Manitoba
Transportation and Infrastructure

PTH 12 and PR 210
In-Service Road Safety Review
and
Design Process

This report presents the outcomes of an In-Service Road Safety Review (ISRSR) conducted at the intersection of PTH 12 and PR 210.

The main goal of the ISRSR review is to identify all safety issues at the intersection and the countermeasures to address the safety issues.

The ISRSR is a fact-finding effort and not a design process. It is not intended to select one single overall safety solution for the intersection. This is because some of the countermeasure options identified in an In-Service Road Safety Review will conflict with each other (such as signalized instersection, roundabout, or intersection closure).

Rather, the ISRSR will identify a list of the countermeasure options to consider implementing. Some of these countermeasures will be short term (such as sign enhancements) and some will be long term (such as intersection reconstruction).

To define the most appropriate long term configuration for the intersection, a further functional design step is usually required. The functional design will evaluate the the most appropriate intersection configurations in the ISRSR and will identify the best solution to address the safety issues.

As part of our commitment to community involvement, we plan to engage with local residents, authorities, and stakeholders during the functional design process. We believe that their insights are crucial to the success of safety enhancements at the PTH 12 and PR 210 intersection.

We value your feedback and collaboration as we work together to create a safer road environment for everyone.

Thank you for your interest in this report.

MTI

In-Service Road Safety Review

Summary of the findings from an in-service road safety review of the stop-controlled intersection of PTH 12 and PR 210 conducted for Manitoba Transportation and Infrastructure.

August 8, 2023

FINAL

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1 INTRODUCTION

1.1 BACKGROUND

At the request of Manitoba Transportation and Infrastructure (MTI), WSP Canada Inc. (WSP) has conducted an in-service road safety review (ISRSR) for the unsignalized intersection of PTH 12 at PR 210 located near Ste. Anne, Manitoba.

The purpose of the ISRSR was to identify safety performance issues associated with the intersection and to suggest potential safety enhancements for consideration by MTI. The ISRSR was an independent and formal process, conducted by a team of road safety engineers who, based on their experience and expertise, provided opinions on the safety issues from the perspective of all road users.

1.2 FOCUS OF ISRSR

The ISRSR addresses road safety and operational issues as well as human factors considerations. In carrying out the work, a site investigation of the intersection study area was conducted and plans and documents supplied by MTI were reviewed.

The various issues identified in this report come from a road safety, human factors, and operational perspective only, and do not consider cost-effectiveness. Readers of this report should recognize that road design and operational decisions necessarily encompass and must be influenced by the need to provide cost-effective overall solutions to design problems. While it is essential that safety be considered explicitly during the process – as is the intent with this review - it is not the only factor that will influence the final overall resolution of the road safety questions under consideration.

1.3 BASIS OF ISRSR

Except as specifically noted in the text, this road safety review has been based on the following:

- A start-up meeting held with MTI representatives on November 3, 2021.
- A day and night field review of the study area conducted between November 15 and 16, 2021.
- Ten years (2010 to 2019) of MTI summary level collision data for the intersection. A warning of the incomplete nature of the data between 2012 and 2013 was provided by MTI. The data was incomplete during this period due to a change in Manitoba's collision data reporting procedures.
- MTI intersection traffic count data for PTH 12 & PR 210 collected between January 25 and 26, 2017 and between September 14 and 18, 2020.
- Results from MTI's intersection safety network screening tool.
- Speed data collected by WSP during the site investigation on November 16, 2021.
- As-built drawings and aerial imagery of the intersection.
- Video footage collected by MTI between September 14 and 18, 2020 for the purpose of the video conflict analysis.

1.4 START-UP MEETING

On November 3, 2021, a virtual project start-up meeting was held between key members of the road safety team and MTI representatives. The following people were present on the meeting call:

- Warren Borgford, Traffic Services Engineer, MTI
- Jennifer Chapman, Traffic Analysis Engineer, MTI
- Archie Miller, Technical Services Engineer, MTI
- Diana Emerson, Project Manager, WSP
- Geoff Millen, Senior Road Safety Advisor & Human Factors Specialist, WSP
- Damir Bjelica, Lead Safety Auditor, WSP
- Brant Magnusson, Geometric Design Review, WSP
- Jaime Lacoste, Safety & Operational Review, WSP

The following points summarize the key findings from this meeting:

- There have been some recent upgrades to the intersection, including pavement markings, signage and rumble strips.
- In recent years there have been some fatal collisions at this intersection. Common collisions include westbound vehicles being struck by northbound vehicles. There may be a sight line issue.
- MTI has received complaints from the public and local governments.

2 METHODOLOGY

2.1 OVERVIEW

In carrying out this work, an assessment of the existing road safety performance of the study area was conducted based on a "lines of evidence" approach. This approach involves two streams of work, a site investigation and a detailed safety analysis. The safety performance of the study area is examined using a range of tools and techniques and is assessed first individually, and then as a whole. Where lines of evidence "overlap" and point to a common conclusion regarding a particular element of the roadway or location, that conclusion is strengthened by the independence of the indicators and the multiplicity of their occurrence as well as the independence of the individual investigators pursuing the different approaches to the analysis.

Our lines of evidence framework examined the performance of the intersection using six distinct examination methods as illustrated in **Figure 2.1.1**, below. Findings from a synthesis of the lines of evidence were then used to identify key road safety concerns and opportunities for road safety improvement. Each step in our methodology is described in further detail in the following sections.

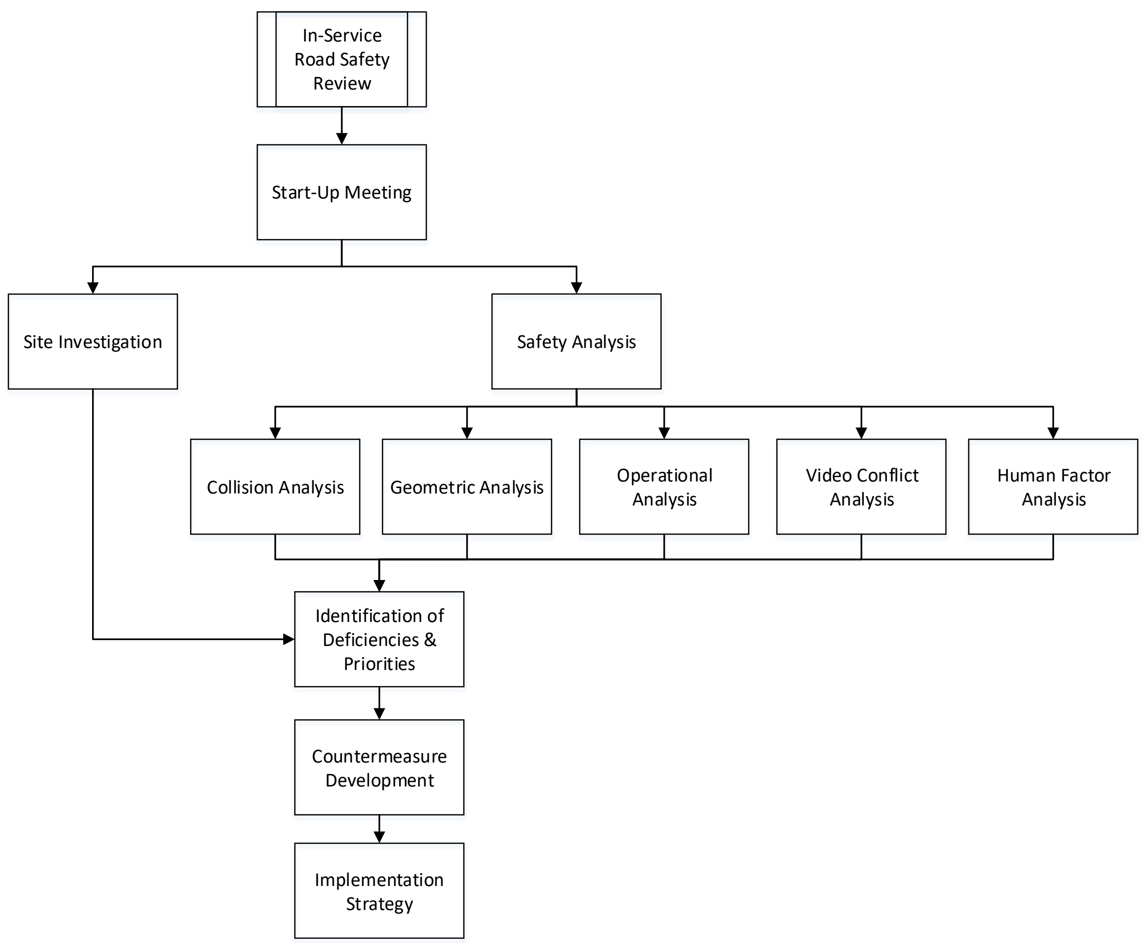


Figure 2.1.1: Overview of Methodology

2.2 SITE INVESTIGATION

The site investigation was an important element of the ISRSR as it provided the team with an opportunity to observe in-service conditions in the field and to collect information on road safety and operational characteristics of the facility.

The site investigation team was multidisciplinary in nature and include road safety, traffic engineering, geometric design and human factors expertise. The site was examined based on the needs of all relevant users and modes (vehicular traffic, heavy trucks, transit, pedestrians, and bicycles). The site investigation examined the facility during both the AM and PM peak hour periods and during day and night conditions.

2.3 SAFETY ANALYSIS

The safety analysis represented the critical problem definition and assessment step in the audit process. Historical collision data provided the primary foundation for this analysis. However, traffic and geometric characteristics were also reviewed. A description of each task in the safety analysis process is provided below.

2.3.1 COLLISION ANALYSIS

Using the most recent 10 years of collision data provided by MTI, an analysis of collision patterns and trends was conducted to develop a clear understanding of the road safety performance characteristics on the facility.

2.3.2 GEOMETRIC ANALYSIS

A review of geometric design elements (horizontal alignment, vertical alignment, cross-section elements, design consistency, sight distance, auxiliary lanes, access management, drainage, pavement condition, etc.) was conducted based on the Transportation Association of Canada's Geometric Design Guide for Canadian Roads and local design standards. While this analysis examined geometrics in the context of current practices, it was not intended to constitute a comprehensive geometric standards compliance check. Rather, the emphasis was on attempting to identify any correlations that may exist between infrastructure characteristics, and collision occurrence.

2.3.3 OPERATIONAL ANALYSIS

A traffic operational analysis was undertaken to identify operational issues that may be contributing to collisions at the intersection. The methodologies contained in the Transportation Research Board's Highway Capacity Manual were applied to the evaluation of the intersection.

2.3.4 VIDEO CONFLICT ANALYSIS

A traffic conflict analysis was conducted using video recordings collected from several locations at the intersection. This analysis examined near miss events between road users to gain an understanding of the probable causes of potential collisions. The results from this analysis provide useful information on the following:

- Near-miss data: Interactions between two road users that cross each other's path (or are expected to do so) within 10 seconds of one another.

- Speeding event data: Speeding violations and events that occur when a road user is traveling above the posted speed.

- Volume data: Turning movement volumes for each road user within the intersection.

Using the results from this analysis, the most critical movements and their conflicting scenarios can be identified and ranked based on the level of road safety risk.

2.3.5 HUMAN FACTORS ANALYSIS

The road safety team consisted of experts with extensive experience in applying human factors to road safety audits and the development of road safety improvement options. Elements examined included driver workload, visual complexity, sign and pavement marking effectiveness, factors influencing speed selection, gap search and manoeuvre distance and decision point spacing.

2.4 IDENTIFICATION OF CONCERNS AND PRIORITIES

Findings from the site investigation and the safety analysis were used to identify areas of higher collision potential and develop appropriate diagnostic statements regarding contributing factors to these situations. This activity helped to develop a finalized list of critical areas of concern, together with statements regarding the nature of the problems occurring at each.

2.5 COUNTERMEASURE DEVELOPMENT

Using the prioritized list of road safety and operational concerns discussed in the section above, the road safety team identified potential countermeasures to address the concerns identified. As part of this task, estimates of countermeasure effectiveness were provided where possible.

2.6 IMPLEMENTATION STRATEGY

Using results from the Countermeasure Development stage outlined above, a prioritized list of locations and recommended safety improvements was prepared. High-level cost estimates were also provided for the recommended improvements. Using this information, short, medium and long-term implementation strategies for improving roadside safety at the site were developed.

3 SITE INVESTIGATION

3.1 OVERVIEW

The site investigation was conducted between November 15th and 16th, 2021 and examined the facility during both the AM and PM peak hour periods and during day and night conditions. The site investigation was conducted in accordance with the Transportation Association of Canada's Road Safety Audit Guide, by a team of experienced road safety engineers with road safety, traffic engineering, geometric design and human factors expertise.

For the purposes of this report, observations made during the site investigation have been organized into the following categories:

- Intersection configuration
- Positive guidance
- General maintenance

Figure 3.1.1 shows the intersection of PTH 12 and PR 210 and includes location identifiers corresponding to the comment tables shown in the following sections. The following tables summarize observations made during the site investigations.

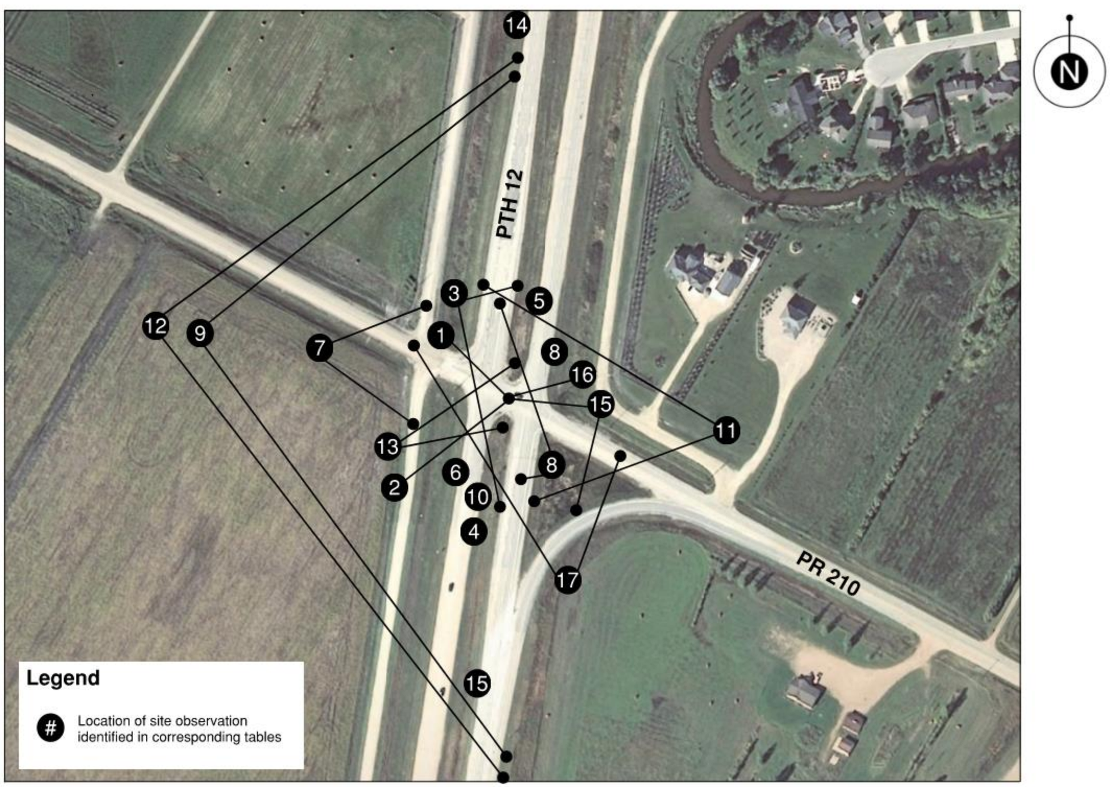


Figure 3.1.1: PTH 12 at PR 210 intersection layout with comment numbers

3.2 INTERSECTION CONFIGURATION

Comment #1	
Concern	
The narrow median width at this intersection limits the available storage and refuge area for vehicles using the median as a two-stage crossing. Of particular concern is the accommodation of long and heavy trucks which accounted for 7% of 2020 traffic volumes at this intersection. Trucks entering from the sideroad have to use the intersection as a single stage crossing and must ensure the median is clear prior to advancing. Trucks cannot stop in the median without potential conflict with other traffic movements.	 *Narrow Median Width*

Comment #2	
Concern	
Several vehicles were observed stopping in the median at the same time. This results in several conflict scenarios, including conflict between vehicles with conflicting orientation waiting in the median, and potential for queuing traffic to extend into the high speed through lanes.	 *Several vehicles attempting to access median at same time*

Comment #3	
Concern	
The PTH 12 left-turn lanes have a negative offset which can limit sightlines for opposing left-turning vehicles. Of particular concern is when vehicles are stopped in the median to perform a two-stage crossing and trucks turning left from mainline lanes must wait at the left-turn deceleration lane for the median to clear before turning.	 *Truck making northbound left blocking access to the median*

Comment #4

Concern

The southbound left-turn acceleration lane appears short. Observation from the site review suggest that vehicles merging from the acceleration lane into the high-speed mainline lane do so at speed of approximately 70-80 km/h. This can result in significant speed differential with through traffic at this location.

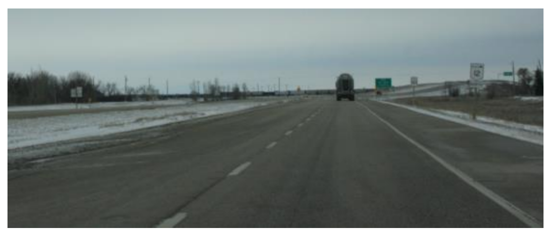
This is of particular concern for larger trucks that generally take longer to accelerate, thus merging at much lower speeds.

Southbound left-turn acceleration lane

Comment #5

Concern

Field observations suggest a significant volume of trucks are turning left from eastbound PR 210 onto northbound PTH 12. No left-turn acceleration lane is provided for this movement. As a result, these trucks are merging directly into the high-speed mainline lane. This introduces significant speed differentials and an increased risk of collision.

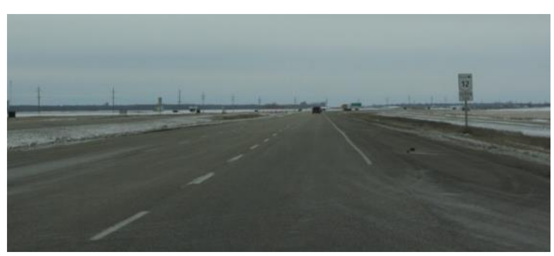


Existing northbound lanes (north of intersection)

Comment #6

Concern

Field observations suggest a significant volume of trucks (26% of 2020 truck turning traffic) is turning right onto southbound PTH 12 from eastbound PR 210. No right-turn acceleration lane is provided for this movement. As a result, these trucks are merging directly into the mainline lane. This introduces significant speed differentials and an increased risk of collision.



Existing southbound lanes (south of intersection)

Comment #7	
Concern	 *Service Road west of intersection*
An intersection with the adjacent service road west of PTH 12 is located in close proximity to the main intersection (PTH 12 / PR 210). The close proximity of this intersection may cause conflicts between through traffic and vehicles turning to/from the service road, especially if there are eastbound queues at the intersection. During the site visit, eastbound queues were observed to be less than three vehicles long (commonly only one or two queuing vehicles were observed).	

3.3 POSITIVE GUIDANCE

Comment #8	
Concern	 *Dashed line on approach in advance of the intersection*
Dashed line painting immediately in advance of the intersection may encourage drivers to perform a passing manoeuvre in advance of the intersection.	

Comment #9

Concern

When approaching the intersection on PTH 12, there is little contrast between the mainline lanes and the intersection. Also, drivers are provided with limited advanced warning of the approaching intersection. As a result, intersection conspicuity is limited.

Example of a Dynamic Advance Intersection Warning System

A Dynamic Advance Intersection Warning System is an intersection recognition treatment that is meant to enhance an expressway driver's awareness of an approaching two-way stop-controlled intersection. The systems typically consist of static Vehicle Entering When Flashing (VEWF) warning signs with traffic-actuated flashers on the expressway approaches and in-pavement loop detectors on the minor roads. When traffic is detected on the minor road, the flashers on the VEWF signs are activated on the expressway approaches, warning expressway drivers that one or more vehicles are present at the intersection and may enter from the minor road

WA-11: Concealed or Unexpected Advance Intersection Sign

Comment #10

Concern

During the site investigation, there were a few instances where vehicles pulled directly into the mainline travel lanes or only used the acceleration lane for a short distance. The southbound acceleration lane is delineated with dashed lines, this may encourage drivers to merge into the high-speed mainline lane shortly after entering the acceleration lane. This may result in significant speed differentials and potential for high-severity conflicts.

Southbound acceleration lane

Comment #11

Concern

Wrong Way signs are not double posted on the mainline lanes north and south of the intersection.

Wrong Way sign in median

Comment #12

Concern

Guide signage on the northbound and southbound approaches to the intersection does not appear to be consistent.

On the northbound approach, an advance guide sign is missing. The intersection guide sign provides information for the westbound direction only, and the sign appears to be located too far in advance of the intersection.

In the southbound direction, an advance guide sign is missing.

Northbound approach to the intersection

Southbound approach to the intersection

Comment #13

Concern

Due to the wide median opening, the yield signs in the median are located at an increased offset from the travel path. As a result, the effectiveness of these signs may be reduced.

Yield signs in median appear small

Comment #14	
Concern	*No photo available*
A speed limit sign is not present on southbound PTH 12 downstream of the interchange with PTH 1. The need for this sign should be confirmed to ensure consistency with signing policy.	

Comment #15	
Concern	*No photo available*
Field observations during the nighttime review suggested the following: • The illumination at the intersection is limited and creates areas with shadows. • The deterioration and poor reflectivity of the pavement markings offers poor guidance to drivers at night. • The absence of delineation makes the northbound right-turn cut-off difficult to see at night	

3.4 MAINTENANCE

Comment #16	
Concern	 *Pavement marking deterioration*
In general, line painting is deteriorated. As a result, delineation within the intersection is poor. This contributes to increased driver workload and risk of driver error.	

<table>
<tr><th colspan="2">Comment #17</th></tr>
<tr><th>Concern</th><td rowspan="2">
Rumble strips on the westbound approach</td></tr>
<tr><td>The rumble strips on the westbound approach to the intersection are worn in the wheel paths. This may impact their effectiveness. It is our understanding that this feature has been installed as a “low noise rumble strips” treatment.</td></tr>
</table>

4 SAFETY ANALYSIS

4.1 OVERVIEW

The following sections outline the safety analysis which includes:

- Collision Analysis
- Geometric Analysis
- Operational Analysis
- Video Conflict Analysis
- Human Factors Analysis

4.2 COLLISION ANALYSIS

Collision analysis is a useful tool at the diagnostic stage of a safety review; however, also provides valuable clues as to the most appropriate candidate countermeasures that should be considered for addressing safety and operational concerns. The following sections provide a summary of the collision analyses undertaken for the PTH 12 and PR 210 intersection.

4.2.1 NETWORK SCREENING

As part of the historical background information, network screening results were provided by MTI for the intersection of PTH 12 and PR 210. The results are summarized in **Table 4.2.1** and include Level of Service of Safety (LOSS) for total collisions (property damage only, injury and fatal collisions) and fatal and injury collisions and Excess Collisions for total collisions and fatal and injury collisions.

LOSS is a measure of a highway's safety performance relative to other similar highway facilities on the network and uses a scale of one to four. When compared to other similar facilities:

- LOSS 1 indicates better safety performance than average for similar facilities and a low potential for crash reduction through implementation of countermeasures;
- LOSS 2 indicates slightly better safety performance than average for similar facilities and a low to moderate potential for crash reduction;
- LOSS 3 indicates slightly poorer safety performance than average for similar facilities and a moderate to high potential for crash reduction; and
- LOSS of 4 indicates poorer safety performance than average and a high potential for crash reduction.

Excess Collisions is another measure of a highway's safety performance. It provides an estimate of the number of collisions expected to occur (at an intersection or for a highway segment) above or below the predicted number of collisions for similar facility types. Excess collisions is expressed in number of collisions per five years.

Table 4.2.1: PTH 12 and PR 210 Network Screening

Intersection	LOSS (N_Total)	LOSS (N_FI)	Excess Collisions (N_Total) / 5 years	Excess Collisions (N_FI) / 5 Years
PTH 12 & PR 210	3	3	+1.3	+1.0

As shown in **Table 4.2.1**, the LOSS values of 3 indicate safety performance slightly poorer than similar intersections on MTI's network and a moderate to high potential for crash reduction. The Excess Collisions indicate that a slightly higher number of collisions will occur every five years compared to other similar intersections.

The network screening was conducted by MTI to identify priority intersections for road safety improvement and was based on 2005-2009 collision data. As the network screening results are based on collision and traffic volume data more than ten years old, these network screening results have been provided for historical background information only. Also, since the time of the network screening, intersection improvements have taken place. It is recommended that MTI consider updating the network screening results based on updated collision and traffic volume data.

4.2.2 COLLISION DATA

For the intersection of PTH 12 and PR 210, 10 years (2010 to 2019) of summary level collision data was provided by MTI. MTI's collision database is populated using available Traffic Accident Reports (TARs) completed by law enforcement agencies as well as claims records from Manitoba Public Insurance (MPI). It is noted that MTI advises that collision data in their database for 2012 to 2013 may be incomplete due to an initial adjustment period experienced by MPI and law enforcement agencies following an amendment to the Highway Traffic Act (HTA) which made changes to the collision reporting process in Manitoba at the end of 2011.

4.2.3 COLLISION PATTERNS

Collision pattern analysis consists of a breakdown and summary of relevant fields and records from available collision data and can be particularly useful in identifying contributing and causal factors associated with collisions.

This section provides a summary of key collision characteristics for the intersection. A full overview of collision parameters examined is presented in **Appendix A** of this report.

