OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 32268030 Date 3/10/11 Initials CW Region (A (B) C D)

Site _____ Location 6.2 mi W of HWY 85 on FAS 6420

Q_{100} = 2720 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = ~~2720~~ 2193 (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

Bridge Width = 40 ft. Flow angle at bridge = 20 ° Abut. Skew = 0 ° Effective Skew = 20 °

Width (W_2) iteration = Vert Wall _____ _____

Avg. flow depth at bridge, y_2 iteration = _____ _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 37.59 ft* $q_2 = Q_2/W_2$ = 58.3 ft²/s

Bridge Vel, V_2 = 6.4 ft/s Final $y_2 = q_2/V_2$ = 9.1 ft Δh = 0.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9.9 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,

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

Water Surface Elev. = _____ ft

Low Steel Elev. = 9.1 ft

n (Channel) = 0.033

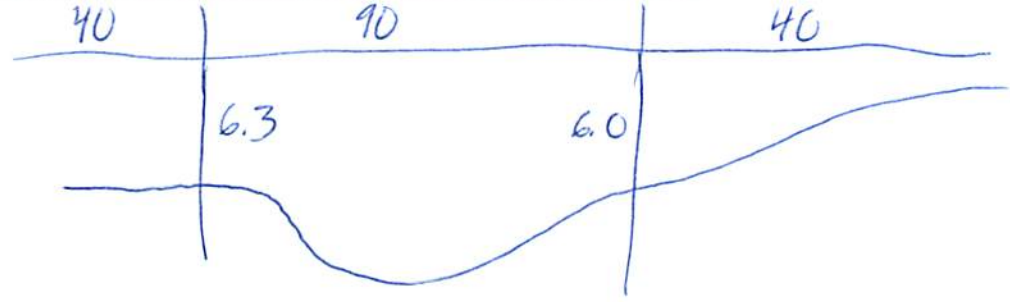
n (LOB) = 0.035

n (ROB) = 0.035

Pier Width = 0.9 ft

30? ft Pier Length = 0.9 ft

Piers for 100 yr = 1 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = ~~1000~~ 90 ft

Width of left overbank flow at approach, W_{lob} = 40 ft Average left overbank flow depth, y_{lob} = 6.3 ft

Width of right overbank flow at approach, W_{rob} = 40 ft Average right overbank flow depth, y_{rob} = 6.0 ft

6 × 2/3 = 4.0

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

x = 21.42 From Figure 9 W_2 (effective) = 36.7 ft y_{cs} = 16.4 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, $V_1 = Q_{100}/(y_1W_1)$ = _____ ft/s

Critical approach velocity, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = _____ 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, $\chi = 0.122y_1[q_2/(D_{50}^{1/3}y_1^{7/6})]^{6/7} - y_1$ = _____ From Figure 10, y_{cs} = _____ ft

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1.0

Froude # at bridge = 0.37 Using pier width a on Figure 11, ξ = 4.4 Pier scour y_{ps} = 3.8 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 6.3 ft right abutment, y_{aRT} = 4.0 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} = 17.3 and ψ_{RT} = 13.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 25.9 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 19.8 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 32268030 Date 8/10/11 Initials CW Region (A B C D)

Site _____ Location 6.2 mi W of HWY 85 on FAS 6420

Q_{50} = ~~Q_{500}~~ = 2080 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 2080 (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 = 20 ° Abut. Skew = 0 ° Effective Skew = 20 °

Width (W_2) iteration = Vert Wall

Avg. flow depth at bridge, y_2 iteration = _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 37.59 ft* $q_2 = Q_2/W_2$ = 55.3 ft^2/s

