RAPID CITY ARTERIAL SAFETY STUDY

Prepared for:

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DRAFT

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FHU Reference No. 10-160-01
November 2011

The preparation of this report has been financed in part through grant[s] from the Federal Highway Administration and Federal Transit Administration, U.S. Department of Transportation, under State Planning and Research Program, Section 505 [or Metropolitan Planning Program, Section 104(f)] of Title 23, U.S. Code. The contents of this report do not necessarily reflect the official views or policy of the U.S. Department of Transportation.

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I. INTRODUCTION

A. Study Background and Purpose

The responsible investment of Rapid City resources in mitigating roadway safety problems is a difficult task. When making decisions affecting road safety, it is critical to understand that the expenditure of limited available funds on improvements in places where it prevents few injuries and saves few lives can mean that injuries will occur and lives will be lost by not spending them in places where more crashes could have been prevented[1]. It is the City of Rapid City's objective to maximize crash reduction within the limitations of available budgets by making arterial road safety improvements at locations where it does the most good or prevents the most crashes.

In an effort to better understand the existing crash problems on the arterial roadway network within Rapid City, the City, in conjunction with the Rapid City Area Metropolitan Planning Organization (MPO), identified the need to complete an arterial roadway safety study within Rapid City. The City enlisted Felsburg Holt and Ullevig (FHU) and Dream Design International (DDI) to complete this assessment with the goal of identifying high-priority traffic safety problems along arterial street segments in Rapid City and to conceptualize projects that will help to address those problems.

The analyses completed and documented in this report focus on the crashes on arterial roadway segments between major arterial to arterial intersections. City staff closely monitors the occurrence of crashes at the major intersections within the City so this study does not include crash analysis for major arterial intersections. The objectives of this study are as follows:

- Develop a citywide safety perspective to set localized crash frequency and severity in the context of other similar facilities in Rapid City
- Identify the top ten arterial crash segments within Rapid City using the Critical Crash Rate Method as outlined in the Highway Safety Manual (AASHTO, 2010). This method utilizes past crash totals, daily traffic volumes and arterial segment lengths to calculate crash rates
- Review each of the fatal crashes that occurred during the study period on arterial segments, to understand the circumstances surrounding each crash and determine if any measures can be taken to improve the safety of the arterial segments that each fatal crash occurred along
- Develop solutions with the greatest potential to improve arterial traffic safety for the top crash locations
- Prioritize future safety improvements to make sure that limited improvement funding is spent in the right places
- Provide the City of Rapid City with a repeatable methodology for analyzing arterial safety in the future using Geographic Information Systems (GIS) based methods

[1] Hauer, E., (1999) Safety Review of Highway 407: Confronting Two Myths. TRB

This report is based on the analysis of three years of crash history (January 2007 through December 2009) and a review of field geometry. The City is advised to verify, through field survey, the information included in this report regarding physical features and roadside characteristics for the design concepts included in this study.

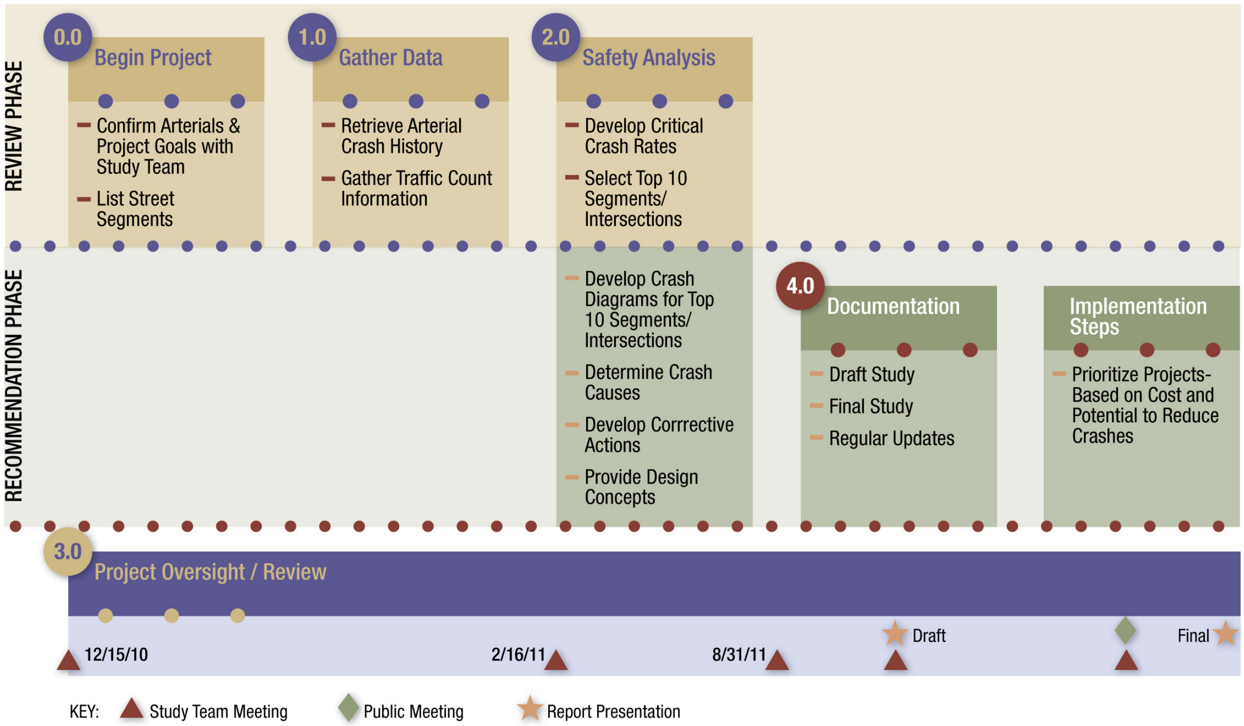
B. Study Process

This arterial safety study began in December 2010 with the project kickoff meeting. The goal was to complete the data collection, the safety analyses and the documentation of this study within one year. Over the course of the project, Steering Committee meetings were held to discuss progress of the project and to make decisions for how to proceed with the analysis going forward. The Steering Committee was comprised of Rapid City, South Dakota Department of Transportation (SDDOT) and Federal Highway staff. The following is a list of the Steering Committee members:

- Patsy Horton – Rapid City Community Planning and Development
- John Less – Rapid City Engineering Services
- Kip Harrington – Rapid City Planning
- Lt. James Johns – Rapid City Police
- Dan Staton – SDDOT
- Brad Remmich – SDDOT
- Josh Hinds – SDDOT
- Mark Hoines – Federal Highway Administration South Dakota

In addition to the Steering Committee meetings, a public meeting was held in conjunction with the completion of the draft report of the study. The goal of the public meeting was to provide the objectives of the study as well as an explanation of the methods and results that determined the top ten crash segments within the City. The final report will be presented to the City Council, City Planning Commission and Metropolitan Planning Organization in December 2011. **Figure 1** shows the work flow diagram developed for this project which outlines the tasks and major milestones of this project.

Figure 1. Arterial Safety Study Work Flow Diagram



II. ANALYSIS METHODOLOGY

A. Data Utilized for Analysis

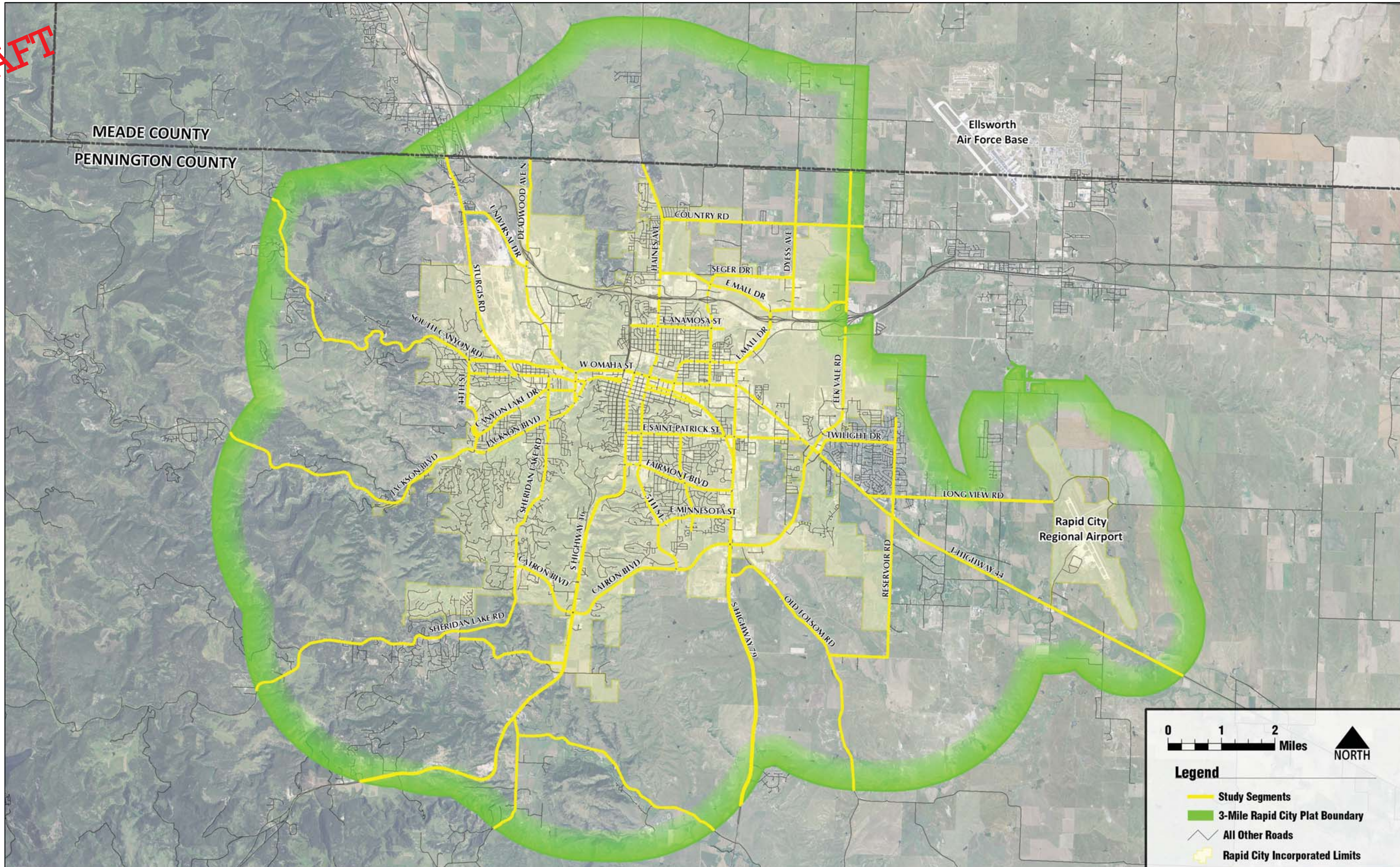
The crash, traffic volume, arterial roadway laneage and GIS data were provided by City and South Dakota Department of Transportation staff. The following provides a summary of the data utilized in this study:

- **Crash Data** – Arterial crash data represents a period of January 2007 through December 2009. The crash data used in this study was provided by the SDDOT in a Geographic Information Systems (GIS) file. The reason a three year study period was selected is that the arterial roadway network within Rapid City has changed in recent years due to various construction projects. In order to limit the effects a changing roadway network has on the crash experience, the most recent available three years of data were used. This was the direction agreed upon by the Steering Committee. In addition, the use of a three year study period helps to normalize the annual fluctuation in crash totals and prevents the selection of segments where a problem does not exist.
- **Daily Traffic Volumes** – Traffic count data were provided for each of the arterial roadway segments within Rapid City by City and Pennington County staff for the 2007 through 2009 study period. The City has a comprehensive traffic count program in which traffic volumes are collected on nearly every arterial roadway within the city on an annual basis. County data were utilized for the segments where count data was unavailable from the City. Arterial segments with more than one traffic count available for the three year study period were averaged to obtain a single representative daily traffic volume.
- **Arterial Roadway Laneage** – The number of travel lanes for each arterial were available in the City's arterial roadway network in GIS.
- **GIS Files** – As mentioned, the crash data was provided in a GIS file from the SDDOT. Each crash that occurred during the study period is represented by a point in this GIS file. The other GIS files utilized in this study were provided by City staff. The files utilized include:
  - The City 3-mile platting jurisdiction and the 1.5-mile airport boundary which were both used to define the limits of the study
  - The City arterial roadway network
  - The City intersection locations point file
  - The City traffic signals locations point file

Each of these data sources were utilized in this analysis and their application to this study will be discussed in more detail in the following sections.

B. Identification of Arterials for Study

As mentioned, the boundaries of the arterial safety study were set based on the City's 3-mile platting jurisdiction and the 1.5-mile boundary for the Rapid City Regional Airport. Any arterial roadway located outside of the plat and airport boundaries was removed from the study. Arterial roadways were identified based on the Rapid City Major Street Plan as furnished in GIS format. **Figure 2** shows the study boundaries and the arterials included in this analysis.



NORTH

Figure 2
Study Area

Several low volume, low speed, non-continuous arterials within the study area were removed from the study. The arterial segments in this category generally have daily volumes of less than 1,000 vehicles per day (vpd) and do not provide for longer trip lengths. The study Steering Committee discussed the removal of these arterials and agreed that if included, the statistics from these arterial segments would skew the crash rate averages due to their low volume and low crash occurrences. There were a total of 14 arterial segments removed based on these criteria. **Table 1** lists the excluded arterial segments.

Table 1. Arterials Removed from Analysis

Roadway	Location	Reason(s)
Creek Drive	Entire arterial segment	Non continuous arterial without traffic count
Elk Vale / Hwy 44 Ramps	At interchange	Should not be considered arterial segments
Airport Road	Entire arterial segment	Non continuous arterial without traffic count
Mickelson Drive	Entire arterial segment	Non continuous arterial without traffic count
Concourse Drive	Entire arterial segment	Non continuous arterial without traffic count
Anamosa Street	Just west of Elk Vale Rd.	Non continuous arterial without traffic count
Cheyenne Boulevard	Entire arterial segment	Non continuous arterial without traffic count
Edwards Street	Entire arterial segment	Non continuous arterial without traffic count
Eglin Street	Entire arterial segment	Non continuous arterial without traffic count
N. Plaza Drive	Entire arterial segment	Non continuous arterial without traffic count
Commerce Road	Entire arterial segment	Non continuous arterial without traffic count
Park Drive	Entire arterial segment	Short arterial without traffic count
Corral Drive	Entire arterial segment	Non continuous arterial without traffic count
Dunsmore Road	Entire arterial segment	Non continuous arterial without traffic count

C. Arterial Segmentation using Geographic Information Systems (GIS)

The arterial roadways within the study area were divided into shorter sub segments. The following methodology was used to complete the segmentation of the 160 miles of arterial roadways within the study area:

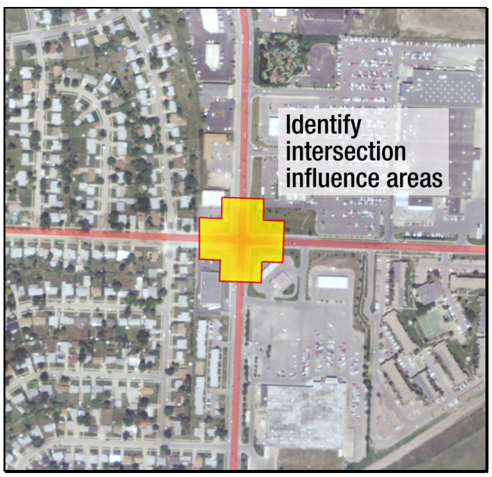
- All arterial to arterial intersections within the study area were isolated and buffered within GIS to remove the major intersections from the analysis. Each intersection buffer was based on an influence area along each intersection approach. As shown in **Table 2**, the size of each buffer was determined by the type of traffic control in place at the intersection. These intersection buffer sizes are currently in use by Rapid City staff when completing safety analyses for intersections and were used in this study to be consistent with current City practice.

