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Memorandum

Date: January 18, 2018 (Updated)
To: David Argue, PTOE, P. Eng., RJ Burnside
From: Owen Karanja, BA /Timothy Oketch, Ph.D., P. Eng.
Project Number: 21-12030
Subject: Sheridan Park Drive EA Study – Safety Performance Assessment

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Distribution To: City of Mississauga

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1. Scope

The City of Mississauga (City) has undertaken a Municipal Class Environmental Assessment (EA) to investigate the proposed extension of Sheridan Park Drive between Homelands Drive and Speakman Drive in the southwestern area of Mississauga. R.J. Burnside & Associates Limited (Burnside) has facilitated the EA on behalf of the City.

The EA Study has followed a comprehensive planning and design process in order to explore the opportunity to connect the east and west sections of Sheridan Park Drive, improve the road network connectivity in the residential neighbourhood and business area, create options for alternative routes and improve multi-modal network connectivity. The EA Study has been completed in accordance with the requirements of a Schedule B Undertaking as outlined in the Municipal Engineers Association Municipal Class Environmental Assessment Document (October 2000, as amended 2007, 2011 & 2015), which is an approved process under the *Ontario Environmental Assessment Act*.

As part of the EA Study, TIMCON has completed a *Sheridan Park Drive Extension Safety Performance Study* to identify whether the proposed Sheridan Park Drive extension will impact transportation safety within the Study Area and determine if any potential mitigation measures are required. This assessment examined both existing and future conditions with the recommended improvements.

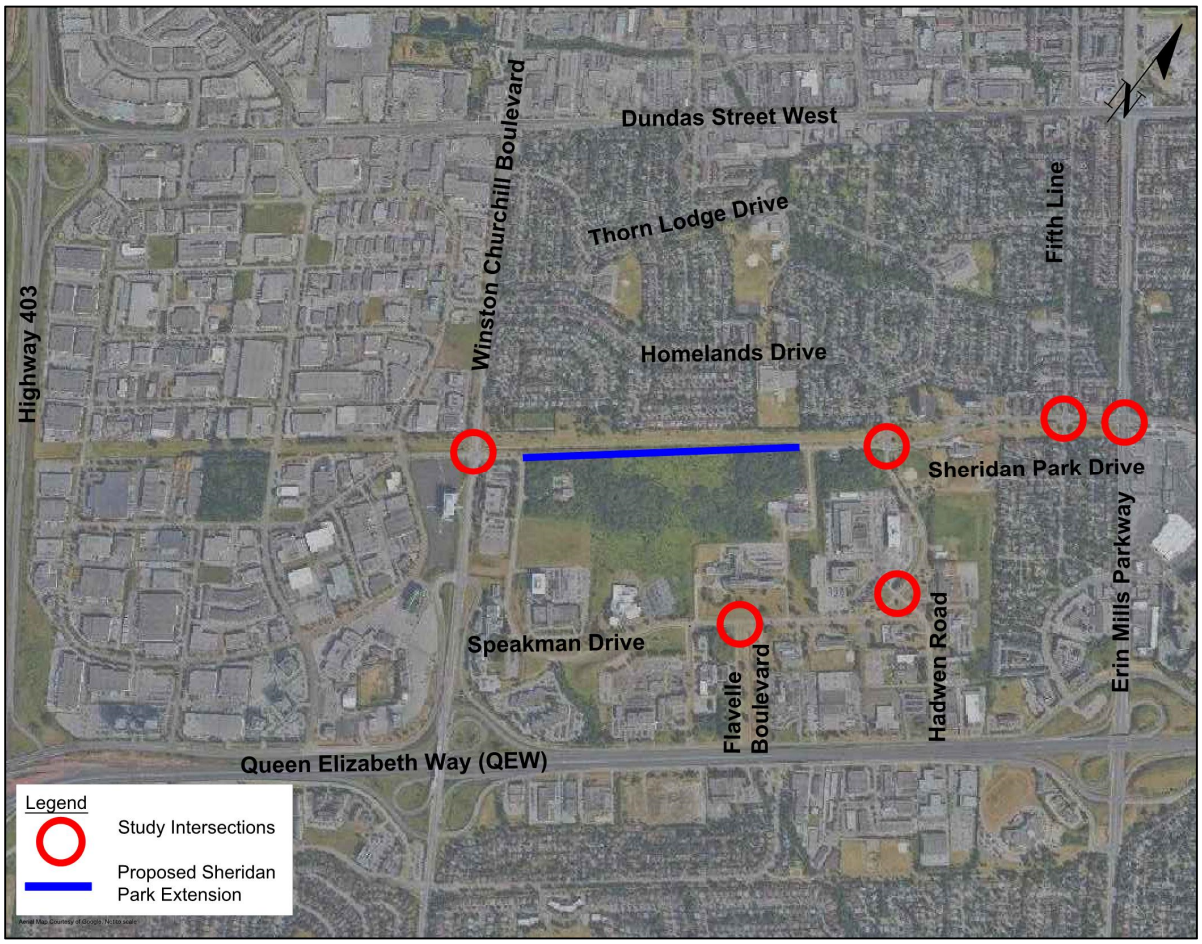
1.1 Study Area

The Study Area is generally bordered by a utility corridor to the north, Winston Churchill Boulevard to the west, Speakman Drive/Homelands Drive to the east and naturalized private lands to the south. The proposed extension of Sheridan Park Drive falls within the existing City of Mississauga owned right-of-way (ROW), which runs through the centre part of the Study Area.

The study area intersections for the transportation safety analysis are shown in **Figure 1**. The Study Area includes a unique combination of uses including the Sheridan Park Corporate Centre (Sheridan Park), a

utility corridor that includes a multi-use trail (MUT) and the Sheridan Homelands residential neighbourhood.

Figure 1: Study Area Intersections



2. Existing Conditions

2.1 Field Review

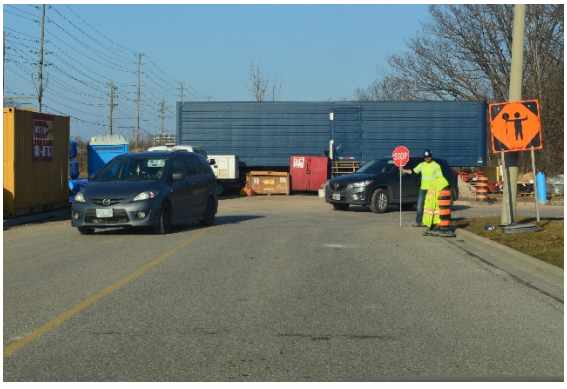
A field review was undertaken on February 23, 2017 and included observations at the Study Area intersections along Sheridan Park Drive. Preliminary review of the collisions data showed that the highest collisions occurred on Erin Mill Parkway / Sheridan Park Drive and Winston Churchill Blvd/ Sheridan Park Drive intersections. Consequently, emphasis was placed on those intersections during the field review. It was observed that reconstruction of Speakman Drive was underway resulting on one-way traffic operations on Speakman Drive between Flavelle Blvd and Sheridan Park Drive, just east of Winston Churchill Blvd. Table 1 show photos of general conditions at the Study Area intersections.

