OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50194059 Date 9-12-10 Initials RLL Region (A B C D)

Site _____ Location Co Hwy 114 on E edge Baltic

Q_{100} = 33000 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 33000 (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 = 368 ft. Flow angle at bridge = 22 ° Abut. Skew = 0 ° Effective Skew = 22°

Width (W_2) iteration = 368 338 343

Avg. flow depth at bridge, y_2 iteration = 13.9 14.5 14.4

Corrected channel width at bridge Section = W_2 times cos of flow angle = 318.02 ft* $q_2 = Q_2/W_2$ = 103.8 ft²/s

Bridge Vel, V_2 = 7.2 ft/s Final $y_2 = q_2/V_2$ = 14.4 ft Δh = 1.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 15.4 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. = 8.0 ft

Low Steel Elev. = 183 ft

n (Channel) = 0.030

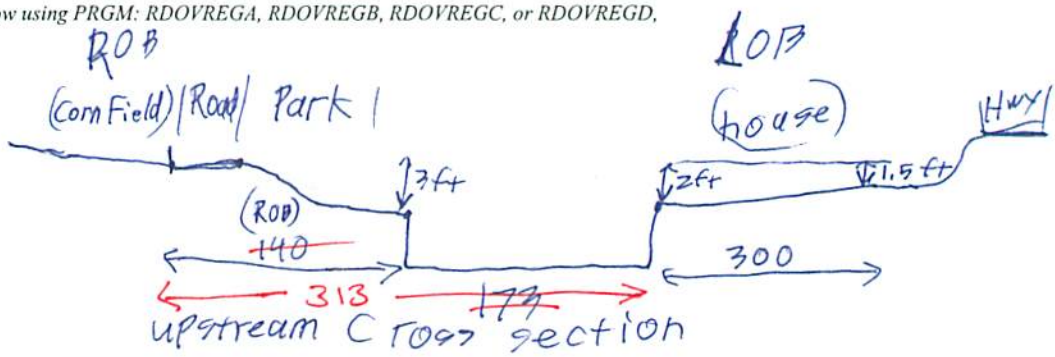
n (LOB) = 0.050

n (ROB) = 0.040

Pier Width = 2.2 ft

Pier Length = 28 ft

Piers for 100 yr = 5 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 177 ft 313

Width of left overbank flow at approach, W_{lob} = 300 ft Average left overbank flow depth, y_{lob} = 1.75 ft

Width of right overbank flow at approach, W_{rob} = 140 ft Average right overbank flow depth, y_{rob} = 1.59 ft

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

x = -6.37 From Figure 9 W_2 (effective) = 307 ft y_{cs} = 10.6 ft .0.9

0.54 307

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 = 12.7 Correction factor for flow angle of attack (from Table 1), K2 = 2.9

Froude # at bridge = 0.33 Using pier width a on Figure 11, ξ = 8.6 Pier scour y_{ps} = 21.2 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 1.75 ft right abutment, y_{aRT} = 15.0 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} = 7.2 and ψ_{RT} = 6.30

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 7.2 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 6.30 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50194059 Date 9-12-10 Initials KHL Region (A B (C) D)

Site _____ Location Co Hwy 114 on E edge Baltic

Q_{500} = 55400 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 55400 (should be Q_{500} unless there is a relief bridge, road overflow, or bridge overtopping)

PGRM: "RegionA", "RegionB", "RegionC", or "RegionD"

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

Bridge Width = 368 ft. Flow angle at bridge = 22 ° Abut. Skew = 0 ° Effective Skew = 22 °

Width (W_2) iteration = 368 356 ____ ____

Avg. flow depth at bridge, y_2 iteration = 18 18.3 ____ ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 330.08 ft* $q_2 = Q_2/W_2$ = 167.8 ft^2/s

Bridge Vel, V_2 = 9.2 ft/s Final $y_2 = q_2/V_2$ = 18.3 ft Δh = 1.7 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 20 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. = 8.0 ft

