BSDMS Summary Report

89 I-90 over Gallatin River near Manhattan, MT

Site Location:

Site ID: 89

Site Name: I-90 over Gallatin River near Manhattan, MT

County: Gallatin

Nearest City: Manhattan

State: MT

Latitude:

Longitude:

USGS Station ID: 06043500

Route Number: I-90

Route Class: Interstate

Service Level: Mainline

Route Direction: NA

Highway Mile Point:

Stream Name: Gallatin River

River Mile:

Contact:

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Publication:

An unpublished level-2 analysis was performed by Montana USGS and is planned for submittal to MDT (March 2001) under the title: "Analysis of scour potentialfor bridge structure no. I00090292+04251 & 52 crossing Gallatin River at Interstate 90, four miles southeast of Manhattan, Montana".

Site Description:

The bridge site is located 4 miles southeast of Manhattan, Montana over the Gallatin River and is part of the I-90 Interstate highway. I-90 crosses the Gallatin River via parrallel bridges, one for eastbound (upstream bridge) and the other for westbound traffic (downstream bridge). Both bridges have two traffic lanes with a space approximately two lanes wide seperating the eastbound and westbound bridges. A USGS gaging station (06043500) is located upstream of the site near Gallatin Gateway providing contiuous discharge data from 1984 to present and annual peak discharge data for 60 years (1889-Present). Diversions for irrigation are common along the Gallatin River in the vicinity of the site. The data from the gage, along with drainage-area-adjustments resulted in flood-frequency estimates for the 100- and 500-year peak discharges at the bridge. Q100 = 12,000 cfs and Q500 = 14,100 cfs at the bridge.

Depending upon the year, the river is either highly anabranched or braided as it approaches the bridge and flow splits around a large flood bar immediately upstream of the I-90 crossing. The bed material is very mobile, and can be compared to mounds of ball bearings. The streambed configuration is highly variable from year to year. Between measurements made on 5/22/97 and 6/18/97 at the bridge, the measured pier scour hole completely moved from pier 1 to pier 2. A guide bank was installed on the right bank in the early 1990's in response to erosion that was encroaching upon the highway embankment. The guide bank eliminated contraction of the river approximately one bridge width upstream of I-90, but 4-5 bridge widths upstream the river braids out considerably and an obvious contration at the bridge

opening is observed.

A level 2 scour analysis was conducted on the site using the WSPRO computer model. The model was used to conduct step-backwater calculations for the 100-year and 500-year peak discharges at the bridge. The 100-year discharge passed through the bridge as free-surface flow without any overtopping of the roadway but approx. 5% (600 cfs) overtopping an embankment on the left bank, just upstream of the bridge. Upon analysis of the 500-year discharge, it was determined that unsubmerged pressure flow conditions would be used in the scour assessment and that 12% of the flow (1,692 cfs) overtopped the same embankment on the left bank, just upstream of the bridge.

The results of the WSPRO hydraulic characteristics are summarized below:

WSPRO Hydraulic Results:

Uncontracted Section 100-yr
Average Velocity = 6.28 ft/s Depth = 6.26
Main Channel K = 182446 Left K = 0 Rigth K = 0

Bridge Section 100-yr
Worst Case K-tube velocity = 10.86 ft/s area = 52.5 sq. ft.

Uncontracted Section 500-yr
Average velocity = 5.22 ft/s Depth = 8.08 ft
Main Channel K=281153 Left K=0 Right K=0

Bridge Section 500-yr
Worst Case K-tube = 10.49 ft/s area = 59.1 sq ft

Elevation Reference

Datum: MSL

MSL (ft):

Description of Reference Elevation:

RM #1 is a chiseled "x" in the left upstream concrete abutment set equal to elevation 4305.48 (NGVD 1929).

