near Whitewood OK RJ

Whitewood Creek

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 4121091 Date 7/12/11 Initials CR Region (A B C D)

Site _____ Location I-90 Exit 23, approx 1 E on Whitewood Valley Rd

Q_{100} = 7550 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = ~~7550~~ 6890 (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 = ~~185~~ ft, 185 Flow angle at bridge = 20° Abut. Skew = 0° Effective Skew = 20°

Width (W_2) iteration = 185

Avg. flow depth at bridge, y_2 iteration = 5.7 > 5.4 → RD Overflow

Corrected channel width at bridge Section = W_2 times cos of flow angle = 173.84 ft* $q_2 = Q_2/W_2$ = 39.6 ft²/s

Bridge Vel, V_2 = 7.3 ft/s Final $y_2 = q_2/V_2$ = 5.4 ft Δh = 1.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 6.5 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. = ____ ft

Low Steel Elev. = 5.4 ft

n (Channel) = 0.050

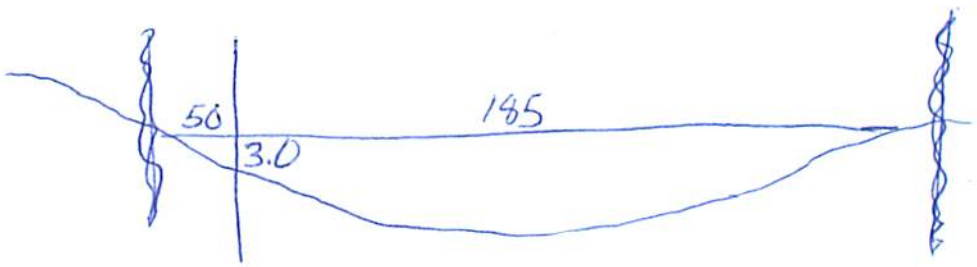
n (LOB) = 0.060

n (ROB) = 0.060

Pier Width = 1.85 ft

Pier Length = 1.85 ft

Piers for 100 yr = 4 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} = 50 ft Average left overbank flow depth, y_{lob} = 1.5 ft

Width of right overbank flow at approach, W_{rob} = 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 = ~~0.87~~ From Figure 9 W_2 (effective) = 166.4 ft y_{cs} = ~~1.3~~ ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = 0.20 ft Average approach velocity, $V_1 = Q_{100}/(y_1 W_1)$ = 4.51 ft/s

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = 8.92 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.053 ft If $D_{50} >= D_{c50}$, $\chi = 0.0$

Otherwise, $\chi = 0.122 y_1 [q_2/(D_{50}^{1/3} y_1^{7/6})]^{6/7} - y_1$ = 0.0 From Figure 10, y_{cs} = 0.0 ft

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 1.0 Correction factor for flow angle of attack (from Table 1), K2 = 1.0

Froude # at bridge = 0.55 Using pier width a on Figure 11, ξ = 7.5 Pier scour y_{ps} = 6.9 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 1.5 ft right abutment, y_{aRT} = 0 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} = 6.3 and ψ_{RT} = 0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 6.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0 ft

2.9

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 412120911 Date 7/12/11 Initials CW Region (A B C D)

Site _____ Location I-90 Exit 23, Approx 1E on Whitewood Valley Rd.

Q_{500} = 21400 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 6890 (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 = 185 ft. Flow angle at bridge = 20 ° Abut. Skew = 0 ° Effective Skew = 20 °

Width (W_2) iteration = 185 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 5.7 > 5.4 _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 173.84 ft* $q_2 = Q_2/W_2$ = 39.6 ft^2/s

Bridge Vel, V_2 = 7.3 ft/s Final $y_2 = q_2/V_2$ = 5.4 ft Δh = 1.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 6.5 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. = _____ ft

Low Steel Elev. = 5.4 ft

n (Channel) = 0.050

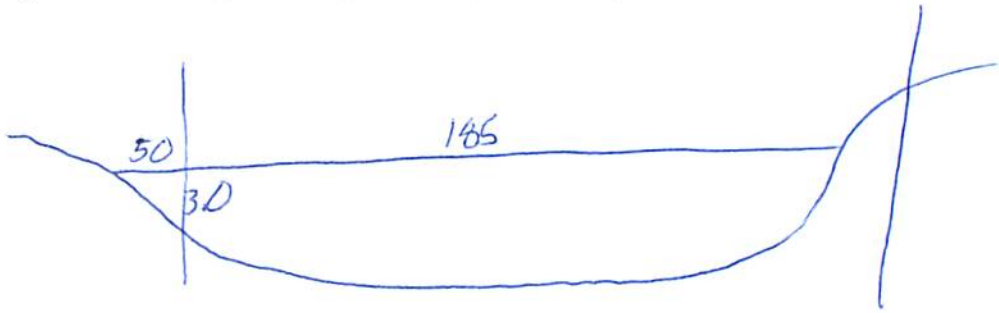
n (LOB) = 0.060

n (ROB) = 0.060

Pier Width = 1.85 ft

Pier Length = 1.85 ft

Piers for 500 yr = 4 ft



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Width of right overbank flow at approach, W_{rob} = 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 = 0.37 From Figure 9~~ W_2 (effective) = 166.4 ft y_{cs} = 1.3 ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = 0.20 ft Average approach velocity, $V_1 = Q_{500}/(y_1W_1)$ = 4.51 ft/s

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Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 6.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0 ft

Whitewood

Route Valley Rd Stream Whitewood Creek MRM _____ Date 7/12/11 Initials CL

Bridge Structure No. 41212091 Location I-90 Exit 23, Approx. 1E on Whitewood Valley Rd

GPS coordinates: N44°28'22.5" W103°37'31.4" taken from: USL abutment X centerline of ↑ MRM end _____

Datum of coordinates: WGS84 X NAD27 ____

Drainage area = 51.62 sq. mi.

The average bottom of the main channel was 9.4 ft below top of guardrail at a point 91 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 7550			Q_{500} = 21400		
Estimated flow passing through bridge	6890			6890		
Estimated road overflow & overtopping	660			14510		
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 X No ____Don't know

Debris Potential? X High ____Med ____Low

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

Riprap	X Yes	____No	____Don't know	____NA
Spur Dike	____Yes	____No	____Don't know	X NA
Other _____	____Yes	____No	____Don't know	X NA

Bed Material Classification Based on Median Particle Size (D_{50})

Material	Silt/Clay____	Sand____	Gravel____	Cobbles X	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos

Photos

1765 - IP
66 - US
67 - US RB
68 - US LB
69 - L. Abut
70 - R. Abut
72 - Piers
73 - US Face bridge
74 - US Face Bridge

Summary of Results

	Q100	Q500
Bridge flow evaluated	6890	6890
Flow depth at left abutment (yaLT), in feet	1.5	1.5
Flow depth at right abutment (yaRT), in feet	0.0	0.0
Contraction scour depth (ycs), in feet	0.0	0.0
Pier scour depth (yps), in feet	6.9	6.9
Left abutment scour depth (yas), in feet	6.3	6.3
Right abutment scour depth (yas), in feet	0.0	0.0
1Flow angle of attack	20	20

See Comments/Diagram for justification where required