ok RT Perkins Co.

South Fork Grand River

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 53240235 Date 7/13/11 Initials CW Region (A B C D)

Site _____ Location 5.5 mi N Bison on White Butte Road

Q_{100} = 16,900 by: drainage area ✓ flood frequency anal. ____ regional regression eq. ___

Bridge discharge (Q_2) = 16900 (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 = 281 ft. Flow angle at bridge = 15 ° Abut. Skew = 0 ° Effective Skew = 15 °

Width (W_2) iteration = 281 281 _____ _____

Avg. flow depth at bridge, y_2 iteration = 9.4 9.4 _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 271.43 ft* $q_2 = Q_2/W_2$ = 62.3 ft^2/s

Bridge Vel, V_2 = 6.6 ft/s Final $y_2 = q_2/V_2$ = 9.4 ft Δh = 0.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10.3 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. = _____ ft

Low Steel Elev. = 12.6 ft

n (Channel) = 0.040

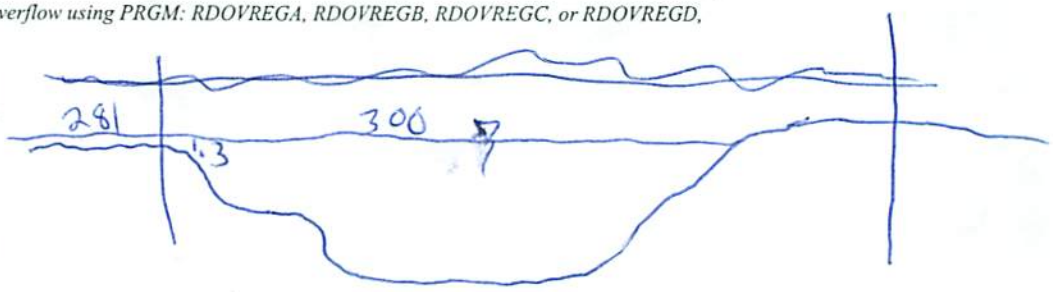
n (LOB) = 0.045

n (ROB) = 0.045

Pier Width = 2.2 ft

Pier Length = 2.35 ft

Piers for 100 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 300 ft

Width of left overbank flow at approach, W_{lob} = 281 ft Average left overbank flow depth, y_{lob} = 1.3 ft

Width of right overbank flow at approach, W_{rob} = ~~2.5~~ 0.0 ft Average right overbank flow depth, y_{rob} = ~~0.3~~ 0.0 ft

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

x = 1.78 From Figure 9 W_2 (effective) = 262.6 ft y_{cs} = 2.3 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 = 1.0 Correction factor for flow angle of attack (from Table 1), K2 = 1.0

Froude # at bridge = 0.38 Using pier width a on Figure 11, ξ = 9.6 Pier scour y_{ps} = 7.4 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 1.3 ft right abutment, y_{aRT} = 0.0 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} = 5.5 and ψ_{RT} = 0.0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = ~~7.7~~ 5.5 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0.0 ft

~~0.78~~

17.9 / 5.3 / 12

3" 14.4 / 10.3 / 3.4

4 ~~12.4~~ 11" / 3.4 / 3

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 53240235 Date 7/13/11 Initials CW Region (A (B) C D)

Site _____ Location 5.5 mi N Bison on White Butte Road

Q_{500} = 30400 by: drainage area ✓ flood frequency anal. _____ regional regression eq. ____

Bridge discharge (Q_2) = 29380 (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 = 281 ft. Flow angle at bridge = 15 ° Abut. Skew = 0 ° Effective Skew = 15 °

Width (W_2) iteration = 281 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 12.4 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 271.43 ft* $q_2 = Q_2/W_2$ = 108.2 ft^2/s

