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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50153200 Date 6/21/12 Initials LAT Region (A B (C) D)

Site _____ Location 0.4 mi S & 0.2 mi E of Ellis on W. Madison St

Q_{100} = 5040 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. →

Bridge discharge (Q_2) = 5040 (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 = 116. ft. Flow angle at bridge = 45 ° Abut. Skew = 0 ° Effective Skew = 45 °

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 = 83.41 ft* $q_2 = Q_2/W_2$ = 60.4 ft^2/s

Bridge Vel, V_2 = 5.5 ft/s Final $y_2 = q_2/V_2$ = 11 ft Δh = 0.6 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,

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

Water Surface Elev. = 0-1.5 ft

Low Steel Elev. = 12.5 ft

n (Channel) = 0.035

n (LOB) = 0.030

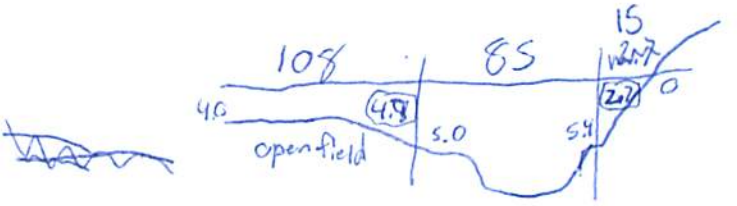
n (ROB) = 0.040

Pier Width = 1.7 ft

Pier Length = 1.7 ft

Piers for 100 yr = 4 ft

16.3 − 3.5 = 12.8



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 85 ft 4.0 5.0

Width of left overbank flow at approach, W_{lob} = 108 ft Average left overbank flow depth, y_{lob} = 4.8 ft

Width of right overbank flow at approach, W_{rob} = 15 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 = 5.82 From Figure 9 W_2 (effective) = 76.6 ft y_{cs} = 6.6 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ 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 = 0.29 Using pier width a on Figure 11, ξ = 7 Pier scour y_{ps} = 5.9 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 4.8 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} = 14.7 and ψ_{RT} = 11

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 14.7 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 11 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50153200 Date 6/21/12 Initials NAT Region (A B C D)

Site _____ Location 0.4 mi S & 0.2 mi E of Ellis on W. Madison St.

Q_{500} = 7730 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 6972 (should be Q_{500} 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 = 119 ft. Flow angle at bridge = 45 ° Abut. Skew = 0 ° Effective Skew = 45 °

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 = 83.44 ft* $q_2 = Q_2/W_2$ = 82.41 ft^2/s

Bridge Vel, V_2 = 6.4 ft/s Final $y_2 = q_2/V_2$ = 12.8 ft Δh = 0.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 13.6 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. = 0-1.5 ft

Low Steel Elev. = 12.8 ft

n (Channel) = 0.035

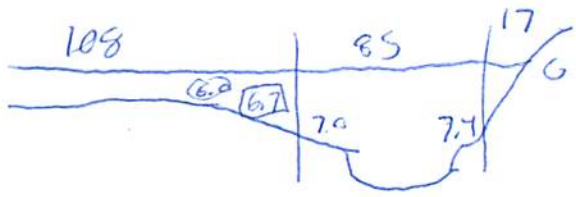
n (LOB) = 0.030

n (ROB) = 0.046

Pier Width = 1.7 ft

Pier Length = 1.7 ft

Piers for 500 yr = 4 ft



PGRM: Contract

CONTRACTION SCOUR

Width of main channel at approach section W_1 = 85 ft

Width of left overbank flow at approach, W_{lob} = 108 ft Average left overbank flow depth, y_{lob} = 6.7 ft

Width of right overbank flow at approach, W_{rob} = 17 ft Average right overbank flow depth, y_{rob} = 3.7 ft

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

x = 9.66 From Figure 9 W_2 (effective) = 76.6 ft y_{cs} = 9.5 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 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.32 Using pier width a on Figure 11, ξ = 7 Pier scour y_{ps} = 5.9 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 6.7 ft right abutment, y_{aRT} = 3.7 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} = 18.1 and ψ_{RT} = 12.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 18.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 12.7 ft

96° 49' 30.432"
43° 33' 29.772

96.82512
43.55827

Route W. Madison St Stream Willow Cr ? MRM _____ Date 6/21/12 Initials RaJ

Bridge Structure No. 50153200 Location 0.4 mi S + 0.2 mi E of Ellis on W. Madison St

GPS coordinates: N 43° 33' 36.0" W 96° 49' 30.4" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 47.32 sq. mi.

The average bottom of the main channel was 16.3 ft below top of guardrail at a point 79 ft from left abutment.

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

6/18
~~8/24~~

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 5040			Q_{500} = 7730		
Estimated flow passing through bridge	5040			6872		
Estimated road overflow & overtopping	0			858		
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	

2	527
5	1300
10	2000
25	3080
50	4020
100	5040
500	7730

Riprap at abutments? X Yes ____No ____Marginal plenty

Evidence of past Scour? X Yes ____No ____Don't know some abutment where concrete meets dirt - see picture

Debris Potential? ____High ____Med X Low

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

Riprap	X Yes	____No	____Don't know	____NA
Spur Dike	____Yes	X No	____Don't know	____NA
Other _____	____Yes	X No	____Don't know	____NA

- rose quartz - everywhere

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 obs
2). main channel
3). right obs.
4). pier
5-6). right abutment
7). left abutment (scour)
8-9). left abutment
10). main channel

Summary of Results

	Q100	Q500
Bridge flow evaluated	5040	6872
Flow depth at left abutment (yaLT), in feet	4.8	6.7
Flow depth at right abutment (yaRT), in feet	2.7	3.7
Contraction scour depth (ycs), in feet	6.6	9.5
Pier scour depth (yps), in feet	5.9	5.9
Left abutment scour depth (yas), in feet	14.7	18.1
Right abutment scour depth (yas), in feet	11	12.7
1Flow angle of attack	45	45

See Comments/Diagram for justification where required