OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50286180 Date 9-19-10 Initials KKL Region (A B C D)

Site _____ Location From I-90 Exit 406, 1.4 S 0.6 E

Q_{100} = 27,900 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 27,900 (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 = 218 ft Flow angle at bridge = 25 ° Abut. Skew = 0 Effective Skew = 25 °

Width (W_2) iteration = 200 204

Avg. flow depth at bridge, y_2 iteration = 17.5 17.3

Corrected channel width at bridge Section = W_2 times cos of flow angle = 184.89 ft* $q_2 = Q_2/W_2$ = 150.9 ft^2/s

Bridge Vel, V_2 = 8.7 ft/s Final $y_2 = q_2/V_2$ = 17.3 ft Δh = 1.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 18.9 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. = 3.9 ft

Low Steel Elev. = 21.6 ft

n (Channel) = 0.033

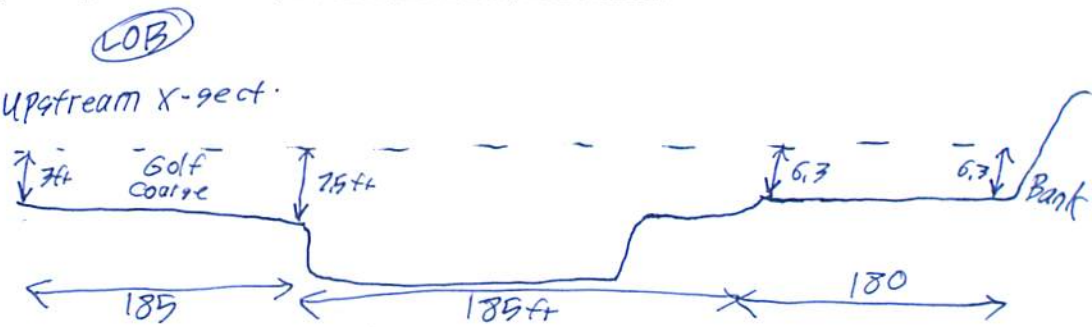
n (LOB) = 0.025

n (ROB) = 0.045

Pier Width = 3 ft

Pier Length = 3 ft

Piers for 100 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 185 ft

Width of left overbank flow at approach, W_{lob} = 185 ft Average left overbank flow depth, y_{lob} = 5.625 ft

Width of right overbank flow at approach, W_{rob} = 180 ft Average right overbank flow depth, y_{rob} = 6.3 ft

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

x = 6.3 From Figure 9 W_2 (effective) = 178.9 ft y_{cs} = 7.1 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ 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 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.37 Using pier width a on Figure 11, ξ = 18.7 Pier scour y_{ps} = 9.2 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 5.625 ft right abutment, y_{aRT} = 6.3 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} = 16.1 and ψ_{RT} = 17.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 16.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 17.3 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50286180 Date 9-19-10 Initials KRZ Region (A B C D)

Site _____ Location From I-90 Exit 406, 1.4S, 0.6E

Q_{500} = 49,600 by: drainage area ratio ✓ flood freq. anal. _____ regional regression eq. ____

Bridge discharge (Q_2) = 37,421 (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 = 218 ft. Flow angle at bridge = 25 ° Abut. Skew = 0 Effective Skew = 25 °

Width (W_2) iteration = 218 _____ _____

Avg. flow depth at bridge, y_2 iteration = 19.4 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 197.58 ft* $q_2 = Q_2/W_2$ = 189.4 ft^2/s

Bridge Vel, V_2 = 9.8 ft/s Final $y_2 = q_2/V_2$ = 19.4 ft Δh = 2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 21.4 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. = 3.9 ft

Low Steel Elev. = 21.6 ft

n (Channel) = 0.033

n (LOB) = 0.025

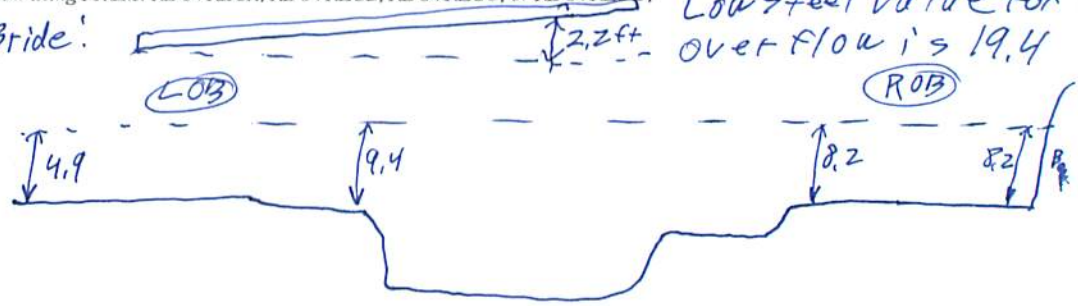
n (ROB) = 0.045

Pier Width = 3 ft

Pier Length = 3 ft

Piers for 500 yr = 2 ft

Bride: Low Steel value for overflow is 19.4



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 185 ft

Width of left overbank flow at approach, W_{lob} = 189 ft Average left overbank flow depth, y_{lob} = 7.525 ft

Width of right overbank flow at approach, W_{rob} = 180 ft Average right overbank flow depth, y_{rob} = 8.2 ft

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

x = 7.02 From Figure 9 W_2 (effective) = 191.6 ft y_{cs} = 7.8 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

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

Froude # at bridge = 0.39 Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 9.3 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 7.525 ft right abutment, y_{aRT} = 8.2 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} = 19.4 and ψ_{RT} = 19.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 19.4 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 19.9 ft

Route Old 99264 Stream Split Rock Creek MRM _____ Date 9-19-10 Initials RAL

Bridge Structure No. 50286180 Location From I-90 Exit 406, 1.4S, 0.6E

GPS coordinates: N43° 35.238' W96° 33.662' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 _____ NAD27 _____

Drainage area = 486.32 sq. mi.

The average bottom of the main channel was 29.1 ft below top of guardrail at a point 51 ft from left abutment.

Method used to determine flood flows: ___Freq. Anal. ✓drainage area ratio ___regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 27900			Q_{500} = 49600		
Estimated flow passing through bridge	27900			37,421		
Estimated road overflow & overtopping	0			12,179		
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? ___Yes ___No X Don't know

Debris Potential? ___High X Med ___Low

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

Riprap	X Yes	___No	___Don't know	___NA
Spur Dike	___Yes	___No	X Don't know	___NA
Other _____	___Yes	___No	X 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- Bridge Deck
2- Looking Upstream
3- Looking Downstream
4- Left Overbank
5- Right Overbank
6- Left Abutment
7- Right Abutment
8- Piers
9-

Summary of Results

	Q100	Q500
Bridge flow evaluated	27,900	37,421
Flow depth at left abutment (yaLT), in feet	5.625	7.525
Flow depth at right abutment (yaRT), in feet	6.3	8.2
Contraction scour depth (ycs), in feet	7.1	7.8
Pier scour depth (yps), in feet	9.2	9.3
Left abutment scour depth (yas), in feet	16.1	19.4
Right abutment scour depth (yas), in feet	17.3	19.9
1Flow angle of attack	25	25

See Comments/Diagram for justification where required