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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 29256060 Date 10-11-12 Initials RFT Region (A B (C) D)

Site ______ Location 2.5 mi E Castlewood on 184th St

Q_{100} = 10400 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 10400 (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 = 93 ft. Flow angle at bridge = 24 ° Abut. Skew = 0 ° Effective Skew = 24 °

Width (W_2) iteration = 93 ____ ____ ____

Avg. flow depth at bridge, y_2 iteration = 15.6 ____ ____ ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 84.96 ft* $q_2 = Q_2/W_2$ = 122.4 ft^2/s

Bridge Vel, V_2 = 7.8 ft/s Final $y_2 = q_2/V_2$ = 15.6 ft Δh = 1.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 16.9 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.

road overflow will begin at approximately y_2 = 17.6

Water Surface Elev. = 3.9 ft

Low Steel Elev. = 11.8 ft

n (Channel) = .035

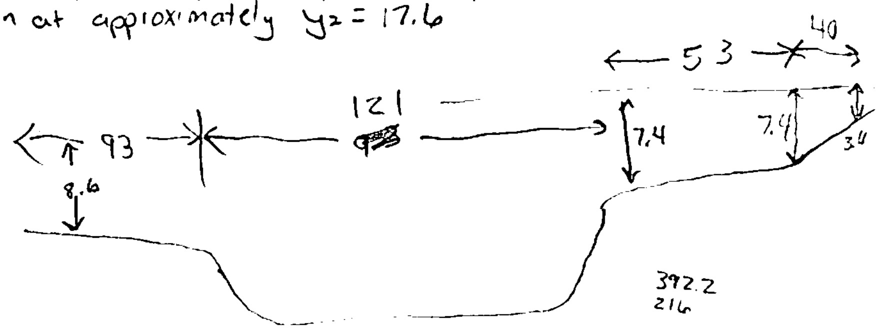
n (LOB) = .035

n (ROB) = .035

Pier Width = NA ft

Pier Length = NA ft

Piers for 100 yr = 0 ft



2.3

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 121 ft

Width of left overbank flow at approach, W_{lob} = 93 ft Average left overbank flow depth, y_{lob} = 6.5 ft

Width of right overbank flow at approach, W_{rob} = 93 ft Average right overbank flow depth, y_{rob} = 8.6 ft

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

x = 16.93 From Figure 9 W_2 (effective) = 85 ft y_{cs} = 16.0 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, $V_1 = Q_{100}/(y_1W_1)$ = ____ ft/s

Critical approach velocity, $V_c = 11.17y_1^{1/6}D_{50}^{1/3}$ = ____ 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 = ____ Correction factor for flow angle of attack (from Table 1), K2 = ____

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

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 6.5 ft right abutment, y_{aRT} = 8.6 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} = 17.7 and ψ_{RT} = 20.2

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 17.7 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 20.2 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 29256060 Date ____ Initials ____ Region (A B (C) D)

Site ____ Location ____

Q_{500} = 18400 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 13240 (should be Q_{500} unless there is a relief bridge, road overflow, or bridge overtopping)

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

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

Bridge Width = 93 ft. Flow angle at bridge = 24 ° Abut. Skew = 0 ° Effective Skew = 24 °

Width (W_2) iteration = 93 ____ ____ ____

Avg. flow depth at bridge, y_2 iteration = 17.6 ____ ____ ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 84.96 ft* $q_2 = Q_2/W_2$ = 155.8 ft^2/s

Bridge Vel, V_2 = 8.9 ft/s Final $y_2 = q_2/V_2$ = 17.6 ft Δh = 1.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 19.2 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,

road overflow will occur at $y_2 \geq 17.6$ assume this is also Qmax scour

Water Surface Elev. = 3.9 ft

Low Steel Elev. = 11.8 ft

n (Channel) = .035

n (LOB) = .035

n (ROB) = .035

Pier Width = NA ft

Pier Length = NA ft

\# Piers for 500 yr = 0 ft

514.1
308

PGRM: Contract

CONTRACTION SCOUR

Width of main channel at approach section W_1 = 121 ft

Width of left overbank flow at approach, W_{lob} = 93 ft Average left overbank flow depth, y_{lob} = 8.8 ft

Width of right overbank flow at approach, W_{rob} = 93 ft Average right overbank flow depth, y_{rob} = 10.9 ft

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

x = 22.05 From Figure 9 W_2 (effective) = 85 ft y_{cs} = 18.8 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, $V_c = 11.17 y_1^{1/6} D_{50}^{1/3}$ = ____ 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 = ____ Correction factor for flow angle of attack (from Table 1), K2 = ____

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

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 8.8 ft right abutment, y_{aRT} = 10.9 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} = 20.4 and ψ_{RT} = 22.1

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 20.4 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 22.1 ft

Route 184 St Stream Stray Horse Ck MRM ______ Date ______ Initials ______

Bridge Structure No. 29256060 Location ______

GPS coordinates: N 44°43.055' taken from: USL abutment ✓ centerline of ⇑ MRM end ______

W 96° 58.390' Datum of coordinates: WGS84 ✓ NAD27 ______

Drainage area = 79.69 sq. mi.

The average bottom of the main channel was 19.8 ft below top of guardrail at a point 29 ft from left abutment.

Method used to determine flood flows: ____Freq. Anal. ✓ drainage area ratio ____regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 10400			Q_{500} = 18400		
Estimated flow passing through bridge	10400			13240		
Estimated road overflow & overtopping	0			5160		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		✓		✓		
Chance of Pressure flow	✓			✓		
Armored appearance to channel		✓			✓	
Lateral instability of channel		✓			✓	

Riprap at abutments? ✓ Yes ____No ____Marginal

Evidence of past Scour? ✓ Yes ____No ____Don't know scour pool under/at bridge

Debris Potential? ____High ____Med ✓ Low

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

Riprap ____Yes ____No ✓ Don't know ____NA

Spur Dike ____Yes ____No ____Don't know ✓ NA

Other ________ ____Yes ____No ____Don't know ✓ NA

some quartzite and some field stone. Fabric is also present, although not covered with rock

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

Str. no.
approach from bridge
LOB from bridge
ROB from bridge
bridge from approach
left abut.
rt. abut.
erosion fabric on left abut.

Summary of Results

	Q100	Q500 max scour
Bridge flow evaluated	10400	13240
Flow depth at left abutment (yaLT), in feet	6.5	8.8
Flow depth at right abutment (yaRT), in feet	8.6	10.9
Contraction scour depth (ycs), in feet	16.0	18.8
Pier scour depth (yps), in feet	NA	NA
Left abutment scour depth (yas), in feet	17.7	20.4
Right abutment scour depth (yas), in feet	20.2	22.1
1Flow angle of attack	24°	24°

See Comments/Diagram for justification where required