Stream Data

Drainage Area (sq mi):	970	**Floodplain Width:**	Narrow
Slope in Vicinity(ft/ft):	.0046	**Natural Levees:**	Little
Flow Impact:	Straight	**Apparent Incision:**	Apparent
Channel Evolution	Unknown	**Channel Boundary:**	Alluvial
Armoring:	None	**Banks Tree Cover:**	Medium
Debris Frequency:	Frequent	**Sinuosity:**	Unknown

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Debris Effect:	Local	**Braiding:**	Locally
Stream Size:	Medium	**Anabranching:**	Locally
Flow Habit:	Perennial	**Bars:**	Irregular
Bed Material:	Gravel	**Stream Width Variability:**	Random
Valley Setting:	High		

Roughness Data

Manning's n Values

	Left Overbank	Channel	Right Overbank
High:			
Typical			
Low:			

Bed Material

Measurement Number	Yr	Mo	Dy	Sampler	D95 (mm)	D84 (mm)	D50 (mm)	D16 (mm)	SP	Shape	Cohesion
1				Grab on bed	85	63	35	18	2.65		Non-Cohesive

Bed Material Comments

Measurement No: 1

Bed material sampling was done at locations where bed material was exposed and judged to be reasonably representative of streambed material and could be readily evaluated using simple equipment and techniques. The particle-size distribution of the surface layer, obtained by a random particle count of the streambed, was used in the analysis because the surface-layer gradation was representative of the bed material in the channel reach. The bed material is very mobile, and can be related to mounds of ball bearings. The streambed configuration is highly variable from year to year.

Bridge Data

Structure No: I00090292+04251

Length(ft): 200

Width(ft): 38.75

Number of Spans: 4

Vertical Configuration: Sloping

Low Chord Elev (ft): 4301.6

Upper Chord Elev (ft): 4303.1

Overtopping Elev (ft): 4305.9

Skew (degrees): 28

Guide Banks: Straight

Waterway Classification: Main

Year Built:

Avg Daily Traffic:

Plans on File: Yes

Parallel Bridges Yes

Upstream/Downstream: Upstream

Continuous Abutment: Yes

Distance Between Centerlines: 70

Distance Between Pier Faces: 38

Bridge Description:

Abutment Data

Left Station: 0

Right Station: 205

Left Skew (deg): 0

Right Skew (deg) 0

Left Abutment Length (ft): 130

Right Abutment Length (ft) 130

Left Abutment to Channel Bank (ft): 0

Right Abutment to Channel Bank (ft): 0

Left Abutment Protection: Riprap

Right Abutment Protection Riprap

Contracted Opening Type: III

Embankment Skew (deg): 28

Embankment Slope (ft/ft):

Abutment Slope (ft/ft) 2

Wingwalls: No

Wingwall Angle (deg):

Pier Data

Pier ID	Bridge Station(ft)	Alignment	Highway Station	PierType	# Of Piles	Pile Spacing(ft)
1	51	-27		Single		
2	103	-27		Single		
3	154	-27		Single		

Pier ID	Pier Width(ft)	Pier Shape	Shape Factor	Length(ft)	Protection	Foundation
1	4	Sharp		130	None	Poured
2	4	Unknown		130	Unknown	Poured
3	4	Unknown		130	Unknown	Poured

Pier ID	Top Elevation(ft)	Bottom Elevation(ft)	Foot or Pile Cap Width(ft)	Cap Shape	Pile Tip Elevation(ft)
1		4281.65	6	Other	
2		4282.01	6	Other	
3		4282.37	6	Square	

Pier Description

Pier ID 1

Note: Elevations for bottom of footing are approximates, final elevations determined by engineer and contractor during construction.

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Pier ID 2

Note: Elevations for bottom of footing are approximates, final elevations determined by engineer and contractor during construction.

Pier ID 3

Note: Elevations for bottom of footing are approximates, final elevations determined by engineer and contractor during construction.

Pier Scour Data

Pier ID	Date	Time	USOrDS
1	6/8/95		Upstream
1	5/22/97		Upstream
2	6/18/97		Upstream
3	6/18/97		Upstream

Pier ID	Scour Depth	Accuracy (ft)	Side Slope (ft/ft)	TopWidth (ft)	Apprch Vel (ft/s)	Apprch Depth(ft)	Effective Pier Width	Skew to Flow(deg)
1	9	1.5	3.7	46				5
1	8	1.5	2.5	41	6.8	3.5		5
2	9	1.5	3.5	60	6	5		5
3	3.5	1	3.2	17	7.3	3		5