Table 1: Selected Photos of Site Issues

Substantial queues on EB approach at the Sheridan Park Dr / Erin Mill Parkway intersection extending back to Fifth Line intersection

Sheridan Park Drive/Speakman Drive intersection – Allway Stop sign with chevrons

Winston Churchill Blvd is a four-lane arterial with a posted speed 60km/h. There is a gentle slope SB towards the Sheridan/ Plymouth intersection



One-way traffic operations on Speakman Drive between Flavelle Blvd and Sheridan Park Drive, just east of Winston Churchill Blvd

2.2 Traffic Data

Traffic volume data was provided by the City of Mississauga and Burnside. They included turning movement counts undertaken at several intersections within the Study Area. The turning movement count volumes were available for six or eight-hour durations. The data was reviewed and summarized for peak hours and six-hour (6) volumes for consistency at all the intersections. Peak hour and six-hour (6) traffic volumes at the various intersection approaches within the Study Area are shown in **Figure 2** and **Figure 3** respectively.

Figure 2: Peak Hour Traffic Volumes at Study Area Intersections

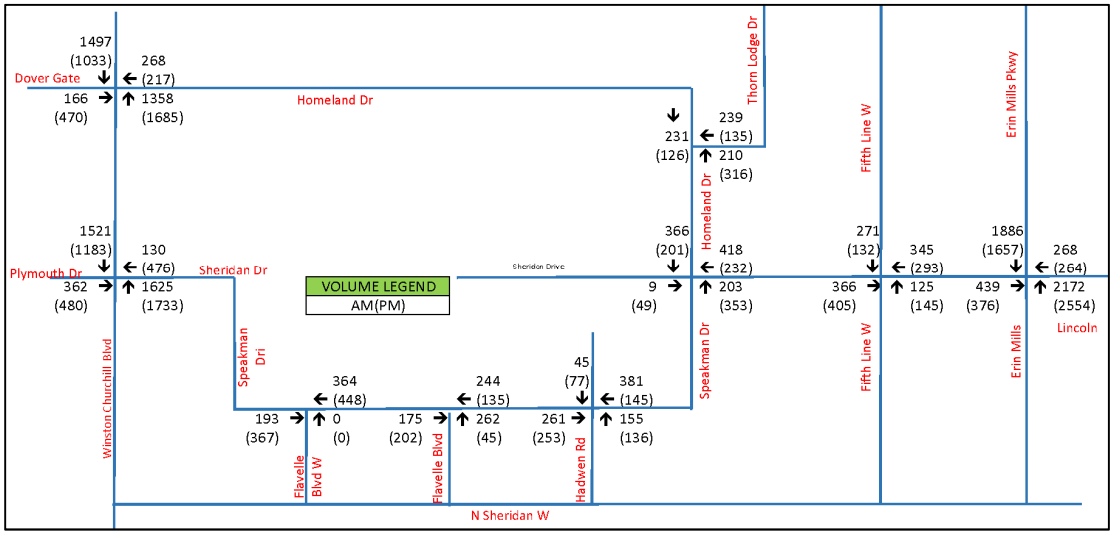
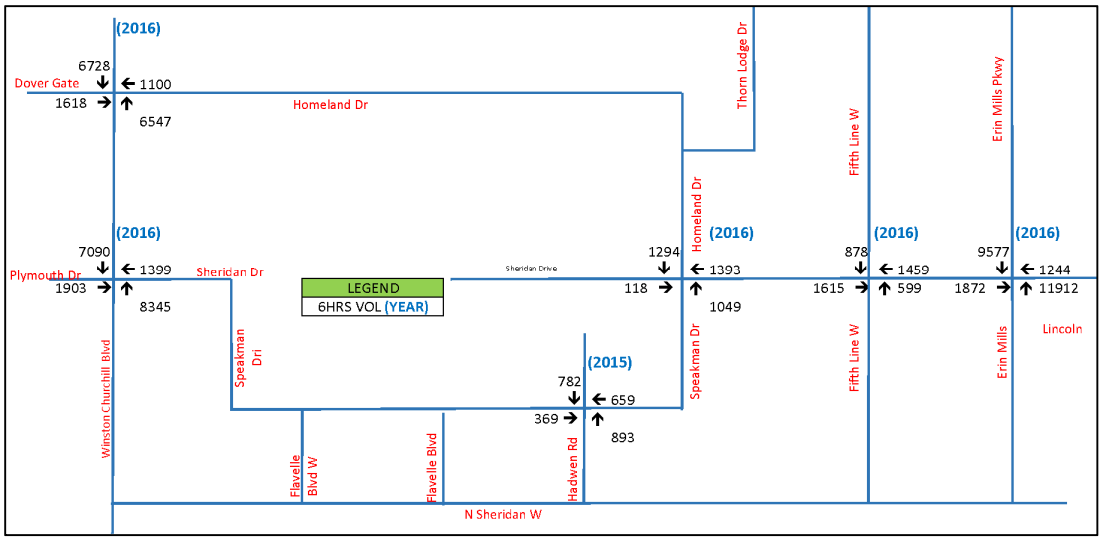


Figure 2 indicates relatively higher volumes during the weekday PM peak hour. The highest approach volume was 2,554 vehicles per hour on the northbound approach at the Erin Mills Pkwy and Sheridan Park Dr intersection.

Figure 3: **Six (6) Hour Traffic Volumes at Study Area Intersections**



2.3 Traffic Signal Operations

Traffic signal phasing and timings were obtained from the City and confirmed at the site. The information is summarized in **Table 2** below.

Table 2: Collision Patterns at Intersections within the Study Area

Intersection	AM- Phasing	PM- Phasing	Comments
Erin Mill Pkwy/ Sheridan Park Dr	SBL – 20s SB/NB – 97/77s WB/EB – 43s Cycle time: 140s	NBL/SBL – 18/15s NB/SB – 74/77s WB/EB – 48s Cycle time: 140s	NBL not provided during PM
Winston Churchill Blvd/Sheridan Park Dr	SBL – 14s SB/NB – 99/85s WB/EB- 41/41s Cycle time 140	SBL – 13s SB/NB – 88/75s WBL – 11s WB/EB- 52/41s Cycle time: 140s	

3. Collisions Analysis

3.1 Overview

Collision analysis was undertaken for intersections within the Study Area limits. Collision data was obtained from the City of Mississauga for the five-year period from 2010 to 2014. The analysis considered the collision severity, type of impact and the environmental conditions. **Table 3** shows the overall annual trends classified according to severity, surface condition and lighting condition.

