OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 5021012 Date 6/19/17 Initials RJT Region (A B C D)

Site _____ Location Cliff Ave & Big Sioux River

Q_{100} = 53300 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. Y

Bridge discharge (Q_2) = 53300 (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 = 303 ft. Flow angle at bridge = 10 ° Abut. Skew = 15 ° Effective Skew = 5 °

Width (W_2) iteration = _____ _____ _____ _____ - see notes

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

Corrected channel width at bridge Section = W_2 times cos of flow angle = 301.85 ft* $q_2 = Q_2/W_2$ = 176.6 ft²/s

Bridge Vel, V_2 = 9.4 ft/s Final $y_2 = q_2/V_2$ = 18.7 ft Δh = 1.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 20.6 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. = 671.6 ft

Low Steel Elev. = 19.3 ft

n (Channel) = 0.045

n (LOB) = 0.020

n (ROB) = 0.020

Pier Width = 1.2 ft

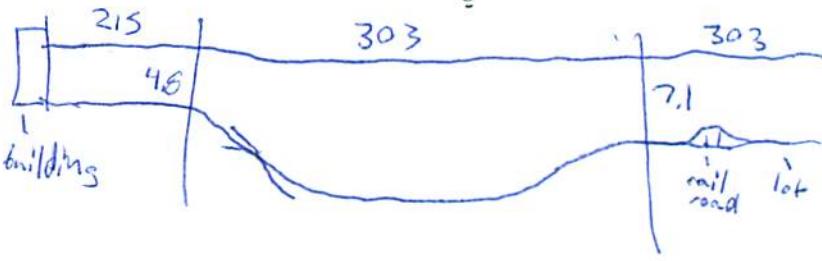
Pier Length = 19 ft

Piers for 100 yr = 4 ft

25.1 - see notes -5.8 19.3

same grass, same asphalt

101.52 80/63



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 303 ft

Width of left overbank flow at approach, W_{lob} = 215 ft Average left overbank flow depth, y_{lob} = 4.8 ft

Width of right overbank flow at approach, W_{rob} = 303 ft Average right overbank flow depth, y_{rob} = 7.1 ft

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

x = 11.38 From Figure 9 W_2 (effective) = 297.1 ft y_{cs} = 12.4 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 57.5 Correction factor for flow angle of attack (from Table 1), K2 = 1.5

Froude # at bridge = 0.38 Using pier width a on Figure 11, ξ = 5.5 Pier scour y_{ps} = 7.1 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 4.8 ft right abutment, y_{aRT} = 7.1 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} = 14.7 and ψ_{RT} = 18.8

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 26.7 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 34.1 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 5621012 Date 6/19/12 Initials RAT Region (A B (C) D)

Site _____ Location Cliff Ave & Big Sioux River

Q_{500} = 95000 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 56582 (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 = 303 ft. Flow angle at bridge = 16 ° Abut. Skew = 15 ° Effective Skew = 5 °

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 = 301.85 ft* $q_2 = Q_2/W_2$ = 187.5 ft^2/s

Bridge Vel, V_2 = 9.7 ft/s Final $y_2 = q_2/V_2$ = 19.3 ft Δh = 1.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 21.2 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. = 0-1.6 ft

Low Steel Elev. = 19.3 ft

n (Channel) = 0.045

n (LOB) = 0.020

n (ROB) = 0.020

Pier Width = 1.2 ft

Pier Length = 69 ft

Piers for 500 yr = 4 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 303 ft

Width of left overbank flow at approach, W_{lob} = 215 ft Average left overbank flow depth, y_{lob} = 5.4 ft

Width of right overbank flow at approach, W_{rob} = 303 ft Average right overbank flow depth, y_{rob} = 7.7 ft

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

x = 12.95 From Figure 9 W_2 (effective) = 297.1 ft y_{cs} = 13.9 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 = 57.5 Correction factor for flow angle of attack (from Table 1), K2 = 1.5

Froude # at bridge = 0.39 Using pier width a on Figure 11, ξ = 5.5 Pier scour y_{ps} = 7.1 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 5.4 ft right abutment, y_{aRT} = 7.7 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} = 15.7 and ψ_{RT} = 19.5

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 28.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 35.5 ft

Route Cliff Ave Stream Big Sioux River MRM _____ Date 6/19/12 Initials RaT

Bridge Structure No. 5021012 Location Cliff Ave & Big Sioux River

GPS coordinates: N 43° 32' 31.3" W 96° 42' 40.3" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 3770.94 sq. mi.

The average bottom of the main channel was 25.1 ft below top of guardrail at a point 198 ft from left abutment.

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

3770.94
6/13

2	5540
5	13300
10	20400
25	31700
50	41900
100	53300
500	85000

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 53300			Q_{500} = 85000		
Estimated flow passing through bridge	53300			56582		
Estimated road overflow & overtopping	0			28418		
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 X Marginal - all on right abutment

Evidence of past Scour? ____Yes X No ____Don't know very little pier/contraction

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

- use quartz on right abutment

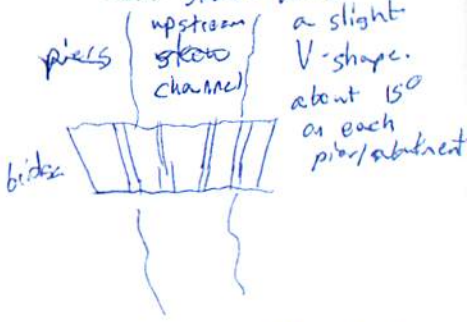
Bed Material Classification Based on Median Particle Size (D_{50})

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
4-5) piers — metal cover, V-face
6-7). left abutment
8-9). right abutment

10). main channel



Summary of Results

	Q100	Q500
Bridge flow evaluated	53300	56582
Flow depth at left abutment (yaLT), in feet	4.8	5.4
Flow depth at right abutment (yaRT), in feet	7.1	7.7
Contraction scour depth (ycs), in feet	12.4	13.9
Pier scour depth (yps), in feet	7.1	7.1
Left abutment scour depth (yas), in feet	26.7	29.6
Right abutment scour depth (yas), in feet	34.1	35.5
1Flow angle of attack	5	5

low steel - took low steel from mean channel depth location. Bridge crests like a hill.

See Comments/Diagram for justification where required