PierID	Sediment Transport	Bed Material	BedForm	Trough (ft)	Crest (ft)	Sigma	Debris Effects
1	Unknown	Non-Cohesive	Unknown				Substantial
1	Unknown	Non-Cohesive	Unknown				Substantial
2	Unknown	Non-Cohesive	Unknown				Substantial
3	Unknown	Non-Cohesive	Unknown				Moderate

PierID	D95 (mm)	D84 (mm)	D50 (mm)	D16 (mm)
1				
1				
2				
3				

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Pier Scour Comments

Pier ID 1 **Time:** **US/DS:** Upstream

WSPRO Results:
100-yr (HEC-18)

Qbridge (cfs)	K1	K2	K3	a	Y1 (ft)	V1 (ft)	Fr	Ys (fps)	(ft)
11,400	.90	1.0	1.1	4.0	14.87	10.86	.50	9.3	

500-yr (HEC-18)

Qbridge (cfs)	K1	K2	K3	a	Y1 (ft)	V1 (ft)	Fr	Ys (fps)	(ft)
12400	.90	1.0	1.1	4.0	15.55	10.49	.47	9.2	

Pier ID 1 **Time:** **US/DS:** Upstream

WSPRO Results:
100-yr (HEC-18)

Qbridge (cfs)	K1	K2	K3	a	Y1 (ft)	V1 (ft)	Fr	Ys (fps)	(ft)
11,400	.90	1.0	1.1	4.0	14.87	10.86	.50	9.3	

500-yr (HEC-18)

Qbridge (cfs)	K1	K2	K3	a	Y1 (ft)	V1 (ft)	Fr	Ys (fps)	(ft)
12400	.90	1.0	1.1	4.0	15.55	10.49	.47	9.2	

Pier ID 2 **Time:** **US/DS:** Upstream

Pier scour totally shifted from pier 1 to pier 2 during the period between measurements on 6/6/97 and 6/18/97.

WSPRO Results:
100-yr (HEC-18)

Qbridge (cfs)	K1	K2	K3	a	Y1 (ft)	V1 (ft)	Fr	Ys (fps)	(ft)
11,400	.90	1.0	1.1	4.0	14.87	10.86	.50	9.3	

500-yr (HEC-18)

Qbridge (cfs)	K1	K2	K3	a	Y1 (ft)	V1 (ft)	Fr	Ys (fps)	(ft)
12400	.90	1.0	1.1	4.0	15.55	10.49	.47	9.2	

Pier ID 3 **Time:** **US/DS:** Upstream

WSPRO Results:
100-yr (HEC-18)

Qbridge (cfs)	K1	K2	K3	a	Y1 (ft)	V1 (ft)	Fr	Ys (fps)	(ft)
11,400	.90	1.0	1.1	4.0	14.87	10.86	.50	9.3	

500-yr (HEC-18)

Qbridge (cfs)	K1	K2	K3	a	Y1 (ft)	V1 (ft)	Fr	Ys (fps)	(ft)
12400	.90	1.0	1.1	4.0	15.55	10.49	.47	9.2	

Abutment Scour

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Measurement Number	Abutment	Date	Time	US/DS	Scour Depth (ft)	Accuracy	Sediment Transport
1	Left	6/18/97		Upstream	0		Unknown
2	Right	6/18/97		Upstream	3	1	Unknown

Measurement Number	Velocity at Abut(ft/s)	Depth at Abut(ft)	Discharge Blocked(cfs)	Avg Velocity Blocked(ft/s)	Avg Depth Blocked(ft)
1					
2					

Measurement Number	Embankment Length (ft)	Bed Material	D50 (mm)	Sigma	Debris Effect
1		Non-Cohesive	35		Unknown
2		Non-Cohesive	35		Moderate

Abutment Scour Comments

MeasurementNo 1

100-yr Left Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta	K2	Ys
28	133	4.75	8.0	3.49	.45	.55	70	.97	7.2 ft

Based on low values of hydraulic variables key to abutment scour calculations, and presence of riprap, abutment scour is believed to not be a factor.

500-yr Left Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta	K2	Ys
23	87	3.78	5.0	4.60	.31	.55	70	.97	7.4 ft

Based on low values of hydraulic variables key to abutment scour calculations, and presence of riprap, abutment scour is believed to not be a factor.

