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Estimated and Measured Bridge Scour at Selected Sites in North Dakota, 1990-97

Water-Resources Investigations Report 99-4124

U.S. Department of the Interior
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By Tara Williams-Sether

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Bismarck, North Dakota
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Estimated and Measured Bridge Scour at Selected Sites in North Dakota, 1990-97

By Tara Williams-Sether

Abstract

A Level 2 bridge scour method was used to estimate scour depths at 36 selected bridge sites located on the primary road system throughout North Dakota. Of the 36 bridge sites analyzed, the North Dakota Department of Transportation rated 15 as scour critical. Flood and scour data were collected at 19 of the 36 selected bridge sites during 1990-97. Data collected were sufficient to estimate pier scour but not contraction or abutment scour. Estimated pier scour depths ranged from -10.6 to -1.2 feet, and measured bed-elevation changes at piers ranged from -2.31 to +2.37 feet. Comparisons between the estimated pier scour depths and the measured bed-elevation changes indicate that the pier scour equations overestimate scour at bridges in North Dakota.

A Level 1.5 bridge scour method also was used to estimate scour depths at 495 bridge sites located on the secondary road system throughout North Dakota. The North Dakota Department of Transportation determined that 26 of the 495 bridge sites analyzed were potentially scour critical.

INTRODUCTION

The erosive action of flowing water (scour) can result in the structural failure of a bridge by exposing or undermining the bridge pier and abutment foundations. Historically, pier and abutment foundation scour has been the most common cause of bridge failures within the United States (Richardson and others, 1991). Scour processes have caused bridge structural damage and bridge failure throughout North Dakota. These scour processes are the result of flooding caused by rapid snowmelt, excessive rainfall, or a combination of the two. During 1950, rapid snowmelt caused flooding in the southern half of the State that resulted in scour damage to many bridges and culverts. Total damages to highways and bridges exceeded $5 million (Oltman and others, 1951). In 1966, excessive rainfall from a severe thunderstorm caused flooding in the southwest-central part of the State. Virtually no bridges or culverts remained in place after the flooding, and the total damages exceeded $1 million (Crosby, 1966). During 1993-97, many county culverts and some bridges received scour damage, particularly in the eastern and northeastern parts of the State. Some of the damage that occurred resulted in the loss of life. Because scour processes always are present at stream crossings, highway engineers rely on information on the scour potential of such structures to avoid damages that cause failures and loss of life.

In 1988, the Federal Highway Administration (FHWA) recommended that "every bridge over a scourable stream, whether existing or under design, should be evaluated as to its vulnerability to floods in order to determine the prudent measures to be taken for its protection" (U.S. Department of Transportation, 1988, p. 2). In response to the FHWA's recommendation, the U.S. Geological Survey (USGS) and the North Dakota Department of Transportation (NDDOT) developed two cooperative studies that assessed scour at selected bridge sites in North Dakota. The first study (Level 2) consisted of (1) estimating scour at 36 selected bridge sites located on primary roads using the 100- and 500-year (or other) design floods and the FHWA scour equations; (2) if possible, obtaining measured scour data for comparison with scour estimates at 19 of the 36 selected bridge sites; and (3) if possible, developing scour estimating techniques that may be transferable from the 19 of the 36 selected bridge sites to other bridge sites in North Dakota. The second study (Level 1.5) consisted of estimating scour at 495 selected bridge sites located on secondary roads using a rapid-estimation technique developed by the USGS in Montana (Holnbeck and Parrett, 1997) to meet time-frame requirements established by the FHWA.

The purpose of this report is to present the results of the Level 2 and Level 1.5 bridge scour estimates and to present the measured scour data collected at selected bridge sites. In this report, measured scour data is referred to as measured

bed-elevation changes. This report describes the methods used to obtain Levels 2 and 1.5 scour estimates and the bed-elevation changes collected at the selected bridge sites during 1990-97. A comparison between the estimated pier scour depths and the measured bed-elevation changes also is made. The information will help the NDDOT decide if present bridge-design criteria with respect to scour are adequate and if existing bridges within the State are at risk to scour. The author thanks the NDDOT for providing bridge site plans and information, bridge surveys, and general assistance for the bridge sites that were analyzed in this study.

LEVEL 2 BRIDGE SCOUR METHOD

The Level 2 bridge scour method uses hydrologic, hydraulic, and sediment-transport-related engineering concepts to analyze scour depth. The method is used to determine the scour susceptibility of existing bridges that were not designed to be scour resistant. An important feature of the Level 2 method is that estimates of scour depth are determined for flood discharges of specified magnitude. A one-dimensional open-channel flow model is used along with site-specific information on the hydrology, hydraulics, channel geometry, and pertinent bridge-related structural features to determine the water-surface profile through the bridge opening for flood discharges having 100- and 500-year recurrence intervals. Resultant hydraulic information from the water-surface profile calculations are then applied to define variables used in scour-prediction equations recommended by the FHWA for determining contraction, abutment, and pier scour (Holnbeck and Parrett, 1997).

Total scour at bridges is made up of three components: (1) general scour, (2) contraction scour, and (3) local scour. General scour is the geomorphological processes that cause degradation and/or aggradation of the stream or river. Degradation and aggradation are the long-term adjustments of the streams and rivers to past disturbances such as construction of bridges, dams, changes in land use, and changes in available sediment load. Contraction scour is the general lowering of the channel section because of acceleration of flow through the channel constriction caused by the bridge. Contraction scour can occur when the bridge abutments are constructed in the main channel or when the bridge is constructed in the flood plain of the river or stream. The stream or river tends to scour the channel bottom to increase the flow area and consequently decrease the flow velocity through a bridge. Local scour is the localized erosion around obstructions in the flow. Local scour at bridges includes abutment and pier scour. Abutment scour is caused by vortices formed where the flow accelerates around the structure (Niehus, 1996). Pier scour is caused by the pileup of water on the upstream face of the pier and the resultant vortices that remove materials from the base region of the pier. The downstream side of the pier undergoes scour because of vortices in the wake region (fig. 1). Generally, a scour depth is determined for each type of scour (general, contraction, and local) and summed to obtain a total scour depth for a bridge.

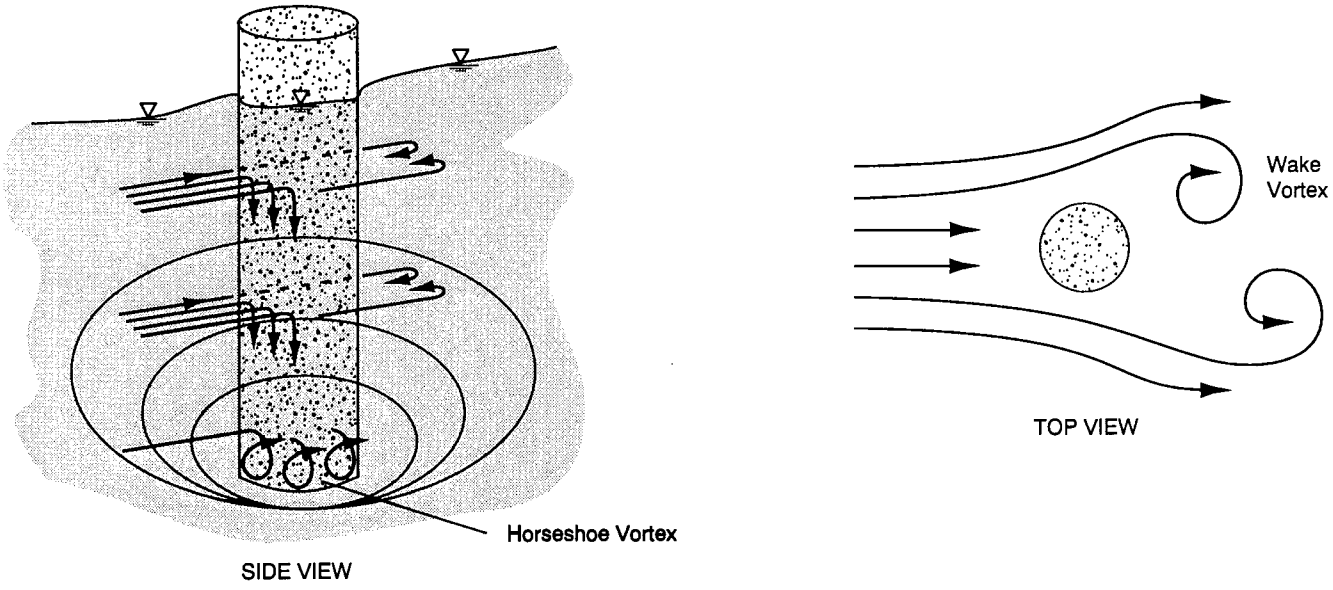

Figure 1. Schematic representation of scour at a cylindrical pier. (From Richardson and others, 1991.)

Selection of the appropriate scour equation requires determination of whether clear-water or live-bed scour conditions exist at specified discharges. Clear-water scour occurs when there is no movement of the streambed material larger than the median grain size upstream from the bridge, but the acceleration of the flow and vortices created by the abutments or piers causes the bed material at the bridge to move. Live-bed scour occurs when there is movement of the streambed material upstream from the bridge. On the basis of general knowledge and assumptions of stream stability in North Dakota during past floods, live-bed scour equations were chosen for use in this study. In this report, equations are listed for live-bed contraction scour developed by Laursen (1960), live-bed abutment scour developed by Froehlich (1989), and pier scour developed by Colorado State University (Richardson and others, 1991, p. 52). Further explanation and use of these equations are described in the FHWA Hydraulic Engineering Circular No. 18 (HEC 18) (Richardson and others, 1991).

The equation for contraction scour is

$$y_{cs} = y_1\left[\left(\frac{Q_2}{Q_1}\right)^{\frac{6}{7}}\left(\frac{w_1}{w_2}\right)^{k_{c1}}\left(\frac{n_2}{n_1}\right)^{k_{c2}}\right] - y_1 \qquad (1)$$

where

y_{cs} is contraction scour depth, in feet;

y_1 is the average depth in the main channel at the approach section, in feet;

Q_1 is the discharge in the main-channel portion of the approach section that is transporting sediment, in cubic feet per second;

Q_2 is the discharge in the main-channel portion of the contracted section that is transporting sediment, in cubic feet per second (the total discharge less any discharge escaping through a relief bridge over a roadway);

w_1 is the width of the main-channel portion of the approach section that is transporting sediment, in feet;

w_2 is the width of the main-channel portion of contracted section that is transporting sediment, in feet;

k_{c1} is a coefficient that depends on whether the material transported is mostly contact bed material (k_{c1}=0.59), contains some suspended material (k_{c1}=0.64), or is mostly suspended bed material (k_{c1}=0.69);

k_{c2} is a coefficient that depends on whether the material transported is mostly contact bed material (k_{c2}=0.066), contains some suspended material (k_{c2}=0.21), or is mostly suspended bed material (k_{c2}=0.37);

n_1 is the coefficient of roughness (Manning's n) for the approach section; and

n_2 is the coefficient of roughness (Manning's n) for the contracted section.

The equation for abutment scour is

$$y_{as} = \left[2.27K_{a1}K_{a2}\left(\frac{a'}{y_a}\right)^{0.43}Fr_a^{0.61} + 1\right]y_a \qquad (2)$$

where

y_{as} is abutment scour depth, in feet;

y_a is depth of flood-plain flow at the abutment, in feet;

K_{a1} is coefficient for abutment shape given in table 1;

K_{a2} is coefficient for angle of embankment to flow, K_{a2} is $\left(\frac{\Theta}{90°}\right)^{0.13}$;

Θ is the angle of the embankment to the flow, in degrees, and

$\Theta < 90°$ if embankment points downstream and $\Theta > 90°$ if embankment points upstream;

a' is length of abutment projected normal to flow, in feet; and

Fr_a is Froude number of approach flow upstream from abutment.

Table 1. Abutment shape coefficients, K_{a1}

[Modified from Richardson and others, 1991]

Description	K_{a1}
Vertical-wall abutment	1.0
Vertical-wall abutment with wingwalls	0.82
Spill-through abutment	0.55

The equation for pier scour is

$$y_{ps} = 2.0K_{p1}K_{p2}\left(\frac{a}{y_p}\right)^{0.65} Fr_p^{0.43} y_p \quad (3)$$

where

y_{ps} is pier scour depth, in feet;

y_p is flow depth just upstream from the pier, in feet;

K_{p1} is correction factor for pier nose shape from table 2;

K_{p2} is correction factor for angle of attack of flow from table 3;

a is pier width, in feet; and

Fr_p is Froude number just upstream from the pier.

Table 2. Correction factor, K_{p1}, for pier nose shape

[Modified from Richardson and others, 1991]

Shape of pier nose	K_{p1}
Square nose	1.1
Round nose	1.0
Circular cylinder	1.0
Sharp nose	0.9
Group of cylinders	1.0

Table 3. Correction factor, K_{p2}, for angle of attack of flow

[Modified from Richardson and others, 1991; Angle, skew angle of flow; L, pier length; a, pier width]

Angle	$\frac{L}{a} = 4$	$\frac{L}{a} = 8$	$\frac{L}{a} = 12$
0	1.0	1.0	1.0
15	1.5	2.0	2.5
30	2.0	2.5	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5.0

Application of the HEC 18 equations used in the Level 2 bridge scour method required estimates of flood discharges, hydraulic properties, and water-surface profiles. Flood discharge estimates for the 100- and 500-year recurrence intervals were determined using techniques described in Williams-Sether (1992). Selected bridge-geometry and hydraulic data were used as explanatory variables in the scour estimation equations. Field data, such as cross sections, bridge geometry, and Manning's Roughness coefficient estimates were obtained for use as input to a step-backwater model. Hydraulic properties and water-surface profiles were determined using the Water-Surface Profile Computation (WSPRO) step-backwater model (Shearman, 1990; Shearman and others, 1986).

LEVEL 1.5 BRIDGE SCOUR METHOD

The Level 1.5 bridge scour method is a limited-detail method. This method is used for quick determination (1 hour or less) of bridge scour estimates and is applied by one person making field measurements. Although the Level 1.5 method is not intended to replace the more detailed Level 2 method used for design purposes, it is considered to be useful for limited-detail efforts of bridge scour assessment and inventory.

The results of the Level 2 bridge scour method for the 100-year peak discharge estimate were used to develop individual envelope curves that relate contraction, abutment, and pier scour depths, predicted by HEC 18 equations, to physical variables obtained in the field based on limited site data (Holnbeck and Parrett, 1997). An envelope curve approach was selected so that scour depths would tend to be overestimated rather than underestimated. When estimating contraction scour, the main-channel and flood-plain flow depths and associated lateral distances were used to derive a contraction-scour variable for estimating scour depth on the basis of an envelope curve (fig. 2). When estimating abutment scour, the average flood-plain flow depth adjusted for any main-channel abutment encroachment was the variable used to obtain an envelope-curve-based scour depth (fig. 3). When estimating pier scour, the average pier width and flow angle of

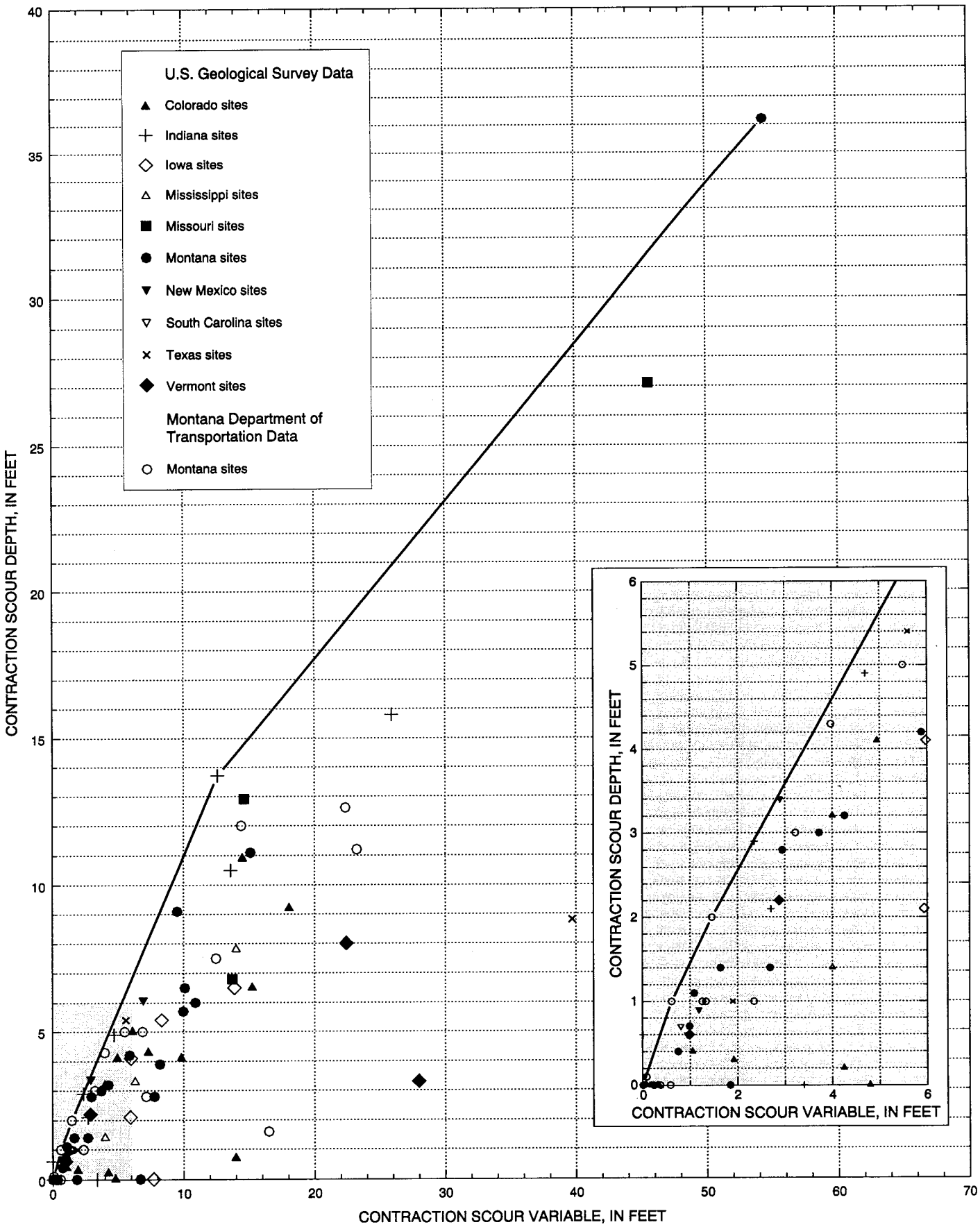

Figure 2. Envelope curve for estimation of live-bed contraction scour. (Modified from Holnbeck and Parrett, 1997.)