Collision Severity: Over the 10-year analysis period (2010 to 2019), a total of 63 collisions were reported at this intersection. This included 3 fatal collisions (5%), 27 injury related collisions (43%) and 33 PDO collisions (52%). The predominant contributing factors for the fatal and injury collisions was either "failing to yield the right-of-way" or "leaving stop sign before safe to do so".

#	%	Severity
33	52%	Property Damage
27	43%	Injury
3	5%	Fatal
63	100%	

Figure 4.2.1: Collision Severity

Collision Type: Collisions with other motor vehicle (48 collisions - 76%) were the most common collision type at this intersection.

#	%	Collision Type
3	5%	Collision with Animal
48	76%	Collision with Other Motor Vehicle
0	0%	Overturn on Roadway
6	10%	Collision with Fixed Object
3	5%	Collision with Other Object
3	5%	Ran Off Road
0	0%	Collision with Pedestrian
63	100%	

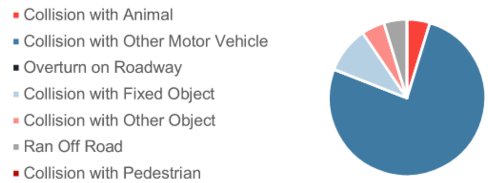


Figure 4.2.2: Collision Type

Collision Configuration: Of the 48 collisions with other motor vehicle, 38 collisions (79%) were classified as “Intersection 90 Degrees”, 7 collisions (15%) were classified as “Rear End”, and 3 collisions (6%) were classified as “Other”, “Left-Turn (Same Direction)” and “Left Turn (Opposing)”. Contributing factors for the majority of the right-angle collisions included leaving the stop sign before safe to do so, and failing to yield right-of-way. Following to close was the contributing factor for the rear-end collisions reported at this intersection.

#	%	Configuration
1	2%	Left Turn (Opposing)
0	0%	Left Turn (Across)
38	60%	Intersection 90 Degrees
2	3%	Off Road - Left
3	5%	Off Road - Right
1	2%	Left Turn (Same Direction)
0	0%	Side Swipe (Same Direction)
7	11%	Other
0	0%	Pedestrian
4	6%	Fixed Object
7	11%	Rear End
63	100%	

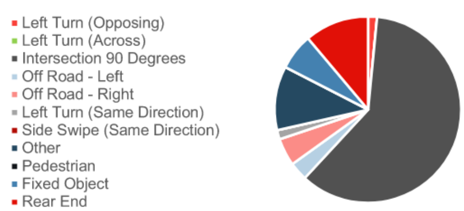


Figure 4.2.3: Collision Configuration

Light Condition: A total of 15 (24%) collisions occurred during periods of reduced lighting levels (dark, dusk or dawn).

#	%	Light Condition
47	75%	Day
10	16%	Dark
4	6%	Dusk
1	2%	Dawn
1	2%	Unknown
63	100%	

Figure 4.2.4: Lighting Conditions

Road Surface Condition: Ice, slush, snow and wet road surface conditions were present in 18 (28%) of reported collisions and half of these collisions resulted in an off-road collision or fixed-object collision. 67% of the collisions occurred during dry road surfaces condition.

#	%	Road Surface Condition
42	67%	Dry
10	16%	Ice
2	3%	Slush
2	3%	Snow
4	6%	Wet
1	2%	Unknown
2	3%	Not Applicable
63	100%	

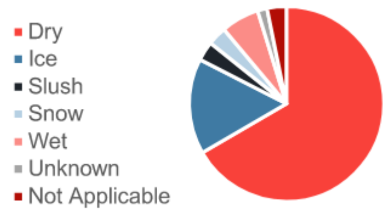


Figure 4.2.5: Road Surface Condition

Vehicle Type: The 63 total collisions reported at this intersection involved 115 vehicles. Automobiles were involved in 69 (60%) collisions, pick-ups or vans under 4500 kg were involved in 25 (22%) collisions, mini vans were involved in 9 (8%), and heavy trucks were involved in 4 (4%) collisions. There were 6 collisions with an unknown vehicle type and 2 collisions with a "truck (other)" vehicle type.

#	%	Vehicle 1 - Type
69	60%	Automobile
9	8%	Mini-van/Multi-Purpose Van
1	1%	Truck Over 4500 KG (Unit Chassis)*
1	1%	Van under 4500 KG
24	21%	Pick-up under 4500 KG
3	3%	Power Unit for Semi-Trailer*
2	2%	Truck (Other)
6	5%	Unknown
115	100%	

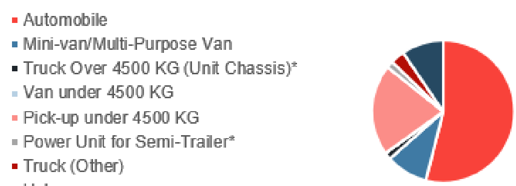


Figure 4.2.6: Vehicle Type

4.2.4 COLLISION DIAGRAM

Collision diagrams indicating the spatial location, type, and severity of recent collisions were prepared as part of this analysis. By providing a visual representation of historical collisions, locations where collisions seem to be clustered can be identified.

Figure 4.2.7 displays the collision diagram prepared for the intersection of PTH 12 and PR 210.

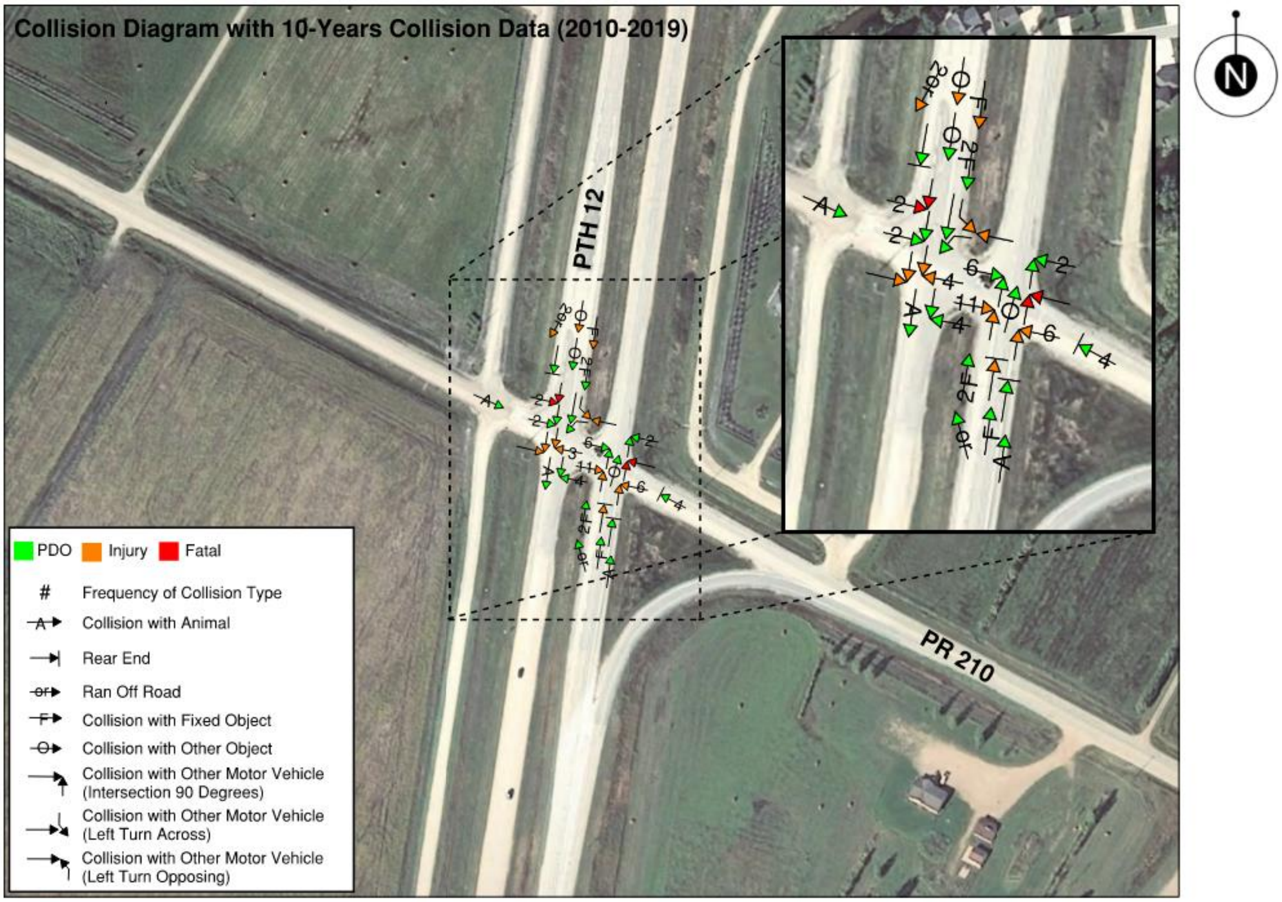


Figure 4.2.7: Collision Diagram

Key findings from an examination of this geospatial plot are summarized in the points below:

- A cluster of collisions is present directly at the intersection. Of particular concern are right-angle collisions, which accounted for 38 of the reported collisions (approximately 60% of total reported collisions) and include 3 fatal collisions and 22 injury collisions. These right-angle collisions were distributed as follows:
    - 5 collisions occurred between southbound and eastbound vehicles
    - 7 collisions occurred between southbound and westbound vehicles
    - 17 collisions occurred between northbound and eastbound vehicles
    - 9 collisions occurred between northbound and westbound vehicles
- The fatal collisions involving right-angle incidents at the intersection indicate that drivers on the secondary roadway may have difficulty assessing when it is safe to cross the highway. The fatal collisions involved the following right-angle incidents:
    - 2 collisions involving southbound and eastbound vehicles
    - 1 collision involving northbound and westbound vehicles

- Rear end collisions occurred on the northbound (2 collisions), southbound (1 collision) and westbound (4 collisions) approaches. The rear end collisions on the northbound and southbound approaches may indicate that there is a speed differential between vehicles and/or drivers are having to slow/stop suddenly to avoid collision with an eastbound or westbound vehicle crossing PTH 12. The rear end collisions on the westbound approach may indicate that drivers are having difficulty assessing appropriate gaps in traffic and stopping suddenly.

- Nine (9) collisions involved a fixed or other object (four in the northbound direction and five in the southbound direction).

- Three (3) collisions involved a vehicle that ran off the side of the road (one in the northbound direction and two in the southbound direction)

- Three (3) collisions involved animals. Two of the three animal collisions occurred during dusk or dark lighting conditions (the third collision lighting condition is unknown) indicating that illumination at the intersection may not be sufficient.

The findings above clearly suggest that right-angle collisions appear to present an increased level of collision risk and collision severity at this intersection.

4.3 GEOMETRIC ANALYSIS

4.3.1 OVERVIEW

Although a detailed standards compliance check was not conducted as part of this in-service road safety audit, a review of geometric design elements including but not limited to horizontal alignment, vertical alignment, cross-section elements, design consistency, sight distance, auxiliary lanes, access management, drainage, and pavement condition was conducted to identify existing conditions which may increase collision potential and to identify any correlations that may exist between infrastructure characteristics and collision history. The following points summarize the key findings from this analysis.

4.3.2 GEOMETRIC DESIGN ELEMENTS

A review of geometric design elements (horizontal alignment, vertical alignment, cross-section elements, design consistency, sight distance, auxiliary lanes, access management, drainage, pavement condition, etc.) was conducted based on the Transportation Association of Canada's Geometric Design Guide for Canadian Roads and local design standards.

A summary of MTI's desired Geometric Design Criteria compared to actual conditions is provided in the **Table 4.3.1**, areas that fall below the desired minimum criteria are highlighted in yellow.

Table 4.3.1: Geometric Design Criteria Comparison to Actual Design

ITEM		PTH 12		PR 210	
		Design Criteria	Actual	Design Criteria	Actual
Speed	Current Posted Speed (km/h)	100	100	East: 70	East: 70
	Design Speed (DS) (km/h)	130	130	East: 80 West: 110	East: 80 West: 110
	Maximum Gradient (%)	3	< 3	3	< 3

ITEM		PTH 12		PR 210	
		Design Criteria	Actual	Design Criteria	Actual
Vertical Elements	Minimum Stopping Sight Distance (m)	260	NB: >260m SB: > 260m	East: 140 West: 220	East: > 140 West: > 220
	Minimum Decision Sight Distance1 (DSD)(m)	415	NB: > 415 SB: > 415	East: 275 West: 390	East: > 275 West: > 390
	Minimum K Value - Sag Curve (Ks) (Headlight)	65	N/A	East: 30 West: 55	N/A
	Minimum K Value - Crest Curve (Kc)	120	N/A	East: 35 West:85	N/A
Horizontal Elements	Curvature - Minimum Radius (m, emax = 6%)	950	N/A	East: 250 West: 600	N/A
	Maximum Superelevation (m/m)	0.06	N/A	0.06	N/A
Roadside	Clear Zone	10.5 – 13.0[3]	No hazards identified within clear zone	East: 6.0-8.0 West:8.5-11.0	No hazards identified within clear zone
Slopes	Minimum Median Slope	6H:1V	4H:1V	N/A	N/A
	Minimum Side Slope	4H:1V	5H:1V	4H:1V	4H:1V
Cross-Section	Lane Widths (m)	3.7	3.7	3.7	3.7
	Left - Paved / Gravel (P/G) (m)	1.5 paved	1.5 asphalt	N/A	N/A
	Right - Paved/Gravel (P/G) (m)	3.0 paved	3.0 paved	East: 2.5 partially paved West: 2.0 partially paved	East: 2.5 partially paved West: 2.0 partially paved
Intersection	Intersection Sight Distance (m)	N/A	N/A	235 (passenger car) / 380 (WB-20)	> 380
	Left Turn Lane Deceleration Length (m)	150m[4]	NB:200 SB: 200	N/A	N/A
	Right Turn Lane Deceleration Length(m)	150m[5]	NB: 190 SB: 176	N/A	N/A
	Right Turn Acceleration Length(m)	540-880	NB: 0 SB: 0	N/A	N/A
	Left Turn Acceleration Length(m)	550-885	NB: N/A SB: 200	N/A	N/A
	Skew Angle	TAC Design Criteria: 70 degrees to 110 degrees Actual: 70 degrees			

[3] *Clear Zone distance as per the TAC GDG 2017 for design speed => 100 km/h and AADT 1,500 – 6,000.*
[4] *Left-turn deceleration lane length obtained from MTI's Blue Sheets.*
[5] *Right-turn deceleration lane length obtained from MTI's Blue Sheets.*

4.3.3 KEY FINDINGS

Geometric Observations:

- There are no right-turn acceleration lanes provided in the northbound or southbound direction.
- The southbound (WB-SB) left turn acceleration lane is significantly shorter than the TAC recommended minimum.
- The intersection is constructed at a skew angle of approximately 70 degrees, which is at the upper limit recommended by TAC. TAC 9.1.2.4 notes: *"At skewed intersections, an adequate view may be difficult to obtain in the direction of the acute angle, especially for older drivers. For skewed intersections, the A pillar and other vehicle parts can obstruct the driver's line of sight. Such obstruction was found to result in less than adequate stopping sight distance for speeds higher than 65 km/h, when the acute angle was less than 70 degrees".*
- The offset construction of the NB and SB left turn lanes restricts sight distance for opposing left turning vehicles.

Access Management:

- Within the study area, private access is provided on the east and west legs of PR 210.
- The service road connection to PR 210 on the west side of PTH 12 is offset approximately 40 m. This meets the minimum standard; however, is less than the typical separation desired for good intersection operations.
- The service road connection on to PR 210 on the east side of PTH 12 is offset approximately 120 m. This intersection is however located within the functional area of the intersection. The NB-EB merging taper extends beyond this T-intersection and a vehicle slowing or stopping to execute a left turn from PR 210 at this location may conflict with a driver using the right turn merging taper.

4.4 OPERATIONAL ANALYSIS

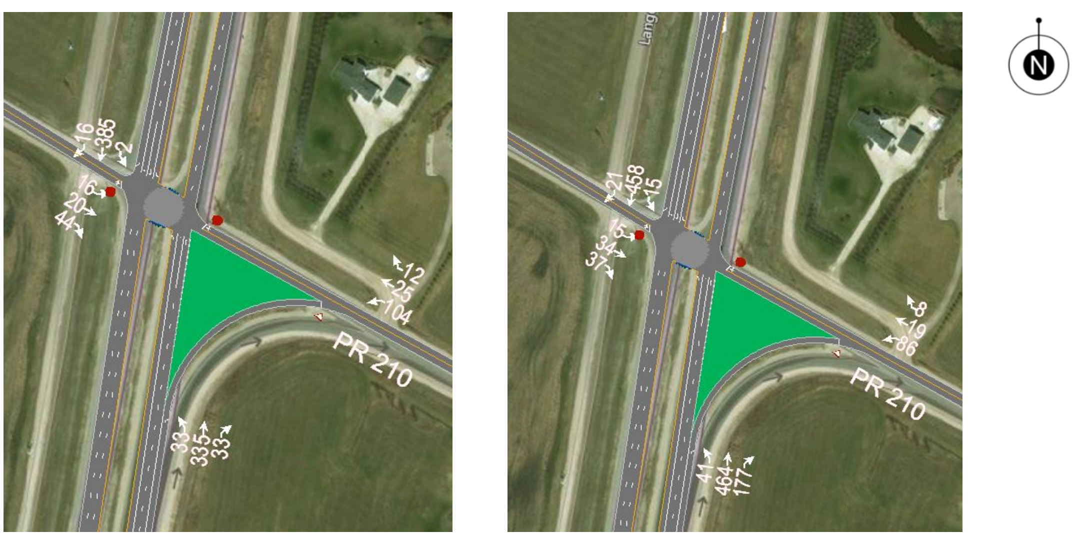
4.4.1 TRAFFIC VOLUMES

MTI provided traffic count data for the intersection of PTH 12 and PR 210 that was collected between January 25 and 26, 2017 and between September 14 and 18, 2020. The 2020 traffic volumes were found to be substantially higher (23%) than the 2017 traffic count volumes, which may be due to seasonal variations in traffic and population growth of communities in the area. For example, the population of Ste. Anne grew 30.0% (from 1,626 to 2,114), Blumenort grew 19.3% (from 1,404 to 1.675) and Steinbach grew 15.3% (from 12,798 to 14,753) between the last two census years (2011 and 2016).

The 2020 traffic count volumes (see **Table 4.4.1**) were forecast to 2022 using an annual growth rate of 2.6% based on a review of historical traffic count data at CCS-Loop #2457 located on PTH 12, 0.2 km north of PR 210 and CCS-Loop #2117 located on PTH 12, 1.4 km north of PR 311, from the *Traffic on Manitoba Highways* (2019) report. A diagram of the 2022 AM and PM peak hour volumes used in the operational analysis (**Section 4.4.2**) are shown in **Figure 4.4.1**.

Table 4.4.1: Traffic Count at PTH 12 & PR 210 conducted on September 15, 2020

Approach	Southbound			Northbound			Westbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
15-Hours (07:00 – 22:00)												
Volume	78	3927	152	333	3618	1285	1117	253	89	150	290	340
Truck %	4	15	20	9	14	2	2	4	7	19	3	9
AM Peak Hour												
Volume	2	365	15	31	318	31	99	24	11	15	19	42
Truck %	0	11	14	6	15	11	5	0	0	0	5	5
PM Peak Hour												
Volume	14	434	20	39	440	168	82	18	8	14	32	35
Truck %	0	12	15	8	10	0	0	6	13	7	3	12



AM Peak Hour Volumes PM Peak Hour Volumes

Figure 4.4.1: 2022 Peak Hour Traffic Volumes

4.4.2 TRAFFIC OPERATIONAL ANALYSIS

The traffic operational analysis for the intersection was undertaken using the HCM 6th Edition methodology by utilizing Synchro 11.0 traffic analysis software and SimTraffic simulation software.

The relative performance of an intersection is measured in terms of Level of Service (LOS), ranging from A (excellent) to F (beyond capacity). In general, LOS E is considered to be at capacity.

LOS for unsignalized intersections is defined in terms of delay. Delay is the total elapsed time from when a vehicle stops at the end of the queue until the vehicle departs from the stop line. This includes the time required for the vehicle to travel from the last in queue position to the first.

The volume to capacity (v/c) ratio is used to determine the level of congestion for each lane group. If the v/c ratio is greater than or equal to 1.00 that approach is operating above capacity.

The 95th queue length is the maximum length of the back of the traffic queue with 95th percentile traffic volumes. This measure is often used to determine whether the length of the storage lane is sufficient.

The PTH 12 and PR 210 intersection was modelled as a four-legged, two-way stop-controlled intersection with the following configuration:

- The northbound approach is free-flowing and consists of a left-turn lane, two through lanes and a right-turn cut-off lane.
- The southbound approach is free-flowing and consists of a left-turn lane, two through lanes and a right-turn lane.
- The westbound approach is stop-controlled and consists of a shared left-turn/through/right-turn lane. Westbound left-turning traffic has a median southbound acceleration lane.
- The eastbound approach is stop-controlled and consists of a shared left-turn/through/right-turn lane.

Results from Synchro indicate that the intersection is operating at LOS A during both AM and PM peak hours. The results for the individual movements are shown in **Table 4.4.2** and indicate that all movements are operating at acceptable levels from an operations perspective. The westbound movement has the highest delay (around 20 seconds) and operates at LOS C in both peak hours. No issues were observed during the SimTraffic simulations. The detailed Synchro reports are provided in **Appendix B**.

Table 4.4.2: PTH 12 & PR 210 Operational Performance

Individual Movement	HCM 6th Edition Operational Metrics									
	Weekday AM Peak Hour					Weekday PM Peak Hour				
	Capacity (veh/h)	V/C Ratio	LOS	Delay (sec)	95% queue length (veh)	Capacity (veh/h)	V/C Ratio	LOS	Delay (sec)	95% queue length (veh)
Northbound Left	1093	0.033	A	8.4	0.1	1011	0.043	A	8.7	0.1
Eastbound	546	0.159	B	12.8	0.6	418	0.218	C	16.0	0.8
Westbound	417	0.368	C	18.6	1.7	327	0.368	C	22.3	1.6
Southbound Left	1206	0.002	A	8.0	0.0	1080	0.015	A	8.4	0.0

4.4.3 PEDESTRIAN & CYCLIST OPERATIONS

No pedestrian or cyclists were identified in the traffic count data provided by MTI and none were observed during the site investigation. Pedestrian and cycling volumes at the intersection are assumed to be very low as no pedestrian and cycling infrastructure currently exist in the vicinity of the intersection.

4.4.4 ASSESSMENT OF SPEED LIMITS

As part of this review, the road safety team was asked to comment on the appropriateness of introducing a localized speed reduction zone on PTH 12 in the vicinity of this intersection as a potential road safety treatment measure. PTH 12 is currently posted with a regulatory speed limit of 100 km/h.

In order to obtain an understanding of current operating speeds on PTH 12, a limited speed survey was conducted by the road safety team as part of the site investigation. The following tables summarize the speed survey results.

Table 4.4.3: PTH 12 at PR 210 – Speed Survey Results

Measurement	SB		NB	
	Car	Truck	Car	Truck
Sample Size	22	10	19	10
Max Speed (km/h)	112	106	124	120
Min Speed (km/h)	89	83	95	87
Average Speed (km/h)	101.1	95.7	104.6	101.9
85th percentile Speed (km/h)	108.0	102.8	110.0	109.6

Table 4.4.4: PTH 12 at PR 210 – 15 km/h Pace and Percent in Pace

Speed Range (km/h)	Observations			Observations in 15 km/h Pace	Percent in Pace
	SB	NB	Total		
75-79	0	0	0	-	-
80-84	1	0	1	-	-
85-89	1	1	2	3	5%
90-94	4	0	4	7	12%
95-99	11	6	17	23	38%
100-104	6	12	18	39	65%
105-109	7	6	13	48	80%
110-114	2	2	4	35	58%
115-119	0	0	0	17	28%
120-124	0	1	1	5	8%
				15 km/h Pace	95-110
				Percent in Pace	80%

Results from the survey indicate that:

- 85^{th} percentile speeds were slightly in excess of the 100 km/h posted speed limit for both intersection approaches; however, were within 10 km/h, suggesting that the posted speed limit is appropriate.

- The percent in pace was well above 60 percent; therefore, the majority of drivers are operating in a consistent manner.

There are a number of challenges associate with introducing a localized speed reduction zone on PTH 12 at this location. These include the following:

- PTH 12 is a high-speed rural divided highway with minor leg stop controlled intersections. The introduction of a localized speed reduction zone would be contrary to driver expectation of this type of highway. As a result, driver compliance to a localized speed reduction would likely be poor.

- The appearance of this section of highway is consistent with portions of the highway posted at 100 km/h located upstream and downstream of the intersection.

- In general, drivers on this section of highway have been driving at high speed for long periods of time. As a result, they will be speed adapted. Speed adaptation is a driver's underestimation of their actual speed after leaving a high-speed highway. This adaptation effect lasts up to 5 or 6 minutes after leaving a freeway and can occur after as little as 5 seconds of high-speed operation.

- Simply introducing a reduced speed limit will likely not be effective at reducing operating speeds on the approaches to the intersection. A speed reduction zone would require a system of speed management measures focused on providing drivers with a series of visual clues focused on the need to change driving behaviour. Such measures may include gateway treatments, cross section changes, alignment changes, closing in of cross section, introduction of side friction, peripheral pavement markings, and speed feedback signs.

- A key contributor to the collision frequency and severity at this intersection appears to be violation of the current traffic control devices. Introducing a reduced speed limit without speed management measures would likely not have a significant impact on this type of collision. An examination of alternative traffic control measures and intersection configurations may be a more effective treatment option.

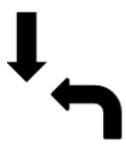
Based on the discussion outlined in the points above, reducing the speed limit on the approaches to this intersection would not be consistent with upstream and downstream sections of PTH 12 and other similar divided highways in Manitoba. As a result, maintaining the current 100 km/h speed limit at this location appears appropriate.