Table 3: General Collision Characteristics at the Study Area Intersections

Year	Severity			Surface Condition		Lighting Condition		
	Fatal	Injury	PDO	Wet	Dry	Daylight	Dark	Total
2010	0	5	19	5	19	16	8	24
2011	0	2	21	5	18	18	5	23
2012	0	4	28	9	23	26	6	32
2013	0	6	19	4	21	20	5	25
2014	0	0	17	3	14	13	4	17
Total	**0**	**17**	**104**	**26**	**95**	**93**	**28**	**121**

There was a total of 121 collisions recorded in the Study Area, all of which were non-fatal. The collisions ranged from 17 in 2014 to 32 in 2012. Property damage collisions accounted for 85% of those. Injury collisions accounted for approximately 15%. Most collisions occurred during dry surface during daylight conditions. As such, wet conditions or darkness did not appear to be of any significance in the collisions experience.

The collision pattern at each intersection is summarized in **Table 4**. The highest number of collisions occurred at the Erin Mills Parkway and Sheridan Park Drive Intersection which experienced 74 (60%) of the total collisions. Winston Churchill Blvd / Sheridan Park Drive Intersection which had comparable traffic volumes, had only 31 collisions.

Table 4: Collision Patterns at Intersections

Intersection	Fatal	Injury	Property Damage	Total	6 Hr Total Volume
Erin Mill Pkwy/ Sheridan Park Dr	0	11	63	74	24,605
Fifth Line W/ Sheridan Park Dr	0	3	6	9	4,551
Homeland Dr/Speakman @ Sheridan Dr	0	0	2	2	3,854
Hadwen Rd/ Speakman Dr	0	0	2	2	2,703
Speakman Dr/ Flavelle Blvd	0	0	3	3	Not available
Winston Churchill Blvd/Sheridan Park Dr	0	3	28	31	18,737
Total	**0**	**17**	**104**	**121**	

Further analysis involved examining initial collision impact at each intersection as shown in **Table 5**. Most of the collisions were rear end, which contributed 43 % of the total collisions analysed. Angle and turning collisions were also common at the intersections together accounting for 41%.

Table 5: Intersection Collision by Initial Impact

Intersection	Type of collision						
	Single Vehicle	Angle	Rear End	Side Swipe	Turning	Other	Total
Erin Mills Pkwy/ Sheridan Park Dr	3	12	30	8	20	1	74
Winston Churchill Blvd/Sheridan Park Dr	3	5	16	2	4	1	31
Fifth Line W/ Sheridan Park Dr	2	3	3	0	1	0	9
Homeland Dr/Sheridan Dr/ Speakman Dr	0	0	2	0	0	0	2
Hadwen Rd/ Speakman Dr	0	1	0	0	1	0	2
Speakman Dr/ Flavelle Blvd	0	0	1	0	2	0	3
Total	**8**	**21**	**52**	**10**	**28**	**2**	**121**

The collisions were also analyzed by the time of day of occurrence. The time periods considered were 6 to 10am for the AM peak, 10 am to 3 pm for the off-peak period; 3 pm to 7 pm for the PM peak and finally 7 pm to 6 am for night time periods respectively. Table 6 shows the pattern obtained.

Table 6: Intersection Collision by Time of Day

Intersection	AM Peak	Off-Peak	PM Peak	Night	TOTAL
	6-10am	10 am-3 pm	3-7pm	7pm-6am	
Erin Mills / Sheridan Park Dr	15	21	20	18	74
Winston Churchill/ Sheridan Park Dr	6	6	14	5	31
Fifth Line W/ Sheridan Park Dr	4	2	3	0	9
Homeland Dr/Sheridan Dr/ Speakman Dr	1	1	0	0	2
Hadwen Rd/ Speakman Dr	0	1	1	0	2
Speakman Dr/ Flavelle Blvd	0	2	0	1	3
Total	**26**	**33**	**38**	**24**	**121**

At most intersections, the collisions appeared spread across all times during the day; therefore, making it not possible to associate any pattern with a specific time period. However, at the Winston Churchill Blvd and Sheridan Park Drive Intersection, almost 50% of all collisions occurred during the PM peak period which may point to traffic volume patterns at that time or signal timing issues at the intersection. This is explored further in Section 3.2 below.

3.2 Detailed Safety Analysis

3.2.1 Winston Churchill /Sheridan Parkway Intersection

Over the analysis period, 31 collisions were recorded at the Winston Churchill Blvd and Sheridan Park Drive intersection. Almost 90% of the collisions (28) at the intersection were property damage with the rest (3) resulting in injury. Review of the patterns showed that rear end collisions accounted for over 50% of all the collisions. Collisions diagram for this intersection is presented in Figure 4.

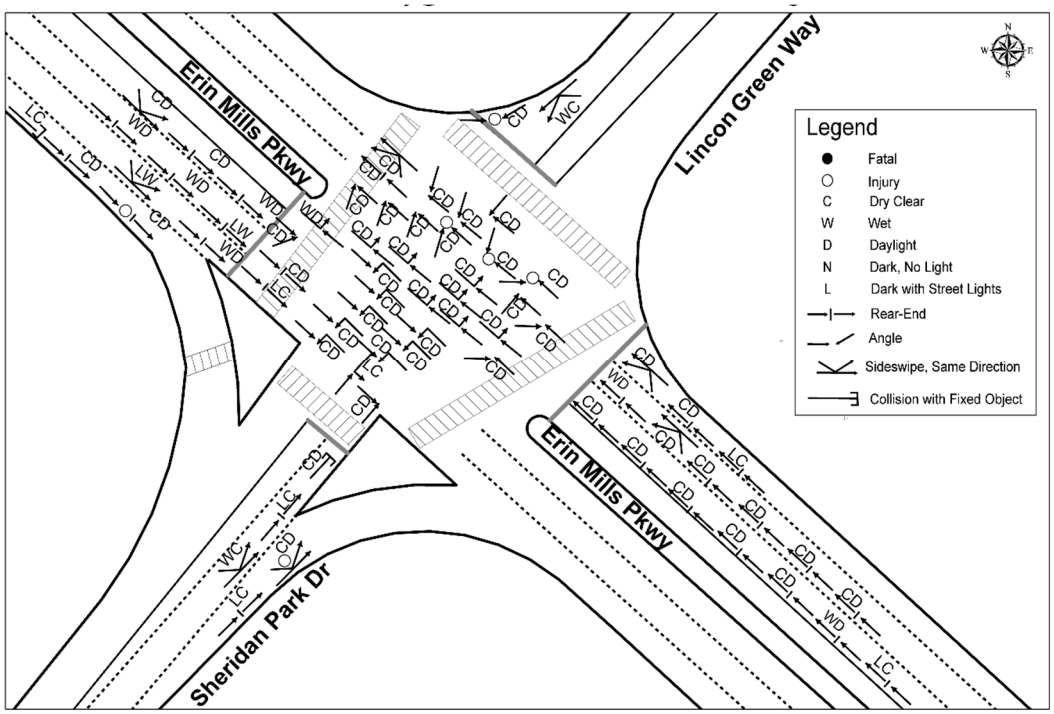
Figure 4: Sheridan Park Drive and Winston Churchill Blvd Intersection Collision Pattern

The figure shows that while several collisions occur within the intersection area, the majority occur on the southbound approach. Most of the collisions on that approach occur during the PM peak hour with the common manoeuvre being vehicles slowing down to stop. A review of traffic operations (provided in a separate report) shows that the intersection operates well at that time with the SB approach at Level of Service B. Noting that the approach slopes downwards towards the intersection, the collisions could be attributed to speeding, and inability of drivers to stop safely once the signal turns red.

