

Memo

Date: Monday, January 25, 2016

Project: Mandan and Bismarck Corridor Improvement Study – Bismarck-Mandan MPO

To: Agency Representatives

From: HDR

Subject: Technical Memo #1

1.0 Introduction

The Bismarck-Mandan MPO has requested a transportation study to evaluate potential improvement of 20 corridors located in the cities of Mandan and Bismarck. Maps of the study areas are provided in Figures 1 and 2.

The purpose of this memorandum (the Memo) is to provide an analysis of the existing conditions of each of the identified corridors. Traffic operations in terms of Level of Service (LOS) and volume-to-capacity (v/c) ratios are also evaluated, as well as unique corridor characteristics such as safety, lane configurations, and multimodal utilization.

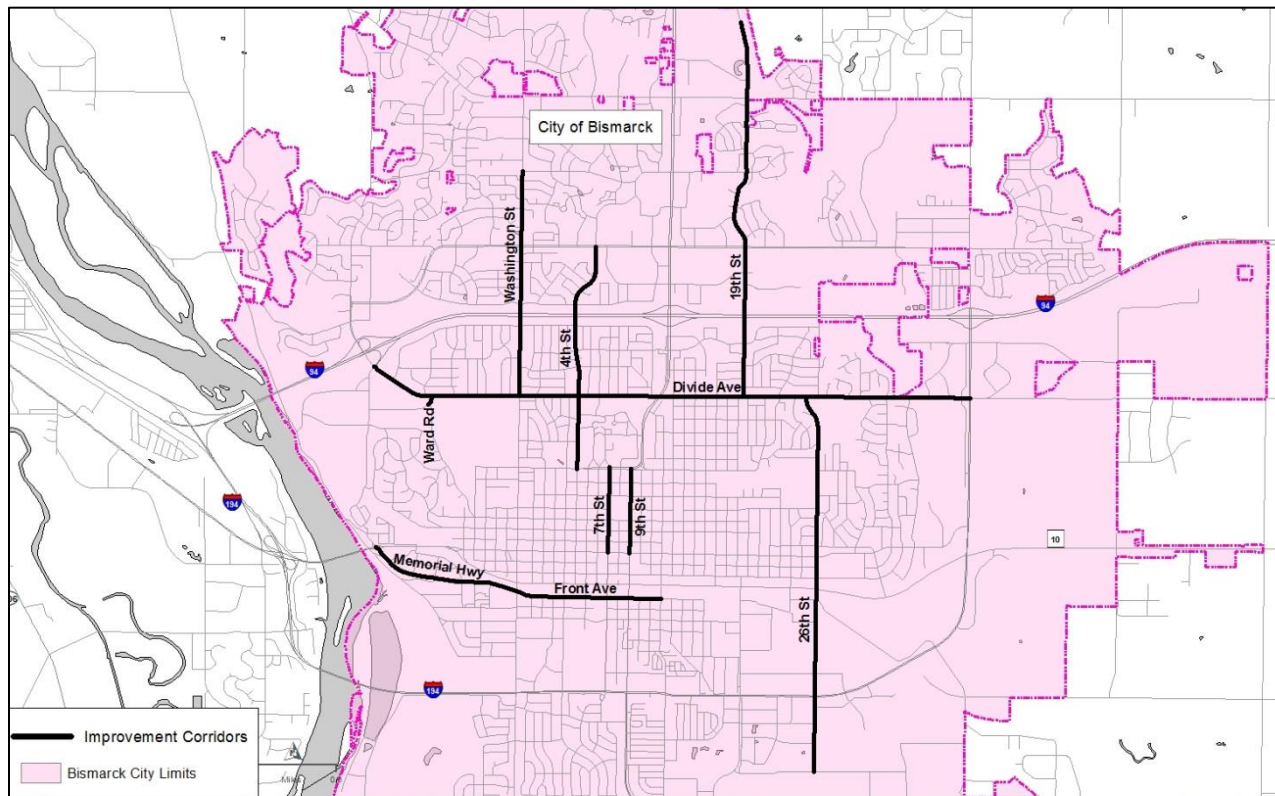


Figure 1. Bismarck Improvement Corridors

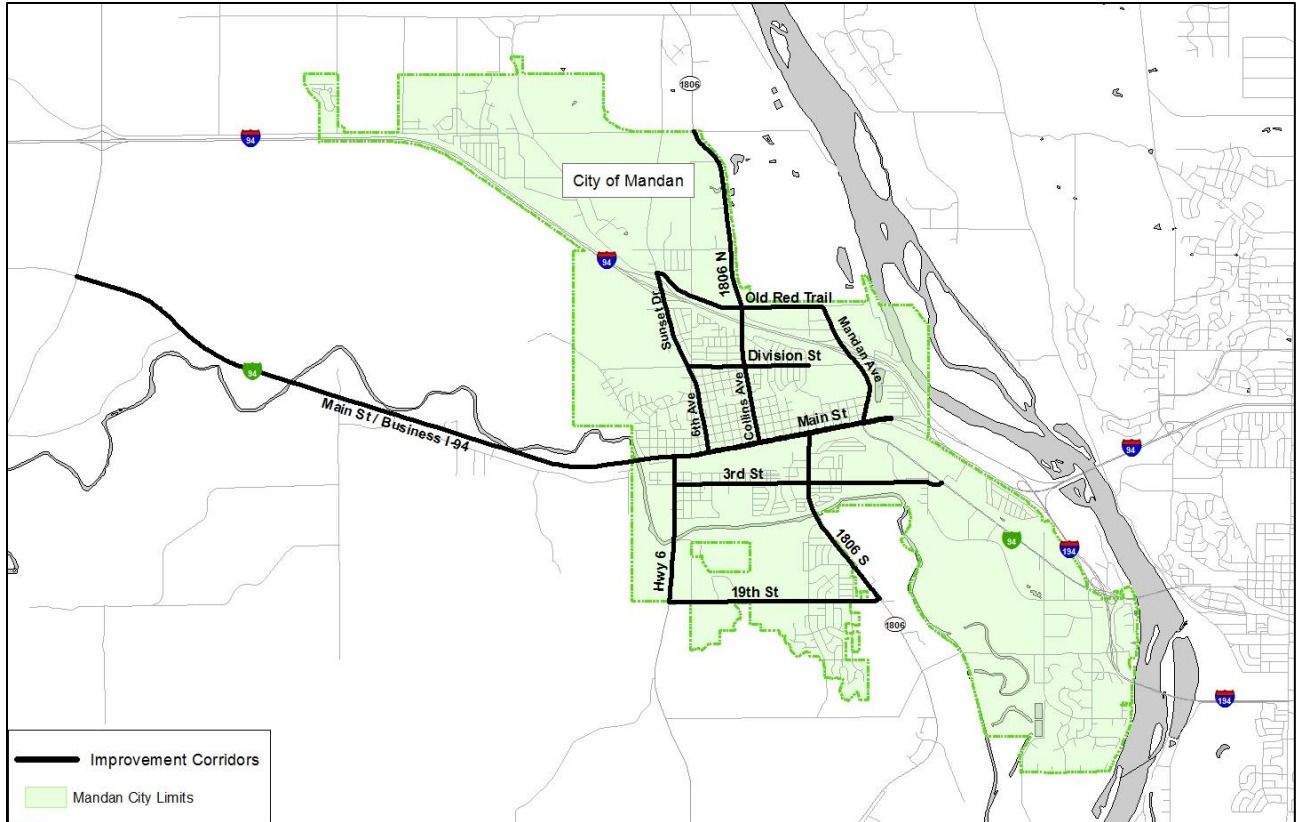


Figure 2. Mandan Improvement Corridors

2.0 Purpose and Need

The purpose of the corridor improvements is to increase the level of safety and mobility for the traveling public along the corridors by examining roadway deficiencies and incorporating feasible improvements throughout. The improvements are needed to reduce congestion, improve connectivity across Mandan and Bismarck, and reduce crashes throughout the study corridors.

The corridors that have been selected by the Bismarck-Mandan MPO for the study include the following for the City of Bismarck:

- Washington Street (Calgary Avenue to Divide Avenue)
- Divide Avenue (Schafer Street to Bismarck Expressway/ND Highway 810)
- 4th Street (Century Avenue to Boulevard Avenue)
- 7th Street (Boulevard Avenue to Rosser Avenue)
- 9th Street (Boulevard Avenue to Rosser Avenue)
- Front Avenue/Memorial Highway (Main Avenue to 12th Street)
- 26th Street (Divide Avenue to Airway Avenue)
- 19th Street (Divide Avenue to LaSalle Drive)
- Ward Road (Edwards Avenue to Divide Avenue)

The corridors that have been selected for the City of Mandan include the following:

- Main Street /Business I-94 (ND Highway 25 to Twin City Drive)
- Sunset Drive/6th Avenue NW (Main Street to Oil Red Trail)
- ND Highway 6 (Main Street to 19th Street NW)
- Old Red Trail (Mandan Avenue to Sunset Drive)
- Mandan Avenue/ND Highway 1806 (Main Street to Old Red Trail)
- 3rd Street (ND Highway 6 to Memorial Highway)
- 19th Street (ND Highway 6 to ND Highway 1806)
- Collins Avenue (Main Street to Oil Red Trail)
- ND Highway 1806 North (Old Red Trail to 38th Street)
- ND Highway 1806 South (Main Street to 19th Street)
- Division Street (Sunset Avenue to 8th Avenue NE)

2014 Average Daily Traffic (ADT) volumes and hourly traffic volume data for specified locations were provided by NDDOT. Site visits were conducted by HDR to observe and verify lane configurations, speed limits, and identify any potential sight distance or safety concerns.

3.0 Traffic Operations

The existing traffic operations of the corridors were assessed using a planning-level volume-to-capacity and LOS approach based on the ARTPLAN analysis program within the HCS software. Using this methodology, characteristics such as daily traffic volumes, signal timings, and basic roadway lane geometry at the major intersections are used as inputs and are tailored with corridor-level information on peak hour traffic levels and heavy truck percentage estimates to generate generalized, locally-specific peak hour estimates of traffic operations. The 2014 ADT and hourly Miovision traffic volumes counts were provided by NDDOT for the major roadway segments within the study area. In addition to geometric, segment length, and segment speed inputs, additional corridor-specific inputs included:

- Proportion of turning traffic: percentage of peak traffic at the intersection turning left or right.
- Heavy vehicle percentage: percentage of peak traffic that is heavy trucks. For the Mandan and Bismarck corridors, the heavy vehicle percentages ranged from 1% to 23%.
- K-factor: percentage of daily traffic that occurs during the peak hour. For the Mandan and Bismarck corridors, the k-factors ranged from 7% to 12% of daily traffic.
- D-factor: percentage of travel in peak direction during peak period. For the Mandan and Bismarck corridors, the d-factors ranged from 51% to 70%.

3.1 Bismarck Corridor Traffic Operations Analysis

The estimated level of service for each corridor segment located within the Bis-Man study area is provided in Figure 3. The analysis is based on 2014 traffic volumes and the figure depicts only the segments identified to have LOS of D, E and F. Segments experiencing LOS D through F under existing 2014 traffic volumes are most likely to experience worsening conditions and operations under long-range forecasted traffic volumes in the years to come.