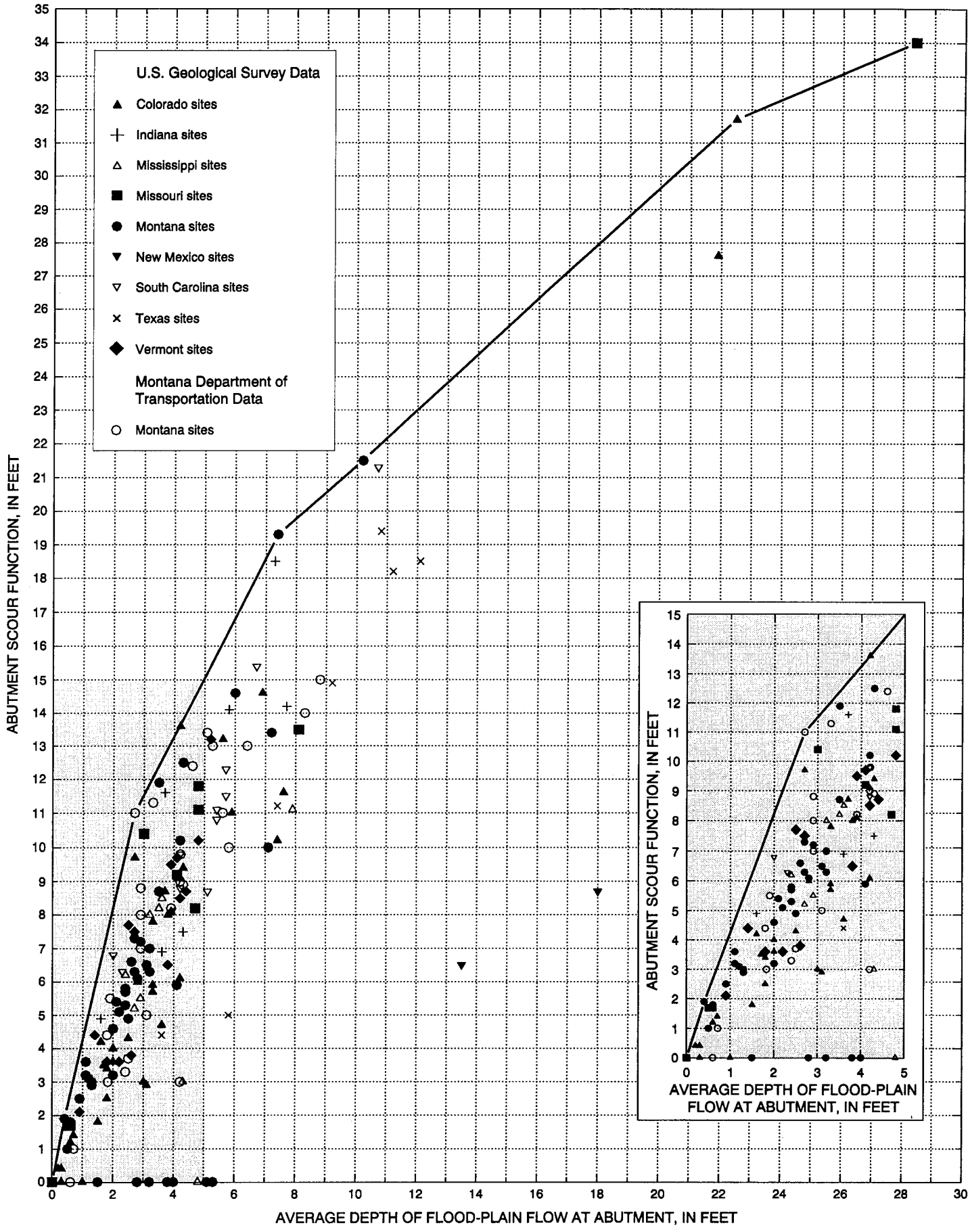

Figure 3. Envelope curve for estimation of abutment scour. (Modified from Holnbeck and Parrett, 1997. Abutment scour function is used to estimate abutment scour depth using the equation presented in Holnbeck and Parrett, 1997, p. 50.)

attack were important variables needed to apply the appropriate envelope curve (fig. 4). Further explanation of the development, testing, and use of the Level 1.5 bridge scour method is described in Holnbeck and Parrett (1997).

To apply the Level 1.5 bridge scour method at bridge sites in North Dakota, two regression equations similar to those described in Holnbeck and Parrett (1997) were developed using results from the North Dakota Level 2 scour analyses. These results were used because data from other states may not be representative of conditions at bridge sites in North Dakota. Data from the 36 selected Level 2 bridge sites in North Dakota plus data provided by the NDDOT from an additional 11 Level 2 bridge sites in North Dakota were used to develop a best-fit relation between logarithms (base 10) of unit discharge at the contracted opening, q_2, and main-channel velocity at the bridge contraction, V_2. The resulting relation is

$$V_2 = 0.8366 q_2^{0.5033} \tag{4}$$

where

V_2 is the main-channel velocity at the bridge contraction, in feet per second; and

q_2 is the unit discharge at the contracted opening, in cubic feet per second per foot-width of main channel at the contracted section.

Equation 4 has a coefficient of determination (r^2) of 0.56 and a standard error of estimate of 0.13 logarithm (base 10) units.

Data from the 47 selected Level 2 bridge sites in North Dakota also were used to develop a second best-fit relation between V_2^2 and the difference in water-surface elevation from the approach section to the downstream side of the bridge opening, Δh. The resulting relation is

$$\Delta h = 0.01998 V_2^2 \tag{5}$$

Equation 5 has a coefficient of determination (r^2) of 0.31 and a standard error of estimate of 0.87 ft.

The Level 1.5 bridge scour method was tested at three bridge sites where analyses using the Level 2 bridge scour method had been completed. Level 1.5 contraction, abutment, and pier scour estimates were calculated and the values were compared with the scour values from the Level 2 method. Results were similar to those in Holnbeck and Parrett (1997) in that the Level 1.5 method generally produced a more conservative (larger) scour-depth estimate than the Level 2 method. Error because of variability among individuals was not checked because only one person tested the Level 1.5 and Level 2 methods in the field. However, the author believes that the results would have been similar to those described in Holnbeck and Parrett (1997). The results described in Holnbeck and Parrett (1997) indicated that the estimates from the Level 1.5 bridge scour method generally were reasonably close to, but conservatively larger than those from the Level 2 bridge scour method. The results also indicated that the error due to variability among individuals is considered to be acceptable as long as the individuals using the Level 1.5 bridge scour method have experience in bridge scour, have experience in hydraulics and flood hydrology, and have been trained in use of the method.

An estimate of the 100-year peak discharge was determined using techniques described in Williams-Sether (1992). Once the 100-year peak discharge estimate was obtained for a bridge site, a graphical and step-wise approximation method was used to estimate flow depth at the approach section. Flow depth is needed to obtain other important variables used with the Level 1.5 contraction and abutment scour envelope curves. Flow depth also is needed to visually estimate the angle of attack of the peak flow on the bridge and on the piers. The data collection efforts for estimating pier scour were relatively straightforward and involved measurements of pier width, pier length, and flow angle of attack. The contraction and abutment scour estimation efforts were more involved because the envelope curve variables required more time to obtain.

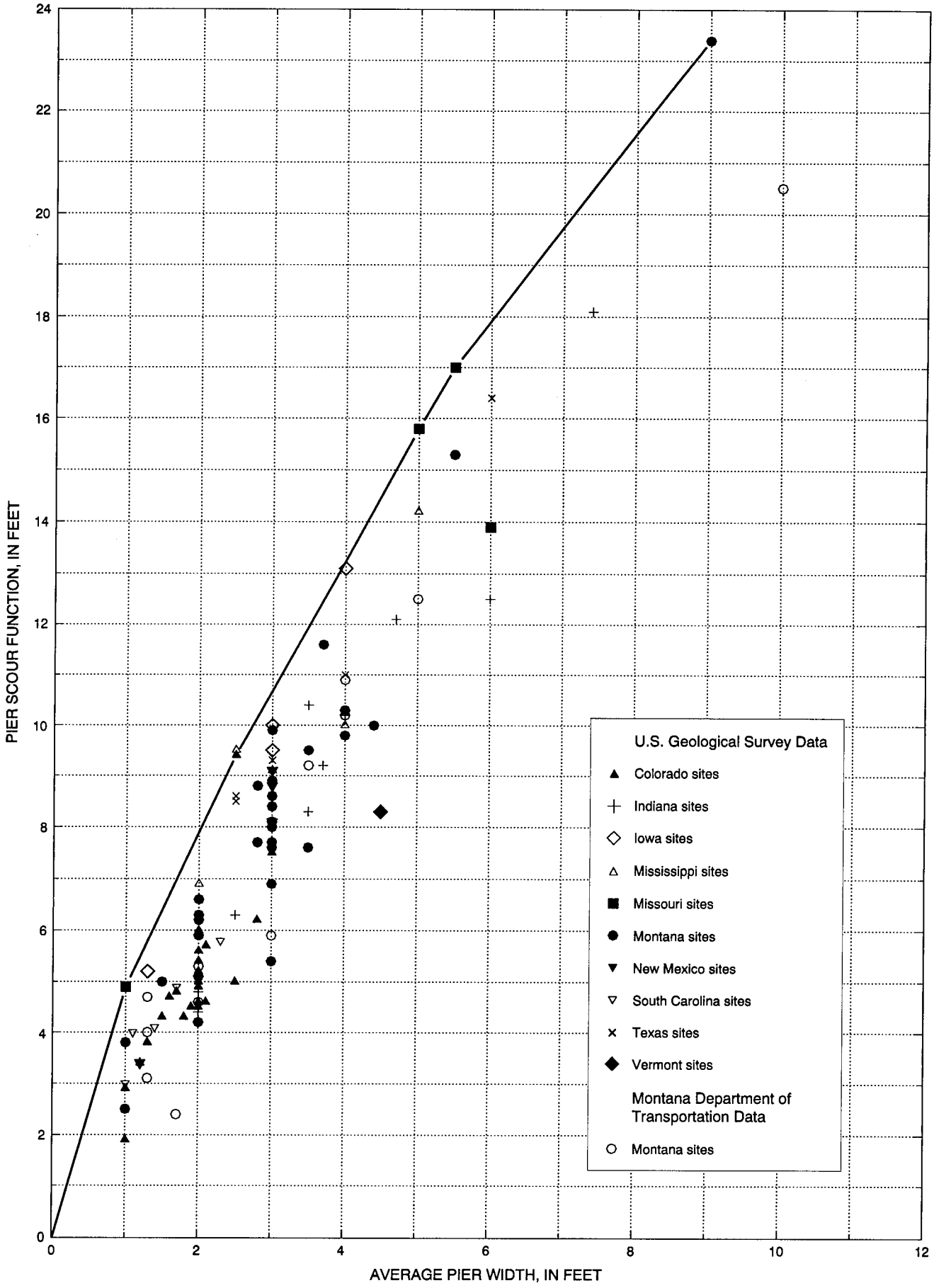

Figure 4. Envelope curve for estimation of pier scour. (Modified from Holnbeck and Parrett, 1997. Pier scour function is used to estimate pier scour depth using the equation presented in Holnbeck and Parrett, 1997, p. 50.)

SCOUR ESTIMATES AND MEASUREMENTS

Level 2

The Level 2 bridge scour method was applied to 36 selected bridge sites located on the primary road system throughout North Dakota. The locations of bridge sites are shown in figure 5. Results of the estimated contraction, abutment, and pier scour and selected hydrologic and bridge-geometry data for each bridge site are listed in table 4. Estimates of channel aggradation and degradation scour were not computed because the long-term data needed for such computations were not available. The NDDOT used the results to determine if the 36 bridge sites were scour critical. A bridge site is considered scour critical if the abutment or pier foundations are rated unstable because of observed scour at the bridge or because of scour potential as estimated using the Level 2 method (Clifford Scott, North Dakota Department of Transportation, oral commun., 1998). Of the 36 bridge sites analyzed, the NDDOT rated 15 as scour critical. To be removed from the critical rating, these 15 bridge sites will need further monitoring or application of bridge structure countermeasures to mitigate scour.

During 1990-97, additional flood and scour data were collected at 19 of the 36 selected bridge sites. These 19 sites will be referred to as monitoring sites. Results of the estimated scour depths and measured scour depths (bed-elevation changes) for each site are listed in table 5. During periods of high flow, standard discharge measurements were taken at the upstream side of the bridge. These measurements consisted of detailed depth and velocity measurements around abutments and piers and depth soundings on the downstream side of the bridge that included detailed soundings around the abutments and piers. During periods of low flow, surveyed cross sections were taken upstream from the bridge (approach section), at the bridge, and downstream from the bridge (exit section). Data collected during the high-flow measurements were used in the HEC 18 pier scour equation to estimate pier-scour depths. Contraction and abutment scour data were not calculated because the measured discharges at the bridge sites were contained within the channel and not enough data could be collected for the scour equations. The estimated pier-scour depths were compared to measured bed-elevation changes determined from cross sections taken before and after the high-flow discharge measurements. Measured bed-elevation changes at the abutments determined from the surveyed cross sections also are listed in table 5.

Estimated pier scour depths determined from the high-flow measurements ranged from -10.6 to -1.2 feet, and measured bed-elevation changes at the piers determined by surveys ranged from -2.31 to +2.37 feet. Scour is signified by the negative (-) sign and deposition is signified by the positive (+) sign. Comparisons between the estimated pier scour depths and the measured bed-elevation changes indicate that the pier scour equations appear to over estimate the scour that occurred at bridge sites in North Dakota. During 1994-97, only two bridge sites, 005-303.364 and 015-106.930 (fig. 1; table 5), had estimated pier scour depths that were close to those determined from the cross section surveys. Measured bed-elevation changes at the abutments ranged from -3.07 to +1.90 feet.

Scour estimating techniques such as regression equations could not be developed because of insufficient data collected at the 19 monitoring sites. However, the collected scour data are being added to a national scour data base, and the data may improve general scour estimating techniques.

