West Fork Vermillion River

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 44080025 Date 10/7/11 Initials GW Region (A B C D)

Site _____ Location ~½ mi N of Unityville on 438 Ave

Q10 ~~Q_{100}~~ = 1220 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 1006 (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 = 35 ft. Flow angle at bridge = 45 ° Abut. Skew = 30 ° Effective Skew = 15 °

Width (W_2) iteration = 35

Avg. flow depth at bridge, y_2 iteration = 8.5

Corrected channel width at bridge Section = W_2 times cos of flow angle = 33.81 ft* $q_2 = Q_2/W_2$ = 29.8 ft^2/s

Bridge Vel, V_2 = 3.9 ft/s Final $y_2 = q_2/V_2$ = 7.7 ft Δh = 0.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.0 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. = 7.7 ft

n (Channel) = 0.040

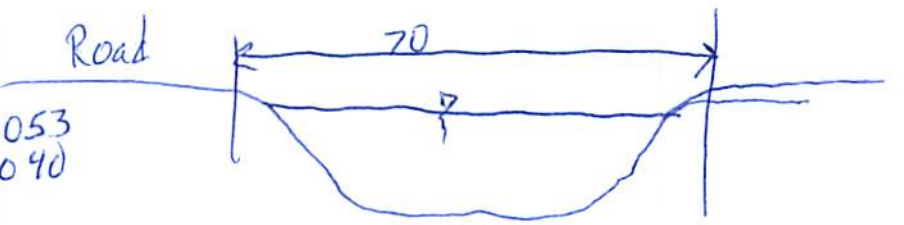
n (LOB) = ~~0.040~~ 0.053

n (ROB) = ~~0.053~~ 0.040

Pier Width = 1.34 ft

Pier Length = 1.34 ft

Piers for 100 yr = 1 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 70 ft

Width of left overbank flow at approach, W_{lob} = 0.0 ft Average left overbank flow depth, y_{lob} = 0.0 ft

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

Estimated bed material D_{50} = 0.40 ft Average approach velocity, $V_1 = Q_{100}/(y_1 W_1)$ = 1.4 ft/s

Critical approach velocity, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = 11.64 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.011 ft If $D_{50} >= D_{c50}$, χ = 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 = 0.25 Using pier width a on Figure 11, ξ = 5.9 Pier scour y_{ps} = 4.8 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0.0 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} = 0.0 and ψ_{RT} = 0.0

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

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 44080025 Date 10/7/11 Initials CM Region (A B C D)

Site _____ Location ~½ mi N of Unityville on 438 Ave

Q_{500} = 606 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 606 (should be Q_{500} unless there is a relief bridge, road overflow, or bridge overtopping)

Q5

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

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

Bridge Width = 35 ft. Flow angle at bridge = 45 ° Abut. Skew = 30 ° Effective Skew = 15 °

Width (W_2) iteration = 35

Avg. flow depth at bridge, y_2 iteration = 6.0 → Vert Wall

Corrected channel width at bridge Section = W_2 times cos of flow angle = 33.41 ft* $q_2 = Q_2/W_2$ = 17.9 ft^2/s

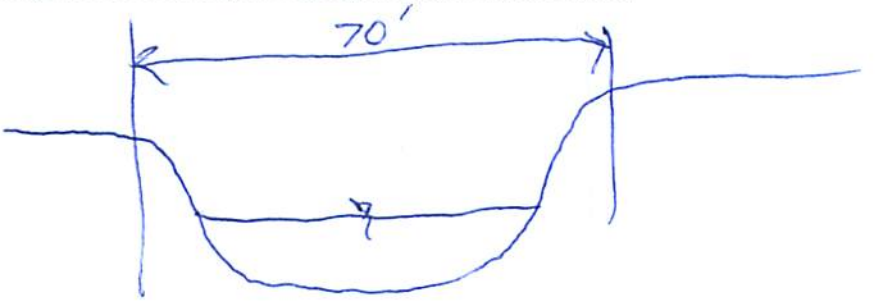
Bridge Vel, V_2 = 3.0 ft/s Final $y_2 = q_2/V_2$ = 6.0 ft Δh = 0.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 6.2 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. = 7.7 ft
n (Channel) = 0.040
n (LOB) = 0.053
n (ROB) = 0.040
Pier Width = 1.34 ft
Pier Length = 1.34 ft
Piers for 500 yr = 1 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 70 ft

Width of left overbank flow at approach, W_{lob} = 0.0 ft Average left overbank flow depth, y_{lob} = 0.0 ft

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

Estimated bed material D_{50} = 0.4 ft Average approach velocity, $V_1 = Q_{500}/(y_1W_1)$ = 1.4 ft/s

Critical approach velocity, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = 11.16 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.006 ft If $D_{50} >= D_{c50}$, $\chi = 0.0$

Otherwise, $\chi = 0.122y_1[q_2/(D_{50}^{1/3}y_1^{7/6})]^{6/7} - y_1$ = 0.0 From Figure 10, y_{cs} = 0.0 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 = 0.22 Using pier width a on Figure 11, ξ = 5.9 Pier scour y_{ps} = 4.7 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 0.0 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} = 0.0 and ψ_{RT} = 0.0

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

Route 436 Ave Stream W. Fk. Vermillion River MRM _____ Date 10/7/11 Initials CM

Bridge Structure No. 44080025 Location ~½ mi N of Unityville on 436 Ave

GPS coordinates: N 43° 48' 42.4" W 97° 26' 56.5" taken from: USL abutment X centerline of ↑↑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 119.75 sq. mi.

The average bottom of the main channel was 12.3 ft below top of guardrail at a point 11.0 ft from left abutment.

Method used to determine flood flows: ____Freq. Anal. ____drainage area ratio ✓ regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	~~Q100~~ Q10 = 1220			~~Q500~~ Q5 = 606		
Estimated flow passing through bridge	1006			606		
Estimated road overflow & overtopping	214					
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? X Yes ____No ____Don't know R, Abut

Debris Potential? ____High ____Med X 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

10/4/11

2	148
5	606
10	1220
25	2490
50	3850
100	5630
500	11700

- I believe entire channel bottom to be rip-rapped @ bridge
- Channel may be incised @ bridge
- lots of rip rap
- @ 1220cfs → flow over road to north

2036-1D
37-US
38-USRB
39-USLB
40-Under looking DS
41-R. Abut
42-R. Abut
43-Rip Rap @ DS opening
47-Scour @ R. Abut
48-US Face

Summary of Results

	~~Q100~~ 10	~~Q500~~ 5
Bridge flow evaluated	1006	606
Flow depth at left abutment (yaLT), in feet	0.0	0.0
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	4.8	4.7
Left abutment scour depth (yas), in feet	0.0	0.0
Right abutment scour depth (yas), in feet	0.0	0.0
1Flow angle of attack	15	15

See Comments/Diagram for justification where required