OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 5031 3088 Date 10-8-10 Initials RRL Region (A B (C) D)

Site _____ Location N end Garretson

Q_{100} = 24000 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 24000 (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 = 243 ft. Flow angle at bridge = 17 ° Abut. Skew = 0 ° Effective Skew = 17 °

Width (W_2) iteration = 156 140 142 ____

Avg. flow depth at bridge, y_2 iteration = 17.9 18.9 18.7 ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 135.8 ft* $q_2 = Q_2/W_2$ = 176.7 ft^2/s

Bridge Vel, V_2 = 9.4 ft/s Final $y_2 = q_2/V_2$ = 18.7 ft Δh = 1.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 20.6 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. = 2.3 ft

Low Steel Elev. = 29.6 ft

n (Channel) = 0.03

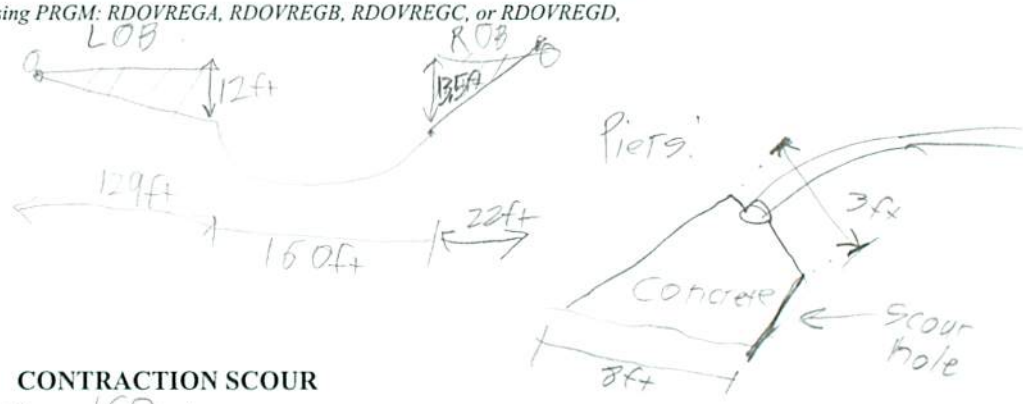
n (LOB) = 0.035

n (ROB) = 0.04

Pier Width = 3ft ft

Pier Length = 3 ft

Piers for 100 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 160 ft

Width of left overbank flow at approach, W_{lob} = 129 ft Average left overbank flow depth, y_{lob} = 6 ft

Width of right overbank flow at approach, W_{rob} = 22 ft Average right overbank flow depth, y_{rob} = 6.75 ft

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

x = 7.45 From Figure 9 W_2 (effective) = 129.8 ft y_{cs} = 8.3 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

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 3.1 CW

Froude # at bridge = 0.38

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

Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 9.3 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 6 ft right abutment, y_{aRT} = 6.75 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} = 16.8 and ψ_{RT} = 18.1

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 16.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 18.1 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50313088 Date 10-8-10 Initials RAL Region (A B C D)

Site _____ Location N end Garretson

Q_{500} = 42700 by: drainage area ratio ✓ flood freq. anal. _____ regional regression eq. ____

Bridge discharge (Q_2) = 42700 (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 = 243 ft. Flow angle at bridge = 17 ° Abut. Skew = 0 ° Effective Skew = 17 °

Width (W_2) iteration = 156 170 158 158

Avg. flow depth at bridge, y_2 iteration = 23.8 22.8 23.7 23.7

Corrected channel width at bridge Section = W_2 times cos of flow angle = 151.1 ft* $q_2 = Q_2/W_2$ = 282.6 ft²/s

Bridge Vel, V_2 = 11.9 ft/s Final $y_2 = q_2/V_2$ = 23.7 ft Δh = 2.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 26.6 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. = 2.3 ft

Low Steel Elev. = 29.6 ft

n (Channel) = 0.03

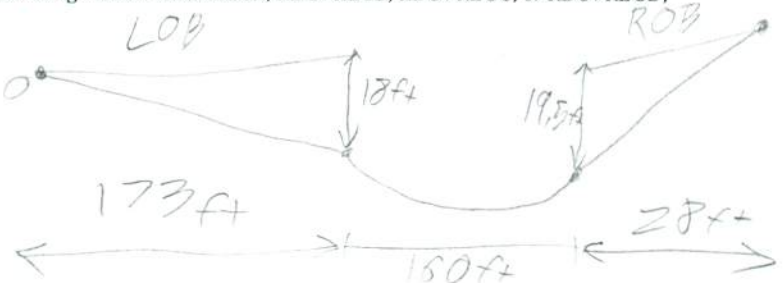
n (LOB) = 0.035

n (ROB) = 0.04

Pier Width = 3 ft

Pier Length = 3 ft

Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 160 ft

Width of left overbank flow at approach, W_{lob} = 173 ft Average left overbank flow depth, y_{lob} = 9 ft

Width of right overbank flow at approach, W_{rob} = 28 ft Average right overbank flow depth, y_{rob} = 9.75 ft

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

x = 7.92 From Figure 9 W_2 (effective) = 145.1 ft y_{cs} = 8.8 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

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = ~~8~~ 1 CV

Froude # at bridge = 0.43

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

Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 9.4 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 9 ft right abutment, y_{aRT} = 9.75 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} = 20.6 and ψ_{RT} = 21.1

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 20.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 21.1 ft

Route 5th St Stream Split Rock Creek MRM _____ Date 10-7-10 Initials RRL

Bridge Structure No. 50313088 Location N end Garretson

GPS coordinates: N 43° 43.139' W 096° 30.249' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 _____ NAD27 _____

Drainage area = 366.07 sq. mi.

The average bottom of the main channel was 74.8 ft below top of guardrail at a point 78 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 24000			Q_{500} = 42700		
Estimated flow passing through bridge	24000			42700		
Estimated road overflow & overtopping	0			0		
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? ____Yes ____No X Marginal

Evidence of past Scour? X Yes ____No ____Don't know

Debris Potential? ____High X Med ____Low

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

Riprap	____Yes	____No	X 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- Upstream Obstruction
2- Bridge Deck
3- Looking Upstream
4- Looking Downstream
5- Left Overbank
6- Right Overbank
7: Left Abutment
8: Right Abutment
9: Pier 2

Notes: upstream Dam structure, Piers built into bedrock, non-uniform arch design,

Summary of Results

	Q100	Q500
Bridge flow evaluated	24000	42700
Flow depth at left abutment (yaLT), in feet	6	9
Flow depth at right abutment (yaRT), in feet	6.75	9.75
Contraction scour depth (ycs), in feet	8.3	8.8
Pier scour depth (yps), in feet	9.3	9.4
Left abutment scour depth (yas), in feet	16.8	20.6
Right abutment scour depth (yas), in feet	18.1	21.1
1Flow angle of attack	17	17

See Comments/Diagram for justification where required