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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52412298 Date 12/3/10 Initials CW Region (A B C D)

Site _____ Location N. 8th St. over Rapid Creek

Q_{100} = 4780 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 4780 (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 = 94 ft. Flow angle at bridge = 20 ° Abut. Skew = 15 ° Effective Skew = 5 °

Width (W_2) iteration = 94 85 86 _____

Avg. flow depth at bridge, y_2 iteration = 6.2 6.6 6.5 _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 85.67 ft* $q_2 = Q_2/W_2$ = 55.8 ft^2/s

Bridge Vel, V_2 = 8.6 ft/s Final $y_2 = q_2/V_2$ = 6.5 ft Δh = 1.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.0 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. = 9.0 ft

n (Channel) = 0.033

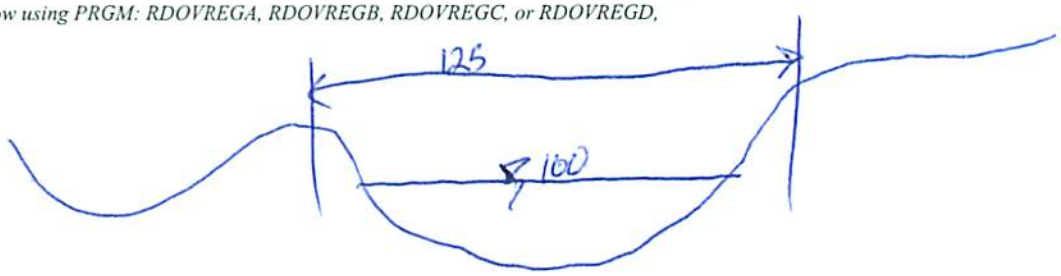
n (LOB) = 0.045

n (ROB) = 0.045

Pier Width = 2.0 ft

Pier Length = 2.0 ft

Piers for 100 yr = 2 ft



2.4

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 125 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} = 0 ft Average right overbank flow depth, y_{rob} = 0.0 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) Z=0

Estimated bed material D_{50} = 0.30 ft Average approach velocity, $V_1 = Q_{100}/(y_1W_1)$ = 4.78 ft/s

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = 10.57 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.0720 ft If $D_{50} >= D_{c50}$, χ = 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} = 0.0 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 = 0.59 Using pier width a on Figure 11, ξ = 8 Pier scour y_{ps} = 7.4 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

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

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

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52412298 Date 12/3/10 Initials CW Region (A B C D)

Site _____ Location N. 8th St. over Rapid Creek

Q_{500} = 17800 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 9460 / 9424 (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 = 94 ft. Flow angle at bridge = 20 ° Abut. Skew = 15 ° Effective Skew = 5 °

Width (W_2) iteration = 94 RD Overflow

Avg. flow depth at bridge, y_2 iteration = 12.8

Corrected channel width at bridge Section = W_2 times cos of flow angle = 93.64 ft* $q_2 = Q_2/W_2$ = 100.6 ft^2/s

Bridge Vel, V_2 = 11.2 ft/s Final $y_2 = q_2/V_2$ = 9.0 ft Δh = 2.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 11.6 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. = 9.0 ft

n (Channel) = 0.033

n (LOB) = 0.045

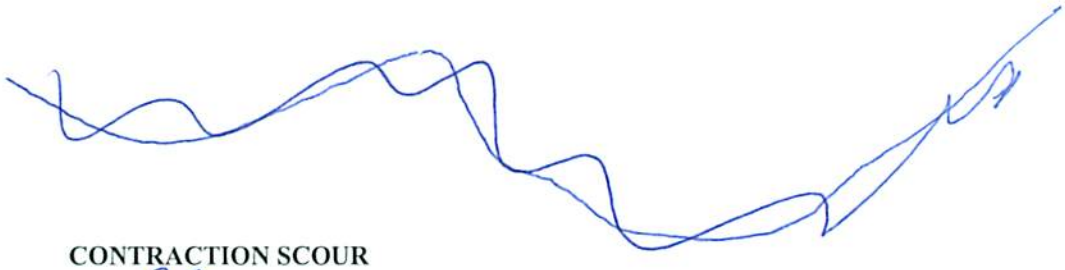
n (ROB) = 0.045

Pier Width = 2.0 ft

Pier Length = 2.0 ft

Piers for 500 yr = 2 ft

See Sketch on next page



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 125 ft

Width of left overbank flow at approach, W_{lob} = 94 ft Average left overbank flow depth, y_{lob} = 5.0 ft

Width of right overbank flow at approach, W_{rob} = ~~60~~ 60 ft Average right overbank flow depth, y_{rob} = ~~1.0~~ ft 1.0

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) Z=0 2.91

Estimated bed material D_{50} = 0.30 ft Average approach velocity, $V_1 = Q_{500}/(y_1 W_1)$ = ~~6.5~~ ft/s

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = 11.25 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.115 ft If $D_{50} >= D_{c50}$, χ = 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} = 0.0 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 = 0.66 Using pier width a on Figure 11, ξ = 8.0 Pier scour y_{ps} = 7.5 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 5.0 ft right abutment, y_{aRT} = 1.0 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} = 15.0 and ψ_{RT} = 4.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 15.0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 4.3 ft

Route N 8th St Stream Rapid Creek MRM _____ Date 12/3/10 Initials Ch

Bridge Structure No. 52412298 Location N. 8th St. over Rapid Creek

GPS coordinates: N 44° 05' 07.8" W 103° 13' 45.6" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 416.60 sq. mi.

The average bottom of the main channel was 14.3 ft below top of guardrail at a point 33 ft from left abutment.

Method used to determine flood flows: ____Freq. Anal. ✓ drainage area ratio ____regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 4780			Q_{500} = 17800		
Estimated flow passing through bridge		4780			9424	
Estimated road overflow & overtopping		—			8376	
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	

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	X Yes	____No	____Don't know	____NA
Other _____	____Yes	____No	____Don't know	X NA

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

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

Comments, Diagrams & orientation of digital photos

Photos

1515-ID

16-US

17-USRB

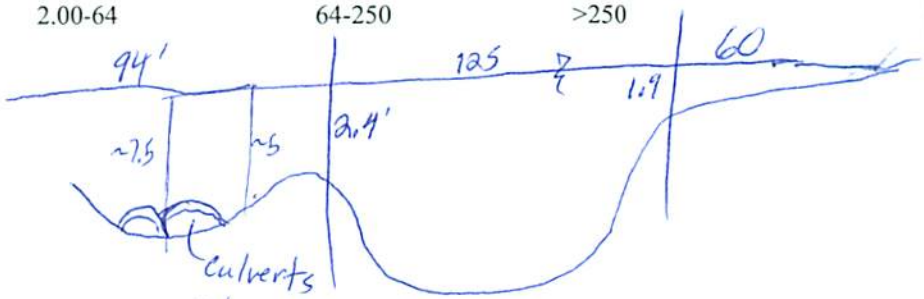
18-USLB

19-US Face Bridge

20-R. Abut

21-L. Abut

22-L. Abut



Summary of Results

	Q100	Q500
Bridge flow evaluated	4780	9424
Flow depth at left abutment (yaLT), in feet	0.0	5.0
Flow depth at right abutment (yaRT), in feet	0.0	1.0
Contraction scour depth (ycs), in feet	0.0	0.0
Pier scour depth (yps), in feet	~~7.4~~ 7.4	7.5
Left abutment scour depth (yas), in feet	0.0	15.0
Right abutment scour depth (yas), in feet	0.0	4.3
1Flow angle of attack	5°	5°

See Comments/Diagram for justification where required