DEVELOPMENT OF A MUNICIPAL-LEVEL STRATEGIC HIGHWAY SAFETY PLAN: CASE STUDY FOR THE CITY OF SASKATOON

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By

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ABSTRACT

There have been many documents published that set strategic goals for the future, including transportation-related goals. However, few documents focus heavily on a specific approach to improve transportation safety. Therefore, a supporting policy document focused on transportation safety is required to ensure that the transportation system runs safely and efficiently; a Strategic Highway Safety Plan (SHSP) serves as that document. A SHSP is a high-level traffic safety policy that represents a scientific, data-driven, four to five year comprehensive safety document that is designed to identify a jurisdiction's emphasis areas (i.e., key areas of safety concern) and target safety goals [i.e., collision reduction goal(s)], and may also include network screening (i.e., identification of high collision locations) and safety strategies/programs for each chosen emphasis area.

There are, however, limited documents that discuss the procedure for the development of a SHSP specifically for a municipality. Therefore, the goal of this research was to improve traffic safety by reducing the number and severity of collisions in municipalities across Canada. The objective for this research was to develop a data-driven and more scientific municipal-level SHSP development process (i.e., procedure and key components) that may be used to improve traffic safety for municipalities across Canada.

Existing procedures, key components and approaches to develop the key components in existing SHSPs published mainly in North America were reviewed. The literature review (FHWA, 2006; CCMTA, 2011b) suggested that the typical procedure for the development of a SHSP is identifying a "champion" (i.e., an individual or unit with high-level leadership), developing a vision, identifying key stakeholders, developing the key components (i.e., selecting the key emphasis areas, establishing target safety goals, selecting the strategies/programs for the chosen key emphasis areas), and updating and evaluating the SHSP. The existing procedures and

key components were adjusted to create the modified process. The modified process consisted of two additional steps to the procedure: 1) Incorporating Upper-Level Policies and 2) Conducting Network Screening. The modified process also outlined the most appropriate approaches to use to develop the key components of a municipal-level SHSP.

The modified process (i.e., procedure and key components) was applied to develop a municipal-level SHSP for the City of Saskatoon through a case study to compare the results to the existing process. Saskatoon's SHSP included seven emphasis areas for a definite period of time (i.e., for the next five years). Target safety goals, network screening and strategies/programs were also developed, but only for the selected emphasis areas. Recent ten-year (2001-2010) collision data from the SGI was used to select emphasis areas, develop target safety goals and conduct network screening.

Based on the case study results, upper-level policies should be incorporated in the development of the key components of a municipal-level SHSP. This is because a municipal-level SHSP is the lowest-level SHSP and should incorporate the emphasis areas, target safety goals and strategies/programs that are included in upper-level SHSPs (i.e., provincial- and federal-level). In addition, the SHSP can act as an operational-level safety action plan that supports a jurisdiction's Strategic Plan. The addition of network screening also provides useful locations in a municipal-level SHSP. The case study results showed that the modified process provided detailed information required by a municipality to make informed safety investment decisions compared to the basic information the existing process provided. Therefore, the modified process is a data-driven and more scientific process that can be used to develop SHSPs that will improve traffic safety for municipalities across Canada.

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LIST OF ABBREVIATIONS

4Es = Education, Enforcement, Engineering and Emergency Medical Services

Accessible Pedestrian Signals = APS

All-Terrain Vehicles = ATVs

American Association of State Highway and Transportation Officials = AASHTO

Autoregressive Integrated Moving Average = ARIMA

Blood Alcohol Content = BAC

Canadian Council of Motor Transport Administrators = CCMTA

Case Numbers = CASENO

CC_{PDO} = Collision cost for PDO collision severity

CC_y = Collision cost for collision severity, y

City of Saskatoon = COS

Consumer Price Index = CPI

Critical Analysis Reporting Environmental = CARE

Critical Collision Rate = CCR

Critical Collision Rate Index = CCRI

Department of Transportation = DOT

DESS = Drink/driving, Engineering, Secondary Safety

Driver Evaluation Program = DEP

Driving While Impaired = DWI

Emergency Medical Services = EMS

Empirical Bayes = EB

Equivalent Property Damage Only = EPDO

Fatal or Injury = FI

Federal Highway Administration = FHWA

$f_{inj(weight)}$ = Injury collision weight

$f_{k(weight)}$ = Fatal collision weight

$f_{PDO(weight)}$ = PDO collision weight

$f_{y(weight)}$ = weighting factor based on collision severity, y

Geographic Information System = GIS

Graduated Driver Licensing = GDL

Highly Visible Enforcement = HVE

Highway Safety Manual = HSM

Ignition Interlock Program = IIP

Immediate Roadside Prohibition = IRP

Integer-valued Autoregressive = INAR

Integrated Growth Plan = IGP

Integrated Safety Management Process = ISMP

Intersection Safety Cameras = ISCs

Liquor Enforcement Team = LET

Million Entering Vehicles = MEV

Mothers Against Drunk Driving = MADD

Multi Agency Seatbelt Team = MASTeam

National Cooperative Highway Research Program = NCHRP

National Highway Traffic Safety Administration = NHTSA

Natural Sciences and Engineering Research Council of Canada = NSERC

Negative Binomial = NB

$N_{observed,i(F)}$ = Number of fatal collisions per intersection, i

$N_{observed,i(I)}$ = Number of injury collisions per intersection, i

$N_{observed,i(PDO)}$ = Number of PDO collisions per intersection, i

Operation Red Nose = ORN

Organization for Economic Cooperation and Development = OECD

Property Damage Only = PDO

Rapid Mass Transit = RMT

Report Impaired Drivers = RID

Road Safety Strategy Plan = RSSP

Road Safety Vision = RSV

Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users = SAFETEA-LU

Safety Performance Function = SPF

Saskatchewan Centre of Excellence for Transportation and Infrastructure = SCETI

Saskatchewan Government Insurance = SGI

Saskatoon Board of Education = SBOE

Saskatoon Health Region = SHR

Saskatoon Police Service = SPS

Standing Committee for Highway Traffic Safety = SCOHTS

Strategic Highway Safety Plan = SHSP

Students Against Drinking & Driving = SADD

Traffic Safety Committee = TSC

Transportation Research Board = TRB

United States = U.S.

Vehicle-Miles Traveled = VMT

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CHAPTER 1
INTRODUCTION

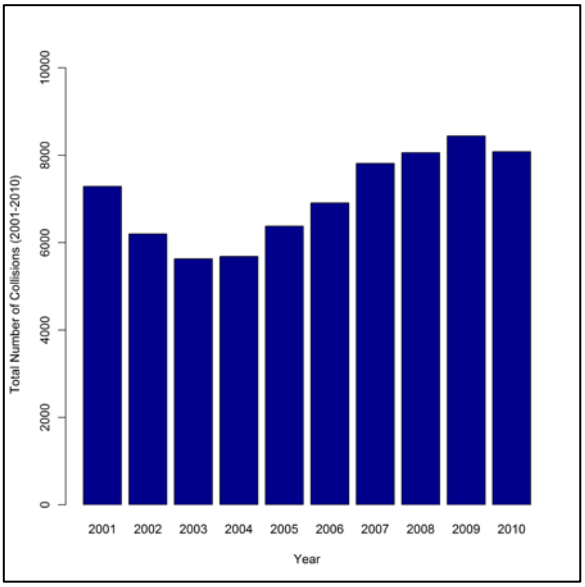
1.1. Collision History

Canada has made significant improvements in road safety, but there is still room for improvement (Transport Canada, 2011). Transport Canada (2011) reported that "[i]n 2008, Canada was ranked 10th in terms of fatalities per billion vehicle kilometers traveled compared to [the other 12] member countries of the Organization for Economic Cooperation and Development [(OECD)]". It is devastating every time another life has ended abruptly by a motor vehicle collision. Therefore, it is crucial that a systematic, data-driven process used to allocate resources to improve the level of safety efficiently and effectively be adopted by every jurisdiction.

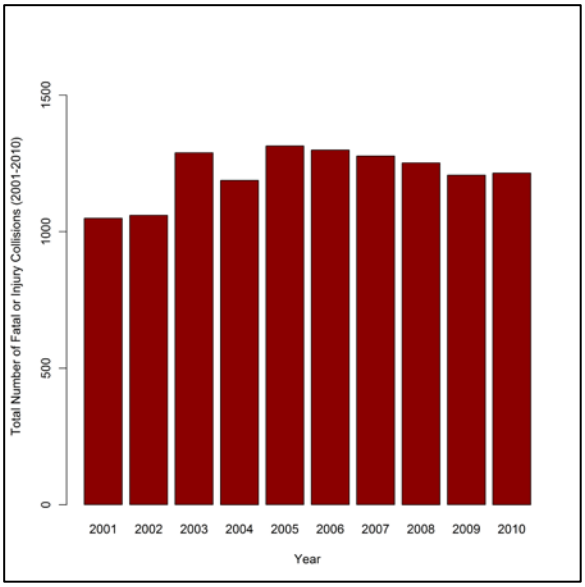
In terms of a provincial and territorial perspective, Saskatchewan was ranked third in terms of fatalities per billion vehicle kilometers in 2008 (Transport Canada, 2011). Saskatchewan Government Insurance (SGI) (2013) reported that a total of 29,651 collisions occurred in Saskatchewan, consisting of 138 fatal, 5,158 injury and 24,355 property damage only (PDO) collisions in 2011. Saskatoon in particular contributed to the highest number of collisions amongst the cities in Saskatchewan with a total of 8,151 collisions, consisting of 8 fatal, 1,311 injury and 6,832 PDO collisions in 2011 (SGI, 2013).

Based on ten-year (2001-2010) collision data, Saskatoon experienced a total of 70,487 collisions, consisting of 63 fatal, 12,087 injury and 58,337 PDO collisions (see Table 1) (SGI, 2011). Figure 1(a) shows the annual trend in the total number of collisions over the study period. The total number of collisions trend has clearly been increasing based on the most recent five-year collision data (2006-2010) despite the up-and-down fluctuations during the ten-year study period (2001-2010). Figure 1(b) shows the annual trend in the total number of fatal or injury

collisions. The total number of fatal or injury collisions trend has slightly decreased during the most recent five years, but has increased based on the entire ten-year period.



(a) Total



(b) Fatal or Injury

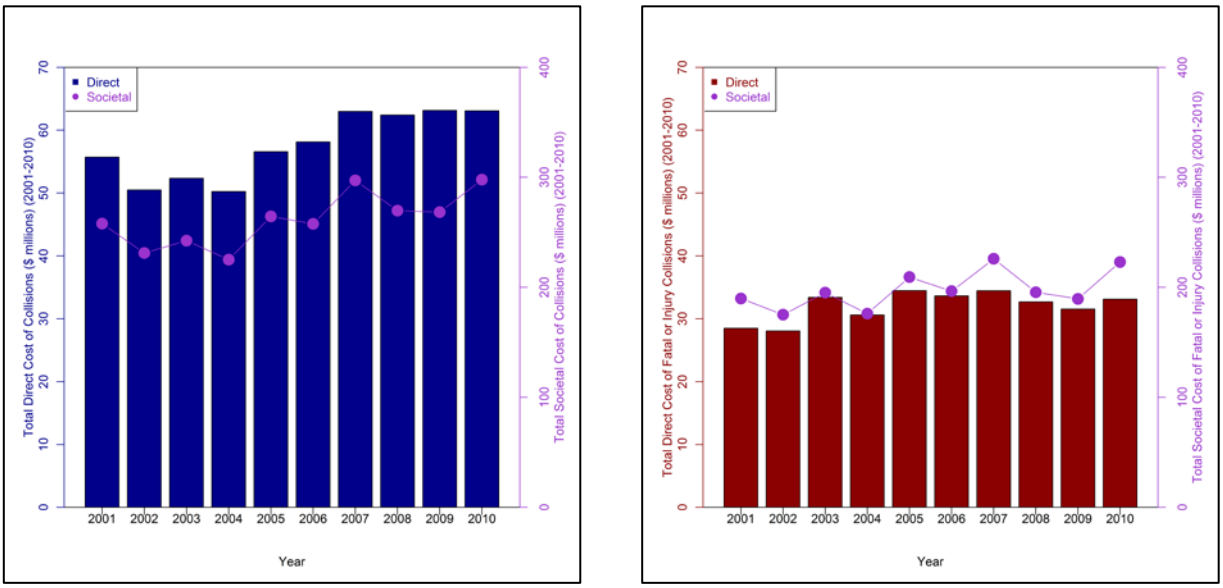
Figure 1: Number of Collisions by Year, 2001-2010 (SGI, 2011).

Table 1: Number of Collisions by Severity and Year, 2001-2010 (SGI, 2011).

Year	Fatal	Injury	PDO	Total
2001	9	1,040	6,239	7,288
2002	6	1,054	5,139	6,199
2003	4	1,285	4,342	5,631
2004	3	1,185	4,497	5,685
2005	6	1,308	5,063	6,377
2006	4	1,295	5,609	6,908
2007	10	1,267	6,536	7,813
2008	5	1,247	6,808	8,060
2009	5	1,202	7,236	8,443
2010	11	1,204	6,868	8,083
Grand Total	63	12,087	58,337	70,487
Average	6	1,209	5,834	7,049

Figure 2 shows the total direct and societal costs of collisions (direct costs on the left y axis and societal costs on the right y axis) in 2007 dollar values. Direct costs are defined as costs associated with a collision, such as property damage, medical expenses, travel expense to and from appointments, and income replacement after seven consecutive days of work missed (SGI,

2012a). Societal costs are defined as the costs a society is willing to pay for in order to reduce or prevent the risks associated with a collision involving a serious injury and/or death (CRISP, 2010). Societal cost includes the value of an individual's life and the pain, grief and suffering from a serious injury and/or death (CRISP, 2010). It is important to note that societal costs may vary as each person values an individual's life differently. Societal cost, rather than direct cost is used in the decision-making process. For example, societal cost is used for a cost-benefit analysis in order to introduce a certain safety initiative. Figure 2 shows that there is a slight increasing trend in both the direct and societal costs of total collisions and fatal or injury collisions over the ten-year period in Saskatoon. Chapter 3 will discuss the way the costs were estimated in detail.



(a) Total (b) Fatal or Injury

Figure 2: Direct and Societal Cost of Collisions by Year (2007 $ millions), 2001-2010 (SGI, 2011).

Based on these statistics, it would be fair to argue that motor vehicle collisions continue to have a significant impact on Saskatoon, resulting in economic, environmental and social concerns. Similar to many other municipalities in Canada, Saskatoon does not have sufficient amount of financial and other resources to implement a full gamut of safety initiatives, programs and surface infrastructure improvements [e.g., 4Es – Education, Enforcement, Engineering and

Emergency Medical Services (EMS)] to prevent collisions ambitiously. Nonetheless, there is still an on-going and possibly increasing need for Saskatoon to develop a high-level traffic safety policy document based on appropriate data-driven approaches to allocate resources more efficiently to generate the greatest safety return for safety investment.

1.2. The City of Saskatoon's Existing Policy Documents

The City of Saskatoon recently updated its first Strategic Plan, titled "Strategic Plan 2012-2022" (2012c) to "Strategic Plan 2013-2023" (2013b). The Strategic Plan describes an integrated approach to make Saskatoon a great place to live, create wealth and prosperity, and make investments to benefit all (COS, 2013b). This will be accomplished through the efficient and effective delivery of the 11 public services (i.e., fire and protective services, police, land development, corporate asset management, utilities, transportation, urban planning and development, recreation and culture, environmental health, community support, and corporate governance and finance) (COS, 2013b). It identified seven strategic goals to achieve a long-term vision of creating a highly desirable and sustainable city that will meet the needs of the present and future citizens of Saskatoon (COS, 2013b). Each of these seven strategic goals has 10 year strategies and four year priorities. By monitoring the performance of each strategy, the City hopes to bring the vision into reality (COS, 2013b). The seven strategic goals in the City of Saskatoon's Strategic Plan (2013b) over the next ten years are:

1. *Continuous Improvement: Saskatoon is the best-managed city in Canada;*
2. *Asset and Financial Sustainability: Saskatoon invests in what matters;*
3. *Quality of Life: Saskatoon is a warm, welcoming people place;*
4. *Environmental Leadership: Saskatoon grows in harmony with nature;*
5. *Sustainable Growth: Saskatoon is known for smart, sustainable growth;*

6. *Moving Around: Saskatoon is a city on the move; and,*
7. *Economic Diversity and Prosperity: Saskatoon thrives thanks to a diverse local economy.*

In terms of transportation, the City of Saskatoon's Strategic Plan (2013b) aims to implement energy-efficient practices, adopt an integrated approach to growth, develop a practical and useful transportation network, and promote active transportation.

The City of Saskatoon's "Integrated Growth Plan" (IGP) (2012b) describes approaches to meet the goals outlined in the City of Saskatoon's Strategic Plan. It directly addresses two of the seven strategic goals outlined in the Strategic Plan – Moving Around and Sustainable Growth (COS, 2012b). The IGP (2012b) developed the following nine strategies to achieve the two aforementioned strategic goals:

1. *Update the basic building blocks of new development – integrated communities;*
2. *Establish infill corridors;*
3. *Continue to support strategic infill areas;*
4. *Amend policies and develop incentives to support strategic infill;*
5. *Develop a city-wide land use plan for employment areas;*
6. *Establish a Rapid Mass Transit (RMT) corridor(s);*
7. *Reinvent the bus transit system based on the RMT corridor;*
8. *New roads and bridges; and,*
9. *Develop and implement funding strategies.*

These documents were developed to prepare the City of Saskatoon to be the "fastest growing city in all of Canada" (COS, 2013b). An increase in population could potentially lead to an increase in the level of congestion currently experienced in the City of Saskatoon, as well as an increase in the number of collisions. These two documents have provided a general plan of

the goals that are developed for the future, including transportation-related goals. However, neither document focuses heavily on a specific approach to improve transportation in terms of safety. Therefore, a supporting policy document that is oriented towards transportation safety to ensure that the transportation system runs safely and efficiently is required; a Strategic Highway Safety Plan (SHSP) can serve as that document.

To gain a better understanding of how the SHSP can serve as a supporting policy document, the main characteristics of policy making must first be understood. According to the literature (Newton and van Deth, 2005; Knill and Tosun, 2008), the three characteristics of policy making are: 1) policy making is constrained by limited time and resources, public opinion and the constitution as examples, 2) policy making involves various policy processes, and 3) policy making forms a never-ending cycle of decisions and policies. The development of a SHSP is similar to the policy making characteristics because a SHSP is developed to allocate resources to areas of traffic safety concern efficiently, and its success depends heavily on public and stakeholder consultation. A SHSP should also incorporate existing policies and form a never-ending cycle of decisions. Thus, a SHSP can serve as a supporting policy document to improve the level of transportation safety.

1.3. Strategic Highway Safety Plan

The SHSP represents a scientific, data-driven, four to five year comprehensive safety policy document in North America to address jurisdiction-specific traffic safety problems. The American Association of State Highway and Transportation Officials (AASHTO) Standing Committee for Highway Traffic Safety (SCOHTS), the Federal Highway Administration (FHWA), the United States (U.S.) National Highway Traffic Safety Administration (NHTSA), and the U.S. Transportation Research Board's (TRB) Committee on Transportation Safety

Management jointly worked together and developed the guidelines to develop a SHSP for each state in America titled "AASHTO Strategic Highway Safety Plan" (AASHTO, 2005). This document strongly encouraged each U.S. state to develop its own comprehensive safety plan and suggested 22 emphasis areas (a.k.a., areas of safety concern), separated by six elements (i.e., drivers, special users, vehicles, highways, EMS and management) as potential safety concerning areas shown in Table 2 (AASHTO, 2005).

Table 2: AASHTO's 22 Emphasis Areas (AASHTO, 2005).

Drivers 1. Graduated Drivers Licensing 2. Licensed, Competent Drivers 3. Older Drivers 4. Aggressive Driving 5. Impaired Drivers 6. Keeping Drivers Alert 7. Driver Safety Awareness 8. Seatbelts and Air Bags Special Users 9. Pedestrians 10. Bicyclists Vehicles 11. Motorcyclists 12. Heavy Trucks 13. In-Vehicle Enhancements	Highways 14. Vehicle-Train Collisions 15. Keeping Vehicles on the Road 16. Minimizing Consequences of Leaving the Road 17. Intersections 18. Head-On and Across-Median Collisions 19. Work Zones Emergency Medical Services (EMS) 20. Increasing EMS Capabilities Management 21. Improving Decision Support Systems 22. Processes and Safety Management Systems

AASHTO's efforts were strengthened with the legislation of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). FHWA (2005) reported that SAFETEA-LU represents the largest surface transportation investment in the history of the U.S. that provided guaranteed funding for highways, highway safety and public transportation. This document mandated that each state develops and implements a SHSP (FHWA, 2005).

Since the creation of the AASHTO SHSP, several documents have been developed to support it further. The FHWA published various documents, such as "Strategic Highway Safety Plans: A Champion's Guide to Saving Lives" (2006), "Transportation Planner's Safety Desk Reference" (2007b), "Highway Safety Improvement Program" (2010a) and "Transportation Planner's Safety Desk Reference" (2010b). Other documents include Ostensen's (2005) "New Focus for Highway Safety" and the Canadian Council of Motor Transportation Administrators' (CCMTA) "Canada's Road Safety Strategy 2015" (2011a). In particular, the National Cooperative Highway Research Program (NCHRP) Report 501: Integrated Safety Management Process (ISMP) funded by the U.S. TRB presents six major steps that help to develop a successful SHSP for a jurisdiction more efficiently (Bahar et al., 2003) shown in Figure 3. The six major steps of the ISMP are:

1. *Review highway safety information;*
2. *Establish emphasis areas and goals;*
3. *Develop objectives, strategies and preliminary action plans to address the emphasis areas;*
4. *Determine the appropriate combination of strategies for identified emphasis areas;*
5. *Develop detailed action plans; and,*
6. *Implement and evaluate the performance of the action plans.*

Figure 3 shows very general steps in developing a SHSP and is targeted towards developing a state-level SHSP (Bahar et al., 2003). CCMTA's (2011b) guidelines, on the other hand, are targeted towards developing a provincial-level SHSP. A municipal-level SHSP is different than that of a state- or provincial-level SHSP and as such, requires detailed steps. For example, the ISMP (Bahar et al., 2003) or CCMTA's (2011b) guidelines do not mention

reflecting upper-level policies such as federal- and provincial-level SHSPs if they are available. A SHSP requires safety stakeholders at all levels of government (municipal, provincial and federal) to collaborate and coordinate resources to address the target emphasis areas, target safety goals, locations and strategies proactively (Bagdade and Ceifetz, 2013). The development of a municipal-level SHSP will bring about enhancements to road safety data, stronger and lasting partnerships, and enhance communication with other agencies and different disciplines, which will result in informed safety investment decisions if it is developed in collaboration with upper-level policies (i.e., provincial and federal) (Warren, 2013).

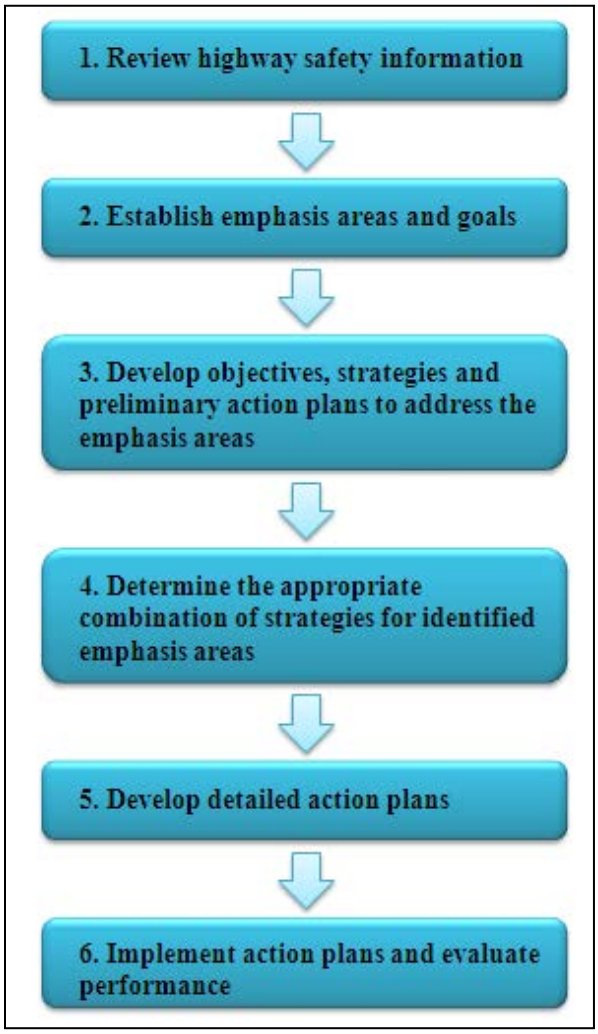


Figure 3: Integrated Safety Management Process (Bahar et al., 2003).

A comparison of a provincial-level and municipal-level SHSP is shown in Table 3. One difference between the two is that a provincial-level SHSP is only limited by the information in the federal-level SHSP whereas a municipal-level SHSP is limited by the federal- and provincial-level SHSPs. Bagdade and Ceifetz (2013) also state that a municipal-level SHSP can help identify unique conditions that contribute to local road safety issues for a provincial-level SHSP, and a provincial-level SHSP in turn can provide inputs for a municipal-level SHSP. Another difference is that provincial-level SHSPs are developed to address road safety issues on rural roadways (i.e., highways) while municipal-level SHSPs are developed to address road safety issues on urban roadways (i.e., freeways, arterials, collectors, locals).

Table 3: Comparison of Provincial-level and Municipal-level SHSPs.

Provincial-level SHSP	Municipal-level SHSP
• Limited by federal-level SHSPs	• Limited by federal- and provincial-level SHSPs
• Can provide inputs for a municipal-level SHSP (Bagdade and Ceifetz, 2013)	• Can identify unique conditions that contribute to local road safety issues for a provincial-level SHSP (Bagdade and Ceifetz, 2013)
• Developed for rural roadways (i.e., highways)	• Developed for urban roadways (i.e., freeways, arterials, collectors, locals)

In Canada, different titles are often used by different agencies to present the same safety policy document. Example titles include “Traffic Safety Plan” (Alberta, 2013), “Traffic Safety Strategy” (Edmonton, 2007; SGI, 2012d) and “Strategic Road Safety Program” (Hamilton, 2009). Regardless of the title of the document, the contents of each document are very similar in such a way that most of them contain some or all of the following: jurisdiction-specific emphasis areas, collision reduction goals, network screening results (i.e., identified collision-prone locations) and important safety strategies/programs for the jurisdictions.

1.4. Research Goal

The goal of this research was to improve traffic safety by reducing the number and severity of collisions in municipalities across Canada.

1.5. Objectives

The objective for this research was to develop a data-driven and more scientific municipal-level SHSP development process (i.e., procedure and key components) that may be used to improve traffic safety for municipalities across Canada.

1.6. Methodology

The methodology proposed for this research involves the following elements and tasks:

Element 1: Literature Review

Task 1: Review of existing procedures to develop a SHSP

Task 2: Review of key components and approaches to develop the key components in existing SHSPs published mainly in North America

Element 2: Process Development

Task 1: Modify the existing procedures

Task 2: Modify the existing key components

Element 3: Case Study for the City of Saskatoon

Task 1: Collect, screen and prepare study data for analysis

Task 2: Apply the procedure and key components in the modified process

Element 4: Recommend Municipal-Level SHSP Development Process

Task 1: Compare the existing process (i.e., procedure and key components) in developing a municipal-level SHSP to the modified process (i.e., procedure and key components)

1.7. Benefits of this Research

The process that was explored in this research can be applied by many municipalities across Canada who might have a desire to develop their own SHSP. The research discusses the minimum amount of data that will be required for a data-driven, scientific SHSP development process so that transportation safety professionals and policymakers in a municipality can use the key components in a SHSP to improve traffic safety proactively. In addition, as stated in Section 1.2, it is highly likely that the investment for safety improvement projects will eventually help Saskatoon's economic growth as planned in the City of Saskatoon's Strategic Plan. For instance, a SHSP will promote road safety awareness, expanding the implementation of new and existing safety strategies/programs to better leverage funding (Bagdade and Ceifetz, 2013).

1.8. Scope

This research focused on the development of a data-driven, scientific process to create a municipal-level SHSP for Saskatoon as a case study area. Saskatoon's SHSP included seven emphasis areas for a definite period of time (i.e., for the next five years). Target safety goals, network screening and strategies/programs were also developed, but only for the selected emphasis areas.

Recent ten-year (2001-2010) collision data from the SGI was used to select emphasis areas and target safety goals. The collision data was also used to conduct safety network screening to identify high collision locations (i.e., hotspots) for the chosen emphasis areas. New collision data was not collected for the study. ArcGIS (ver. 10.0) using a Geographic Information System (GIS) street map from the City of Saskatoon was used as a main tool to visually display the hotspots relevant to the chosen emphasis areas.

This study did not include the following components – development of an implementation plan (e.g., budget plan and data improvement plan), and the evaluation and monitoring (e.g., cost-benefit analysis) of target goals and safety programs. The last component (i.e., evaluation) is not a part of a first generation SHSP for a jurisdiction but is a component for an updated SHSP in the future.

1.9. Layout of Thesis

Chapter two presents a literature review of the existing procedures to develop a SHSP and the key components in existing SHSPs – emphasis areas, target safety goals, network screening and safety strategies/programs. Chapter three presents the modified process (i.e., procedure and key components) that was applied to the case study area of Saskatoon. Chapter four contains a case study of the development of a municipal-level SHSP for the City of Saskatoon using the modified process. Chapter five discusses the results from the case study conducted for the City of Saskatoon. Chapter six presents the conclusions and recommendations.

1.10. Chapter Summary

Motor vehicle collisions continue to have a significant impact on society, resulting in economic, environmental and social concerns for many municipalities including the City of Saskatoon. There is a strong need to create a high-level traffic safety policy document such as a SHSP for a municipality so that municipalities can allocate their resources as efficiently as possible to prevent collisions proactively. A SHSP represents a scientific, data-driven, four to five year comprehensive safety policy document that addresses jurisdiction-specific traffic safety problems. Guiding documents have been published, but have only showed very general steps in developing a SHSP and are targeted towards developing a state- or provincial-level SHSP (FHWA, 2006; CCMTA, 2011b). Developing a municipal-level SHSP is different as it requires

detailed steps. Therefore, the ultimate goal of this research was to develop a data-driven municipal-level SHSP process (i.e., procedure and key components) that can be used to improve traffic safety for municipalities across Canada. This will be achieved by comparing the existing process (i.e., procedure and key components) in developing a municipal-level SHSP to the modified process (i.e., procedure and key components). The modified process may then be used to develop a SHSP that can improve traffic safety for municipalities across Canada. The most recent ten-year (2001-2010) collision data from the SGI and the GIS street map from the City of Saskatoon were used to select emphasis areas, to set target safety goals, and to conduct network screening for each emphasis area.

The case study result of this research is expected to be used by other municipalities across Canada who have a desire to develop a SHSP. Transportation safety professionals and policymakers will be knowledgeable in addressing the challenges of developing a municipal-level SHSP and to use the developed SHSP process to prevent collisions for their jurisdictions in a proactive manner.

CHAPTER 2
LITERATURE REVIEW

A total of 34 documents were investigated to determine the general procedures, key components and suitable data requirements to develop a municipal-level SHSP. The literature review includes 20 federal-level, three provincial-level, two state-level and nine municipal-level documents. The following sections contain detailed description of general procedures to develop a SHSP and four key components of a SHSP (i.e., emphasis areas, target safety goals, network screening and safety strategies/programs).

2.1. Strategic Highway Safety Plan Procedures

FHWA (2006) outlined the following procedure to assist U.S. states in creating their SHSPs (see Figure 4):

- Gain Leadership Support and Initiative: Influences the policy direction, focuses on priorities for the stakeholders and establishes performance expectations for the staff;
- Identify a Champion: A "champion", often an individual or unit with high-level leadership of other agencies and organizations, ensures all stakeholders are collaborating;
- Initiate the Development Process: Some examples to initiate the development process include determining a jurisdiction's current safety activities, thinking of the long-term vision, reviewing other jurisdictions' SHSPs, experiences and challenges, and reviewing existing literature;
- Gather and Analyze Data: Identify, analyze, prioritize and evaluate the collision data;
- Establish a Working Group and Bring Stakeholders Together: Build upon existing relationships, interagency working groups and committees preferably from the 4Es;
- Adopt a Strategic Goal: Adopt a strategic goal that focuses on behavioural and infrastructure problems and opportunities on all public roads;

- Identify Key Emphasis Areas: Identify four to eight key emphasis areas (e.g., impaired driving, intersections) that also reflect the 4Es;
- Form Task Groups: Form task groups based on the emphasis areas;
- Identify Key Emphasis Area Performance Goals: Performance goals help to achieve the strategic goal and are needed to evaluate the effectiveness of strategies/countermeasures; and,
- Identify Strategies/Countermeasures and Determine Priorities for Implementation: Select strategies or programs that aim to reduce hazards, which can be considered while identifying priorities for implementation.

FHWA (2006) noted that these steps are not necessarily in order and could be iterative in nature.

Figure 4: Strategic Highway Safety Plan Development Procedure (FHWA, 2006).

Figure 5 shows the procedure in the CCMTA's (2011b) guiding document to develop a jurisdictional road safety plan that supports CCMTA's (2010) "Canada's Road Safety Strategy 2015". The following steps summarize CCMTA's (2011b) procedure and are similar to those outlined in FHWA's (2006) procedure, but slightly differ in order:

- Identify Key Road Safety Challenges: Assess the current state of road safety in the jurisdiction by discussions amongst key safety stakeholders;
- Establish Priorities, Objectives and Time Frame of the Road Safety Plan: Identify policies, programs and interventions, establish quantitative/qualitative targets, and choose a time frame that is consistent with "Canada's Road Safety Strategy 2015" (CCMTA, 2010);
- Identify Key Stakeholders and Agree on Their Roles and Responsibilities: Identify key participating stakeholders, and agree on the roles and responsibilities for the expected outputs;
- Identify Funding Mechanisms: Identify sustainable funding mechanisms that will support the interventions adopted or conduct cost-benefit or cost-effectiveness analysis on proposed strategies/interventions;
- Build Support: Build political, public and enforcement agencies support;
- Identify Safety Performance Indicators for Targeted Areas: Safety performance indicators, such as quantitative (i.e., age groups, gender, percentage of fatally injured drivers/pedestrians who tested positive for alcohol/drugs etc.) and qualitative (i.e., public perception of road safety, level of stakeholder concerns being met etc.) safety performance indicators are useful for comparing different risk aspects of a road safety system; and,

- Monitor and Evaluate Initiatives/Strategies and Report Progress: Conduct a cost-benefit or cost-effectiveness analysis or conduct before and after studies to monitor the effectiveness of road safety measures.

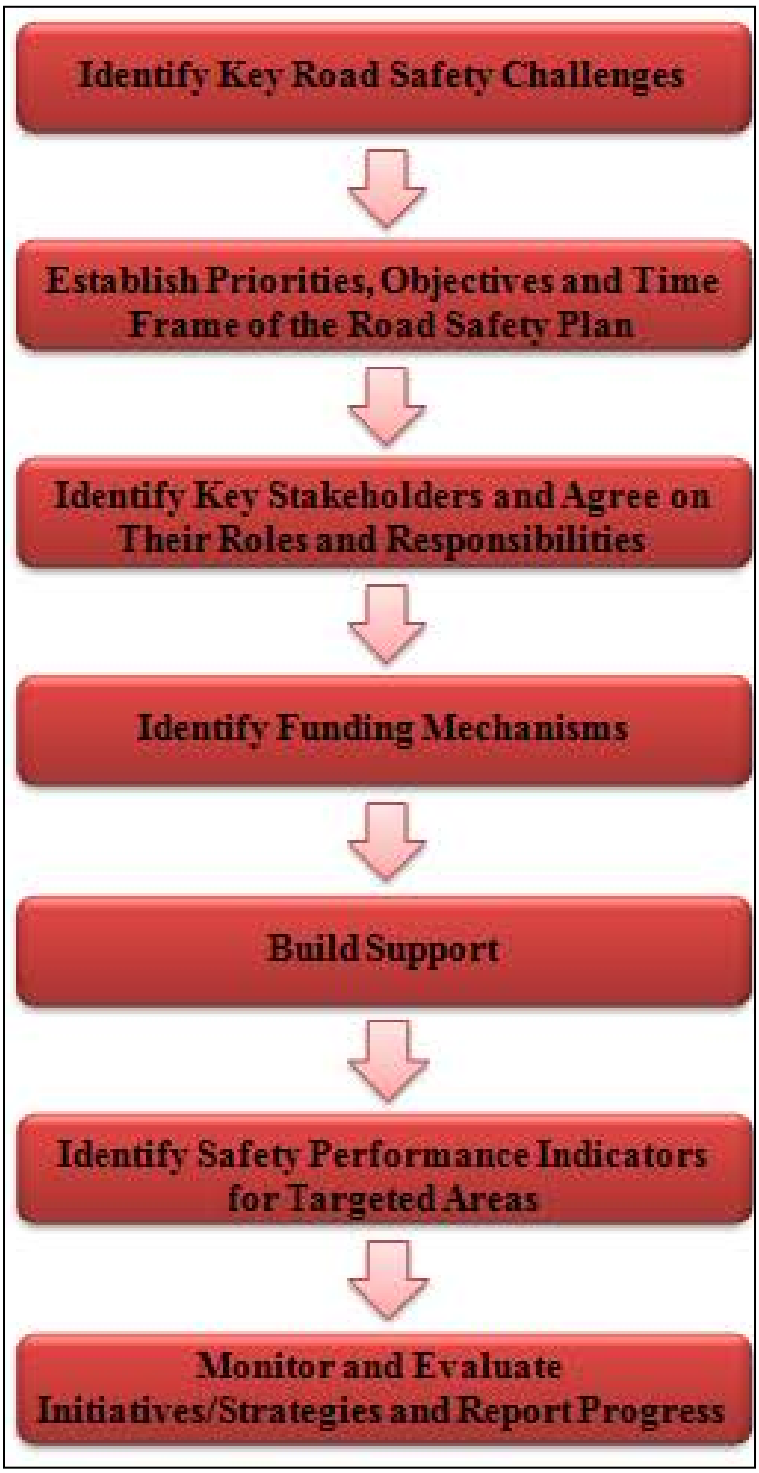


Figure 5: Road Safety Plan Development Procedure (CCMTA, 2011b).

2.2. Key Components

2.2.1. Emphasis Areas

Emphasis areas are safety concerning areas for a jurisdiction. Various approaches have been used to select emphasis areas in a SHSP for a jurisdiction. Some jurisdictions have relied mainly upon a data-driven collision analysis. Parrish et al. (2003), for instance, developed the Critical Analysis Reporting Environment (CARE) software system that is designed for easily analyzing various formats of collision frequency data. The CARE system was used to assist in the development of a SHSP for the Alabama State Department of Transportation (DOT) (Benifield et al., 2006). An advantage of this approach is that it provides a quantitative look at current trends for a jurisdiction based on real numbers. A disadvantage of this approach is that it requires heavy amounts of collision data that many jurisdictions might not have in a ready-to-use format. In addition, some emphasis areas can never be selected based purely on a data-driven, scientific approach mainly due to the lack of available collision and other data related to the emphasis area (e.g., EMS) (Park and Young, 2012).

On the other hand, some European countries such as Norway and Britain used a kind of bureaucratic political approach that relies heavily on communications and decisions made by stakeholders and policymakers to select emphasis areas (Elvik, 2008; Allsop, 2009). There are many potential advantages and disadvantages in using this approach. It is beneficial to use this approach because the emphasis areas chosen can reflect an agency's area of interest and expertise (Park and Young, 2012). This approach also allows an emphasis area that is not reflected in the collision data to be chosen (e.g., EMS) (Park and Young, 2012). However, this approach is not data-driven.

The third approach can be regarded as a hybrid approach between the two approaches described above (i.e., combination between mainly data-driven approach and mainly political decision). The approach first investigates what emphasis areas have been chosen by other jurisdictions and regards the areas as potential emphasis areas for the target jurisdiction. The approach then generates a set of high-level collision frequency tables and figures using descriptive data analysis such as histograms and/or pie charts for each potential emphasis area to assist in the selection of the most appropriate emphasis areas for the jurisdiction (FHWA, 2006; Masliah and Bahar, 2006; Masliah et al., 2006). This approach emphasizes the effective communication amongst stakeholders in the emphasis area selection process using descriptive collision data analysis as a seed source of communication.

Currently, the majority of jurisdictions in North America follow the third approach (i.e., hybrid approach) to select the emphasis areas in their SHSP. The following illustrates the emphasis areas selected in SHSPs developed in North America using the third approach.

Transport Canada's (2001) "Road Safety Vision (RSV) 2010" is an example of a federal-level SHSP which chose nine emphasis areas [i.e., unbelted occupants, drinking driving, speeding, intersections, high-risk drivers, young drivers/riders, commercial vehicles, vulnerable road users (i.e., pedestrians, motorcyclists and cyclists) and rural roadways]. CCMTA's (2011a) "Canada's Road Safety Strategy 2015" selected a total of 10 emphasis areas as representative safety concerning areas for all Canadian jurisdictions based on the third method. CCMTA's (2011a) emphasis areas are separated by four contributing factors (i.e., impaired driving, speed and aggressive driving, occupant protection, and environmental factors) and six target groups (i.e., young drivers, medically-at-risk-drivers, vulnerable road users, motor carriers, high-risk drivers and general population).

Provincial-level SHSPs were also reviewed. SGI's Traffic Safety Strategy (2012d) included seven unique emphasis areas to Saskatchewan (i.e., impaired driving, wildlife-vehicle collisions, distracted driving, seatbelt use, speed management, intersection safety and new drivers). Alberta's (2013) SHSP included a total of 10 emphasis areas, which are occupant restraints, speed management, impaired driving, infrastructure, young drivers/riders, vulnerable road users, motor carriers, high-risk and medically unfit drivers, aging drivers and new drivers. British Columbia's (2013) "Road Safety Strategy 2015 and Beyond" selected seven emphasis areas, which were safe road users (i.e., impaired driving, distracted driving, speeding, high-risk drivers and vulnerable road users), safe vehicles (i.e., vehicle safety technologies), and safe roadways (i.e., road infrastructure).

In addition, state-level SHSPs [i.e., Montana (2010), North Dakota (2010)] that were similar to Saskatchewan in terms of roadway characteristics and population were investigated. Montana (2010) chose 12 emphasis areas (i.e., safety belt use, alcohol- and drug-impaired driving collisions, Native American collisions, single-vehicle run-off-the-road collisions, traffic records management, young driver collisions, high collision corridors/high collision locations, truck collisions, EMS delivery, urban area collisions, motorcycle collisions, and older driver collisions). North Dakota (2010) only chose seven emphasis areas. The seven emphasis areas were alcohol impaired driving, seatbelt usage, younger driver/older driver safety, aggressive driving, lane departure collisions, emergency medical capabilities to enhance survivability, and intersection safety.

Burlington (2006) is an example of a municipal-level SHSP. The SHSP included 10 emphasis areas (i.e., aggressive driving, arterial traffic flow, cyclist safety, driver safety awareness, young driver safety, pedestrian safety, impaired driving, safety on rural roadways,

local road safety data collection and analysis, and implement road safety strategy plan (RSSP) task force). Edmonton (2007) selected a total of four emphasis areas (i.e., intersections, seatbelt wearing rate, impaired driving and speeding). New Westminster (2007) included 12 emphasis areas, which were excessive traffic speeds, red light and signing violations, limited accommodation of left turn movements at intersections, congestion and high traffic volumes, impact of truck traffic on road safety, pedestrian safety, cyclist safety, sightlines at intersections, adequacy of signs and pavement markings, steep gradients, signal operations and display, and at-grade railway crossings. Red Deer (2007) contained five emphasis areas (i.e., seatbelt usage, impaired driving, aggressive driving, vulnerable road users and winter road conditions). Strathcona County (2008) chose 11 emphasis areas (i.e., collision data management, handling of public complaints, separating and communicating perception and reality, training and knowledge transfer, explicit consideration of traffic safety, staff resources and funding, urban intersection safety, school traffic safety, pedestrian and bicycle safety, rural stop sign violations, and rural road hazards). Hamilton's (2009) SHSP included 14 emphasis areas, categorized into three primary (i.e., aggressive driving, intersections and vulnerable road users), 10 secondary (i.e., older drivers, hill sections, young drivers, curved sections, winter weather, impaired driving, commercial vehicles, improper restraint usage, roadway departure and work zones) and one associated emphasis area (i.e., data improvement). A total of eight emphasis areas were selected by North Vancouver (2010b). The eight emphasis areas were excessive traffic speeds, channelized right-turn operations, congestion and high traffic volumes, pedestrian safety, cyclist safety, signal operations and display, sightlines at intersections, and transit safety. Grande Prairie (2011) only chose four emphasis areas (i.e., speed, alcohol, occupant restraints and intersection offences). Ottawa (2011) included seven emphasis areas (i.e., distracted driving, vulnerable road

users, aggressive driving, angle collisions, turning movement collisions, rear end collisions and young drivers).

Note that there is no consensus and/or scientific rationale amongst traffic safety researchers and policymakers in terms of the number of emphasis areas for a jurisdiction-specific SHSP. Indeed, the SHSP documents listed above show varying number of emphasis areas ranging from four (Edmonton, 2007; Grande Prairie, 2011) to 14 (Hamilton, 2009). Choosing a small number of emphasis areas does not effectively reduce the numbers of collisions; choosing a large number of emphasis areas would also be ineffective because only a few resources could be allocated to each emphasis area. Nonetheless, FHWA's (2009) guidance of selecting four to eight emphasis areas may be regarded as a 'rule-of-thumb' principle to present a typical range for the number of emphasis areas for SHSPs in North America.

2.2.2. Target Safety Goals

Target safety goals that are often presented by the percentage collision reduction values for a preset time period is also a key component of a SHSP. FHWA (2006) stated that target goals are an important component of a SHSP because it indicates what the SHSP is intending to accomplish and presents a jurisdiction's vision and ambition to improve traffic safety for the preset time period. Elvik and Vaa (2004) also reported that the adoption of quantitative target goals in a safety policy statement can result in better safety programs and initiatives, more effective allocation of scarce resources, and a more efficient achievement of safety improvements for a jurisdiction. Furthermore, the target goals will be used as a key input for a jurisdiction to monitor and evaluate the overall performance of safety improvement programs applied during the preset time period. Without target goals and the time designated to achieve the

target goals, a jurisdiction will not be in a position to determine whether the level of safety has improved after the implementation of any safety improvement program.

For a target goal to be specific and measurable, it requires a safety measure, a target and a time frame. As each agency has used a different approach to determine target safety goals for its emphasis areas, the safety measure, target and time frame selected vary from jurisdiction to jurisdiction. The result is that there is no common set of safety measures, target safety goals and time frames that apply to each jurisdiction. The CCMTA (2011a), for instance, considered this issue, but did not produce any firm safety measures or hard numbers that could be regarded as nation-wide safety measures and target safety goals. Instead, CCMTA (2011a) recognizes that circumstances vary, and encourages individual jurisdictions to select their own safety measures and target safety goals for each jurisdiction's SHSP. The following illustrates the safety measures selected in existing SHSPs.

Transport Canada (2001) chose *total number of fatalities or total number of serious injuries,* as well as *seatbelt wearing rate and proper use of child restraints* and *percent of drivers who commit three high-risk driving infractions.* CCMTA (2011a) only chose *total number of fatalities and serious injuries*.

In terms of provincial-level SHSPs, SGI (2012d) chose *total number of fatalities and injuries.* Alberta (2013) and British Columbia (2013) selected *total number of fatalities and serious injuries*.

Montana (2010) chose various safety measures for different emphasis areas. For example, Montana selected *seatbelt usage* for the safety belt use emphasis area, and *number of fatalities* and *fatality rate* for the alcohol- and drug-impaired driving collisions emphasis area. North Dakota (2010) also used various safety measures, such as *number of fatalities* for the alcohol

impaired driving emphasis area, *seatbelt usage* for the seatbelt emphasis area, and *total number of fatal and injury collisions* for the young driver/older driver safety emphasis area.

Burlington (2006), however, did not specify target goals in their SHSP. The City of Edmonton (2007) used multiple safety measures for different emphasis areas. For instance, Edmonton used *number of collisions* for the intersection emphasis area and the *seatbelt wearing rate* for the seatbelt emphasis area. The other two emphasis areas (i.e., impaired driving and speed-related collisions) did not have target goals established. New Westminster (2007) did not specify target goals in their SHSP at all. Red Deer (2007) chose *total number of fatalities and injuries* while Strathcona County (2008) chose *average annual rate of total collisions per population*. The City of Hamilton (2009) used *total number of fatal and injury collisions* (as opposed to the *number of fatalities and injuries*), as well as *PDO collisions* as their safety measure. Similar to Burlington (2006) and New Westminster (2007), North Vancouver (2010b) did not include any target goals. Grande Prairie (2011) used *total number of fatal and injury collisions* similar to Hamilton. Ottawa (2011) used *total number of fatal or injury collisions.*

In general, it appears that the most frequently chosen safety measures in Canada are *number of fatal and/or injury collisions*, *number of fatalities and/or injuries*, and/or *fatal and/or injury rate* over a given time frame. As stated, there is no common safety measure that applies to every jurisdiction in Canada.

In terms of setting target goals, Marsden and Bonsall (2006) described three representative approaches: 1) model-based approach, 2) extrapolation and evidence-led judgment approach, and 3) aspirational approach.

The model-based approach requires the development of rigorous mathematical models, such as time series models, that can predict future status of safety measures (e.g., number of

fatalities and/or injuries) (Marsden and Bonsall, 2006). Figure 6 illustrates this approach and shows the fitting results of predicted number of fatalities using three different time series models – autoregressive integrated moving average (ARIMA), Negative Binomial (NB) with a time trend and integer-valued autoregressive (INAR) Poisson (Quddus, 2008). Figure 6 also shows the observed number of fatalities for comparison.

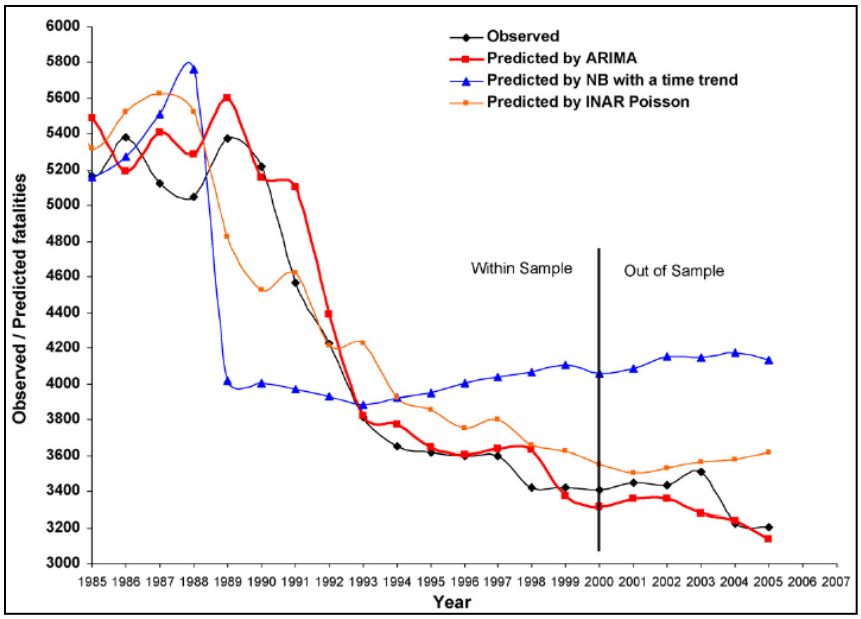


Figure 6: Time Series Models (Quddus, 2008).

The extrapolation and evidence-led judgment approach is less rigorous than the model-based approach, but still relies at least on a basic-level collision data analysis that may show changes in collision trends over time (Marsden and Bonsall, 2006). Broughton and Knowles (2010) describe an example of a method based on extrapolation that is used by the British government to set up target goals in Great Britain (see Figure 7). Broughton and Knowles (2010) state that the actual rate in the figure refers to the trend from 1980 to 1998 and the adjusted rate shows the slower decline if there had been no countermeasures [i.e., DESS measures (D for drink/driving, E for engineering, SS for secondary safety (crashworthiness in cars))] introduced. Broughton and Knowles (2010) shows that the slower decline represented by the adjusted rate is

then extrapolated from 1998 to 2010 to create the baseline forecast. Broughton and Knowles (2010) then reported that the final forecast is simply based on an assumption of the effect of new policies.

