Implementing Traffic Safety Evaluations to Enhance Roadway Safety

Jason Baker, PE
Associate Research Fellow

Kurt Johnson
Program Director – ATAC, DOTSC

Kim Vachal, PhD
Program Director - RTSSC

Upper Great Plains Transportation Institute
North Dakota State University
Fargo, ND 58108

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Disclaimer

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1. LITERATURE REVIEW

The economic and health-related impacts of crashes remain an important focus area for improving the transportation system. According to the Federal Highway Administration (FHWA) there are nearly 43,000 crash -related fatalities every year, with an additional 3 million injuries. The cost of these crashes is estimated at over $230 billion each year [1]. The U.S. Department of Transportation has indicated that if poor/outdated roadway conditions and geometry were updated, approximately one-third of the crashes could be avoided.

According to the National Highway Traffic Safety Administration (NHTSA), the national fatal crash rates (per 100 million vehicle miles traveled) were 1.37 and 1.28 for 2007 and 2008, respectively. In addition, the corresponding injury rates for 2007 and 2008 were 82 and 80, respectively [2]. In comparison, the corresponding crash rates for North Dakota during 2007 and 2008 were 1.44 and 1.37 for fatalities and 54 and 56 for injuries, respectively [3]. Figure 1.1 illustrates the comparison between North Dakota and national fatal crash rates from 1997 to 2008.

Crash data compiled for Barnes County, North Dakota, show one fatal crash in 2007 and 3 fatal crashes in 2008. Injury crashes from the same years totaled 27 and 26, respectively [3]. It should be noted that rural roads accounted for 86.6% of the fatal crashes and 32.1% of injury crashes in North Dakota in 2008 [3]. Figures 1.2 and 1.3 illustrate the fatal and injury crashes by roadway functional class from 2002 to 2008.

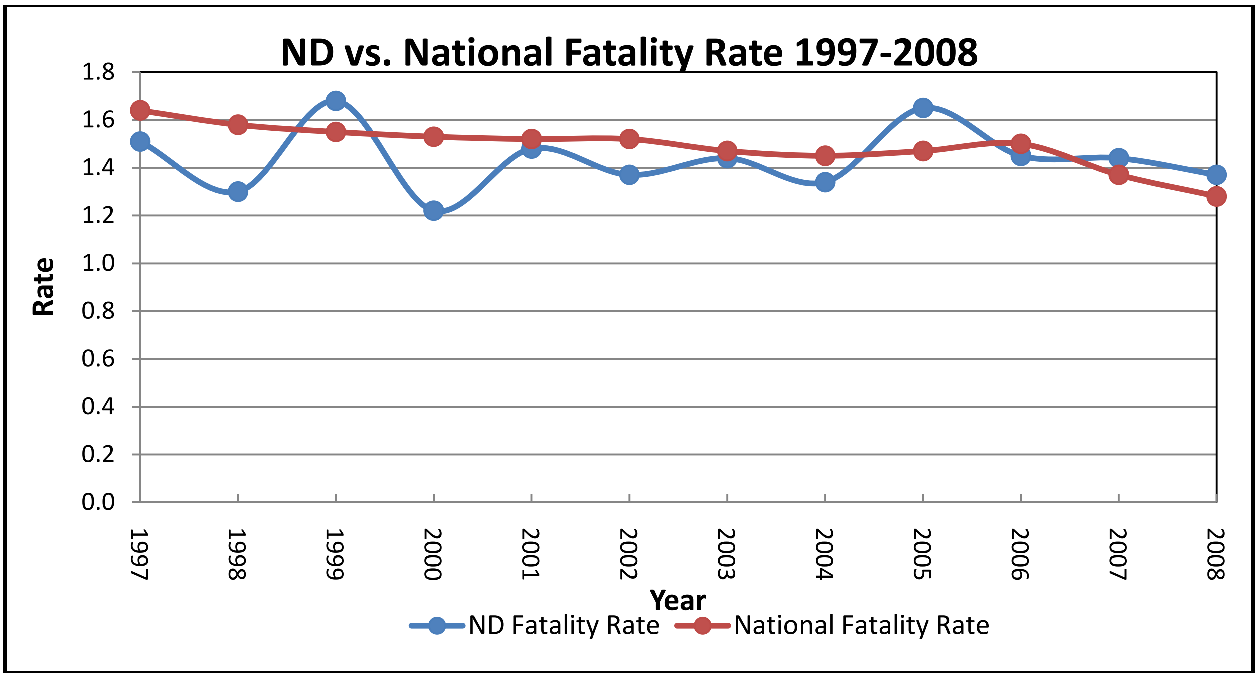

Figure 1.1 North Dakota vs. National Fatality Rate [3]

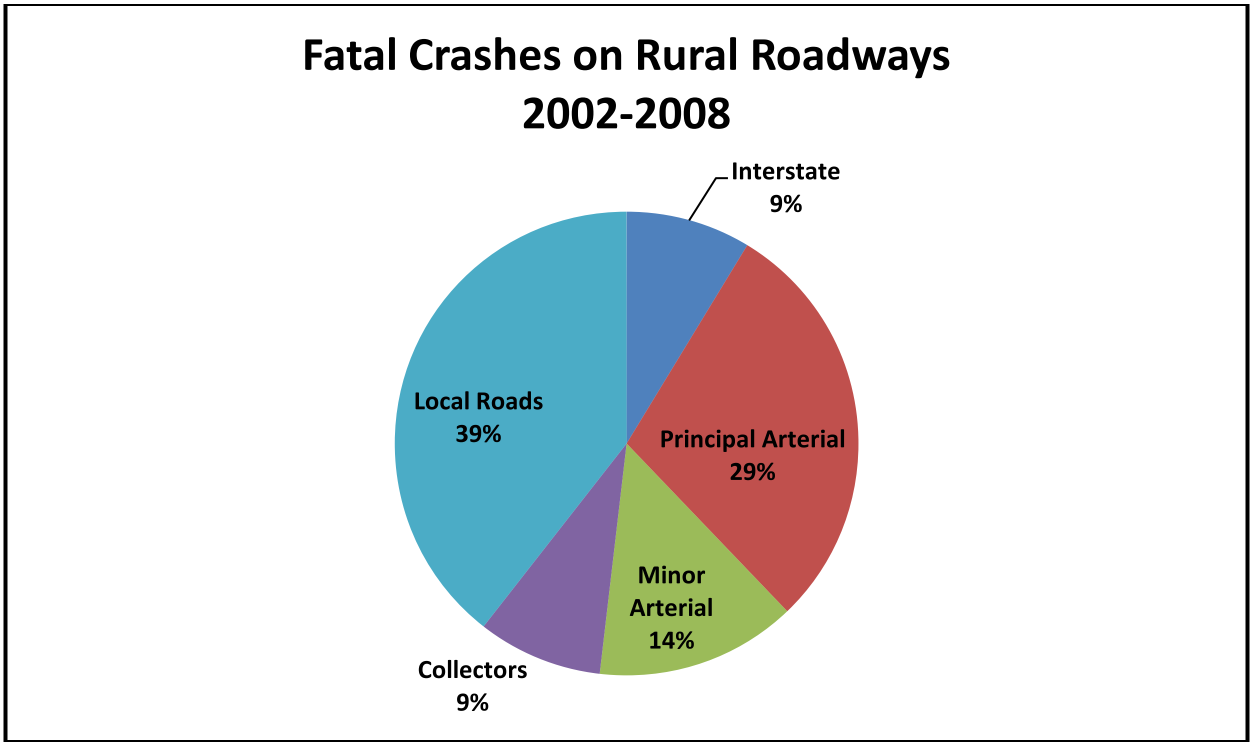

Figure 1.2 ND Rural Road Fatal Crashes [3]

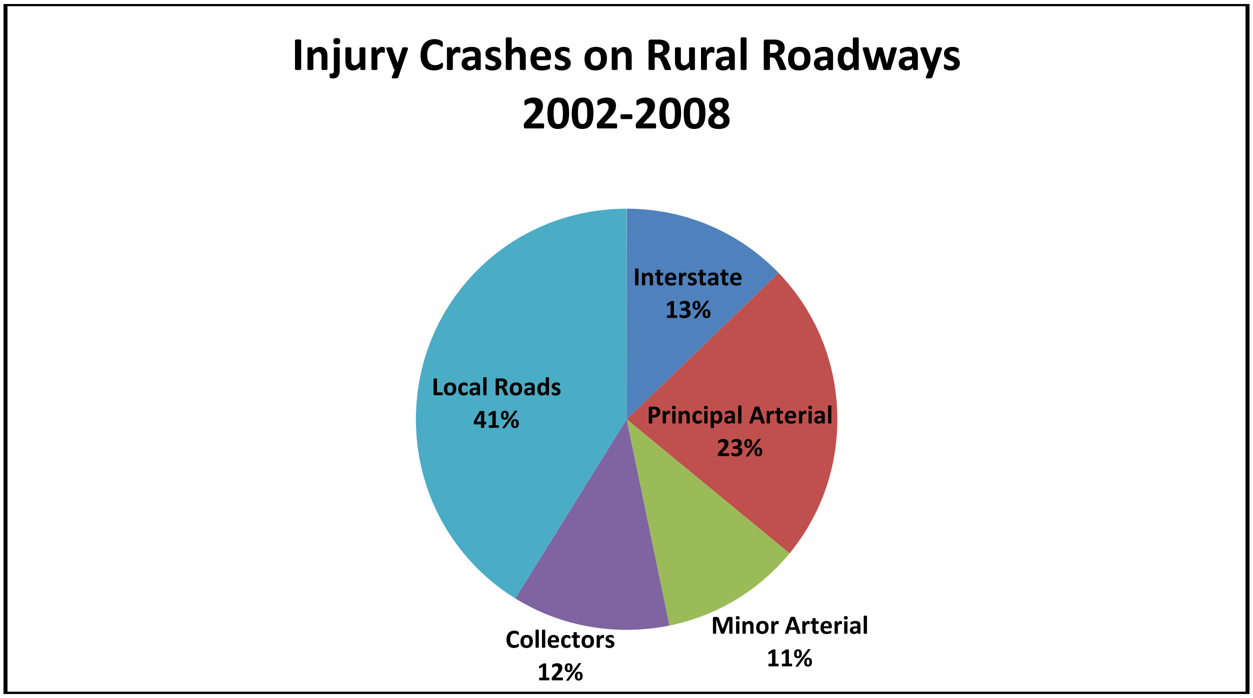

Figure 1.3 ND Rural Road Injury Crashes [3]

