OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 69150171 Date 8/10/11 Initials CW Region (A B C D)

Site _____ Location 9.25 mi NW of Jct of 224 Ave & 157 St

Q_{100} = 13400 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 13400 (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 = 185 ft. Flow angle at bridge = 30 ° Abut. Skew = 30 ° Effective Skew = 0 °

Width (W_2) iteration = 185 133 142 135 137

Avg. flow depth at bridge, y_2 iteration = 10.2 12.1 11.7 12 11.9

Corrected channel width at bridge Section = W_2 times cos of flow angle = 137 ft* $q_2 = Q_2/W_2$ = 97.8 ft^2/s

Bridge Vel, V_2 = 8.2 ft/s Final $y_2 = q_2/V_2$ = 11.9 ft Δh = 1.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 13.3 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. = _____ ft

n (Channel) = 0.035

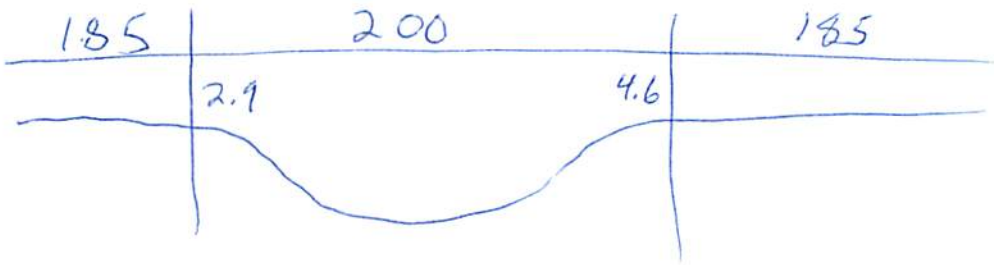
n (LOB) = 0.045

n (ROB) = 0.055

Pier Width = 3.0 ft

Pier Length = 3.0 ft

Piers for 100 yr = 7 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 200 ft

Width of left overbank flow at approach, W_{lob} = 185 ft Average left overbank flow depth, y_{lob} = 2.9 ft

Width of right overbank flow at approach, W_{rob} = 185 ft Average right overbank flow depth, y_{rob} = 4.6 ft

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

x = 10.2 From Figure 9 W_2 (effective) = 131 ft y_{cs} = 11.2 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ 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 = 0.42 Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 9.4 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 2.9 ft right abutment, y_{aRT} = 4.6 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} = 11.3 and ψ_{RT} = 14.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 11.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 14.3 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 69150171 Date 8/10/11 Initials CW Region (A B C D)

Site _____ Location 9.25 mi NW of [illegible] int of 224 Ave & 151 St

Q_{500} = 22800 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 22800 (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 = 185 ft. Flow angle at bridge = 30 ° Abut. Skew = 30 ° Effective Skew = 0 °

Width (W_2) iteration = 185 135 151 145 147

Avg. flow depth at bridge, y_2 iteration = 13.5 15.9 15.0 15.3 15.2

Corrected channel width at bridge Section = W_2 times cos of flow angle = 147 ft* $q_2 = Q_2/W_2$ = 155.1 ft^2/s

Bridge Vel, V_2 = 10.2 ft/s Final $y_2 = q_2/V_2$ = 15.2 ft Δh = 2.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 17.4 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. = _____ ft

Low Steel Elev. = _____ ft

n (Channel) = 0.035

n (LOB) = 0.045

n (ROB) = 0.055

Pier Width = 3.0 ft

Pier Length = 3.0 ft

Piers for 500 yr = 2 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 200 ft

Width of left overbank flow at approach, W_{lob} = 185 ft Average left overbank flow depth, y_{lob} = 7.0 ft

Width of right overbank flow at approach, W_{rob} = 185 ft Average right overbank flow depth, y_{rob} = 8.7 ft

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

x = 15.75 From Figure 9 W_2 (effective) = 141 ft y_{cs} = 15.4 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 $D_{50} >= D_{c50}$, $\chi = 0.0$

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 = 0.46 Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 9.5 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 7.0 ft right abutment, y_{aRT} = 8.7 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} = 18.6 and ψ_{RT} = 20.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 18.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 20.3 ft

Route Thunder Butte Rd Stream Thunder Butte Ck MRM _____ Date 8/10/11 Initials CW

Bridge Structure No. 69150171 Location 9.25 mi NW of nt of 224 Ave & 157 St

GPS coordinates: N45° 13' 31.2" W101° 42' 33.8" taken from: USL abutment____ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84____ NAD27____

Drainage area = 522.4 sq. mi.

The average bottom of the main channel was 25.2 ft below top of guardrail at a point 38 ft from left abutment.

Method used to determine flood flows: ___Freq. Anal. ___drainage area ratio ✓ regional regression equations.

Pk Calc'd on 8/8

PK	
2	660
5	2680
10	4660
25	7520
50	10300
100	13400
500	22800

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 13400			Q_{500} = 22800		
Estimated flow passing through bridge		13400			22500	
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? X Yes ____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 _____ ____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

1969 - US
70 - US RB
71 - US LB
72 - R. Abut
73 - L. Abut
74 - US Face
75 - US Face
76 - Scour

Summary of Results

	Q100	Q500
Bridge flow evaluated	13400	22800
Flow depth at left abutment (yaLT), in feet	2.9	7.0
Flow depth at right abutment (yaRT), in feet	4.6	9.1
Contraction scour depth (ycs), in feet	11.2	15.4
Pier scour depth (yps), in feet	9.4	9.5
Left abutment scour depth (yas), in feet	11.3	18.6
Right abutment scour depth (yas), in feet	14.3	20.3
1Flow angle of attack	0	0

See Comments/Diagram for justification where required