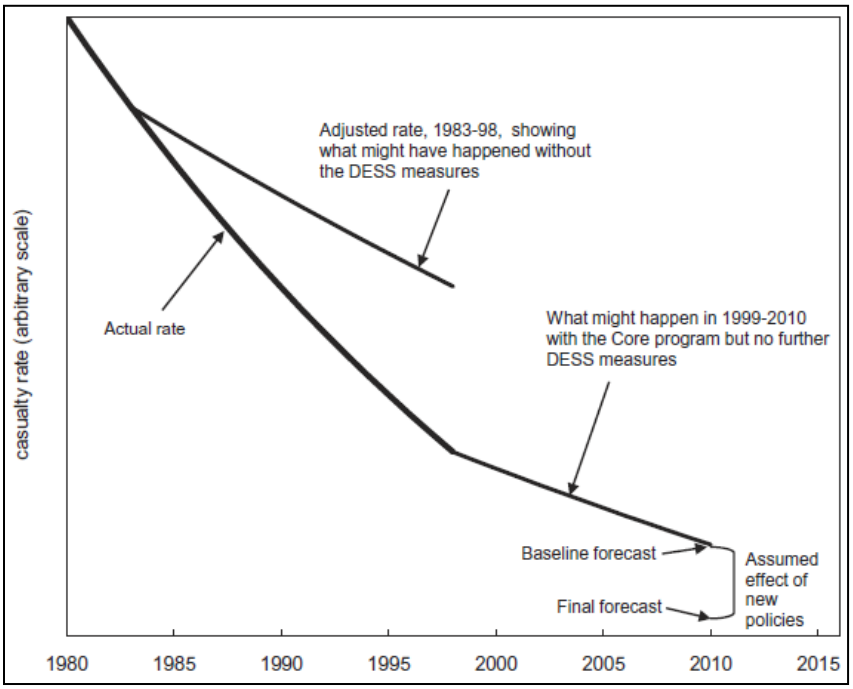


Figure 7: Target Goal Forecasts (Broughton and Knowles, 2010).

The aspirational approach is not a rigorous data-driven approach (Marsden and Bonsall, 2006). Marsden and Bonsall (2006) reported that this approach determines target safety goals on the basis of political will and on "what *should* be achieved" rather than what *can* be achieved. An example is "Vision Zero", which can be regarded as an aspirational approach. The Vision Zero approach was first adopted by the Swedish Parliament and pursues zero fatal or injury collisions (or zero fatalities and injuries) as a long term goal (Belin et al., 2011). Elvik (2008) reported that Norwegian politicians, for example, support this approach since they believe that it is unethical to apply any goals other than zero fatality or zero fatal collision as a long-term goal. Furthermore, target goals should be ambitious, but realistic. If the target goals are unrealistically ambitious, officials and the public might perceive the targets as out of reach and might not accept

them. On the other hand, if the target goals are easily achievable, a major opportunity for saving lives might have been lost as the goals are achieved and support for safety programs or initiatives might decrease. This implies that the determination of target goals can hardly be determined based purely by data-driven analyses and/or by mathematical models since these approaches are not, for instance, intended to reflect policymakers' or the general public's ambition.

In addition, FHWA (2006) emphasized the importance of considering a jurisdiction's target goals to the national and/or partnering agencies' safety target goals so that multiple agencies can coordinate and unify the safety target goals in a complementary manner. As a result, currently the combination of the second (i.e., basic-level collision trend analysis) and third approach (i.e., political will) is the most commonly used approach to determine the target goals for the emphasis areas of a SHSP in North America. Example targets (i.e., percentage collision reductions) based on the combination of the two methods and the associated time frames are as follows.

Transport Canada's (2001) "RSV 2010" chose an overall target goal of 30% decrease in the average number of fatalities or serious injuries during the 2008 to 2010 period over comparable 1996 to 2001 figures. Transport Canada (2001) also selected varying target goals for each of its emphasis areas, ranging from 20% to 40% reduction in fatalities or serious injuries in the previously mentioned time frame. In addition, Transport Canada (2001) included target goals of a minimum of 95% seatbelt wearing rate and proper child restraint use by all motor vehicle occupants in the same time frame, and 20% reduction in drivers who commit three high-risk driving infractions within a two-year time frame. As was previously stated, CCMTA's (2011a) "Canada's Road Safety Strategy 2015" did not specify target goals but simply aims to achieve overall downward trends in fatalities and serious injuries by 2015.

SGI (2012d) on the other hand, suggested dual overall goals in Saskatchewan [i.e., 30% reduction for fatalities and 10% reduction for injuries over a four-year time period (2011-2015)]. Alberta (2013) chose an overall target goal of 15% reduction in the 2013 to 2015 average compared to the 2008 to 2010 baseline average for fatalities and serious injuries. The target goal also applies to all of the chosen emphasis areas, except high-risk and medically unfit drivers, aging drivers and new drivers. British Columbia (2013) selected an overall target goal of zero fatalities and serious injuries for an unknown time frame.

In terms of state-level SHSPs, the target goals in Montana's (2010) and North Dakota's (2010) SHSPs varied greatly because multiple safety measures were chosen. The time frame was not specified in Montana's (2010) SHSP and the target goals in North Dakota's (2010) SHSP were set to 2011.

Burlington (2006) also did not specify their target goals, but Burlington did state that their SHSP will be implemented from 2007 to 2009. The City of Edmonton's (2007) target safety goals included a 20% reduction in the number of intersection collisions and a 95% seatbelt wearing rate from 2006 to 2010. New Westminster (2007) did not clearly specify its target goals or a time frame. Red Deer (2007) chose the same target goals as Transport Canada's (2001) "RSV 2010" (i.e., 20% to 40% reduction in fatalities and injuries) for all the emphasis areas except winter road conditions. Red Deer (2007), however, chose a three-year time frame (2007 to 2010). An overall target goal of 30% reduction in the average annual rate of total collisions per population was established by Strathcona County (2008) from 2014 to 2016 compared to 2004 to 2006. Hamilton (2009) chose a single target safety goal of 10% reduction for all their emphasis areas, but Hamilton's goal includes PDO collisions as well as fatal and injury collisions over a three-year period from 2008 to 2011. North Vancouver (2010b) and Grande

Prairie (2011), on the other hand, did not include specific target goals and time frames in their SHSPs. Similar to Hamilton (2009), Ottawa (2011) chose a 10% reduction in the number of fatal or injury collisions for each of the chosen emphasis areas over a four-year period from 2011 to 2015. However, Hamilton's goal is far more ambitious than Ottawa's goal as Ottawa's goal does not include PDO collisions.

Hamilton and Ontario's target goals are lower (i.e., 10% fatal and/or injury collisions) than the chosen target goals for the same emphasis area (i.e., seatbelts) in other SHSPs [i.e., 15% fatalities and serious injuries for Alberta (2013), 40% fatalities and injuries for Red Deer (2007)]. A study conducted in Virginia by Kweon (2006) recommends that realistic goals range from 10% to 20% for fatalities and 5% to 10% for injuries, and that 40% was highly optimistic. In addition, several jurisdictions' target goals include a percentage reduction, but do not indicate the time period that the percentage reduction will be achieved. Without the time frame, a jurisdiction will not be able to determine whether the target goal has been achieved.

2.2.3. Network Screening

Network screening refers to the process in identifying and ranking high collision locations also known as hotspots (AASHTO, 2010). AASHTO's Highway Safety Manual (HSM) (2010) described 13 network screening methods.

AASHTO (2010) reported that the Average Collision Frequency method ranks the locations based on the highest number of total collisions or the highest collisions of a particular collision severity or type. AASHTO (2010) described another method, the Collision Rate performance measure, and stated that this method normalizes collision frequency with the exposure (e.g., traffic volume). AASHTO (2010) also reported that the Equivalent Property Damage Only (EPDO) Average Collision Frequency method identifies riskiest locations by

assigning weighting factors to collisions by severity to produce a single combined frequency and severity score for each location. The weighting factors are calculated relative to PDO collisions and the societal collision costs are used to calculate the EPDO weights (AASHTO, 2010). AASHTO (2010) described the Expected Average Collision Frequency with Empirical Bayes (EB) Adjustment method and stated that this method consists of weighting the observed average collision frequency and the predicted average collision frequency from a safety performance function (SPF).

Among the four network screening methods mentioned, the Average Collision Frequency method and EPDO Average Collision Frequency method are the only methods that do not require traffic volume as an input (AASHTO, 2010). The other two methods (i.e., Collision Rate and Expected Average Collision Frequency with EB Adjustment) require traffic volume as input data (AASHTO, 2010). Traffic volume cannot be used in the development of a SHSP as a type of exposure data because there is no appropriate exposure for the emphasis areas.

The following is a review of network screening results in existing SHSPs. The federal-level SHSPs in Canada [i.e., Transport Canada (2001) and CCMTA (2011a)] and the provincial-level SHSPs [i.e., Saskatchewan (2012d), Alberta (2013) and British Columbia (2013)] did not include any network screening analysis. The state-level SHSPs [i.e., Montana (2010) and North Dakota (2010)] also do not include network screening results. Municipal-level SHSPs, such as Burlington (2006) and Edmonton (2007) did not include network screening results as well. However, New Westminster (2007) included suggested locations. These locations were based on preliminary consultation with stakeholders and a review of high collision locations (New Westminster, 2007). Red Deer (2007) and Strathcona County (2008) did not include network screening results either. The City of Hamilton's (2009) SHSP included results of safety network

screening based on high proportion testing. Network screening was also conducted for North Vancouver (2010b). However, they used a different method; one based on Critical Collision Rate (CCR) and Critical Collision Rate Index (CCRI) (North Vancouver, 2010b). Grande Prairie (2011) did not include network screening results. Ottawa (2011) included high collision locations, but did not specify the type of network screening method that was used.

Overall, only a few SHSPs have included network screening in their SHSPs. There are also a limited number of literature sources that suggest which network screening method is the most appropriate to use for the development of a SHSP.

2.2.4. Safety Strategies/Programs

Selecting strategies/programs that could potentially reduce the number of collisions in each chosen emphasis area is the fourth component of a SHSP. Several SHSPs included additional information such as safety countermeasures/initiatives/programs that can be useful in reducing collisions in a particular emphasis area. NCHRP 500 series (2011) provides a variety of strategies/programs that can be chosen by jurisdictions.

A SHSP should be comprehensive and FHWA (2006) suggested that the following questions should be addressed when identifying strategies and countermeasures for emphasis areas:

- *What are the priorities for a particular emphasis area?*
- *What strategies and resources are available for a particular emphasis area?*
- *What strategies lend themselves to collaborative efforts and how might the SHSP leverage various resources each partner brings to the table?*
- *What proactive approaches can be taken to address potentially hazardous locations and features on a system-wide basis?*

FHWA (2006) also suggests incorporating input from representatives from the 4Es in the selection of safety strategies/programs.

The following provides a summary of the strategies and programs that have been included in existing SHSPs.

Transport Canada (2001) included initiatives, such as improved collision and exposure data, safer motor vehicles, enhanced enforcement initiatives and road infrastructure initiatives. CCMTA (2011a) divided strategies into “proven” road user initiatives (e.g., random breath testing and 911 program targeted towards impaired driving), “proven” infrastructure initiatives (e.g., rumble strips targeted towards impaired driving, speed and aggressive driving, and environmental factors), and “proven” vehicle initiatives (e.g., crash avoidance technologies targeted towards impaired driving, and speed and aggressive driving).

Saskatchewan (2012d) described actions for each strategy, as well as resources and implementation time. Alberta (2013) listed a set of key actions over the two-year time frame. In addition, each of the actions showed the months during which the specific action will be implemented. British Columbia (2013) included several strategies to address each one of its emphasis areas, such as working with corporate consumers, the automotive industry and researchers to assess and showcase new safety technologies to address safer vehicles.

The state-level SHSPs, Montana (2010) and North Dakota (2010) also included comprehensive strategies for each chosen emphasis area. Montana (2010) divided the strategies into existing and new. It also provided detailed information, such as funding agency, implementing agency, actions and effectiveness for each strategy. North Dakota (2010) included a list of potential strategies for each chosen emphasis area.

Burlington (2006) included strategies for each of the chosen emphasis areas, as well as actions, responsible agencies and completion target dates for each strategy. Edmonton (2007) included multiple actions for each emphasis area. An example of some actions to reduce intersection-related collisions are modifying or changing road configuration to improve traffic safety, lobby for legislation that covers the use of Intersection Safety Cameras (ISCs) to detect speeding drivers. Strathcona County (2008) also included strategies and specific actions to implement the strategies. New Westminster (2007) chose 38 education, enforcement, engineering and institutional/policy strategies. Each strategy had information discussing the details, such as discipline, term (short, medium and long) and evaluation score. Each of the 38 strategies was evaluated against effectiveness, ease of implementation, sustainability and public support. Red Deer (2007) included strategies for each of their emphasis areas, but it is not comprehensive. They have given examples of strategies from the 4Es, but did not provide any specifics details with regards to their strategies compared to other jurisdictions. Strathcona County (2008) is comprehensive as it presents 11 strategies and has divided them into short-, medium- and long-term strategies. They have also included details of each strategy, actions to be performed between 2008 and 2018, the responsible leading and participating departments, and the role of the Office of Traffic Safety. Hamilton (2009) also provided a comprehensive set of strategies/programs. They included the program, lead agency, support team, action description, historical effectiveness, status and the issues that could potentially impact the strategy's effectiveness. North Vancouver (2010b) chose to include a table of engineering, education and enforcement strategies, and listed the emphasis area that each strategy targeted. Grande Prairie (2011) also described their strategies from the 4Es, but did not provide any detailed information.

The layout of Ottawa's (2011) strategies/programs was similar to Hamilton, but included additional information – risks associated with a specific strategy.

Most jurisdictions have provided detailed information and have addressed the questions listed above by FHWA (2006). CCMTA (2011a), Saskatchewan (2012d), Burlington (2006), Edmonton (2007), Red Deer (2007), Hamilton (2009), North Vancouver (2010b), Ottawa (2011), Montana (2010) and North Dakota (2010) have set priorities and strategies for particular emphasis areas. However, Burlington (2006), Hamilton (2009), Ottawa (2011) and Montana (2010) have taken their strategies a step further by including additional information, such as the collaborative efforts amongst stakeholders in their SHSPs.

2.3. Chapter Summary

A literature review of the general procedures, key components and data requirements for the development of a SHSP was conducted.

FHWA (2006) and CCMTA (2011b) published documents that outline the general procedure to develop a SHSP. The steps mainly consisted of identifying a "champion" (i.e., an individual or unit with high-level leadership), developing a vision, identifying stakeholders, selecting the key emphasis areas, establishing target safety goals, selecting the strategies/programs for the chosen key emphasis areas, and updating and evaluating the SHSP.

Table 4 summarizes the findings from the literature review of the key components. Two federal-level SHSPs, three provincial-level SHSPs, two state-level SHSPs similar to Saskatchewan in nature, and nine municipal-level SHSPs were reviewed. The number of emphasis areas selected typically ranged from four to 14. The emphasis areas were mainly selected using the hybrid approach (i.e., combination of a data-driven approach and political decision).

The second component is target safety goals. A combination of the second (i.e., basic-level collision trend analysis) and third approach (i.e., political will) was the most commonly used approach to determine the target goals. Target goals should consist of specific safety measures, targets and time frames. Based on Table 4, 10 out of the 16 SHSPs that were reviewed developed target goals with specific safety measures, targets and time frames. The other six did not specify at least one of the three, which decreases the effectiveness of the target goal in reaching the overall long-term goal. Table 4 also shows that the chosen safety measures, targets and time frames vary for each jurisdiction.

Based on network screening results shown in Table 4, very few SHSPs included this component. Only four out of the 16 included a network screening component and only three of those that did, specified the network screening method. The methods described in AASHTO's (2010) HSM include various network screening methods; however, only two methods (i.e., Average Collision Frequency method and EPDO Average Collision Frequency method) can be used for the emphasis areas as they do not require traffic volume as input data.

In terms of safety strategies/programs, the literature sources state that a comprehensive review of strategies from the 4Es should be chosen and that existing strategies should also be considered. Table 4 shows that almost every SHSP, except Red Deer (2007) and Grande Prairie (2011) included comprehensive safety strategies/programs to achieve the chosen emphasis areas and target goals.

The most feasible procedure, key components and data requirements will be identified and presented in Chapter 3 based on the findings from the literature review.

Table 4: Summary of Key Components from North American SHSPs.

Type	North American Jurisdictions	Number of Emphasis Areas Selected	Target Goals			Network Screening		Strategies/Programs Comprehensive*
			Safety Measures	Targets (%)	Time Frames	Included	Method	
Federal-level	Transport Canada (2001)	9	Fatalities or Serious Injuries	20-40 Reduction (Overall and for each Emphasis Area)	2 year average (2008-2010)	N	NA	Y
			Seatbelt Wearing Rate	Minimum of 95				
			Proper Use of Child Restraints	All Motor Vehicle Occupants				
			Percent of Drivers who Commit Three High-Risk Driving Infractions	20 Reduction				
	CCMTA (2011a)	10	Fatalities and Serious Injuries	Downward Trends (Overall)	By 2015	N	NA	Y
Provincial-level	Saskatchewan (2012d)	7	Fatalities and Injuries	30 Reduction for Fatalities and 10 Reduction for Injuries (Overall)	4 year (2011-2015)	N	NA	Y
	Alberta (2013)	10	Fatalities and Serious Injuries	15 Reduction (Overall and for each Emphasis Area)	2 year average (2013-2015)	N	NA	Y
	British Columbia (2013)	7	Fatalities and Serious Injuries	Zero (Overall)	NA	N	NA	Y
	Montana (2010)	12	Varies	Varies Widely	NA	N	NA	Y
	North Dakota (2010)	7	Varies	Varies Widely	By 2011	N	NA	Y
Municipal-level	Burlington (2006)	10	NA	NA	2 year (2007-2009)	N	NA	Y
	Edmonton (2007)	4	Collisions	20 Reduction	4 year (2006-2010)	N	NA	Y
			Seatbelt Wearing Rate	95				
	New Westminster (2007)	12	NA	NA	NA	Y	Stakeholder Consultation & Collision Data Analysis	Y
	Red Deer (2007)	5	Fatalities and Injuries	20-40 Reduction	3 year (2007-2010)	N	NA	N
	Strathcona County (2008)	11	Average Annual Rate of Total Collisions per Population	30 Reduction (Overall)	2 year (2014-2016)	N	NA	Y
	Hamilton (2009)	14	Fatal and Injury Collisions, and PDO Collisions	10 Reduction (For each Emphasis Area)	3 year (2008-2011)	Y	High Proportion Testing	Y
	North Vancouver (2010b)	8	NA	NA	NA	Y	Critical Collision Rate (CCR) and Critical Collision Rate Index (CCRI)	Y
	Grande Prairie (2011)	4	Fatal and Injury Collisions	NA	NA	N	NA	N
	Ottawa (2011)	7	Fatal or Injury Collisions	10 Reduction (For each Emphasis Area)	4 year (2011-2015)	Y	Unknown	Y

Note: “Comprehensive” means the 4Es and/or existing strategies were considered, and/or additional information was included.

CHAPTER 3
PROCESS DEVELOPMENT

3.1. General Procedures

There are modifications that can be made to the SHSP development procedure (see Figure 8). As FHWA (2006) stated, the order of the procedure does not necessarily have to be sequential. However, it is beneficial to add the following steps in order to increase the effectiveness of a municipal-level SHSP. The first modification is the addition of "Incorporating Upper-Level Policies". This step is necessary because a municipal-level SHSP is the lowest-level SHSP, and is limited by federal- and provincial-level SHSPs. A municipal-level SHSP must consider incorporating the strategic goal or vision, emphasis areas, target safety goals, network screening and safety strategies/programs already in place by the federal and provincial government. This way, collaborative efforts can be used to effectively reduce the number of collisions in an efficient manner. The second modification is the addition of "Conducting Network Screening", preferably after identifying target safety goals and before identifying safety strategies/programs. Very few jurisdictions have included network screening in their SHSPs. It is a good idea to include network screening as it determines the locations to allocate the safety strategies/programs to.

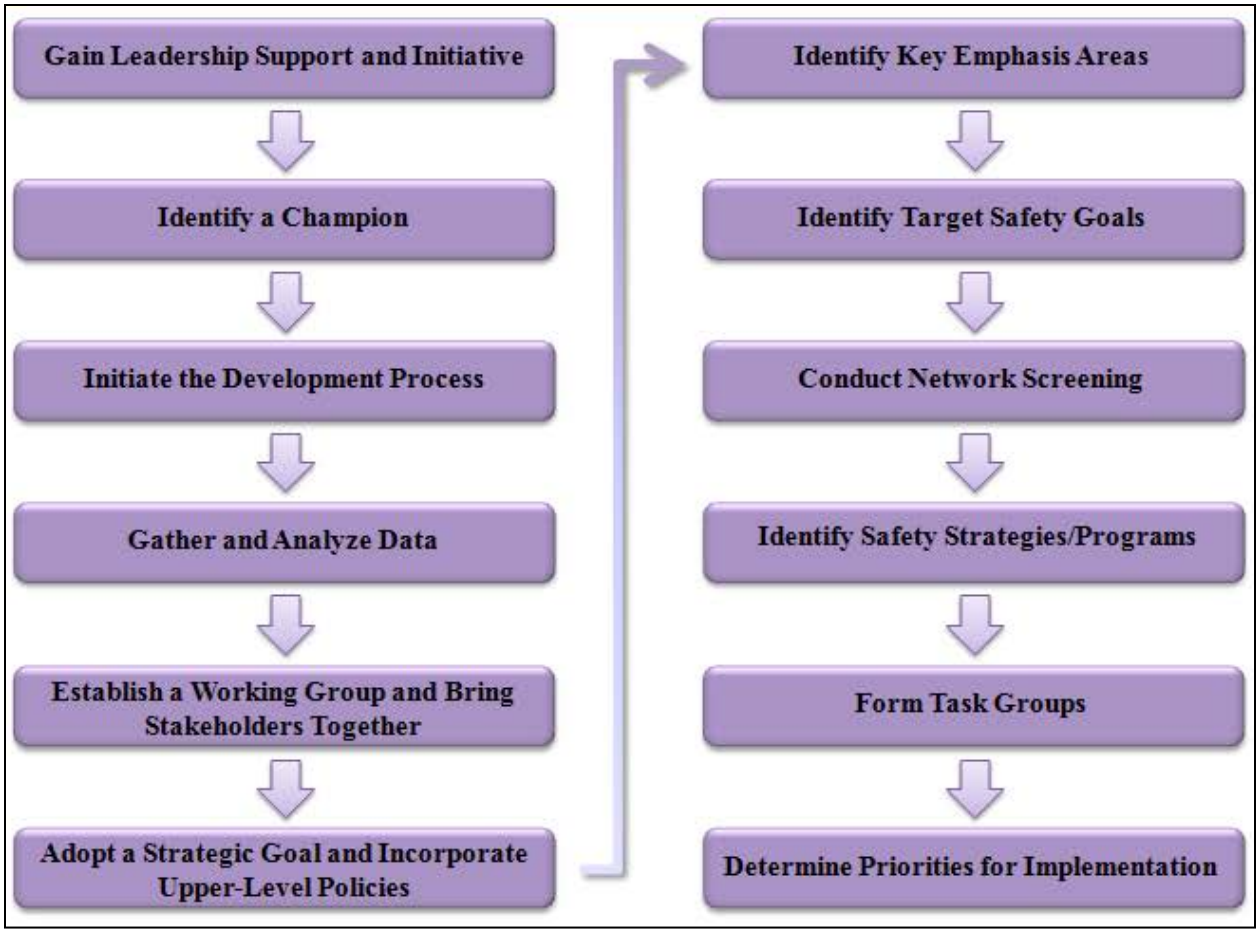


Figure 8: Modified Municipal-level Strategic Highway Safety Plan Development Procedure.

3.2. Key Components

3.2.1. Emphasis Areas

The first key component that needs to be developed is emphasis areas. The hybrid approach (i.e., combination of a data-driven approach and political decision) will be used to select emphasis areas because it is the most commonly used approach based on the literature review. This is a comprehensive approach that begins with a review of existing SHSPs. Reviewing existing SHSPs is particularly important in the development of a municipal-level SHSP because a municipal-level SHSP needs to complement the components already established in the upper-level SHSPs [i.e., CCMTA (2011a); SGI (2012d)]. The municipal-level SHSP should work with

and not against the upper-level policies already in place for a jurisdiction. This approach also includes the development of histograms and/or pie charts. Basic-level collision data can be used to conduct high-level descriptive data analysis in order to get a better understanding of the level of road safety in a jurisdiction from all perspectives. Comparing the collision trends will help in selecting appropriate emphasis areas for a municipality. This approach also requires communication between stakeholders to select emphasis areas. In addition, the four to eight emphasis areas 'rule-of-thumb' principle outlined in the literature review will be followed.

3.2.2. Target Safety Goals

The second key component in the development of a municipal-level SHSP is target safety goals. A safety measure, a target and a time frame need to be determined in the establishment of target safety goals.

In terms of safety measures, *fatal or injury collisions* should be chosen for the following reasons:

1. The number of fatalities or injuries in a particular collision is determined mainly by the number of passengers in the vehicles involved in a collision, and this number is largely uncontrollable;
2. Many safety countermeasures/programs (e.g., red light cameras and speeding enforcement) are designed to prevent or reduce the number of fatal or injury collisions (and cannot be designed to take into account single or multiple vehicle occupancy);
3. Current engineering practice uses the number of collisions as the primary safety measure for various safety-related tasks including network screening, diagnosis, countermeasure selection and economic appraisal; and,

4. Evaluation of safety countermeasures/programs also requires the number of collisions rather than the number of persons as an input. As a result, when the progress of safety initiatives is monitored in the future, the number of collisions (not the number of persons) is needed as an input. The number of persons is more appropriate for emphasis areas, such as seatbelts.

Similar to the hybrid approach to select emphasis areas, a combination of basic-level collision data analysis and stakeholder communication should be used to develop targets because this is the most commonly used approach in North America. Setting targets cannot be based on mathematical formulas or equations. It requires a basic-level collision data analysis to estimate the current level of safety and strike a balance between an ambitious and realistic goal based on stakeholder and policymaker decisions (e.g., “Vision Zero” approach). Similar to the selection of emphasis areas, a municipality must complement the goals established in upper-level policies. A few existing SHSPs copied the target goals of upper-level SHSPs; however, this is not what was intended.

3.2.3. Network Screening

Network screening was not mentioned in the general procedures outlined by FHWA (2006) or CCMTA (2011b). Network screening should be added to the general procedure because it serves purposeful for a municipal-level SHSP.

Based on the literature review, there were limited studies specifying the recommended network screening method to be used in the development of a SHSP. Additionally, very few SHSPs included network screening in their SHSPs. Nevertheless, the most appropriate network screening method is the Observed EPDO Average Collision Frequency method because this method is simple and straightforward for a small municipality to use.

This method simply needs the number of collisions by severity and a set of severity weightings. The method's approach to collision severity is also very simple. The method assigns an easily calculated severity weighting factor (the EPDO weight) to each collision using Equation 1 and then calculates a single combined frequency and severity score (total EPDO score) for each location using Equation 2 (AASHTO, 2010).

The weighting factors are calculated as follows (AASHTO, 2010):

$$f_{y(weight)} = \frac{CC_y}{CC_{PDO}} \qquad \text{[Equation 1]}$$

where:

$f_{y(weight)}$ = weighting factor based on collision severity, y

CC_y = collision cost for collision severity, y

CC_{PDO} = collision cost for PDO collision severity

The total EPDO scores are calculated as follows (AASHTO, 2010):

$$\text{Total EPDO Score} = f_{k(weight)}\left(N_{observed,i(F)}\right) + f_{inj(weight)}\left(N_{observed,i(I)}\right) + f_{PDO(weight)}\left(N_{observed,i(PDO)}\right) \qquad \text{[Equation 2]}$$

where:

$f_{k(weight)}$ = fatal collision weight

$N_{observed,i(F)}$ = number of fatal collisions per intersection, i

$f_{inj(weight)}$ = injury collision weight

$N_{observed,i(I)}$ = number of injury collisions per intersection, i

$f_{PDO(weight)}$ = PDO collision weight

$N_{observed,i(PDO)}$ = number of PDO collisions per intersection, i

In addition, the method does not require hourly traffic volume as an input. This is a great advantage when screening the Saskatoon network to develop peak collision maps. For instance, if a different network screening method was used, such as a collision rate method, to identify the riskiest locations of the peak collision period, traffic volume information for the peak collision period for each and every location would be needed. However, this information is not easily obtainable.

3.2.4. Safety Strategies/Programs

The last component of a municipal-level SHSP is safety strategies/programs. Similar to the approach in selecting emphasis areas and target safety goals, a combination of a literature review and stakeholder communication is important in the selection of safety strategies/programs. Just as FHWA (2006) recommends, a jurisdiction developing a SHSP should review and combine the efforts already in place and continue to enhance on existing safety strategies/programs as these do not require new funding. It is also important to implement strategies from various stakeholders.

3.3. Chapter Summary

This chapter discusses the modified process for a municipal-level SHSP. It outlines the procedures and key components that should be used to develop a municipal-level SHSP based on the findings from the literature review.

Two modifications to the existing procedures outlined by FHWA (2006) and CCMTA (2011b) were discussed. The first being the addition of “Incorporating Upper-Level Policies” and the second being the addition of “Conducting Network Screening”.

The most appropriate approaches to develop the four key components (i.e., emphasis areas, target safety goals, network screening and safety strategies/programs) of a municipal-level

SHSP were also presented. The hybrid approach (i.e., combination of a data-driven approach and political decision) should be used to select the first key component, emphasis areas because it is the most commonly used approach based on the literature review. The second key component, target safety goals require a safety measure, a target and a time frame. The most appropriate safety measure is *fatal or injury collisions*. Similar to the selection of emphasis areas, a combination of basic-level collision data analysis and stakeholder communication (i.e., "Vision Zero" approach) should be used to develop the target and time frame. The additional and third key component is network screening. The Observed EPDO Average Collision Frequency method is the most appropriate network screening method to use to develop a municipal-level SHSP as it does not require traffic volume information to develop collision maps. Safety strategies/programs is the fourth key component. A combination of a literature review and stakeholder communication from the 4Es is recommended for the selection of safety strategies/programs.

CHAPTER 4
CASE STUDY FOR THE CITY OF SASKATOON

4.1. Study Data

Two types of information were used to conduct this research: road network information and collision data (e.g., severity and major contributing factor information).

4.1.1. Road Network Information

The City of Saskatoon uses a GIS to manage, analyze and display various surface and underground infrastructure data. About 80% of the municipal data are spatial in nature and can be presented visually (Park et al., 2012). The City's GIS street map also contains a transportation model that stores transportation-related spatial information (COS, 2005). Examples of the information from the City of Saskatoon's (2013a) street map for intersections and road segments are shown in Table 5 and Table 6, respectively. Table 5 shows intersection location identifiers (ID), traffic control type (INT_TYPE), intersection status (INT_STAT), intersection name (NEW_INTERS), common location identifier (UGRID), etc. Table 6 shows road location identifiers (ROAD_ID), road classification (ROAD_TYPE), road status (ROAD_STATU), roadway length (ROAD_LENGT), street name (ONLINE_STR), common location identifier (UGRID), etc.

Table 5: City of Saskatoon's Intersection GIS Street Map Example (COS, 2013a).

ID	INT_TYPE	INT_STAT	NEW_INTERS	UGRID
32	Traffic Signal	Current	College Dr & Central Ave	SKN8-2
3504	Stop Sign	Current	Ave I N & 33rd St W	SKE5-2
2949	Yield Sign	Current	Ave L N & 29th St	SKE6-18
1970	Uncontrolled	Current	Ave I N & 30th St	SKE6-3
3073	Traffic Signal	Current	Ave P S & 11th St	SKE9-59
4239	Traffic Signal	Current	Clancy Dr & Circle Dr	SKC9-11

Table 6: City of Saskatoon's Road Segment GIS Street Map Example (COS, 2013a).

ROAD_ID	ROAD_TYPE	ROAD_STATU	ROAD_LENGT	ONLINE_STR	UGRID
2685	40	1	284.002	Perehudoff Cres	SKP5-15
2625	30	1	135.082	Kenderdine Rd	SKP5-4
2680	40	1	345.402	Perehudoff Cres	SKP5-6
14658	20	1	344.944	Attridge Dr	SKP5-13
11547	40	1	269.039	AE Adams Way	SKL1-51
11546	22	1	94.982	Lenore Dr	SKM1-8

Figure 9 shows the City of Saskatoon's roadway network.

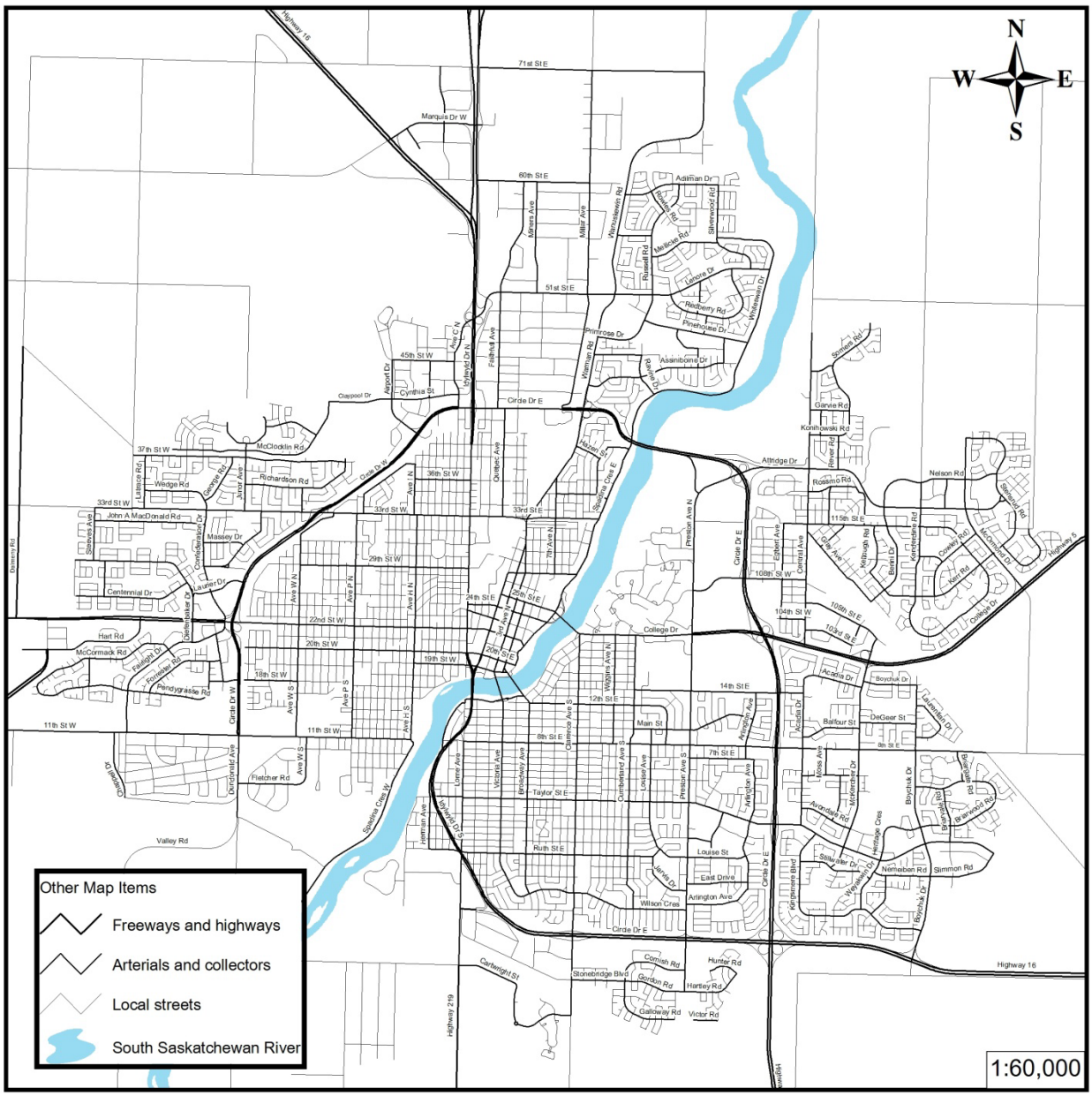


Figure 9: The City of Saskatoon's Roadway Network Shape File (COS, 2013a).

4.1.2. Collision Data

Collision data was provided by the SGI (2011). The collision data was provided in three separate tables – Accident (SASKAC) table, Vehicle (SASKVE) table and Occupant (SASKOC) table.

The SASKAC table includes information (e.g., severity, date, time etc.) related to a particular collision (SGI, 2007). A single row in this table represents one collision. The 2001 to 2010 collision data contains 70,487 individual collisions for all locations within the City of Saskatoon. Table 7 shows an example of the information contained in the SASKAC table, including the case number (CASENO), severity (SEVERITY), accident date (ACCDATE), accident time (ACCTIME), common location identifier (UGRID), accident site (ACCSITE), collision configuration (CONFIG) etc. The UGRIDS are listed in the City of Saskatoon's (2007) Grid Codes document.

Table 7: Accident (SASKAC) Table Example (SGI, 2011).

CASENO	SEVERITY	ACCDATE	ACCTIME	UGRID	ACCSITE	CONFIG
84486	1	11-Jan-08	1302	SKE8-34	01	08
132504	1	8-Jul-04	1830	SKG6-3	01	16
151857	1	19-Oct-05	1105	SKN11-9	01	06
157820	2	29-May-07	1718	SKG5-51	04	09
158705	1	19-Jun-07	742	SKH6-101	01	05
159570	1	11-May-07	725	SKO8-19	01	16

The SASKVE table contains information on the vehicles and drivers involved in a collision (SGI, 2007). A single row in this table represents one vehicle. Table 8 shows an example of the information contained in the SASKVE table, including case number (CASENO), vehicle number (VEHNO), driver sex (DRVSEX), driver age (DRVAGE), major contributing factor (MCF1), traffic control device present (CONTROLS), vehicle identification (VIDENT), etc.

Table 8: Vehicle (SASKVE) Table Example (SGI, 2011).

CASENO	VEHNO	DRVSEX	DRVAGE	MCF1	CONTROLS	VIDENT
84486	1	M	60	31	01	02
84486	2	M	67	99	01	01
132504	1	M	33	07	01	11
132504	2	-	0	99	01	03
150995	2	-	0	99	-	01
151857	1	F	76	68	01	01

Note: "-" means that no data was entered into the database.

SGI (2007) reports that the SASKOC table lists information on each individual involved in an injury collision, whether or not they were injured. A single row in this table represents an individual involved in an injury collision. Table 9 shows an example of the information contained in the SASKOC table, including case number (CASENO), vehicle number (VEHNO), occupant number (OCCNO), occupant position (OCCPOS), occupant age (AGE), occupant sex (SEX), safety equipment used (SAFETEQ) etc.

Table 9: Occupant (SASKOC) Table Example (SGI, 2011).

CASENO	VEHNO	OCCNO	OCCPOS	AGE	SEX	SAFETYEQ
842633	1	1	1	70	M	-
842633	2	1	1	47	F	1
842636	1	1	1	25	M	-
842636	2	1	1	33	M	1
842637	1	1	3	53	F	1
842637	1	2	1	19	F	1

Note: "-" means that no data was entered into the database.

The five databases/tables – two databases (i.e., ArcGIS Intersections and ArcGIS Road Segments) and three tables (i.e., SASKAC, SASKVE and SASKOC) – needed to be integrated with each other to develop databases that could be used for the case study because one database/table contained information that the other database/table did not have. Integrating the five databases/tables was also required because there were duplicate case numbers for the SASKVE and SASKOC tables whereas the SASKAC did not.

4.2. Emphasis Areas

4.2.1. Emphasis Area Selection Process

The first component in the development of a municipal-level SHSP for the City of Saskatoon was the selection of emphasis areas. The hybrid approach (i.e., combination of data-driven approach and political decision) was used to select the emphasis areas as it is the most common approach in North American SHSPs.

In order to select potential emphasis areas for the City of Saskatoon, emphasis areas in existing SHSPs were first reviewed. A number of SHSPs were reviewed – federal-level SHSPs (Transport Canada, 2001; CCMTA, 2011a), provincial-level SHSPs (Alberta, 2006; British Columbia, 2010a; Saskatchewan, 2012d), municipal-level SHSPs (Burlington, 2006; Edmonton, 2007; New Westminster, 2007; Red Deer, 2007; Strathcona County, 2008; Hamilton, 2009; North Vancouver, 2010b; Grande Prairie, 2011; Ottawa, 2011) and the AASHTO (2005) SHSP.

A frequency table was created to determine the number of emphasis areas chosen by each municipality (see Table 10). The emphasis areas were divided into CCMTA's (2011a) four contributing factors (i.e., impaired driving, speed and aggressive driving, occupant protection, and environmental factors) and six target groups (i.e., young drivers, medically-at-risk-drivers, vulnerable road users, motor carriers, high-risk drivers and general population) categories. The emphasis areas considered were those with a percentage greater than 1%, which are highlighted in gray.

Table 10: Selected Emphasis Areas by Cities.

Emphasis Areas			Number of Cities	Percentage (%)
Contributing Factors	Impaired Driving	Cell Phone Usage	1	**1**
		Distracted/Fatigued Drivers	1	**1**
		Impaired Driving (Drug and Alcohol)	5	**6**
	Speed & Aggressive Driving	Aggressive Drivers	5	**6**
		Speeding	6	**7**
	Occupant Protection	Seatbelts & Air Bags	4	**5**
	Environmental Factors	Avalanches	0	**0**
		Bridges	0	**0**
		Fixed Object Collisions	0	**0**
		Guiderail	0	**0**
		Head-On & Cross-Median Collisions	0	**0**
		High-Risk Locations	0	**0**
		Horizontal Curves	1	**1**
		Intersections	4	**5**
		Lane Departures	1	**1**
		Lights on Road	0	**0**
		Local Roads	0	**0**
		Minimize Effects of Leaving Roadway	0	**0**
		Municipal Road Network	3	**4**
		Pavement Markings	2	**2**
		Railroad Crossings	1	**1**
		Rear End Crashes	1	**1**
		Angle Collisions	1	**1**
		Road Safety Audits	0	**0**
		Roadway and Roadside Design and Operation	2	**2**
		Road Improvement Program	0	**0**
		Road Engineering	0	**0**
		Road Materials	0	**0**
		Roadway Configuration	2	**2**
		Rockfall	0	**0**
		Roll Over	0	**0**
		Rural Roadways	2	**2**
		Safety Corridors	0	**0**
		School Zones	1	**1**
		Secondary on Interstate	0	**0**
		Side Swipe	0	**0**
		Signage	0	**0**
		Transport of Goods	0	**0**
		Turning Movement Collisions	1	**1**
		Urban Roadways	0	**0**
		Winter Driving	2	**2**
		Wildlife	0	**0**
		Work Zone Collisions	1	**1**

Table 10: Selected Emphasis Areas by Cities (Continued).

Emphasis Areas			Number of Cities	Percentage (%)
Key Target Groups	Young Drivers	Graduated Drivers Licensing	3	**4**
	Medically-at-risk-Drivers	Medically Unfit Drivers	0	**0**
		Older Drivers	1	**1**
	Vulnerable Road Users	Bicycles	7	**9**
		Equestrian	0	**0**
		Motorcyclists/Mopeds	3	**4**
		Pedestrians	7	**9**
	Motor Carriers	All-Terrain Vehicles (ATVs)	0	**0**
		Auto Crime	0	**0**
		Buses	0	**0**
		Commercial Vehicles/Heavy Trucks	2	**2**
		Pick-Up Trucks	0	**0**
		Public Transit	1	**1**
		In-Vehicle Enhancements/Safer Vehicles	0	**0**
		School Buses	0	**0**
	High-Risk Drivers	Dangerous Driving	0	**0**
		Multiple Collision Drivers (Repeat Offenders)	0	**0**
		Restricted Drivers	0	**0**
		Suspended Drivers	0	**0**
		Unlicensed Drivers	0	**0**
	General Population	Access Management	0	**0**
		Data Analysis	1	**1**
		Data Collection	1	**1**
		Data/Records	2	**2**
		Driver Education	2	**2**
		Information Systems for Decision-Making	0	**0**
		Emergency Medical Services (EMS)	0	**0**
		Incident Clearance	0	**0**
		Incident Management	0	**0**
		Incident Management Task Force	0	**0**
		Legislation	0	**0**
		Policing	0	**0**
		Policy Maker Awareness	0	**0**
		Public Information	1	**1**
		Research & Development	0	**0**
		Safety Management System	0	**0**
		Technology	0	**0**
		Traffic Safety Improvements	4	**5**
		Transportation Safety Planning	0	**0**
OTHER		Improve Driver Decisions-Rights of Way/Turning	0	**0**
		Limited English Proficiency	0	**0**
		Native American Drivers	0	**0**
		Uninsured Drivers	0	**0**

The next step was to consider the data available in the SGI's collision database. Table 11 shows 33 potential emphasis areas that were screened on the basis of the literature review. 10 (highlighted in gray) of the 33 potential emphasis areas were discarded because of a lack of collision data linked to these particular emphasis areas. For example, there is no collision record relating to EMS. Seven of the 10 (i.e., Signage, Data Collection/Record/Analysis Improvement, Driver Education, Municipal Road Network Improvement, Public Information, Roadway and Roadside Design and Operation Improvement, and Traffic Safety Legislation) that were discarded were countermeasures rather than emphasis areas. For example, Driver Education can be used to reduce the number of collisions in a particular emphasis area rather than be an emphasis area. Once the 10 emphasis areas were discarded, 23 potential emphasis areas remain.

Table 11: Potential Emphasis Areas (SGI, 2011).

Drivers 1. Aggressive Driving 2. Distracted Driving 3. Fatigued Driving 4. Impaired Driving 5. Medically-at-risk Driving 6. Older Drivers 7. Seatbelts 8. Young Drivers Environmental Conditions 9. Angle Collisions 10. At-Grade Crossings 11. Horizontal Curves 12. Intersections 13. Lane Departure Collisions 14. Pavement Markings 15. Rear End Collisions 16. Road Condition 17. Roadway Configuration 18. Rural Roadways 19. Signage 20. School Zones	21. Turning Movement Collisions 22. Wildlife 23. Winter Driving 24. Work Zones Data Management/Public Education 25. Data Collection/Record/Analysis Improvement 26. Driver Education 27. Municipal Road Network Improvement 28. Public Information 29. Roadway and Roadside Design and Operation Improvement Special Road Users 30. Commercial Vehicles (Public Transit and Heavy Trucks) 31. Vulnerable Road Users (Bicycles/Motorcycles/Pedestrians) Others 32. Emergency Medical Services (EMS) 33. Traffic Safety Legislation

4.2.2. Data Management

The hybrid approach requires collision data to conduct descriptive data analysis, which refers to histograms that present the collision trends. Therefore, the five databases/tables (ArcGIS Intersections, ArcGIS Road Segments, SASKAC, SASKVE and SASKOC) needed to be integrated with each other to develop databases that could be inputted into R-language (ver. 2.1.3.1) to produce various histograms (i.e., by year, season, month, day of the week, hour etc.). The data collected was first reviewed for missing or incomplete data and unreasonable record of collisions.

Microsoft Access 2007 was used to link the five databases/tables, and create queries to develop the integrated databases.

The first integrated database was created from the SASKAC table in order to present the total number of collisions. The total number of collisions is required to observe the collision history for the City of Saskatoon. This database was needed to create histograms from data that Table 7 was lacking (i.e., year, season, month, day of the week, hour, road classification and traffic control). While year, season, month, day of the week and hour consisted of simply reformatting ACCDATE and ACCTIME and adding those two as column headers, road classification and traffic control needed to be linked in a different manner. Road classification was linked from the ArcGIS Intersections and ArcGIS Road Segments databases while traffic control was linked from the SASKVE table. Table 12 shows an example of the information from the integrated "Total Number of Collisions" database, including road classification (RC) and traffic controls (CONTROLS).

The second integrated database contained all of the 23 potential emphasis areas for the City of Saskatoon. This integrated database was created by linking the SASKAC, SASKVE and SASKOC tables. Some of the potential emphasis areas were created from the SASKAC and SASKVE tables as the SASKAC table contained the accident information and the SASKVE table contained the major contributing factors. SGI (2007) defines major contributing factors as "any factor that the reporting police officer perceives to have directly contributed to the occurrence of the collision or increased its severity". Microsoft Access was first used to create a query that filtered out case numbers based on the major contributing factor, which defined a potential emphasis area. Appendix A contains the definitions of the 23 potential emphasis areas by major contributing factors. For example, the Aggressive Driving potential emphasis area was created from major contributing factor codes 21 (fail to yield the right-of-way), 22 (traffic control device disregarded), 23 (following too closely), 24 (driving too fast for road conditions),

25 (exceeding speed limit), 26 (turning improper), 27 (passing or lane usage improper) and 32 (careless driving/stunting), and was linked to the accident information from the SASKAC table. Other potential emphasis areas were created from the SASKAC and SASKOC tables. For example, the Seatbelts potential emphasis area was created from SAFETYEQ 8 code from the SASKOC table and linked to the accident information from the SASKAC table. Other potential emphasis areas were simpler because the data required was already contained in the same table – the SASKAC table. For example, the Angle Collisions potential emphasis area was created by filtering the case numbers that were CONFIG 09, which are defined as right angle collisions. Table 13 shows an example of the information in the integrated "All Potential Emphasis Areas" database, including emphasis area (EA), road classification (RC), traffic controls (CONTROLS) etc.

Table 12: Integrated Total Number of Collisions Database Example (SGI, 2011; COS, 2013a).

CASENO	SEVERITY	ACCDATE	ACCTIME	UGRID	ACCSITE	CONFIG	YEAR	SEASON	MONTH	DAYofWEEK	HOUR	RC	CONTROLS
84486	1	11-Jan-08	1302	SKE8-34	01	8	2008	Winter	1	Friday	14	Intersection	1
132504	1	8-Jul-04	1830	SKG6-3	01	16	2004	Summer	7	Thursday	19	Intersection	1
151857	1	19-Oct-05	1105	SKN11-9	01	6	2005	Fall	10	Wednesday	12	Major Arterial Uncontrolled	1
157820	2	29-May-07	1718	SKG5-51	04	9	2007	Spring	5	Tuesday	18	Intersection	6
158705	1	19-Jun-07	742	SKH6-101	01	5	2007	Summer	6	Tuesday	8	Intersection	1
159570	1	11-May-07	725	SKO8-19	01	16	2007	Spring	5	Friday	8	Intersection	1

Table 13: Integrated All Potential Emphasis Areas Database Example (SGI, 2011; COS, 2013a).

EA	CASENO	SEVERITY	ACCDATE	ACCTIME	UGRID	ACCSITE	CONFIG	YEAR	SEASON	MONTH	DAYofWEEK	HOUR	RC	CONTROLS
1	84486	1	11-Jan-08	1302	SKE8-34	1	8	2008	Winter	1	Friday	14	Intersection	1
1	132504	1	8-Jul-04	1830	SKG6-3	1	16	2004	Summer	7	Thursday	19	Intersection	1
2	1323092	1	21-May-02	859	SKL4-1	1	4	2002	Spring	5	Tuesday	9	Intersection	1
2	1323109	1	10-Jun-01	2220	SKE8-33	1	5	2001	Summer	6	Sunday	23	Minor Arterial	1
3	1403488	1	30-Apr-02	2345	SKJ8-75	4	5	2002	Spring	4	Tuesday	24	Intersection	2
3	1403508	1	30-Nov-01	1530	SKP5-5	4	9	2001	Fall	11	Friday	16	Intersection	6

Some of the potential emphasis areas were non vehicle-to-vehicle collisions (i.e., includes vehicle-to-pedestrian and vehicle-to-cyclist collisions) and some were vehicle-to-vehicle collisions (i.e., excluding vehicle-to-pedestrian and vehicle-to-cyclist collisions). Therefore, a third (non vehicle-to-vehicle collisions) and fourth (vehicle-to-vehicle collisions) integrated database had to be created. This required the use of the SASKVE and SASKOC tables.

Table 14 shows an example of the information in the integrated "Non Vehicle-to-Vehicle" database, including case numbers from the SASKVE table (SASKVE.CASENO), vehicle number (VEHNO), driver sex (DRVSEX), driver age (DRVAGE), major contributing factor (MCF1), traffic control type (CONTROLS), vehicle identification (SASKVE.VIDENT), information from the SASKAC table, etc. Note that the table shows that bicycles (SASKVE.VIDENT 13) were included in this database.

