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Alberta Transportation

Final

Highway 2 at Township Road 204 Safety Review

July 2019

Corporate Authorization

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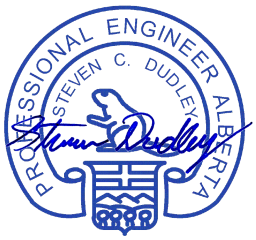

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1.0 Introduction

Alberta Transportation (AT) retained ISL Engineering and Land Services Ltd. (ISL) to undertake a safety review of the intersection of Highway 2:12 at Township Road 204 (TR204) located in the Municipal District (MD) of Foothills. TR204 is the first intersection north of the Highway 7 interchange on Highway 2 and provides an alternate route to the town of Okotoks, which is located approximately 4.1 km to the west.

The purpose of this safety review is to identify existing issues that affect the overall safety and traffic operations of the intersection, and to identify counter measures to mitigate the identified issues.

1.1 Scope of Work

ISL confirmed the scope of work with AT staff in an email dated Wednesday, June 12, 2018. The agreed-upon scope of work for the safety review included the following:

- Collect data (as-built drawings, traffic counts, collision info, etc.).
- Retrieve and review as-built drawings.
- Assess the data and existing conditions.
- Develop sketches.
- Develop a report for the safety review.

1.2 Study Methodology

This review includes a systematic review of the functional, traffic, collision, operational and geometric characteristics of the intersection. The review considers the guidelines and procedures provided in the following AT, Transport Canada (TC) and Transportation Association of Canada (TAC) manuals:

- “Canadian Guide to In-Service Road Safety Reviews” (TAC, 2003) - IRSR
- “Rural Intersection Safety Handbook” (TC, 2006); and
- “Methods of Reducing Collisions on Alberta Roads” (AT, 2010) - MORCAR

ISL considered the following relevant guidelines as part of this study:

- “Highway Geometric Design Guide” (AT, 1999) - HGDG
- “Roadside Design Manual” (AT, 2007) - RDM
- “Highway Lighting Guide” (AT, 2003)
- “Highway Pavement Marking Guide” (AT, 2003)
- “Manual of Uniform Traffic Control Devices for Canada” (TAC, 1998) - MUTCDC
- “Geometric Design Guide for Canadian Roads” (TAC, 2017) - GDG
- “Illumination of Isolated Rural Intersections” (TAC, 2001)
- “Traffic Signal Warrant Handbook” (TAC, 2007)

2.0 Site Characteristics

2.1 Background Information

ISL obtained background information about the study intersection including the following:

- As-built drawings for the study intersection (Appendix A)
- Information from the AT website including, but not limited to:
  - Design guidelines/bulletins
  - Turning Movement Summary Diagrams (Appendix B)
  - Directional Traffic Count Summaries (Appendix B)
  - Traffic control and sign information
- Information from the Transportation Infrastructure Management System (TIMS) including:
  - roadway classification, linear referencing information, geometric information, and collision data from AT Maps
  - Reports generated from the Network Expansion Support System (NESS) (Appendix C)

2.2 Roadway Classification

Highway 2

Highway 2:12, also referred to as the Queen Elizabeth II Highway, is a rural four-lane divided highway that forms a part of the CANAMEX north-south trade corridor. It has a Level 1 Service Classification and a Freeway/Expressway Functional Classification. At the study location, Highway 2 is oriented north-south and has a 110 km/h posted speed limit. Although Highway 2 predominantly has a four-lane cross section, the highway segment within the study area provides five (5) through lanes: three (3) southbound and two (2) northbound. Highway 2 is designated as a Long Combination Vehicle (LCV) route.

Township Road 204

TR204, also known as 370th Avenue East, intersects Highway 2 and forms intersection number 1277. Both TR204 approaches are stop-controlled.

West of Highway 2, TR204 is a paved rural two-lane undivided roadway that is oriented east-west, with an 80 km/h posted speed limit and connects to North Railway Street, approximately 4 km to the west, in the town of Okotoks.

East of Highway 2, TR204 is a paved rural two-lane undivided roadway that bends 90° to become Range Road 290 (RR290). TR204 has a statutory 80 km/h speed limit.

Range Road 290

RR290, also known as 80th Street East, is a paved rural two-lane undivided roadway that is a continuation of TR204. RR290 is oriented north-south and has a statutory 80 km/h speed limit.

2.3 Traffic Volumes

Traffic characteristics for the TR204 intersection are presented in Figure 1 and include:

- Annual Average Daily Traffic (AADT);
- percent trucks (including RVs and buses); and
- AM and PM 100th highest hour turning movement estimates.

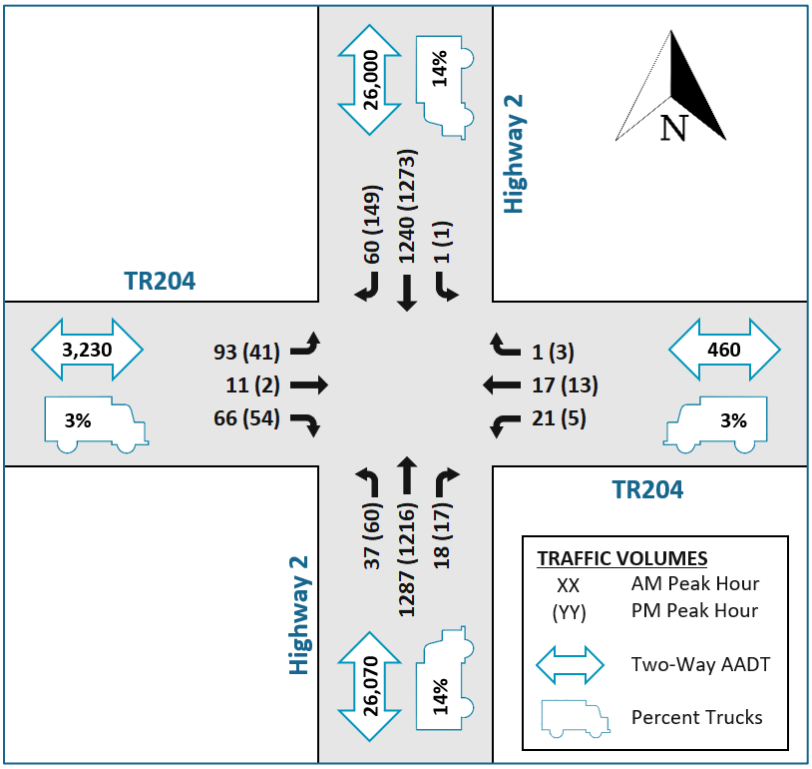


Figure 1: 2018 Traffic Characteristics

The traffic characteristics and patterns illustrate the following:

- The Highway 2 two-way AADT is approximately 26,000, including significant truck traffic (14%).
- TR204 has a two-way AADT of 3,230 west of Highway 2, and a two-way AADT of 460 east of Highway 2. In both cases, truck traffic is in the order of 3%.
- Highway 2 northbound and southbound through traffic are the dominant movements in both the AM and PM peak hours.
- Major turning movements at the intersection consist of northbound left turns, southbound right turns, eastbound left turns and eastbound right turns.
- In the AM peak, more vehicles depart the west TR204 approach than enter it. In the PM peak hour, this pattern is reversed and more vehicles enter the west TR204 approach than depart it.
- Westbound right turns and southbound left turns are minimal in both peak hours.

- The AM Peak hour is 9:45 a.m. to 10:45 a.m.
- The PM Peak hour is 4:00 p.m. to 5:00 p.m.

Table 1 provides the growth rates reported in TIMS NESS (ATR Number 60021260). ISL used historical Highway 2 AADT at the Highway 7 / Highway 547 interchange (obtained from "Alberta Highways 1 to 986 Traffic Volume History (1962 - 2017)") to check the growth rates provided in NESS. The NESS and calculated five-year growth rates are similar while the calculated ten-year and twenty-year growth rates are higher than the rates provided from NESS.

Table 1: Historical Growth Rates for Highway 2

Growth Rate (Method)	Growth Rates (%)		
	5 Year	10 Year	20 Year
TIMS NESS (Linear Regression)	3.85	2.97	2.98
TIMS NESS (Two-Point)	4.27	2.56	2.76
Calculated (Two-Point from AADT)	3.57	4.41	5.18

3.0 Collision Analysis

Collision information for the period of 2012 to 2016 was obtained for the TR204 TIMS intersection polygon, which extends 255 m to the south and 295 m to the north. From 2012 to 2016, a total of 40 collisions were recorded, which corresponds to an intersection collision rate of 86.2 collisions per hundred million entering vehicles (100MEV), a rate that exceeds AT's threshold for special monitoring sites (69.8 collisions per 100MEV). Intersection collision rates and provincial thresholds for special monitoring sites are summarized in Table 2.

Table 2: Intersection Collision Rates, 2012 to 2016 *(Source: TIMS NESS)*

Collision Statistic	Actual Value for Intersection	Special Monitoring Threshold	Exceeds Threshold?
Total Rate (Collisions/100MEV)	86.2	69.8	**Yes**
Non-animal Rate (Collisions/100MEV)	77.6	69.6	**Yes**
5-Year Collision Cost (Million Dollars)	10.262	1.752	**Yes**

The spatial distribution of collisions are provided in Figure 2.

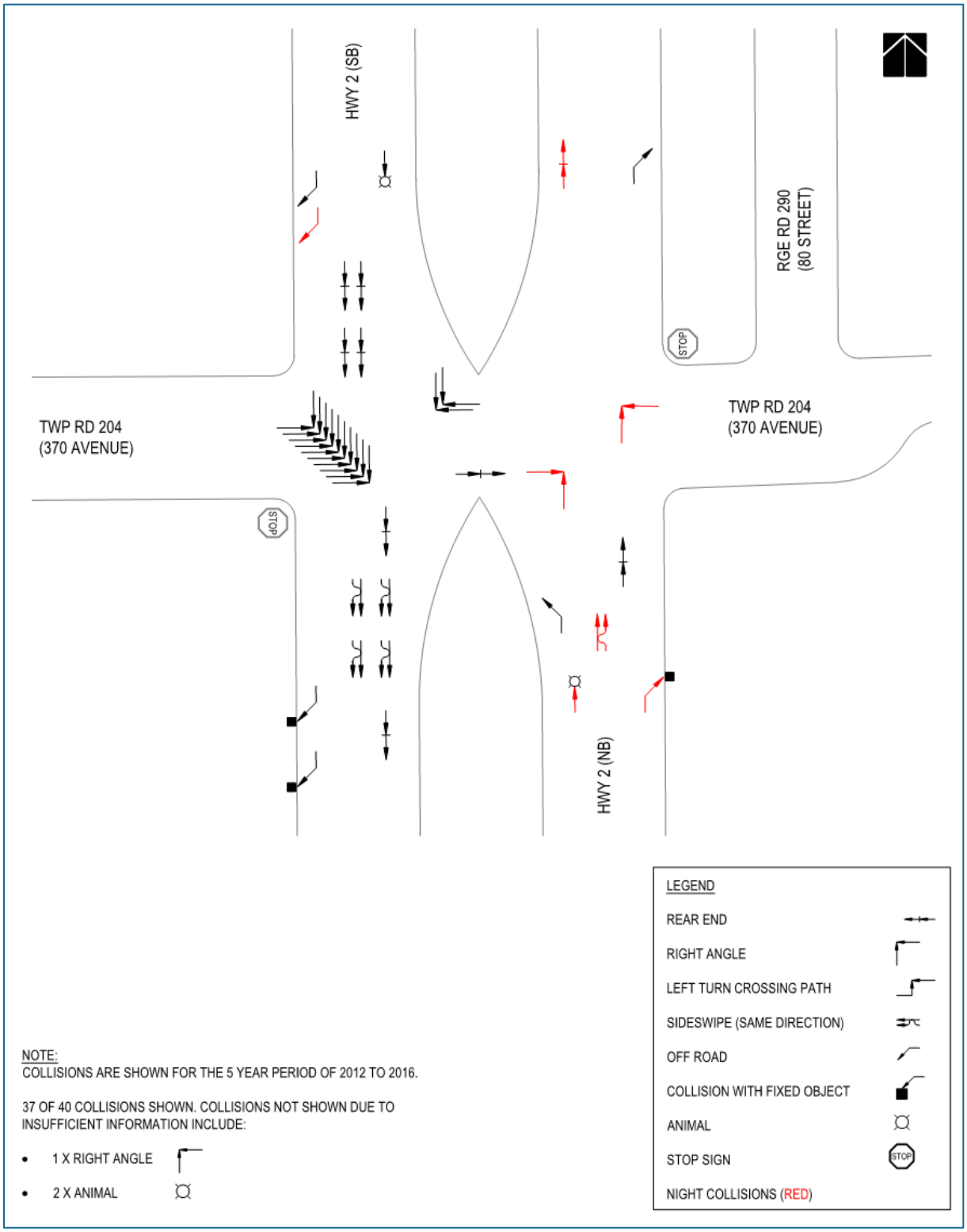


Figure 2: Collision Diagram

3.1 Collision Types and Severity

Figure 3 provides a summary of collisions by type and severity.