The functional classes for rural areas are defined by the American Association of State Highway and Transportation Officials (AASHTO) as follows [4]:

- Freeways and Principal Arterials
  - Corridor movement with trip length and density suitable for substantial statewide or interstate travel
  - Movement among (all) urban areas with populations over 50,000 and a majority of those with populations greater than 25,000
  - Integrated movement without stub connections
- Minor Arterials
  - Linkage of cities, larger towns, and other traffic generators capable of attracting travel over long distances
  - Integrated interstate and intercounty service
  - Internal spacing consistent with population density, so all developed areas are within reasonable distances of arterial highways
- Collector Roads
  - Routes which serve county seats not on arterial roads, and link them to nearby larger towns or cities
  - Serve the more important intracounty travel corridors
- Local Roads
  - Provides access to land adjacent to the collector network and serves travel over relatively short distances

1.1 Road Safety Audits/Traffic Safety Evaluations

Traffic Safety Evaluations (TSEs), commonly referred to as Road Safety Audits (RSAs), are a tool used to assess the safety performance of a roadway facility [5]. A TSE generally takes a proactive approach to addressing safety concerns, and can be done at any stage of a project from planning and design to existing facilities. This section will provide discussion on the purpose and procedure of conducting a TSE, as well as some of the documented benefits.

1.1.1 Purpose

Traffic Safety Evaluations consist of a formal examination of the safety and performance of a roadway facility by an independent, multi-disciplinary team [6]. The purpose of conducting a TSE is to account for all roadway users in identifying potential safety issues and opportunities for safety improvements. TSEs can be conducted for existing roadway facilities or during the design/construction of a new facility.

A TSE evaluates the elements of a roadway facility which present a safety concern in the context of the extent of the safety concern, the road users who are affected, and the circumstances which pose the greatest safety issue. Based on these concerns, a TSE looks to provide opportunities to eliminate or mitigate the identified safety concerns. It should be noted that TSEs are not a means to evaluate design work, compliance with standards, or a tool to rank various projects/designs [7].

1.1.2 Procedure

The process of conducting a TSE is outlined by the FHWA, and consists of the following steps:
1. Identify the roadway facility or project to be evaluated
2. Select the independent, multidisciplinary evaluation team
3. Conduct a pre-evaluation meeting
4. Perform field reviews under various conditions
5. Conduct analysis and document the findings
6. Present findings to project owner/management
7. Prepare a formal response
8. Incorporate findings into the project when appropriate

Conducting a TSE is a process based on several factors such as site crash history, project size, staff availability, and budget. It is recommended that the project team consist of personnel familiar with aspects of roadway/traffic safety, enforcement, geometric highway design, traffic engineering, and the traffic characteristics of the site under review. Based on the information collected during the evaluation, the project team then provides improvement suggestions/alternatives.

1.1.3 Benefits

There are quantitative and qualitative benefits to conducting a TSE. Several of the qualitative benefits are defined by the FHWA as follows [7]:
- Takes a pro-active approach to addressing safety
- Results should produce fewer and less severe crashes
- Allows for the identification of low-cost/high-value improvements
- Promotes a safety-conscious environment by improving the consistency of how safety is considered
- Provides a continuous advancement of safety knowledge
- Provides a benchmark for safety issues on future projects
- Promotes an efficient use of time, money, and resources

The USDOT has stipulated the costs of automotive crashes based on academic research, and determined that the value of a statistical life is equivalent to $5.8 million dollars. Based on this value, estimates for various types of crashes were calculated as follows [8]:
- $4,422,500 for a critical injury
- $1,087,500 for a severe injury
- $333,500 for a serious injury
- $89,900 for a moderate injury
- $11,600 for a minor injury

The quantifiable benefits of conducting a TSE are primarily based on the reduction of crash costs as road safety is improved [5]. However, several other quantifiable benefits have been documented, such as: 1) the elimination of re-construction costs to correct safety deficiencies in roadway facilities (pre-construction evaluation); 2) the reduction in lifecycle costs due to the lower maintenance costs of safer designs; 3) the reduction of societal costs due to collisions; and 4) the reduction of liability costs due to safer roadway facilities [7]. It should be noted that the achievement of a target cost/benefit ratio is generally not the motivation for support of a TSE.

1.2 Case Studies

Several case studies have been conducted by various agencies to determine the effectiveness of TSEs. This section will highlight several TSEs which have been performed to give an idea of the various applications they are suitable for.

Maryland

The Maryland State Highway Administration Pilot conducted a road safety audit review on four Maryland roadways that range from a 6-lane urban arterial to a rural 2-lane roadway. The studies were done in January, 2006, by individuals with various backgrounds such as traffic engineers, construction engineers, highway engineers, and traffic safety coordinators. The teams used historical crash data, aerial photographs, traffic volumes, video logs, and other resources to obtain information on the various roadways. The recommended improvements ranged from reduced speed limits and traffic calming measures, pedestrian countdown signals, and chevron signs.

Minnesota

Several TSE studies have been conducted in Minnesota. One of the studies was conducted by SRF Consulting Group in accordance with MNDOT in December, 2006, in Farmington, Minn. The study location was a segment of TH 3, which had been perceived to have safety issues due to crash history and individual observations and experiences within the community. The evaluation team utilized information from crash history, traffic volume, corridor plan sheets, and aerial photography. The team then conducted a field review and observed the issues related to the corridor. Improvements for each safety issue were then organized into short-range, mid-range, and long-range improvements to consider. Some of the main improvements include upgrading signing, adding new pavement markings, and changing the geometric characteristics of various intersections.

Pennsylvania

A study done in Pennsylvania was conducted by PENNDOT and the Delaware Valley Regional Planning Commission in November, 2007. This study was conducted over an 8-mile stretch of roadway which spanned two counties in Pennsylvania. The roadway was classified as a minor arterial and was surrounded by a mix of residential, agricultural, and industrial areas. This study involved a significant amount of crash data collection and geometrical analysis of several intersections. The report generated from the study explained each safety issue which was found, along with a corresponding remedial strategy. In addition, each improvement suggestion was categorized by the level of effort and potential safety benefit of the task.

2. BACKGROUND/INTRODUCTION

Improving roadway safety is an ongoing priority for transportation agencies. However, addressing safety issues in rural areas is difficult for local governments due to the limited resources available for maintenance and improvement projects. According to statistics from the North Dakota Department of Transportation (NDDOT), 85% of fatal crashes occurred on rural roads in 2007.

Traffic Safety Evaluations (TSEs) have emerged as an effective type of proactive tool for identifying and addressing roadway safety issues. According to the Federal Highway Administration (FHWA), Road Safety Audits noticeably improve the safety performance of roadway facilities. For example, the South Carolina Department of Transportation recorded a 60% reduction in fatalities in a location at which a safety audit was conducted. Several benefits can be achieved through the implementation of Road Safety Audits, such as low-cost/high-value improvement opportunities, promoting the awareness of safe design and maintenance practices, and providing a means to tailor the resources of an agency to meet specific problems.

The main goal of this project is to develop a methodology for identifying and conducting traffic safety evaluations in North Dakota. Specific objectives include the following:

1. Conduct case studies at sites with recognized safety issues.
2. Provide research and information on conducting safety evaluations among county transportation agencies in North Dakota.
3. Demonstrate the effectiveness of conducting TSEs to agencies in North Dakota and other locations in the MPC region, along with a low-cost improvement tool-kit.

The general framework for the research approach consists of using a real-world case study to conduct TSEs and demonstrate the methodology and application to agencies in North Dakota.

The critical issues addressed by this research are listed as follows:

1. High-Risk Rural Roads. Rural roads continue to experience a disproportionate number of crashes, resulting in more fatalities and injuries than their urban counterparts. Fatalities on rural roads occur at a rate two-and-a-half times greater than on all other routes. Research proposals should address the unique characteristics which contribute to increased risks at particular locations, including highway geometry, use of alcohol and other substances that impair drivers, monotonous driving conditions, and high crash rates on Native American reservation roads.

4. Human Factors. Because rural crashes often involve single-vehicle, run-off-the-road crashes, there is a need to examine unique human factors corresponding to the characteristics of the Mountain-Plains Region. These critical factors include driver behavior, driver attitudes to speed, alcohol, seat belt use, and other regional and cultural factors. These issues are equally applicable to drivers of commercial and passenger vehicles.

5. Low-Cost Safety Improvements. Technology transfer projects are needed to help disseminate available information regarding successful low-cost safety improvements to local and county transportation agencies in the region. Research is needed to identify improvements in roadway inventory data and road safety audit procedures, which are necessary to identify cost-effective safety improvements.

8. Safety of Unpaved Roads. Most local agencies in the Mountain-Plains Region manage hundreds of miles of gravel roads. For some agencies, the percentage of gravel roads approaches 95% of their total networks. Research into the causes of crashes on unpaved roads will help local governments improve the safety of their networks.

This project will provide a blueprint for conducting low-cost road safety audits for counties in North Dakota. The information generated from this project is potentially helpful to county agencies to outline the process of identifying potential problem areas and the process for conducting audits. Another potential benefit of this study is to generate interest and a sharing of resources and best practices among counties regarding the improvement of roadway safety.

