OK by RFT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52470336 Date 9/7/17 Initials RAJ Region (A B C D)

Site _____ Location Andersen Rd & Rapid Ck in RC

Q_{500} = 15900 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = ~~10500~~ 9086 (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 = 65 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° 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 = 64.75 ft* $q_2 = Q_2/W_2$ = ~~162.4~~ 140.3 ft^2/s

Bridge Vel, V_2 = 13.0 ft/s Final $y_2 = q_2/V_2$ = ~~10.7~~ 10.8 ft Δh = ~~3.5~~ 3.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = ~~14.2~~ 14.3 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. = 2.1 ft

Low Steel Elev. = 10.8 ft

n (Channel) = 0.030

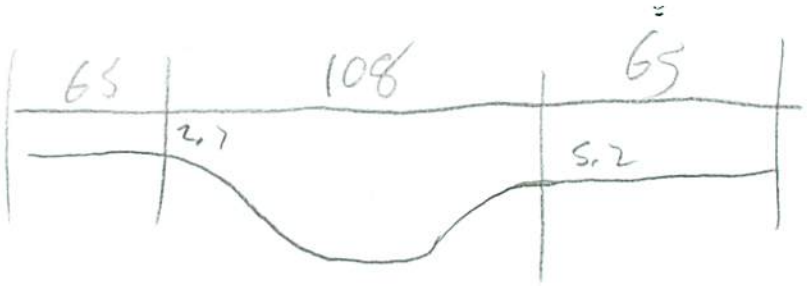
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = X ft

Pier Length = X ft

Piers for 500 yr = X ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 108 ft

Width of left overbank flow at approach, W_{lob} = 65 ft Average left overbank flow depth, y_{lob} = 2.7 ft

Width of right overbank flow at approach, W_{rob} = 65 ft Average right overbank flow depth, y_{rob} = 5.2 ft

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

x = 13.1 From Figure 9 W_2 (effective) = 64.8 ft y_{cs} = 14.0 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 = _____ Correction factor for flow angle of attack (from Table 1), K2 = _____

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

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 2.7 ft right abutment, y_{aRT} = 5.2 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} = 11 and ψ_{RT} = 15.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 16.4 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 22.9 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52470336 Date 9/7/12 Initials RAL Region (A B C D)

Site _____ Location Andersen Ck & Rapid Ck in RC

Q_{100} = 6280 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 6280 (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 = 65 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° 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 = 64.75 ft* $q_2 = Q_2/W_2$ = 97 ft^2/s

Bridge Vel, V_2 = 11 ft/s Final $y_2 = q_2/V_2$ = 8.8 ft Δh = 2.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 11.3 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. = 2.1 ft

Low Steel Elev. = 11.7 ft

n (Channel) = 0.030

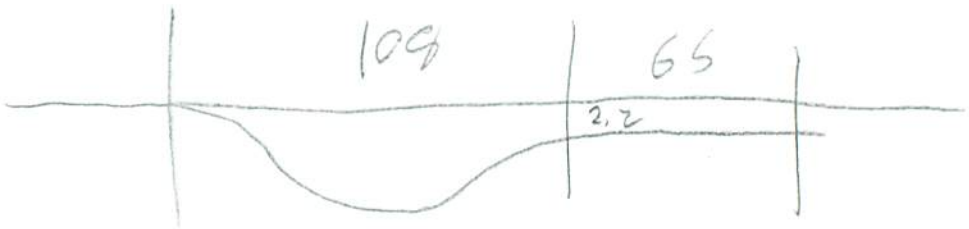
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = X ft

Pier Length = X ft

Piers for 100 yr = X ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 108 ft

Width of left overbank flow at approach, W_{lob} = 650 ft Average left overbank flow depth, y_{lob} = 0 ft

Width of right overbank flow at approach, W_{rob} = 65 ft Average right overbank flow depth, y_{rob} = 2.2 ft

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

x = 0.29 From Figure 9 W_2 (effective) = 64.8 ft y_{cs} = 9.2 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, $\chi = 0.122 y_1 [q_2/(D_{50}^{1/3} y_1^{7/6})]^{6/7} - y_1$ = _____ From Figure 10, y_{cs} = _____ ft

PGRM: Pier

PIER SCOUR CALCULATIONS

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

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} = 2.2 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} = 9 and ψ_{RT} = 9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 13.5 ft

103.11123
44.02872

Route Anderson Rd Stream Rapid Ck MRM _____ Date RQ 9/7/12 Initials RJT

Bridge Structure No. 52470336 Location Anderson Rd in Rapid Ck in RC

GPS coordinates: N 44° 1' 43.91" W 103° 6' 40.51" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 446.05 sq. mi.

The average bottom of the main channel was 16.8 ft below top of guardrail at a point 23 ft from left abutment.

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

7/3

2	2227
5	661
10	1230
25	2460
50	4040
100	6260
500	15900

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 6260			Q_{500} = 15900		
Estimated flow passing through bridge	6260			~~10598~~ 9058		
Estimated road overflow & overtopping	0			~~5302~~ 6812		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		X		X		
Chance of Pressure flow	X	~~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 contraction

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

Comments, Diagrams & orientation of digital photos

1). left OB
2). main channel
3). right OB
4-5). right abutment
6-7). left abutment
8). main channel

Summary of Results

	Q100	Q500
Bridge flow evaluated	6260	4040
Flow depth at left abutment (yaLT), in feet	0	2.7
Flow depth at right abutment (yaRT), in feet	2.2	5.2
Contraction scour depth (ycs), in feet	9.2	14.0
Pier scour depth (yps), in feet	X	X
Left abutment scour depth (yas), in feet	0	16.4
Right abutment scour depth (yas), in feet	13.5	22.9
1Flow angle of attack	5	5

See Comments/Diagram for justification where required