A query was developed in Microsoft Access to eliminate pedestrians (OCCPOS 9) and bicyclists (VIDENT 13) to create the vehicle-to-vehicle collisions database. Table 15 presents an example of the information in the integrated "Vehicle-to-Vehicle" database. This database includes the same information as the Non Vehicle-to-Vehicle database, but excludes bicyclist (VIDENT 13) and pedestrian (OCCPOS 9) records.

The integrated databases could then be inputted into R-language to produce histograms to further analyze collision trends described in the next section.

Table 14: Integrated Non Vehicle-to-Vehicle Database Example (SGI, 2011; COS, 2013a).

SASKVE.CASENO	VEHNO	DRVSEX	DRVAGE	MCF1	CONTROLS	SASKVE.VIDENT	SASKAC.CASENO	SEVERITY	ACCDATE	ACCTIME	UGRID
1085269	1	M	20	25	1	11	1085269	2	14-Aug-03	1756	SKN3-1
1085269	2	F	53	99	1	3	1085269	2	14-Aug-03	1756	SKN3-1
1085270	1	M	40	22	2	3	1085270	1	15-Aug-03	2305	SKB7-26
1085270	2	F	26	99	2	3	1085270	1	15-Aug-03	2305	SKB7-26
1085271	1	M	15	1	2	13	1085271	2	16-Aug-03	2340	SKN8-2
1085271	2	M	59	99	2	1	1085271	2	16-Aug-03	2340	SKN8-2

Table 15. Integrated Vehicle-to-Vehicle Database Example (SGI, 2011; COS, 2013a).

SASKVE.CASENO	SASKVE.VEHNO	DRVSEX	DRVAGE	MCF1	CONTROLS	SASKVE.VIDENT	SASKAC.CASENO	SEVERITY	ACCDATE	ACCTIME	UGRID
1185406	1	M	19	62	1	3	1185406	1	22-Oct-01	945	SKJ7-1
1185406	2	M	24	62	1	1	1185406	1	22-Oct-01	945	SKJ7-1
1186016	1	M	85	51	1	2	1186016	1	28-Jan-01	1500	SKG8-23
1186017	1	F	22	74	1	1	1186017	1	15-Feb-01	53	SKG8-64
1186018	1	F	42	21	2	1	1186018	1	6-Apr-01	1130	SKF8-82
1186018	2	F	44	99	2	1	1186018	1	6-Apr-01	1130	SKF8-82

4.2.3. Collision Comparison between Potential Emphasis Areas

Figure 10 and Figure 11 show the frequency and percentage of the 23 potential emphasis areas sorted in descending order by total collisions and fatal or injury (FI) collisions, respectively during the ten-year study period (2001-2010). Table 16 summarizes the number and percentage of collisions by severity (FI, fatal, injury, PDO and total), and shows the detailed collision numbers, percentages and ranks. Note that the grand total is not the sum of the 23 potential emphasis areas' collisions because the collisions are not mutually exclusive. Some collisions can be categorized under the same emphasis area (e.g., a collision caused by aggressive driving could occur at an intersection). As a result, the grand totals shown in the last row of Table 16 do not present the sum of the collisions in each column, but refer to the total number of collisions for each severity during the study period (2001-2010) shown in Table 1. The rankings are based on the totals shown in the Grand Total row.

The ten potential emphasis areas that account for less than 2% of total collisions (i.e., Medically-at-risk Driving, Winter Driving, Wildlife, Seatbelts, At-Grade Crossings, Fatigued Driving, Work Zones, School Zones, Pavement Markings and Commercial Vehicles) were removed. Thus, 13 remained as potential emphasis areas for the City of Saskatoon.

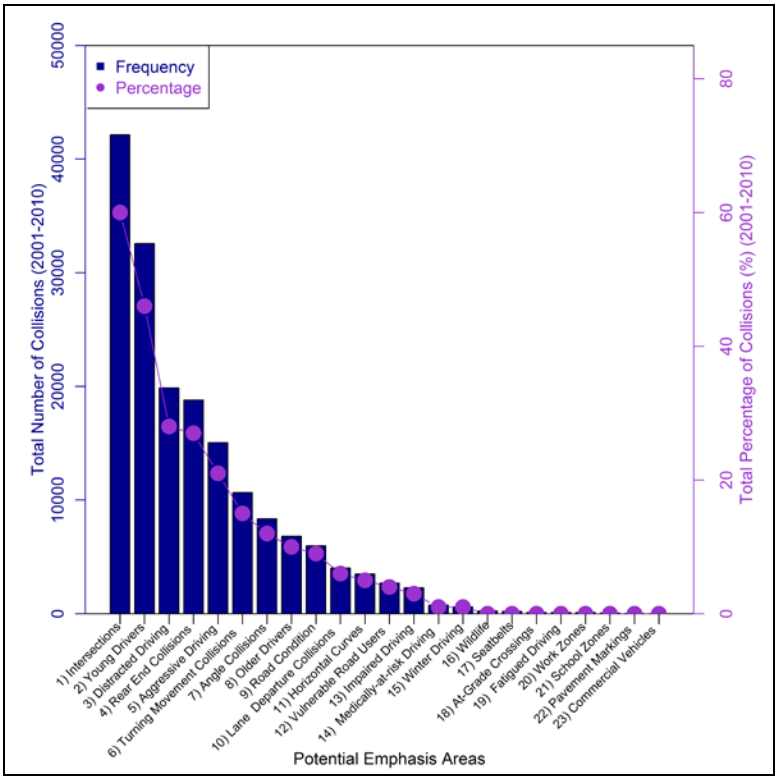


Figure 10: Total Number of Collisions by Potential Emphasis Areas, 2001-2010 (SGI, 2011; COS, 2013a).

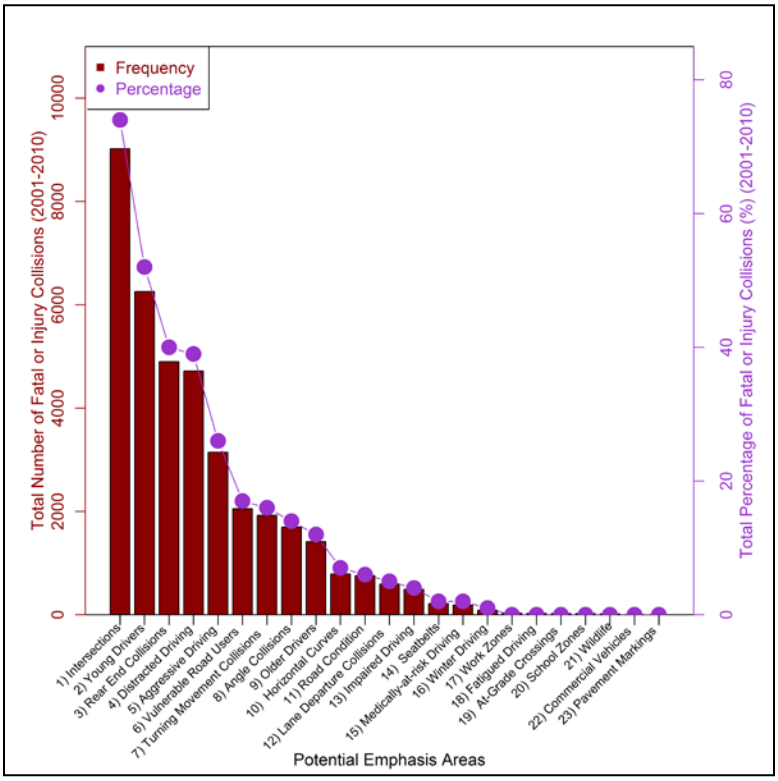


Figure 11: Total Number of Fatal or Injury Collisions by Potential Emphasis Areas, 2001-2010 (SGI, 2011; COS, 2013a).

The ranking for total collisions (by percentage) are as follows (see Table 16):

1. Intersections (60%);
2. Young Drivers (46%);
3. Distracted Driving (28%);
4. Rear End Collisions (27%);
5. Aggressive Driving (21%);
6. Turning Movement Collisions (15%);
7. Angle Collisions (12%);
8. Older Drivers (10%);
9. Road Condition (9%);
10. Lane Departure Collisions (6%);
11. Horizontal Curves (5%);
12. Vulnerable Road Users (4%); and,
13. Impaired Driving (3%).

The ranking for fatal or injury collisions is slightly different, but the top 13 potential emphasis areas are the same for both the total and fatal or injury collision lists.

Table 16: Number of Collisions by Severity and Potential Emphasis Area, 2001-2010 (SGI, 2011; COS, 2013a).

Potential Emphasis Areas		FI			Fatal			Injury			PDO			Total		
		Number	%	Rank	Number	%	Rank	Number	%	Rank	Number	%	Rank	Number	%	Rank
Drivers	Aggressive Driving	3,147	26	5	18	29	4	3,129	26	5	11,916	20	5	15,063	21	5
	Distracted Driving	4,718	39	4	11	17	9	4,707	39	4	15,153	26	3	19,871	28	3
	Fatigued Driving	29	0	18	0	0	23	29	0	18	93	0	18	122	0	19
	Impaired Driving	493	4	13	8	13	10	485	4	13	1,815	3	12	2,308	3	13
	Medically-at-risk Driving	190	2	15	7	11	12	183	2	15	580	1	14	770	1	14
	Older Drivers	1,417	12	9	13	21	7	1,404	12	9	5,417	9	8	6,834	10	8
	Seatbelts	217	2	14	7	11	11	210	2	14	1	0	22	218	0	17
	Young Drivers	6,260	52	2	23	37	2	6,237	52	2	26,324	45	2	32,584	46	2
Environmental Conditions	Angle Collisions	1,698	14	8	13	21	8	1,685	14	8	6,657	11	7	8,355	12	7
	At-Grade Crossings	25	0	19	1	2	16	24	0	19	107	0	17	132	0	18
	Horizontal Curves	790	7	10	13	21	6	777	6	10	2,711	5	11	3,501	5	11
	Intersections	9,020	74	1	38	60	1	8,982	74	1	33,118	57	1	42,138	60	1
	Lane Departure Collisions	592	5	12	14	22	5	578	5	12	3,450	6	10	4,042	6	10
	Pavement Markings	0	0	23	0	0	19	0	0	23	1	0	21	1	0	22
	Rear End Collisions	4,900	40	3	3	5	14	4,897	41	3	13,907	24	4	18,807	27	4
	Road Condition	759	6	11	1	2	17	758	6	11	5,236	9	9	5,995	9	9
	School Zones	23	0	20	0	0	20	23	0	20	38	0	20	61	0	21
	Turning Movement Collisions	1,928	16	7	6	10	13	1,922	16	7	8,737	15	6	10,665	15	6
	Wildlife	17	0	21	0	0	22	17	0	21	246	0	16	263	0	16
	Winter Driving	89	1	16	2	3	15	87	1	16	522	1	15	611	1	15
	Work Zones	33	0	17	0	0	21	33	0	17	87	0	19	120	0	20
Special Road Users	Commercial Vehicles	0	0	22	0	0	18	0	0	22	0	0	23	0	0	23
	Vulnerable Road Users	2,053	17	6	21	33	3	2,032	17	6	653	1	13	2,706	4	12
Grand Total		12,150	NA	NA	63	NA	NA	12,087	NA	NA	58,337	NA	NA	70,487	NA	NA

Direct and societal costs can also be used as supplementary information in the selection of emphasis areas. Table 17 summarizes the direct and societal costs by severity. The direct costs were taken from the SGI's 2005 to 2009 collision costs (SGI, 2012a). The 2007 dollar values used for direct costs are based on the average of the 2005 to 2009 costs. Societal costs were taken from CRISP's (2010) collision cost study which reported 2007 dollar values. The costs used were not inflated.

Table 17: Direct and Societal Costs by Severity (CRISP, 2010; SGI, 2012a).

Severity	Direct Costs (2007 $)	Societal Costs (2007 $)
Fatal	251,973	5,543,800
Injury	25,204	134,600
PDO	4,365	10,900

Figure 12 and Figure 13 present the direct cost of total collisions and fatal or injury collisions, respectively for each of the 23 potential emphasis areas. For example, intersection collisions (the top ranked emphasis area) resulted in a direct cost of $380.52 million for total collisions and $235.96 million for fatal or injury collisions over the ten-year study period (2001-2010). Table 18 shows the detailed direct costs. Young drivers ranked second ($277.90 million) and distracted driving ranked third ($187.55 million).

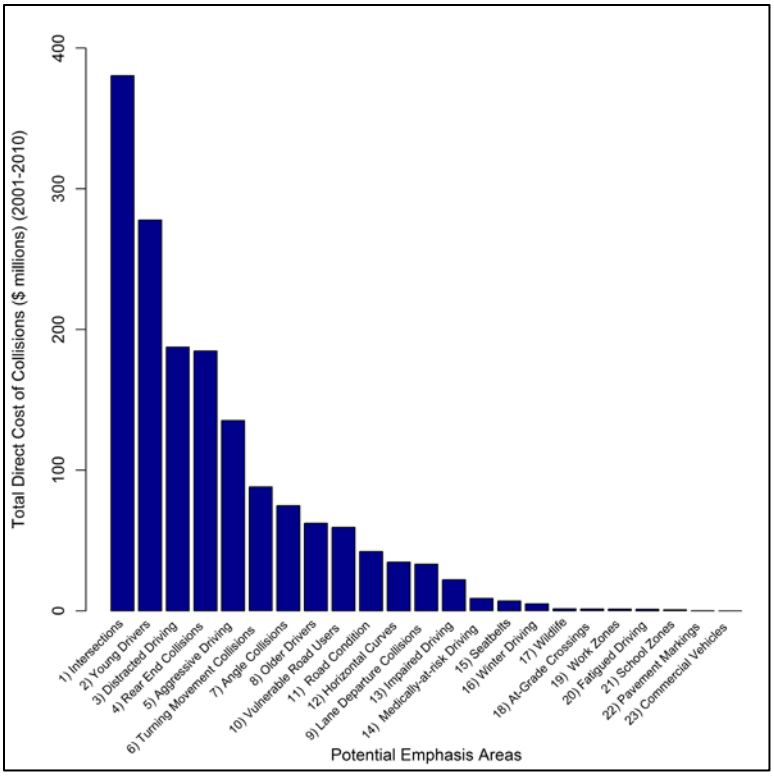


Figure 12: Total Direct Cost of Collisions by Potential Emphasis Areas (2007 $ millions), 2001-2010 (SGI, 2011; COS, 2013a).

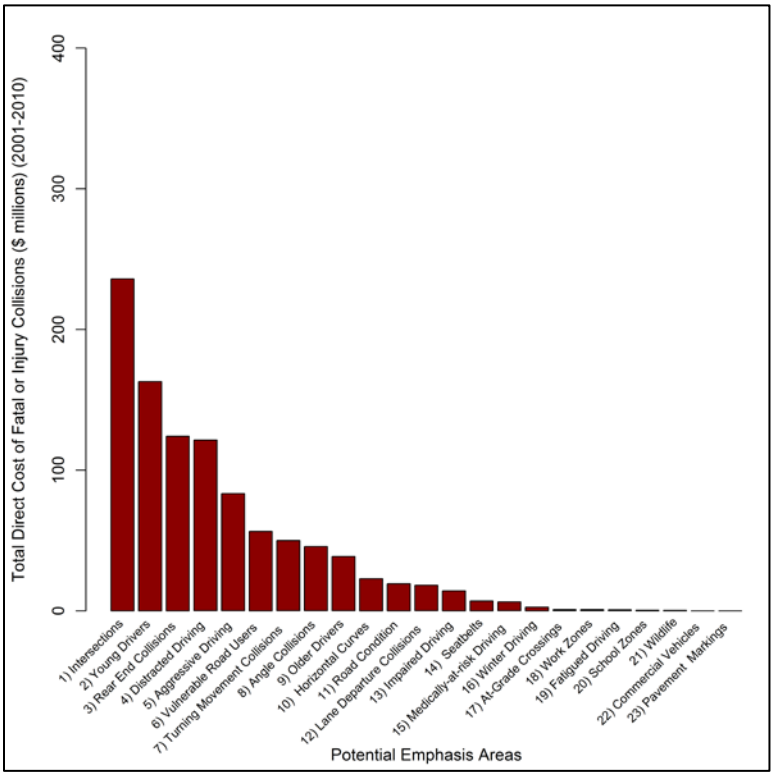


Figure 13: Total Direct Cost of Fatal or Injury Collisions by Potential Emphasis Areas (2007 $ millions), 2001-2010 (SGI, 2011; COS, 2013a).

Table 18: Direct Cost of Collisions by Severity and Potential Emphasis Area (2007 $ millions), 2001-2010 (SGI, 2011; COS, 2013a).

Potential Emphasis Area		FI	Fatal	Injury	PDO	Total
Drivers	Aggressive Driving	83.40	4.54	78.86	52.01	135.41
	Distracted Driving	121.41	2.77	118.64	66.14	187.55
	Fatigued Driving	0.73	0.00	0.73	0.41	1.14
	Impaired Driving	14.24	2.02	12.22	7.92	22.16
	Medically-at-risk Driving	6.38	1.76	4.61	2.53	8.91
	Older Drivers	38.66	3.28	35.39	23.65	62.31
	Seatbelts	7.06	1.76	5.29	0.00	7.06
	Young Drivers	162.99	5.80	157.20	114.90	277.90
Environmental Conditions	Angle Collisions	45.74	3.28	42.47	29.06	74.80
	At-Grade Crossings	0.86	0.25	0.60	0.47	1.32
	Horizontal Curves	22.86	3.28	19.58	11.83	34.69
	Intersections	235.96	9.57	226.38	144.56	380.52
	Lane Departure Collisions	18.10	0.00	0.00	0.00	33.15
	Pavement Markings	0.00	0.00	0.00	0.00	0.00
	Rear End Collisions	124.18	0.76	123.42	60.70	184.88
	Road Condition	19.36	0.25	19.10	22.86	42.21
	School Zones	0.58	0.00	0.58	0.17	0.75
	Turning Movement Collisions	49.95	1.51	48.44	38.14	88.09
	Wildlife	0.43	0.00	0.43	1.07	1.50
	Winter Driving	2.70	0.50	2.19	2.28	4.98
	Work Zones	0.83	0.00	0.83	0.38	1.21
Special Road Users	Commercial Vehicles	0.00	0.00	0.00	0.00	0.00
	Vulnerable Road Users	56.51	5.29	51.21	2.85	59.36
Grand Total		1,012.91	46.62	948.20	581.94	1,609.90

Figure 14 and Figure 15 present the societal cost of total collisions and fatal or injury collisions, respectively for each of the 23 potential emphasis areas. Intersection collisions resulted in a societal cost of $1.78 billion, approximately 4.7 times higher than the direct cost of the same emphasis area. Table 19 shows the detailed societal costs.

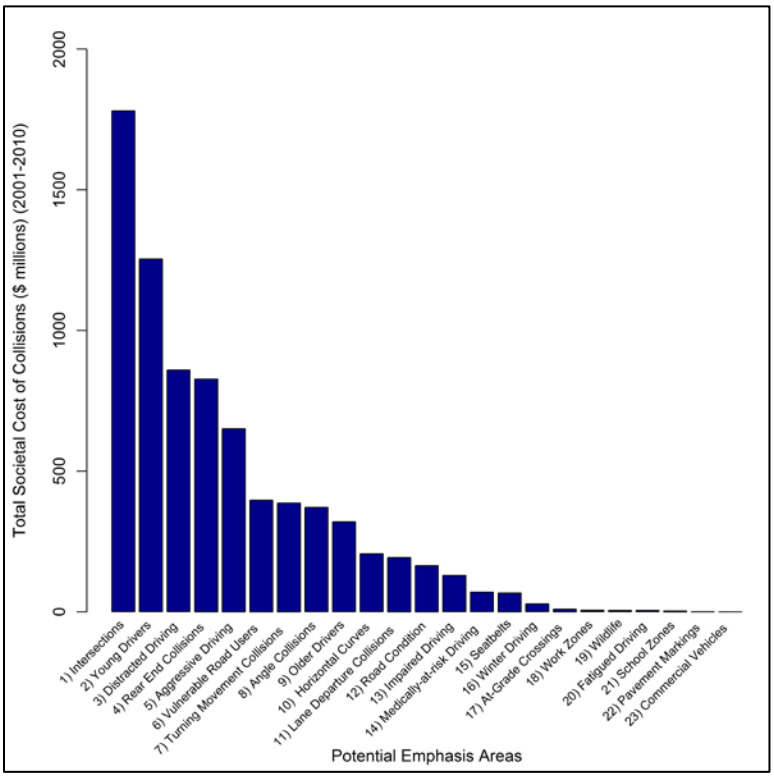


Figure 14: Total Societal Cost of Collisions by Potential Emphasis Area (2007 $ millions), 2001-2010 (SGI, 2011; COS, 2013a).

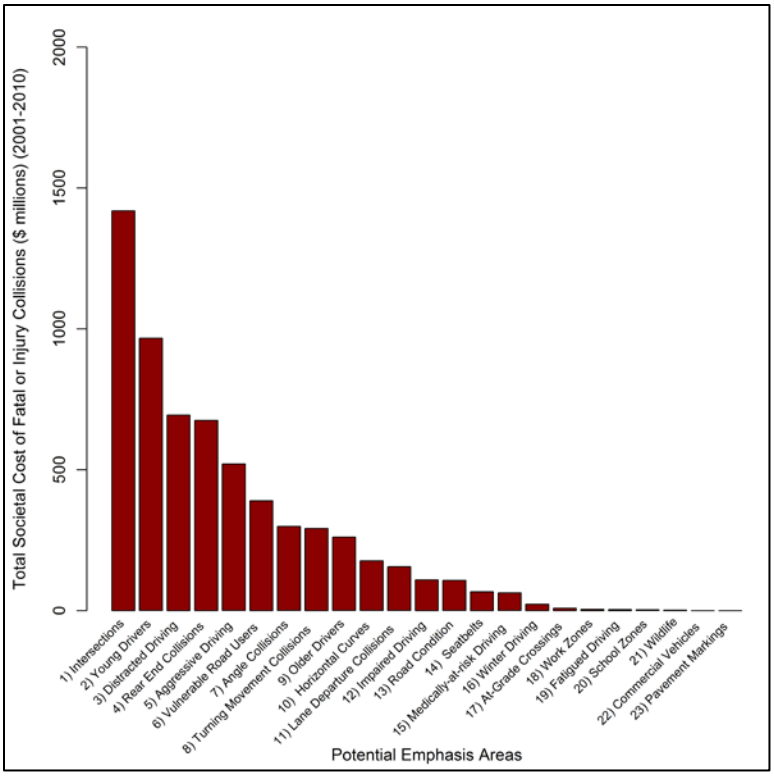


Figure 15: Total Societal Cost of Fatal or Injury Collisions by Potential Emphasis Area (2007 $ millions), 2001-2010 (SGI, 2011; COS, 2013a).

Table 19: Societal Cost of Collisions by Severity and Potential Emphasis Area (2007 $ millions), 2001-2010 (SGI, 2011; COS, 2013a).

Potential Emphasis Area		FI	Fatal	Injury	PDO	Total
Drivers	Aggressive Driving	520.95	99.79	421.16	129.88	650.84
	Distracted Driving	694.54	60.98	633.56	165.17	859.71
	Fatigued Driving	3.90	0.00	3.90	1.01	4.92
	Impaired Driving	109.63	44.35	65.28	19.78	129.41
	Medically-at-risk Driving	63.44	38.81	24.63	6.32	69.76
	Older Drivers	261.05	72.07	188.98	59.05	320.09
	Seatbelts	67.07	38.81	28.27	0.01	67.08
	Young Drivers	967.01	127.51	839.50	286.93	1,253.94
Environmental Conditions	Angle Collisions	298.87	72.07	226.80	72.56	371.43
	At-Grade Crossings	8.77	5.54	3.23	1.17	9.94
	Horizontal Curves	176.65	72.07	104.58	29.55	206.20
	Intersections	1,419.64	210.66	1,208.98	360.99	1,780.63
	Lane Departure Collisions	155.41	0.00	0.00	0.00	193.02
	Pavement Markings	0.00	0.00	0.00	0.01	0.01
	Rear End Collisions	675.77	16.63	659.14	151.59	827.35
	Road Condition	107.57	5.54	102.03	57.07	164.64
	School Zones	3.10	0.00	3.10	0.41	3.51
	Turning Movement Collisions	291.96	33.26	258.70	95.23	387.20
	Wildlife	2.29	0.00	2.29	2.68	4.97
	Winter Driving	22.80	11.09	11.71	5.69	28.49
	Work Zones	4.44	0.00	4.44	0.95	5.39
Special Road Users	Commercial Vehicles	0.00	0.00	0.00	0.00	0.00
	Vulnerable Road Users	389.93	116.42	273.51	7.12	397.04
Grand Total		6,244.80	1,025.60	5,063.79	1,453.18	7,735.59

Detailed collision statistics for the top 13 potential emphasis areas (i.e., the safety concerning areas with greater than 2% total collision frequency shown in Figure 10) were created. The 13 emphasis areas are grouped under three headings shown in Table 20.

Table 20: 13 Potential Emphasis Areas (SGI, 2011; COS, 2013a).

Drivers 1. Aggressive Driving (21%) 2. Distracted Driving (28%) 3. Impaired Driving (3%) 4. Older Drivers (10%) 5. Young Drivers (46%) Environmental Conditions 6. Angle Collisions (12%) 7. Horizontal Curves (5%)	8. Intersections (60%) 9. Lane Departure Collisions (6%) 10. Rear End Collisions (27%) 11. Road Condition (9%) 12. Turning Movement Collisions (15%) Special Road Users 13. Vulnerable Road Users (4%) (Bicycles/Motorcycles/Pedestrians)

The City of Saskatoon's detailed collision history is included in Appendix B. The collision trends including direct and societal cost trends were created for each potential emphasis area. The direct and societal costs per year for the 13 potential emphasis areas are found in Appendix C. The collision trends were compared to each other and to Saskatoon's collision history in order to select the chosen emphasis areas for the City of Saskatoon's SHSP discussed in the next section.

4.2.4. Selection of the City of Saskatoon's Emphasis Areas

The collision statistics for each of the 13 potential emphasis areas were analyzed at an interim stakeholder workshop held on November 26th, 2012 in order to gather input from the various agencies involved. A total of 11 personnel from six different agencies (City of Saskatoon (COS), COS Traffic Safety Committee (TSC), Saskatoon Board of Education (SBOE), SGI, Saskatoon Police Service (SPS) and University of Saskatchewan) participated in the workshop. The collision statistics were presented and a questionnaire was circulated. A copy of the

questionnaire can be found in Appendix D. The top 13 potential emphasis areas that resulted from the questionnaire were ranked as shown in Table 21.

Table 21: 13 Potential Emphasis Areas Ranked by Stakeholders.

1. Intersections 2. Vulnerable Road Users 3. Distracted Driving 4. Aggressive Driving 5. Young Drivers 6. Impaired Driving 6. Angle Collisions	8. Turning Movement Collisions 9. Road Condition 10. Older Drivers 11. Rear End Collisions 12. Horizontal Curves 13. Lane Departure Collisions

Note: Duplicate rank values indicate equally ranked potential emphasis areas.

Following intensive discussions about the collision data and survey results, the stakeholders reduced the two lists of 13 potential emphasis areas (the Section 4.2.3 list and the stakeholders' list) to seven emphasis areas. These seven emphasis areas were considered to be major areas of safety concern for the City of Saskatoon. They are:

- Emphasis Area #1: Aggressive Driving;
- Emphasis Area #2: Distracted Driving;
- Emphasis Area #3: Impaired Driving;
- Emphasis Area #4: Intersections;
- Emphasis Area #5: Older Drivers;
- Emphasis Area #6: Vulnerable Road Users; and,
- Emphasis Area #7: Young Drivers.

The seven chosen emphasis areas are listed in alphabetical order. The emphasis areas are not ranked, but are equal in priority.

Various factors supported the selection of each of the seven emphasis areas. Aggressive Driving was chosen because the stakeholders believe that congestion in Saskatoon will increase as Saskatoon is known to be one of the fast growing cities in western Canada, and Aggressive

Driving is known to stem from drivers' frustration with congested roads. The use of new communication technologies, such as handset devices, is a fast growing safety problem in Saskatoon and thus, Distracted Driving was selected. Impaired Driving was included because the public is keenly aware of the problem of Impaired Driving and demands action. The number and percentage of Impaired Driving collisions is, however, relatively small. Far more collisions occur at intersections than on road segments and for that reason, Intersections was selected (see Figure B18 in Appendix B). Collisions at both signalized and unsignalized intersections are included in the Intersections emphasis area. Stakeholders also agreed that potential safety issues relating to Older Drivers must be considered as Saskatoon's population is aging. Vulnerable Road Users was also chosen as the consequences of collisions involving pedestrians or bicyclists are often very severe. The number and percentage of Vulnerable Road Users collisions is, however, relatively small. Lastly, Young Drivers was included as they are involved in many collisions related to the selected emphasis areas (e.g., Distracted Driving and Impaired Driving).

Six of the 13 potential emphasis areas were excluded for various reasons. Angle Collisions and Turning Movement Collisions were not selected as emphasis areas because Angle Collisions occur mainly at unsignalized intersections, and Turning Movement Collisions occur mainly at signalized intersections; the Intersections emphasis area already includes both types of collisions. Road Condition was not selected because it is heavily related to weather conditions which are not easily controllable through safety strategies/programs. Rear End Collisions, Horizontal Curves Collisions and Lane Departure Collisions were also excluded because these emphasis areas were ranked low (11th, 12th and 13th, respectively) in the questionnaire ranking.

4.3. Target Safety Goals

The step following the selection of emphasis areas is the development of target goals. The City of Saskatoon's target safety goal requires a safety measure, a target and a time frame.

Based on the literature review, *fatal or injury collisions* was chosen as the safety measure for the City of Saskatoon. City of Saskatoon's collision history showed that fatal collisions are too few to be used as a sole safety measure and need to be combined with injury collisions to produce meaningful collision patterns. The "Vision Zero" approach was used to determine the City of Saskatoon's target safety goals. Figure 16 shows the Vision Zero approach applied to the City of Saskatoon using the total number of fatal or injury collisions. The baseline for Figure 16 is the average number of fatal or injury collisions for the most recent five-year total collision data (2006-2010). This value (1,250) becomes the baseline number of fatal or injury collisions for 2012. It is assumed that the level of safety in terms of the number of fatal or injury collisions remained constant from 2010 to 2012.

Figure 16 presents three different time horizons for estimating the rate of reduction required to meet the target safety goal of zero collisions (i.e., Vision Zero): 30 years (aggressive), 40 years (ambitious) and 50 years (conservative). These three time horizons result in three different target safety goals over five years: 20%, 15% and 10%, respectively. Figure 16 shows that, if the number of collisions can be reduced by 10% every five years for 50 years, Vision Zero would be achieved in 2062.

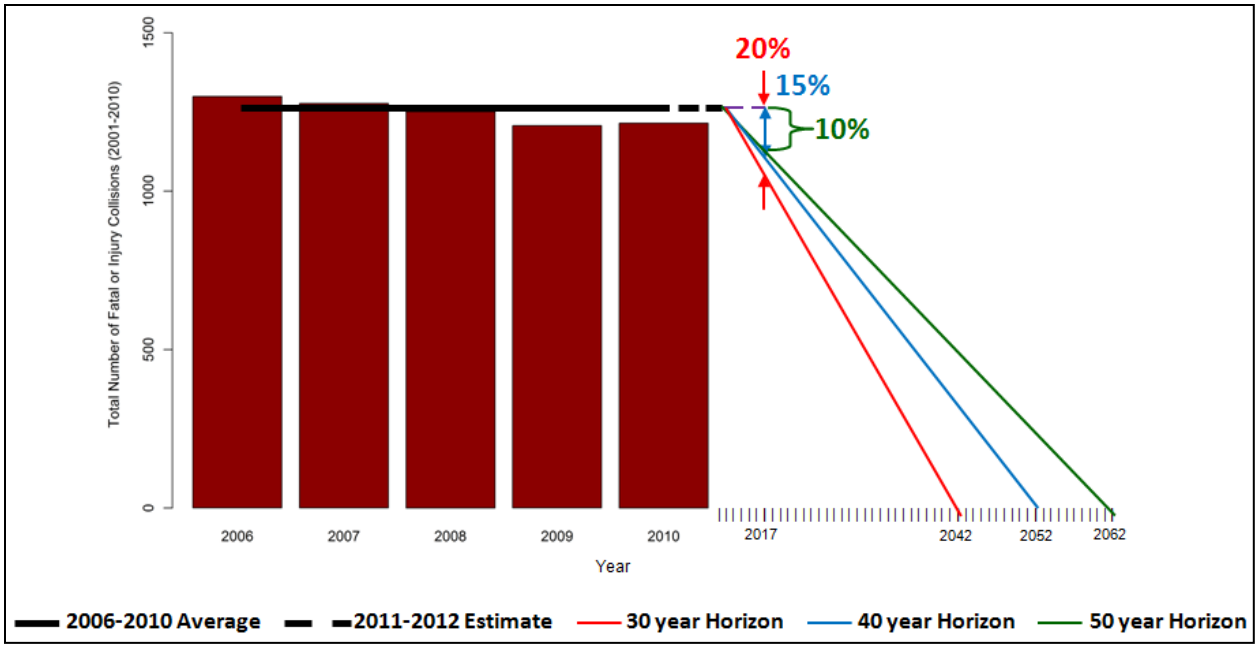


Figure 16: Vision Zero Target Safety Goals, 2006-2010 (SGI, 2011).

A 10% reduction in fatal or injury collisions over the next five years should be the target safety goal for the City of Saskatoon. The 10% target was chosen to take into account the City's circumstance and role in Saskatchewan, and strike the best balance between percentage reductions that could be too high or too low. The City of Saskatoon's population is growing rapidly and this trend is expected to continue. The increase in population will inevitably result in increased traffic volume which is likely to result in an increase in the number of severe collisions. As a result, the aggressive (20%) and ambitious (15%) target safety goals may be unrealistic and unachievable for a city that is growing rapidly. The 10% target appears more reasonable.

The chosen 10% target also takes into account upper-level target safety goals. SGI's provincial-level collision reduction targets are a 30% reduction for fatalities and a 10% reduction for injuries. The City of Saskatoon is the largest city in the province in terms of population (and thus the number of collisions). If the City of Saskatoon selected a target safety goal considerably

lower (e.g., 5%) than the provincial-level goal, SGI's provincial target safety goals would become very challenging.

In addition, the City of Saskatoon's 10% target is very much in line with the targets chosen by many other municipalities across Canada [Hamilton (2009) and Ottawa (2011)], reinforcing the sense that 10% is a good balance between attractive, but possibly unrealistic targets, a feasible approach and determination to increase safety. The feasible approach has the higher chance of gaining widespread public and council support, and enthusiastic collaborative safety investments amongst the various agencies.

Table 22 shows that the number of fatal or injury collisions needs to be reduced by a total of 125 to meet the 10% target safety goal over the next five years. The 125 total is categorized by emphasis area. As emphasis areas are not mutually exclusive, the sum of the individual emphasis areas is greater than 125.

Table 22: Reduction in Number of FI Collisions Required to Meet 10% Target, by Emphasis Area, 2012-2017 (SGI, 2011).

Emphasis Areas	FI Collision Reduction by 2017	Target FI Collision Reduction Goal by 2017 (%)
#1: Aggressive Driving	34	10
#2: Distracted Driving	46	10
#3: Impaired Driving	5	10
#4: Intersections	91	10
#5: Older Drivers	13	10
#6: Vulnerable Road Users	20	10
#7: Young Drivers	60	10
Total	125	10

4.4. Network Screening

4.4.1. Methodology

The Observed EPDO Average Collision Frequency method (AASHTO, 2010) was used to identify the riskiest collision locations (a.k.a., hotspots) associated with the seven emphasis areas.

Societal collision costs were used to calculate the EPDO weights (CRISP, 2010). Table 23 shows the societal costs and EPDO weights calculated for each collision severity using Equation 1 in Section 3.2.3. The weighting of a fatal collision, for example, is 509 times the weighting of a PDO collision.

Table 23: Societal Costs and EPDO Weights by Severity (CRISP, 2010).

Severity	Societal Cost (2007 $/collision)	Weight
Fatal	$5,543,800	509
Injury	$134,600	12
PDO	$10,900	1

The EPDO weights are multiplied by the corresponding number of fatal, injury and PDO collisions for each location using Equation 2 in Section 3.2.3. Note that the weights are based on the number of fatal or injury collisions, not the number of fatalities or injuries per collision. In the case of Aggressive Driving, the EPDO weight calculated at intersection SKG7-44 located at 2nd Avenue North and 25th Street East is shown as follows.

Total EPDO Score = (1 Fatal Collision×509) + (4 Injury Collisions×12) + (23 PDO Collisions×1) = 580

When screening the network, the EPDO score was used to rank locations from highest to lowest. The riskiest locations can then be shown on the collision maps.

4.4.2. Collision Maps

The SGI's collision database was linked to the City's GIS street map using the UGRID location codes. Records for individual vehicles involved in specific collisions were related to the collision

locations using common case numbers (CASENO). The UGRID locations were then displayed in a collision map using their X,Y coordinates, the most recent five-year collision data (2006-2010) and ArcGIS (ver. 10.0).

The collision maps produced show the ten riskiest locations for each emphasis area. Some collision maps, however, show more than ten locations because multiple locations had the same Observed EPDO value.

During the process of identifying the riskiest locations, five locations had to be excluded. Reasons for excluding a location included: intersection configuration updated after 2010; realignment of Circle Drive and Highway 16 due to the Circle Drive South Bridge Project; and lack of information on the location of a UGRID. Some UGRIDS could not be found in the City of Saskatoon's GIS street map or the City of Saskatoon's (2007) Collision Grid Codes Index. Table 24 lists the excluded locations and the emphasis areas affected.

Two types of collision maps were produced for each of the seven emphasis areas: the total number of collisions; and the peak time collisions.

Table 24: Excluded Locations.

Reason	UGRID	Location	Emphasis Areas Affected
Updated Intersection Configuration	SKJ11-30	Clarence Avenue South & Ruth Street East	Aggressive Driving_Total
Realignment of Circle Drive and Highway 16	SKJ13-1	Clarence Avenue South & Circle Drive	Older Drivers_PeakTime
Unknown Location	SKG6-45	Unknown	Impaired Driving_Total Impaired Driving_PeakTime
	SKJ7-1	Unknown	Vulnerable Road Users_Total
	SKLANE	Unknown	Vulnerable Road Users_Total

4.4.3. Collision Maps based on Total Number of Collisions

Figure 17 to Figure 23 show an example of a collision map based on total number of collisions for the Aggressive Driving, Distracted Driving, Impaired Driving, Intersections, Older Drivers, Vulnerable Road Users and Young Drivers emphasis area, respectively.

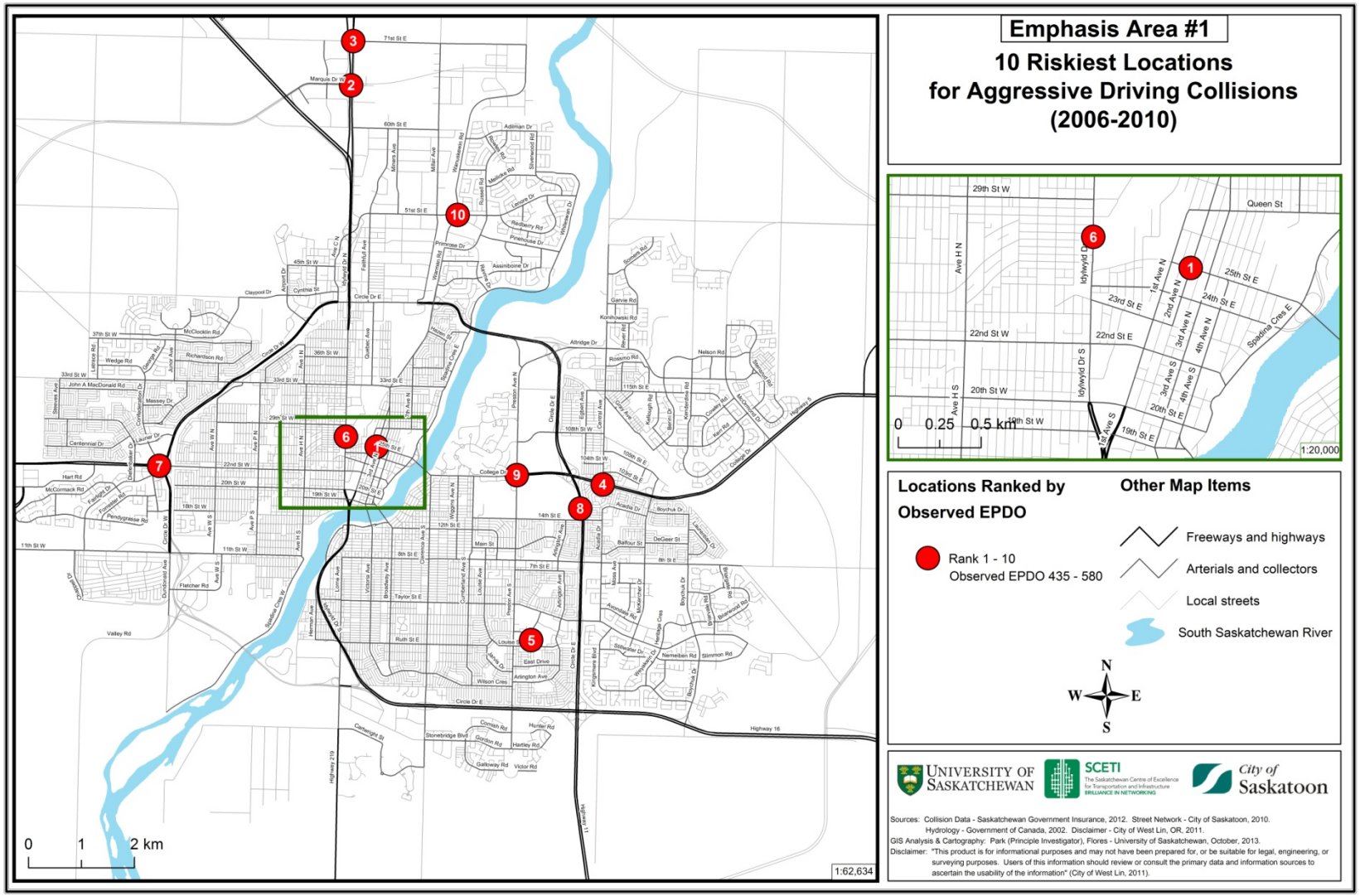


Figure 17: Aggressive Driving Hotspots, 2006-2010 (SGI, 2011; COS, 2013a).

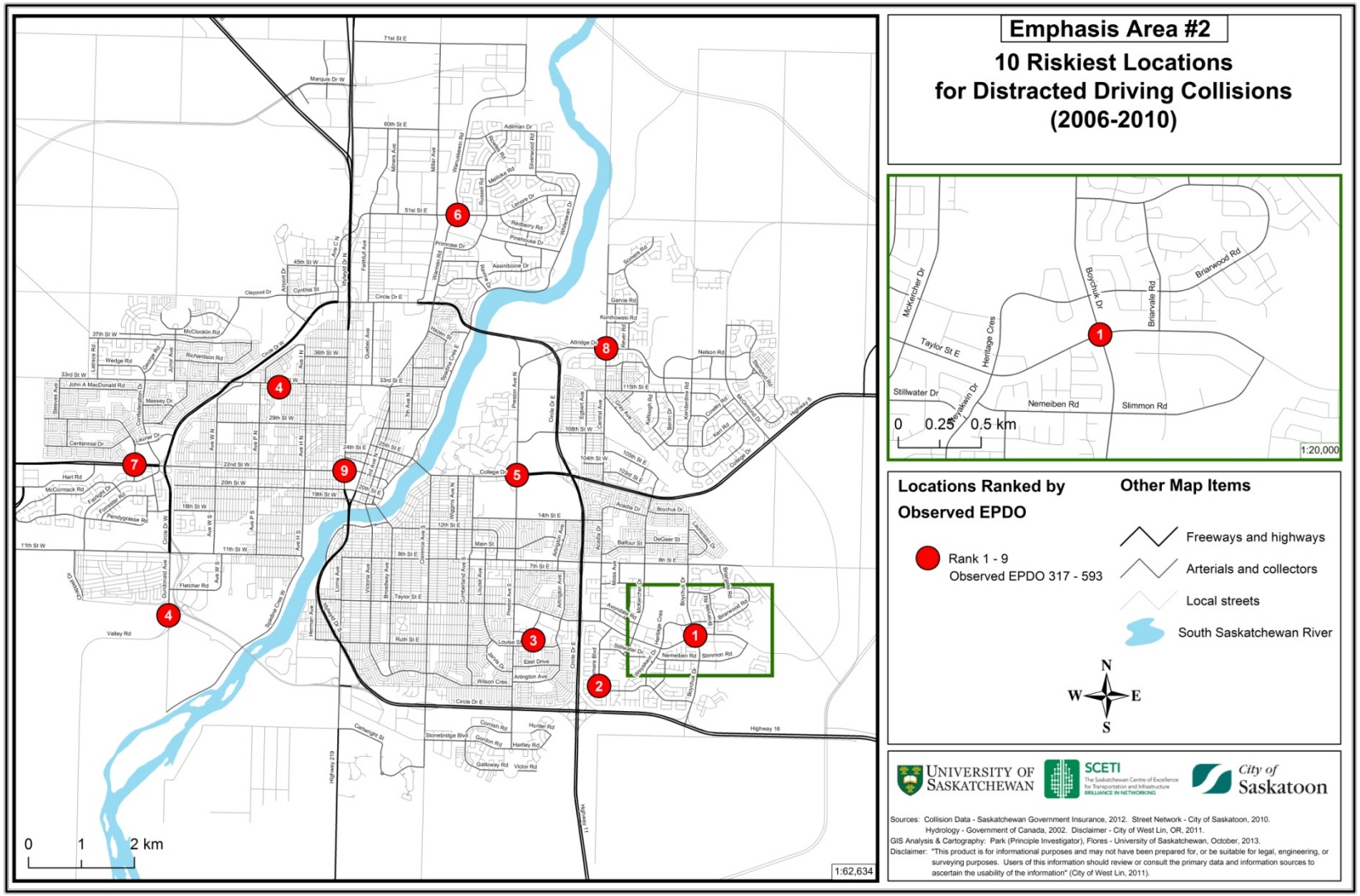


Figure 18: Distracted Driving Hotspots, 2006-2010 (SGI, 2011; COS, 2013a).

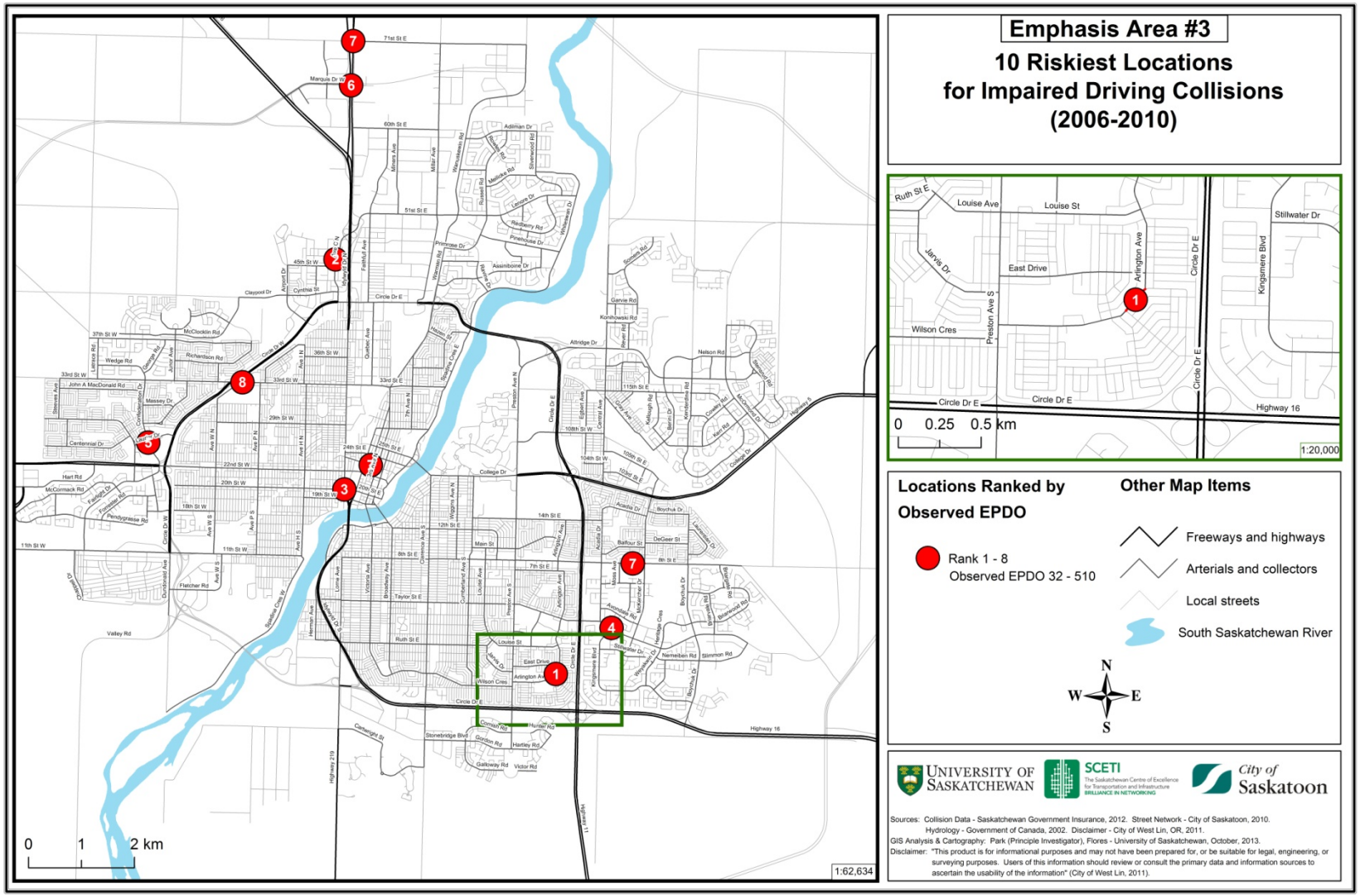


Figure 19: Impaired Driving Hotspots, 2006-2010 (SGI, 2011; COS, 2013a).

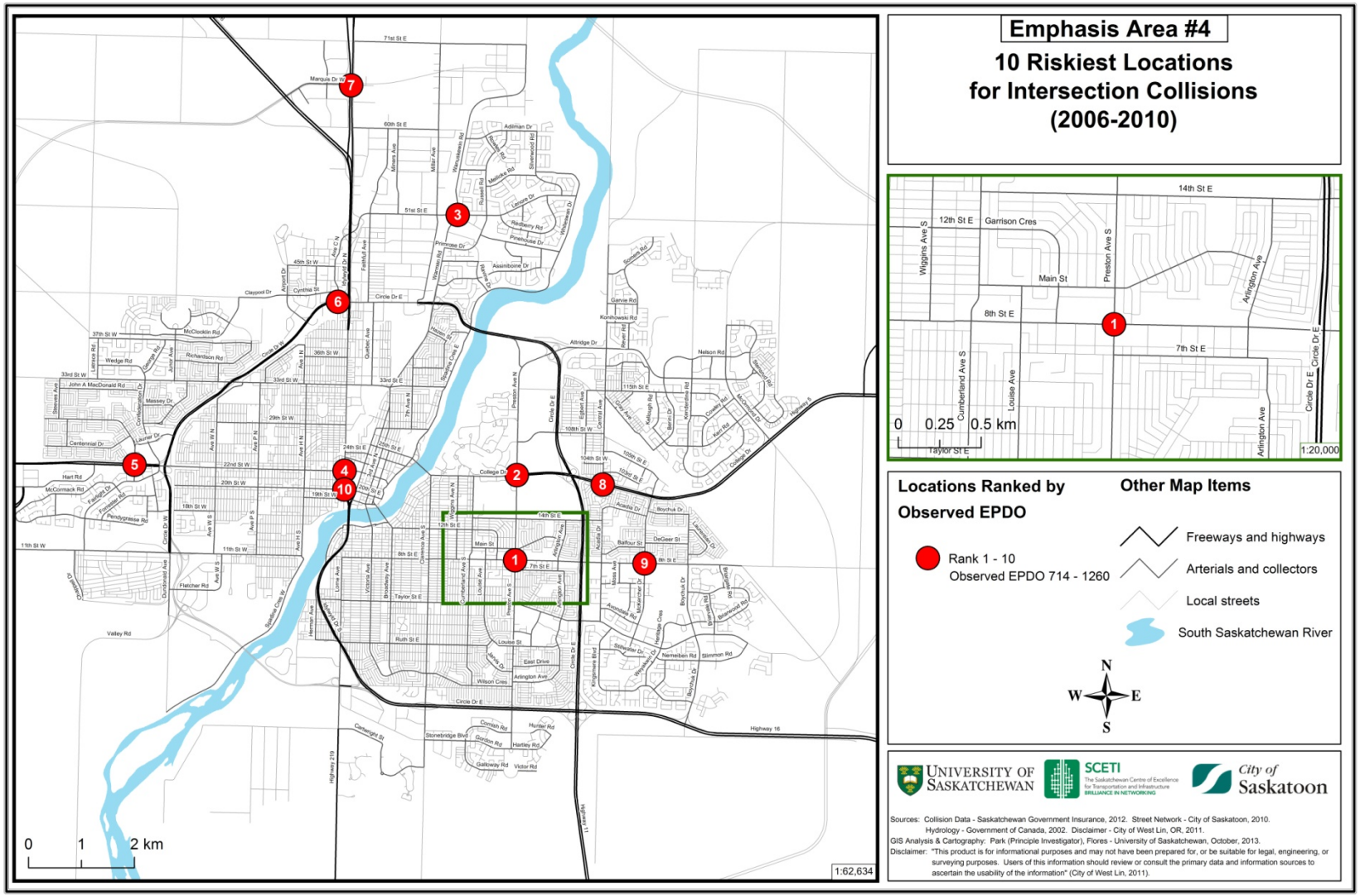


Figure 20: Intersection Hotspots, 2006-2010 (SGI, 2011; COS, 2013a).