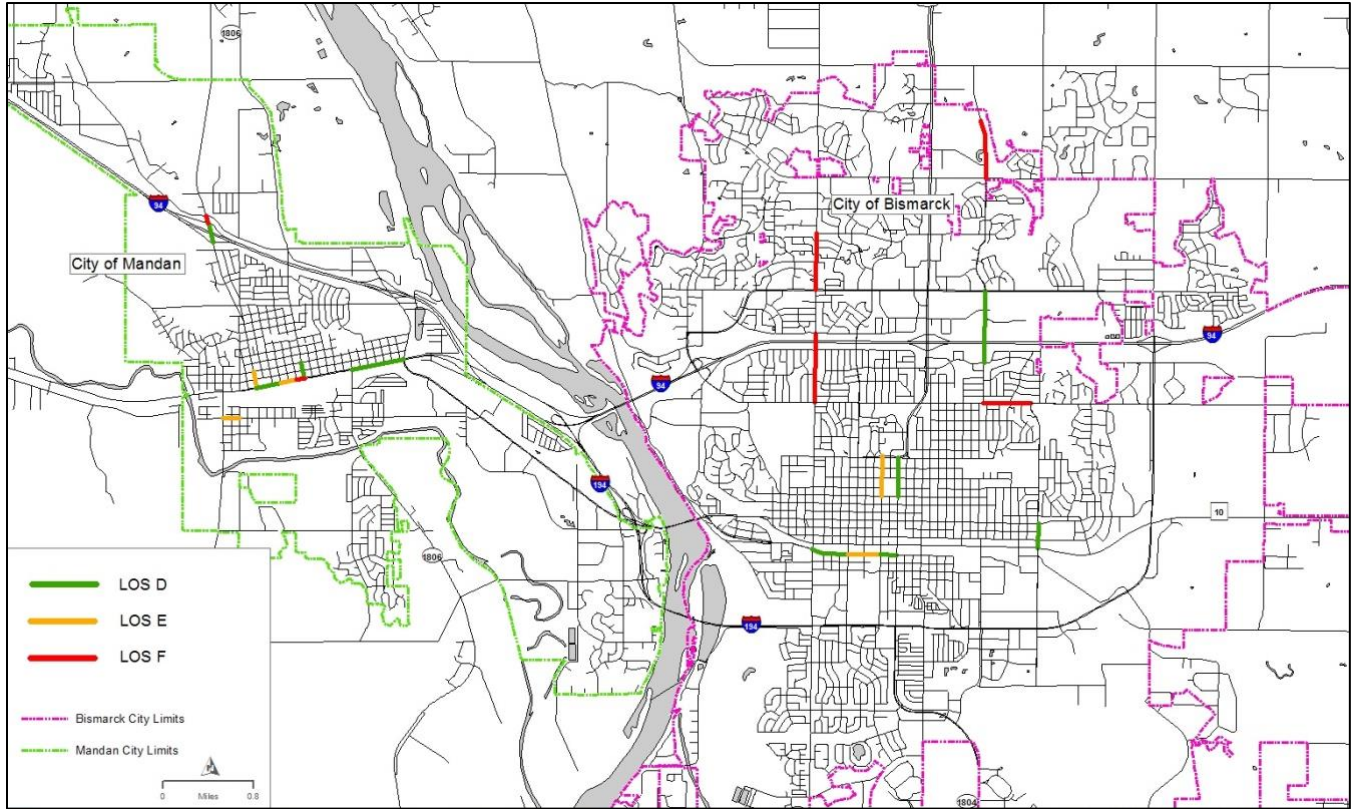


Figure 3. Bis-Man Corridor Estimated 2014 Existing LOS

Complete LOS results are provided in Appendix A. The results are shown for the through-movement intersection LOS at each main (primarily signalized) intersection as well as the LOS along each corridor segment. The through-movement intersection LOS is based on control delay for the primary through movements at the intersection. This LOS measure takes into account turning percentages and can be used as a method of showing when a corridor may require expansion or other improvement. For example, if the through movement LOS is D then the corridor is likely near capacity at the intersections, while a through movement of LOS E or F means expansion of the corridor should be assumed necessary at the planning level.

The segment LOS reflects the quality of travel along each corridor. For the analysis, each corridor is broken up into smaller segments with major intersections on each end to determine each segment's LOS. It is based on the combination of travel time delay due to intersection control and the travel speed for each segment. While it provides similar indication as to whether the road will likely require widening as the through-movement LOS, since it is based on travel speed, it is much better for creating an aggregate performance level for the corridor.

3.2 Bicycle Operations

Due to the presence of on-street bicycle lanes along various corridors, further assessment was given to this mode of transit to provide a generalized overview of its current efficiency. Figure 4 is a map provided by the Bismarck-Mandan MPO of designated bike routes and shared road usage within the City of Bismarck. Mandan does not currently have any designated on-street bike routes. As shown in Figure 4, currently Divide Avenue and Rosser Avenue consist of alternating segments of bike lanes and shared road signage. 16th street provides share the road signage from the intersection with Divide Avenue to Rosser Avenue. 26th Street incorporates shared road signage between the intersections of Divide Avenue and Railroad Avenue, and then provides a designated bike lane between Railroad Avenue and Bismarck Expressway. Wachter Avenue consists of share the road signage only.

The concept of Bicycle LOS is meant to correspond to the cyclist’s perception of comfort and service that a roadway provides to bicyclists as a function of various roadway factors. The Bicycle LOS is similar to vehicle LOS methodology from HCM. It is based on delay encountered at the intersections and focuses on facility attributes such as the volume and speed of adjacent vehicles, heavy vehicle presence, and the presence of on-street parking. The bicycle LOS was determined for Divide Avenue and 26th Street as those corridors were included in the study. Divide Avenue was found to have an overall bicycle LOS of D due to the corridor alternating between a shared use lane and designated bike lane. 26th Street had an overall bicycle LOS of D for the length of the study corridor.

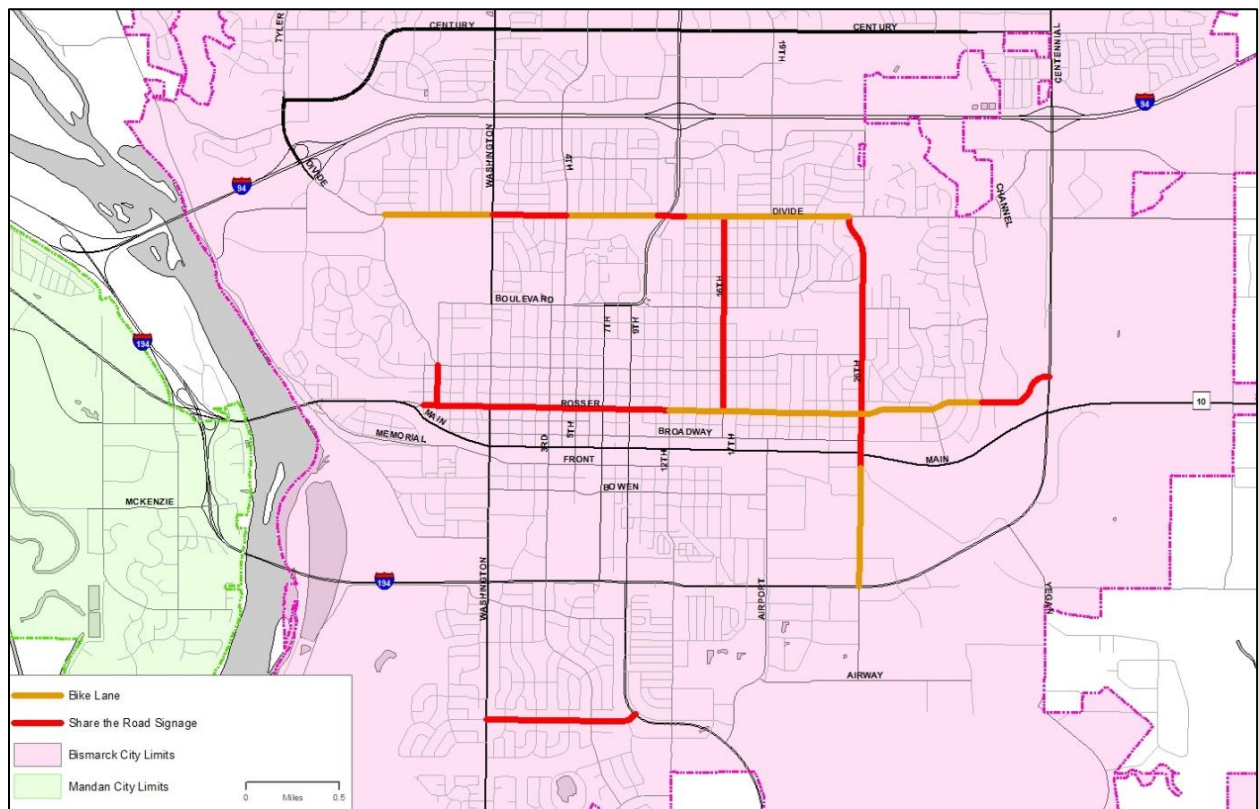


Figure 4. City of Bismarck On-Street Bike Facilities

4.0 Safety Analysis

The NDDOT provided crash data for the calendar years of 2012 to 2014. Only crashes that met the reportable crash threshold limits set by the State of North Dakota were provided by NDDOT. For the purpose of this report, the term “crash” is considered reportable by the North Dakota Crash Standards.

The data provided by the NDDOT contains crash report information for each collision that designates it as taking place on either a roadway segment or at an intersection, followed by the associated crash characteristics and injuries as well. This information was used to separate the crashes for the analysis for each corridor segment and intersection. A summary of total crashes and total injury-related crashes for all corridors and intersections within the study area is provided in Table 1.

Table 1. Crash Frequency for Study Area

Location	Total Intersection Crashes	Injury-Related Intersection Crashes	Total Segment Crashes	Injury-Related Segment Crashes
City of Bismarck				
2012	207	14	220	8
2013	170	15	271	3
2014	147	13	225	9
Total	524	42	716	20
City of Mandan				
2012	76	8	56	5
2013	99	6	61	5
2014	84	5	66	6
Total	259	19	183	16

4.1 City of Bismarck Crashes

Total crashes occurring on Bismarck corridors were separated into two categories: intersection-related or segment-related, based on how they were classified in the crash reports received from NDDOT. Crashes resulting in incapacitating and non-incapacitating injuries were also given extra consideration. The NDDOT crash data showed no fatalities occurring between the years 2012 to 2014 for any of the study corridors located within Bismarck. Bismarck intersection crashes are shown in Figure 5. Figure 6 provides the locations of injury-related intersection crashes.

Bismarck segment crashes are provided in Figure 7. Figure 8 provides the locations of injury-related segment crashes.

