B2. Traffic Safety Report

AECOM

Region of Peel

Dixie Road from Queen Street to Mayfield Road Class Environmental Assessment Traffic Safety Report

Prepared by:

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Project Number:

60118562

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Hitesh Topiwala, MCIP, RPP
Project Manager, Transportation Program Planning
Transportation Division, Public Works
Region of Peel
9445 Airport Road
Brampton ON L6S 4J3

Dear Mr. Topiwala:

Re: Dixie Road from Queen Street to Mayfield Road Class Environmental Assessment - Traffic Safety Report

Enclosed please find the Traffic Safety Report for this project.

Sincerely,
AECOM Canada Ltd.

Brenda Jamieson, P.Eng.
Associate Vice President, Transportation
Brenda.Jamieson@aecom.com

Encl. Traffic Safety Report

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1. Introduction

The Region of Peel has initiated a Class Environmental Assessment for improvements of Dixie Road between Queen Street East and Mayfield Road. In order to best address operational deficiencies and the need for additional north-south capacity in the area, a number of alternative designs have been examined and proposed to the Region. As part of this study a road safety assessment of existing conditions has been conducted. **Section 2** below presents the findings of safety assessment of existing conditions. Also **Section 3** deals with the safety performance assessment of the proposed alternative design in comparison to the existing design in a quantitative way.

2. Safety Assessment of Existing Condition

A safety assessment of the existing conditions within the study area - Dixie Road from Queen Street to approximately two kilometres north of Mayfield Road including the intersection of Mayfield Road and Dixie Road - was conducted with the aim of identifying locations that have poor safety performance and that require more detailed safety investigation on this portion of Dixie Road within the study area. The following intersections and midblock road sections along Dixie Road were analyzed as part of this safety assessment:

- Dixie Road Intersections at:

    1. Queen Street East;
    2. Hillside Drive;
    3. Hazelwood Drive;
    4. Howden Boulevard;
    5. Crescent Hill Drive South;
    6. Crescent Hill Drive North;
    7. Lascelles Boulevard;
    8. Williams Parkway East;
    9. Northampton Street;
    10. North Park Drive;
    11. Northcliffe Street;
    12. Bovaird Drive East;
    13. Peter Robertson Boulevard;
    14. Springtown Trail;
    15. Sandalwood Parkway;
    16. Octillo Boulevard;
    17. Father Tobin Road;
    18. Countryside Drive;
    19. Mayfield Road; and

- Mid-block sections along Dixie Road between:

    1. Queen Street East and Hillside Drive;
    2. Hillside Drive and Hazelwood Drive;
    3. Hazelwood Drive and Howden Boulevard;
    4. Howden Boulevard and Crescent Hill Drive South;
    5. Crescent Hill Drive South and Crescent Hill Drive North;
    6. Crescent Hill Drive North and Lascelles Boulevard;
    7. Lascelles Boulevard and Williams Parkway East;
    8. Williams Parkway East and Northampton Street;
    9. Northampton Street and North Park Drive;
    10. North Park Drive and Northcliffe Street;
    11. Northcliffe Street and Bovaird Drive East;
    12. Bovaird Drive East and Peter Robertson Boulevard;
    13. Peter Robertson Boulevard and Springtown Trail;
    14. Springtown Trail and Sandalwood Parkway;
    15. Sandalwood Parkway and Octillo Boulevard;
    16. Octillo Boulevard and Father Tobin Road;
    17. Father Tobin Road and Countryside Drive;
    18. Countryside Drive and Mayfield Road, and
    19. Mayfield Road to two kilometres north of Mayfield Road.

2.1 Collision Data

The Region of Peel provided AECOM team with three years of collision data (2005 to 2007) detailing collisions that occurred at all intersections and along all the mid-blocks in the study area.

Collision details included location, collision severity, collision type, date, time, lighting condition, road surface condition, and environmental conditions. A review of the collisions was undertaken to identify:

- Observed collision trends;
- Locations that showed a potential for safety improvement; and
- Over-represented collision characteristics.

Table 1 and **Table 2** summarize the number of collisions for each location. It should be noted that intersections and road sections that had no collisions reported over the period of 2005 through 2007 (highlighted in grey in **Table 1** and **Table 2**) were not taken into consideration in this analysis as including these locations in the analysis would not result in any meaningful or significant findings.

Table 1: Observed Number of Collisions Classified by Severity Occurred at Intersections along Dixie Road from 2005 to 2007

Location ID	Location Description – Intersections At:	Fatal	Injury	Property Damage Only	Unknown	Total
00420119S	Queen Street East	0	14	105	3	122
00420298N	Hillside Drive	0	1	7	0	8
00420632N	Hazelwood Drive	0	0	1	1	2
00420805S	Howden Boulevard	0	5	18	1	24
00421091N	Crescent Hill Drive South	0	0	0	0	0
00421248N	Crescent Hill Drive North	0	0	0	0	0
00421409N	Lascelles Boulevard	0	0	0	0	0
00421753S	Williams Parkway East	0	6	18	0	24
00422014S	Northampton Street	0	1	7	0	8
00422452S	North Park Drive	0	1	12	1	14
00422827N	Northcliffe Street	0	2	6	0	8
00423204S	Bovaird Drive East	0	14	100	0	114
00423821S	Peter Robertson Boulevard	0	5	18	0	23
00424503S	Springtown Trail	0	0	2	0	2
00424821S	Sandalwood Parkway	0	9	13	0	22
00425302S	Octillo Boulevard *	0	2	4	0	6
00425892S	Father Tobin Road	0	0	4	0	4
00426281S	Countryside Drive	0	2	1	0	3
00427526S	Mayfield Road	0	4	4	0	8
Total		**0**	**66**	**320**	**6**	**392**

* Intersection of Dixie Road at Octillo Boulevard converted to a signalized intersection in 2007.

Table 2: Observed Number of Collisions Classified by Severity Occurred on Mid-block Road Sections along Dixie Road from 2005 to 2007

Location ID	Location Description – Mid-Blocks Between:	Fatal	Injury	Property Damage Only	Unknown	Total
00420119L	Queen Street East and Hillside Drive	0	1	6	0	7
00420298L	Hillside Drive and Hazelwood Drive	0	0	1	0	1
00420632L	Hazelwood Drive and Howden Boulevard	0	1	0	0	1
00420805L	Howden Boulevard and Crescent Hill Drive South	0	0	0	0	0
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	0	0	0	0	0
00421248L	Crescent Hill Drive North and Lascelles Boulevard	0	0	0	1	1
00421409L	Lascelles Boulevard and Williams Parkway East	0	0	1	0	1
00421753L	Williams Parkway East and Northampton Street	0	1	2	0	3
00422014L	Northampton Street and North Park Drive	0	0	2	0	2
00422452L	North Park Drive and Northcliffe Street	0	0	0	1	1
00422827L	Northcliffe Street and Bovaird Drive East	0	0	1	0	1
00423204L	Bovaird Drive East and Peter Robertson Boulevard	0	0	2	0	2
00423821L	Peter Robertson Boulevard and Springtown Trail	0	0	0	0	0
00424503L	Springtown Trail and Sandalwood Parkway	0	0	0	0	0
00424821L	Sandalwood Parkway and Octillo Boulevard	0	0	1	0	1
00425302L	Octillo Boulevard and Father Tobin Road	0	1	0	0	1
00425892L	Father Tobin Road and Countryside Drive	0	0	1	0	1
00426281L	Countryside Drive and Mayfield Road	0	0	1	0	1
	Mayfield Road to 2 Km North of Mayfield Road	0	0	3	0	3
Total		**0**	**4**	**21**	**2**	**27**

2.2 Collision Analysis

2.2.1 Collision Trends

Collision records were analyzed to identify trends. Various collision characteristics for each of the intersections and road segments were examined in terms of the following characteristics:

- Collision severity including property damage only, injury and fatal;
- Collision impact type;
- Month and Season of collision;
    - Winter (December 22 to March 21)
    - Spring (March 22 to June 21)
    - Summer (June 22 to September 21)
    - Fall (September 22 to December 21)
- Time of day; and
    - Early Morning (12am to 6am)
    - AM Rush Hour (6am to 10am)
    - Midday (10am to 4pm)
    - PM Rush Hour (4pm to 8pm)
    - Evening (8pm to 12am)
- Lighting condition,
- Road surface condition, and
- Environmental condition.

Throughout the entire study area a total number of 419 reported collisions occurred over the period of three years between 2005 and 2007. From a total of 419 collisions 27 collisions occurred along the midblock road sections and the remaining 392 collisions were reported to occur at 19 intersections along Dixie Road. As can be seen in **Table 1** and **Table 2**, the majority of collisions (81.6% for intersections and 77.8% for mid-block road sections) were property damage only collisions. Also no fatal collision has been reported throughout the study area over the study period.

The following trends were observed with regard to other characteristics of the collisions which occurred on mid-block road sections or at intersections located inside the study area over the period of 2005 through 2007.

Collision Impact Type - Table A1 and **Table A2** in **Appendix A** present the observed number of collisions classified by impact type that occurred at intersections or on mid-block road sections respectively. The predominant impact type along this portion of Dixie Road were rear-end collisions representing (41.3% for intersections and 48.1% for mid-block road sections), followed by

angle collisions (20.9%) for intersections and sideswipe collisions (14.8%) for mid-block road sections.

Month and Season of Collisions – As can be seen in **Table A3** in **Appendix A**, for intersections, fall appears to be the season with the highest proportion (33.7%) of collisions. Whereas presented in **Table A4**, for midblock road sections, the majority of the collisions distributed fairly equally between winter (37.0%) and summer (29.6%). Also presented in **Table A5**, for intersections, months of November (12.7%) and December (11.9%) have the greatest number of collisions while as illustrated in **Table A6**, for midblock road sections, months of February (19.2%), July (15.4%), and September (15.4%) have the highest number of collisions.

Time of Day – **Table A7** and **Table A8** in **Appendix A** show that for intersections, Midday appears to be the time of day with highest number of collisions (31.4%). For midblock road sections, the highest portion of collisions occurred during AM rush hour (44.4%).

Lighting, Road Surface, and Environmental Conditions – As can be seen in **Table A9** through **Table A14**, for both intersections and midblock road sections, the majority of the collisions (ranging between 66.7% to 81.5%) occurred under ideal driving conditions which is daylight, dry road surface, and clear environmental conditions.

2.2.2 Potential for Safety Improvement (PSI)

In order to identify the locations with the highest potential for safety improvements, it is vital that a sound procedure be used to screen the study area. A location with potential for safety improvement is defined as any location that exhibits a collision potential that is significantly high when compared with some normal collision potential derived from a group of similar locations. Many road agencies describe the collision potential of a location using a measure of collision frequency, which is defined as the number of collisions occurring at a location during a specific time period.

Evaluating the potential for safety improvement (PSI) for the study area involved the following steps:

- Use safety performance function (SPFs) developed by AECOM (then doing business as Synectics Transportation Consultants) for the Region of Halton, for similar type of roadway and intersections, to predict yearly number of severe collisions (fatal and injury) and minor collisions (property damage only) for the intersections and mid-block road sections within the study area.
- Use the Empirical Bayes (EB) technique to calculate the expected number of collisions by combining the predicted yearly number of fatal and injury (FI)

and property damage only (PDO) collisions and the observed number of FI and PDO respectively.

- Calculate the potential for safety improvement at each location which is the difference between the expected and predicted number of collisions. This methodology is depicted graphically in **Figure 1**.

Appendix B contains a complete description of the methodology and a sample calculation to obtain the potential for safety improvement.

The PSI ranking in this report pertains strictly to the study area and has no bearing on the overall Region of Peel's intersections.

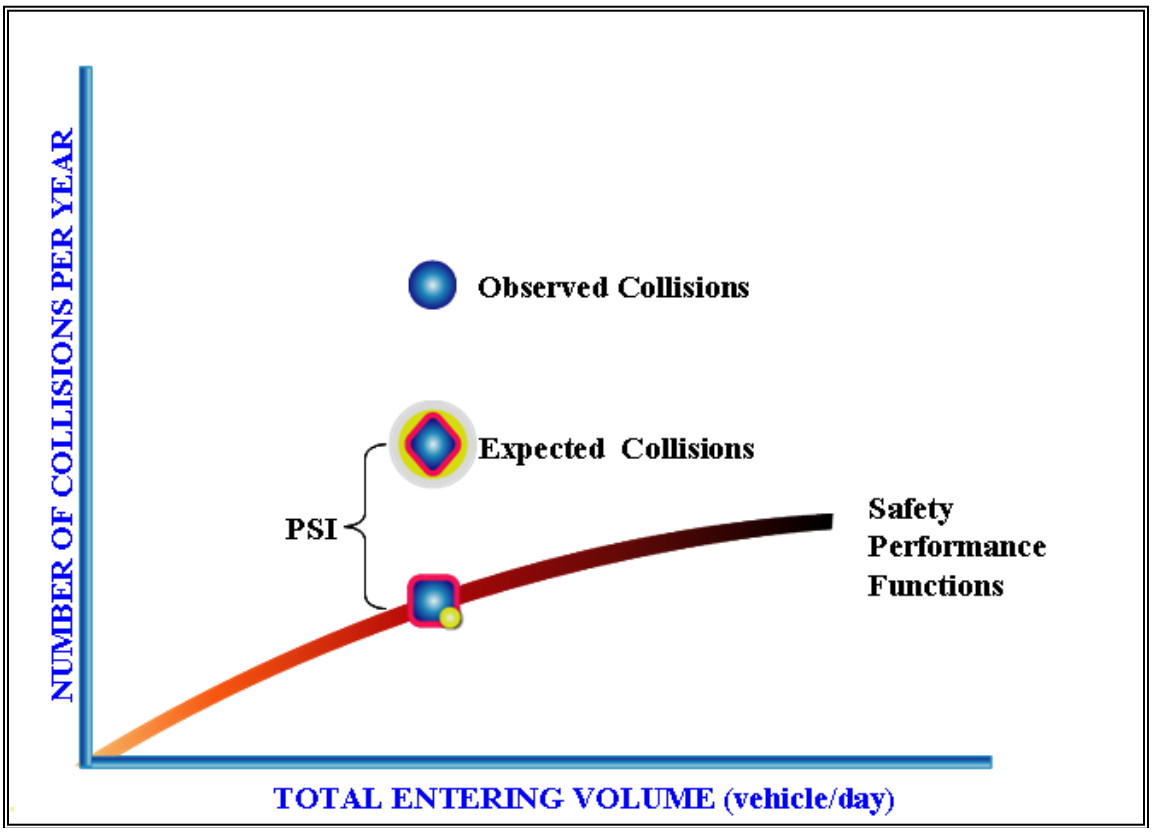

Figure 1. Potential for Safety Improvement (PSI)

The collision and roadway characteristics for the entire study area used in the analysis are detailed below in **Table 3** and **Table 4**.

