OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50144020 Date 6/26/12 Initials RAT Region (A B C D)

Site _____ Location 3.2 mi W of I-90 on 246 St

Q_{100} = Qs 2760 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 2760 (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 = 95 ft. Flow angle at bridge = 15 ° Abut. Skew = 0 ° Effective Skew = 15 °

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 = 91.76 ft* $q_2 = Q_2/W_2$ = 30.1 ft^2/s

Bridge Vel, V_2 = 3.9 ft/s Final $y_2 = q_2/V_2$ = 7.7 ft Δh = 0.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8 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. = 0.3-1.3 ft

Low Steel Elev. = 8.41 ft

n (Channel) = 0.040

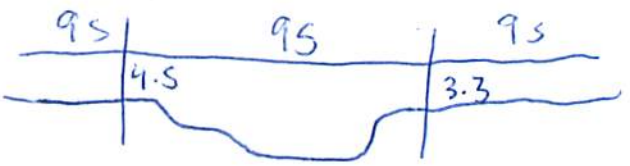
n (LOB) = 0.030

n (ROB) = ~~0.035~~ 0.025

Pier Width = 1.65 ft

Pier Length = 1.65 ft

Piers for 100 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = ~~95~~ 95 ft

Width of left overbank flow at approach, W_{lob} = 95 ft Average left overbank flow depth, y_{lob} = 4.5 ft

Width of right overbank flow at approach, W_{rob} = ~~95~~ 95 ft Average right overbank flow depth, y_{rob} = ~~3.3~~ ft 3.3

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

x = 6.43 From Figure 9 W_2 (effective) = 66.8 ft y_{cs} = 9.3 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, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = _____ 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, $\chi = 0.122 y_1 [q_2^2/(D_{50}^{1/3} y_1^{7/6})]^{6/7} - y_1$ = _____ From Figure 10, y_{cs} = _____ ft

PGRM: Pier

PIER SCOUR CALCULATIONS

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

Froude # at bridge = 0.25 Using pier width a on Figure 11, ξ = 6.9 Pier scour y_{ps} = 5.6 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 4.5 ft right abutment, y_{aRT} = 3.3 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} = 14.1 and ψ_{RT} = 12

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 14.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 12 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50144020 Date 6/26/12 Initials NaT Region (A B C D)

Site _____ Location 3.2 mi W of I-90 on 246 St

~~Q_{500}~~ = Q_{10} 4250 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 3251 (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 = 95 ft. Flow angle at bridge = 15 ° Abut. Skew = 0 ° Effective Skew = 15 °

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 = 91.76 ft* $q_2 = Q_2/W_2$ = 35.4 ft^2/s

Bridge Vel, V_2 = 4.2 ft/s Final $y_2 = q_2/V_2$ = 8.4 ft Δh = 4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.8 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. = 0.3-1.3 ft

Low Steel Elev. = 6.4 ft

n (Channel) = 0.040

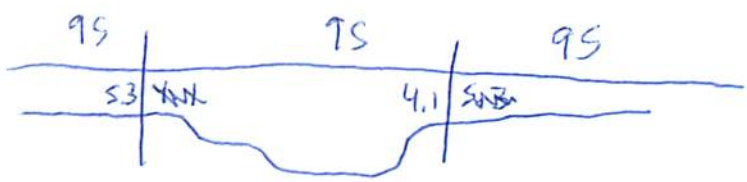
n (LOB) = 0.030

n (ROB) = 0.025

Pier Width = 1.65 ft

Pier Length = 1.65 ft

Piers for 500 yr = 0 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 95 ft

Width of left overbank flow at approach, W_{lob} = 95 ft Average left overbank flow depth, y_{lob} = 5.3 ft

Width of right overbank flow at approach, W_{rob} = 95 ft Average right overbank flow depth, y_{rob} = 4.1 ft

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

x = 10.66 From Figure 9 W_2 (effective) = 96.9 ft y_{cs} = 11.7 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 = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.26 Using pier width a on Figure 11, ξ = 6.9 Pier scour y_{ps} = 5.6 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 5.3 ft right abutment, y_{aRT} = 4.1 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} = 15.6 and ψ_{RT} = 13.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 15.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 13.4 ft

96° 50' 40.848"
43° 49' 8.76"

96.844468
43.819101

Route 246 St Stream Skunk Ck MRM _____ Date 6/24/12 Initials FaT

Bridge Structure No. 50144020 Location 3.2 mi W of I-90 on 246 St

GPS coordinates: N 43° 49' 8.91" W 96° 50' 40.91" taken from: USL abutment ^ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 273.62 sq. mi.

The average bottom of the main channel was 12.4 ft below top of guardrail at a point 21 ft from left abutment.

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

273.62
6/13

2	1100
5	2760
10	4280
25	6690
50	8320
100	11200
500	17600

MISCELLANEOUS CONSIDERATIONS

Flows	~~Q100~~ = Q25 2760			~~Q500~~ = Q10 ~~3R~~ 4280		
Estimated flow passing through bridge	2760			3251		
Estimated road overflow & overtopping	0			1029		
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 mostly on right, ~~Some on~~ and outside left abutment

Evidence of past Scour? X Yes ____No ____Don't know some contraction pier, minor abutment

Debris Potential? ____High ____Med X Low

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

Riprap	X Yes	____No	____Don't know	____NA	rose quartz
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

Comments, Diagrams & orientation of digital photos

1). left CB
2) main channel
3) right CB
4). right abutment
5-6). left abutment
7). pier scour
8). piers
9). left abutment
10-11). right abutment
12). main channel

Summary of Results

	~~Q100~~ Q25	~~Q500~~ Q100
Bridge flow evaluated	2760	3251
Flow depth at left abutment (yaLT), in feet	4.5	5.3
Flow depth at right abutment (yaRT), in feet	3.3	4.1
Contraction scour depth (ycs), in feet	9.3	11.7
Pier scour depth (yps), in feet	5.6	5.6
Left abutment scour depth (yas), in feet	14.1	15.6
Right abutment scour depth (yas), in feet	12	13.4
1Flow angle of attack	15	15

See Comments/Diagram for justification where required