OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 27089250 Date 8/16/11 Initials CW Region (A (B) C D)

Site ______ Location 3 mi S + 3 mi W of Burke on 294 St

Q_{100} = 7210 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 7210 (should be Q_{100} unless there is a relief bridge, road overflow, or bridge overtopping)

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

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

Bridge Width = 137 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 137 108 126 120 121

Avg. flow depth at bridge, y_2 iteration = 8.6 9.8 9.0 9.3 9.2

Corrected channel width at bridge Section = W_2 times cos of flow angle = 120.54 ft* $q_2 = Q_2/W_2$ = 59.8 ft^2/s

Bridge Vel, V_2 = 6.5 ft/s Final $y_2 = q_2/V_2$ = 9.2 ft Δh = 0.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10.1 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

0.100 n (Channel) = ~~0.070~~ 0.070

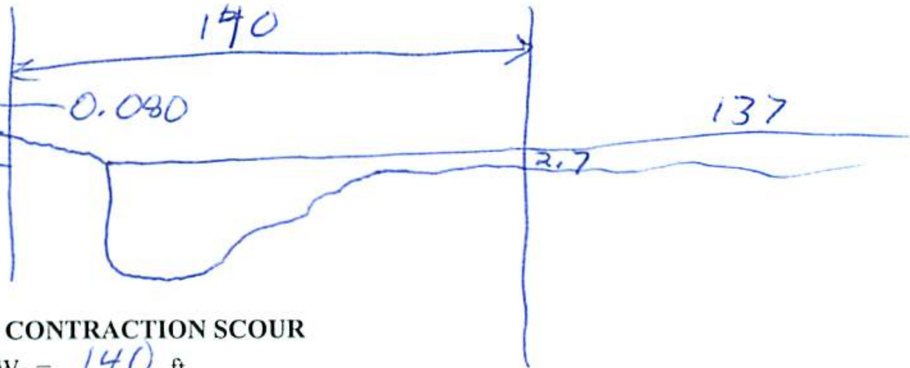
n (LOB) = ~~0.060~~ ~~0.060~~

0.100 n (ROB) = ~~0.070~~ 0.070

Pier Width = 1.7 ft

Pier Length = 1.7 ft

\# Piers for 100 yr = 4 ft



PGRM: Contract

CONTRACTION SCOUR

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} = 137 ft Average right overbank flow depth, y_{rob} = 2.7 ft

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

x = 3.64 From Figure 9 W_2 (effective) = 113.7 ft y_{cs} = 4.3 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, $V_1 = Q_{100}/(y_1W_1)$ = ______ 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 = 0.38 Using pier width a on Figure 11, ξ = 7.0 Pier scour y_{ps} = 6.1 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 0.0 ft right abutment, y_{aRT} = 2.7 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} = 11.0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0.0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 11.0 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 27089250 Date 8/16/11 Initials Cw Region (A (B) C D)

Site ______ Location 3 mi S & 3 mi W of Burke on 294 St

Q_{500} = 12000 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 12000 (should be Q_{500} 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 = 137 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 137 ______ ______

Avg. flow depth at bridge, y_2 iteration = 11.3 Vert Wall ______

Corrected channel width at bridge Section = W_2 times cos of flow angle = 136.48 ft* $q_2 = Q_2/W_2$ = 87.9 ft²/s

Bridge Vel, V_2 = 7.8 ft/s Final $y_2 = q_2/V_2$ = 11.3 ft Δh = 1.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 12.5 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

0.100 n (Channel) = ~~0.070~~

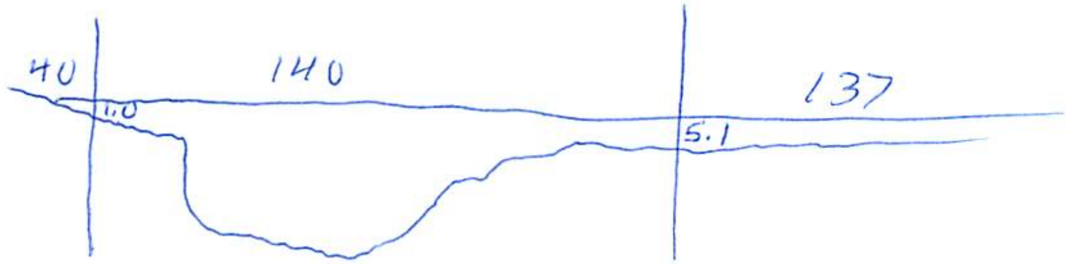
0.080 n (LOB) = ~~0.060~~

0.100 n (ROB) = ~~0.070~~

Pier Width = 1.7 ft

Pier Length = 1.7 ft

Piers for 500 yr = 4 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} = 40 ft 1.0 ÷ 2 = 0.5 Average left overbank flow depth, y_{lob} = 0.5 ft

Width of right overbank flow at approach, W_{rob} = 137 ft Average right overbank flow depth, y_{rob} = 5.1 ft

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

x = 3.98 From Figure 9 W_2 (effective) = 129.7 ft y_{cs} = 4.6 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, $V_c = 11.17y_1^{1/6}D_{50}^{1/3}$ = ______ 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

PIER SCOUR CALCULATIONS

PGRM: Pier

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

Froude # at bridge = 0.41 Using pier width a on Figure 11, ξ = 7.0 Pier scour y_{ps} = 6.2 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0.5 ft right abutment, y_{aRT} = 5.1 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} = 2.3 and ψ_{RT} = 15.2

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 2.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 15.2 ft

5.4
2.4
2.7

107
28
135

Route 294 St Stream Ponca Ck MRM____ Date 8/16/11 Initials Cy
Bridge Structure No. 27089250 Location 3 mi S + 3 mi W of Burke on 294 St
GPS coordinates: N43°08'25.0" W99°21'17.8" taken from: USL abutment X centerline of ⇑ MRM end ____
Datum of coordinates: WGS84 X NAD27____

Drainage area = 215.4 sq. mi.

The average bottom of the main channel was 18.5 ft below top of guardrail at a point 58 ft from left abutment.

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

Pk Calc'd 8/8

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 7210			Q_{500} = 12000		
Estimated flow passing through bridge	7210			12000		
Estimated road overflow & overtopping						
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	
2	495
5	1480
10	2550
25	4090
50	5550
100	7210
500	12000

Riprap at abutments? X Yes ____No ____Marginal
Evidence of past Scour? X Yes ____No ____Don't know
Debris Potential? X High ____Med ____Low

Rip rap added in last couple years b/c channel was eroding banks

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

Riprap	____Yes	X No	____Don't know	____NA
Spur Dike	____Yes	X No	____Don't know	____NA
Other ________	____Yes	____No	____Don't know	X NA

Dike is remains of old bridge

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

Material	Silt/Clay X	Sand____	Gravel____	Cobbles____	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos

1971 - ID
72 - US
73 - US RB
74 - US LB
75 - L. Abut
76 - L. Abut
77 - R. Abut
78 - US Face
79 - R. Abut Rip Rap
80 - LB Rip Rap
81 - Old bridg abut / Dike

Spoke w/ Rancher Dave Steffen?

Summary of Results

	Q100	Q500
Bridge flow evaluated	7210	12000
Flow depth at left abutment (yaLT), in feet	0	6.5
Flow depth at right abutment (yaRT), in feet	2.7	5.1
Contraction scour depth (ycs), in feet	4.3	4.6
Pier scour depth (yps), in feet	6.1	6.2
Left abutment scour depth (yas), in feet	0	2.3
Right abutment scour depth (yas), in feet	11.0	15.2
1Flow angle of attack	5	5

See Comments/Diagram for justification where required