MeasurementNo 2

100-yr Right Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta
458	2155	4.71	128.6	3.56	.44	.55	62

Because ratio of a'/Ya exceeds 25, use Eqn 25 from Hec-18 for right abutment scour - Ys=10.9
Adjust calculated scour for abutment scew from fig11, HEC-18, theta=54, adustment=1.03 Ys=5.9 ft

500-yr Right Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta
621	2480	3.99	118.2	5.25	.31	.55	62

Because ratio of a'/Ya exceeds 25, use Eqn 25 from Hec-18 for right abutment scour - Ys=14.2
Adjust calculated scour for abutment scew from fig11, HEC-18, theta=62, adustment=.54 Ys=7.7 ft

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ContractionScour

Measurement Number	Contracted Date	Contracted Time	Uncontracted Date	Uncontracted Time	US/DS	Scour Depth(ft)
1						

Measurement Number	Accuracy	Contracted Avg Vel(ft/s)	Contracted Discharge(cfs)	Contracted Depth(ft)	Contracted Width(ft)
1					

Measurement Number	Uncontracted Avg Vel(ft/s)	Uncontracted Discharge(cfs)	Uncontracted Depth(ft)	Uncontracted Width(ft)	Channel Contraction Ratio
1					

Measurement Number	Pier Contraction Ratio	Scour Location	Eccent-ricity	Sediment Transport	Bed Form	Debris Effects
1		Unknown		Unknown	Unknown	Moderate

Measurement Number	D95 (mm)	D84 (mm)	D50 (mm)	D16 (mm)	Sigma Bed Material	Bed Material
1						Non-Cohesive

Contraction Scour Comments

Measurement No. 1

WSPRO Calculations: 500- yr Live-Bed Calculations Y1=8.08 Qmc1=12400 Qmc2=12400 Wc1= 294 Wc2 = 158.4 K1 =.59 Y2 = 11.64 Ys = 3.6 Clear-Water Calculations Y1=8.08 D50=.098 Dm = .12 W2=158.4 Ys = 1.7 -------- 100-yr Live-Bed Calculations Y1=6.26 Qmc1=11400 Qmc2=11400 Wc1=290 Wc2=127.5 K1 = .59 Y2 = 10.17 Ys=3.9 Clear-Water Calculations Y1=6.26 D50=.098 Dm=.12 W2=127.5 Ys=4.7

Stage and Discharge Data

Peak Discharge year	mo	dy	hr	mi	Flow (cfs)	Qacc	Peak Stage year	mo	dy	hr	mi	Stage (ft)	Water Temp (C)	Return Period(yr)
			17:00		5,270					17:20		9.45		2
					14,100									500
					12,000									100

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Hydrograph

Supporting Files

Gallatin(I90).xls - Excel worksheet with survey data (1995-1997) and the resulting plot of bathymetric profiles used to estimate depth of scour during the various Spring-runoff flood events.

Photos of the Site (DSCN0 prefix; .jpg format):

#	Description
263.	from right bank at upstream side of bridge (10/27/00).
264.	from right bank at right upstream side of bridge (10/27/00)
265.	looking upstream at guidebank on right bank (10/27/00)
266.	looking from right bank along upstream side of bridge (10/27/00)
267.	looking at left upstream bank (10/27/00)
268.	scour at left most pier (10/27/00)
269.	looking upstream from bridge (10/27/00)
270.	looking upstream from bridge (10/27/00)
271.	looking upstream (10/27/00)
272.	looking downstream from upstream bridge (10/27/00)
273.	looking from right bank between bridges (10/27/00)
274.	looking from right bank along downstream edge of downstream bridge (10/27/00)

Photos of the Site (P000 prefix; .jpg format):

#	Description
1099.	Looking across river at right bank upstream of bridge and guide bank (9/25/01)
1100.	Looking downstream at bridge opening (9/25/01)
1101.	same as 1100.
1102.	Standing on guide bank looking downstream at bridge (9/25/01).
1103.	Standing on guide bank looking across river in the upstream direction (9/25/01).
1104.	Looking downstream at bridge opening from right bank (9/25/01).
1105.	Looking upstream at westbound lane of I-90 from under railroad bridge (9/25/01).
1106.	Pier #2, upstream face of eastbound lane I-90 (9/25/01).
1107.	Looking upstream from bridge deck (9/25/01).