Infrastructure Investment Needs of County and Township Bridges in North Dakota

Report to the North Dakota Legislative Council and Budget Section

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Synopsis

This report responds to the request of the Budget Section for an analysis of county and township bridge investment needs. It utilizes the National Bridge Inventory for North Dakota and bridge replacement costs synthesized from bridge reconstruction projects in 2011 and 2012.

Altogether, 2,667 county and township bridges have been analyzed. However, the focus of this study is on the 474 bridges that are classified as structurally deficient—i.e., in poor, serious, or critical condition. The classification of a bridge as structurally deficient does not mean that the bridge is unsafe. Rather, it means that its serviceability is diminished, the weights of vehicles using the bridge may have to be restricted, and more frequent inspections and higher maintenance costs can be expected.

Replacement costs are estimated for bridges in poor or worse condition by assuming that bridges $\leq$ 40 feet in length will be replaced by culvert structures. However, bridges that are longer than 40 feet in length will be replaced by modern bridges. Specifically, a deficient bridge that is less than 30 feet in length is assumed to be replaced by a culvert structure costing $350,000. A deficient bridge between 30 and 40 feet in length is assumed to be replaced by a culvert structure costing $450,000. Costs for bridges longer than 40 feet are estimated from the square footage of the structure and an average replacement cost of $205 per square foot, which has been derived from recent bridge replacement jobs in North Dakota.

Typically, when older substandard bridges are replaced by modern ones the lengths and widths of the structures increase. According to recent bridge replacement projects in North Dakota, a new structure is roughly 70% longer than the original one. A replacement width of 32.5 feet is assumed in this study to allow clearances for wider loads.

As shown in the report, the replacement cost of bridges in critical condition is $29.5 million. Replacing bridges that are in serious or critical condition would cost $95.7 million. In total, it would cost $288 million to replace all bridges in poor, critical, or serious condition. In addition to these costs, annual maintenance expenditures will be needed. An estimated biennial maintenance cost of $2.37 million is shown in the report, which assumes biennial inspection of each bridge, along with routine maintenance such as the removal of debris from channels and spot maintenance. The report shows a break out of estimated replacement and maintenance cost needs by county.

Note that the decision to replace an existing bridge with a culvert or a new bridge structure is based on many considerations, including the surrounding terrain and total drainage area, the potential risk of flooding, and the likelihood of channel debris becoming an issue. Further note that many of the bridges classified as structurally deficient have very low traffic levels.

The infrastructure needs shown in this report have not been prioritized. One way to prioritize needs is to rank the bridges according to the additional vehicle-miles of travel that would result from closing the bridge—i.e., detour vehicle-miles. However, this simple approach does not consider the condition of (or the potential presence of weight restrictions) at the nearest alternative bridge, or the fact that a trip may be rerouted at origin and take a different path altogether. The development a new model is recommended in which the effects of bridge restrictions and closures on commerce can be quantified.

Introduction

This report responds to the request of the legislature for an analysis of county and township bridge infrastructure needs. It utilizes the National Bridge Inventory (NBI) dataset for North Dakota. According to the NBI, there are 3,150 bridges in North Dakota owned and maintained by county, township, or town governments. Of this total, 483 are culverts. All but two of these bridges are owned and maintained by county governments.[1]

The age distribution of county and township bridges (excluding culverts) is summarized in Table 1. As shown in Table 1, roughly 37% of the bridges are older than 50 years. Another 44% are between 26 and 49 years of age. Nearly 300 bridges were built more than 75 years ago.

Table 1: Age Distribution of County and Township Bridges in North Dakota

Age (Years)	Frequency of Bridges	Percent	Cumulative Frequency	Cumulative Percent
≤ 10	113	4.2%	113	4.2%
> 10 and ≤ 25	392	14.7%	505	18.9%
> 25 and ≤ 50	1,169	43.8%	1,674	62.8%
> 50 and ≤ 75	704	26.4%	2,378	89.2%
> 75	289	10.8%	2,667	100.0%
Age is the elapsed time since original construction or reconstruction				

The condition assessment scale used in the National Bridge Inventory is shown in Table 2. In this scale, a brand-new bridge element deteriorates from excellent condition to failure via eight interim steps or levels. Independent ratings are developed for three major elements – deck, superstructure, and substructure. In this approach, it is possible for a bridge to have three different condition ratings.