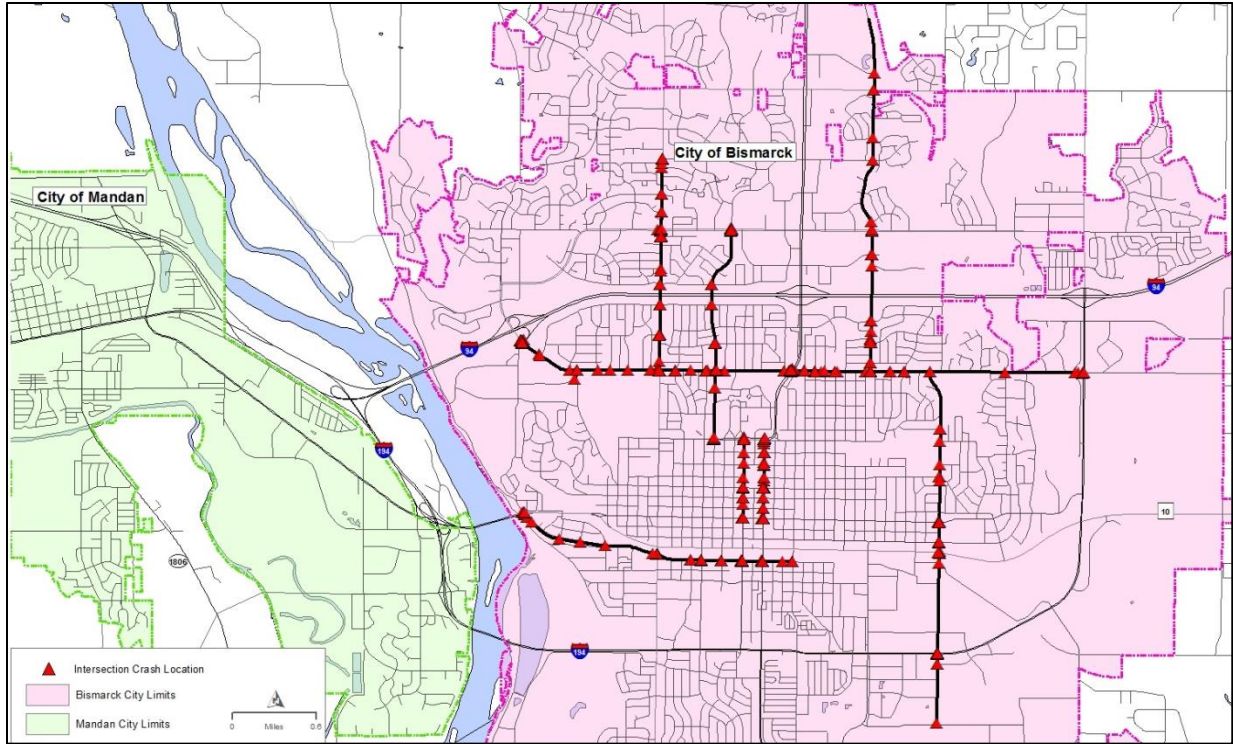


Figure 5. Bismarck Intersection Crashes 2012-2014

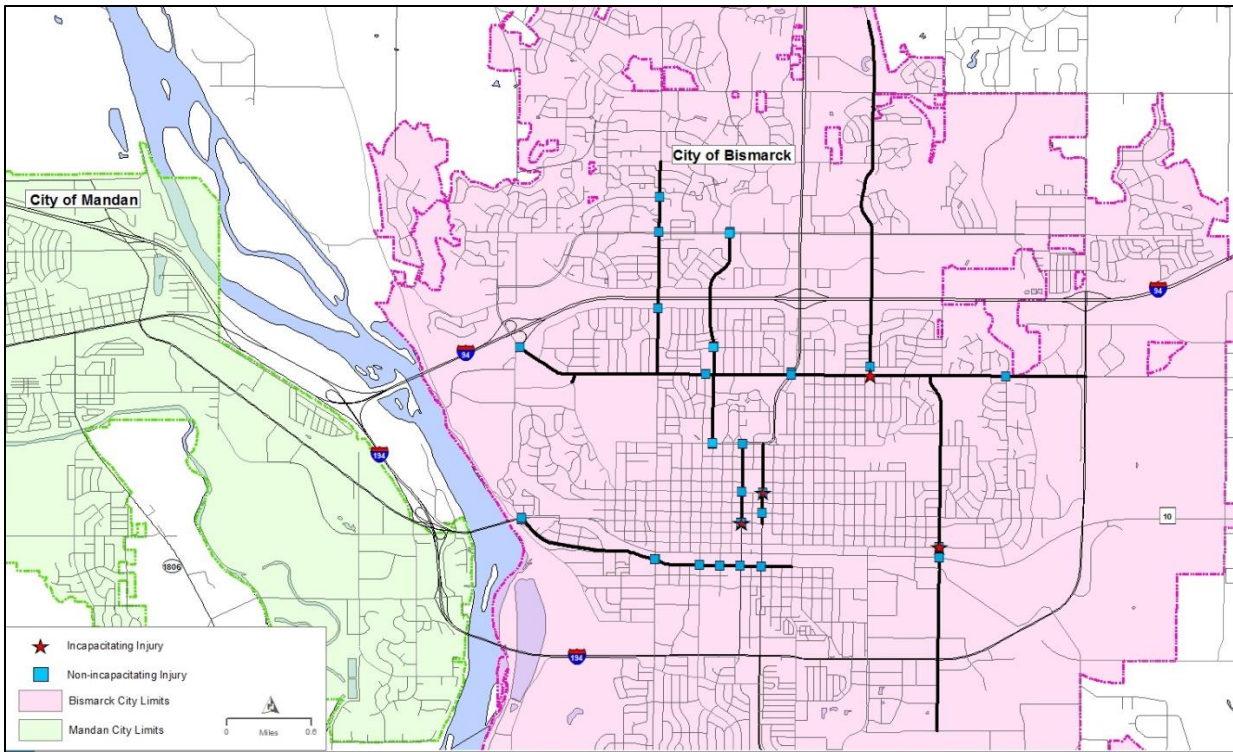


Figure 6. Bismarck Intersection Injury-Related Crashes 2012-2014

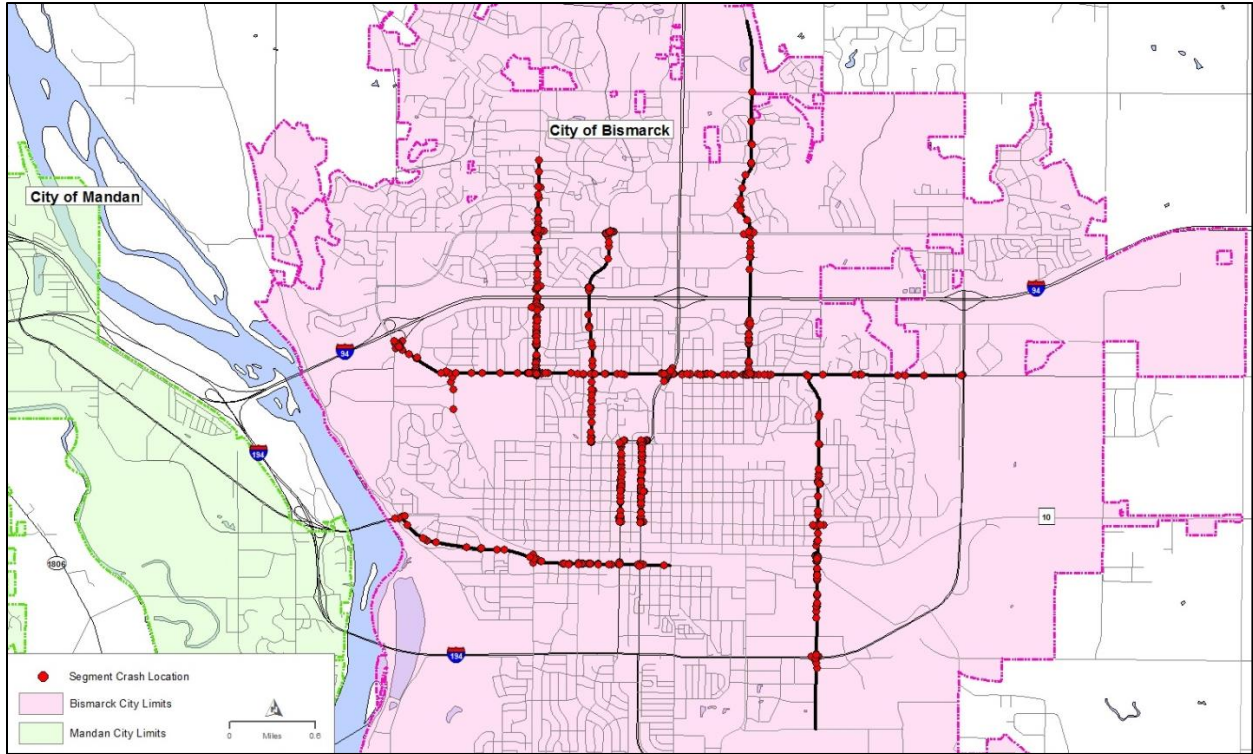


Figure 7. Bismarck Segment Crashes 2012-2014

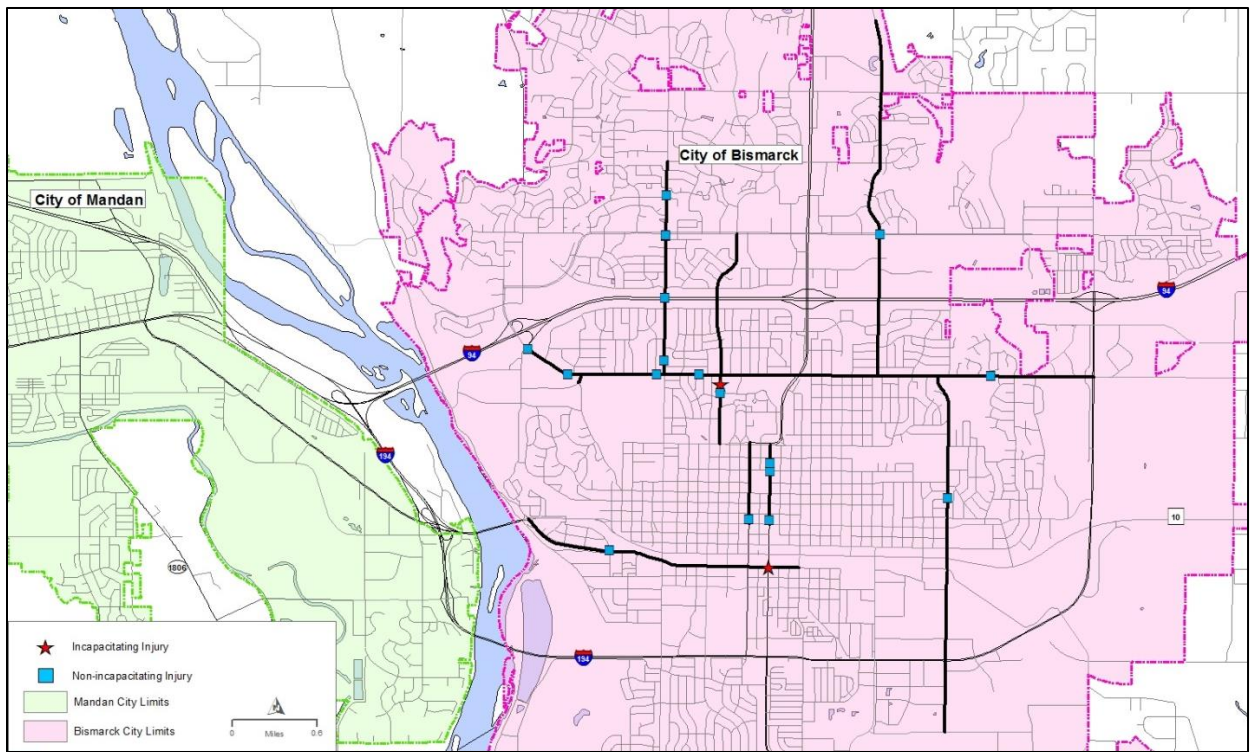


Figure 8. Bismarck Segment Injury-Related Crashes 2012-2014

Number of Injury-Related Crashes by Location in Bismarck

The intersections that experienced the most crashes resulting in incapacitating injuries between 2012 and 2014 were:

- 26th St and Broadway: 1 incapacitating crash
- 7th Street and E Rosser Ave: 2 incapacitating crashes
- 9th Street and E Ave C: 1 incapacitating crash
- Divide Ave and 19th St: 1 incapacitating crash

The segments that experienced the most injury-related crashes between 2012 and 2014 were:

- Washington Street: 5 non-incapacitating injury-related crashes
- Memorial-Front Street: 1 incapacitating and 1 non-incapacitating injury-related crashes
- Divide Avenue: 5 non-incapacitating injury-related crashes
- 9th Street: 3 non-incapacitating injury-related crashes
- 4th Street: 1 incapacitating and 1 non-incapacitating injury-related crashes

Manner of Collision by Location in Bismarck

Bismarck segment crashes were analyzed by manner of collision. The most common crash type to occur along segments was rear end crashes, as shown in Figure 7. Divide Ave had the highest number of total segment crashes, as well as having the highest total of head-on collisions (4 crashes) and non-collision with motor vehicle crashes (19 crashes). Washington Street, 9th Street, and Divide experienced the highest total crashes resulting in injury, as shown in Table 2 and Figure 9.

Table 2. Bismarck Segment Crashes by Manner of Collision 2012-2014

Segment	Head On	Angle	Rear End	Sideswipe (SD)*	Sideswipe (OD)*	Non-Collision w/ Motor Vehicle	Total
4th St	0	4	35	6	0	6	51
7th St	0	17	32	10	0	4	63
9th St	1	11	65	9	0	3	89
19th St	0	6	39	5	2	5	57
26th St	1	11	46	6	2	9	75
Divide Ave	4	20	123	19	3	17	186
Memorial-Front	1	17	36	9	0	9	72
Ward	0	1	1	0	0	2	4
Washington	1	12	86	15	0	5	119

*SD = Same Direction

*OD = Opposite Direction

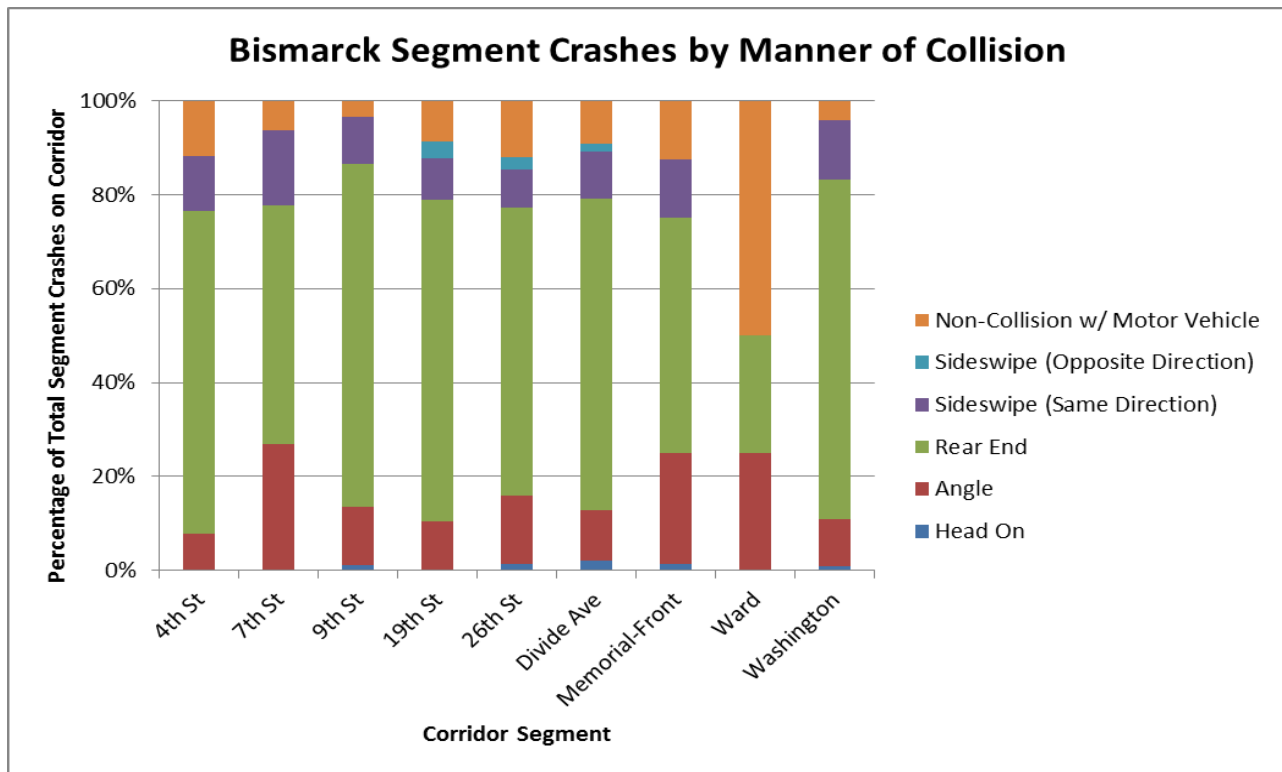


Figure 9. Bismarck Segment Crashes by Manner of Collision 2012-2014

Intersection crashes were analyzed along each study corridor. The ten intersections shown to experience the highest level frequency of crashes over the three-year period were selected and examined further to determine intersection crash rates and comparisons of crash characteristics. Table 3 and Figure 10 show a crash comparison for each of the selected intersections based on manner of collision.