Level 1.5

The Level 1.5 bridge scour method was applied to 495 selected bridge sites located on the secondary road system throughout North Dakota. The results of the estimated contraction, abutment, and pier scour for each bridge site are listed in supplement 1. The NDDOT used the results to analyze 467 bridge sites and determine if they were scour critical. The 28 bridge sites that the NDDOT did not analyze were sites that were either being replaced or had unknown bridge structure information to compare estimated scour depths against. Of the 467 bridge sites analyzed, the NDDOT determined that 26 sites were potentially scour critical (Clifford Scott, North Dakota Department of Transportation, oral commun., 1998). These 26 sites will require additional analysis by the Level 2 bridge scour method.

Figure 5. Location of selected Level 2 bridge sites in North Dakota.

Table 4. Results of the Level 2 bridge scour analyses at selected bridge sites in North Dakota

[mi^2, square miles; ft^3/s, cubic feet per second; Q_{100}, discharge estimate for the 100-year recurrence interval and associated scour estimates; Q_{500}, discharge estimate for the 500-year recurrence interval and associated scour estimates; Q_a, maximum flow that could be routed through bridge without overtopping and associated scour estimates; --, not determined; ***L***, left; ***R***, right; ***C***, center]

Bridge number	River name	Drainage area (mi^2)	Bridge length (feet)	Pier nose shape	Abutment shape	Q_{100} (ft^3/s)	Q_{500} (ft^3/s)	Q_a (ft^3/s)	Contraction scour (feet)			Abutment scour (feet)			Pier scour (feet)		
									Q_{100}	Q_{500}	Q_a	Q_{100}	Q_{500}	Q_a	Q_{100}	Q_{500}	Q_a
001-143.430	Sheyenne River near Pekin, N. Dak.	790	160	Sharp	Spill-through	6,900	10,200	--	7.7	12.2	--	5.4*L* 7.1*R*	6.7*L* 8.6*R*	-- --	4.5*L* 4.2*R*	4.9*L* 4.7*R*	-- --
005-303.364	Tongue River near Akra, N. Dak.	[1]86	53	Square	Vertical wall	3,540	5,370	1,600	--	--	1.2	-- --	-- --	0*L* 2.7*R*	--	--	2.8
006-035.187	Cannonball River at Breien, N. Dak.	4,100	445	Sharp	Spill-through	46,500	78,500	--	0	0	--	6.0*L* 6.2*R*	6.4*L* 7.6*R*	-- --	5.4*L* 5.3*LC* 5.1*RC* 4.8*R*	6.5*L* 6.4*LC* 6.1*RC* 5.9*R*	-- -- -- --
008-045.173	Cannonball River at Mott, N. Dak.	726	154	Square	Spill-through	19,400	28,200	20,500	5.8	--	6.0	7.0*L* 5.9*R*	-- --	6.7*L* 6.2*R*	8.4*L* 4.7*R*	-- --	8.6*L* 4.8*R*
008-099.579	Knife River at Marshall, N. Dak.	722	140	Round	Vertical wall with wingwall	11,300	16,200	--	3.8	5.1	--	9.4*L* 10.4*R*	10.1*L* 11.8*R*	-- --	4.9*L* 6.6*R*	5.7*L* 8.4*R*	-- --
011-141.391	Wild Rice River above Cayuga, N. Dak.	466	42	None	Vertical wall with wingwall	3,360	6,000	2,770	--	--	2.8	-- --	-- --	3.0*L* 2.0*R*	--	--	--
011-182.459	Bois de Sioux near Fairmount, N. Dak.	380	115	Sharp	Spill-through	4,770	8,150	--	4.5	9.7	--	6.8*L* 7.1*R*	7.7*L* 8.0*R*	-- --	3.2*L* 3.3*R*	3.8*L* 3.8*R*	-- --
012-006.555	Little Missouri River at Marmarth, N. Dak.	4,640	410	Sharp	Spill-through	48,000	65,500	--	0	0	--	9.6*L* 7.1*R*	14.0*L* 15.0*R*	-- --	6.3*L* 6.8*LC* 6.7*RC* 3.6*R*	6.7*L* 7.1*LC* 7.0*RC* 6.4*R*	-- -- -- --
012-073.283	Flat Creek near Hettinger, N. Dak.	65.6	47	None	Vertical wall with wingwall	3,640	5,750	5,170	10.1	--	16.2	4.7*L* 8.0*R*	-- --	5.4*L* 9.5*R*	--	--	--
013-386.299L	Wild Rice River near Wahpeton, N. Dak.	1,560	65	Square	Vertical wall with wingwall	4,400	7,860	4,400	--	--	8.6	-- --	-- --	7.7*L* 6.9*R*	--	--	7.6
013-386.306R	Wild Rice River near Wahpeton, N. Dak.	1,560	135	Sharp	Spill-through	4,400	7,860	--	0	0	--	2.4*L* 2.4*R*	3.0*L* 3.2*R*	-- --	3.2*L* 3.5*R*	3.8*L* 4.1*R*	-- --
013-387.788L	Unnamed Creek near Wahpeton, N. Dak.	9.7	22	None	Vertical wall with wingwall	450	750	--	2.2	2.4	--	3.8*L* 3.6*R*	4.6*L* 4.2*R*	-- --	--	--	--
013-920.047	Unnamed Creek at Wahpeton, N. Dak.	6.5	53	Square	Vertical wall with wingwall	330	550	--	2.7	4.4	--	4.4*L* 4.6*R*	5.6*L* 5.9*R*	-- --	2.1	2.6	--

Table 4. Results of the Level 2 bridge scour analyses at selected bridge sites in North Dakota—Continued

[mi^2, square miles; ft^3/s, cubic feet per second; Q_{100}, discharge estimate for the 100-year recurrence interval and associated scour estimates; Q_{500}, discharge estimate for the 500-year recurrence interval and associated scour estimates; Q_a, maximum flow that could be routed through bridge without overtopping and associated scour estimates; --, not determined; ***L***, left; ***R***, right; ***C***, center]

Bridge number	River name	Drainage area (mi^2)	Bridge length (feet)	Pier nose shape	Abutment shape	Q_{100} (ft^3/s)	Q_{500} (ft^3/s)	Q_a (ft^3/s)	Contraction scour (feet)			Abutment scour (feet)			Pier scour (feet)		
									Q_{100}	Q_{500}	Q_a	Q_{100}	Q_{500}	Q_a	Q_{100}	Q_{500}	Q_a
015-106.930	Goose River near Northwood, N. Dak.	[1]260	120	Sharp	Spill-through	4,370	6,280	--	1.1	5.3	--	8.7*L* 4.1*R*	10.8*L* 4.5*R*	-- --	3.1	3.5	--
018-109.934N	Elm River near Blanchard, N. Dak.	117	51	Round	Vertical wall with wingwall	3,210	4,690	3,000	--	--	8.4	-- --	-- --	4.4*L* 4.8*R*	--	--	1.5
018-110.903N	Elm River near Blanchard, N. Dak.	112	64.5	Round	Vertical wall with wingwall	3,130	4,570	3,000	--	--	4.7	-- --	-- --	12.6*L* 3.5*R*	-- --	-- --	2.9*L* 2.8*R*
018-129.843	Goose River near Portland, N. Dak.	517	137	Sharp	Spill-through	7,650	12,600	--	0	0	--	3.6*L* 4.5*R*	6.2*L* 10.3*R*	-- --	5.6*L* 5.3*R*	6.5*L* 6.2*R*	-- --
018-203.479	Middle Branch Park River near Hoople, N. Dak.	116	86	Square	Vertical wall	4,470	6,860	--	0	0	--	11.0*L* 7.5*R*	14.6*L* 10.1*R*	-- --	3.3*L* 3.5*R*	3.9*L* 4.0*R*	-- --
018-223.986	Unnamed Creek near Cavalier, N. Dak.	1.8	22	None	Vertical wall with wingwall	209	284	--	4.0	4.9	--	3.5*L* 4.8*R*	3.7*L* 5.1*R*	-- --	--	--	--
021-064.818	Thirty Mile Creek near Bently, N. Dak.	259	155	Sharp	Spill-through	7,890	12,600	--	3.9	4.0	--	8.8*L* 6.5*R*	9.4*L* 7.3*R*	-- --	4.0*L* 5.8*R*	4.4*L* 6.2*R*	-- --
022-045.841	Cannonball River at New England, N. Dak.	274	175	Sharp	Spill-through	11,600	18,500	--	3.3	6.4	--	0*L* 9.5*R*	0*L* 12.0*R*	-- --	5.5*L* 5.8*R*	6.3*L* 6.7*R*	-- --
022-076.287	Green River near Dickinson, N. Dak.	264	125	Sharp	Spill-through	7,820	12,500	--	0	0.2	--	2.5*L* 1.9*R*	8.5*L* 5.7*R*	-- --	7.2	8.1	--
024-000.320	Four Mile Creek near Fort Yates, N. Dak.	13.6	53	None	Vertical wall with wingwall	1,540	2,400	2,100	1.0	--	1.1	5.2*L* 5.6*R*	-- --	6.8*L* 7.2*R*	--	--	--
027-001.456	Bear Creek near Verona, N. Dak.	47	32	None	Vertical wall with wingwall	1,970	3,680	888	--	--	0.1	-- --	-- --	9.5*L* 5.2*R*	--	--	--
027-027.907	Sheyenne River near Lisbon, N. Dak.	2,690	190	Sharp	Spill-through	7,200	10,100	--	2.2	2.5	--	3.5*L* 3.0*R*	3.4*L* 2.8*R*	-- --	4.0*L* 4.2*R*	5.2*L* 4.6*R*	-- --
031-012.802	Cannonball River near Raleigh, N. Dak.	638	195.5	Sharp	Vertical wall	36,400	52,700	27,000	--	--	2.0	-- --	-- --	9.2*L* 8.4*R*	-- --	-- --	6.4*L* 5.2*R*
031-029.214	Dog Tooth Creek at Raleigh, N. Dak.	23.4	42	Square	Vertical wall	2,220	3,460	1,800	--	--	0	-- --	-- --	6.4*L* 8.0*R*	--	--	4.0

Table 4. Results of the Level 2 bridge scour analyses at selected bridge sites in North Dakota—Continued

[mi^2, square miles; ft^3/s, cubic feet per second; Q_{100}, discharge estimate for the 100-year recurrence interval and associated scour estimates; Q_{500}, discharge estimate for the 500-year recurrence interval and associated scour estimates; Qa, maximum flow that could be routed through bridge without overtopping and associated scour estimates; --, not determined; *L*, left; *R*, right; *C*, center;]

Bridge number	River name	Drainage area (mi^2)	Bridge length (feet)	Pier nose shape	Abutment shape	Q_{100} (ft^3/s)	Q_{500} (ft^3/s)	Q_a (ft^3/s)	Contraction scour (feet)			Abutment scour (feet)			Pier scour (feet)		
									Q_{100}	Q_{500}	Q_a	Q_{100}	Q_{500}	Q_a	Q_{100}	Q_{500}	Q_a
040-022.345	White Earth River at Battleview, N. Dak.	104	100	Round	Spill-through	3,980	6,400	5,100	0	--	0	6.8*L* 5.4*R*	-- --	7.5*L* 5.8*R*	2.8*L* 2.7*R*	-- --	3.0*L* 2.9*R*
049-007.354	Cedar Creek near Thunder Hawk, S. Dak.	1,140	230	Sharp	Spill-through	31,600	60,800	57,200	8.5	--	21.1	7.5*L* 10.6*R*	-- --	9.5*L* 11.4*R*	8.2*L* 7.7*R*	-- --	9.1*L* 8.7*R*
049-027.574	Cannonball River near New Leipzig, N. Dak.	1,170	325	Sharp	Spill-through	22,800	31,000	--	0	0	--	7.0*L* 0*R*	12.9*L* 0*R*	-- --	5.0*L* 6.4*R*	5.6*L* 7.0*R*	-- --
052-175.923	James River above Manfred, N. Dak.	[1]110	110	Sharp	Spill-through	2,620	4,370	--	0	0	--	4.3*L* 3.3*R*	5.0*L* 4.6*R*	-- --	2.2*L* 2.2*R*	2.6*L* 2.5*R*	-- --
066-040.369	Mauvais Coulee near Egeland, N. Dak.	64	85	Square	Vertical wall	1,520	2,580	--	3.2	5.8	--	10.8*L* 9.8*R*	12.3*L* 12.2*R*	-- --	2.6*L* 2.6*R*	3.1*L* 3.1*R*	-- --
083-025.889	Unnamed Creek at Linton N. Dak.	2.60	32	None	Vertical wall with wingwall	554	860	--	1.9	3.2	--	4.8*L* 4.0*R*	7.2*L* 5.1*R*	-- --	--	--	--
200-124.008	Spring Creek at Dodge, N. Dak.	353	140	Sharp	Vertical wall	8,800	12,600	--	0.9	0.8	--	0*L* 0*R*	0*L* 0*R*	-- --	4.7*L* 7.1*R*	5.0*L* 7.4*R*	-- --
200-156.701	Kineman Creek near Hazen, N. Dak.	32	170	Sharp	Spill-through	2,630	4,100	--	3.4	4.8	--	6.0*L* 0*R*	8.1*L* 0*R*	-- --	4.2*L* 3.6*R*	4.7*L* 4.3*R*	-- --
281-193.777	Big Coulee near Cando, N. Dak.	122	42	None	Vertical wall with wingwall	2,830	4,730	2,200	--	--	0	-- --	-- --	7.4*L* 8.0*R*	--	--	--

[1]Contributing drainage area.

Table 5. Results of estimated scour depths and measured scour depths (bed-elevation changes) at selected bridge sites in North Dakota

[ft^3/s, cubic feet per second; ft/s, feet per second; --, no data; *L*, left; *R*, right; *C*, center]

Bridge number	Discharge measurement and bridge data										Bed-elevation changes, upstream side (feet)			
	Date	Discharge (ft^3/s)	Gage height (feet)	Pier depth, below water surface (feet)	Pier velocity (ft/s)	Abutment depth, below water surface (feet)		Abutment velocity (ft/s)		Estimated scour (feet)	Survey years	Abutment		Pier
						Left	Right	Left	Right	Pier		Left	Right	
001-143.430	4/17/96	4,320	13.74	13.4*L* 10.2*R*	4.31*L* 2.39*R*	--	--	--	--	-4.2*L* -3.1*R*	91-94	+0.06	-0.12	+1.29*L* -0.13*R*
	4/24/97	3,500	13.21	12.6*L* 11.0*R*	3.94*L* 1.85*R*	--	--	--	--	-4.0*L* -2.9*R*	94-96	-0.77	-0.12	-0.58*L* -0.60*R*
											96-97	-0.02	-0.41	-1.71*L* -0.37*R*
005-303.364	7/26/93	535	11.70	5.8	3.15	1.2	7.4	0.4	0.8	-5.4	91-94	-0.04	-0.89	-0.33
	7/30/93	418	11.19	5.5	2.55	--	--	--	--	-5.5	94-97	-3.07	-1.16	-1.24
	4/22/97	[1]464	11.84	7.3	1.2 to 1.7	5.8	7.8	0.24	1.46	-1.5 to -1.7				
006-035.187	7/16/93	3,240	9.00	7.5*L* 4.4*LC* --*RC* --*R*	3.76*L* 2.70*LC* --*RC* --*R*	--		--		-6.2*L* -5.0*LC* --*RC* --*R*	90-[2]93	-0.02	-0.04	-0.24*L* +0.06*LC* +0.26*RC* +0.78*R*
	3/17/94	3,040	8.06	5.6*L* 4.0*LC* 2.1*RC* --*R*	5.26*L* 2.44*LC* 0.532*RC* --*R*	--	--	--	--	-6.1*L* -4.7*LC* -3.6*RC* --*R*	[2]93-[3]93	+0.01	-0.57	-0.42*L* -0.54*LC* +0.86*RC* 0.00*R*
	3/14/95	5,800	11.13	9.8*L* 5.6*LC* --*RC* --*R*	4.60*L* 4.02*LC* --*RC* --*R*	--	--	--	--	-4.9*L* -4.0*LC* --*RC* --*R*	[3]93-94	0.00	+0.79	+0.06*L* -0.40*LC* +0.16*RC* -0.02*R*
	3/24/97	27,800	20.28	19.8*L* 15.2*LC* 11.5*RC* 9.2*R*	7.30*L* 6.34*LC* 4.91*RC* 2.52*R*	--	--	--	--	-5.6*L* -5.1*LC* -4.8*RC* -3.5*R*	94-96	-0.03	+0.07	-0.34*L* +2.18*LC* +1.28*RC* +0.74*R*
											96-97	-0.85	-1.28	+0.80*L* -0.21*LC* -1.06*RC* +1.71*R*
008-099.579	3/22/97	8,840	19.02	18.0*L* 16.5*R*	2.37*L* 5.0*R*	--	6.4	--	4.15	-6.6*L* -6.8*R*	90-96	+0.13	-0.04	--*L* -0.48*R*
											96-97	-0.03	-0.48	--*L* +1.03*R*