3.0 PROJECT DESCRIPTION

After inquiring about potential study locations in various counties in North Dakota, a suitable location was found in Barnes County. Barnes County is located in east central North Dakota, and has a population of 11,775, according to the 2000 census (Figure 3.1). The number of road miles in Barnes County is 233 (paved), and 117 (gravel) [9]. Valley City, which is the county seat, is also the largest city in Barnes County. Valley City lies on the northern part of the Scenic Byway.

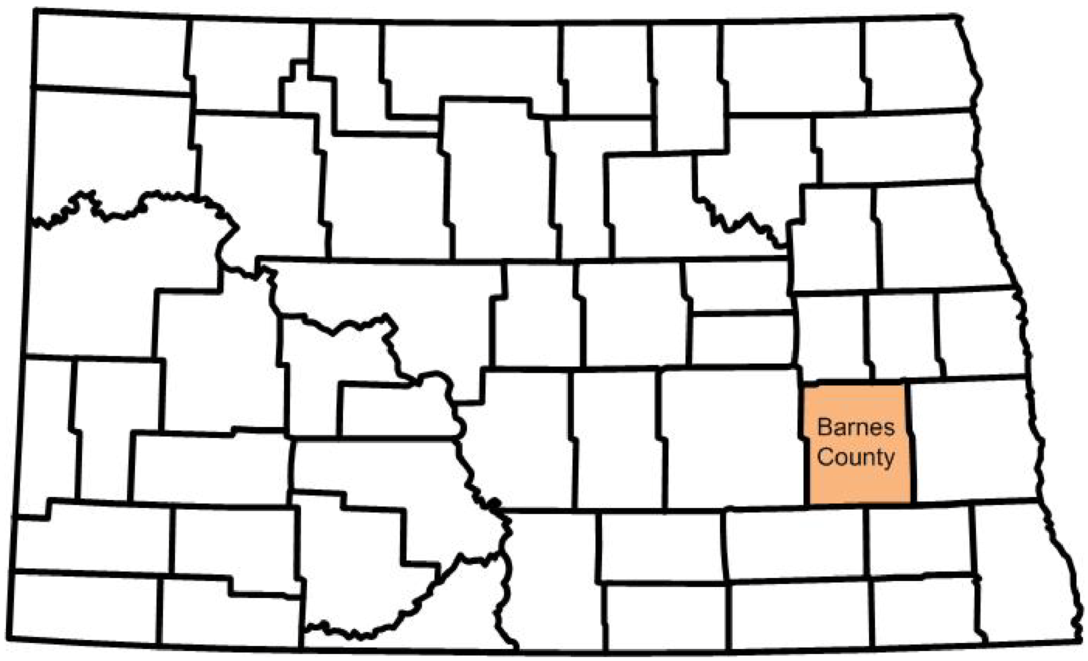

Figure 3.1 Location of Barnes County, N.D.

The agencies involved in the evaluation included the Barnes County Road Department, Barnes County Commission, Barnes County Sheriff's office, Safe Communities of Sheyenne Valley, Sheyenne Valley Scenic Byway, and the Upper Great Plains Transportation Institute. Representatives from each agency were involved in the site visit, which occurred on July 22, 2009.

The location of the study was identified as County Highway 21 from approximately three miles north of Valley City, N.D. to Kathryn, N.D. (Figure 3.2). The scope of the study area was approximately 15 miles along Highway 21. In addition, an approximate three mile section of River Road to the northwest of Valley City was also observed (adjacent to Highway 21), and evaluated for safety concerns.

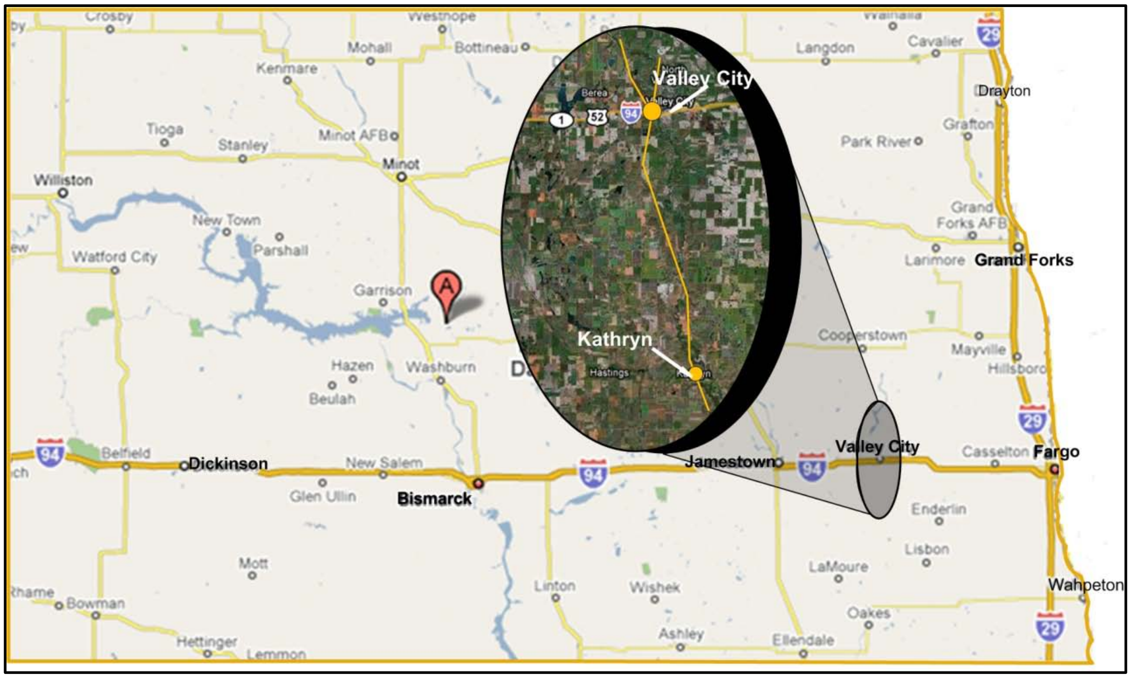

Figure 3.2 Location of Highway 21

This roadway is also classified as a Scenic Byway, and is part of the Sheyenne River Valley Scenic Byway. This section of roadway was identified by Barnes County personnel due to perceived safety issues at several locations. The scenic byway portion of Highway 21 has several horizontal and vertical curves, most of which are located south of Valley City. In addition to the curvature, there are several locations which have limited clear-zone distances due to vegetation (Figure 3.3).

Figure 3.3 Roadway Curvature and Limited Clear Zone

4. METHODOLOGY

Prior to the site visit along Highway 21, the TSE team held a preliminary meeting at the Barnes County Road Department office. The goal of the meeting was to outline the process for conducting the evaluation of the roadway. Due to the extended scope of the project area, it was determined by the evaluation team that the optimal means of evaluating the roadway would be to drive the highway from one end of the focus area to the other, and stopping at locations of interest to take photos and note any safety issues. In addition to the comments and photos, a handheld GPS unit was used to mark locations of interest along the project area as a reference for all of the photos taken during the field visit.

After the field visit, all of the comments and photos were compiled for each of the sites which were evaluated. Once all of the comments from the site visit were received, the focus areas were defined and submitted to the group for review. A survey was compiled to compare the six most commented sites, as well as a “miscellaneous” location in which the survey respondents could add comments on additional locations not included in the survey (Appendix B).

The survey responses were used to determine the critical locations in the project area, and were rated according to the perceived risk of the site and the overall rank in comparison to the other sites. Once the surveys were returned, the top four sites were chosen for review.

Recommendations for improvements of those sites were given based on other similar studies from previous RSAs/TSEs by various agencies.

5. KEY FINDINGS

This evaluation looked at several locations along the Scenic Byway from north of Valley City to Kathryn. To the north of Valley City, three sites were evaluated due to safety concerns and previous crash occurrences. In addition, several locations were examined on the highway corridor between Valley City and Kathryn. This section will provide details on each of the locations that were observed, and the safety issues that were noted
.
Crash data were obtained from NDDOT for the extent of the study area from 2002 to 2009 (Table 5.1). Although there were several crashes reported, it was interesting to note that a majority of the crashes involve animals. There was only one fatal crash within the study area, which occurred in 2003 on the curve north of Valley City. In addition, a majority of the reported crashes involved property damage only, followed by non-incapacitating injuries. Further details on the crash data obtained by NDDOT can be seen in Appendix D.

Table 5.1 NDDOT Crash Data for the Study Area

Reported Crashes Occurring Without Animals				
Year	Fatal	InjB	PDO	Total
2002	0	0	0	0
2003	1	4	4	9
2004	0	4	4	8
2005	0	2	2	4
2006	0	1	2	3
2007	0	0	0	0
2008	0	1	0	1
2009	0	1	3	4
			Total Crashes	**29**
Reported Crashes Occurring with Animals				
Year	Fatal	InjB	PDO	Total
2002	0	0	5	5
2003	0	0	5	5
2004	0	0	9	9
2005	0	0	11	11
2006	0	0	7	7
2007	0	0	6	6
2008	0	0	5	5
2009	0	0	2	2
			Total Crashes	**50**
Total Reported Crashes				
Year	Fatal	InjB	PDO	Total
2002	0	0	5	5
2003	1	4	9	14
2004	0	4	13	17
2005	0	2	13	15
2006	0	1	9	10
2007	0	0	6	6
2008	0	1	5	6
2009	0	1	5	6
			Total Crashes	**79**

Note: Fatal – Fatal Crash; InjB – Non-incapacitating Injury;
PDO – Property Damage Only

5.1 Horizontal Curve North of Valley City

The first site evaluated was a large horizontal curve approximately three miles north of Valley City (Figures 5.1-5.2). It was noted that several run-off-the-road crashes have occurred at this location, with one resulting in a fatality. In addition to the roadway curvature, there are other characteristics which contributed to the safety issues at this location. An intersection with a gravel road, which isn't aligned perpendicular to the highway, is located at the midway point between the two horizontal curves. This alignment may potentially cause some sight-distance issues and driver confusion. In addition, several trees are located in the vicinity of the southern edge of the curve (Figure 5.2).