Table 3: Intersections Characteristics

Location ID	Location Description - Dixie Road At	Number of Legs - Traffic Control Type	Total Entering AADT on Major Road	Total Entering AADT on Minor Road	Period (Years)	Fatal and Injury	Property Damage Only
00420119S	Queen Street East	Four - Traffic Control	38600	26770	3	14	105
00420298N	Hillside Drive	Three - Stop Sign	25750	650	3	1	7
00420632N	Hazelwood Drive	Three - Stop Sign	24590	300	3	0	1
00420805S	Howden Boulevard	Four - Traffic Signal	24160	9210	3	5	18
00421091N	Crescent Hill Drive South	Three - Stop Sign	22778 *	200 *	3	0	0
00421248N	Crescent Hill Drive North	Three - Stop Sign	22778 *	200 *	3	0	0
00421409N	Lascelles Boulevard	Three - Stop Sign	22940	1230	3	0	0
00421753S	Williams Parkway East	Four - Traffic Signal	21070	19120	3	6	18
00422014S	Northampton Street	Four - Traffic Signal	21030	2540	3	1	7
00422452S	North Park Drive	Four - Traffic Signal	18980	8840	3	1	12
00422827N	Northcliffe Street	Four - Stop Sign	17880	1750	3	2	6
00423204S	Bovaird Drive East	Four - Traffic Signal	35300	15980	3	14	100
00423821S	Peter Robertson Boulevard	Four - Traffic Signal	15990	8580	3	5	18
00424503S	Springtown Trail	Four - Traffic Signal	14460	380	3	0	2
00424821S	Sandalwood Parkway	Four - Traffic Signal	30410	14190	3	9	13
00425302S	Octillo Boulevard	Three - Traffic Signal	14790	1870	3	2	4
00425892S	Father Tobin Road	Three - Traffic Signal	15680	2180	3	0	4
00426281S	Countryside Drive	Four - Traffic Signal	12190	1920	3	2	1
00427526S	Mayfield Road	Four - Traffic Signal	11790	8490	3	4	4

* Turning movement counts were not available for intersections along Dixie Road at Crescent Hill Drive South and Crescent Hill Drive North. Therefore for analysis purposes the major and minor AADTs were estimated based on turning movement counts on adjacent mid-block road sections and analysts judgement.

Table 4: Mid-Block Road Sections Characteristics

Location ID	Location Description – Dixie Road Between:	Type – No. of Lanes	Section Length (m)	AADT	Period (Years)	Fatal and Injury	Property Damage Only
00420119L	Queen Street East and Hillside Drive	U - 4	173	25548	3	1	6
00420298L	Hillside Drive and Hazelwood Drive	U - 4	334	24778	3	0	1
00420632L	Hazelwood Drive and Howden Boulevard	U - 4	172	24816	3	1	0
00420805L	Howden Boulevard and Crescent Hill Drive South	U - 4	291	22778 *	3	0	0
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	U - 4	160	22778 *	3	0	0
00421248L	Crescent Hill Drive North and Lascelles Boulevard	U - 4	159	22778 *	3	0	0
00421409L	Lascelles Boulevard and Williams Parkway East	U - 4	347	22085	3	0	1
00421753L	Williams Parkway East and Northampton Street	U - 4	261	21447	3	1	2
00422014L	Northampton Street and North Park Drive	U - 4	436	19000	3	0	2
00422452L	North Park Drive and Northcliffe Street	U - 4	378	18319	3	0	0
00422827L	Northcliffe Street and Bovaird Drive East	U - 4	377	16911	3	0	1
00423204L	Bovaird Drive East and Peter Robertson Boulevard	U - 4	618	17220	3	0	2
00423821L	Peter Robertson Boulevard and Springtown Trail	U - 4	685	15078	3	0	0
00424503L	Springtown Trail and Sandalwood Parkway	U - 4	319	14255	3	0	0
00424821L	Sandalwood Parkway and Octillo Boulevard	U - 4	476	15684	3	0	1
00425302L	Octillo Boulevard and Father Tobin Road	U - 4	594	16034	3	1	0
00425892L	Father Tobin Road and Countryside Drive	U - 4	385	13111	3	0	1
00426281L	Countryside Drive and Mayfield Road	SU - 2	1245	10603	3	0	1
	Mayfield Road to 2 Km North of Mayfield Road	SU - 2	2000	9041	3	0	3

U = Urban and SU = Suburban

* Turning movement counts were not available for intersections along Dixie Road at Crescent Hill Drive South and Crescent Hill Drive North. Therefore for analysis purposes the AADTs were estimated based on turning movement counts on adjacent mid-block road sections and analysts judgement.

The safety performance functions used to determine the expected numbers of collisions for the intersections are found in **Table 5** and **Table 6** and those for mid-block road sections in **Table 7** and **Table 8**. It is noteworthy that in the study corridor all the mid-block road sections along Dixie Road have been categorized as urban multi-lane roads except for the portion of Dixie Road from Countryside Road to two kilometres north of Mayfield Road which was regarded as a suburban two-lane road.

Table 5: Safety Performance Functions for 4-legged Intersections

		Collision Classification		
		Fatal and Injury	**Property Damage Only**	**Total**
Signalized	**Model Form**	$\alpha(F_1)^d(F_2)^e$	$\alpha(F_1+F_2)^b(\frac{F_2}{F_1+F_2})^e$	$\alpha(F_1)^d(F_2)^e$
	Ln(α)	-9.8141 (0.3008, -32.63)	-10.2393 (0.4240, -24.15)	-9.1138 (0.3356, -27.16)
	b		1.2760 (0.415, 30.78)	
	c		0.5954 (0.0312, 19.11)	
	d	0.5614 (0.0643, 8.73)		0.5312 (0.0330, 16.08)
	e	0.5707 (0.0672, 8.49)		0.6916 (0.0348, 19.85)
	Pearson Chi-Square	1.0957	1.1248	1.1237
	k	0.4842	0.5413	0.5251
Stop-Controlled	**Model Form**	$\delta(F_1+F_2)^b(\frac{F_2}{F_1+F_2})^c$	$\delta(F_1)^d(F_2)^e$	$\delta(F_1+F_2)^b(\frac{F_2}{F_1+F_2})^c$
	Ln(α)	-3.4949 (0.7633, -4.58)	-4.9268 (0.5941, -8.29)	-3.8119 (0.6724, -5.67)
	b	0.3113 (0.1003, 3.10)		0.4831 (0.0841, 5.75)
	c	0.3164 (0.0874, 3.62)		0.3319 (0.0338, 9.82)
	d		0.2179 (0.0590, 3.69)	
	e		0.3611 (0.0491, 7.35)	
	Pearson Chi-Square	1.0152	1.1463	1.1104
	k	1.3779	1.0475	1.1718

Note: (Standard Error, Z)
F_1 = Total Entering AADT for Major Road
F_2 = Total Entering AADT for Minor Road

Table 6: Safety Performance Functions for 3-legged Intersections

		Collision Classification		
		Fatal and Injury	**Property Damage Only**	**Total**
Signalized	**Model Form**	$\delta(F_1)^d(F_2)^e$	$\delta(F_1)^d(F_2)^e$	$\delta(F_1)^d(F_2)^e$
	Ln(α)	-5.9342 (1.3545, -4.38)	-6.5880 (0.5524, -11.93)	-5.6150 (0.7400, -7.59)
	b			
	c			
	d	0.3148 (0.1193, 2.64)	0.4087 (0.0568, 7.20)	0.3567 (0.0704, 5.07)
	e	0.3310 (0.0909, 3.64)	0.4400 (0.0407, 10.81)	0.4154 (0.0542, 7.66)
	Pearson Chi-Square	1.1274	1.0438	1.0872
	k	0.8486	1.0407	1.1066
Stop-Controlled	**Model Form**	$\delta(F_1+F_2)^b(\frac{F_2}{F_1+F_2})^c$	$\delta(F_1+F_2)^b(\frac{F_2}{F_1+F_2})^c$	$\delta(F_1)^d(F_2)^e$
	Ln(α)	-9.4430 (0.8302, -11.37)	-7.7853 (0.4777, -16.30)	-7.4457 (0.3671, -20.28)
	b	0.9466 (0.0960, 9.86)	0.9113 (0.0566, 16.11)	
	c	0.3617 (0.0144, 25.05)	0.4830 (0.0423, 11.42)	
	d			0.4256 (0.0375, 11.34)
	e			0.4910 (0.0339, 14.49)
	Pearson Chi-Square	1.2466	1.2157	1.2490
	k	1.4829	1.2061	1.1891

Note: (Standard Error, Z)
F_1 = Total Entering AADT for Major Road
F_2 = Total Entering AADT for Minor Road

Table 7: Safety Performance Functions for Urban Multi-Lane Mid-Block Road Sections

	Collision Classification		
	Fatal and Injury	**Property Damage Only**	**Total**
Model Form	$\alpha \times (L)^c \times (F)^b$	$\alpha \times (L)^c \times (F)^b$	$\alpha \times (L)^c \times (F)^b$
Ln(α)	-14.5297 (0.6817, 21.32)	-13.0149 (0.3839, -33.90)	-12.8012 (0.4067, -31.48)
b	0.6758 (0.0523, 12.91)	0.7498 (0.0400, 18.74)	0.7379 (0.0398, 18.53)
c	1.0844 (0.0586, 18.50)	0.9488 (0.0235, 40.32)	0.9686 (0.0247, 39.19)
Pearson Chi-Square	0.9773	1.1016	1.0816
k	1.6062	1.7162	1.6004

Note: (Standard Error, Z)
F = Total AADT for Road Section
L = Length of Road Section

Table 8: Safety Performance Functions for Suburban Two-Lane Mid-Block Road Sections

	Collision Classification		
	Fatal and Injury	**Property Damage Only**	**Total**
Model Form	$\alpha \times (L) \times (F)^b$	$\alpha \times (L)^c \times (F)^b$	$\alpha \times (L)^c \times (F)^b$
Ln(α)	-20.4183 (1.1019, -18.53)	-13.3195 (0.5794, -22.99)	-14.0149 (0.4570, -30.67)
b	1.3507 (0.1280, 10.56)	0.7970 (0.0549, 14.52)	0.8867 (0.0419, 21.16)
c		0.8919 (0.0358, 24.90)	0.9132 (0.0346, 26.37)
Pearson Chi-Square	0.9100	1.2897	1.3664
k	1.0115	1.6010	1.5478

Note: (Standard Error, Z)
F = Total AADT for Road Section
L = Length of Road Section

The study team obtained the potential for improvements for both property damage only (PDO) and fatal and injury (FI) collisions in terms of number of collisions by simply obtaining the differences between “predicted numbers of FI collisions” and “expected number of FI collisions” and the difference between corresponding PDO values.

Locations with positive PSI values (those highlighted in grey in **Table 9**) have a potential for safety improvement; the larger the positive value, the greater the

potential. In contrary, locations with zero PSI values (In this study the negative PSI values have been considered equal to zero) have no potential for improvement because the expected number of collisions is less than the predicted number of collisions. A summary of the results is shown below in **Table 9** and **Table 10**. It is essential to note the PSI presented ranking in these Tables is pertaining strictly to the study area and has no bearing on the overall Region of Peel's intersections and mid-block road sections.

Table 9: Collision Prediction and Potential for Safety Improvement (PSI) for Intersections within the Study Area

Location ID	Location Description - Dixie Road At	Observed Fatal and Injury (2005 to 2007)	Observed Property Damage Only (2005 to 2007)	Predicted Fatal and Injury (2007) - $N_{Y(FI)}$	Predicted Property Damage Only (2007) - $N_{Y(PDO)}$	Expected No. of FI Collisions (E_{FI})	Expected No. of PDO Collisions (E_{PDO})	RSI	Potential for Safety Improve-ment for FI Collisions	Potential for Safety Improve-ment for PDO Collisions	Overall Potential for Safety Improve-ment	Rank
00420119S	Queen Street East	14	105	6.9113	29.2885	4.8700	34.8824	4.14	0.0000	5.5939	5.5939	2
00420298N	Hillside Drive	1	7	0.3181	0.7435	0.3270	1.9025	6.13	0.0547	1.1590	1.2137	4
00420632N	Hazelwood Drive	0	1	0.2324	0.4991	0.1143	0.3924	6.13	0.0000	0.0000	0.0000	-
00420805S	Howden Boulevard	5	18	2.8898	9.8185	1.9020	6.2254	4.14	0.0000	0.0000	0.0000	-
00421091N	Crescent Hill Drive South	0	0	0.1915	0.3965	0.1034	0.1629	6.13	0.0000	0.0000	0.0000	-
00421248N	Crescent Hill Drive North	0	0	0.1915	0.3965	0.1034	0.1629	6.13	0.0000	0.0000	0.0000	-
00421409N	Lascelles Boulevard	0	0	0.3805	0.9742	0.1413	0.2153	6.13	0.0000	0.0000	0.0000	-
00421753S	Williams Parkway East	6	18	4.0601	17.2143	2.2987	6.3873	4.14	0.0000	0.0000	0.0000	-
00422014S	Northampton Street	1	7	1.2817	3.5991	0.6647	2.5183	4.14	0.0000	0.0000	0.0000	-
00422452S	North Park Drive	1	12	2.4653	8.4659	0.7987	4.3028	4.14	0.0000	0.0000	0.0000	-
00422827N	Northcliffe Street	2	6	0.3065	0.9078	0.5078	1.7165	4.81	0.9683	0.8087	1.7770	3
00423204S	Bovaird Drive East	14	100	4.8966	18.2612	4.6950	32.8417	4.14	0.0000	14.5805	14.5805	1
00423821S	Peter Robertson Boulevard	5	18	2.2013	7.6425	1.7940	6.1225	4.14	0.0000	0.0000	0.0000	-
00424503S	Springtown Trail	0	2	0.3512	0.8476	0.2326	0.7428	4.14	0.0000	0.0000	0.0000	-
00424821S	Sandalwood Parkway	9	13	4.2082	15.4723	3.1699	4.7597	4.14	0.0000	0.0000	0.0000	-
00425302S	Octillo Boulevard	2	4	0.6584	1.9175	0.6636	1.4169	5.83	0.0302	0.0000	0.0302	5
00425892S	Father Tobin Road	0	4	0.7056	2.1010	0.2523	1.4349	5.83	0.0000	0.0000	0.0000	-
00426281S	Countryside Drive	2	1	0.8044	2.1487	0.7302	0.7377	4.14	0.0000	0.0000	0.0000	-
00427526S	Mayfield Road	4	4	1.8440	6.6649	1.4722	1.7843	4.14	0.0000	0.0000	0.0000	-

Table 10: Collision Prediction and Potential for Safety Improvement (PSI) for Mid-Block Road Sections within the Study Area

Location ID	Location Description – Dixie Road Between:	Observed Fatal and Injury (2005 to 2007)	Observed Property Damage Only (2005 to 2007)	Predicted Fatal and Injury (2007) - $N_{Y(FI)}$	Predicted Property Damage Only (2007) - $N_{Y(PDO)}$	Expected No. of FI Collisions (E_{FI})	Expected No. of PDO Collisions (E_{PDO})	RSI	Potential for Safety Improve-ment for FI Collisions	Potential for Safety Improve-ment for PDO Collisions	Overall Potential for Safety Improve-ment	Rank
00420119L	Queen Street East and Hillside Drive	1	6	0.1245	0.5968	0.2028	1.6554	3.87	0.3030	1.0587	1.3617	1
00420298L	Hillside Drive and Hazelwood Drive	0	1	0.2489	1.0887	0.1132	0.4477	3.87	0.0000	0.0000	0.0000	-
00420632L	Hazelwood Drive and Howden Boulevard	1	0	0.1213	0.5807	0.1996	0.1455	3.87	0.3027	0.0000	0.3027	2
00420805L	Howden Boulevard and Crescent Hill Drive South	0	0	0.2025	0.8968	0.1025	0.1597	3.87	0.0000	0.0000	0.0000	-
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	0	0	0.1059	0.5084	0.0701	0.1405	3.87	0.0000	0.0000	0.0000	-
00421248L	Crescent Hill Drive North and Lascelles Boulevard	0	0	0.1052	0.5054	0.0698	0.1403	3.87	0.0000	0.0000	0.0000	-
00421409L	Lascelles Boulevard and Williams Parkway East	0	1	0.2401	1.0355	0.1113	0.4442	3.87	0.0000	0.0000	0.0000	-
00421753L	Williams Parkway East and Northampton Street	1	2	0.1728	0.7732	0.2457	0.6880	3.87	0.2823	0.0000	0.2823	3

Location ID	Location Description – Dixie Road Between:	Observed Fatal and Injury (2005 to 2007)	Observed Property Damage Only (2005 to 2007)	Predicted Fatal and Injury (2007) - $N_{Y(FI)}$	Predicted Property Damage Only (2007) - $N_{Y(PDO)}$	Expected No. of FI Collisions (E_{FI})	Expected No. of PDO Collisions (E_{PDO})	RSI	Potential for Safety Improve-ment for FI Collisions	Potential for Safety Improve-ment for PDO Collisions	Overall Potential for Safety Improve-ment	Rank
00422014L	Northampton Street and North Park Drive	0	2	0.2778	1.1488	0.1188	0.7364	3.87	0.0000	0.0000	0.0000	-
00422452L	North Park Drive and Northcliffe Street	0	0	0.2321	0.9762	0.1096	0.1620	3.87	0.0000	0.0000	0.0000	-
00422827L	Northcliffe Street and Bovaird Drive East	0	1	0.2193	0.9171	0.1066	0.4354	3.87	0.0000	0.0000	0.0000	-
00423204L	Bovaird Drive East and Peter Robertson Boulevard	0	2	0.3794	1.4858	0.1341	0.7614	3.87	0.0000	0.0000	0.0000	-
00423821L	Peter Robertson Boulevard and Springtown Trail	0	0	0.3878	1.4829	0.1352	0.1717	3.87	0.0000	0.0000	0.0000	-
00424503L	Springtown Trail and Sandalwood Parkway	0	0	0.1630	0.6886	0.0913	0.1515	3.87	0.0000	0.0000	0.0000	-
00424821L	Sandalwood Parkway and Octillo Boulevard	0	1	0.2684	1.0814	0.1170	0.4472	3.87	0.0000	0.0000	0.0000	-
00425302L	Octillo Boulevard and Father Tobin Road	1	0	0.3463	1.3565	0.3382	0.1699	3.87	0.0000	0.0000	0.0000	-
00425892L	Father Tobin Road and Countryside Drive	0	1	0.1889	0.7730	0.0989	0.4216	3.87	0.0000	0.0000	0.0000	-
00426281L	Countryside Drive and Mayfield Road	0	1	0.4621	1.5285	0.1924	0.4766	6.37	0.0000	0.0000	0.0000	-
	May Field Road to 2 Km North	0	3	0.5986	2.0545	0.2125	1.0970	6.37	0.0000	0.0000	0.0000	-

The majority of the intersections within the study area have zero PSI values. However, there are five intersections that have positive PSI values, including the intersection of Dixie Road and Bovaird Drive East with the highest PSI value of 14.5805, meaning that there is a potential for safety improvements at these intersections.