3.2.2 Erin Mills Parkway /Sheridan Park Drive Intersection

The highest number of collisions was recorded at the Erin Mills Parkway/Sheridan Park Drive intersection during the analysis period. The intersection also had the highest traffic volumes of over 24,000 vehicles in the busiest six hours. A total of 74 collisions were recorded with the majority (85%) being property damage only. No fatal collisions were recorded anywhere in the Study Area. Collisions diagram for this intersection is shown in Figure 5.

Figure 5: Sheridan Park Drive and Erin Mills Pkwy Intersection Collision Pattern



Majority of the collisions (43%) occurred at the intersection area and were either turning or angle collisions. That was closely followed by rear end collisions that accounted for 41%. A greater percentage of the rear end collisions occurred on the northbound approach.

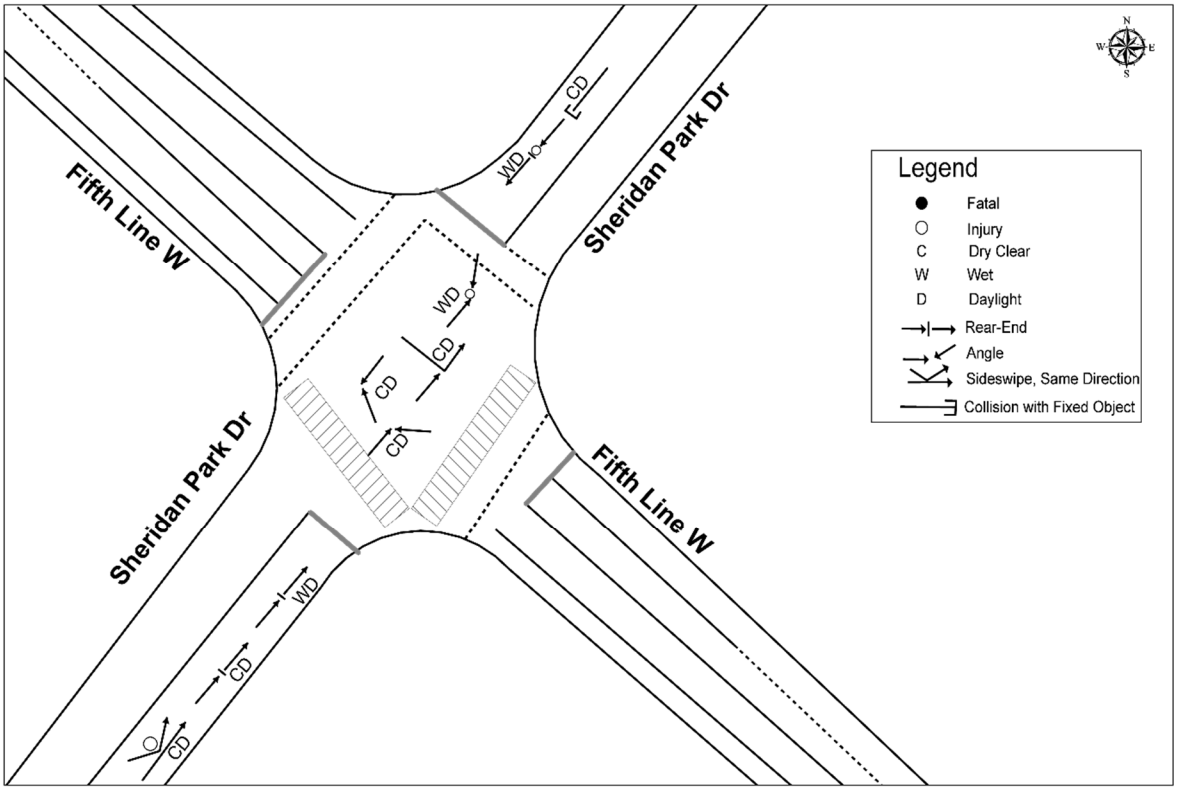
Operations at this intersection were reported to be fair at LOS C, but the east-west movements operated poorly at Level of Service E or F during both AM and PM peak hours. The poor operations are attributed to lower capacity on the approaches. That situation results in long delays for motorists who may often be tempted to enter the intersection even when the green signal has ended. As noted previously, queues on the eastbound approach are long and occasionally extend to Fifth Line West and Sheridan Park Drive Intersection. Coupled with that, there is a downward slope on the approach, thereby requiring greater effort to decelerate and stop when the signal is changing.

These factors could explain the high number of angle or turning collisions with east west traffic. Such a situation could be mitigated through measures that enhance capacities on those approaches such as the provision of protected left turn phasing or widening to accommodate more lanes.

3.2.3 Fifth Line /Sheridan Parkway Intersection

A total of nine collisions were recorded at this intersection over the five-year period. The collision diagram is shown in **Figure 6**. It is noteworthy to mention that three rear end collisions were on the EB approach. Because of the extensive queueing on the EB approach of the downstream intersection (Erin Mills Parkway), there is a high likelihood that the long queue played a contributory role in those rear end collisions.

Figure 6: Fifth Line W and Sheridan Park Dr Intersection Collision Pattern



3.2.4 Other Intersections

Collisions at the other Study Area intersections were few and did not warrant detailed considerations.

3.3 Potential for Safety Improvement (PSI)

Assessment for Potential for Safety Improvement was undertaken based on the calibrated City of Mississauga Models. The analysis was undertaken for the Erin Mills/Sheridan Park and the Winston Churchill /Sheridan Parkway intersections that experienced the highest number of collisions. The PSI models are based on the Empirical Bayes framework that aims at estimating long term safety performance of intersections and considers factors impacting road safety and how safety measures can reduce accident frequency and severity. The provided models for the City of Mississauga are included in the Appendix.

The PSI of an intersection is the difference between the long term expected safety performances and its predicted safety performance also including the societal cost of collision. The PSI of an intersection is comprised of both the PSI for the severe and PDO collisions. Only positive PSI value are used for consideration. Usually if the PSI is negative for a roadway element, it should be assigned a value of zero since the negative sign means that the intersection experiences fewer collisions than is expected.

3.3.1 Comparison of Predicted and Average Collisions

Predicted number of collisions were estimated using the Equation 1 below:

$$E(Y) = \boldsymbol{\alpha} \times \boldsymbol{F_{tot}^{b}} \times \{\frac{F\ min}{F\ tot}\}^{c} \qquad \textit{EQ 1}$$

Where,

E(Y) is the predicted number of collisions:
F_{maj} is the entering AADT on the major approach
F_{min} is the entering AADT on the minor approach
F_{tot} is the total entering volume of an intersection which is equal to F_{maj} + F_{min}
α , b, c are the model parameters estimated through the Full Bayes approaches.