Figure 5.1 Horizontal curve north of Valley City

Figure 5.2 Intersection in the middle of the horizontal curve
Note: photo was taken facing to the southeast

5.2 Bloomberg Hill

The second site which was evaluated was located to the northwest of Valley City and consisted of an intersection on a horizontal and vertical curve (Figure 5.3). There were several characteristics about this intersection which cause safety issues such as, intersection alignment, approach grade and roadway material, and sight distance.

Figure 5.3 Approaching the Bloomberg Hill intersection from the southeast

The paved highway intersects with a gravel road, which approaches the intersection at a significant downgrade. Due to the alignment of the intersection and orientation of the gravel road, it is extremely difficult to see the intersection and gravel road when approaching from the north on the paved roadway (Figure 5.4).

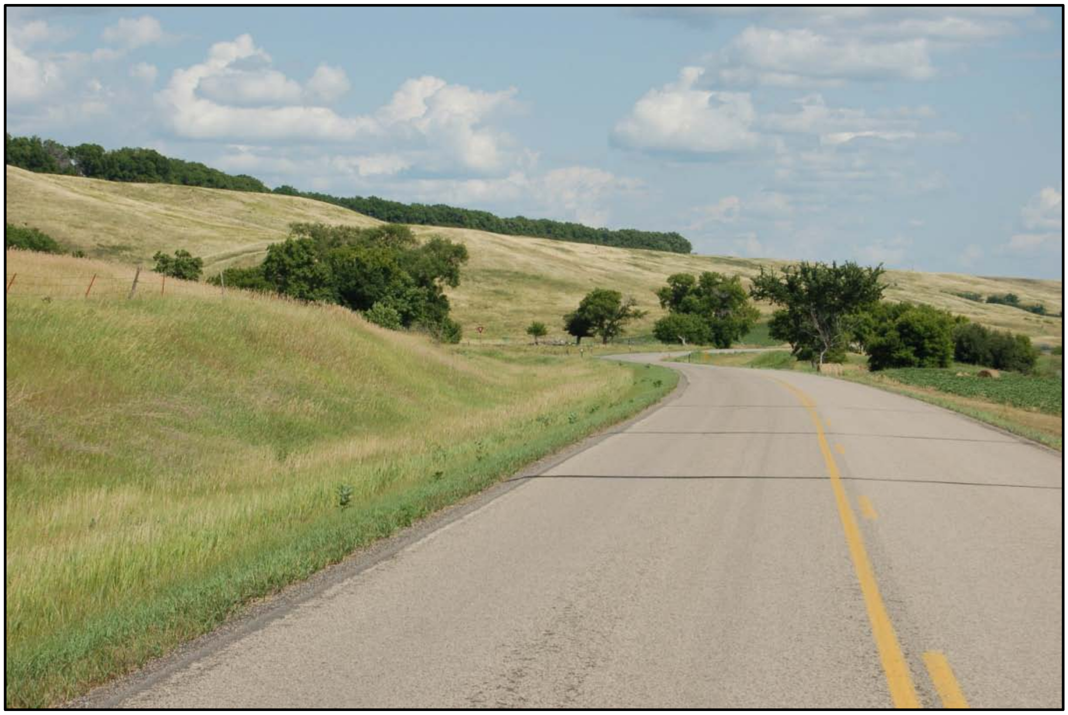

Figure 5.4 Approaching the Bloomberg Hill intersection from the northwest.

Several small trees and shrubs are located in the northwest quadrant of the intersection and block the view to the northwest for vehicles approaching the intersection on the gravel road. This is compounded by the fact that the intersection alignment already makes the view of oncoming traffic difficult (Figure 5.5).

Figure 5.5 Obstruction and alignment issues at the Bloomberg Hill intersection

5.3 Railroad Crossing North of Valley City

A railroad runs parallel to the highway northwest of Valley City (in the vicinity of Bloomberg Hill), and has access roads crossing at certain locations. One of these crossings was examined during the site visit. It was noted that when a train was present, the storage of the approach to the crossing may be insufficient in preventing spillback onto the highway (Figure 5.6).

Figure 5.6 Railroad crossing northwest of Valley City, N.D.

5.4 Curve South of Valley City

Approximately three miles south of Valley City, the evaluation team examined a bridge located on a horizontal curve along Highway 21 (Figure 5.7). Comments from this location regarded excessive speed and the narrowness of the bridge. Past observations have shown that due to the narrowness of the bridge, drivers tend to track along the center of the road when crossing. Proactive measures have been taken to improve the safety of this location through the addition of a speed advisory plate on the curve sign and updated guardrails at the bridge.

Figure 5.7 Bridge and horizontal curve south of Valley City, N.D.

5.5 Skorpen Curve

One of the most significant safety issues was observed approximately halfway between Valley City and Kathryn. This location is referred to as Skorpen Curve, and has been the site of several crashes. Skorpen Curve consists of a large reverse curve, with a bridge crossing the Sheyenne River at the midpoint. The north end of the curve includes an intersection with a gravel road (Figure 5.8).

Figure 5.8 North end of Skorpen Curve
Note: Photo was taken facing to the southeast

The bridge at the midpoint of the reverse curve is relatively narrow in comparison to the roadway, which results in the road having no shoulder on the bridge (Figure 5.9). It was observed during the site visit that the southbound guardrail attenuator was damaged, indicating that it had been struck by a vehicle. It should be noted that a road crew was repairing the guardrail at the time of the field visit.

Figure 5.9 Bridge at Skorpen Curve
Note: Photo was taken facing to the east

The south end of Skorpen Curve also intersects with a gravel road (Figures 5.10-5.11). This intersection had several safety issues, which were noted by the evaluation team. Due to the alignment of the intersection, vehicles travelling southbound on Highway 21 may think that the roadway continues straight, especially in low-light or inclement weather conditions (Figure 5.9). This alignment may cause drivers to inadvertently run off the road.

Vehicles approaching Highway 21 on the gravel road from the east have several factors to consider. The approach to the intersection with Highway 21 is on a downgrade and controlled by a stop sign (Figures 5.10-5.11). This may be hazardous for drivers unfamiliar with the roadway (especially if they don't see the stop sign and think the road continues straight).

Figure 5.10 Westbound approach at the south end of Skorpen Curve

Figure 5.11 Westbound approach at Skorpen Curve
Note: Photo was taken facing to the east

Vehicles approaching Skorpen Curve from the south have two speed advisory signs warning of the roadway curve (Figures 5.12-5.13). It was noted that the northbound direction at this location had a history of safety issues, primarily related to speeding. The advanced speed advisory sign was added in 2007 to encourage drivers to reduce their speed.

Figure 5.12 Advanced speed advisory sign (northbound at Skorpen Curve)

Figure 5.13 Curve advisory sign and speed limit sign at Skorpen Curve

5.6 Roadway Curves North of Kathryn

It was observed during the site visit that several horizontal curves were located on a section of road approximately five miles north of Kathryn (Figures 5.14-5.16). The safety issues observed at this location were primarily due to the close proximity of vegetation to the roadway. This results in limited sight distance at the curves, and requires drivers to reduce speed. It should be noted that the Sheyenne River is adjacent to Highway 21 at this location, and road crews have difficulty trimming vegetation close to the river. Guardrails have been placed at locations where the road is close to the river and locations where trees are adjacent to the road.

Figure 5.14 Vegetation growth along the road shoulder
Note: Sheyenne River is located on the left side of the photo

Figure 5.15 Speed advisory sign and horizontal curves


Figure 5.16 Clear zone encroachment due to vegetation

5.7 In-slope Slough

The evaluation team examined a location at which the roadway in-slope is unstable (Figures 5.17-5.18). This instability is causing the in-slope to slide (slough) approximately eight feet from the edge of the road shoulder. At the time of the site visit, the slough was approximately four feet deep (in comparison to the existing grade). In addition to the slough, the in-slope itself is considerably steep at this location. It was noted that a previous repair of the in-slope slough only lasted a few weeks before it began sliding again. There were no safety devices at this location except for two posts delineating the edges of the slough.

Figure 5.17 Roadway in-slope slough

Figure 5.18 Roadway in-slope slough

5.8 Roadway Curves South of Kathryn

Several curves were observed on Highway 21 southwest of Kathryn (Figures 5.19-5.21). Although there were no obvious sight-distance issues caused by vegetation, some of the curves had relatively small radii due to the landscape, which required speed reductions to 35 mph.

Figure 5.19 Large horizontal curve on Highway 21

Figure 5.20 Horizontal curve with speed reduction

Figure 5.21 Horizontal curve with speed reduction and culvert delineators

6.0 SUGGESTIONS FOR IMPROVEMENT

The evaluation team identified four locations along Highway 21 that warranted improvements based on a ranking system of all the sites which were observed. These four locations are listed as follows:

1. Bloomberg Hill
2. Roadway curves and slough south of Kathryn
3. Skorpen Curve
4. Horizontal curve north of Valley City

The ranking of the four locations can be seen in Appendix B. It should be noted that both Bloomberg Hill and the in-slope slough by Kathryn had the same ranking.

The improvement suggestions have been organized by approximate cost (based on NDDOT average bid prices) and approximate ease of installation. The cost data can be found in Appendix C. This section will discuss each of the four locations and provide improvements for each. The improvement suggestions are based on past studies done by various agencies which had similar characteristics and safety issues.