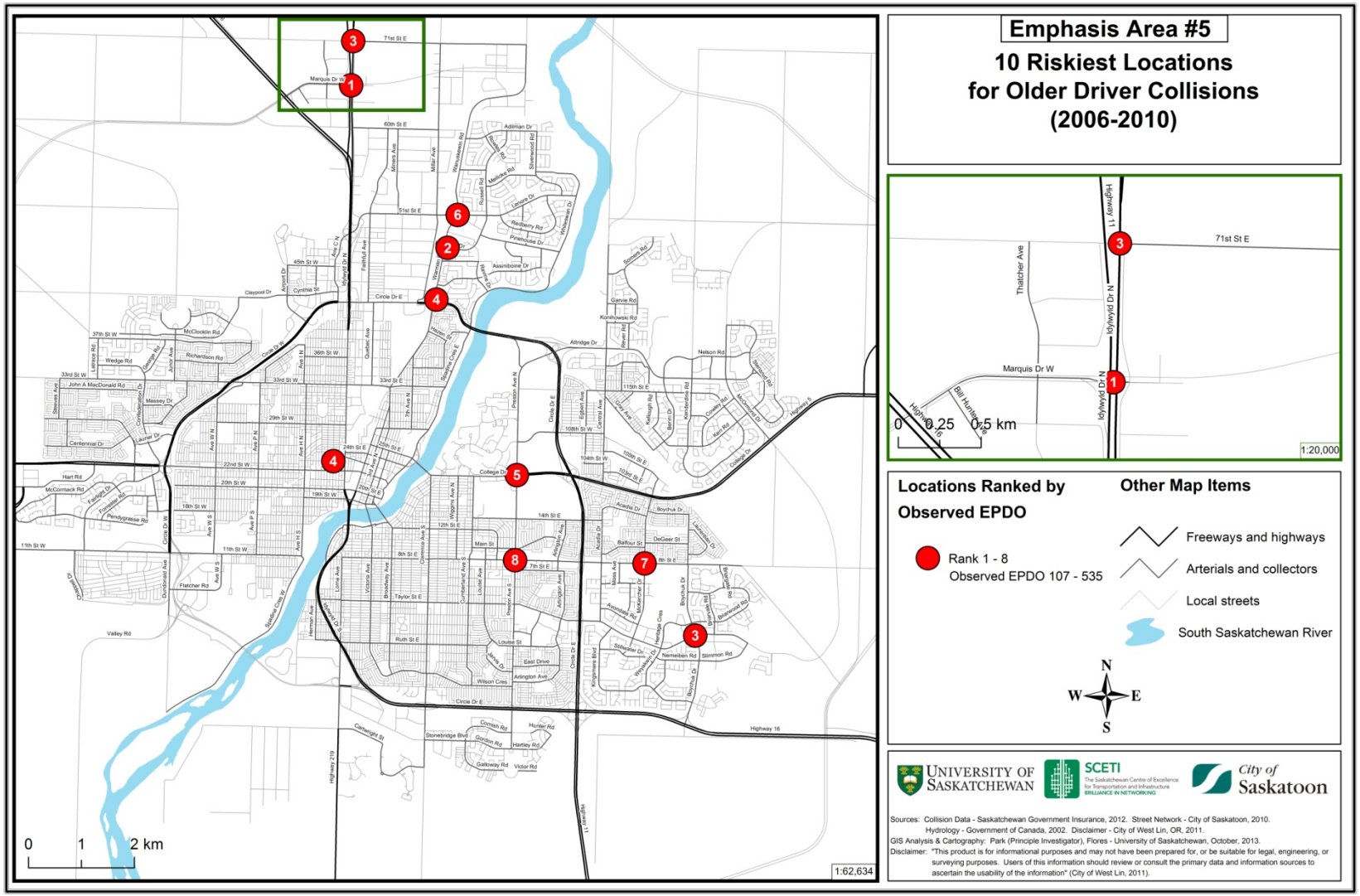


Figure 21: Older Driver Hotspots, 2006-2010 (SGI, 2011; COS, 2013a).

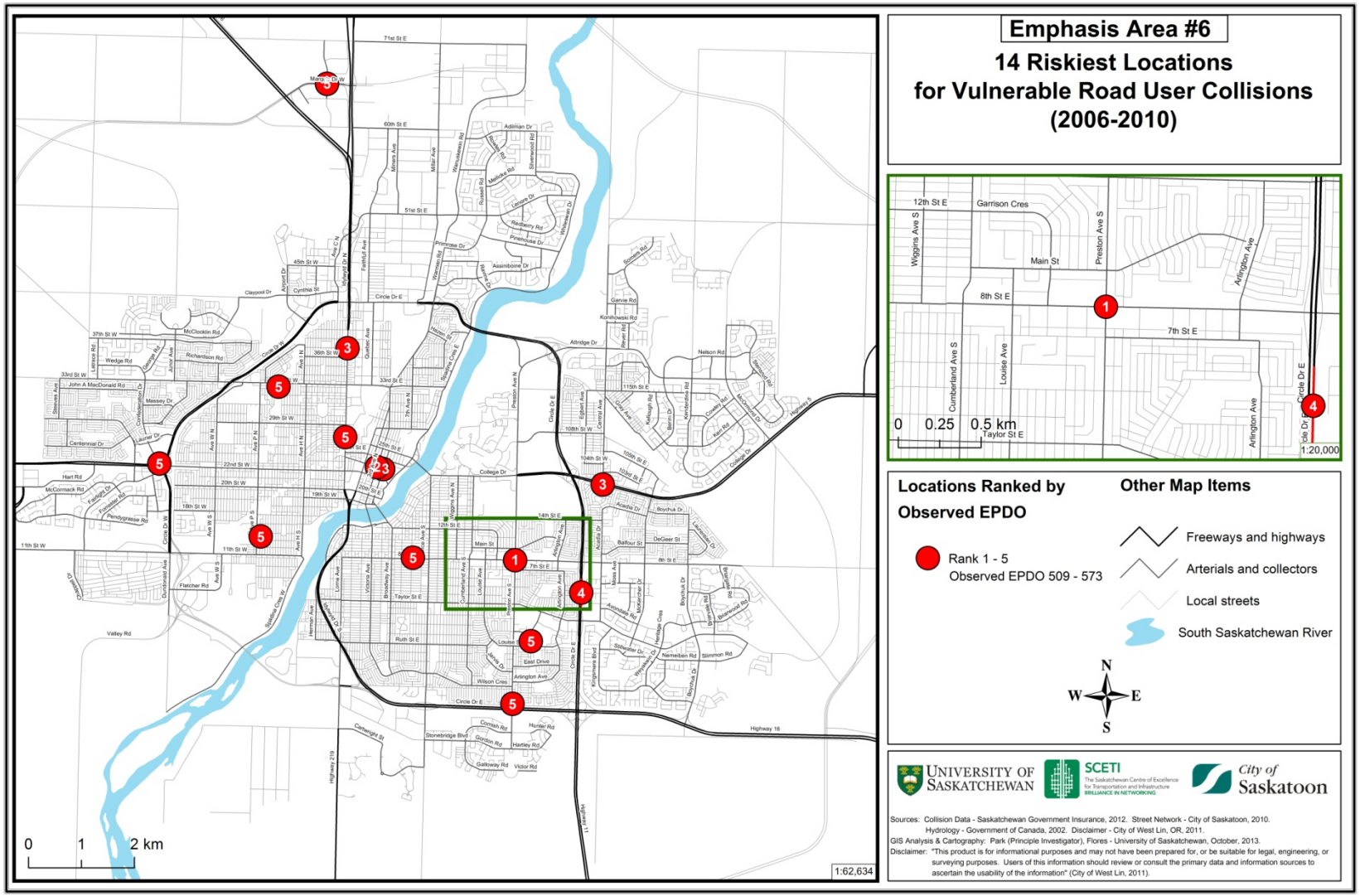


Figure 22: Vulnerable Road User Hotspots, 2006-2010 (SGI, 2011; COS, 2013a).

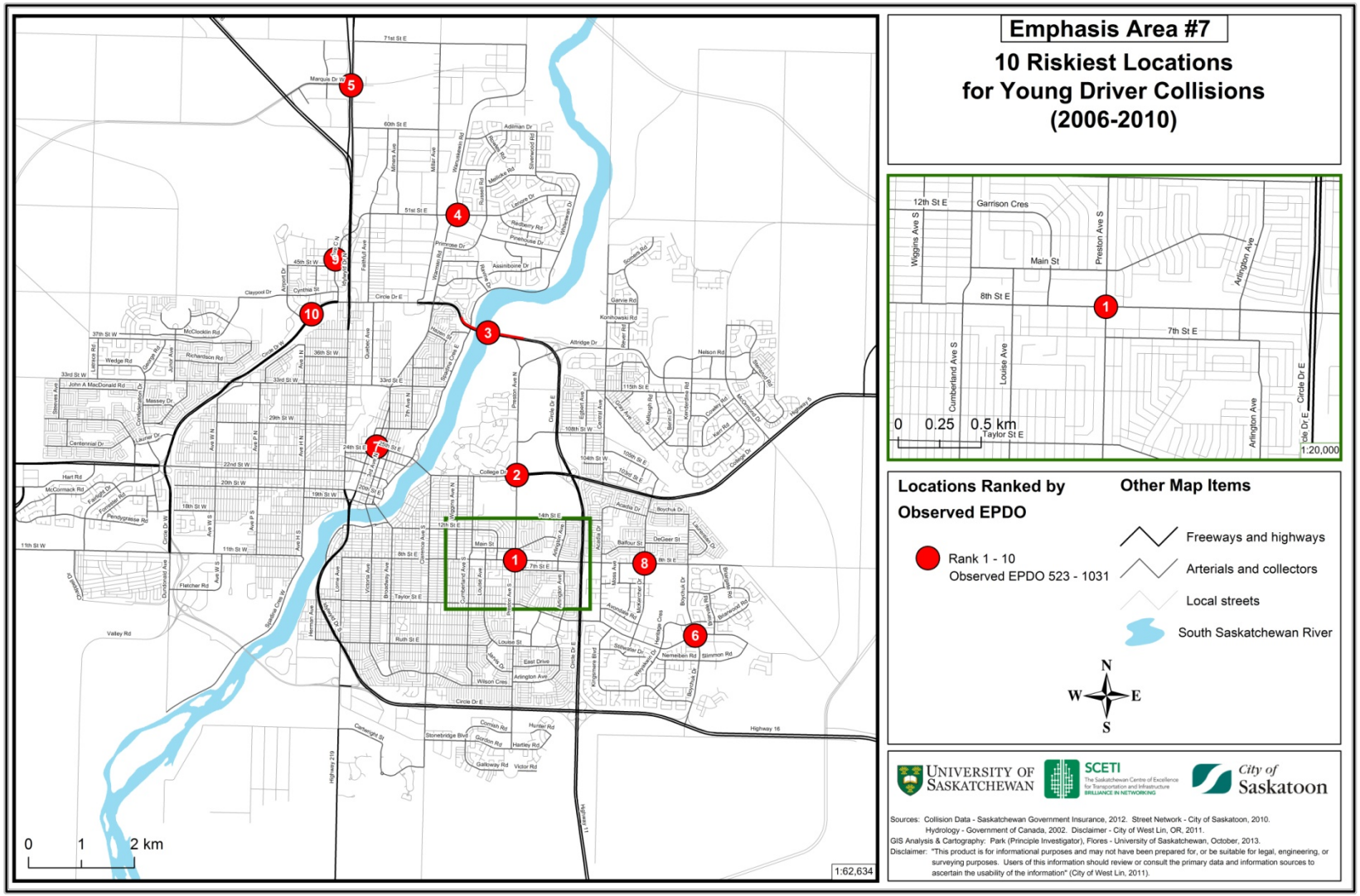


Figure 23: Young Driver Hotspots, 2006-2010 (SGI, 2011; COS, 2013a).

4.4.4. Collision Maps based on Peak Time Collisions

The peak time of collisions for a particular emphasis area was determined by creating a series of clockplot analyses. For example, Figure 24 clearly shows that most aggressive driving collisions occurred from 3pm to 6pm. The peak time collision map for Aggressive Driving collisions is therefore based on Aggressive Driving collisions that occurred from 3pm to 6pm.

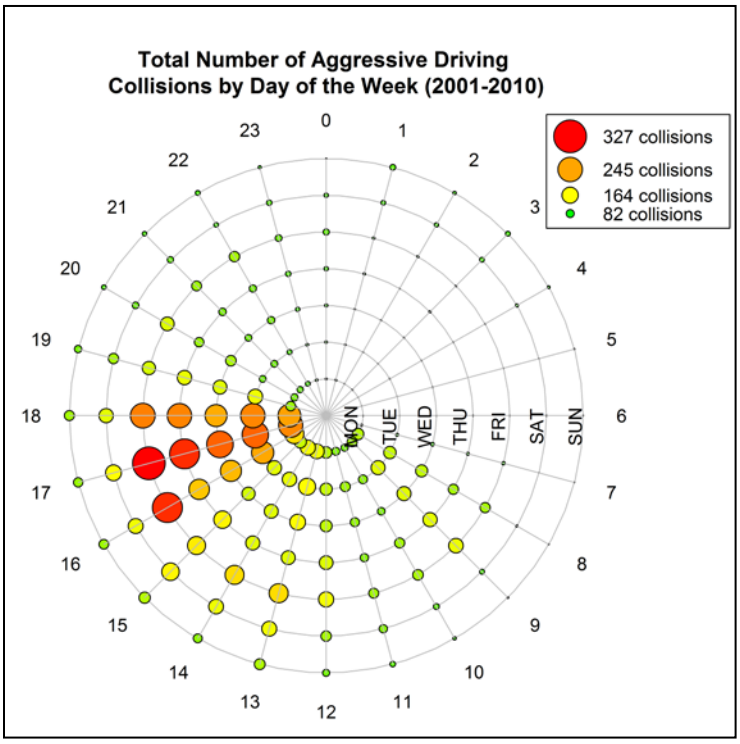


Figure 24: Clockplot of Aggressive Driving Collisions by Hour and Day of the Week, 2001-2010 (SGI, 2011; COS, 2013a).

Figure 25 to Figure 31 shows an example of a collision map based on peak time collisions for the Aggressive Driving, Distracted Driving, Impaired Driving, Intersections, Older Drivers, Vulnerable Road Users and Young Drivers emphasis area, respectively.

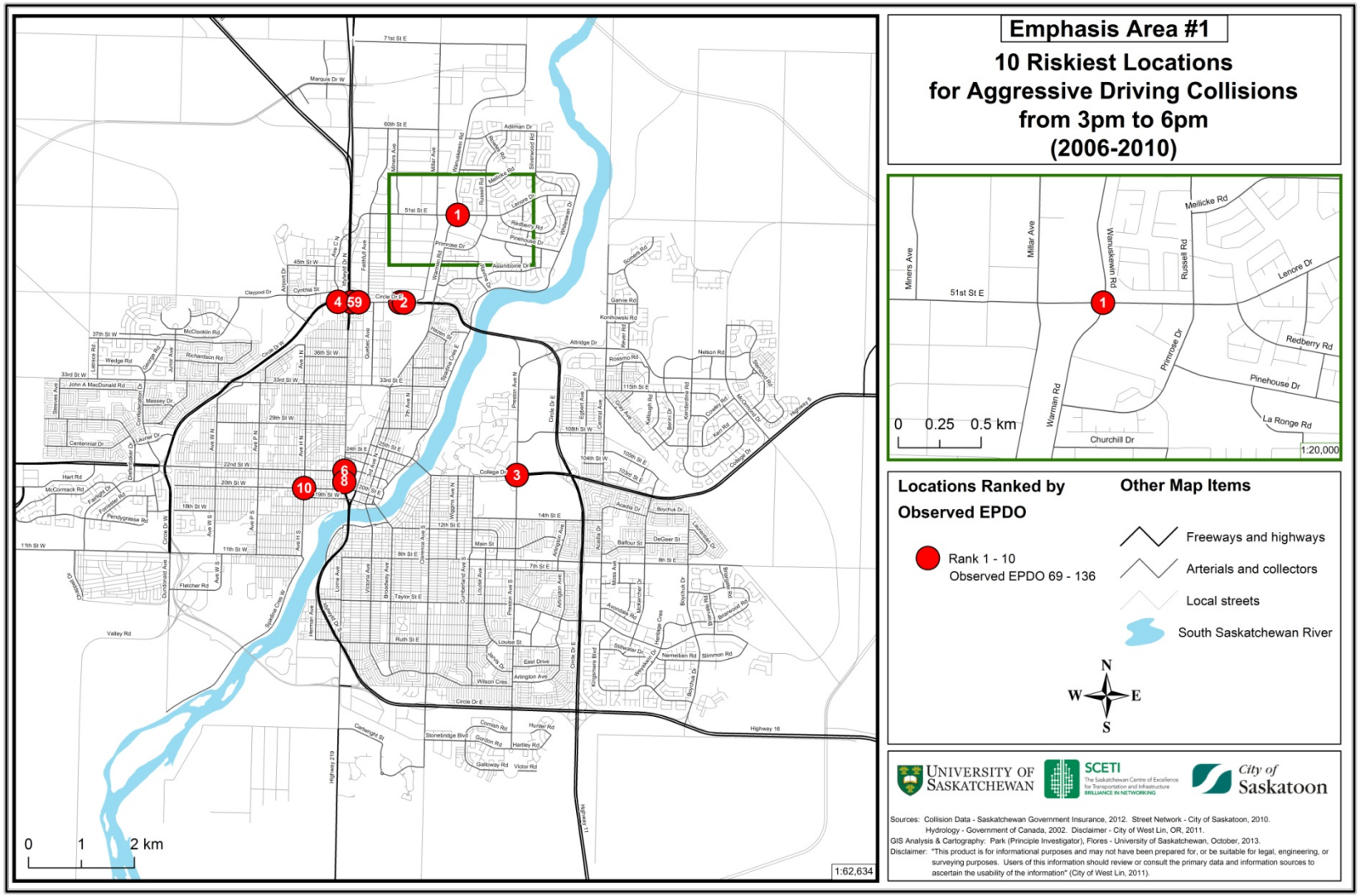


Figure 25: Aggressive Driving Hotspots from 3pm to 6pm, 2006-2010 (SGI, 2011; COS, 2013a).

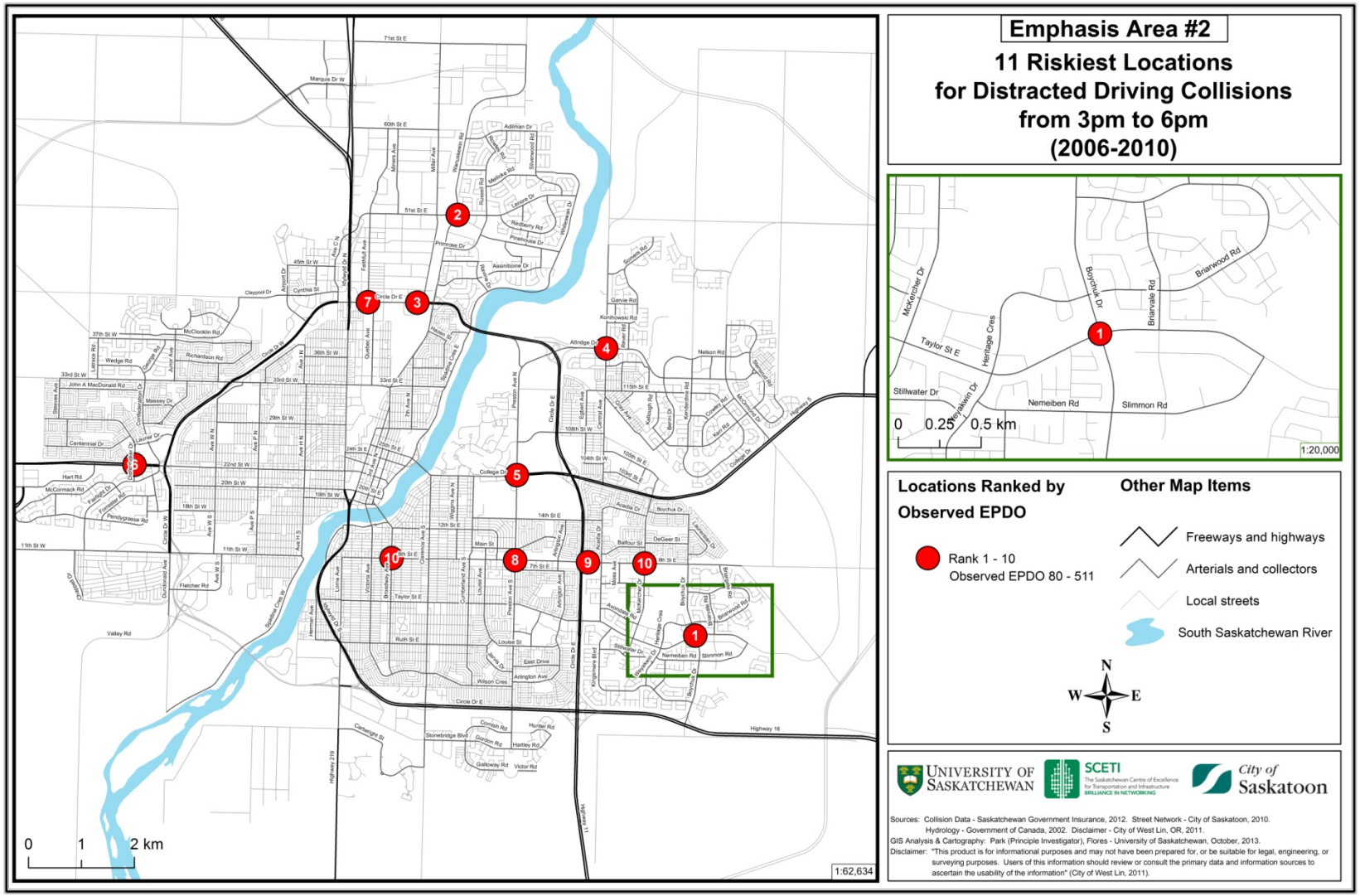


Figure 26: Distracted Driving Hotspots from 3pm to 6pm, 2006-2010 (SGI, 2011; COS, 2013a).

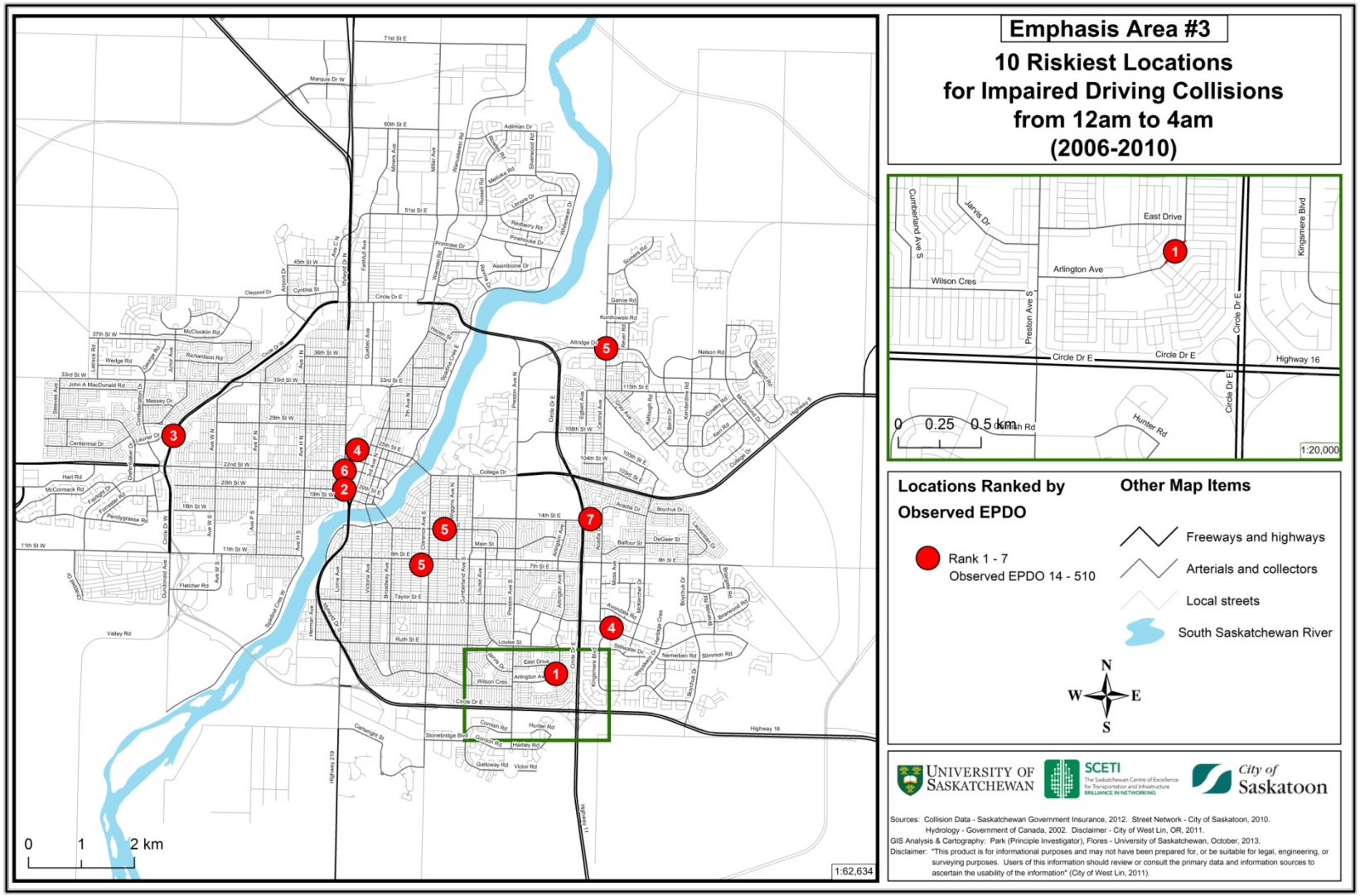


Figure 27: Impaired Driving Hotspots from 12am to 4am, 2006-2010 (SGI, 2011; COS, 2013a).

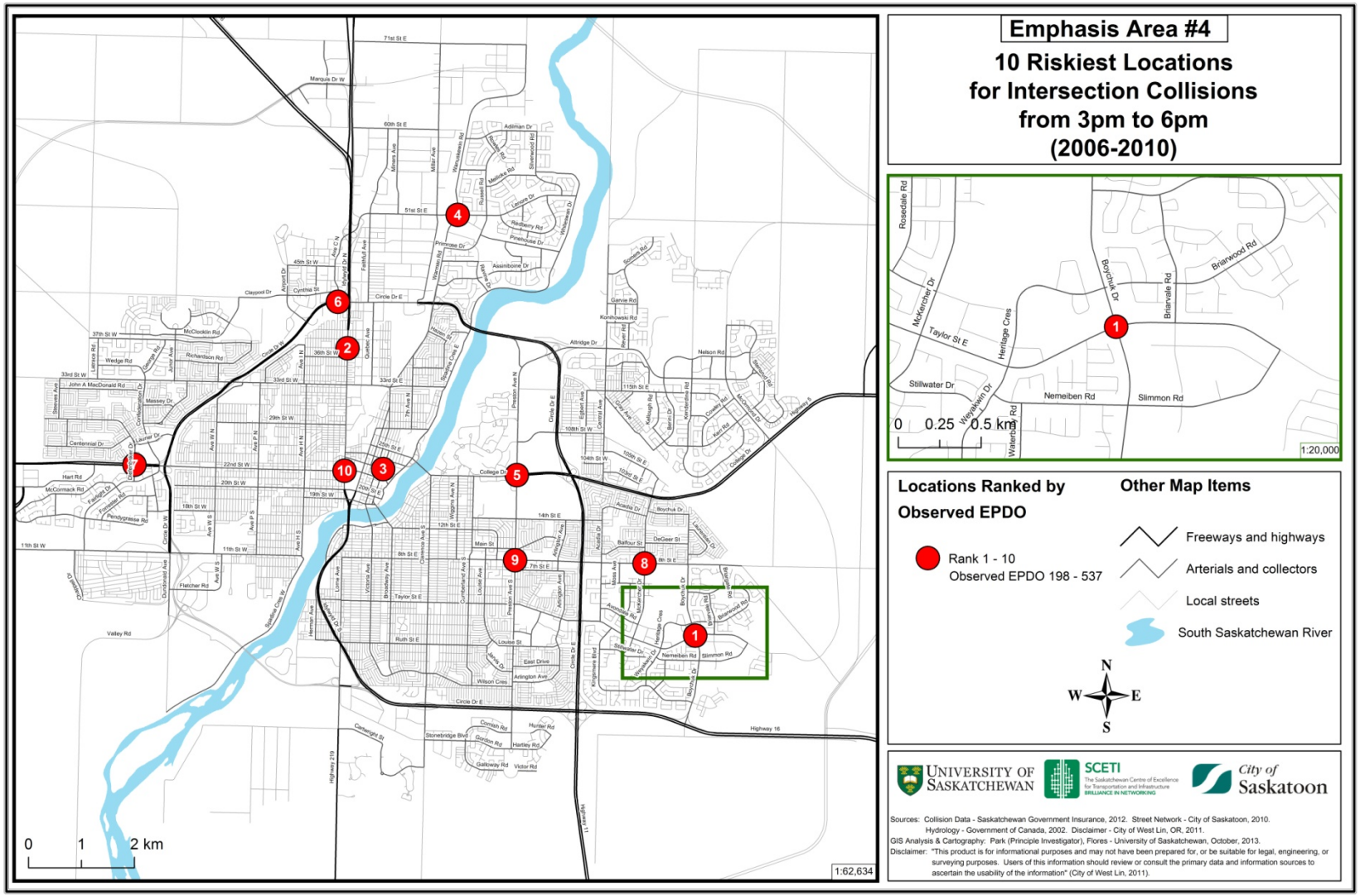


Figure 28: Intersection Hotspots from 3pm to 6pm, 2006-2010 (SGI, 2011; COS, 2013a).

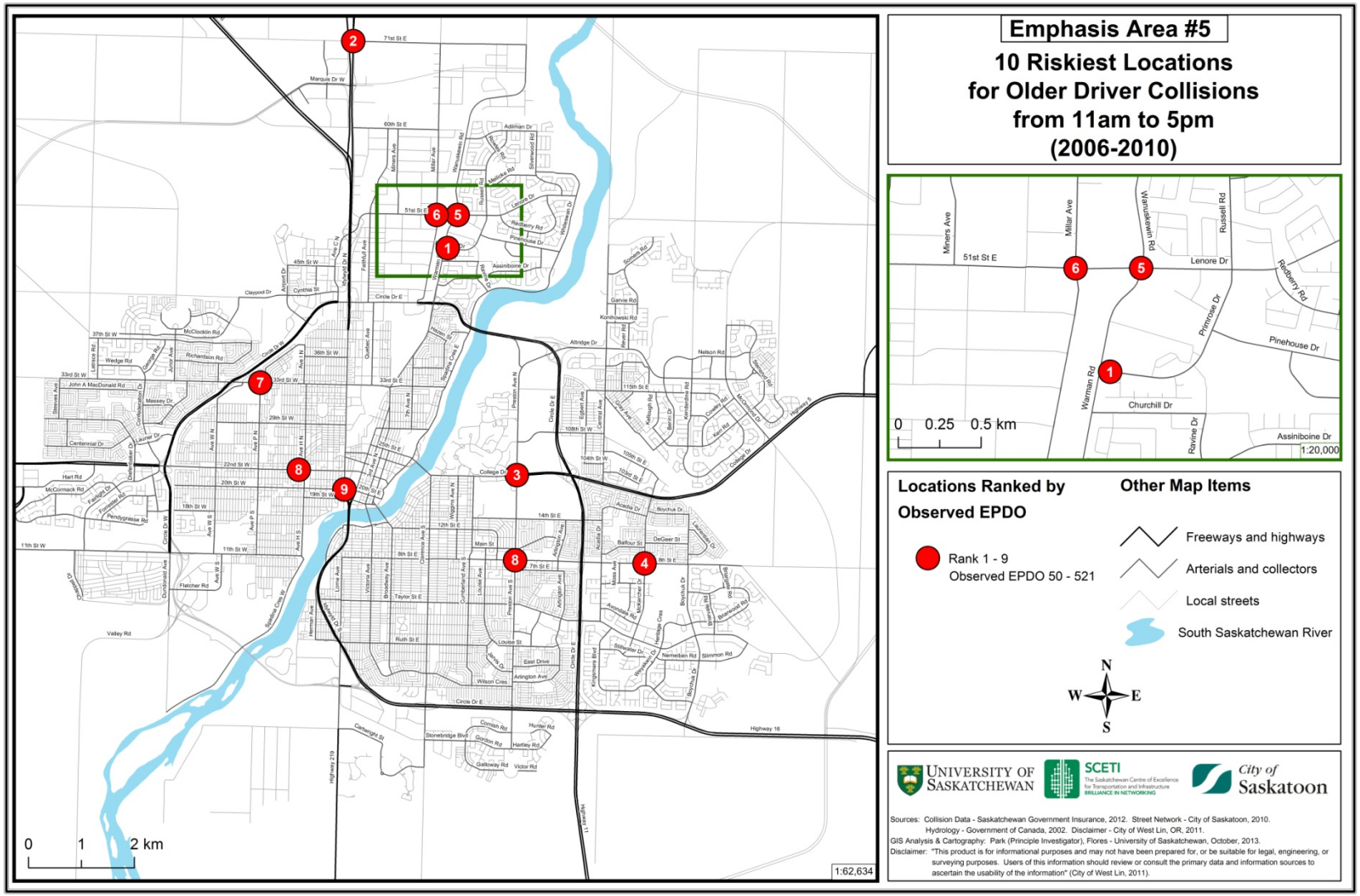


Figure 29: Older Driver Hotspots from 11am to 5pm, 2006-2010 (SGI, 2011; COS, 2013a).

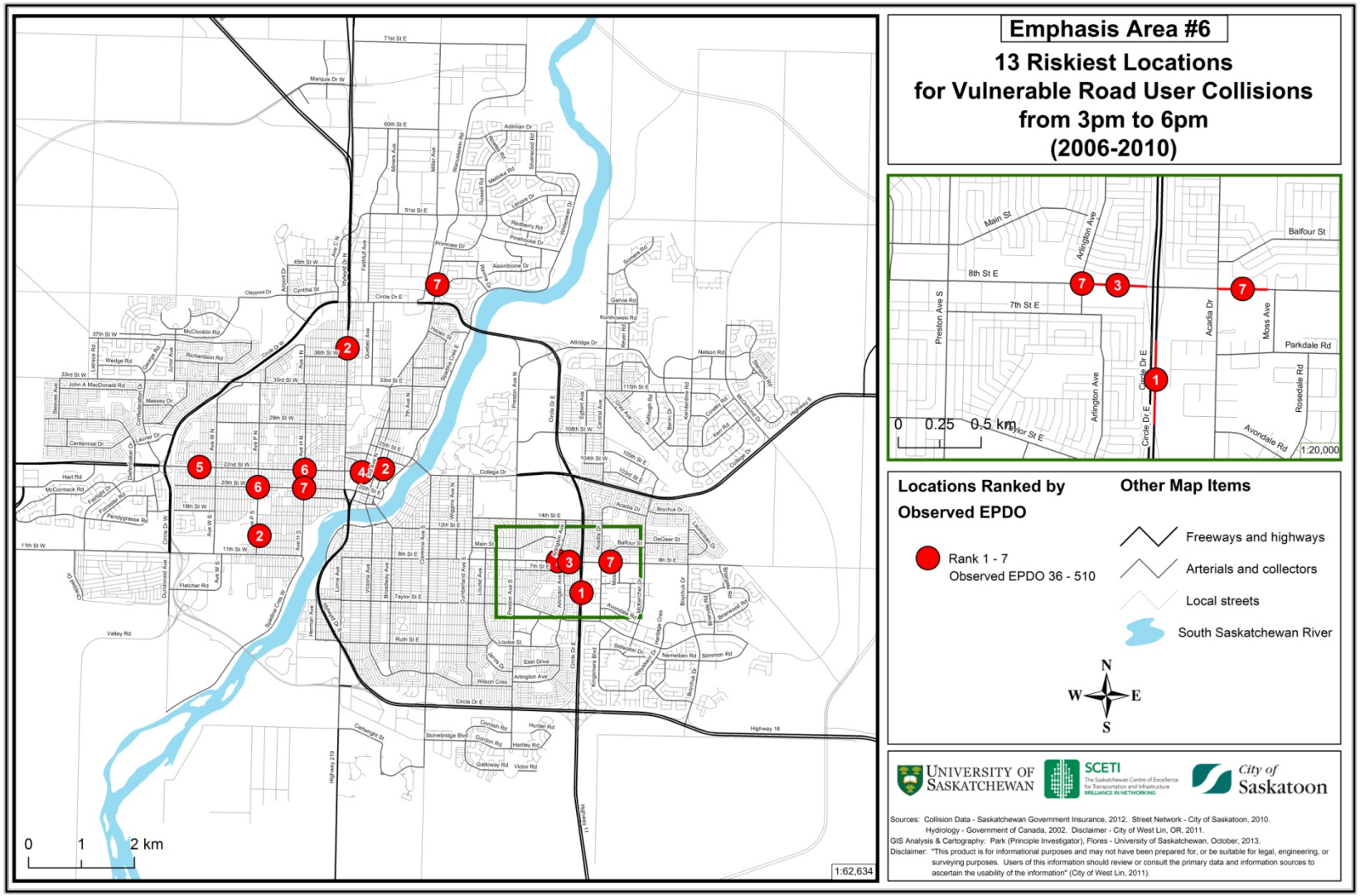


Figure 30: Vulnerable Road User Hotspots from 3pm to 6pm, 2006-2010 (SGI, 2011; COS, 2013a).

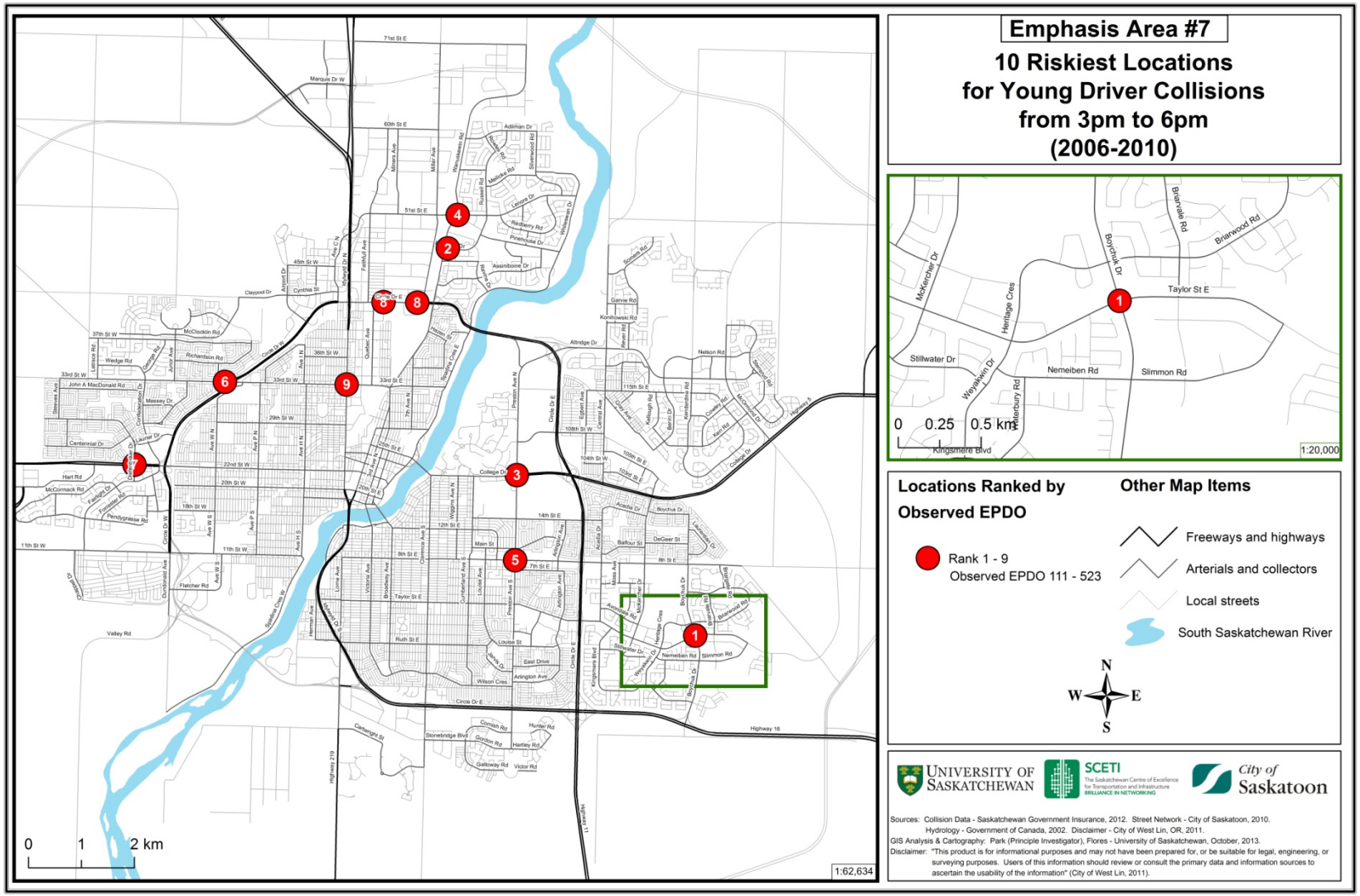


Figure 31: Young Driver Hotspots from 3pm to 6pm, 2006-2010 (SGI, 2011; COS, 2013a).

4.4.5. Summary of Network Screening Results

The total number of collisions was used to list the riskiest locations in Table 25. The table lists 41 locations. The table also shows the emphasis areas of the collisions at these locations. 17 (41%) of the locations relate to more than one emphasis area.

The peak time of collisions were used to show the riskiest locations in Table 26. The table lists 35 locations. The emphasis areas of the collisions at these locations are also shown. This table is for 3pm to 6pm, the peak period for Aggressive Driving, Distracted Driving, Intersections, Vulnerable Road Users and Young Drivers collisions. The peak periods for Impaired Drivers and Older Drivers are different so these two emphasis areas are excluded. 12 (34%) of the locations relate to more than one emphasis area.

Table 25: Emphasis Areas involved in Screened Locations based on Total Number of Collisions (SGI, 2011; COS, 2013a).

Location Number	Location	UGRID	Type	Traffic Control	Emphasis Area							Total Number of Emphasis Areas
					Aggressive Driving	Distracted Driving	Impaired Driving	Intersections	Older Drivers	Vulnerable Road Users	Young Drivers	
1	Hwy #11 & Marquis Dr W	SKG02-2	Intersection	Signalized	1	0	1	1	1	0	1	5
2	College Dr & Preston Ave	SKL8-2	Intersection	Signalized	1	1	0	1	1	0	1	5
3	51st St & Warman Rd	SKJ1-5	Intersection	Signalized	1	1	0	1	1	0	1	5
4	Preston Ave S & 8th St	SKL9-18	Intersection	Signalized	0	0	0	1	1	1	1	4
5	71st St E & Idylwyld Dr N	SKG03-1	Intersection	Unsignalized	1	0	1	0	1	0	0	3
6	College Dr & Central Ave	SKN8-2	Intersection	Signalized	1	0	0	1	0	1	0	3
7	McEown Ave	SKL11-21	Segment	-	1	1	0	0	0	1	0	3
8	Taylor St E & Boychuk Dr	SKP11-2	Intersection	Signalized	0	1	0	0	1	0	1	3
9	McKercher Dr & 8th St	SKN9-32	Intersection	Signalized	0	0	0	1	1	0	1	3
10	2nd Ave N & 25th St E	SKG7-44	Intersection	Signalized	1	0	0	0	0	0	1	2
11	Idylwyld Dr N	SKG7-4	Segment	-	1	0	0	0	0	1	0	2
12	Confederation Dr	SKB7-32	Segment	-	1	0	0	0	0	1	0	2
13	Faulkner Cres	SKE6-40	Segment	-	0	1	0	0	0	1	0	2
14	Diefenbaker Dr & 22nd St	SKB7-26	Intersection	Signalized	0	1	0	1	0	0	0	2
15	22nd St E & Idylwyld Dr	SKG7-99	Intersection	Signalized	0	1	0	1	0	0	0	2
16	46th St W & Ave C	SKF3-62	Intersection	Unsignalized	0	0	1	0	0	0	1	2
17	Idylwyld Dr & 20th St	SKG8-45	Intersection	Signalized	0	0	1	1	0	0	0	2
18	Circle Dr E & 14th St E Off Ramp	SKM8-28	Intersection	Unsignalized	1	0	0	0	0	0	0	1
19	Kingsmere Blvd	SKN12-5	Segment	-	0	1	0	0	0	0	0	1
20	Dundonald Ave & Valley Rd	SKC11-4	Intersection	Unsignalized	0	1	0	0	0	0	0	1
21	Attridge Dr E & Central Ave	SKN5-47	Intersection	Signalized	0	1	0	0	0	0	0	1
22	Arlington Ave	SKM12-9	Segment	-	0	0	1	0	0	0	0	1
23	Kingsmere Blvd & Taylor St	SKN11-18	Intersection	Signalized	0	0	1	0	0	0	0	1
24	Laurier Dr & Confederation Dr	SKB7-10	Intersection	Signalized	0	0	1	0	0	0	0	1
25	2nd Ave N & 23rd St	SKG7-82	Intersection	Signalized	0	0	1	0	0	0	0	1

Note: “-” means that no data was entered into the database.

Table 25: Emphasis Areas involved in Screened Locations based on Total Number of Collisions (Continued) (SGI, 2011; COS, 2013a).

Location Number	Location	UGRID	Type	Traffic Control	Emphasis Area							Total Number of Emphasis Areas
					Aggressive Driving	Distracted Driving	Impaired Driving	Intersections	Older Drivers	Vulnerable Road Users	Young Drivers	
26	8th St E	SKN9-19	Segment	-	0	0	1	0	0	0	0	1
27	Edmonton Ave & 33rd St	SKD5-8	Intersection	Signalized	0	0	1	0	0	0	0	1
28	Ave C N & Circle Dr	SKF4-28	Intersection	Signalized	0	0	0	1	0	0	0	1
29	Primrose Dr	SKJ2-6	Segment	-	0	0	0	0	1	0	0	1
30	Ave C N & 23rd St	SKF7-21	Intersection	Unsignalized	0	0	0	0	1	0	0	1
31	Warman Rd Off Ramp & Circle Dr	SKJ4-43	Intersection	Unsignalized	0	0	0	0	1	0	0	1
32	23rd St E & 3rd Ave	SKG7-84	Intersection	Signalized	0	0	0	0	0	1	0	1
33	Idylwyld Dr & 37th St	SKG5-38	Intersection	Unsignalized	0	0	0	0	0	1	0	1
34	23rd St E & 4th Ave	SKG7-86	Intersection	Signalized	0	0	0	0	0	1	0	1
35	Circle Dr E	SKM10-11	Segment	-	0	0	0	0	0	1	0	1
36	Thatcher Ave & Marquis Dr	SKF02-1	Intersection	Unsignalized	0	0	0	0	0	1	0	1
37	Weldon Ave	SKE9-131	Segment	-	0	0	0	0	0	1	0	1
38	Lansdowne Ave	SKH9-111	Segment	-	0	0	0	0	0	1	0	1
39	Preston Ave S	SKL13-2	Segment	-	0	0	0	0	0	1	0	1
40	Circle Dr E	SKK4-1	Segment	-	0	0	0	0	0	0	1	1
41	Circle Dr	SKF4-27	Segment	-	0	0	0	0	0	0	1	1

Note: "-" means that no data was entered into the database.

Table 26: Emphasis Areas involved in Screened Locations based on Peak Time Collisions (SGI, 2011; COS, 2013a).

Location Number	Location	UGRID	Type	Traffic Control	Emphasis Area					Total Number of Emphasis Areas
					Aggressive Driving	Distracted Driving	Intersections	Vulnerable Road Users	Young Drivers	
1	51st St & Warman Rd	SKJ1-5	Intersection	Signalized	1	1	1	0	1	4
2	College Dr & Preston Ave	SKL8-2	Intersection	Signalized	1	1	1	0	1	4
3	Preston Ave S & 8th St	SKL9-18	Intersection	Signalized	0	1	1	0	1	3
4	Taylor St E & Boychuk Dr	SKP11-2	Intersection	Signalized	0	1	1	0	1	3
5	Diefenbaker Dr & 22nd St	SKB7-26	Intersection	Signalized	0	1	1	0	1	3
6	22nd St E & Idylwyld Dr	SKG7-99	Intersection	Signalized	1	0	1	0	0	2
7	McKercher Dr & 8th St	SKN9-32	Intersection	Signalized	0	1	1	0	0	2
8	Ave C N & Circle Dr	SKF4-28	Intersection	Signalized	1	0	1	0	0	2
9	Ave H S & 20th St	SKF8-42	Intersection	Signalized	1	0	0	1	0	2
10	Circle Dr E & Millar Ave	SKH4-10	Intersection	Signalized	0	1	0	0	1	2
11	Idylwyld Dr & 37th St	SKG5-38	Intersection	Unsignalized	0	0	1	1	0	2
12	23rd St E & 4th Ave	SKG7-86	Intersection	Signalized	0	0	1	1	0	2
13	Attridge Dr E & Central Ave	SKN5-47	Intersection	Signalized	0	1	0	0	0	1
14	Primrose Dr	SKJ2-6	Segment	-	0	0	0	0	1	1
15	Venture Cres & Circle Dr	SKH4-30	Intersection	Unsignalized	1	0	0	0	0	1
16	Circle Dr E & Idylwyld Dr	SKG4-67	Intersection	Signalized	1	0	0	0	0	1
17	Circle Dr E	SKH4-28	Segment	-	1	0	0	0	0	1
18	Auditorium Ave & Idylwyld Dr	SKG8-95	Intersection	Signalized	1	0	0	0	0	1
19	Alberta Ave & Circle Dr	SKG4-18	Intersection	Signalized	1	0	0	0	0	1
20	Circle Dr E & Faithfull Ave	SKG4-50	Intersection	Signalized	0	1	0	0	0	1
21	8th St E	SKM9-81	Segment	-	0	1	0	0	0	1
22	Broadway Ave & 8th St	SKH9-49	Intersection	Signalized	0	1	0	0	0	1
23	Circle Dr E	SKM10-11	Segment	-	0	0	0	1	0	1
24	Weldon Ave	SKE9-131	Segment	-	0	0	0	1	0	1
25	8th St E	SKM9-1	Segment	-	0	0	0	1	0	1

Note: "-" means that no data was entered into the database.

Table 26: Emphasis Areas involved in Screened Locations based on Peak Time of Collisions (Continued) (SGI, 2011; COS, 2013a).

