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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 680.3001A Date 6/9/12 Initials LaT Region (A B C D)

Site _____ Location 6.1 S of Nemo on 431 Ave

Q_{100} = Qzs 49000 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 49000 (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 = 378 ft. Flow angle at bridge = 25 Abut. Skew = 0 ° Effective Skew = 25°

Width (W_2) iteration = _____ _____ _____ _____

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

Corrected channel width at bridge Section = W_2 times cos of flow angle = 342.58 ft* $q_2 = Q_2/W_2$ = 143 ft^2/s

Bridge Vel, V_2 = 8.5 ft/s Final $y_2 = q_2/V_2$ = 16.9 ft Δh = 1.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 18.3 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. = 0.6 ft 21 22.3 5.4 16.9

Low Steel Elev. = 16.9 ft

n (Channel) = 0.035 0.040

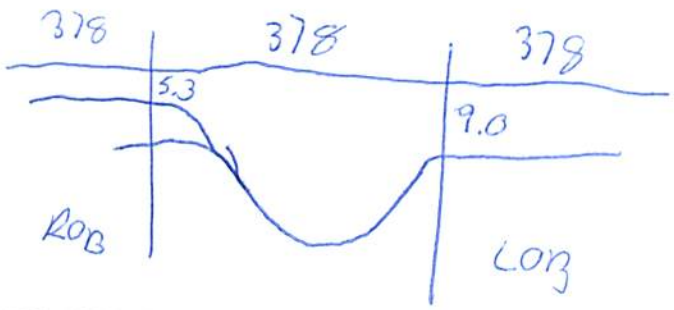
n (LOB) = 0.030

n (ROB) = 0.035

Pier Width = 2.2 ft

Pier Length = 2.5 ft

Piers for 100 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 378 ft

Width of left overbank flow at approach, W_{lob} = 378 ft Average left overbank flow depth, y_{lob} = 9.0 ft

Width of right overbank flow at approach, W_{rob} = 378 ft Average right overbank flow depth, y_{rob} = 5.3 ft

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

x = 13.89 From Figure 9 W_2 (effective) = 333.8 ft y_{cs} = 14.4 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ 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 = 1.14 Correction factor for flow angle of attack (from Table 1), K2 = 1.03

Froude # at bridge = 0.36 Using pier width a on Figure 11, ξ = 8.6 Pier scour y_{ps} = 7.6 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 9.0 ft right abutment, y_{aRT} = 5.3 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} = 15.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 20.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 15.6 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 68030018 Date 6/9/12 Initials RAT Region (A B C D)

Site _____ Location 6.1 S of Menno on 431 & Ave

Q_{500} = Q500 83500 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 47834 49224 (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 = 374 ft. Flow angle at bridge = 25 ° Abut. Skew = 0 ° Effective Skew = 25 °

Width (W_2) iteration = _____ _____ _____ _____

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

Corrected channel width at bridge Section = W_2 times cos of flow angle = 312.58 ft* $q_2 = Q_2/W_2$ = 143.7 ft²/s

Bridge Vel, V_2 = 6.5 ft/s Final $y_2 = q_2/V_2$ = 16.9 ft Δh = 1.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 18.4 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. = 0-60 ft

Low Steel Elev. = 16.9 ft

n (Channel) = 0.040

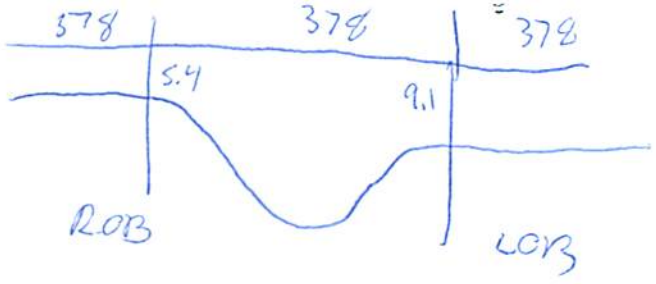
n (LOB) = 0.030

n (ROB) = 0.035

Pier Width = 2.2 ft

Pier Length = 2.5 ft

Piers for 500 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 378 ft

Width of left overbank flow at approach, W_{lob} = 378 ft Average left overbank flow depth, y_{lob} = 9.1 ft

Width of right overbank flow at approach, W_{rob} = 378 ft Average right overbank flow depth, y_{rob} = 5.4 ft

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

x = 14.12 From Figure 9 W_2 (effective) = 333.8 ft y_{cs} = 14.5 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

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 1.14 Correction factor for flow angle of attack (from Table 1), K2 = 1.03

Froude # at bridge = 0.36 Using pier width a on Figure 11, ξ = 9.6 Pier scour y_{ps} = 7.6 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 9.1 ft right abutment, y_{aRT} = 5.4 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} = 15.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 20.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 15.7 ft

Route 431 Ave Stream James River MRM _____ Date 6/9/12 Initials RaT

Bridge Structure No. 68030018 Location 6.1 S of Menno on 431 Ave

GPS coordinates: N 43° 01' 42.81" W 97° 34' 36.41" taken from: USL abutment X centerline of ↑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 18756.4 sq. mi.

The average bottom of the main channel was 22.3 ft below top of guardrail at a point 313 ft from left abutment.

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

5/22

2	1730
5	8860
10	20500
25	49000
50	83500
100	133000
500	329000

MISCELLANEOUS CONSIDERATIONS

Flows	~~Q_{100}~~ Q_{25} = 49000			~~Q_{500}~~ Q_{50} = 83509		
Estimated flow passing through bridge	49000			49221		
Estimated road overflow & overtopping	0			34279		
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 contraction pier

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	X No	____Don't know	____NA
Other _____	____Yes	X 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

1). main channel
2). right OB
3). left OB is more
4). piers
5). right abutment
6-7) left abutment
8). pier scour
9). right abutment
10). main channel
11). left OB
12). left OB

Summary of Results

	~~Q100~~ Q_{25}	~~Q500~~ Q_{50}
Bridge flow evaluated	49000	49221
Flow depth at left abutment (yaLT), in feet	9.0	9.1
Flow depth at right abutment (yaRT), in feet	5.3	5.4
Contraction scour depth (ycs), in feet	14.4	14.5
Pier scour depth (yps), in feet	7.6	7.6
Left abutment scour depth (yas), in feet	20.6	20.6
Right abutment scour depth (yas), in feet	15.6	15.7
1Flow angle of attack	25	25

See Comments/Diagram for justification where required