OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 47378444 Date 8/11/11 Initials CW Region (A (B) C D)

Site ______ Location 5 mi NE of Hereford on New Underwood Rd

Q_{100} = 38100 by: drainage area ratio ___ flood freq. anal. ___ regional regression eq. ✓

Bridge discharge (Q_2) = 38100 (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 = 390 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 390 258 343 301 340 301 → 340

Avg. flow depth at bridge, y_2 iteration = 12.0 15.0 12.9 13.8 12.9 → 13.4

Corrected channel width at bridge Section = W_2 times cos of flow angle = ~~[struck out]~~ 334.83 ft* $q_2 = Q_2/W_2$ = 113.8 ft²/s

Bridge Vel, V_2 = 8.8 ft/s Final $y_2 = q_2/V_2$ = 12.9 ft Δh = 1.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 14.5 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. = ~~[struck out]~~ ft ~~[struck out]~~ 21.0

n (Channel) = 0.033

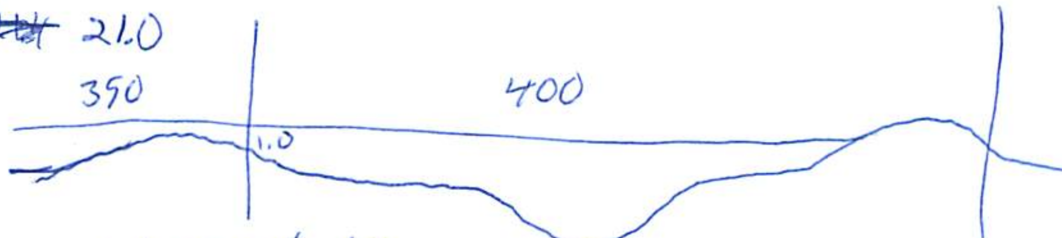
n (LOB) = 0.037

n (ROB) = 0.037

Pier Width = 3.0 ft

Pier Length = 3.0 ft

Piers for 100 yr = 4 ft



Different sized piers → just use largest or make equivalent?

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 400 ft

Width of left overbank flow at approach, W_{lob} = 390 ft Average left overbank flow depth, y_{lob} = 1.0 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 = ~~3.26~~ 3.65 From Figure 9 W_2 (effective) = ~~328~~ 322.4 ft y_{cs} = ~~4.0~~ 4.3 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

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 = 0.43 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} = 1.0 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} = 4.3 and ψ_{RT} = 0.0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 4.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0.0 ft

? 1.6 / 1.7 / 3.6 / 6.1   24.2 / 6.1 / 30.1   2.4 / 1.5 / 5.1   6.6 / 2.4 / 9.0

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 47378444 Date 8/11/11 Initials Cw Region (A (B) C D)

Site ______ Location 5 mi NE of Hereford on New Underwood Rd

Q_{500} = 98000 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 94000 (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 = 390 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 390 ____ ____ ____

Avg. flow depth at bridge, y_2 iteration = 19.8 → Vert Wall ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 384.08 ft* $q_2 = Q_2/W_2$ = 255.2 ft²/s

Bridge Vel, V_2 = 12.9 ft/s Final $y_2 = q_2/V_2$ = 19.8 ft Δh = 3.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 23.2 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. = ~~[illegible]~~ 210 ft
n (Channel) = 0.033
n (LOB) = 0.037
n (ROB) = 0.037
Pier Width = 3.0 ft
Pier Length = 3.0 ft
\# Piers for 500 yr = 4 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 400 ft

Width of left overbank flow at approach, W_{lob} = 390 ft Average left overbank flow depth, y_{lob} = 9.0 ft

Width of right overbank flow at approach, W_{rob} = 390 ft Average right overbank flow depth, y_{rob} = 7.8 ft

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

x = 9.74 From Figure 9 W_2 (effective) = 372.1 ft y_{cs} = 10.7 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

PIER SCOUR CALCULATIONS

PGRM: Pie

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

Froude # at bridge = 0.51 Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 9.7 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

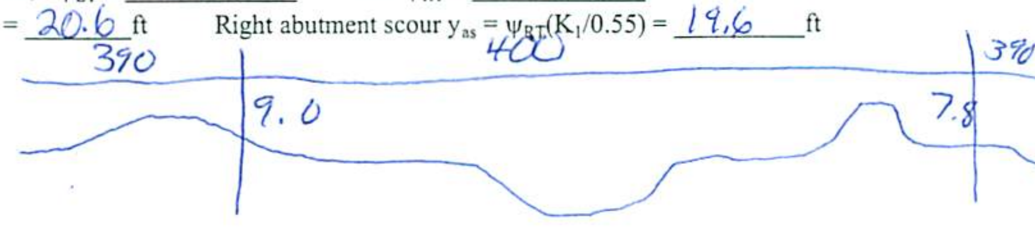
Average flow depth blocked by: left abutment, y_{aLT} = 9.0 ft right abutment, y_{aRT} = 7.8 ft

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} = 20.6 and ψ_{RT} = 19.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 20.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 19.6 ft

9.2 / 23.2 / 14.5 / 6.1



Route New Underwood Rd Stream West Elm Ck MRM________ Date 8/11/11 Initials Cn

Bridge Structure No. 47398444 Location 5 mi NE of Hereford on New Underwood Rd

GPS coordinates: N 44°23'54.7" W102°48'31.2" taken from: USL abutment X centerline of ⇑ MRM end ______

Datum of coordinates: WGS84 X NAD27_____

Drainage area = 392 sq. mi.

The average bottom of the main channel was 28.2 ft below top of guardrail at a point 137 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 38100			Q_{500} = 98000		
Estimated flow passing through bridge	38100			98000		
Estimated road overflow & overtopping	—			—		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		X				X
Chance of Pressure flow		X		~~[illegible]~~		X
Armored appearance to channel		X			X	
Lateral instability of channel		X			X	

Pk Calc'd 8/8

Pk	
2	706
5	2870
10	6200
25	14100
50	23800
100	38100
500	94000

Riprap at abutments? ____Yes X No ____Marginal

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

Debris Potential? ____High X Med ____Low

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

Riprap ____Yes ____No ____Don't know X NA

Spur Dike X Yes ____No ____Don't know X NA

Other ______________ ____Yes ____No ____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

2 sizes of Piers → larger used to calc scour small diam = 1.0 !

Photos
1882 - ID
83 - US
84 - US RB & Spur dike
85 - US LB
86 - LB Spur Dike
87 - LB Spur Dike
88 - R. Abut
89 - L. Abut
90 - US Face
91 - US Face

Summary of Results

	Q100	Q500
Bridge flow evaluated	38100	98000
Flow depth at left abutment (yaLT), in feet	1.0	9.0
Flow depth at right abutment (yaRT), in feet	0.0	7.8
Contraction scour depth (ycs), in feet	4.3	10.7
Pier scour depth (yps), in feet	9.4	9.7
Left abutment scour depth (yas), in feet	4.3	20.6
Right abutment scour depth (yas), in feet	0.0	19.6
1Flow angle of attack	10	10

See Comments/Diagram for justification where required