OK RT Bridge length = 1573

Check

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50205209 Date 6/25/12 Initials LAT Region (A B C D)

Site _____ Location 3rd Ave, Big Sioux R & R int with 11th St

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

Bridge discharge (Q_2) = 53300 (should be Q_{100} unless there is a relief bridge, road overflow, or bridge overtopping)

76+108+90

pier to pier 72+81+75+75+33+85+90+70+80+66+115+143+112+70+82+100+100+79

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

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

Bridge Width = 1580 ft. 1560 Flow angle at bridge = 10 ° Abut. Skew = 40 ° Effective Skew = 50 °

Width (W_2) iteration = 348 1580 348 1580 348 — does not converge!

Avg. flow depth at bridge, y_2 iteration = 8.2 17.4 8.2 17.4

Corrected channel width at bridge Section = W_2 times cos of flow angle = 1580 ft* $q_2 = Q_2/W_2$ = 33.7 ft²/s

Bridge Vel, V_2 = 4.1 ft/s Final $y_2 = q_2/V_2$ = 8.2 ft Δh = 0.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.5 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. = 0-21.2 ft 4.23

Low Steel Elev. = 37.9 ft 1.3 see notes

n (Channel) = 0.040 3.55

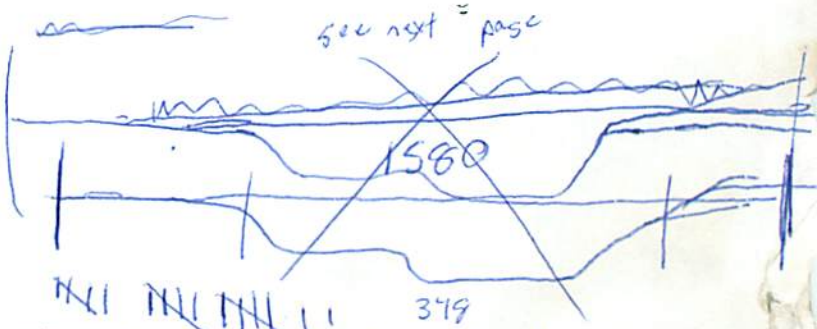
n (LOB) = N/A

n (ROB) = N/A

Pier Width = 3.5 ft

Pier Length = ~~3.5~~ 50 ft

Piers for 100 yr = 17 ft



CONTRACTION SCOUR

Note: calculated contraction based on diagram on next page. Assume 4 piers

PGRM: Contract

Width of main channel at approach section W_1 = 348 ft

Width of left overbank flow at approach, W_{lob} = _____ ft Average left overbank flow depth, y_{lob} = 0 ft

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

see backside of last page.

Assumed contraction scour only occurs within the main floodway.

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, $V_c = 11.17 y_1^{1/6} D_{50}^{1/3}$ = _____ 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 = 14.29 Correction factor for flow angle of attack (from Table 1), K2 = 1

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} = 0 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} = 0 and ψ_{RT} = 0

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

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50205209 Date _____ Initials _____ Region (A B C D)

Site _____ Location 3rd Ave & Big Sioux R+R Int w/ 11th St

Q_{500} = 85000 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 85000 (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

Bridge Width = 1580 ft. Flow angle at bridge = 40 ° Abut. Skew = 48 ° Effective Skew = 0 °

Width (W_2) iteration = ~~1580~~ 1580 438 1580 _____ Doesn't Converge!

Avg. flow depth at bridge, y_2 iteration = ~~10.9~~ 10.9 19.6 10.3 _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = ~~1580~~ 1580 ft* $q_2 = Q_2/W_2$ = 53.8 ft^2/s

Bridge Vel, V_2 = 5.2 ft/s Final $y_2 = q_2/V_2$ = 10.3 ft Δh = 0.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10.9 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. = 0-2.2 ft

