CONTRACTION SCOUR

Y1=	13.3	ft
Wc1=	54	ft
Wc2=	54	ft
Qmc1=	1330	cfs
Qmc2=	1186	cfs
K1=	0.59	

Y2= Y1*(Qmc2/Qmc1)^(6/7)*(Wc1/Wc2)^K1)

Y2=	12.1	ft
Ys=Y2-Y1=	-1.2	ft

500 YEAR CHANNEL CONTRACTION SCOUR

Y1=	14.8	ft
Wc1=	54	ft
Wc2=	54	ft
Qmc1=	1679	cfs
Qmc2=	1359	cfs
K1=	0.59	

Y2= Y1*(Qmc2/Qmc1)^(6/7)*(Wc1/Wc2)^K1)

Y2=	12.3	ft
Ys=Y2-Y1=	-2.4	ft

100 YEAR CHANNEL PIER SCOUR

Y1=	13.49		
K1=	1.1		
K2=	3.2	L/a=	6
K3=	1.1		
a=	1.3	ft	
V1=	4.07		
Fr1=	0.195		

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

Ys=	11.5

500 YEAR CHANNEL PIER SCOUR

Y1=	14.9	
K1=	1.1	
K2=	3.2	
K3=	1.1	
a=	1.3	ft
V1=	4.11	
Fr1=	0.188	

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

Ys=	11.7

STR. # 132000100400 US-1 OVER BLACK CREEK CHESTERFIELD CO.
100 YR EASTERN ABUTMENT SCOUR

a' LENGTH OF ABUT.		
PROJ. NORMAL TO FLOW=	83.5	
OBSTRUCTED FLOW AREA=	125	
Ya=	1.5	
VERT. WALL	1	
VERT. WALL W/ WINGS	0.82	
SPILL THROUGH	0.55	
K1=	0.55	
EMB. ANGLE (PERP.=90)	42	SIDE WITH FLOW REVERSAL HAS HIGHER ANGLE
K2=	0.906	
OBSTRUCTED FLOW (cfs)	39	
Ve=	0.31	
Fre=Ve/(gYa)^0.5=	0.0446	

Ys/Ya=2.27 K1 K2 (a'/Ya)^0.43 Fre^0.61 + 1

Ys=	2.4

500 YR EASTERN ABUTMENT SCOUR

a' LENGTH OF ABUT.		
PROJ. NORMAL TO FLOW=	143.2	
OBSTRUCTED FLOW AREA=	263	
Ya=	1.8	
VERT. WALL	1	
VERT. WALL W/ WINGS	0.82	
SPILL THROUGH	0.55	
K1=	0.55	
EMB. ANGLE (PERP.=90)	42	SIDE WITH FLOW REVERSAL HAS HIGHER ANGLE
K2=	0.906	
OBSTRUCTED FLOW (cfs)	79	
Ve=	0.30	
Fre=Ve/(gYa)^0.5=	0.0390	

Ys/Ya=2.27 K1 K2 (a'/Ya)^0.43 Fre^0.61 + 1

Ys=	2.9

STR. # 132000100400 US-1 OVER BLACK CREEK CHESTERFIELD CO.
100 YR WESTERN ABUTMENT SCOUR

a' LENGTH OF ABUT.		
PROJ. NORMAL TO FLOW=	145.2	
OBSTRUCTED FLOW AREA=	529	
Ya=	3.6	
VERT. WALL	1	
VERT. WALL W/ WINGS	0.82	
SPILL THROUGH	0.55	
K1=	0.55	
EMB. ANGLE (PERP.=90)	138	SIDE WITH FLOW REVERSAL HAS HIGHER ANGLE
K2=	1.057	
OBSTRUCTED FLOW (cfs)	263	
Ve=	0.50	
Fre=Ve/(gYa)^0.5=	0.0459	

Ys/Ya=2.27 K1 K2 (a'/Ya)^0.43 Fre^0.61 + 1

Ys=	4.6

500 YR WESTERN ABUTMENT SCOUR

a' LENGTH OF ABUT.		
PROJ. NORMAL TO FLOW=	157.2	
OBSTRUCTED FLOW AREA=	726	
Ya=	4.6	
VERT. WALL	1	
VERT. WALL W/ WINGS	0.82	
SPILL THROUGH	0.55	
K1=	0.55	
EMB. ANGLE (PERP.=90)	138	SIDE WITH FLOW REVERSAL HAS HIGHER ANGLE
K2=	1.057	
OBSTRUCTED FLOW (cfs)	368	
Ve=	0.51	
Fre=Ve/(gYa)^0.5=	0.0415	

Ys/Ya=2.27 K1 K2 (a'/Ya)^0.43 Fre^0.61 + 1

Ys=	5.0

APPENDIX 4

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.

LETTER OF TRANSMITTAL

RALPH WHITEHEAD ASSOCIATES, INC.
P.O. Box 35624 1201 Greenwood Cliff
CHARLOTTE, NORTH CAROLINA 28235

(704) 372-1885

TO Randy Williamson
SCDOT Hydraulics Unit

DATE	JOB NO.
12-8-94	2316-213

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☐ Shop drawings ☐ Prints ☐ Plans ☐ Samples ☐ Specifications

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			Chesterfield Co # 1320001004 00

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