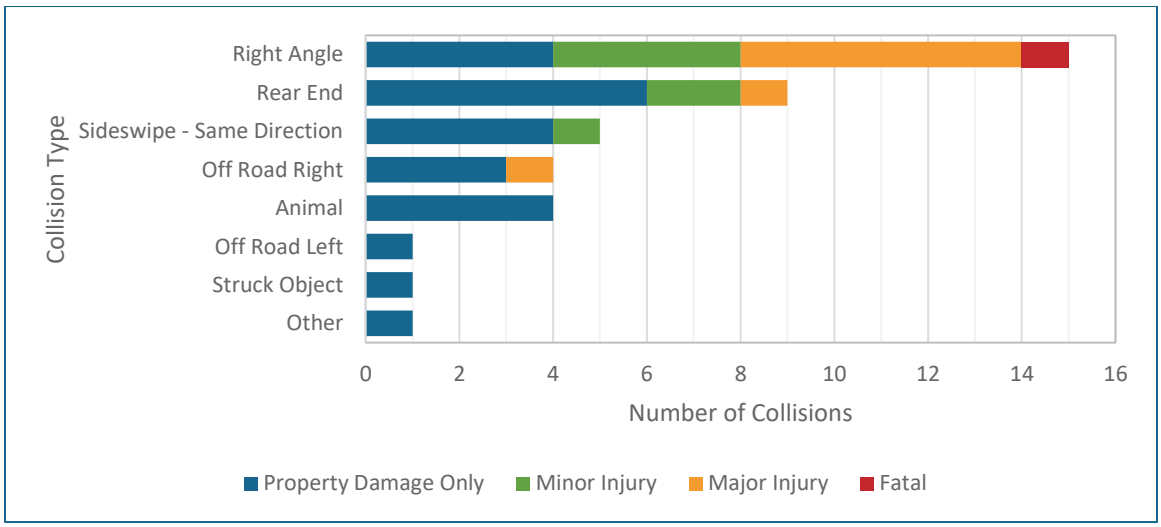


Figure 3: Summary of Collisions by Types and Severity (2012 to 2016)

The following observations are related to the type and severity of collisions at the study intersection:

- The prevalent collision types are “Right Angle” (37.5% of collisions) and “Rear End” (22.5% of collisions).
- Broken down by severity, the intersection experienced one (1) fatal, eight (8) major injury, seven (7) minor injury, and 24 property damage only (PDO) collisions.
- Almost half of the “Right Angle” collisions were fatal or major injury severity.
- Four (4) animal collision occurred at the intersection. Animal and non-animal collisions are analyzed separately for the remainder of the discussion as the causes of animal collisions are different from the other collision types.

3.2 Temporal Collision Patterns

Figure 4, Figure 5 and Figure 6 provide the temporal distributions of collisions by year, month and time of day.

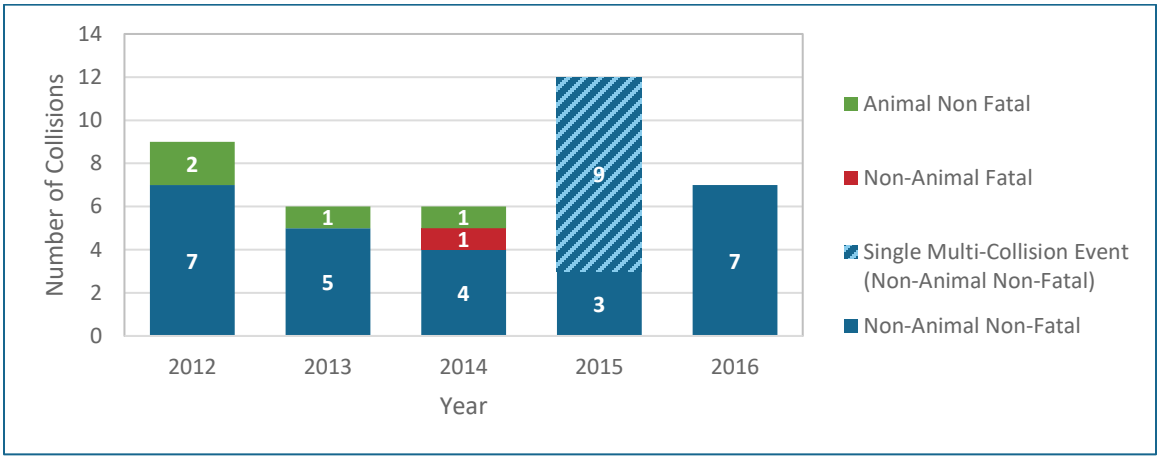


Figure 4: Distribution of Collisions by Year (2012 to 2016)

The distribution of collisions by year reveals the following patterns:

- Not including 2015, the annual number of collisions ranged from six (6) to nine (9) collisions per year.
- In 2015, the intersection experienced 12 collisions, nine (9) of which are related to a multi-collision event that occurred on March 23 (see Section 3.4. for further details).
- The single fatal collision occurred in 2014.
- Animal collisions only occurred in the first three (3) years (2012, 2013 and 2014).

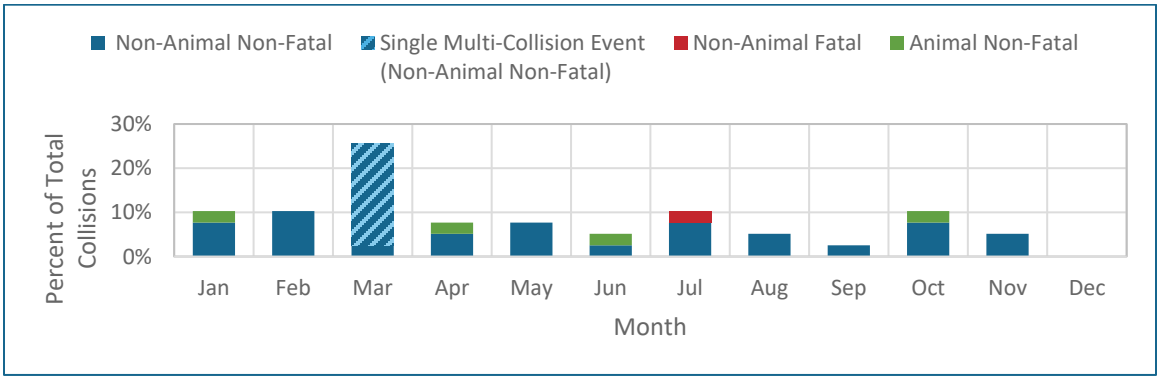


Figure 5: Distribution of Collisions by Month (2012 to 2016)

The distribution of collisions by month reveals the following patterns:

- Over a quarter of collisions (10 collisions) occurred in the month of March, nine (9) of which are related to a multi-collision event that occurred on March 23, 2015 (see Section 3.4. for further details).
- Excluding the total number of collision reports for the multi-collision event, collisions are distributed somewhat evenly over the year with up to four (4) collisions per month.
- The single fatal collision occurred in July.

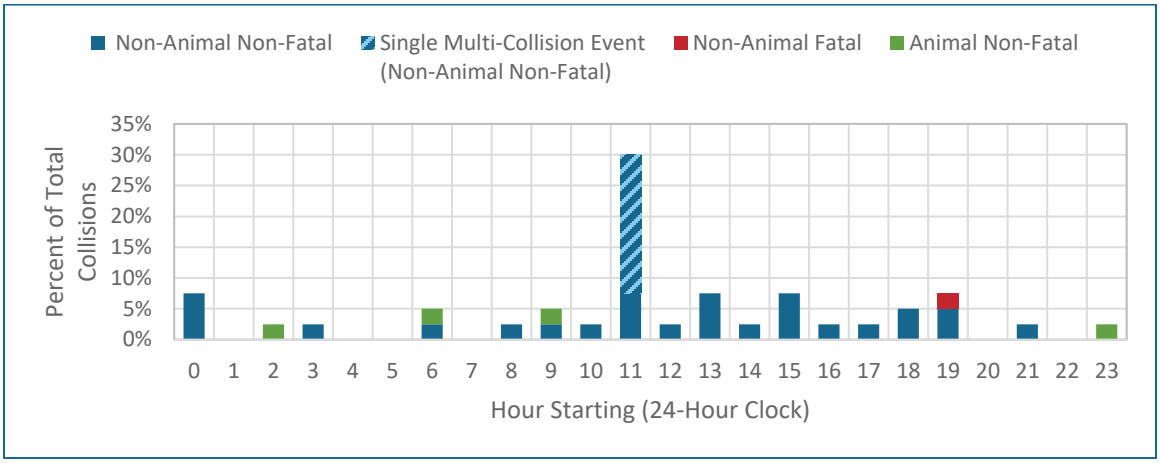


Figure 6: Distribution of Collisions by Time of Day (2012 to 2016)

The distribution of collisions by time of day reveals the following patterns:

- 30% of collisions (12 collisions) occurred in the hour starting at 11 a.m., nine (9) of which are related to a multi-collision event that occurred on March 23, 2015 (see Section 3.4. for further details).
- The single fatal collision occurred in the evening (7 p.m. hour).
- Animal collisions occurred in the morning (6 a.m. to 10 a.m.) and late night (11 p.m. to 3 a.m.) hours. Except for the collision that occurred in the 9 a.m. hour, animal collisions occurred in darkness.

3.3 Environmental, Lighting and Surface Conditions

Table 3 provides a summary of collisions related to lighting, environmental and surface conditions.

Reviewing the lighting, environmental and surface conditions reveals the following patterns:

- The majority of non-animal collisions occurred during daylight conditions and the majority of animal collisions occurred during darkness.
- 50% of the collisions occurred in clear conditions and 30% occurred in snow conditions.
- 50% of the collisions occurred in dry surface conditions and 35% occurred in slush/snow/ice surface conditions.
- Environmental and road surface conditions were unknown / unspecified in three (3) out of four (4) animal collision reports.

Table 3: Lighting, Environmental and Surface Conditions for Collisions (2012 to 2016)

Condition	Non-Animal		Animal		Total	
	Number	Percent	Number	Percent	Number	Percent
Lighting Condition						
Darkness	6	16.7%	3	75.0%	9	22.5%
Daylight	29	80.5%	1	25.0%	30	75.0%
Sunglare	1	2.8%	0	--	1	2.5%
Total	**36**	**100%**	**4**	**100%**	**40**	**100%**
Environmental Condition						
Clear	19	52.8%	1	25.0%	20	50.0%
Raining	1	2.8%	0	--	1	2.5%
Snow	12	33.3%	0	--	12	30.0%
Unknown/Unspecified	4	11.1%	3	75.0%	7	17.5%
Total	**36**	**100%**	**4**	**100%**	**40**	**100%**
Surface Conditions						
Dry	19	52.8%	1	25.0%	20	50.0%
Slush/Snow/Ice	14	38.9%	0	--	14	35.0%
Unknown/Unspecified	3	8.3%	3	75.0%	6	15.0%
Total	**36**	**100%**	**4**	**100%**	**40**	**100%**

3.4 Collision Characteristics

Collision characteristics include:

- **Left Turn Across Path:** The collision reports identified one (1) collision (minor injury "Left Turn Across Path") that involved a southbound vehicle colliding with a vehicle completing a northbound left turn. For the purposes of this report, the "Left Turn Across Path" collision was reclassified as a "Right Angle" collision to represent the type of collision that occurred between the vehicle leaving the median to cross southbound Highway 2 and the southbound vehicle.
- **Right Angle Collision:** Fifteen (15) collisions (one (1) fatal, six (6) major injury, three (4) minor injury, and four (4) PDO "Right Angle") involved a vehicle on the minor approach proceeding into the intersection unsafely and colliding with a Highway 2 vehicle. The following items were noted in the review of "Right Angle" collisions:
  - All 15 of the collisions occurred in clear, dry conditions.
  - Eleven (11) collisions involved vehicles departing from a stop-controlled approach. The other four (4) collisions involved vehicles departing from the median.
  - Of the collisions involving a vehicle departing a stop-controlled approach, five (5) involved a vehicle unsafely entering the intersection after stopping at the Stop sign; the other six (6) did not clearly indicate whether the vehicle stopped at the Stop sign before proceeding.
  - Ten (10) collisions involved southbound and eastbound vehicles. All of them occurred in daylight.
  - Two (2) collisions involved southbound and westbound vehicles and occurred in daylight.
  - One (1) collision involved northbound and eastbound vehicles and occurred in darkness.