Table 3. Bismarck Intersection Crashes by Manner of Collision 2012-2014

Intersection	Head On	Angle	Rear End	Sideswipe (SD)*	Sideswipe (OD)*	Non-Collision w/ Motor Vehicle	Total
Memorial Hwy / 3rd St	0	24	4	1	0	1	30
4th St / Century Ave	1	24	4	0	0	0	29
Front Ave / 9th St	0	14	0	1	0	2	17
Front Ave / 7th St	0	18	0	2	0	0	20
9th St / Ave C	0	19	0	0	0	1	20
Divide Ave / Schaffer St	0	11	19	0	0	3	33
4th St / Boulevard Ave	0	11	3	0	0	1	15
7th St / Rosser Ave	0	12	0	1	0	2	15
Divide Ave / State St	1	7	16	3	0	1	28
Washington Ave / Century Ave	0	4	7	0	0	2	13

*SD = Same Direction

*OD = Opposite Direction

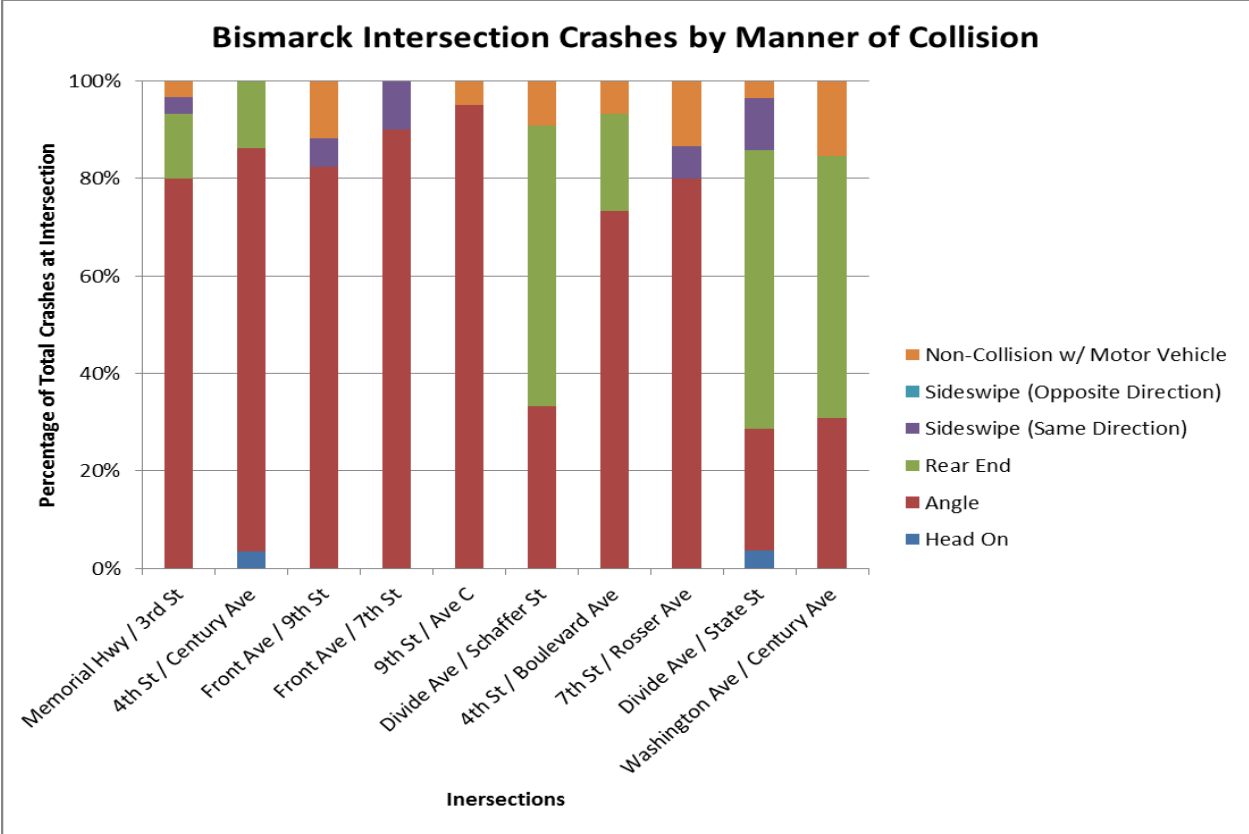


Figure 10. Bismarck Intersection Crashes by Manner of Collision 2012-2014

The intersections of Divide Ave/ Schaffer St and Divide Ave/ State St experienced the most rear end collisions with 19 (58%) and 16 (57%) respectively. Only two head-on collisions were reported during the study period, one occurring at the intersection of 4th St/ Century Ave and one at the intersection of Divide Ave/ State St.

Crash Severity by Location in Bismarck

Segment crashes were also analyzed based on severity. Table 4 provides the crash values while Figure 11 provides a visual comparison of the severity of crash percentages experienced by each corridor. 4th Street and Memorial Highway – Front Ave were the only corridors that experienced crashes resulting in incapacitating injuries. Ward Rd was the only corridor segment to consist of 100% property-damage only (PDO) crashes (7 crashes).

Table 4. Bismarck Segment Crashes by Severity 2012-2014

Segment	Fatality	Incapacitating Injury	Non-incapacitating Injury	Possible Injury	Property Damage Only	Total
4th St	0	1	1	8	41	51
7th St	0	0	1	12	50	63
9th St	0	0	3	18	68	89
19th St	0	0	1	12	44	57
26th St	0	0	1	11	63	75
Divide Ave	0	0	5	24	157	186
Memorial-Front	0	1	1	15	55	72
Ward	0	0	0	0	4	4
Washington	0	0	5	24	90	119

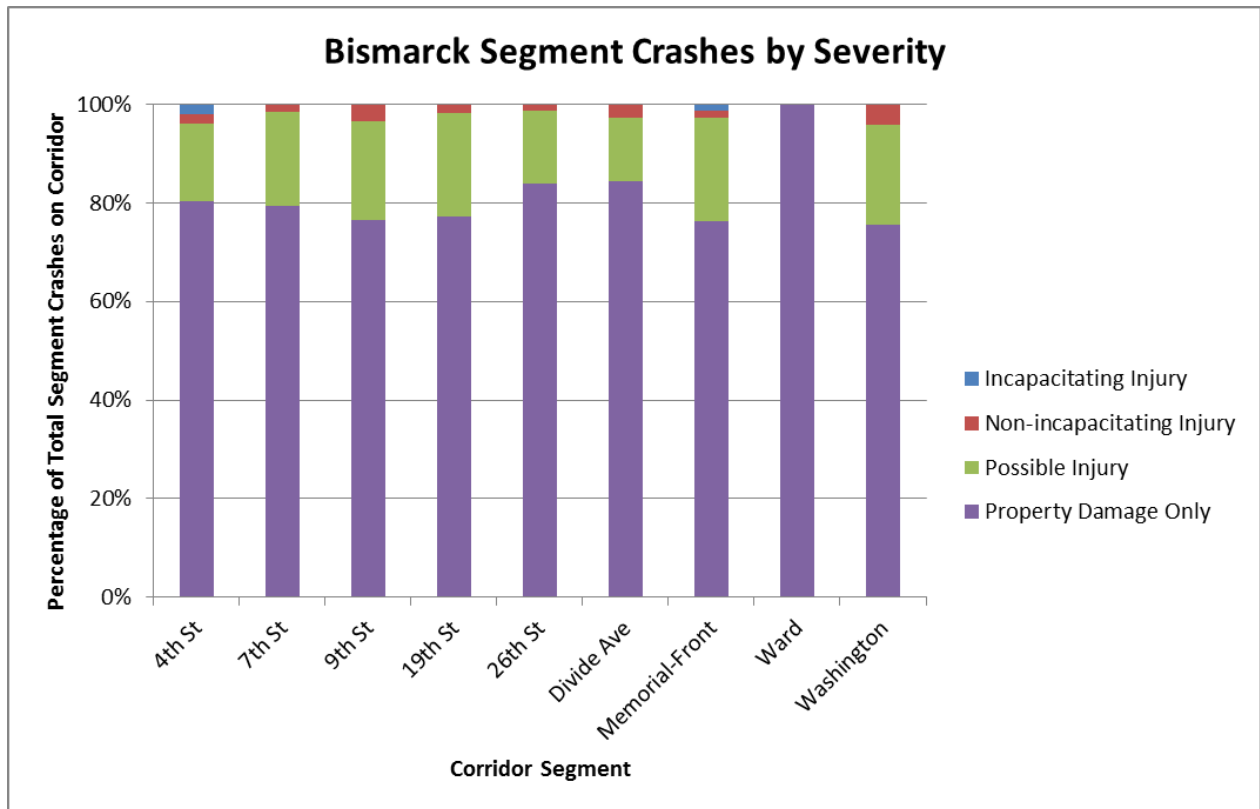


Figure 11. Bismarck Segment Crashes by Severity 2012-2014

Table 5 and Figure 12 show comparisons of intersection crashes based on severity.

Table 5. Bismarck Intersection Crashes by Severity 2012-2014

Intersection	Fatality	Incapacitating Injury	Non-incapacitating Injury	Possible Injury	Property Damage Only	Total
Memorial Hwy / 3rd St	0	0	2	6	22	30
4th St / Century Ave	0	0	2	8	19	29
Front Ave / 9th St	0	0	2	2	13	17
Front Ave / 7th St	0	0	1	7	12	20
9th St / Ave C	0	1	1	7	11	20
Divide Ave / Schaffer St	0	0	1	1	31	33
4th St / Boulevard Ave	0	0	2	2	11	15
7th St / Rosser Ave	0	2	2	2	9	15
Divide Ave / State St	0	0	2	3	23	28
Washington Ave / Century Ave	0	0	1	2	10	13