Condition of County and Township Bridges

The distributions of the 2012 condition ratings are shown in Tables 3, 4, and 5 for substructures, superstructures, and decks, respectively. As shown in Table 3, the substructure conditions of 364 county and township bridges are rated as poor or worse. Of these substructures, 127 are in serious or worse condition. As shown in Table 4, 200 superstructures are in poor or worse condition. Of these superstructures, 50 are in serious or worse condition. As shown in Table 5, the decks of 121 county and township bridges are in poor or worse condition. Of these decks, 29 are in serious or worse condition.

[1] The two remaining bridges are located in West Fargo.

Table 2: Bridge Condition Ratings

Code	Meaning	Description
9	Excellent	
8	Very Good	No problems noted.
7	Good	Some minor problems.
6	Satisfactory	Structural elements show some minor deterioration.
5	Fair	All primary structural elements are sound but may have minor section loss, cracking, spalling or scour.
4	Poor	Advanced section loss, deterioration, spalling or scour.
3	Serious	Loss of section, deterioration, spalling or scour has seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	Critical	Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	Imminent Failure	Major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put back in light service.
0	Failed	Out of service -- beyond corrective action.

Table 3: Substructure Condition Ratings of County and Township Bridges in North Dakota

Condition Rating	Frequency of Bridges	Percent	Cumulative Frequency	Cumulative Percent
0	3	0.1%	3	0.1%
1	8	0.3%	11	0.4%
2	23	0.9%	34	1.3%
3	93	3.5%	127	4.8%
4	237	8.9%	364	13.7%
5	473	17.7%	837	31.4%
6	493	18.5%	1,330	49.9%
7	655	24.6%	1,985	74.4%
8	563	21.1%	2,548	95.5%
9	119	4.5%	2,667	100.0%

Overall bridge condition is determined from the lowest rating for the deck, superstructure, or substructure. Altogether, 474 bridges are in poor or worse condition, while 161 bridges are in serious or worse condition.

Table 4: Superstructure Condition Ratings of County and Township Bridges in North Dakota

Condition Rating	Frequency of Bridges	Percent	Cumulative Frequency	Cumulative Percent
0	3	0.1%	3	0.1%
2	8	0.3%	11	0.4%
3	39	1.5%	50	1.9%
4	150	5.6%	200	7.5%
5	359	13.5%	559	21.0%
6	524	19.7%	1083	40.6%
7	740	27.8%	1823	68.4%
8	722	27.1%	2545	95.4%
9	122	4.6%	2667	100.0%

Table 5: Deck Condition Ratings of County and Township Bridges in North Dakota

Condition Rating	Frequency of Bridges	Percent	Cumulative Frequency	Cumulative Percent
0	1	0.1%	1	0.1%
1	1	0.1%	2	0.1%
2	8	0.4%	10	0.5%
3	19	1.0%	29	1.5%
4	92	4.7%	121	6.2%
5	310	15.9%	431	22.1%
6	461	23.7%	892	45.8%
7	579	29.7%	1,471	75.6%
8	397	20.4%	1,868	95.9%
9	79	4.1%	1,947	100.0%
Deck condition ratings are missing for 720 bridges				

Estimated Bridge Replacement and Maintenance Costs

Replacement costs are estimated for bridges in poor or worse condition using unit costs and factors from 2011 and 2012 bridge construction projects in North Dakota and assumptions about the type of replacement structure that will be built. It is assumed that bridges ≤ 40 feet in length will be replaced with culvert structures. However, bridges > 40 feet in length are assumed to be replaced by modern bridges.

Specifically, a deficient bridge that is less than 30 feet in length is assumed to be replaced by a culvert structure costing $350,000. A deficient bridge between 30 and 40 feet in length is assumed to be replaced by a culvert structure costing $450,000. Costs for bridges longer than 40 feet are estimated from the square footage of the structure and an average replacement cost of

$205 per square foot, which has been estimated from recent bridge replacement projects in North Dakota.

