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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52996352 Date 8/11/11 Initials CW Region (A (B) C D)

Site _____ Location 3 mi E, 2.5 mi N of Cottonwood on Big Foote Rd

Q_{100} = 10900 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 9835 (should be Q_{100} unless there is a relief bridge, road overflow, or bridge overtopping)

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

PGRM: "RegionA", "RegionB", "RegionC", or "RegionD"

Bridge Width = 77 ft. Flow angle at bridge = 15 ° Abut. Skew = 0 ° Effective Skew = 15 °

Width (W_2) iteration = 77

Avg. flow depth at bridge, y_2 iteration = 14.8 > 2.5 → RD Overflow 132.2

Corrected channel width at bridge Section = W_2 times cos of flow angle = 74.36 ft* $q_2 = Q_2/W_2$ = ~~132.38~~ ft²/s

Bridge Vel, V_2 = 9.4 ft/s Final $y_2 = q_2/V_2$ = 14.0 ft Δh = 1.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 15.8 ft

* *NOTE: repeat above calculations until y_2 changes by less than 0.2* *Effective pier width = L sin(q) + a cos(q)*

If y_2 is above LS, then account for Road Overflow using PRGM: RDOVREGA, RDOVREGB, RDOVREGC, or RDOVREGD,

Water Surface Elev. = _____ ft

Low Steel Elev. = 14.0 ft

n (Channel) = 0.070

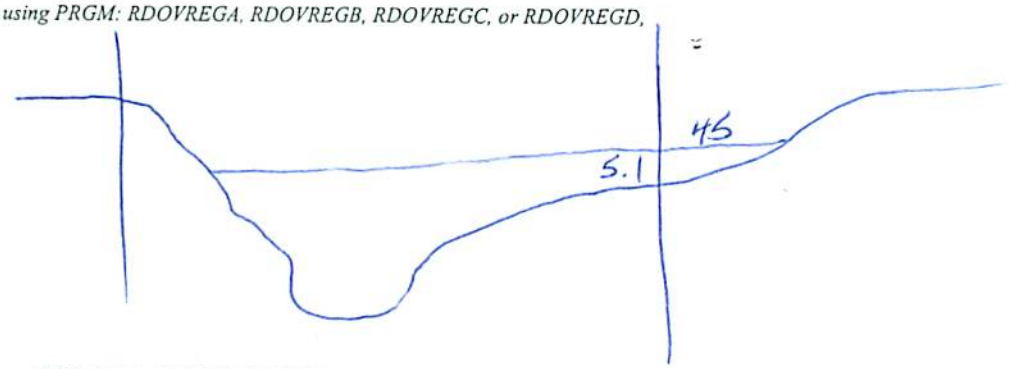
n (LOB) = 0.040

n (ROB) = 0.045

Pier Width = 0.80 ft

Pier Length = 0.45 ft

Piers for 100 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 140 ft

Width of left overbank flow at approach, W_{lob} = ~~[illegible]~~ 0 ft ~~5.1 → 2.5~~ Average left overbank flow depth, y_{lob} = ~~0.0~~ 2.5 ft 0.0

Width of right overbank flow at approach, W_{rob} = 0 ft 45 Average right overbank flow depth, y_{rob} = ~~0.0~~ 5.1 → 2.5 ft 2.5

Live Bed Contraction Scour (use if bed material is small cobbles or finer)

x = 15.3 From Figure 9 W_2 (effective) = 72.8 ft y_{cs} = 15.2 ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = _____ ft Average approach velocity, $V_1 = Q_{100}/(y_1 W_1)$ = _____ ft/s

Critical approach velocity, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = _____ ft/s

If $V_1 < V_c$ and $D_{50} >= 0.2$ ft, use clear water equation below, otherwise use live bed scour equation above.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = _____ ft If $D_{50} >= D_{c50}$, $\chi = 0.0$

Otherwise, $\chi = 0.122 y_1 [q_2/(D_{50}^{1/3} y_1^{7/6})]^{6/7} - y_1$ = _____ From Figure 10, y_{cs} = _____ ft

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 1.0

Froude # at bridge = 0.44

Correction factor for flow angle of attack (from Table 1), K2 = 1.0

Using pier width a on Figure 11, ξ = 3.9 Pier scour y_{ps} = 3.4 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 0.0 ft right abutment, y_{aRT} = 2.5 ft

Shape coefficient K_1= 1.00 for vertical-wall, 0.82 for vertical-wall with wingwalls, 0.55 for spill-through

Using values for y_{aLT} and y_{aRT} on figure 12, ψ_{LT} = 0.0 and ψ_{RT} = 10.2

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0.0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 10.2 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52990352 Date 8/11/11 Initials GW Region (A (B) C D)

Site _____ Location 3 mi E, 2.5 mi N of Cottonwood on Big Foote Rd

Q_{500} = 7320 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 7320 (should be Q_{500} unless there is a relief bridge, road overflow, or bridge overtopping)

Q50

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

PGRM: "RegionA", "RegionB", "RegionC", or "RegionD"

Bridge Width = 77 ft. Flow angle at bridge = 15 ° Abut. Skew = 0 ° Effective Skew = 15 °

Width (W_2) iteration = 77

Avg. flow depth at bridge, y_2 iteration = 12.0 ⇒ Vert Wall

Corrected channel width at bridge Section = W_2 times cos of flow angle = 74.36 ft* $q_2 = Q_2/W_2$ = 98.4 ft²/s

Bridge Vel, V_2 = 8.2 ft/s Final $y_2 = q_2/V_2$ = 12.0 ft Δh = 1.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 13.4 ft