Bridge Vel, V_2 = 8.6 ft/s Final $y_2 = q_2/V_2$ = 12.6 ft Δh = 1.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 14.1 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. = 12.6 ft

n (Channel) = 0.040

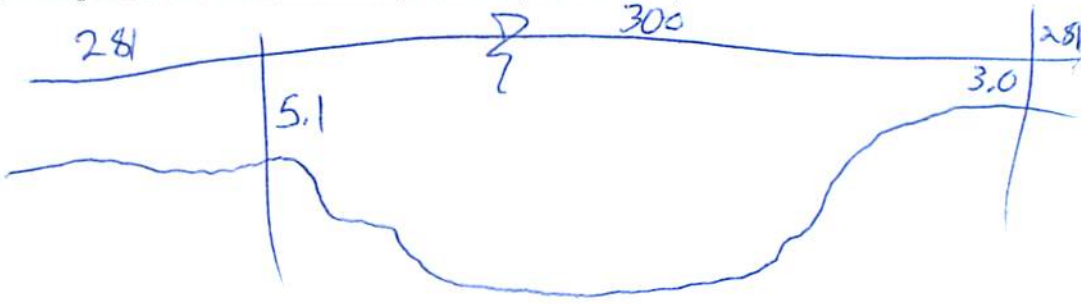
n (LOB) = 0.045

n (ROB) = 0.045

Pier Width = 2.2 ft

Pier Length = 2.35 ft

Piers for 500 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 300 ft

Width of left overbank flow at approach, W_{lob} = 281 ft Average left overbank flow depth, y_{lob} = 5.1 ft

Width of right overbank flow at approach, W_{rob} = 281 ft Average right overbank flow depth, y_{rob} = ~~4.1~~ 3.0 ft

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

x = 5.49 From Figure 9 W_2 (effective) = 262.6 ft y_{cs} = 6.2 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, $V_1 = Q_{500}/(y_1 W_1)$ = _____ 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

PGRM: Pier

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

Froude # at bridge = 0.43 Using pier width a on Figure 11, ξ = 8.6 Pier scour y_{ps} = 7.6 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 5.1 ft right abutment, y_{aRT} = 3.0 ft

Shape coefficient K_1 = R (1.00) for vertical-wall, 0.82 for vertical-wall with wingwalls, L 0.55 for spill-through

Using values for y_{aLT} and y_{aRT} on figure 12, ψ_{LT} = 15.2 and ψ_{RT} = 11.5

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = ~~21.6~~ 15.2 ft CW Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = ~~16.3~~ 20.9 ft CW

CW 78

271.43

White Butte

Route Road Stream S. Fk. Grand River MRM _____ Date 7/13/11 Initials CW

Bridge Structure No. 53240235 Location 5.5 mi N Bison on White Butte Road

GPS coordinates: N 45° 36' 37.5" W 102° 27' 23.9" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 1422.50 sq. mi.

The average bottom of the main channel was 17.9 ft below top of guardrail at a point 182 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 16900			Q_{500} = 30400		
Estimated flow passing through bridge	16900			29380		
Estimated road overflow & overtopping				1020		
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 ~~X~~ No X Marginal

Evidence of past Scour? ____Yes ____No X Don't know

Debris Potential? ____High ____Med X Low

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

Riprap ____Yes ____No X Don't know ~~X~~ 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 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

1412 - ID
13 - US
14 - US RB
15 - US LB
16 - L. Abut
17 - R. Abut
18 - 2 mule deer
19 - " "
20 - US Face
21 - App XS LB

Summary of Results

	Q100	Q500
Bridge flow evaluated	16900	29350
Flow depth at left abutment (yaLT), in feet	1.3	5.1
Flow depth at right abutment (yaRT), in feet	0.0	3.0
Contraction scour depth (ycs), in feet	2.3	6.2
Pier scour depth (yps), in feet	7.4	7.6
Left abutment scour depth (yas), in feet	~~7.7~~ 5.5	~~21.6~~ 15.2
Right abutment scour depth (yas), in feet	0.0	~~16.3~~ 20.9
1Flow angle of attack	15	15

See Comments/Diagram for justification where required