Table 5. Results of estimated scour depths and measured scour depths (bed-elevation changes) at selected bridge sites in North Dakota—Continued

[ft^3/s, cubic feet per second; ft/s, feet per second; --, no data; ***L***, left; ***R***, right; ***C***, center]

Bridge number	Discharge measurement and bridge data										Bed-elevation changes, upstream side (feet)			
	Date	Discharge (ft^3/s)	Gage height (feet)	Pier depth, below water surface (feet)	Pier velocity (ft/s)	Abutment depth, below water surface (feet)		Abutment velocity (ft/s)		Estimated scour (feet)	Survey years	Abutment		Pier
						Left	Right	Left	Right	Pier		Left	Right	
011-182.459	--	--	--	--	--	--	--	--	--	--	90-94 94-96 96-97	-0.08 +0.12 -0.01	-0.22 +0.01 -0.07	-0.05***L*** -0.49***R*** +0.46***L*** +0.27***R*** -0.72***L*** -0.73***R***
012-006.555	5/17/95	7,760	10.21	6.8***L*** 12.7***LC*** 6.95***RC*** --***R***	3.27***L*** 5.0***LC*** 2.20***RC*** --***R***	--	--	--	--	-4.1***L*** -5.5***LC*** -3.5***RC*** --***R***	90-94	-0.09	-0.09	+0.45***L*** -0.35***LC*** -0.21***RC*** -0.02***R***
	3/21/97	8,530	11.30	8.0***L*** 11.0***LC*** 6.0***RC*** --***R***	1.6***L*** 5.63***LC*** 3.5***RC*** --***R***	--	--	--	--	-9.5***L*** -5.6***LC*** -4.1***RC*** --***R***	94-96 96-97	-0.04 +0.22	-0.03 -2.47	-0.35***L*** -1.30***LC*** +0.08***RC*** -0.02***R*** -0.34***L*** -0.21***LC*** +0.07***RC*** -0.07***R***
013-386.299L	7/29/93	1,210	12.97	13.1	1.41	6.6	8.2	[4]0.636	0.935	-4.1	90-94	+1.29	-0.58	+0.42
013-386.306R	3/31/93	1,280	[5]13.86	10.0***L***	0.746***L***	--	--	--	--	-1.4***L***	90-94	+0.05	-0.02	-0.10***L***
	7/29/93	1,130	12.86	10.4***R***	2.47***R***					-2.4***R***	94-96	-0.06	-0.05	-0.44***R***
	4/16/97	3,080	--	8.7***L***	0.588***L***	--	--	--	--	-1.3***L***	96-97	-0.13	+0.10	+0.31***L***
				10.7***R***	2.02***R***					-2.2***R***				-0.40***R***
				14.6***L***	2.02***L***	3.0	2.8	--	--	-2.8***L***				-0.68***L***
				14.4***R***	3.26***R***					-2.9***R***				+0.26***R***
015-106.930	7/26/93	216	11.80	10.5	0.752	--	--	--	--	-1.2	91-94	+0.19	-0.95	+0.24
	4/17/96	1,100	13.54	16.0	1.84	--	--	--	--	-1.9	94-97	-1.22	+0.04	-1.48

Table 5. Results of estimated scour depths and measured scour depths (bed-elevation changes) at selected bridge sites in North Dakota—Continued

[ft^3/s, cubic feet per second; ft/s, feet per second; --, no data; ***L***, left; ***R***, right; ***C***, center]

Bridge number	Discharge measurement and bridge data										Bed-elevation changes, upstream side (feet)			
	Date	Discharge (ft^3/s)	Gage height (feet)	Pier depth, below water surface (feet)	Pier velocity (ft/s)	Abutment depth, below water surface (feet)		Abutment velocity (ft/s)		Estimated scour (feet)	Survey years	Abutment		Pier
						Left	Right	Left	Right	Pier		Left	Right	
018-203.479	5/17/96	651	9.67	6.5*L*	0.65*L*	1.5	3.2	--	--	-1.9*L*	91-97	-0.11	-0.42	-0.02*L*
	4/20/97	599	10.28	8.0*R*	1.69*R*					-3.0*R*				-0.78*R*
				6.2*L*	0.504*L*	2.0	2.0	--	--	-1.4*L*				
				9.2*R*	1.26*R*					-2.3*R*				
022-076.287	3/22/97	4,330	16.61	15.3	6.08	--	--	--	--	-2.7	90-94	+0.06	-0.02	-0.60
											94-96	+0.01	+1.90	-0.02
											96-97	-0.04	-1.91	-0.06
027-001.456	7/28/93	319	14.10	--	--	6.1	5.9	1.79	1.31	--	90-94	0.00	-0.05	--
	4/13/96	262	--			6.0	5.3	1.59	1.19					
	4/22/97	[1]468	--			6.5	5.8	1.40	1.84					
027-027.907	8/02/93	3,340	14.40	7.6*L*	1.28*L*	--	--	--	--	-2.3*L*	Data lost due to instrument problems and extreme high water in channel making survey impossible.			
	4/04/95	4,470	14.50	10.8*R*	2.74*R*					-9.4*R*				
	4/26/96	4,670	15.81	11.2*L*	2.12*L*	--	--	--	--	-3.0*L*				
	4/08/97	4,750	16.63	4.7*R*	1.80*R*					-2.4*R*				
	4/18/97	3,890	15.34	8.7*L*	1.28*L*	--	--	--	--	-2.2*L*				
				13.2*R*	3.65*R*					-5.1*R*				
				--*L*	--*L*	--	--	--	--	--*L*				
				15.9*R*	4.18*R*					-4.3*R*				
				8.2*L*	1.24*L*	--	--	--	--	-2.2*L*				
				12.1*R*	2.88*R*					-10.6*R*				
031-012.802	3/26/97	5,400	10.60	13.8*L*	6.64*L*	--	--	--	--	-5.7*L*	90-96	-1.53	-1.88	--*L*
				3.8*R*	1.65*R*					-2.5*R*				+0.27*R*
											96-97	+0.29	+0.01	-2.31*L*
														+0.23*R*
052-175.923	--	--	--	--	--	--	--	--	--	--	91-94	-0.07	-0.17	-0.20*L*
											94-97	--	--	-1.18*R*
														+0.05*L*
														0.00*R*

Table 5. Results of estimated scour depths and measured scour depths (bed-elevation changes) at selected bridge sites in North Dakota—Continued

[ft^3/s, cubic feet per second; ft/s, feet per second; --, no data; ***L***, left; ***R***, right; ***C***, center]

Bridge number	Discharge measurement and bridge data										Bed-elevation changes, upstream side (feet)			
	Date	Discharge (ft^3/s)	Gage height (feet)	Pier depth, below water surface (feet)	Pier velocity (ft/s)	Abutment depth, below water surface (feet)		Abutment velocity (ft/s)		Estimated scour (feet)	Survey years	Abutment		Pier
						Left	Right	Left	Right	Pier		Left	Right	
066-040.369	4/21/97	[1]553	6.88	7.0***L*** 7.0***R***	1.6***L*** 1.0***R***	6.0	5.5	--	--	-1.7***L*** -1.4***R***	96-97	-2.01	-1.27	+1.48***L*** +2.37***R***
083-025.889	--	--	--	--	--	--	--	--	--	--	91-94	+0.72	+0.69	--
200-124.008	--	--	--	--	--	--	--	--	--	--	90-96 96-97	-0.01 -1.96	-0.01 --	-0.56***L*** -0.27***R*** -0.08***L*** -0.75***R***
281-193.777	4/15/96 4/21/97	374 628	5.64 5.83	--	--	4.0 6.2	4.4 5.1	1.32 1.64	1.51 -0.56	--	91-94 94-96 96-97	-0.02 -0.12 -0.79	-0.06 +1.73 -2.23	--

[1]Measurements made on downstream side of bridge.
[2]Bridge surveyed on May 6, 1993.
[3]Bridge surveyed on September 16, 1993.
[4]Estimated.
[5]To ice.

SUMMARY

A Level 2 bridge scour method was used to estimate contraction, abutment, and pier scour depths at 36 selected bridge sites located on the primary road system throughout North Dakota. The North Dakota Department of Transportation used the scour results to determine if the bridge sites were scour critical. Of the 36 bridge sites analyzed, 15 were rated scour critical and will need further monitoring or application of bridge structure countermeasures.

Flood and scour data were collected at 19 of the 36 selected bridge sites. Data collected during the high flows were used to estimate pier scour depths. The estimated pier scour depths were compared to measured bed-elevation changes determined from cross section surveys taken before and after the high-flow measurements. Estimated pier scour depths ranged from -10.6 to -1.2 feet, and measured bed-elevation changes at the piers ranged from -2.31 to +2.37 feet. Comparisons between the estimated pier scour depths and the measured bed-elevation changes indicate that the pier scour equations overestimate scour at bridges in North Dakota. Collected flow data were insufficient to estimate contraction and abutment scour. However, measured abutment bed-elevation changes determined from cross section surveys ranged from -3.07 to +1.90 feet.

A Level 1.5 bridge scour method was used to estimate contraction, abutment, and pier scour depths at 495 selected bridge sites located on the secondary road system throughout North Dakota. The North Dakota Department of Transportation used the results to analyze the bridge sites and determined that 26 bridge sites were potentially scour critical and will require additional analysis.

REFERENCES

Crosby, O.A., 1966, Floods of June 24-25, 1966, in southwest-central North Dakota: U.S. Geological Survey open-file report, 15 p.

Froehlich, D.C., 1989, Abutment scour prediction: Paper presented at the 68th annual Transportation Research Board meeting, Washington, D.C.

Holnbeck, S.R., and Parrett, C., 1997, Method for rapid estimation of scour at highway bridges based on limited site data: U.S. Geological Survey Water-Resources Investigations Report 96-4310, 79 p.

Laursen, E.M., 1960, Scour at bridge crossings: American Society of Civil Engineering, Journal of Hydraulic Engineering, v. 86, no. 2, p. 39-55.

Niehus, C.A., 1996, Scour assessments and sediment-transport simulation for selected bridge sites in South Dakota: U.S. Geological Survey Water-Resources Investigations Report 96-4075, 80 p.

Oltman, R.E., and others, 1951, Missouri River basin floods of April-May 1950 in North and South Dakota: U.S. Geological Survey Water-Supply Paper 1137-A, 114 p.

Richardson, E.V., Harrison, L.J., and Davis, S.R., 1991, Evaluating scour at bridges: U.S. Department of Transportation Publication No. FHWA-IP-90-017 Hydraulic Engineering Circular No. 18, 105 p.

Shearman, J.O., 1990, User's manual for WSPRO--A computer model for water surface profile computations: U.S. Department of Transportation Publication No. FHWA-IP-89-027 Hydraulic Computer Program HY-7, 177 p.

Shearman, J.O., Kirby, W.H., Schneider, V.R., and Flippo, H.N., 1986, Bridge waterways analysis model-research report: U.S. Department of Transportation Publication No. FHWA/RD-86/108, 112 p.

U.S. Department of Transportation, 1988, Scour at bridges: Washington, D.C., Federal Highway Administration Technical Advisory T 5140.20, 6 p.

Williams-Sether, Tara, 1992, Techniques for estimating peak-flow frequency relations for North Dakota streams: U.S. Geological Survey Water-Resources Investigations Report 92-4020, 57 p.

Bridge length

Bridge length is provided by the North Dakota Department of Transportation.

Method

17B, Bulletin 17B frequency curve (Williams-Sether, 1992)
DA, drainage area ratio method (Williams-Sether, 1992)
EQN, regression equation (Williams-Sether, 1992)
EST, estimate

Distance below lowsteel to streambed

A, abutment
C, center
L, left
P, pier
R, right
S, stream
ice, distance below lowsteel to ice in channel

Other abbreviations and symbols

ft^3/s, cubic feet per second
Q_{100}, discharge estimate for the 100-year recurrence interval
Q_a, adjusted Q_{100}; discharge determined to flow through bridge without overtopping; scour estimates are based on Q_a when determined
--, not determined

Note

Number is parentheses after county is county number.

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Adams County (01)											
111-03.0	108	Cedar Creek	7,700	--	EQN	6.0 LA 15.0 LP(ice) 16.0 S(ice) 15.0 RP(ice) 2.0 RA	11.4	1.5	0	20.9	16.4
115-05.0	112	Cedar Creek	8,210	--	EQN	4.0 LA 14.0 LP(ice) 14.0 S(ice) 14.0 RP(ice) 4.0 RA	11.5	2.0	14.5	14.5	16.4
120-12.1	40	Duck Creek	3,380	2,500	EQN	6.0 LA 8.0 S(ice) 7.0 RA	10.2	20.5	23.8	23.8	--
132-13.0	150	Cedar Creek	20,900	15,000	DA	3.0 LA 19.0 LP(ice) 19.0 S(ice) 20.0 RP(ice) 3.0 RA	15.2	2.7	24.0	14.5	16.0
132-20.0	102	Duck Creek	3,360	--	EQN	2.0 LA 9.0 LP(ice) 9.0 S(ice) 9.0 RP(ice) 2.0 RA	7.5	4.7	24.0	24.0	15.9
135-21.0	87	Duck Creek	3,160	--	EQN	2.0 LA 10.0 P(ice) 10.0 S(ice) 3.0 RA	8.5	10.5	27.3	27.3	24.1
146-11.0	126	Sheep Creek	1,170	--	EQN	3.0 LA 11.0 LP(ice) 11.0 S(ice) 11.0 RP(ice) 4.0 RA	4.3	0	0	0	6.4

