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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 15181170 Date 4/16/10 Initials CW Region (A B C D)

Site _____ Location Big Sioux River on 3rd Ave N in Watertown

Q_{100} = 5930 by: drainage area ✓ flood frequency anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 5596 (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 = 105 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 105 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 10.7 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 103.4 ft* $q_2 = Q_2/W_2$ = 54.1 ft^2/s

Bridge Vel, V_2 = 5.2 ft/s Final $y_2 = q_2/V_2$ = 10.4 ft Δh = 0.6 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,

Y_2 = 10.7 is above LS → RD Overflow

Ymax = 10.3 → Q = 5596

Water Surface Elev. = 2.4 ft

Low Steel Elev. = 10.3 ft

n (Channel) = 0.037

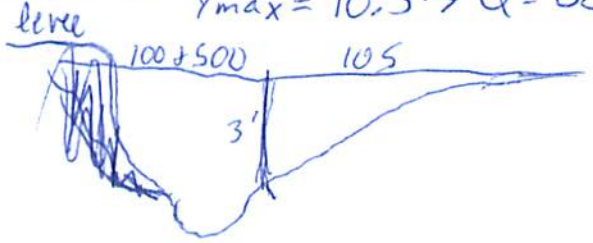
n (LOB) = 0.030

n (ROB) = 0.035

Pier Width = 1.35 ft

Pier Length = 1.35 ft

Piers for 100 yr = 5 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 130 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} = 105 ft Average right overbank flow depth, y_{rob} = 1.5 ft

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

x = 4.22 From Figure 9 W_2 (effective) = 96.7 ft y_{cs} = 4.9 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ ft/s

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = _____ 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 = 1.0

Froude # at bridge = 0.28

Correction factor for flow angle of attack (from Table 1), K2 = 1.0

Using pier width a on Figure 11, ξ = 6 Pier scour y_{ps} = 4.9 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 0 ft right abutment, y_{aRT} = 1.5 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} = 6.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 9.3 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 15181170 Date 8/16/10 Initials CW Region (A B C D)

Site _____ Location Big Sioux River on 3rd Ave N in Watertown

Q_{500} = 9570 9710 by: drainage area ✓ flood frequency anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 5596 (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 = 105 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 105

Avg. flow depth at bridge, y_2 iteration = 13.7

Corrected channel width at bridge Section = W_2 times cos of flow angle = 103.4 ft* $q_2 = Q_2/W_2$ = 54.1 ft^2/s

Bridge Vel, V_2 = 5.2 ft/s Final $y_2 = q_2/V_2$ = 10.4 ft Δh = 0.6 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,

$Y_2 = 13.7$ is above LS = ~~10.3~~ 10.3 → Q = 5596

Water Surface Elev. = 2.4 ft

Low Steel Elev. = 10.3 ft

n (Channel) = 0.037

n (LOB) = 0.030

n (ROB) = 0.035

Pier Width = 1.35 ft

Pier Length = 1.35 ft

Piers for 500 yr = 5 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 130 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} = 105 ft Average right overbank flow depth, y_{rob} = 1.5 ft

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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, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = _____ 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

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L/a ratio = 1.0 Correction factor for flow angle of attack (from Table 1), K2 = 1.0

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ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0 ft right abutment, y_{aRT} = 1.5 ft

Shape coefficient K_1= 1.00 for vertical-wall, 0.82 for vertical-wall with wingwalls, 0.55 for spill-through

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Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 9.3 ft

Route 3rd Ave N Stream Big Sioux River MRM _____ Date 8/16/10 Initials CW

Bridge Structure No. 151181170 Location in Watertown

GPS coordinates: N 44°54'17.0" taken from: USL abutment X centerline of ⇑ MRM end _____

W097°07'30.2" Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 362.30 sq. mi.

The average bottom of the main channel was 15.0 ft below top of guardrail at a point 37 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 5930			Q_{500} = ~~9570~~ 9710		
Estimated flow passing through bridge	5596			5596		
Estimated road overflow & overtopping	334			~~Yes~~ 4114		
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? ____Yes X No ____Marginal

Evidence of past Scour? X Yes ____No ____Don't know Some washing away @ abutment (very little)

Debris Potential? X High ____Med ____Low

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

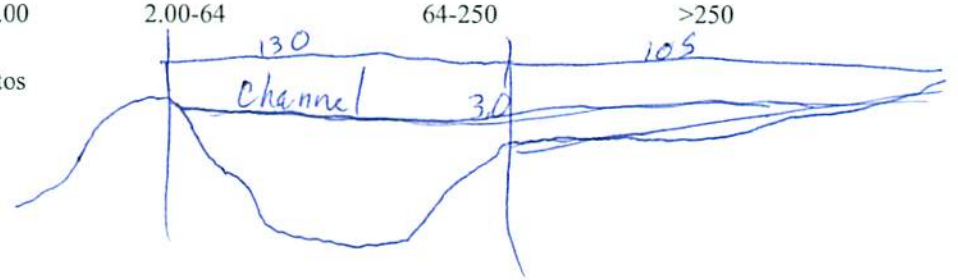
Riprap	____Yes	____No	____Don't know	X NA
Spur Dike	X Yes	____No	____Don't know	____NA
Other _____	____Yes	____No	____Don't know	X NA

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

Material	Silt/Clay 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

Big Sioux River
1089 - Bridge #
90 - US from bridge
91 - US RB
92 - US LB
93 - US face of bridge



Does not top levee on LOB

Summary of Results

	Q100	Q500
Bridge flow evaluated	5596	5596
Flow depth at left abutment (yaLT), in feet	0	0
Flow depth at right abutment (yaRT), in feet	1.5	1.5
Contraction scour depth (ycs), in feet	4.9	4.9
Pier scour depth (yps), in feet	4.9	4.9
Left abutment scour depth (yas), in feet	0.0	0.0
Right abutment scour depth (yas), in feet	9.3	9.3
IFlow angle of attack	10	10

See Comments/Diagram for justification where required