6.1 Bloomberg Hill

This location was perceived to have the highest safety issue as noted by the ranking done by members of the evaluation team. There are several recommended suggestions for improvement at this location (Figure 6.1). The various improvement strategies are listed as follows:

Short Term Improvements:

- Remove the vegetation in the northwest quadrant of the intersection
- Install roadside delineators along the curve
- Install a ‘Blind Intersection Ahead’ sign for southbound traffic on the paved road
- Improve pavement markings (edgeline)

Long-Term Improvements:

- Install edgeline rumble strips
- Install centerline rumble stripes
- Re-align the intersection so the gravel road is perpendicular to the highway
- Widen the shoulders on the curve

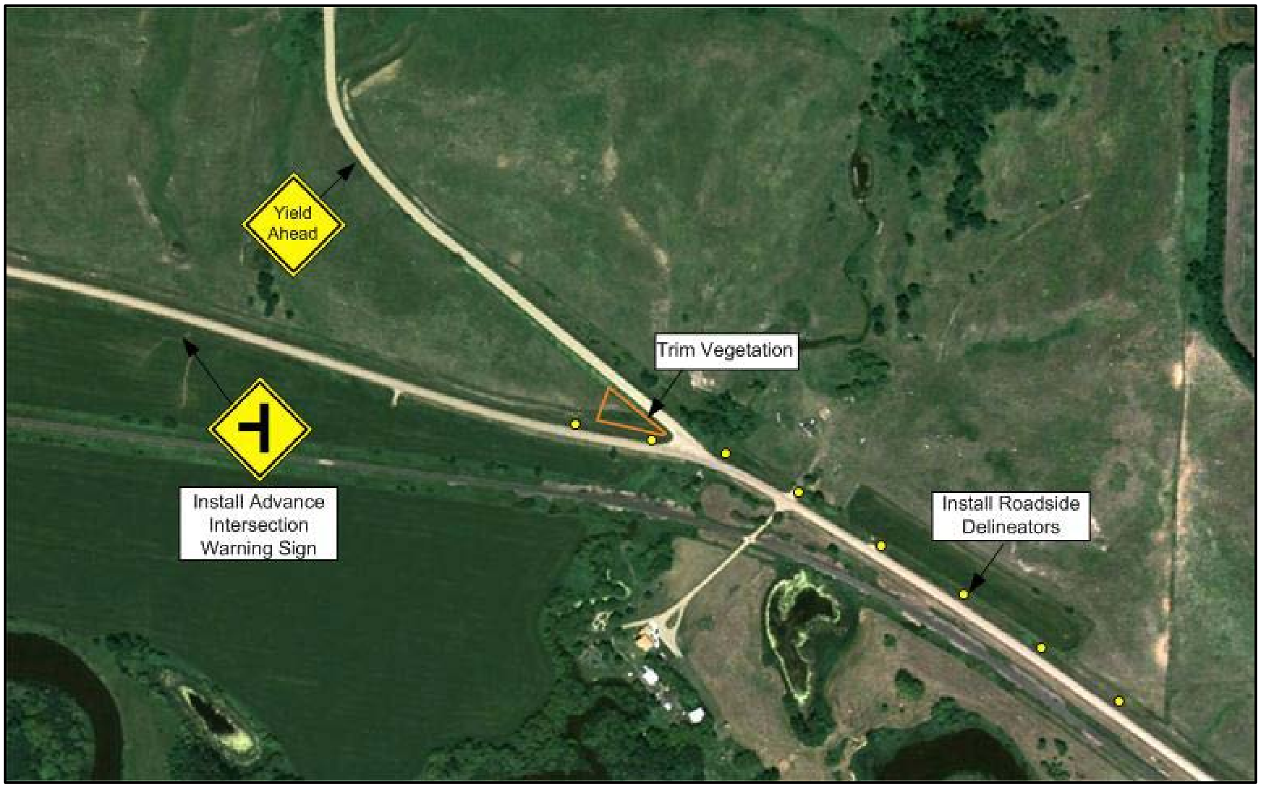

Figure 6.1 Improvement suggestions for Bloomberg Hill

6.2 Roadway Curves and Slough South of Kathryn

This location received the same ranking as Bloomberg Hill due to the safety issues caused by the in-slope instability. Although there are several temporary solutions to improve the safety at this location, it will be necessary to remediate the soil instability before the structure of the roadway facility becomes affected. The recommended improvement strategies for this location are as follows:

Short-Term Improvements:

- Install chevrons along the curves which require a reduction in speed
- Reduce the speed limit in the vicinity of the slough
- Install guardrails at the location of the slough
- Improve pavement markings (edgeline)

Long-Term Improvements:

- Widen shoulders on the curves and at the location of the slough
- Flatten the side-slopes of the roadway

6.3 Skorpen Curve

Although this location was not ranked as high as the previous two, the ranking was only lower by .25, which illustrates the importance of evaluating the safety of this curve. It should be noted that two of the respondents ranked this location as having the worst safety issues (see Appendix B). The general layout and safety issues at Skorpen Curve are relatively similar in nature to the issues encountered at Bloomberg Hill, with a few exceptions. As a result, the strategies for improving the safety at this location are similar (Figure 6.2). The improvement strategies for Skorpen Curve are listed at follows:

Short-Term Improvements:

- Install chevrons along the curves
- Install a 'Blind Intersection Ahead' for northbound traffic on the paved road
- Install an advance traffic control sign for westbound traffic on the gravel road
- Improve pavement markings (edgeline)

Long-Term Improvements:

- Install edgeline rumble strips
- Install centerline rumble stripes
- Install dynamic speed advisory signs to alert drivers to their speed
- Widen the shoulders on the curves and bridge

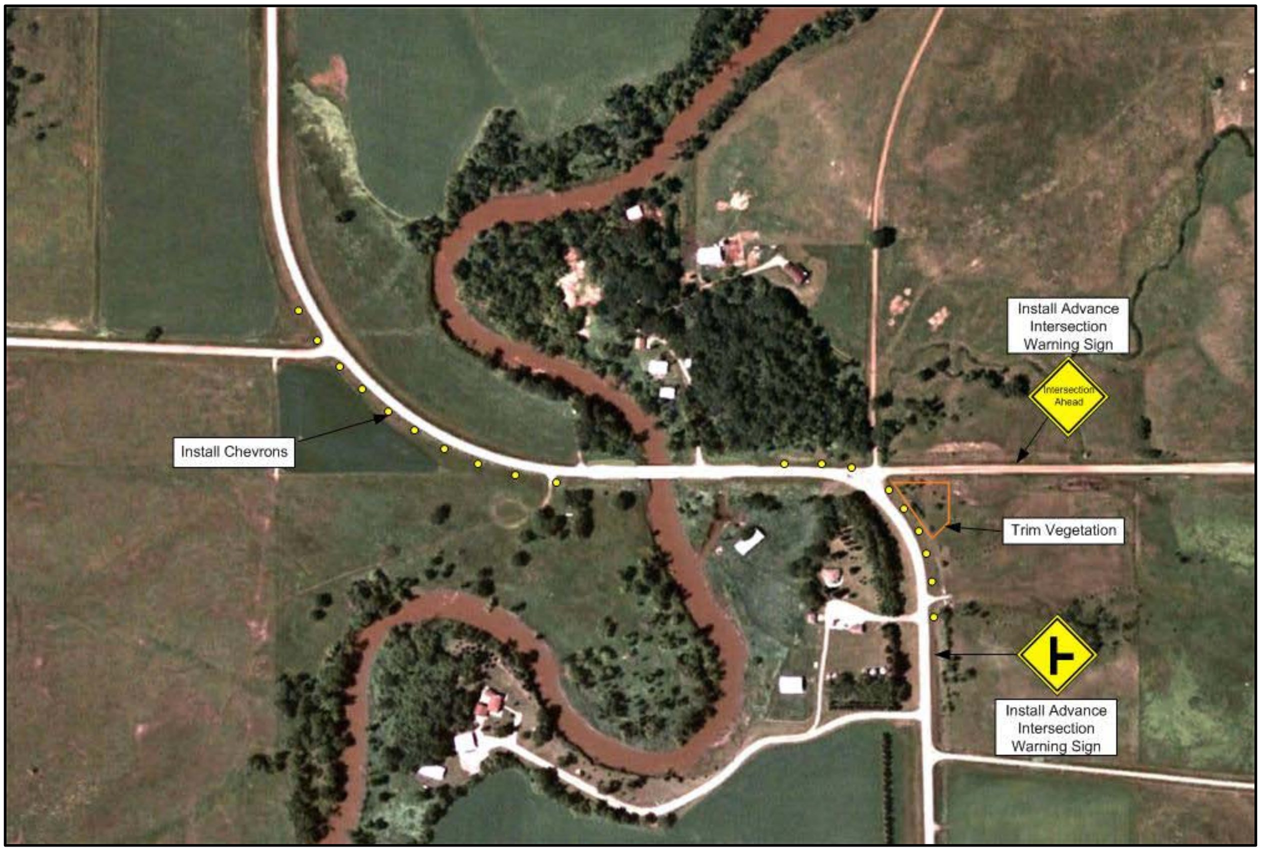

Figure 6.2 Short-term improvements for Skorpen Curve

6.4 Roadway Curve North of Valley City

This location was examined by the evaluation team due to concerns resulting from previous crashes (one of which resulted in a fatality). This location is a reverse curve having similar safety issues as the others, such as vegetation/trees blocking the view and an intersection at the center of the curve. This location had a ranking of 3.5, with the highest respondent ranking of 2 (Appendix B). The recommended safety improvements for this location are listed as follows:

Short-Term Improvements (Figure 6.3):

- Install chevrons along the curves
- Improve pavement markings (edgeline)
- Install Advance Intersection Control signs for east-west traffic

Long-Term Improvements:

- Install edgeline rumble strips
- Install centerline rumble stripes
- Widen the shoulders on the curves
- Install dynamic speed advisory signs to alert drivers to their speed
- Re-align the gravel road (30^{th} St. SE) so it is perpendicular to Highway 21

Figure 6.3 Short-term improvement suggestions for the curve north of Valley City

7. SUMMARY/CONCLUSIONS

This evaluation was conducted for Barnes County, N.D. and included approximately 15 miles along Highway 21. The study area ranged from approximately three miles north of Valley City south to Kathryn. This section of highway has been classified as a scenic byway, and is part of the Sheyenne River Valley Scenic Byway.