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
									Abutment		
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Left	Right	Pier
Barnes County (02)											
118-15.0	122	Sheyenne River	7,410	--	17B	--	10.5	4.7	19.1	19.1	8.2
118-16.0	113	Sheyenne River	7,530	--	DA	--	10.9	10.5	10.9	[1]10.9	5.5
119-07.0	154	Baldhill Creek	7,540	--	DA	--	9.2	4.3	[1]20.9	24.0	13.6
122-25.0	110	Sheyenne River	6,840	--	DA	5.0 LA 15.0 LP 18.0 S 17.0 RP 4.0 RA	13.3	0.5	14.5	7.3	10.1
122-27.0	124	Sheyenne River	6,860	--	DA	3.0 LA 13.0 LP 18.0 S 16.0 RP 3.0 RA	12.0	0.6	10.9	0	10.2
122-29.0	110	Sheyenne River	6,890	--	DA	8.0 LA 24.0 P 24.0 S 5.0 RA	16.4	3.1	22.4	0	16.5
123-31.0	132	Sheyenne River	6,930	--	DA	2.0 LA 13.0 LP 19.0 S 14.0 RP 3.0 RA	11.7	0.2	0	7.3	12.7
123-33.0	114	Sheyenne River	6,940	--	DA	4.0 LA 17.0 LP 20.0 S 18.0 RP 4.0 RA	13.2	2.5	24.0	14.5	9.5
123-35.0	124	Sheyenne River	6,950	--	DA	4.0 LA 23.0 LP 25.0 S 23.0 RP 4.0 RA	13.2	8.0	20.9	0	9.5
123-38.0	133	Sheyenne River	6,960	--	DA	3.0 LA 13.0 LP 18.0 S 16.0 RP 3.0 RA	13.9	1.2	24.0	20.9	19.0
135-21.0	26	Koldok Waterway	1,260	--	EQN	--	--	--	--	--	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Benson County (03)											
110-33.1	70	Sheyenne River	6,110	--	DA	3.0 LA 4.0 RA	12.8	1.5	0	7.3	--
112-28.0	30	Big Coulee	1,540	--	DA	6.0 LA 6.0 RA	9.1	13.0	21.2	19.7	--
116-34.0	75	Sheyenne River	6,740	--	DA	8.0 LA 8.0 RA	12.9	3.0	20.9	24.0	--
120-32.0	55	Sheyenne River	6,800	6,000	DA	10.0 LA 12.0 RA	15.2	11.0	18.6	25.0	--
129-13.0	50	Big Coulee	2,940	--	17B	5.0 LA 9.0 S 5.0 RA	10.2	15.8	24.0	27.3	--
141-35.0	60	Sheyenne River	6,930	4,500	DA	10.0 LA 15.0 S 10.0 RA	16.5	5.7	27.3	22.7	--
Billings County (04)											
106-15.0	82	Ash Coulee	2,660	--	EQN	--	7.2	0.6	8.0	0	--
106-30.0	71	Sully Creek	2,310	--	EQN	--	7.4	0.8	14.5	0	--
108-18.0	132	Franks Creek	2,860	--	EQN	--	6.9	0	0	0	6.6
109-19.0	124	Franks Creek	2,860	--	EQN	--	6.9	0	0	0	6.6
110-19.0	76	Franks Creek	2,860	--	EQN	--	8.9	0.4	0	0	--
124-18.0	72	Green River	2,480	--	EQN	--	7.7	1.6	7.3	14.5	--
126-17.0	66	Unnamed Creek	2,270	--	EQN	--	7.8	2.6	14.5	18.2	--
127-06.0	72	Knife River	2,500	--	EQN	--	7.7	3.6	20.9	7.3	--
127-21.0	74	Green River	2,600	--	EQN	--	7.7	0.8	14.5	7.3	--
129-21.0	50	Green River	5,860	--	EQN	--	16.4	16.0	22.4	22.4	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Bottineau County (05)											
103-12.0	41	East Cut Bank Creek	3,700	3,400	EQN	10.0 LA 10.0 S 8.0 RA	13.6	7.5	22.4	22.4	--
121-26.0	51	Cut Bank Creek	5,370	4,000	EQN	11.0 LA 18.0 S 11.0 RA	17.4	29.0	0	27.6	--
128-12.0	50	Boundary Creek	6,580	4,000	DA	12.0 LA 12.0 S 10.0 RA	14.9	15.8	30.5	0	--
133-23.0	158	Souris River	5,500	--	EST	--	9.5	4.0	25.0	25.0	15.4
135-07.0	45	Boundary Creek	3,500	--	EQN	--	11.5	12.5	0	0	--
137-05.0	31	Boundary Creek	3,250	2,000	EQN	--	10.8	7.5	17.1	17.1	--
140-20.0	41	Stone Creek	2,860	2,000	EQN	--	9.1	6.9	19.7	19.7	--
149-13.0	32	Oak Creek	4,180	1,000	EQN	--	7.0	1.6	20.9	14.5	--
149-13.1	36	Oak Creek	4,220	1,000	EQN	--	7.3	2.1	0	20.9	--
149-14.1	33	Oak Creek	4,270	1,000	EQN	--	7.7	0	0	0	--
161-23.0	33	Unnamed Tributary to Willow Creek	4,040	3,000	EQN	--	13.2	12.0	22.4	22.4	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Bowman County (06)											
103-01.0	49	Corral Creek	2,000	--	EQN	5.0 LA 14.0 S 5.0 RA	9.0	0	0	0	--
114-10.0	40	Spring Creek	1,430	--	EQN	10.0 LA 11.0 S 10.0 RA	7.5	6.8	11.9	11.9	--
127-20.0	50	North Fork Grand River	2,660	--	EQN	2.0 LA 9.0 S(ice) 2.0 RA	9.5	5.6	26.2	22.4	--
128-01.0	30	Deep Creek	1,500	--	EQN	8.0 LA 8.0 S 8.0 RA	9.0	18.1	21.2	23.8	--
128-01.1	40	Deep Creek	1,500	--	EQN	2.0 LA 5.0 S 2.0 RA	7.7	8.5	24.0	--	--
138-01.0	45	Cedar Creek	1,260	--	EQN	4.0 LA 6.0 S(ice) 4.0 RA	6.7	6.9	20.9	0	--
143-14.0	40	Unnamed Creek	737	--	EQN	4.0 LA 8.0 S 4.0 RA	5.6	5.1	0	20.5	--
144-17.0	50	Lightning Creek	6,360	4,000	EQN	3.0 LA 10.0 S 12.0 S 10.0 S 3.0 RA	11.8	16.5	25.0	0	--
148-01.0	50	Cedar Creek	4,970	3,000	EQN	5.0 LA 12.0 S 5.0 RA	11.6	13.3	28.9	14.5	--
150-20.0	65	Lightning Creek	6,360	4,500	EQN	2.0 LA 8.0 S(ice) 2.0 RA	11.1	14.8	29.1	29.1	--
151-02.0	25	South Cedar Creek	1,920	1,920	EQN	7.0 LA 9.0 S 8.0 RA	11.8	8.6	22.4	11.9	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Burleigh County (08)											
107-29.0	71	Burnt Creek	8,480	--	17B	3.3 LA 7.0 S 14.5 S 6.8 S 3.7 RA	15.0	3.7	0	17.0	--
108-28.1	71	Burnt Creek	7,120	--	DA	--	13.4	2.3	18.6	22.4	--
110-20.0	53	Burnt Creek	2,420	--	EQN	--	9.0	3.6	13.2	13.2	--
110-21.0	46	Burnt Creek	2,420	--	EQN	--	9.6	3.0	10.0	4.0	--
110-26.0	40	Burnt Creek	1,950	--	EQN	--	9.2	8.5	18.6	14.9	--
111-25.0	41	Burnt Creek	1,940	--	EQN	--	8.9	3.2	4.0	4.0	--
113-38.0	75	Apple Creek	7,870	--	DA	5.0 LA 5.0 RA	14.5	2.4	0	0	--
115-05.0	70	Painted Woods Creek	3,390	--	DA	3.0 LA 2.0 RA	9.6	9.2	0	20.7	--
117-36.0	70	Apple Creek	7,700	5,000	DA	8.0 LA 9.0 S(ice) 7.0 RA	11.3	2.9	19.7	19.7	--
118-02.0	52	McClusky Canal	1,950	--	--	3.0 LA 17.0 S 3.0 RA	5.4	0.4	0	0	6.4
119-02.0	52	McClusky Canal	1,950	--	--	3.0 LA 18.0 S 2.0 RA	5.4	0.4	0	0	9.7
119-21.0	27	West Branch Apple Creek	2,260	1,600	EQN	6.5 LA 9.0 S 7.5 RA	9.6	2.4	6.0	8.9	--
121-34.0	56	Apple Creek	7,530	--	DA	8.0 LA 7.0 RA	15.1	2.2	0	11.9	--
129-41.0	51	Long Lake Creek	3,640	2,400	DA	5.0 LA 5.0 S(ice) 5.0 RA	8.9	6.3	17.1	17.1	--
135-47.0	68	Long Lake Creek	8,830	3,400	[2]17B	6.0 LA 6.0 S(ice) 6.0 RA	9.6	8.5	19.7	19.7	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
					Cass County (09)						
101-03.0	69	Maple River	3,500	--	EQN	--	9.8	0.2	0	0	12.5
103-13.0	38	Maple River Tributary	2,120	--	EQN	12.0 LA 13.0 S 9.0 RA	9.8	4.5	16.8	19.7	--
104-31.1	74	Maple River	9,000	5,600	EQN	--	11.7	4.7	0	0	4.4
111-39.0	150	Maple River	12,200	--	EQN	--	12.7	3.0	[1]15.0	[1]15.0	5.6
117-28.0	56	Buffalo Creek	2,740	--	EQN	--	9.6	8.5	[1]13.2	[1]13.2	--
120-21.0	72	Swan Creek	1,930	--	EQN	--	6.6	1.5	8.0	0	4.2
120-32.0	56	Buffalo Creek Tributary	1,520	--	EQN	--	6.9	5.5	[1]11.5	[1]11.5	--
121-32.0	88	Buffalo Creek Tributary	1,880	--	EQN	--	6.9	3.6	11.5	11.5	11.8
126-32.1	180	Maple River	12,500	--	EQN	--	12.6	3.6	[1]15.0	[1]15.0	4.4
129-03.0	100	Elm River	3,150	--	EQN	--	7.3	0.7	11.5	11.5	10.7
132-19.1	55	Rush River	3,510	--	EQN	--	10.6	4.0	10.0	12.5	--
133-21.0	63	Raymond Coulee	1,420	--	EQN	--	6.7	2.0	6.0	6.0	--
136-18.0	72	County Drain 2	1,510	--	EQN	--	6.2	3.1	0	0	6.3
136-39.1	170	Sheyenne River	6,830	--	DA	1.5 LA 16.5 LP 16.0 RP 3.0 RA	19.2	0	8.0	8.0	5.7
137-34.0	169	Sheyenne River	6,830	--	DA	2.5 LA 12.0 LP 6.0 RP 2.0 RA	18.2	0.2	11.5	0	3.7
138-20.1	304	Sheyenne River	6,960	--	DA	3.0 LA 11.5 LP 22.5 LCP 23.0 RCP 11.5 RP 3.0 RA	21.0	0.3	11.5	11.5	6.5
138-21.0	299	Sheyenne River	6,960	--	DA	2.0 LA 8.5 LP 25.0 CP 21.0 RP 3.0 RA	25.0	0	27.6	17.1	6.6
138-31.1	246	Sheyenne River	5,890	--	DA	3.0 LA 17.0 LP 11.0 RP 2.0 RA	17.1	0	0	0	5.5

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment Left	Abutment Right	Pier
Cass County (09)-Continued											
139-18.0	375	Sheyenne River	6,960	--	DA	2.5 LA 8.5 LP 13.0 LCP 24.5 RCP 11.0 RP 2.0 RA	16.0	0.4	13.2	13.2	5.0
140-30.0	66	County Drain 27	549	--	EQN	--	4.7	3.3	[1]8.0	[1]8.0	--
141-15.0	452	Sheyenne River	7,150	--	DA	2.0 LA 11.0 LP 14.0 LCP 25.0 CP 32.0 S 27.0 RCP 15.0 RP 2.0RA	5.9	1.3	10.0	10.0	8.4
142-04.0	206	Red River of the North	49,000	--	EST	3.0 LA 39.0 S 41.0 P 5.0 RA	17.1	1.0	30.5	30.5	14.5
142-10.0	553	Red River of the North	44,300	--	EST	2.0 LA 36.0 LP 36.0 S 19.0 RP 2.0 RA	19.0	2.9	18.5	16.8	21.5
142-36.1	106	Wild Rice River	14,000	--	EQN	--	16.1	9.5	8.0	0	12.5
143-34.0	241	Wild Rice River	14,000	--	EQN	--	10.8	3.9	4.0	0	11.3
0029061417 T	70	Rose Coulee	614	--	EQN	--	4.9	5.6	[1]8.0	[1]8.0	4.1
Cavalier County (10)											
142-32.0	45	South Branch Park River	4,530	--	EQN	--	13.9	24.0	17.0	12.1	--
146-10.0	102	Little South Pembina River	14,200	9,400	17B	5.5 LA 15.5 P 4.0 RA	12.8	1.8	27.3	0	6.2

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Dickey County (11)											
109-23.0	22	Unnamed Creek	603	--	EQN	--	6.7	15.5	14.9	11.9	--
114-24.0	22	Unnamed Creek	1,020	--	EQN	--	8.9	36.5	0	0	--
116-16.0	25	Unnamed Creek	1,610	1,000	EQN	--	9.2	28.5	17.1	17.1	--
122-04.0	65	Maple River	4,520	--	EQN	--	11.3	9.2	27.3	24.0	--
122-08.0	80	South Fork Maple River	3,000	--	EQN	--	7.9	9.0	0	0	10.0
127-24.0	100	Maple River	9,330	--	17B	--	13.6	10.0	30.5	30.5	20.0
128-10.0	90	Maple River	8,040	--	DA	--	12.6	13.5	0	24.0	6.8
128-13.0	92	Maple River	8,340	--	DA	--	13.6	9.0	20.9	20.9	19.0
128-15.0	100	Maple River	8,400	6,400	DA	--	10.6	13.0	24.0	27.3	5.5
130-10.0	100	Maple River	8,250	6,000	DA	--	10.2	6.8	0	7.3	6.8
136-03.0	122	James River	6,200	--	DA	--	9.4	12.5	14.5	20.9	13.4
140-06.0	130	James River	6,290	--	DA	--	9.1	5.6	24.0	22.7	10.1
142-15.0	142	James River	6,770	--	DA	--	9.0	25.0	0	0	6.7
143-10.0	168	James River	6,720	--	DA	--	8.2	18.5	24.5	0	6.6
Divide County (12)											
135-03.0	70	Long Creek	11,500	--	DA	--	20.1	12.0	20.9	20.9	--
137-11.0	22	Long Creek Tributary	1,870	1,600	EQN	9.0 LA 9.0 S 9.0 RA	11.2	32.5	22.4	22.4	--
143-05.0	28	Long Creek Tributary	3,420	2,900	EQN	14.0 LA 16.0 S 14.0 RA	14.4	16.0	22.4	22.4	--
145-02.0	75	Long Creek	13,100	--	17B	--	18.4	1.8	19.7	19.7	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Dunn County (13)											
105-55.0	82	Green River	6,210	--	DA	3.0 LA 15.0 P 3.3 RA	14.8	0	0	7.3	14.7
114-39.0	110	Knife River	7,240	--	DA	3.6 LA 18.1 LP 17.0 RP 4.5 RA	12.7	0	0	0	5.3
117-30.0	54	Spring Creek	2,970	--	EQN	5.3 LA 5.7 RA	11.6	0.8	14.7	7.3	--
122-43.0	91	Knife River	8,220	--	DA	2.3 LA 3.6 RA	15.8	0.2	7.3	10.9	--
122-45.3	98	Crooked Creek	5,410	--	EQN	4.0 LA 8.0 LP(ice) 8.0 RP(ice) 4.0 RA	10.1	0.2	3.8	3.8	9.1
122-49.0	82	Deep Creek	2,570	--	EQN	4.0 LA 3.7 RA	7.7	0.3	7.3	10.9	--
125-50.0	86	Deep Creek	3,150	--	EQN	4.4 LA 3.3 RA	8.9	1.2	0	0	--
131-31.0	86	Spring Creek	7,280	--	EQN	3.5 LA 3.8 RA	15.5	1.4	14.7	24.0	--
134-31.0	120	Spring Creek	8,640	--	EQN	2.6 LA 14.4 LP 17.3 RP(ice) 3.3 RA	17.5	0	0	0	11.2
141-34.0	120	Spring Creek	10,000	--	EQN	1.8 LA 13.0 LP 14.6 RP 4.0 RA	14.9	0.1	7.3	7.3	5.3
141-47.0	120	Knife River	12,400	--	DA	4.2 LA 18.5 LP 17.3 RP(ice) 4.3 RA	15.6	2.2	0	0	6.7
142-52.0	85	Branch Knife River	7,480	--	EQN	3.2 LA 3.6 RA	14.2	1.8	0	0	--
143-47.0	25	Schaffner Creek	1,730	1,100	EQN	6.8 LA 6.8 RA	8.6	7.5	0	0	--
143-48.0	68	Knife River	15,900	--	DA	4.0 LA 33.0 S 3.0 RA	15.5	7.5	0	0	8.2