- One (1) collision involved northbound and westbound vehicles and occurred in darkness.
- Five (5) collisions occurred in the two-hour period of 3:30 p.m. to 5:30 p.m.
- Descriptions for two (2) of the collisions suggested that the driver of the vehicle on the minor approach or in the median opening did not see oncoming Highway 2 traffic.

- **Rear End Collision:** Nine (9) collisions (one (1) major injury, two (2) minor injury, and six (6) PDO "Rear End") involved a vehicle colliding with a preceding vehicle. The following items were noted in the review of "Rear End" collisions:
  - Six (6) collisions occurred on southbound Highway 2 as part of a multi-collision event on March 23, 2015. Slush/snow/ice surface conditions were present at the time.
  - Two (2) collisions occurred on northbound Highway 2. Slush/snow/ice surface conditions were present for both collisions.
  - One (1) collision involved a eastbound left vehicle being hit from behind while waiting in the median to turn north onto Highway 2. The collision occurred in clear, dry conditions.
- **Sideswipe Collisions:** Five (5) collisions (one (1) minor injury and four (4) PDO "Sideswipe Same Direction") involved a vehicle swiping another vehicle travelling in the same direction. The following items were noted in the review of "Sideswipe Same Direction" collisions:
  - All five (5) collisions occurred in winter months (January, February and March).
  - In four (4) collisions, slush/snow/ice surface conditions were present.
  - Four (4) collisions occurred between southbound vehicles. Two (2) of the collisions were part of the March 23, 2015 multi-collision event.
- **Multi-Collision Event:** Nine (9) collisions (one (1) major injury, one (1) minor injury, and four (4) PDO "Rear End"; two (2) PDO "Sideswipe – Same Direction"; and one (1) PDO "Off Road Right") are part of a multi-collision event, on southbound Highway 2, that occurred between 11:00 a.m. and 11:30 a.m. on March 23, 2015. Information for the collisions indicate that:
  - Slush/snow/ice surface conditions were present.
  - The first collision involved a southbound vehicle rear-ending a trailer.
  - Subsequent collisions appear to have occurred when vehicles attempted to slow or stop upon arriving at the collision. Collision reports indicated the majority of vehicles slid on the slush/snow/ice and lost control.
  - Collisions occurred on either side of the intersection and were all within 200 m of each other.

Avoidance Maneuver: Two (2) collisions (one (1) major injury "Off Road Right" and one (1) PDO "Off Road Left") involved vehicles losing control after swerving to avoid a collision. In one, a northbound vehicle lost control after swerving to avoid colliding with another vehicle (sun glare may have contributed). In the other, a vehicle swerved to miss a deer. Additionally, the multi-collision event on March 23, 2015 included one (1) collision where a vehicle went in the ditch after attempting to avoid colliding with another vehicle.

- **Drowsiness:** One (1) collision (PDO "Off Road Right") involved a southbound vehicle driving into the ditch after the driver fell asleep.
- **Mechanical Failure:** One (1) collision (PDO "Off Road Right") occurred when the front-left tire broke off a southbound vehicle, causing the vehicle to lose control.
- **Animal Collision:** Four (4) PDO "Animal" collisions occurred on Highway 2 south of the intersection.

4.0 Site Visit

ISL completed site visits on Wednesday, July 18, 2018 between the hours of 9 a.m. and 6 p.m. Site visits included:

- site drive-through in daylight;
- observations of site conditions; and
- observations of traffic operations.

Weather conditions during the site visit included a partially overcast sky, a moderate amount of wind and a late afternoon thunderstorm. Pavement surfaces were dry for most of the site visit. Site photographs are provided in Appendix D.

4.1 Drive-Through Observations

South Approach (Northbound Travel)

- **Sight Lines and Intersection Awareness:** Northbound drivers ascend a hill and travel a crest curve in advance of the intersection. The intersection is visible shortly after passing the start of taper for the northbound left turn lane. Vehicles stopped on the median and east approaches are visible to approaching highway drivers. An advance Local Road Name sign and Tourist Oriented Directional signage are provided and enhance driver recognition of the intersection. Street light poles assist drivers with nighttime and daytime recognition of the intersection.
- **Northbound Right Turn:** No issues were identified for this movement.
- **Northbound Through Movement:** No issues were identified for this movement.
- **Northbound Left Turn to Median:** No issues were identified for this movement.

North Approach (Southbound Travel)

- **Sight Lines and Intersection Awareness:** The north approach is relatively flat in advance of the intersection. The intersection is visible in advance of the turn lane tapers. Vehicles stopped on the median and west approaches are visible to approaching highway drivers. A Local Road Name sign is not provided in advance of the intersection. A Tourist Oriented Directional sign is provided and assists with driver recognition of the intersection. Street light poles assist drivers with nighttime and daytime recognition of the intersection.
- **Southbound Right Turn:** No issues were identified for this movement.
- **Southbound Through Movement:** No issues were identified for this movement.
- **Southbound Left Turn to Median:** No issues were identified for this movement.

West Approach (Eastbound Travel)

- **Sight Lines and Intersection Awareness:** Eastbound drivers travel a crest curve followed by a relatively flat section of road in advance of the intersection. Sight lines are satisfactory and the intersection is visible in excess of 400 m west of the stop line. A Divided Highway sign provides advance warning of the intersection. Transverse rumble strips, Stop Ahead sign,

STOP AHEAD word marking, and an oversize Stop sign with a flashing red light provide advance warning of the stop condition.

- **Eastbound Right Turn:** No issues were identified for this movement.
- **Eastbound Crossing to Median:**
  - It can be challenging to find a sufficient gap to cross the five (5) southbound lanes (i.e., three (3) through lanes, a right turn lane and left turn lane).
  - The higher elevation of southbound Highway 2 relative to northbound Highway 2 limits visibility of the median and makes it appear smaller than it is.
  - Visibility of southbound vehicles can be obstructed by vehicles in the right turn deceleration lane.
- **Road Ban:** A 75% road ban was in effect at the time of the site visit.

East Approach (Westbound Travel)

- **Sight Lines and Intersection Awareness:** Sight lines approaching the intersection from the east are limited due to a bend on TR204/RR290 immediately east of Highway 2. The Stop sign and flashing red light may be within a driver's peripheral vision however, they are outside of the driver's cone of vision until the driver is within 30 m of the stop line. A "T" Intersection sign and Right Checkerboard sign provide advance warning of the bend, and a Stop Ahead sign provides advance warning of the stop condition.
- **Westbound Right Turn:** No issues were identified for this movement.

  Westbound Crossing to Median:
  - Visibility of northbound vehicles can be obstructed by vehicles in the right turn deceleration lane.
  - Tall grass on the outside edge of northbound Highway 2 in combination with the crest curve south of the intersection could limit visibility of oncoming northbound vehicles on the highway.
- **RR290 Intersection:** The "T" Intersection and Bidirectional Checkerboard signs on the east approach give the impression that the intersection of TR204 and RR290 should operate as a "T" intersection; however, the intersection is uncontrolled and the north and west legs operate as a single continuous route with a 90° bend. The east leg provides access to six (6) residences. Although traffic operations, appearance, and signage (Rural Address sign, No Trespassing sign, etc.) suggest that the east leg is a private access, it is shown as a public roadway on MD of Foothills maps.
- **90° Bend:** Pavement deterioration is evident on the 90° bend between the north and west legs of the TR204/TR290 intersection, especially along the inside of the bend. The area adjacent to the pavement appears to be heavily travelled.
- **Road Ban:** A 90% road ban was in effect at the time of the site visit.

Highway 2 Median Opening (Eastbound Travel)

- There are no markings or signs to guide drivers through the median opening.
- Tall grass on the median edge of northbound Highway 2 in combination with the crest curve south of the intersection could limit visibility of oncoming northbound vehicles on the highway.

- When left turn and through vehicles are queued side-by-side in the median, there is potential for visibility of northbound vehicles on the highway to be obstructed by the eastbound through vehicle.
- The left turn acceleration lane is relatively short. Safe entry into the highway requires selection of a gap sufficiently large to accelerate before being overtaken by through highway traffic.

Highway 2 Median Opening (Westbound Travel)

- There are no markings or signs to guide drivers through the median opening.
- It can be challenging to find a sufficient gap to cross the five (5) southbound lanes (i.e., three (3) through lanes, a right turn lane and left turn lane).
- When left turn and through vehicles are queued side-by-side in the median, there is potential for visibility of southbound vehicles on the highway to be obstructed by the westbound through vehicle.
- There is no left turn acceleration lane. Safe entry into the highway requires selection of a gap sufficiently large to accelerate before being overtaken by through highway traffic.

4.2 Traffic Control Devices

Figure 7 identifies the existing signage and pavement markings observed at the intersection during the site visit.

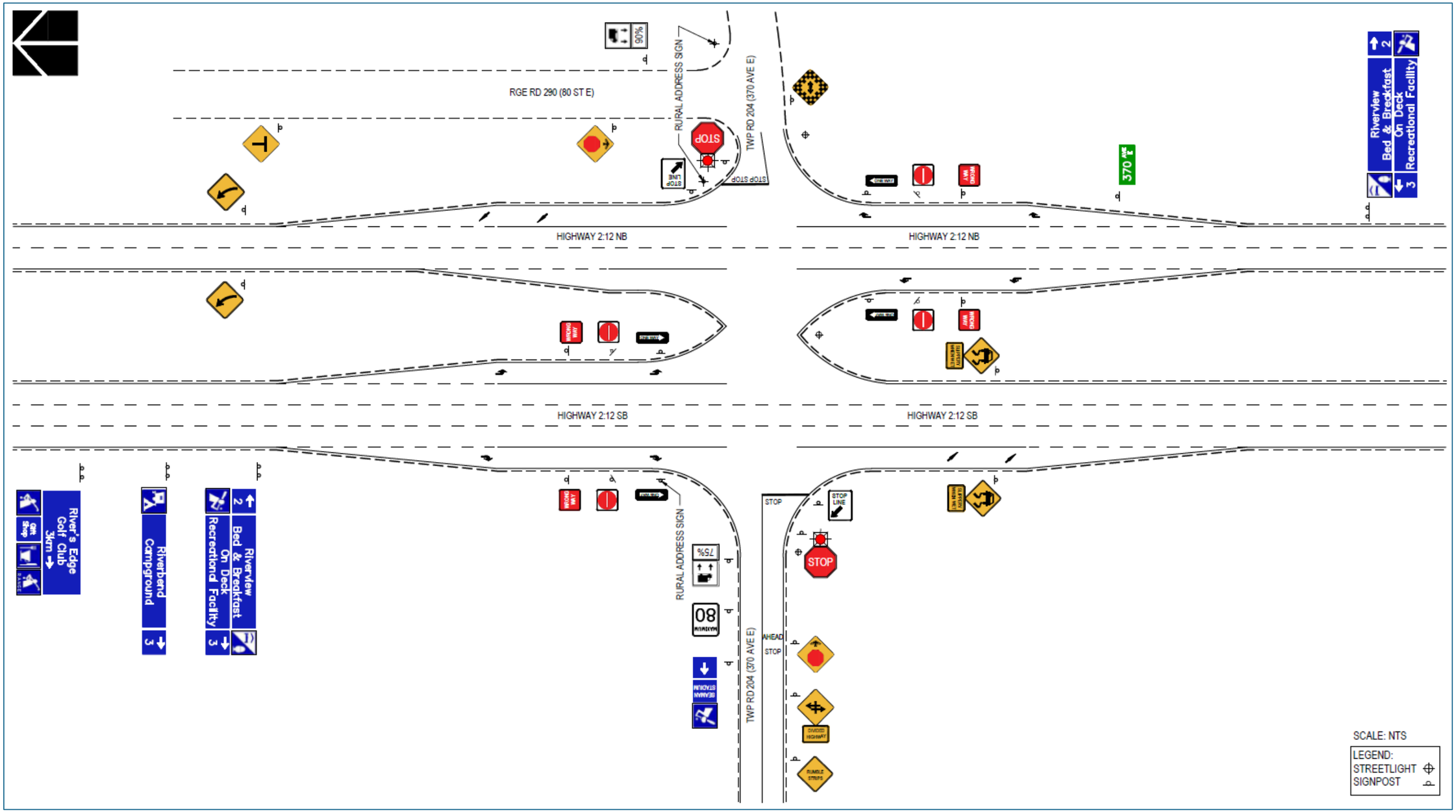


Figure 7: Intersection Geometry, Lane Configuration and Traffic Control Devices

The following comments relate to site visit observations at the intersection:

General

- Some of the wood sign posts located within the clear zone do not have holes drilled into the post to complete the breakaway feature.
- Rural Address signs (i.e. Street Name signs) are located in the northeast and northwest quadrants of the intersection and are in good condition.

South Approach (Northbound Travel)

- The Do Not Enter sign on the median side of the northbound lanes has minor damage (fading symbols) to the sign face. The sign is still legible.
- Pavement markings for the northbound lanes of Highway 2 are in good condition.
- Arrow markings in the northbound lanes appear to have faded more than those in the southbound lanes, however, they are still in relatively good condition.
- Centreline and shoulder rumble strips terminate in advance of the tapers and are in good condition.

North Approach (Southbound Travel)

- No issues with signs were observed.
- Pavement markings for the southbound lanes of Highway 2 are in good condition.
- Centreline and shoulder rumble strips terminate in advance of the tapers and are in good condition.

West Approach (Eastbound Travel)

- The eastbound Stop sign is oversize (1,200 mm by 1,200 mm) and is supplemented with a flashing red light and a Stop Line sign. The Stop sign is installed on a double-wide wood post that appears to have been installed recently.
- The Stop Line sign is bent and has minor damage (scuff marks) to the sign face. The sign is still legible.
- The stop line, STOP word marking and centreline are in good condition.
- The north and south edge lines are deteriorating. The north edge line is significantly deteriorated for a 50 m section starting 20 m west of the stop line.
- The Stop Ahead sign is oversize (1,200 mm by 1,200 mm) and has minor damage (cracking) to the sign face. The sign is still legible.
- The STOP AHEAD word marking is in good condition.
- The Rumble Strips sign has significant damage (shotgun damage) to the sign face. The sign is only partially legible.
- The transverse rumble strips in advance of the Stop sign are worn in the wheel paths.
- Neither centreline nor shoulder rumble strips were identified for this approach.

East Approach (Westbound Travel)

- The westbound Stop sign is oversize (1,200 mm by 1,200 mm) and is supplemented with a flashing red light and a Stop Line sign. The Stop sign is installed on a double-wide wood post that appears to have been installed recently.
- The Stop Line sign is bent and has minor damage (scuff marks) to the sign face. The sign is still legible.
- The stop line and left STOP word marking are in good condition.
- The right STOP word marking is fading.
- The centreline and edge line markings are in good condition and terminate near the highway right of way boundary.
- The Bidirectional Checkerboard sign has minor damage (flaking) to the sign face. The sign is still legible.
- The Stop Ahead sign has minor damage (flaking) to the sign face. The sign is still legible.
- Rumble strips were not identified for this approach.

4.3 Illumination

The study intersection has delineation lighting consisting of three (3) street lights. The power distribution cabinet (PDC) is located in the southwest quadrant of the intersection. Details for individual street light poles are provided in Table 4.

Table 4: Street Light Pole Details

Pole Number	Location	Bulb Size (W)	Pole Offset * (m)	Breakaway Assembly	Comment
17035312	Southwest Quadrant	400	6.4	Yes	Pole in good condition.
17035338	South Median	400	4.1	Yes	Pole in good condition.
17035403	Southeast Quadrant	400	8.3	Yes	Pole in good condition.

* Pole offsets are approximate measurements from face of pole to the nearest edge line.

Observations of the illumination system from the site visit include:

- **Pole Condition:** All street light poles appeared to be galvanized and in good condition.
- **Operational Check:** The photocell in the PDC was covered temporarily during the site visit to check the operation of the lighting system. The lighting system operated without issue.
- **PDC Condition:** The top of the PDC is rusting. The access louvre on north side of PDC is off and lying in grass at the base of the PDC.

4.4 General Observations

- **Left Turn Vehicle Behavior:** Left turn vehicles were observed entering and travelling through the median opening along different paths. When left turn vehicles from opposite directions

entered the median opening together, they were observed turning in front of one another (simultaneous left turns) or behind each other (i.e., interlocking left turns) as illustrated in Figure 8.

- Simultaneous left turns may conflict with traffic from the minor approach entering the median opening.
- Interlocking left turns may result in left turn queues blocking the completion of through or left turn movements from the median opening.

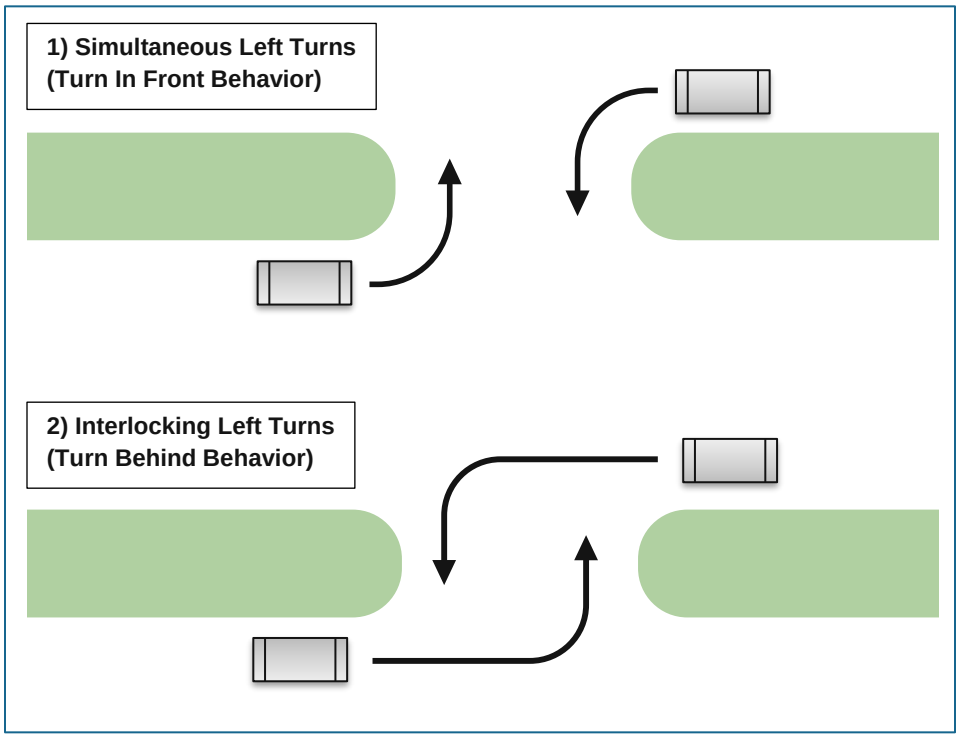


Figure 8: Opposing Left Turn Behavior *(Source: Adapted from NCHRP Report 650)*

- **Queuing on West Approach:** Queue lengths of up to four (4) vehicles were observed at the eastbound stop line.
- **Vehicles Stopping on TR204 Shoulder:** There is evidence that vehicles pull off the pavement on the north shoulder of the west approach. One vehicle was observed pulled over in this area during the site visit. The roadside geometry at this location (0.6 m paved shoulder and ~4:1 side slope) is not adequate to accommodate stopped vehicles.
- **Memorial Marker:** Flowers were attached to the eastbound Stop Line sign and nearby street light pole, and appear to be a memorial marker.

5.0 Operational Analysis

5.1 Traffic Operations

The Highway Capacity Manual (HCM) provides a methodology for assessing intersection traffic operations. The quality of intersection traffic operations are commonly reported in terms of level of service (LOS) and intersection capacity.

The LOS is based on average total delay per vehicle, and ranges from LOS of 'A' (free flow) to LOS of 'F' (very congested). For rural areas, a LOS of 'C' is generally considered as an acceptable standard for operations, and a LOS of 'D' may be accepted when limited to low-volume movements. When intersection operations are below the accepted standard, intersection improvements may be required. LOS criteria for unsignalized intersections are shown in Table 5.

Table 5: LOS Criteria for Unsignalized Intersections

Level of Service (LOS)	Control Delay per Vehicle (sec)
A	≤ 10.0
B	> 10.0 and ≤ 15.0
C	> 15.0 and ≤ 25.0
D	> 25.0 and ≤ 35.0
E	> 35.0 and ≤ 50.0
F	> 50.0

The capacity of a controlled intersection approach is based on the distribution of gaps in the major road traffic flow; driver judgement in selecting a gap through which to execute the desired maneuver; and the follow-up time required by each driver in a queue. The volume-to-capacity (V/C) ratio is a ratio of the traffic flow for a given lane group to the capacity. A V/C ratio of 1.0 indicates that the flow rate equals the capacity. A V/C ratio of 0.85 or less for all intersection movements is a generally accepted standard for peak hour operations. The HCM 2010 indicates that any traffic movement with a V/C ratio of 1.0 or greater is considered to have a LOS of 'F' regardless of delay.

Characteristics for the study intersection were coded into Trafficware Synchro 9 software with the following adjustments and parameters:

- All turning movement volumes lower than 10 vehicles were increased to 10 vehicles.
- The percent heavy vehicles for each turning movement were based on AADT values. Percentages less than 2% were increased to 2%.
- Calculated peak hour factor (PHF) values from the raw traffic count data were used.

The HCM 2010 two-way stop control (TWSC) procedure utilized by Synchro is incapable of analyzing this intersection due to the magnitude of the traffic volumes and the number of lanes. The procedure uses a gap-acceptance model that considers the size and distribution (availability) of gaps on the major road, the usefulness of gaps to drivers on the minor approaches, and the

relative priority of the various movements at the intersection. Stop-controlled movements are assigned a lower priority than movements from the major road. When the volume of major road movements are high, there is minimal opportunity for the stop-controlled movements to accept gaps resulting in the stop-controlled movements having little or no capacity. Based on the 100th highest hour traffic volumes, an insufficient number of gaps are available to accommodate the volume of stop-controlled movements and therefore, the Synchro HCM 2010 analysis does not provide results for crossing or turning movements from the stop-controlled approaches.

5.2 Traffic Control Devices

Stop Sign and Stop Line Placement

The current usage and placement of Stop signs, stop lines, and Stop Line signs were reviewed and compared against the AT guidelines. Table 6 provides a summary of the review.

Table 6: Stop Sign, Stop Line, and Stop Line Sign Review

Item	Alberta Transportation Guideline	West Approach	East Approach
Stop Sign Placement *(from edge of intersecting road)*	2.0 m Min. (*Design Bulletin #82/2014*) 15.0 m Max. (*Design Bulletin #82/2014*) ≤ 5.0 m Preferred. (*2012 Recommended Practice*)	~10.8 m	~10.0 m
Stop Line Placement	4.7 m or 4.9 m from nearest lane line (*Design Bulletin #56/2007*) or 1.2 m to 10 m from edge of intersecting roadway. (*2013 Recommended Practice*)	~10.3 m from nearest lane line	~6.0 m from nearest lane line
Stop Line Sign	Consider when Stop sign is ≥ 15 m from stop line.	Present, Not Warranted	Present, Not Warranted

The existing placement of Stop signs and stop lines meet AT guidelines.