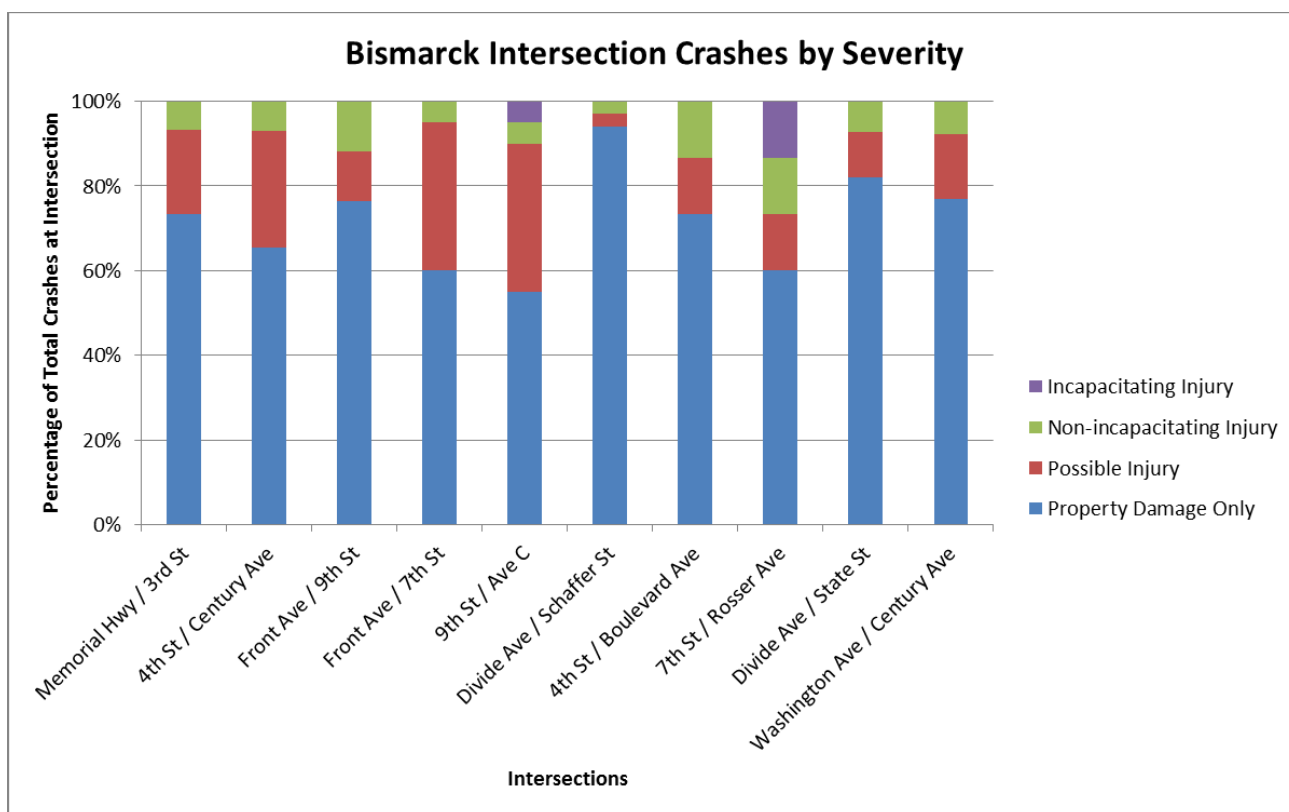


Figure 12. Bismarck Intersection Crashes by Severity 2012-2014

The intersection of 9th St / Ave C was one of only two intersections that experience an incapacitating injury, and it also had one of the highest angle crash percentages of 95% as shown previously in Figure 10. The intersection of 7th St / Rosser Ave was found to experience the highest frequency of injury-related crashes.

Crash Rates by Location in Bismarck

Based on the crash data, ADT available, and segment lengths, crash rates were then calculated for each intersection and corridor segment to provide a consistent method of comparison in terms of relative safety. These crash rate values serve as a tool to prioritize and distinguish which corridors and intersections have the highest need for potential safety improvements. Each crash rate takes into account the total number of segment crashes during the study year period, ADT, and segment length. A list of segment crash rates, measured in crashes per million vehicle-miles of travel (MVM) in accordance with FHWA safety guidelines, for the Bismarck corridor segments is provided in Table 6. The corridors are listed in order of highest to lowest in accordance with their segment crash rate value.

Table 6. Bismarck Corridor Segment Crash Rates

Corridor	Total Segment Crashes	Segment Crash Rate (Crashes/MVM)	Total Segment Injury Crashes	Segment Injury Crash Rate (Crash/MVM)
9th St	89	11.30	3	0.38
7th St	63	9.16	1	0.15
Memorial Hwy –Front Ave	72	6.99	2	0.19
Washington St	119	5.55	5	0.23
Divide Ave	186	4.63	5	0.12
4th St	51	3.72	2	0.15
26th St	75	3.39	1	0.05
Ward Rd	4	2.62	0	0.00
19th St	57	2.59	1	0.05

Based on the analysis, 9th Street and 7th Street were found to have the highest segment crash rates for corridors studied within the City of Bismarck at 11.30 and 9.16 crashes per million vehicle-miles of travel, respectfully. Memorial Highway – Front Street was found to have the third highest segment crash rate at 6.99 crashes per million vehicle-miles of travel. The 9th St and Washington Ave corridors were also found to experience the highest number of injury-related crashes crash rates, resulting in either incapacitating or non-incapacitating injuries as previously shown in Figure 11.

The ten intersections shown to experience the highest level frequency of crashes over the three-year period were selected and examined further to determine intersection crash rates. A comparison of intersection crash rates, measured as crashes per million entering vehicles (MEV), is provided in Table 7:

Table 7. Bismarck Corridor Intersection Crash Rates

Intersection	Total Intersection Crashes	Intersection Crash Rate (Crash/MEV)	Total Intersection Injury Crashes	Intersection Injury Crash Rate (Crash/MEV)
Front Ave / 3rd St	30	1.55	2	0.10
4th St / Century Ave	29	1.28	2	0.09
Front Ave / 9th St	17	1.12	2	0.13
Front Ave / 7th St	20	1.02	1	0.05
9th St / Ave C	20	1.00	2	0.10
Divide Ave / Schafer St	33	0.98	1	0.03
4th St / Boulevard Ave	15	0.84	2	0.11
7th St / Rosser Ave	15	0.63	4	0.17
Divide Ave / State St	28	0.59	2	0.04
Washington Ave / Century Ave	13	0.43	1	0.03

The Bismarck intersection with the highest intersection crash rate was identified as Memorial Highway and 3rd Street with 1.55 crashes per million entering vehicles. The intersection of 4th Street and Century Ave had the second highest crash rate at 1.28, and the intersection of Front Ave and 9th Street had the third highest at 1.12. The intersection with the highest injury crash rate was identified as 7th Street and Rosser Ave.

Site Visit Observations

The majority of the study corridors located within the City of Bismarck share similar characteristics in that they are two-lane undivided roadways, less than 35 mph speed limits, and located within residential or urban setting. 7th St and 9th St differ from the rest in that they are one-way directional travel only, each running adjacent to Bismarck Public High School and several nearby churches. The 19th Street corridor extends from Divide Avenue to north of 43rd Street. The corridor experiences variation in its typical section and grade north of its intersection with Century Ave and approaching the intersection with 43rd Ave.

4.2 City of Mandan Crashes

Similarly to what was done for the City of Bismarck crash analysis, total crashes were identified as either intersection- or segment-related. They were then classified based on severity. Overall intersection crash locations for the City of Mandan are shown in Figure 13. The most severe of those intersection crashes resulting in either a fatality, incapacitating or non-incapacitating injuries are provided in Figure 14. Segment crashes are provided in Figure 15, with corresponding severity locations provided in Figure 16.