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment Left	Abutment Right	Pier
Eddy County (14)											
101-09.0	60	James River	10,700	2,500	DA	3.0 LA 6.0 S(ice) 3.0 RA	8.3	13.2	27.3	27.3	--
112-14.0	65	James River	11,500	3,000	DA	2.0 LA 8.0 S(ice) 2.0 RA	10.5	15.5	24.0	24.0	--
112-16.0	76	James River	11,000	4,000	DA	2.0 LA 9.0 S(ice) 3.0 RA	11.3	9.5	27.3	18.2	--
115-18.0	78	James River	11,000	4,500	DA	5.0 LA 14.0 S(ice) 5.0 RA	12.9	20.0	30.5	30.5	--
117-01.0	99	Sheyenne River	6,960	--	DA	2.0 LA 12.0 P 12.0 S 2.0 RA	12.9	2.0	25.8	25.8	9.8
122-07.0	98	Sheyenne River	7,140	--	DA	5.0 LA 17.0 P 15.0 S 5.0 RA	15.3	5.6	24.0	7.3	9.4
Emmons County (15)											
105-19.0	64	Horsehead Creek	4,470	--	EQN	--	11.0	1.2	0	11.5	4.4
107-09.0	55	Badger Creek	2,880	--	EQN	--	9.7	0.5	8.0	2.3	--
108-39.0	50	Cattail Creek	3,610	--	EQN	3.0 LA 11.0 S 5.0 RA	11.7	6.3	7.3	7.3	--
108-40.0	51	Cattail Creek	3,610	3,500	EQN	5.0 LA 10.0 S 5.0 RA	11.9	6.8	20.9	0	--
118-26.1	121	Beaver Creek	18,300	7,000	[3]17B	2.0 LA 15.0 P(ice) 15.0 S(ice) 2.0 RA	11.8	2.6	24.0	25.8	20.4
123-04.0	62	Long Lake Creek	5,490	3,600	EQN	7.0 LA 7.0 P(ice) 7.0 S(ice) 7.0 RA	10.1	6.2	25.8	25.8	4.3
130-29.0	47	Beaver Creek	14,000	--	DA	3.3 LA 18.3 S 22.3 P 18.5 S 3.0 RA	23.7	18.5	14.5	25.8	23.9
131-32.1	83	South Branch Beaver Creek	5,460	--	EQN	3.0 LA 9.0 P(ice) 9.0 S(ice) 3.0 RA	10.7	5.5	24.0	24.0	6.8
131-33.0	55	South Branch Beaver Creek	5,460	4,660	EQN	15.0 LA 15.0 S(ice) 14.0 RA	15.7	10.6	19.7	22.4	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Foster County (16)											
104-16.0	38	Pipestem Creek	4,480	2,000	EQN	4.0 LA 9.0 S 5.0 RA	10.7	6.5	27.3	27.3	--
105-16.1	25	Pipestem Creek	4,510	1,500	EQN	8.0 LA 10.0 S 6.0 RA	12.0	9.0	19.7	23.8	--
106-18.0	45	Pipestem Creek	4,580	3,000	EQN	9.0 LA(ice) 9.0 S(ice) 9.0 RA(ice)	13.8	11.2	21.0	22.4	--
115-01.0	60	James River	11,300	3,500	DA	7.0 LA 13.0 S 7.0 RA	11.9	16.6	27.3	33.6	--
119-02.0	85	James River	10,700	5,000	17B	6.5 LA 10.5 S 5.5 RA	10.6	33.7	20.5	7.3	--
121-04.0	62	James River	10,200	3,400	DA	3.0 LA 9.0 S 4.0 RA	12.1	5.3	24.0	33.6	--
122-05.0	45	James River	10,200	4,000	DA	9.0 LA 17.0 S 11.0 RA	18.3	14.1	22.4	19.7	--
123-13.0	60	James River	11,400	4,600	17B	12.0 LA 14.0 S 9.0 RA	17.0	8.0	33.6	33.6	--
Golden Valley County (17)											
110-29.0	27	Unnamed Creek	1,190	--	EQN	--	8.6	20.0	0	0	--
112-35.0	31	North Branch Garner Creek	1,790	--	EQN	--	9.8	14.9	22.4	0	--
112-37.0	40	South Branch Garner Creek	1,780	--	EQN	--	8.6	8.5	17.1	17.1	--
112-44.0	40	Bullion Creek	5,120	4,120	EQN	--	13.5	10.5	19.7	11.9	--
116-03.0	146	Beaver Creek	15,630	--	EQN	--	19.4	1.3	8.0	11.5	18.5

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment Left	Abutment Right	Pier
Grand Forks County (18)											
107-09.0	37	Turtle River	3,420	1,500	EQN	--	8.8	20.0	19.7	19.7	--
107-11.0	37	North Branch Turtle River	2,750	1,300	EQN	--	8.5	10.0	19.7	19.7	--
107-13.0	37	Turtle River Tributary	1,260	--	EQN	--	7.5	13.0	19.7	19.7	--
110-01.0	64	South Branch Forest River	9,370	5,000	EQN	--	12.4	9.5	19.7	8.9	--
115-35.0	84	Goose River	5,460	--	EQN	--	11.0	4.2	7.3	7.3	--
124-13.0	51	Turtle River	7,350	4,000	EQN	7.0 LA 11.0 S 13.0 RA	13.8	11.0	19.7	0	--
125-12.0	75	Turtle River	8,120	4,200	EQN	4.0 LA 12.0 S 4.0 RA	13.8	7.2	24.0	27.3	--
127-03.1	114	Country Drain No. 12	3,380	--	EQN	--	6.9	0	0	0	6.6
127-13.0	80	Turtle River	8,120	4,000	EQN	5.0 LA 14.0 S 5.0 RA	14.3	3.3	24.0	24.0	--
133-10.0	96	Turtle River	14,300	5,700	DA	3.0 LA 13.0 S 14.0 P 13.0 S 3.0 RA	13.8	6.3	20.9	20.9	5.1
133-10.1	114	Turtle River	14,300	7,000	DA	4.0 LA 12.0 S 13.0 P 12.0 S 4.0 RA	12.8	1.9	20.9	24.0	9.6
133-11.3	87	Turtle River	14,200	5,700	DA	5.0 LA 14.0 P 14.0 S 5.0 RA	13.3	4.5	24.0	20.9	6.4
133-12.0	110	Turtle River	14,200	7,000	DA	5.0 LA 11.0 P 11.0 S 5.0 RA	12.4	5.2	24.0	14.5	6.5
134-05.1	118	Turtle River	15,200	7,000	DA	--	13.5	7.5	27.3	24.0	9.7
134-06.0	176	Turtle River	14,800	7,000	DA	--	16.1	3.5	27.3	24.0	18.8
134-09.0	119	Turtle River	14,300	5,800	DA	3.0 LA 15.0 LP 16.0 S 15.0 RP 3.0 RA	12.5	3.8	24.0	24.0	19.3
137-10.0	130	Marais River	119	--	EQN	4.0 LA 13.0 S 14.0 P 4.0 RA	1.6	0.1	0	0	18.5
138-11.0	86	Marais River	88	--	EQN	7.0 LA 15.0 S 6.0 RA	1.8	0.3	0	0	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Grand Forks County (18)--Continued											
141-26.1	65	Elm Coulee	1,820	--	EQN	4.0 LA 12.0 S 3.0 RA	6.9	9.5	24.0	7.3	--
146-30.0	551	Red River of the North	69,400	--	EST	3.0 LA 16.0 LP 3.0 RA	22.4	1.2	0	20.9	20.6
146-36.0	68	Buffalo Coulee	2,530	--	EQN	3.0 LA 14.0 S 4.0 RA	8.0	2.9	0	24.0	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Grant County (19)											
103-08.0	32	Unnamed Creek	2,520	--	EQN	10.0 LA 9.5 RA	12.8	11.5	0	0	--
112-48.0	190	Cedar Creek	34,700	--	17B	2.0 LA 24.0 LP 21.0 RP 3.0 RA	19.2	0.2	14.5	0	7.1
113-25.0	188	Cannonball River	31,200	--	DA	2.0 LA 24.0 LP(ice) 22.0 RP 2.0 RA	17.7	0.2	0	20.9	9.4
118-20.0	99	Antelope Creek	4,780	--	EQN	3.0 LA 15.0 LP 15.0 RP 5.0 RA	9.0	0	0	0	6.7
118-35.1	32	Unnamed Creek	2,140	--	EQN	6.0 LA 6.0 RA	10.9	13.5	11.9	17.1	--
119-20.0	100	Antelope Creek	4,780	--	EQN	5.0 LA 15.0 LP 13.0 RP 6.0 RA	9.2	0.8	14.5	14.5	16.8
121-33.0	194	Cannonball River	32,200	--	DA	4.0 LA 19.0 LP 20.0 RP 6.0 RA	17.7	0	0	0	7.0
123-10.0	178	Heart River	34,300	--	DA	5.0 LA 13.0 LP 20.0 RP 4.0 RA	19.8	0.7	14.5	24.0	17.7
127-09.0	32	Unnamed Creek	1,120	--	EQN	15.0 LA 14.0 RA	8.0	0.3	6.0	6.0	--
127-35.0	224	Cannonball River	33,700	--	DA	2.0 LA 7.0 LP 20.0 CP 19.0 RP 5.0 RA	16.3	0.4	14.5	24.0	9.4
130-35.0	169	Cannonball River	34,200	--	DA	2.0 LA 15.0 LP 22.0 RP 4.0 RA	19.9	0.7	20.9	14.5	9.5
143-35.0	63	Unnamed Creek	1,950	--	EQN	5.0 LA 5.0 RA	7.3	4.9	20.9	20.9	--
146-33.0	99	Unnamed Tributary	3,320	--	EQN	3.0 LA 14.0 LP(ice) 11.0 RP 1.0 RA	7.6	0.7	24.0	7.3	15.6
147-35.0	296	Cannonball River	52,800	--	DA	14.0 LA 14.0 LP 15.0 LCP 28.0 RCP 28.0 RP 11.0 RA	18.4	1.0	17.1	0	14.2

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Griggs County (20)											
118-02.0	116	Sheyenne River	8,290	--	DA	2.0 LA 13.0 LP(ice) 15.0 S 15.0 RP 3.0 RA	15.9	2.1	24.0	27.3	9.4
118-06.0	123	Sheyenne River	8,360	--	DA	3.0 LA 19.0 LP 19.0 S 15.0 RP 3.0 RA	14.5	2.2	25.4	25.4	9.4
122-19.0	120	Sheyenne River	8,510	--	DA	4.0 LA 22.0 LP 23.0 S 20.0 RP 4.0 RA	15.3	5.3	24.0	25.4	9.4
124-12.0	92	Sheyenne River	8,470	8,000	DA	3.0 LA 17.0 P 17.0 S 3.0 RA	18.9	4.9	27.3	20.9	9.2
124-22.0	112	Sheyenne River	8,550	--	DA	4.0 LA 15.0 LP 19.0 S 19.0 RP 4.0 RA	16.3	4.4	27.3	27.3	6.2
124-25.0	126	Sheyenne River	8,560	--	DA	3.0 LA 15.0 LP 21.0 S 17.0 RP 3.0 RA	14.5	6.3	27.3	30.5	6.3

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
					Hettinger County (21)						
104-20.1	50	Chanta Peta Creek	3,610	2,800	EQN	6.0 LA(ice) 6.0 S(ice) 6.0 RA(ice)	10.3	9.1	25.8	20.9	--
109-12.0	31	Coal Bank Creek	3,550	2,500	EQN	8.0 LA(ice) 8.0 S(ice) 8.0 RA(ice)	12.0	15.8	19.7	17.1	--
114-12.0	154	North Fork Cannonball River	21,000	17,000	DA	2.0 LA 14.0 LP 19.0 S(ice) 16.0 RP 2.0 RA	17.1	4.4	20.9	33.6	6.5
120-14.1	26	Spring Creek	2,200	1,500	EQN	6.0 LA 7.0 S 6.0 RA	8.5	11.2	8.9	6.0	--
122-06.0	26	Unnamed Creek	1,450	--	EQN	9.0 LA 9.0 S 9.0 RA	9.8	19.5	22.4	22.4	--
125-16.0	26	Unnamed Creek	1,320	--	EQN	10.0 LA(ice) 10.0 S(ice) 10.0 RA(ice)	9.2	15.5	21.2	19.7	--
128-27.0	45	North Branch Timber Creek	1,750	--	EQN	5.0 LA 5.0 S 5.0 RA	8.0	14.0	21.2	21.2	--
130-03.0	26	Beaver Creek	1,650	--	EQN	8.0 LA 8.0 S(ice) 8.0 RA	10.2	14.2	22.4	22.4	--
130-27.0	53	Unnamed Creek	2,300	--	EQN	5.0 LA 5.0 S(ice) 5.0 RA	8.7	17.1	21.2	19.7	--
134-11.0	86	Thirty Mile Creek	6,580	--	EQN	3.0 LA 15.0 S(ice) 3.0 RA	13.1	8.5	25.8	24.0	--
134-12.0	91	Thirty Mile Creek	6,740	--	EQN	3.0 LA 13.0 LP 16.0 S(ice) 13.0 RP 4.0 RA	13.4	11.8	33.6	27.3	16.4
135-30.0	52	Unnamed Creek	3,980	2,700	EQN	6.0 LA 6.0 S(ice) 6.0 RA	9.2	15.8	21.2	21.2	--
137-15.2	125	Thirty Mile Creek	7,370	--	EQN	6.0 LA 16.0 LP 18.0 S(ice) 12.0 RP 6.0 RA	13.3	9.0	33.6	30.5	6.5

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Hettinger County (21)--Continued											
137-20.0	184	North Fork Cannonball River	25,900	20,000	DA	2.0 LA 19.0 LP 21.0 S(ice) 14.0 RP 2.0 RA	17.0	2.9	25.8	25.8	8.8
141-20.0	174	North Fork Cannonball River	26,700	20,000	DA	2.0 LA 23.0 LP 24.0 S(ice) 20.0 RP 2.0 RA	18.1	4.1	33.6	29.1	11.4
LaMoure County (23)											
115-05.0	29	Bone Hill Creek	3,620	2,000	EQN	--	11.3	20.5	19.7	19.7	--
115-21.0	24	Maple River	1,280	--	EQN	--	9.4	25.5	19.7	19.7	--
117-17.0	25	Maple Creek	2,020	1,500	EQN	--	10.0	20.0	22.4	22.4	--
119-07.0	24	Bone Hill Creek	3,720	1,500	EQN	--	9.9	17.0	19.7	0	--
120-07.0	32	Bone Hill Creek	3,720	2,100	EQN	--	11.1	16.1	27.3	29.1	--
121-07.0	32	Bone Hill Creek	3,890	2,100	EQN	--	11.1	21.0	24.0	20.9	--
121-22.0	60	Maple River	3,160	--	EQN	--	10.7	7.5	0	0	--
122-07.0	26	Bone Hill Creek	4,630	1,630	EQN	--	10.3	33.0	0	0	--
123-02.0	155	James River	8,310	--	DA	--	12.2	5.3	20.9	20.9	6.7
127-06.0	124	James River	8,340	--	DA	--	11.0	4.6	0	0	13.6
129-07.0	91	James River	8,370	--	DA	--	14.8	9.0	17.1	19.7	10.6
129-08.0	123	James River	8,370	--	DA	--	11.1	2.9	14.5	14.5	6.8
133-12.0	123	James River	8,750	--	DA	--	12.2	3.7	24.0	20.9	18.8
133-22.0	60	Cottonwood Creek	3,620	--	EQN	--	10.4	6.5	24.0	0	--
135-16.0	120	James River	8,780	--	DA	--	11.8	7.5	14.5	14.5	6.7
139-24.0	130	James River	5,990	--	DA	--	8.8	8.5	18.2	20.9	10.1
Logan County (24)											
102-24.0	70	Beaver Creek	8,640	--	EQN	--	--	--	--	--	--
103-22.0	94	Beaver Creek	8,580	--	EQN	--	13.7	5.9	27.3	[1]27.3	6.9
105-18.0	102	Beaver Creek	7,750	6,550	EQN	--	11.9	10.2	27.3	27.3	17.1
105-21.0	60	Beaver Creek	7,880	5,500	EQN	--	12.8	9.1	[1]25.3	[1]25.3	--
110-17.0	41	Beaver Creek	7,310	2,500	EQN	--	10.3	6.0	[1]24.6	[1]24.6	--
115-18.0	23	Beaver Creek	5,000	1,000	EQN	6.5 LA 8.0 S 6.5 RA	10.2	31.5	11.9	16.7	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
McHenry County (25)											
101-17.0	50	Little Deep Creek	2,700	2,200	EQN	5.0 LA 8.0 S(EST) 4.0 RA	9.8	15.5	27.3	27.3	--
107-40.0	32	Spring Creek	2,640	1,400	EQN	7.0 LA 7.0 S 3.0 RA	8.9	7.0	18.6	18.6	--
108-04.0	57	Little Deep Creek	6,270	4,000	EQN	7.0 LA 14.0 S 7.0 RA	13.4	10.5	21.2	21.2	--
120-02.0	156	Souris River	5,000	--	DA	4.0 LA 13.0 LP 17.0 S 13.0 RP 3.0 RA	13.1	7.5	30.5	30.5	5.8
123-31.0	63	Wintering River	2,880	--	DA	9.0 LA 12.0 S 12.0 P 8.0 RA	11.2	4.1	24.0	24.0	6.1
123-36.0	63	Wintering River	2,400	--	DA	5.0 LA 10.0 S 11.0 P 4.0 RA	8.5	6.2	27.3	27.3	4.2
129-02.0	92	Willow Creek	7,750	--	DA	11.0 LA 13.0 P 13.0 S 12.0 RA	13.9	5.2	22.4	25.0	6.6
McIntosh County (26)											
102-13.0	60	South Branch Beaver Creek	4,490	--	EQN	--	11.5	8.6	17.1	17.1	--
107-10.0	43	South Branch Beaver Creek	1,570	--	EQN	9.5 LA 10.5 S 8.0 RA	8.1	14.5	14.5	14.5	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
			McKenzie County (27)								
102-31.1	52	Cheney Creek	1,470	--	EQN	--	8.2	2.2	11.9	11.9	--
106-20.0	96	Charbonneau Creek	8,800	--	EQN	3.0 LA 20.0 LP 20.0 S 11.0 RP 3.0 RA	14.1	1.4	14.5	14.5	5.5
111-41.0	78	Bennie Peer Creek	4,080	--	EQN	--	9.3	0.5	20.9	14.5	--
113-20.1	92	Charbonneau Creek	10,400	--	17B	--	14.5	8.8	30.5	14.5	--
115-23.0	50	Antelope Creek	2,190	--	EQN	--	8.4	0.6	7.3	14.5	--
117-23.0	31	Antelope Creek	2,070	--	EQN	--	11.9	8.0	24.0	20.9	--
123-51.0	94	Little Beicegel Creek	1,430	--	EQN	--	5.0	0.1	[1]14.5	[1]14.5	--
124-11.0	84	Timber Creek	6,610	--	EQN	--	11.7	0.5	17.1	11.9	--
124-50.0	142	Beicegel Creek	5,250	--	EQN	--	7.9	0.1	[1]14.5	[1]14.5	4.3
126-36.0	49	Red Wing Creek	1,800	--	EQN	--	8.2	0.1	6.0	6.0	--
132-29.1	45	Cherry Creek	4,650	3,650	EQN	--	12.0	5.8	19.7	17.1	--
143-10.1	50	Clear Creek	5,110	--	EQN	--	13.9	9.0	22.4	19.7	--
			McLean County (28)								
111-08.0	64	Deepwater Creek	7,740	6,740	EQN	--	14.3	8.0	[1]20.9	20.9	--
130-17.0	32	West Branch Douglas Creek	5,050	3,000	EQN	--	12.9	22.5	--	--	--
162-39.0	31	Turtle Creek	2,760	--	DA	--	12.4	15.9	20.9	20.9	--
164-41.0	75	Painted Woods Creek	8,260	7,460	EQN	--	13.3	2.9	15.0	8.0	--
166-35.0	25	Turtle Creek	2,560	--	DA	--	13.5	23.0	22.4	22.4	--
170-40.0	94	Painted Woods Creek	3,860	--	17B	--	8.4	8.5	14.5	24.5	9.9