4.5 VIDEO CONFLICT ANALYSIS

In this line of evidence, intersection video recordings were used to examine vehicle interactions including conflicts and near-miss events to obtain an understanding of probable causes of potential collisions. For this purpose, 60 hours of video recording collected on two occasions (between September 14^{th} and September 18^{th} of 2020 and between December 13^{th} and 16^{th} of 2021) was processed and analyzed. A total of 2,754 conflicts were recorded at the intersection during this period.

For the purpose of this analysis, filters were developed and applied to focus on conflicts with the highest probable collision severity and collision likelihood. As a result, the main focus of the analysis was on crossing (right-angle) conflict types, as these conflict types are typically associated with higher severity collision outcomes. **Table 4.5.1** illustrates four typical crossing conflict configurations considered for this purpose. Ten conflicting movements with these types of crossing conflict were present at the intersection.

Table 4.5.1: Typical crossing conflict configurations

Left-Turn vs. Through Oncoming	Through vs. Through	Left-Turn vs. Through from Left	Left-Turn vs. Left-Turn from Left
			

In addition, the post-encroachment time (PET) value was used to assess the likelihood of a collision occurring. Post-Encroachment Time (PET) is a surrogate safety measure used to measure the available reaction time that road users typically experience when interacting with one another in a conflict. Lower PET value suggests less reaction time that drivers have to react and therefore this suggests a higher likelihood of collision. For the purpose of this analysis, PET values less than five seconds were selected.

To quantify the level of risk present at this intersection, the ten crossing conflicting movements identified at the intersection were individually analyzed and assigned a risk level based on the PET value and maximum speed of vehicles involved in the conflict. The risk rating was performed using risk level categories indicated in **Figure 4.5.1** and **Table 4.5.2** below.

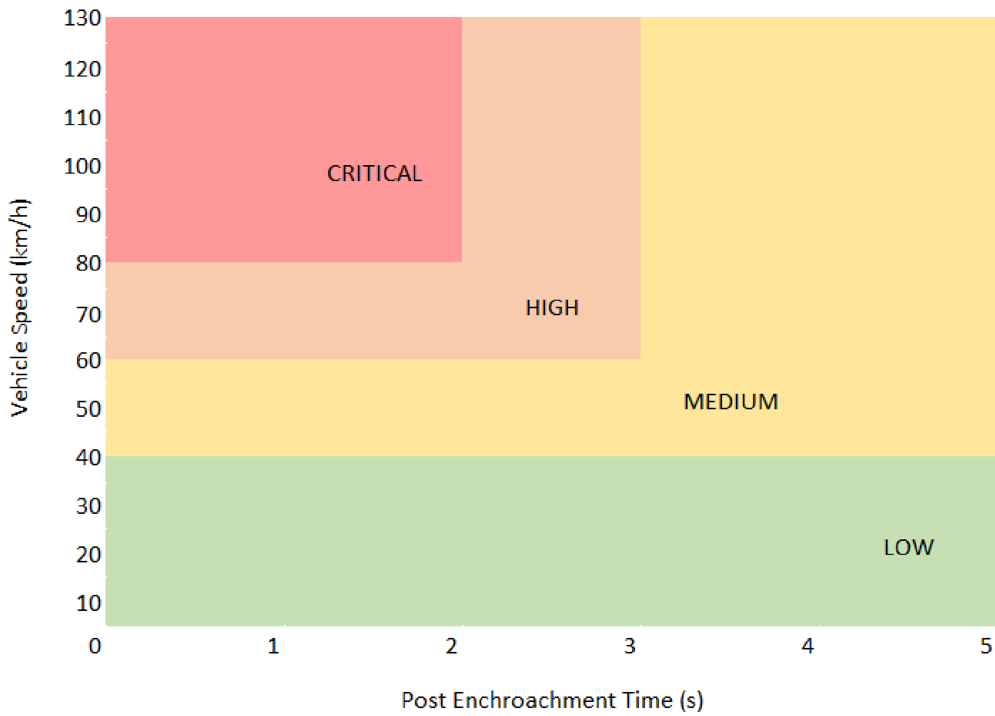


Figure 4.5.1: Risk Level Categories

Table 4.5.2: Risk Level Category Thresholds

Risk Level	**Critical Risk (C)**	**High Risk (H)**		**Medium Risk (M)**		**Low Risk (L)**
Conflicts	PET<= 2 sec AND Speed > 80 km/h	PET<= 2 sec AND Speed 80-60 km/h	PET 2-3 sec AND Speed > 60 km/h	PET <= 3 AND Speed 60-40 km/h	PET 3-5 sec AND Speed > 40 km/h	PET <= 5 sec AND Speed < 40 km/h

The results of the risk rating exercise are summarized in **Table 4.5.3** and **Figure 4.5.2** below. Details specific for each conflicting movement are presented in **Appendix C** of this report.

Table 4.5.3: Summary of Risk Level Rating for Crossing Conflicts [6]

	Conflicting Movements		**Crossing Conflict Type**	**Total Number of Crossing Conflicts**	**Number of Crossing Conflicts for PET < 5 sec**	**Risk Level Rating**			
						CRITICAL	**HIGH**	**MEDIUM**	**LOW**
1	Northbound Through vs. Through from Median		Through vs. Through	81	46	0	2	13	31
2	Northbound Through vs. Westbound Through		Through vs. Through	361	197	3	23	81	90
3	Left-Turn from Median vs. Westbound Through		Left-Turn vs. Through Oncoming	60	35	0	0	2	33

[6] *Due to the wide intersection median and limitations of the collected video footage, some issues in distinguishing the origin of traffic crossing the mainline lanes from the median were encountered. As a result, the video processing methodology was not always able to determine if crossing vehicles originate from the sideroad or from a mainline left-turn lane. To overcome this limitation, these movements were combined and classified as "Through from Median" movements for the purpose of this analysis.*

	Conflicting Movements		Crossing Conflict Type	Total Number of Crossing Conflicts	Number of Crossing Conflicts for PET < 5 sec	Risk Level Rating			
						CRITICAL	HIGH	MEDIUM	LOW
4	Northbound Left-Turn vs. Through from Median		Left-Turn vs. Through from Left	87	32	0	0	1	31
5	Northbound Left-Turn vs. Left-Turn from Median		Left-Turn vs. Left-Turn from Left	17	8	0	0	0	8
6	Southbound Through vs. Through from Median		Through vs. Through	799	453	14	24	132	283
7	Southbound Through vs. Eastbound Through		Through vs. Through	811	454	23	130	277	24

	Conflicting Movements		**Crossing Conflict Type**	**Total Number of Crossing Conflicts**	**Number of Crossing Conflicts for PET < 5 sec**	**Risk Level Rating**			
						CRITICAL	**HIGH**	**MEDIUM**	**LOW**
8	Left-Turn from Median vs. Eastbound Through		Left-Turn vs. Through Oncoming	433	250	0	0	2	248
9	Southbound Left-Turn vs. Through from Median		Left-Turn vs. Through from Left	32	14	0	0	1	13
10	Southbound Left-Turn vs. Left-Turn from Median		Left-Turn vs. Left-Turn from Left	73	34	0	0	0	34

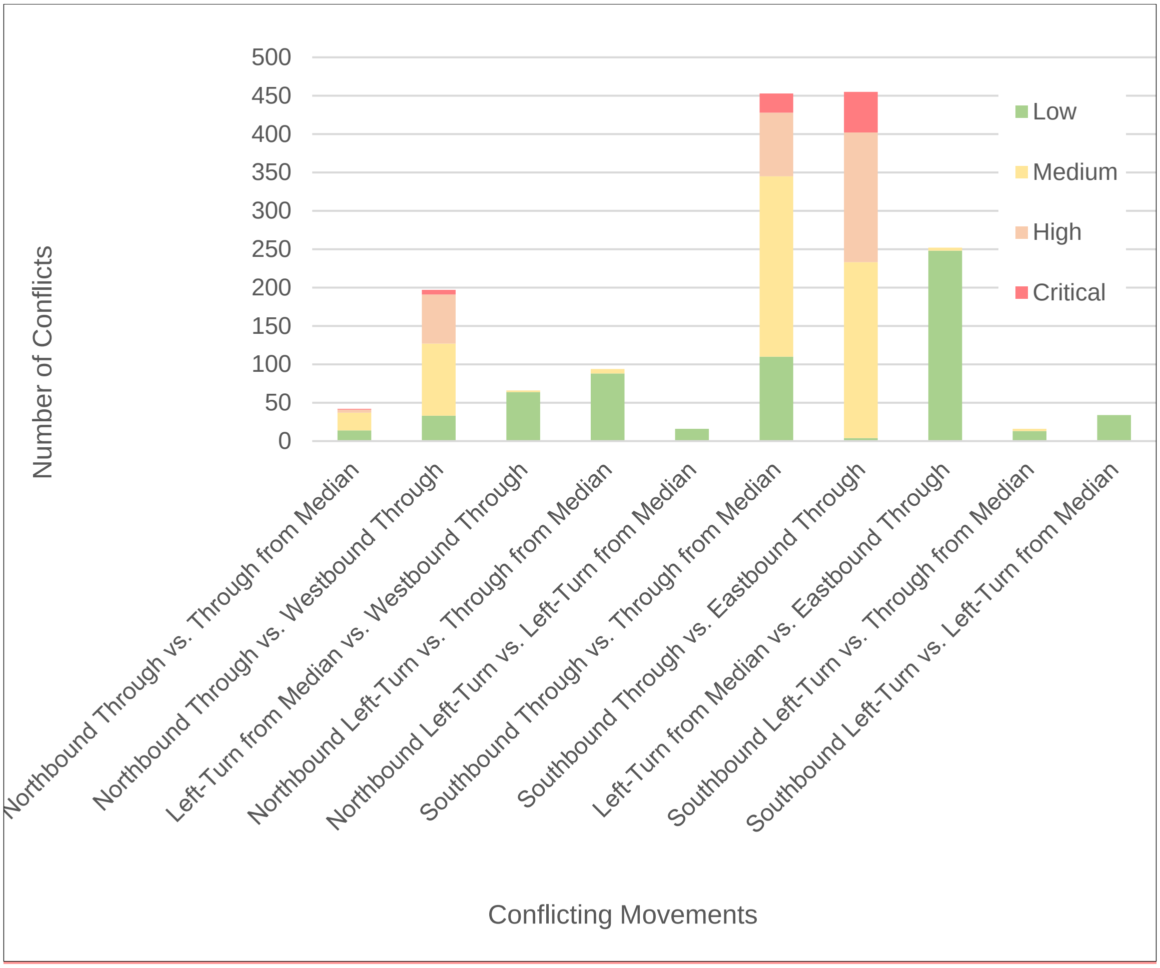


Figure 4.5.2: Summary of Risk Level Rating for Crossing Conflicts

The following points summarize key findings from this analysis:

- The most frequent conflicts are those occurring at the west part of the intersection. This is illustrated in **Figure 4.5.3** below.

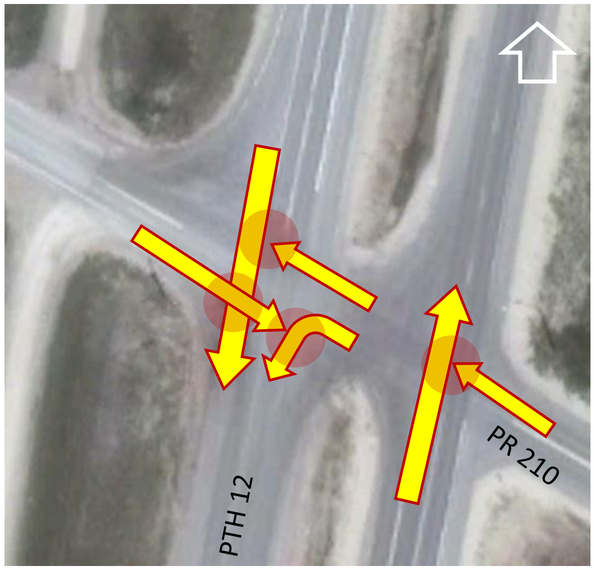


Figure 4.5.3: The most frequent crossing conflicts

- The highest frequency of conflicts involved the following movements:
    - Southbound Through vs. Eastbound Through,
    - Southbound Through vs. Westbound Through from Median,
    - Eastbound Through vs. Left-Turn from Median, and
    - Northbound Through vs. Westbound Through

- The highest number of critical-risk conflicts involved the following two movements:
    - Southbound Through vs. Eastbound Through, and
    - Southbound Through vs. Westbound Through from Median

  These conflicts appear to present the greatest potential for collision as the available reaction time for drivers is less then 2 seconds, which is less then the PET comfort boundary for many drivers.

- The Northbound Through vs. Westbound Through movements resulted in significant number of medium-risk and high-risk conflicts.

- A significant number of medium-risk and high-risk conflicts observed with the above listed movements suggests that drivers crossing the mainline lanes may be frustrated due to higher waiting times and are willing to take more risk by selecting smaller gaps within the high-volume mainline traffic stream.

- The Eastbound Through vs. Left-Turn from Median movements result in significant number of low-risk conflicts which occurred at low-speeds. This type of conflicts suggests undesirable behaviour within the median and/or improper use of median refuge area when occupied by several vehicles at one time. Similar concerns were observed on the video footage (see **Figure 4.5.4** below) when a westbound left-turn vehicle destined to the southbound median acceleration lane occupied the center portion of the median and conflicted with opposing traffic.

Figure 4.5.4: Median occupied by multiple vehicles

- Due to limitation in the video collected, the northbound through movements were not fully captured. As a result, the number of conflicts captured between northbound through traffic and turning traffic at the intersection is lower than would be expected for the traffic volumes present.

- It should also be noted that there are limitations on speed data determined through video conflict analysis. With this type of analysis there is a certain level of error and as such, speed data from video conflict analysis should be carefully used as speed data accuracy is dependent on the quality of video which is affected by camera placement, camera height, weather conditions including wind speed, as well as quality of aerial imagery available. In this analysis, specific calibrations were required for the speed data due to the quality of video and aerial imagery.

4.6 HUMAN FACTORS ANALYSIS

As part of the human factors analysis, the road safety team examined factors including driver workload, visual complexity, sign and pavement marking effectiveness, factors influencing speed selection, gap search and manoeuvre distance, and decision point spacing. The following points summarize the key findings from this analysis:

- The narrow median width at this intersection limits the available storage and refuge area offered to drivers in the median. This is of particular concern as more than one vehicle often occupies the median at one time. This situation contributes to increased driver workload and the potential for vehicle conflicts in close proximity to the high-speed through lanes.

- Although vehicles turning left into the high speed through lanes from the sideroad (PR 210) are provided with a median left-turn acceleration lane in the southbound direction, the length of the acceleration lane provided appears short. This is of particular concern for heavy trucks. This is a complex manoeuvre as this merge often results in significant speed differentials. This contributes to an increased level of workload and risk of driver error. For truck drivers merging into the through lane from the acceleration lane, visibility of approaching traffic is limited to the side mirror. This increases the complexity of this task.

- Conspicuity of the intersection is limited as there is little contrast between the through lanes and the intersection. Advanced warning of the intersection is also limited to side mounted guide signs. Conspicuity of the intersection at night is also a concern as lighting is limited and portions of the intersection are shadowed.

- The positive guidance offered to drivers is limited and may contribute to increased workload and the potential for driver error. Examples include:

  - Stop bar line painting is deteriorated.

  - Pavement edge and lane line painting is deteriorated and missing in some instances.

  - Several inconsistencies in the advanced guide signage offered to drivers were observed.

- This intersection is configured with a skew angle of approximately 70°. Although the value is within TAC guidelines, an adequate view may be difficult to obtain in the direction of the acute angle, especially for older drivers. In addition, the A pillar and other vehicle parts can obstruct the driver's line of sight.

- Left-turn lanes on PTH 12 have a negative offset. As a result, left-turning traffic in the opposing lanes obstruct sightlines to oncoming traffic in the though lanes of PTH 12. These sightline limitations contribute to an increased risk of driver error.

5 IDENTIFICATION OF PRIORITIES

5.1 OVERVIEW

The work conducted up to this point has focused on documenting the existing road safety characteristics of the facility. In this phase of the analysis, the knowledge gained from this review is applied to provide guidance with regards to prioritizing key elements of the intersection for road safety improvement.

5.2 LINES OF EVIDENCE SUMMARY

The following table presents a summary of findings from the lines of evidence evaluation of the existing safety performance for this intersection. In the following table, locations identified by each line of evidence are compared to each other to identify commonalities. Where lines of evidence “overlap” and point to a common conclusion regarding a particular location, that conclusion is strengthened by the independence of the indicators and the multiplicity of their occurrence as well as the independence of the individual investigators pursuing the different approaches to the analysis.

Table 5.2.1: Lines of Evidence Summary

Intersection Element	Road Safety Observations	Site Investigation	Safety Analysis				
			Collision Analysis	Geometric Analysis	Operational Analysis	Video Conflict Analysis	Human Factors Analysis
Intersection Configuration							
Median	The narrow median width (approximately 13m wide) at this intersection limits the available storage and refuge area for vehicles using the median as a two-stage crossing. Of particular concern is the accommodation of long and heavy trucks which accounted for 7% of 2020 traffic volumes at this intersection.	X	X	X		X	X
	Trucks entering from the sideroad have to use the intersection as a single stage crossing and must ensure the median is clear prior to advancing. Trucks cannot stop in the median without potential conflict with other traffic movements.	X	X	X		X	X
	Several vehicles were observed stopping in the median at the same time. This results in several conflict scenarios, including conflict between vehicles with conflicting orientation waiting in the median, and potential for queuing traffic to extend into the high speed through lanes.	X	X	X		X	X
	The collision analysis also indicated a high number of right-angle collisions at the intersection (accounting for 60% of all collisions, 80% of injury collisions and 100% of fatal collisions) with the	X	X	X		X	X

Intersection Element	Road Safety Observations	Site Investigation	Safety Analysis				
			Collision Analysis	Geometric Analysis	Operational Analysis	Video Conflict Analysis	Human Factors Analysis
	predominate contributing factor being “failing to yield the right-of-way” or “leaving stop sign before safe to do so” suggesting that drivers travelling eastbound and westbound on PR 210 across the median may be accepting gaps that are too small.						
Left-Turns from PTH 12	The PTH 12 left-turn lanes have a negative offset which can limit sightlines for opposing left-turning vehicles. Of particular concern is when vehicles are stopped in the median to perform a two-stage crossing and trucks turning left from mainline lanes are waiting in at the left-turn deceleration lane for the median to clear before turning. The left-turn lane deceleration length of 200m in both the northbound and southbound direction is slightly below the TAC recommended minimum length.	**X**	**X**	**X**	**X**		**X**
Left-Turns from PR 210	Westbound vehicles turning left to head southbound on PTH 12 have an acceleration lane in the median. Observations from the site review suggest that vehicles merging from the acceleration lane into the high-speed mainline lane do so at speeds of approximately 70-80 km/h, which results in significant speed differential at this location. The median left-turn acceleration lane is also significantly	**X**	**X**	**X**	**X**		**X**

Intersection Element	Road Safety Observations	Site Investigation	Safety Analysis				
			Collision Analysis	Geometric Analysis	Operational Analysis	Video Conflict Analysis	Human Factors Analysis
	shorter than the TAC recommended minimum. No left-turn acceleration lane is provided for the eastbound left-turn movement. As a result, these left turning trucks are merging into the high-speed mainline lane. This introduces significant speed differentials and an increased risk of collision.						
Right-Turns from PTH 12	The southbound right turn deceleration lane is shorter than the TAC recommended minimum length. In addition, delineation of the northbound right-turn cut-off is not obvious to drivers at night.	X		X			
Right-Turns from PR 210	Field observations suggest a significant volume of trucks (26% of 2020 truck turning volumes) are turning right onto southbound PTH 12 from eastbound PR 210. No right-turn acceleration lane is provided for this movement. There is also no acceleration lane provided in the northbound direction.	X	X	X			
Adjacent Intersections	An intersection with adjacent service road west of PTH 12 is located in close proximity to the main intersection (approximately 40m). This meets the minimum standard; however, the close proximity may cause conflicts between	X		X			

Intersection Element	Road Safety Observations	Site Investigation	Safety Analysis				
			Collision Analysis	Geometric Analysis	Operational Analysis	Video Conflict Analysis	Human Factors Analysis
	through traffic and vehicles turning to/from the service road, especially if there are eastbound queues at the intersection.						
	The service road connection on to PR 210 on the east side of PTH 12 is offset approximately 120 m. This intersection is however located within the functional area of the intersection. The NB-EB merging taper extends beyond this T- intersection and a vehicle slowing or stopping to execute a left turn from PR 210 at this location may conflict with a driver using the right turn merging taper.			X			
Skew Angle	The intersection is constructed at a skew angle of approximately 70 degrees. This angle is at the upper limit recommended by TAC. TAC 9.1.2.4 notes: “At skewed intersections, an adequate view may be difficult to obtain in the direction of the acute angle, especially for older drivers. For skewed intersections, the A pillar and other vehicle parts can obstruct the driver’s line of sight. Such obstruction was found to result in less than adequate stopping sight distance for speeds higher than 65 km/h, when the acute angle was less than 70 degrees”. Collision data suggested that the skew angle may be limiting sightlines. In addition, the skew may also be	X	X	X		X	X

Intersection Element	Road Safety Observations	Site Investigation	Safety Analysis				
			Collision Analysis	Geometric Analysis	Operational Analysis	Video Conflict Analysis	Human Factors Analysis
	contributing to the high number of conflicts resulting from the video conflict analysis.						
Positive Guidance							
Guide Signage	Guide signage on the northbound and southbound approaches to the intersection does not appear to be consistent. On the northbound approach, an advance guide sign is missing. The intersection guide sign provides information for the westbound direction only, and the sign appears to be located too far in advance of the intersection. In the southbound direction, an advance guide sign is missing.	X					X
Intersection Conspicuity	When approaching the intersection on PTH 12, there is little contrast between the mainline lanes and the intersection. Also, drivers are provided with limited advanced warning of the approaching intersection. As a result, intersection conspicuity is limited.	X	X			X	X
Signage	Yield signs at the median installed at significant offset and appear small and may be less effective as such.	X	X				
	Wrong Way signs are not double posted on the mainline lanes north and south of the intersection.	X					
	The speed limit sign after entering southbound PTH 12 from the interchange	X					

Intersection Element	Road Safety Observations	Site Investigation	Safety Analysis					
			Collision Analysis	Geometric Analysis	Operational Analysis	Video Conflict Analysis	Human Factors Analysis
	is missing and drivers may not be aware of the posted speed limit in this area.						
Illumination	The illumination at the intersection is limited and creates areas with shadows. This results in poor conspicuity of the intersection. Delineation of the northbound right-turn cut-off is not obvious to drivers at night.	X	X				X
Delineation & Line Painting	In general, line painting is deteriorated and delineation within the intersection is poor. These issues contribute to increased driver workload and the potential for driver error. Deterioration and poor reflectivity of pavement markings results in poor guidance at night. Stop bar lines are missing in some instances.	X					X
	Line painting immediately in advance of the intersection may encourage drivers to perform passing in advance or within the intersection. The southbound acceleration lane is delineated with a dashed line thus encouraging drivers to encroach or merge into the high-speed mainline lane shortly after entering the acceleration lane. This	X	X				X

Intersection Element	Road Safety Observations	Site Investigation	Safety Analysis				
			Collision Analysis	Geometric Analysis	Operational Analysis	Video Conflict Analysis	Human Factors Analysis
	results in significant speed differentials and potential for high-severity conflicts.						
Rumble Strips	The rumble strips on the westbound approach to the intersection appeared to have been worn off in the wheel paths. This may impact their effectiveness. It is our understanding that this feature has been installed as a “mumble strips” treatment, which are designed to have lower noise levels than traditional rumble strips.	X					

5.3 INTERSECTION PRIORITIES

An examination of the overlapping lines of evidence outlined in the tables above helps identify key elements of the intersection that appears to offer the greatest potential for road safety improvement. For the purposes of this analysis, high priority elements have been categorized as elements that appear in three or more lines of evidence. Medium priorities have been categorized as elements that appear in 2 lines of evidence, and low priorities have been categorized as elements that appear only in 1 line of evidence.

Although the level of potential road safety improvement may be lower, it is still important to consider the treatment of lower priority elements as treatment can often be implemented for a relatively low cost or as part of routine maintenance activities.

5.3.1 HIGH PRIORITY

- **Median:** The narrow median width at this intersection limits the available storage and refuge area for vehicles crossing the median. Of particular concern is the accommodation of long and heavy trucks which accounted for 7% of 2020 traffic volumes at this intersection. Trucks have to use the intersection as a single stage crossing and must ensure the median is clear prior to advancing. Trucks cannot stop in the median without potential conflict with other traffic movements. Several vehicles were also observed stopping in the median at the same time. This results in vehicle conflicts and the potential for queuing traffic to extend into the high speed through lanes.

- **Left-Turns from PTH 12:** The PTH 12 left-turn lanes have a negative offset which can limit sightlines for left-turning vehicles. Of particular concern is when vehicles are stopped in the median and trucks turning left from mainline lanes must wait at the left-turn deceleration lane for the median to clear before turning.

- **Left-Turns from PR 210:**

    - Westbound vehicles turning left to head southbound on PTH 12 have an acceleration lane in the median. Observations from the site review suggest that vehicles merging from the acceleration lane into the high-speed mainline lane do so at speeds of approximately 70-80 km/h, which results in significant speed differential at this location. This is of particular concern for larger trucks that generally take longer to accelerate and thus merging at much lower speeds which is resulting in even greater speed differentials at this location. The southbound left-turn acceleration lane is also significantly shorter than the TAC recommended minimum.

    - Field observations suggest a significant volume of trucks (23% of 2020 truck turning volumes) are turning left from eastbound PR 210 onto northbound PTH 12. No left-turn acceleration lane is provided for this movement. As a result, these left turning trucks are merging into the high-speed mainline lane. This introduces significant speed differentials and an increased risk of collision.