Table 2. Intersection and Arterial Buffer Sizes

Location Type	GIS Buffer Size
Signalized Arterial Intersections	200 feet
All Way Stop Controlled Arterial Intersections	150 feet
All Other Stop Controlled Arterial Intersections	100 feet
Arterial Roadway Buffer Widths	20 feet

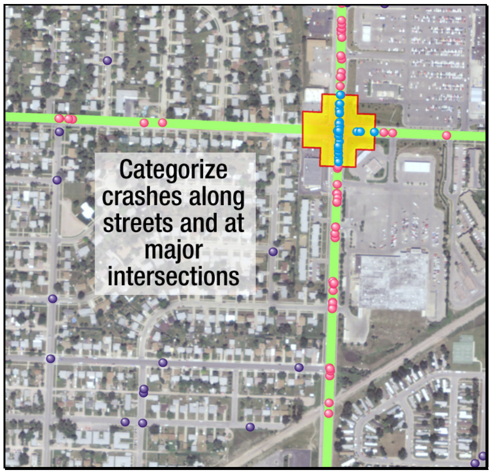
The distances shown in **Table 1** are measured in each direction from either the center point of the intersection or the center line of the arterial segment. **Figure 3** shows an example of an intersection influence area.

Figure 3. Typical Intersection Influence Area



- Crashes were identified as occurring within a major intersection influence area or along an arterial segment, and those occurring at a major intersection were removed from further consideration. Crashes that occurred along each of the 249 arterial segments were retained for further study. **Figure 4** shows an example of arterial segment crashes as well as the intersection related crashes removed from the analysis.

Figure 4. Classification of Crash Data Points



- The number of crashes was associated with the segment daily traffic volume, number of lanes and segment length. Each of the 249 arterial segments and associated information were then carried forward for analysis using the Critical Crash Rate method. This approach is generally consistent with the methods approved by the SDDOT. Use of this methodology was supported by the project Steering Committee.
- Of note, the central business district crashes were analyzed separately from the other arterial roadway crashes due to the unique geometric and travel conditions of the downtown area. The crashes in the downtown area will be discussed in more detail later in this report.

D. Critical Crash Rate Methodology

The Critical Crash Rate methodology is outlined in the Highway Safety Manual (AASHTO, 2010). This method compares the observed crash rate for an arterial segment to a critical crash rate that is unique for each arterial segment. The observed crash rate for a segment is calculated by dividing the number of crashes on the segment by the million vehicle miles of travel (MVMT) for the segment. The MVMT takes the daily traffic of the segment, the length of the segment and the number of years in the analysis (3 years) into account.

The critical crash rate is a threshold value that when compared to the crash rate for a segment can help to determine if the crash experience on a given segment is unusual or not. This threshold is developed by developing city wide crash rates for arterial segments with similar characteristics. For the purposes of this analysis, the number of travel lanes on each arterial segment was used to define the segment grouping classifications. For this analysis there are seven groups which include:

- 2-lane arterials
- 3-lane arterials
- 4-lane arterials

- 5-lane arterials
- 6-lane arterials
- 4-lane divided arterials
- 6-lane divided arterials

Citywide average crash rates were calculated for each of these arterial classifications. In addition, the P-value used in this analysis was 1.645 which corresponds to a 95 percent confidence level in a one-tailed Poisson distribution. These values, as well as the MVMT, for each segment were used to calculate the critical crash rate for each segment. Each arterial segment was then ranked according to its critical crash ratio which is the segment’s observed crash rate divided by the critical crash rate.

In general, a segment with a crash ratio greater than 1.0 would be flagged for further analysis. However, for the purposes of this report, the critical crash ratio was used to rank the segments in order to identify the 10 worst crash segments for further analysis. A table showing the results of the critical crash rate analysis for all 249 arterial segments can be found in **Appendix A**.

III. CRASH ANALYSIS AND SUMMARY OF RESULTS

A. Top Crash Segments

Critical crash rate calculations were completed for all 249 arterial segments both considering the total crashes as well as only the severe crashes. For the purposes of this analysis, a severe crash is a crash that has been reported as a fatal, incapacitating injury or non-incapacitating injury crash. Both “possible injury” and “no injury” crashes have been classified as a property damage only (PDO) crash. The purpose of completing both total and severe crash rate calculations was to ensure that locations with a demonstrated history of severe crashes were given due consideration in the study. An arterial segment that did not make the top ten arterial list based on the total critical crash ratio but did make the top ten list based on the severe critical crash ratio list could be considered for further analyses.

A total of 14 top crash segments were identified for preliminary analysis. This top segment crash list and the preliminary analyses were presented to the Steering Committee on August 31, 2011. Through discussions with the Steering Committee, the list was reduced to ten arterial segments identified for more in depth analysis to be included in this report. **Table 3** shows the ten crash segments indentified for analysis as well their critical crash ratios. Each segment is discussed in more detail in the following sections. As mentioned, the complete segment rankings for all 249 segments can be found in **Appendix A.**

Table 3. Top Ten Crash Segments

Segment Number	Total Crash Rank (Severe Crash Rank)	Road Segment Name	From	To	Total Crashes (Severe Crashes)	Critical Crash Ratio Total (Critical Crash Ratio Severe)
Segment 1	1 (2)	Haines Ave	Lindbergh	I-90	33 (8)	2.43 (1.89)
Segment 2	2 (1)	Haines Ave	I-90	Disk	31 (8)	2.30 (1.88)
Segment 3	4 (3)	Saint Joseph St	5th	East Blvd	27 (5)	2.02 (1.39)
Segment 4	7 (145)	Jackson Blvd	City Limit	Chapel	15 (0)	1.87 (0.00)
Segment 5	10 (5)	W Main St	Sheridan Lake	Mountain View	49 (11)	1.66 (1.36)
Segment 6	14 (43)	N LaCrosse St	Anamosa	Meridian	18 (2)	1.42 (0.74)
Segment 7	49 (7)	S Highway 16 NB	Neck Yoke	Busted 5 Ct	41 (8)	0.90 (1.26)
Segment 8	15 (20)	N LaCrosse St	E North	Anamosa	53 (10)	1.39 (0.99)
Segment 9	26 (14)	W Omaha St	Mountain View	West Blvd	40 (12)	1.11 (1.08)
Segment 10	35 (17)	E Saint Patrick St	Elm	St Joseph	28 (8)	0.77 (1.04)

