in Spearfish OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 41093081 Date 7/13/11 Initials CW 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) = 6332 (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 = 78 ft. Flow angle at bridge = 0 ° Abut. Skew = 0 ° Effective Skew = 0 °

Width (W_2) iteration = 78

Avg. flow depth at bridge, y_2 iteration = 9.5 > 8.0

Corrected channel width at bridge Section = W_2 times cos of flow angle = 78.0 ft* $q_2 = Q_2/W_2$ = 81.2 ft^2/s

Bridge Vel, V_2 = 10.1 ft/s Final $y_2 = q_2/V_2$ = 8.0 ft Δh = 2.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10.1 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. = 8.0 ft

n (Channel) = 0.045

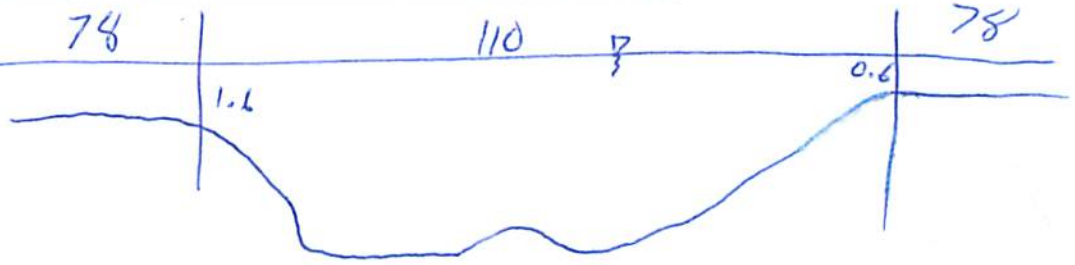
n (LOB) = 0.100

n (ROB) = 0.050

Pier Width = ____ ft

Pier Length = ____ ft

Piers for 100 yr = ____ ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 110 ft

Width of left overbank flow at approach, W_{lob} = 78 ft Average left overbank flow depth, y_{lob} = 1.6 ft

Width of right overbank flow at approach, W_{rob} = 78 ft Average right overbank flow depth, y_{rob} = 0.6 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} = 0.2 ft Average approach velocity, $V_1 = Q_{100}/(y_1W_1)$ = 2.36 ft/s

Critical approach velocity, $Vc = 11.52y_1^{1/6}D_{50}^{1/3}$ = 9.6 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.098 ft If $D_{50} >= D_{c50}$, χ = 0.0

Otherwise, $\chi = 0.122y_1[q_2/(D_{50}^{1/3}y_1^{7/6})]^{6/7} - y_1$ = 0.0 From Figure 10, y_{cs} = 0.0 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} = 1.6 ft right abutment, y_{aRT} = 0.6 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, ψ_{LT} = 6.6 and ψ_{RT} = 2.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 9.9 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 4.0 ft

110
78
78
266

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 41093081 Date 7/13/11 Initials CW Region (A B C D)

Site _____ Location In Spearfish, on Court St between Meier & 3rd St

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

Bridge discharge (Q_2) = 6337 (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 = 78 ft. Flow angle at bridge = 0 ° Abut. Skew = 0 ° Effective Skew = 0 °

Width (W_2) iteration = 78

Avg. flow depth at bridge, y_2 iteration = 16.6 > 8.0

Corrected channel width at bridge Section = W_2 times cos of flow angle = 78.0 ft* $q_2 = Q_2/W_2$ = 81.2 ft²/s

Bridge Vel, V_2 = 10.1 ft/s Final $y_2 = q_2/V_2$ = 8.0 ft Δh = 2.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10.1 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. = 8.0 ft

n (Channel) = 0.045

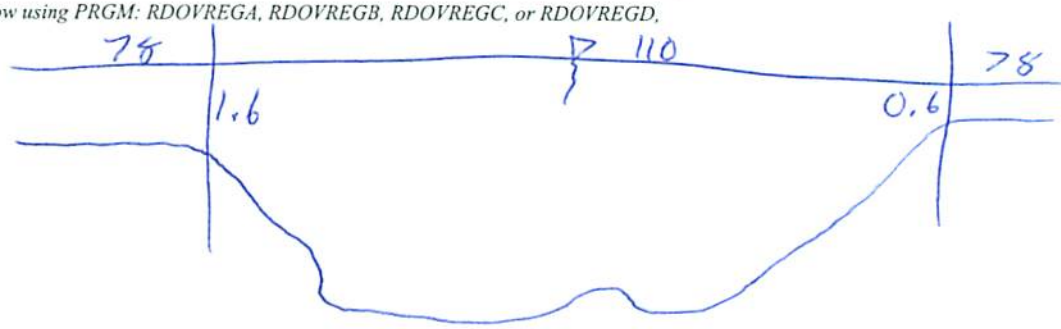
n (LOB) = 0.100

n (ROB) = 0.050

Pier Width = — ft

Pier Length = — ft

Piers for 500 yr = — ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 110 ft

Width of left overbank flow at approach, W_{lob} = 78 ft Average left overbank flow depth, y_{lob} = 1.6 ft

Width of right overbank flow at approach, W_{rob} = 78 ft Average right overbank flow depth, y_{rob} = 0.6 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} = 0.2 ft Average approach velocity, $V_1 = Q_{500}/(y_1W_1)$ = 2.36 ft/s

Critical approach velocity, $Vc = 11.52y_1^{1/6}D_{50}^{1/3}$ = 9.6 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.096 ft If $D_{50} >= D_{c50}$, $\chi = 0.0$

Otherwise, $\chi = 0.122y_1[q_2/(D_{50}^{1/3}y_1^{7/6})]^{6/7} - y_1$ = 0.0 From Figure 10, y_{cs} = 0.0 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} = 1.6 ft right abutment, y_{aRT} = 0.6 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, ψ_{LT} = 6.6 and ψ_{RT} = 2.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 9.9 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 4.0 ft

Route Grant St Stream Spearfish Ck MRM _____ Date 7/13/11 Initials CW

Bridge Structure No. 41093081 Location In Spearfish, on Grant St between Meier & 3rd St

GPS coordinates: N44° 29' 13.5" W103° 51' 49.1" taken from: USL abutment X centerline of ↑↑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 164.98 sq. mi.

The average bottom of the main channel was 14.3 ft below top of guardrail at a point 57 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	6332			6332		
Estimated road overflow & overtopping	2918			17568		
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

Evidence of past Scour? ____Yes X No ____Don't know

Debris Potential? X High ____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____	Sand____	Gravel____	Cobbles X	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos

1602 - 1D
03 - US
04 - US RB
05 - US LB
06 - concrete & rock bank
07 _ App XS LB
06 - App XS RB
09 - US Face
10 - L. Abut
11 - R. Abut

Summary of Results

	Q100	Q500
Bridge flow evaluated	6332	6332
Flow depth at left abutment (yaLT), in feet	1.6	1.6
Flow depth at right abutment (yaRT), in feet	0.6	0.6
Contraction scour depth (ycs), in feet	0.0	0.0
Pier scour depth (yps), in feet		
Left abutment scour depth (yas), in feet	9.9	9.9
Right abutment scour depth (yas), in feet	4.0	4.0
1Flow angle of attack	0	0

See Comments/Diagram for justification where required