Also the majority of the road sections within the study area except for three of those as highlighted in grey in **Table 10** have no potential for safety improvement.

Based on the above findings, in the following sub-section, the study team took a closer look at the locations with positive PSI values to identify any over-represented collision categories for given collision characteristic that have abnormally higher proportions than corresponding region-wide figures. Moreover the team did the same detailed over-representation analysis for the entire road section along Dixie Road within the study area.

2.2.3 Over-Representation Analysis

The over-representation analysis is based on statistical hypotheses tests involving the chi-square Statistical Distribution. Specifically, the computed chi-square value (estimated from observed and expected collision frequencies) is compared to critical values of the theoretical chi-square Statistical Distribution for a user-specified 'significance level' and the appropriate 'degrees of freedom' (which is the total number of variables categories minus one) for the statistical hypothesis that is being tested.

In general, value of the chi-square is computed as:

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \qquad \text{(Eq. 1)}$$

where,

O_i = Observed collision frequencies,
E_i = Expected collision frequencies,
n = Total number of variable categories,

and,

the number of degrees of freedom is given by:

$$df = n - 1$$

As expressed above in equation 1, the value of the χ^2 statistic is a measure of the discrepancy between the observed and expected collision frequencies. If $\chi^2 = 0$, the observed and expected collision frequencies agree exactly; while, if $\chi^2 > 0$, they do not agree. The larger the value of χ^2, the greater is the discrepancy between the observed and expected collision frequencies.

The collision data were examined to determine if any particular collision characteristics were over represented compared to Region-wide collision characteristics. Because collision data for entire Region of Peel were not available at the time of this analysis, region-wide data for Region of Halton were used for comparison purposes in this analysis. The objective of over-representation analysis is to help identify what may be the collision causal factors relating to geometric and operational characteristics by determining what collision categories in a given collision characteristic are over-represented at the locations. Several characteristics of collisions were used in the over-representation analysis including the following:

- Severity;
- Collision Impact Types;
- Season;
- Road Surface Conditions; and
- Lighting Conditions.

The chi-squared test was used to identify collisions that were abnormally high compared to Regional norms. The following road elements within the study area have been examined and their respective over-represented collision characteristics identified (based on a 95 percent confidence level) as collisions that were abnormally high compared to Regional norms are as follows:

Entire Mid-Block Road Sections within the Study Area – No characteristics were over-represented.

Entire Signalized Four-Legged Intersections within the Study Area – Angle collisions (20%) was the only collision characteristic that was over-represented. This finding shows the need for a more detailed safety study that requires site investigation and a road safety audit of the signalized four-legged intersection within the study area.

Entire Signalized Three-Legged Intersections within the Study Area – No characteristics were over-represented.

The Only Stop-Controlled Four-Legged Intersections within the Study Area (Intersection of Dixie Road and Northcliffe Street) – No characteristics were over-represented.

Entire Stop-Controlled Three-Legged Intersections within the Study Area – No characteristics were over-represented.

Dixie Road Mid-Block Road Section between Queen Street East and Hillside Drive - No characteristics were over-represented.

Dixie Road Mid-Block Road Section between Hazelwood Drive and Howden Boulevard - No characteristics were over-represented.

Dixie Road Mid-Block Road Section between Williams Parkway East and Northampton Street - No characteristics were over-represented.

Intersection of Dixie Road at Queen Street East - Collisions under dry road surface condition (79%) was the only collision characteristic that was over-represented at this intersection.

Intersection of Dixie Road at Hillside Drive - No characteristics were over-represented.

Intersection of Dixie Road at Bovaird Drive East - Collisions under wet road surface condition (39%) was the only collision characteristic that was over-represented at this intersection. Again this finding shows the need for a more detailed safety study that requires site investigation and a road safety audit of this specific intersection.

Intersection of Dixie Road at Octillo Boulevard - No characteristics were over-represented.

3. Safety Assessment Methodology for the Proposed Preferred Design

The purpose of this evaluation is to assess the safety performance of the proposed preferred design in comparison to the existing design in a quantitative way.

In order to evaluate the safety performance of the preferred design, an estimate of the safety performance of the existing design was required as well. Site specific Empirical Bayes (EB) estimates of the expected collision frequency were previously obtained for each mid-block road section and intersection in the study corridor for the existing condition. The detailed methodology of obtaining these estimates and the results has already been explained in **Section 2** and **Appendix B.**
The expected collision frequency pertaining to the existing design was also estimated for 2031 which was selected as planning horizon year for the proposed

design. These estimates were obtained in order to determine what the safety performance of the study corridor will be in year 2031 if the existing design continues to be in place as it is now without making any improvement to it.

Based on the existing and proposed lane configurations for the year 2031 following are the proposed changes in the geometry of both the intersections and mid-block road sections:

- Increase in number of lanes from four lanes to six lanes along Dixie Road between north of Queen Street East to south of Countryside Drive and from two lanes to four lanes from north of Countryside Drive to approximately two kilometres north of Mayfield Road East;
- Accommodating a raised-curb median between two directions of travel along most of mid-block road sections within the study corridor; and
- Addition of right turn and left turn lanes on the approaches to some of the intersections located inside the study corridor.

Also the intersection of Dixie Road and Northcliff Street is proposed to be a signalized intersection in horizon year of 2031.

3.1 Collision Modification Factors (CMFs)

To conduct a quantitative safety assessment, collision modification factors are required in order to more accurately obtain the change in expected number of collisions as a result of the implementation of the proposed changes to the existing design in terms of geometry (lane configuration).

CMFs provide estimates of the reduction / increase in the frequency of collisions that occur due to deviation from standard geometric design practice in terms of roadway geometric design, roadside design, etc. CMFs are developed in such a way to yield a value of 1.0 when the associated design component or element represents a standard condition. For instance, CMF related to lane width assumes a value of 1.0 when the lane width of the road under consideration is 3.66m and deviation from this typical condition to a more generous or desirable design condition results in CMF value of less than 1.0 and deviation to a more restricted condition results in a CMF value of more than 1.0.

The ratio of the CMF after the improvement to the CMF before the improvement represents the CMF for the improvement itself. Therefore, in this study CMF values for the proposed alternative design is calculated by dividing the CMFs for the geometric design features proposed in the alternative design by the corresponding values for the existing condition.

A literature review of available CMFs was conducted in order to find out and select the best applicable CMFs for the road segments and intersections within the study corridor.

CMFs used for this analysis were extracted from the following three references:

- Application and Evaluation of Collision Modification Factors (CMFs) for Ontario Highway Applications—Geometric Design and Safety Design[1];
- FHWA CMF Clearinghouse[2]; and
- Road Safety Design Synthesis[3] .

Table 12 to **Table 15** present the traffic control devices, entering traffic volumes, and lane configurations for the intersections and mid-block road sections inside the study corridor both in existing conditions and proposed alternative design in horizon year of 2031. It is noteworthy that unlike **Table 13** on **Table 12** the median widths are not presented as it was found that Google images are not clear enough to help us measure the lane widths precisely.

3.1.1 Collision Modification Factors for Intersections

The following CMFs were used in the analysis:

- **CMF for Installation / Adding of Right-Turn Lanes on Intersection Approaches ($CMF_{Right\text{-}Turn\ Lane}$)**
  -

[1] "Application and Evaluation of Collision Modification Factors (CMFs) for Ontario Highway Applications—Geometric Design and Safety Design", Ministry of Transportation of Ontario, Agreement Number: 9015-A-000195, by Synectics Transportation Consultants Inc., February 2003.

[2] www.CMFClearinghouse.org (Accessed on February 2010)

[3] Bonneson J., Zimmerman, K., and K. Fitzpatrick, "Roadway Safety Design Synthesis", Publication No. FHWA/TX-05/0-4703-P1, November 2005

Table 11 presents the CMF values related to the installation / addition of right-turn lane to urban four-leg intersections which are excerpted from the MTO document **"**Application and Evaluation of (CMFs) for Ontario Highway Applications—Geometric Design and Safety Design".

Table 11: CMF for Adding One Right-Turn Lane to Urban Four-Leg Intersections

CMF for Total Intersection Collisions		
No. of Approaches to Which Right-Turn Lanes are added	**One**	**Two**
Signalized Intersection	0.96	0.92

In the preferred design the horizon year 2031, exclusive right-turn lanes are proposed to be installed / added on one or more approaches to some intersections under consideration in this study. Those are Dixie Road four-leg intersections at Williams Parkway (EB, WB, and NB approaches), Sandalwood Parkway (EB and WB approaches), Countryside Drive (EB and WB approaches), and Mayfield Road (WB and SB approaches). All these intersections are four-leg signalized type.

As per the above table, CMFs of 0.96, 0.92 (= 0.96 × 0.96), and 0.88 (= 0.92 x 0.96) were used if one, two, and three right-turn lanes were proposed to be installed / added respectively.

If a shared or no right-turn lane has been present in the existing design, the CMF for the existing condition was considered as 1.00 and therefore the CMF for the safety improvement following the installation of one right-turn lane was derived as,

CMF preferred design/ CMF existing design = 0.96 / 1.00 = 0.96. (Eq. 2)

Table 12: Traffic Signal Control, Entering Traffic Volumes, and Lane Configurations at Intersections along the Study Corridor in Existing Conditions (2007)

Location ID	Location Description – Intersections At:	Number of Legs - Traffic Control Type	Total Entering AADT on Major Road	Total Entering AADT on Minor Road	Lane Configuration (Number of Through Lanes – Average Lane Width in Meters – Median Type)	
					NB	SB
00420119S	Queen Street East	Four - Traffic Control	38600	26770	LL – TTT – R (3 – 3.70 - RC)	LL – TTT – R (3 – 3.65 - RC)
00420298N	Hillside Drive	Three - Stop Sign	25750	650	L – TT (2 – 3.65 - RC)	T – T / R (2 – 3.75 - RC)
00420632N	Hazelwood Drive	Three - Stop Sign	24590	300	L – TT (2 – 3.65 - U)	T – T / R (2 – 3.70 - U)
00420805S	Howden Boulevard	Four - Traffic Signal	24160	9210	L – T– T / R (2 – 3.50 - RC)	L – T – T / R (2 – 3.50 - RC)
00421091N	Crescent Hill Drive South	Three - Stop Sign	22778	200	TT – R (2 – 3.75 - U)	L – TT (2 – 3.70 - U)
00421248N	Crescent Hill Drive North	Three - Stop Sign	22778	200	T – T / R (2 – 3.75 - U)	L – TT (2 – 3.75 - U)
00421409N	Lascelles Boulevard	Three - Stop Sign	22940	1230	TT – R (2 – 3.60 - U)	L – TT (2 – 3.60 - U)
00421753S	Williams Parkway East	Four - Traffic Signal	21070	19120	L – T – T / R (2 – 3.60 - RC)	L – TT – R (2 – 3.60 - RC)
00422014S	Northampton Street	Four - Traffic Signal	21030	2540	L – TT – R (2 – 3.65 - U)	L – TT – R (2 – 3.65 - U)
00422452S	North Park Drive	Four - Traffic Signal	18980	8840	L – TT – R (2 – 3.65 - RC)	L – T – T / R (2 – 3.65 - RC)
00422827N	Northcliffe Street	Four - Stop Sign	17880	1750	L / T - T / R (2 – 3.75 - U)	L / T - T / R (2 – 3.65 - U)
00423204S	Bovaird Drive East	Four - Traffic Signal	35300	15980	L – TT – R (2 – 3.75 - RC)	L – TT – R (2 – 3.75 - RC)
00423821S	Peter Robertson Boulevard	Four - Traffic Signal	15990	8580	L – TT – R (2 – 3.65 - RC)	L – TT – R (2 – 3.65 - RC)
00424503S	Springtown Trail	Four - Traffic Signal	14460	380	L – TT – R (2 – 3.65 - RC)	L – TT – R (2 – 3.65 - RC)
00424821S	Sandalwood Parkway	Four - Traffic Signal	30410	14190	L – TT – R (2 – 3.75 - RC)	L – TT – R (2 – 3.75 - RC)
00425302S	Octillo Boulevard *	Three - Traffic Signal	14790	1870	TT – R (2 – 3.65 - RC)	L – TT (2 – 3.65 - RC)
00425892S	Father Tobin Road	Three - Traffic Signal	15680	2180	L / T - T – R (2 – 3.50 - RC)	L – T – T / R (2 – 3.50 - RC)
00426281S	Countryside Drive	Four - Traffic Signal	12190	1920	L – T – R (1 – 3.65 - U)	L - T / R (1 – 3.75 - U)
00427526S	Mayfield Road	Four - Traffic Signal	11790	8490	L – T – R (1 – 3.65 - RC)	L - T / R (1 – 3.75 - RC)

L = Left-Turn Lane, T / R = Shared Through and Right Lane, LL = Double Left-Turn Lanes, TTT = Triple Through Lanes, and
L / T / R = Shared Left, Through and Right-Turn Lane.
RC = Raised Curb and U = Undivided

Table 13: Traffic Signal Control, Entering Traffic Volumes, and Lane Configurations at Intersections along the Study Corridor in Proposed Alternative Design (2031)

