Cherry Creek

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 47644200 Date 10/28/11 Initials CW Region (A B C D)

Site _____ Location ~3.3mi N of Red owl Rd on Arapahoe Rd

10 Q_{100} = 18300 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 18300 (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 = 150 ft. Flow angle at bridge = 17 ° Abut. Skew = 0 ° Effective Skew = 17 °

Width (W_2) iteration = 150 113 120 117

Avg. flow depth at bridge, y_2 iteration = 13.7 15.9 15.5 15.7

Corrected channel width at bridge Section = W_2 times cos of flow angle = ~~113.15~~ 111.89 ft* $q_2 = Q_2/W_2$ = 163.6 ft²/s

Bridge Vel, V_2 = 10.4 ft/s Final $y_2 = q_2/V_2$ = 15.7 ft Δh = 2.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 17.9 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. = ~~21.4~~ 20.3 ft

n (Channel) = 0.045

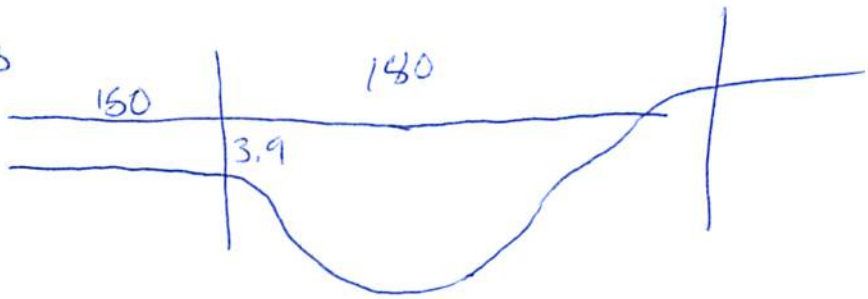
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 2.3 ft

Pier Length = 2.3 ft

Piers for 100 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = ~~160~~ 180 ft

Width of left overbank flow at approach, W_{lob} = 150 ft Average left overbank flow depth, y_{lob} = 3.9 ft

Width of right overbank flow at approach, W_{rob} = 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 = 15.09 From Figure 9 W_2 (effective) = 107.3 ft y_{cs} = 15.0 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, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = ____ 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 = 0.46 Using pier width a on Figure 11, ξ = 8.9 Pier scour y_{ps} = 7.9 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 3.9 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} = 13.1 and ψ_{RT} = 0.0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 13.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0.0 ft

2.75 2.50 4.25 25.00 4.25 21.35 20.3 17.9 2.4 20.3 1.2 19.1 4 5.4 1.2 3.9

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 47644200 Date 10/28/11 Initials CW Region (A B C D)

Site _____ Location About 3.3 m: N of Red Owl Rd on Arauca Rd

25

Q_{500} = 43200 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 38421 (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 = 150 ft. Flow angle at bridge = 17 ° Abut. Skew = 0 ° Effective Skew = 17 °

Width (W_2) iteration = 150

Avg. flow depth at bridge, y_2 iteration = 21.6 > 21.4 RD overflow

Corrected channel width at bridge Section = W_2 times cos of flow angle = 143.45 ft* $q_2 = Q_2/W_2$ = 267.8 ft^2/s

Bridge Vel, V_2 = 13.2 ft/s Final $y_2 = q_2/V_2$ = 20.3 ft Δh = 3.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 23.9 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. = ~~21.4~~ ft 20.3

n (Channel) = 0.045

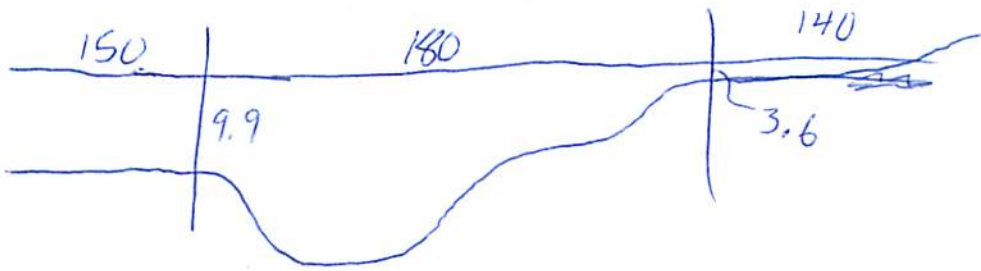
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 2.3 ft

Pier Length = 2.3 ft

Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = ~~160~~ ft 140

Width of left overbank flow at approach, W_{lob} = 150 ft Average left overbank flow depth, y_{lob} = 9.9 ft

Width of right overbank flow at approach, W_{rob} = 140 ft Average right overbank flow depth, y_{rob} = 1.8 ft 3.6

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

x = 16.48 From Figure 9 W_2 (effective) = 134.9 ft y_{cs} = 15.8 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, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = _____ 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 $D_{50} >= D_{c50}$, χ = 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 = 0.52 Using pier width a on Figure 11, ξ = 8.9 Pier scour y_{ps} = 8.1 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 9.9 ft right abutment, y_{aRT} = 1.8 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} = 21.3 and ψ_{RT} = 7.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 21.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 7.4 ft

Route Avana Rd Stream Cherry Ck MRM _____ Date 10/28/11 Initials CW

Bridge Structure No. 47644200 Location ~3.3 mi N of Red Owl Rd on Avana Rd

GPS coordinates: N 44° 44' 52.2" taken from: USL abutment X centerline of ⇑ MRM end _____

W 102° 16' 46.5" Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 796.86 sq. mi.

The average bottom of the main channel was 25.6 ft below top of guardrail at a point 53 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS 25

Flows 10	~~Q100~~ = 18300			~~Q500~~ = 43200		
Estimated flow passing through bridge		18300			38421	
Estimated road overflow & overtopping		—			4779	
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 ____No X Marginal Upper portion intact, lower washed away

Evidence of past Scour? X Yes ____No ____Don't know incised

Debris Potential? ____High X 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 X	Sand X	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

10/4/11

2	1970
5	8250
10	18300
25	43200
50	75100
100	123,000
500	333,000

Photos

2160-1D
61 - US
62 - US RB
63 - US LB
64 - L. Abut
65 - R. Abut
66 - Rip Rap on banks
67 - US Face
68 - RB App XS

Summary of Results

	~~Q100~~ 10	~~Q500~~ 25
Bridge flow evaluated	18300	38421
Flow depth at left abutment (yaLT), in feet	3.9	9.9
Flow depth at right abutment (yaRT), in feet	0.0	1.8
Contraction scour depth (ycs), in feet	15.0	15.8
Pier scour depth (yps), in feet	7.9	8.1
Left abutment scour depth (yas), in feet	13.1	21.3
Right abutment scour depth (yas), in feet	0.0	7.4
1Flow angle of attack	17	17

See Comments/Diagram for justification where required