The predicted annual collisions were then compared with actual average number of collisions obtained by dividing the observed number of collisions with the five-year analysis period at the two intersections as shown in Table 7.

Table 7: Expected Collisions

Intersection	Severity	AADT Major	AADT Minor	Inα	α	b	c	Predicted Collisions	Avg. Actual Collisions
Winston Churchill /Sheridan Park	Severe	31,700	6,800	-12.0015	6.135E-06	1.2137	0.480	**0.9649**	**0.60**
	PDO	31700	6,800	-12.0953	5.5857E-06	1.3955	0.566	**5.2516**	**5.60**
Erin Mill Pkwy/ Sheridan Park Dr	Severe	42,600	7,000	-12.0015	6.135E-06	1.2137	0.490	**1.1757**	**2.20**
	PDO	42,600	7,000	-12.0953	5.5857E-06	1.3955	0.566	**6.5877**	**12.60**

The results indicate that the Winston Churchill intersection is experiencing generally average number of collisions, the collisions frequency at the Erin Mills Pkwy intersections is much higher than expected. In fact, the intersection experienced approximately twice as much as the predicted number of collisions over the five-year period considered.

3.3.2 Estimation of Potential for Safety Improvement

The Potential for Safety Improvement is calculated for specific collision severity level:

i. Fatal and Injury (F&I)
ii. Property Damage Only (PDO)

In the Mississauga model, the number of factor collisions has a weighting factor of 135.5 while the number of injury collisions has a factor of 3.3. A weighting factor for economic and societal costs, the Relative Safety Index (RSI), is used to substitute the societal costs of collisions and is calculated thus:

$$\text{RSI} = \frac{135.5 \times Number\ of\ fatal\ Collisions + 3.3 \times Number\ of\ Injury\ Collisions}{Total\ Number\ of\ fatal\ and\ Injury\ Collisions} \qquad \textit{EQ 2}$$

The RSI value for an intersection is therefore assessed based on the respective numbered of recorded fatal and injury collisions. **Table 8** below shows the RSI values from the equation above for the two intersections considered.

Table 8: Relative Safety Index

Traffic Control Type/ Number of Legs	Intersection	Fatal	Injury	PDO	RSI
Signalized-4 Legged	Erin Mill Pkwy/ Sheridan Park Dr	0	11	63	3.3
Signalized-4 Legged	Winston Churchill Blvd/Sheridan Park Dr	0	3	28	3.3

Then the Potential for Safety Improvement is calculated as for each severity level and final factor obtained by summing up the various factors thus:

$$PSI_{F\&I} = (m_{F\&I} - E\{m\}_{F\&I}) - (RSI) \quad \textbf{EQ 3}$$

$$PSI_{PDO} = = (m_{PDO} - E\{m\}_{PDO}) \quad \textbf{EQ 4}$$

$$PSI_{ALL} = PSI_{F\&I} + PSI_{PDO} \quad \textbf{EQ 5}$$

Where,

m = the long term number of collision s expected to occur at the location per year,

$E\{m\}$= the number of collisions predicted to occur as an average per year.

The finally obtained PSI as well as selected intermediate model parameters are shown in **Table 9**. Negative results indicate the intersection experiences less than the expected collisions, and hence are assigned a value of zero (0.0).

Table 9: Potential for Safety Improvement

Model Parameters	Winton Churchill		Erin Mills	
	F&I Collisions	PDO Collisions	F&I Collisions	PDO Collisions
E{m}	0.9649	5.2516	1.1757	6.5877
m	0.7082	5.5725	1.9367	12.2151
m-E{m}	-0.2567	0.3208	0.7611	5.6275
RSI	3.3000	1.0000	3.3000	1.0000
PSI	-0.8471	0.3208	2.5115	5.6275
PSI (All)	-0.5262 (0.0)		8.1390	

The results provide PSI values of zero (0.0) and 8.1 for the Winston Churchill Blvd and Erin Mills Parkway intersections respectively. The PSI results indicate that there are benefits in undertaking safety improvements at the Erin Mills Parkway/Sheridan Park Drive intersection. However, those benefits may not accrue at the Winston Churchill Blvd and Sheridan Park Drive Intersection.

4. Future Conditions Review

Review of the safety performance under future conditions was undertaken following the design of improvements along the Sheridan Park Drive. It is recognized that safety performance will change in the future due to normal traffic growth and more so as a result of any recommended improvements on the road. This section reviews the changes in safety performance that will arise due to those factors in the future.

4.1 Review of Future Transportation Conditions

R.J Burnside & Associates Limited undertook future transportation analysis as documented in the *Sheridan Park Drive Extension Transportation Report,* that included assessment of future traffic demands and applying them to develop suitable improvements within the Study Area. The report assessed future traffic volumes on the basis of patterns developed from EMME outputs provided by the City of Mississauga and observed turning movement volume patterns at intersections. It was found that traffic growth at intersections would generally range from 0.5% to 3.5% per year up to future horizon years considered of 2021 and 2031.

The report recommended various improvements on the road network to address existing and projected traffic operational concerns. **Table 10** lists some of the proposed improvements from the traffic operations analysis of the Study Area.

Table 10:Summary of the Future improvements

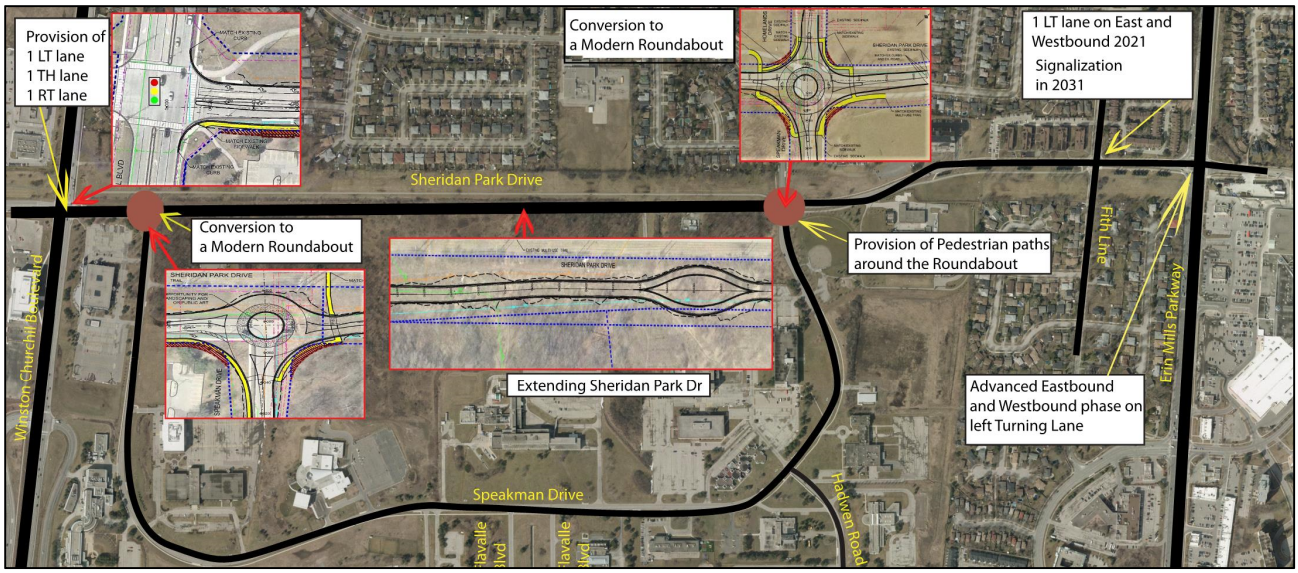
2021 Improvements	2031 Improvements
Conversion of the Sheridan Park Drive/Homeland cross Intersection to a roundabout	Signalization of the Fifth Line/Sheridan Park Drive intersection
Introduction of Eastbound and Westbound LT lanes of Fifth Line W/ Sheridan Park Drive	Winston Churchill Blvd 3 Lanes per Direction[1]
Introduction of sidewalks and crossing areas	
Introduction of Westbound RT lane on Winston Churchill Blvd/Sheridan Park Drive	
Introduction of a roundabout at Sheridan Park Drive / Speakman Drive (west leg)	