Location ID	Location Description – Intersections At:	Number of Legs - Traffic Control Type	Total Entering AADT on Major Road	Total Entering AADT on Minor Road	Lane Configuration (Number of Through Lanes – Average Lane Width in Meters – Median Type – Median Width in Meters)	
					NB	SB
00420119S	Queen Street East	Four - Traffic Control	62,550	40,230	LL – TTT – R (3 – 3.75 – RC – 2.50)	LL – TTT – R (3 – 3.75 – RC - 2.50)
00420298N	Hillside Drive	Three - Stop Sign	38,670	820	L – TTT (3 – 3.75 – RC - 2.50)	TT – T / R (3 – 3.75 – RC - 2.50)
00420632N	Hazelwood Drive	Three - Stop Sign	38,500	370	L – TTT (3 – 3.75 – RC - 2.50)	TT – T / R (3 – 3.75 – RC - 2.50)
00420805S	Howden Boulevard	Four - Traffic Signal	36,690	11,680	L – TT– T / R (3 – 3.75 – RC - 2.50)	L – TT – T / R (3 – 3.75 – RC - 2.50)
00421091N	Crescent Hill Drive South	Three - Stop Sign	38,058	334	TTT – R (3 – 3.75 – RC - 2.50)	L – TTT (3 – 3.75 – RC - 2.50)
00421248N	Crescent Hill Drive North	Three - Stop Sign	38,058	334	TT – T / R (3 – 3.75 – RC - 2.50)	L – TTT (3 – 3.75 – RC - 2.50)
00421409N	Lascelles Boulevard	Three - Stop Sign	35,380	1,550	TTT – R (3 – 3.75 – RC - 2.50)	L - TTT (3 – 3.75 – RC - 2.50)
00421753S	Williams Parkway East	Four - Traffic Signal	33,430	33,370	L – TTT – R (3 – 3.75 – RC - 2.50)	L – TTT – R (3 – 3.75 – RC - 2.50)
00422014S	Northampton Street	Four - Traffic Signal	32,580	3,460	L – TTT – R (3 – 3.75 – RC - 2.50)	L – TTT – R (3 – 3.75 – RC - 2.50)
00422452S	North Park Drive	Four - Traffic Signal	32,270	11,620	L – TTT – R (3 – 3.75 – RC – 2.00)	L – TT – T / R (3 – 3.75 – RC – 2.00)
00422827N	Northcliffe Street	Four – Traffic Signal	31,750	2,270	L – TT - T / R (3 – 3.75 – RC – 2.50)	L – TT – T / R (3 – 3.75 – RC - 2.50)
00423204S	Bovaird Drive East	Four - Traffic Signal	69,500	35,970	L – TTT – R (3 – 3.75 – RC - 2.50)	LL – TTT – R (3 – 3.75 – RC - 2.50)
00423821S	Peter Robertson Boulevard	Four - Traffic Signal	35,660	12,110	L – TTT – R (3 – 3.75 – RC - 2.50)	L – TTT – R (3 – 3.75 – RC - 2.50)
00424503S	Springtown Trail	Four - Traffic Signal	37,910	1,110	L – TTT – R (3 – 3.75 – RC - 2.50)	L – TTT – R (3 – 3.75 – RC - 2.50)
00424821S	Sandalwood Parkway	Four - Traffic Signal	59,890	37,090	L – TTT – R (3 – 3.75 – RC - 2.50)	L – TTT – R (3 – 3.75 – RC - 2.50)
00425302S	Octillo Boulevard *	Three - Traffic Signal	39,040	2,790	TTT – R (3 – 3.75 – RC – 6.00)	L – TTT (3 – 3.75 – RC – 2.50)
00425892S	Father Tobin Road	Four - Traffic Signal	38,160	4,350	TTT – R (3 – 3.75 – RC - 2.50)	L – TT – T / R (3 – 3.75 – RC - 2.50)
00426281S	Countryside Drive	Four - Traffic Signal	31,600	30,540	L – TTT – R (3 – 3.75 – RC - 2.50)	LL - TT – T / R (3 – 3.75 – RC - 2.50)
00427526S	Mayfield Road	Four - Traffic Signal	55,280	32,470	LL – TT – R (2 – 3.75 – RC - 2.50)	L – TT – R (2 – 3.75 – RC - 2.50)

L = Left-Turn Lane, T / R = Shared Through and Right Lane, LL = Double Left-Turn Lanes, TTT = Triple Through Lanes, and
L / T / R = Shared Left, Through and Right-Turn Lane.
RC = Raised Curb and U = Undivided

Table 14: Geometric Characteristics for Mid-Block Road Sections along the Study Corridor in Existing Conditions (2007)

Location ID	Location Description – Dixie Road Between:	Type – Number of Lanes (both sides)	AADT	Lane Width (Meters)	Number of Driveways (both sides)	Presence, Type, and width of Median	Shoulder Type and Width
00420119L	Queen Street East and Hillside Drive	Urban - Four	25,548	3.65	0	Yes – Raised Curb – 4.00	Curb and Gutter
00420298L	Hillside Drive and Hazelwood Drive	Urban - Four	24,778	3.70	1	No - Undivided	Curb and Gutter
00420632L	Hazelwood Drive and Howden Boulevard	Urban - Four	24,816	3.60	0	Yes – Raised Curb - 2.90	Curb and Gutter
00420805L	Howden Boulevard and Crescent Hill Drive South	Urban - Four	22,778	3.62	1	No - Undivided	Curb and Gutter
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	Urban - Four	22,778	3.72	2	No - Undivided	Curb and Gutter
00421248L	Crescent Hill Drive North and Lascelles Boulevard	Urban - Four	22,778	3.68	2	No - Undivided	Curb and Gutter
00421409L	Lascelles Boulevard and Williams Parkway East	Urban - Four	22,085	3.60	2	No - Undivided	Curb and Gutter
00421753L	Williams Parkway East and Northampton Street	Urban - Four	21,447	3.62	0	No - Undivided	Curb and Gutter
00422014L	Northampton Street and North Park Drive	Urban - Four	19,000	3.65	2	No - Undivided	Curb and Gutter
00422452L	North Park Drive and Northcliffe Street	Urban - Four	18,319	3.70	0	No - Undivided	Curb and Gutter
00422827L	Northcliffe Street and Bovaird Drive East	Urban - Four	16,911	3.70	0	No - Undivided	Curb and Gutter
00423204L	Bovaird Drive East and Peter Robertson Boulevard	Urban - Four	17,220	3.70	1	Yes – Raised Curb – 6.00	Curb and Gutter
00423821L	Peter Robertson Boulevard and Springtown Trail	Urban - Four	15,078	3.65	2	Yes – Raised Curb - 6.00	Curb and Gutter
00424503L	Springtown Trail and Sandalwood Parkway	Urban - Four	14,255	3.70	0	Yes – Raised Curb - 6.60	Curb and Gutter
00424821L	Sandalwood Parkway and Octillo Boulevard	Urban - Four	15,684	3.70	0	Yes – Raised Curb - 6.15	Curb and Gutter
00425302L	Octillo Boulevard and Father Tobin Road	Urban - Four	16,034	3.58	3	Yes – Raised Curb - 6.00	Curb and Gutter
00425892L	Father Tobin Road and Countryside Drive	Urban - Four	13,111	3.58	0	Yes – Raised Curb - 6.10	Curb and Gutter
00426281L	Countryside Drive and Mayfield Road	Suburban - Two	10,603	3.70	14	No - Undivided	Rural Gravel Shoulder
	Mayfield Rd and Two Kilometres North of Mayfield Rd	Suburban - Two	9,041	3.70	18	No - Undivided	Rural Gravel Shoulder

Table 15: Geometric Characteristics for Mid-Block Road Sections along the Study Corridor in Proposed Alternative Design (2031)

Location ID	Location Description – Dixie Road Between:	Type – Number of Lanes (both sides)	AADT	Lane Width (Meters)	Number of Driveways (both sides)	Presence, Type, and width of Median	Shoulder Type and Width
00420119L	Queen Street East and Hillside Drive	Urban - Six	38,930	3.75	0	Yes – Raised Curb –	Curb and Gutter
00420298L	Hillside Drive and Hazelwood Drive	Urban - Six	37,780	3.75	1	No - Undivided	Curb and Gutter
00420632L	Hazelwood Drive and Howden Boulevard	Urban - Six	38,045	3.75	0	Yes – Raised Curb – 6.00	Curb and Gutter
00420805L	Howden Boulevard and Crescent Hill Drive South	Urban - Six	35,020	3.75	1	Yes – Raised Curb – 6.00	Curb and Gutter
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	Urban - Six	35,020	3.75	2	Yes – Raised Curb – 6.00	Curb and Gutter
00421248L	Crescent Hill Drive North and Lascelles Boulevard	Urban - Six	35,020	3.75	2	Yes – Raised Curb – 6.00	Curb and Gutter
00421409L	Lascelles Boulevard and Williams Parkway East	Urban - Six	33,810	3.75	2	Yes – Raised Curb – 6.00	Curb and Gutter
00421753L	Williams Parkway East and Northampton Street	Urban - Six	32,495	3.75	0	Yes – Raised Curb – 2.50	Curb and Gutter
00422014L	Northampton Street and North Park Drive	Urban - Six	29,735	3.75	2	Yes – Raised Curb – 2.50	Curb and Gutter
00422452L	North Park Drive and Northcliffe Street	Urban - Six	29,435	3.75	0	Yes – Raised Curb – 2.50	Curb and Gutter
00422827L	Northcliffe Street and Bovaird Drive East	Urban - Six	29,130	3.75	0	Yes – Raised Curb – 2.50	Curb and Gutter
00423204L	Bovaird Drive East and Peter Robertson Boulevard	Urban - Six	38,030	3.75	1	Yes – Raised Curb – 5.00	Curb and Gutter
00423821L	Peter Robertson Boulevard and Springtown Trail	Urban - Six	37,300	3.75	2	Yes – Raised Curb – 6.00	Curb and Gutter
00424503L	Springtown Trail and Sandalwood Parkway	Urban - Six	37,785	3.75	0	Yes – Raised Curb – 6.00	Curb and Gutter
00424821L	Sandalwood Parkway and Octillo Boulevard	Urban - Six	40,375	3.75	0	Yes – Raised Curb – 6.00	Curb and Gutter
00425302L	Octillo Boulevard and Father Tobin Road	Urban - Six	39,360	3.75	3	Yes – Raised Curb – 6.00	Curb and Gutter
00425892L	Father Tobin Road and Countryside Drive	Urban - Six	34,050	3.75	0	Yes – Raised Curb – 6.00	Curb and Gutter
00426281L	Countryside Drive and Mayfield Road	Urban - Four	28,285	3.75	14	No – Undivided	Curb and Gutter
	Mayfield Rd and Two Kilometres North of Mayfield Rd	Urban - Four	29,920	3.75	18	No – Undivided	Curb and Gutter

- **CMF for Installation / Adding of Left-Turn Lanes on Intersection Approaches ($CMF_{Left\text{-}Turn\ Lane}$)**

Table 16 presents the CMF values related to the installation / addition of left-turn lane to urban intersections which are excerpted from the same MTO document.

Table 16: CMF for Adding One Left-Turn Lane to Urban Intersections

CMF for Total Intersection Collisions		
No. of Approaches to Which Left-Turn Lanes are added	**One**	**Two**
Three-Leg Intersections		
Signalized Intersection *	0.93	Not Applicable
Four-Leg Intersections		
Signalized Intersection	0.90	0.81

* The MTO-sponsored document does not contain the CMF for adding one left-turn lane to three-leg signalized intersections in order to consider reduction in total intersection collisions. Therefore the corresponding CMF calibrated for reduction in intersection approach collisions has been presented instead in the above table and used for the safety analysis.

In the preferred design for the horizon year 2031, exclusive left-turn lanes are proposed to be installed / added on one or more approaches to some intersections under consideration in this study. Those are Dixie Road intersections at Queen Street East (WB approach), Northcliffe Street (NB and SB approaches), Bovaird Drive East (EB, WB, and SB approaches), Sandalwood Parkway (EB and WB approaches), Father Tobin Road (WB approach), Countryside Drive (EB, WB, and SB approaches), and Mayfield Road (NB and EB approaches). All these intersections are four-leg signalized type except for the intersection of Dixie Road at Father Tobin Road which is a three-leg intersection.

Again if a shared or no left-turn lane has been present in the existing design, the CMF for the existing condition was considered as 1.00 and therefore the CMF for the safety improvement following the installation of one left-turn lane to a four-leg signalized intersection was derived as,

CMF preferred design/ CMF existing design = 0.90 / 1.00 = 0.90. (Eq. 3)

- **CMF for Lane Width ($CMF_{Lane\ Width}$)**

In the preferred design for the horizon year 2031, there are also some changes recommended to the existing design with respect to the average lane width of the approaches to the intersection. According to “Road Safety Design Synthesis”, the

CMF value related to a change in the lane width of the approaches to the intersections will be calculated by using the following formulas:

$CMF_{Lane\ Width} = e^{-0.053\ (W - 12)}$ for urban signalized intersections and (Eq. 4)
$CMF_{Lane\ Width} = e^{-0.057\ (W - 12)}$ for urban unsignalized intersections (Eq. 5)

Where "W" is the average lane width of the approach to the intersection. However please note that the CMF value obtained for signalized intersections are applicable to all collisions whereas the one for unsignalized intersection is only applicable to severe collisions.

- **CMF for Number of Through Lanes at Intersection Approaches ($CMF_{Through\ Lane}$)**

In the preferred design, Dixie Road is proposed to be widened from four lanes to six lanes between north of Queen Street East to south of Countryside Drive and from two lanes to four lanes from north of Countryside Drive to north of Mayfield Road East.

According to "Road Safety Design Synthesis", "an increase in lanes at a signalized intersection is associated with an increase in severe crash frequency with all other factors remaining unchanged. In contrast, an increase in lanes at an unsignalized intersection is associated with a decrease in severe crash frequency". His study provides the CMFs for number of through lanes at urban signalized intersections. According to that study, the CMF values reflect a base condition of four through lanes on Major Street and two through lanes on the minor street. **Table 17** presents the CMF values for the changes in number of through lanes at urban signalized and unsignalized intersections.

Table 17: CMF for Number of Through Lanes on Intersection Approaches

Approach Type	Unsignalized		Signalized	
	Number of Through Lanes	CMF	Number of Through Lanes	CMF
Major	3 or Fewer	1.20	3 or Fewer	0.99
	4 or 5	1.00	4 or 5	1.00
	6 or More	0.83	6 or More	1.01
Minor	3 or Fewer	1.00	3 or Fewer	1.00
	4 or More	0.83	4 or More	1.01

As such for instance the CMF value for the proposed improvement at an urban signalized intersection of increasing the number of through lanes from four lanes in existing condition to six lanes in proposed alternative design along its major street is:

CMF preferred design (major street with six lane) / CMF existing design (major street with four lane) = 1.01 / 1.00 = 1.01 and (Eq. 6)

- **CMF for Shoulder Width at Intersection Approaches ($CMF_{Shoulder\ Width}$)**

According to "Road Safety Design Synthesis", with a base condition of curb-and-gutter, which is estimated to have an equivalent shoulder width of 1.5 ft, the CMF values accounting for the deviation from this base conditions on approaches to an unsignalized intersection is calculated by the following formula:

$$CMF_{Shoulder\ Width} = e^{-0.020\ (W - 1.5)} \quad \text{(Eq. 7)}$$

In this study in both existing and proposed alternative designs, all the intersections with the exception of the Dixie Road at Mayfield Road in the existing condition design have curb and gutter shoulder type and therefore the CMF related to the shoulder width was considered to be 1.00 for both designs.

- **CMF for Median Presence ($CMF_{Median\ Presence}$)**

According to "Road Safety Design Synthesis", for unsignalized intersections, the CMF values accounting for installation of a raised curb median in the middle of the road (conversion from an undivided to a divided roadway) is 0.83.