- **Skew Angle:** The intersection is constructed at a skew angle of approximately 70 degrees. This angle is at the upper limit recommended by TAC. TAC 9.1.2.4 notes: “At skewed intersections, an adequate view may be difficult to obtain in the direction of the acute angle, especially for older drivers. For skewed intersections, the A pillar and other vehicle parts can obstruct the driver’s line of sight. Such obstruction was found to result in less than adequate stopping sight distance for speeds higher than 65 km/h, when the acute angle was less than 70 degrees".

- **Intersection Conspicuity:** When approaching the intersection on PTH 12, there is little contrast between the mainline lanes and the intersection. Also, drivers are provided with limited advanced warning of the approaching intersection. As a result, intersection conspicuity is limited.

5.3.2 MEDIUM PRIORITY

- **Right-Turns from PR 210:** Field observations suggest a significant volume of trucks (26% of 2020 truck turning volumes) are turning right onto southbound PTH 12 from eastbound PR 210. No right-turn acceleration lane is provided for this movement. As a result, these right turning trucks are merging into the mainline lane. This introduces significant speed differentials and an increased risk of collision. There is also no acceleration lane provided in the northbound direction.

- **Illumination:** The illumination at the intersection is limited and creates areas with shadows. This results in poor conspicuity of the intersection.

- **Delineation & Line Painting:** In general, line painting is deteriorated and delineation within the intersection is poor. These issues contribute to increased driver workload and the potential for driver error. Delineation of the northbound right-turn cut-off is not obvious to drivers at night.

5.3.3 LOW PRIORITY

- **Adjacent Intersection (west):**
  - An intersection with adjacent service road west of PTH 12 is located in close proximity to the main intersection (approximately 40m). This meets the minimum standard, however, the close proximity may cause conflicts between through traffic and vehicles turning to/from the service road, especially if there are eastbound queues at the intersection.
  - The service road connection on to PR 210 on the east side of PTH 12 is offset approximately 120 m. This intersection is however located within the functional area of the intersection. The NB-EB merging taper extends beyond this T- intersection and a vehicle slowing or stopping to execute a left turn from PR 210 at this location may conflict with a driver using the right turn merging taper.

- **Guide Signage:** Guide signage on the northbound and southbound approaches to the intersection does not appear to be consistent. On the northbound approach, an advance guide sign is missing. The intersection guide sign provides information for the westbound direction only, and the sign appears to be located too far in advance of the intersection. In the southbound direction, an advance guide sign is missing.

- **Signage**
  - Yield signs at the median appear small, and may be less effective as such.
  - Wrong Way signs are not double posted on the mainline lanes north and south of the intersection.

    - The speed limit sign after entering southbound PTH 12 from the interchange is missing and drivers may not be aware of the posted speed limit in this area.

- **Rumble Strips:** The rumble strips on the westbound approach to the intersection appeared to have been worn off in the wheel paths. This may impact their effectiveness. It is our understanding that this feature has been installed as a “mumble strips” treatment, which are designed to have lower noise levels than traditional rumble strips.

6 COUNTERMEASURE DEVELOPMENT

6.1 OVERVIEW

Using the prioritized list of road safety and operational concerns discussed in the section above, the road safety team identified potential countermeasures to address the concerns identified. As part of this task, estimates of countermeasure effectiveness were provided.

6.2 COST EFFECTIVENESS

Cost-effectiveness is an important consideration in the selection of situations for safety countermeasure treatment. An adaptation of an Australian[7] approach offers one model for adjusting priorities for their potential cost effectiveness. In that application, the risk elements are initially assigned to one of three categories of risk level, and then subject to a modification of their priority depending on the cost of mitigating the risk element. The following table summarizes this approach.

Table 6.2.1: Cost Effectiveness Prioritization Modification

Risk Level	Suggested Treatment Priority Modification Rules
High	Should be corrected or the risk significantly reduced, even if the treatment cost is high.
Medium	Should be corrected or the risk significantly reduced, if the treatment cost is moderate, but not high.
Low	Should be corrected or the risk reduced, if the treatment cost is low.

The approach is relatively simple and involves comparing the risk level with the cost of its mitigation. Situations assigned a “high” risk are typically addressed even if the treatment cost is high.

Medium risk elements are only addressed if their treatment cost is moderate (or lower), and low risk situations would only be corrected if the treatment cost were low.

For the purposes of this analysis, the following cost threshold levels were applied:

- High: Greater than $500,000
- Moderate: $100,000 to $500,000
- Low: Less than $100,000

6.3 QUANTIFYING COUNTERMEASURE EFFECTIVENESS

The goal of the countermeasure evaluation process was to quantify the potential road safety benefits associated with each of the countermeasures identified – where possible - using a toolset of evaluation techniques. Given the diverse nature of the countermeasures identified, several different analytical tools were applied to quantify potential road safety benefits.

For the purpose of this analysis, the toolsets applied included the following:

[7] Austroads, Road Safety Audit, Second Edition 2002.

- **MTI Safety Performance Functions (SPF's):** Crash Reduction Factors from the FHWA's CMF Clearinghouse, AASHTO Highway Safety Manual and the FHWA's Desktop Reference for Crash Reduction Factors were applied to the Manitoba SPF's to determine estimated levels of crash reduction that might be expected after implementing a given countermeasure at a specific site.

- **AASHTO Roadside Safety Analysis Program software (RSAP):** The AASHTO Roadside Safety Analysis Program (RSAP) is a cost-effectiveness analysis procedure for use in assessing roadside safety improvements. The analysis technique used was a before-and-after study approach. The before condition represents the existing condition of a typical road safety risk (i.e. a critical embankment slope located in close proximity to the driving lane). The after condition was then represented by making changes to the before situation based on the countermeasures identified above (flattening the slope or shielding the slope with barrier).

- **FHWA CMF Clearinghouse:** Crash Modification Factors from the FHWA's CMF Clearinghouse used to estimate the level of crash reduction that might be expected after implementing a given countermeasure at a specific site.

6.4 ANALYSIS RESULTS

The results of this analysis are summarized in tables provided in **Appendix D** of this report. The tables provide a description of the countermeasure, details on the analysis tool or techniques applied, a discussion on any assumptions or Crash Reduction Factors used, details on application locations, and the estimated impact of the countermeasure on collisions. Cost-effectiveness is also examined using the methodology outlined in **Section 6.2** above. Strategies for implementation of specific safety countermeasures are outlined in **Section 7**.

6.5 INTERSECTION CLOSURE OPTIONS DISCUSSION

Restriction of turning movements or partial/full intersection closure can be an effective way of improving safety. The following three closure options were explored as part of this study:

- **Restriction of PR 210 left-turn and through movements, and provision of channelization for the PTH 12 left-turn movements:** This strategy is similar to the R-CUT configuration identified in previous sections; however, instead of providing a median U-Turn location on PTH 12, traffic from PR 210 would be re-routed to the adjacent interchange through existing local roadway network. Details on possible route options are discussed further below. By restricting these movements, the number of potential conflict points would be reduced from 42 to 12.

- **Partial intersection closure:** This strategy would assume the median closure and restriction of all left-turn movements at the intersection, as well as left-turns from PTH 12. Only right-turn movements would be allowed at the intersection. Details on possible route options are discussed further below. By restricting these movements, the number of potential conflict points would be reduced from 42 to 4.

- **Full intersection closure:** This strategy would assume closing off the PR 210 access completely and only maintaining the PTH 12 through movements. Details on possible route options are discussed further below. Closing the intersection would eliminate all intersection related conflicts at this location.

All three options identified above would result in the re-routing of traffic to the adjacent PR 207 interchange located further to the north. The re-routing of traffic would be relatively straight forward on the east side of PTH 12, as PR 207 interchange is accessible through local roadway network in the Town of Ste. Anne. On the west side of PTH 12, one option would be to use the service road to access Langevin Road and the rest of local roadway network further to the north. **Figure 6.5.1** shows the potential routing for the intersection closure options.

Although all three options have a great potential to significantly reduce the number of potential conflicts at the PTH 12 and PR 210 intersection, the re-routing of traffic elsewhere on the local roadway network and adjacent interchange will result in increase of potential conflicts elsewhere (i.e., at crossing points elsewhere along the local roadway network due to increase in traffic volumes).

Figure 6.5.1: Re-routing of traffic with intersection full closure

The majority of the proposed re-routing route includes gravel roadway and would need to be upgraded if it were to accommodate heavy trucks. Alternatively, truck traffic could use PR 206 and PR 207 to connect to PTH 12, which would result in a substantial detour (see **Figure 6.5.2**).

Figure 6.5.2: Alternative route for trucks

Before any of the proposed intersection closure options are considered at this location, an extensive planning exercise is recommended to assess environmental, operational and safety impact associated with each option. This can be part of a future functional design study for the intersection.

6.6 ALTERNATIVE INTERSECTION CONFIGURATIONS DISCUSSION

As part of the countermeasure development task, several alternative intersection configurations were examined to address the road safety concerns present at this intersection. These alternative configurations are discussed in the sections below.

6.6.1 TRAFFIC SIGNAL

Although a traffic signal can provide some operational benefits when properly applied, the isolated nature of the intersection under review raises concern regarding speed adapted drivers, and the potential signal violation and high-speed rear-end collisions. Therefore, careful consideration of a system of speed management measures focused on reducing vehicle approach speeds would be required. These speed management measures can include, advanced warning provisions, speed feedback signs, the application of peripheral pavement markings etc.

MTI had previously completed a signal warrant for this intersection, and it was deemed that signals were not warranted at that time. MTI uses a 50-point warrant based on the Transportation Association of Canada (TAC) *Traffic Signal & Pedestrian Signal Head Warrant Analysis* and MTI's Policy/Standard No. 400-A-2 *Traffic Signal Warrants*. MTI has advised that they have continued to monitor this intersection and have recently determined that the intersection has reached the point where intersection improvements can be considered. As noted above, due to the rural isolated nature of the intersection, careful consideration of a system of speed management measures to reduce vehicle approach speeds should be included as part of the consideration of traffic signals at this intersection.

6.6.2 ROUNDABOUT

A roundabout can provide significant road safety benefits due to its characteristic low speed operations and reduced vehicle conflicts and collision severity. However, in an isolated high-speed rural environment, careful consideration of a system of speed management measures focused on reducing vehicle approach speeds is required. These speed management measures can include advanced warning provisions, speed feedback signs, the application of peripheral pavement markings, and the introduction of alignment shifts using long splitter islands. In addition, a comprehensive traffic analysis would be required to assess the operational impacts associated with optimal roundabout configuration using a set of traffic analysis models and microsimulation tools including SIDRA and VISSIM.

6.6.3 RESTRICTED CROSSING U-TURN (RCUT)

A stop-controlled or yield-controlled RCUT intersection is sometimes used as a safety treatment at isolated intersections on four-lane divided highways in a rural area. There are known safety benefits for this type of RCUT intersection. The RCUT intersection differs from a conventional intersection by eliminating the left-turn and through movements from cross road approaches. To accommodate these movements, the RCUT intersection requires drivers to turn right onto the main road and then make a U-turn maneuver at a one-way median opening located downstream of the intersection. On the major road approaches, the left turns are typically accommodated similar to left turns at conventional intersections.

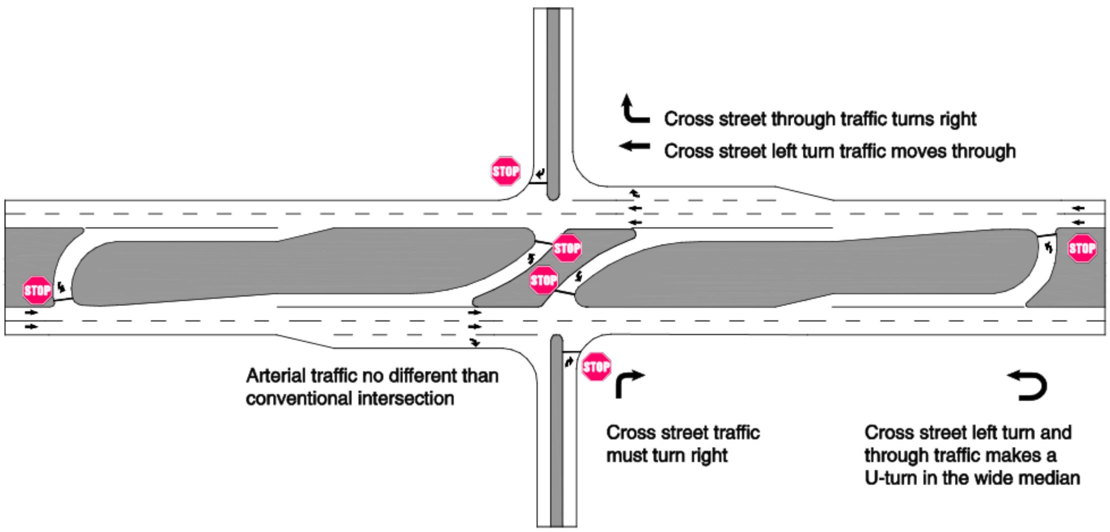


Figure 6.6.1: Rural stop controlled RCUT configuration

Due to the significant truck volumes on PTH 12, the application of this configuration would require careful consideration. Of particular concern is providing adequate gap search and maneuver distance between the main intersection and the upstream U-turn provisions to ensure heavy trucks have sufficient distance to merge onto the highway, make the necessary lane change maneuvers, and decelerate into the U-turn. If the median width is less than adequate for larger vehicle U-turns, additional pavement can be added at the far side of the U-turn crossover in the form of loons to accommodate this movement as shown in **Figure 6.6.2** below.

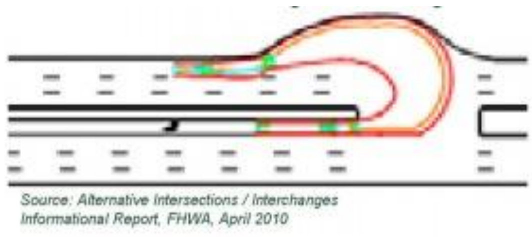


Figure 6.6.2: Example of a truck turning loon

By restricting several movements at the main crossing intersection, RCUT intersections reduce vehicular intersection conflict points from 32 to 18, including the conflict points introduced at the median U-turn crossovers, as shown in the figure below.

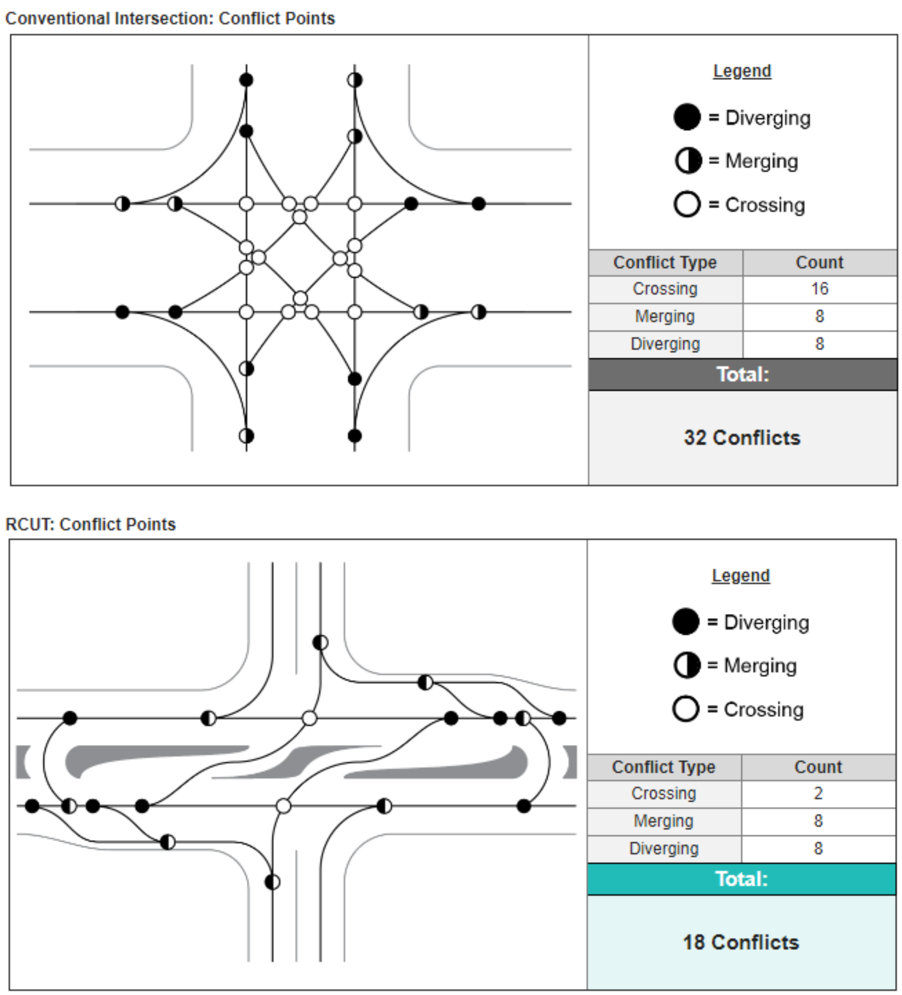


Figure 6.6.3: Conventional intersection and RCUT intersection conflict points

6.6.4 MEDIAN U-TURN (MUT)

The median U-turn (MUT) intersection, which is also referred to as Michigan Left, has been used extensively in Michigan. At an MUT intersection, left turns are not allowed at the major intersection. Rather, drivers turning left from the major road approach must first proceed through the intersection. At a location that is several hundred feet downstream of the major intersection, these drivers can make a U-turn, travel back toward the intersection, and then subsequently execute a right turn onto the minor road. This type of treatment is most effective on boulevard-type streets with wide medians.

The MUT intersection can be classified as either a partial MUT intersection or a full MUT intersection. At a partial MUT intersection, the side road approaches operate in a manner similar to the side road approaches at conventional intersections. At a full MUT intersection, no left turns are permitted from either the major road or the intersecting side road.

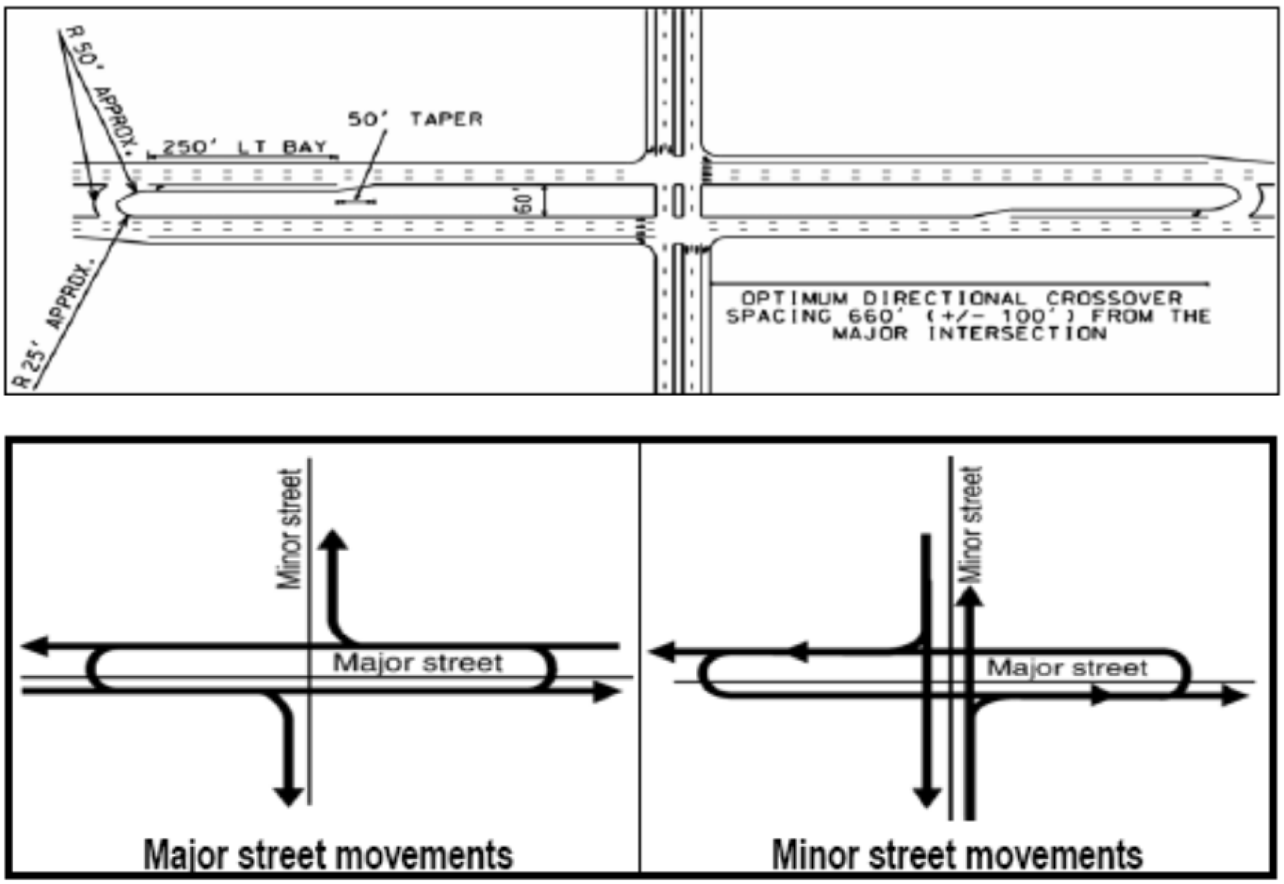


Figure 6.6.4: MUT typical design and movements

By restricting direct left turns at the main crossing intersection, MUT intersections reduce vehicular intersection conflict points from 32 to 16, including the conflict points introduced at the median U-turn crossovers, as shown in the figure below.

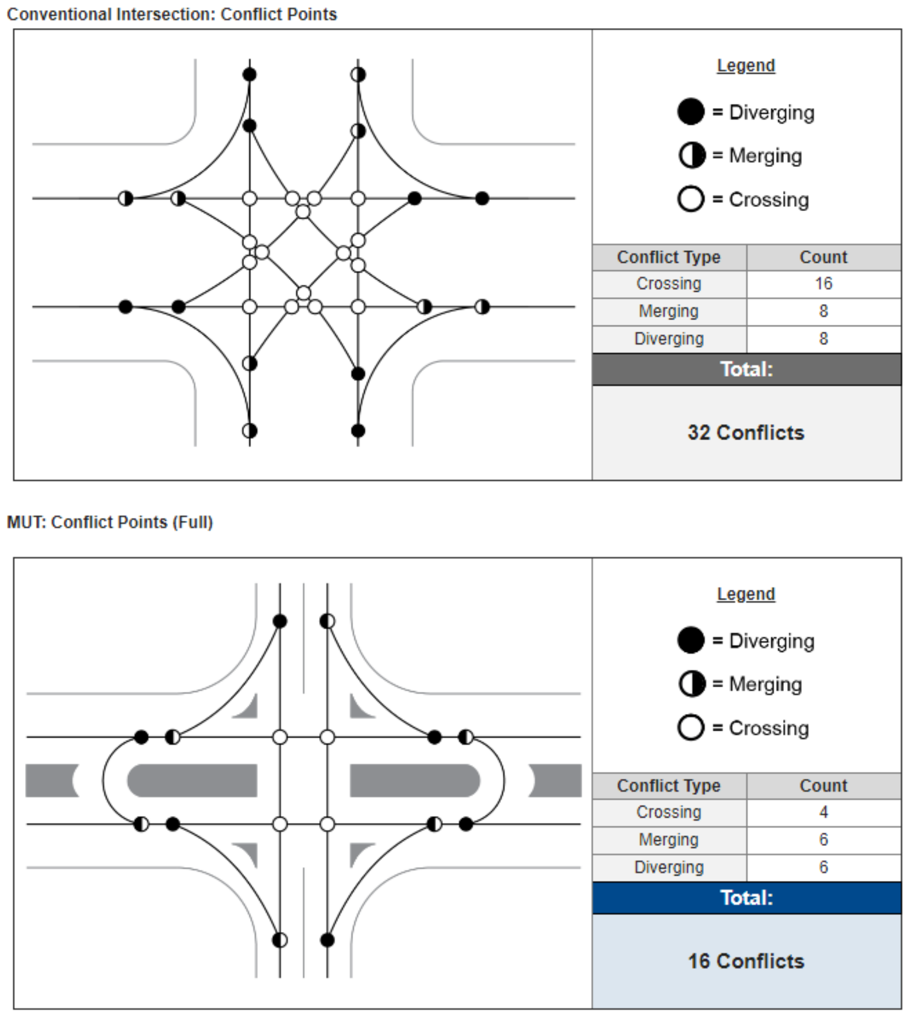


Figure 6.6.5: Conventional intersection and MUT intersection conflict points

6.6.5 JUG-HANDLE INTERSECTION

Jug-handle intersections have been in use for more than 50 years in the State of New Jersey. It is seen less commonly in other US states and in Canada, though its safety performance and superior capacity is well known.

Jug-handles redirect left-turning movements at the main intersection using two types of turning movements as shown in the figure below. In the first type of turning movement, left-turn vehicles exit to the right using a connector and then turn left to complete their desired movement. The other type of turning movement requires left-turning traffic to pass through the intersection, exit via a connector (which loops around to the right), and then transverses the intersection as part of the through movement.

Figure 6.6.6: Jug-handle intersection

Research suggests that a forward/reverse jug-handle reduced average intersection delay and increased capacity when traffic conditions were nearly saturated. At low-to-medium traffic conditions, the operational performance of the jug-handle was comparable to the conventional intersection.

Research also indicates that a jug-handle intersection exhibits lower collisions rates (PDO, fatal, injury and head-on) than a conventional intersection. It also exhibits a higher proportion of rear-end and PDO collisions and lower proportion of left-turn collisions when compared to a conventional intersection. Although there are several types of jug-handle configurations, the reverse jug-handle exhibits the lowest collision rate of angle and left-turn collisions, and the lowest number of total conflict points.

The summary of conflict points for the reverse jug-handle configuration is presented below.