Most of the improvements will be required by 2021 and will include construction of the central section of Sheridan Park Drive into a two-lane cross section to provide a through roadway from Winston Churchill Boulevard to Erin Mills Parkway. In addition, several modifications are proposed on individual intersections that will include conversion from stop controlled intersections to roundabouts and widening to accommodate through movement or turning lanes. The improvements are illustrated schematically in **Figure 7**.

[1] *Improvements done with EMME Model and did not include any other roadway improvement.*

The proposed improvements will impact safety performance in the future and hence the need to undertake assessment to quantify those impacts.

Figure 7: Proposed Measures



4.2 General Impacts of Measures

4.2.1 Intersections Improvements

A summary of the proposed improvements and expected safety benefits is shown in **Table 11**.

Table 11: Summary of Proposed Improvements and Expected Safety Benefits

Intersection	Improvement	Expected Benefits
Erin Mill Pkwy/ Sheridan Park Dr	• Advanced Eastbound and Westbound phase on the LT lane	• Reduced conflicts
Fifth Line W/ Sheridan Park Dr	• Introduction LT in East and Westbound Direction 2021 • Signalizing the intersection prior to 2031 [2]	• Reduced conflicts
Homeland Dr/ Speakman @ Sheridan Dr	• Conversion of the intersection to roundabout.	• Improved traffic circulation • Reduced number of conflict points • Improved pedestrian safety
Hadwen Rd/ Speakman Dr	N/A	
Speakman Dr/ Flavelle Blvd	N/A	
Winston Churchill Blvd/Sheridan Park Dr	• Widening of the Sheridan approach from 2 to 3 lanes with 1 LT ,1 TH and 1 RT. • Signalization of the intersection	• Reduced conflicts with opposing traffic • Channelization of traffic • Improved pedestrian safety
Sheridan Park Drive/ Speakman Drive (West Leg)	• Conversion to a roundabout	• Improved traffic circulation • Reduced number of conflict points

[2] *Without Sheridan park Drive Extension, Signalization by 2021 with Sheridan Park Drive Extension.*

4.2.2 Impacts of Conversions to Modern Roundabouts

4.2.2.1 Homelands Dr/Speakman @ Sheridan Dr

The intersections as currently existing is designed as a 2 way stop control and is characterised by rear end and angle collisions by the vehicles approaching from the Sheridan Park Drive east leg. This may be attributed to sudden changes in speed as vehicles approach the intersection and inadequate turning space for the left turn movement. The conversion of the intersection to a modern roundabout will change the conflict points from crossing conflicts to merging conflicts. The roundabout is expected to reduce travel speeds and thereby reduce the likelihood of a rear end collision.

Potential Benefits of a roundabout

1. One-way travel -The traffic at the roundabout circles in one direction ruling out the possibility of a head on collision and significantly reducing the angle collisions.
2. Low travel speeds- Roundabouts have fewer severe collisions because of the low speeds and drivers must yield before entering the roundabout.
3. Roundabouts keep the traffic flow smooth thus vehicles can move into and out of an intersection faster and therefore less congestion.
4. Pedestrians experience fewer conflict points compared to the cross intersections.

Disadvantages of the roundabout

1. Drivers yield when approaching the intersection, this create a confusion for the pedestrians since the traffic does not come to a full stop.
2. The crosswalk locations are further out from the intersection about 6 metres or behind the yield point. This creates confusion since pedestrians must adjust to these roundabout operations.

4.2.2.2 Sheridan Park Drive/Speakman Drive (West Leg)

The conversion of the intersection to a roundabout will result in similar benefits on safety as discussed above on the Sheridan Park Drive and Homelands Drive. Additionally, the roundabout is expected to provide efficient operation for traffic from the new Sheridan Park extension and cater well for the various modes of transportation. This is expected to improve the overall safety experience within the entire Study Area and eliminate traffic infiltration and truck traffic on Homeland Drive neighbourhood.

4.2.3 Impacts of the Other improvements

4.2.3.1 Winston Churchill Blvd/Sheridan Park Dr

The design has proposed widening of the Sheridan Park Dr eastbound approach from 2 to 3 lanes (LT, TH, RT). This improvement will significantly impact on the traffic operations at the intersection. The right turn and the left turn lanes separate traffic movements at the intersection.

Benefit of provision of the turning lanes

1. They provide a safe place for turning drivers to wait for a gap in the opposing traffic therefore reducing the likelihood of angle collisions.
2. They improve the intersection capacity.
3. There is significant improvement on traffic flow within the intersection as traffic is channelized into definite paths as they approach the intersection.

4.3 Crash Modification Factors (CMF)

CMF's quantify the change in expected average crash frequency at a site resulting from implementation of a certain countermeasures. The CMF approach adopted from *Highway Safety Manual Vol. 3* was applied at three intersections where modifications are recommended in the future. An extract from the Manual showing the relevant CMF for the considered improvements is included in **Appendix 3. Table 12** tabulates a summary of the existing and future expected crashes at each intersection following implementation of the various improvements.

As an example, at the Winston Churchill/Sheridan Park intersection, the improvement is expected to result in a CMF of 0.73 that translate to reduced future crashes from existing 0.96 to anywhere between 0.63 to 0.78. This corresponds to 19% to 35% reduction in crashes. The range indicates the lower bound and upper bound limits for 95th percentile confidence on the factors and expected reductions.