The total required CMF was obtained for total collisions, by multiplying all the CMF's described above, as shown by the equation below:

$$CMF_{Total} = CMF_{Right\text{-}Turn\ Lane} \times CMF_{Left\text{-}Turn\ Lane} \times CMF_{Lane\text{-}Width} \times \ldots \quad \text{(Eq. 8)}$$

3.1.2 Collision Modification Factors for Mid-Block Road Sections

- **CMF for Lane Width ($CMF_{Lane\ Width}$)**

According to "Road Safety Design Synthesis", with a base condition of a four-lane, raised-curb median urban street, the CMF value related to a change in the lane width of the mid-block road sections will be calculated by using the following formulas:

$$CMF_{Lane\ Width} = (e^{-0.040\ (W - 12)} - 1.0) \times (Pi) \times 4.17 + 1.0 \quad \text{(Eq. 9)}$$

Where "W" is the average lane width of the mid-block road sections and "Pi" can be obtained from below.

Table 18: Collision Distribution for Urban Street Lane Width CMF

Median Type	Collision Type Subset	Number of Through Lanes	Subset Proportion
Undivided or TWLTL	Single-Vehicle Run-Off Road, Either Side Same Direction Sideswipe, Multiple Vehicle Opposite Direction	2	0.25
		4	0.18
		6	0.14
Raised Curb	Single-Vehicle Run-Off Road, Either Side Same Direction Sideswipe	4	0.24
		6	0.27

- **CMF for Increase in Number of Lanes ($CMF_{No\ of\ Lane}$)**

According to "FHWA – CMF Clearinghouse", CMF for the increase in number of lanes is 0.8 (Gan et. al. 2005). However the quality of this CMF cannot be rated. Therefore for the purpose of the safety evaluation of alternative design the CMF for increasing the number of lanes from four to six lanes is assumed to be 1.00. However as urban two-lane roads have different SPF than urban multi-lane roads, the change in safety performance resulted from the increase in the number of lanes for the northern portion of Dixie Road from existing two to four lanes in the horizon year can be quantified.

Also it is noteworthy that the increase in number of lanes will increase the distance a pedestrian / cyclist must cross at the intersections and can as a result decrease the safety of vulnerable road users if proper countermeasures are not considered. Countermeasures that can be considered to improve pedestrian / cyclist safety are discussed in **Sub Section 3.3.1** called "Safety of Vulnerable Road Users at Intersections".

3.2 Estimate of the Expected Number of Collisions per Year

The safety assessment of the proposed preferred design was done in the planning horizon year for the preferred design (2031) by providing an answer to the following question:

- What will be the expected average collision frequency in planning horizon year (2031) for the preferred design and how it will be different

from the expected average collision frequency if the changes to the study corridor are not applied?

The expected average collision frequencies for the existing design were estimated previously following the EB methodology that combines the observed numbers of collisions and the predicted numbers of collisions. The expected average number of collisions in the horizon year (2031), for the existing condition design was obtained using the following equation, assuming that the proportion of the expected and predicted numbers of collision in the horizon year will be similar to that of existing design:

$$E_{ef} = \frac{P_{ef} \times E_e}{P_e} \qquad \text{(Eq. 10)}$$

Where:

E_{ef} = Expected average number of collisions in horizon year (2031) if no changes are applied to the existing design

E_e = Expected average number of collisions in the base year (2007) for the existing condition design (already known from **Section 1**)

P_{ef} = Predicted number of collisions in horizon year (2031) if the changes are not applied (obtained by using the AADT values pertaining to the horizon year and proper SPF formula)

P_e = Predicted number of collisions in the base year (2007) for the existing design (already known from **Section 1**)

The Predicted number of collisions for preferred design in the horizon year was obtained by multiplying the SPF (obtained using AADT values pertaining to the horizon year) with the total CMF as shown below:

$$p_p = SPF \times CMF_{Total} \qquad \text{(Eq. 11)}$$

To estimate the expected average number of collisions per year for the preferred design the following formula was used.

$$E_p = \frac{P_p \times E_e}{P_e} \qquad \text{(Eq. 12)}$$

Where:

E_p = expected average number of collisions for the preferred design

E_e = expected average number of collisions for the existing design

P_e = predicted number of collisions for existing design (already known from **Section 1**)

P_p = predicted number of collisions for preferred design (obtained from **Equation 11**)

Figure 2 illustrates the theoretical relationship between the existing and proposed designs.

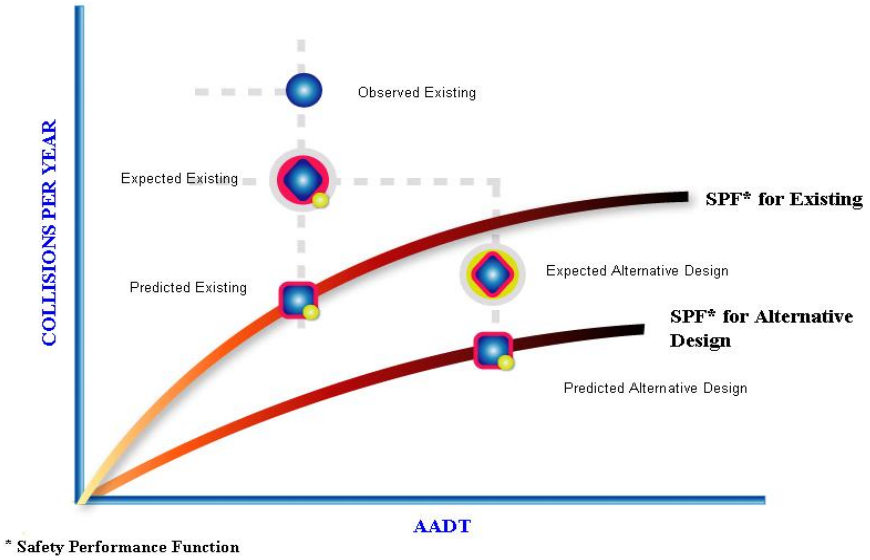

Figure 2: Use of Regression Relationship in the Empirical Bayes Approach for Preferred Design

3.3 Safety Assessment for Planning Horizon Year (2031)

3.3.1 Intersection Safety Assessment

Safety of Motorized Vehicles at Intersections

The predicted and expected numbers of collisions at the intersections in the planning horizon year (2031) with the existing design was obtained from SPF and using **Equation 10** respectively**.** The results are shown in **Table 19**.

Also the predicted and expected number of collisions in the future year considering the preferred alternative design was obtained using **Equations 11** and **12.** The corresponding results are shown in **Table 20**.

Table 21 shows the safety of individual intersections in the future year with the preferred design.

Table 19: Predicted and Expected Numbers of Collisions in the Planning Horizon Year (2031) with Existing Design for All the Intersections within the Study Area

Location ID	Location Description – Dixie Road At:	Number of Legs – Traffic Control	Major AADT	Major AADT	Total Predicted No. of Collisions in 2031 with Existing Design	Total Expected No. of Collisions in 2031 with Existing Design
00420119S	Queen Street East	Four - Traffic Signal	62,550	40,230	62.2248	68.3315
00420298N	Hillside Drive	Three - Stop Sign	38,670	820	1.4263	2.9954
00420632N	Hazelwood Drive	Three - Stop Sign	38,500	370	0.9938	0.6884
00420805S	Howden Boulevard	Four - Traffic Signal	36,690	11,680	18.7458	11.9885
00421091N	Crescent Hill Drive South	Three - Stop Sign	38,058	334	0.9441	0.4275
00421248N	Crescent Hill Drive North	Three - Stop Sign	38,058	334	0.9441	0.4275
00421409N	Lascelles Boulevard	Three - Stop Sign	35,380	1,550	1.8364	0.4834
00421753S	Williams Parkway East	Four - Traffic Signal	33,430	33,370	41.1202	16.7886
00422014S	Northampton Street	Four - Traffic Signal	32,580	3,460	7.7310	5.0418
00422452S	North Park Drive	Four - Traffic Signal	32,270	11,620	17.4696	8.1530
00422827N	Northcliffe Street	Four – Traffic Signal	31,750	2,270	1.4619	2.6780
00423204S	Bovaird Drive East	Four - Traffic Signal	69,500	35,970	59.7393	96.8321
00423821S	Peter Robertson Boulevard	Four - Traffic Signal	35,660	12,110	18.9562	15.2449
00424503S	Springtown Trail	Four - Traffic Signal	37,910	1,110	4.2109	3.4259
00424821S	Sandalwood Parkway	Four - Traffic Signal	59,890	37,090	57.1687	23.0341
00425302S	Octillo Boulevard *	Three - Traffic Signal	39,040	2,790	4.4203	3.5702
00425892S	Father Tobin Road	Four - Traffic Signal	38,160	4,350	5.2689	3.1675
00426281S	Countryside Drive	Four - Traffic Signal	31,600	30,540	37.2640	18.5229
00427526S	Mayfield Road	Four - Traffic Signal	55,280	32,470	49.5857	18.9770

Table 20: Predicted and Expected Numbers of Collisions in the Planning Horizon Year (2031) with Preferred Alternative Design for All the Intersections within the Study Area

Location ID	Location Description – Dixie Road At:	Number of Legs – Traffic Control	Major AADT	Minor AADT	Predicted No. of Severe Collisions in 2031 w/ Alternative Design	Predicted No. of PDO Collisions in 2031 w/ Alternative Design	Total Predicted No. of Collisions in 2031 w/ Alternative Design	CMF for Severe Collisions	CMF for All Collisions	Total Predicted No. of Collisions in 2031 w/ Alternative Design w/ CMFs	Total Expected No. of Collisions in 2031 w/ Alternative Design
00420119S	Queen Street East	Four - Traffic Signal	62,550	40,230	11.4343	50.7905	62.2248	1.0000	0.9870	61.4186	67.4461
00420298N	Hillside Drive	Three - Stop Sign	38,670	820	0.4379	0.9884	1.4263	0.8223	1.0000	1.3485	2.8319
00420632N	Hazelwood Drive	Three - Stop Sign	38,500	370	0.3253	0.6684	0.9938	0.8184	0.8300	0.7758	0.5374
00420805S	Howden Boulevard	Four - Traffic Signal	36,690	11,680	4.1842	14.5615	18.7458	1.0100	0.9575	17.9884	11.5041
00421091N	Crescent Hill Drive South	Three - Stop Sign	38,058	334	0.3113	0.6328	0.9441	0.8261	0.8300	0.7387	0.3345
00421248N	Crescent Hill Drive North	Three - Stop Sign	38,058	334	0.3113	0.6328	0.9441	0.8300	0.8300	0.7397	0.3349
00421409N	Lascelles Boulevard	Three - Stop Sign	35,380	1,550	0.5301	1.3062	1.8364	0.8070	0.8300	1.4393	0.3789
00421753S	Williams Parkway East	Four - Traffic Signal	33,430	33,370	7.2297	33.8905	41.1202	1.0100	0.9353	38.5267	15.7298
00422014S	Northampton Street	Four - Traffic Signal	32,580	3,460	1.9548	5.7762	7.7310	1.0100	0.9828	7.6170	4.9674
00422452S	North Park Drive	Four - Traffic Signal	32,270	11,620	3.8819	13.5877	17.4696	1.0100	0.9828	17.2066	8.0302
00422827N	Northcliffe Street	Four – Traffic Signal	31,750	2,270	1.5148	4.3212	5.8360	1.0100	0.8030	4.6984	8.6067
00423204S	Bovaird Drive East	Four - Traffic Signal	69,500	35,970	11.3804	48.3590	59.7393	1.0100	0.9000	53.8678	87.3149
00423821S	Peter Robertson Boulevard	Four - Traffic Signal	35,660	12,110	4.2037	14.7525	18.9562	1.0100	0.8845	16.8037	13.5138
00424503S	Springtown Trail	Four - Traffic Signal	37,910	1,110	1.1124	3.0984	4.2109	1.0100	0.8845	3.7343	3.0382
00424821S	Sandalwood Parkway	Four - Traffic Signal	59,890	37,090	10.6530	46.5157	57.1687	1.0100	0.9000	51.5477	20.7693
00425302S	Octillo Boulevard *	Three - Traffic Signal	39,040	2,790	1.0203	3.4000	4.4203	1.0100	0.9828	4.3541	3.5167
00425892S	Father Tobin Road	Four - Traffic Signal	38,160	4,350	2.4344	7.4069	9.8413	1.0100	0.9575	9.4460	5.6786
00426281S	Countryside Drive	Four - Traffic Signal	31,600	30,540	6.6593	30.6047	37.2640	1.0100	0.8922	33.3067	16.5558
00427526S	Mayfield Road	Four - Traffic Signal	55,280	32,470	9.4400	40.1457	49.5857	1.0100	0.8565	42.5520	16.2851

Table 21: Change in Safety Performance of Individual Intersections in the Planning Horizon Year (2031) Following the Implementation of the Preferred Alternative Design

Location ID	Location Description – Dixie Road At:	Number of Legs – Traffic Control	Total Expected No. of Collisions in 2031 with Existing Design	Total Expected No. of Collisions in 2031 w/ Alternative Design	Reduction in No. of Collisions	Percentage of Reduction in No. of Collisions
00420119S	Queen Street East	Four - Traffic Signal	68.3315	67.4461	0.8853	1.2957%
00420298N	Hillside Drive	Three - Stop Sign	2.9954	2.8319	0.1634	5.4564%
00420632N	Hazelwood Drive	Three - Stop Sign	0.6884	0.5374	0.1510	21.9334%
00420805S	Howden Boulevard	Four - Traffic Signal	11.9885	11.5041	0.4844	4.0403%
00421091N	Crescent Hill Drive South	Three - Stop Sign	0.4275	0.3345	0.0930	21.7579%
00421248N	Crescent Hill Drive North	Three - Stop Sign	0.4275	0.3349	0.0926	21.6519%
00421409N	Lascelles Boulevard	Three - Stop Sign	0.4834	0.3789	0.1045	21.6233%
00421753S	Williams Parkway East	Four - Traffic Signal	16.7886	15.7298	1.0589	6.3071%
00422014S	Northampton Street	Four - Traffic Signal	5.0418	4.9674	0.0744	1.4753%
00422452S	North Park Drive	Four - Traffic Signal	8.1530	8.0302	0.1227	1.5054%
00422827N	Northcliffe Street	Four – Traffic Signal	2.6780	8.6067	-5.9287	-221.3874%
00423204S	Bovaird Drive East	Four - Traffic Signal	96.8321	87.3149	9.5172	9.8285%
00423821S	Peter Robertson Boulevard	Four - Traffic Signal	15.2449	13.5138	1.7311	11.3553%
00424503S	Springtown Trail	Four - Traffic Signal	3.4259	3.0382	0.3877	11.3178%
00424821S	Sandalwood Parkway	Four - Traffic Signal	23.0341	20.7693	2.2648	9.8323%
00425302S	Octillo Boulevard *	Three - Traffic Signal	3.5702	3.5167	0.0534	1.4970%
00425892S	Father Tobin Road	Four - Traffic Signal	3.1675	5.6786	-2.5111	-79.2782%
00426281S	Countryside Drive	Four - Traffic Signal	18.5229	16.5558	1.9671	10.6196%
00427526S	Mayfield Road	Four - Traffic Signal	18.9770	16.2851	2.6919	14.1849%

Considering all the intersections, the overall improvement in safety in the future year with the preferred alternative design is shown in **Table 22**.

Table 22: Overall Safety Improvement at the Intersections in the Planning Horizon Year (2031) with Preferred Alternative Design

Reduction in Number of Collisions / Year	Percentage of Reduction in Number of Collisions
13.4036	**4.4563%**

Safety of Vulnerable Road Users at Intersections

A review of the preferred alternative design indicates that the change in number of lanes (from 4 lanes to 6 lanes along Dixie Road anywhere from Queen Street to south of Countryside Road and from 2 lanes to 4 lanes north of Countryside Road) will increase the distance a pedestrian / cyclist must cross at the intersections and can as a result decrease safety of vulnerable road users if proper countermeasures are not considered.