Location Number	Location	UGRID	Type	Traffic Control	Emphasis Area					Total Number of Emphasis Areas
					Aggressive Driving	Distracted Driving	Intersections	Vulnerable Road Users	Young Drivers	
26	22nd St E & 1st Ave	SKG8-1	Intersection	Signalized	0	0	0	1	0	1
27	Witney Ave S & 22nd St	SKC7-8	Intersection	Signalized	0	0	0	1	0	1
28	Ave P S & 20th St	SKE8-46	Intersection	Signalized	0	0	0	1	0	1
29	Ave H N & 22nd St	SKF7-83	Intersection	Signalized	0	0	0	1	0	1
30	Assiniboine Dr & Warman Rd	SKJ3-14	Intersection	Signalized	0	0	0	1	0	1
31	Arlington Ave & 8th St	SKL9-22	Intersection	Signalized	0	0	0	1	0	1
32	8th St E	SKN9-1	Segment	-	0	0	0	1	0	1
33	33rd St W & Circle Dr	SKD5-5	Intersection	Signalized	0	0	0	0	1	1
34	1st Ave N & Circle Dr	SKG4-5	Intersection	Signalized	0	0	0	0	1	1
35	Idylwyld Dr N & 33rd St	SKG5-28	Intersection	Signalized	0	0	0	0	1	1

Note: "-" means that no data was entered into the database.

4.5. Safety Strategies/Programs

The next component in the development of a municipal-level SHSP for the City of Saskatoon is the selection of strategies/programs. Safety strategies with the potential to meet the developed target goals were suggested for the emphasis areas chosen by the City of Saskatoon.

This section presents general strategies/programs that could be useful for reducing the number of collisions in particular emphasis areas. The literature for each of the seven emphasis areas were reviewed in detail to find and recommend the most suitable and most doable safety strategies/programs for the City of Saskatoon. Special attention was given to existing safety-related strategies/programs of the various local agencies [e.g., SGI, SPS, Mothers Against Drunk Driving (MADD) and Students Against Drinking & Driving (SADD)]. These safety-related strategies/programs were considered a primary and central source of information as the collaborative efforts of the agencies are crucial to the success of the programs and the realization of the City's target safety goals for the next five years. The strategies/programs selected can be grouped into four major categories: Education, Enforcement, Engineering and Legislation.

A final stakeholder workshop was held on September 12th, 2013 and a total of 12 personnel from seven different agencies (COS, COS TSC, SBOE, SGI, Saskatoon Health Region (SHR), SPS and University of Saskatchewan) participated in the workshop. Initially, 38 unique safety strategies/programs were presented and a questionnaire was circulated. A copy of the questionnaire can be found in Appendix D. After a discussion amongst the stakeholders, it was decided that all safety strategies/programs will be included except for the following five safety strategies/programs: Aerial Speed Enforcement, Addiction Screening, Coloured Pavement for Bicycle Lanes, Coloured Curbs and Seasonal Speed Limits.

Aerial Speed Enforcement was excluded because the program had little impact in the City of Saskatoon. Addiction Screening was also excluded because it had been evaluated and had been found to be ineffective. Coloured Pavement for Bicycles and Coloured Curbs were excluded as well because they are not used in the winter season and would be costly to implement. The effectiveness of Coloured Pavement for Bicycle Lanes is also unknown and including Coloured Curbs would increase public expectation. Seasonal Speed Limits was also excluded because these could possibly create driver confusion.

The following four additional safety strategies/programs were added based on communication with the City of Saskatoon: Audio Accessible Pedestrian Signals, Sidewalk Retrofit, Accessibility Ramps and Work Zone Regulation. The first three – Audio Accessible Pedestrian Signals, Sidewalk Retrofit and Accessibility Ramps – were a few traffic safety projects for which the City of Saskatoon had requested funding. Work Zone Regulation was also added due to a high number of work zone collisions in the City of Saskatoon.

Although the five safety strategies/programs (i.e., Aerial Speed Enforcement, Addiction Screening, Coloured Pavement for Bicycle Lanes, Coloured Curbs and Seasonal Speed Limits) were removed, information was still provided in the event that they are to be used again in the future. Therefore, there are 42 unique safety strategies/programs listed in the following sections. Sections 4.5.1.to 4.5.4. present the strategies/programs suggested for each emphasis area for Education, Enforcement, Engineering and Legislation, respectively. Note that the safety strategies/programs that are bolded are proven initiatives published by the CCMTA (2010).

In the tables presented in Sections 4.5.1. to 4.5.4., the strategies/programs are listed in descending order by the number of emphasis areas targeted by each strategy/program. “Enhance” refers to an existing strategy/program that may need to be strengthened and “Introduce” presents

a strategy/program that may be considered as a new safety initiative for Saskatoon over the next five years. For example, Table 27 shows that “Awareness Campaigns using Multimedia and Community Newsletters” may need to be strengthened for all seven emphasis areas during the next five years. The last column simply indicates the number of emphasis areas involved with a particular strategy/program. The last three rows show the total number of new and existing strategies/programs for each emphasis area. For example, Aggressive Driving has two new (Introduce) and three existing (Enhance) education strategies/programs for a total of five strategies/programs.

Appendix E provides details of the strategies/programs proposed for each emphasis area. Appendix E also includes the stakeholders involved in the implementation of the strategies/programs, reported effectiveness of the strategies/programs and the source of the reported effectiveness of the strategies/programs.

4.5.1. Education Strategies/Programs

Table 27 lists nine Education strategies/programs. Awareness campaigns are seen as relevant to all emphasis areas and useful ways to increase awareness of the severe consequences and legal responsibilities that arise from many collisions. Awareness strategies/programs include classic mass media campaigns (e.g., local radio, TV, newspapers) and modern communication tools such as social media (e.g., Facebook).

Education strategies/programs are seen as particularly important for Impaired Driving.

Table 27: Education Strategies/Programs.

Strategy/Program		Description	Emphasis Areas							No. of Emphasis Areas Involved
ID	Title		#1: Aggressive Driving	#2: Distracted Driving	#3: Impaired Driving	#4: Inter-sections	#5: Older Drivers	#6: Vulnerable Road Users	#7: Young Drivers	
1	**Awareness Campaigns using Multimedia and Community Newsletters**	**Local broadcasting channels (radio, TV, community newsletters, CAA articles, etc.) create and promote awareness.**	**Enhance**	**Enhance**	**Enhance**	**Enhance**	**Enhance**	**Enhance**	**Enhance**	**7**
2	**Awareness Campaigns using Social Media and Various Organizations' Homepages**	**Popular social media (e.g., Facebook) and stakeholders' homepages (e.g., COS, SPS) can be used to create and promote awareness.**	**Enhance**	**Enhance**	**Enhance**	**Enhance**		**Enhance**	**Enhance**	**6**
3	Educational Activities targeted at High Schools	Traffic safety themed activities can be designed for high school students. These activities can be coordinated and promoted by SBOE.	Introduce	Introduce	Introduce			Introduce	Introduce	**5**
4	**Message Boards**	**Billboards or changing message signs create and promote awareness, and advise drivers of safety issues and associated regulations and fines.**	**Enhance**	**Enhance**	**Enhance**				**Enhance**	**4**
5	**Awareness Week**	**An awareness week can be used to create and promote awareness.**	**Introduce**	**Introduce**	**Enhance**					**3**
6	Rollover Simulator Demonstrations at High Schools	SGI demonstrates its rollover simulator at Saskatoon high schools to emphasize the safety benefits of seatbelts in severe rollover collisions.							Enhance	**1**

Table 27: Education Strategies/Programs (Continued).

Strategy/Program		Description	Emphasis Areas							No. of Emphasis Areas Involved
ID	Title		#1: Aggressive Driving	#2: Distracted Driving	#3: Impaired Driving	#4: Inter-sections	#5: Older Drivers	#6: Vulnerable Road Users	#7: Young Drivers	
7	Smartphone Apps	Smartphone apps can be used to create and promote awareness. For example, SGI's Safe Ride App provides information on taxis, designated driving services, etc.			Enhance					**1**
8	Operation Red Nose (ORN)	ORN (operationrednose.com) is a national road safety campaign focused on reducing impaired driving during holiday periods. ORN volunteers to drive impaired or tired people and their vehicles home from parties, events, etc.			Enhance					**1**
9	55 Alive (Mature Driver Course)	55 Alive is a free six-hour course that educates older drivers about how the physical changes of aging can affect driving, and explains how older drivers with, for example, compromised vision or hearing, can adapt to adverse road and weather conditions. At least 12 participants are required in each class.					Enhance			**1**
Sum of New Strategies/Programs			**2**	**2**	**1**	**0**	**0**	**1**	**1**	
Sum of Existing Strategies/Programs			**3**	**3**	**6**	**2**	**2**	**2**	**4**	
Total Strategies/Programs			**5**	**5**	**7**	**2**	**2**	**3**	**5**	

4.5.2. Enforcement Strategies/Programs

Table 28 lists six Enforcement strategies/programs. All of the Enforcement strategies/programs already exist in Saskatoon.

Selective enforcement programs are relevant to almost all the emphasis areas, and these strategies/programs include highly visible and/or invisible law enforcement.

Table 28: Enforcement Strategies/Programs.

Strategy/Program		Description	Emphasis Areas							No. of Emphasis Areas Involved
ID	Title		#1: Aggressive Driving	#2: Distracted Driving	#3: Impaired Driving	#4: Inter-sections	#5: Older Drivers	#6: Vulnerable Road Users	#7: Young Drivers	
1	**Selective Enforcement Programs**	**Selective enforcement programs may use highly visible and/or invisible law enforcement. Collision maps can be used to select the program's locations/times.**	**Enhance**	**Enhance**	**Enhance**	**Enhance**		**Enhance**	**Enhance**	**6**
2	Aerial Speed Enforcement	SPS's Air Support Unit is used to curb aggressive driving and increase pressure on drivers to abide by the rules of the road.	Enhance							**1**
3	Highly Visible Enforcement (HVE)	Liquor enforcement team (LET) officers provide HVE within and around drinking establishments to continually reinforce the message that impaired drivers will be stopped and arrested.			Enhance					**1**
4	**Report Impaired Drivers (RID) Program**	**The RID program is a new road safety initiative that encourages residents to call 911 to report a suspected impaired driver. RID allows the public to assist law enforcement in finding and removing impaired drivers from the roads. RID also serves as a warning to impaired drivers that many eyes are watching them.**			**Enhance**					**1**
5	**High Collision Intersection Enforcement**	**Saskatoon police officers have been focusing on enforcement at intersections considered high risk from past collision statistics. An intersection collision map can be used to select the target intersections/times.**				**Enhance**				**1**

Table 28: Enforcement Strategies/Programs (Continued).

Strategy/Program		Description	Emphasis Areas							No. of Emphasis Areas Involved
ID	Title		#1: Aggressive Driving	#2: Distracted Driving	#3: Impaired Driving	#4: Inter-sections	#5: Older Drivers	#6: Vulnerable Road Users	#7: Young Drivers	
6	Multi Agency Seatbelt Team (MASTeam) Seatbelt Checkstops	The MASTeam program focuses on seatbelt enforcement. Enforcement agencies throughout Saskatchewan conduct checkstops to enforce seatbelt use. To target young drivers, a young driver collision map can be used to select the program's locations/times.							Enhance	**1**
Sum of New Strategies/Programs			**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Sum of Existing Strategies/Programs			**2**	**1**	**3**	**2**	**0**	**1**	**2**	
Total Strategies/Programs			**2**	**1**	**3**	**2**	**0**	**1**	**2**	

4.5.3. Engineering Strategies/Programs

Table 29 lists 20 Engineering strategies/programs. Most of the Engineering strategies/programs already exist in Saskatoon.

The existing program for improving road surface friction/winter maintenance is expected to be especially beneficial to four emphasis areas: Aggressive Driving, Intersections, Older Drivers and Young Drivers.

Engineering strategies/programs are expected to be especially beneficial to Vulnerable Road Users (10 programs), Aggressive Driving (8 programs) and Intersections (6 programs).

Table 29: Engineering Strategies/Programs.

Strategy/Program		Description	Emphasis Areas							No. of Emphasis Areas Involved
ID	Title		#1: Aggressive Driving	#2: Distracted Driving	#3: Impaired Driving	#4: Inter-sections	#5: Older Drivers	#6: Vulnerable Road Users	#7: Young Drivers	
1	Improved Road Surface Friction/Winter Maintenance	Winter maintenance programs (e.g., sanding and snowplowing) improve road surface friction on high speed roadways and high classification roadways (e.g., Circle Drive and major/minor arterials).	Enhance			Enhance	Enhance		Enhance	4
2	Clearview Street Signs	Street name signs that use the Clearview font and larger street name plates are designed to help drivers to find their route, choose their lane, etc. and thus negotiate the intersection more safely and more easily.				Introduce	Introduce		Introduce	3
3	Well Maintained Pavement Markings	Missing and faded pavement markings (crosswalks, lane markings, lane ending indicators, etc.) at/near City intersections are maintained throughout the year to ensure good visibility. Clear markings are important at all intersections, but may be especially important at locations screened as high collision locations.				Enhance	Enhance		Enhance	3
4	Improved Traffic Signal Operation	Traffic signal phasing at high collision intersections. Possible countermeasures include providing a protected left turn signal phase, prohibiting left turns, and extending the yellow, green or red signal phase as appropriate.	Enhance			Enhance		Enhance		3

Table 29: Engineering Strategies/Programs (Continued).

Strategy/Program		Description	Emphasis Areas							No. of Emphasis Areas Involved
ID	Title		#1: Aggressive Driving	#2: Distracted Driving	#3: Impaired Driving	#4: Inter-sections	#5: Older Drivers	#6: Vulnerable Road Users	#7: Young Drivers	
5	**Professional Engineering Projects Designed to Improve Surface Infrastructure (e.g., in-service road safety review projects)**	**In-service safety review projects can be conducted at selected intersections to determine engineering countermeasures that will improve the surface infrastructure. Typical engineering countermeasures include adding exclusive left/right turn lanes, installing advanced signal change warning signs, providing clear sight triangles on stop/yield-controlled intersections, providing larger and/or dual stop signs at stop-controlled intersections, etc. An intersection collision map can be used to select target intersections for in-service road safety review projects.**				**Enhance**		**Enhance**		**2**
6	**Red Light Cameras**	**Red light cameras are installed at high collision intersections.**	**Enhance**			**Enhance**				**2**
7	Engineering Projects that help to reduce Peak Period Congestion	Certain types of aggressive driving (e.g., speeding and unsafe lane changing) are known to stem from drivers' frustration with congested roads. COS's various surface infrastructure projects are designed to reduce congestion on the road network and can therefore help to reduce aggressive driving.	Enhance							**1**
8	Changeable Message Signs	Changeable message signs are installed at locations where aggressive driving is leading to collisions. The signs may also be used to advise road users of adverse weather and road conditions.	Enhance							**1**

Table 29: Engineering Strategies/Programs (Continued).

Strategy/Program		Description	Emphasis Areas							No. of Emphasis Areas Involved
ID	Title		#1: Aggressive Driving	#2: Distracted Driving	#3: Impaired Driving	#4: Inter-sections	#5: Older Drivers	#6: Vulnerable Road Users	#7: Young Drivers	
9	**Speed Reader Boards**	**Speed reader boards are installed at locations where aggressive driving is leading to collisions. The signs show each driver his or her speed.**	**Enhance**							**1**
10	**Variable Speed Limit for Winter Road Conditions (a.k.a. seasonal speed limit)**	**SGI has been researching the possibility of introducing seasonal speed limits at high collision locations where drivers speed even when road conditions are adversely affected by weather. The program would need public support and a Cabinet decision.**	**Introduce**							**1**
11	**Photo Radar Technology**	**SGI has been considering expanding the use of photo radar technology in Saskatchewan from work zones (as at present) to other roadways. The program would need public support and a Cabinet decision.**	**Introduce**							**1**
12	**Roadway Safety Improvements to reduce the Likelihood and Severity of Collisions**	Numerous engineering countermeasures can help to reduce the problem of distracted driving: advance stop signs, advance signing for lane closures, larger and more reflective signage, **installation of medians**, removal of obstacles, and improved lane marking and delineation of curbs.		**Enhance**						**1**
13	**Countdown Pedestrian Signals**	**Pedestrian signals with countdown timers inform pedestrians how many seconds remain for crossing. The countdown timers may be visual only, or visual and audible.**						**Enhance**		**1**

Table 29: Engineering Strategies/Programs (Continued).

Strategy/Program		Description	Emphasis Areas							No. of Emphasis Areas Involved
ID	Title		#1: Aggressive Driving	#2: Distracted Driving	#3: Impaired Driving	#4: Inter-sections	#5: Older Drivers	#6: Vulnerable Road Users	#7: Young Drivers	
14	Coloured Curbs	Curb cuts can be painted yellow to clearly delineate pedestrian walkways from roadways at intersections.						Introduce		**1**
15	Bicycle Lane Connectivity (i.e., continuous right-of-way for bicyclists) and Bicycle Friendly Facilities	Bicycle lane connectivity can be provided where possible. During surface infrastructure improvement, raised/exclusive bicycle lanes (rather than curbside bicycle lanes) can be considered to maximize bicyclists' safety.						Enhance		**1**
16	Coloured Pavement for Bicycle Lanes	Curbside bike lanes can be painted a colour that contrasts with the colour of the pavement to clearly delineate the bicycle traffic area from the general traffic area.						Introduce		**1**
17	Winter Maintenance of Transit Facilities	Bus stops where access is impeded by snow, ice or broken pavement are identified, and COS can be informed of these problems from Saskatoon Transit so that these problems can be addressed quickly.						Enhance		**1**
18	**Accessible Pedestrian Signals (APS)**	**APS communicate information in non-visual formats (e.g., audio).**						**Enhance**		**1**
19	Sidewalk Retrofit	Sidewalks can be added to old neighbourhoods with missing sidewalks, or upgrade sidewalks.						Enhance		**1**
20	**Accessibility Ramps**	**Create access by adding curb ramps on street corners.**						**Enhance**		**1**
Sum of New Strategies/Programs			**2**	**0**	**0**	**1**	**1**	**2**	**1**	
Sum of Existing Strategies/Programs			**6**	**1**	**0**	**5**	**2**	**8**	**2**	
Total Strategies/Programs			**8**	**1**	**0**	**6**	**3**	**10**	**3**	

4.5.4. Legislation Strategies/Programs

Table 30 lists seven Legislation strategies/programs for the seven emphasis areas. Most of the Legislation strategies/programs already exist in Saskatoon.

Most of the Legislation strategies/programs are specialized and focused and applicable to only one emphasis area. Legislation strategies/programs are expected to be especially beneficial to Impaired Driving (3 programs).

Table 30: Legislation Strategies/Programs.

Strategy/Program		Description	Emphasis Areas							No. of Emphasis Areas Involved
ID	Title		#1: Aggressive Driving	#2: Distracted Driving	#3: Impaired Driving	#4: Inter-sections	#5: Older Drivers	#6: Vulnerable Road Users	#7: Young Drivers	
1	**Work Zone Regulation**	**Impose tougher fines on motorists who do not reduce their speed when driving in construction zones when workers are present.**	**Introduce**				**Introduce**		**Introduce**	**3**
2	Driver Improvement Program	Drivers are assigned demerit points every time they are convicted of a traffic offence related to aggressive driving. In Saskatchewan, drivers are currently assigned 4 demerit points for running a stop sign, and 1 demerit point for exceeding the speed limit.	Enhance							**1**
3	Administrative Licence Suspension Program (a.k.a. Immediate Roadside Prohibition (IRP) Program)	The licence suspension program is applied at the roadside to drivers with 0.08 blood alcohol content (BAC). Saskatchewan has various driver licence suspension programs. The sanctions vary with the driver's offence and include 90-day administrative suspensions, roadside suspensions, statutory suspensions, and criminal code suspensions.			Enhance					**1**
4	**Ignition Interlock Program (IIP)**	**An ignition interlock is an alcohol testing device connected to the ignition and power systems of a vehicle. It prevents an alcohol impaired driver from starting the vehicle. In Saskatchewan, drivers who are convicted of impaired driving, who drive over 0.08 BAC or who refuse to take a breath test are eligible for the IIP.**			**Enhance**					**1**

Table 30: Legislation Strategies/Programs (Continued).

Strategy/Program		Description	Emphasis Areas							No. of Emphasis Areas Involved
ID	Title		#1: Aggressive Driving	#2: Distracted Driving	#3: Impaired Driving	#4: Inter-sections	#5: Older Drivers	#6: Vulnerable Road Users	#7: Young Drivers	
5	**Addiction Screening**	**Addiction screening monitors all drivers convicted of impaired driving. Since 1996, drivers convicted of drinking and driving offences (including certain types of alcohol-related roadside suspensions) are screened. Those found to have an alcohol problem are referred to a recovery program.**			**Enhance**					**1**
6	Driver Evaluation Program (DEP)	DEPs monitor drivers who have medical conditions that may affect their ability to drive.					Enhance			**1**
7	**Graduated Driver Licensing (GDL) Program**	**GDL programs are designed to ensure that young drivers' exposure to higher levels of risk increases incrementally as the drivers gain more experience driving. The details of such programs vary. SGI is considering toughening the current GDL program.**							**Enhance**	**1**
Sum of New Strategies/Programs			**1**	**0**	**0**	**0**	**1**	**0**	**1**	
Sum of Existing Strategies/Programs			**1**	**0**	**3**	**0**	**1**	**0**	**1**	
Total Strategies/Programs			**2**	**0**	**3**	**0**	**2**	**0**	**2**	

4.5.5. Summary of Strategies/Programs

This section provides an overview of the 42 new or existing strategies/programs by emphasis area. Table 31 summarizes the number of new and existing strategies/programs shown in Table 27 to Table 30 by the strategy/program category and emphasis area.

Many strategies/programs are recommended for more than one emphasis area, but the total number of unique strategies/programs is 42. Nine of the 42 strategies/programs fall under Education, six under Enforcement, 20 under Engineering and seven under Legislation.

The number of strategies/programs per emphasis area ranges from 17 for Aggressive Driving to seven for Distracted Driving and seven for Older Drivers. In the case of Aggressive Driving, for example, the recommended strategies/programs includes five new strategies/programs plus 12 existing strategies/programs. Five of the Aggressive Driving strategies/programs fall under Education, two under Enforcement, eight under Engineering and two under Legislation.

Table 31: Strategies/Programs Summary.

Strategy/Program Category		Emphasis Areas						
		#1: Aggressive Driving	**#2: Distracted Driving**	**#3: Impaired Driving**	**#4: Inter-sections**	**#5: Older Drivers**	**#6: Vulnerable Road Users**	**#7: Young Drivers**
Education	Number of New Strategies/Programs	2	2	1	0	0	1	1
	Number of Existing Strategies/Programs	3	3	6	2	2	2	4
	Number of Total Strategies/Programs	5	5	7	2	2	3	5
Enforcement	Number of New Strategies/Programs	0	0	0	0	0	0	0
	Number of Existing Strategies/Programs	2	1	3	2	0	1	2
	Number of Total Strategies/Programs	2	1	3	2	0	1	2
Engineering	Number of New Strategies/Programs	2	0	0	1	1	2	1
	Number of Existing Strategies/Programs	6	1	0	5	2	8	2
	Number of Total Strategies/Programs	8	1	0	6	3	10	3
Legislation	Number of New Strategies/Programs	1	0	0	0	1	0	1
	Number of Existing Strategies/Programs	1	0	3	0	1	0	1
	Number of Total Strategies/Programs	2	0	3	0	2	0	2
Grand Total	**Sum of New Strategies/Programs**	**5**	**2**	**1**	**1**	**2**	**3**	**3**
	Sum of Existing Strategies/Programs	**12**	**5**	**12**	**9**	**5**	**11**	**9**
	Total Strategies/Programs	**17**	**7**	**13**	**10**	**7**	**14**	**12**

4.6. Chapter Summary

The modified process was used in the case study to develop a municipal-level SHSP for the City of Saskatoon.

Study data was collected, screened and prepared for the case study. Two types of information were used: road network information and collision data.

The first key component in the modified process was the selection of emphasis areas. The hybrid approach (i.e., combination of data-driven approach and political decision) was used as it is a commonly used approach in North American SHSPs. The hybrid approach consisted of a comprehensive literature review, rigorous analysis of collision statistics and intensive communication amongst stakeholders. The approach resulted in a selection of seven emphasis areas for the City of Saskatoon. The seven emphasis areas are: 1) Aggressive Driving, 2) Distracted Driving, 3) Impaired Driving, 4) Intersections, 5) Older Drivers, 6) Vulnerable Road Users and 7) Young Drivers.

The second key component following the selection of emphasis areas was the development of target safety goals. The literature stated that target safety goals needed to have a safety measure, target and time frame. *Fatal or injury collisions* was the chosen safety measure as it was the most appropriate for the City of Saskatoon. In terms of setting target goals, a combination of a basic-level collision trend analysis approach and the political will (i.e., "Vision Zero") approach was used. As a result, a target safety goal of 10% fatal or injury collisions reduction is recommended over the next five years.

Safety network screening was the third key component in the development of a municipal-level SHSP for the City of Saskatoon. Hotspots were identified using the Observed EPDO Average Collision Frequency method. 14 collision maps and tables showing the top ten

riskiest locations, and in some cases more than ten riskiest locations for each emphasis area were created. Seven of the maps are based on the total number of collisions and the other seven maps are based on peak time collisions. There were 41 locations based on the total number of collisions; 17 (41%) of which relate to more than one emphasis area. There were 35 locations based on the peak time collisions; 12 (34%) of which relate to more than one emphasis area.

Safety strategies/programs for the City of Saskatoon was the fourth key component. The recommendations outlined by FHWA (2006) were considered whilst selecting safety strategies/programs. Based on a thorough literature review of the most suitable strategies/programs and communication between stakeholders, a total of 42 comprehensive safety strategies/programs were recommended. These strategies/programs were categorized by Education, Enforcement, Engineering and Legislation, and by each emphasis area targeted. Many of the strategies/programs are not new, but require more intense implementation of current strategies/programs to meet the target safety goals of the SHSP.

CHAPTER 5
DISCUSSION OF CASE STUDY RESULTS

5.1. Emphasis Areas

The hybrid approach (i.e., combination of data-driven approach and political decision) was used to select emphasis areas in the case study for the City of Saskatoon. This approach was the most appropriate as it provides a comprehensive approach that begins with a literature review of existing SHSPs. Reviewing existing SHSPs is particularly important in the development of a municipal-level SHSP because a municipal-level SHSP should incorporate the emphasis areas already selected in the upper-level SHSPs (i.e., CCMTA, 2011a; SGI, 2012d), which is emphasized in the modified process. The existing process does not specifically indicate incorporating upper-level policies and thus, a municipality could miss out on an opportunity to collaborate with the federal- and provincial-level government in addressing an emphasis area.

The modified process also outlines the importance of using both high-level descriptive data analysis and communication between stakeholders to select emphasis areas. Table 32 shows the results of ranking the 13 potential emphasis area by collision data analysis and by the stakeholders. The results show some similarities in ranking and others that largely differ. For example, Intersections was ranked first in both rankings. Distracted Driving, Aggressive Driving and Young Drivers were similar. More interestingly, Impaired Driving was ranked 13th by the collision data analysis, but was ranked 6th or 7th by the stakeholders. There were also considerable differences in the rankings for Rear End Collisions and Vulnerable Road Users. The differences in ranking by each approach demonstrate the need to use a combination of both approaches. This way, a balance can be established to select the finalized list of emphasis areas for a municipality. The existing process, however, does not specifically suggest the most

appropriate approach to use to select emphasis areas in the development of a municipal-level SHSP.

Seven emphasis areas were chosen for the City of Saskatoon as listed: 1) Aggressive Driving, 2) Distracted Driving, 3) Impaired Driving, 4) Intersections, 5) Older Drivers, 6) Vulnerable Road Users and 7) Young Drivers. Note that the modified process ensures that the number of chosen emphasis areas is in line with the four to eight 'rule-of-thumb' principle.

Table 32: Potential Emphasis Areas Ranking Summary.

Collision Data Analysis	Stakeholders
1. Intersections	1. Intersections
2. Young Drivers	2. Vulnerable Road Users
3. Distracted Driving	3. Distracted Driving
4. Rear End Collisions	4. Aggressive Driving
5. Aggressive Driving	5. Young Drivers
6. Turning Movement Collisions	6. Impaired Driving
7. Angle Collisions	6. Angle Collisions
8. Older Drivers	8. Turning Movement Collisions
9. Road Condition	9. Road Condition
10. Lane Departure Collisions	10. Older Drivers
11. Horizontal Curves	11. Rear End Collisions
12. Vulnerable Road Users	12. Horizontal Curves
13. Impaired Driving	13. Lane Departure Collisions

Note: Duplicate rank values indicate equally ranked potential emphasis areas.

5.2. Target Safety Goals

The City of Saskatoon's target safety goal includes a safety measure, target and time frame. The modified process shows that *fatal or injury collisions* should be the chosen safety measure because it produces meaningful collision patterns compared to fatal collisions alone. It is also used in safety-related tasks, such as network screening, diagnosis, countermeasure selection, economic appraisal, and evaluation. The existing process outlines many safety measures, but does not state which safety measure is most appropriate for a municipality.

A combination of a basic-level collision trend analysis and political will (i.e., "Vision Zero") approach was used to establish target safety goals for the City of Saskatoon. Three target safety goals over five years were developed for three different time horizons – 20% (30 year horizon), 15% (40 year horizon) and 10% (50 year horizon). The modified process suggests that the target safety goals incorporate the target safety goals in the upper-level SHSPs. Therefore, a 10% target safety goal was chosen as it is in line with SGI's provincial-level target safety goal of a 30% reduction for fatalities and a 10% reduction for injuries. If a municipality were to follow the existing process, a municipality could potentially choose a target safety goal that would make it very challenging to achieve the provincial-level target safety goal.

A target safety goal of 10% reduction in fatal or injury collisions every five years where Vision Zero would be achieved in 2062 was developed for the City of Saskatoon using the modified process. Unlike the existing process, the modified process specifies the most appropriate safety measure, target and time frame for a municipal-level SHSP.

5.3. Network Screening Results

Network screening was not included in the existing process. Based on the case study results from the application of the modified process, network screening provides a large amount of information that would not have been available using the existing process.

The modified process suggests that the Observed EPDO Average Collision Frequency network screening method should be used for the development of a municipal-level SHSP. This method was used to develop two types of collision maps for the City of Saskatoon – total number of collisions and peak time collisions. The two types of collision maps were helpful since one map can reveal locations that were not shown on the other map. Each map also serves a specific purpose. Collision maps showing the total number of collisions may be used, for example, to

select locations for engineering countermeasures/strategies that provide round the clock benefits (e.g., surface infrastructure improvement projects). Collision maps showing collisions that occurred during the peak time for a particular type of collision (e.g., peak time for impaired driving collisions) may be useful, for example, for police enforcement strategies. Police officers usually apply enforcement strategies for a limited time of day only rather than on a continuous basis.

In addition, the locations identified from the collision maps can be grouped together to determine locations that target more than one emphasis area. As 17 (41%) of the locations relate to more than one emphasis area, Table 25 can be used to select locations where it may be possible to target and resolve safety concerns for more than one emphasis area. For example, collisions at intersection SKG02-2 located at Highway #11 and Marquis Drive West were associated with five emphasis areas: Aggressive Driving, Impaired Driving, Intersections, Older Drivers and Young Drivers. As 12 (34%) of the locations relate to more than one emphasis area, Table 26 can also be used to select locations where it may be possible to target and resolve safety concerns for more than one emphasis area. For example, as collisions at intersection SKJ1-5 at 51st Street and Warman Road were associated with four emphasis areas (Aggressive Driving, Distracted Driving, Intersections and Young Drivers), law enforcement strategies might be particularly effective at this location as it would target more than one emphasis area. Making these locations a priority would definitely be a step towards a more proactive approach as it allocates resources more wisely.

5.4. Safety Strategies/Programs

In terms of safety strategies/programs, the modified process uses a combination of a literature review and stakeholder communication for the selection of safety strategies/programs which is

similar to the existing process. The case study showed the importance of reviewing and combining the efforts already in place and to continue to enhance on existing safety strategies/programs as these do not require new funding. It is also important to implement strategies from various stakeholders. The City of Saskatoon's 42 existing and new strategies/programs were divided into four categories – Education, Enforcement, Engineering and Legislation. The various agencies involved could play off of their strengths to reduce collisions more efficiently. The stakeholders could also identify effective, ineffective and existing strategies through their experience and expertise. For example, Aerial Speed Enforcement was first suggested and was later excluded as SGI stated that the program had little impact in Saskatoon.

The modified process suggests additional considerations in the selection of safety strategies/programs that are not presented in the existing process. Similar to the network screening results, safety strategies/programs that target more than one emphasis areas should be considered a priority. The collision maps may also be used to select the best locations and times of day for certain strategies/programs. This will increase the effectiveness of the safety strategies/programs in a municipality's SHSP.

5.5. Contribution of a SHSP to a Strategic Plan

Following the additional step of incorporating upper-level policies outlined in the modified process, the SHSP can act as an operational-level safety action plan supporting the following strategic goals: 1) Quality of Life, 2) Sustainable Growth, 3) Moving Around and 4) Economic Diversity and Prosperity in the COS's (2013b) "Strategic Plan 2013-2023". Table 33 outlines the SHSP's contribution to the COS's Strategic Plan. The proposed safety strategies/programs can reduce the number of impaired driving collisions (a crime-coded collision), which in turn will

improve the quality of life for Saskatoon citizens. The SHSP also includes strategies/programs (e.g., “Winter Maintenance of Transit Facilities”, “Engineering Projects that help to reduce Peak Period Congestion” etc.) that address the Sustainable Growth and Moving Around strategic goals. There are strategies identified that can also be used to promote active transportation. “Bicycle Lane Connectivity” and “Coloured Pavement for Bicycle Lanes” can be used to accommodate cycling, and “Accessible Pedestrian Signals (APS)” and “Sidewalk Retrofit” can be used to accommodate pedestrian movement. The engineering strategies/programs (e.g., “Clearview Street Signs”, “Countdown Pedestrian Signals” etc.) directly relate to the improvement of transportation infrastructure, which can indirectly contribute to regional economic growth and business development.

The modified process therefore allows municipalities to link their SHSP to their Strategic Plan after carefully developing the components of a SHSP, which is not considered in the existing process. This way, a SHSP can be used proactively in not only reducing motor vehicle collisions, but in improving the transportation system as well. This in turn will improve the municipality as a whole since transportation is one of the most important business lines in a jurisdiction. Many municipalities have already developed a SHSP (Edmonton, 2007; Hamilton, 2009) and a Strategic Plan (Edmonton, 2012; Hamilton, 2011) just as the City of Saskatoon has so there would be no trouble in linking them together. A SHSP should also be linked to a Strategic Plan so that various agencies will be aware of all the efforts in a jurisdiction to better allocate resources. The SHSP could complement and build upon the efforts already in place.

Table 33: Expected Contributions of SHSP towards the COS's Strategic Plan.

COS Strategic Plan				Expected Contributions of SHSP
Strategic Goal	**Success Drivers**	**COS's 10 Year Long-Term Strategies**	**Success Indicator**	
Quality of Life	▪ Public Safety	▪ Reduce and prevent crime and provide protective services in our downtown core and neighbourhoods	▪ Public perceptions of safety ▪ Public perceptions of quality of life	The SHSP's emphasis areas include Impaired Driving which is a crime-coded collision. Reducing the number of impaired driving collisions through the proposed strategies/programs (e.g., Operation Red Nose (ORN), Ignition Interlock Program (IIP), Report Impaired Drivers (RID), etc.) will certainly contribute to reducing the total number of crimes in Saskatoon, and will be perceived by Saskatoon citizens as a noticeable improvement in their safety and quality of life.
Sustainable Growth	▪ Neighbourhood Quality and Character	▪ Adopt an integrated approach to growth related to transportation, servicing, transit and land use	▪ Residents' perception of the quality of their neighbourhood	The SHSP includes a number of strategies/programs designed to support Sustainable Growth and Moving Around, for example strategies/programs introducing/enhancing "Bicycle Lane Connectivity", "Coloured Pavement for Bicycle Lanes" and "Winter Maintenance of Transit Facilities (e.g., bus stops)", etc. These strategies/programs will increase in length and improve the quality of the cycling network, and will contribute to increasing transit and bicycle ridership in the city. The SHSP also recommended "Engineering Projects that help to reduce Peak Period Congestion" as a strategy/program for Aggressive Driving. Implementation of this strategy will contribute to relieving frustration with city congestion.
Moving Around	▪ Perceptions of Public Transit ▪ Efficient Road Systems ▪ Infrastructure Maintenance ▪ Transportation Network Connectivity	▪ Significantly increase transit ridership by establishing transit as a viable option for transportation ▪ Develop an integrated transportation network that is practical and useful for vehicles, buses, bikes and pedestrians	▪ Length and quality of walking and cycling network ▪ Residents' perception of traffic congestion ▪ Transit ridership to and around City Centre	
Economic Diversity and Prosperity	▪ Transportation ▪ Infrastructure	▪ Develop Saskatoon's transportation network to support regional economic development	▪ Distribution of employment sectors	The SHSP includes 20 engineering strategies/programs. Most relate directly to the improvement of transportation infrastructure which indirectly contributes to regional economic growth and business development. Examples include "Clearview Street Signs", "Countdown Pedestrian Signals", "Well Maintained Pavement Markings", "Improved Traffic Signal Operation" and "Improved Road Surface Friction/Winter Maintenance".

5.6. Economic Benefits of the Results

The proposed research will improve the allocation of budgets for reducing collisions, which will lead to substantial economic benefits.

Table 34 shows the benefit and cost analysis using the engineering strategy, "Red Light Cameras" as an example. The analysis requires a number of assumptions. The literature (City of Hamilton, 2013; The Regional Municipality of York, 2013; City of Ottawa, 2014) reported that the estimated total cost, including start-up costs, engineering, equipment purchase, installation, maintenance and operating costs, for a red light camera per location is approximately $100,000. Red light cameras have been successfully implemented in a number of cities. For example, Calgary (2014) reported a 17% reduction in total collisions, 100% reduction in fatal collisions, 47% reduction in injury collisions, and 11% reduction in PDO collisions at the Intersection Safety Cameras (ISCs) locations from 2000 to 2011, which equates to approximately 7% reduction in fatal or injury collisions per year. A recent study stated that Saskatoon (2014) experienced a 22% reduction in severe collisions since red light cameras were installed in 2005, which is approximately 3% reduction in fatal or injury collisions per year. Therefore, a 5% reduction in fatal or injury collisions per year was used in the analysis. The most recent collision data used is 2009/2010 so the average fatal or injury collisions per year are 1211. The 2007 dollar values for direct and societal unit costs presented in Section 4.2.3 were converted to 2014 dollar values by applying the consumer price index (CPI) factor of 1.12331 (Statistics Canada, 2014). Therefore, the estimated benefit of a red light camera per location is $19 million per year for direct costs and $386 million per year for societal costs. This results in an estimated benefit-cost ratio of 188.53 for direct costs and a benefit-cost ratio of 3,862.24 for societal costs for the installation of a red light camera per location.

Table 34. Benefit-Cost Analysis.

Cost of Red Light Camera per Location (2014$)	100,000
FI Collision Reduction (%/Year)	5
2009/10 (Average Number of FI Collisions/Year)	1211
SGI Direct Unit Cost for FI Collisions (2014$)	311,355.70
Societal Unit Cost for FI Collisions (2014$)	6,378,603.50
SGI Direct Cost for FI Collisions (2014$/Year)	377,051,752.70
Societal Cost for FI Collisions (2014$/Year)	7,724,488,838.50
Estimated Direct Cost Benefit for FI Collisions (2014$/Year)	18,852,587.64
Estimated Societal Cost Benefit for FI Collisions (2014$/Year)	386,224,441.93
Direct Benefit-Cost Ratio	188.53
Societal Benefit-Cost Ratio	3,862.24

5.7. Chapter Summary

This chapter discusses the results of applying the modified process (i.e., procedure and key components) through a case study for the City of Saskatoon. The results of the modified process to develop each key component (i.e., emphasis areas, target safety goals, network screening and safety strategies/programs) in a municipal-level SHSP were compared to the existing process.

One of the additions in the modified process is the incorporation of upper-level policies. This step influences the development of each of the key components.

In particular, a municipality could miss out on an opportunity to collaborate with the federal- and provincial-level government in addressing an emphasis area if they do not incorporate upper-level policies in the selection of emphasis areas. The modified process suggests that a combination of a data-driven approach and political decision be used since some of the potential emphasis area ranking results from the data-driven approach differ largely from the political decision approach.

Developing target safety goals must also incorporate upper-level policies to ensure that a municipality does not select a target safety goal that would make it challenging to achieve the target safety goals of upper-level SHSPs. A combination of a basic-level collision trend analysis

and political will (i.e., “Vision Zero”) approach was suggested to establish target safety goals for the City of Saskatoon.

Another addition in the modified process was the key component of network screening. Based on the case study results from the application of the modified process, network screening provides a large amount of information (i.e., locations based on total number of collisions, locations based on peak time collisions, locations that target more than one emphasis area) that would not have been available using the existing process. The most appropriate approach to conduct network screening is the Observed EPDO Average Collision Frequency as it does not require traffic volume as input data.

The modified process suggests additional considerations in the selection of safety strategies/programs that are not presented in the existing process. Similar to the network screening results, safety strategies/programs that target more than one emphasis areas should be considered a priority. The collision maps may also be used to select the best locations and times of day for certain strategies/programs. The modified process also suggests that a combination of a literature review and stakeholder communication from the 4Es is recommended for the selection of safety strategies/programs.

Furthermore, the components of a SHSP can be used to support the strategic goals in a jurisdiction’s Strategic Plan just as the City of Saskatoon’s SHSP supports the strategic goals outlined in the City of Saskatoon’s Strategic Plan. Therefore, a jurisdiction’s SHSP should be linked to a jurisdiction’s Strategic Plan, which can be easily done as many jurisdictions already have developed a SHSP and a Strategic Plan. This way, a SHSP not only reduces collisions, but improves the quality of life for citizens living in a municipality to generate the greatest benefit in terms of transportation safety investment.

CHAPTER 6
SUMMARY AND CONCLUSIONS

There have been many documents published that set strategic goals for the future, including transportation-related goals. However, few documents focus heavily on a specific approach to improve transportation safety. Therefore, a supporting policy document focused on transportation safety is required to ensure that the transportation system runs safely and efficiently; a Strategic Highway Safety Plan (SHSP) serves as that document.

The research aimed to improve traffic safety by reducing the number and severity of collisions in municipalities across Canada. The objective for this research was to develop a data-driven and more scientific municipal-level SHSP development process (i.e., procedure and key components) that may be used to improve traffic safety for municipalities across Canada.

Existing procedures to develop a SHSP were first reviewed. A review of the key components (i.e., emphasis areas, target safety goals, network screening and safety strategies/programs) and approaches to develop the key components in existing SHSPs published mainly in North America were reviewed as well. The literature review (FHWA, 2006; CCMTA, 2011b) suggested that the typical procedure for the development of a SHSP is identifying a "champion" (i.e., an individual or unit with high-level leadership), developing a vision, identifying key stakeholders, developing the key components (i.e., selecting the key emphasis areas, establishing target safety goals, selecting the strategies/programs for the chosen key emphasis areas), and updating and evaluating the SHSP. The existing procedures and key components were adjusted to create the modified process. A case study in creating a municipal-level SHSP for the City of Saskatoon was then conducted. Road network information and collision data was collected, screened and prepared for the case study. The modified process (i.e., procedure and key components) was applied to the City of Saskatoon to compare the results to

the existing process. It was determined that the modified process was a more data-driven and scientific process in developing a municipal-level SHSP that will improve traffic safety for municipalities across Canada. It provided detailed information required by a municipality to make informed safety investment decisions compared to the basic information the existing process provided. The following sections discuss the detailed information resulting from using the modified process (i.e., procedure and key components) compared to the existing process to develop a municipal-level SHSP.

6.1. Procedure

The procedure in the modified process included two additional steps that were not present in the existing procedure. The first step is incorporating upper-level policies in the development of a municipal-level SHSP as a municipal-level SHSP is the lowest-level SHSP and should incorporate the policies that are included in upper-level SHSPs (i.e., provincial- and federal-level). The second step is the addition of the network screening key component as it provides a large amount of information that can help a SHSP become more effective. The following sections present how these two additional steps influenced the development of the key components, which in turn leads to a detailed municipal-level SHSP process.

6.2. Key Components

6.2.1. Emphasis Areas

The modified process recommends that the hybrid approach (i.e., combination of data-driven approach and political decision) be used for the selection of emphasis areas (i.e., areas of safety concern). This is the most appropriate approach because the results of the case study showed that each approach ranks emphasis areas differently; therefore, both should be used to strike a balance between emphasis areas selected purely by a data-driven approach and purely by

political decision. An approach based on political decision is particularly important because municipalities should consider and incorporate emphasis areas selected by upper-level SHSPs so that stakeholders at all levels of government (municipal, provincial and federal) can collaborate and coordinate resources to address the same target areas. Based on the case study results, both approaches were used to select the City of Saskatoon's seven chosen emphasis areas – Aggressive Driving, Distracted Driving, Impaired Driving, Intersections, Older Drivers, Vulnerable Road Users, and Young Drivers. The results show that the seven chosen emphasis areas differ from the top seven ranked by the collision data analysis and the top seven ranked by the stakeholders.

6.2.2. Target Safety Goals

Target safety goals (i.e., collision reduction goals) represent a jurisdiction's safety improvement vision. Target safety goals require a safety measure, a target and a time frame. The modified process emphasizes the importance of ensuring all three have been included. Without one of the three, the target safety goal will not be effective.

The modified process goes into more detail than the existing process as it recommends the most appropriate safety measure, target and time frame for a municipality. Based on the results of the case study, the recommended safety measure is *fatal or injury collisions* because it produces meaningful collision patterns compared to fatal collisions alone. It is also used in safety-related tasks, such as network screening, diagnosis, countermeasure selection, economic appraisal, and evaluation. Similar to the selection of emphasis areas, a combination of basic-level collision data analysis and stakeholder communication (i.e., "Vision Zero" approach) is the recommended approach to develop the target and time frame. Target safety goals can hardly be determined based purely by data-driven analyses and/or by mathematical models since these

approaches are not, for instance, intended to reflect policymakers/general public's ambition. The case study showed that three different target safety goals over a five-year period were first suggested [i.e., 20% (for 30 years), 15% (for 40 years) and 10% (for 50 years)]. However, a target safety goal of 10% every five years so Vision Zero would be achieved over 50 years was selected because the target safety goal needed to work with rather than against the provincial-level target goal (i.e., 30% decrease in fatalities and 10% decrease in injuries). Therefore, a combination of a data-driven analyses and stakeholder communication should be used to establish target safety goals.

6.2.3. Network Screening

Network screening refers to the identification of high collision locations or hotspots. Network screening is not included in the existing process and there are limited studies discussing the most appropriate network screening method that should be used for the development of a SHSP.

The modified process demonstrates the use of the Observed EPDO Average Collision Frequency method to conduct network screening in the case study. This is the most appropriate network screening method because it does not require traffic volume information to develop collision maps. Other methods require traffic volume data, but traffic volume for specific emphasis areas is not easily obtained. The Observed EPDO Average Collision Frequency method can be used to develop two types of collision maps – total number of collisions and peak time collisions. Two different types of collision maps are important because one map is capable of revealing locations not easily shown by the other. This is valuable information that the modified process is capable of providing, which the existing process cannot. It is also highly recommended that locations identified from the collision maps be grouped together to determine locations that target more than one emphasis area. This way, the SHSP can allow policymakers

to make informed safety investment decisions to better allocate resources to reduce collisions more proactively. This shows that the modified process, which includes network screening can be used to develop detailed municipal-level SHSPs based on data-driven approaches compared to the existing process.

6.2.4. Safety Strategies/Programs

Safety strategies/programs are safety initiatives/countermeasures/programs that can be used to reduce collisions in particular emphasis areas. Similar to the selection of emphasis areas and target safety goals, a combination of a literature review and stakeholder communication from the 4Es is necessary for the selection of safety strategies/programs. The case study results show that the modified process identifies safety strategies/programs that target more than one emphasis area and that collision maps may also be used to select best locations and times of day for certain strategies/programs, which again provides more information than the existing process. This type of information is needed for policymakers to make informed safety investment decisions towards safety strategies/programs.

6.3. Contribution of a SHSP to a Strategic Plan

A SHSP not only reduces collisions, but improves the municipality as a whole in a more proactive manner. The case study of the application of the modified process shows how a jurisdiction's SHSP can be linked to a jurisdiction's Strategic Plan, which can be easily done as many jurisdictions already have developed a SHSP and a Strategic Plan. The case study presents the relationship between the components of a SHSP and the strategic goals of a Strategic Plan. The case study results also demonstrate that the safety strategies/programs have a significant benefit. For example, implementing a red light camera at one location at a cost of $100,000

could result in savings of $19 million per year in direct costs and $386 million per year in societal costs of fatal or injury collisions in Saskatoon.

6.4. Future Work

There are a few factors that can further increase the effectiveness of a SHSP. This study did not include the evaluation and monitoring of safety programs and target goals. As this research was based on developing a first generation SHSP, the evaluation and monitoring component cannot be measured; rather, it is a component for an updated SHSP in the future. It is important to note that a SHSP should be monitored, evaluated and updated in the future to see whether the strategies/programs are successfully and appropriately addressing the safety issues in the chosen emphasis areas and whether the municipality is moving towards satisfying its target safety goals. The creation of a SHSP should never be regarded as a one-time effort, but as a continuous effort and updated to achieve the municipality's long-term safety goal every four to five years. The updated SHSP will show the annual collision data that was not available at the time the development process had started.

In addition, there are more than the stated 4Es [i.e., Education, Enforcement, Engineering and Emergency Medical Services (EMS)]. One example is Electronics, which refers to vehicle safety technology that can be combined with safe driving behaviour to improve road safety (Robertson et al., 2013). Roberston et al. (2013) reported that it is important for drivers to know about the function, capabilities and limitations of vehicle safety features to ensure safety on the road. Additional work can be done to investigate improvement in safety standards of automobiles. Therefore, Electronics or other Es can be considered and included as future work.

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APPENDIX A
DESCRIPTION OF THE 23 POTENTIAL EMPHASIS AREAS

The 23 potential emphasis areas are described below. The definition of each potential emphasis area was based on an extensive literature review. The Saskatchewan Government Insurance's (SGI) (2011) collision database consisted of codes, which were chosen to categorize the collisions into the 23 potential emphasis areas based on the definitions found in the literature review.

DRIVERS

Aggressive Driving

The City of Ottawa (2011) defines aggressive driving "as operating a motor vehicle in a selfish, pushy, or impatient manner, often unsafely, that directly affects other drivers". Examples of aggressive driving include failing to yield the right-of-way, disregarding traffic control devices, following too closely, driving too fast for road conditions, exceeding the speed limit, turning improper, improper passing or lane usage, and careless driving/stunting (SGI, 2012c; The City of Ottawa, 2011). Therefore, the following SGI (2007; 2011) major contributing factor codes were used:

- *MCF1 21 - Fail to yield the right-of-way:* A person or vehicle failing to allow lawful passage to others (e.g., disregarding a stop sign).
- *MCF1 22 - Traffic control device disregarded:* A person's failure to obey a traffic control device contributed to the collision (e.g., disregarding traffic lights).
- *MCF1 23 - Following too closely:* Failure to allow sufficient space between vehicles to avoid a collision.
- *MCF1 24 - Driving too fast for road conditions:* Driving at a speed which may be well within the posted speed limit, but does not allow the driver safe vehicle control when considering adverse road environmental conditions.

- *MCF1 25 - Exceeding speed limit:* A vehicle traveling at a speed level higher than legally posted or established on that roadway.
- *MCF1 26 - Turning improper:* Turns that were not made in accordance with the prescribed natural path or a turn was made under prohibited circumstances (e.g., turning in the wrong direction).
- *MCF1 27 - Passing or lane usage improper:* A maneuver related to the changing of lanes for the act of passing or overtaking (e.g., passing when prohibited or turning from a non-turning lane). This can be the vehicle being passed or the overtaking vehicle.
- *MCF1 32 - Careless driving/stunting:* A collision which was a result of neglectful or inconsiderate actions done for thrills, daring or attracting attention from onlookers.

Distracted Driving

Distracted driving refers to distractions, such as reaching for a moving object, an insect in the vehicle, looking at an external object, reading, applying make-up, dialing a hand-held device, inserting/retrieving a CD, eating, reaching for a non-moving object, talking or listening to a hand-held device, drinking from an open container, other personal hygiene (e.g., shaving), adjusting the radio, passenger in the front seat, passenger in the rear seat, combing hair, and child in the rear seat (NHTSA, 2006; SGI, 2012d). Therefore, the following SGI (2007; 2011) major contributing factor codes were used:

- *MCF1 01 - Inattentive:* Any failure to pay particular attention to the driving task.
- *MCF1 02 - Distracted:* Any condition or activity inside or outside the vehicle causing attention to be diverted.