IV. INDIVIDUAL ARTERIAL SEGMENTS

This section of the report includes detailed information about each of the top ten segments analyzed in this study. Contents include a description of the road design, overview of crash history, identified correctable crash pattern(s) and mitigation concepts. The mitigation concepts developed for each of the top crash segments in this report are a rendering of what could be completed. If implemented, each concept will require further engineering analysis and / or design prior to construction.

A. Segment 1 – Haines Avenue (Lindbergh Avenue to Interstate 90)

Segment Description

This segment of Haines Avenue is located just south of Interstate 90 (I-90) adjacent to the Shopko Shopping Center. The segment is approximately 0.20 miles in length and runs from Lindbergh Avenue on the south to I-90 on the north. Haines Avenue has two northbound lanes, two southbound lanes and a center left turn lane. The center median on Haines Avenue is painted. There is curb and gutter throughout this segment. The posted speed limit on Haines Avenue is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 19,900 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 33 crashes on this segment. Of these, 25 were Property Damage Only (PDO) crashes and 8 were injury crashes. There were no fatal crashes on this segment during the study period. The majority of the crashes were angle crashes (mostly broadsides) with rear-end crashes the second most common crash type. A diagram showing the type and location of each crash for this segment can be found in **Appendix B**.

As can be seen on the crash diagram, the majority of crashes on this segment occurred at the unsignalized intersection with Knollwood Drive. The majority of the crashes at this intersection were broadside type crashes that occurred when a vehicle from Knollwood Drive failed to yield the right-of-way and pulled out in front of either a northbound or southbound vehicle on Haines Avenue. In addition to the angle crashes at this intersection, there are also angle (access related) crashes at the intersections with Wright Street and Curtis Street.

Mitigation Measures and Concepts

Based on the angle crash pattern along this segment, consideration should be given to developing an access management plan for the corridor. A concept of a possible access management plan developed for this segment can be found in **Appendix B**. This concept would construct a raised median and provide one full movement intersection along the segment at the Wright Street intersection. If this concept is implemented, the City should consider completing a traffic signal warrant study per the Manual on Uniform Traffic Control Devices (MUTCD) (Federal Highway Administration, 2009) for the Wright Street intersection to determine if the intersection should be signalized or remain unsignalized. All other driveways and intersections (including Knollwood Drive) would be restricted to right-in/right-out or ¾ movement intersections. Of note, this concept would not preclude the City from continuing with plans to reroute Knollwood Drive to Lindbergh Avenue as has been discussed in the past.

It is also worth noting that the intersection of Knollwood Drive and Haines Avenue was evaluated as part of the SDDOT 2010 Roadway Safety Improvement Program (RSI). The recommendation in the DOT study is to sign the Knollwood Drive approaches for no left turns during afternoon hours and provide enforcement during that time.

B. Segment 2 – Haines Avenue (I-90 to Disk Drive)

Segment Description

This segment of Haines Avenue is located just north of I-90. The segment is approximately 0.16 miles in length and runs from I-90 on the south to Disk Drive on the north. Haines Avenue has two northbound lanes, two southbound lanes and a center left turn lane. The center median on Haines Avenue is painted. There is curb and gutter throughout this segment. The posted speed limit on Haines Avenue is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 25,000 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 31 crashes on this segment. Of these, 23 were PDO crashes and 8 were injury crashes. There were no fatal crashes on this segment during the study period. There were an even split between angle type and rear end type crashes on this segment. A diagram showing the type and location of each crash for this segment can be found in **Appendix C**.

As can be seen on the crash diagram, the majority of the angle crashes are related to intersections and driveways along the segment. Most of the approach turn type angle crashes occurred at Howard Street while the majority of the broadside type angle crashes occurred at the Conoco driveway. Nearly all of the rear end crashes occurred on the southbound approach to the I-90 interchange intersection.

Mitigation Measures and Concepts

Based on the angle crash pattern along this segment, consideration should be given to reconfiguring local access intersections along the segment. A concept of a possible access reconfiguration for this segment can be found in **Appendix C**. If implemented, this concept would construct a raised median and would restrict all driveways between Howard Street and Disk Drive to right-in / right-out or ¾ movement intersections.

In addition, consideration should be given to reviewing the visibility of the existing signal heads on the southbound approach at the intersection with I-90 and reviewing the length of the green interval for the southbound left turn. Improving the visibility of the signal heads could help to reduce the number of rear end type crashes. In addition, lengthening the southbound left turn phase could help to reduce the number of rear end type crashes.

C. Segment 3 – Saint Joseph Street (5th Street to East Boulevard)

Segment Description

This segment of Saint Joseph Street is located on the east side of downtown. The segment is approximately 0.44 miles in length and runs from 5th Street on the west to East Boulevard on the east. Saint Joseph Street is a one-way roadway eastbound and has three travel lanes with on-street parking, both angle and parallel. There is curb and gutter throughout this segment. The posted speed limit on Saint Joseph Street is 30 miles per hour (mph). The average daily traffic for this segment during the study period was about 10,500 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 27 crashes on this segment. Of these, 22 were PDO crashes and 5 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash type were sideswipe same direction crashes (13) followed closely by broadside type crashes (11). A diagram showing the type and location of each crash for this segment can be found in **Appendix D**.

