ok RJ

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 15184181 Date 8/16/10 Initials CW Region (A B C D)

Site _____ Location Big Sioux River on South Broadway in Watertown

Q_{100} = 6170 by: drainage area ✓ flood frequency anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 3992 (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 = 96 ft. Flow angle at bridge = 0 ° Abut. Skew = 0 ° Effective Skew = 0 °

Width (W_2) iteration = 96 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 11.3 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 96 ft* $q_2 = Q_2/W_2$ = 41.6 ft^2/s

Bridge Vel, V_2 = 4.6 ft/s Final $y_2 = q_2/V_2$ = 9.1 ft Δh = 0.4 ft

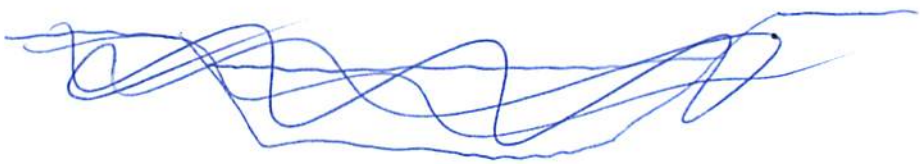
Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9.5 ft

** 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,

Road over flow ymax = 9.1 ft
Q = 3992

Water Surface Elev. = _____ ft
Low Steel Elev. = 9.1 ft
n (Channel) = 0.033
n (LOB) = 0.050
n (ROB) = .030
Pier Width = 1.2 ft
Pier Length = 1.2 ft
Piers for 100 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = ~~105~~ 118 ft

Width of left overbank flow at approach, W_{lob} = 60 ft Average left overbank flow depth, y_{lob} = 0.5 ft

Width of right overbank flow at approach, W_{rob} = 96 ft Average right overbank flow depth, y_{rob} = 4.5 ft

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

x = 5.59 From Figure 9 W_2 (effective) = 93.6 ft y_{cs} = 6.3 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 1.0

Froude # at bridge = 0.27

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

Using pier width a on Figure 11, ξ = 5.5 Pier scour y_{ps} = 4.5 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0.5 ft right abutment, y_{aRT} = 4.5 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} = 2.3 and ψ_{RT} = 14.1

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 4.2 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 25.7 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 151841B1 Date 8/16/10 Initials CW Region (A B C D)

Site _____ Location Big Sioux River on South Broadway in Watertown

Q_{500} = ~~4200~~ 10100 by: drainage area ✓ flood frequency anal. _____ regional regression eq. ____

Bridge discharge (Q_2) = 3992 (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 = 96 ft. Flow angle at bridge = 0 ° Abut. Skew = 0 ° Effective Skew = 0 °

Width (W_2) iteration = 96

Avg. flow depth at bridge, y_2 iteration = 9.1

Corrected channel width at bridge Section = W_2 times cos of flow angle = 96 ft* $q_2 = Q_2/W_2$ = 41.6 ft^2/s

Bridge Vel, V_2 = 4.6 ft/s Final $y_2 = q_2/V_2$ = 9.1 ft Δh = 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9.5 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,

Road over flow y_{max} = 9.1 → Q = 3992

Water Surface Elev. = _____ ft

Low Steel Elev. = 9.1 ft

n (Channel) = 0.033

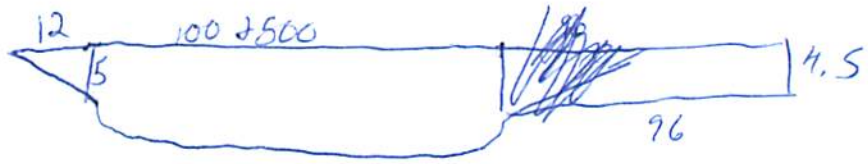
n (LOB) = 0.050

n (ROB) = 0.030

Pier Width = 1.2 ft

Pier Length = 1.2 ft

Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 114 ft

Width of left overbank flow at approach, W_{lob} = 60 ft Average left overbank flow depth, y_{lob} = 0.5 ft

Width of right overbank flow at approach, W_{rob} = 96 ft Average right overbank flow depth, y_{rob} = 4.5 ft

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

x = 5.59 From Figure 9 W_2 (effective) = 93.6 ft y_{cs} = 6.3 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, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = _____ 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

PGRM: Pier

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

Froude # at bridge = 0.27 Using pier width a on Figure 11, ξ = 5.5 Pier scour y_{ps} = 4.5 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0.5 ft right abutment, y_{aRT} = 4.5 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} = 2.3 and ψ_{RT} = 14.1

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 4.2 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 25.7 ft

Route S. Broadway Stream Big Sioux River MRM _____ Date 8/16/10 Initials CW

Bridge Structure No. 15184181 Location in Watertown

GPS coordinates: N 44°53'21.9" W 97°07'08.5" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 390.21 sq. mi.

The average bottom of the main channel was 14.0 ft below top of guardrail at a point 31 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 6170			Q_{500} = ~~9200~~ 10100		
Estimated flow passing through bridge	3992			3992		
Estimated road overflow & overtopping	2178			6108		
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 ____Marginal

Evidence of past Scour? X Yes ____No ____Don't know Appears cobbles have ~~eroded~~ washed away

Debris Potential? X High ____Med ____Low Sloping abut. washed away

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

Riprap	X Yes	____No	____Don't know	____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____	Sand____	Gravel X	Cobbles____	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos

1084- Upstream
1085- US RB
1086- US LB
1087- Bridge from Approach XS
1088- Bridge ID

Both 100 & 500 year floods top bridge & spur dike

Summary of Results

	Q100	Q500
Bridge flow evaluated	3992	3992
Flow depth at left abutment (yaLT), in feet	0.5	0.5
Flow depth at right abutment (yaRT), in feet	4.5	4.5
Contraction scour depth (ycs), in feet	6.3	6.3
Pier scour depth (yps), in feet	4.5	4.5
Left abutment scour depth (yas), in feet	4.2	4.2
Right abutment scour depth (yas), in feet	25.7	25.7
1Flow angle of attack	0	0

See Comments/Diagram for justification where required