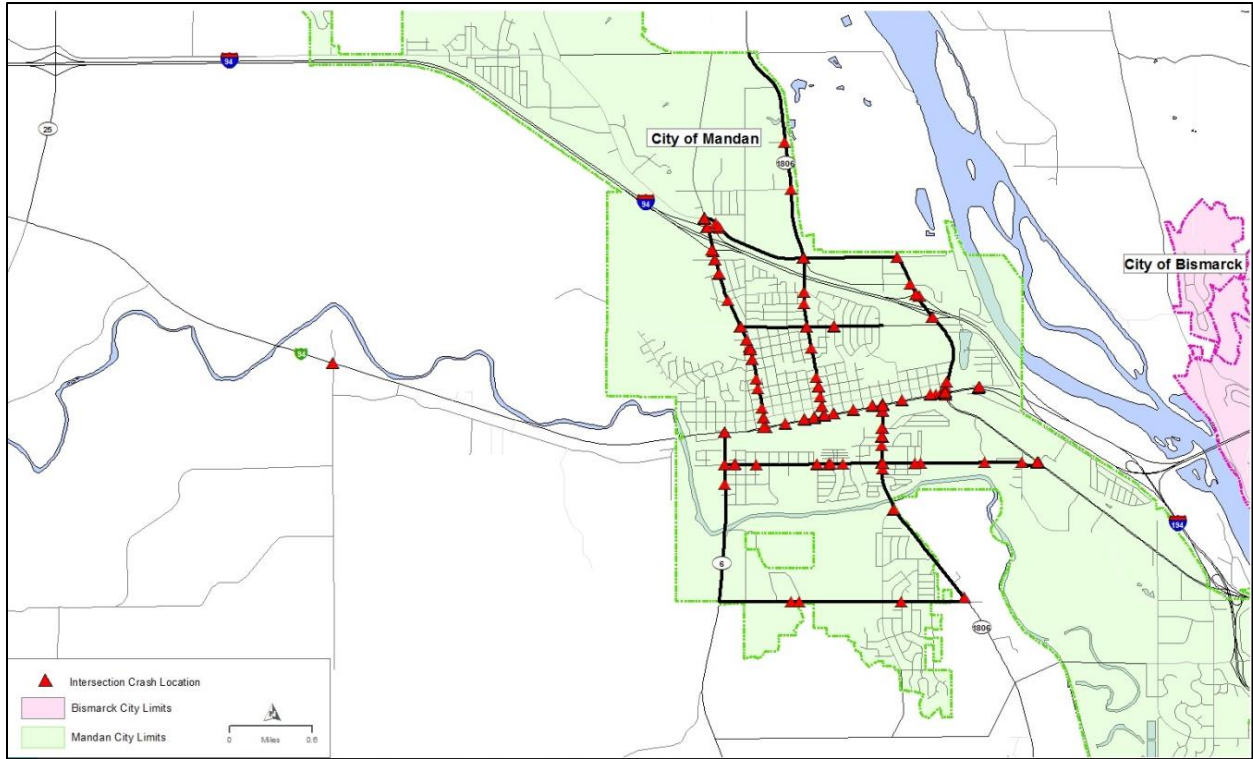


Figure 13. Mandan Intersection Crashes 2012-2014

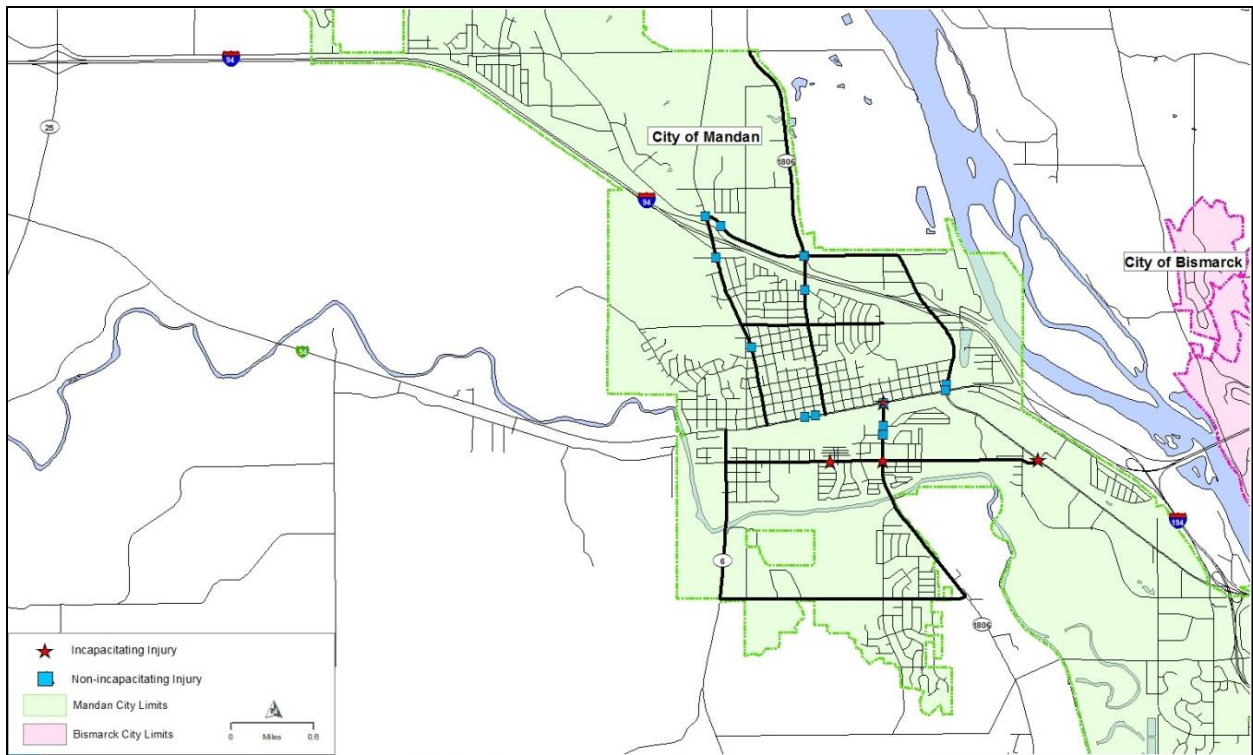


Figure 14. Mandan Intersection Injury-Related Crashes 2012-2014

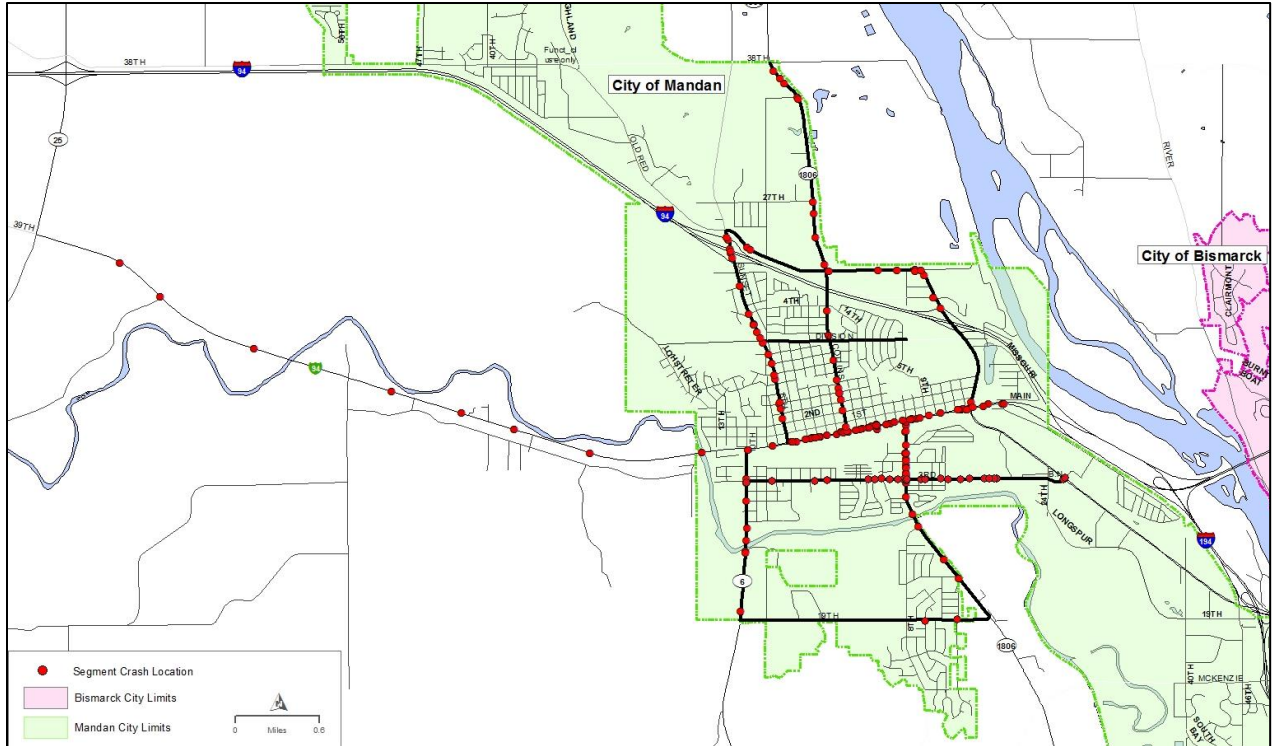


Figure 15. Mandan Segment Crashes 2012-2014

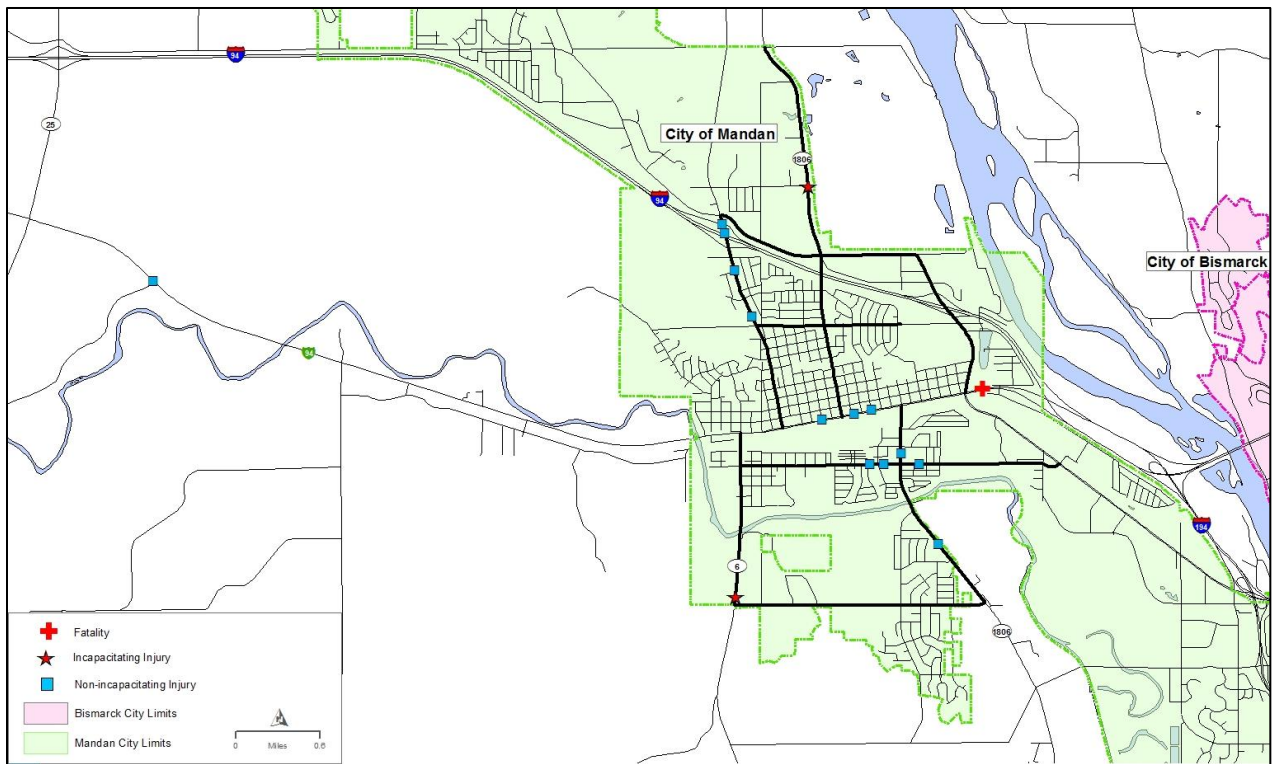


Figure 16. Mandan Segment Injury-Related Crashes 2012-2014

Number of Crashes by Location in Mandan

The intersections that experienced the most injury-related crashes between 2012 and 2014 were:

- Main St and ND 1806 S: 1 incapacitating and 1 non-incapacitating injury-related crashes
- ND 1806 S and Burlington St SE: 2 non-incapacitating injury-related crashes
- 3rd St and Memorial Highway: 1 incapacitating injury-related crash
- 3rd St and ND 1806 S: 1 incapacitating injury-related crash

The segments that experienced the fatality and most injury-related crashes between 2012 and 2014 were:

- Main Street: 1 fatality and 3 non-incapacitating injury-related crashes
- 3rd Street: 3 non-incapacitating injury-related crashes
- Sunset Dr / 6th Ave: 4 non-incapacitating injury-related crashes

Manner of Collision by Location in Mandan

The total overall segment crashes were analyzed based on manner of collision, as shown in Table 8 and Figure 17. Division Street experienced zero segment crashes during the study period. It is important to note that the Main Street corridor was as analyzed as two separate segments: the west portion between ND Hwy 25 and ND Hwy 6, and the east portion between ND Hwy 6 and Twin City Drive. The reason for this separation is due to the difference in characteristics such as ADT, speed limit, and rural vs urban setting between the two portions of roadway.

Table 8. Mandan Segment Crashes by Manner of Collision 2012-2014

Segment	Head On	Angle	Rear End	Sideswipe (SD)*	Sideswipe (OD)*	Non-Collision w/ Motor Vehicle	Total
Sunset Dr / 6th Ave	2	4	9	1	1	6	23
Hwy 6	0	1	3	0	0	5	9
Old Red Trail	0	1	3	0	1	3	8
Mandan Ave	0	1	3	0	0	0	4
3rd St	0	2	14	1	0	6	23
19th St	0	0	0	1	0	1	2
Collins Ave	0	2	5	2	0	2	11
Hwy 1806 N	0	0	0	1	1	7	9
Hwy 1806 S	1	7	12	1	1	3	25
Division St	0	0	0	0	0	0	0
Main St (Hwy 25 to Hwy 6)	0	1	1	0	0	6	8
Main St (Hwy 6 to Twin City Dr)	2	20	18	12	0	9	61

*SD = Same Direction

*OD = Opposite Direction

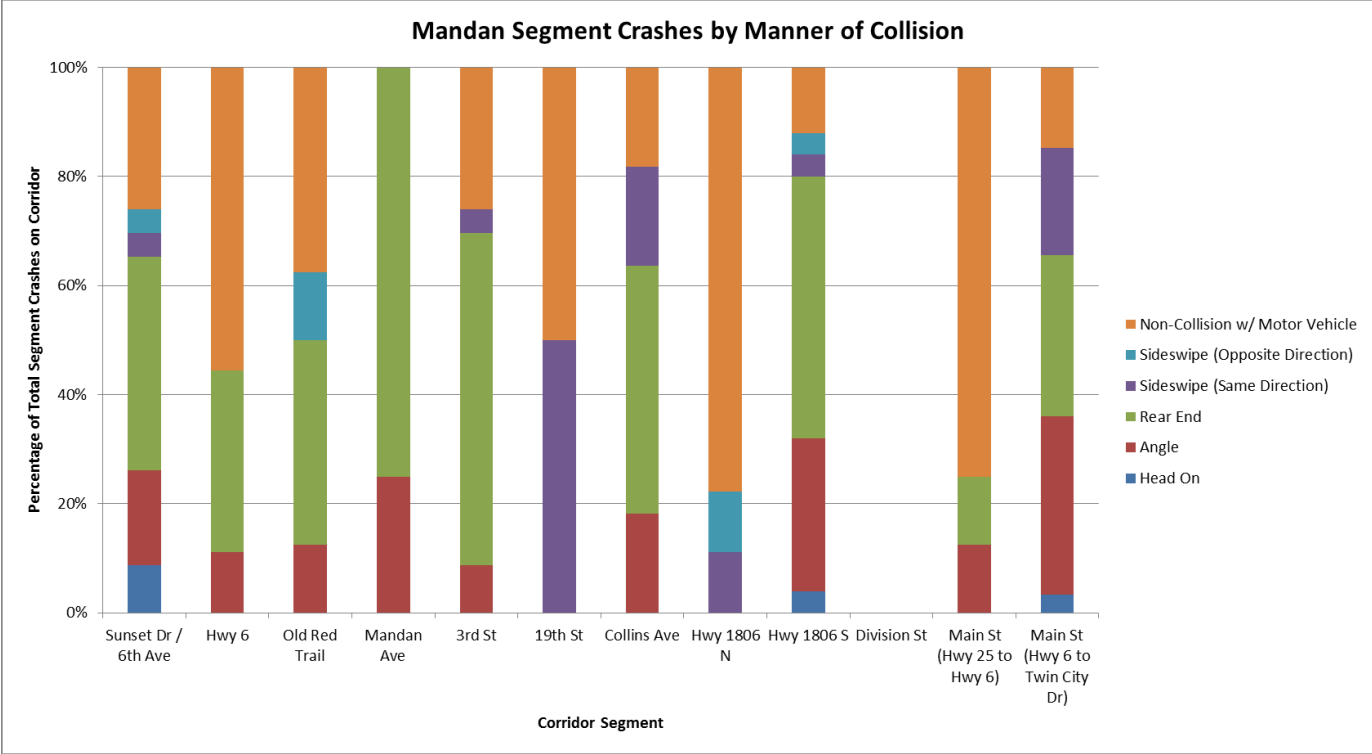


Figure 17. Mandan Segment Crashes by Manner of Collision 2012 - 2014

Main Street between ND Hwy 6 and Twin City Dr experienced the most angle crashes in comparison to other corridors, comprising approximately 33% of its total crashes. 3rd Street and Hwy 1806 S had the highest total rear-end crashes totaling to 14 (61%) and 12 (48%) respectively. Sunset Drive, Highway 1806 S, and Main St were the only segments to experience head-on collisions.

Intersections were also analyzed along each study corridor in Mandan to identify the ten intersections shown to experience the highest frequency of crashes over the three-year period. Table 9 and Figure 18 show the crash comparisons for each of the selected intersections based on manner of collision. Three intersections were reported to have three head-on collisions each: 3rd St / ND 1806 S, 3rd St/Memorial Hwy, and Main St/ND 1806 S. The intersection with the highest total of nine angle crashes (75% of the intersection’s crashes) was determined to be ND 1806 S and Burlington St SE, while the intersection with the highest total of 13 rear end crashes (54% of the intersection’s total crashes) was found to be Main St and ND 1806 S.