As can be seen on the crash diagram, the sideswipe same direction crashes are spread throughout the corridor but are typically on the approach to an intersection. A large portion of these crashes occurred due to illegal lane changes when a vehicle in the center lane of traffic attempted to make a left turn onto an intersecting side street.

Nearly all of the broadside type crashes occurred at the intersection of Saint Joseph Street with 4th Street. These crashes typically occurred when a vehicle on 4th Street misjudged the gap in traffic and was struck by an eastbound vehicle on Saint Joseph Street. However, sight distance from the stop bar on 4th Street is also restricted due to the angled parking on Saint Joseph Street (as seen in **Figure 5**) and could be a contributing factor to these crashes.

Mitigation Measures and Concepts

Based on the angle crash pattern and restricted sight distance at 4th Street, consideration should first be given to removing the existing parking on Saint Joseph Street just west of 4th Street. This would help to improve the sight distance and could reduce the number of angle crashes. However, if the parking cannot be removed or if the angle crash problem does not improve, consideration should be given to installing a traffic signal at the St. Joseph Street/4th Street intersection. The number of broadside crashes during the study period meets Part B of the criteria for Warrant 7 in the MUTCD. However, further analysis should be considered to determine if Parts A and C of Warrant 7 are also met. If warranted, the installation of a traffic signal at this location would help to reduce the number of broadside crashes at this intersection.

Consideration should be given to signing and striping the approaches to the intersections along this segment with lane use arrows. This could help to reduce the number of sideswipe same direction crashes on the approaches to the intersections.

A concept showing both the proposed traffic signal and striping developed for this segment can be found in **Appendix D**.

Figure 5. Saint Joseph Street and 4th Street Sight Distance

D. Segment 4 – South Dakota 44 (Jackson Boulevard) (City Limit to Chapel Lane)

Segment Description

This segment of Jackson Boulevard is located on the western side of Rapid City. The segment is approximately 1.08 miles in length and runs from Chapel Lane on the east to the City Limit on the west. Jackson Boulevard is a four-lane roadway with two lanes in the eastbound direction and two lanes in the westbound direction. There is not a center turn lane. There is curb and gutter throughout this segment. The posted speed limit on Jackson Boulevard is 45 miles per hour (mph). The average daily traffic for this segment during the study period was about 4,600 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 15 crashes on this segment, all of which were PDO crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were wild animal type crashes (7) followed by angle type crashes (4). A diagram showing the type and location of each crash for this segment can be found in **Appendix E**.

As can be seen on the crash diagram, the wild animal type crashes are spread throughout the segment. Since no pattern exists due to the inconsistent location of the crashes, no recommendations have been made to address this crash type.

Nearly all of the angle type crashes occurred at the intersection of Jackson Boulevard with Cleghorn Canyon Road. These crashes typically occurred when a vehicle turning left from Cleghorn Canyon Road misjudged the gap in traffic and was struck by a westbound vehicle on Jackson Boulevard.

Mitigation Measures and Concepts

Based on the angle crash pattern at Cleghorn Canyon Road, consideration should be given to installing an intersection warning sign (W2-2) and a supplemental advisory speed plaque (W13-1P) on the westbound approach to the intersection. A similar sign group is currently in place on the eastbound approach to the intersection.

In addition, consideration should be given to improving the sight distance for vehicles looking to the south from Cleghorn Canyon Road. **Figure 6** shows the current obstructions in place for vehicles at this intersection.

Figure 6. Jackson Boulevard and Cleghorn Canyon Road Sight Distance

A concept showing the recommended signing and striping for this segment can be found in **Appendix E**.

E. Segment 5 – West Main Street (Sheridan Lake Road to Mountain View Road)

Segment Description

This segment of West Main Street is west of Mountain View Road and is adjacent to the Baken Park Shopping Center for a portion of the segment. The segment is approximately 0.45 miles in length and runs from Sheridan Lake Road to Mountain View Road and also crosses Rapid Creek. West Main Street has two eastbound lanes, two westbound lanes and a center left turn lane. The center median on West Main Street is painted. There is curb and gutter throughout this segment. The posted speed limit on West Main Street is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 22,800 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 49 crashes on this segment. Of these, 38 were PDO crashes and 11 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were angle type crashes (25) followed by rear end type crashes (16). It is also worth noting that there were three crashes involving a bicycle. A diagram showing the type and location of each crash for this segment can be found in **Appendix F**.

As can be seen on the crash diagram, the angle and rear end type crashes were spread throughout the corridor and were typically associated with driveways or intersections along the segment. The locations with the highest concentration of crashes include the driveways to / from the Baken Park Shopping Center. The driveways to / from McDonalds as well as the intersections of Dakota Drive, Sheffer Street and Piedmont Street also had a high concentration of crashes.

Mitigation Measures and Concepts

Based on the angle crash pattern along this segment, consideration should be given to developing an access management plan for the arterial segment. A concept of a possible access management plan developed for this segment can be found in **Appendix F**. If implemented, this concept would construct a raised median along the entire length of the segment and would restrict nearly all of driveways on the segment to right-in / right-out or ¾ movement intersections. The only exception would be the intersection with Dakota Drive which is recommended to remain a full movement access. There is also one driveway recommended for closure. If this concept is implemented, consideration should be given to completing a traffic signal warrant study per the MUTCD at Dakota Drive and, if warranted, installing a traffic signal at this location.