Table 12: Summary of Expected Crashes

Intersection	Treatment	CMF	Existing Crashes/ year	Future Crashes /year	% Decrease
Winston Churchill Blvd/Sheridan Park Dr	Provide a Right Turn lane on one major road approaches	0.73	0.96	0.63 to 0.78	19% - 35%
Homeland Dr/ Speakman @ Sheridan Dr	Convert Intersection to modern roundabout	0.61	0.33	0.13 to 0.27	19% - 59%
Fifth Line W/ Sheridan Park Dr	Provide a Left Turn lane on both major road approaches	0.53	0.26	0.11 to 0.16	39% - 55%

The results indicate that the improvements will result in percentage crash reduction of between 19% to 35% at the Winston Churchill Blvd/Sheridan Park Drive intersection where a LT lane and one through lane are proposed, while at the Homeland/Sheridan Park Drive intersection, conversion to a roundabout will decrease collisions by between 19% – 59%.

It should be noted that these changes assume that all factors would remain relatively the same at the intersections. With increased volumes, higher collision rates are expected. It is estimated that without improvements, collision rates could escalate by 5 to 10% by 2021 as a result of traffic volume increases as per the assessed growth rates.

5. Conclusions and Recommendations

The analysis in this memorandum points to higher than normal collisions at the Erin Mills Parkway/Sheridan Park Drive intersection. The collision patterns point predominantly to poor operations on the intersection East-West movement that do not have protected left turn signals. These operations results in long queues that may in turn impact the safety at the Fifth Line/Sheridan Park Drive Intersection.

While the collision frequency at the Winston Churchill / Sheridan Park Drive / Plymouth Drive intersection was generally as expected, there was a disproportionate number on the southbound approach.

Under future conditions, the assessment indicates that the proposed measures will result in positive safety impacts with reduced number of collisions at the intersections where changes are planned.

It is recommended that the designed improvements be implemented as they would result in improved safety performance within the Study Area.

APPENDICES

Appendix 1:

Potential for safety Improvement (PSI) Model & Procedure

Collision Prediction Model for the City of Mississauga

Group	Type	Ln(α)	*b*	*c*	*k*	Pearson Chi-Square/Df	
Signalized 4-leg	**Severe**	-12.0015	1.2137	0.4897	0.4918	0.979	$E(Y) = \alpha \times F_{tot}^{b} \times \left(\frac{F_{min}}{F_{tot}}\right)^{c}$
Signalized 3-leg	**Severe**	-6.7111	0.606	0.3382	1.1451	0.9893	$E(Y) = \alpha \times F_{maj}^{b} \times \left(\frac{F_{min}}{F_{tot}}\right)^{c}$
2-way stop control 4-leg	**Severe**	-12.2183	1.2155	0.5337	0.4256	0.9456	$E(Y) = \alpha \times F_{tot}^{b} \times \left(\frac{F_{min}}{F_{tot}}\right)^{c}$
2-way stop control 3-leg	**Severe**	-13.3843	1.3362	0.6523	0.297	1.0087	$E(Y) = \alpha \times F_{tot}^{b} \times \left(\frac{F_{min}}{F_{tot}}\right)^{c}$
Signalized 4-leg	**PDO**	-12.0953	1.3955	0.5655	0.4439	0.9299	$E(Y) = \alpha \times F_{tot}^{b} \times \left(\frac{F_{min}}{F_{tot}}\right)^{c}$
Signalized 3-leg	**PDO**	-7.1172	0.8422	0.4217	0.7491	0.9348	$E(Y) = \alpha \times F_{tot}^{b} \times \left(\frac{F_{min}}{F_{tot}}\right)^{c}$
2-way stop control 4-leg	**PDO**	-9.5475	1.048	0.2517	0.6055	1.0618	$E(Y) = \alpha \times F_{tot}^{b} \times \left(\frac{F_{min}}{F_{tot}}\right)^{c}$
2-way stop control 3-leg	PDO	-11.1226	1.3123	0.7337	0.7693	1.0404	$E(Y) = \alpha \times F_{tot}^{b} \times \left(\frac{F_{min}}{F_{tot}}\right)^{c}$

E(Y) is the predicted number of collisions;

F_{maj} is the entering AADT on the major approaches;

F_{min} is the entering AADT on the minor approaches;

F_{tot} is the total entering volume of an intersection which is equal to $F_{maj} + F_{min}$;

α, b, and c are the model parameters estimated through the Full Bayes approach.

WEIGHTING FACTOR		
Fatal	Injury	PDO
135.5	3.3	1

Potential for safety Improvement (PSI) Model & Procedures

The formulae used are follows:

$$m = w_1 \times x + w_2 \times E\{m\} \qquad \textit{EQ 1}$$

Where w_1 and w_2 are the weighting factors that can be estimated by:

$$w_1 = \frac{E\{m\}}{(\frac{1}{k}) + (n \times E\{m\})} \qquad \textit{EQ 2}$$

$$w_2 = \frac{(\frac{1}{k})}{(\frac{1}{k}) + (n \times E\{m\})} \qquad \textit{EQ 3}$$

Where,

m = the long term number of collision s expected to occur at the location per year,

$E\{m\}$= the number of collisions predicted to occur as an average per year.

X = Observed number of collisions at a specific location per years,
n= number of years for which the collisions counts are available
k= the over –dispersion parameter that describe the relationship between $E\{m\}$ and VAR $\{m\}$ as previously described.

The PSI of an intersection is the difference between the long term expected safety performances and its predicted safety performance also including the societal cost of collision.

Therefore the PSI is calculated by:

$PSI_{TOTAL} = PSI_{severe} + PSI_{PDO}$ **EQ 4**

Where,

$PSI_{severe} = (m_{severe} - E\{m\}_{severe}) \times$ (Societal Cost of Fatal and Injury Collisions)

$PSI_{PDO} = = (m_{PDO} - E\{m\}_{PDO}) \times$ (Societal Cost of PDO)

In light of this study, the estimated weighting factors for the fatal, injury and PDO collisions was 135:3.3:1. The weighting factor is used to substitute the societal costs of collisions.
Then:

$PSI_{F+1} = (m_{severe} - E\{m\}_{severe}) \times$ (weighted factor of fatal and Injury Collisions)

$PSI_{PDO} = = (m_{PDO} - E\{m\}_{PDO})$

Because the SPF $_{severe}$ is used in this study, the economic weighted factor, or relative safety index (RSI), must be derived for severe collisions. The RSI for intersections is estimated by,

$$RSI = \frac{135.5 \times Number\ of\ fatal\ Collisions + 3.3 \times Number\ of\ Injury\ Collisions}{Total\ Number\ of\ fatal\ and\ Injury\ Collisions} \quad \textbf{EQ 5}$$

For this study, RSI value for intersection are acquired based on the respective numbered of recorded fatal and injury collisions for intersections in the Region. The table below shows the RSI values from the equation above.

Take together the following equation are used in this study to estimate the PSI for the intersection.

$PSI_{F+1} = (m_{severe} - E\{m\}_{severe}) - (RSI)$ **EQ 6**

$PSI_{PDO} = = (m_{PDO} - E\{m\}_{PDO})$ **EQ 7**

$PSI_{ALL} = PSI_{severe} + PSI_{PDO}$ **EQ 8**

Only positive PSI value are used for consideration. Usually if the PSI is negative for a roadway element, it should be assigned a value of zero since the negative sign means that the intersection experiences fewer collisions than is expected.