The following countermeasures can be considered to improve pedestrian safety at the cross walks:

- Restrict right-turn-on-red (RTOR): RTOR movements can potentially contribute to pedestrian / cyclist collisions and it is anticipated that restricting this movement can reduce the likelihood of collisions involving vulnerable road users;
- Reassess traffic signal operations, considering pedestrian walking speeds and pedestrian signal timing: If pedestrians with wheel chairs or limited mobility routinely use the cross walk, a walking speed of less than 4ft/sec can be considered in determining the pedestrian clearance time;
- Far-side bus stop;
- Use of necessary and adequate warning signs; and
- Use of in-pavement lights as per guidance provided in MUTCD (Manual for Uniform Traffic Control Devices) etc.

3.3.2 Mid-Block Road Sections Safety Assessment

The predicted and expected numbers of collisions along the mid-block road sections in the planning horizon year (2031) with the existing design was obtained from the proper SPFs and using **Equation 10** respectively**.** The results are shown in **Table 23**.

Also the predicted and expected number of collisions in the future year considering the preferred alternative design was obtained using **Equations 11** and **12.** The corresponding results are shown in **Table 24**.

Table 25 shows the safety of individual mid-block road sections in the future year with the preferred alternative design.

Table 23: Predicted and Expected Numbers of Collisions in the Planning Horizon Year (2031) with Existing Design for All the Mid-Block Road Sections within the Study Area

Location ID	Location Description – Dixie Road Between:	Type – No. of Lanes	AADT in 2031	Total Predicted No. of Collisions in 2031 with Existing Design	Total Expected No. of Collisions in 2031 with Existing Design
00420119L	Queen Street East and Hillside Drive	Urban - Four	38,930	0.9839	2.5349
00420298L	Hillside Drive and Hazelwood Drive	Urban - Four	37,780	1.8247	0.7651
00420632L	Hazelwood Drive and Howden Boulevard	Urban - Four	38,045	0.9619	0.4729
00420805L	Howden Boulevard and Crescent Hill Drive South	Urban - Four	35,020	1.5090	0.3598
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	Urban - Four	35,020	0.8435	0.2892
00421248L	Crescent Hill Drive North and Lascelles Boulevard	Urban - Four	35,020	0.8384	0.2885
00421409L	Lascelles Boulevard and Williams Parkway East	Urban - Four	33,810	1.7452	0.7601
00421753L	Williams Parkway East and Northampton Street	Urban - Four	32,495	1.2846	1.2681
00422014L	Northampton Street and North Park Drive	Urban - Four	29,735	1.9833	1.1889
00422452L	North Park Drive and Northcliffe Street	Urban - Four	29,435	1.7129	0.3850
00422827L	Northcliffe Street and Bovaird Drive East	Urban - Four	29,130	1.6955	0.8086
00423204L	Bovaird Drive East and Peter Robertson Boulevard	Urban - Four	38,030	3.3394	1.6033
00423821L	Peter Robertson Boulevard and Springtown Trail	Urban - Four	37,300	3.6398	0.5972
00424503L	Springtown Trail and Sandalwood Parkway	Urban - Four	37,785	1.7451	0.4975
00424821L	Sandalwood Parkway and Octillo Boulevard	Urban - Four	40,375	2.7057	1.1311
00425302L	Octillo Boulevard and Father Tobin Road	Urban - Four	39,360	3.2952	0.9833
00425892L	Father Tobin Road and Countryside Drive	Urban - Four	34,050	1.9411	1.0504
00426281L	Countryside Drive and Mayfield Road	Suburban - Two	28,285	5.0802	1.7073
NA	Mayfield Rd and Two Kilometres North of Mayfield Rd	Suburban - Two	29,920	8.3468	4.1199

Table 24: Predicted and Expected Numbers of Collisions in the Planning Horizon Year (2031) with Preferred Alternative Design for All the Mid-Block Road Sections within the Study Area

Location ID	Location Description – Dixie Road Between:	Type – No. of Lanes	AADT in 2031	Median Type – Width (m)	Lane Width (m)	Total Predicted No. of Collisions in 2031 w/ Alternative Design	CMF for All Collisions	Total Predicted No. of Collisions in 2031 w/ Alternative Design w/ CMFs	Total Expected No. of Collisions in 2031 w/ Alternative Design
00420119L	Queen Street East and Hillside Drive	Urban - Six	38,930	Raised Curb - 6.00	3.75	0.9839	0.9854	0.9696	2.4980
00420298L	Hillside Drive and Hazelwood Drive	Urban - Six	37,780	Undivided	3.75	1.8247	0.9971	1.8195	0.7629
00420632L	Hazelwood Drive and Howden Boulevard	Urban - Six	38,045	Raised Curb - 6.00	3.75	0.9619	0.9790	0.9417	0.4629
00420805L	Howden Boulevard and Crescent Hill Drive South	Urban - Six	35,020	Raised Curb - 6.00	3.75	1.5090	0.9828	1.4830	0.3536
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	Urban - Six	35,020	Raised Curb - 6.00	3.75	0.8435	0.9925	0.8372	0.2871
00421248L	Crescent Hill Drive North and Lascelles Boulevard	Urban - Six	35,020	Raised Curb - 6.00	3.75	0.8384	0.9886	0.8289	0.2852
00421409L	Lascelles Boulevard and Williams Parkway East	Urban - Six	33,810	Raised Curb - 6.00	3.75	1.7452	0.9808	1.7118	0.7455
00421753L	Williams Parkway East and Northampton Street	Urban - Six	32,495	Raised Curb - 2.50	3.75	1.2846	0.9828	1.2625	1.2462
00422014L	Northampton Street and North Park Drive	Urban - Six	29,735	Raised Curb - 2.50	3.75	1.9833	0.9857	1.9549	1.1719
00422452L	North Park Drive and Northcliffe Street	Urban - Six	29,435	Raised Curb - 2.50	3.75	1.7129	0.9906	1.6967	0.3813
00422827L	Northcliffe Street and Bovaird Drive East	Urban - Six	29,130	Raised Curb - 2.50	3.75	1.6955	0.9906	1.6794	0.8010
00423204L	Bovaird Drive East and Peter Robertson Boulevard	Urban - Six	38,030	Raised Curb - 5.00	3.75	3.3394	0.9919	3.3125	1.5904
00423821L	Peter Robertson Boulevard and Springtown Trail	Urban - Six	37,300	Raised Curb - 6.00	3.75	3.6398	0.9854	3.5868	0.5885
00424503L	Springtown Trail and Sandalwood Parkway	Urban - Six	37,785	Raised Curb - 6.00	3.75	1.7451	0.9919	1.7310	0.4935
00424821L	Sandalwood Parkway and Octillo Boulevard	Urban - Six	40,375	Raised Curb - 6.00	3.75	2.7057	0.9919	2.6839	1.1220
00425302L	Octillo Boulevard and Father Tobin Road	Urban - Six	39,360	Raised Curb - 6.00	3.75	3.2952	0.9764	3.2175	0.9601
00425892L	Father Tobin Road and Countryside Drive	Urban - Six	34,050	Raised Curb - 6.00	3.75	1.9411	0.9764	1.8954	1.0256
00426281L	Countryside Drive and Mayfield Road	Urban - Four	28,285	Undivided	3.75	5.3236	0.9967	5.3061	1.7832
NA	Mayfield Rd and Two Kilometres North of Mayfield Rd	Urban - Four	29,920	Undivided	3.75	8.8210	0.9967	8.7920	4.3397

Table 25: Change in Safety Performance of Individual Mid-Block Road Sections in the Planning Horizon Year (2031) Following the Implementation of the Preferred Alternative Design

Location ID	Location Description – Dixie Road Between:	Total Expected No. of Collisions in 2031 with Existing Design	Total Expected No. of Collisions in 2031 w/ Alternative Design	Reduction in No. of Collisions	Percentage of Reduction in No. of Collisions
00420119L	Queen Street East and Hillside Drive	2.5349	2.4980	0.0369	1.4554%
00420298L	Hillside Drive and Hazelwood Drive	0.7651	0.7629	0.0022	0.2883%
00420632L	Hazelwood Drive and Howden Boulevard	0.4729	0.4629	0.0099	2.1004%
00420805L	Howden Boulevard and Crescent Hill Drive South	0.3598	0.3536	0.0062	1.7219%
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	0.2892	0.2871	0.0022	0.7495%
00421248L	Crescent Hill Drive North and Lascelles Boulevard	0.2885	0.2852	0.0033	1.1392%
00421409L	Lascelles Boulevard and Williams Parkway East	0.7601	0.7455	0.0146	1.9156%
00421753L	Williams Parkway East and Northampton Street	1.2681	1.2462	0.0218	1.7219%
00422014L	Northampton Street and North Park Drive	1.1889	1.1719	0.0170	1.4308%
00422452L	North Park Drive and Northcliffe Street	0.3850	0.3813	0.0036	0.9445%
00422827L	Northcliffe Street and Bovaird Drive East	0.8086	0.8010	0.0076	0.9445%
00423204L	Bovaird Drive East and Peter Robertson Boulevard	1.6033	1.5904	0.0129	0.8062%
00423821L	Peter Robertson Boulevard and Springtown Trail	0.5972	0.5885	0.0087	1.4554%
00424503L	Springtown Trail and Sandalwood Parkway	0.4975	0.4935	0.0040	0.8062%
00424821L	Sandalwood Parkway and Octillo Boulevard	1.1311	1.1220	0.0091	0.8062%
00425302L	Octillo Boulevard and Father Tobin Road	0.9833	0.9601	0.0232	2.3573%
00425892L	Father Tobin Road and Countryside Drive	1.0504	1.0256	0.0248	2.3573%
00426281L	Countryside Drive and Mayfield Road	1.7073	1.7832	-0.0759	-4.4466%
	Mayfield Rd and Two Kilometres North of Mayfield Rd	4.1199	4.3397	-0.2198	-5.3348%

Considering all the mid-block road sections, there is a slight increase in number of collisions occurring along mid-block road sections in the future year with the preferred alternative design as shown in **Table 26**. However overall, considering both intersections and mid-block road sections, there is an improvement in safety with the preferred alternative design (**Table 27)**.

Table 26: Overall Change in Safety for the Mid-Block Road Sections in the Planning Horizon Year (2031) with Preferred Alternative Design

Reduction in Number of Collisions / Year	Percentage of Reduction in Number of Collisions
-0.0877	-0.4212%

Table 27: Overall Safety Improvement for in the Planning Horizon Year (2031) with Preferred Alternative Design

Reduction in Number of Collisions / Year	Percentage of Reduction in Number of Collisions
13.3159	4.1407%

4. Conclusions

The main purpose of this report was to provide a safety assessment of the existing conditions within the study area and quantitatively evaluating the safety impact of the proposed preferred alternative design.

The safety assessments of the existing condition revealed that the predominant impact types on this road section are rear end and sideswipe collisions. For intersections, the most predominant impact types on the road sections in the study area are rear end and angle collisions. No general trends can be made on the study area as a whole in terms of season, month, or time of day trends. The collisions seem to be occurring during fairly different periods among the different intersections and road sections. Also the majority of the collisions occurred under ideal driving conditions.

The results of PSI (Potential for Safety Improvement) analysis showed that the majority of the intersections and mid-block road sections within the study area have zero PSI values; therefore there is limited potential for improving any of these locations in terms of safety. However, there are five intersections and three mid-block road sections that have positive PSI values, including the intersection of Dixie Road and Bovaird Drive East with the highest PSI value of 14.5805, meaning that there are potentials for safety improvements at these locations.

Also the results of the over-representation analysis indicated that for signalized four-legged intersections angle type collisions were over-represented. Also for the intersection of Dixie Road and Bovaird Street East collisions under wet road surface conditions was over-represented. Of the three mid-block road sections analyzed none of them had any over-represented collision characteristic.

The safety assessment of the proposed preferred design was based on the most up to date research information available on SPFs and CMFs. The safety assessment of the proposed preferred alternative design was carried out for the planning horizon year of 2031.

For the planning horizon year, the results showed that the preferred alternative design would result in a net decrease of **4.46%** in total number of collisions for intersections whereas the results for the mid-block road sections indicated that the proposed preferred design would result in a net increase of **-0.42%** in total number of collisions. Overall with implementation of the preferred alternative design in the planning horizon year, there will be 13 fewer collisions in 2031.

Also the safety impact of the road widening was assessed qualitatively in terms of vulnerable road user's safety. The road widening will increase the distance a pedestrian / cyclist must cross at the intersections and can as a result deteriorate pedestrian safety if proper countermeasures are not considered.

APPENDIX A – Collision Distributions Based on Different Collision Characteristics

Table A1: Observed Number of Collisions Classified by Impact Type Occurred at Intersections along Dixie Road from 2005 to 2007

Location ID	Location Description - Dixie Road At:	Angle	Approaching	Rear End	Side Swipe	Turning Movement	SMV	Other	Total
00420119S	Queen Street East	15	6	68	11	18	1	2	121
00420298N	Hillside Drive	1	0	4	1	2	0	0	8
00420632N	Hazelwood Drive	0	0	0	1	0	0	1	2
00420805S	Howden Boulevard	8	0	6	2	6	1	1	24
00421091N	Crescent Hill Drive South	0	0	0	0	0	0	0	0
00421248N	Crescent Hill Drive North	0	0	0	0	0	0	0	0
00421409N	Lascelles Boulevard	0	0	0	0	0	0	0	0
00421753S	Williams Parkway East	7	4	4	3	5	0	1	24
00422014S	Northampton Street	2	1	3	0	2	0	0	8
00422452S	North Park Drive	2	4	4	1	2	0	0	13
00422827N	Northcliffe Street	2	1	5	0	0	0	0	8
00423204S	Bovaird Drive East	28	6	46	8	22	1	1	112
00423821S	Peter Robertson Boulevard	6	2	5	4	5	0	0	22
00424503S	Springtown Trail	0	0	1	0	1	0	0	2
00424821S	Sandalwood Parkway	6	3	5	2	5	1	0	22
00425302S	Octillo Boulevard	1	1	3	1	0	0	0	6
00425892S	Father Tobin Road	0	0	1	1	1	0	1	4
00426281S	Countryside Drive	0	0	3	0	0	0	0	3
00427526S	Mayfield Road	3	0	2	0	2	1	0	8
Total		**81**	**28**	**160**	**35**	**71**	**5**	**7**	**387**

Table A2: Observed Number of Collisions Classified by Impact Type Occurred on Mid-block Road Sections along Dixie Road from 2005 to 2007

Location ID	Location Description – Dixie Road Between:	Angle	Approa-ching	Rear End	Side Swipe	Turning Movem-ent	SMV	Other	Total
00420119L	Queen Street East and Hillside Drive	1	0	4	2	0	0	0	7
00420298L	Hillside Drive and Hazelwood Drive	0	0	1	0	0	0	0	1
00420632L	Hazelwood Drive and Howden Boulevard	0	0	1	0	0	0	0	1
00420805L	Howden Boulevard and Crescent Hill Drive South	0	0	0	0	0	0	0	0
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	0	0	0	0	0	0	0	0
00421248L	Crescent Hill Drive North and Lascelles Boulevard	1	0	0	0	0	0	0	1
00421409L	Lascelles Boulevard and Williams Parkway East	0	0	1	0	0	0	0	1
00421753L	Williams Parkway East and Northampton Street	0	0	2	1	0	0	0	3
00422014L	Northampton Street and North Park Drive	0	0	1	0	0	1	0	2
00422452L	North Park Drive and Northcliffe Street	0	1	0	0	0	0	0	1
00422827L	Northcliffe Street and Bovaird Drive East	0	0	1	0	0	0	0	1
00423204L	Bovaird Drive East and Peter Robertson Boulevard	0	1	0	1	0	0	0	2
00423821L	Peter Robertson Boulevard and Springtown Trail	0	0	0	0	0	0	0	0
00424503L	Springtown Trail and Sandalwood Parkway	0	0	0	0	0	0	0	0
00424821L	Sandalwood Parkway and Octillo Boulevard	0	0	1	0	0	0	0	1
00425302L	Octillo Boulevard and Father Tobin Road	0	1	0	0	0	0	0	1
00425892L	Father Tobin Road and Countryside Drive	0	0	0	0	1	0	0	1
00426281L	Countryside Drive and Mayfield Road	0	0	0	0	0	0	1	1
	Mayfield Road to 2 Km North of Mayfield Road	0	0	1	0	0	0	2	3
Total		**2**	**3**	**13**	**4**	**1**	**1**	**3**	**27**

