DUP ok-RaT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 41093081 Date 9-18-12 Initials RFT Region ([✓ A] B C D)

Site ______ Location In Spearfish on Grant St between Meier & 3rd St

Q_{100} = 9250 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 7859 (should be Q_{100} unless there is a relief bridge, road overflow, or bridge overtopping)

← estimated Q max scour

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

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

79.69

Bridge Width = 80 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 80

Avg. flow depth at bridge, y_2 iteration = 8.9

Corrected channel width at bridge Section = W_2 times cos of flow angle = 79.7 ft* $q_2 = Q_2/W_2$ = 98.6 ft^2/s

Bridge Vel, V_2 = 11.1 ft/s Final $y_2 = q_2/V_2$ = 8.9 ft Δh = 2.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 11.4 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.

y max scour ≈ 8.9, flow overtops rt bank above this

Water Surface Elev. = 0.1 ft

Low Steel Elev. = 7.6 ft

n (Channel) = ~~0.040~~ .045 straight, flat, rocky

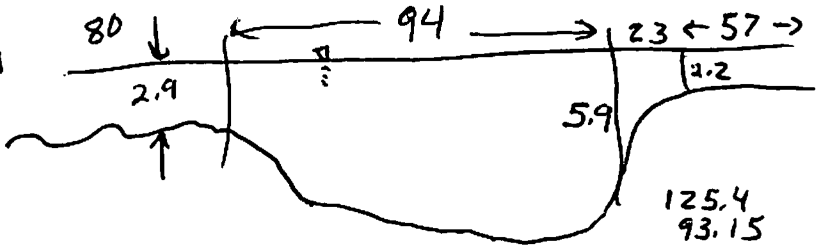
n (LOB) = 0.095 wooded

n (ROB) = .045 grass + trees

Pier Width = NA ft

Pier Length = NA ft

Piers for 100 yr = 0 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 94 ft

Width of left overbank flow at approach, W_{lob} = 80 ft Average left overbank flow depth, y_{lob} = 2.9 ft

Width of right overbank flow at approach, W_{rob} = 80 ft Average right overbank flow depth, y_{rob} = 2.73 ft

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

x = 3.66 From Figure 9 W_2 (effective) = 79.7 ft y_{cs} = 4.3 ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = 0.2 ft Average approach velocity, $V_1 = Q_{100}/(y_1 W_1)$ = 2.71 ft/s

Critical approach velocity, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = 9.8 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = .115 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} = 0 ft

PIER SCOUR CALCULATIONS

PGRM: Pier

NA

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} = 2.9 ft right abutment, y_{aRT} = 2.73 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} = 11.3 and ψ_{RT} = 11.1

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 11.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 11.1 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 41093081 Date ____ Initials ____ Region ([✓ A] B C D)

Site ____ Location ____

Q_{500} = 23900 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 7859 (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 = ____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. = 0.1 ft

Low Steel Elev. = 7.6 ft

n (Channel) = .045

n (LOB) = .095

n (ROB) = .045

Pier Width = NA ft

Pier Length = NA ft

Piers for 500 yr = 0 ft

See Q_{100} calcs

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: Pie

NA

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 Grant St Stream Spearfish Ck MRM______ Date 9-18-12 Initials RFT

Bridge Structure No. 41093081 Location in Spearfish, on Grant St between Meier + 3rd

GPS coordinates: N 44° 29.233' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

W 103° 51.795' Datum of coordinates: WGS84 ✓ NAD27_____

Drainage area = 164.98 sq. mi.

The average bottom of the main channel was 14.4 ft below top of guardrail at a point 32 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 9250			Q_{500} = 23900		
Estimated flow passing through bridge	7859			7859		
Estimated road overflow & overtopping	1391			16041		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		✓				✓
Chance of Pressure flow	✓			✓		
Armored appearance to channel	✓			✓		
Lateral instability of channel		✓			✓	

road overflow likely for Q_{100}

Riprap at abutments? X Yes ____No ____Marginal

Evidence of past Scour? ____Yes X No ____Don't know none obvious

Debris Potential? ____High X Med ____Low many trees, but no piers to catch debris

riprap has been placed at both abutments, upstream, under bridge, and downstream

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

Riprap X Yes ____No ____Don't know ____NA

Spur Dike ____Yes ____No ____Don't know ✓ NA

Other armored rt bank ____Yes ____No ✓ Don't know ____NA

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

Material	Silt/Clay____	Sand____	Gravel X	Cobbles X	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

low flow channel bottom is gravel + cobbles, assume CWCS

Comments, Diagrams & orientation of digital photos

str. no.
approach from bridge
LOB from bridge
ROB from bridge
bridge from near rt. abut
armored rt. bank upstream

left abut. under bridge
rt abut. under bridge

Summary of Results

	Q100	Q500
Bridge flow evaluated	7859 = Q max scour	
Flow depth at left abutment (yaLT), in feet	2.9	
Flow depth at right abutment (yaRT), in feet	2.7	
Contraction scour depth (ycs), in feet	4.3	
Pier scour depth (yps), in feet	NA	NA
Left abutment scour depth (yas), in feet	11.3	
Right abutment scour depth (yas), in feet	11.1	
1Flow angle of attack	5°	

See Comments/Diagram for justification where required