Spacing and Placement of Other Signs

The spacing and placement of other signs were reviewed against the following AT guidelines:

- Recommended Practices for Traffic Controls
- Typical Signage Drawings
- Highway Guide and Information Sign Manual
- “Design Bulletin #82/2014”, Longitudinal Sign Placement at Highway Intersections

South Approach:

- The Do Not Enter and Wrong Way signage are located approximately 21 m and 64 m from the intersection. Drawing TCS-A4-430G indicates they should be 27 m and 75 m from the intersection. Current sign placement does not appear to impact their effectiveness.

- The advance Local Road Name sign is located 165 m from the intersection. The "2008 Recommended Practice for Local Road Name Signs" indicates that it should be 150 m to 300 m in advance of the intersection, or at the start of the taper. The current placement appears to be suitable.
- Two (2) of the Tourist Oriented Directional signs (Riverbend Campground and the Riverview Bed & Breakfast / On Deck Recreational Facility) are 100 m apart and appear to be spaced too closely. A review of required reading distances (10 words) at 110 km/h speed suggests that a 200 m spacing would be more appropriate.

North Approach:

- The Do Not Enter and Wrong Way signage are located approximately 24 m and 66 m from the intersection. Drawing TCS-A4-430G indicates they should be 27 m and 75 m from the intersection. Current placement for these signs does not appear to impact their effectiveness.

West Approach:

- The Stop Ahead, Divided Highway and Rumble Strips signs are located at 215 m, 270 m, and 315 m, respectively, west of the intersecting road. Drawing TCS-A4-430C indicates that the Stop Ahead and Rumble Strips signs should be 250 m and 400 m, respectively, from the intersecting road. Sign adjustment should be considered with the next overlay or sign maintenance activity. A minimum of 50 m should be provided between signs.

East Approach:

- The Stop Ahead sign is 145 m in advance of the westbound stop line. Drawing TCS-A4-430C indicates that the Stop Ahead sign should be 250 m from the intersecting road. Although current sign placement differs from Drawing TCS-A4-430C, the Stop Ahead sign appears to be effective in the current location.

TR204/RR290 Intersection:

- This is currently an uncontrolled intersection. Two (2) potential operational issues that may arise with an uncontrolled intersection at this location are:
  - A southbound left turn vehicle may arrive at the same time as an eastbound through or left turn vehicle. If the southbound left turn driver does not know the intersection is uncontrolled, the driver may proceed into the path of the eastbound TR204 driver.
  - A westbound through vehicle may arrive at the same time as a southbound left or right turn vehicle. If the westbound driver does not know the intersection is uncontrolled, the driver may proceed into the path of the RR290 vehicle.
- In both of the above scenarios the Traffic Safety Act right hand rule provides direction for the uncontrolled intersection, however, as the predominant movements on the roadway consider traffic flows between Highway 2 and RR290, it is expected that many drivers may interpret the east approach as a private approach with an associated stop condition.
- The following options may resolve the identified issue:
  - The typical signage configuration for this scenario would be the installation of a Stop sign on southbound RR290.
  - An alternate atypical signing solution could provide a Yield sign for southbound RR290 and a Stop sign for westbound TR204. The Stop sign for westbound TR204 is necessary as without the Stop sign, the Yield sign on southbound RR290 would not meet sight distance requirements due to the mature trees on the east approach of TR204.

- An alternate option to the identified signage revisions would be realignment of the east approach to a new intersection location on RR290. This would have a significantly higher cost than the signage option and could have reduced benefit if traffic volumes at the TR204/RR290 intersection decrease due to Highway 2/TR204 intersection improvements, such as closure of the median opening.

Additional Traffic Controls for Stop-Controlled Approaches

AT specifies a four-level system of traffic control devices that can be implemented as safety measures to improve intersection recognition and stop sign compliance at rural stop-controlled approaches ("2011 Recommended Practice, Safety Measures at Rural Stop-Controlled Intersections"). The warrant is sequential and requires that a preceding level of the warrant is met before considering the next level.

From 2012 to 2016, none of the collisions specifically stated Stop sign non-compliance as a contributing factor to the collision; therefore, for the purposes of this analysis, the following collisions are considered potential Stop sign violations:

- Four (4) collisions that involved vehicles departing the west approach.
- A single collision that involved a vehicle departing the east approach.

The warrant results are shown in Table 7.

For both approaches, existing traffic control devices exceed what is identified by the warrant. All of the traffic control devices identified in the warrant are already in place on the west approach, and all except the STOP AHEAD word marking are in place on the east approach.

Advance Intersection Signage and Road Name Signs

The following AT guidelines describe the use of Rural Address signs (i.e., road name signs for rural roadways) and advance road name signs.

- "2003 Recommended Practice for Rural Address Signs"
- "2008 Recommended Practice for Local Road Name Signs"

Rural Address signs assist emergency personnel and motorists in wayfinding by providing them with a reference to the grid road system. Typical rural address signs are shown in Figure 9.

Figure 9: Typical Rural Address Signs

Although Rural Address signs provide a means for motorists to positively identify an intersection, they may not be suitable to make wayfinding decisions in advance of the intersection due to their small size and placement at the intersection. Advance Township/Range Road signs or Local Road Name signs assist motorists to make appropriate wayfinding decisions in advance of intersections, and may be placed in addition to, or in lieu of, the Rural Address sign. These signs are beneficial at night where an intersection may be challenging to recognize and identify. A typical Advance Township/Range Road sign is shown in Figure 10.

Table 7: Warrants for Additional Traffic Control Devices at Stop-Controlled Intersections

	Traffic Control Device	Warrant	Approach	
			West	East
1	Oversize Stop Sign (900 mm)	One of the following conditions present:		
		1. Major intersection on two-lane or four-lane highway.	✓	✓
		2. ≥ three (3) collisions involving Stop sign violations over five (5) year period.	✓	
		3. Low visibility/sight line restrictions on stop-controlled approach.		✓
		4. Complex visual environment.		
		5. Complex and frequent turning maneuvers.		
		Warrant Met	**Yes**	**Yes**
	Oversize Stop Sign (1200 mm or 1500 mm)	Both of the following conditions present:		
		1. ≥ three (3) collisions involving Stop sign violations over five (5) year period.	✓	
		2. Other measures (e.g. improving sight lines, 900 mm Stop sign) proven ineffective.	?	?
		Warrant Met	**Yes**	**No**
2	Stop Ahead Sign	One of the following conditions present:		
		1. Low visibility/sight line restrictions on stop-controlled approach.		✓
		2. Rapid change in roadway alignment.		✓
		3. Complex visual environment.		
		4. Existing oversize stop sign has proven ineffective.	?	?
		Warrant Met	**No**	**Yes**
3	STOP Word Marking	All of the following conditions met:		
		1. ≥ three (3) collisions involving Stop sign violations over five (5) year period.	*	
		2. Approaching roadway posted at ≥ 80 km/h.	*	✓
		3. Approach traffic volume > 500 vehicles per day.	*	
		4. Other measures ineffective in preventing failing-to-stop collisions.	?	?
		Warrant Met	*****	**No**
	STOP AHEAD Word Marking	All of the following conditions met:		
		1. STOP word marking present/warranted.	*	*
		2. Stop Ahead sign present/warranted.	*	*
		Warrant Met	*****	*****
4	Flashing Red Light	All of the following conditions met:		
		1. ≥ three (3) collisions involving Stop sign violations over five (5) year period.	*	
		2. Approaching roadway posted at ≥ 80 km/h.	*	*
		3. Approach traffic volume > 500 vehicles per day.	*	
		4. Other measures ineffective in preventing failing-to-stop collisions.	?	?
		Warrant Met	*****	**No**

* indicates that a condition is met but not considered due to the sequential nature of the warrant.
? indicates insufficient information available to determine whether condition is met or not.

Figure 10: Typical Advance Township/Range Road Sign

It is noted that the MD of Foothills uses a street/avenue grid that aligns with the City of Calgary's grid, and therefore, rural address signage provides the name of the street/avenue rather than the township/range road.

At the study intersection, there is an advance Local Road Name sign on the northbound approach but not on the southbound approach. Although a Local Road Name sign is optional, having one on the southbound approach would assist drivers to identify the name of the intersecting road and could be installed 190 m to 240 m north of the intersection without interfering with existing signage.

There are Rural Address signs (i.e., road name sign) in the northwest and northeast quadrants of the intersection.

5.3 Traffic Signal Warrant

Traffic signal warrant analysis was undertaken by applying the warrant procedure described in the TAC "Traffic Signal Warrant Handbook", which uses a point system to determine the need for signalization. In this warrant system, a cumulative score of 100 points is considered the minimum value required to warrant a traffic signal.

Typically, the hourly volumes for the peak six (6) hours of the day are totaled and averaged in the traffic signal warrant. For the study intersection, design hour volumes (i.e., 100th highest hour) were available for AM and PM peak periods and therefore, a factor was developed from the raw traffic count to create an estimate of the total six-hour peak based on the AM and PM 100th highest hours. The factor was developed by summing the three (3) highest AM hourly volumes and the three (3) highest PM hourly volumes, and then dividing by the sum of the highest AM and the highest PM hour. The resulting factor is 2.80.

A traffic signal is warranted based on the results of the warrant (174 points). The completed warrant sheet is provided in Appendix F.

6.0 Geometric Analysis

6.1 Roadway Alignment

Roadway characteristics, including traffic volumes and flow characteristics, speed limits, vehicle mix and adjacent land uses, indicate that Highway 2 functions as a rural divided freeway / expressway, and that TR204 functions as a rural collector roadway to the west of Highway 2 and as a rural local roadway east of Highway 2. Design designations for the roadways appear to be:

- **Highway 2:** RFD-516.1/11.4-130
- **TR204 to the West of Highway 2:** RCU-208.2-90
- **TR204/RR290 to the East of Highway 2:** RLU-209-90

Roadway alignment elements were reviewed against design standards provided in Table A-10-1a of the HGDG. Highway 2 geometric characteristics were obtained from AT Maps.

Highway 2 Northbound Lanes

The northbound lanes of Highway 2 are tangent through the study area with no horizontal curvature. No geometric issues were identified for the horizontal alignment.

In the direction of travel (south to north), the vertical profile includes:

- Uphill tangent (km 16.981 to 17.463; 2.6% grade).
- Crest curve (km 17.463 to 17.884; K value of 162) through the intersection (km 17.677).
- Flat tangent (km 17.884 to 18.253; 0.0% grade).

As the through road, Highway 2 has a grade line that carries through the intersection unaffected by the intersecting roads. No geometric issues were identified for the northbound vertical alignment.

Highway 2 Southbound Lanes

The southbound lanes of Highway 2 are tangent through the study area with no horizontal curvature. No geometric issues were identified for the horizontal alignment.

In the direction of travel (north to south), the vertical profile includes:

- Downhill tangent (km 18.404 to 17.808; -0.1% grade).
- Crest curve (km 17.808 to 17.290; K value of 125) through the intersection (km 17.677).
- Sag curve (km ~17.290 to 16.665; K value of 105).

As the through road, Highway 2 has a grade line that carries through the intersection unaffected by the intersecting roads. No geometric issues were identified for the southbound vertical alignment.

West Approach (TR204)

Alignment elements for the west approach are:

- The horizontal alignment is straight.
- The vertical alignment includes a crest curve followed by a sag curve before flattening out on the approach to the intersection.
- The alignment of TR204 appears to meet or exceed the applicable design standards for a rural local roadway with an 80 km/h posted speed limit.

East Approach (TR204 / 290)

Considering TR204 to RR290 as the primary route on the east approach, alignment elements for the east approach are:

- The horizontal alignment includes a 90° bend that starts approximately 18 m west of the Highway 2 stop line and has an approximate radius of 20 m. Without superelevation, the safe travel speed around the bend would be in the order of 20 km/h, which is less than the 80 km/h speed limit. Existing signage ("T" Intersection and Bidirectional Checkerboard) provides adequate advance warning of the abrupt change in alignment.
- The vertical alignment is relatively flat.
- The alignment of the east approach appears to meet applicable design standards.