Based on the site visit conducted by the evaluation team and the corresponding comments that were gathered, a survey was compiled to rank the sites by the perceived risk/safety deficiencies. The survey was completed by members of the evaluation team, and the four highest ranked locations were chosen for improvement suggestions. The improvement suggestions were based on past studies having similar roadway characteristics and geometry.

Although each of the four sites has their own characteristics and safety issues, a trend was noticed, primarily involving the locations with horizontal curves. Three of the four sites that ranked the highest on the survey involved horizontal curves which have limited sight distance. In addition, there have been previous reports of run-off-the-road crashes and concerns about the continuing potential for drivers running off the road at these locations. It is important that safety improvements done on the corridor be uniform (i.e., adding chevrons to curves having similar sight-distance issues and radii) to maintain the same safety standards throughout and minimize driver confusion. A majority of the reported crashes along the study corridor have occurred due to animals. Appendix D illustrates the location and type of crashes along Highway 21. It would be beneficial for county officials to use the maps (particularly the animal crash map) to warn drivers of areas with high animal activity.

Although system-wide improvements are limited by funding, efforts should be made to improve the overall safety of the corridor, such as updating pavement markings (particularly the edgeline striping). Additional benefits could also be realized by adding rumble stripes/strips. The county has been taking proactive steps to improve safety (road crews were observed repairing a guardrail and trimming vegetation along the shoulders during the site visit), and it is imperative that these activities continue in the future.

It was determined during this study that the most effective low-cost improvement strategies would be the following:

- Improve sight distance by removing/cutting back vegetation
- Install chevron and advance warning signs on curves
- Improve pavement markings
- Install guardrails at warranted locations
- Install edgeline rumble strips and centerline rumble stripes

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3. *North Dakota 2008 Crash Summary*. North Dakota Department of Transportation. Bismarck, N.D. 2008.

4. American Association of State Highway and Transportation Officials. *A Policy on Geometric Design of Highways and Streets 2001*. Fourth Edition. Washington, D.C. 2001.

5. Gibbs, Margaret et al. *Road Safety Audits: Case Studies*. Opus Hamilton Consultants Ltd, Vanasse Hangen Brustlin Inc, Federal Highway Administration. December, 2006.

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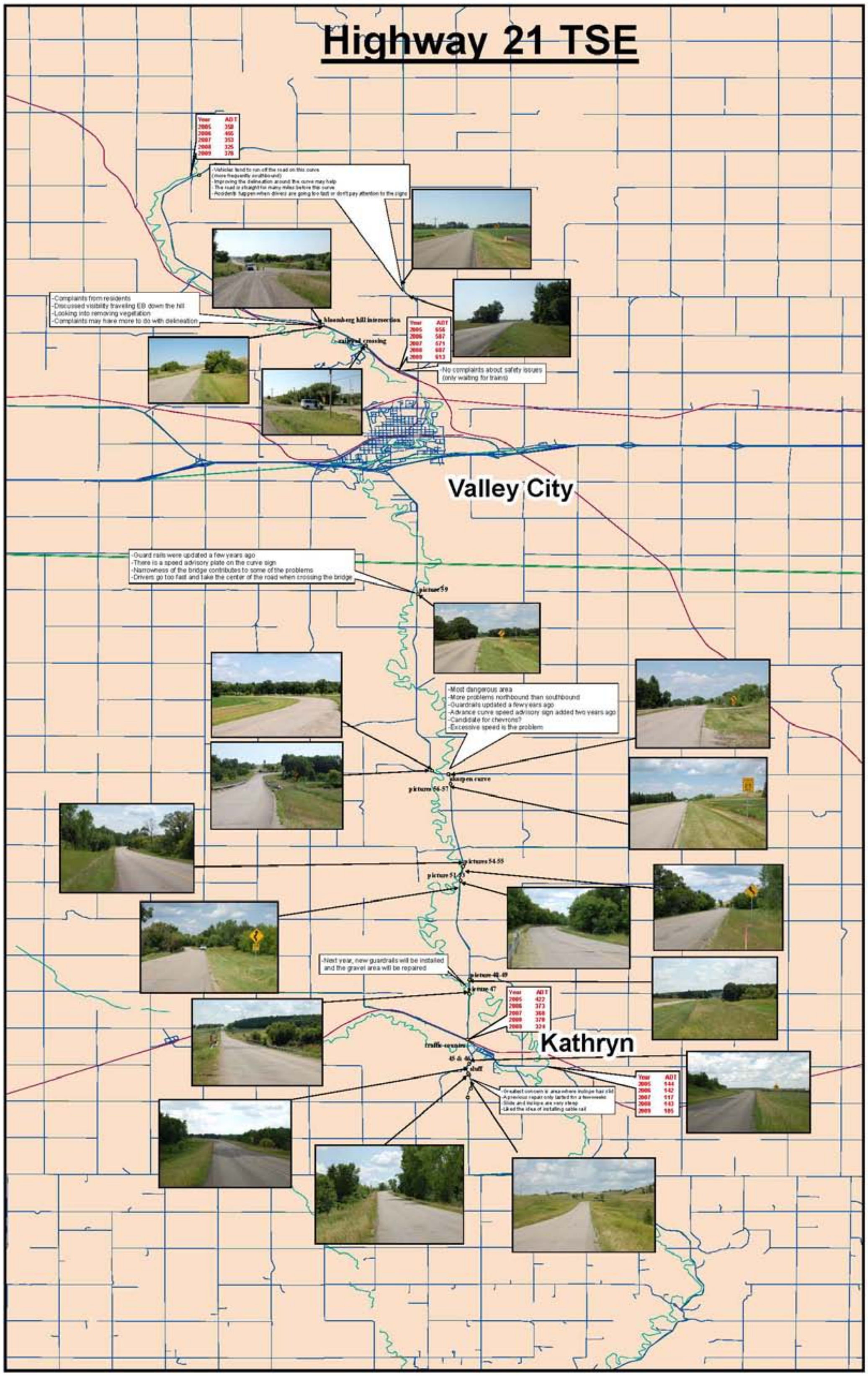
7. McGill, J. et al. *Road Safety Audit Guidelines*. Science Applications International Corporation, Synectics Transportation Consultants, Kittelson and Associates, CTRE, Penn State, Federal Highway Administration. Washington, D.C. February, 2005.

8. Duvall, Tyler D. "Treatment of the Economic Value of a Statistical Life in Departmental Analyses." Memorandum to Secretarial Officers and Modal Administrators. United States Department of Transportation. February 5, 2008.

9. Barnes County, N.D. http://www.co.barnes.nd.us/

APPENDIX A: TSE SITE VISIT COMMENTS



APPENDIX B: TSE SITE VISIT SURVEY

Focus Areas	Survey												Average	
	Respondent 1		Respondent 2		Respondent 3		Respondent 4							
Safety Issues (with received comments)	Perceived Risk Rating (A-D)	Rank	Perceived Risk Rating (A-D)	Rank	Perceived Risk Rating (A-D)	Rank	Perceived Risk Rating (A-D)	Rank	Perceived Risk Rating (A-D)	Rank	Perceived Risk Rating (A-D)	Rank	Perceived Risk Rating (A-D)	Rank
•Bloomberg Hill -Complaints from residents -Discussed visibility traveling EB down the hill -Looking into Removing vegetation -Complaints may have more to do with delineation	B	4	D	1	D	1	C	3						2.25
•Curve Aprrox. 3 miles North of Valley City -Vehicles tend to run off the road on this curve (more frequently SB) -Improving the delineation around the curve may help -The road is straight for many miles before this curve -Accidents happen when drivers are going too fast or don't pay attention to the signs	C	2	C	5	C	3	C	4						3.5
•Curve 3 Miles South of Valley City -Guard rails were updated a few years ago -There is a speed advisory plate on the curve sign -Narrowness of the bridge contributes to some of the problems -Drivers go too fast and take the center of the road when crossing the bridge	D	5	C	3	C	5	C	5						4.5
•Skorpen Curve 8 miles South of Valley City -Most Dangerous Area -More problems northbound than southbound -Guard rails were updated a few years ago -Advance curve speed advisory sign added two years ago -Excessive speed is the problem	D	1	C	4	C	4	D	1						2.5
•Curves and Sluff South of Kathryn -Greatest concern is area where inslope has slid -A previous repair only lasted for a few weeks -Slide and inslope are very steep -Liked the idea of installing cable rail	C	3	D	2	D	2	D	2						2.25
•Other Location(s) of Concern (please describe)														
•Perceived Safety Issues - Would like to see edge line stripes	C													

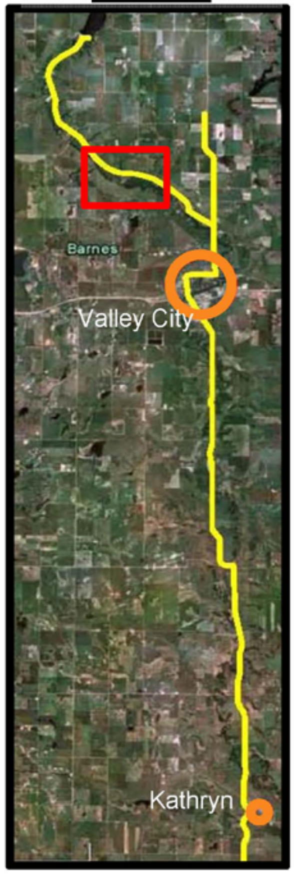
APPENDIX C: SUGGESTED IMPROVEMENT STRATEGIES

Bloomberg Hill

(Rank: 2.25)

- Low-Cost Improvement Strategies
  - -Remove/trim vegetation (MNDOT 2006)
  - -Install chevrons/delineators (MNDOT/SRF 2006)
  - -Install advance curve sign with speed advisory (PENNDOT 2007)
  - -Install "Blind Intersection Ahead" sign
  - ***Approximate cost: $4,800**
- Medium-Cost Improvement Strategies
  - -Improve striping (MNDOT 2006)
  - -Install a dynamic speed advisory sign that alerts drivers their speed (MNDOT/SRF 2006)
  - ***Approximate cost: $9,000 (includes low-cost improvements)**
- High-Cost Improvement Strategies
  - -Install edgeline rumble strips (MSHWA)
  - -Install centerline rumble strips (MSHWA)
  - -Improve curve radius/superelevation
  - -Widen shoulders on curves
  - -Improve pavement friction
  - -Widen lanes and shoulders (PENNDOT 2007)
  - ***Approximate cost: $37,898 (one mile length)**

