OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52312311 Date 9/24/10 Initials CW Region (A B C D)

Site _____ Location near S end Shields Rd, near intersection with HWY 44

Q_{100} = 858 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 854 (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 = ~~43~~ 40 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 40 Verti. Abut

Avg. flow depth at bridge, y_2 iteration = 3.4

Corrected channel width at bridge Section = W_2 times cos of flow angle = ~~40~~ 39.85 ft* $q_2 = Q_2/W_2$ = 21.5 ft^2/s

Bridge Vel, V_2 = 5.6 ft/s Final $y_2 = q_2/V_2$ = 3.9 ft Δh = 0.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 4.5 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. = 9.3 ft

n (Channel) = 0.050

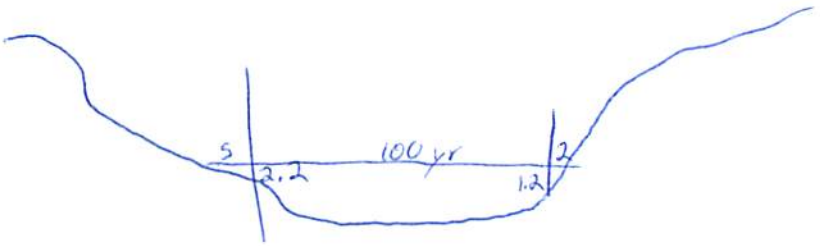
n (LOB) = ~~0.150~~ 0.100

n (ROB) = ~~0.150~~ 0.100

Pier Width = — ft

Pier Length = — ft

Piers for 100 yr = 0 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 45 ft

Width of left overbank flow at approach, W_{lob} = 5 ft Average left overbank flow depth, y_{lob} = 1.1 ft

Width of right overbank flow at approach, W_{rob} = 2 ft Average right overbank flow depth, y_{rob} = 0.6 ft

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

x = _____ From Figure 9 W_2 (effective) = _____ ft y_{cs} = _____ ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles) ~~0.911~~ ~~0.632~~ 0.0

Estimated bed material D_{50} = 0.20 ft Average approach velocity, $V_1 = Q_{100}/(y_1W_1)$ = ~~4.77~~ ~~4.24~~ 3.67 ft/s

Critical approach velocity, $Vc = 11.52y_1^{1/6}D_{50}^{1/3}$ = 4.39 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.030 ft If $D_{50} >= D_{c50}$, χ = 0.0

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

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} = 1.1 ft right abutment, y_{aRT} = 0.6 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} = 4.7 and ψ_{RT} = 2.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = ~~4.5~~ 7.0 ft CW Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = ~~4.9~~ 4.0 ft CW

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52312311 Date 9/24/10 Initials CW Region (A B C D)

Site _____ Location near S end Shields Rd, near intersection with HWY 44

Q_{500} = 1280 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 1280 (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 = 40 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 40 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = Vert 4but _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 39.85 ft* $q_2 = Q_2/W_2$ = 32.1 ft^2/s

Bridge Vel, V_2 = 6.7 ft/s Final $y_2 = q_2/V_2$ = 4.8 ft Δh = 0.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 5.7 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. = 9.3 ft

n (Channel) = 0.050

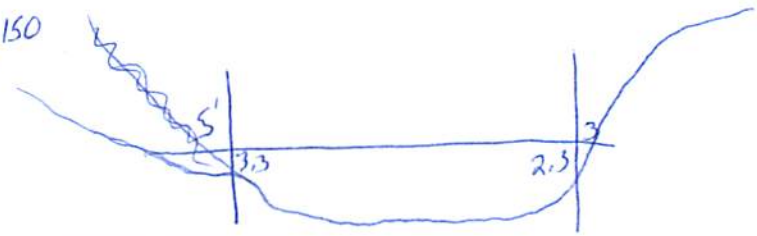
n (LOB) = ~~0.150~~ ~~0.100~~ 0.150

n (ROB) = ~~0.150~~ 0.100

Pier Width = — ft

Pier Length = — ft

Piers for 500 yr = 0 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 45 ft

Width of left overbank flow at approach, W_{lob} = 5 ft Average left overbank flow depth, y_{lob} = 1.65 ft

Width of right overbank flow at approach, W_{rob} = 3 ft Average right overbank flow depth, y_{rob} = 1.15 ft

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

x = _____ From Figure 9 W_2 (effective) = _____ ft y_{cs} = _____ ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles) ~~2=0.94~~ 0.0 ~~4.99~~ 4.24

Estimated bed material D_{50} = 0.20 ft Average approach velocity, $V_1 = Q_{500}/(y_1W_1)$ = ~~5.61~~ ft/s

Critical approach velocity, $Vc = 11.52y_1^{1/6}D_{50}^{1/3}$ = 4.73 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.04489 ft If $D_{50} >= D_{c50}$, $\chi = 0.0$

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

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 1.65 ft right abutment, y_{aRT} = 1.15 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} = 6.4 and ψ_{RT} = 4.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = ~~12.4~~ 10.2 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = ~~8.8~~ 7.3 ft

Route Shields Rd Stream Rapid Creek MRM _____ Date 9/24/10 Initials CH

Bridge Structure No. 52312311 Location near S end of Shields Rd, near intersection with SD44

GPS coordinates: N 44°09'00.3" W 103°25'33.4" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 336.22 sq. mi.

The average bottom of the main channel was 13.9 ft below top of guardrail at a point 22 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 858			Q_{500} = 1280		
Estimated flow passing through bridge	858			1280		
Estimated road overflow & overtopping						
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 ____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 ____Yes ____No ____Don't know X NA

Spur Dike ____Yes ____No ____Don't know X NA

Other Long wing walls X Yes ____No ____Don't know ____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

1254-10
55 - US from bridge
56 - US RB
57 - US LB
58 - Bed Material
59 - R. Abut
60 - L. Abut
61 - US face of bridge
62 - US Approach XS LB
63 - US Approach XS RB

Summary of Results

	Q100	Q500
Bridge flow evaluated	~~858~~	1280
Flow depth at left abutment (yaLT), in feet	1.1	1.65
Flow depth at right abutment (yaRT), in feet	0.6	1.15
Contraction scour depth (ycs), in feet	0.0	0.0
Pier scour depth (yps), in feet	~~0.0~~ NA	~~0.0~~ NA
Left abutment scour depth (yas), in feet	~~CA 4.5~~ 7.0	~~12.4~~ 10.2
Right abutment scour depth (yas), in feet	~~CA 4.4~~ 4.0	~~6.8~~ 7.3
1Flow angle of attack	5°	5°

See Comments/Diagram for justification where required