Table 9. Mandan Intersection Crashes by Manner of Collision 2012-2014

Intersection	Head On	Angle	Rear End	Sideswipe (SD)*	Sideswipe (OD)*	Non-Collision w/ Motor Vehicle	Total
Sunset Dr / Old Red Trail	1	4	7	1	0	0	13
Main St / Mandan Ave / Memorial Hwy	0	7	8	1	0	1	17
3rd St / ND 1806 S	3	8	2	3	0	4	20
3rd St / Memorial Hwy	3	5	0	2	0	1	11
Main St / ND 1806 S	3	7	13	0	0	1	24
ND 1806 S / Burlington St SE	1	9	1	0	0	1	12
Sunset Dr / 8th St NW	0	4	3	0	0	0	7
Main St / Twin City Dr	0	4	3	0	0	0	7
Main St / ND Hwy 6	1	2	3	0	0	1	7
Main St / Collins Ave	0	4	0	1	0	1	6

*SD = Same Direction

*OD = Opposite Direction

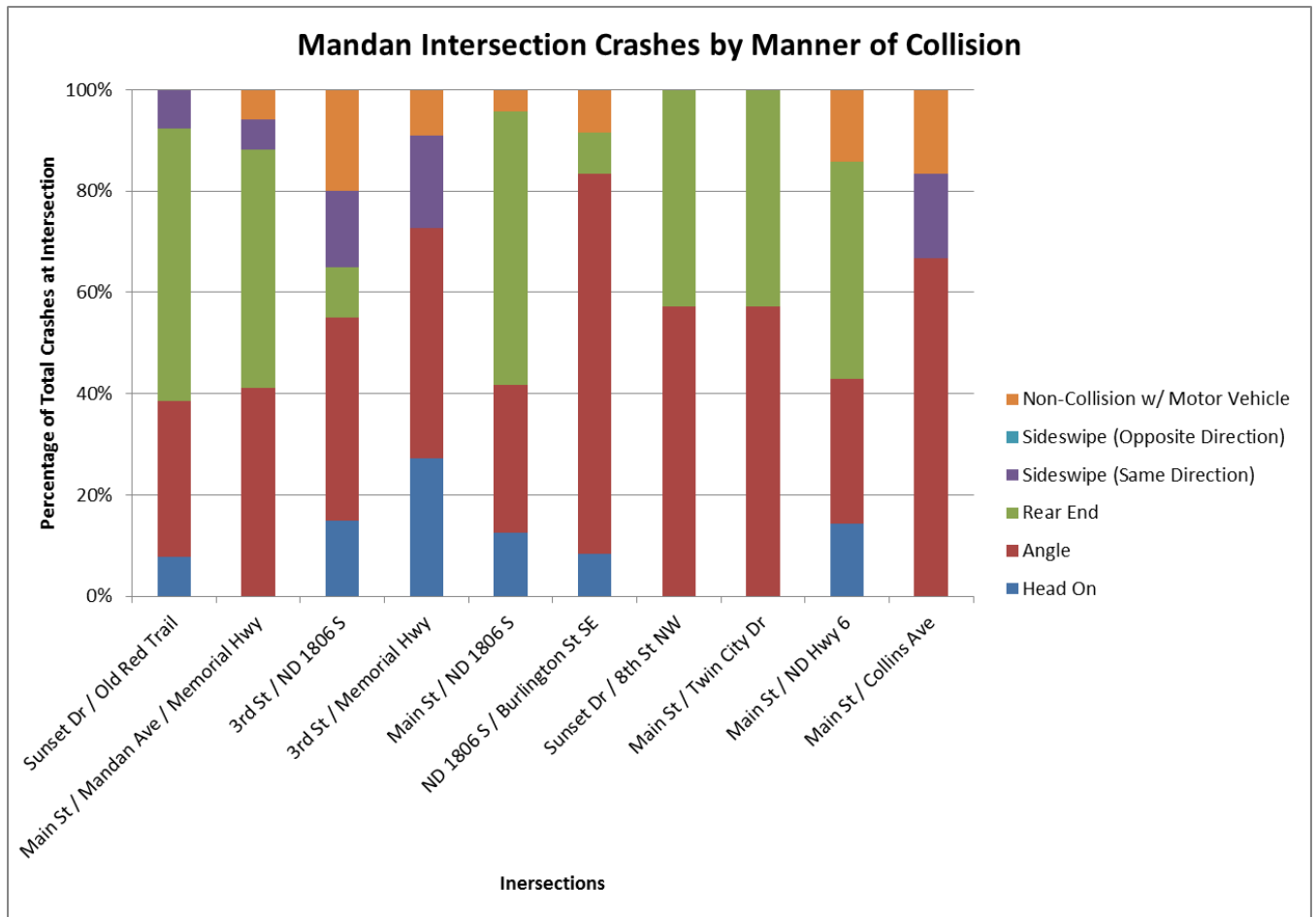


Figure 18. Mandan Intersection Crashes by Manner of Collision 2012-2014

Crash Severity by Location in Mandan

Segment crashes were also analyzed based on severity. Table 10 gives the total number of crashes for each segment based on severity. Figure 19 provides a visual comparison of the severity of crashes experienced by each corridor. Main Street was the only corridor within the study to experience a fatality. The fatality occurred as a non-collision with motor vehicle type crash in 2012 and involved a motorcycle. Incapacitating injury-related crashes occurred on two corridors: ND 1806 N, and the south portion of Highway 6 near 19th Street.

Table 10. Mandan Segment Crashes by Severity 2012-2014

Segment	Fatality	Incapacitating Injury	Non-incapacitating Injury	Possible Injury	Property Damage Only	Total
Sunset Dr / 6th Ave	0	0	4	3	16	23
Hwy 6	0	1	0	3	5	9
Old Red Trail	0	0	0	1	7	8
Mandan Ave	0	0	0	0	4	4
3rd St	0	0	3	2	18	23
19th St	0	0	0	1	1	2
Collins Ave	0	0	0	2	9	11
Hwy 1806 N	0	1	0	0	8	9
Hwy 1806 S	0	0	2	4	19	25
Division St	0	0	0	0	0	0
Main St (Hwy 25 to Hwy 6)	0	0	1	1	6	8
Main St (Hwy 6 to Twin City Dr)	1	0	3	10	47	61

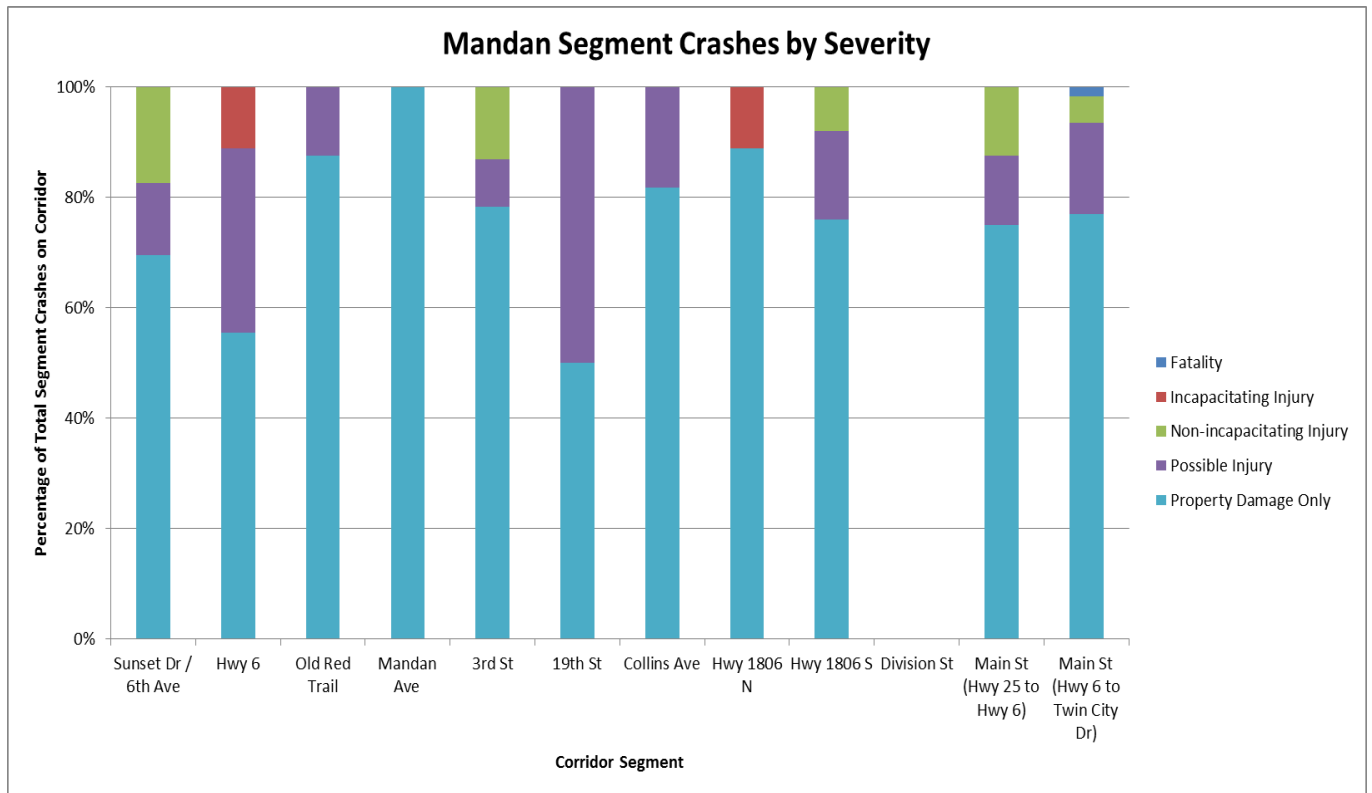


Figure 19. Mandan Segment Crashes by Severity 2012 - 2014

Table 11 and Figure 20 show comparisons of intersection crashes based on severity.

Table 7. Mandan Intersection Crashes by Severity 2012-2014

Intersection	Fatality	Incapacitating Injury	Non-incapacitating Injury	Possible Injury	Property Damage Only	Total
Sunset Dr / Old Red Trail	0	0	1	3	9	13
Main St / Mandan Ave / Memorial Hwy	0	0	1	2	14	17
3rd St / ND 1806 S	0	1	0	5	14	20
3rd St / Memorial Hwy	0	1	0	1	9	11
Main St / ND 1806 S	0	1	1	4	18	24
ND 1806 S / Burlington St SE	0	0	2	2	8	12
Sunset Dr / 8th St NW	0	0	1	1	5	7
Main St / Twin City Dr	0	0	0	1	6	7
Main St / ND Hwy 6	0	0	0	3	4	7
Main St / Collins Ave	0	0	0	2	4	6

