SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 58049160 Date 10-11-11 Initials RT Region (A B C (D))

Site ______ Location 1.3 mi NW Athol on 164th St

Q_{100} = 22,100 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 9000 (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 = 118 ft. Flow angle at bridge = 15 ° Abut. Skew = 17 ° Effective Skew = 15 °

Width (W_2) iteration = 114 ____ ____ ____

Avg. flow depth at bridge, y_2 iteration = 18.3 ____ ____ ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 114 ft* $q_2 = Q_2/W_2$ = 79 ft^2/s

Bridge Vel, V_2 = 4.3 ft/s Final $y_2 = q_2/V_2$ = 18.3 ft Δh = 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 18.7 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,

too deep to wade to piers - diam estimated

Water Surface Elev. = 3.8 ft

Low Steel Elev. = 15.6 ft

n (Channel) = .025 smooth, muddy

n (LOB) = .027 tall ungrazed grass

n (ROB) = .028 corn field

Pier Width = 2.25 ft

Pier Length = 2.25 ft

\# Piers for 100 yr = 2 ft

Bridge will not pass Q_{100}. Road overflow will begin at approximately 17.2 ft. Assume Qmax scour occurs at 18.0 ft and is approximately 9000cfs

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 118 ft

Width of left overbank flow at approach, W_{lob} = 5 ft Average left overbank flow depth, y_{lob} = 3.8 - 1.9 = 1.9 ft

Width of right overbank flow at approach, W_{rob} = 5 ft Average right overbank flow depth, y_{rob} = 6.8 + 1 = 7.8 ft

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

x = 0.93 From Figure 9 W_2 (effective) = 113.5 ft y_{cs} = 1.4 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, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = ______ 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.

NA

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = ______ 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 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.18 Using pier width a on Figure 11, ξ = 8.8 Pier scour y_{ps} = 6.8 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 1.9 ft right abutment, y_{aRT} = 6.8 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} = 7.8 and ψ_{RT} = 18.2

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 7.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 18.2 ft

left bank is high and almost level with roadway
overbank lengths will be small because of overtopping

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 58049160 Date ______ Initials ______ Region (A B C (D))

Site ______ Location ______

Q_{500} = 49,500 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)

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

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

Bridge Width = ____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 Δh = ____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

Bridge will not pass Q_{100}. See top sheet for evaluation at approx. Q_{max} scour.

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

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} = ____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, ψ_{LT} = ____ and ψ_{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 164th St Stream S. Fork Snake MRM ______ Date ______ Initials ______

Bridge Structure No. 58049160 Location 1.3 mi NW from Athol on 164th St

GPS coordinates N 45° 00.827' W 98° 37.029' taken from: USL abutment ____ ✓ centerline of ⇑ MRM end ____

Datum of coordinates: WGS84 ✓ NAD27 ____

Drainage area = 1415.94 (cont.) sq. mi.

The average bottom of the main channel was 20.1 ft below top of guardrail at a point 28 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 22,100			Q_{500} = 49,500		
Estimated flow passing through bridge	9000					
Estimated road overflow & overtopping	13,100					
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 at abutments (see photos)

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

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

Abutment scour is probably overestimated because of road overflow beginning at bridge.

Photos
structure number
approach section from bridge
bridge section from Left approach
left overbank
right overbank
left abutment under bridge

Summary of Results

	Q100	Q500
Bridge flow evaluated	9000	
Flow depth at left abutment (yaLT), in feet	1.9	~~[illegible]~~
Flow depth at right abutment (yaRT), in feet	6.8	
Contraction scour depth (ycs), in feet	1.4	
Pier scour depth (yps), in feet	6.8	
Left abutment scour depth (yas), in feet	7.8	
Right abutment scour depth (yas), in feet	18.2	
1Flow angle of attack	15°	

See Comments/Diagram for justification where required

Basin characteristics from provisional StreamStats (10-7-11)

Cont. D.A. = 1415.94 mi.^{2}

PII = 0.82

100% subregion B

Manually calculated peaks:

Q_{100} = ~~[illegible]~~ 22,100 cfs

Q_{500} = 49,500 cfs