Grand River

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 16149190 Date 10/29/11 Initials CL Region (A (B) C D)

Site ______ Location On 222 Ave? S of Morristown

Q_{100} = 41,100 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 41100 (should be Q_{100} 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 = 175 ft. Flow angle at bridge = 3 ° Abut. Skew = 0 ° Effective Skew = 3 °

Width (W_2) iteration = 175 172 ____ ____

Avg. flow depth at bridge, y_2 iteration = 19.0 19.1 ____ ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 171.76 ft* $q_2 = Q_2/W_2$ = 239.3 ft²/s

Bridge Vel, V_2 = 12.5 ft/s Final $y_2 = q_2/V_2$ = 19.1 ft Δh = 3.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 22.4 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. = 20.9 ft

n (Channel) = 0.043

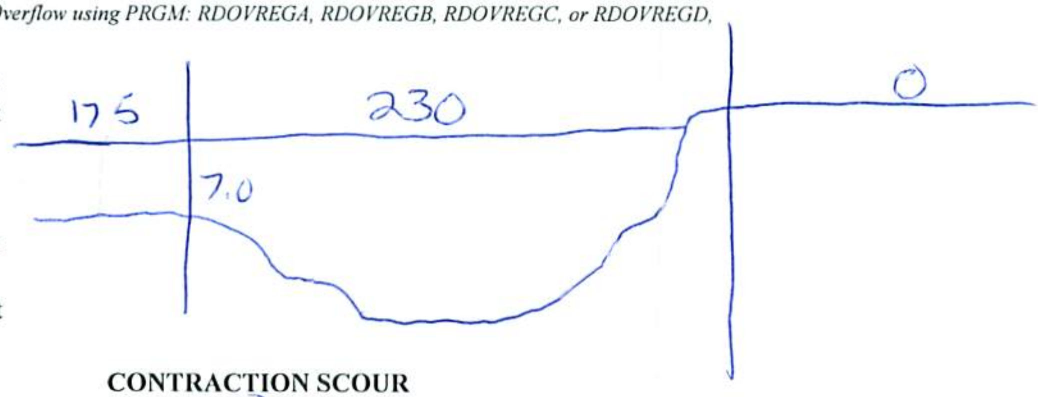
n (LOB) = 0.050

n (ROB) = 0.035

Pier Width = 2.4 ft

Pier Length = 23 ft

\# Piers for 100 yr = 2 ft



PGRM: Contract

CONTRACTION SCOUR

Width of main channel at approach section W_1 = 230 ft

Width of left overbank flow at approach, W_{lob} = 175 ft Average left overbank flow depth, y_{lob} = 7.0 ft

Width of right overbank flow at approach, W_{rob} = 0 ft Average right overbank flow depth, y_{rob} = 0 ft

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

x = 11.36 From Figure 9 W_2 (effective) = 167 ft y_{cs} = 12.4 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, $V_c = 11.17y_1^{1/6}D_{50}^{1/3}$ = ____ 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

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 9.58 Correction factor for flow angle of attack (from Table 1), K2 = ~1.4

Froude # at bridge = 0.5 Using pier width a on Figure 11, ξ = 9.2 Pier scour y_{ps} = 11.7 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 7.0 ft right abutment, y_{aRT} = 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} = 18.6 and ψ_{RT} = 0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 18.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 16149190 Date ~~[scribbled out]~~ 10/28/11 Initials CW Region (A (B) C D)

Site ______________ Location On 222 Ave? S of Morristown

Q_{500} = 66300 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 49470 (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 = 175 ft. Flow angle at bridge = 3 ° Abut. Skew = 0 ° Effective Skew = 3 °

Width (W_2) iteration = 175 ____ ____ ____

Avg. flow depth at bridge, y_2 iteration = 24.4 → RD Overflow ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 174.76 ft* $q_2 = Q_2/W_2$ = 283.1 ft^2/s