Appendix 2:

Estimation of Future Collision Rates due to Traffic Volume Increase

Table A2-1: Severe Crash Projections

Severe Collisions									
Intersection	**AADT Major 2016**	**AADT Minor 2016**	**% Growth 2021**	**AADT Major 2021**	**AADT Minor 2021**	**EB-adjusted Collisions 2016**	**Actual Avg. Annual Collisions**	**EB-Adjusted Predicted Collisions 2021**	**% Increase**
Erin Mill Pkwy/ Sheridan Park Dr	42600	7000	1.5	43676	7541	1.18	2.2	1.25	6%
Fifth Line W/ Sheridan Park Dr	7680	4220	0.5	8274	4546	0.26	0.6	0.28	9%
Homeland Dr/Speakman @ Sheridan Dr	7850	5700	1.0	8457	5844	0.33	0.0	0.34	5%
Hadwen Rd/ Speakman Dr	5530	3590	1.0	5670	3681	0.24	0.0	0.25	3%
Speakman Dr/ Flavelle Blvd	5410	3700	1.0	5547	3889	0.54	0.0	0.57	6%
WinstonChurchill Blvd/Sheridan Park Dr	31700	6800	2.0	32500	8076	0.96	0.6	1.09	13%

Table A2-2: Property Damage Only Projections

PDO Collisions									
Intersection	**AADT Major 2016**	**AADT Minor 2016**	**% Growth 2021**	**AADT Major 2021**	**AADT Minor 2021**	**EB-Adjusted Collisions 2016**	**Actual Avg. Annual Collisions**	**EB-Adjusted Predicted Collisions 2021**	**% Increase**
Erin Mill Pkwy/ Sheridan Park Dr	42600	7000	1.5	43676	7541	6.59	12.6	7.06	7%
Fifth Line W/ Sheridan Park Dr	7680	4220	0.5	8274	4546	1.51	1.2	1.68	11%
Homeland Dr/Speakman @ Sheridan Dr	7850	5700	1.0	8457	5844	1.05	0.4	1.11	5%
Hadwen Rd/ Speakman Dr	5530	3590	1.0	5670	3681	1.11	0.4	1.15	4%
Speakman Dr/ Flavelle Blvd	5410	3700	1.0	5547	3889	1.20	0.6	1.27	6%
WinstonChurchill Blvd/Sheridan Park Dr	31700	6800	2.0	32500	8076	5.25	0.6	6.05	15%

Appendix 3: Collision Modification Factors

Roundabout Conversion CMF

Table 14-4. Potential Crash Effects of Converting a Stop-Controlled Intersections into a Modern Roundabout (29)

Treatment	Setting (Intersection Type)	Traffic Volume	Crash Type (Severity)	CMF	Std. Error
Convert intersection with minor-road stop control to modern roundabout	All settings (One or two lanes)	Unspecified	All types (All severities)	**0.56**	**0.05**
			All types (Injury)	**0.18**	**0.04**
	Rural (One lane)		All types (All severities)	**0.29**	**0.04**
			All types (Injury)	**0.13**	**0.04**
	Urban (One or two lanes)		All types (All severities)	**0.71**	**0.1**
			All types (Injury)	**0.19**	**0.1**
	Urban (One lane)		All types (All severities)	**0.61**	**0.1**
			All types (Injury)	**0.22**	**0.1**
	Urban (Two lanes)		All types (All severities)	*0.88*	*0.2*
	Suburban (One or two lanes)		All types (All severities)	**0.68**	**0.08**
			All types (Injury)	**0.29**	**0.1**
	Suburban (One lane)		All types (All severities)	**0.22**	**0.07**
			All types (Injury)	**0.22**	**0.1**
	Suburban (Two lanes)		All types (All severities)	**0.81**	**0.1**
			All types (Injury)	**0.32**	**0.1**
Convert all-way, stop-controlled intersection to roundabout	All settings (One or two lanes)		All types (All severities)	*1.03**	*0.2*

Base Condition: Stop-controlled intersection.

LT on both Major Road Conversion CMF

Table 14-12. Potential Crash Effects of Providing a Left-Turn Lane on Two Approaches to Four-Leg Intersections (16)

Treatment	Setting (Intersection Type)	Traffic Volume AADT (veh/day)	Crash Type (Severity)	CMF	Std. Error
Provide a left-turn lane on both major-road approaches	Rural (Four-leg, minor-road stop-controlled intersection)	Major road 1,500 to 32,400, minor road 50 to 11,800	All types (All severities)	**0.52**	**0.04**
			All types (Injury)	**0.42**	**0.04**
	Urban (Four-leg, minor-road stop-controlled intersection)	Major road 1,500 to 40,600, minor road 200 to 8,000	All types (All severities)	**0.53**	**0.04**
			All types (Injury)	**0.50**	**0.06**
	Rural (Four-leg signalized intersection)	Unspecified	All types (All severities)	0.67	N/A°
	Urban (Four-leg Signalized intersection)	Major road 7,200 to 55,100, minor road 550 to 2,600	All types (All severities)	**0.81**	**0.1**
			All types (Injury)	**0.83**	**0.02**
	Urban (Four-leg newly signalized[a] intersection)	Major road 4,600 to 40,300, minor road 100 to 13,700	All types (All severities)	**0.58**	**0.04**
			All types (Injury)	**0.52**	**0.07**

Base Condition: A four-leg intersection without a left-turn lane

LT on one Major Road Conversion CMF

Table 14-11. Potential Crash Effects of Providing a Left-Turn Lane on One Approach to Four-Leg Intersections (16)

Treatment	Setting (Intersection Type)	Traffic Volume AADT (veh/day)	Crash Type (Severity)	CMF	Std. Error
Provide a left-turn lane on one major-road approach	Rural (Four-leg, minor-road stop-controlled intersection)	Major road 1,600 to 32,400, minor road 50 to 11,800	All types (All severities)	**0.72**	**0.03**
			All types (Injury)	**0.65**	**0.04**
	Urban (Four-leg, minor-road stop-controlled intersection)	Major road 1,500 to 40,600, minor road 200 to 8,000	All types (All severities)	**0.73**	**0.04**
			All types (Injury)	**0.71**	**0.05**
	Rural (Four-leg signalized intersection)	Unspecified	All types (All severities)	0.82	N/A°
	Urban (Four-leg signalized intersection)	Major road 7,200 to 55,100, minor road 550 to 2,600	All types (All severities)	**0.90***	**0.1**
			All types (Injury)	**0.91**	**0.02**
	Urban (Four-leg newly signalized intersection)	Major road 4,600 to 40,300, minor road 100 to 13,700	All types (All severities)	**0.76**	**0.03**
			All types (Injury)	**0.72**	**0.06**

Base Condition: A four-leg intersection without left-turn lanes.