- *MCF1 67 - View from vehicle obstructed:* Refers to the driver's view to the road obstructed by something in or on the vehicle such as a dirty windshield, defective mirrors, or a person in the vehicle.
- *MCF1 68 - Sun glare:* Refers to insufficient visibility of the roadway due to bright sunlight.

Fatigued Driving

Fatigued driving consists of collisions that are due to extreme fatigue and falling asleep. Therefore, the following SGI (2007; 2011) major contributing factor codes were used:

- *MCF1 05 - Extreme fatigue:* Extreme fatigue due to normal physical exhaustion and not caused by drugs or medical condition.
- *MCF1 06 - Fell asleep:* Fell asleep while driving.

Impaired Driving

Impaired driving refers to driving while impaired by alcohol or drug use (legal or illicit) (SGI, 2012d). Therefore, the following SGI (2007; 2011) major contributing factor codes were used:

- *MCF1 03 - Had been drinking:* The person had consumed alcohol, but the driving or walking ability was apparently not over the legal acceptable impairment level.
- *MCF1 04 - Impaired:* Ability to cope with a situation in traffic is impaired by alcohol consumption. Impairment usually implies over the legal limit even though charges may or may not have been laid.
- *MCF1 10 - Drugs (prescription or legal):* Impairment due to the use of drugs or medication.

Medically-at-risk Driving

CCMTA (2011a) defines medically-at-risk driving as drivers whose existing medical condition may affect the safe operation of their vehicles, their occupants and the safety of other road users (e.g., epilepsy, ischemic heart disease etc.) and driver performance outside of the boundaries of normal driving behaviour related to the aging process (e.g., poor cognitive or perception skills, slow reaction time to decision-making situations, visual or auditory limitations). Therefore, the following SGI (2007; 2011) major contributing factor codes were used:

- *MCF1 08 - Lost-consciousness/other illness:* A "black-out", sickness, disease or medical disorder.
- *MCF1 09 - Physical/medical disability:* A person's physical/medical condition which hampers the ability to drive properly.
- *MCF1 11 - Defective eyesight/hearing:* A person with a condition lacking proper vision or hearing.
- *MCF1 12 - Other human condition:* The state of a person's physical or mental condition, immediately prior to the involvement in the collision, not listed otherwise in the SGI collision database that may have been a factor in the collision.

Older Drivers

AASHTO (2005) defines older drivers as drivers aged 65 years old or greater. Therefore, the following SGI (2007; 2011) driver age code was used:

- *DRVAGE - 65 to 100 years old.*

Seatbelts

This emphasis area refers to injuries and fatalities caused by lack of or improper use of lap and shoulder safety belts (SGI, 2012d). Therefore, the following SGI (2007; 2011) safety equipment code was used:

- *SAFETYEQ 8 - Safety equipment not used or improperly used:* Victims who were not using any safety equipment or were using it improperly, such as an under arm shoulder strap or loose fitting lap belt.

Young Drivers

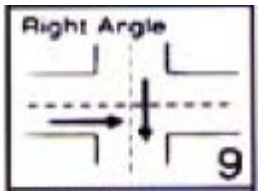
Young drivers are drivers between the ages of 15 and 24 years old (SGI, 2012b). Therefore, the following SGI (2007; 2011) driver age code was used:

- *DRVAGE - 15 to 24 years old.*

ENVIRONMENTAL CONDITIONS

Angle Collisions

The City of Ottawa (2011) defines angle collisions as "t-bone or 90 degree angle collisions mostly occurring at signalized or stop sign-controlled intersections". Therefore, the following SGI (2007; 2011) collision configuration was used:



(SGI, 2007)

- *CONFIG 09 - Right angle:* Two or more vehicles involved in a right angle collision neither of which was attempting a turn.

At-Grade Crossings

This emphasis area refers to collisions that occur at at-grade crossings. Therefore, the following SGI (2007; 2011) accident site code was used:

- *ACCSITE 7 - Railroad level crossing.*

Horizontal Curves

Horizontal curves represent all collisions that occur on a horizontally curved section of streets. Therefore, this emphasis area includes collisions that occur on horizontal curves and the following SGI (2007; 2011) road alignment horizontal code was used:

- *HOR 2 - Curved.*

Intersections

The intersection emphasis area is concerned with all collisions that occurred at intersections. Therefore, this emphasis area includes collisions that occur at intersections and the following SGI (2007; 2011) road type code was used:

- *Intersection.*

Lane Departure Collisions

The City of Hamilton (2009) defines roadway departure collisions as those that "involve vehicles that leave the travel lane and encroach onto the shoulder and beyond and hit one or more of any number of natural and artificial objects, such as bridge walls, poles, embankments, guardrails, parked vehicles, and trees". Therefore, the following SGI (2007; 2011) collision configuration codes were used:

(SGI, 2007)

- *CONFIG 02 - Lost control – Left ditch:* A single vehicle that lost control, crossed the road surface and entered the area to the left of the road surface.
- *CONFIG 03 - Lost control – Right ditch to left ditch:* A single vehicle that lost control, left one side of the road then crossed the road to the area on the other side of the driving surface, regardless of which side of the driving surface was left first.
- *CONFIG 04 - Lost control – Right ditch:* A single vehicle that lost control and entered the area to the right of the road surface.

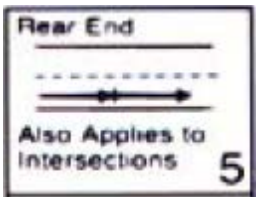
Pavement Markings

This emphasis area refers to collisions caused by inadequate lane markings. Therefore, the following SGI (2007; 2011) major contributing factor code was used:

- *MCF1 72 - Lane markings inadequate:* Refers to obliterated, worn, misplaced pavement markings which are lacking reflectivity or difficult to see.

Rear End Collisions

The City of Ottawa (2011) defines rear end collisions as "collisions that occur when the vehicle following the vehicle ahead crashes into the back of that vehicle". Therefore, the following SGI (2007; 2011) collision configuration code was used:



(SGI, 2007)

- *CONFIG 05 - Rear end:* Two or more vehicles involved in a rear end collision. This can involve a parked vehicle or vehicle operating in reverse.

Road Condition

This emphasis area refers to all collisions that are caused by the condition of the road. This refers to collisions that did not occur on dry road surface and normal/good road conditions (SGI, 2007). Therefore, the following SGI (2007; 2011) major contributing factor codes were used:

- *MCF1 62 - Surface or structure:* Prevailing constructed and maintained condition of the road at the accident site (e.g., potholes, ruts, bumps, under construction/repair, uneven pavement surface/sharp drop off, obscured or faded pavement markings).
- *MCF1 63 - Excessive loose gravel:* A condition where excessive gravel has been applied to the roadway to such an excess to sway the vehicle and contribute to a loss of control.
- *MCF1 71 - Soft or defective shoulder:* Refers to a sharp drop off the driving surface and to adverse shoulder condition, such as holes or bumps.

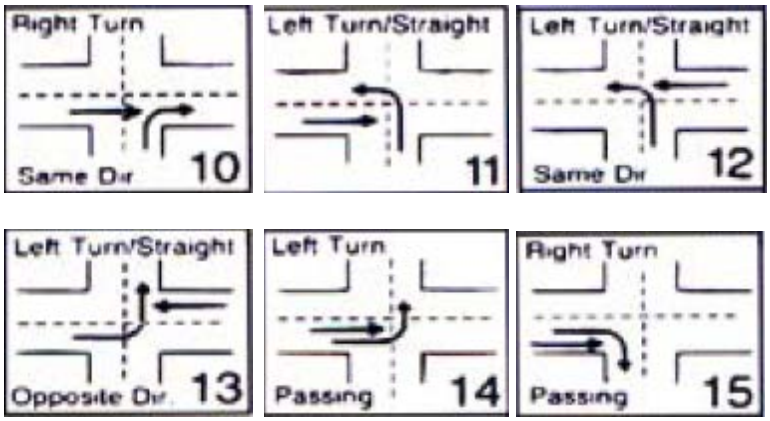
School Zones

This emphasis area refers to collisions that occur in school zones. Therefore, the following SGI (2007; 2011) traffic control code was used:

- *CONTROLS 14 - Reduced speed zone:* A length of roadway on which the legal speed limit is lower than the speed limit on the entire road (i.e., school zones, playgrounds). This does not include advisory speed zones.

Turning Movement Collisions

The City of Ottawa (2011) defines turning movement collisions as "collisions where one or more motorists are in the act of turning at the time of the collision". Therefore, the following SGI (2007; 2011) collision configuration codes were used:



(SGI, 2007)

- *CONFIG 10 - Right turn – Same direction:* Two or more vehicles involved in a right angle collision with at least one vehicle attempting a right turn and one vehicle traveling straight through.
- *CONFIG 11 - Left turn/straight:* Two or more vehicles involved in a collision with at least one vehicle attempting a left turn and one traveling straight through.
- *CONFIG 12 - Left turn/straight – Same direction:* Two or more vehicles involved in a collision with at least one vehicle attempting a left turn and one traveling straight through.
- *CONFIG 13 - Left turn/straight - Opposite direction:* Two or more vehicles involved in a collision with at least one vehicle attempting a left turn and one vehicle traveling straight through in the opposite direction.
- *CONFIG 14 - Left turn – Passing:* Two or more vehicles traveling in the same direction involved in a collision where one attempts a left turn in front of the other.

- *CONFIG 15 - Right turn – Passing:* Two or more vehicles traveling in the same direction involved in a collision where one attempts a right turn in front of the other.

Wildlife

SGI (2012d) defines this emphasis area as vehicle "collisions involving wildlife". Therefore, the following SGI (2007; 2011) major contributing factor codes were used:

- *MCF1 60 - Animal action (wild):* Refers to animals living in their natural state, such as deer or moose.
- *MCF1 61 - Animal action (domestic):* Refers to domesticated farm animals, such as cattle.

Winter Driving

The City of Hamilton (2009) defines this emphasis area as collisions "occurring under drifting snow/snow/freezing rain conditions". The City of Red Deer (2007) also defines this emphasis area as "snow related collisions ... [due] to slick driving conditions and a loss of control". Therefore, the following SGI (2007; 2011) major contributing codes were used:

- *MCF1 64 - Snow drift.*
- *WEATHER 4, 5, 7 - Weather:* Snowing, sleet/hail/freezing rain, drifting snow/dust.

Work Zones

The City of Hamilton (2009) defines this emphasis area as "collisions [occurring] within or related to work zone activities". Therefore, the following SGI (2007; 2011) major contributing factor code was used:

- *MCF1 69 - Construction zone:* Refers to any collision in a construction or maintenance zone where the existence of the zone or equipment and persons in the zone contributed to the collision.

SPECIAL ROAD USERS

Commercial Vehicles

The City of Hamilton (2009) defines this emphasis area as "collisions involving commercial vehicles ... [such as] closed truck, construction equipment, dump truck, open truck, tank truck, tow truck, tractor truck or truck other". Therefore, the following SGI (2007; 2011) vehicle classification codes were used:

- *VIDENT 04 - Trucks over 4500 kg:* All single unit vehicles designed primarily for carrying property, with single or tandem drive axles.
- *VIDENT 05 - Power units for semi trailers:* A road tractor designed for towing semi trailers.

Vulnerable Road Users

CCMTA (2011a) defines vulnerable road users as collisions involving bicycles, motorcycles/mopeds and/or pedestrians, which are described below.

Bicycles

This emphasis area includes collisions that involve a bicycle. Therefore, the following SGI (2007; 2011) vehicle classification code was used:

- *VIDENT 13 - Bicycle:* A non-motorized two or three wheel vehicle propelled by pedaling.

Motorcycles/Mopeds

This emphasis area includes collisions that involve a motorcycle or moped. Therefore, the following SGI (2007; 2011) vehicle classification code was used:

- *VIDENT 11 - Motorcycle:* A two or three wheel motor vehicle intended for roadway use.
- *VIDENT 12 - Moped/Power bicycle:* A speed-limited motor-driven cycle which may be propelled by pedaling.

Pedestrians

This emphasis area includes collisions that involve a pedestrian. Therefore, the following SGI (2007; 2011) occupant position code was used:

- *OCCPOS 9 - Pedestrians:* Persons pushing a bike or riding in a wheelchair.

APPENDIX B
SASKATOON'S COLLISION HISTORY

This section includes a comprehensive and overall collision data analysis of Saskatoon's collision data. This includes: 1) collision trend analysis (i.e., annual, seasonal, monthly, daily and hourly), 2) collision rate analysis (i.e., collisions per capita, collisions per registered vehicle), 3) collision cost analysis (i.e., direct cost, societal cost), 4) collisions per road configuration and 5) collisions by driver group (by age group and gender).

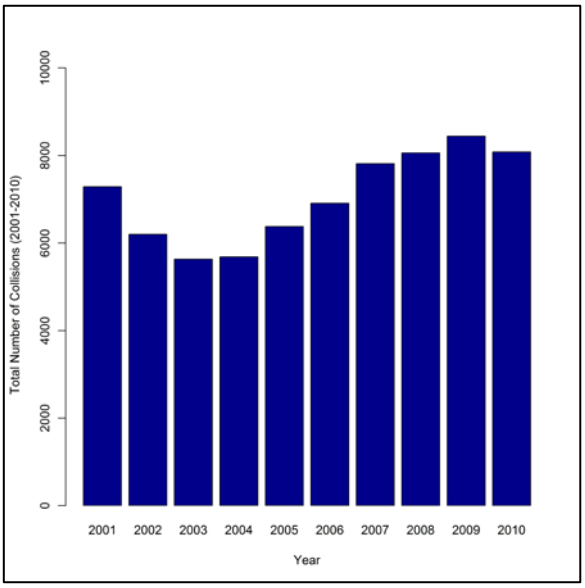
Five different severities were analyzed as safety measures. They are: 1) total, 2) fatal, 3) injury, 4) PDO, and 5) fatal or injury collisions (i.e., fatal plus injury). However, in order to highlight the City of Saskatoon's traffic safety issues more effectively, only the total and fatal or injury collisions were included in the research due to the following general patterns in collision statistics noticed during the process of collision data analysis (as discussed in detail in later sections):

- As fatal collisions were extremely rare and random events in Saskatoon, the collisions cannot be analyzed as meaningful collision patterns and cannot be used as a sole safety measure. Thus, fatal collisions were combined with injury collisions to present clearer collision patterns that will be more useful to assist in the determination of emphasis areas and target goals.
- Most collisions in Saskatoon during the study period (2001-2010) were PDO collisions. Thus, PDO collisions were not presented separately because the total number of collisions largely reflects the same collision patterns over the period.

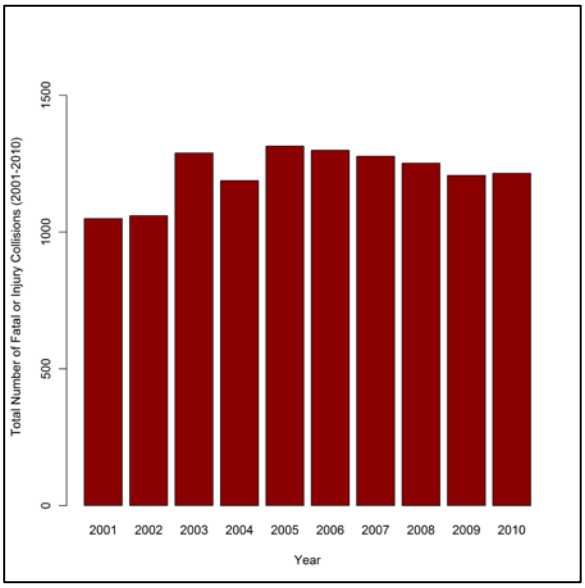
Collision Trend Analysis

The City of Saskatoon experienced a total of 70,487 collisions, consisting of 63 fatal, 12,087 injury and 58,337 PDO collisions, during the study period (2001-2010) (See Table B1).

Figure B1(a) shows the annual trend in the total number of collisions over the study period. Although the total number of collisions shows up-and-down fluctuations during the ten-year period, the total has clearly been increasing if we focus only on the most recent five years' collision data (2006-2010). Figure B1(b) shows the annual trend in the total number of fatal or injury collisions. This figure shows a slight increasing trend during the ten-year period. Similar to the other Canadian jurisdictions, the City is currently aiming to achieve a roadway system with zero deaths and injuries on the road as a long-term goal (Belin et al., 2011). The current collision trend cannot be regarded as a satisfactory condition in terms of traffic safety.



(a) Total



(b) Fatal or Injury

Figure B1: Number of Collisions by Year, 2001-2010 (SGI, 2011).

Table B1: Number of Collisions by Severity and Year, 2001-2010 (SGI, 2011).

Year	Fatal	Injury	PDO	Total
2001	9	1,040	6,239	7,288
2002	6	1,054	5,139	6,199
2003	4	1,285	4,342	5,631
2004	3	1,185	4,497	5,685
2005	6	1,308	5,063	6,377
2006	4	1,295	5,609	6,908
2007	10	1,267	6,536	7,813
2008	5	1,247	6,808	8,060
2009	5	1,202	7,236	8,443
2010	11	1,204	6,868	8,083
Grand Total	63	12,087	58,337	70,487
Average	6	1,209	5,834	7,049

Figure B2 is a 3D diagram known as a clockplot and presents the total number of collisions by hour and severity. Clockplots are used to compare a variable, in this case severity, with the hours of the day. The first hour, for example, consists of circles that represent collisions that occurred between 12 am and 1 am. The legend located on the top right hand corner shows the range of collisions categorized by the size and colour of the circle in the clockplot. For example, Figure B2 shows that the largest number of collisions occurred at 4 pm to 5 pm with a large red circle representing 4,946 collisions. The size and value of the circles were divided into quarterly sections based on the largest number of collisions (i.e., 2,473 collisions is half of 4,946 collisions). The colour of the circles represent the number of collisions from largest (red) to smallest (green). It is evident that most collisions in Saskatoon were PDO collisions that occurred during the afternoon hours between 12 pm and 6 pm.

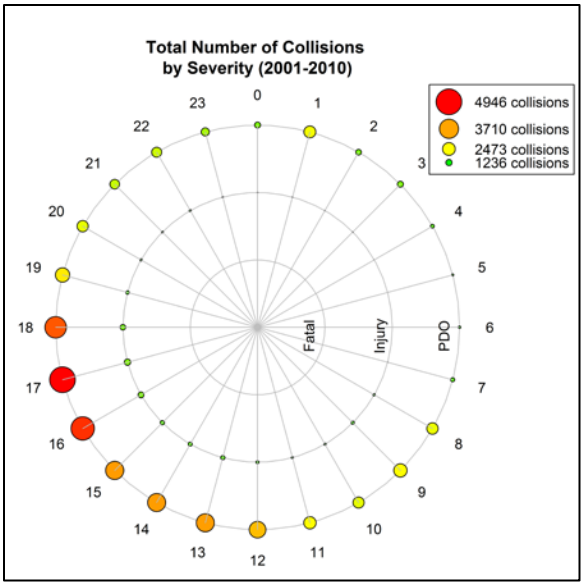


Figure B2: Number of Collisions by Hour and Severity, 2001-2010 (SGI, 2011).

Figure B3 presents the proportion of collisions by severity. For the ten-year study period, the City experienced 83% (58,337) PDO collisions, 17% (12,087) injury collisions and less than 1% (63) fatal collisions. Almost all of the collisions were PDO or injury collisions. Thus, as mentioned, fatal collisions are difficult to use as a reliable and sole safety measure for the City.

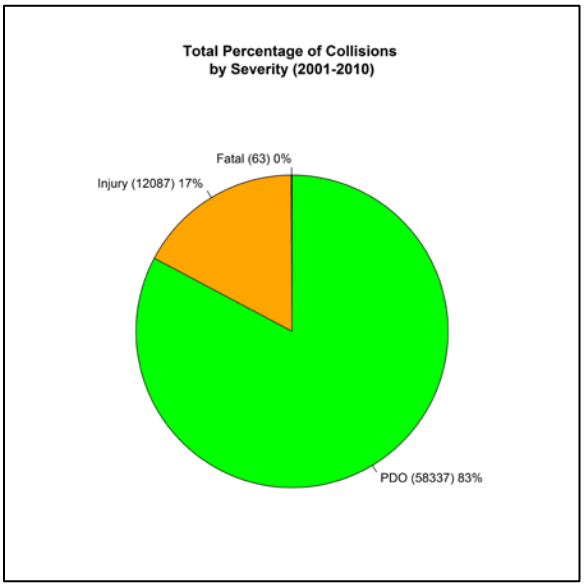
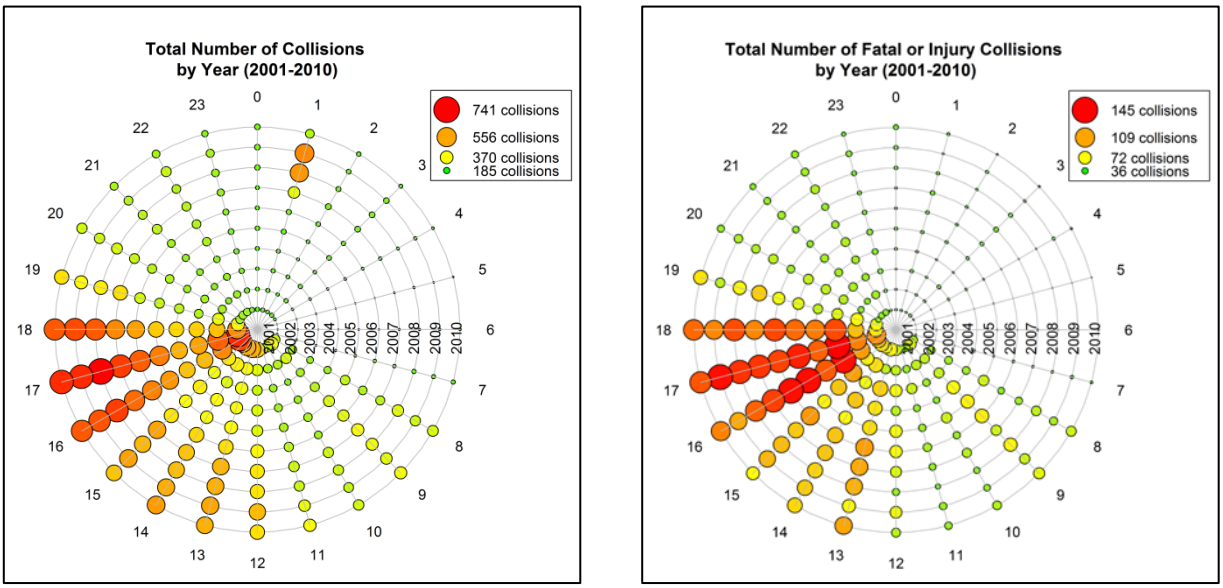


Figure B3: Percentage of Collisions by Severity, 2001-2010 (SGI, 2011).

Figure B4(a) shows a clockplot of the total number of collisions by hour and year. It is clear that the majority of collisions occurred from 12 pm to 6 pm where the highest number of collisions was 741 between 4 pm and 5 pm in 2008. A similar pattern is shown in the clockplot of the total number of fatal or injury collisions by hour and year shown by Figure B4(b). The 3 pm to 6 pm period is the peak time period of fatal or injury collisions where the highest number of collisions in an hour was 145 between 4 pm and 5 pm in 2003.



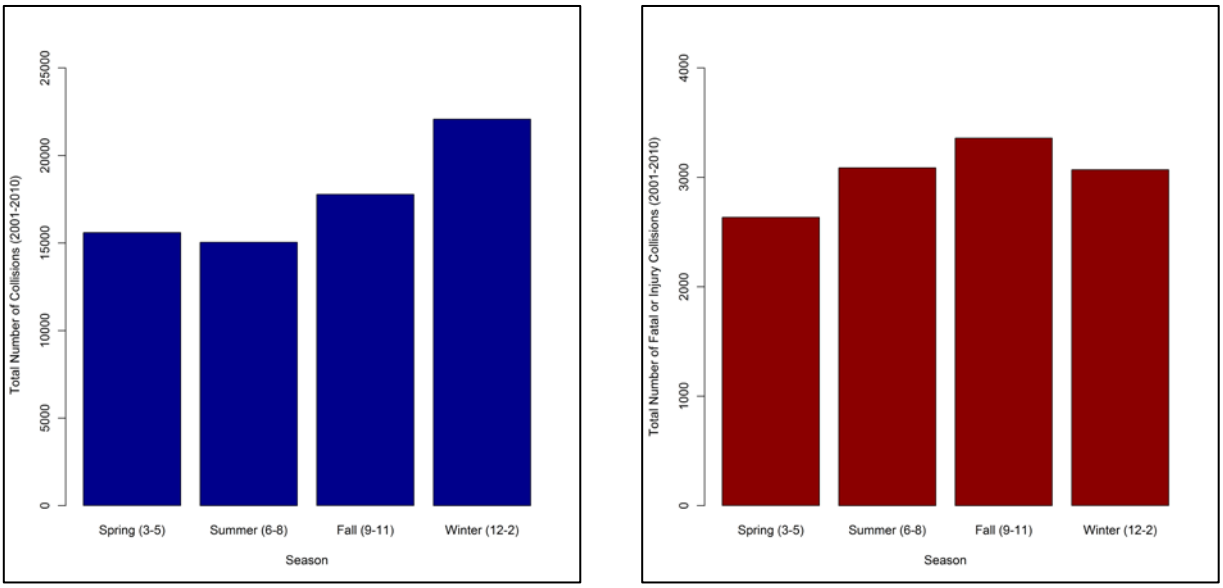
(a) Total (b) Fatal or Injury

Figure B4: Number of Collisions by Hour and Year, 2001-2010 (SGI, 2011).

Figure B5(a) shows the total number of collisions by season [Spring (March, April and May), Summer (June, July and August), Fall (September, October and November) and Winter (December, January and February)]. The peak in the winter season may be caused by winter roadway conditions (e.g., icy roadway conditions). On the other hand, the total number of fatal or injury collisions in Figure B5(b) shows an inverse U-curve collision pattern with a peak in the fall season. It may be due to the fact that a vehicle's travel speed is often higher during the mild weather seasons than the winter season, and high speed is one of the major contributing factors

of severe collisions. It is unclear why the spring season shows the lowest number of fatal or injury collisions.

Table B2 summarizes the collisions by severity and season, and shows that there are peaks of 22,073 total collisions in the winter season and 3,359 fatal or injury collisions in the fall season during the ten-year study period.



(a) Total (b) Fatal or Injury

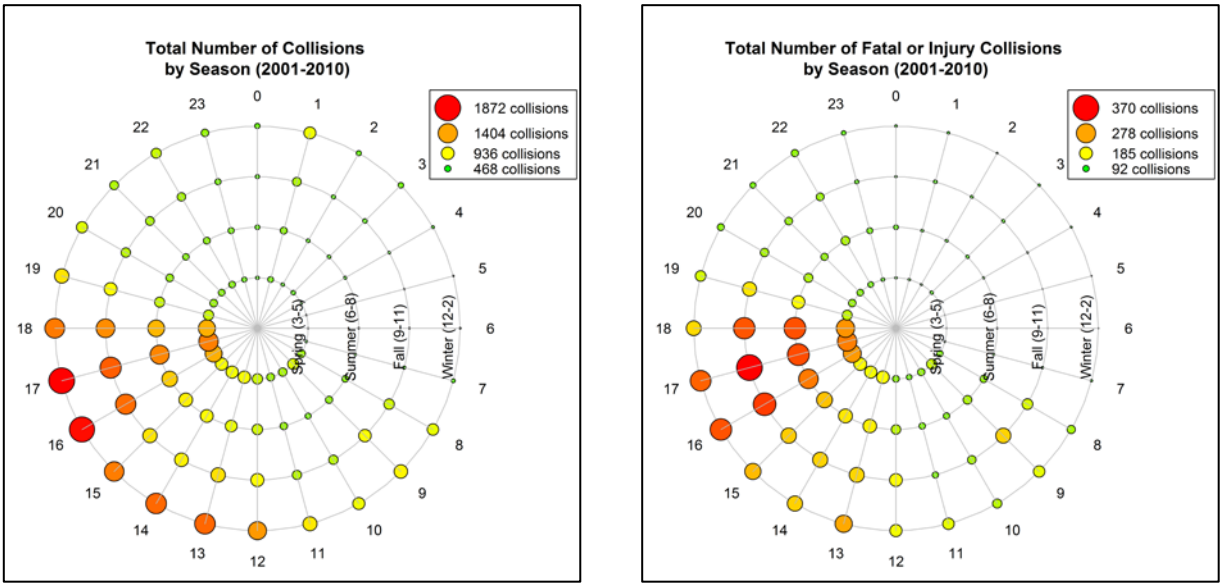
Figure B5: Number of Collisions by Season, 2001-2010 (SGI, 2011).

Table B2: Number of Collisions by Severity and Season, 2001-2010 (SGI, 2011).

Season	Fatal	Injury	PDO	Total
Spring	19	2,615	12,957	15,591
Summer	16	3,072	11,955	15,043
Fall	21	3,338	14,421	17,780
Winter	7	3,062	19,004	22,073
Grand Total	63	12,087	58,337	70,487

Figure B6(a) presents a clockplot of the total number of collisions by hour and season. Except in the winter season, it appears that the majority of the collisions occurred between 3 pm and 6 pm. However, more collisions occurred during the winter season (1,872) and most of the collisions occurred during the afternoon hours (12 pm to 6 pm) during this season. Figure B6(b)

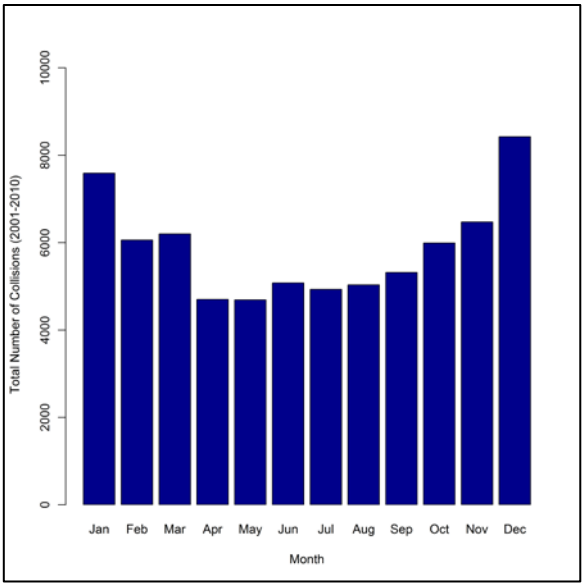
shows in general that the majority of fatal or injury collisions occurred between 3 pm and 6 pm over a ten-year period.



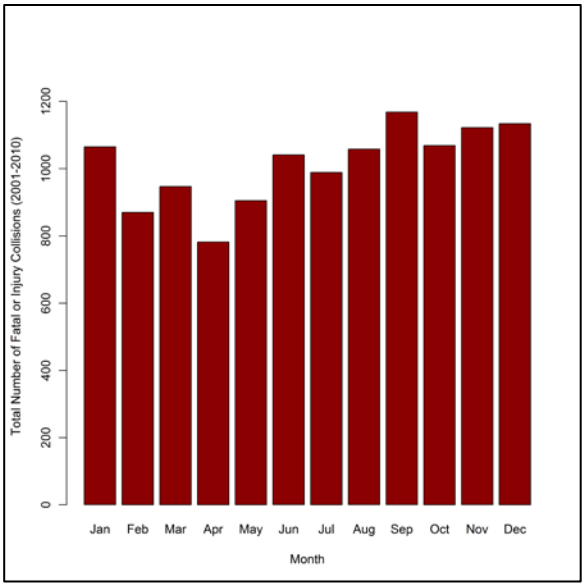
(a) Total (b) Fatal or Injury

Figure B6: Number of Collisions by Hour and Season, 2001-2010 (SGI, 2011).

In terms of the total number of collisions, the two winter months (December and January) are clearly the peak months [Figure B7(a)]. In terms of the total number of fatal or injury collisions, there is no apparent peak month, but Figure B7(b) shows that the total number of fatal or injury collisions are relatively lower during the four-month period between February and May. Table B3 summarizes the collisions by severity and month.



(a) Total



(b) Fatal or Injury

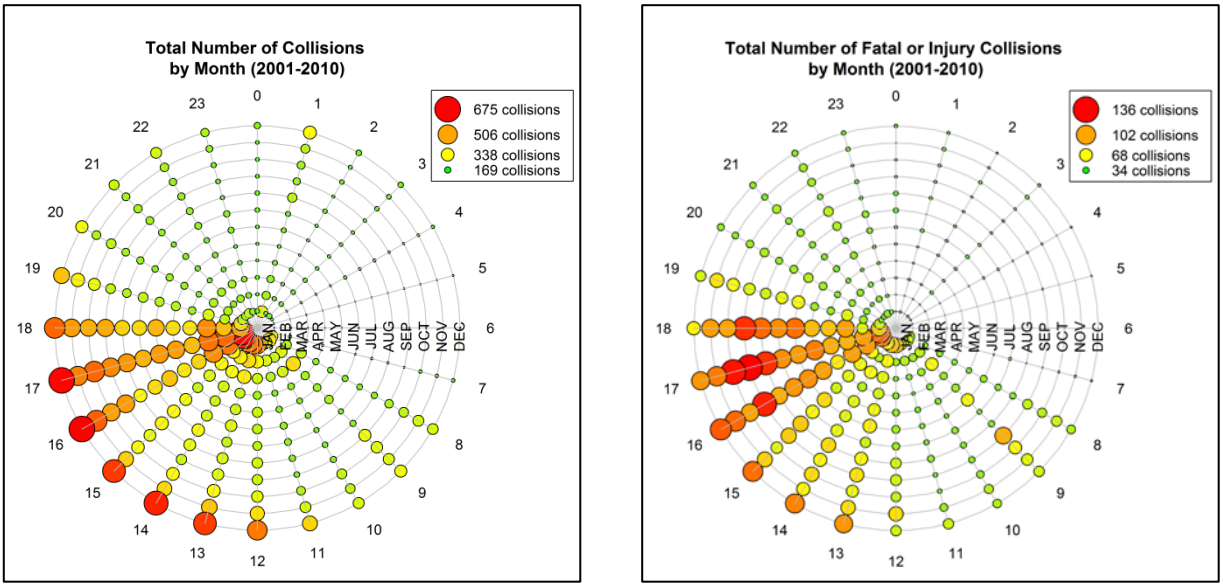
Figure B7: Number of Collisions by Month, 2001-2010 (SGI, 2011).

Table B3: Number of Collisions by Severity and Month, 2001-2010 (SGI, 2011).

Month	Fatal	Injury	PDO	Total
January	3	1,062	6,525	7,590
February	1	869	5,189	6,059
March	8	939	5,253	6,200
April	1	781	3,919	4,701
May	10	895	3,785	4,690
June	7	1,034	4,039	5,080
July	5	984	3,940	4,929
August	4	1,054	3,976	5,034
September	6	1,162	4,151	5,319
October	7	1,062	4,921	5,990
November	8	1,114	5,349	6,471
December	3	1,131	7,290	8,424
Grand Total	63	12,087	58,337	70,487

Figures B8(a) and B8(b) are clockplots showing the total number of collisions and total number of fatal or injury collisions by hour and month, respectively. As discussed, the months that experienced the most collisions are December and January. In addition, these two months show more spread out collision patterns in terms of the hours of collision occurrence. For these two months, the entire afternoon hours (12 pm to 6 pm) experienced a very high number of

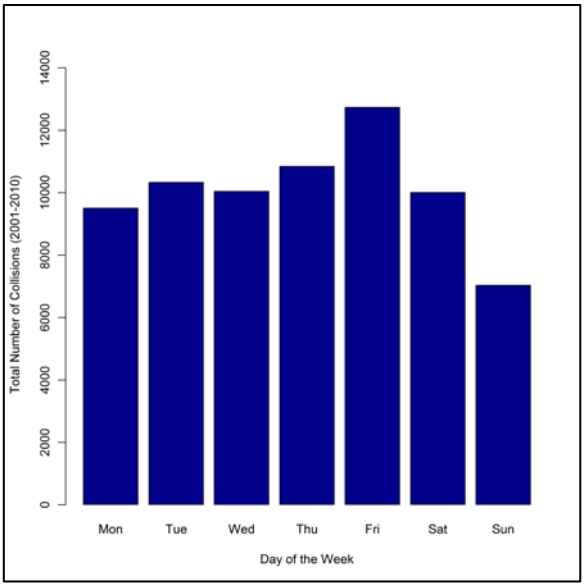
collisions compared to the other months' collisions. Fatal or injury collisions occurred more frequently during the three afternoon hours (3 pm to 6 pm) from August to October in particular.



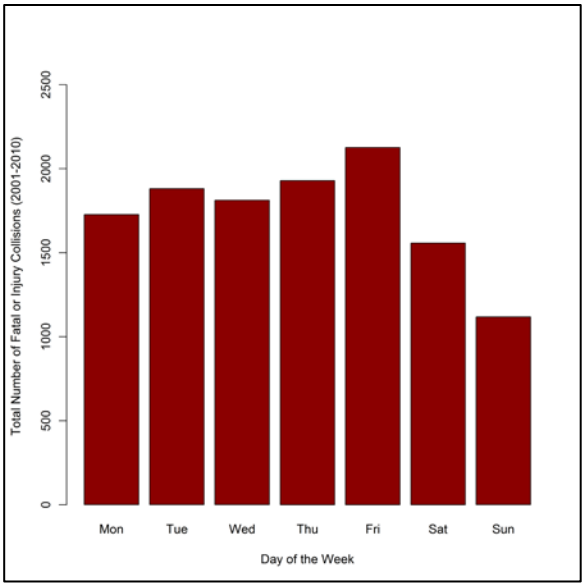
(a) Total (b) Fatal or Injury

Figure B8: Number of Collisions by Hour and Month, 2001-2010 (SGI, 2011).

Figures B9(a) and B9(b) present the total number of collisions and the total number of fatal or injury collisions in a week, respectively. Friday is a concern in terms of both the frequency and severity. Sunday experienced the lowest number of collisions for fatal and injury collisions. Table B4 summarizes the collisions by severity and day of the week, and shows Friday as the peak day of the week with 12,732 total collisions and 2,126 fatal or injury collisions over the ten-year study period (2001-2010).



(a) Total



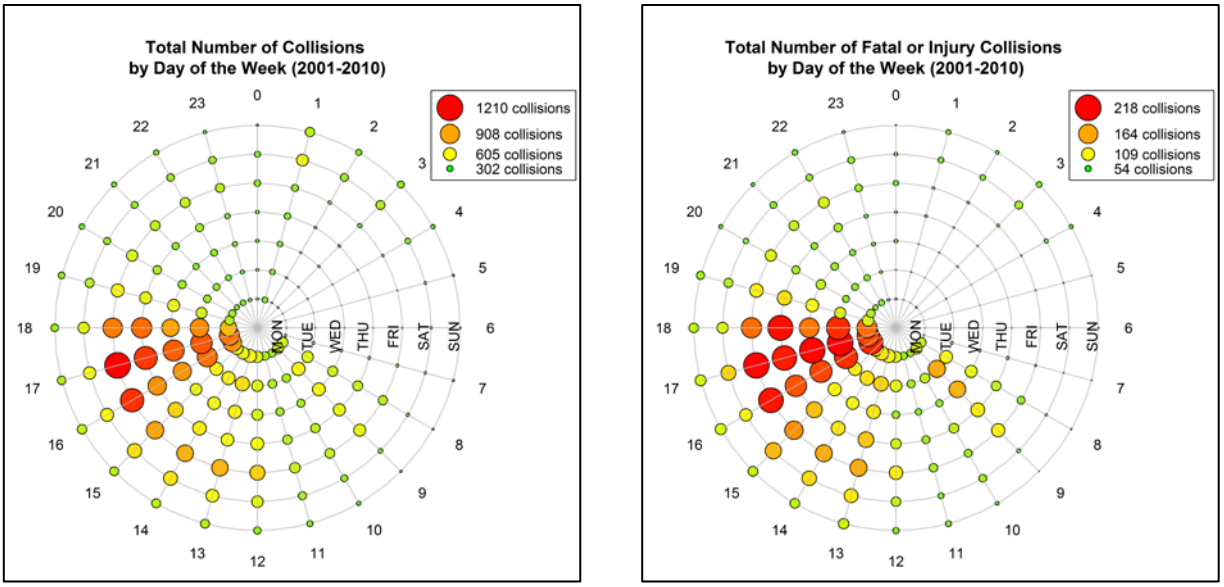
(b) Fatal or Injury

Figure B9: Number of Collisions by Day of the Week, 2001-2010 (SGI, 2011).

Table B4: Number of Collisions by Severity and Day of the Week, 2001-2010 (SGI, 2011).

Day of the Week	Fatal	Injury	PDO	Total
Monday	1	1,726	7,777	9,504
Tuesday	12	1,869	8,447	10,328
Wednesday	12	1,800	8,231	10,043
Thursday	9	1,920	8,913	10,842
Friday	10	2,116	10,606	12,732
Saturday	9	1,548	8,448	10,005
Sunday	10	1,108	5,915	7,033
Grand Total	63	12,087	58,337	70,487

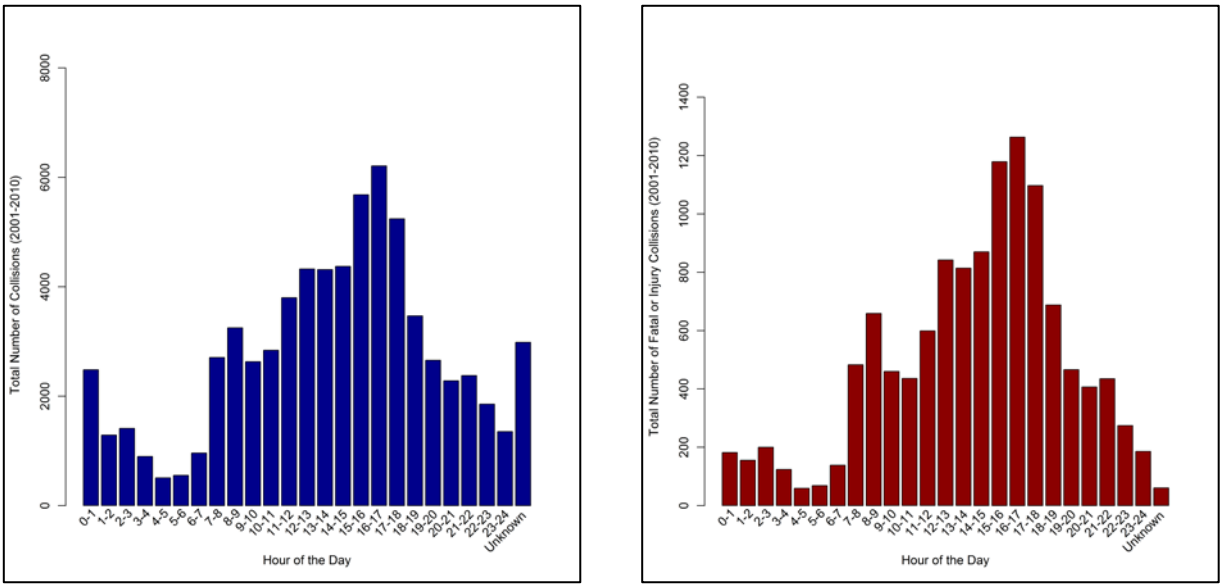
A clockplot of the total number of collisions by hour and day of the week is shown in Figure B10(a) and a clockplot of the total number of fatal or injury collisions by hour and day of the week is shown in Figure B10(b). The City experienced a larger number of total and fatal or injury collisions during the weekdays (Monday to Friday) and a much lower number of collisions during the weekends (Saturday to Sunday). From Monday to Friday, the highest number of total and fatal or injury collisions have occurred between 3 pm and 6 pm where the totals reach 1,210 total collisions and 218 fatal or injury collisions, respectively.



(a) Total (b) Fatal or Injury

Figure B10: Number of Collisions by Hour and Day of the Week, 2001-2010 (SGI, 2011).

Collisions by hour of the day are presented in Figures B11(a) and B11(b). There are clear peaks in total and fatal or injury collisions from 3 pm to 6 pm. The total number of fatal or injury collisions by hour of the day is presented in Figure B11(b). Table B5 summarizes the number of collisions by severity and hour of the day.



(a) Total (b) Fatal or Injury

Figure B11: Number of Collisions by Hour of the Day, 2001-2010 (SGI, 2011).

Table B5: Number of Collisions by Severity and Hour of the Day, 2001-2010 (SGI, 2011).

Hour of the Day	Fatal	Injury	PDO	Total
0-1	3	179	2,301	2,483
1-2	3	153	1,135	1,291
2-3	3	197	1,212	1,412
3-4	2	122	776	900
4-5	0	60	450	510
5-6	3	66	487	556
6-7	5	134	824	963
7-8	0	483	2,226	2,709
8-9	5	654	2,592	3,251
9-10	2	458	2,173	2,633
10-11	3	433	2,404	2,840
11-12	1	598	3,203	3,802
12-13	2	840	3,485	4,327
13-14	3	811	3,501	4,315
14-15	2	868	3,505	4,375
15-16	1	1,178	4,504	5,683
16-17	4	1,259	4,946	6,209
17-18	3	1,094	4,147	5,244
18-19	5	683	2,780	3,468
19-20	1	465	2,191	2,657
20-21	3	404	1,876	2,283
21-22	3	432	1,944	2,379
22-23	5	270	1,582	1,857
23-24	0	186	1,168	1,354
Unknown	1	60	2,925	2,986
Grand Total	63	12,087	58,337	70,487

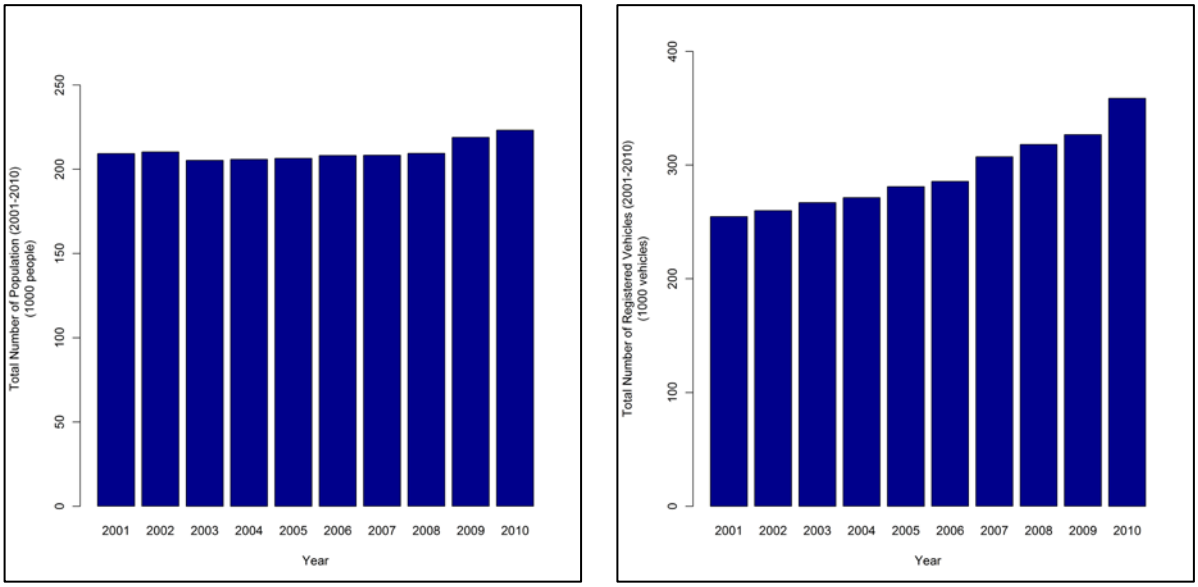
Collision Rate Analysis

Collision rate is a popular safety measure commonly presented by the number of collisions normalized by an exposure. Ideally, an exposure is measured by traffic volume, such as million entering vehicles (MEV) per intersection or vehicle-miles traveled (VMT) for the study period (AASHTO, 2010). Unfortunately, this study was unable to obtain traffic volume based exposures that could be used to estimate the City's network-wide collision rate for each year. This study used the population and number of registered vehicles for each year as proxy exposures in order

to examine collision rate as a safety measure. We start with investigating the time trend of population and registered vehicles over the ten-year study period (2001-2010).

Trend of Population and Registered Vehicles

Figures B12(a) and B12(b) present the trend in population (COS, 2012a) and registered vehicles (SGI, 2011) from 2001 to 2010. The City of Saskatoon has experienced a large growth from 2005 to 2010 by nearly 8% in population. The number of registered vehicles has increased even more dramatically (28%) during the same time period (See Table B6).



(a) Total Population (b) Total Registered Vehicles

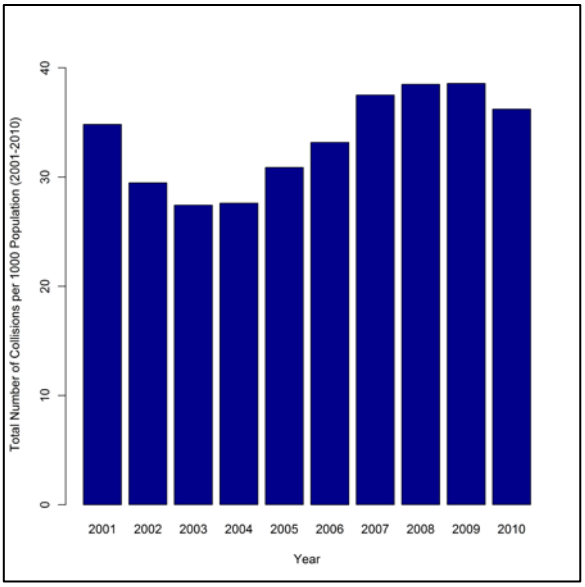
Figure B12: Population and Registered Vehicles by Year, 2001-2010 (COS, 2012a; SGI, 2011).

Table B6: Population and Registered Vehicles, 2001-2010 (COS, 2012a; SGI, 2011).

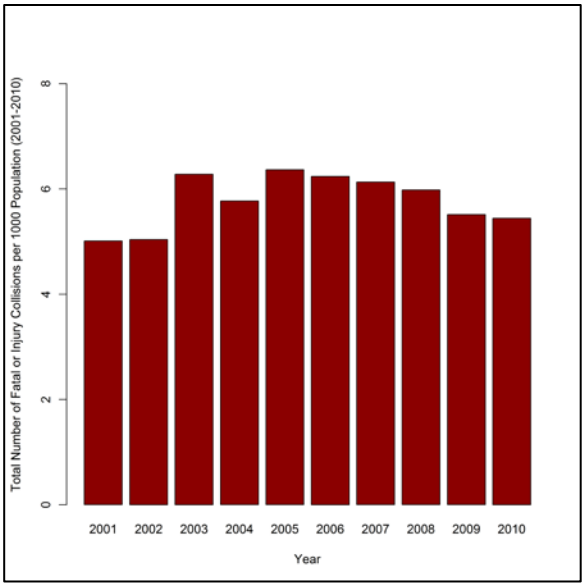
Year	Population (COS, 2012a)	Registered Vehicles (SGI, 2011)
2001	209,264	254,681
2002	210,312	259,919
2003	205,300	267,022
2004	205,900	271,351
2005	206,500	281,074
2006	208,208	285,638
2007	208,300	307,292
2008	209,400	318,032
2009	218,900	326,723
2010	223,200	358,746
Total	2,105,284	2,930,478
Average	210,528	293,048

Collisions per Capita

Figure B13 shows the collision rate based on the number of collisions per capita (i.e., total number of collisions per year per 1000 population and number of fatal or injury collisions per year per 1000 population). Figure B13(a) does not suggest that this collision rate has decreased for total collisions during the past ten years (2001-2010) or the recent five-year time period (2006-2010). In the case of fatal or injury collisions, there is a clear decreasing trend [Figure B13(b)]. Table B7 summarizes the number of total collisions per 1000 population. The average number of total collisions per 1000 population during the study period is 33, consisting of 6 fatal or injury collisions and 28 PDO collisions.



(a) Total



(b) Fatal or Injury

Figure B13: Number of Collisions per 1000 Population by Year, 2001-2010 (SGI, 2011).