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment Left	Abutment Right	Pier
					Mercer County (29)						
101-12.1	61	Goodman Creek	1,470	--	EQN	2.6 LA 2.3 RA	6.5	0.2	0	0	--
105-30.0	134	Knife River	16,300	--	DA	5.0 LA 22.0 LP(ice) 22.5 RP(ice) 5.4 RA	18.0	2.1	0	0	5.6
106-19.0	119	Spring Creek	7,580	--	DA	2.3 LA 15.0 P(ice) 2.3 RA	11.3	2.4	0	0	15.9
107-20.0	141	Spring Creek	7,700	--	DA	1.8 LA 18.0 P(ice) 1.8 RA	13.0	8.9	0	0	5.7
107-28.0	145	Knife River	17,000	--	17B	5.2 LA 23.5 LP(ice) 23.0 RP(ice) 5.7 RA	16.7	5.5	0	0	7.0
108-32.0	90	Elm Creek	7,390	--	17B	2.7 LA 1.5 RA	16.5	2.5	0	0	--
114-20.1	71	Spring Creek	8,230	--	17B	13.2 LA 12.0 RA	15.9	5.9	11.9	0	--
114-25.0	150	Knife River	18,400	--	DA	5.0 LA 18.3 LP 25.0 S 21.8 RP 5.0 RA	21.6	1.3	0	0	19.0
114-25.1	60	Coyote Creek	10,200	6,300	[2]17B	10.9 LA 11.2 RA	16.0	6.5	17.1	0	--
117-34.0	32	Coyote Creek	2,310	--	EQN	13.3 LA 11.2 RA	11.5	15.8	23.8	23.8	--
120-21.0	106	Spring Creek	8,440	--	DA	1.5 LA 17.3 LP(ice) 17.4 RP(ice) 1.8 RA	14.9	0.3	0	10.0	18.8
122-21.0	184	Knife River	32,300	--	DA	3.7 LA 25.0 LP(ice) 25.0 RP(ice) 2.5 RA	23.0	0.2	6.0	8.0	6.8
125-21.0	84	Knife River	34,000	12,700	EST	6.0 LA 7.2 RA	19.0	7.5	30.5	25.6	--
128-19.0	137	Knife River	32,500	--	17B	8.0 RA 26.0 S 8.0 LA	22.7	0	0	0	6.8
139-15.0	202	Knife River	36,100	--	DA	3.2 LA 26.0 LP(ice) 21.7 RP 4.8 RA	23.1	0	0	0	17.9

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Morton County (30)											
103-06.1	77	Little Knife River	2,770	--	EQN	--	8.6	2.1	14.5	14.5	--
103-06.2	51	Little Knife River	2,890	--	EQN	--	8.0	1.3	16.8	16.8	--
104-05.0	51	Little Knife River	2,810	--	EQN	--	9.8	1.8	27.3	20.9	--
112-04.1	32	Haymarsh Creek Tributary	1,270	--	EQN	--	8.3	2.4	9.2	6.0	--
112-06.0	32	Haymarsh Creek Tributary	1,410	--	EQN	--	8.8	2.4	6.0	6.0	--
112-06.1	41	Haymarsh Creek	2,230	--	EQN	--	9.8	6.6	11.9	11.9	--
112-12.0	110	Big Muddy Creek	3,790	--	EQN	--	7.5	2.0	7.3	7.3	6.6
113-11.0	41	Big Muddy Creek	3,790	--	EQN	--	12.8	3.7	30.5	24.0	--
117-03.0	41	Wilson Creek	1,110	--	EQN	--	6.6	3.6	6.0	9.2	--
117-11.0	42	Big Muddy Creek	5,300	--	EQN	1.5LA 8.0LP 19.0S 6.0RP 1.5RA	10.7	3.4	0	0	11.3
124-14.0	112	Big Muddy Creek	8,390	--	EQN	--	11.9	0.5	0	20.9	19.1
126-16.1	112	Big Muddy Creek	8,650	--	EQN	--	12.0	0	0	0	6.8
127-16.0	106	Big Muddy Creek	8,340	--	EQN	--	11.8	0	0	0	6.8
128-15.0	98	Hailstone Creek	3,900	--	EQN	--	8.5	0.1	3.6	7.3	20.7
132-21.0	126	Big Muddy Creek	18,300	--	DA	--	16.3	0.8	24.0	0	7.0
137-07.0	138	Sweet Briar Creek	5,010	--	EQN	--	8.2	0.1	14.5	14.5	6.7
139-07.0	90	Sweet Briar Lake	6,500	--	EQN	--	11.9	0.7	14.5	14.5	--
139-12.1	31	Sweet Briar Tributary	1,440	--	EQN	--	9.1	6.0	11.9	11.9	--
140-11.2	45	Sweet Briar Tributary	1,970	--	EQN	--	9.7	9.2	19.8	11.9	--
140-29.0	214	Heart River	40,600	--	DA	--	18.9	0.9	0	20.9	7.1
140-30.0	26	Unnamed Creek	2,140	1,500	EQN	--	10.5	15.8	19.7	11.9	--
142-37.0	82	Louse Creek	5,640	--	EQN	--	10.9	0	0	0	--
143-19.0	233	Heart River	41,400	--	17B	--	20.0	0.3	24.0	14.5	6.8
145-12.0	104	Sweet Briar Creek	8,630	--	EQN	--	12.1	0	0	0	6.8
146-15.0	237	Heart River	44,000	--	DA	--	21.1	0.1	24.0	20.9	6.8
148-34.1	50	Chanta Peta Creek	2,280	--	EQN	--	9.0	3.4	14.5	14.5	--
149-41.0	100	Chanta Peta Creek	9,690	--	EQN	--	12.9	1.5	20.9	20.9	6.9
153-25.0	31	South Branch Little Heart River	1,520	--	EQN	--	9.6	6.2	11.9	11.9	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Morton County (30)--Continued											
154-43.0	156	Chanta Peta Creek	11,800	--	EQN	--	11.3	0.1	14.5	14.5	6.8
158-25.0	50	Southeast Branch Little Heart River	2,620	--	EQN	--	9.4	6.8	11.9	11.9	--
159-21.0	123	Little Heart River	8,280	--	EQN	--	11.5	1.3	27.3	30.5	6.8
161-20.0	116	Little Heart River	8,190	--	EQN	--	11.7	0.7	20.9	24.0	6.8
161-32.0	26	Northwest Branch Chanta Peta Creek	783	--	EQN	--	7.2	9.2	11.9	17.1	--
162-34.0	31	Northwest Branch Chanta Peta Creek	1,360	--	EQN	--	8.6	4.9	11.9	6.0	--
162-34.1	26	Northwest Branch Chanta Peta Creek	619	--	EQN	--	6.2	3.0	6.0	11.9	--
162-41.0	252	Cannonball River	57,700	--	DA	--	24.2	1.1	25.0	27.6	9.2
169-38.0	74	Chanta Peta Creek	5,200	--	EQN	--	12.4	3.7	10.9	20.9	--
0094915101	310	Heart River	49,800	--	DA	7.0 LA 23.0 LP 33.0 S 36.0 RP 8.5 RA	23.6	2.5	0	15.0	8.8
Mountrail County (31)											
106-11.0	64	White Earth River Tributary	6,750	--	EQN	--	13.3	1.2	27.3	27.3	--
106-12.1	75	White Earth River	9,650	--	EQN	--	12.3	1.9	20.9	24.0	4.2

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment Left	Abutment Right	Pier
Nelson County (32)											
101-29.0	124	Sheyenne River	8,070	--	DA	5.0 LA 18.0 LP 18.0 S 18.0 RP 4.0 RA	14.5	14.0	16.8	0	15.7
104-29.0	148	Sheyenne River	8,110	7,000	DA	4.0 LA 14.0 LP(ice) 15.0 S 14.0 RP(ice) 4.0 RA	16.7	14.5	27.3	24.0	6.2
107-29.0	105	Sheyenne River	8,160	7,500	DA	3.0 LA 13.0 LP(ice) 14.0 S(ice) 13.0 RP(ice) 4.0 RA	15.1	2.0	27.3	24.0	9.4
108-29.0	126	Sheyenne River	8,170	--	DA	4.0 LA 15.0 LP 13.0 S(ice) 15.0 RP 4.0 RA	13.9	4.6	22.7	14.5	6.3
111-31.0	136	Sheyenne River	8,200	--	DA	4.0 LA 21.0 LP(ice) 24.0 S 21.0 RP(ice) 4.0 RA	12.9	1.4	13.2	10.0	6.3
114-32.0	114	Sheyenne River	8,230	7,500	DA	1.0 LA 9.0 LP(ice) 9.0 County (ice) 9.0 RP(ice) 2.0 RA	14.9	1.4	24.0	21.8	17.5
115-33.0	132	Sheyenne River	8,240	--	DA	2.0 LA 15.0 LP 16.0 S 15.0 RP 3.0 RA	14.1	0.9	27.3	0	6.3
117-34.0	135	Sheyenne River	8,260	6,800	DA	2.0 LA 10.0 P(ice) 15.0 S 3.0 RA	17.9	4.5	25.8	22.7	9.3
119-35.0	120	Sheyenne River	8,280	--	DA	7.0 LA 17.0 LP 20.0 S 17.0 RP 5.0 RA	15.7	3.5	27.3	27.3	17.5
Oliver County (33)											
116-13.0	52	Square Butte Creek	1,090	--	EQN	--	6.5	4.6	18.5	11.1	--
117-11.0	67	Square Butte Creek	1,880	--	EQN	--	7.1	3.5	7.3	20.9	--
124-14.0	57	Square Butte Creek	8,070	5,500	[2]DA	--	13.8	10.2	[1]27.3	27.3	--
132-18.0	36	Square Butte Creek	14,200	4,500	DA	--	15.0	18.2	22.4	[1]22.4	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Pembina County (34)											
102-07.0	156	Pembina River	23,000	--	17B	--	17.2	2.3	12.4	8.1	22.4
109-05.0	182	Pembina River	13,900	--	--	--	12.7	5.2	4.0	13.2	17.4
110-28.0	57	Cart Creek	7,790	--	DA	--	16.3	20.0	11.4	12.4	--
111-16.0	50	Tongue River	1,800	--	--	--	8.1	12.2	19.7	9.2	--
112-03.0	142	Pembina River	24,100	13,900	--	--	13.5	0.1	8.0	4.0	7.0
115-03.0	140	Pembina River	13,900	--	--	--	15.4	4.8	4.0	10.2	10.4
122-08.1	80	Tongue River	7,680	--	EQN	--	14.0	14.1	10.0	15.0	
124-03.0	126	Pembina River	13,900	--	DA	8.0LA 7.0RA	17.5	5.7	11.4	6.0	21.7
125-04.0	150	Pembina River	14,000	--	DA	--	16.7	0	[1]4.0	[1]4.0	14.0
129-05.0	149	Pembina River	14,000	--	DA	--	15.1	0	2.7	0	12.3
129-06.0	107	Tongue River	9,980	--	EQN	--	13.0	0	2.0	4.0	10.3
130-05.1	165	Pembina River	15,100	--	DA	--	15.9	0	[1]8.0	[1]8.0	17.5
133-03.0	154	Pembina River	15,600	--	DA	9.0 LA 35.0 S 13.5 RA	9.4	0	0	0	16.8
Ramsey County (36)											
101-20.0	72	Big Coulee	2,090	--	DA	4.0 LA 4.0 RA	6.8	2.6	12.1	12.1	--
102-19.0	75	Big Coulee	2,090	--	DA	5.0 LA 5.0 RA	6.9	4.8	17.1	0	--
114-18.0	58	Webster Coulee	3,560	--	EST	5.0 LA 5.0 RA	10.2	6.5	17.1	11.9	--
117-14.0	52	Starkweather Coulee	813	--	DA	6.0 LA 6.0 RA	5.2	4.0	17.1	11.9	--
119-23.0	74	Edmore Coulee	4,420	--	DA	3.5 LA 3.5 RA	10.3	1.2	11.9	11.9	--
124-20.0	64	Edmore Coulee	4,180	--	DA	8.0 LA 7.0 RA	10.9	5.1	22.4	12.1	10.4
125-15.0	86	Edmore Coulee	3,540	--	17B	8.0 LA 8.0 RA	8.3	1.8	24.0	7.3	--
0002250546R	--	Channel A	--	--	--	--	--	--	--	--	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Ransom County (37)											
106-08.0	147	Sheyenne River	8,050	--	DA	--	10.1	0.1	0	14.5	20.3
107-04.0	124	Sheyenne River	8,010	--	DA	--	10.7	0.8	7.3	0	10.2
110-08.1	120	Sheyenne River	8,080	--	DA	--	10.8	3.4	25.8	0	6.8
113-09.0	131	Sheyenne River	8,100	--	DA	--	10.4	0.4	18.2	7.3	6.8
118-14.0	145	Sheyenne River	8,140	--	17B	--	9.9	1.1	24.0	0	13.5
122-01.0	142	Maple River	13,000	--	17B	--	11.1	1.6	24.5	0	21.1
123-18.0	114	Sheyenne River	7,350	--	DA	--	10.7	8.0	0	20.9	10.2
126-09.0	154	Sheyenne River	7,440	--	DA	--	11.2	2.7	8.0	8.0	24.0
133-09.0	130	Sheyenne River	7,500	--	DA	--	11.3	0.8	8.0	8.0	10.0
Renville County (38)											
104-02.2	240	Souris River	15,800	15,800	DA	5.0 LA 13.0 LP 23.0 CP 26.0 S 23.0 RP 5.0 RA	16.2	1.7	24.0	20.9	5.0
110-13.0	90	Souris River	15,900	9,000	DA	11.0 LA 20.0 P 21.0 S 14.0 RA	21.7	5.3	17.1	17.1	10.9
111-14.0	149	Souris River	15,900	11,000	DA	8.0 LA 17.0 LP 16.0 S 17.0 RP 5.0 RA	17.0	1.0	24.0	24.0	12.3
119-27.0	180	Lake Darling	16,000	--	DA	6.0 LA 26.0 LP 28.0 S 28.0 RP 5.0 RA	23.0	15.5	0	0	5.8
121-02.0	37	Cut Bank Creek	3,200	2,000	EQN	9.0 LA 10.0 S 9.0 RA	10.6	14.7	22.4	22.4	--
121-36.0	25	Mackobee Coulee	1,570	--	EQN	6.0 LA 9.0 S 6.0 RA	10.3	13.1	19.7	22.4	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Richland County (39)											
103-07.0	152	Sheyenne River	7,580	--	DA	--	12.1	0	10.9	0	9.8
111-31.0	82	Wild Rice River	3,530	--	DA	--	8.8	2.8	20.9	22.7	--
124-14.0	118	Wild Rice River	15,500	--	DA	--	16.2	2.5	27.3	27.3	23.0
126-04.0	265	Red River of the North	12,700	--	EST	--	10.9	0.8	0	11.5	10.2
126-17.0	102	Wild Rice River	3,910	--	DA	--	9.9	2.0	14.5	25.8	23.3
126-19.1	126	Wild Rice River	3,910	--	DA	--	7.4	2.2	20.9	20.9	21.0
126-29.1	105	Wild Rice River	3,830	--	DA	--	8.8	3.6	14.5	7.3	10.1
126-31.1	104	Wild Rice River	3,820	--	DA	--	8.3	1.7	24.0	14.5	10.0
126-31.2	91	Wild Rice River	3,820	--	DA	--	8.6	3.6	24.0	18.2	10.0
127-13.0	320	Red River of the North	12,400	--	EST	--	11.8	2.1	24.0	25.8	19.8
128-20.0	100	Wild Rice River	3,900	--	DA	--	8.2	4.6	24.0	0	16.0
129-24.0	121	Wild Rice River	3,840	--	DA	--	9.1	2.4	25.8	25.8	29.5
130-18.0	324	Red River of the North	12,300	--	EST	--	9.1	0.4	15.0	15.0	13.2
134-33.0	156	Bois de Sioux River	4,450	--	EST	--	8.0	0.7	0	0	6.6
Rolette County (40)											
102-28.0	46	Ox Creek	5,220	--	EQN	10.0 LA 9.5 RA	14.4	25.8	29.1	29.1	--
102-28.1	41	Ox Creek	7,510	4,800	EQN	9.0 LA 8.0 RA	15.3	18.0	29.1	25.0	--
113-28.1	40	Ox Creek	4,850	3,350	EQN	--	11.9	2.3	14.5	24.0	--
115-27.0	40	Ox Creek	4,370	2,990	EQN	3.5 LA 5.5 RA	11.3	3.2	11.9	11.9	--
117-26.0	38	Ox Creek	4,160	2,000	EQN	6.5 LA 7.0 S 12.0 RA	12.9	16.0	6.0	6.0	--
Sargent County (41)											
116-24.0	29	Wild Rice Creek	3,240	1,700	EQN	--	10.5	18.5	11.9	11.9	--
136-24.1	23	Shortfoot Creek	1,950	500	EQN	--	6.3	11.5	14.9	14.9	--
Sioux County (43)											
113-27.0	190	Cedar Creek	34,800	--	EQN	--	20.3	0	7.3	7.3	6.8
121-29.0	190	Cedar Creek	39,000	--	EQN	--	23.2	0.8	14.5	18.2	10.1
132-25.0	75	Unnamed Creek	1,960	--	EQN	--	6.8	4.2	8.9	7.5	18.4
147-15.0	93	Porcupine Creek	5,020	--	EQN	--	9.5	4.5	15.0	0	8.2