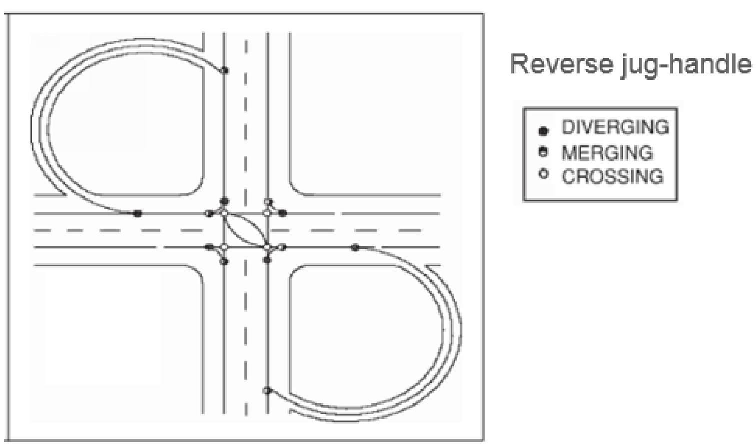


Figure 6.6.7: Conflict point diagram for the reverse jug-handle intersection

6.6.6 SUMMARY OF ALTERNATIVE INTERSECTION CONFIGURATIONS REVIEW

The above sections reviewed possible alternative intersection configurations for MTI's further consideration including traffic signals, roundabout, restricted crossing U-turn (RCUT), median U-Turn (MUT) and jug-handle intersection. Further evaluation of the alternative intersection configurations presented is recommended as part of a future functional level study to select the most appropriate option based on site conditions and in consideration of safety and operational implications of each alternative intersection configuration as they relate to this site. If considering these alternative intersection configurations further, there are a number of important factors that will require further review including the following:

- Due to the rural isolated and high-speed environment the PTH 12 and PR 210 intersection is situated in, installation of traffic signals should only be considered along with a comprehensive set of speed management measures.
- Roundabouts are still a relatively new intersection configuration on rural Manitoba highways with only one roundabout constructed in a rural highway setting to date. As such, although the roundabout offers potential significant road safety benefits due to its low-speed operations and reduced vehicle conflicts, if selected for further consideration by MTI, it will be important to consider the rural highway environment, comprehensive speed management measures and the unique locational attributes of the site including its proximity to the CP overpass to the north.
- Although the RCUT, MUT and jug-handle intersection configurations feature significantly fewer conflict points as compared to a traditional signalized intersection, as well as the potential for reduced collision potential associated with fewer conflict points, there are presently no existing RCUT, MUT and jug-handle intersections on rural highways in Manitoba and as such, careful consideration of each of these would be required as well as appropriate driver educational measures.
- The significant truck volumes on PTH 12 would need to be considered in any potential application of the RCUT and MUT intersection configurations.
- The horizontal curves on either side of the intersection and the intersection's proximity to the CP overpass would need to be carefully considered for both the RCUT and MUT configurations.
- As the highest frequency conflicts observed at this intersection involved through movements from the minor road, this will need to be considered when assessing the appropriateness of the MUT and jug-handle intersection configurations.

7 IMPLEMENTATION STRATEGY

An examination of the installation costs and potential road safety improvement associated with each of the proposed countermeasures was conducted to identify priorities and develop an implementation strategy.

Based on the results of this evaluation, the following implementation strategies were developed.

7.1 MAINTENANCE ISSUES

These items include countermeasures that should be addressed as part of routine maintenance activities on the highway. These include:

- Reapply line painting and pavement markings to improve positive guidance within the intersection.
- Provide solid line painting on the intersection approaches immediately in advance of the intersection to discourage passing manoeuvres within the intersection.
- Provide solid line painting between the median left-turn acceleration lane and adjacent through lane in the southbound direction.
- Review the speed limit sign location and placement along PTH 12 and adjust as necessary to ensure consistency.
- Provide double-posted wrong way signs.
- Review the yield sign location and placement and adjust as necessary. Also, consider installing an oversized yield signs to improve driver's awareness and compliance.
- Review level of deterioration of low noise rumble strips on the westbound approach and reapply as necessary.
- Guide signage on the northbound and southbound approaches to the intersection should be reviewed for content and sequence to ensure navigational consistency is provided to drivers.

7.2 SHORT-TERM STRATEGY

These items include low-cost countermeasures that can be implemented with little project development effort.

- Improve delineation of the northbound right-turn cut-off at night. One option may include the installation of post-mounted delineators.
- Install the Concealed or Unexpected Intersection Signs (MUTCDC: WA-11) on the PTH 12 approaches to the intersection to provide advanced warning on the approaching intersection. This sign can be supplemented with continuous or active flashing beacons (recommended).
- Install a "Left-Turn Traffic Use Acceleration Lane on PTH 12" sign to improve positive guidance for vehicles using the median left-turn acceleration lane.

7.3 MEDIUM-TERM STRATEGY

These items include countermeasures that will require project development effort.

- Consider installing a Dynamic Advance Intersection Warning System: A Dynamic Advance Intersection Warning System is an intersection recognition treatment that is meant to enhance an expressway driver's awareness of an approaching two-way stop-controlled intersection. The systems typically consist of static Vehicle Entering When Flashing (VEWF) warning signs with traffic-actuated flashers on the expressway approaches and in-pavement loop detectors on the minor roads. When traffic is detected on the minor road, the flashers on the VEWF signs are activated on the expressway approaches, warning expressway drivers that one or more vehicles are present at the intersection and may enter from the minor road.

Figure 7.3.1: Example of a Dynamic Advance Intersection Warning System

- Enhance intersection illumination.
- Add northbound median left-turn acceleration lane (this should be supported with proper signage and educational campaigns to educate drivers on how to properly use a median left-turn lane).
- Extend southbound median left-turn acceleration lane (this should be supported with proper signage and educational campaigns to educate drivers on how to properly use a median left-turn lane).

7.4 LONG-TERM STRATEGY

These items include countermeasures that will require significant planning and analysis due to their potential impacts on surrounding communities and developments. These items can be considered alternatives for further review as part of any future highway rehabilitation.

- Improving the intersection skew angle.
- Intersection signalization (this should be supplemented with provision of slotted left-turn lanes with positive off-set).
- Alternative intersection configurations RCUT, MUT, Jug-handle, and roundabout. As noted in **Section 6.6**, careful consideration would be required before proceeding with any of the alternative intersection configurations presented to review operational characteristics of PTH 12 due to the isolated high-speed rural nature of this intersection.
- Restriction of certain PR 210 movements.
- Partial or Full intersection closure.

7.5 WATCH LIST

Due to the low cost-effectiveness associated with some of the countermeasures identified to address high and medium risk observations from the field review, these items have been placed on a "watch list" and should be monitored on an ongoing basis for changes in safety performance that might trigger reconsideration of the need to invest in mitigation. These include:

- Add EB-SB and WB-NB right-turn acceleration lane.

- Service road realignments.
- Interchange.

8 AUDIT SIGNATURE PAGE

This review and commentary was prepared by WSP Canada Group Limited (WSP) for Manitoba Transportation and Infrastructure (MTI). The material in it reflects WSP's best judgement in light of the information available to us at the time of the review. Any use which MTI or any third party makes of this review, or any reliance on it or decisions made based on it, are the responsibility of MTI or the third party. WSP accepts no responsibility for damages, if any, suffered by MTI or any third party as a result of decisions made or actions based on this review.

		August 8, 2023
Diana Emerson, P. Eng.	WSP	Date
		August 8, 2023
Geoff Millen, P. Eng.	WSP	Date
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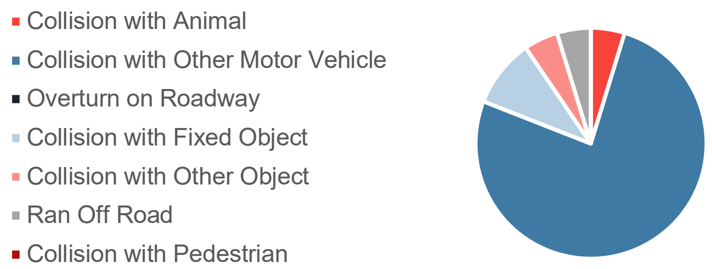
Damir Bjelica, P. Eng.	WSP	Date
		August 8, 2023
Brant Magnusson, P. Eng.	WSP	Date
		August 8, 2023
Jaime Lacoste, P. Eng.	WSP	Date

APPENDIX A: HISTORICAL COLLISION DATA ANALYSIS

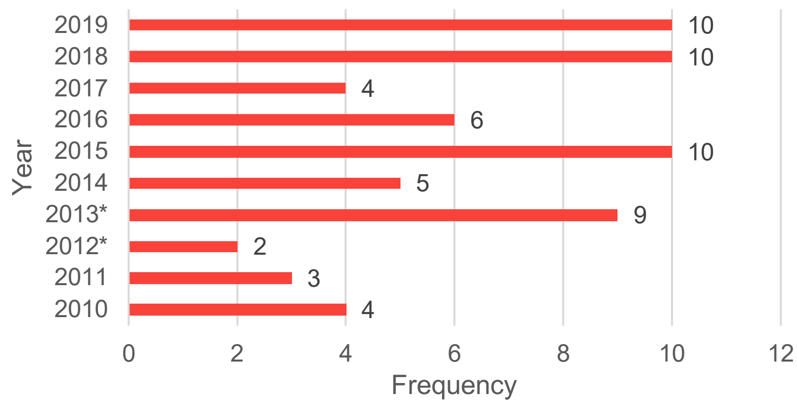
PTH 12 at PR 210

*2012-2013 INCOMPLETE DUE TO COLLISION REPORTING CHANGES IN MANITOBA

#	%	Collision Type
3	5%	Collision with Animal
48	76%	Collision with Other Motor Vehicle
0	0%	Overturn on Roadway
6	10%	Collision with Fixed Object
3	5%	Collision with Other Object
3	5%	Ran Off Road
0	0%	Collision with Pedestrian
63	100%	

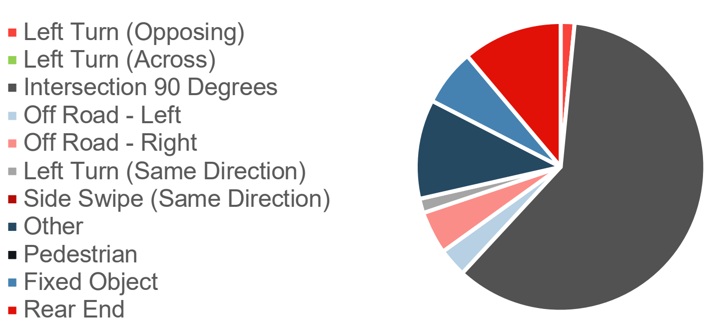


#	%	Year
4	6%	2010
3	5%	2011
2	3%	2012*
9	14%	2013*
5	8%	2014
10	16%	2015
6	10%	2016
4	6%	2017
10	16%	2018
10	16%	2019
63	100%	

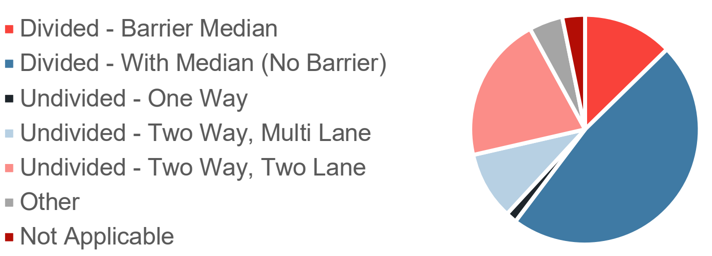


#	%	Severity
33	52%	Property Damage
27	43%	Injury
3	5%	Fatal
63	100%	

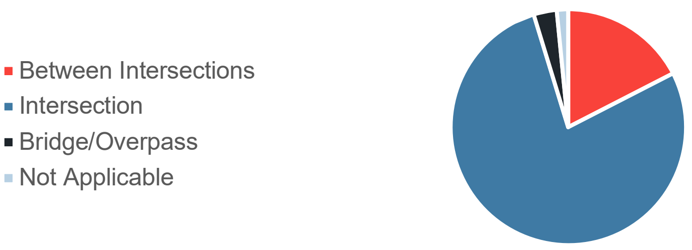
#	%	Configuration
1	2%	Left Turn (Opposing)
0	0%	Left Turn (Across)
38	60%	Intersection 90 Degrees
2	3%	Off Road - Left
3	5%	Off Road - Right
1	2%	Left Turn (Same Direction)
0	0%	Side Swipe (Same Direction)
7	11%	Other
0	0%	Pedestrian
4	6%	Fixed Object
7	11%	Rear End
63	100%	



#	%	Road Category
8	13%	Divided - Barrier Median
30	48%	Divided - With Median (No Barrier)
1	2%	Undivided - One Way
6	10%	Undivided - Two Way, Multi Lane
13	21%	Undivided - Two Way, Two Lane
3	5%	Other
2	3%	Not Applicable
63	100%	



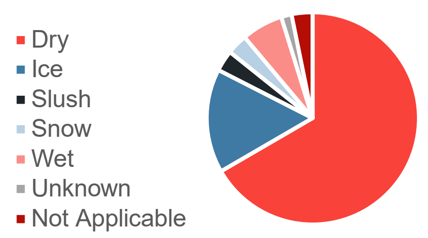
#	%	Collision Site
11	17%	Between Intersections
49	78%	Intersection
2	3%	Bridge/Overpass
1	2%	Not Applicable
63	100%	



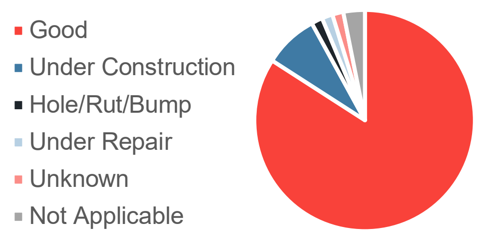
PTH 12 at PR 210

*2012-2013 INCOMPLETE DUE TO COLLISION REPORTING CHANGES IN MANITOBA

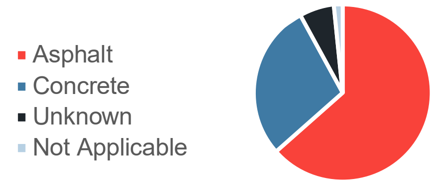
#	%	Road Surface Condition
42	67%	Dry
10	16%	Ice
2	3%	Slush
2	3%	Snow
4	6%	Wet
1	2%	Unknown
2	3%	Not Applicable
63	100%	



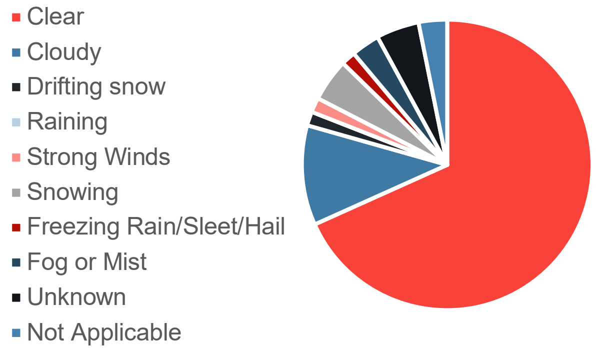
#	%	Road Condition
53	84%	Good
5	8%	Under Construction
1	2%	Hole/Rut/Bump
1	2%	Under Repair
1	2%	Unknown
2	3%	Not Applicable
63	100%	



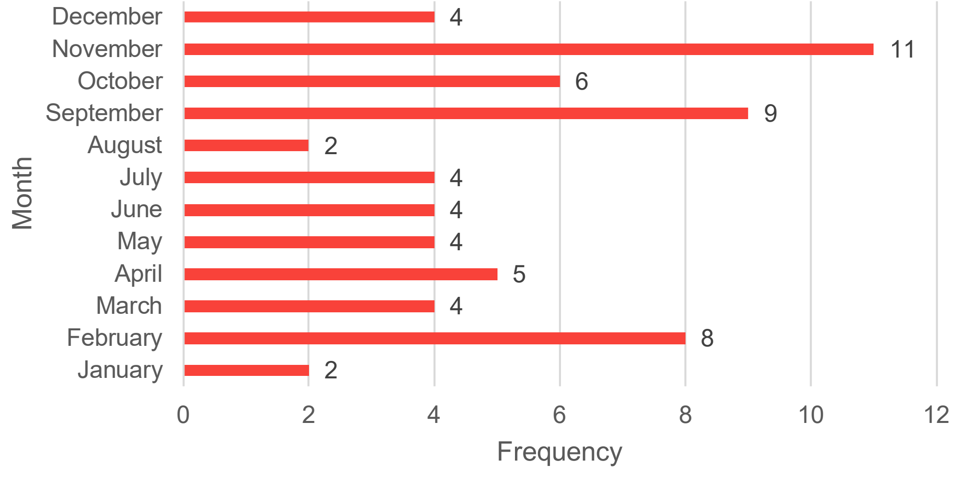
#	%	Road Surface
40	63%	Asphalt
18	29%	Concrete
4	6%	Unknown
1	2%	Not Applicable
63	100%	



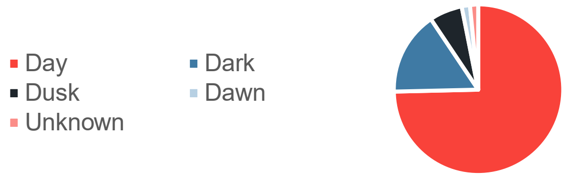
#	%	Weather Condition
43	68%	Clear
7	11%	Cloudy
1	2%	Drifting snow
0	0%	Raining
1	2%	Strong Winds
3	5%	Snowing
1	2%	Freezing Rain/Sleet/Hail
2	3%	Fog or Mist
3	5%	Unknown
2	3%	Not Applicable
63	100%	



#	%	Month
2	3%	January
8	13%	February
4	6%	March
5	8%	April
4	6%	May
4	6%	June
4	6%	July
2	1%	August
9	14%	September
6	10%	October
11	17%	November
4	6%	December
63	98%	



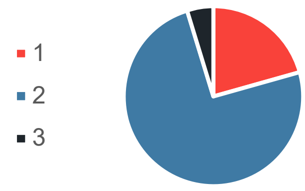
#	%	Light Condition
47	75%	Day
10	16%	Dark
4	6%	Dusk
1	2%	Dawn
1	2%	Unknown
63	100%	



PTH 12 at PR 210

*2012-2013 INCOMPLETE DUE TO COLLISION REPORTING CHANGES IN MANITOBA

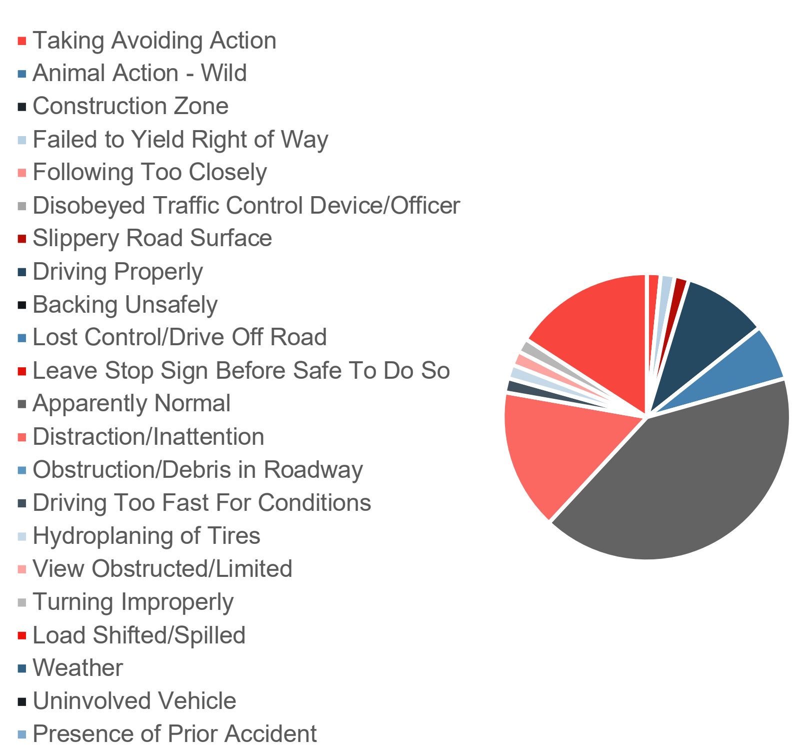
#	%	Number of Vehicles
13	21%	1
47	75%	2
3	5%	3
63	100%	



#	%	Vehicle 1 - Type
34	54%	Automobile
6	10%	Mini-van/Multi-Purpose Van
1	2%	Truck Over 4500 KG (Unit Chassis)*
0	0%	Van under 4500 KG
13	21%	Pick-up under 4500 KG
1	2%	Power Unit for Semi-Trailer*
2	3%	Truck (Other)
6	10%	Unknown
63	100%	

#	%	Vehicle 1 - Contributing Factor 1
3	5%	Taking Avoiding Action
3	5%	Animal Action - Wild
1	2%	Construction Zone
8	13%	Failed to Yield Right of Way
3	5%	Following Too Closely
0	0%	Disobeyed Traffic Control Device/Officer
6	10%	Slippery Road Surface
24	38%	Driving Properly
0	0%	Backing Unsafely
0	0%	Lost Control/Drive Off Road
8	13%	Leave Stop Sign Before Safe To Do So
0	0%	Apparently Normal
0	0%	Distraction/Inattention
2	3%	Obstruction/Debris in Roadway
1	2%	Driving Too Fast For Conditions
0	0%	Hydroplaning of Tires
1	2%	View Obstructed/Limited
0	0%	Turning Improperly
1	2%	Load Shifted/Spilled
1	2%	Weather
1	2%	Uninvolved Vehicle
0	0%	Presence of Prior Accident
0	0%	Unknown
63	100%	

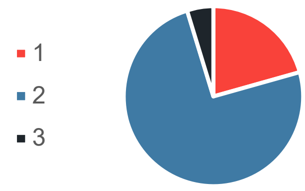
#	%	Vehicle 1 - Contributing Factor 2
1	2%	Taking Avoiding Action
0	0%	Animal Action - Wild
0	0%	Construction Zone
1	2%	Failed to Yield Right of Way
0	0%	Following Too Closely
0	0%	Disobeyed Traffic Control Device/Officer
1	2%	Slippery Road Surface
6	10%	Driving Properly
0	0%	Backing Unsafely
4	6%	Lost Control/Drive Off Road
0	0%	Leave Stop Sign Before Safe To Do So
26	41%	Apparently Normal
10	16%	Distraction/Inattention
0	0%	Obstruction/Debris in Roadway
1	2%	Driving Too Fast For Conditions
1	2%	Hydroplaning of Tires
1	2%	View Obstructed/Limited
1	2%	Turning Improperly
0	0%	Load Shifted/Spilled
0	0%	Weather
0	0%	Uninvolved Vehicle
0	0%	Presence of Prior Accident
10	16%	Unknown
63	100%	



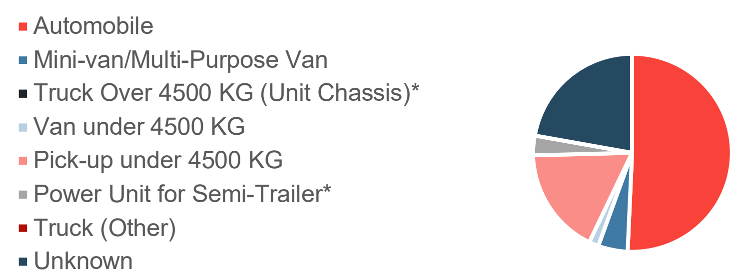
PTH 12 at PR 210

*2012-2013 INCOMPLETE DUE TO COLLISION REPORTING CHANGES IN MANITOBA

#	%	Number of Vehicles
13	21%	1
47	75%	2
3	5%	3
63	100%	

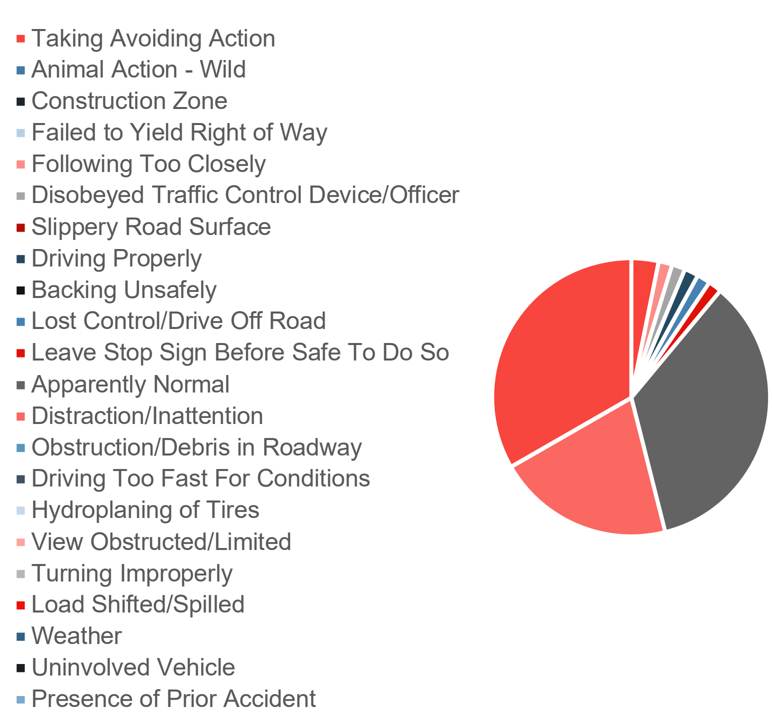


#	%	Vehicle 2 - Type
32	51%	Automobile
3	5%	Mini-van/Multi-Purpose Van
0	0%	Truck Over 4500 KG (Unit Chassis)*
1	2%	Van under 4500 KG
11	17%	Pick-up under 4500 KG
2	3%	Power Unit for Semi-Trailer*
0	0%	Truck (Other)
14	22%	Unknown
63	100%	