Bridge Vel, V_2 = 13.5 ft/s Final $y_2 = q_2/V_2$ = 20.9 ft Δh = 3.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 24.7 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. = 20.9 ft

n (Channel) = 0.043

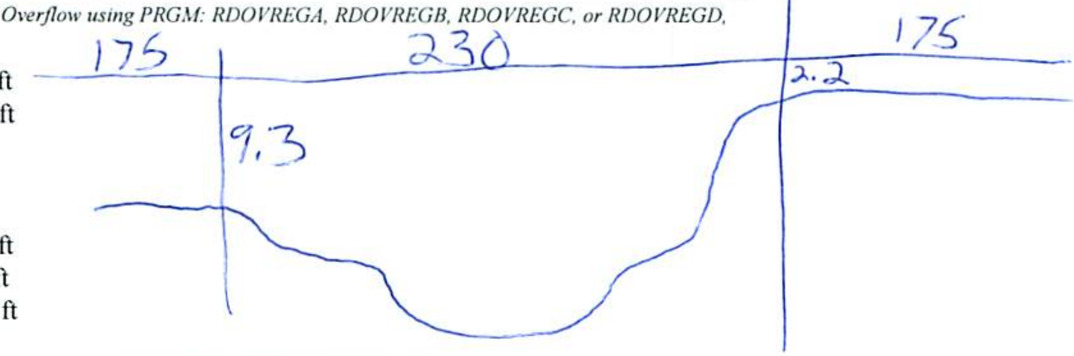
n (LOB) = 0.050

n (ROB) = 0.045

Pier Width = 2.4 ft

Pier Length = 23 ft

\# Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 230 ft

Width of left overbank flow at approach, W_{lob} = 175 ft Average left overbank flow depth, y_{lob} = 9.3 ft

Width of right overbank flow at approach, W_{rob} = 175 ft Average right overbank flow depth, y_{rob} = 2.2 ft

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

x = 13.45 From Figure 9 W_2 (effective) = 170 ft y_{cs} = 14.2 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, $V_1 = Q_{500}/(y_1 W_1)$ = ____ 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: Pier

L/a ratio = 9.58 Correction factor for flow angle of attack (from Table 1), K2 = 1.4

Froude # at bridge = 1.65 Using pier width a on Figure 11, ξ = 9.2 Pier scour y_{ps} = 13.9 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 9.3 ft right abutment, y_{aRT} = 2.2 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} = 20.8 and ψ_{RT} = 9.0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 20.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 9.0 ft

Route 222 Ave ? Stream Grand River MRM Date 10/29/11 Initials CW

Bridge Structure No. 16149190 Location On 222 Ave? S of Morristown

GPS coordinates: N45° 40' 32.8" W101° 41' 50.7" taken from: USL abutment X centerline of ⇑ MRM end ___

Datum of coordinates: WGS84 X NAD27 ___

Drainage area = 3947.9 sq. mi.

The average bottom of the main channel was 25.6 ft below top of guardrail at a point 46 ft from left abutment.

Method used to determine flood flows: ___ Freq. Anal. ___ drainage area ratio ✓ regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 41100			Q_{500} = 66300		
Estimated flow passing through bridge	41100			49470		
Estimated road overflow & overtopping	—			16830		
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? X Yes ___ No ___ Marginal Concrete lined channel / not riprap

Evidence of past Scour? ___ Yes ___ No X Don't know Banks up and downstream not @ bridge

Debris Potential? ___ High X Med ___ Low

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

Riprap X Yes ___ 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 X	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

10/4/11

2	2780
5	8690
10	15100
25	23,800
50	32,100
100	41,100
500	66,300

Photos
2180-1D
81-US
82-USRB
83-USLB
84-L. Abut
85 R. Abut
86-US Face
87-LB App XS
88-RB App XS

Summary of Results

	Q100	Q500
Bridge flow evaluated	41100	49470
Flow depth at left abutment (yaLT), in feet	7.0	9.3
Flow depth at right abutment (yaRT), in feet	0.0	2.2
Contraction scour depth (ycs), in feet	12.4	~~13.4~~ 14.2
Pier scour depth (yps), in feet	11.7	13.9
Left abutment scour depth (yas), in feet	18.6	20.8
Right abutment scour depth (yas), in feet	0.0	9.0
1Flow angle of attack	3.	3

See Comments/Diagram for justification where required