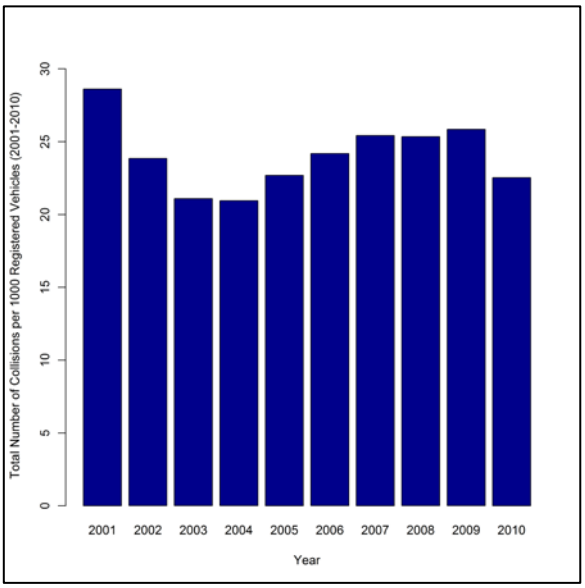
Table B7: Number of Collisions per 1000 Population by Severity and Year, 2001-2010 (SGI, 2011).

Year	Fatal	Injury	PDO	Total
2001	0.04	5	30	35
2002	0.03	5	24	29
2003	0.02	6	21	27
2004	0.01	6	22	28
2005	0.03	6	25	31
2006	0.02	6	27	33
2007	0.05	6	31	37
2008	0.02	6	33	38
2009	0.02	5	33	39
2010	0.05	5	31	36
Grand Total	0.30	57	276	334
Average	0.03	6	28	33

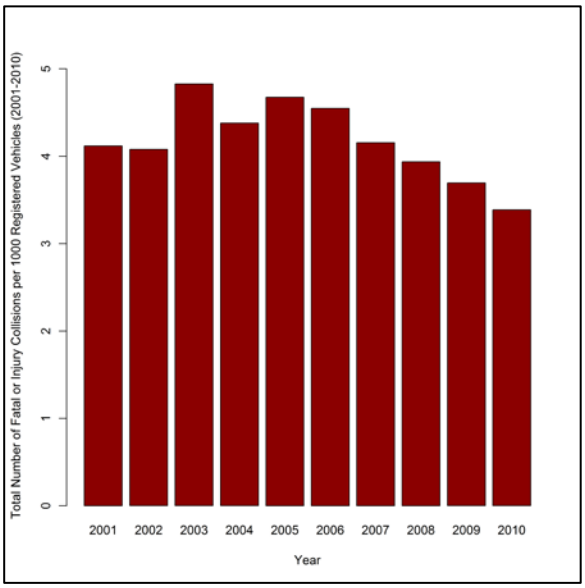
Collisions per Registered Vehicle

Figure B14 shows a different collision rate. This one is based on the number of collisions per 1000 registered vehicles. Figure B14(a) shows that the collision rate for total collisions per 1000 registered vehicles over the ten-year period has fluctuated and does not show an increasing or decreasing trend. In the case of fatal or injury collisions, Figure B14(b) shows a 40% decrease in

the rate of fatal or injury collisions from 2005 to 2010. Table B8 summarizes the collisions per 1000 registered vehicles by severity and year. The average number of total collisions per 1000 registered vehicles during the study period is 24, consisting of 4 fatal or injury collisions and 20 PDO collisions.



(a) Total



(b) Fatal or Injury

Figure B14: Number of Collisions per 1000 Registered Vehicles by Year, 2001-2010 (SGI, 2011).

Table B8: Number of Collisions per 1000 Registered Vehicles by Severity and Year, 2001-2010 (SGI, 2011).

Year	Fatal	Injury	PDO	Total
2001	0.04	4	24	29
2002	0.03	4	20	24
2003	0.03	5	16	21
2004	0.03	4	17	21
2005	0.03	5	18	23
2006	0.03	5	20	24
2007	0.03	4	21	25
2008	0.03	4	21	25
2009	0.03	4	22	26
2010	0.03	3	19	23
Grand Total	0.31	42	199	241
Average	0.03	4	20	24

Collision Cost Analysis

Collision costs are an important safety measure and part of assessing the level of traffic safety for Saskatoon. Two different types of costs, direct and societal costs, are used to estimate collision costs.

Direct costs are costs associated with a collision including property damage, medical expenses, travel expense to and from appointments, and income replacement after seven consecutive days of work missed (SGI, 2012a). Societal costs are the costs that a society is willing to pay to prevent or reduce the risks associated with a collision that involves a serious injury and/or death (CRISP, 2010). Note that the societal cost (not the direct cost) is used in the decision making process (e.g., benefit/cost analysis for safety initiatives) to introduce a certain safety initiative.

Table B9 summarizes the direct and societal costs by severity. The direct costs were taken from the SGI's 2005 to 2009 collision costs. The 2007 dollar values used for direct costs are based on the average of the 2005 to 2009 costs. Societal costs were taken from CRISP's (2010) collision cost study which reported 2007 dollar values. The costs used have not been inflated.

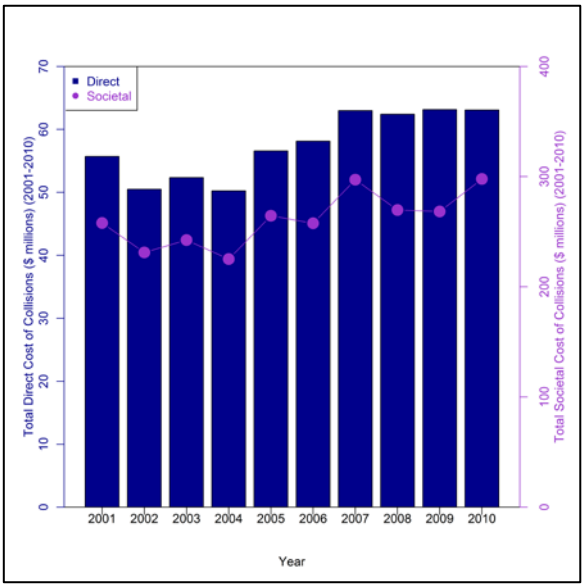
Table B9: Direct and Societal Costs by Severity (CRISP, 2010; SGI, 2012a).

Severity	Direct Costs (2007 $) (SGI, 2012a)	Societal Costs (2007 $) (CRISP, 2010)
Fatal	251,973	5,543,800
Injury	25,204	134,600
PDO	4,365	10,900

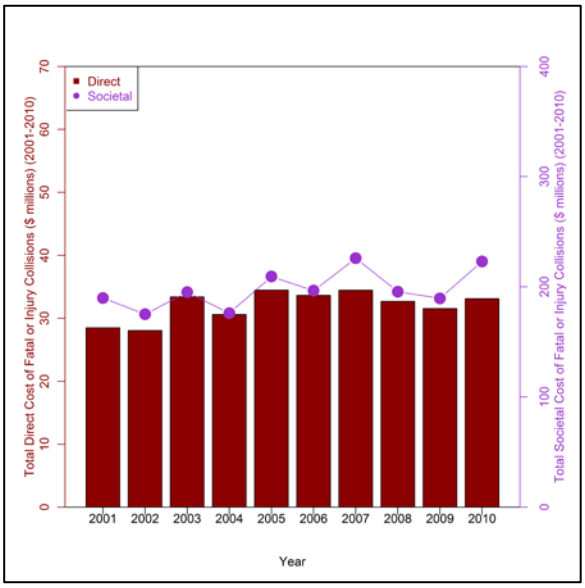
Figure B15 shows the total direct and societal costs of collisions (direct costs on the left y axis and the societal costs on the right y axis) in 2007 dollar values. Figure B15 shows a slight increasing trend in both the direct and societal costs of total collisions and fatal or injury collisions over the ten-year study period.

Table B10 summarizes the direct and societal cost of collisions by severity and year. The table shows that the direct cost of total collisions for the ten-year study period is $575.16 million ($57.52 million per year) in 2007 dollar values. The societal cost is more than four times greater than the direct cost at about $2.61 billion ($261.20 million per year) in 2007 dollar values.

Note that although the PDO collisions accounted for most collisions in the City in terms of frequency (83% = 58,337÷70,487×100%) during the ten-year study period (see Table B1), the fatal or injury collisions were more costly collisions than PDO collisions in terms of both direct costs (56% = 320.51÷575.16×100%) and societal costs (76% = 1,976.17÷2,612.04×100%).



(a) Total



(b) Fatal or Injury

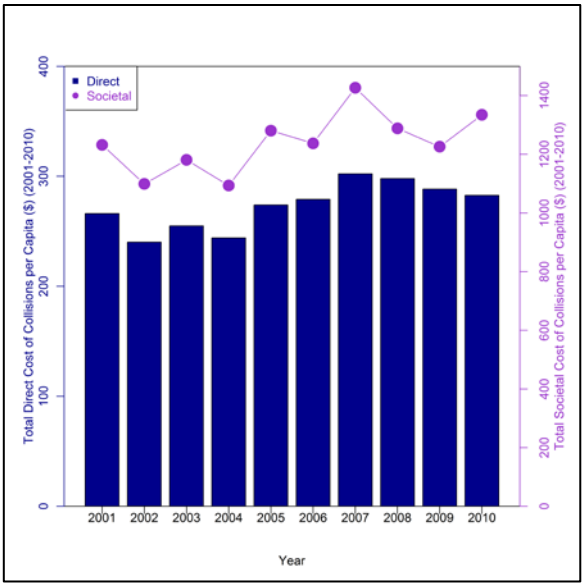
Figure B15: Direct and Societal Cost of Collisions by Year (2007 $ millions), 2001-2010 (SGI, 2011).

Table B10: **Direct and Societal Cost of Collisions by Severity and Year (2007 $ millions), 2001-2010 (SGI, 2011).**

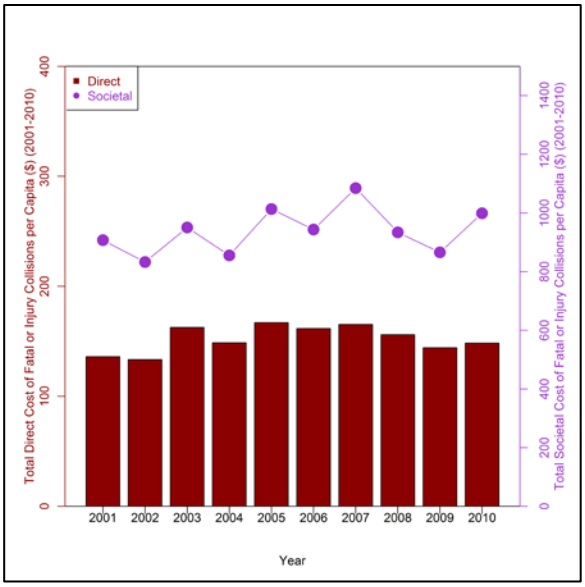
Year	Direct Costs (2007 $ millions)				Societal Costs (2007 $ millions)			
	Fatal	**Injury**	**PDO**	**Total**	**Fatal**	**Injury**	**PDO**	**Total**
2001	2.27	26.21	27.23	55.71	49.89	139.98	68.01	257.88
2002	1.51	26.57	22.43	50.51	33.26	141.87	56.02	231.15
2003	1.01	32.39	18.95	52.35	22.18	172.96	47.33	242.46
2004	0.76	29.87	19.63	50.25	16.63	159.50	49.02	225.15
2005	1.51	32.97	22.10	56.58	33.26	176.06	55.19	264.51
2006	1.01	32.64	24.48	58.13	22.18	174.31	61.14	257.62
2007	2.52	31.93	28.53	62.98	55.44	170.54	71.24	297.22
2008	1.26	31.43	29.72	62.41	27.72	167.85	74.21	269.77
2009	1.26	30.30	31.59	63.14	27.72	161.79	78.87	268.38
2010	2.77	30.35	29.98	63.10	60.98	162.06	74.86	297.90
Grand Total	15.87	304.64	254.64	575.16	349.26	1,626.91	635.87	2,612.04
%	3	53	44	100	13	62	24	100
Average	1.59	30.46	25.46	57.52	34.93	162.69	63.59	261.20

Figures B16(a) and B16(b) show the direct and societal cost of total collisions and fatal or injury collisions per capita, respectively. Costs have fluctuated with no clear trend.

Table B11 summarizes the direct and societal cost of collisions per capita by severity and year. The table shows that the average direct and societal costs per capita for the total number of collision are $273.01 and $1,240.01 per capita, respectively.



(a) Total



(b) Fatal or Injury

Figure B16: Direct and Societal Cost of Collisions per Capita by Year (2007 $), 2001-2010 (SGI, 2011).

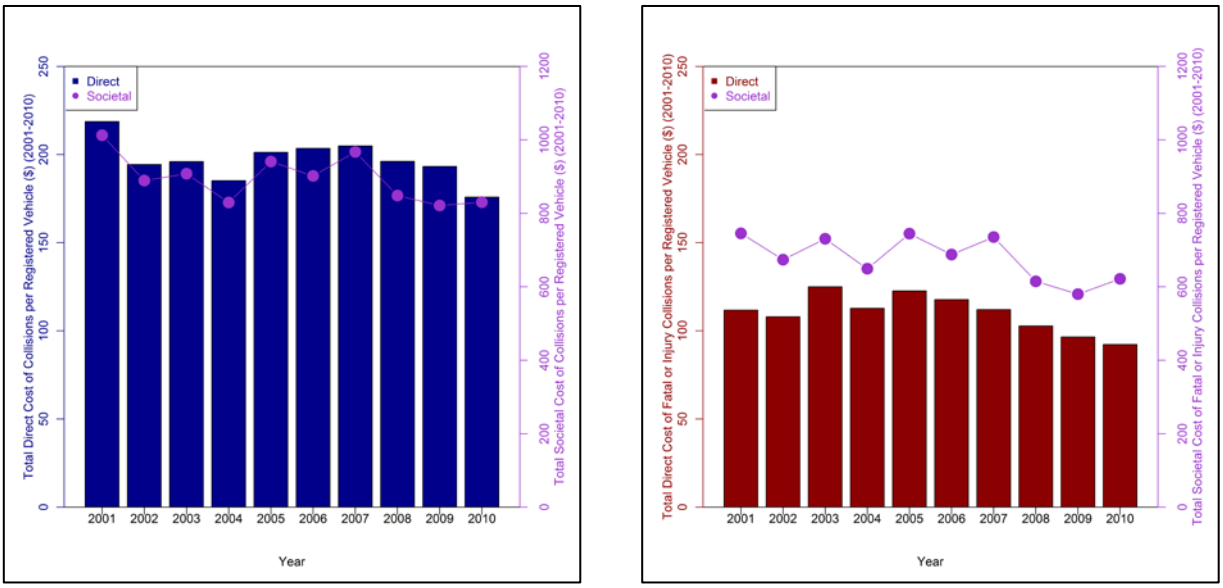
Table B11: **Direct and Societal Cost of Collisions per Capita by Severity and Year (2007 $), 2001-2010 (SGI, 2011).**

Year	Direct Cost of Collisions per Capita (2007 $)				Societal Cost of Collisions per Capita (2007 $)			
	Fatal	Injury	PDO	Total	Fatal	Injury	PDO	Total
2001	10.84	125.26	130.14	266.23	238.43	668.93	324.97	1,232.34
2002	7.19	126.31	106.66	240.16	158.16	674.56	266.34	1,099.06
2003	4.91	157.76	92.32	254.98	108.01	842.48	230.53	1,181.02
2004	3.67	145.05	95.33	244.06	80.77	774.65	238.06	1,093.49
2005	7.32	159.65	107.02	273.99	161.08	852.58	267.25	1,280.90
2006	4.84	156.76	117.59	279.19	106.51	837.18	293.64	1,237.32
2007	12.10	153.31	136.96	302.37	266.15	818.71	342.02	1,426.88
2008	6.02	150.09	141.91	298.02	132.37	801.56	354.38	1,288.31
2009	5.76	138.40	144.29	288.44	126.63	739.10	360.31	1,226.04
2010	12.42	135.96	134.31	282.69	273.22	726.07	335.40	1,334.68
Grand Total	75.05	1,448.54	1,206.54	2,730.14	1,651.32	7,735.82	3,012.91	12,400.05
%	3	53	44	100	13	62	24	100
Average	7.51	144.85	120.65	273.01	165.13	773.58	301.29	1,240.01

Figures B17(a) and B17(b) show the total direct and societal cost per registered vehicle of collisions and fatal or injury collisions, respectively. There was neither increasing nor decreasing trends in Figure B17(a) over the ten-year study period (if we ignore 2001 collision data).

However, it appears that there is a clear decreasing trend from 2005 to 2010 in terms of the direct cost for fatal or injury collisions in particular [see Figure B17(b)].

Table B12 shows that the average direct and societal cost per registered vehicle for total collisions is $196.94 and $894.99, respectively. The average direct and societal cost per registered vehicle for fatal or injury collisions amounts to $110.20 and $678.39, respectively.



(a) Total (b) Fatal or Injury

Figure B17: Direct and Societal Cost of Collisions per Registered Vehicle by Year (2007 $), 2001-2010 (SGI, 2011).

Table B12: Direct and Societal Cost of Collisions per Registered Vehicle by Severity and Year (2007 $), 2001-2010 (SGI, 2011).

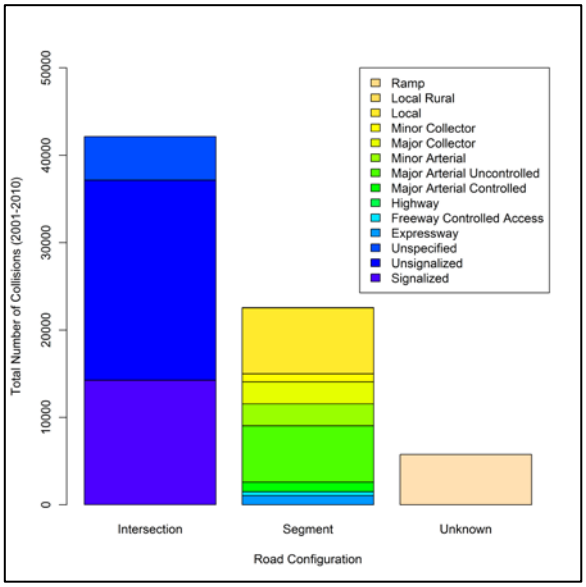
Year	Direct Cost of Collisions per Registered Vehicle (2007 $)				Societal Cost of Collisions per Registered Vehicle (2007 $)			
	Fatal	Injury	PDO	Total	Fatal	Injury	PDO	Total
2001	8.90	102.92	106.93	218.76	195.91	549.64	267.02	1,012.57
2002	5.82	102.21	86.30	194.32	127.97	545.82	215.51	889.30
2003	3.77	121.29	70.98	196.04	83.05	647.74	177.24	908.03
2004	2.79	110.07	72.34	185.19	61.29	587.80	180.64	829.74
2005	5.38	117.29	78.63	201.29	118.34	626.37	196.34	941.06
2006	3.53	114.27	85.71	203.51	77.63	610.24	214.04	901.91
2007	8.20	103.92	92.84	204.96	180.41	554.97	231.84	967.22
2008	3.96	98.82	93.44	196.23	87.16	527.77	233.33	848.26
2009	3.86	92.72	96.67	193.25	84.84	495.19	241.40	821.43
2010	7.73	84.59	83.57	175.88	169.99	451.74	208.67	830.40
Grand Total	53.93	1,048.10	867.41	1,969.44	1,186.59	5,597.28	2,166.05	8,949.91
%	3	53	44	100	13	63	24	100
Average	5.39	104.81	86.74	196.94	118.66	559.73	216.60	894.99

Collisions per Road Configuration

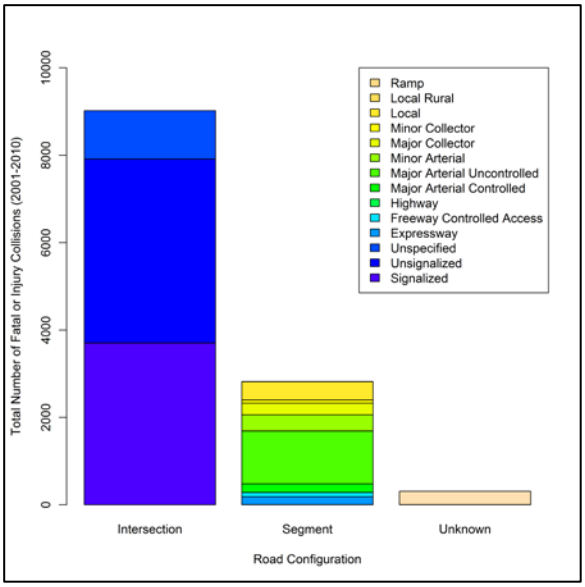
Figure B18(a) and Table B13 show the total number of collisions by road configuration (intersection, segment and unknown). The intersections experienced almost twice the number of collisions (42,138; 60%) as segments (22,571; 32%), taking the unknown category into account and this is indeed a typical collision pattern for a roadway network in an urban area. Most collisions at intersections occurred at unsignalized intersections (22,880; 54%). On segments, most collisions occurred on major arterial uncontrolled (6,439; 29%) and local roads (7,557; 33%).

Figure B18(b) and Table B13 show fatal or injury collisions by road configuration. Fatal or injury collisions were far more likely to occur at intersections than on segments. Note that an even higher proportion of fatal or injury collisions (9,020; 51%) occurred at intersections compared to that on segments (2,821; 16%). There were 1,209 (43%) fatal or injury collisions

that occurred on major arterial uncontrolled segments and 416 (15%) fatal or injury collisions that occurred on local road segments during the ten-year study period.



(a) Total



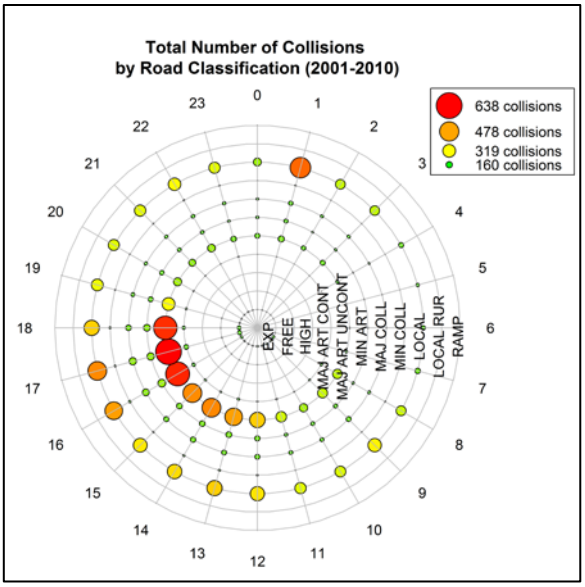
(b) Fatal or Injury

Figure B18: Number of Collisions by Road Configuration and Road Classification, 2001-2010 (SGI, 2011).

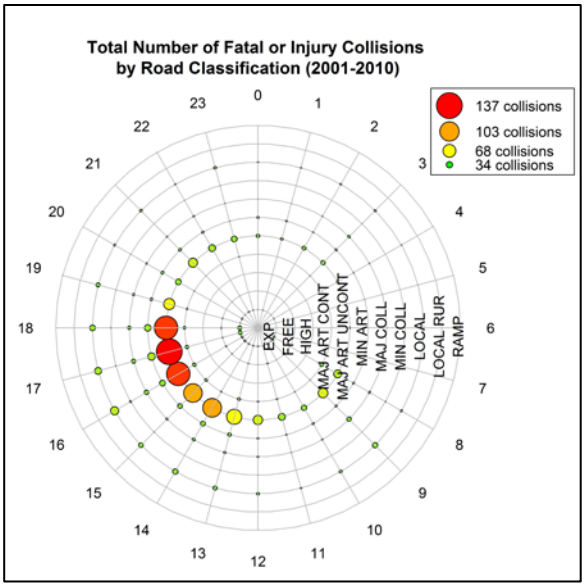
Table B13: Number of Collisions by Severity, Road Configuration and Road Classification, 2001-2010 (SGI, 2011).

Road Configuration	Road Classification	FI	Fatal	Injury	PDO	Total
Intersection	Signalized	3,703	13	3,690	10,547	14,250
	Unsignalized	4,207	23	4,184	18,673	22,880
	Unspecified	1,110	2	1,108	3,898	5,008
	Sum	**9,020**	**38**	**8,982**	**33,118**	**42,138**
Segment	Expressway	184	4	180	871	1,055
	Freeway Controlled Access	96	1	95	348	444
	Highway	3	1	2	5	8
	Major Arterial Controlled	195	2	193	885	1,080
	Major Arterial Uncontrolled	1,209	4	1,205	5,230	6,439
	Minor Arterial	371	3	368	2,148	2,519
	Major Collector	269	3	266	2,253	2,522
	Minor Collector	72	2	70	836	908
	Local	416	5	411	7,141	7,557
	Local Rural	0	0	0	2	2
	Ramp	6	0	6	31	37
	Sum	**2,821**	**25**	**2,796**	**19,750**	**22,571**
Unknown		**5,778**	**5,469**	**309**	**0**	**5,778**
Grand Total		**17,619**	**5,532**	**12,087**	**52,868**	**70,487**

Figure B19(a) shows a clockplot of total collisions by hour and road classification. Most collisions occurred on major arterial uncontrolled and local roads. Most total collisions on major arterial uncontrolled roads occurred between 12 pm and 6 pm. Total collisions on local roads were also higher than other classification of roadways and evenly distributed compared to major arterial uncontrolled roads. Figure B19(b) shows a clockplot of fatal or injury collisions by hour and road classification. It is very clear that most fatal or injury collisions occurred on major arterial uncontrolled roads between 3 pm and 6 pm.



(a) Total

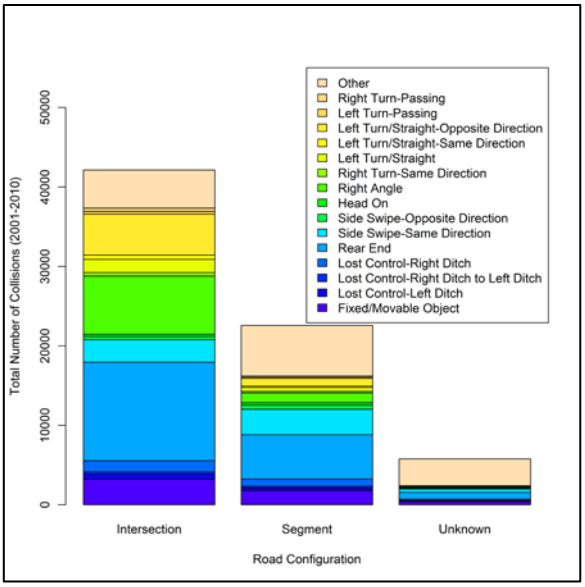


(b) Fatal or Injury

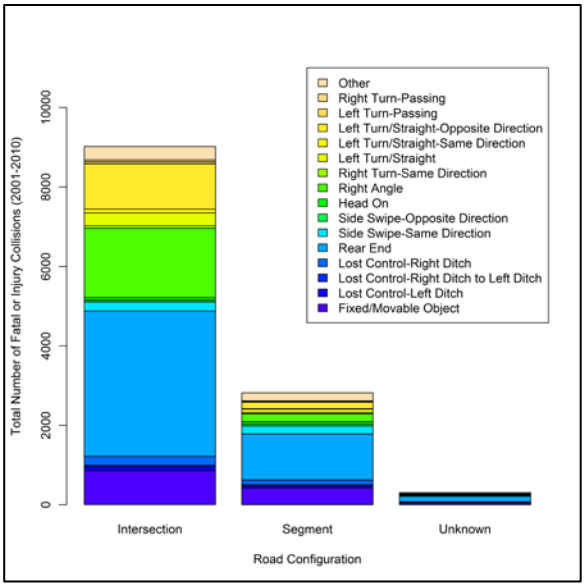
Figure B19: Number of Collisions by Hour and Road Classification, 2001-2010 (SGI, 2011).

Figure B20(a) shows that the most common total collisions collision configuration at both intersections and segments is rear end collisions. Rear end collisions are a typical collision configuration at intersections, but not on segments. This finding may imply that many segments (e.g., arterials) in Saskatoon need stronger access control. Figure B20(b) shows that in the case of fatal or injury collisions, the most common collision configuration is also rear end collisions for both intersections and segments.

Table B14 summarizes the data for collisions by road configuration, collision configuration and collision severity. For total collisions, rear end collisions accounted for 12,399 (29%) of the intersection collisions and 5,607 (25%) of the segment collisions. For fatal or injury collisions, rear end collisions accounted for even higher percentages: 3,659 (41%) of the intersection collisions and 1,158 (41%) of the segment collisions.



(a) Total



(b) Fatal or Injury

Figure B20: Number of Collisions by Road Configuration and Collision Configuration, 2001-2010 (SGI, 2011).

Table B14: Number of Collisions by Severity, Road Configuration and Collision Configuration, 2001-2010 (SGI, 2011).

Road Configuration	Collision Configuration	FI	Fatal	Injury	PDO	Total
Intersection	Fixed/Movable Object	860	5	855	2,358	3,218
	Lost Control-Left Ditch	94	2	92	531	625
	Lost Control-Right Ditch to Left Ditch	39	0	39	235	274
	Lost Control-Right Ditch	223	6	217	1,202	1,425
	Rear End	3,659	3	3,656	8,740	12,399
	Side Swipe-Same Direction	231	0	231	2,616	2,847
	Side Swipe-Opposite Direction	38	0	38	356	394
	Head On	70	4	66	215	285
	Right Angle	1,745	13	1,732	5,578	7,323
	Right Turn-Same Direction	67	0	67	380	447
	Left Turn/Straight	324	1	323	1,331	1,655
	Left Turn/Straight-Same Direction	93	0	93	448	541
	Left Turn/Straight-Opposite Direction	1,136	3	1,133	4,022	5,158
	Left Turn-Passing	53	0	53	261	314
	Right Turn-Passing	50	0	50	369	419
	Other	338	1	337	4,476	4,814
	Sum	**9,020**	**38**	**8,982**	**33,118**	**42,138**
Segment	Fixed/Movable Object	416	10	406	1,362	1,778
	Lost Control-Left Ditch	59	0	59	286	345
	Lost Control-Right Ditch to Left Ditch	28	2	26	194	222
	Lost Control-Right Ditch	120	4	116	755	875
	Rear End	1,158	1	1,157	4,449	5,607

Table B14: Number of Collisions by Severity, Road Configuration and Collision Configuration, 2001-2010 (Continued) (SGI, 2011).

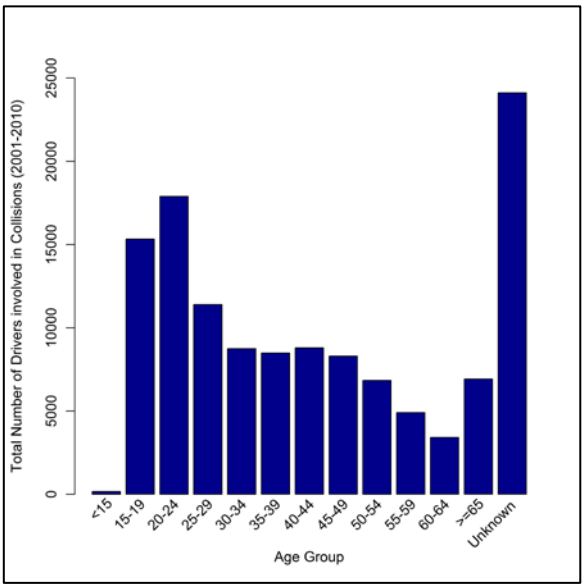
Road Configuration	Collision Configuration	FI	Fatal	Injury	PDO	Total
Segment	Side Swipe-Same Direction	202	1	201	2,985	3,187
	Side Swipe-Opposite Direction	53	0	53	463	516
	Head On	58	1	57	262	320
	Right Angle	196	1	195	1,039	1,235
	Right Turn-Same Direction	23	0	23	168	191
	Left Turn/Straight	91	0	91	400	491
	Left Turn/Straight-Same Direction	14	0	14	158	172
	Left Turn/Straight-Opposite Direction	166	2	164	811	977
	Left Turn-Passing	15	0	15	125	140
	Right Turn-Passing	16	0	16	137	153
	Other	206	3	203	6,156	6,362
	Sum	**2,821**	**25**	**2,796**	**19,750**	**22,571**
Unknown	Fixed/Movable Object	43	0	43	372	415
	Lost Control-Left Ditch	9	0	9	66	75
	Lost Control-Right Ditch to Left Ditch	5	0	5	27	32
	Lost Control-Right Ditch	20	0	20	158	178
	Rear End	139	0	139	737	876
	Side Swipe-Same Direction	17	0	17	402	419
	Side Swipe-Opposite Direction	4	0	4	57	61
	Head On	3	0	3	17	20
	Right Angle	20	0	20	109	129
	Right Turn-Same Direction	0	0	0	14	14
	Left Turn/Straight	1	0	1	40	41
	Left Turn/Straight-Same Direction	3	0	3	16	19
	Left Turn/Straight-Opposite Direction	13	0	13	65	78
	Left Turn-Passing	2	0	2	11	13
	Right Turn-Passing	3	0	3	15	18
	Other	27	0	27	3,363	3,390
	Sum	**309**	**0**	**309**	**5,469**	**5,778**
Grand Total		**23,991**	**126**	**23,865**	**111,205**	**135,196**

Collisions by Driver Group

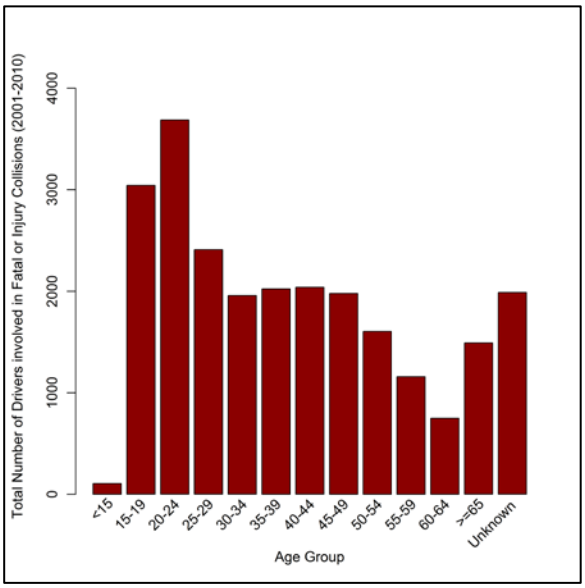
Figures B21(a) and B21(b) show the age group of the drivers involved in total collisions and fatal or injury collisions, respectively. Both figures show that young drivers (15 to 19 and 20 to 24 years old) were involved in more collisions than were drivers in other age groups. Young drivers (15 to 24 years old) accounted for 27% (33,220) of the total collisions and 28% (6,730) of the fatal or injury collisions. Many reported collisions (24,115; 19%), especially in the case of total collisions, lacked drivers' age information (i.e., unknown). Considering that a driver's age

is very basic information for collision data analysis, this can be regarded as evidence for the need to improve the quality of the collision database for future collision analysis.

Table B15 summarizes the data for the age group of drivers involved in total collisions and fatal or injury collisions.



(a) Total



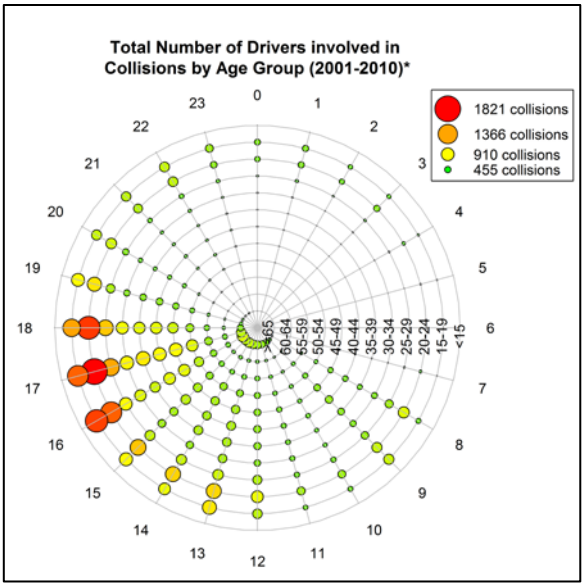
(b) Fatal or Injury

Figure B21: Number of Drivers involved in Collisions by Age Group, 2001-2010 (SGI, 2011).

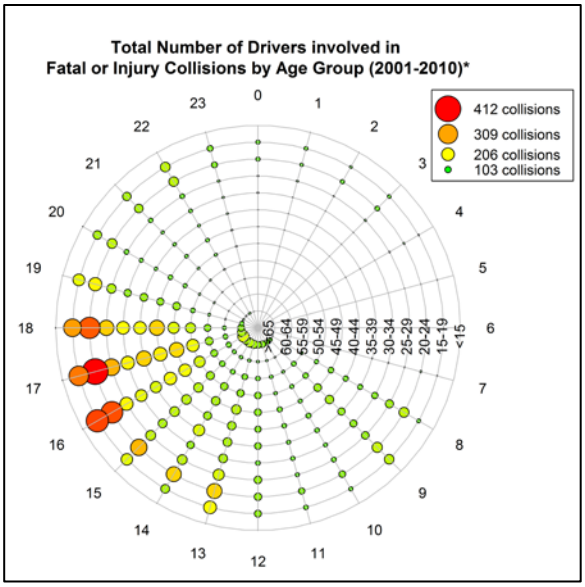
Table B15: Number of Drivers involved in Collisions by Severity and Age Group, 2001-2010 (SGI, 2011).

Age Group	Fatal	Injury	PDO	Total
<15	0	107	63	170
15-19	13	3,030	12,284	15,327
20-24	13	3,674	14,206	17,893
25-29	12	2,398	8,991	11,401
30-34	5	1,953	6,794	8,752
35-39	16	2,008	6,466	8,490
40-44	7	2,032	6,760	8,799
45-49	7	1,972	6,317	8,296
50-54	5	1,600	5,237	6,842
55-59	7	1,152	3,747	4,906
60-64	2	748	2,669	3,419
>=65	13	1,478	5,434	6,925
Unknown	14	1,974	22,127	24,115
Grand Total	114	24,126	101,095	125,335

Figures B22(a) and B22(b) are clockplots by hour and age group for total collisions and fatal or injury collisions, respectively. Both figures show that drivers between the ages of 15 to 24 years old are involved in the most collisions in terms of both number and severity during the hours between 3 pm and 6 pm in particular.



(a) Total

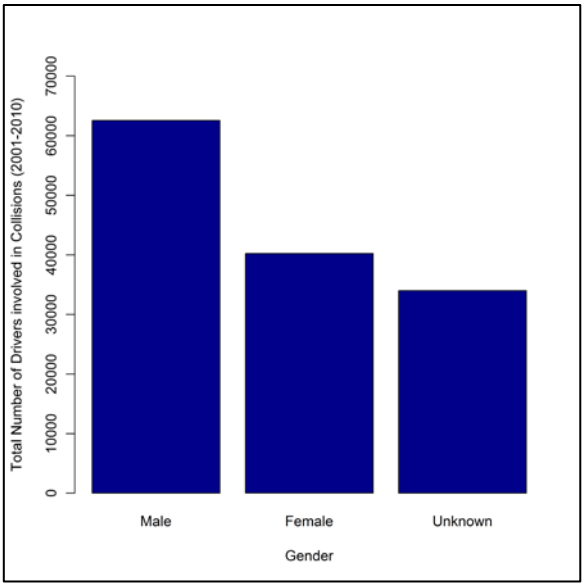


(b) Fatal or Injury

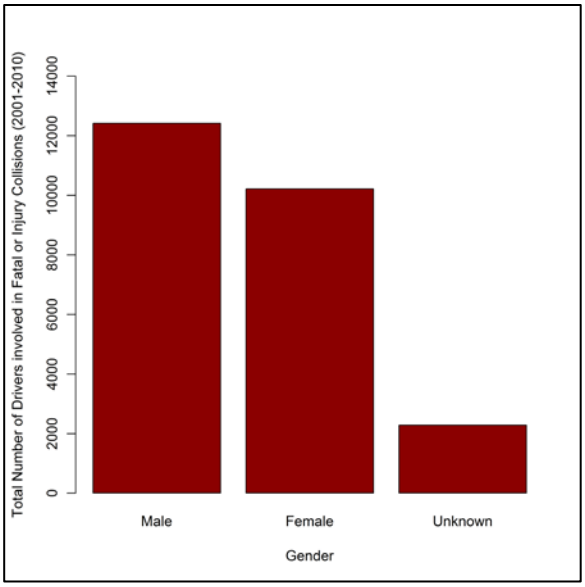
* Note: Excludes unknowns

Figure B22: Number of Drivers involved in Collisions by Hour and Age Group, 2001-2010 (SGI, 2011).

Figures B23(a) and B23(b) shows the gender of drivers involved in total collisions and fatal or injury collisions, respectively. Table B16 summarizes the data for driver gender. Unfortunately, gender information was not available for 34,008 (unknown) of the 136,812 collisions, but the figures and table clearly show that male drivers are involved in more collisions than female drivers: 62,578 of the total collisions (46%, compared with 40,226 or 29% for females) and 12,415 of the fatal or injury collisions (50% compared with 10,215 or 41% for females). In the case of fatal collisions, male drivers were involved in 66% and females were involved in 19%.



(a) Total



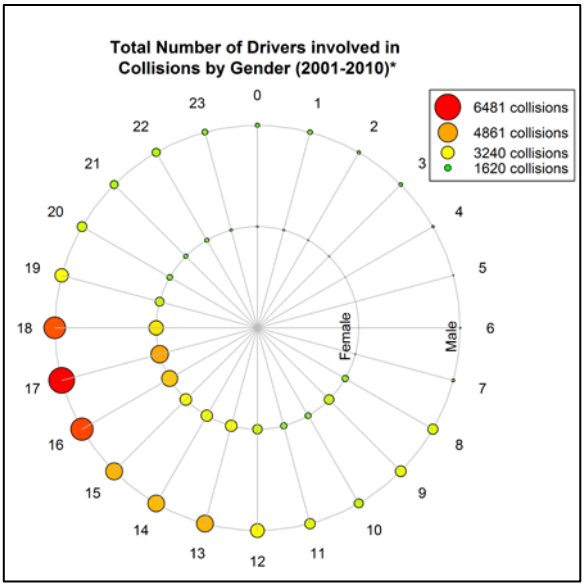
(b) Fatal or Injury

Figure B23: Number of Drivers involved in Collisions by Gender, 2001-2010 (SGI, 2011).

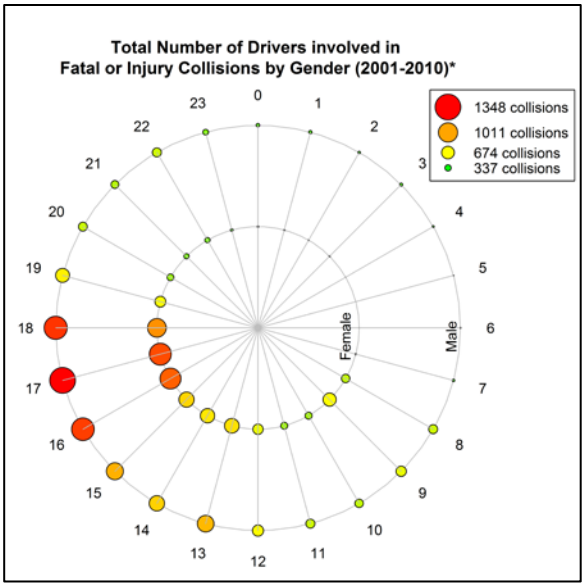
Table B16: Number of Drivers involved in Collisions by Severity and Gender, 2001-2010 (SGI, 2011).

Gender	Fatal	Injury	PDO	Total
Male	77	12,338	50,163	62,578
Female	22	10,193	30,011	40,226
Unknown	17	2,265	31,726	34,008
Grand Total	116	24,796	111,900	136,812

Figures B24(a) and B24(b) are clockplots by hour and gender of total collisions and fatal or injury collisions, respectively. Both figures show that drivers were involved in collisions between 3 pm and 6 pm regardless of gender. The hours from 3 pm to 6 pm were particularly important in the case of fatal or injury collisions.



(a) Total



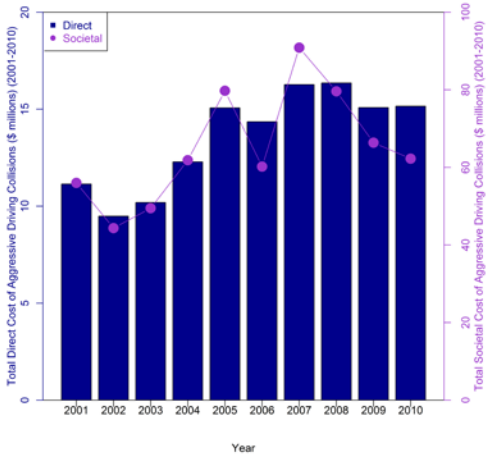
(b) Fatal or Injury

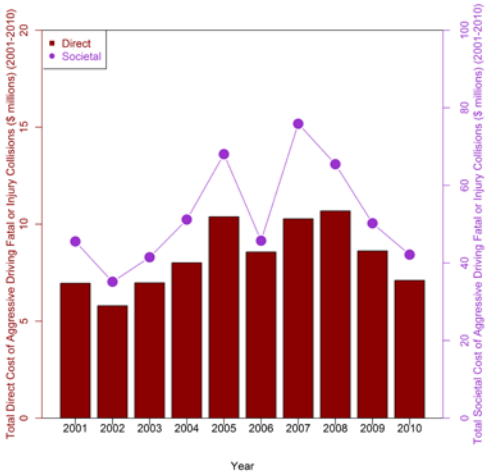
* Note: Excludes unknowns

Figure B24: Number of Drivers involved in Collisions by Hour and Gender, 2001-2010 (SGI, 2011).