** NOTE: repeat above calculations until y_2 changes by less than 0.2* *Effective pier width = L sin(q) + a cos(q)*

If y_2 is above LS, then account for Road Overflow using PRGM: RDOVREGA, RDOVREGB, RDOVREGC, or RDOVREGD,

Water Surface Elev. = _____ ft

Low Steel Elev. = _____ ft

n (Channel) = 0.070

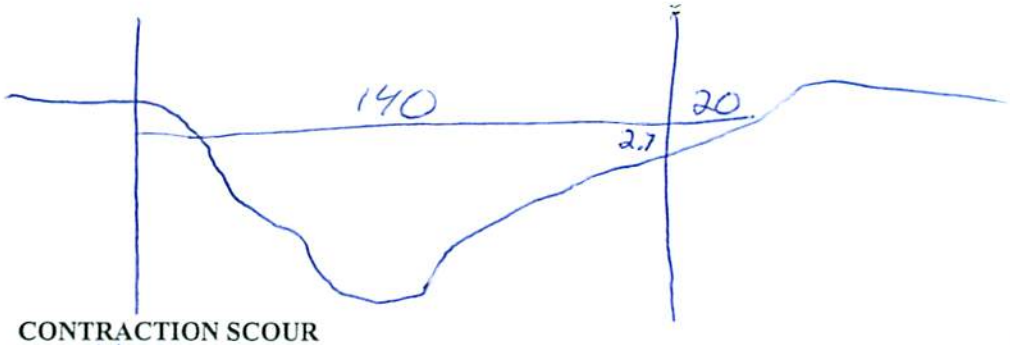
n (LOB) = 0.040

n (ROB) = 0.045

Pier Width = 0.80 ft

Pier Length = 0.45 ft

Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 140 ft

Width of left overbank flow at approach, W_{lob} = 0 ft Average left overbank flow depth, y_{lob} = 0.0 ft

Width of right overbank flow at approach, W_{rob} = 20 ft Average right overbank flow depth, y_{rob} = 12.4 ft

Live Bed Contraction Scour (use if bed material is small cobbles or finer)

x = 12.51 From Figure 9 W_2 (effective) = 72.8 ft y_{cs} = 13.6 ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = _____ ft Average approach velocity, $V_1 = Q_{500}/(y_1W_1)$ = _____ ft/s

Critical approach velocity, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = _____ ft/s

If $V_1 < V_c$ and $D_{50} >= 0.2$ ft, use clear water equation below, otherwise use live bed scour equation above.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = _____ ft If $D_{50} >= D_{c50}$, $\chi = 0.0$

Otherwise, $\chi = 0.122y_1[q_2/(D_{50}^{1/3}y_1^{7/6})]^{6/7} - y_1$ = _____ From Figure 10, y_{cs} = _____ ft

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 1.0 Correction factor for flow angle of attack (from Table 1), K2 = 1.0

Froude # at bridge = ~~1.02~~ 0.42 Using pier width a on Figure 11, ξ = 3.9 Pier scour y_{ps} = ~~3.9~~ 3.4 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 0.0 ft right abutment, y_{aRT} = ~~4.5~~ 1.4 ft

Shape coefficient K_1= 1.00 for vertical-wall, 0.82 for vertical-wall with wingwalls, 0.55 for spill-through

Using values for y_{aLT} and y_{aRT} on figure 12, ψ_{LT} = 0.0 and ψ_{RT} = 5.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0.0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 5.9 ft

4 ft 11 in

2.4/1

Sg.

Route Big Foote Rd Stream Cottonwood Ck MRM _____ Date 8/11/11 Initials EG

Bridge Structure No. 52990352 Location 3 mi E, 2.5 mi N of Cottonwood on Big Foote Rd

GPS coordinates: N44° 00' 27.3" W102° 04' 03.4" taken from: USL abutment X, centerline of ↑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 74.04 sq. mi.

The average bottom of the main channel was 16.2 ft below top of guardrail at a point 29 ft from left abutment.

Method used to determine flood flows: ____Freq. Anal. ____drainage area ratio ✓ regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 10900			~~Q_{500}~~ = 7320		
Estimated flow passing through bridge	9835			7320		
Estimated road overflow & overtopping	1065					
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping	X				X	
Chance of Pressure flow	X				X	
Armored appearance to channel		X			X	
Lateral instability of channel		X			X	

Pk Calc'd 8/8

Pk 2	318
5	1160
10	2300
25	4660
50	7320
100	10900
500	24600

Riprap at abutments? X Yes ____No ____Marginal

Evidence of past Scour? ____Yes X No ____Don't know

Debris Potential? X High ____Med ____Low

Does scour countermeasure(s) appear to have been designed?

Riprap X Yes ____No ____Don't know ____NA

Spur Dike ____Yes ____No ____Don't know X NA

Other _____ ____Yes ____No ____Don't know X NA

Bed Material Classification Based on Median Particle Size (D_{50})

Material	Silt/Clay____	Sand X	Gravel ~~X~~	Cobbles____	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos

Photos

1923-1D

24 - US

25 - US RB

26 - US LB

27 - L. Abut

28 - L. Abut

29 - R. Abut

30 - US Face

Summary of Results

	Q100	~~Q500~~ 50
Bridge flow evaluated	9835	7320
Flow depth at left abutment (yaLT), in feet	0.0	0.0
Flow depth at right abutment (yaRT), in feet	2.5	1.4
Contraction scour depth (ycs), in feet	15.2	13.6
Pier scour depth (yps), in feet	3.4	3.4
Left abutment scour depth (yas), in feet	0.0	0.0
Right abutment scour depth (yas), in feet	10.2	5.9
1Flow angle of attack	15	15

See Comments/Diagram for justification where required

9 9 1C
10900
9835
1065