#	%	Vehicle 2 - Contributing Factor 1
3	5%	Taking Avoiding Action
0	0%	Animal Action - Wild
1	2%	Construction Zone
14	22%	Failed to Yield Right of Way
3	5%	Following Too Closely
0	0%	Disobeyed Traffic Control Device/Officer
1	2%	Slippery Road Surface
19	30%	Driving Properly
0	0%	Backing Unsafely
0	0%	Lost Control/Drive Off Road
5	8%	Leave Stop Sign Before Safe To Do So
0	0%	Apparently Normal
0	0%	Distraction/Inattention
1	2%	Obstruction/Debris in Roadway
0	0%	Driving Too Fast For Conditions
0	0%	Hydroplaning of Tires
1	2%	View Obstructed/Limited
0	0%	Turning Improperly
1	2%	Load Shifted/Spilled
0	0%	Weather
0	0%	Uninvolved Vehicle
1	2%	Presence of Prior Accident
13	21%	Unknown
63	100%	

#	%	Vehicle 2 - Contributing Factor 2
2	3%	Taking Avoiding Action
0	0%	Animal Action - Wild
0	0%	Construction Zone
0	0%	Failed to Yield Right of Way
1	2%	Following Too Closely
1	2%	Disobeyed Traffic Control Device/Officer
0	0%	Slippery Road Surface
1	2%	Driving Properly
0	0%	Backing Unsafely
1	2%	Lost Control/Drive Off Road
1	2%	Leave Stop Sign Before Safe To Do So
22	35%	Apparently Normal
13	21%	Distraction/Inattention
0	0%	Obstruction/Debris in Roadway
0	0%	Driving Too Fast For Conditions
0	0%	Hydroplaning of Tires
0	0%	View Obstructed/Limited
0	0%	Turning Improperly
0	0%	Load Shifted/Spilled
0	0%	Weather
0	0%	Uninvolved Vehicle
0	0%	Presence of Prior Accident
21	33%	Unknown
63	100%	



APPENDIX B: SYNCHRO REPORTS

Intersection												
Int Delay, s/veh	3.8											

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	16	20	44	104	25	12	33	335	33	2	385	16
Future Vol, veh/h	16	20	44	104	25	12	33	335	33	2	385	16
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	Yield	-	-	None
Storage Length	-	-	-	-	-	-	2000	-	1900	2000	-	1760
Veh in Median Storage, #	-	1	-	-	1	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	5	5	5	0	0	6	15	11	0	11	14
Mvmt Flow	17	22	48	113	27	13	36	364	36	2	418	17

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	690	858	209	660	875	182	435	0	0	364	0	0
Stage 1	422	422	-	436	436	-	-	-	-	-	-	-
Stage 2	268	436	-	224	439	-	-	-	-	-	-	-
Critical Hdwy	7.5	6.6	7	7.6	6.5	6.9	4.22	-	-	4.1	-	-
Critical Hdwy Stg 1	6.5	5.6	-	6.6	5.5	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.5	5.6	-	6.6	5.5	-	-	-	-	-	-	-
Follow-up Hdwy	3.5	4.05	3.35	3.55	4	3.3	2.26	-	-	2.2	-	-
Pot Cap-1 Maneuver	335	287	788	342	290	836	1093	-	-	1206	-	-
Stage 1	585	579	-	561	583	-	-	-	-	-	-	-
Stage 2	720	571	-	750	582	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	304	277	788	299	280	836	1093	-	-	1206	-	-
Mov Cap-2 Maneuver	414	384	-	403	381	-	-	-	-	-	-	-
Stage 1	566	578	-	542	564	-	-	-	-	-	-	-
Stage 2	652	552	-	677	581	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	12.8	18.6	0.7	0
HCM LOS	B	C		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1093	-	-	546	417	1206	-	-
HCM Lane V/C Ratio	0.033	-	-	0.159	0.368	0.002	-	-
HCM Control Delay (s)	8.4	-	-	12.8	18.6	8	-	-
HCM Lane LOS	A	-	-	B	C	A	-	-
HCM 95th %tile Q(veh)	0.1	-	-	0.6	1.7	0	-	-

Intersection	
Int Delay, s/veh	3.2

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	15	34	37	86	19	8	41	464	177	15	458	21
Future Vol, veh/h	15	34	37	86	19	8	41	464	177	15	458	21
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	Yield	-	-	None
Storage Length	-	-	-	-	-	-	2000	-	1900	2000	-	1760
Veh in Median Storage, #	-	1	-	-	1	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	94	94	94	94	94	94	94	94	94	94	94	94
Heavy Vehicles, %	7	3	12	0	6	13	8	10	0	0	12	15
Mvmt Flow	16	36	39	91	20	9	44	494	188	16	487	22

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	864	1101	244	876	1123	247	509	0	0	494	0	0
Stage 1	519	519	-	582	582	-	-	-	-	-	-	-
Stage 2	345	582	-	294	541	-	-	-	-	-	-	-
Critical Hdwy	7.64	6.56	7.14	7.5	6.62	7.16	4.26	-	-	4.1	-	-
Critical Hdwy Stg 1	6.64	5.56	-	6.5	5.62	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.64	5.56	-	6.5	5.62	-	-	-	-	-	-	-
Follow-up Hdwy	3.57	4.03	3.42	3.5	4.06	3.43	2.28	-	-	2.2	-	-
Pot Cap-1 Maneuver	240	209	727	246	198	721	1011	-	-	1080	-	-
Stage 1	495	528	-	471	487	-	-	-	-	-	-	-
Stage 2	630	495	-	695	509	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	215	197	727	203	187	721	1011	-	-	1080	-	-
Mov Cap-2 Maneuver	330	311	-	318	296	-	-	-	-	-	-	-
Stage 1	473	520	-	450	466	-	-	-	-	-	-	-
Stage 2	570	473	-	603	501	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	16	22.3	0.5	0.3
HCM LOS	C	C		

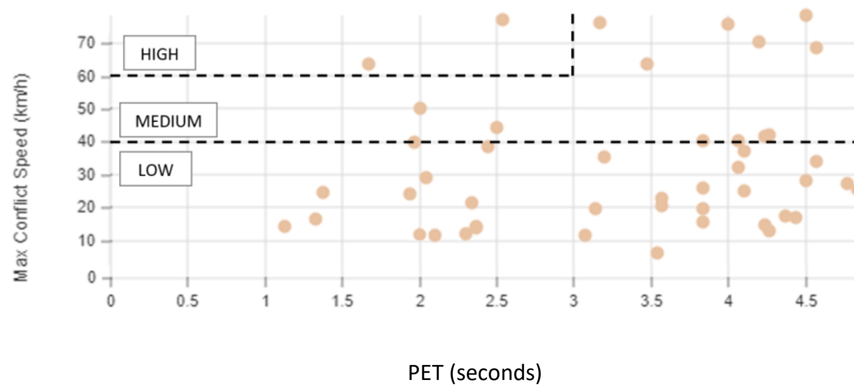
Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1011	-	-	418	327	1080	-	-
HCM Lane V/C Ratio	0.043	-	-	0.219	0.368	0.015	-	-
HCM Control Delay (s)	8.7	-	-	16	22.3	8.4	-	-
HCM Lane LOS	A	-	-	C	C	A	-	-
HCM 95th %tile Q(veh)	0.1	-	-	0.8	1.6	0	-	-

APPENDIX C: VIDEO CONFLICT ANALYSIS – Risk Level Rating Details

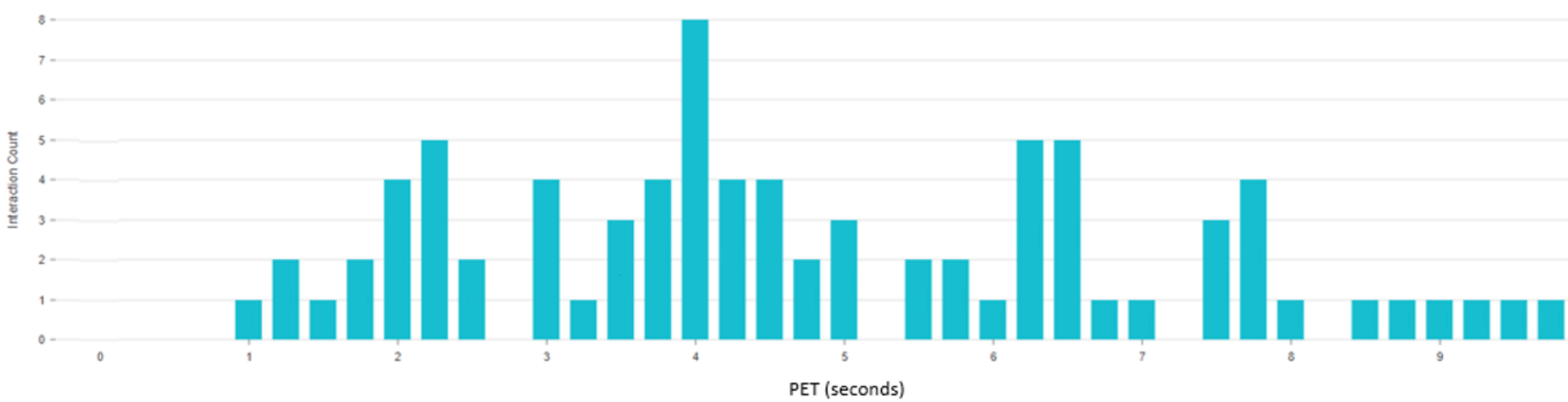
1. Northbound Through vs. Through from median *(Through vs. Through)*

Risk Level	Critical Risk	High Risk	Medium Risk	Low Risk
Number of Crossing Conflicts	0	2	13	31

Speed vs. PET scatter

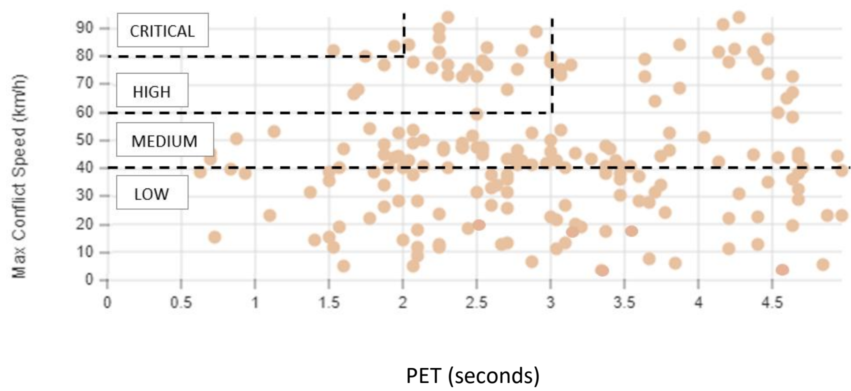


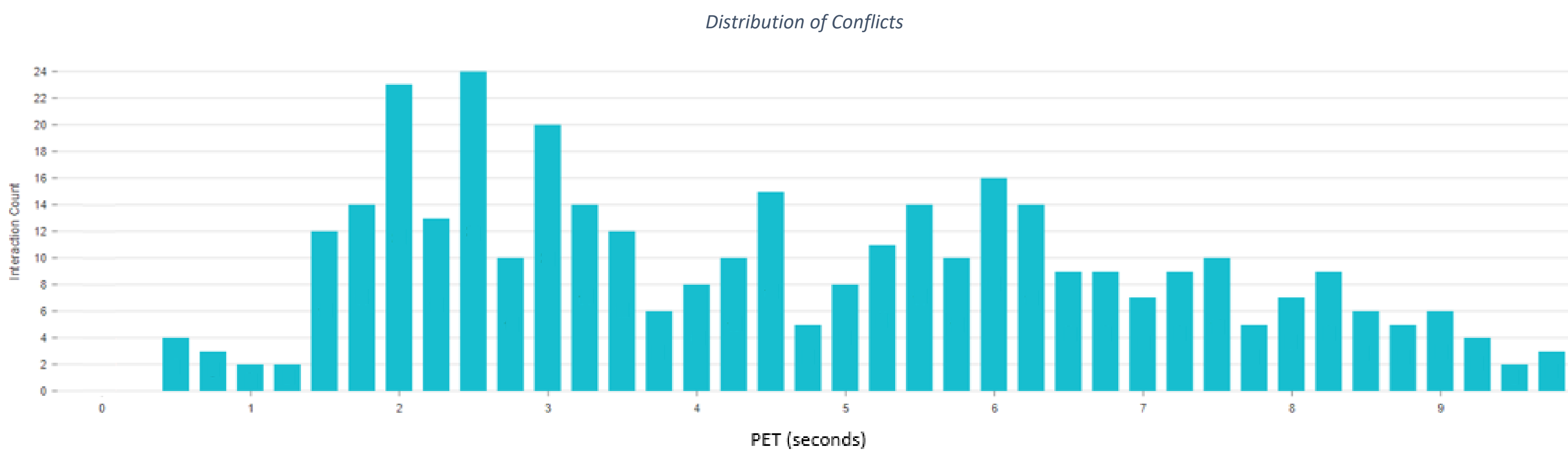
Distribution of conflicts



2. Northbound Through vs. Westbound Through *(Through vs. Through)*

Risk Level	Critical Risk	High Risk	Medium Risk	Low Risk
Number of Crossing Conflicts	3	23	81	90

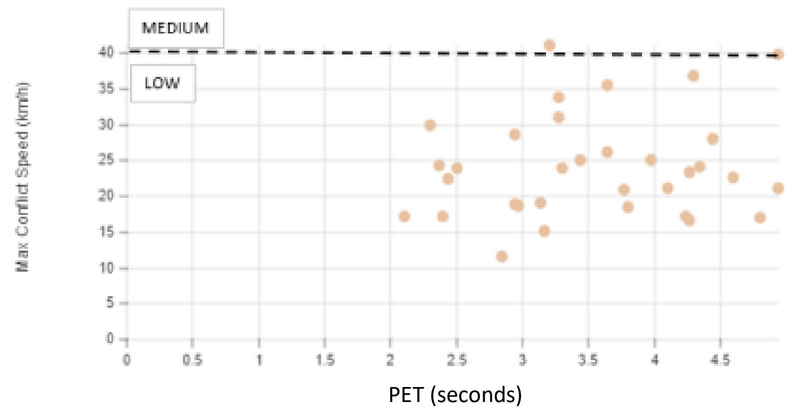




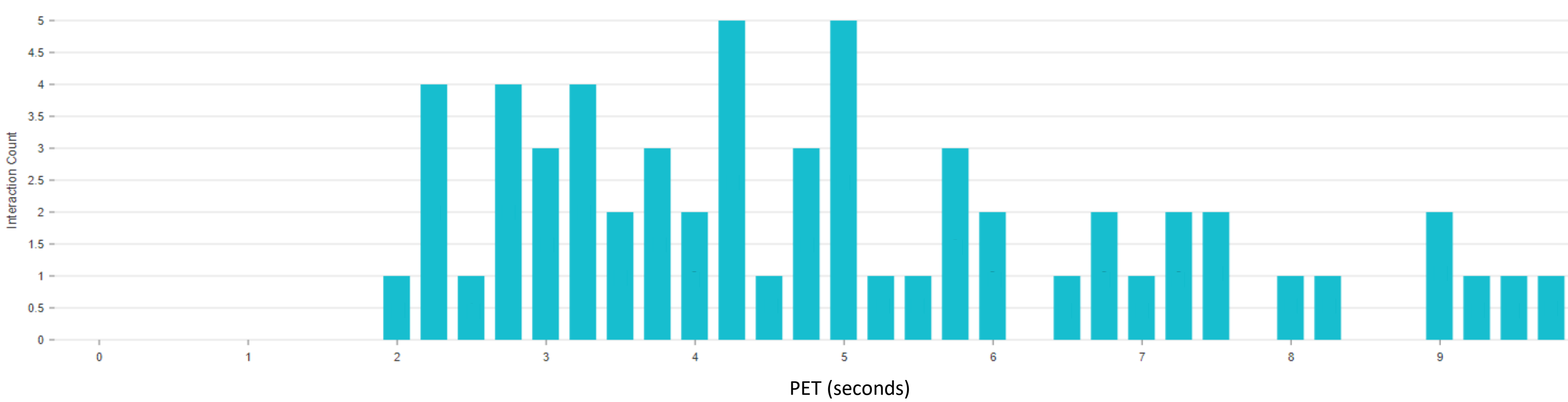
3. Left-Turn from Median vs. Westbound Through *(Left-Turn vs. Through Oncoming)*

Risk Level	Critical Risk	High Risk	Medium Risk	Low Risk
Number of Crossing Conflicts	0	0	2	33

Speed vs. PET scatter



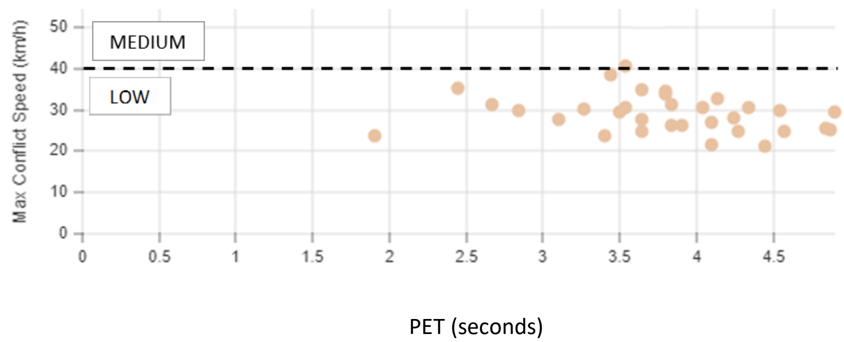
Distribution of Conflicts



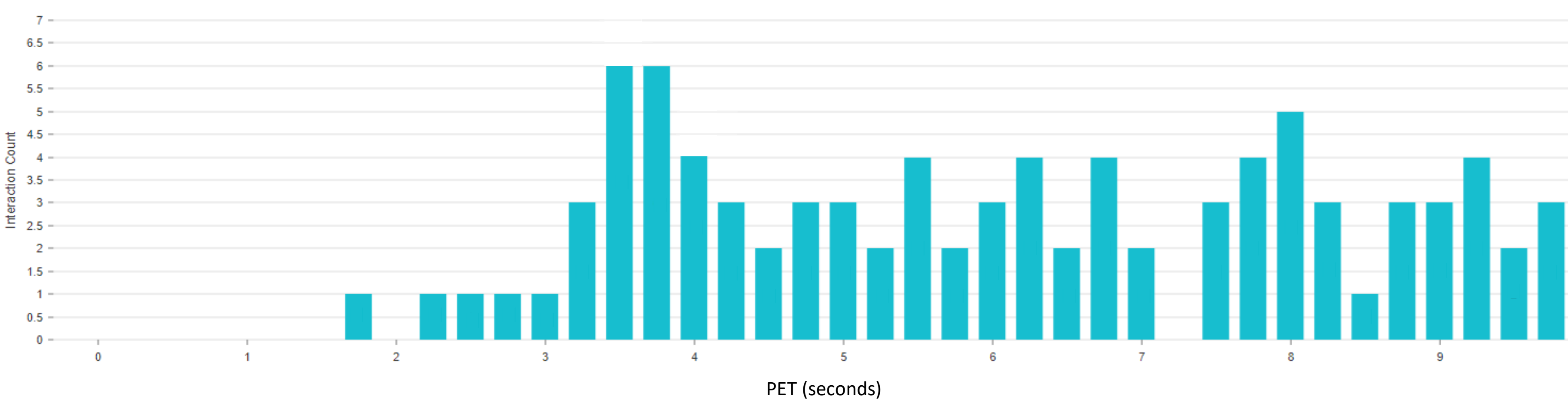
4. Northbound Left-Turn vs. Through from Median *(Left-Turn vs. Through from Left)*

Risk Level	Critical Risk	High Risk	Medium Risk	Low Risk
Number of Crossing Conflicts	0	0	1	31

Speed vs. PET scatter



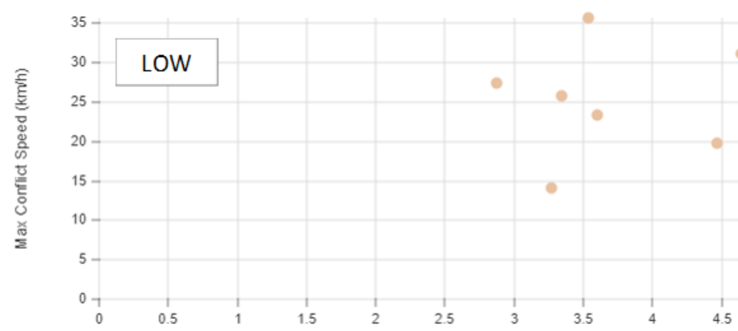
Distribution of Conflicts



5. Northbound Left-Turn vs. Left-Turn from Median *(Left-Turn vs. Left-Turn from Left)*

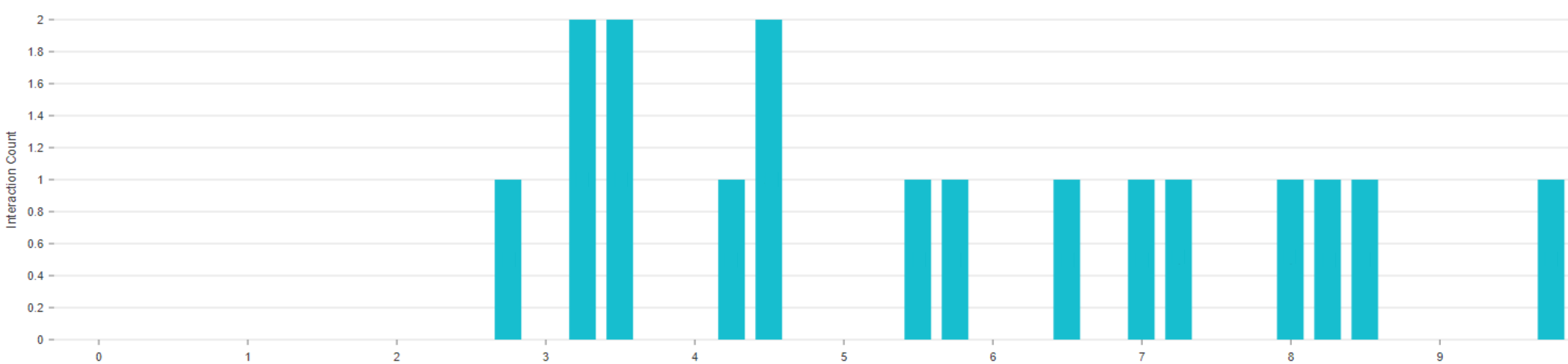
Risk Level	Critical Risk	High Risk	Medium Risk	Low Risk
Number of Crossing Conflicts	0	0	0	8

Speed vs. PET scatter



PET (seconds)

Distribution of Conflicts

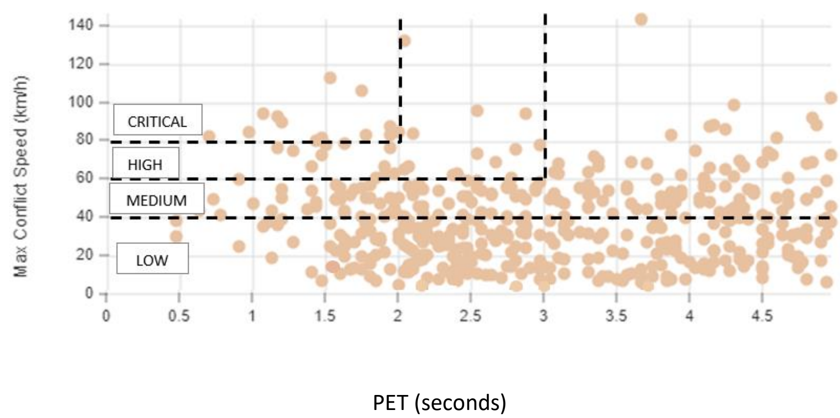


PET (seconds)

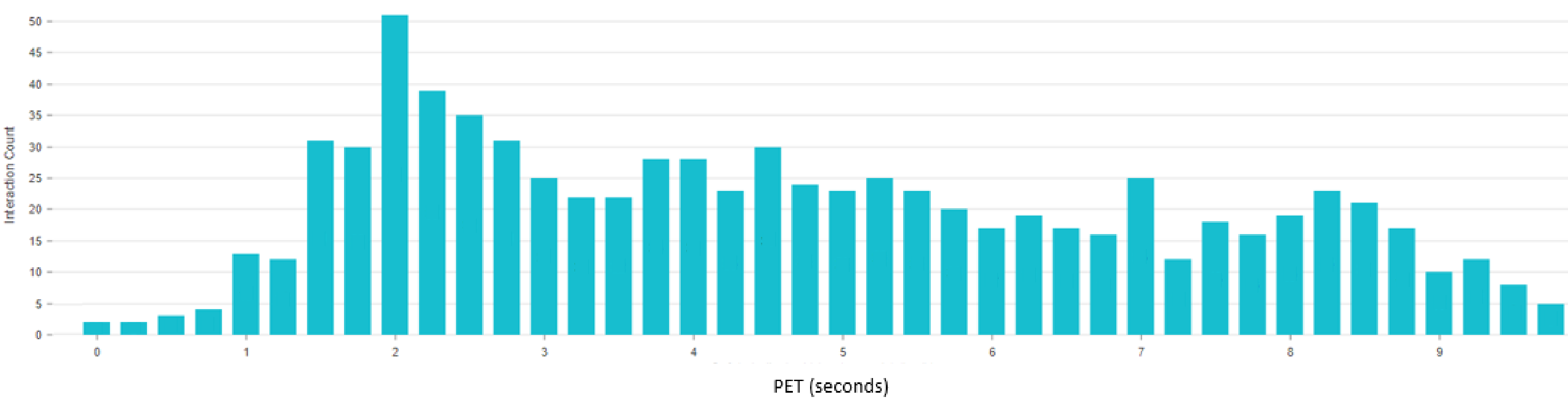
6. Southbound Through vs. Through from Median *(Through vs. Through)*

Risk Level	Critical Risk	High Risk	Medium Risk	Low Risk
Number of Crossing Conflicts	14	24	132	283