6.2 Cross Section Elements

Highway 2 Northbound Lanes

The typical cross section for northbound Highway 2 is approximately 11.4 m consisting of a 1.0 m inner shoulder, two (2) 3.7 m travel lanes and a 3.0 m outer shoulder. Northbound Highway 2 is crowned and appears to have adequate cross slope to shed water away from the road surface. Side slopes are relatively flat and appear to be appropriate for the roadway classification.

Median Width

The typical median width, shoulder line to shoulder line between northbound and southbound Highway 2, is approximately 30.3 m.

Highway 2 Southbound Lanes

The typical cross section for southbound Highway 2 is approximately 16.1 m consisting of a 2.0 m inner shoulder, three (3) 3.7 m travel lanes and a 3.0 m outer shoulder. Southbound Highway 2 is crowned and appears to have adequate cross slope to shed water away from the road surface. Side slopes are relatively flat and appear to be appropriate for the roadway classification.

West Approach (TR204)

TR204 has a typical cross section of approximately 8.2 m consisting of a 3.5 m travel lane and 0.6 m shoulder in each direction. Figure A-7-1b of the HGDG suggests that an 11.0 m cross section would be more appropriate for the current AADT. The roadway is crowned and appears to have adequate cross slope to shed water away from the road surface. Side slopes appear to be appropriate for the roadway classification.

East Approach (TR204)

TR204 has a typical cross section of approximately 8.6 m to the edge of the Highway 2 right of way consisting of a 3.5 m travel lane and 0.8 m shoulder in each direction. Outside the highway right of way, TR204 intersects with RR290 and then narrows down to an approximate cross section of 5.0 m.

The roadway is crowned and appears to have adequate cross slope to shed water away from the road surface. Side slopes appear to be appropriate for the roadway classification.

Range Road 290

RR290 has a typical cross section of approximately 9.0 m consisting of a 4.5 m travel lane in each direction. The paved roadway width appears to be appropriate for current traffic volumes. The roadway is crowned and appears to have adequate cross slope to shed water away from the road surface. Side slopes appear to be appropriate for the roadway classification.

The pavement on the 90° bend between the north and west legs of the TR204/RR290 intersection is deteriorated and may be narrower than the paved width of the north and west legs. An operational issue may arise at this location when a southbound right turn vehicle arrives at the same time as an eastbound left turn vehicle as:

- The pavement width could be insufficient to accommodate the simultaneous completion of both turn movements comfortably.
- Pavement deterioration and wear on the inside edge of the bend suggests that southbound right turn vehicles track off the pavement.
- Although identified as a potential issue:
  - Pavement deterioration could be addressed through regular maintenance activities.
  - The collision information did not identify any collisions occurring at the TR204/RR290 intersection.

6.3 Intersection Elements

Existing Lane Configuration

Deceleration lanes are provided for left and right turns for both the northbound and southbound direction. Acceleration lanes are provided for the eastbound left turn, eastbound right turn, and westbound right turn movements. Through and left turn movements from the minor approaches must complete a two-stage maneuver to cross or enter the highway.

Angle of Intersection

The angle of intersection is approximately 90° and meets AT guidelines.

Median Opening

A bullet nose median opening is used at the intersection, which is consistent with Section D.8.5 of the HGDG that indicates bullet nose median openings should be used on all openings where conditions for a semi-circular or flat nose median opening are not met. This type of median opening permits simultaneous left turn movements for trucks from each direction on the highway, as well as turns from the minor approaches.

The as-built drawings indicate that the geometric parameters for this median opening are:

- 75 m radius for turnout curve at the median edge (R1).
- 5.364 m radius at the tip of the bullet nose (R2).
- 20.946 m median opening width (L).
- 48.331 m offset from centre of intersection to the start of R1 (b).
- 26.82 m (approximate) median width from edge of northbound 3.5 m left turn lane to edge of nearest southbound through lane (M).

The geometric parameters suggest that the control radius at the sharpest portion of turn (R_c) is approximately 25 m, which is suitable for the maximum turning template of the WB-23 (25 m long Super B-Train) design vehicle and all shorter truck-trailer combinations.

The median design meets AT guidelines, however, a bullet-nose median opening presents unique challenges as described below.

- There are no markings or signs to guide drivers through the median.
- The Alberta “Use of Highway and Rules of the Road Regulation” and “Driver’s Guide to Operation, Safety and Licensing, Cars and Light Trucks” do not provide clear guidance on left turns through a median opening on a divided highway. This potentially leads to driver confusion as to what path they should take through the median opening.
- Considering a left turn from a divided highway to be a movement from a one-way road onto a two-way road, the driver is legally required to enter the two-way road on the right side of the centreline. The geometric layout of a bullet-nose median opening encourages left turn vehicles to make simultaneous left turns (turn-in-front behavior) and enter the median opening on the left side of centre.
- When a highway left turn vehicle enters the median opening at the same time as an opposing through or left turn vehicle from the minor approach, it is expected that the highway left turn vehicle has the right of way as the minor approach vehicle movement is controlled by a Stop sign. Vehicles departing the stop-controlled approach to enter the median opening, however, are considering the provision of a suitable gap in the adjacent highway lanes to complete a safe, staged crossing and are not typically checking for the presence of highway left turn vehicles on the far side of the median before crossing to the median. The highway left turn vehicle, if not directed by a traffic control device (pavement marking) to the right side of the median centreline, may potentially utilize the same space in the median as the vehicle entering from the minor approach.
- The potential for driver confusion in the median opening increases with higher traffic volumes because there is a greater probability of conflicting movements occurring at the same time and there are more things requiring the driver’s attention.

Note that despite the potential confusion in the median, the collision information did not identify any collisions in the median between vehicles turning left from the highway and/or vehicles entering the median from the minor approaches.

Left Turn Lane Warrant

The left turn warrant considers the operational and safety impacts of left turning vehicles on the highway. The interference caused by a standing left turn vehicle can reduce capacity and create

a safety hazard. The left turn lane warrant analysis was completed using the methodology described in Section D.8.6 of the HGDG. Table 8 provides results of the left turn warrants and the worksheets are included in Appendix F.

Table 8: Warrant for Excusive (Parallel) Left Turn Lane

Period	Volumes			HGDG Chart	Warrant Met?	Storage	
	V_L	Vo	T			S (m)	S_T (m)
Northbound							
AM	37	1301	0%	Figure D-8.6C	**Yes**	15*	0
PM	60	1423	2%	Figure D-8.6C	**Yes**	30*	0
Southbound							
AM	1	1342	0%	Figure D-8.6C	No	N/A	N/A
PM	1	1293	0%	Figure D-8.6C	No	N/A	N/A

V_L = Volume Left Turns; V_O = Volume Opposing; T = Percent Trucks in V_L; S = Storage; S_T = Storage for Trucks (HGDG Table D.7.6a)
* The opposing volume for the northbound left turn movement was adjusted as there are three (3) opposing through lanes and HGDG Figure D 8.6c is based on a left turn with only two (2) opposing through lanes. The adjusted opposing volume only considers volumes from the two (2) right-most opposing through lanes plus the opposing left and right turns. A 40 / 35 / 25 split (right to left) was assumed for lane utilization for the southbound through lanes. Further evaluation may be required to confirm northbound left turn storage requirements.

A left turn treatment with 30 m of storage is warranted for the northbound direction.

Right Turn Lane Warrant

To warrant an exclusive right turn lane on a divided highway facility, the right turn volume must be greater than 360 vehicles per day. Results of the left turn lane warrant are provided in Table 9.

Table 9: Warrant for Exclusive (Parallel) Right Turn Lane

Direction	Volumes		Warrant Met?
	Daily Right Turn	Threshold	
Northbound	140	≥ 360	No
Southbound	810	≥ 360	**Yes**

An exclusive right turn treatment is warranted for the southbound direction.

Median Acceleration Lane Warrant

AT recently released Design Bulletin #100/2019 Median Acceleration Lane Design Guidelines which identify installation conditions (warrants). Median acceleration lanes (MALs) may be considered where the first two conditions plus any of the last three conditions stated below exist:

1. There is left turning traffic from minor road merging with high-speed divided highway through traffic.
2. There are limited gaps available in the major road traffic stream.
3. There is a significant collision history of sideswipe or rear end type crashes.
4. There is insufficient intersection sight distance at the intersections for some of the design vehicles making the left turn off the minor roadway.
5. There are enough large vehicles originating on the minor roadway for it to be an operational concern for the major road.

The first two conditions are met for both northbound and southbound Highway 2. The collision history indicates a combined total of ten (10) “Rear End” or “Sideswipe” collisions in the southbound lanes, and a total of three (3) “Rear End” or “Sideswipe” collisions in the northbound lanes. The drive through observations identified potential sight line limitations for left turns from the median onto both northbound and southbound Highway 2, albeit some of the sight limitations are dynamic restrictions as they are related to other vehicles in the median opening or vehicles approaching the median opening in the left turn deceleration lane. The sight distance review related to static sight obstructions, provided in Section 6.4, indicates sight distance appears to be adequate for all approaches and departures at the intersection. For the review of MALs, the dynamic sight constraints are considered to be relevant.

Turn Lane Geometry

The existing lengths of acceleration and deceleration lanes were checked against the applicable design standards provided in Section D.8 of the HGDG.

Generally, an 87.5 m (25:1) lane taper is sufficient for low-volume turning movements. Higher-volume turn movements may warrant a taper and a parallel lane. Standard taper and parallel lengths for various design speeds are given in Table D.8.4 of the HGDG and are generally applicable where the highway has a high level of service (i.e., LOS of “A”). Where the highway operates at a LOS lower than “A”, it is desirable that the parallel lane length be sufficient for all deceleration to take place in the auxiliary lane. Adjustments to the parallel deceleration lane length may be required for additional storage, for the effect of trucks on storage requirements, and for the effect of grade on deceleration (HGDG Table D.6.2.6).

In Alberta, the level of service for a typical four-lane divided highway is “A” in the design hour unless the AADT exceeds 17,000. Northbound Highway 2 is expected to have a LOS lower than “A” as the two-way AADT exceeds 17,000 and there are two (2) northbound through lanes making it desirable, but not required, for all deceleration to take place in the auxiliary lane. In contrast, it is expected that southbound Highway 2 has a higher level of service as having three (3) through lanes would provide additional capacity and make it less necessary for deceleration to take place completely in the auxiliary lane.

Beyond the intersection, an acceleration lane is typically provided to facilitate right turns from the minor approach. Generally, the acceleration lane is similar in design to the deceleration lane preceding the intersection that facilitates right turns from the highway. Adjustments to the acceleration lane length may be required for the effect of grade on acceleration (HGDG Table No. 2, Figure D-6.3.4).

In Table 10, warranted auxiliary lane lengths (minimum and desirable, where applicable) are shown side-by-side with as-built auxiliary lane lengths.

Table 10: Auxiliary Lane Geometry

Direction	Lane	Lane Length		Sufficient?
		Warranted (130 km/h Design Speed)	As-built Length	
Deceleration Lanes				
Northbound	Left Turn	110 m Parallel (min.) 260 m Parallel (des.) 140 m Taper	110 m Parallel 140 m Taper*(~115 m)	Yes
	Right Turn	87.5 m Taper	110 m Parallel 140 m Taper	Exceeds
Southbound	Left Turn	87.5 m Taper	110 m Parallel 140 m Taper	Exceeds
	Right Turn	110 m Parallel (min.) 140 m Taper	110 m Parallel 140 m Taper	Yes
Acceleration Lanes				
Eastbound	Left Turn	610 m (min.) 695 m (des.)	50 m Parallel 140 m Taper	**No**
	Right Turn	87.5 m Taper	110 m Parallel 140 m Taper	Exceeds
Westbound	Left Turn	610 m (min.) 695 m (des.)	75 m Radius	**No**
	Right Turn	82.5 m Parallel (min.) 140 m Taper	110 m Parallel 140 m Taper	Exceeds

min. = minimum; des. = desirable
* measurements from GoogleEarth suggest the taper is shorter (~115 m) than identified on the as-built drawings (140 m).