Bridge Vel, V_2 = 6.3 ft/s Final $y_2 = q_2/V_2$ = 8.9 ft Δh = 0.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9.6 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. = 9.1 ft

n (Channel) = 0.033

n (LOB) = 0.035

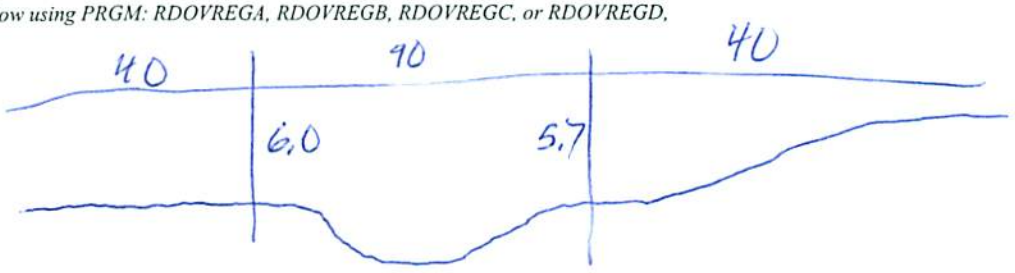
n (ROB) = 0.035

Pier Width = 0.9 ft

30ft ? Pier Length = 0.9 ft

Piers for ~~500 yr~~ = 1 ft

50



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 90 ft

Width of left overbank flow at approach, W_{lob} = 40 ft Average left overbank flow depth, y_{lob} = 6.0 ft

Width of right overbank flow at approach, W_{rob} = 40 ft Average right overbank flow depth, y_{rob} = 5.7 ft

5.7 x 2/3 = 3.7

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

x = 20.47 From Figure 9 W_2 (effective) = 36.7 ft y_{cs} = 17.9 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, $V_1 = Q_{500}/(y_1W_1)$ = _____ ft/s

Critical approach velocity, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = _____ 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, $\chi = 0.122y_1[q_2/(D_{50}^{1/3}y_1^{7/6})]^{6/7} - y_1$ = _____ From Figure 10, y_{cs} = _____ ft

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 1.0

Froude # at bridge = 0.37

Correction factor for flow angle of attack (from Table 1), K2 = 1.0

Using pier width a on Figure 11, ξ = 4.4 Pier scour y_{ps} = 3.4 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 6.0 ft right abutment, y_{aRT} = 3.7 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} = 16.8 and ψ_{RT} = 12.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 25.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 19.0 ft

3.60
0.66
3360
3360
3696

Route FAS 6420 Stream Crooked Ck MRM _____ Date 8/10/11 Initials CR

Bridge Structure No. 32268030 Location 6.2 mi W of HWY 85 on FAS 6420

GPS coordinates: N 45° 54' 24.1" W 103° 30' 11.1" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 32.53 sq. mi.

The average bottom of the main channel was 14.0 ft below top of guardrail at a point 15.0 ft from left abutment.

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

Flows calc'd on 8/8

Pk	Q
2	141 cfs
5	542
10	938
25	1520
50	2080
100	2720
500	4600

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 2720			~~Q_{500}~~ Q_{50} = 2080		
Estimated flow passing through bridge	2193			2080		
Estimated road overflow & overtopping	527					
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping	X		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

Evidence of past Scour? ____Yes X No ____Don't know

Debris Potential? ____High ____Med X Low

Does scour countermeasure(s) appear to have been designed?

Riprap	____Yes	X 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 ____	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

Pier could be modeled as continuous but I did individual piers.

See photos.

1447 - 1D

44 - US

49 - US RB

50 - US LB

51 - Pier config

52 - US Face bridge

Summary of Results

	Q100	~~Q500~~ Q50
Bridge flow evaluated	2193	2080
Flow depth at left abutment (yaLT), in feet	6.3	6.0
Flow depth at right abutment (yaRT), in feet	4.0	3.7
Contraction scour depth (ycs), in feet	18.4	17.9
Pier scour depth (yps), in feet	3.8	3.8
Left abutment scour depth (yas), in feet	25.9	25.1
Right abutment scour depth (yas), in feet	19.8	19.0
1Flow angle of attack	20	20

See Comments/Diagram for justification where required

64 10
2720
2193
527