Speed vs. PET scatter



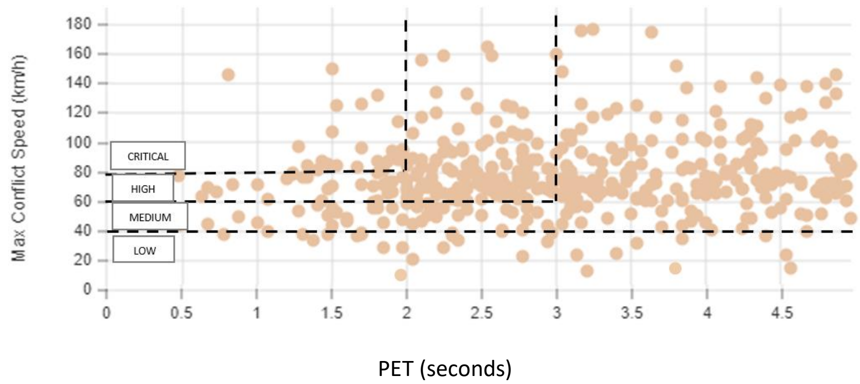
Distribution of Conflicts



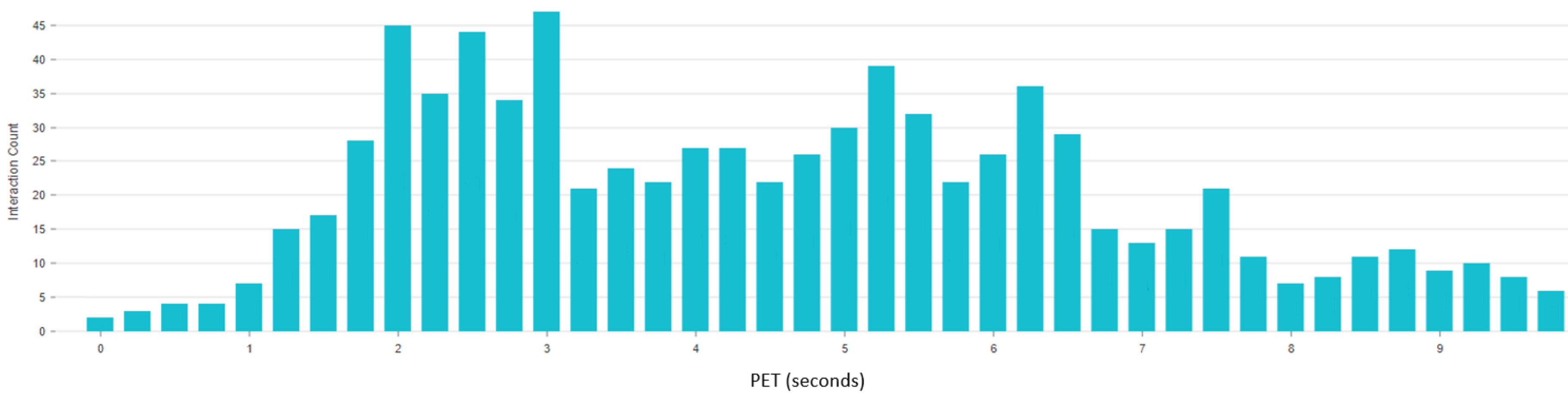
7. Southbound Through vs. Eastbound Through *(Through vs. Through)*

Risk Level	Critical Risk	High Risk	Medium Risk	Low Risk
Number of Crossing Conflicts	23	130	277	24

Speed vs. PET scatter



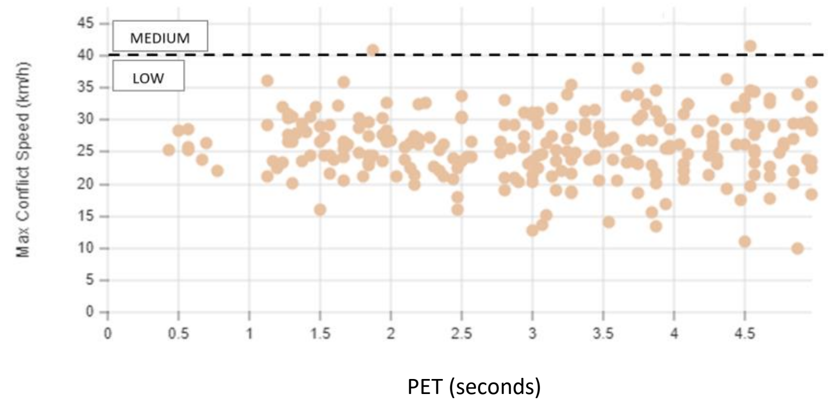
Distribution of Conflicts



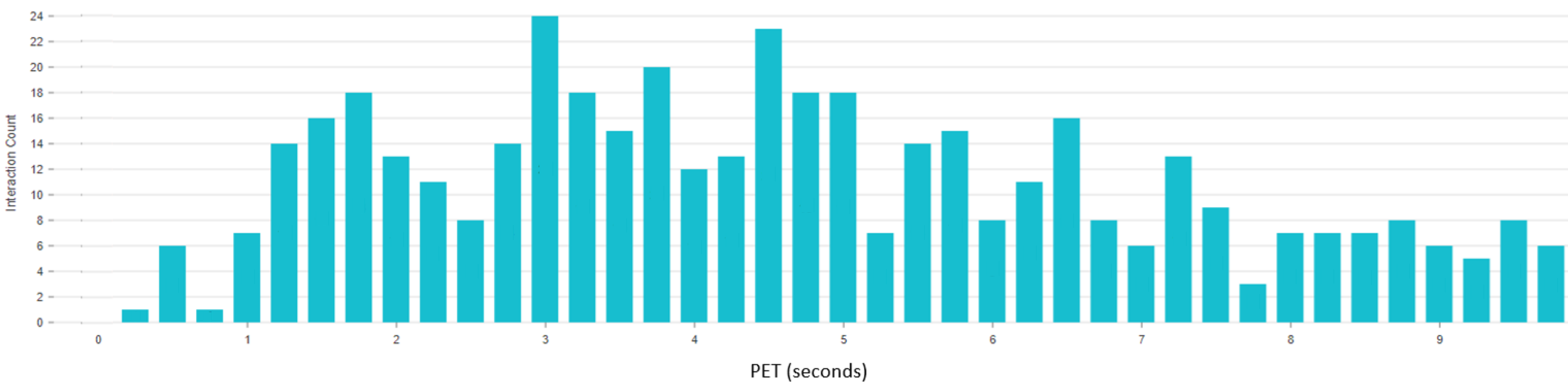
8. Left-turn from Median vs. Eastbound Through *(Left-Turn vs. Through Oncoming)*

Risk Level	Critical Risk	High Risk	Medium Risk	Low Risk
Number of Crossing Conflicts	0	0	2	248

Speed vs. PET scatter

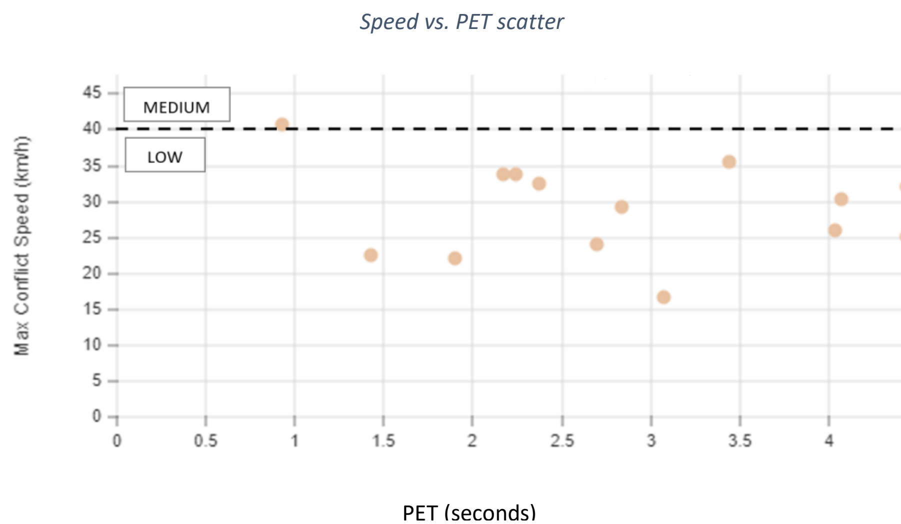


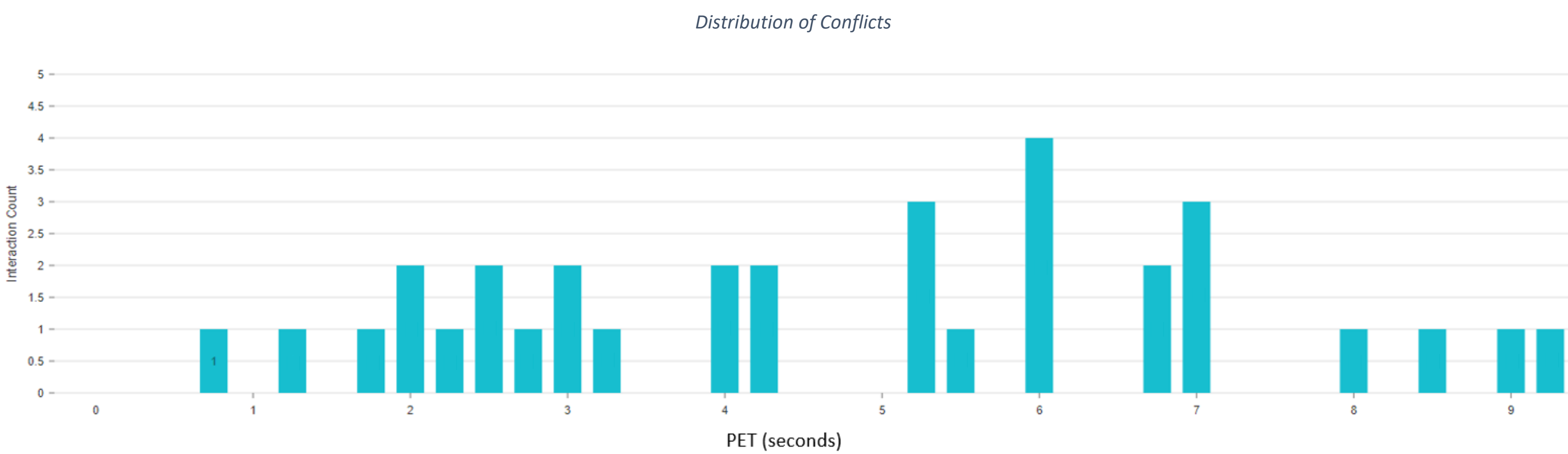
Distribution of Conflicts



9. Southbound Left-Turn vs. Through from Median *(Left-Turn vs. Through from Left)*

Risk Level	Critical Risk	High Risk	Medium Risk	Low Risk
Number of Crossing Conflicts	0	0	1	13

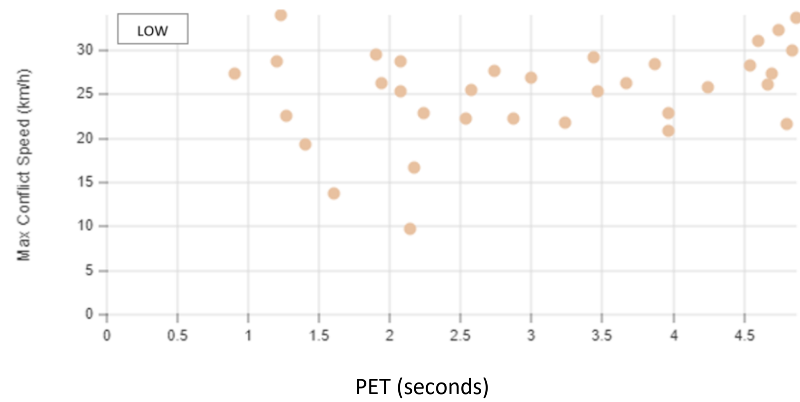




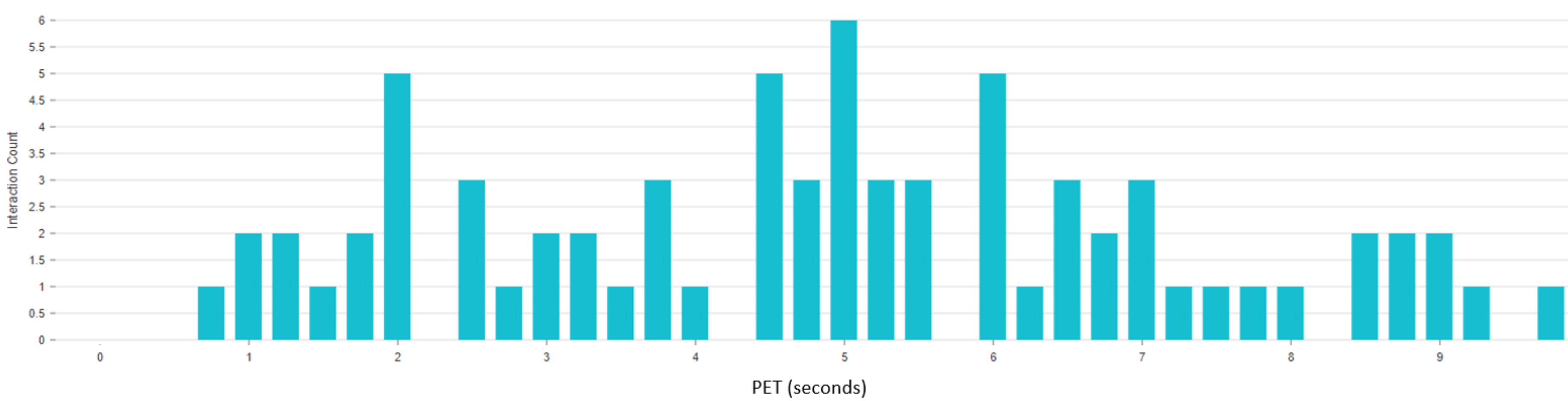
10. Southbound Left-Turn vs. Left-Turn from Median *(Left-Turn vs. Left-Turn from Left)*

Risk Level	Critical Risk	High Risk	Medium Risk	Low Risk
Number of Crossing Conflicts	0	0	0	34

Speed vs. PET scatter



Distribution of Conflicts



APPENDIX D: COUNTERMEASURE EVALUATION

<table>
<tr><th>Intersection Element</th><th>Road Safety Concern</th><th></th><th>Potential Countermeasure</th><th>Analysis Type</th><th>Potential Effectiveness</th><th>Source</th><th>Priority / Risk Level</th><th>Implementation Cost</th><th>Cost-Effectiveness</th><th>Implementation Strategy</th><th>Additional Comments</th></tr>
<tr><td rowspan="8">Median</td><td rowspan="8">The narrow median width at this intersection limits the available storage and refuge area for vehicles crossing the median. Of particular concern is the accommodation of long and heavy trucks which accounted for 7% of 2020 traffic volumes at this intersection. Trucks have to use the intersection as a single stage crossing and must ensure the median is clear prior to advancing. Trucks cannot stop in the median without potential conflict with other traffic movements. Several vehicles were also observed stopping in the median at the same time. This results in vehicle conflicts and the potential for queuing traffic to extend into the high speed through lanes.</td><td>1.1</td><td>Restriction of PR 210 left-turn and through movements, and provision of provide channelization for the PTH 12 left-turn movements</td><td>Subjective</td><td>This strategy is similar to the R-CUT configuration identified in the previous sections; however, instead of providing a median U-Turn location on PTH 12, traffic from PR 210 would be re-routed to the adjacent interchange through existing local roadway network. By restricting these movements, the number of potential conflict points would be reduced from 42 to 12.</td><td></td><td>High</td><td>Moderate</td><td>Should be corrected or the risk significantly reduced, even if the treatment cost is high.</td><td>Long-term</td><td>The re-routing related with this option may require roadway upgrades and/or substantial detours. An extensive planning exercise is recommended to assess environmental, operational and safety impact related with this option.</td></tr>
<tr><td>1.2</td><td>Partial intersection closure</td><td>Subjective</td><td>This strategy would assume the median closure and restriction of all left-turn movements at the intersection along and through , as well as left-turns from PTH 12. Only right-turn movements would be allowed at the intersection. By restricting these movements, the number of potential conflict points would be reduced from 42 to 4</td><td></td><td>High</td><td>Moderate</td><td>Should be corrected or the risk significantly reduced, even if the treatment cost is high.</td><td>Long-term</td><td>The re-routing related with this option may require roadway upgrades and/or substantial detours. An extensive planning exercise is recommended to assess environmental, operational and safety impact related with this option.</td></tr>
<tr><td>1.3</td><td>Full Intersection Closure</td><td>Subjective</td><td>This strategy would assume closing off the PR 210 access completely and only maintening the PTH 12 through movements. Closing the intersection would eliminate all intersection related conflicts at this location.</td><td></td><td>High</td><td>Moderate</td><td>Should be corrected or the risk significantly reduced, even if the treatment cost is high.</td><td>Long-term</td><td>The re-routing related with this option may require roadway upgrades and/or substantial detours. An extensive planning exercise is recommended to assess environmental, operational and safety impact related with this option.</td></tr>
<tr><td>1.4</td><td>Convert stop controlled intersection to signal controlled intersection with protected left-turn phases.</td><td>SPF</td><td>Using MTI's SPF for signalized intersections on Manitoba rural highways, the total, fatal and injury collisions is expected to increase with the implementation of a signalized intersection.
<table>
<tr><th>PTH 12 & PR 210</th><th>Type</th><th colspan="3">Annually Expected Collision Frequency (collision/year)</th></tr>
<tr><th>Configuration Alternative</th><th></th><th>PDO</th><th>FI</th><th>Total</th></tr>
<tr><td>Baseline: Existing configuration *</td><td>4-leg Stop</td><td>3.6</td><td>2.2</td><td>5.8</td></tr>
<tr><td>Alternative 1: Signalized intersection</td><td>4-leg Signal</td><td>19.9</td><td>5.4</td><td>25.2</td></tr>
<tr><td>Alternative 2: Roundabout intersection</td><td>4-leg Roundabout</td><td>5.6</td><td>1.2</td><td>6.8</td></tr>
</table>
* Smoothed SPF Estimates</td><td>Manitoba Transportation and Infrastructure</td><td>High</td><td>High</td><td>Should be corrected or the risk significantly reduced, even if the treatment cost is high.</td><td>Long-term</td><td>This countermeasure results in increased total and FI collision frequencies. In addition, MI indicated that a Traffic Signal Warrant analysis conducted suggests that a traffic signal is not warranted.</td></tr>
<tr><td>1.5</td><td>Convert stop controlled intersection to a roundabout interesection configuration.</td><td>SPF</td><td>Research shows that converting two-way stop controlled intersections to roundabouts often results in an increase in the overall intersection collision rate; however, significantly reduces the injury and fatal collision rate. NCHRP Report 888 (2018) provides collision prediction models to quantify the safety performance for roundabouts and includes both safety performance functions (SPFs) and collision modification factors (CMFs from HSM 2010) that can be used for planning-level analysis. The TAC Roundabout Design Guide suggests using the same CMFs.

Using the SPF (Equation 6-1 from NCHRP Report 888), the total number of collisions is expected to increase with a roundabout; however, the number of fatal and injury collisions is significantly reduced.
<table>
<tr><th>PTH 12 & PR 210</th><th>Type</th><th colspan="3">Annually Expected Collision Frequency (collision/year)</th></tr>
<tr><th>Configuration Alternative</th><th></th><th>PDO</th><th>FI</th><th>Total</th></tr>
<tr><td>Baseline: Existing configuration *</td><td>4-leg Stop</td><td>3.6</td><td>2.2</td><td>5.8</td></tr>
<tr><td>Alternative 1: Signalized intersection</td><td>4-leg Signal</td><td>19.9</td><td>5.4</td><td>25.2</td></tr>
<tr><td>Alternative 2: Roundabout intersection</td><td>4-leg Roundabout</td><td>5.6</td><td>1.2</td><td>6.8</td></tr>
</table>
* Smoothed SPF Estimates</td><td>NCHRP Report 888 Development of Roundabout Crash Prediction Models and Methods, TAC Roundabout Design Guide</td><td>High</td><td>High</td><td>Should be corrected or the risk significantly reduced, even if the treatment cost is high.</td><td>Long-term</td><td>While this treatment may increase the overall collision frequency (based on SPF analysis), it would reduce the risk of injury and fatal collisions at the interesection.

A roundabout would require a significant change to the operational characteristics of PTH 12 due to the isolated high-speed rural nature of this intersection. An aggressive system of speed management measures focused on reducing vehicle approach speeds would be required.</td></tr>
<tr><td>1.6</td><td>Convert stop controlled intersection to an RCUT alternative intersection configuration.</td><td>CMF</td><td>Research shows that a high percentage of crashes that take place on high-speed rural expressways occur at intersections with minor roads. One low-cost alternative design for improving the safety of at-grade intersections on such expressways is the RCUT. In the last few years, the Missouri Department of Transportation has converted some two-way stop controlled (TWSC) intersections into RCUT. This study evaluated the effectiveness of the RCUT intersection design in Missouri utilizing field studies, a public survey, crash analysis, and traffic conflict analysis. The field studies collected detailed video data at an RCUT site and a control site. The crash analysis included a statistically rigorous empirical Bayes before-after safety evaluation of five RCUT sites in Missouri. The RCUT design resulted in a 34.8% reduction in crash frequency for all crashes and a 53.7% reduction in crash frequency for all injury and fatal crashes. Both reductions were significant at the 95% confidence level. Annual disabling injury crashes and minor injury crashes decreased by 86% and 50%, respectively. None of the five sites exhibited a fatal crash following RCUT implementation. This five-site analysis showed that annual right angle crashes decreased from 6.3 to 1.3, an 80% reduction. One of the most severe crash types, the left turn, right angle crash, was completely eliminated by the RCUT.

Based on the 63 collisions reported during the 2010-2019 study period, the implementation of an RCUT configuration would reduce the frequency of all collisions from approximatley 6.3 collisions/year to 4.1 collisions/year. Injury and fatal collisions would drop from 3.0 collisions/year to 1.4 collisions/year.</td><td>CMF Clearinghouse: Edara, P., C. Sun, and S. Breslow. "Evaluation of J-turn Intersection Design Performance in Missouri". Missouri Department of Transportation, December 2013.</td><td>High</td><td>High</td><td>Should be corrected or the risk significantly reduced, even if the treatment cost is high.</td><td>Long-term</td><td>Based on the relatively small reduction in collision frequency and severity, the implementation of this treatment option does not appear cost-effective at this time.</td></tr>
<tr><td>1.7</td><td>Convert stop controlled intersection to a MUT alternative intersection configuration</td><td>CMF</td><td>Research shows that MUTs can reduce crash severity by 30% to 60% (Michigan DOT n.d.). A safety evaluation by Rista et al. (2018) found that crash reductions were achieved with the MUT. Another safety evaluation of MUTs in Michigan found signifcant crash reductions for fatal/injury crashes at unsignalized MUTs, although there were more PDO crashes at higher volumes (Kay et al. 2019).

When the available CMF's are used, the MUT design resulted in a 36.7% reduction in crash frequency for all crashes and a 22.7% reduction in crash frequency for all injury and fatal crashes.