Low Steel Elev. = 18.3 ft

n (Channel) = 0.030

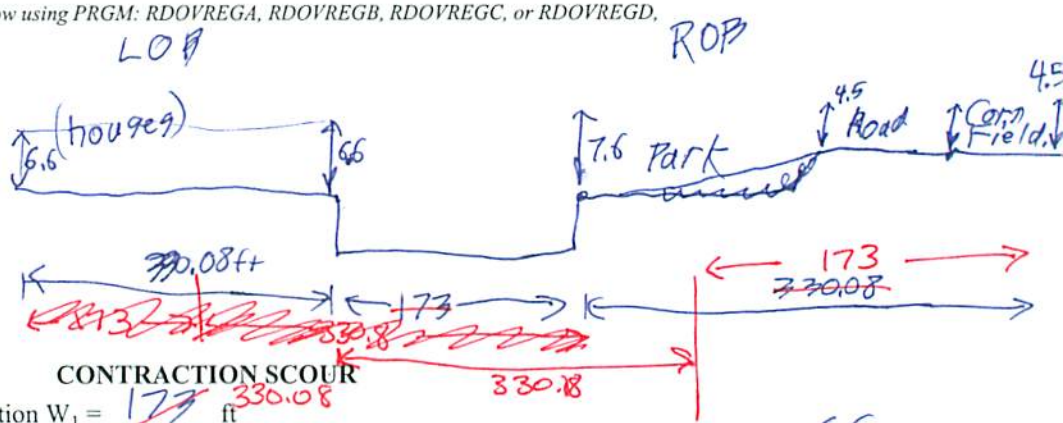
n (LOB) = 0.050

n (ROB) = 0.040

Pier Width = 2.2 ft

Pier Length = 28 ft

Piers for 500 yr = 5 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 173 ft 330.08

Width of left overbank flow at approach, W_{lob} = 330.08 ft Average left overbank flow depth, y_{lob} = 6.6 ft

Width of right overbank flow at approach, W_{rob} = 330.08 ft 173 Average right overbank flow depth, y_{rob} = 6.05 ft est. 4.5

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

x = ~~-5.08~~ 3.32 From Figure 9 W_2 (effective) = 319.1 ft y_{cs} = ~~8.5~~ 3.9 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 = 12.7 Correction factor for flow angle of attack (from Table 1), K2 = 2.9

Froude # at bridge = 0.38 Using pier width a on Figure 11, ξ = 8.6 Pier scour y_{ps} = 21.6 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 6.6 ft right abutment, y_{aRT} = ~~6.05~~ 4.5 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} = 17.9 and ψ_{RT} = ~~16.9~~ 14.1

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 17.9 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = ~~16.9~~ 14.1 ft

Route Co. Hwy 114 Stream Big Sioux River MRM _____ Date 9-12-10 Initials KRL

Bridge Structure No. 50194059 Location Co. Hwy 114 on E. edge of Baltic

GPS coordinates: N43° 45.684' W96° 44.608' taken from: USL abutment _____ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 _____ NAD27 _____

Drainage area = 3064.78 sq. mi.

The average bottom of the main channel was 24.1 ft below top of guardrail at a point 80 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 33000			Q_{500} = 55400		
Estimated flow passing through bridge	33000			55400		
Estimated road overflow & overtopping	0			0		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		X				X
Chance of Pressure flow		X		X		~~X~~
Armored appearance to channel		X			X	
Lateral instability of channel	~~X~~		X			X

Riprap at abutments? _____Yes _____No __X__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 _____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) Bridge Deck
2) Looking Upstream
3) Looking Downstream
4) LOB
5) ROB
6) Piers
7) Left Abutment
8) Close up of Piers.
9) Right Abutment

Notes: Approach section is significantly smaller than bridge section. "expanded" main channel to include portion of ROB so Level 1.5 method can be used.

Summary of Results

	Q100	Q500
Bridge flow evaluated	33,000	55,400
Flow depth at left abutment (yaLT), in feet	1.75	6.6
Flow depth at right abutment (yaRT), in feet	~~1.50~~	~~6.05~~ 4.5 (est)
Contraction scour depth (ycs), in feet	~~10.6~~ 0.9	~~8.5~~ 3.9
Pier scour depth (yps), in feet	21.2	21.6
Left abutment scour depth (yas), in feet	7.2	17.9
Right abutment scour depth (yas), in feet	~~6.30~~	~~16.9~~ 14.1
1Flow angle of attack	22	22

See Comments/Diagram for justification where required