As shown in Table 10, the as-built geometry of all deceleration lengths meet or exceed current AT standards, however, for the northbound left turn, the actual taper length appears to be shorter than identified on the as-built drawings.

Although MALs may be warranted as an interim safety improvement, it is expected that MALs will not be a suitable upgrade for this location as:

- The operational analysis indicates that the existing all-turns TWSC intersection is no longer sufficient to provide adequate traffic operations.
- Potential improvement strategies (i.e., median closure or traffic signal) do not benefit from the provision of MALs.

6.4 Sight Distance

Stopping Sight Distance

Adequate sight distances are critical for safe traffic operations. The minimum sight distance required at each point on the highway is stopping sight distance (SSD), which is the sight distance available on the roadway that allows a driver travelling at an assumed running speed (based on the design speed) to stop before reaching a stationary object in its path.

SSD may be inadequate when drivers must make complex or instantaneous decisions, when information is difficult to perceive, or when unexpected or unusual maneuvers are required. In such situations, it is beneficial to provide drivers with decision sight distance, a longer sight distance that provides drivers more time to react. The study intersection is rural and has a relatively simple layout, requiring drivers to make relatively few decisions or maneuvers. Therefore, for this intersection, minimum SSD is expected to be adequate.

SSD for this intersection was reviewed using minimum SSD values from Table B.2.3 of the HGDG, which are based on:

- A perception reaction time of 2.5 s;
- Typical friction factors;
- An eye height of 1.05 m; and
- An object height of 0.38 m.

Available SSD was reviewed for each approach. Table 11 provides minimum SSD (Table B.2.3 of the HGDG) side-by-side with available sight distances.

Table 11: Stopping Sight Distances

Approach	Design Speed (km/h)	Minimum SSD (HGDG Table B.2.3) (m)	Available SD (m)	Sufficient?
North	130	275	> 275	Yes
South	130	275	> 275	Yes
East	90*	170	~40	Yes*
West	90	170	> 170	Yes

* Although sight distance is limited by the approach geometry, signage ("T" Intersection, Stop Ahead, and Bidirectional Checkerboard) provides drivers with advance warning of the need to slow down. Available sight distances for these signs exceed the minimum stopping sight distance.

Minimum visibility triangles for stop-controlled approaches were checked using Figure D-4.2.1 of the HGDG and a design speed of 130 km/h for the major road. The minimum visibility triangles were determined to be clear for both the north and south approaches.

Intersection Sight Distance

Intersection sight distance (ISD) is defined as the sight distance available from a point where vehicles are required to stop on the intersecting road, while drivers are looking left and right along the major roadway, before entering the intersection. ISD is adequate when it allows design vehicles to safely make all maneuvers without significantly affecting vehicles travelling on the major roadway.

Intersection sight distances are summarized in Table 12. Required crossing sight distance values are based on Section D.4.2.2.1 of the HGDG and are larger for crossing southbound Highway 2 due to the additional crossing width associated with a third through lane on the highway. Sight distances for left turns are from Figure D-4.2.2.2 of the HGDG. Available sight distance was estimated using time-based measurements and an estimated vehicle speed of 130 km/h.

Table 12: Sight Distances for Vehicles Departing from Minor Approach or Median

Crossing or Entering	Design Vehicle on Minor Road	Required ISD (m)		Available ISD (m)	Sufficient?
		Crossing	Left Turn		
Hwy 2 NB	WB-23	500*	500*	> 500	Yes
	SU	408	385	> 500	Yes
	P	300	255	> 500	Yes
Hwy 2 SB	WB-23	500*	500*	> 500	Yes
	SU	437	385	> 500	Yes
	P	314	255	> 500	Yes

Note: Figure D-4.2.2.2 of the HGDG indicates the usefulness of sight distances in excess of 500 m has been debated. Therefore, 500 m was selected as the maximum applicable sight distance requirement.

Sight distance appears to be adequate for all approaches and departures at this intersection.

6.5 Access Management and Intersection Spacing

Highway 2

Access Management

With a Freeway/Expressway Functional Classification, Highway 2 is a strategically important corridor that requires a high level of access management. In the study area, Highway 2 currently functions as an expressway with a mix of interchanges and at-grade intersections. Ultimately, Highway 2 will evolve into a freeway with access only permitted via grade-separated interchanges. Table I.5 of the HGDG identifies the following access management guidelines for public roads intersecting an Expressway/Future Freeway:

- Minimum spacing of 1.6 km is required.
- Existing intersections may remain on temporary basis only if minimum spacing attained. Non-conforming accesses are to be removed when upgrading of highway occurs.
- New accesses not permitted unless minimum spacing is attained.
- Service interchanges are normally spaced up to 16 km apart in a rural environment.

Planning Studies

ISL did not receive or find any studies identifying future plans for the Highway 2 corridor at the intersection.

Intersection Spacing

Junctions on Highway 2 are listed in Table 13 along with their existing configuration and spacing.

Table 13: Highway 2 Accesses

Access Type (Intersection Type)	Intersecting Road	Intersection Number	km	Distance to Last Access (km)	
				Access	Public Road
Highway (interchange)	Hwy 7 / Hwy 547	1664	15.377	6.932	6.932
Municipal Road (at-grade)	TR204 (Study Intersection)	1277	17.677	2.300	2.300
Municipal Road (at-grade)	TR210	19291	21.448	3.771	3.771
Municipal Road (at-grade)	TR212	1200	25.465	4.017	4.017
Highway (interchange)	Hwy 2A / Hwy 522	34	28.669	3.204	3.204

The existing intersection spacing on Highway 2 exceeds the minimum spacing requirement of 1.6 km.

6.5.1 Township Road 204

Access Management

Chapter I (Access Management Guidelines) of the HGDG does not indicate the minimum offset for a private access from an expressway, however, it is expected that it would be similar to the minimum offset for a private access from a major two lane highway, which is 50 m. An offset of 400 m or greater is desirable for a major access (i.e. public roadway, multi-parcel residential, commercial, or industrial).

Frontage Service Roads

Frontage service roads are public roads that are adjacent to and generally parallel to major roads such as freeways, expressways and major arterials. RR290 intersects with TR204 east of Highway 2 and functions as a frontage service road. The HGDG provides the following guidance regarding highway to service road intersection spacing:

- Section D.3.6 indicates that the minimum offset distance between the highway and service road intersections is the length of the design vehicle plus a 3.0 m buffer to the edge of travel lane on each end of the design vehicle. For a WB-21 or WB-23, the required offset distance, including buffers at each end, is 31 m. For a WB-36, the required offset distance including buffers at each end is 44 m.
- Figure 9.1f indicates the distance from the centreline of the service road intersection to the centreline of the intersection with the nearside highway lanes is 46 m, which could be considered the minimum.

Intersection Spacing

Accesses on TR204 are listed in Table 14 along with their existing configuration and spacing from the study intersection.

Table 14: Township Road 204 Accesses

Access Type (Intersection Type)	Intersecting Road	From Study Intersection	
		Spacing*	Direction
Field (at-grade)	--	440	West
Municipal Road (at-grade)	76th St E	425	West
Residential (at-grade)	--	218	West
Municipal Road (at-grade)	RR290	48	East

Note: Spacing is the centreline to centreline distance between intersecting roads, and is measured from the centreline of the nearside highway lanes when measured from Highway 2.

Considering Table 14 the following conclusions can be made;

- The location of the field access in relation to Highway 2 is acceptable as it exceeds the 50 m minimum offset for a private access.
- The location of the 76th Street E in relation to Highway 2 is acceptable as it exceeds the 400 m desirable offset for a major access.
- The location of the residential access in relation to Highway 2 is acceptable as it exceeds the 50 m minimum offset for a private access.
- The location of the RR290 service road in relation to Highway 2 just exceeds the 46 m spacing shown for an at-grade intersection in Figure 9.1f of the HGDG, and allows just enough space (i.e., 31 m) for a WB-21 or a WB-23 with a 3.0 m buffer on each end.

6.6 Illumination Warrant and Analysis

Illumination requirements were considered for the study intersection using guidelines contained in the AT “Highway Lighting Guide” and the TAC guideline “Illumination of Isolated Rural Intersections”.

Illumination Warrant

The TAC Warrant for Illumination of Isolated Rural Intersections was used to evaluate the intersection. The warrant considers the geometric, operational, environmental and safety characteristics of the intersection. Nighttime collisions are considered in the safety portion of the warrant. For unsignalized intersections, the following point system is used to determine if illumination is warranted:

- Full illumination is warranted for a score of greater than 240 points;
- Partial and/or delineation lighting is warranted for a score of between 120 and 240 points; and
- Lighting is not warranted for a score of less than 120 points.

Partial lighting refers to the illumination of key decision areas on the approach to an intersection; delineation lighting refers to “sentry” lighting that marks an intersection location for approaching traffic and illuminates vehicles or pedestrians on the cross street.

For the safety portion of the warrant, four (4) nighttime collisions occurred over the past three (3) years, however, two (2) of the collisions are considered to be attributable to slush/snow/ice conditions rather than inadequate lighting:

- One (1) “Sideswipe Same Direction” collision that occurred when a northbound vehicle slid in slush/snow/ice conditions and collided with other northbound vehicles.
- One (1) “Rear End” collision that occurred when a northbound vehicle slid in slush/snow/ice conditions to the side of the road before being rear-ended by another northbound vehicle.

The safety portion of the warrant was completed for two (2) scenarios: the first considers collision frequency rounded up to 1.0 (for two (2) nighttime collisions over a three year period); the second considers collision frequency rounded up to 2.0 (for all four (4) nighttime collisions over a three year period). Results of the illumination warrant analysis are provided in Table 15 and warrant worksheets are included in Appendix F.

Table 15: Illumination Warrant for Existing Conditions

Scenario	Warrant Points	Lighting Warranted	Upgrades Required?
Collision Frequency of 1.0	231	Delineation Lighting	No
Collision Frequency of 2.0	261	Full Illumination	**Yes**

For the first scenario, the warrant point value exceeds 120 points and delineation lighting is warranted. It is noted that the warrant point value is only 9 points shy of the threshold for full illumination (240 points). Delineation lighting is currently installed at the intersection.

For the second scenario, the warrant point value exceeds 240 and full illumination is warranted.

Illumination Analysis

- **Lighting Levels:** Analysis was not undertaken by ISL to confirm the actual lighting levels of the existing illumination system. Note that analysis of design lighting levels is not required for delineation lighting.
- **Pole Offsets**: Measured pole offsets were compared to Figure 5.1 of the AT “Highway Lighting Guide” to confirm pole protection requirements.
  - For Highway 2 (130 km/h design speed), poles must be protected if they are offset less than 5.5 m from the edge of the through lane.
  - For the minor approaches (90 km/h design speed), poles must be protected if they are offset less than 3.5 m from the edge of the through lane.

The offsets for each pole are sufficient for a breakaway assembly to be satisfactory. The 4.1 m offset for the pole in the south median (Pole #17035338) is relative to the edge line within the median and is expected to be sufficient as the vehicles travelling closest to the pole will be those completing an eastbound left turn and travelling at speeds substantially less than 130 km/h. The existing 4.1 m offset is adequate for speeds of up to 100 km/h. The distance between the pole to the edge of the adjacent Highway 2 through lanes is significantly greater than 4.1 m.

Based on the review of light standard offsets, no additional protection is recommended.