Table A3: Observed Number of Collisions Classified by Season for Intersections along Dixie Road from 2005 to 2007

Location ID	Location Description - Dixie Road At	Winter	Spring	Summer	Fall	Other	Total
00420119S	Queen Street East	16	30	25	46	5	122
00420298N	Hillside Drive	0	3	3	2	0	8
00420632N	Hazelwood Drive	1	0	0	1	0	2
00420805S	Howden Boulevard	6	5	5	7	1	24
00421091N	Crescent Hill Drive South	0	0	0	0	0	0
00421248N	Crescent Hill Drive North	0	0	0	0	0	0
00421409N	Lascelles Boulevard	0	0	0	0	0	0
00421753S	Williams Parkway East	7	3	9	4	1	24
00422014S	Northampton Street	2	2	2	2	0	8
00422452S	North Park Drive	1	6	4	3	0	14
00422827N	Northcliffe Street	1	2	2	3	0	8
00423204S	Bovaird Drive East	21	25	30	32	6	114
00423821S	Peter Robertson Boulevard	5	2	3	13	0	23
00424503S	Springtown Trail	1	0	0	1	0	2
00424821S	Sandalwood Parkway	7	2	2	11	0	22
00425302S	Octillo Boulevard	1	1	1	3	0	6
00425892S	Father Tobin Road	0	1	1	2	0	4
00426281S	Countryside Drive	1	1	1	0	0	3
00427526S	Mayfield Road	1	2	3	2	0	8
Total		**71**	**85**	**91**	**132**	**13**	**392**

Table A4: Observed Number of Collisions Classified by Season for Mid-block Road Sections along Dixie Road from 2005 to 2007

Location ID	Location Description – Dixie Road Between:	Winter	Spring	Summer	Fall	Other	Total
00420119L	Queen Street East and Hillside Drive	1	2	3	0	1	7
00420298L	Hillside Drive and Hazelwood Drive	1	0	0	0	0	1
00420632L	Hazelwood Drive and Howden Boulevard	1	0	0	0	0	1
00420805L	Howden Boulevard and Crescent Hill Drive South	0	0	0	0	0	0
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	0	0	0	0	0	0
00421248L	Crescent Hill Drive North and Lascelles Boulevard	1	0	0	0	0	1
00421409L	Lascelles Boulevard and Williams Parkway East	0	0	1	0	0	1
00421753L	Williams Parkway East and Northampton Street	2	0	0	1	0	3
00422014L	Northampton Street and North Park Drive	1	1	0	0	0	2
00422452L	North Park Drive and Northcliffe Street	0	0	1	0	0	1
00422827L	Northcliffe Street and Bovaird Drive East	0	0	1	0	0	1
00423204L	Bovaird Drive East and Peter Robertson Boulevard	0	1	1	0	0	2
00423821L	Peter Robertson Boulevard and Springtown Trail	0	0	0	0	0	0
00424503L	Springtown Trail and Sandalwood Parkway	0	0	0	0	0	0
00424821L	Sandalwood Parkway and Octillo Boulevard	0	0	1	0	0	1
00425302L	Octillo Boulevard and Father Tobin Road	1	0	0	0	0	1
00425892L	Father Tobin Road and Countryside Drive	1	0	0	0	0	1
00426281L	Countryside Drive and Mayfield Road	0	0	0	1	0	1
	Mayfield Road to 2 Km North of Mayfield Road	1	1	0	1	0	3
Total		**10**	**5**	**8**	**3**	**1**	**27**

Table A5: Observed Number of Collisions Classified by Month for Intersections along Dixie Road from 2005 to 2007

Location ID	Location Description - Dixie Road At	1	2	3	4	5	6	7	8	9	10	11	12	Total
00420119S	Queen Street East	6	8	3	4	18	8	8	8	12	16	12	14	117
00420298N	Hillside Drive	0	0	0	1	1	1	2	1	0	1	0	1	8
00420632N	Hazelwood Drive	0	0	1	0	0	0	0	0	0	1	0	0	2
00420805S	Howden Boulevard	3	2	0	1	3	1	2	0	3	2	3	3	23
00421091N	Crescent Hill Drive South	0	0	0	0	0	0	0	0	0	0	0	0	0
00421248N	Crescent Hill Drive North	0	0	0	0	0	0	0	0	0	0	0	0	0
00421409N	Lascelles Boulevard	0	0	0	0	0	0	0	0	0	0	0	0	0
00421753S	Williams Parkway East	1	2	4	0	2	2	1	2	5	1	2	1	23
00422014S	Northampton Street	0	0	2	2	0	1	0	1	0	1	1	0	8
00422452S	North Park Drive	0	0	1	2	2	2	2	2	0	0	2	1	14
00422827N	Northcliffe Street	1	0	0	0	2	1	0	0	2	0	2	0	8
00423204S	Bovaird Drive East	7	7	7	3	10	11	8	13	9	5	13	15	108
00423821S	Peter Robertson Boulevard	3	1	0	0	1	1	0	3	1	6	4	3	23
00424503S	Springtown Trail	0	1	0	0	0	0	0	0	0	0	1	0	2
00424821S	Sandalwood Parkway	6	1	0	1	0	3	1	1	0	0	6	3	22
00425302S	Octillo Boulevard	1	0	0	0	1	0	0	0	1	1	1	1	6
00425892S	Father Tobin Road	0	0	0	0	1	0	1	0	0	0	1	1	4
00426281S	Countryside Drive	0	0	1	1	0	0	0	1	0	0	0	0	3
00427526S	Mayfield Road	0	0	0	0	1	1	0	2	1	1	0	2	8
Total		**28**	**22**	**19**	**15**	**42**	**32**	**25**	**34**	**34**	**35**	**48**	**45**	**379**

Table A6: Observed Number of Collisions Classified by Month for Mid-block Road Sections along Dixie Road from 2005 to 2007

Location ID	Location Description – Dixie Road Between:	1	2	3	4	5	6	7	8	9	10	11	12	Total
00420119L	Queen Street East and Hillside Drive	0	0	1	0	2	0	2	0	1	0	0	0	6
00420298L	Hillside Drive and Hazelwood Drive	1	0	0	0	0	0	0	0	0	0	0	0	1
00420632L	Hazelwood Drive and Howden Boulevard	1	0	0	0	0	0	0	0	0	0	0	0	1
00420805L	Howden Boulevard and Crescent Hill Drive South	0	0	0	0	0	0	0	0	0	0	0	0	0
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	0	0	0	0	0	0	0	0	0	0	0	0	0
00421248L	Crescent Hill Drive North and Lascelles Boulevard	0	1	0	0	0	0	0	0	0	0	0	0	1
00421409L	Lascelles Boulevard and Williams Parkway East	0	0	0	0	0	0	0	0	1	0	0	0	1
00421753L	Williams Parkway East and Northampton Street	0	1	1	0	0	0	0	0	0	0	1	0	3
00422014L	Northampton Street and North Park Drive	0	1	0	1	0	0	0	0	0	0	0	0	2
00422452L	North Park Drive and Northcliffe Street	0	0	0	0	0	0	1	0	0	0	0	0	1
00422827L	Northcliffe Street and Bovaird Drive East	0	0	0	0	0	0	0	0	1	0	0	0	1
00423204L	Bovaird Drive East and Peter Robertson Boulevard	0	0	0	1	0	0	1	0	0	0	0	0	2
00423821L	Peter Robertson Boulevard and Springtown Trail	0	0	0	0	0	0	0	0	0	0	0	0	0
00424503L	Springtown Trail and Sandalwood Parkway	0	0	0	0	0	0	0	0	0	0	0	0	0
00424821L	Sandalwood Parkway and Octillo Boulevard	0	0	0	0	0	0	0	0	1	0	0	0	1
00425302L	Octillo Boulevard and Father Tobin Road	0	1	0	0	0	0	0	0	0	0	0	0	1
00425892L	Father Tobin Road and Countryside Drive	0	1	0	0	0	0	0	0	0	0	0	0	1
00426281L	Countryside Drive and Mayfield Road	0	0	0	0	0	0	0	0	0	1	0	0	1
	Mayfield Road to 2 Km North of Mayfield Road	0	0	1	0	0	0	0	0	0	1	0	1	3
Total		**2**	**5**	**3**	**2**	**2**	**0**	**4**	**0**	**4**	**2**	**1**	**1**	**26**

Table A7: Observed Number of Collisions Classified by Time of Day for Intersections along Dixie Road from 2005 to 2007

Location ID	Location Description - Dixie Road At	Early Morning	AM Rush Hour	Midday	PM Rush Hour	Evening	Total
00420119S	Queen Street East	14	30	50	22	6	122
00420298N	Hillside Drive	0	3	3	1	1	8
00420632N	Hazelwood Drive	0	1	1	0	0	2
00420805S	Howden Boulevard	1	4	9	8	2	24
00421091N	Crescent Hill Drive South	0	0	0	0	0	0
00421248N	Crescent Hill Drive North	0	0	0	0	0	0
00421409N	Lascelles Boulevard	0	0	0	0	0	0
00421753S	Williams Parkway East	2	5	10	2	5	24
00422014S	Northampton Street	0	3	4	1	0	8
00422452S	North Park Drive	2	4	3	3	2	14
00422827N	Northcliffe Street	0	1	2	3	2	8
00423204S	Bovaird Drive East	7	28	24	34	21	114
00423821S	Peter Robertson Boulevard	3	5	5	8	2	23
00424503S	Springtown Trail	1	0	1	0	0	2
00424821S	Sandalwood Parkway	2	6	4	6	4	22
00425302S	Octillo Boulevard	0	4	1	0	1	6
00425892S	Father Tobin Road	0	1	1	1	1	4
00426281S	Countryside Drive	0	3	0	0	0	3
00427526S	Mayfield Road	0	1	5	2	0	8
Total		**32**	**99**	**123**	**91**	**47**	**392**

Table A8: Observed Number of Collisions Classified by Time of Day for Mid-block Road Sections along Dixie Road from 2005 to 2007

Location ID	Location Description – Dixie Road Between:	Early Morning	AM Rush Hour	Midday	PM Rush Hour	Evening	Total
00420119L	Queen Street East and Hillside Drive	0	1	5	1	0	7
00420298L	Hillside Drive and Hazelwood Drive	0	1	0	0	0	1
00420632L	Hazelwood Drive and Howden Boulevard	0	0	1	0	0	1
00420805L	Howden Boulevard and Crescent Hill Drive South	0	0	0	0	0	0
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	0	0	0	0	0	0
00421248L	Crescent Hill Drive North and Lascelles Boulevard	1	0	0	0	0	1
00421409L	Lascelles Boulevard and Williams Parkway East	0	1	0	0	0	1
00421753L	Williams Parkway East and Northampton Street	0	2	0	0	1	3
00422014L	Northampton Street and North Park Drive	0	1	0	1	0	2
00422452L	North Park Drive and Northcliffe Street	0	1	0	0	0	1
00422827L	Northcliffe Street and Bovaird Drive East	0	1	0	0	0	1
00423204L	Bovaird Drive East and Peter Robertson Boulevard	1	1	0	0	0	2
00423821L	Peter Robertson Boulevard and Springtown Trail	0	0	0	0	0	0
00424503L	Springtown Trail and Sandalwood Parkway	0	0	0	0	0	0
00424821L	Sandalwood Parkway and Octillo Boulevard	0	1	0	0	0	1
00425302L	Octillo Boulevard and Father Tobin Road	0	1	0	0	0	1
00425892L	Father Tobin Road and Countryside Drive	0	0	1	0	0	1
00426281L	Countryside Drive and Mayfield Road	1	0	0	0	0	1
	Mayfield Road to 2 Km North of Mayfield Road	0	1	0	1	1	3
Total		**3**	**12**	**7**	**3**	**2**	**27**

Table A9: Observed Number of Collisions Classified by Lighting Condition for Intersections along Dixie Road from 2005 to 2007

Location ID	Location Description - Dixie Road At	Dawn	Day-light	Dusk	Dark	Other	Total
00420119S	Queen Street East	3	84	5	29	1	122
00420298N	Hillside Drive	0	8	0	0	0	8
00420632N	Hazelwood Drive	0	2	0	0	0	2
00420805S	Howden Boulevard	0	16	2	6	0	24
00421091N	Crescent Hill Drive South	0	0	0	0	0	0
00421248N	Crescent Hill Drive North	0	0	0	0	0	0
00421409N	Lascelles Boulevard	0	0	0	0	0	0
00421753S	Williams Parkway East	1	17	0	6	0	24
00422014S	Northampton Street	0	7	0	1	0	8
00422452S	North Park Drive	0	11	0	3	0	14
00422827N	Northcliffe Street	0	4	0	4	0	8
00423204S	Bovaird Drive East	5	71	4	32	2	114
00423821S	Peter Robertson Boulevard	1	15	1	6	0	23
00424503S	Springtown Trail	0	1	1	0	0	2
00424821S	Sandalwood Parkway	0	16	0	5	1	22
00425302S	Octillo Boulevard	0	5	0	1	0	6
00425892S	Father Tobin Road	0	2	0	2	0	4
00426281S	Countryside Drive	0	3	0	0	0	3
00427526S	Mayfield Road	0	7	0	1	0	8
Total		**10**	**269**	**13**	**96**	**4**	**392**

Table A10: Observed Number of Collisions Classified by Lighting Condition for Mid-block Road Sections along Dixie Road from 2005 to 2007

Location ID	Location Description – Dixie Road Between:	Dawn	Daylight	Dusk	Dark	Other	Total
00420119L	Queen Street East and Hillside Drive	0	7	0	0	0	7
00420298L	Hillside Drive and Hazelwood Drive	1	0	0	0	0	1
00420632L	Hazelwood Drive and Howden Boulevard	0	1	0	0	0	1
00420805L	Howden Boulevard and Crescent Hill Drive South	0	0	0	0	0	0
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	0	0	0	0	0	0
00421248L	Crescent Hill Drive North and Lascelles Boulevard	0	0	0	0	1	1
00421409L	Lascelles Boulevard and Williams Parkway East	0	1	0	0	0	1
00421753L	Williams Parkway East and Northampton Street	0	2	0	1	0	3
00422014L	Northampton Street and North Park Drive	0	2	0	0	0	2
00422452L	North Park Drive and Northcliffe Street	0	0	0	1	0	1
00422827L	Northcliffe Street and Bovaird Drive East	0	1	0	0	0	1
00423204L	Bovaird Drive East and Peter Robertson Boulevard	0	2	0	0	0	2
00423821L	Peter Robertson Boulevard and Springtown Trail	0	0	0	0	0	0
00424503L	Springtown Trail and Sandalwood Parkway	0	0	0	0	0	0
00424821L	Sandalwood Parkway and Octillo Boulevard	0	1	0	0	0	1
00425302L	Octillo Boulevard and Father Tobin Road	0	1	0	0	0	1
00425892L	Father Tobin Road and Countryside Drive	0	1	0	0	0	1
00426281L	Countryside Drive and Mayfield Road	0	0	0	1	0	1
	Mayfield Road to 2 Km North of Mayfield Road	0	1	0	2	0	3
Total		**1**	**20**	**0**	**5**	**1**	**27**

Table A11: Observed Number of Collisions Classified by Road Surface Condition for Intersections along Dixie Road from 2005 to 2007

Location ID	Location Description - Dixie Road At	Dry	Wet	Slippery *	Other **	Total
00420119S	Queen Street East	96	23	3	0	122
00420298N	Hillside Drive	5	3	0	0	8
00420632N	Hazelwood Drive	2	0	0	0	2
00420805S	Howden Boulevard	16	5	3	0	24
00421091N	Crescent Hill Drive South	0	0	0	0	0
00421248N	Crescent Hill Drive North	0	0	0	0	0
00421409N	Lascelles Boulevard	0	0	0	0	0
00421753S	Williams Parkway East	18	3	2	1	24
00422014S	Northampton Street	2	6	0	0	8
00422452S	North Park Drive	8	6	0	0	14
00422827N	Northcliffe Street	6	2	0	0	8
00423204S	Bovaird Drive East	63	44	7	0	114
00423821S	Peter Robertson Boulevard	16	6	1	0	23
00424503S	Springtown Trail	2	0	0	0	2
00424821S	Sandalwood Parkway	14	6	2	0	22
00425302S	Octillo Boulevard	4	2	0	0	6
00425892S	Father Tobin Road	3	0	0	1	4
00426281S	Countryside Drive	2	1	0	0	3
00427526S	Mayfield Road	8	0	0	0	8
Total		**265**	**107**	**18**	**2**	**392**

* Slippery road surface condition includes ice, slush, loose snow, and packed snow.
** Other road surface condition includes mud, loose sand and gravel.