Based on the 21 collisions reported during the 2010-2019 study period, the implementation of a MUT configuration would reduce the frequency of all collisions from approximatley 2.1 collisions/year to 1.33 collisions/year. Injury and fatal collisions would drop from 0.5 collisions/year to 0.39 collisions/year.</td><td>CMF Clearinghouse: Al-Omari, M.M.A., M. Abdel-Aty, J. Lee, L. Yue, and A. Abdelrahman. "Safety Evaluation of Median U-Turn Crossover-Based Intersections". Transportation Research Record, Vol. 2674 (7), (2020) pp. 206-218..</td><td>High</td><td>High</td><td>Should be corrected or the risk significantly reduced, even if the treatment cost is high.</td><td>Long-term</td><td>Based on the relatively small reduction in collision frequency and severity, the implementation of this treatment option does not appear cost-effective at this time.</td></tr>
<tr><td>1.8</td><td>Convert stop controlled intersection to a Jug-handle alternative intersection configuration</td><td>Literature Search</td><td>Research indicates that a jug-handle intersection exhibits lower collision rates (PDO, fatal, injury and head-on) than a conventional signalized intersection. It also exhibits a higher proportion of rear-end and PDO collisions and lower proportion of left-turn collisions when compared to a conventional intersection. Although there are several types of jug-handle configurations, the reverse jug-handle exhibits the lowest collision rate of angle and left-turn collisions, and the lowest number of total conflict points.</td><td>R. Jagannathan, MaryAnn Gimbel, Joe G. Bared, Warren E. Hughes, Bhagwant Persaud, and Craig Lyon, "Safety Comparison of New Jersey Jug Handle Intersections and Conventional Intersections," Transportation Research Record, No. 1953, pp. 187-200, 2006.</td><td>High</td><td>High</td><td>Should be corrected or the risk significantly reduced, even if the treatment cost is high.</td><td>Long-term</td><td>The implementation of this treatment option does not appear cost-effective at this time.</td></tr>
</table>

Intersection Element	Road Safety Concern		Potential Countermeasure	Analysis Type	Potential Effectiveness	Source	Priority / Risk Level	Implementation Cost	Cost-Effectiveness	Implementation Strategy	Additional Comments
		1.9	Convert stop controlled intersection to an interchange.	CMF	Research shows that converting an at-grade intersection into a grade-separated interchange may reduce all collisions by 42% (CMF = 0.58) and fatal/injury collisions by 57% (CMF = 0.43). Based on the 63 collisions reported during the 2010-2019 study period, the implementation of a grade-separated interchange would reduce the frequency of collisions from approximately 6.3 collisions/year to 3.7 collisions/year. Injury and fatal collisions would drop from 3.0 collisions/year to 1.3 collisions/year.	CMF Clearinghouse: Elvik, R. and Erke, A., "Revision of the Hand Book of Road Safety Measures: Grade-separated junctions." (3-27-2007)	High	Very High	Should be corrected or the risk significantly reduced, even if the treatment cost is high.	Watch List	While implementing an interchange at this intersection may decrease overall collisions, there are other factors to consider, including: -The proximity to the adjacent interchange (less than 1.5 km) may result in insufficient merge/diverge lengths or introduce an additional weaving movement which may affect the safety of the combined intersections. -The geometry of an interchange at this location would need to be further explored to determine viability. - Currently a signal is not warranted, which suggests that the volumes are too low to warrant an interchange as well. - The high costs associated with an interchange may not justify the increased safety benefits, as there are alternative countermeasures with similar safety benefits that may be considered. This road safety concern should be placed on a Watch List and if MI decides to proceed with this option, additional analysis would be required.
		1.10	Modify the highway alignment to provide an increased median width sufficient to accommodate storage of a B-Train. With the wide median, the intersection would operate as a two-stage crossing.	Literature Search	Findings from NCHRP 375 suggest that, at rural, unsignalized intersections, the frequency of collisions and undesirable driving behavior decreases as the median width increases. At suburban, unsignalized intersections, the opposite result was observed—indicating that the frequency of traffic collisions and instances of undesirable driving behavior increases as the median width increases. There is no obvious explanation for the different effects of median width at rural and suburban, unsignalized intersections. However, these findings appear to be well founded empirically because they are supported by both the collision studies and the field observational studies. With regard to heavy vehicles, increasing the median width may result in trucks turning left into the through lanes from a stop. This will contribute to increased speed differentials and conflict points (trucks turning into the outside lane).	Harwood, D., Pietrucha, M., Wooldridge, M., Brydia, R., Fitzpatrick, K. "NCHRP Report 375 Median Intersection Design" Transportation Research Board, Washington DC. (1995)	High	High	Should be corrected or the risk significantly reduced, even if the treatment cost is high.	Not recommended	Implementation of this treatment option would require careful consideration of the accommodation of heavy trucks turning left onto the through lanes from a stop. Based on the relatively small reduction in collision frequency and severity, the implementation of this treatment option does not appear practical at this time and modified intersection configuration may result in additional number of conflicts This road safety treatment is not recommended.
Left-Turns from PTH 12	The PTH 12 left-turn lanes have a negative offset which can limit sightlines for left-turning vehicles. Of particular concern is when vehicles are stopped in the median and trucks turning left from mainline lanes must wait at the left-turn deceleration lane for the median to clear before turning.	2.1	Provision of slotted left-turn lanes with positive off-set.	CMF	This strategy is intended to improve safety by providing better visibility to drivers that are turning left. An FHWA study indicated at 33.8% reduction in all collisions and 35.6% reduction in fatal and injury collisions when the left-turn lane off-set was improved to a positive off-set at signalized intersections. No CMFs are available for unsignalized intersections.	CMF Clearinghouse: Persaud, B., C. Lyon, K. Eccles, N. Lefler, and F. Gross. "Safety Evaluation of Offset Improvements for Left-Turn Lanes." Report No. FHWA-HRT-09-035. Federal Highway Administration. Washington, DC. (June 2009)	Medium	High	Should be corrected or the risk significantly reduced, if the treatment cost is moderate, but not high.	Long-term	Research suggests that this strategy is most effective when permissive/protected phasing for left-turn movements are in effect. Implementation of this countermeasure should be considered together with the option to signalize the intersection to achieve the greatest safety benefits.
Left-Turns from PR 210	Westbound left-turning vehicles are provided with a median acceleration lane on PTH 12 southbound. This lane is shorter than the TAC recommended minimum. Observations from the site review suggest that vehicles merging from the acceleration lane into the high-speed mainline lane do so at speeds of approximately 70-80 km/h, which results in speed differential at this location. This is of particular concern for larger trucks that generally take longer to accelerate and thus merging at much lower speeds which is resulting in even greater speed differentials at this location. No median left-turn acceleration lane is provided in the northbound direction for eastbound left-turning vehicles. As a result, left turning trucks are merging into the high-speed mainline lane. This introduces significant speed differentials and an increased risk of collision. Field observations suggest a significant volume of trucks (23% of 2020 truck turning volumes) are turning left from eastbound PR 210 onto northbound PTH 12.	3.1	Extend southbound median left-turn acceleration lane.	Literature Search	Providing longer acceleration lanes is a strategy that can be used to improve safety at intersections by making it easier for left-turning minor road drivers to find acceptable gaps in traffic, providing additional median storage for left-turning minor road vehicles, allowing drivers to cross the near lanes without having to simultaneously assess gaps in the far lanes, and allowing traffic to merge at higher speeds and reducing speed differentials to allow mainline drivers to better anticipate the presense of a vehicle entering the roadway. In general, median left-turn lanes are expected to reduce right-angle, rear end and sideswipe collisions, but only if they are used properly (driver education and additional signage/markings may be necessary).	NCHRP Report 500, Volume 5, A Guide for Addressing Unsignalized Intersection Collisions NCHRP Report 650, Median Intersection Design for Rural High-Speed Divded Highways	Medium	Moderate	Should be corrected or the risk significantly reduced, if the treatment cost is moderate, but not high.	Medium-term	While research has suggested that installing a median left-turn lane provides several safety benefits and may reduce overall collisions; some before-after studies have found that right-angle collisions have increased at two-way stop controlled intersections where a median left-turn lane is installed. This is likely due to drivers not using the acceleration lanes or not using them properly; therefore, it is important that positive guidance be provided to drivers to make them aware of the acceleration lane and adequate acceleration lane length be provided.
		3.2	Install the "Left Turn Traffic Use Acceleration Lane on PTH 12"	CMF	The quality of the available CMFs is poor. The CMFs suggest that there is little change in the level of road safety performance associated with improved signage, however, it is our opinion that providing clear and concise advanced warning of an uncommon intersection configuration is required from both a liability and driver expectation standpoint. This type of signage has also been used at other locations in Manitoba with left-turn accelleration lanes.	Maze, T., Hochstein, J., Souleyrette, R., Preston, H., Storm, R., "NCHRP Report 650: Median Intersection Design for Rural High-Speed Divided Highways." Transportation Research Board, Washington D.C., (2010).	Low	Low	Should be corrected or the risk reduced, if the treatment cost is low.	Short-term	The provision of this lane should be supported with proper signage and educational campaigns to educate drivers on how to properly use a median left-turn lane. Resesarch has indicated that median left-turn lanes are expected to reduce right-angle, rear end and sideswipe collisions, but only if they are used properly (driver education and additional signage/markings may be necessary). MnDOT has developed an educational brochure to show drivers how to use median left-turn lanes.
		3.3	Provision of northbound median left-turn acceleration lane.	Literature Search	Providing median acceleration lanes for left-turning traffic is a strategy that can be used to improve safety at two-way stop-controlled intersections by reducing the speed differential between the vehicles on the mainline and vehicles entering the roadway. See Countermeasure 3.1 for additional information. NCHRP Report 650 noted a study conducted in Minnesota that examined the safety benefits of median left turn lanes at two-way stop controlled intersections on expressways. The study compared 9 intersections with median acceleration lanes and 8 interesections without acceleration lanes and found that median left-turn lane intersections had a 50% lower preventable collision rate, 77% lower same-direction sideswipe collision rate and 15% lower right angle collision rate. It also noted that 75% of the preventable collisions that occured at the median left-turn lane intersections were caused by drivers that did not use the median left-turn lanes, suggesting that collisions could be further reduced if the median left-turn acceleration lane was used properly. Six of the median left-turn lane intersections had before-and-after collision data and found that the preventable collision rate reduced by 15%. The rear-end collisions were reduced by 40%, but the right-angle crashes increased by 57%.	NCHRP Report 500, Volume 5, A Guide for Addressing Unsignalized Intersection Collisions NCHRP Report 650, Median Intersection Design for Rural High-Speed Divded Highways	Medium	Moderate	Should be corrected or the risk significantly reduced, if the treatment cost is moderate, but not high.	Medium-term	The provision of this lane should be supported with proper signage and educational campaigns to educate drivers on how to properly use a median left-turn lane. Resesarch has indicated that median left-turn lanes are expected to reduce right-angle, rear end and sideswipe collisions, but only if they are used properly (driver education and additional signage/markings may be necessary). MnDOT has developed an educational brochure to show drivers how to use median left-turn lanes.
		3.4	Close or partial closure of intersection.	See above (comment 1.1-1.3)	See above (comment 1.1-1.3)	See above (comment 1.1-1.3)	See above (comment 1.1-1.3)	See above (comment 1.1-1.3)	See above (comment 1.1-1.3)	See above (comment 1.1-1.3)	See above (comment 1.1-1.3)
		3.5	Convert two-way stop controlled intersection to an alternative RCUT intersection configuration	See above (comment 1.6)	See above (comment 1.6)	See above (comment 1.6)	See above (comment 1.6)	See above (comment 1.6)	See above (comment 1.6)	See above (comment 1.6)	See above (comment 1.6)
Right-Turns from PR 210	Field observations suggest a significant volume of trucks (26% of 2020 truck turning volumes) are turning right onto southbound PTH 12 from eastbound PR 210. No right-turn acceleration lane is provided for this movement. As a result, these right turning trucks are merging into the mainline lane. This introduces significant speed differentials and an increased risk of collision. There is also no acceleration lane provided in the northbound direction.	4.1	Provision of EB-SB right-turn acceleration lane.	Subjective	The provision of an acceleration lane at this location would provide trucks with more opportunity to accelerate and merge into the through lane at an appropriate speed. This may contribute to reduced speed differentials and risk of rear-end and sideswipe collisions at this location.		Low	Moderate	Should be corrected or the risk reduced, if the treatment cost is low.	Watch List	No collision history was recorded at this location, and considering very low right-turning volumes, the provision of the acceleration lane is not anticiapted to result in a significant safety benefit. The need and warrant for provision of southbound right-turn acceleration lane should be reviewed. This road safety concern should be placed on a Watch List. Due to higher left-turning volumes, the provision of eastbound left-turning acceleration lane would be a priority over the westbound left-turning acceleration lane.
		4.2	Provision of WB-NB right-turn acceleration lane.	Subjective	The provision of an acceleration lane at this location would provide trucks with more opportunity to accelerate and merge into the through lane at an appropriate speed. This may contribute to reduced speed differentials and risk of rear-end and sideswipe collisions at this location		Low	Moderate	Should be corrected or the risk reduced, if the treatment cost is low.	Watch List	No collisions history was recorded at this location, and considering very low right-turing volumes, the provision of the acceleration lane isn't anticiapted to result in a significant safety benefit. The need and warrant for provision of southbound right-turn acceleration lane should be reviewed. This road safety concern should be placed on a Watch List.

<table>
<tr><th>Intersection Element</th><th>Road Safety Concern</th><th></th><th>Potential Countermeasure</th><th>Analysis Type</th><th>Potential Effectiveness</th><th>Source</th><th>Priority / Risk Level</th><th>Implementation Cost</th><th>Cost-Effectiveness</th><th>Implementation Strategy</th><th>Additional Comments</th></tr>
<tr><td>Skew Angle</td><td>The intersection is constructed at a skew angle of approximately 70 degrees. This angle is at the upper limit recommended by TAC GDG.</td><td>5.1</td><td>Realignment of the intersection approaches to reduce or eliminate the skew angle.</td><td>CMF</td><td>Although the intersection is within the recommended limits identified by TAC, the CMF was applied to estimate the safety effectiveness of improving the skew angle. Based on this analysis, an 11% reduction in all collisions is expected when the angle is reduced from 70 degrees to 80 degrees or 30% when the angle is adjusted from 70 degrees to 90 degrees.
$$CMF = \frac{0.053 \times skew}{(1.43 + 0.053 \times skew)} + 1.0$$
Based on the 63 collisions reported during the 2010-2019 study period, the adjustment of the skew angle from 70 to 80 degrees would reduce the frequency of collisions from approximately 6.3 collisions/year to 5.6 collisions/year, and adjustmenet of the skew angle from 70 to 90 degrees would reduce the frequency of collisions from approximately 6.3 collisions/year to 4.4 collisions/year.</td><td>CMF Clearinghouse: Harwood et al., "Prediction of the Expected Safety Performance of Rural Two-Lane Highways." FHWA-RD-99-207, McLean, Va., Federal Highway Administration, (2000)</td><td>High</td><td>High</td><td>Should be corrected or the risk significantly reduced, if the treatment cost is moderate, but not high.</td><td>Long-term</td><td>If this countermeasure is considered for implementation, additional analyses related to geometry, property requirements, etc. would be required.</td></tr>
<tr><td rowspan="2">Adjacent Intersection</td><td>An intersection with adjacent service road west of PTH 12 is located in close proximity to the main intersection (approximately 40m). This meets the minimum standard, however, the close proximity may cause conflicts between through traffic and vehicles turning to/from the service road, especially if there are eastbound queues at the intersection.</td><td>6.1</td><td>Realignment of the service road to increase the separation between the intersections.</td><td>CMF</td><td>The quality of the available CMFs is poor. The CMFs suggest that the closure or complete relocation of all driveways from the functional area of an interection may reduce all collisions by 7% in urban areas; A CMF for rural areas is not available.

Generally, realigning the service road to provide additional separation from the intersection should improve operations and may reduce conflicts between traffic queuing on the side road. However, traffic volume on the service road is anticipated to be very low and no collision history was recorded to be related with this access.</td><td>CMF Clearinghouse: Lall et all., "Analysis of Traffic Accidents within the Functional Area of Intersections and Driveways." TRANS-1-95, Portland, Ore., Portland State University, Department of Civil Engineering, (1995)</td><td>Low</td><td>Moderate</td><td>Should be corrected or the risk reduced, if the treatment cost is low.</td><td>Watch List</td><td></td></tr>
<tr><td>The service road connection on to PR 210 on the east side of PTH 12 is offset approximately 120 m. This intersection is however located within the functional area of the intersection. The NB-EB merging taper extends beyond this T- intersection and a vehicle slowing or stopping to execute a left turn from PR 210 at this location may conflict with a driver using the right turn merging taper.</td><td>6.2</td><td>Realignment of the service road to increase the separation between the intersections.</td><td>CMF</td><td>The quality of the available CMFs is poor. The CMFs suggest that the closure or complete relocation of all driveways from the functional area of an interection may reduce all collisions by 7% in urban areas; A CMF for rural areas is not available.

Generally, realigning the service road to provide additional separation from the intersection should improve operations and may reduce conflicts between traffic queuing on the side road. However, traffic volume on the service road is anticipated to be very low and no collision history was recorded to be related with this access.</td><td>CMF Clearinghouse: Lall et all., "Analysis of Traffic Accidents within the Functional Area of Intersections and Driveways." TRANS-1-95, Portland, Ore., Portland State University, Department of Civil Engineering, (1995)</td><td>Low</td><td>Moderate</td><td>Should be corrected or the risk reduced, if the treatment cost is low.</td><td>Watch List</td><td></td></tr>
<tr><td>Guide Signage</td><td>Guide signage on the northbound and southbound approaches to the intersection does not appear to be consistent. On the northbound approach, an advance guide sign is missing. The intersection guide sign provides information for the westbound direction only, and the sign appears to be located too far in advance of the intersection. In the southbound direction, an advance guide sign is missing.</td><td>7.1</td><td>Guide signage on the approaches to the intersection should be reviewed to ensure navigational consistency is provided to drivers.</td><td>CMF</td><td>The quality of the available CMFs is poor. Although these CMFs suggest that there is little change in the level of road safety performace associated with improved signage, it is our opinion that providing clear and concise advanced warning of an uncommon intersection configuration is required from both a liability and driver expectation standpoint.

Category:Signs
Countermeasure: Install improved advance freeway guidance signage
<table>
<tr><th>CMF</th><th>CRF(%)</th><th>Quality</th><th>Crash Type</th><th>Crash Severity</th><th>Roadway Type</th><th>Area Type</th></tr>
<tr><td>1.07</td><td>-7</td><td>★★☆☆☆</td><td>All</td><td>All</td><td>Principal Arterial Other Freeways and Expressways</td><td>Rural</td></tr>
<tr><td>0.69</td><td>31</td><td>★☆☆☆☆</td><td>Angle</td><td>All</td><td>Principal Arterial Other Freeways and Expressways</td><td>Rural</td></tr>
<tr><td>2</td><td>-100</td><td>☆☆☆☆☆</td><td>Rear end</td><td>All</td><td>Principal Arterial Other Freeways and Expressways</td><td>Rural</td></tr>
</table></td><td>Maze, T., Hochstein, J., Souleyrette, R., Preston, H., Storm, R., "NCHRP Report 650: Median Intersection Design for Rural High-Speed Divided Highways." Transportation Research Board, Washington D.C., (2010).</td><td>Low</td><td>Low</td><td>Should be corrected or the risk reduced, if the treatment cost is low.</td><td>Maintenance</td><td>Address as part of routine maintenance.</td></tr>
<tr><td rowspan="2">Intersection Conspicuity</td><td rowspan="2">When approaching the intersection on PTH 12, there is little contrast between the mainline lanes and the intersection. Also, drivers are provided with limited advanced warning of the approaching intersection and the potential for entering vehicles. As a result, intersection conspicuity is limited.</td><td>8.1</td><td>Improve conspicuity of the intersection and vehicles entering from the sideroad by installing a Dynamic Advance Intersection Warning Systems - VEHICLES ENTERING WHEN FLASHING (VEWF) warning signs with traffic-actuated flashers on the expressway approaches and in-pavement loop detectors on the minor roads.</td><td>CMF</td><td>The safety effectiveness of this strategy was examined at two locations in North Carolina and the results are summarized in the following table. Both sites experienced statistically significant reductions in overall annual crash frequency and, although the distribution of right-angle collisions remained high after the dynamic advance intersection warning systems were installed, the right-angle crash frequency was reduced at both locations. Furthermore, crash severity was reduced at both locations, demonstrating that this strategy can be an effective crash countermeasure, but given the limited number of sites and the shortcomings of the naïve before-after crash analysis methodology, definitive conclusions regarding the safety effectiveness of this strategy cannot be exclusively drawn from this study.

Additional reasearch suggests that with installation of a VEWF sign, a CMF=0.68 (reduction of 32%) can be expected for all collisions and a CMF=0.73 (reduction of 27%) can be expected for fatal and injury collisions.
<table>
<tr><th></th><th>US-74/76 and SR-1800 % Change</th><th>US-421 and NC-210 % Change</th></tr>
<tr><td>Overall Crash Frequency/Year</td><td>−60*</td><td>−42*</td></tr>
<tr><td>Overall Crash Rate/mev</td><td>−70</td><td>−54</td></tr>
<tr><td>Right-Angle Crash Frequency/Year</td><td>−57*</td><td>−31</td></tr>
<tr><td>Right-Angle Crash Rate/mev</td><td>−67</td><td>−45</td></tr>
<tr><td>Fatal Crash Frequency/Year</td><td>−50</td><td>−100*</td></tr>
<tr><td>Fatal Crash Rate/mev</td><td>−62</td><td>−100</td></tr>
<tr><td>Injury Crash Frequency/Year</td><td>−60*</td><td>+11</td></tr>
<tr><td>Injury Crash Rate/mev</td><td>−70</td><td>−11</td></tr>
</table>
*Statistically significant change at 90% confidence level (changes in crash rates were not tested).</td><td>CMF Clearinghouse: Maze, T., Hochstein, J., Souleyrette, R., Preston, H., Storm, R., "NCHRP Report 650: Median Intersection Design for Rural High-Speed Divided Highways." Transportation Research Board, Washington D.C., (2010).

Evaluation of the Safety Effectiveness of "VEHICLE ENTERING WHEN FLASHING" Signs and Actuated Flashers at 74 Stop-Controlled Intersections in North Carolina, Simpson and Troy, 2013</td><td>High</td><td>Moderate</td><td>Should be corrected or the risk significantly reduced, even if the treatment cost is high.</td><td>Medium-term</td><td></td></tr>
<tr><td>8.2</td><td>Install the Concealed or Unexpected Intersection Signs (WA-11) sign that could be installed with continuous or active flashing beacons.</td><td>CMF</td><td>Research indicates that installing an advance intersection warning sign may result in a 35% reduction in right-angle collisions.

Based on the 10 right-angle collisions reported during the 2010-2019 study period, the implementation of this countermeasure would reduce the frequency of all collisions from approximatley 1.0 collision/year to 0.65 collisions/year.

Research also suggests that adding a flashing beacon to an advance warning sign generally results in a 62% reduction in right-angle related collisions. This countermeasure also reduces the number of all collisions by 20% during night or poor weather conditions.</td><td>Polanis, S. F., "Low-Cost Safety Improvements." Chapter 27, The Traffic Safety Toolbox: a primer on traffic safety, Washington, D.C., Institution of Transportation Engineers, (1999) pp. 265-272.

BC CMF Guide 2008</td><td>High</td><td>Low</td><td>Should be corrected or the risk significantly reduced, even if the treatment cost is high.</td><td>Short-term</td><td>The provision of active flashing beacon is recommended.
This treatment should be considered as an alternative to countermeasure option 8.2</td></tr>
<tr><td rowspan="3">Signage</td><td>Yield signs at the median appear small, and may be less effective as such.</td><td>9.1</td><td>Review the sign location and placement and adjust as necessary.
Also, install oversized yield signs.</td><td>Literature Search</td><td>Provides improved positive guidance. Potential reduction in the risk of driver error.Installing larger signs can improve driver awareness and complinace</td><td>NCHRP Report 500, Volume 5, A Guide for Addressing Unsignalized Intersection Collisions</td><td>Low</td><td>Low</td><td>Should be corrected or the risk reduced, if the treatment cost is low.</td><td>Maintenance</td><td>Address as part of routine maintenance.</td></tr>
<tr><td>Wrong Way signs are not double posted on the mainline lanes north and south of the intersection.</td><td>9.2</td><td>Provide double-posted wrong way signs.</td><td>Subjective</td><td>Provides improved positive guidance. Potential reduction in the risk of driver error.</td><td></td><td>Low</td><td>Low</td><td>Should be corrected or the risk reduced, if the treatment cost is low.</td><td>Maintenance</td><td>Address as part of routine maintenance.</td></tr>
<tr><td>The speed limit sign after entering southbound PTH 12 from the interchange is missing and drivers may not be aware of the posted speed limit in this area.</td><td>9.3</td><td>Review the speed limit sign location and placement along PTH 12 and adjust as necessary to ensure consistency.</td><td>Literature Search</td><td>Potential for reduced speed differentials on the approaches to the intersection. May result in slight reduction in collision frequency and severity.</td><td>NCHRP Report 500, Volume 5, A Guide for Addressing Unsignalized Intersection Collisions</td><td>Low</td><td>Low</td><td>Should be corrected or the risk reduced, if the treatment cost is low.</td><td>Maintenance</td><td>Address as part of routine maintenance.</td></tr>
<tr><td>Illumination</td><td>The illumination at the intersection is limited and creates areas with shadows. This results in poor conspicuity of the intersection. Delineation of the northbound right-turn slip lane is not obvious to drivers at night.</td><td>10.1</td><td>Enhance intersection illumination.</td><td>Literature Search</td><td>Poorly illuminated intersections may result in increased levels of night-time collisions. The collision data for the study period (2010-2019) indicated that 39% of collisions occurred during reduced lighting levels.</td><td>NCHRP Report 500, Volume 5, A Guide for Addressing Unsignalized Intersection Collisions</td><td>Medium</td><td>Moderate</td><td>Should be corrected or the risk significantly reduced, if the treatment cost is moderate, but not high.</td><td>Medium-term</td><td></td></tr>
<tr><td>Delineation and Line Painting</td><td>Delineation of the northbound right-turn slip lane is not obvious to drivers at night.</td><td>11.1</td><td>Improve delineation of northbound right-turn slip lane at night.</td><td>CMF</td><td>Research indicates that installing post-mounted delineators results in 15% reduction of ran-off-road collisions.</td><td>Estimating Crash Modification Factors for Lane Departure Countermeasures in Kansas, Dissanayake and Galgamuwa, 2017</td><td>Low</td><td>Low</td><td>Should be corrected or the risk reduced, if the treatment cost is low.</td><td>Short-term</td><td></td></tr>
</table>

Intersection Element	Road Safety Concern		Potential Countermeasure	Analysis Type	Potential Effectiveness	Source	Priority / Risk Level	Implementation Cost	Cost-Effectiveness	Implementation Strategy	Additional Comments
	In general, line painting is deteriorated and delineation within the intersection is poor. These issues contribute to increased driver workload and the potential for driver error.	11.2	Reapply line painting and pavement markings to improve positive guidance at night.	No analysis was conducted as this item should be addressed as part of routine maintenance	Provides improved positive guidance. Potential reduction in the risk of driver error.		Low	Low	Should be corrected or the risk reduced, if the treatment cost is low.	Maintenance	Address as part of routine maintenance.
	Line painting immediately in advance of the intersection may encourage drivers to perform a passing manoeuvre within the intersection. Also, the westbound left-turn acceleration lane is delineated with a dashed line thus encouraging drivers to encroach or merge into the high-speed mainline lane shortly after entering the acceleration lane.	11.3	Provide solid line painting to discourage passing in advance of the intersection and between the median left-turn acceleration lane and adjacent through lane in the southbound direction.	No analysis was conducted as this item should be addressed as part of routine maintenance	Provides improved positive guidance and discoursges passing maneuvers within the intersection.		Low	Low	Should be corrected or the risk reduced, if the treatment cost is low.	Maintenance	Address as part of routine maintenance.
Rumble Strips	The rumble strips on the westbound approach to the intersection appeared to have been worn off in the wheel paths, which may impact their effectiveness. It is our understanding that this feature has been installed as a "low noise rumble strips" treatment.	12.1	Review level of deterioration of low noise rumble strips and reapply if necessary.	Literature Search	This marking/warning device generally provided improved speed management and positive guidance on approach to the intersection.	NCHRP Report 500, Volume 5, A Guide for Addressing Unsignalized Intersection Collisions	Low	Low	Should be corrected or the risk reduced, if the treatment cost is low.	Maintenance	Address as part of routine maintenance.