OK RLT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50203205 Date 6/28/12 Initials RLT Region (A B (C) D)

Site ______ Location 6th St & Big Sioux River in SF

~~Q_{100}~~ = Q_{25} 31700 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 31700 (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 = 232 ft. Flow angle at bridge = 15 ° Abut. Skew = 10 ° Effective Skew = 5 °

Width (W_2) iteration = ____ ____ ____ ____ Pier skew 10°

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

Corrected channel width at bridge Section = W_2 times cos of flow angle = 231.12 ft* $q_2 = Q_2/W_2$ = 137.2 ft^2/s

Bridge Vel, V_2 = 8.3 ft/s Final $y_2 = q_2/V_2$ = 16.5 ft Δh = 1.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 17.9 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,

Water Surface Elev. = 0-4.4 ft

Low Steel Elev. = 17.0 ft 1.75+0.6 H.55

n (Channel) = 0.025

n (LOB) = 0.030

n (ROB) = 0.020

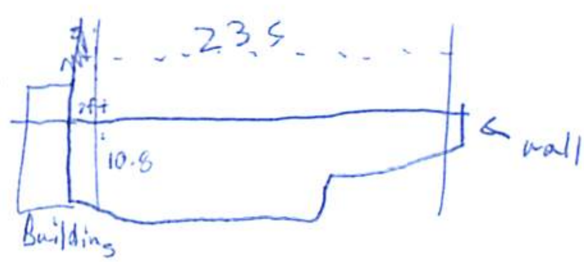
Pier Width = 1.55 ft

Pier Length = ~~58~~ 59 ft V-face w/ Steel protector.

\# Piers for 100 yr = 3 ft

23.9
6.9
17.0

16.8
-6.
9.9



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 232 ft

Width of left overbank flow at approach, W_{lob} = 87 ft Average left overbank flow depth, y_{lob} = 10.8 ft

Width of right overbank flow at approach, W_{rob} = ~~7~~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 = 0.64 From Figure 9 W_2 (effective) = 226.5 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, $V_1 = Q_{100}/(y_1W_1)$ = ____ ft/s

Critical approach velocity, $V_c = 11.17y_1^{1/6}D_{50}^{1/3}$ = ____ 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 38 Correction factor for flow angle of attack (from Table 1), K2 = 1.5

Froude # at bridge = 0.36 Using pier width a on Figure 11, ξ = 6.6 Pier scour y_{ps} = 8.5 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 10.8 ft $K_1=1$ right abutment, y_{aRT} = 0 ft $K_1=0.55$

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} = 22 and ψ_{RT} = 0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 40 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50203205 Date 6/28/12 Initials RaT Region (A B (C) D)

Site ______ Location 6th St & Big Sioux River in SF

Q_{500} = Q50 41900 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 33601 (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 = 232 ft. Flow angle at bridge = 15 ° Abut. Skew = 10 ° 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 = 231.12 ft* $q_2 = Q_2/W_2$ = 145.4 ft²/s

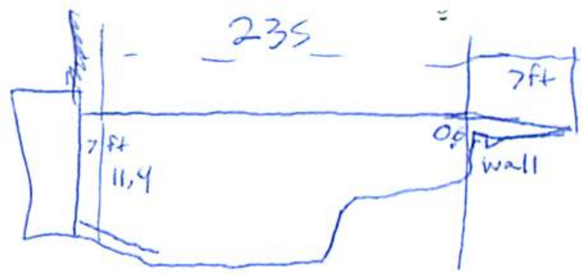
Bridge Vel, V_2 = 8.6 ft/s Final $y_2 = q_2/V_2$ = 17 ft Δh = 1.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 18.5 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 4.4 ft
Low Steel Elev. = 17.0 ft
n (Channel) = 0.025
n (LOB) = 0.030
n (ROB) = 0.020
Pier Width = 1.55 ft
Pier Length = 59 ft
\# Piers for 500 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 232 ft

Width of left overbank flow at approach, W_{lob} = 7 ft Average left overbank flow depth, y_{lob} = 11.4 ft

Width of right overbank flow at approach, W_{rob} = 7 ft Average right overbank flow depth, y_{rob} = 0.6 ft

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

x = ~~0.96~~ 0.67 From Figure 9 W_2 (effective) = 226.5 ft y_{cs} = ~~0.8~~ 1.1 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, $V_c = 11.17 y_1^{1/6} D_{50}^{1/3}$ = ______ 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 38 Correction factor for flow angle of attack (from Table 1), K2 = 1.5

Froude # at bridge = 0.37 Using pier width a on Figure 11, ξ = 6.6 Pier scour y_{ps} = 8.5 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 11.4 ft K_1=1 right abutment, y_{aRT} = 0.6 ft K_1=0.55

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} = 22.5 and ψ_{RT} = 2.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 40.9 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 2.7 ft

96.72363
43.55123

Route 6th St Stream Big Sioux River MRM____ Date 6/28/12 Initials [illegible]

Bridge Structure No. 50203205 Location 6th St on Big Sioux River in SF

GPS coordinates: N 43° 33' 4.3" taken from: USL abutment X centerline of ⇑ MRM end ____

W 96° 43' 29.2" Datum of coordinates: WGS84 X NAD27____

Drainage area = 3772.76 sq. mi.

The average bottom of the main channel was 23.9 ft below top of guardrail at a point 45 ft from left abutment.

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

3772.76

6/13

2	5540
5	13300
10	20400
25	31700
50	41900
100	53300
500	85100

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = Q_{25} = 31700			Q_{500} = Q_{50} 41900		
Estimated flow passing through bridge	31700			33601		
Estimated road overflow & overtopping	0			8299		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		~~X~~	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? ____Yes ____No X Don't know

Debris Potential? ____High ____Med X Low

likely some pier/contraction, unable to look @ left abutment

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 ________ X Yes ____No ____Don't know ____NA – Bike trail on right abutment prevents overbank flow. cement filled abutment under bridge.

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). pier
5-6). right abutment
7-8). left abutment
9). main channel

Notes: unable to reach left abutment due to ~~contract~~ construction and steep wall downstream of bridge. However there is about 7ft of exposed abutment, very susceptible to scour.

Summary of Results

	~~Q100~~ Q_{25}	~~Q500~~ Q_{50}
Bridge flow evaluated	31700	33601
Flow depth at left abutment (yaLT), in feet	10.8	11.4
Flow depth at right abutment (yaRT), in feet	0	0.6
Contraction scour depth (ycs), in feet	1	~~0.8~~ 1.1
Pier scour depth (yps), in feet	8.5	8.5
Left abutment scour depth (yas), in feet	~~10.8~~ 40	40.4
Right abutment scour depth (yas), in feet	0	2.7
1Flow angle of attack	5	5

See Comments/Diagram for justification where required