Table A12: Observed Number of Collisions Classified by Road Surface Condition for Mid-block Road Sections along Dixie Road from 2005 to 2007

Location ID	Location Description – Dixie Road Between:	Dry	Wet	Slippery *	Other **	Total
00420119L	Queen Street East and Hillside Drive	3	2	1	0	7
00420298L	Hillside Drive and Hazelwood Drive	0	1	0	0	1
00420632L	Hazelwood Drive and Howden Boulevard	0	1	0	0	1
00420805L	Howden Boulevard and Crescent Hill Drive South	0	0	0	0	0
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	0	0	0	0	0
00421248L	Crescent Hill Drive North and Lascelles Boulevard	1	0	0	0	1
00421409L	Lascelles Boulevard and Williams Parkway East	1	0	0	0	1
00421753L	Williams Parkway East and Northampton Street	3	0	0	0	3
00422014L	Northampton Street and North Park Drive	2	0	0	0	2
00422452L	North Park Drive and Northcliffe Street	1	0	0	0	1
00422827L	Northcliffe Street and Bovaird Drive East	1	0	0	0	1
00423204L	Bovaird Drive East and Peter Robertson Boulevard	1	1	0	0	2
00423821L	Peter Robertson Boulevard and Springtown Trail	0	0	0	0	0
00424503L	Springtown Trail and Sandalwood Parkway	0	0	0	0	0
00424821L	Sandalwood Parkway and Octillo Boulevard	1	0	0	0	1
00425302L	Octillo Boulevard and Father Tobin Road	1	0	0	0	1
00425892L	Father Tobin Road and Countryside Drive	1	0	0	0	1
00426281L	Countryside Drive and Mayfield Road	0	0	0	1	1
	Mayfield Road to 2 Km North of Mayfield Road	2	0	1	0	3
Total		**18**	**5**	**2**	**1**	**27**

* Slippery road surface condition includes ice, slush, loose snow, and packed snow.
** Other road surface condition includes mud, loose sand and gravel.

Table A13: Observed Number of Collisions Classified by Environmental Condition for Intersections along Dixie Road from 2005 to 2007

Location ID	Location Description - Dixie Road At	Clear	Rain	Snow	Freezing Rain	Drifting Snow	Other *	Total
00420119S	Queen Street East	106	10	5	0	0	1	122
00420298N	Hillside Drive	6	2	0	0	0	0	8
00420632N	Hazelwood Drive	2	0	0	0	0	0	2
00420805S	Howden Boulevard	20	2	2	0	0	0	24
00421091N	Crescent Hill Drive South	0	0	0	0	0	0	0
00421248N	Crescent Hill Drive North	0	0	0	0	0	0	0
00421409N	Lascelles Boulevard	0	0	0	0	0	0	0
00421753S	Williams Parkway East	19	2	2	0	0	1	24
00422014S	Northampton Street	2	4	2	0	0	0	8
00422452S	North Park Drive	8	5	1	0	0	0	14
00422827N	Northcliffe Street	6	2	0	0	0	0	8
00423204S	Bovaird Drive East	74	29	7	0	1	3	114
00423821S	Peter Robertson Boulevard	20	2	0	0	0	1	23
00424503S	Springtown Trail	2	0	0	0	0	0	2
00424821S	Sandalwood Parkway	18	1	2	1	0	0	22
00425302S	Octillo Boulevard	5	1	0	0	0	0	6
00425892S	Father Tobin Road	3	0	0	0	0	1	4
00426281S	Countryside Drive	3	0	0	0	0	0	3
00427526S	Mayfield Road	8	0	0	0	0	0	8
Total		**302**	**60**	**21**	**1**	**1**	**7**	**392**

* Other environmental condition includes fog, mist, smoke, dust and others.

Table A14: Observed Number of Collisions Classified by Environmental Condition for Mid-block Road Sections along Dixie Road from 2005 to 2007

Location ID	Location Description – Dixie Road Between:	Clear	Rain	Snow	Freezing Rain	Drifting Snow	Other *	Total
00420119L	Queen Street East and Hillside Drive	5	1	0	0	1	0	7
00420298L	Hillside Drive and Hazelwood Drive	1	0	0	0	0	0	1
00420632L	Hazelwood Drive and Howden Boulevard	1	0	0	0	0	0	1
00420805L	Howden Boulevard and Crescent Hill Drive South	0	0	0	0	0	0	0
00421091L	Crescent Hill Drive South and Crescent Hill Drive North	0	0	0	0	0	0	0
00421248L	Crescent Hill Drive North and Lascelles Boulevard	1	0	0	0	0	0	1
00421409L	Lascelles Boulevard and Williams Parkway East	1	0	0	0	0	0	1
00421753L	Williams Parkway East and Northampton Street	3	0	0	0	0	0	3
00422014L	Northampton Street and North Park Drive	2	0	0	0	0	0	2
00422452L	North Park Drive and Northcliffe Street	1	0	0	0	0	0	1
00422827L	Northcliffe Street and Bovaird Drive East	1	0	0	0	0	0	1
00423204L	Bovaird Drive East and Peter Robertson Boulevard	1	1	0	0	0	0	2
00423821L	Peter Robertson Boulevard and Springtown Trail	0	0	0	0	0	0	0
00424503L	Springtown Trail and Sandalwood Parkway	0	0	0	0	0	0	0
00424821L	Sandalwood Parkway and Octillo Boulevard	1	0	0	0	0	0	1
00425302L	Octillo Boulevard and Father Tobin Road	1	0	0	0	0	0	1
00425892L	Father Tobin Road and Countryside Drive	1	0	0	0	0	0	1
00426281L	Countryside Drive and Mayfield Road	0	0	0	0	0	1	1
	Mayfield Road to 2 Km North of Mayfield Road	2	0	0	0	1	0	3
Total		**22**	**2**	**0**	**0**	**2**	**1**	**27**

* Other environmental condition includes fog, mist, smoke, dust and others.

APPENDIX B – The EB Framework to Calculate Potential for Safety Improvement (PSI)

The EB Framework to Calculate Potential for Safety Improvement (PSI)

The objective of the Empirical Bayes (EB) framework is to estimate the long-term safety performance of a site. Specifically, it aims to smooth out the random fluctuations in the collision data by specifying the actual safety of a segment as an estimate of its long-term mean (m) instead of its short-term counts (x). The estimate of m is obtained by combining the x of a specific segment in the most recent n years with an estimate of the expected annual number of collisions based on history of similar segments, E{m}.

According to the EB technique, for a specific collision severity level,

$$m = w_1 \times x + w_2 \times E\{m\} \quad \text{(B1)}$$

where w_1 and w_2 are the weighting factors that can be estimated by,

$$w_1 = \frac{E\{m\}}{(1/k) + (n \times E\{m\})} \quad \text{(B2)}$$

$$w_2 = \frac{1/k}{(1/k) + (n \times E\{m\})} \quad \text{(B3)}$$

where,

m = the long-term number of collisions expected to occur at the location, per year;
E{m} = the number of collisions expected to occur at an “average” per year;
x = observed number of collisions at a specific location over n years;
n = number of years for which the collision counts are available;
k = the over-dispersion parameter that describes the relationship between E{m} and VAR{m}, as previously described.

The “sites with potential for safety improvement” can be identified from a list of many locations by the PSI values. Because the PSI of a location is the difference between its long-term safety performance and its expected safety performance, taking into account the societal cost of collisions, in this study the $PSI_{(All)}$ of a location is comprised of both the PSI for severe (fatal and injury) collisions , and also PSI for PDO collisions.

As mentioned above, a PSI for a location is estimated by:

$$PSI_{(All)} = PSI_{(Severe)} + PSI_{(PDO)} \quad \text{(B4)}$$

where,

$$PSI_{(Severe)} = [\text{Expected Number of Severe Collisions}] \times [\text{Societal Cost of Fatal and Injury Collisions}]$$
$$PSI_{(PDO)} = [\text{Expected Number of PDO Collisions}] \times [\text{Societal Cost of PDO Collisions}]$$

For the purpose of this study, according to values obtained for Region of Halton, an approximate weighted ratio of 135.5:3.3:1 is used for fatal, injury, and PDO collisions.

To simplify the calculation process, some weighting factors could be used to substitute for the societal costs of collisions in estimating the PSI. If assigning the weighting factor of PDO collisions = 1, then:

$$PSI_{(F+I)} = [\text{Expected Number of Severe Collisions}] \times [\text{Weighted Factor of Fatal and Injury Collisions}]$$
$$PSI_{(PDO)} = [\text{Expected Number of PDO Collisions}]$$

Because the $SPF_{(Severe)}$ is used in this study, the weighted factor, or relative safety index (RSI), must be derived for severe collisions. The RSI for intersections and midblock road sections is estimated by,

$$RSI = \frac{135.5 \times Number\ of\ Fatal\ Collisions + 3.3 \times Number\ of\ Injury\ Collisions}{Total\ Number\ of\ Fatal\ and\ Injury\ Collisions} \qquad \text{(B5)}$$

For this study as there have been no fatal collisions observed within the study area over the period of 2005 to 2007 inclusive and in order to make the results more realistic, RSI value for both midblock road sections and intersections are obtained based on the respective number of recorded fatal and injury collisions for midblock road sections and intersections in the entire Region of Halton over the period of 2000 to 2004. **Table B1** shows the RSI values and the pertaining number of injury and fatal collisions for midblock road sections and intersections from Region of Halton.

Taken together, the following equations are used in this study to estimate the PSIs for the intersections and midblock segments:

$$PSI_{(F+I)} = [\text{Expected Number of Severe Collisions}] \times [RSI] \qquad \text{(B6)}$$

$$PSI_{(PDO)} = [\text{Expected Number of PDO Collisions}] \qquad \text{(B7)}$$

$$PSI_{(All)} = PSI_{(Severe)} + PSI_{(PDO)} \qquad \text{(B8)}$$

Table B1: RSI Values for Intersections and Mid-Block Road Sections

Element	Type	Fatal	Injury	PDO	RSI
Intersections	Signalized – 4 Legged	12	1874	8011	4.14
	Signalized – 3 Legged	6	308	757	5.83
	Stop-Controlled – 4 Legged	3	260	925	4.81
	Stop-Controlled – 3 Legged	7	320	1045	6.13
Midblock Road Sections	Suburban - Two-Lane	4	167	758	6.37
	Urban - Multi-Lane	1	230	1198	3.87

It should be noted that only positive PSI values are used for consideration. Generally, if the PSI is negative for an intersection, it should be assigned a value of zero since the negative sign means that the intersection experiences fewer collisions than is expected.

Sample Calculations

To illustrate the presented methodology in this report, a case study is presented in this section. The following example serves as a step-by-step analysis to identify "intersections with promise". Let's consider the intersection with the characteristics given below, whose collisions are observed between 2005 and 2007. The intersection that is analyzed is location ID: 00420298N – a three-legged stop-controlled intersection between Dixie Road and Hillside Drive. The relevant information for this intersection is shown in **Table B2**.

Table B2: Information for Location ID 00420298N – A Three-Legged Stop-Controlled Intersection between Dixie Road and Hillside Drive

Collision Information					Intersection Characteristics	
Fatal = 0					Number of Approaches = 3	
Injury = 1					Traffic Control Type = Stop Sign	
PDO = 7						
Entering AADT					**Input Variables**	
Year	**NB**	**SB**	**EB**	**WB**	**Major AADT (F_1)**	**Minor AADT (F_2)**
2007	17,670	8,080	650	-	25,750	650

Step 1: Collision prediction model form identification
Identify the SPFs pertaining to this intersection for prediction of number FI and PDO collisions. Since the intersection in this example is a 3-legged stop-controlled intersection, the following models for severe and PDO collisions were used.

a) Severe Collisions

$$E(m_{PDO}) = 7.924 \times 10^{-5} \times (F_1 + F_2)^{0.9466} \times \left(\frac{F_2}{F_1 + F_2}\right)^{0.3617}$$

b) PDO Collisions

$$E(m_{PDO}) = 4.158 \times 10^{-4} \times (F_1 + F_2)^{0.9113} \times \left(\frac{F_2}{F_1 + F_2}\right)^{0.4830}$$

Step 2: Estimate the expected number of collisions
In this step, the expected number of collisions for each year of analysis was calculated using the models reported in the Step 1. These values are shown in **Table B3**.

Table B3: Expected Annual Collisions Using Collision Prediction Model

$E(m_{Severe})$	$E(m_{PDO})$
0.3181	0.7435

Step 3: Estimate the long-term number of collisions
Estimate the long-term number of collisions expected to occur at this intersection combining the short-term collisions observed at the segment over n-year period (2005 through 2007) with its SPF.

Detailed calculations, using Equations B1, B2, and B3, to obtain the long-term number of PDO and severe collisions expected to occur at this segment are shown below in **Table B4**. Note that in this example, n=3 (period from 2005 through 2007). From **Table B2**, the number of PDO collisions observed is 7, and the number of severe collisions observed is 0 + 1 = 1.

Table B4: Estimate the Long-Term Number of Collisions

Data Readily Available				
Data available		**Severe Collisions**	**PDO Collisions**	**Data source**
E{m}		0.3181	0.7435	From Step 2
k		1.4829	1.2061	Table 6
n		3	3	Study period
x		1	7	Table B2
Terms to be Estimated				
Term		**Severe Collisions**	**PDO collisions**	**Equation**
w_1	**Expression**	0.32/((1/1.4829)+3×0.32)	0.74/((1/1.2061)+3×0.74)	B2
	Value	0.1958	0.2427	
w_2	**Expression**	(1/1.4829)/((1/1.4829)+3×0.32)	(1/1.2061)/((1/1.2061)+3×0.74)	B3
	Value	0.4126	0.2719	
m	**Expression**	0.1958×1+0.4126×0.32	0.2427×7+0.2719×0.74	B1
	Value	0.3270	1.9025	

Step 4: Computing the RSIs

Table B1 contains the RSI value for stop-controlled three-legged intersection which is 6.13.

Step 5: PSI calculation

Calculate the $PSI_{(All)}$ for the location. Using Equations B6 to B9, and the RSI values for intersections, the $PSI_{(All)}$ for this intersection is calculated and shown in **Table B5**.

Table B5: PSI Calculation

Model Parameters	Severe Collisions	PDO Collisions
E{m}	0.3181	0.7435
m	0.3270	1.9025
m-E{m}	0.0089	1.1590
RSI	6.13	1
PSI	0.0547	1.1590
$PSI_{(All)}$	1.2137	