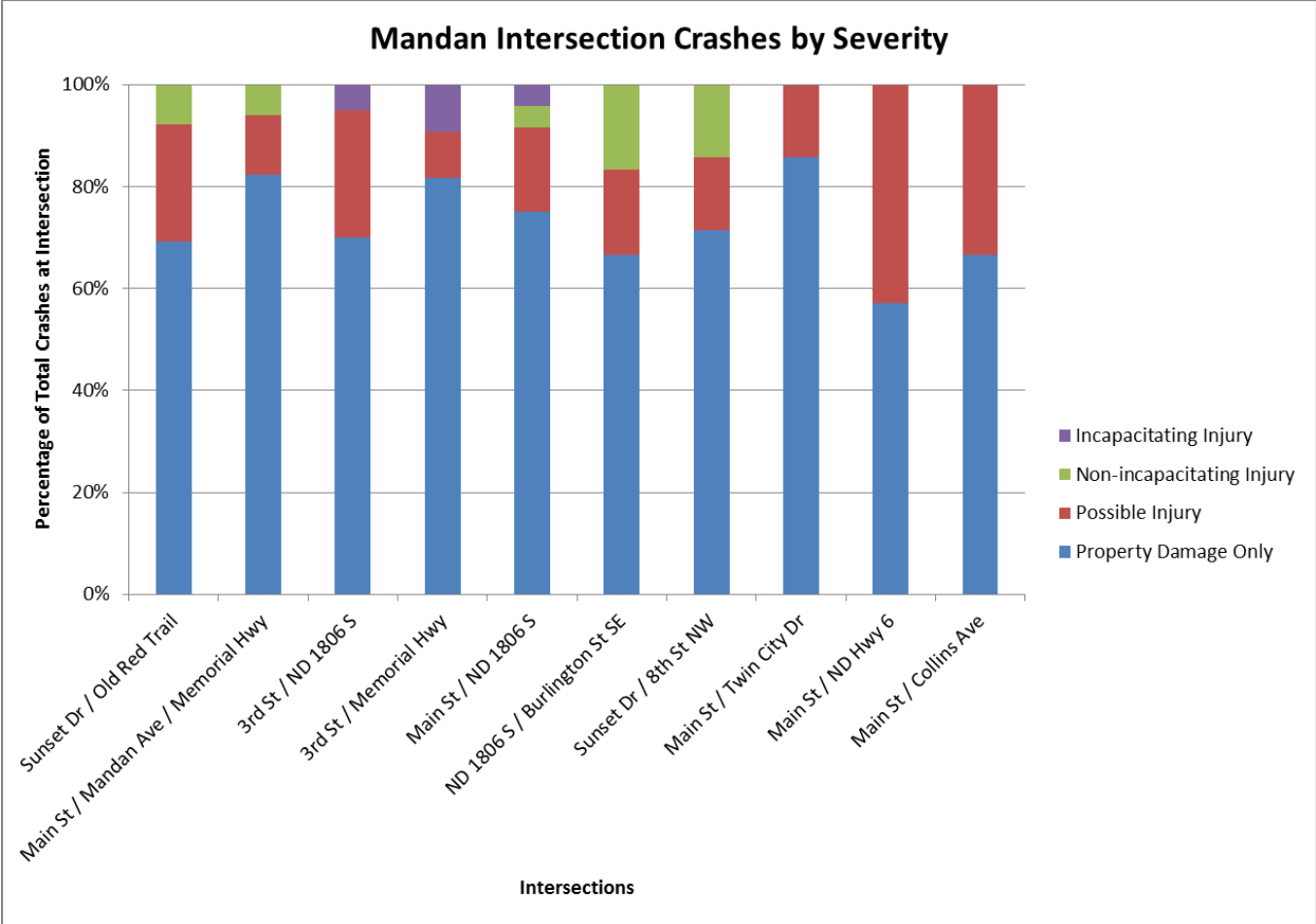


Figure 20. Mandan Intersection Crashes by Severity 2012-2014

Crash Rates by Location in Mandan

A list of segment crash rates, measured in crashes per million vehicles-miles of travel (MVM), for the Mandan corridor segments is provided in Table 12. These rates take into account the total number of segment crashes during the study year period, ADT, and segment length and provide a comparison between the relative corridors. As was noted previously, Main St was separated into two segments from Hwy 25 to Hwy 6 and from Hwy 6 to Twin City Dr. The corridor with the highest crash rate of 2.11 crashes/MVM was identified as Main St between Hwy 6 and Twin City Drive. Hwy 1806 S had the second highest segment crash rate of 1.89 crashes/MVM, followed by Sunset Dr/6th Ave with a crash rate of 1.84 crashes/MVM. Sunset Dr/6th Ave also had the highest segment injury crash rate of 0.32 crashes/MVM. 3rd St was determined to have the second highest injury crash rate of 0.21 crashes/MVM.

Table 8. Mandan Corridor Segment Crash Rates

Corridor	Total Segment Crashes	Segment Crash Rate (Crashes/MVM)	Total Segment Injury Crashes	Segment Injury Crash Rate (Crash/MVM)
Main St (Hwy 6 to Twin City Dr)	61	2.11	4	0.14
Hwy 1806 S	25	1.89	2	0.15
Sunset Dr / 6th Ave	23	1.84	4	0.32
Collins Ave	11	1.65	0	0.00
3rd St	23	1.64	3	0.21
Hwy 6	9	1.47	1	0.16
Hwy 1806 N	9	1.15	1	0.13
Old Red Trail	8	0.92	0	0.00
19th St	2	0.63	0	0.00
Main St (Hwy 25 to Hwy 6)	8	0.55	1	0.07
Mandan Ave	4	0.55	0	0.00
Division St	0	0.00	0	0.00

Ten intersections having the highest crash frequency were analyzed to determine intersection crash rates. A comparison of intersection crash rates, measured as crashes per million entering vehicles (MEV), is provided in Table 13.

The Mandan intersection with the highest study area crash rate was ND 1806 S and Burlington St SE with 1.06 crashes/MEV. This intersection also had the highest injury crash rate at 0.18 crashes/MEV. The intersection with the second highest crash rate was 3rd St and ND 1806 S with 1.05 crashes/MEV, followed by the intersection of Main St and ND 1806 S at 0.98 crashes/MEV. Main St and ND 1806 S also had the second highest injury crash rate of 0.08 crashes/MEV.

Table 9. Mandan Corridor Intersection Crash Rates

Intersection	Total Intersection Crashes	Intersection Crash Rate (Crash/MEV)	Total Intersection Injury Crashes	Intersection Injury Crash Rate (Crash/MEV)
ND 1806 S / Burlington St SE	12	1.06	2	0.18
3rd St / ND 1806 S	20	1.05	1	0.05
Main St / ND 1806 S	24	0.98	2	0.08
Sunset Dr / Old Red Trail	13	0.75	1	0.06
Main St / ND Hwy 6	7	0.73	0	0.00
3rd St / Memorial Hwy	11	0.56	1	0.05
Main St / Mandan Ave / Memorial Hwy	17	0.52	1	0.03
Sunset Dr / 8th St NW	7	0.45	1	0.06
Main St / Collins Ave	6	0.39	0	0.00
Main St / Twin City Dr	7	0.29	0	0.00

Site Visit Observations

Based on site visits, several corridors were identified as having potential sight distance issues along horizontal curves and various intersections. The corridors in particular where concern was noted was the vertical grade and sight distance at the intersection of Sunset Drive and Division St, and horizontal curves along Old Red Trail/Mandan Ave and 19th Street. These corridors experience inconsistencies regarding lane widths and shoulder/curb as well.

Main Street was found to experience the most crashes between Highway 6 and Twin City Drive. This 2-mile long segment of Main St has high access density, with approximately 24 cross-streets and over 30 private entries with direct access to the Main Street corridor. In addition, on-street parking is available along some portions as well. Managing the high level of access points could potentially help address the relatively high number of angle, head-on, and opposite-direction sideswiping crashes that occurred along this segment.

5.0 Conclusions

Based on the ARTPLAN results, various corridors within the City of Mandan and the City of Bismarck were identified as having a LOS of D or worse under existing 2014 traffic conditions. These corridors can be expected to experience continued travel delays during peak conditions under forecasted conditions of expected traffic growth.

Regarding other modes of travel, future improvements should consider improved connectivity for designated bicycle routes. The bicycle level of service indicates that bicycle service levels are higher when a corridor incorporated a designated bike route throughout its entirety rather than small alternating segments. Also, as potential roadway improvements are considered in the next phase of the study, future on-street bicycle needs (both to current bike routes and planned bike routes in the LRTP) should be considered in any recommendations.

The safety analysis recognized the corridor segments and intersections with the highest crash rates and most severe crashes. While no fatalities occurred for any Bismarck corridors within the three-year study period, there were 42 intersection and 20 segment crashes resulting in incapacitating and non-incapacitating injuries. Bismarck's 9th St corridor between Boulevard Ave and Rosser Ave was determined to have both the highest segment crash rate of 11.3 crashes/MVM and the highest segment injury crash rate of 0.38 crashes/MVM. Bismarck's 19th St corridor between Divide Ave and LaSalle Dr was found to have the lowest segment crash rate of 2.59 crashes/MVM, while Ward St from Divide Ave to Edwards Ave had the lowest segment injury crash rate of zero. Divide Ave, Washington St, and 9th St were found to have the highest occurrences of segment rear-end crashes. Divide Ave was also found to have the highest frequency of head-on collisions as well.

Ten intersections with the highest crash frequencies were also identified within the Bismarck study area. Their intersection crash rates ranged from 0.43 crashes/MEV to 1.55 crashes/MEV, with the intersection of Washington Ave and Century Ave ranking at the lowest and the intersection of Memorial Highway and 3rd Street ranking at the highest.

In the City of Mandan there were 16 segment and 19 intersection injury-related crashes that occurred during the three-year study period. Of the 16 injury-related segment crashes, one

consisted of a fatality and occurred on Main St. The segment with the highest segment crash rate was determined to be the Main St corridor between ND Hwy 6 and Twin City Dr with a crash rate of 2.11 crashes/MVM. The segment with the highest injury-related crash rate was Sunset Dr/6th Ave at 0.32 crashes/MVM. Division St had values of zero for both segment crash rate and segment injury crash rates. Main St between Hwy 6 and Twin City Dr was found to have the highest total of angle crashes than any other corridor. 3rd St and Hwy 1806 S had the highest occurrences of rear-end crashes.

The ten intersections in Mandan with the highest crash frequencies had intersection crash rates ranging from 0.29 to 1.06 crashes/MEV. The intersection of Main St and Twin City Dr had the lowest of 0.29 crashes/MEV and no injuries reported, while the intersection of ND 1806 S and Burlington St SE had the highest intersection rate of 1.06 crashes/MEV as well as the highest intersection injury crash rate of 0.18 crashes/MEV. The intersection of 3rd St and ND 1806 S had the second-highest intersection crash rate of 1.05 crashes/MEV.

APPENDIX A

Bismarck Corridors

Washington St

Segment	Through Movement Intersection LOS	Segment LOS
Divide Ave - Interstate Ave	F	F
Interstate Ave - Century Ave	B	B
Century Ave - Calgary	E	F

4th Street

Segment	Through Movement Intersection LOS	Segment LOS
Boulevard - Divide	C	C
Divide - Interstate	C	C
Interstate - Century	B	C

9th Street

Segment	Through Movement Intersection LOS	Segment LOS
Rosser - E Ave C	C	C
E Ave C - Boulevard	B	D

26th St

Segment	Through Movement Intersection LOS	Segment LOS
Airway Ave - Bismarck Exp	C	B
Bismarck Exp - Main St	B	A
Main St - Rosser	C	D
Rosser - Divide Ave	C	B

Ward Rd

Segment	Through Movement Intersection LOS	Segment LOS
Ewards Ave - Divide Ave	A	A

Divide Ave

Segment	Through Movement Intersection LOS	Segment LOS
Bismarck Expressway - 26th St	B	B
26th St - 19th St	F	F
19th St - State St	B	B
State St - 4th St	C	C
4th St - Washington St	C	C
Washington St - Schaffer St	B	A

7th Street

Segment	Through Movement Intersection LOS	Segment LOS
Boulevard - E Ave C	C	E
E Ave C - Rosser	B	C

Front Ave - Memorial Hwy

Segment	Through Movement Intersection LOS	Segment LOS
Main Ave - Washington	C	A
Washington - 3rd St	C	D
3rd St - 5th St	C	E
5th St - 7th St	C	E
7th St - 9th St	B	D
9th St - 12th St	B	C

19th St

Segment	Through Movement Intersection LOS	Segment LOS
Divide - Capitol	C	D
Capitol - Century	B	A
Century - 43rd Ave	F	F
43rd Ave - LaSalle Dr	C	C

Mandan Corridors

Sunset Drive/6th Ave

Segment	Through Movement Intersection LOS	Segment LOS
Old Red Trail - N Interchange	F	F
N Interchange - S Interchange	C	D
S Interchange - 2nd St	B	B
2nd St- 1st St	B	E
1st St - Main St	B	E

Highway 6

Segment	Through Movement Intersection LOS	Segment LOS
19th - Main st	C	B

Old Red Trail

Segment	Through Movement Intersection LOS	Segment LOS
Sunset Dr - Collins Ave	B	A
Collins Ave - Mandan Ave	B	B

Mandan Ave

Segment	Through Movement Intersection LOS	Segment LOS
Old Red Trail -Main St	B	A

Division Street

Segment	Through Movement Intersection LOS	Segment LOS
6th St - ND 1806	B	B
ND 1806 - 8th Ave	B	B

Main Street

Segment	Through Movement Intersection LOS	Segment LOS
Hwy 25 - 10th Ave NW	B	A
10th Ave NW - 6th Ave NW	B	C
6th Ave NW - 3rd Ave NW	B	D
3rd Ave NW - 1st St	C	E
1st St - Collins Ave	D	F
Collins Ave - 6th Ave NW	C	B
6th Ave NW - Memorial Hwy	D	D
Memorial Hwy - Twin City Dr	C	C

3rd Street SW

Segment	Through Movement Intersection LOS	Segment LOS
Hwy 6 - 9th Ave	B	E
9th Ave - 8th Ave	B	E
8th Ave - 1806	B	A
1806 - Memorial Hwy	E	B

19th Street SE

Segment	Through Movement Intersection LOS	Segment LOS
Hwy 6 - 8th Ave	B	A
8th Ave - ND 1806	B	B

Collins Ave

Segment	Through Movement Intersection LOS	Segment LOS
Old Red Trail - 14th St	B	C
14th St - 2nd St	B	B
2nd St - Main St	B	D

Highway 1806 N

Segment	Through Movement Intersection LOS	Segment LOS
38th St - Old Red Trail	B	A

Highway 1806 S

Segment	Through Movement Intersection LOS	Segment LOS
19th St - 3rd St	C	A
3rd St - Main St	B	B