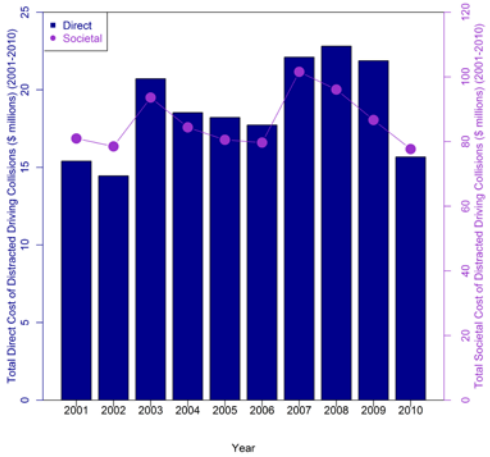
APPENDIX C
DIRECT AND SOCIETAL COST CHARTS FOR THE 13 POTENTIAL EMPHASIS AREAS

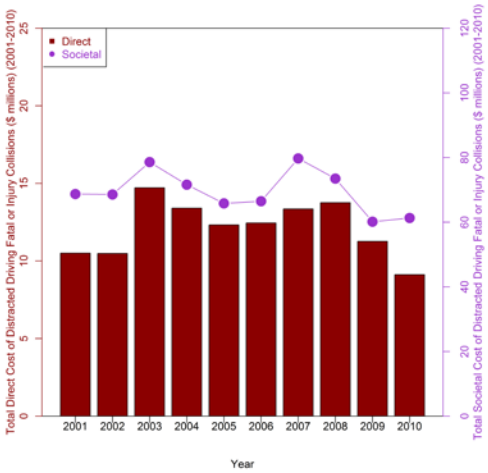
1. Aggressive Driving



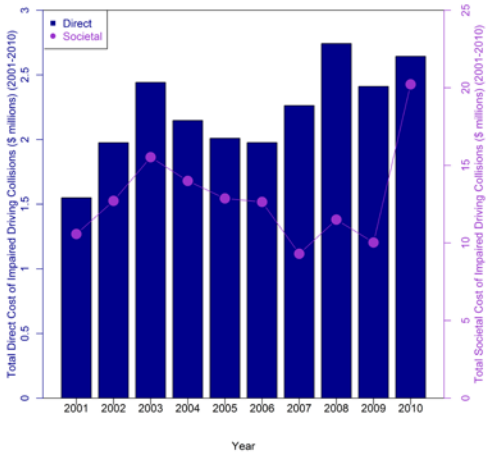


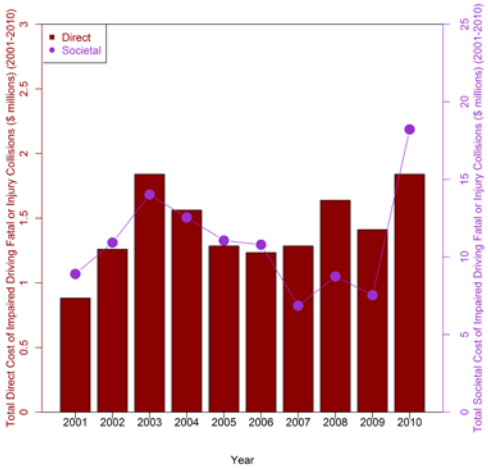
2. Distracted Driving



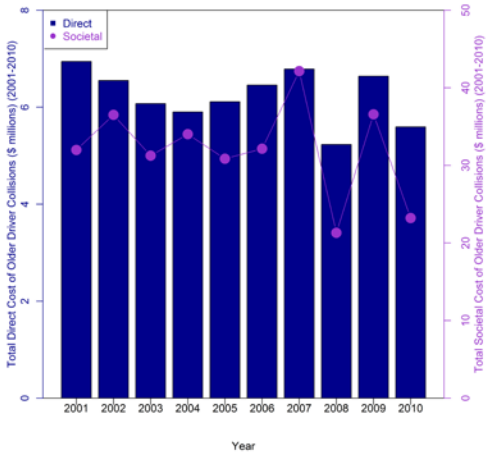


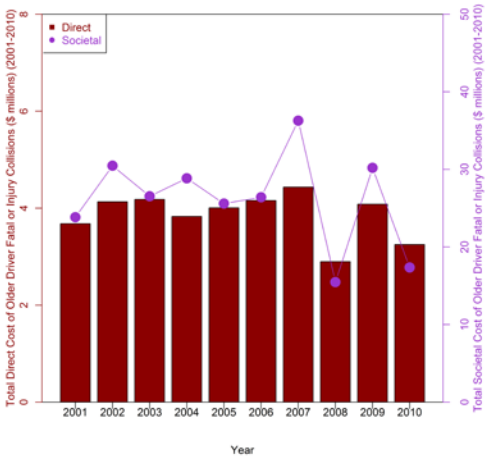
3. Impaired Driving



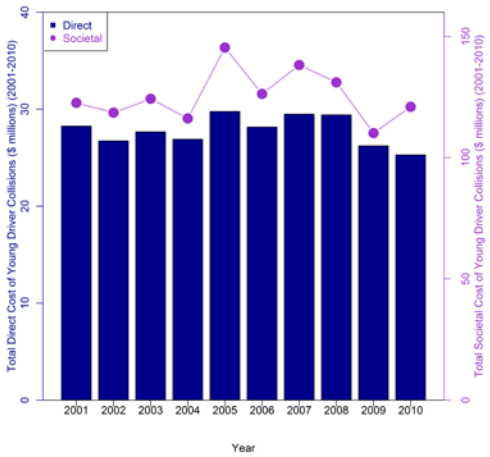


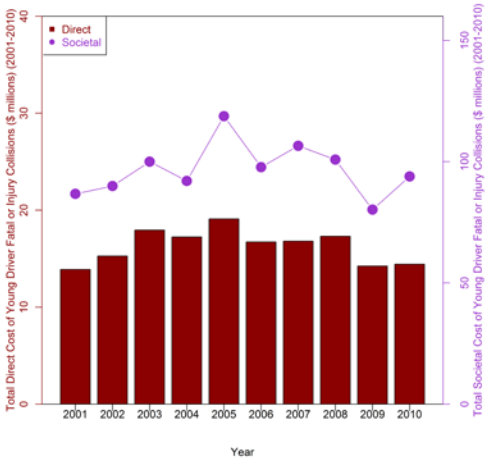
4. Older Drivers



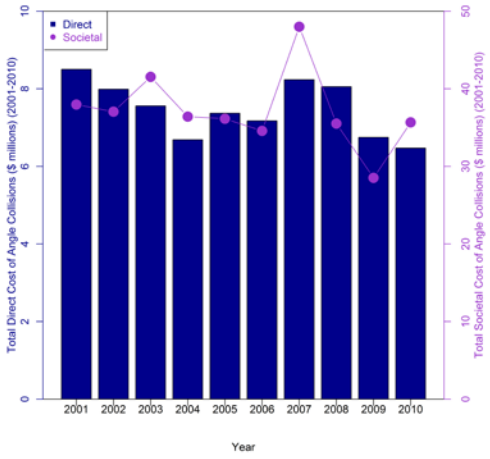


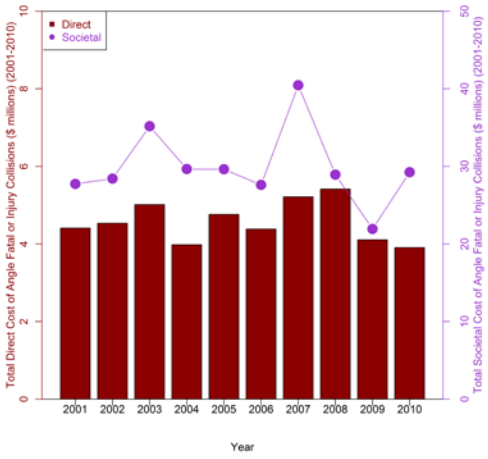
5. Young Drivers



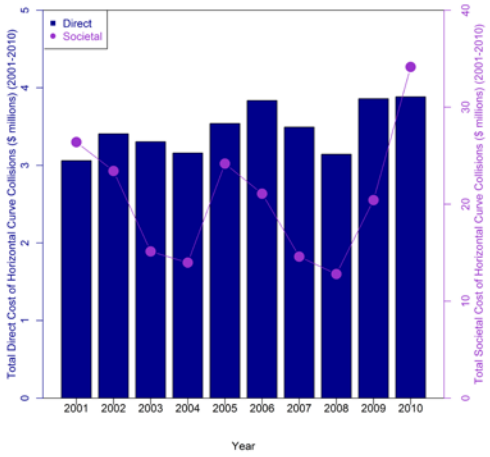


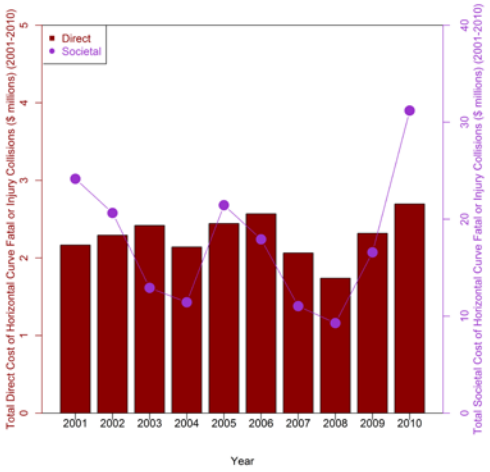
6. Angle Collisions



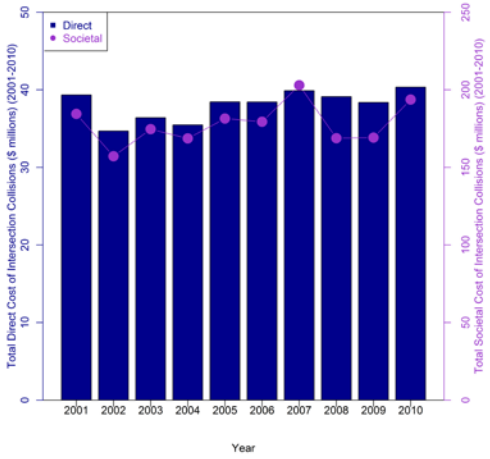


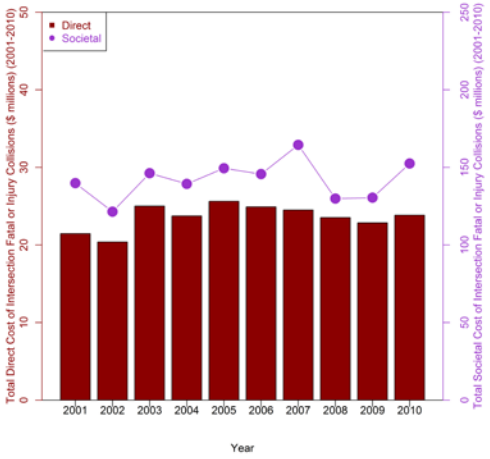
7. Horizontal Curves



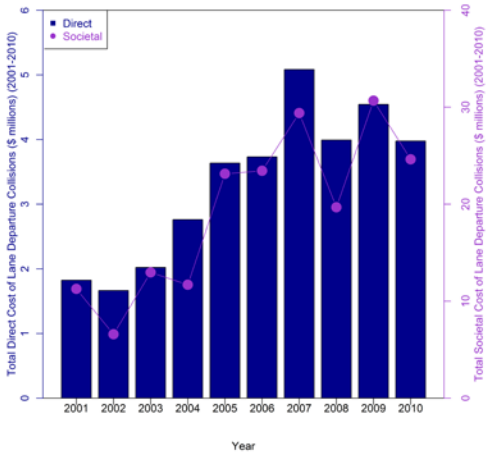


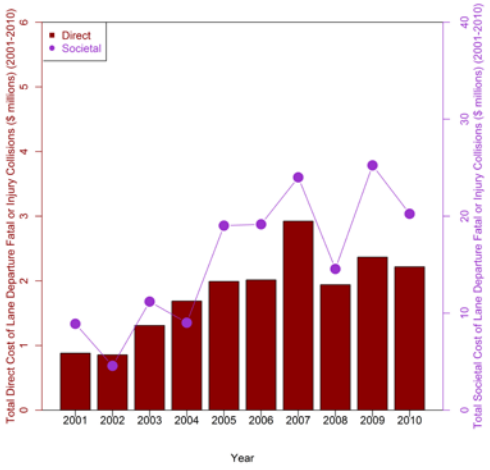
8. Intersections



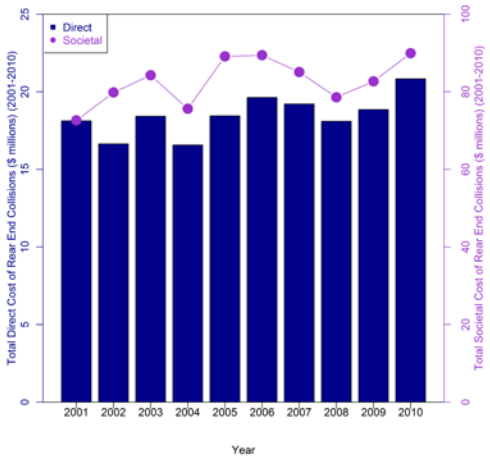


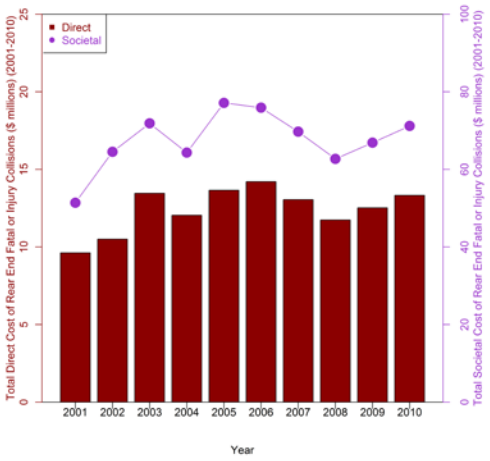
9. Lane Departure Collisions



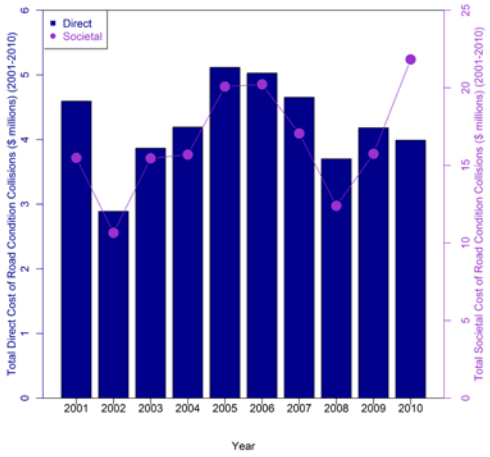


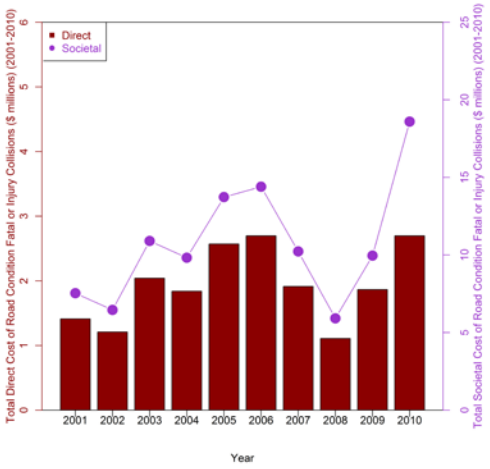
10. Rear End Collisions



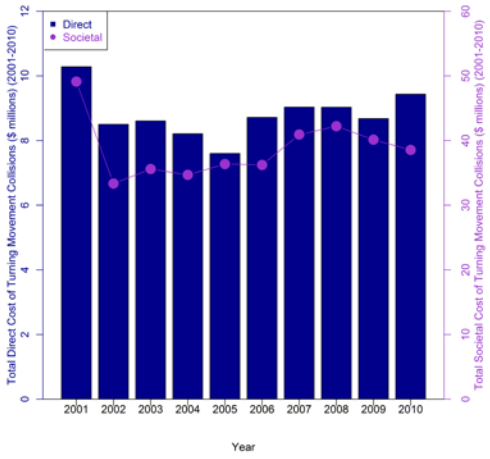


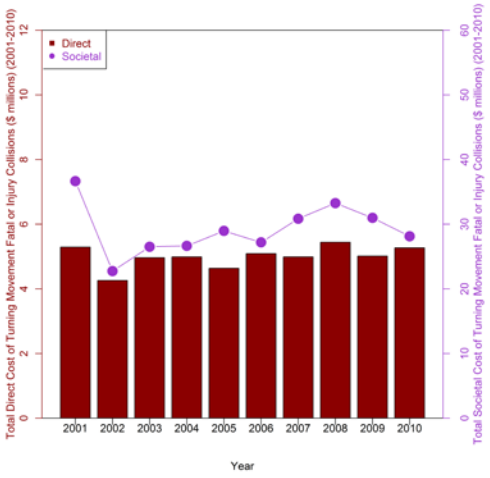
11. Road Condition



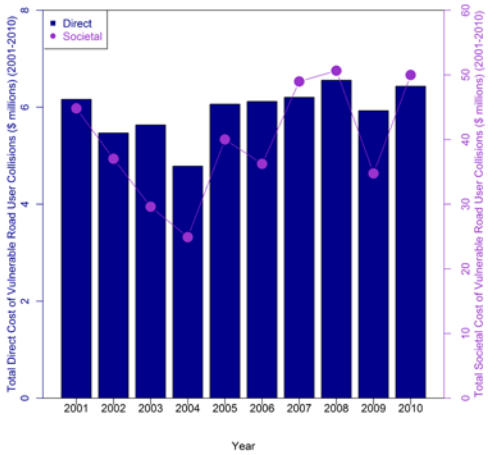


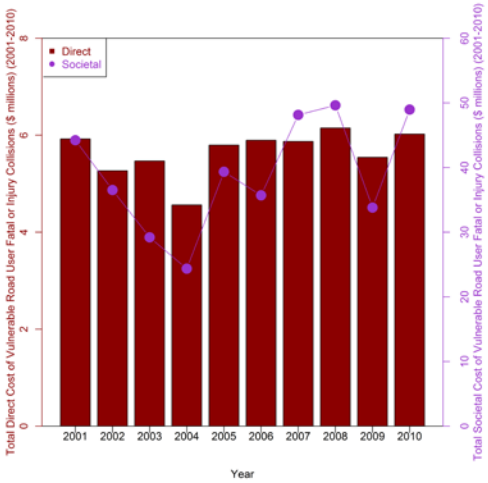
12. Turning Movement Collisions





13. Vulnerable Road Users





APPENDIX D
STAKEHOLDER WORKSHOP QUESTIONNAIRES

Strategic Traffic Safety Action Plan for the City of Saskatoon
2012 Stakeholder Workshop Questionnaire

This survey will provide valuable information in the Strategic Traffic Safety Action Plan for the City of Saskatoon. We encourage and appreciate all comments.

SECTION 1: PLEASE TELL ABOUT YOURSELF

Name: _____

Daytime Phone: _____

E-mail: _____

Gender: ▪*Male* ▪ *Female*

Age: ▪*16-24* ▪ *25-40* ▪ *41-64* ▪ *65+*

SECTION 2: PLEASE SELECT POTENTIAL EMPHASIS AREAS (See Tables D1, D2 & D3)

Based on the collision data analysis (2001-2010), the following 13 potential emphasis areas were chosen for further consideration.

Q2.1. The 13 potential emphasis areas are described and listed below. Please circle the importance of each emphasis area.

Potential Emphasis Area #1: Intersections

- Concerned with collisions that occurred at intersections
- Ranked First in terms of total collisions (60%) and fatal or injury collisions (74%). "Intersections" accounted for a total direct and societal cost of $38.05 million and $178.06 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

_____

_____

_____

Potential Emphasis Area #2: Young Drivers

- Concerned with collisions involving drivers between the ages of 15 and 24 years old

- Ranked Second in terms of total collisions (46%) and fatal or injury collisions (52%). "Young Drivers" accounted for a total direct and societal cost of $27.79 million and $125.39 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

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Potential Emphasis Area #3: Distracted Driving

- Concerned with collisions involving the following major contributing factors: inattentive, distracted, sun glare and view from vehicle obstructed
- Ranked Third in terms of total collisions (28%) and Fourth in terms of fatal or injury collisions (39%). "Distracted Driving" accounted for a total direct and societal cost of $18.75 million and $85.97 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

_____

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Potential Emphasis Area #4: Rear End Collisions

- Concerned with collisions that involved two or more vehicles through a rear end collision, which can involve a parked vehicle or vehicle operating in reverse
- Ranked Fourth in terms of total collisions (27%) and Third in terms of fatal or injury collisions (40%). "Rear End Collisions" accounted for a total direct and societal cost of $18.49 million and $82.74 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

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Potential Emphasis Area #5: Aggressive Driving

- Refers to failing to yield the right-of-way, disregarding traffic control devices, following too closely, driving too fast for road conditions, exceeding the speed limit, turning improper, improper passing or lane usage, and careless driving/stunting
- Ranked Fifth in terms of total collisions (21%) and fatal or injury collisions (26%). "Aggressive Driving" accounted for a total direct and societal cost of $13.54 million and $65.08 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

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Potential Emphasis Area #6: Turning Movement Collisions

- Concerned with collisions involving the following configurations: Right turn-Same direction, Left turn/straight, Left turn/straight-Same direction, Left turn/straight-Opposite direction, Left turn-Passing and Right turn-Passing
- Ranked Sixth in terms of total collisions (15%) and Seventh in terms of fatal or injury collisions (16%). "Turning Movement Collisions" accounted for a total direct and societal cost of $8.81 million and $38.72 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

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Potential Emphasis Area #7: Angle Collisions

- Two or more vehicles involved in a right angle collision neither of which was attempting a turn
- Ranked Seventh in terms of total collisions (12%) and Eighth in terms of fatal or injury collisions (14%). "Angle Collisions" accounted for a total direct and societal cost of $7.48 million and $37.14 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

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Potential Emphasis Area #8: Older Drivers

- Concerned with collisions involving drivers aged 65 to 100 years old
- Ranked Eighth in terms of total collisions (10%) and Ninth in terms of fatal or injury collisions (12%). "Older Drivers" accounted for a total direct and societal cost of $6.23 million and $32.01 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

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Potential Emphasis Area #9: Road Condition

- Concerned with collisions that did not occur on dry road surface and normal/good road conditions, and caused by surface or structure, excessive loose gravel, or soft or defective shoulder
- Ranked Ninth in terms of total collisions (9%) and Eleventh in terms of fatal or injury collisions (6%). "Road Condition" accounted for a total direct and societal cost of $4.22 million and $16.46 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

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Potential Emphasis Area #10: Lane Departure Collisions

- Concerned with collisions involving the following configurations: Lost control-Left ditch, Lost control-Right ditch to left ditch and Lost control-Right ditch
- Ranked Tenth in terms of total collisions (6%) and Twelfth in terms of fatal or injury collisions (5%). "Lane Departure Collisions" accounted for a total direct and societal cost of $3.32 million and $19.30 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

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Potential Emphasis Area #11: Horizontal Curves

- Concerned with collisions that occur on a horizontally curved section of streets
- Ranked Eleventh in terms of total collisions (5%) and Tenth in terms of fatal or injury collisions (7%). "Horizontal Curves" accounted for a total direct and societal cost of $3.47 million and $20.62 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

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Potential Emphasis Area #12: Vulnerable Road Users

- Concerned with collisions involving bicycles, motorcycles, mopeds/power bicycles and/or pedestrians

- Ranked Twelfth in terms of total collisions (4%) and Sixth in terms of fatal or injury collisions (17%). "Vulnerable Road Users" accounted for a total direct and societal cost of $5.94 million and $39.70 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

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Potential Emphasis Area #13: Impaired Driving

- Refers to driving while impaired by alcohol or drug use (legal or illicit)
- Ranked Thirteenth in terms of total collisions (3%) and in terms of fatal or injury collisions (4%). "Impaired Driving" accounted for a total direct and societal cost of $2.22 million and $12.94 million per year, respectively.

▪ *Very Important* ▪ *Quite Important* ▪ *Fairly Important* ▪ *Slightly Important* ▪ *Not Important*

Comments

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Q2.2. Were there other areas you think are important that were not discussed? If so, please state why you think these areas are also important.

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SECTION 3: PLEASE SELECT TARGET GOALS (See Table D4)

Q3.1. The project aims towards a zero fatal or injury collision target goal. The next five year target goal could be 15% (40 years), 20% (30 years), or other percentage values (e.g., 10% with 50 years) depending on the time horizon for this

target setting. Please suggest an appropriate target goal for our city.

- *Number of Fatal or Injury Collisions*
  (250 collision reduction with 30 yrs. horizon vs. 187 collision reduction with 40 yrs. horizon)

- *Number of Fatal or Injury Collisions per 1000 Population*
  (5.6 collision reduction with 30 yrs. horizon vs. 4.2 collision reduction with 40 yrs. horizon)

- *Number of Fatal or Injury Collisions per 1000 Registered Vehicles*
  (4.0 collision reduction with 30 yrs. horizon vs. 3.0 collision reduction with 40 yrs. horizon)

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Thank you for taking the time to complete this survey for road safety in Saskatoon. Your input is appreciated and will be considered as the City of Saskatoon works to improve safety on our streets. All comments and suggestions provided will be considered in the development of the Strategic Traffic Safety Action Plan.

Table D1: Collision Statistics for each Potential Emphasis Area, 2001-2010 (SGI, 2011).

Potential Emphasis Areas		Fatal or Injury			Total		
		Number	%	Rank	Number	%	Rank
Drivers	Aggressive Driving	3,147	26	5	15,063	21	5
	Distracted Driving	4,718	39	4	19,871	28	3
	Impaired Driving	493	4	13	2,308	3	13
	Older Drivers	1,417	12	9	6,834	10	8
	Young Drivers	6,260	52	2	32,584	46	2
Environmental Conditions	Angle Collisions	1,698	14	8	8,355	12	7
	Horizontal Curves	790	7	10	3,501	5	11
	Intersections	9,020	74	1	42,138	60	1
	Lane Departure Collisions	592	5	12	4,042	6	10
	Rear End Collisions	4,900	40	3	18,807	27	4
	Road Condition	759	6	11	5,995	9	9
	Turning Movement Collisions	1,928	16	7	10,665	15	6
Special Road Users	Vulnerable Road Users	2,053	17	6	2,706	4	12
Grand Total		12,150	NA	NA	70,487	NA	NA

Table D2: Direct Cost for each Potential Emphasis Area (2007 $ millions), 2001-2010 (SGI, 2011).

Potential Emphasis Areas		Fatal or Injury	Total
Drivers	Aggressive Driving	83.40	135.41
	Distracted Driving	121.41	187.55
	Impaired Driving	14.24	22.16
	Older Drivers	38.66	62.31
	Young Drivers	162.99	277.90
Environmental Conditions	Angle Collisions	45.74	74.80
	Horizontal Curves	22.86	34.69
	Intersections	235.96	380.52
	Lane Departure Collisions	18.10	33.15
	Rear End Collisions	124.18	184.88
	Road Condition	19.36	42.21
	Turning Movement Collisions	49.95	88.09
Special Road Users	Vulnerable Road Users	56.51	59.36
Grand Total		993.36	1,583.03

Table D3: Societal Cost for each Potential Emphasis Area (2007 $ millions), 2001-2010 (SGI, 2011).

Potential Emphasis Areas		Fatal or Injury	Total
Drivers	Aggressive Driving	520.95	650.84
	Distracted Driving	694.54	859.71
	Impaired Driving	109.63	129.41
	Older Drivers	261.05	320.09
	Young Drivers	967.01	1,253.94
Environmental Conditions	Angle Collisions	298.87	371.43
	Horizontal Curves	176.65	206.20
	Intersections	1,419.64	1,780.63
	Lane Departure Collisions	155.41	193.02
	Rear End Collisions	675.77	827.35
	Road Condition	107.57	164.64
	Turning Movement Collisions	291.96	387.20
Special Road Users	Vulnerable Road Users	389.93	397.04
Grand Total		6,068.98	7,541.5

Table D4: Suggested Target Goals for each Safety Performance Measure, 2001-2010 (SGI, 2011).

Safety Performance Measures	Ambitious (30 year Horizon)				Conservative (40 year Horizon)			
	Estimated		Recommended		Estimated		Recommended	
	Collision Reduction by 2017	Target Goal by 2017 (%)	Collision Reduction by 2017	Target Goal by 2017 (%)	Collision Reduction by 2017	Target Goal by 2017 (%)	Collision Reduction by 2017	Target Goal by 2017 (%)
Number of Fatal or Injury Collisions	208	16.6	250	20	156	12.5	187	15
Number of Fatal or Injury Collisions per 1000 Population	4.7	16.7	5.6	20	3.5	12.5	4.2	15
Number of Fatal or Injury Collisions per 1000 Registered Vehicles	3.4	16.7	4.0	20	2.5	12.5	3.0	15

Strategic Traffic Safety Action Plan for the City of Saskatoon
2013 Stakeholder Workshop Questionnaire
September 12th, 2013 (2:30 – 4:30pm)

This survey will provide valuable information in the Strategic Traffic Safety Action Plan for the City of Saskatoon. We encourage and appreciate all comments.

SECTION 1: PLEASE TELL ABOUT YOURSELF

Name: _____

Agency: _____

Daytime Phone: _____

E-mail: _____

Gender: ▪*Male* ▪ *Female*

Age: ▪*16-24* ▪ *25-40* ▪ *41-64* ▪ *65+*

SECTION 2: PLEASE COMMENT ON THE SUGGESTED STRATEGIES/PROGRAMS

Q2.1. Are there safety strategies/programs you think should be removed? If so, please state why.

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Q2.2. Are there safety strategies/programs that were not listed that you think should be added? If so, please state why.

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Q2.3. Are there safety strategies/programs that you think are not appropriate to publish on the City of Saskatoon's website? If so, please state why.

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Thank you for taking the time to complete this questionnaire for road safety in Saskatoon. Your input is appreciated and will be considered as the City of Saskatoon works to improve safety on our streets. All comments and suggestions provided will be considered in the development of the Strategic Traffic Safety Action Plan.

APPENDIX E
SAFETY STRATEGIES/PROGRAMS

Emphasis Area #1: Aggressive Driving						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Education	**Message Boards**	**Enhance**	**Billboards or changing message signs on high speed roadways remind people to drive according to the road conditions and to follow the speed limit.**	**COS TSC, SGI**	**Unknown**	
	Awareness Campaigns using Multimedia and Community Newsletters	**Enhance**	**Local broadcasting channels (radio, TV, community newsletters, CAA articles, etc.) create and reinforce awareness of the serious consequences of aggressive driving.**	**COS TSC, Radio and TV Stations, SGI**	**Unknown**	
	Aggressive Driving Awareness Week (ADAW)	**Introduce**	**An ADAW can be used to create and reinforce awareness of the consequences of aggressive driving. The week could concentrate on specific aspects (e.g., speeding).**	**COS TSC, SGI**	**Unknown**	
	Awareness Campaigns using Social Media and Various Organizations' Homepages	**Enhance**	**Popular social media (e.g., Facebook) and stakeholders' homepages (e.g., COS, SPS) can be used to promote awareness of the serious consequences of aggressive driving.**	**COS, SGI, SPS**	**Unknown**	
	Educational Activities targeted at High Schools	Introduce	Traffic safety themed activities focusing on aggressive driving can be designed for high school students. These activities can be coordinated and promoted by the SBOE.	SBOE, SGI	Unknown	
Enforcement	**Selective Enforcement Programs (e.g., Operation Spring Brake)**	**Enhance**	**Selective enforcement programs may use highly visible and/or invisible law enforcement. An example is Operation Spring Brake (a.k.a. Operation March Madness) which usually takes place in spring (e.g., April). The program is designed to put the brakes on violations such as speeding, driving too fast for road conditions, running red lights, not stopping at stop signs, stunting, racing and passing to the right on a highway. The program could be extended throughout the year. An aggressive driving collision map can be used to select the program's locations/times.**	**SGI, SPS**	**▪ 12% reduction in speeding-related collisions**	**Stuster, 2001; Neuman et al., 2009**

Emphasis Area #1: Aggressive Driving						
Strategy/Program		**Introduce/Enhance**	**Description**	**Stakeholders**	**Reported Effectiveness**	**Sources**
Enforcement	Aerial Speed Enforcement	Enhance	SPS's Air Support Unit is used to curb aggressive driving and increase pressure on drivers to abide by the rules of the road.	Ministry of Justice, SGI, SPS	Unknown	
Engineering	**Improved Road Surface Friction/Winter Maintenance on High Speed Highways**	**Enhance**	**Winter maintenance programs (e.g., sanding and snowplowing) improve road surface friction on high speed roadways and high classification roadways (e.g., Circle Drive and major/minor arterials).**	**COS, SGI**	**Unknown**	
	Improved Traffic Signal Operation	Enhance	Traffic signal phasing at high collision intersections where aggressive driving is a problem are examined. Possible countermeasures include providing a protected left turn signal phase, prohibiting left turns, and extending the yellow, green, or red signal phase as appropriate.	COS	"Provide protected left turn signal phase" ▪ 16% reduction in left turn collisions ▪ 19% reduction in angle collisions "Prohibit left turns with 'No Left Turn' sign" ▪ 68% reduction in all collision types and all collision severities "Extend the yellow, green or red signal phase" ▪ 8% reduction in all collisions	FHWA, 2007a; The City of Hamilton, 2009 Brich and Cottrell, 1994; FHWA, 2013 FHWA, 2007a; The City of Hamilton, 2009
	Engineering Projects that help to reduce Peak Period Congestion	Enhance	Certain types of aggressive driving (e.g., speeding and unsafe lane changing) are known to stem from drivers' frustration with congested roads. COS's various surface infrastructure projects are designed to reduce congestion on the road network and can therefore help to reduce aggressive driving.	COS	Unknown	
	Changeable Message Signs	Enhance	Changeable message signs are installed at locations where aggressive driving is leading to collisions. The signs may also be used to advise road users of adverse weather and road conditions.	COS TSC, SGI	Unknown	

Emphasis Area #1: Aggressive Driving						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Engineering	**Speed Reader Boards**	**Enhance**	**Speed reader boards are installed at locations where aggressive driving is leading to collisions. The signs show each driver his or her speed.**	**COS TSC, SGI**	**▪ 4% reduction in aggressive driving-related collisions estimated for use of warning letters**	**Preusser et al., 2008; The City of Hamilton, 2009**
	Variable Speed Limit for Winter Road Conditions (a.k.a. seasonal speed limit)	**Introduce**	**SGI has been researching the possibility of introducing seasonal speed limits at high collision locations where drivers speed even when road conditions are adversely affected by weather. The program would need public support and a Cabinet decision.**	**SGI**	**▪ 8% reduction in all collision types and all collision severities**	**Bham et al., 2010; FHWA, 2013**
	Photo Radar Technology	**Introduce**	**SGI has been considering expanding the use of photo radar technology in Saskatchewan from work zones (as at present) to other roadways. The program would need public support and a Cabinet decision.**	**SGI**	**▪ 20% to 25% reduction in injury collisions**	**Decina et al., 2007; NHTSA, 2009**
	Red Light Cameras	**Enhance**	**Red light cameras are installed at high collision intersections where aggressive driving is a problem.**	**COS, SGI**	**▪ 31% reduction in right angle collisions ▪ 11% reduction in left turn collisions ▪ 29% increase in rear end collisions ▪ 34% reduction in other collision configurations (i.e., head on or side swipe collisions)**	**SGI, 2012**
Legislation	**Work Zone Regulation**	**Introduce**	**Impose tougher fines on motorists who do not reduce their speed when driving in construction zones when workers are present.**	**COS, SGI**	**Unknown**	
	Driver Improvement Program	Enhance	Drivers are assigned demerit points every time they are convicted of a traffic offence related to aggressive driving. In Saskatchewan, drivers are currently assigned 4 demerit points for running a stop sign, and 1 demerit point for exceeding the speed limit.	SGI	▪ 6% reduction in collisions ▪ 8% reduction in violations	NHTSA, 2009

Emphasis Area #2: Distracted Driving						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Education	**Message Boards**	**Enhance**	**Billboards or changing message signs advise drivers of distracted driving regulations and fines.**	**COS TSC, SGI**	**Unknown**	
	Driver Distraction Campaigns using Multimedia and Community Newsletters	**Enhance**	**Local broadcasting channels (radio, TV, community newsletters, CAA articles, etc.) create and reinforce awareness of the consequences of distracted driving, and the new legislation that banned cell phone use while driving in Saskatchewan.**	**COS TSC, Radio and TV Stations, SGI**	**Unknown**	
	Distracted Driving Awareness Week (DDAW)	**Introduce**	**A DDAW can be used to create and reinforce awareness of the consequences of distracted driving and the new legislation that banned cell phone use while driving in Saskatchewan.**	**COS TSC, SGI**	**Unknown**	
	Driver Distraction Campaigns using Social Media and Various Organizations' Homepages	**Enhance**	**Popular social media (e.g., Facebook) and stakeholders' homepages (e.g., COS, SPS) can be used to create and promote awareness of the consequences of distracted driving and the new legislation that has banned cell phone use while driving in Saskatchewan.**	**COS, SGI, SPS**	**Unknown**	
	Educational Activities targeted at High Schools	Introduce	Traffic safety themed activities focusing on distracted driving can be designed for high school students. These activities can be coordinated and promoted by SBOE.	SBOE, SGI	Unknown	
Enforcement	**Selective Enforcement Programs (e.g., Operation Overdrive Program)**	**Enhance**	**Selective enforcement programs may use visible and/or invisible law enforcement. An example is Operation Overdrive which allows police officers to conduct checkstops and penalize distracted drivers. The program takes place every May throughout Saskatchewan. Such programs could be conducted throughout the year. A distracted driving collision map can be used to select the location/time of the checkstops.**	**SGI, SPS**	**Unknown**	

Emphasis Area #2: Distracted Driving						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Engineering	Roadway Safety Improvements to reduce the Likelihood and Severity of Distracted Driving Collisions	Enhance	Numerous engineering countermeasures can help to reduce the problem of distracted driving: advance stop signs, advance signing for lane closures, larger and more reflective signage, installation of medians, removal of obstacles, and improved lane marking and delineation of curbs.	COS, SGI	"Rolled-in rumbles and concrete intermittent rumbles" ▪ 20% reduction in collisions"Milled design rumble strips"▪ 39% reduction in collisions	Morena, 2003; Stutts, 2005

Emphasis Area #3: Impaired Driving						
	Strategy/Program	**Introduce/Enhance**	**Description**	**Stakeholders**	**Reported Effectiveness**	**Sources**
Education	**Message Boards**	**Enhance**	**Billboards or changing message signs advise drivers of impaired driving regulations and legal consequences.**	**COS TSC, SGI**	**▪ 30% reduction in collisions**	**Blomberg, 1992; Goodwin et al., 2005**
	Awareness Campaigns using Multimedia and Community Newsletters	**Enhance**	**Local broadcasting channels (radio, TV, community newsletters, CAA articles, etc.) create and reinforce awareness of the consequences of impaired driving especially before and during long weekends and holiday periods.**	**COS TSC, Radio and TV Stations, SGI**	**▪ 13% reduction in alcohol-related collisions**	**Elder et al., 2004; NHTSA, 2009**
	Impaired Driving Awareness Week (IDAW)	**Enhance**	**An IDAW creates and reinforces awareness of the safety and legal consequences of impaired driving. The week can be coordinated by MADD and SADD.**	**COS TSC, MADD, SADD, SGI**	**▪ 30% reduction in collisions**	**Blomberg, 1992; Goodwin et al., 2005**
	Awareness Campaigns using Social Media and Various Organizations' Homepages	**Enhance**	**Popular social media (e.g., Facebook) and stakeholders' homepages (e.g., COS, SPS) can be used to promote awareness of the consequences of impaired driving.**	**COS, SGI, SPS**	**▪ 30% reduction in collisions**	**Blomberg, 1992; Goodwin et al., 2005**
	Smartphone Apps	Enhance	Smartphone apps can be used to create and promote awareness. For example, SGI's Safe Ride App provides information on taxis, designated driving services, etc.	SGI	Unknown	
	Operation Red Nose (ORN)	Enhance	ORN (operationrednose.com) is a national road safety campaign focused on reducing impaired driving during holiday periods. ORN volunteers to drive impaired or tired people and their vehicles home from parties, events, etc.	SGI	Unknown	
	Educational Activities targeted at High Schools	Introduce	Traffic safety themed activities focusing on impaired driving are designed for high school students. These activities can be coordinated and promoted by SADD, SBOE and through social media.	SADD, SBOE, SGI	Unknown	

Emphasis Area #3: Impaired Driving						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Enforcement	**Selective Enforcement Programs (e.g., Operation Overdrive Program)**	**Enhance**	**Selective enforcement programs may use visible and/or invisible law enforcement. An example is Operation Overdrive which allows police officers to conduct checkstops and apprehend impaired drivers. The program takes place every May throughout Saskatchewan. Such programs could be conducted throughout the year. An impaired driving collision map can be used to select the location/time of the checkstops.**	**SGI, SPS**	**▪ 20% reduction in impaired driver collisions**	**Preusser, 2008; The City of Hamilton, 2009**
	Highly Visible Enforcement (HVE)	Enhance	Liquor enforcement team (LET) officers provide HVE within and around drinking establishments to continually reinforce the message that impaired drivers will be stopped and arrested.	SPS	▪ 15% reduction in alcohol-related fatalities	NHTSA, 2004; Goodwin et al., 2005
	Report Impaired Drivers (RID) Program	**Enhance**	**The RID program is a new road safety initiative that encourages residents to call 911 to report a suspected impaired driver. RID allows the public to assist law enforcement in finding and removing impaired drivers from the roads. RID also serves as a warning to impaired drivers that many eyes are watching them.**	**COS TSC, SGI**	**Unknown**	
Legislation	Administrative Licence Suspension Program (a.k.a. Immediate Roadside Prohibition (IRP) Program)	Enhance	The licence suspension program is applied at the roadside to drivers with 0.08 BAC. Saskatchewan has various driver licence suspension programs. The sanctions vary with the driver's offence and include 90-day administrative suspensions, roadside suspensions, statutory suspensions, and criminal code suspensions.	SGI, SPS	▪ 5% reduction in alcohol-related fatal collision involvement	Wagenaar and Maldonado-Molina, 2007; NHTSA, 2009

Emphasis Area #3: Impaired Driving						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Legislation	Ignition Interlock Program (IIP)	Enhance	An ignition interlock is an alcohol testing device connected to the ignition and power systems of a vehicle. It prevents an alcohol impaired driver from starting the vehicle. In Saskatchewan, drivers who are convicted of impaired driving, who drive over 0.08 BAC or who refuse to take a breath test are eligible for the IIP.	SGI	▪ At least a 50% reduction in driving while impaired (DWI) recidivism while they are installed	Beirness and Marques, 2004; NHTSA, 2009
	Addiction Screening	Enhance	Addiction screening monitors all drivers convicted of impaired driving. Since 1996, drivers convicted of drinking and driving offences (including certain types of alcohol-related roadside suspensions) are screened. Those found to have an alcohol problem are referred to a recovery program.	SGI, SHR	Unknown	

Emphasis Area #4: Intersections						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Education	Awareness Campaigns using Multimedia and Community Newsletters	Enhance	Local broadcasting channels (radio, TV, community newsletters, CAA articles, etc.) create and reinforce awareness of the especially high incidence of collisions at intersections.	COS TSC, Radio and TV Stations, SGI	Unknown	
	Awareness Campaigns using Social Media and Various Organizations' Homepages	Enhance	Popular social media (e.g., Facebook) and stakeholders' homepages (e.g., COS, SPS) promote awareness of the especially high incidence of collisions at intersections.	COS, SGI, SPS	Unknown	
Enforcement	Selective Enforcement Programs (e.g., Operation Crossroads)	Enhance	Selective enforcement programs may use highly visible and/or invisible law enforcement. Examples include Operation Crossroads at/near intersections. Operation Crossroads is a provincial-wide program that usually takes place in winter (e.g., Jan/Feb). The program includes activities designed to reduce intersection violations. These violations include disobeying traffic signals or stop signs, making u-turns at light controlled intersections, turning right on a red light without coming to a complete stop, motorists failing to yield to pedestrians at crosswalks, etc. The program could be extended to run throughout the year.	SGI, SPS	▪ 23% to 83% reduction in traffic law violations	Pline, 1999; Neuman et al., 2003
	High Collision Intersection Enforcement	Enhance	Saskatoon police officers have been focusing on enforcement at intersections considered high risk from past collision statistics. An intersection collision map can be used to select the target intersections/times.	SPS	Unknown	
Engineering	Improved Road Surface Friction/Winter Maintenance	Enhance	Winter maintenance programs (e.g., sanding and snowplowing) to improve road surface friction are important at all intersections, but may be especially valuable at high collision intersections.	COS, SGI	▪ 13.8% reduction in all collision types and all collision severities	Lyon and Persaud, 2008; FHWA, 2013

Emphasis Area #4: Intersections						
	Strategy/Program	**Introduce/Enhance**	**Description**	**Stakeholders**	**Reported Effectiveness**	**Sources**
Engineering	**Clearview Street Signs**	**Introduce**	**Street name signs that use the Clearview font and larger street name plates are designed to help drivers to find their route, choose their lane, etc. and thus negotiate the intersection more safely and more easily .**	**COS**	**Unknown**	
	Improved Traffic Signal Operation	Enhance	Traffic signal phasing at high collision intersections is examined. Possible countermeasures include providing a protected left turn signal phase, prohibiting left turns, and extending the yellow, green, or red signal phase.	COS	"Provide protected left turn signal phase" ▪ 16% reduction in left turn collisions ▪ 19% reduction in angle collisions "Prohibit left turns with 'No Left Turn' sign" ▪ 68% reduction in all collision types and all collision severities "Extend the yellow, green or red signal phase" ▪ 8% reduction in all collisions	FHWA, 2007a; The City of Hamilton, 2009 Brich and Cottrell, 1994; FHWA, 2013 FHWA, 2007a; The City of Hamilton, 2009
	Professional Engineering Projects Designed to Improve Surface Infrastructure (e.g., in-service road safety review projects)	**Enhance**	**In-service safety review projects can be conducted at selected intersections to determine engineering countermeasures that will improve the surface infrastructure. Typical engineering countermeasures include adding exclusive left/right turn lanes, installing advanced signal change warning signs, providing clear sight triangles on stop/yield controlled intersections, providing larger and/or dual stop signs at stop-controlled intersections, etc. An intersection collision map (Appendices E and F) can be used to select target intersections for in-service road safety review projects.**	**COS, SGI**	**"Provide left turn lanes"** **▪ 27% reduction for four-legged intersections** **▪ 33% reduction for three-legged intersections** **"Provide right turn lanes"** **▪ 5% reduction in total collisions at three-legged and four-legged intersections on one major-road approach** **▪ 10% reduction on both major-road approaches** **"Install advanced signal change warning signs"** **▪ 62% reduction in right angle collisions at signalized four-legged intersections** **▪ 36% reduction in rear end collisions at signalized four-legged intersections**	**Neuman et al., 2003** **Harwood et al., 2000; Neuman et al., 2003** **FHWA, 2007a; The City of Hamilton, 2009**

Emphasis Area #4: Intersections						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Engineering	Well Maintained Pavement Markings	Enhance	Missing and faded pavement markings (crosswalks, lane markings, lane ending indicators, etc.) at/near City intersections are maintained throughout the year to ensure good visibility. Clear markings are important at all intersections, but may be especially important at locations screened as high collision locations.	COS	Unknown	
	Red Light Cameras	Enhance	Red light cameras are installed at high collision intersections.	COS, SGI	▪ 31% reduction in right angle collisions ▪ 11% reduction in left turn collisions ▪ 29% increase in rear end collisions ▪ 34% reduction in other collision configurations (i.e., head on or side swipe collisions)	SGI, 2012

Emphasis Area #5: Older Drivers						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Education	**Awareness Campaigns using Multimedia and Community Newsletters**	**Enhance**	**Local broadcasting channels (radio, TV, community newsletters, CAA articles, etc.) create and reinforce awareness of the physical limitations of aging that may affect the driving capabilities of older drivers. These limitations, which include loss of hearing, loss of peripheral vision and physical infirmities like arthritis, may have severe consequences for older drivers and others involved in any resulting collisions.**	**COS TSC, Radio and TV Stations, SGI**	**Unknown**	
	55 Alive (Mature Driver Course)	Enhance	55 Alive is a free six-hour course that educates older drivers about how the physical changes of aging can affect driving, and explains how older drivers with, for example, compromised vision or hearing, can adapt to adverse road and weather conditions. At least 12 participants are required in each class.	Saskatchewan Safety Council, SGI	Unknown	
Engineering	**Improved Road Surface Friction/Winter Maintenance**	**Enhance**	**Winter maintenance programs (e.g., sanding and snowplowing) to improve road surface friction are important to all drivers, but may be particularly valuable to older drivers. It is especially important for drivers with reduced reaction times that roads are not icy and slippery, and that the safest lanes are easily recognized.**	**COS, SGI**	**▪ 13.8% reduction in all collision types and all collision severities**	**Lyon and Persaud, 2008; FHWA, 2013**
	Clearview Street Signs	**Introduce**	**Street name signs that use the Clearview font and larger street name plates are designed to help drivers to find their route, choose their lane, etc. These may be especially useful to older drivers with reduced vision and/or visual perception limitations.**	**COS**	**Unknown**	

Emphasis Area #5: Older Drivers						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Engineering	**Well Maintained Pavement Markings**	**Enhance**	**Missing and faded pavement markings (centre lines, lane lines, lane narrowing lines, crosswalks, lane ending indicators, etc.) on City streets are maintained throughout the year to ensure good visibility. Clear markings are important to all drivers, but are likely to be especially helpful to older drivers whose vision and visual perceptual limitations may otherwise affect their ability to keep in lane and change lane safely.**	**COS**	**Unknown**	
Legislation	**Work Zone Regulation**	**Introduce**	**Impose tougher fines on motorists who do not reduce their speed when driving in construction zones when workers are present.**	**COS, SGI**	**Unknown**	
	Driver Evaluation Program (DEP)	Enhance	DEPs monitor drivers who have medical conditions that may affect their ability to drive.	SGI	Unknown	

Emphasis Area #6: Vulnerable Road Users						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Education	**Awareness Campaigns using Multimedia and Community Newsletters**	**Enhance**	**Local broadcasting channels (radio, TV, community newsletters, CAA articles, etc.) create and reinforce awareness of the especially high incidence and severe consequences of vulnerable road user collisions.**	**COS TSC, Radio and TV Stations, SGI**	**Unknown**	
	Awareness Campaigns using Social Media and Various Organizations' Homepages	**Enhance**	**Popular social media (e.g., Facebook) and stakeholders' homepages (e.g., COS, SPS) can be used to promote awareness of the especially high incidence and severe consequences of vulnerable road user collisions.**	**COS, SGI, SPS**	**Unknown**	
	Educational Activities targeted at Elementary Schools	Introduce	Traffic safety themed activities focusing on the especially high incidence and severe consequences of pedestrian/bicycle collisions involving children can be designed for elementary school students. These activities can be coordinated and promoted by the SBOE. The School Resource Unit in SPS can partner with Saskatoon's elementary schools to support the elementary schools' pedestrian/bicycle safety-related activities.	SBOE, SGI, SPS	▪ 20% reduction in child dart-out collisions	NHTSA, 2009
Enforcement	**Selective Enforcement Programs (e.g., Operation Crossroads)**	**Enhance**	**Selective enforcement programs may use highly visible and/or invisible law enforcement to increase the safety of pedestrians and bicyclists. Operation Crossroads is a province wide program that usually takes place in winter (e.g., Jan/Feb). The program includes activities designed to reduce motorist/pedestrian violations such as motorists ignoring "Don't Walk" signals at pedestrian crosswalk or failing to yield to pedestrians at crosswalks. The program could be extended to run throughout the year. A vulnerable road user collision map can be used to select the target locations/times.**	**SGI, SPS**	**Unknown**	

Emphasis Area #6: Vulnerable Road Users						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Engineering	Improved Traffic Signal Operation	Enhance	Traffic signal phasing at intersections with a high incidence of collisions involving vulnerable road users is examined. Possible traffic signal countermeasures include providing a protected left turn signal phase, prohibiting left turns and prohibiting right-turns-on-red.	COS	"Improve signal timing" ▪ 37% reduction in pedestrian collisions	FHWA, 2007a; The City of Hamilton, 2009
	Professional Engineering Projects to Improve Surface Infrastructure Condition (e.g., in-service road safety review projects)	**Enhance**	**In-service safety review projects can be conducted at selected sites (e.g., 22nd Street) to determine engineering countermeasures that will improve the surface infrastructure for vulnerable road users. Typical engineering countermeasures include: adding crosswalks; installing pedestrian fencing, refuge islands, exclusive bicycle lanes, and/or raised pedestrian crossings; adding lighting; restricting parking; etc. A vulnerable road user collision map can be used to select the target locations for in-service road safety review projects.**	**COS, SGI**	**"Install crosswalks on one minor approach" ▪ 65% reduction in all collision types and all collision severities "Install refuge island" ▪ 56% reduction in pedestrian collisions "Install raised pedestrian crossings" ▪ 46% reduction in vehicle/pedestrian collision types, and serious injury and minor injury collision severities "Improve lighting" ▪ 42% reduction in night-time pedestrian collisions**	**Haleem and Abdel-Aty, 2010; FHWA, 2013 ITE, 2004; FHWA, 2008 Elvik and Vaa, 2004; FHWA, 2013 FHWA, 2007a; The City of Hamilton, 2009**
	Countdown Pedestrian Signals	**Enhance**	**Pedestrian signals with countdown timers inform pedestrians how many seconds remain for crossing. The countdown timers may be visual only, or visual and audible.**	**COS**	**▪ 25% reduction in pedestrian collisions**	**FHWA, 2007a; The City of Hamilton, 2009**
	Coloured Curbs	Introduce	Curb cuts can be painted yellow to clearly delineate pedestrian walkways from roadways at intersections.	COS	▪ 37% reduction in vehicle/pedestrian collision types for all collision severities	Feldman et al., 2010; FHWA, 2013
	Bicycle Lane Connectivity (i.e., continuous right-of-way for bicyclists) and Bicycle Friendly Facilities	Enhance	Bicycle lane connectivity can be provided where possible. During surface infrastructure improvement, raised/exclusive bicycle lanes (rather than curbside bicycle lanes) can be considered to maximize bicyclists' safety.	COS	Unknown	

Emphasis Area #6: Vulnerable Road Users						
Strategy/Program		**Introduce/Enhance**	**Description**	**Stakeholders**	**Reported Effectiveness**	**Sources**
Engineering	Coloured Pavement for Bicycle Lanes	Introduce	Curbside bike lanes can be painted a colour that contrasts with the colour of the pavement to clearly delineate the bicycle traffic area from the general traffic area.	COS	▪ 39% reduction in vehicle/bicycle collision types and all collision severities	Turner et al., 2011; FHWA, 2013
	Winter Maintenance of Transit Facilities	Enhance	Bus stops where access is impeded by snow, ice or broken pavement are identified, and COS can be informed of these problems by Saskatoon Transit so that the problems can be addressed quickly.	COS, Saskatoon Transit	Unknown	
	Accessible Pedestrian Signals (APS)	**Enhance**	**APS communicate information in non-visual formats (e.g., audio).**	**COS, SGI**	**Unknown**	
	Sidewalk Retrofit	Enhance	Sidewalks can be added to old neighbourhoods with missing sidewalks, or upgrade sidewalks.	COS, SGI	Unknown	
	Accessibility Ramps	**Enhance**	**Create access by adding curb ramps on street corners.**	**COS, SGI**	**Unknown**	

Emphasis Area #7: Young Drivers						
Strategy/Program		**Introduce/Enhance**	**Description**	**Stakeholders**	**Reported Effectiveness**	**Sources**
Education	**Message Boards/Posters**	**Enhance**	**Billboards or posters at bus shelters near high schools remind young and future drivers to drive according to traffic regulations and to follow the speed limit.**	**COS TSC, SGI**	**Unknown**	
	Awareness Campaigns using Multimedia and Community Newsletters	**Enhance**	**Local broadcasting channels (radio, TV, community newsletters, CAA articles, etc.) create and reinforce awareness of the especially high incidence of collisions involving young drivers.**	**COS TSC, Radio and TV Stations, SGI**	**Unknown**	
	Awareness Campaigns using Social Media and Various Organizations' Homepages	**Enhance**	**Popular social media (e.g., Facebook) and stakeholders' homepages (e.g., COS, SPS) can be used to promote awareness of the especially high incidence of collisions involving young drivers.**	**COS, SGI, SPS**	**Unknown**	
	Educational Activities targeted at High Schools	Introduce	Traffic safety themed activities focusing on the especially high incidence of collisions involving young drivers and the large number of alcohol-related collisions can be designed for high school students. These activities can be coordinated and promoted by MADD, SADD and SBOE. The School Resource Unit in SPS can partner with Saskatoon's high schools to support the high schools' traffic safety-related activities.	MADD, SADD, SBOE, SGI, SPS	Unknown	
	Rollover Simulator Demonstrations at High Schools	Enhance	SGI demonstrates its rollover simulator at Saskatoon high schools to emphasize the safety benefits of seatbelts in severe rollover collisions.	SBOE, SGI	Unknown	

Emphasis Area #7: Young Drivers						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Enforcement	**Selective Enforcement Programs (e.g., school zone enforcement, Operation Street Sweep)**	**Enhance**	**Selective enforcement programs may use highly visible and/or invisible law enforcement. Examples include school zone enforcement near high schools, and Operation Street Sweep, a city wide program that usually takes place in spring (e.g., May). Operation Street Sweep is designed to reduce violations such as cell phone use while driving, failing to use a seatbelt, etc. Part of the program could target young drivers and the program could be extended to run throughout the year. A young driver collision map can be used to select the program's locations/times.**	**SGI, SPS**	**Unknown**	
	Multi Agency Seatbelt Team (MASTeam) Seatbelt Checkstops	Enhance	The MASTeam program focuses on seatbelt enforcement. Enforcement agencies throughout Saskatchewan conduct checkstops to enforce seatbelt use. To target young drivers, a young driver collision map can be used to select the program's locations/times.	SPS	Unknown	
Engineering	**Improved Road Surface Friction/Winter Maintenance**	**Enhance**	**Winter maintenance programs (e.g., sanding and snowplowing) to improve road surface friction are important to all drivers, but may be especially valuable to young and/or less experienced drivers learning to stay in the lane and when to change lane on slippery roadways.**	**COS, SGI**	**▪ 13.8% reduction in all collision types and all collision severities**	**Lyon and Persaud, 2008; FHWA, 2013**
	Clearview Street Signs	**Introduce**	**Street name signs that use the Clearview font and larger street name plates are designed to help all drivers to find their route, choose their lane, etc. more easily. Their introduction may be especially useful to young and/or inexperienced drivers not yet familiar with the roadway network.**	**COS**	**Unknown**	

Emphasis Area #7: Young Drivers						
Strategy/Program		Introduce/Enhance	Description	Stakeholders	Reported Effectiveness	Sources
Engineering	Well Maintained Pavement Markings	Enhance	Missing and faded pavement markings (centre lines, lane lines, lane narrowing lines, crosswalks, lane ending indicators, etc.) on City streets are maintained throughout the year to ensure good visibility. Clear markings are important to all drivers, but may be especially helpful to young and/or less experienced drivers learning to change lanes and drive safely.	COS	Unknown	
Legislation	Work Zone Regulation	Introduce	Impose tougher fines on motorists who do not reduce their speed when driving in construction zones when workers are present.	COS, SGI	Unknown	
	Graduated Driver Licensing (GDL) Program	Enhance	GDL programs are designed to ensure that young drivers' exposure to higher levels of risk increases incrementally as the drivers gain more experience driving. The details of such programs vary. SGI is considering toughening the current GDL program.	SGI	▪ 15% to 21% reduction in collisions involving new drivers	SGI, 2012