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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 39353040 Date 10-11-12 Initials RFT Region (A B (C) D)

Site _____ Location 2.1 mi E Badger on 200 St

Q_{100} scour 1500 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = _____ (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 = 53 ft. Flow angle at bridge = 22 ° Abut. Skew = 0 ° Effective Skew = 22 °

Width (W_2) iteration = 53 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 7.8 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 49.14 ft* $q_2 = Q_2/W_2$ = 30.5 ft^2/s

Bridge Vel, V_2 = 3.9 ft/s Final $y_2 = q_2/V_2$ = 7.8 ft Δh = 0.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.1 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. = dry ft

Low Steel Elev. = 8.0 ft

n (Channel) = .035

n (LOB) = .035

n (ROB) = .035

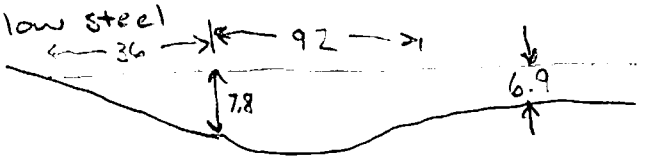
Pier Width = 1.5 ft

Pier Length = 1.5 ft

Piers for 100 yr = 2 ft

The vegetation in the dry channel indicates a larger angle of attack but the low flow channel is shallow and may have little effect at very high flows.

There appears to be a low spot in the road east of bridge where road overflow would occur at about the same elevation as low steel



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 92 ft

Width of left overbank flow at approach, W_{lob} = 36 ft Average left overbank flow depth, y_{lob} = 3.9 ft

Width of right overbank flow at approach, W_{rob} = 55 ft Average right overbank flow depth, y_{rob} = 6.9 ft

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

x = 17.31 From Figure 9 W_2 (effective) = 46.1 ft y_{cs} = 16.2 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, $Vc = 1.17 y_1^{1/6} D_{50}^{1/3}$ = _____ 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

PIER SCOUR CALCULATIONS

PGRM: Pier

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

Froude # at bridge = 0.25 Using pier width a on Figure 11, ξ = 6.4 Pier scour y_{ps} = 5.2 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 3.9 ft right abutment, y_{aRT} = 6.9 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} = 13.1 and ψ_{RT} = 18.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 23.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 33.5 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 3935304 D Date _____ Initials_____ Region (A B C D)

Site _____ Location _____

Q_{500} = 82.3 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = _____ (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 = _____ft. Flow angle at bridge = _____° Abut. Skew = _____° Effective Skew = _____°

Width (W_2) iteration = _____ _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = _____ _____ _____ _____

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

Bridge Vel, V_2 = _____ft/s Final $y_2 = q_2/V_2$ = _____ft Δh = _____ft

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

n (LOB) = _____

n (ROB) = _____

Pier Width = _____ ft

Pier Length = _____ ft

Piers for 500 yr = _____ ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = _____ft

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

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

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

x = _____ From Figure 9 W_2 (effective) = _____ft y_{cs} = _____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, $V_1 = Q_{500}/(y_1 W_1)$ = _____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 = _____ Correction factor for flow angle of attack (from Table 1), K2 = _____

Froude # at bridge = _____ Using pier width a on Figure 11, ξ = _____ Pier scour y_{ps} = _____ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = _____ft right abutment, y_{aRT} = _____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} = _____ and ψ_{RT} = _____

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

Route 200 St Stream _____ MRM _____ Date _____ Initials _____

Bridge Structure No. 39353040 Location 2.1 mi E Badger on 200 St

GPS coordinates: N 44° 29.119' W 97° 8.620' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 ✓ NAD27 ____

Drainage area = 50.4 sq. mi.

The average bottom of the main channel was 11.4 ft below top of guardrail at a point 16 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} max scour			Q_{500} =		
Estimated flow passing through bridge	1500					
Estimated road overflow & overtopping	0					
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping			✓			
Chance of Pressure flow	✓					
Armored appearance to channel		✓				
Lateral instability of channel		✓				

Riprap at abutments? ____Yes ____No ✓Marginal a few rocks and some concrete rubble

Evidence of past Scour? ✓Yes ____No ____Don't know Obvious contraction/abutment scour

Debris Potential? ____High ____Med ✓Low

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

Riprap ____Yes ____No ____Don't know ✓NA

Spur Dike ____Yes ____No ____Don't know ✓NA

Other _____ ____Yes ____No ____Don't know ✓NA

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

Str. no.
approach from bridge
LOB from channel
ROB from channel
bridge from approach
left abut. under bridge
rt. abut. under bridge

Summary of Results

	Q_{100} max scour	Q500
Bridge flow evaluated	1500	
Flow depth at left abutment (yaLT), in feet	3.9	
Flow depth at right abutment (yaRT), in feet	6.9	
Contraction scour depth (ycs), in feet	16.2	
Pier scour depth (yps), in feet	5.2	
Left abutment scour depth (yas), in feet	23.8	
Right abutment scour depth (yas), in feet	33.5	
Flow angle of attack	22°	

See Comments/Diagram for justification where required