## SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 26019100 Date 10-12-11 Initials RT Region ( A B (C) D )

Site BSR nr Florence Location From Milbank, 25, 27 W

$Q_{100}$ = 2360 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge ($Q_2$) = 2350 (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 = 50.8 ft. Flow angle at bridge = 20 ° Abut. Skew = 0 ° Effective Skew = 20 °

Width ($W_2$) iteration = 47.7 ____ ____ ____

Avg. flow depth at bridge, $y_2$ iteration = 9.9 ____ ____ ____ ____

Corrected channel width at bridge Section = $W_2$ times cos of flow angle = 47.7 ft* $q_2 = Q_2/W_2$ = 49.2 $ft^2/s$

Bridge Vel, $V_2$ = 5.0 ft/s Final $y_2 = q_2/V_2$ = 9.9 ft $\Delta h$ = 10.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10.4 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. = 0,85 ft

Low Steel Elev. = 8.9 ft

n (Channel) = .027

n (LOB) = .028

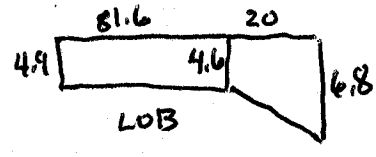
n (ROB) = .028

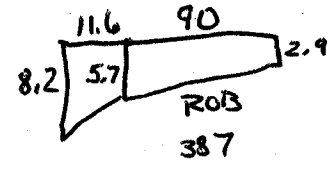
Pier Width = 1.35 ft

Pier Length = 1.35 ft

# Piers for 100 yr = 2 ft

Bridge will probably not quite pass $Q_{100}$. Estimated Qmax scour will occur at verge of road overflow or 9.6' ($Q_{100} \approx 9.9'$)




### CONTRACTION SCOUR

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PGRM: Contract

Width of main channel at approach section $W_1$ = 72 ft

Width of left overbank flow at approach, $W_{lob}$ = 101.6 ft Average left overbank flow depth, $y_{lob}$ = 4.9 ft

Width of right overbank flow at approach, $W_{rob}$ = 101.6 ft Average right overbank flow depth, $y_{rob}$ = 4.6 ft

2 x bridge length

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

x = 18.5 From Figure 9 $W_2$ (effective) = 45 ft $y_{cs}$ = 16.9 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, $V_1 = Q_{100}/(y_1 W_1)$ = ____ 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

### PIER SCOUR CALCULATIONS

PGRM: Pier

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

Froude # at bridge = 0.28 Using pier width a on Figure 11, $\xi$ = 6 Pier scour $y_{ps}$ = 4.9 ft

### ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, $y_{aLT}$ = 4.9 ft right abutment, $y_{aRT}$ = 4.6 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, $\psi_{LT}$ = 14.8 and $\psi_{RT}$ = 14.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 22.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 21.3 ft

## SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 26019100 Date _____ Initials _____ Region ( A B C D )

Site _____ Location _____

$Q_{500}$ = _____ by: drainage area ratio _____ flood freq. anal. _____ regional regression eq. _____

Bridge discharge ($Q_2$) = _____ (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 = 50.8 ft. Flow angle at bridge = _____° Abut. Skew = _____° Effective Skew = _____°

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 = _____ft* $q_2 = Q_2/W_2$ = _____$ft^2/s$

Bridge Vel, $V_2$ = _____ft/s Final $y_2 = q_2/V_2$ = _____ft $\Delta h$ = _____ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = _____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. = _____ ft
n (Channel) = _____
n (LOB) = _____
n (ROB) = _____
Pier Width = _____ ft
Pier Length = _____ ft
# Piers for 500 yr = _____ ft

Qmax scour ≤ $Q_{100}$
see top sheet

### CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section $W_1$ = _____ft

Width of left overbank flow at approach, $W_{lob}$ = _____ft Average left overbank flow depth, $y_{lob}$ = _____ft

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

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

$x$ = _____ From Figure 9 $W_2$ (effective) = _____ft $y_{cs}$ = _____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

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, $\xi$ = _____ Pier scour $y_{ps}$ = _____ft

PGRM: Abutment

### ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, $y_{aLT}$ = _____ft right abutment, $y_{aRT}$ = _____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, $\psi_{LT}$ = _____ and $\psi_{RT}$ = _____

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

Route 152 St Stream Big Sioux River MRM ____ Date ____ Initials ____

Bridge Structure No. 26019100 Location 25, 27 W from Milbank

GPS coordinates: N 45° 10.85[81] taken from: USL abutment ✓ centerline of ⇑ MRM end ____

W 97° 11.[175] Datum of coordinates: WGS84 ✓ NAD27 ____

Drainage area = 68.25 sq. mi.

The average bottom of the main channel was 13.5 ft below top of guardrail at a point 8.4 ft from left abutment.

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

## MISCELLANEOUS CONSIDERATIONS

| Flows | $Q_{100}$ = 2360 | | | $Q_{500}$ = 3830 | | |
|---|---|---|---|---|---|---|
| Estimated flow passing through bridge | 2350 | | | | | |
| Estimated road overflow & overtopping | 10 | | | | | |
| 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

Debris Potential? ____High ____Med ✓Low

Scour pool under bridge. very little pier scour. small cobbles have been dumped near end of wingwalls.

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 |

Bed Material Classification Based on Median Particle Size ($D_{50}$)

| Material | Silt/Clay____ | 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

~~Bridge~~ road overflow may begin at a lower stage than estimated, but it is at a point too far east of bridge to "see" with hand level

Photos

Structure number
looking upstream from bridge
LOB from bridge
ROB from bridge
Bridge from left approach
cobbles at USL wingwall

Summary of Results

| | Q100 | Q500 |
|---|---|---|
| Bridge flow evaluated | 2350 | |
| Flow depth at left abutment (yaLT), in feet | 4.9 | |
| Flow depth at right abutment (yaRT), in feet | 4.6 | |
| Contraction scour depth (ycs), in feet | 16.9 | |
| Pier scour depth (yps), in feet | 4.9 | |
| Left abutment scour depth (yas), in feet | 22.1 | |
| Right abutment scour depth (yas), in feet | 21.3 | |
| 1Flow angle of attack | 20° | |

See Comments/Diagram for justification where required

Basin characteristics from Provisional StreamStats 10-7-11

Cont. D.A. = 68.25

PII = 0.93

100% Subregion A

Manually Calculated Peaks

$Q_{100}$ = 2360 cfs

$Q_{500}$ = 3830 cfs