When older substandard bridges are replaced by new modern ones the lengths and widths of the structures typically increase. According to recent bridge replacement projects in North Dakota, the average length of a new structure is roughly 70% greater than the length of the original one. The replacement width is assumed to be 32.5 feet, which will allow clearances for wider loads.

As shown in Table 6, the replacement cost of bridges in critical or worse condition is $29.5 million. Alternatively, it would cost $95.7 million to replace all bridges in serious or worse condition (including bridges in critical condition). Moreover, it would cost $288 million to replace all bridges in poor or worse condition (including bridges in critical and serious condition).

Table 6: County and Township Replacement Costs for Bridges in Deficient Condition

Current Condition	Number of Bridges	Replacement Cost
Poor or Worse	474	$ 288,090,837
Serious or Worse	161	$ 95,703,018
Critical or Worse	46	$ 29,530,611

In addition to replacement costs, a total biennial maintenance cost of $2.37 million has been estimated for all 2,667 county and township bridges. This estimate assumes biennial inspection of each bridge, along with routine maintenance such as the removal of debris from channels and spot maintenance. If all of the replacement needs are addressed in the upcoming biennium, the total estimated need is roughly $290.5 million, including maintenance.

Variations and Uncertainties in Cost Estimates

Several alternative assessments (other than the ones presented in this report) are possible, based on variations in practices and costs.

1. A few of the bridges with deficient decks (i.e., decks with condition ratings of 4 or lower) do not yet have deficient superstructures or substructures. Nevertheless, the condition ratings of these components are approaching poor and may transition from fair to poor in the very near future. While it is possible to replace only the decks of these bridges in 2013-2015, it may not be practical or cost-effective to do so; since the superstructures or substructures are likely to become deficient in the near future.
2. Some of the bridges rated in fair condition may transition to poor in the near future. However, most of these needs are expected to occur beyond the 2013-2014 biennium.
3. The decision as to whether a culvert or bridge structure is selected is based on many considerations, including the surrounding terrain, design discharge frequency, total drainage area, potential risk of flooding, potential effects of flooding on nearby structures and buildings, and the likelihood of channel debris becoming an issue based on trees and vegetation in the vicinity. For these and many other reasons, decisions as to whether a

culvert or bridge is the most desirable and cost-effective structure require detailed assessments that reflect a variety of design factors.

Estimated Needs by County

The near-term needs estimates are presented by county in Table 7.

Table 7: Near-Term County and Township Bridge Costs in Thousands of 2012 Dollars

County	Bridge Replacement Cost			Biennial Maintenance Cost	Total Cost
	Condition Level				
	Critical	Serious	Poor		
Adams	$970	$2,766	$5,368	$26	$5,394
Barnes	.	.	$800	$29	$829
Benson	$350	$1,390	$3,485	$20	$3,505
Billings	.	$691	$691	$23	$714
Bottineau	.	.	$4,692	$89	$4,781
Bowman	.	.	.	$38	$38
Burke	.	$758	$2,008	$10	$2,018
Burleigh	$350	$2,250	$3,202	$52	$3,254
Cass	$2,152	$7,876	$28,530	$183	$28,713
Cavalier	$1,050	$4,131	$10,239	$50	$10,288
Dickey	.	.	.	$24	$24
Divide	$520	$1,320	$1,670	$8	$1,678
Dunn	$800	$1,989	$5,769	$41	$5,810
Eddy	.	$1,925	$1,925	$14	$1,939
Emmons	.	$613	$1,483	$32	$1,515
Foster	.	$1,720	$1,720	$11	$1,731
Golden Valley	$680	$2,398	$2,398	$17	$2,415
Grand Forks	.	$2,323	$12,522	$206	$12,728
Grant	$1,350	$2,150	$3,300	$39	$3,339
Griggs	.	.	$1,156	$11	$1,167
Hettinger	$862	$3,405	$12,976	$44	$13,020
LaMoure	$800	$800	$4,659	$37	$4,696
Logan	.	.	$800	$8	$808
McHenry	.	$702	$7,802	$72	$7,874
McIntosh	.	.	.	$7	$7
McKenzie	.	$826	$3,323	$62	$3,384
McLean	.	$450	$1,502	$24	$1,526
Mercer	.	.	.	$41	$41