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment Left	Abutment Right	Pier
Slope County (44)											
106-24.0	76	Little Beaver Creek	14,200	--	DA	6.0 LA 17.0 S 8.0 RA	12.0	6.5	12.5	0	16.8
125-11.0	112	Deep Creek	5,800	--	DA	3.0 LA 14.0 LP(ice) 14.0 S(ice) 14.0 RP(ice) 3.0 RA	9.9	3.3	30.5	30.5	21.0
130-04.0	70	First Creek	2,380	--	EQN	2.0 LA 13.0 S 2.0 RA	7.6	3.0	7.3	18.2	--
149-03.0	82	Philbrick Creek	3,310	--	EQN	2.0 LA 15.0 S 3.0 RA	8.4	4.1	0	24.0	--
151-21.0	60	North Fork Cedar Creek	3,140	--	17B	1.0 LA 6.0 S 1.0 RA	9.5	9.0	27.3	27.3	--
153-17.0	66	Chanta Peta Creek	3,040	--	EQN	3.0 LA 8.0 S 3.0 RA	9.0	6.5	27.3	30.5	--
Stark County (45)											
102-09.2	68	Heart River	1,330	--	EQN	--	5.8	0.7	0	0	--
104-09.0	70	Heart River	2,980	--	EQN	--	8.4	6.5	0	0	--
108-13.0	102	South Branch Heart River	5,020	--	EQN	--	9.3	3.7	24.0	24.0	15.5
110-12.0	92	South Branch Heart River	5,450	--	EQN	--	12.7	4.1	22.7	25.8	25.1
112-10.0	102	Heart River	10,400	9,400	DA	--	13.4	4.9	20.9	20.9	13.6
116-11.1	140	Heart River	11,900	--	DA	--	12.1	4.3	20.9	20.9	6.8
116-14.1	80	Ash Creek	2,190	--	EQN	--	7.6	3.3	20.9		--
130-08.0	37	Green River	11,100	--	17B	9.0 LA 18.0 S 3.0 RA	15.4	5.7	0	0	13.5
139-17.0	190	Heart River	19,500	--	DA	--	15.1	2.6	20.9		17.5
148-02.0	48	Branch of Knife River	2,590	--	EQN	--	9.9	7.8	17.1	17.1	--
151-21.0	124	Government Creek	5,190	--	EQN	--	9.6	1.5		11.5	10.1
152-02.0	40	Branch of Knife River	3,780	2,500	EQN	--	10.9	8.0	19.7	21.2	--
153-04.0	40	Branch of Knife River	3,530	--	EQN	--	12.5	18.0	22.4	11.9	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Steele County (46)											
109-19.0	40	Maple River	1,100	--	EQN	--	6.9	5.5	11.3	11.3	--
115-05.0	30	Beaver Creek	3,340	1,840	DA	--	10.4	2.8	6.0	6.0	--
117-01.0	58	Spring Creek	2,650	--	EQN	--	8.9	4.2	14.5	14.5	--
117-04.0	55	Beaver Creek	3,370	--	DA	--	10.4	2.9	24.0	24.0	--
117-16.0	53	Unnamed Creek	2,480	--	EQN	--	9.1	8.5	22.7	14.5	--
117-16.1	62	Unnamed Creek	2,490	--	EQN	--	9.1	4.4	7.3	20.9	--
120-02.0	97	Goose River	6,920	--	EQN	--	13.6	3.4	20.9	14.5	6.6
120-03.0	86	Goose River	7,020	--	EQN	--	12.5	4.2	18.2	14.6	12.7
120-03.1	75	Goose River	7,000	6,000	EQN	--	14.9	7.5	14.5	14.5	--
122-16.0	61	South Branch Goose River	3,870	--	EQN	--	10.6	10.9	27.3	24.0	--
122-19.0	72	South Branch Goose River	3,760	--	EQN	--	9.7	8.5	24.0	20.9	--
123-16.0	53	South Branch Goose River	4,410	--	EQN	--	12.1	15.1	18.2	27.3	--
123-16.1	87	South Branch Goose River	4,420	--	EQN	--	10.5	3.6	20.9	0	10.2
Stutsman County (47)											
117-00.0	44	Pipestem Creek	5,700	2,400	EQN	8.0 LA 12.0 S 8.0 RA	9.6	15.8	23.8	23.8	--
119-03.0	48	Pipestem Creek	6,000	3,000	EQN	5.5 LA 10.0 S 4.0 RA	10.2	45.0	30.5	30.5	--
122-06.1	63	Pipestem Creek	6,240	4,240	DA	--	11.0	4.9	24.0	24.0	--
122-07.0	50	Pipestem Creek	6,260	4,260	DA	--	12.1	2.5	20.9	20.9	--
123-08.0	50	Pipestem Creek	6,330	3,330	DA	--	10.7	7.5	27.3	30.5	--
125-09.0	60	Pipestem Creek	6,360	4,000	DA	--	11.6	16.9	27.3	14.5	--
127-18.0	50	Pipestem Creek	9,970	8,000	17B	--	17.1	11.1	30.5	27.3	--
130-05.0	61	James River	13,000	8,000	DA	--	17.9	18.4	39.1	39.1	--
135-29.0	61	Pipestem Creek	[4]1,800	--	--	--	6.8	4.0	14.5	7.3	--
141-43.0	60	Beaver Creek	5,620	--	EQN	--	12.7	6.5	27.3	27.3	--
142-44.0	80	James River	2,260	--	DA	--	6.7	2.5	0	13.0	--
142-45.0	84	James River	2,400	--	DA	--	7.7	3.3	0	13.2	--
143-32.0	90	James River	2,180	--	DA	--	6.2	0.2	7.3	7.3	4.2
143-37.0	110	James River	2,190	--	DA	--	5.5	4.5	11.9	11.9	4.2
143-39.0	175	James River	2,200	--	DA	--	6.6	0	0	0	6.5

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Towner County (48)											
119-44.0	72	Mauvais Coulee	8,260	5,260	EST	5.0 LA 3.0 RA	12.9	0.9	20.9	20.9	--
120-39.0	75	Mauvais Coulee	5,820	--	EQN	4.0 LA 4.0 RA	11.7	1.4	0	20.9	--
120-40.0	60	Mauvais Coulee	5,830	--	EQN	5.0 LA 4.5 RA	14.5	4.6	0	27.3	--
Traill County (49)											
103-11.0	146	Goose River	7,100	--	DA	--	9.5	0	--	--	10.1
110-12.0	66	North Branch Goose River	3,090	--	EQN	--	8.9	9.6	27.3	--	4.3
115-25.0	72	Elm River	3,560	--	DA	--	9.6	6.2	24.5	24.5	12.5
116-26.0	70	Elm River	3,620	--	DA	--	10.0	7.0	27.3	0	--
117-18.0	220	Goose River	12,200	--	DA	--	9.7	0.3	0	8.0	18.9
120-19.0	143	Goose River	12,300	--	17B	--	12.4	5.2	24.0	24.0	6.8
120-24.0	84	North Branch Elm River	2,900	--	EQN	--	8.1	9.2	18.6	17.1	--
121-29.0	57	Elm River	6,530	--	EQN	15.0 LA 16.0 S 16.0 RA	16.7	11.3	22.4	22.4	--
123-25.0	70	North Branch Elm River	2,900	--	EQN	--	8.6	16.5	20.9	25.4	--
125-28.0	150	Elm River	6,570	--	EQN	--	11.5	3.5	20.9	20.9	20.5
128-15.1	210	Goose River	12,600	--	DA	4.0 LA 11.0 LP 18.0 CP 30.0 S 22.0 RP 5.0 RA	14.5	1.3	0	0	5.2
129-05.0	757	Red River of the North	66,600	--	EST	3.0 LA 22.0 LP 28.0 RP 2.0 RA	20.9	0	0	0	20.9
129-10.0	177	Red River of the North	65,000	--	EST	4.0 LA 40.0 S 41.0 P 4.0 RA	26.1	2.3	38.9	38.9	17.8
130-15.0	443	Red River of the North	63,600	--	EST	1.0 LA 13.0 LP 37.0 S 38.0 RP 2.0 RA	29.7	0.3	20.9	0	14.8
131-28.0	196	Red River of the North	57,000	--	EST	19.0 LA 40.0 S 42.0 P 17.0 RA	19.9	1.4	35.8	30.5	18.1

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
					Walsh County (50)						
117-08.1	33	South Branch Park River	6,080	6,080	EQN	11.0 LA 13.5 S 9.5 RA	12.8	31.2	27.3	38.9	14.9
117-16.0	52	Unnamed Creek	1,070	1,070	EQN	--	5.9	0.3	10.9	7.3	10.2
120-16.0	28	Unnamed Creek	1,460	--	EQN	--	11.3	5.6	18.2	7.3	--
122-16.0	63	North Branch Forest River	3,490	--	EQN	--	9.8	0	10.9		--
124-24.0	90	North Branch Forest River	8,170	--	EQN	--	12.6	0.8	6.4	7.3	6.7
127-03.1	41	Middle Branch Park River	3,950	3,350	EQN	--	11.8	13.8	18.6	19.7	--
136-08.1	94	South Branch Park River	7,090	--	EQN	--	13.1	0	10.9	10.9	6.9
136-08.2	26	Unnamed Creek	1,580	--	EQN	--	10.6	25.0	24.0	30.5	--
138-23.0	85	Forest River	14,200	--	DA	--	18.7	7.8	24.0	25.6	14.1
139-05.1	50	Park River	6,720	4,000	EQN	--	12.0	0.2	10.9	13.1	--
139-21.1	27	Unnamed Creek	2,290	--	EQN	--	12.6	30.8	26.2	25.0	--
139-22.1	80	Forest River	14,200	13,000	DA	--	18.6	0	10.9	14.5	13.7
139-23.0	41	Forest River overflow	14,200	1,500	DA	--	7.9	2.5	11.9	8.9	--
146-19.0	140	Forest River	13,200	--	EST	--	13.0	4.4	20.9	24.0	6.9
151-18.0	112	Forest River	14,800	--	DA	--	17.9	19.0	35.4	33.6	7.0
152-17.0	36	Forest River overflow	14,800	1,300	DA	--	7.8	18.5	27.3	27.3	--
152-17.1	94	Forest River	14,800	13,500	DA	2.0 P	16.3	20.0	27.3	24.0	10.5
153-21.0	125	North Marais River	934	--	EQN	--	4.5	0	0	0	12.7
154-13.0	92	Forest River	15,200	--	DA	--	18.0	2.5	6.2	18.4	10.5
154-17.0	140	North Marais River	1,360	--	EQN	--	5.7	1.5	9.4	22.7	16.2
0029168629L	200	Forest River	15,100	--	DA	4.5 LA 17.5 LP 12.0 RP 2.0 RA	11.3	0.8	20.7	20.7	6.1
0029168632R	200	Forest River	15,100	15,100	DA	2.5 LA 16.5 LP 12.5 RP 2.0 RA	11.3	0	0	0	6.1

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Ward County (51)											
117-20.1	30	Des Lacs River	4,100	3,100	DA	10.0 LA 11.0 S 12.0 RA	14.3	18.0	6.0	20.9	--
131-29.0	31	Des Lacs River	4,550	3,600	17B	21.0 LA(est) 21.0 S(est) 21.0 RA(est)	24.9	21.1	20.9	0	--
134-29.0	120	Souris River	10,600	7,000	17B	6.0 LA 11.0 S 12.0 P 6.0 RA	14.7	3.1	20.9	25.8	6.3
137-35.3	103	Des Lacs River	4,880	--	DA	5.0 LA 19.0 S 6.0 RA	14.0	2.4	0	14.9	--
140-38.0	138	Souris River	9,750	--	17B	4.0 LA 16.0 LP(est) 18.0 S 15.0 RP(est) 4.0 RA	15.3	1.1	22.7	27.3	6.2
151-25.0	35	Little Deep Creek	2,660	1,300	EQN	6.0 LA(ice) 6.0 S(ice) 6.0 RA(ice)	10.7	21.5	19.7	19.7	--
154-31.0	25	Egg Creek	3,240	1,300	EQN	7.0 LA(est) 8.0 S(est) 7.0 RA(est)	11.4	17.4	22.4	22.4	--
155-49.0	150	Souris River	9,050	--	DA	8.0 LA 24.0 LP(est) 26.0 S(est) 22.0 RP(est) 8.0 RA	14.7	5.7	0	0	15.4
Wells County											
115-11.0	75	James River	3,070	--	DA	2.0 LA 6.0 S(ice) 3.0 RA	8.3	16.1	20.9	20.9	--
121-11.0	60	James River	6,800	3,500	EQN	6.0 LA 9.0 S(ice) 7.0 RA	13.1	15.8	22.4	25.0	--
129-12.0	85	James River	7,000	4,500	EQN	3.0 LA 16.0 S(ice) 3.0 RA	14.4	15.5	30.5	33.6	--
130-11.0	51	James River	7,470	2,900	EQN	7.0 LA 10.0 S(ice) 7.0 RA	13.4	27.0	25.8	29.1	--
132-09.0	40	James River	9,590	2,700	DA	9.0 LA(ice) 12.0 S 9.0 RA(ice)	14.1	24.9	20.9	20.9	--

Bridge number	Bridge length (feet)	Stream name	Flood discharge			Distance below low-steel to streambed (feet)	Main channel depth (feet)	Estimated scour (feet)			
			Q_{100} (ft^3/s)	Q_a (ft^3/s)	Method			Contraction	Abutment		Pier
									Left	Right	
Williams County (53)											
105-07.0	25	Cottonwood Creek	3,220	1,500	EQN	--	10.2	22.8	22.4	25.0	--

[1]Overbank flow assumed negligible; scour depth is an estimate.
[2]Average with regression equation.
[3]Average with drainage area ratio method.
[4]Discharge provided by U.S. Army Corps of Engineers, Omaha District (oral commun., 1997).

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