Location



*Cost based on 2009 NDDOT Average Bid Prices

Skorpen Curve

(Rank: 2.5)

- **Low-Cost Improvement Strategies**
  - -Install chevrons (MNDOT/SRF 2006)
  - -Educate younger drivers more (MNDOT/SRF 2006)
  - -Install signs that have road geometry with intersections shown
  - -Install raised pavement markers on centerline for night and bad weather driving (PENNDOT 2007)
  - ***Approximate cost: $702**

- **Medium-Cost Improvement Strategies**
  - -Improve striping (MNDOT 2006)
  - -Increase law enforcement in area for speeding (MNDOT 2006)
  - -Install a dynamic speed advisory sign that alerts drivers their speed (MNDOT/SRF 2006)
  - ***Approximate cost: $4892 +law enforcement (includes low-cost improvements)**

- **High-Cost Improvement Strategies**
  - -Install edgeline rumble strips (MSHWA)
  - -Install centerline rumble strips (MSHWA)
  - -Improve curve radius/superelevation
  - -Widen shoulders on curves
  - -Improve pavement friction
  - -Widen lanes and shoulders (PENNDOT 2007)
  - ***Approximate cost: $37,898 (one mile length)**

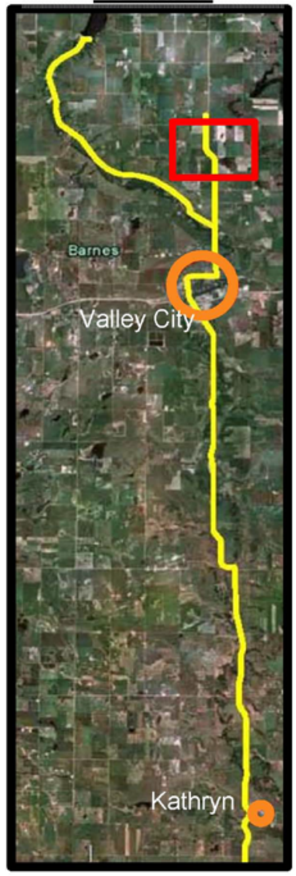
*Cost based on 2009 NDDOT Average Bid Prices

Location

Curve 3 mi. North of Valley City

(Rank:3.5)

Location



- Low-Cost Improvement Strategies
  - -Install chevrons/delineators (MNDOT/SRF 2006)
  - -Advance curve sign with speed advisory (PENNDOT 2007)
  - -Install raised pavement markers on centerline for night and bad weather driving (PENNDOT 2007)
  - ***Approximate cost: $702**

- Medium-Cost Improvement Strategies
  - -Improve striping (MNDOT 2006)
  - -Install a dynamic speed advisory sign that alerts drivers their speed (MNDOT/SRF 2006)
  - ***Approximate cost: $4,792**

- High-Cost Improvement Strategies
  - -Install edgeline rumble strips (MSHWA)
  - -Install centerline rumble strips (MSHWA)
  - -Improve curve radius/superelevation
  - -Widen shoulders on curves
  - -Improve pavement friction
  - -Widen lanes and shoulders (PENNDOT 2007)
  - ***Approximate cost: $37,898 (one mile length)**

*Cost based on 2009 NDDOT Average Bid Prices

Roadway Curves and Sluff South of Kathryn (Rank: 2.25)

- Low-Cost Improvement Strategies
  - -Install chevrons (MNDOT/SRF 2006)
  - -Have uniform signage (MNDOT/SRF 2006)
  - -Consider reducing speed limit (MSHWA)
  - ***Approximate cost: $400**
- Medium-Cost Improvement Strategies
  - -Improve striping (MNDOT 2006)
  - -Install up-to-date guardrails (PENNDOT 2007)
  - ***Cost depends on the number and length of guardrails**
- High-Cost Improvement Strategies
  - -Install edgeline rumble strips (MSHWA)
  - -Improve curve radius/superelevation
  - -Widen shoulders on curves
  - -Repave road/improve pavement friction
  - -Flatten side slopes
  - -Widen lanes and shoulders (PENNDOT 2007)
  - ***Approximate cost: $37,898 (one mile length)**

*Cost based on 2009 NDDOT Average Bid Prices

Location

NDDOT Average Improvement Prices 2009

Low-Cost Improvement Strategies

-Install chevrons…………………………………………………….$33-$40 /sign
-Educate younger drivers more…………………………………………….NA
-Install signs that have road geometry with intersections shown………Vary
-Install raised pavement markers on centerline for night and bad weather driving ………………………………………………………$1.25 ea.
-Advance curve sign with speed advisory …………………………………Vary
-Install "Blind Intersection Ahead" sign……………………………………Vary
-Remove/trim vegetation………………………………………….$4120 L sum

Medium-Cost Improvement Strategies

-Improve striping…………………………………………………….$215 /mile
-Increase law enforcement in area for speeding……………………$50 /hr
-Install a dynamic speed advisory sign……………….$.75 /hr. or $3980 ea.
-Install up-to-date guardrails…………………………………………$32.22 /LF

High-Cost Improvement Strategies

-Install edgeline rumble strips……………………………………$676.09 /mi.
-Install centerline rumble strips………………………………$749.95 /mi.
-Improve curve radius/superelevation…………………………$5,168.13 /mi.
-Widen shoulders on curves……………………………………….$1142 /mi.
-Improve pavement friction……………………………………………….NA
-Widen lanes and shoulders………………………………………………..NA
-Flatten side slopes……………………………………………………$890 /mi.

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- PENNDOT. (November 2007). PA 412 - Road Safety Audit Report. Retrieved from http://safety.fhwa.dot.gov/rsa/resources/library/delvalley_rpts/07042b/07042b.pdf

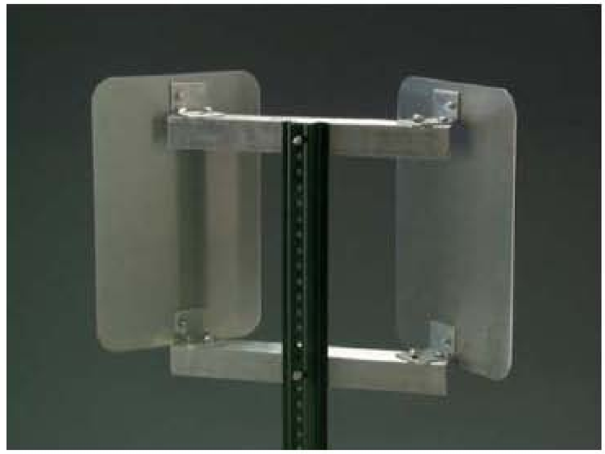
Summary of Improvement Strategies for 4 Worst Areas

- Low-Cost Improvement Strategies
  - -Install chevrons (MNDOT/SRF 2006)
    - (Installation of 10 signs is about $500-FHWA)
  - -Have uniform signage (MNDOT/SRF 2006)
    - ($45-85 /sign + installation-USA Traffic Signs)
  - -Install signs that have road geometry with intersections shown
    - ($45-85 /sign + installation-USA Traffic Signs)
  - -Have signs with advance speed warning (PENNDOT 2007)
    - ($1350/site for pavement markings-FHWA, $45-85 + labor for sign)
  - -Educate younger drivers more (MNDOT/SRF 2006)
  - -Install raised pavement markers on centerline for night and bad weather driving (PENNDOT 2007) ($16.50-23.98 /unit for snowplowable type)
  - -Install "Blind Intersection Ahead" sign
    - ($45-85 /sign + installation-USA Traffic Signs)
  - -Remove/trim vegetation (MNDOT 2006)

- Medium-Cost Improvement Strategies
  - -Improve striping (MNDOT 2006)
    - (Cost depends on how many lines are redone and material used)
  - -Install up-to-date guardrails (PENNDOT 2007)
    - ($11.00 /linear foot-FHWA)
  - -Widen shoulders on curves
    - (Cost is $1.00 /yd² for seal-coating-FHWA)
  - -Increase law enforcement for speeding issues (MNDOT 2006)
  - -Install a dynamic speed advisory sign that alerts drivers their speed (MNDOT/SRF 2006)
    - (Cost is $18,000 for radar sign and flashing beacon-FHWA)

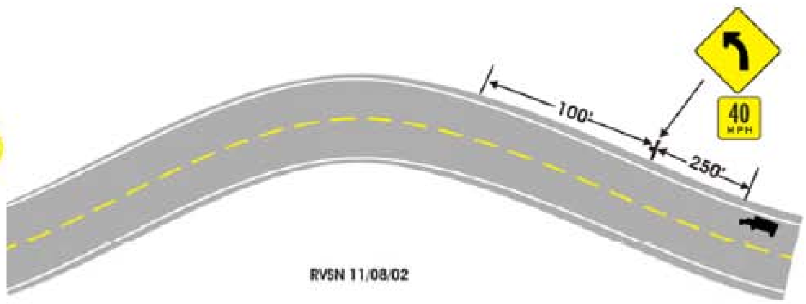
- High-Cost Improvement Strategies
  - -Install edgeline rumble strips (MSHWA)
    - ($3 /linear foot-FHWA)
  - -Install centerline rumble strips (MSHWA)
    - ($5,000 /mile-FHWA)
  - -Improve curve radius/superelevation
  - -Repave road/improve pavement friction
    - ($100,000 /mile in 1996-FHWA)
  - -Flatten side slopes
  - -Widen lanes and shoulders (PENNDOT 2007)
    - ($130 /linear foot for shoulders-http://www.cumberlandmaine.com/RT88/Rte88SHOULDER_WIDENING.pdf)