Low Steel Elev. = 37.8 ft

n (Channel) = 0.010

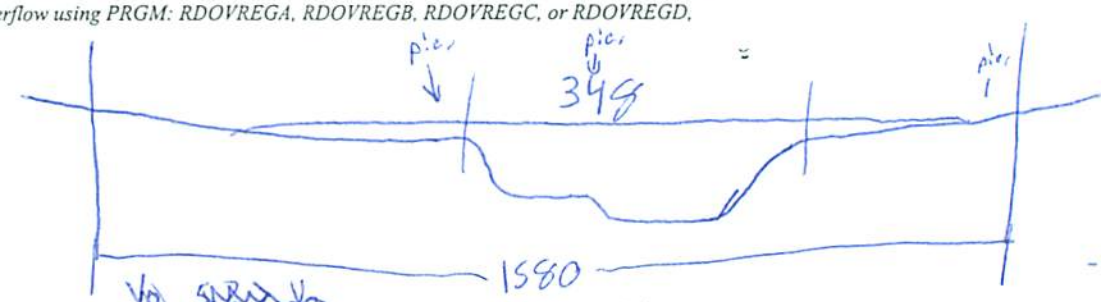
n (LOB) = N/A

n (ROB) = N/A

Pier Width = 3.5 ft

Pier Length = 50 ft

Piers for 500 yr = 17 ft



V_2 SWAG V_2

V_2, 5.2 < V_2 7.0 assume 6.1 Y_2, 10.9 < Y_{12} < 19.6

Assume: 15.3

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 1580 ft

Width of left overbank flow at approach, W_{lob} = 0 ft Average left overbank flow depth, y_{lob} = 0 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 = 0.6 From Figure 9 W_2 (effective) = 1520.5 ft y_{cs} = 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, $V_1 = Q_{500}/(y_1 W_1)$ = _____ 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 14.29 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.27 Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 8.8 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0 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} = 0 and ψ_{RT} = 0

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

Scour Calculations

1. Assuming main floodway $W_2 = 348$ $LS = 14.0$ ft, flow = 34294 cfs

so there is some overflow into the flood plain

$N_{C.\ piers} = 2$
pier width = 3.5
$Y_1 = 15.0$
$W_2 = 348$
$W_1 = 349$
$W_{LOB} = 0$
$W_{ROB} = 0$
$N_1 = 0.040$
$X = 0.31$
$W_2 = 341$

$YCS = 0.5$

piers: $Q_2 = 98.5$ $V_2 = 7$ $Y_2 = 14$ $H = 1$ $Y_1 = 15$

$F_2 = 0.33$ $Z_1 = 11.9$ $Y_{PS} = 10.1$

Abutment:

left $Y_{as} = 0$

right $Y_{as} = 0$

if bank-full flow is ≈ 34294 cfs, floodplain carries:

≈ 19006 cfs at Q_{100}. If flow is abutment to abutment, depth in floodplain is approximately 5.6'

≈ 50706 cfs at Q_{500}. If flow is abutment to abutment, depth in floodplain is approximately 9.1'

estimate flow depth in main channel at $Q_{500} \approx 23$ ft, with approximate velocity of ≈ 12 ft/s

$V_2 = 12$ $F_2 = 0.44$

$H_2 = 23$ $Z_i = 11.9$

$Y_{PS} \approx 10.5$ ft

96.71793
43.916417

Route 11th St Stream Big Sioux River MRM _____ Date 6/25/12 Initials RaT

Bridge Structure No. 50205209 Location 3rd Ave, Big Sioux RR int w/ 11th St

GPS coordinates: N 43° 32' 40.7" taken from: USL abutment X centerline of ⇑ MRM end _____

W 96° 43' 24.0" Datum of coordinates: WGS84 X NAD27 ____

Drainage area = 3772 sq. mi.

The average bottom of the main channel was 46.9 ft below top of guardrail at a point 686 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 53300			Q_{500} = 85000		
Estimated flow passing through bridge	53300			85000		
Estimated road overflow & overtopping	0			0		
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	17.4
5	48.8
10	66.4
25	99.6
50	126
100	153
500	219

6/15

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

Riprap at abutments? ____Yes X No ____Marginal very minor contraction

Evidence of past Scour? X Yes ____No ____Don't know

Debris Potential? ____High ____Med X 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

* the level 1.5 method is not well-suited to bridges this large!

Comments, Diagrams & orientation of digital photos

1-3). right abutment

4). main channel

5). right Bank

6). left bank

7-9). left abutment

9). left OB

10. main channel

11. right OB.

12). pier - also there is a cement connection similar to the top of the pier - like so on two of the piers in the floodway.

Note: Bridge covers almost if not all of the floodplain, channel at current flow is 135 ft wide, see pictures (4-6). Bank surrounding channel is about 345 wide, 14ft deep.

Note: Bridge level crests like a hill, took low steel from mean channel location

Summary of Results

Note: Scour calc. for floodway described above.

	(bank full) Q100 Qfloodway	Q500 see pg 2 for assumptions
Bridge flow evaluated		
Flow depth at left abutment (yaLT), in feet	≈ 0	≈ 0
Flow depth at right abutment (yaRT), in feet	≈ 0	≈ 0
Contraction scour depth (ycs), in feet	* minor	* minor
Pier scour depth (yps), in feet	8.8	10.5
Left abutment scour depth (yas), in feet	* ≈ 0	* ≈ 0
Right abutment scour depth (yas), in feet	* ≈ 0	* ≈ 0
1Flow angle of attack	40	40

*since bridge spans entire floodplain, contraction and abutment scour are estimated to be minor.

See Comments/Diagram for justification where required

Note:

B). pier

14-15) left Bank

16-17) right Bank

17-20) main channel

Note: Q_{100} & Q_{500} do flow the surrounding bank but do no leave the floodplain. Iteration however does not coverage as floodplain is fairly flat.