Table 7: Near-Term County and Township Bridge Costs in Thousands of 2012 Dollars

County	Bridge Replacement Cost			Biennial Maintenance Cost	Total Cost
	Condition Level				
	Critical	Serious	Poor		
Morton	$914	$3,049	$8,904	$156	$9,060
Mountrail	.	.	$2,568	$14	$2,582
Nelson	.	.	$884	$14	$899
Oliver	$951	$951	$951	$14	$965
Pembina	.	$2,890	$9,749	$119	$9,867
Pierce	.	.	$350	$2	$352
Ramsey	.	$1,693	$5,646	$34	$5,680
Ransom	.	$1,564	$3,943	$17	$3,960
Renville	.	.	$1,405	$13	$1,417
Richland	$5,452	$11,417	$22,858	$110	$22,967
Rolette	.	.	.	$9	$9
Sargent	.	$350	$1,500	$21	$1,521
Sioux	.	.	.	$5	$5
Slope	.	$758	$1,458	$23	$1,481
Stark	.	$2,400	$8,823	$76	$8,899
Steele	$769	$1,219	$3,514	$70	$3,583
Stutsman	$565	$565	$1,018	$26	$1,044
Towner	$700	$1,050	$5,961	$35	$5,996
Traill	$5,165	$9,657	$38,399	$105	$38,504
Walsh	$3,783	$11,174	$28,038	$171	$28,209
Ward	.	$543	$2,439	$50	$2,490
Wells	.	$769	$1,695	$20	$1,715
Williams	$1,346	$5,169	$15,967	$48	$16,015
Statewide	$29,529	$95,701	$288,090	$2,370	$290,456

Effects of Potential Bridge Closures

The needs shown in Table 7 have not been prioritized. Several factors are important when assessing funding urgencies. (1) Some of the bridges classified as structurally deficient (i.e., in poor or worse condition) have very low traffic levels. (2) The classification of a bridge as structurally deficient does not mean that the bridge is unsafe. Rather, it means its serviceability is diminished, the weights of vehicles using the bridge may have to be restricted, and more frequent inspections and higher maintenance costs can be expected.

One way to prioritize investment needs is to rank the bridges according to the additional vehicle-miles of travel that would result from closing the bridge—i.e., detour vehicle-miles. This factor reflects two components: (1) the number of vehicles crossing the bridge each day, and (2) the detour distance to the nearest bridge. However, the detour distance in the NBI does not necessarily reflect the condition of or the potential presence of weight restrictions at the nearest alternative bridge, or the fact that a trip may be rerouted at origin and take a different path altogether.

Five percent of the bridges reflected in Table 6 have detour vehicle-miles of greater than 900. One-fourth of the bridges have estimated detour vehicle-miles of 145 or greater. Roughly half of the bridges have estimated detour vehicle-miles of 60 or more.

Conclusion

The purpose of this report is to quickly respond to the Budget Section's request for an assessment of the investment and maintenance needs of county and township bridges. In this study, condition ratings from the 2012 National Bridge Inventory have been used to identify bridges that are structurally deficient. These bridges are not necessarily unsafe, but are candidates for replacement. Seventy-five percent of these bridges are more than 60 years old. One-fourth of the bridges are 85 years of age or older. However, many of them have relatively low traffic levels.

Although the study has identified structurally deficient bridges, a more detailed study is needed which examines the conditions of specific structural elements (e.g., trusses, girders, abutments, etc.) that may be causing structural deficiency ratings. While detour vehicles-miles are useful indicators of the impacts of bridge closures, they do not tell the network value of a bridge or its effects on the commerce of particular industries. A more detailed study is recommended in which the economic value of each bridge and the effects of rerouting traffic on other roads are considered. A detailed GIS model can be developed that considers several alternative routes with different weight restrictions and potential costs to more precisely predict the effects of potential closures on commercial traffic. In a longer-term study, piecemeal rehabilitation strategies may be envisioned for less traveled bridges and tradeoffs analyzed between restricted vehicle weights and economic productivity.