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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 671S0259 Date 1/22/12 Initials RAL Region (A B C (D)

Site _____ Location 0.9 S Ordway, Elm River

Q_{100} = Q25 7920 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 7920 (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

Bridge Width = 169 ft. Flow angle at bridge = 15 ° Abut. Skew = 0 ° Effective Skew = 15 °

Width (W_2) iteration = 163.24 | 138.13 (145) | 145.85 (151) | 149

Avg. flow depth at bridge, y_2 iteration = 14.4 | 15.4 | 15 | ____ 142.96

Corrected channel width at bridge Section = W_2 times cos of flow angle = ~~163.24~~ ft* $q_2 = Q_2/W_2$ = ~~48.5~~ 55.4 ft^2/s

Bridge Vel, V_2 = ~~3.3~~3.7 ft/s Final $y_2 = q_2/V_2$ = ~~14.7~~ 15.2 ft Δh = 0.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = ~~14.4~~ 15.4 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,

~~22.5~~ 55.4 17.1

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

Water Surface Elev. = 4.2 ft 23.6

Low Steel Elev. = 17.4 ft 6.2 17.4

n (Channel) = 0.035

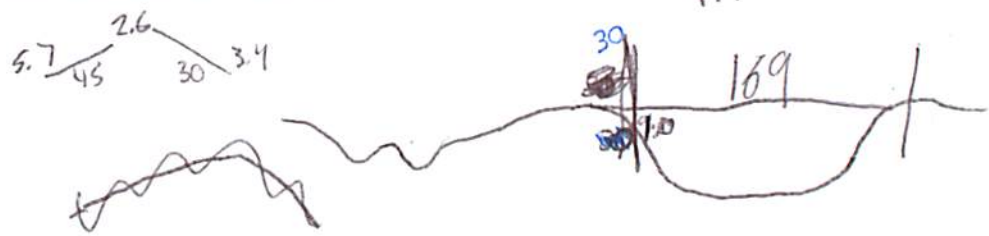
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 2.5 ft

Pier Length = 2.5 ft

Piers for 100 yr = 2 ft



7.7 − 3.4 = 4.3

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 169 ft

Width of left overbank flow at approach, W_{lob} = 30 ft Average left overbank flow depth, y_{lob} = ~~5.1~~ 1 ft

Width of right overbank flow at approach, W_{rob} = 0 ft Average right overbank flow depth, y_{rob} = 0 ft

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

x = 3.51 From Figure 9 W_2 (effective) = 138 ft y_{cs} = 4.1 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 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.17 Using pier width a on Figure 11, ξ = 9.5 Pier scour y_{ps} = 7.3 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 1 ft right abutment, y_{aRT} = 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} = 4.3 and ψ_{RT} = 0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 4.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 0715 0259 Date 7/22/12 Initials DaJ Region (A B C (D))

Site _____ Location _____

Q_{500} = Q50 12900 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 11724 (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 = 169 ft. Flow angle at bridge = 15 ° Abut. Skew = 0 ° Effective Skew = 15 °

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 = 163.24 ft* $q_2 = Q_2/W_2$ = 71.8 ft²/s

Bridge Vel, V_2 = 4.1 ft/s Final $y_2 = q_2/V_2$ = 17.4 ft Δh = 0.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 17.7 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. = 4.2 ft

Low Steel Elev. = 17.4 ft

n (Channel) = 0.035

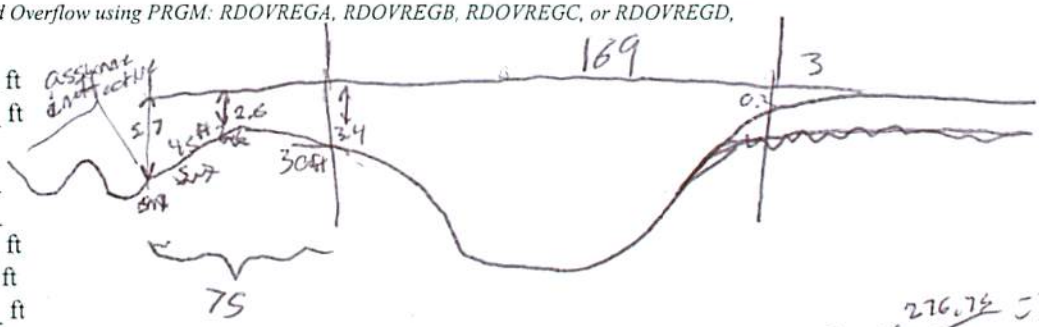
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 2.5 ft

Pier Length = 2.5 ft

Piers for 500 yr = 2 ft



$\frac{3.4+2.6}{2} \cdot 30 + \frac{2.6+5.7}{2} \cdot 45 = \frac{276.75}{75} = 3.69$

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 169 ft

Width of left overbank flow at approach, W_{lob} = 75 ft Average left overbank flow depth, y_{lob} = 3.7 ft

Width of right overbank flow at approach, W_{rob} = 3 ft Average right overbank flow depth, y_{rob} = 0.3 ft

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

x = 1.92 From Figure 9 W_2 (effective) = 158.2 ft y_{cs} = 2.4 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 = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.17 Using pier width a on Figure 11, ξ = 9.5 Pier scour y_{ps} = 7.3 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 3.7 ft right abutment, y_{aRT} = 0.3 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} = 12.7 and ψ_{RT} = ~~1.4~~ 1.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 12.7 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 1.4 ft

Route _____ Stream Elm River MRM _____ Date 7/22/12 Initials RAL

Bridge Structure No. _____ Location 0.9 S Ordway

GPS coordinates: N 45° 33' 42.2" W 98° 24' 46.3" taken from: USL abutment X centerline of ↑ MRM end _____

Datum of coordinates: WGS84 X NAD27 ____

Drainage area = 1224.35 sq. mi.

The average bottom of the main channel was 23.6 ft below top of guardrail at a point 87 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	~~Q100~~ = Q25 7920			~~Q500~~ = Q50 12900		
Estimated flow passing through bridge	7920			11724		
Estimated road overflow & overtopping	0			1176		
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	

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2	295
5	1570
10	3520
25	7920
50	12900
100	19600
500	43600

Riprap at abutments? ____Yes X No ____Marginal

Evidence of past Scour? X Yes ____No ____Don't know some contraction heavy abutment. some scour under the bridge but abutments have retreated alot. ~60° incline

Debris Potential? ____High ____Med ____Low

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	X 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

1). left OB
2) main channel
3). right OB
4). pier
5). right abutment
6). left abutment
7). ~~left~~ right abutment
8). ~~left~~ right abutment
9). main channel

Note: had to estimate pier length/~~deep~~ width as water level too deep.

Summary of Results

	~~Q100~~ Q25	~~Q500~~ Q50
Bridge flow evaluated	7920	11724
Flow depth at left abutment (yaLT), in feet	1	3.7
Flow depth at right abutment (yaRT), in feet	0	0.3
Contraction scour depth (ycs), in feet	4.1	2.4
Pier scour depth (yps), in feet	7.3	7.3
Left abutment scour depth (yas), in feet	4.3	12.7
Right abutment scour depth (yas), in feet	0	1.4
1Flow angle of attack	~~NS~~ 15	15

See Comments/Diagram for justification where required