Types of Chevrons and Mounting Brackets



The requirements for size, spacing, and alignment of chevron signs is discussed in Section 2C.09 of the 2009 MUTCD

Improvement Strategies



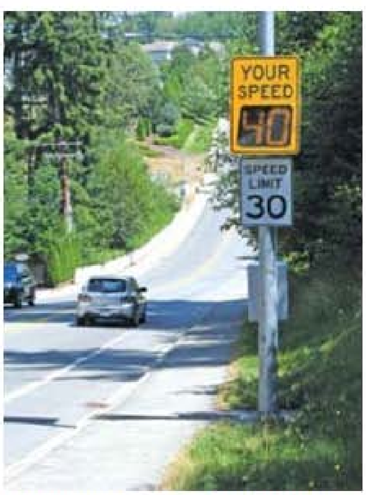
Advanced curve warning with speed limit

Sign with road geometry

Raised Deliniators

Blind intersection warning

Guardrail



Dynamic speed advisory sign

Rumble Strips

Snow Plowable Raised Delineators

Recessed, Snow Plowable Marker System

This marker system consists of a tapered slot that is cut into the roadway. A marker similar to the raised marker is affixed in the slot using epoxy. This design allows the snowplow blade to slide over the slot and not contact the marker because it is just below the roadway surface. These markers can only be used effectively where there is sufficient traffic speed (35+ mph) to "whip" out any water and/or dirt that may collect on or in front of the marker lenses. This type of marker has a plastic body with a reflective surface.

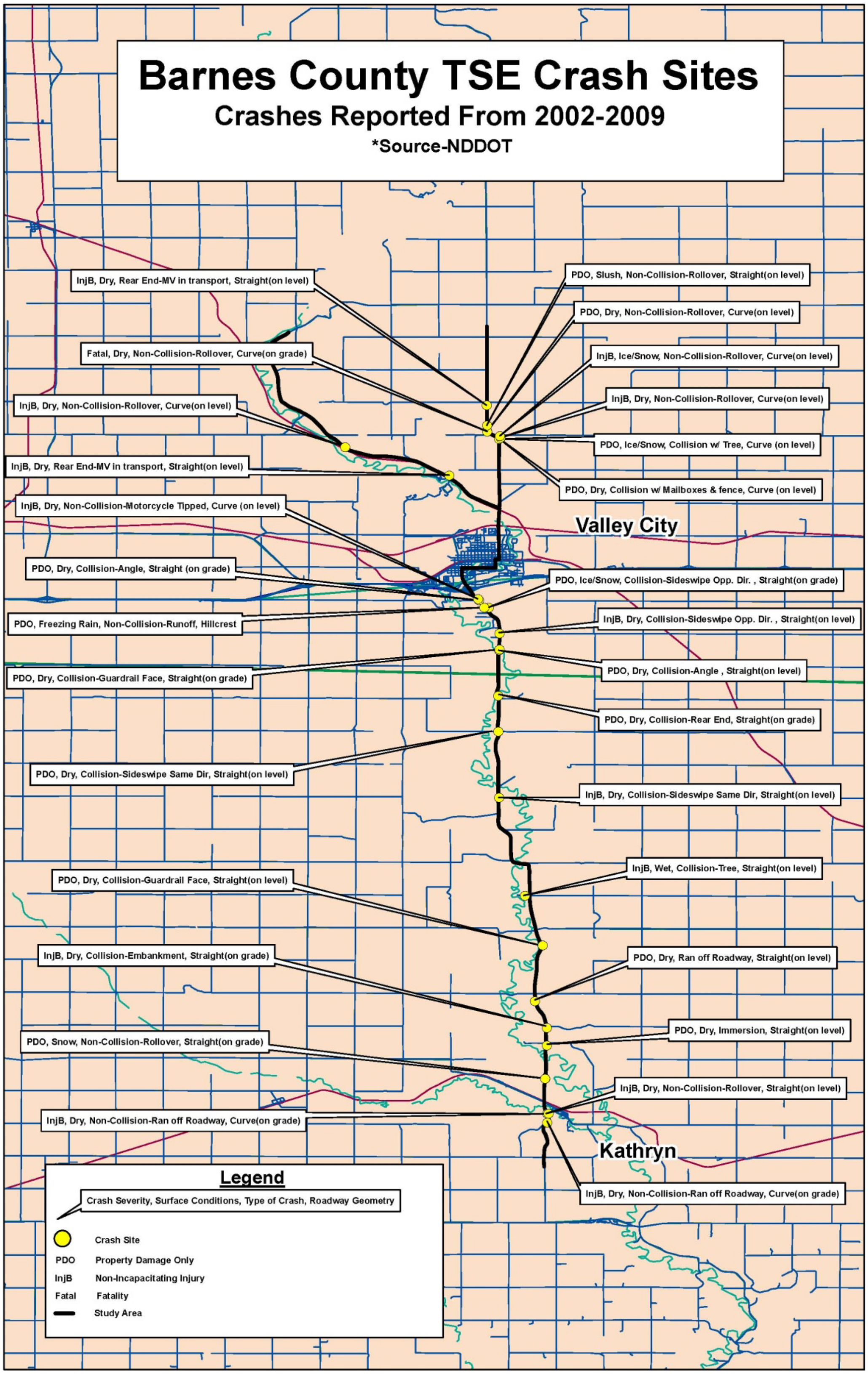
Raised, Snow Plowable Marker System

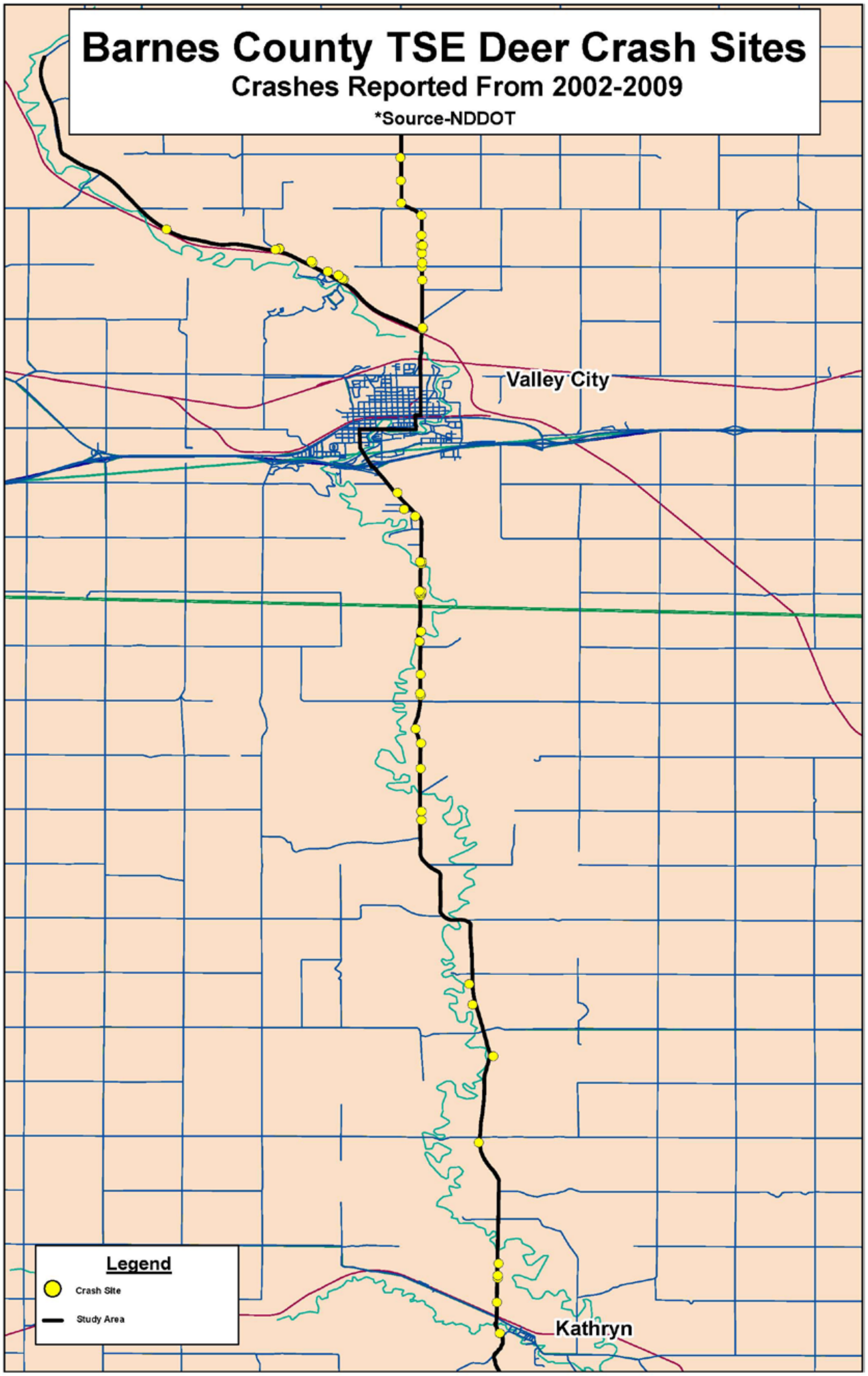
This marker system generally consists of a reflective marker glued in a protective steel or cast-iron casting. This casting is applied with epoxy into a groove that is cut in the pavement surface. The system is designed so that a snowplow blade will ride up and over the reflective marker, leaving it undamaged. The reflective marker can be replaced in the casting.

The cost for these delineators ranges from $20 - $30 per marker

Source: http://www.virginiadot.org/business/resources/bu-mat-PaveMarkCh9.pdf

APPENDIX D: TSE STUDY-AREA CRASH DATA




Barnes County TSE Deer Crash Sites
Crashes Reported From 2002-2009
*Source-NDDOT
Valley City
Kathryn
Legend
Crash Site
Study Area