In addition, the recently released Rapid City Area Bicycle and Pedestrian Master Plan (Alta / KL&J, July 2011) recommended that a bike lane be constructed along West Main Street. Due to the occurrence of bicycle crashes along this segment, consideration should be given to constructing the bike lane in association with the access management project.

The concept for this segment in **Appendix F** shows both the raised median and the bike lane.

F. Segment 6 – LaCrosse Street (Anamosa Street to Meridian Lane)

Segment Description

This segment of LaCrosse Street is located just north of Anamosa Street and is adjacent to the Wal-Mart Shopping Center. The segment is approximately 0.06 miles in length and runs from Anamosa Street on the south to Meridian Lane on the north. LaCrosse Street has two northbound lanes, two southbound lanes and a center left turn lane. The center median on LaCrosse Street is painted. There is curb and gutter throughout this segment. The posted speed limit on LaCrosse Street is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 21,200 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 18 crashes on this segment. Of these, 16 were PDO crashes and 2 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were rear end type crashes (10) followed by angle type crashes (5). It is also worth noting that all of the angle crashes were broadside crashes that occurred at the unsignalized Wal-Mart access. A diagram showing the type and location of each crash for this segment can be found in **Appendix G**.

As can be seen on the crash diagram, the rear end crashes were spread throughout the corridor. The largest concentration of crashes was focused on the Wal-Mart access with a mix of rear end and broadside crashes.

Mitigation Measures and Concepts

Based on the concentration of crashes at the unsignalized Wal-Mart access primarily related to the number of angle crashes at this location, consideration should be given to restricting the driveway to a right-in / right-out access only. A concept of the new configuration of this access can be found in **Appendix G**. If implemented, this concept would construct a raised channelization island. The implementation of this concept would assist compliance and reduce the number of broadside crashes at this intersection. It is also worth noting that this shopping center will still have a full movement signalized access at Meridian Lane at which exiting vehicles can head south on LaCrosse Street.

G. Segment 7 – Northbound US Highway 16 (Neck Yoke Road to Busted 5 Court)

Segment Description

This segment of northbound US Highway 16 is located south of Rapid City and is near Bear Country USA. The segment is approximately 3.68 miles in length and runs from Busted 5 Court on the south to Neck Yoke Road on the north. Highway 16 is a four lane divided highway with a depressed center median. The posted speed limit on Highway 16 is 65 miles per hour (mph). The average daily traffic in the northbound direction for this segment during the study period was about 6,200 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 41 crashes on this segment in the northbound direction. Of these, 33 were PDO crashes and 8 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were wild animal type crashes (21) followed by run-off-road type crashes (9) and angle type crashes (6). Run-off-road type crashes include guardrail / cable rail crashes as well as any crash where the vehicle left the travel lane. A diagram showing the type and location of each crash for this segment can be found in **Appendix H**.

As can be seen on the crash diagram, the majority of the wild animal type crashes were located in the curve to the east of Bear Country USA. Many of these crashes occurred around dawn or dusk. In addition, many of the angle crashes occurred when a vehicle that was either slowing to turn into one of the paved median cuts or accelerate from one of the pave median cuts was struck by another vehicle on Highway 16.

Mitigation Measures and Concepts

Based on the concentration of wild animal type crashes, consideration should be given installing wild animal fences through the curve to the east of Bear Country USA. Openings in the fence should be provided for existing driveways as well as at locations designated as crossings for the wild animals. If provided, consideration should be given to signing all designated crossings with deer crossing signs (W11-3) as well as flashing beacons.

In addition, consideration should be given to installing acceleration / deceleration lanes at several of the paved median cuts on the west end of the corridor. The acceleration / deceleration lanes will allow exiting / entering vehicles to safely exit or enter the paved median cuts.

Finally, consideration should be given to installing rumble strips and using safety edge paving techniques on the shoulder where there is not guardrail or cable rail against the shoulder. An informational brochure on safety edge has been place in **Appendix H**.

The proposed location of the wild life fencing as well as the acceleration / deceleration lanes can be found in **Appendix H**.

H. Segment 8 – LaCrosse Street (E. North Street to Anamosa Street)

Segment Description

This segment of LaCrosse Street is located just south of Anamosa Street. The segment is approximately 0.55 miles in length and runs from Anamosa Street on the north to E. North Street on the south. LaCrosse Street has two northbound lanes, two southbound lanes and a center left turn lane. The center median on LaCrosse Street is painted. There is curb and gutter throughout this segment. The posted speed limit on LaCrosse Street is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 24,800 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 53 crashes on this segment. Of these, 43 were PDO crashes and 10 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were angle type crashes (31) followed by rear end type crashes (15). A diagram showing the type and location of each crash for this segment can be found in **Appendix I**.

As can be seen on the crash diagram, the majority of the angle type crashes occurred at the intersections with public streets. The only private driveway with a significant number of angle crashes was the north driveway to / from the former Sam's Club parking lot.

The rear end type crashes were generally spread throughout the corridor and were typically due to a vehicle stopping to turn into a driveway or a vehicle stopping for the existing railroad crossing.

Mitigation Measures and Concepts

Based on the concentration of crashes at the unsignalized former Sam's Club access primarily related to the number of angle crashes at this location, consideration should be given to restricting the driveway to a right-in / right-out access only. A concept of the new configuration of this access can be found in **Appendix I**. This concept would construct a raised channelized island on LaCrosse Street. The implementation of this concept would assure compliance and reduce the number of broadside crashes at this intersection.

In addition, consideration should be given to completing a traffic signal warrant study at the intersection with Monroe Street. The number of broadside crashes during the study period meets Part B of the criteria for Warrant 7 in the MUTCD. Further analysis should be considered to determine if Parts A and C of Warrant 7 are also met. However, it is worth noting that the 24/7 program located on Monroe Street moved in 2009 which may lead to a reduction in the traffic and number of crashes at this intersection. If angle crashes are still a problem at this intersection, the installation of a traffic signal at this location, if warranted, would help to reduce the number of broadside crashes at this intersection.

In addition, consideration should be given to relocating the existing utility pole located on the southwest corner of the Monroe Street intersection. This pole was struck twice during the study period likely due to its close spacing to the edge of the roadway.

It is worth noting, that the intersection with Van Buren Street would also likely warrant a traffic signal based on the criteria of Warrant 7 but due to the intersection's close proximity to the railroad crossing, a traffic signal is not recommended for this intersection.

Finally, consideration should be given to installing automatic crossing gates at the existing railroad crossing. Currently, there are flashing lights, pavement markings and signs for this railroad crossing. However, based on the given ADT on LaCrosse Street and the number of trains that use this crossing daily (4), the crossing exposure factor is approximately 100,000. According to the Railroad – Highway Grade Crossing Handbook (FHWA, 2007), consideration should be given to installing automatic gates in addition to other active devices, such as flashing lights, at an at grade rail road crossing with an exposure factor this high. This measure would help to prevent any future vehicle / rail crashes on this corridor. However, it is important to note that several arterial at-grade railroad crossings in Rapid City are configured similar to the current LaCrosse Street crossing, reducing the urgency of changes to this crossing.

Each of the measures outlined above can be seen on the segment concept drawing in **Appendix I**.

I. Segment 9 – West Omaha Street (Mountain View Road to West Boulevard)

Segment Description

This segment of West Omaha Street is west of West Boulevard. The segment is approximately 0.83 miles in length and runs from Mountain View Road to West Boulevard. West Omaha Street has two eastbound lanes, two westbound lanes and a center left turn lane. The center median on West Omaha Street is painted. There is curb and gutter throughout this segment. The posted speed limit on West Main Street is 40 miles per hour (mph). The average daily traffic for this segment during the study period was about 15,400 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 40 crashes on this segment. Of these, 28 were PDO crashes and 12 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were angle type crashes (18) followed by rear end type crashes (16). A diagram showing the type and location of each crash for this segment can be found in **Appendix J**.

As can be seen on the crash diagram, the angle and rear end type crashes were spread throughout the corridor and were typically associated with driveways or intersections along the segment. However, the only substantial grouping of crashes with a correctable pattern was at the intersection with 12th Street. All of the angle crashes at this intersection occurred when one vehicle failed to yield the right-of-way to a vehicle traveling on West Omaha Street.

Mitigation Measures and Concepts

The City and SDDOT have both completed signal warrant studies at the 12th Street intersection in the past. To date, these studies have found that a traffic signal is not warranted at this intersection either from a traffic volume or crash standpoint. It is likely that this intersection may warrant signalization in the future but likely will not be needed until further development is completed north of Omaha Street. However, in an effort to be proactive, the City continually monitors traffic volumes at this intersection to determine if a traffic signal is needed. It is recommended the City continue with this count program into the future and consider installing a traffic signal when warranted.

The concept for this segment in **Appendix J** shows the location of the proposed traffic signal.

J. Segment 10 – Saint Patrick Street (Elm Avenue to Saint Joseph Street)

Segment Description

This segment of Saint Patrick Street is west of Saint Joseph Street. The segment is approximately 0.76 miles in length and runs from Elm Avenue to Saint Joseph Street. Saint Patrick Street has two eastbound lanes, two westbound lanes and a center left turn lane. The center median on Saint Patrick Street is painted. There is curb and gutter throughout this segment. The posted speed limit on West Main Street is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 12,400 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 28 crashes on this segment. Of these, 20 were PDO crashes and 8 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were angle type crashes (17) followed by rear end type crashes (4). A diagram showing the type and location of each crash for this segment can be found in **Appendix K**.

As can be seen on the crash diagram, the angle and rear end type crashes were spread throughout the corridor and were typically associated with driveways or intersections along the segment. Approximately 1/3 of the angle and rear end crashes occurred in poor roadway conditions and one driver was typically driving faster than appropriate for the conditions. Otherwise, no other correctable pattern has been identified for this segment.

Mitigation Measures and Concepts

Consideration should be given to reviewing snow removal procedures for this segment as well as providing additional speed enforcement.

K. Central Business District (Downtown) Crashes

For the purposes of this study, the downtown area of Rapid City was designated as the area bounded by Kansas City Street to Omaha Street and West Boulevard to 5th Street. The central business district crashes were analyzed separately from the other arterial roadway crashes due to the unique geometric and travel conditions of the downtown area. Based on a review of the crashes occurring within the central business district during the study period, the most common crash types were rear end crashes (50%), angle crashes (23%) and sideswipe same direction crashes (15%). A little over 92 percent of these crashes were property damage only crashes with the remaining 8 percent of crashes classified as injury crashes. It is worth noting, there was only one incapacitating injury crash in the downtown area during the study period and no fatal crashes.

The high occurrence of property damage crashes and low occurrence of injury crashes is not uncommon for a downtown area. This is primarily due to the low travel speeds and one way roadways common to the downtown area. Based on this, there does not appear to be a correctable crash pattern in the Rapid City downtown area. Therefore, no recommendations have been made in this study.