7.0 Traffic Conflicts

During the intersection review, close attention was paid to traffic operations and potential conflicts at the intersection. The following potential conflicts were identified:

- Due to operational and geometric conditions (i.e., high traffic volumes, large crossing distance), it may be challenging for a vehicle crossing Highway 2 to judge safe gaps for a crossing maneuver. ***Potential for "Right Angle" collision between Highway 2 vehicle and westbound/eastbound vehicle attempting crossing maneuver.***
- For a vehicle on a stop-controlled approach, visibility of oncoming highway vehicles may be blocked by other highway vehicles, including those in the adjacent right turn deceleration lane. ***Potential for "Right Angle" collisions as sight lines for drivers on the stop-controlled approach are temporarily blocked and drivers may be unable to adequately judge gaps.***
- At the eastbound stop line on the west approach, drivers have limited visibility of the Highway 2 median and cannot easily discern how much space is available in the median opening. This could create an unsafe situation if the eastbound driver realizes there is inadequate space in the median opening after initiating the crossing maneuver. ***Potential for "Right Angle" collision between eastbound vehicle and southbound Highway 2 vehicle. Potential for a "Rear End" or "Sideswipe" collision between eastbound vehicle and a vehicle in the median opening.***
- Traffic conflicts may occur when multiple vehicles enter or occupy the median opening simultaneously, such as:
  - When a highway left turn vehicle enters the median opening at the same time as an opposing highway left turn vehicle, drivers may be unsure of whether to turn in front of or behind one another. ***Potential for "Left Turn Across Path" or "Sideswipe – Opposite Direction" collision between opposite left turn vehicles.***
  - When a highway left turn vehicle enters the median opening at the same time as an opposing through or left turn vehicle from the stop-controlled approach, the highway left turn vehicle may enter the median opening on the left side of centre and potentially try to utilize the same space as the vehicle entering from the minor approach. ***Potential for "Head On" collision or "Sideswipe – Opposite Direction" collision between left turn vehicle from the highway and vehicle entering median from stop-controlled approach.***
  - When a minor approach left turn vehicle and through vehicle are queued side-by-side in the median opening, there is potential for visibility of oncoming highway vehicles to be obstructed by the through vehicle. ***Potential for "Rear End" collisions as sight lines for driver of left turn vehicle is temporarily blocked and the driver may be unable to adequately judge gaps to enter the highway. Potential for "Side Swipe – Same Direction" or "Off-Road" collision if higher speed vehicle on the highway attempts evasive maneuver.***
- There is no acceleration lane for westbound left turn vehicles and the acceleration lane for eastbound left turn vehicles is relatively short. Left turn vehicles from the median must complete most of their acceleration in the left through lane of the highway. ***Potential for "Rear End" collisions if the vehicle in the left highway lane does not recognize that a vehicle has just completed the left turn and is travelling significantly slower. Potential for "Sideswipe – Same Direction" or "Off-Road" collision if higher speed vehicle attempts evasive maneuver.***

- Slush/snow/ice surface conditions were a factor in a high number of collisions at the intersection and resulted in vehicles losing control. ***Potential for "Right Angle", "Rear End" or "Sideswipe – Same Direction" collision between two or more vehicles that have difficulty slowing or stopping. Potential for "Off Road" collision by vehicle completing an evasive maneuver to avoid a vehicle that has been involved in a collision, or that has slowed or stopped.*** Although identified as a traffic conflict, winter driving conditions occur throughout Alberta and there is an expectation that drivers recognize winter driving conditions and adjust their vehicle equipment and driving behavior to match the prevailing environmental and roadway conditions.
- On the west approach, a vehicle pulled over on the north shoulder of TR204 may encroach into the westbound travel lane and present a hazard to westbound traffic. ***Potential for "Rear End" or "Sideswipe – Same Direction" collision between westbound vehicle and vehicle that is pulled over onto the north shoulder.***
- At the TR204/RR290 intersection, right of way control is not provided by traffic control devices for simultaneous arrival of:
  - A southbound left turn vehicle and an eastbound through or left turn vehicle. ***Potential for "Left Turn Across Path" collision at the TR204/RR290 intersection between southbound left turn vehicle and eastbound left turn vehicle. Potential for "Sideswipe – Same Direction" collision between southbound left turn vehicle and eastbound through vehicle.***
  - A westbound through vehicle and a southbound left or right turn vehicle. ***Potential for "Left Turn Across Path" collision at the TR204/RR290 intersection between southbound left turn vehicle and westbound through vehicle. Potential for "Rear End" or "Sideswipe – Same Direction" collision between westbound through vehicle and southbound right turn vehicle.***

8.0 Identified Safety Issues

Based on the collision analysis, site visit, geometric analysis, operational analysis and observed traffic conflicts, the following safety issues are identified:

- **Inadequate Level of Traffic Control:** Both the HCM 2010 TWSC procedure and the traffic signal warrant suggest that an all-turns TWSC intersection is no longer sufficient.
- **Challenging Gap Selection:** Drivers on the stop-controlled approaches and in the median opening have difficulty selecting safe gaps to cross the highway, especially to cross the three (3) through lanes of southbound Highway 2.
- **Blocked Sight Lines:** The following sight line issues were identified:
  - When a minor approach left turn vehicle and through vehicle are queued side-by-side in the median opening, there is potential for visibility of oncoming highway vehicles to be obstructed by the adjacent through vehicle.
  - For a vehicle on a stop-controlled approach, visibility of oncoming highway traffic may be obstructed by a vehicle in the adjacent right turn deceleration lane, the sight line issue can be mitigated if drivers wait for the deceleration lane to clear.
  - For a vehicle on a stop-controlled approach, visibility of faster oncoming highway traffic can be obstructed by closer, slower highway vehicles and make it difficult to select a safe gap. At this intersection, the potential for this to occur is higher when crossing southbound Highway 2 than northbound Highway 2 as there is an additional through lane in the southbound direction.
  - Vehicles slowing in the left turn deceleration lanes may block sight lines for vehicles turning left or crossing from the median.
  - The difference in elevation between southbound and northbound Highway 2 limits visibility of the median for eastbound vehicles on the west approach and conceals the amount of available space.
- **Challenges with Bullet-Nose Median Opening:** Bullet-nose median openings present unique challenges for drivers including:
  - There are no markings or signs to guide drivers through the median.
  - The Alberta Use of Highway and Rules of the Road Regulation and the Alberta Drivers Handbook do not provide clear guidance on left turns through a median opening on a divided highway. This potentially leads to driver confusion as to what path they should take through the median opening.
  - When highway left turn vehicles enter the median opening at the same time as an opposing through or left turn vehicle from the stop-controlled approach, the highway left turn may enter the median opening on the left side of centre and potentially try to utilize the same space as the vehicle entering from the minor approach.
  - The potential for driver confusion in the median opening increases with higher traffic volumes because there is a greater probability of conflicting movements occurring at the same time and there are more things requiring the driver's attention.
- **Speed Differential for Median Left Turns:** There is a significant speed differential between left turn vehicles departing the median opening and through vehicles on Highway 2.

- **Stopping on West Approach:** Site observations, tire marks and wear indicate that vehicles pull over on the north shoulder of the west approach, a location where stopping is undesirable as it could contribute to a collision.
- **Insufficient Traffic Control at TR204/RR290 Intersection:** Traffic control is insufficient at the TR204/RR290 intersection to clearly assign right of way to the conflicting southbound left turn and eastbound through or left turn traffic movements; and the westbound through and southbound left or right traffic movements. In each case, drivers may not expect or recognize that the right hand rule applies.

8.1 Signage and Rumble Strip Deficiencies

The following signage deficiencies were identified. The majority of the deficiencies are not urgently in need of repair, however, if not addressed, further deterioration could lead to the sign(s) and/or rumble strips becoming inoperative and/or impact safe operation of the intersection:

- **Incomplete Breakaway Features:** Some of the wood sign posts located within the clearzone do not have holes drilled into the post to complete the breakaway feature.
- **Sign Spacing and Placement:**
  - Two (2) of the Tourist Oriented Directional signs (Riverbend Campground and the Riverview Bed & Breakfast / On Deck Recreational Facility) on the southbound approach are spaced at 100 m and appear to be spaced too closely. For the number of words on the signs, 200 m spacing would be more appropriate.
  - On the eastbound approach, the Stop Ahead, Divided Highway and Rumble Strips signs are located at 215 m, 270 m, and 315 m, respectively, west of the intersecting road. Drawing TCS-A4-430C indicates that the Stop Ahead and Rumble Strips signs should be 250 m and 400 m, respectively, from the intersecting road. Consideration should be given to adjusting the sign placement with the next pavement overlay to follow Drawing TCS-A4-430C. A minimum of 50 m should be provided between signs.
- **Misaligned and/or Damaged Signage:**
  - The Do Not Enter sign on the median side of the northbound lanes has minor damage (fading symbols) to the sign face. The sign is still legible.
  - The Stop Line sign on the west approach is bent and has minor damage (scuff marks) to the sign face. The sign is still legible.
  - The Stop Ahead sign on the west approach has minor damage (cracking) to the sign face. The sign is still legible.
  - The Rumble Strips sign has significant damage (shotgun damage) to the sign face. The sign is only partially legible and should be replaced.
  - The Stop Line sign on the east approach is bent and has minor damage (scuff marks) to the sign face. The sign is still legible.
  - The Bidirectional Checkerboard sign on the east approach has minor damage (flaking) to the sign face. The sign is still legible.
  - The Stop Ahead sign on the east approach has minor damage (flaking) to the sign face. The sign is still legible.

- **Rumble Strips:**
  - The transverse rumble strips in advance of the eastbound Stop sign are worn in the wheel paths. Consideration should be given to re-milling the rumble strips if an overlay is not planned for the near future.

8.2 Pavement Marking Deficiencies

The majority of the pavement marking deficiencies are not urgently in need of repair, however, further deterioration could lead to pavement markings becoming inoperative and/or impact safe operation of the intersection:

- The north and south edge lines on the west approach are deteriorating.
- The right STOP word marking on the east approach is fading.

It is recognized that AT completes ongoing maintenance of pavement markings and that these pavement markings may have been repainted as part of the maintenance program following completion of the site inspection.

9.0 Improvement Strategies

The review of improvement strategies considered, among other things, the NCHRP Report 650, “Median Intersection Design for Rural High-Speed Divided Highways”, which provides a table of potential rural expressway intersection safety improvements. These improvements are categorized into three fundamental types:

1. **Conflict-point reduction** treatments aim to reduce the number of conflict points or to replace conflict points associated with the greatest crash risk (e.g., crossing path) with less risky conflict points (e.g., merge and diverge).
2. **Gap selection aids** are meant to help the minor road driver determine whether a gap is safe to accept and could include any measures that help minor road drivers better see and anticipate the speed of oncoming traffic.
3. **Intersection recognition devices** are intended to help approaching drivers become more aware of the intersection so that they might be better prepared to react accordingly, and can be divided into two (2) categories: those for drivers on the minor road, and those for drivers on the major road.

Potential safety improvement options are listed in Table 16 and highlighted as follows:

- Green highlighting identifies potential solutions to address known safety issues.
- Yellow highlighting identifies options that are considered viable components if included with one of the green options.
- Red highlighting identifies options that are not considered suitable strategies for addressing the safety issues identified at the Highway 2 / TR204 intersection.

The options highlighted in green are discussed further in the following sections.

Table 16: Potential Rural Expressway Intersection Safety Treatments

Category	Subcategory	Treatment	Discussion
1. Conflict Point Management Strategies	*1. Removal / Reduction Through Access Control*	1. Conversion of entire expressway corridor to freeway	This is the ultimate plan for the Highway 2 corridor and resolves the safety issues identified for the TR204 intersection, however, this is not an interim solution.
		2. Isolated conversion to grade separation or interchange	Given the proximity of the intersection to the existing Highway 7 / Highway 547 interchange, conversion of the intersection to an interchange is not expected to be a viable option.
		3. Close low-volume minor road intersections and use frontage roads	Total closure of the TR204 intersection is expected to be part of the ultimate plan to convert the expressway corridor to freeway, however, total closure may not be an acceptable interim solution.
		4. Close median crossovers (right-in, right-out access only)	Closure of the TR204 median opening is a viable option. Although median closure would result in additional trip lengths for some movements, prohibited movements can be re-routed to make use of the Highway 2 interchanges at Highway 7 / Highway 547 and Highway 2A / Highway 522. Options for median closure include: 1. Minor Approach Turn Restrictions – use channelization to restrict minor approach left and through movements. Provide channelization to allow unrestricted Highway 2 left turns. 2. Full Median Closure – full median closure to prohibit Highway 2 left turns and minor approach left and through movements.
		5. Convert four-legged intersection into "T" intersection, or initially construct "T" intersections instead of four-legged intersections * Use a "one-quadrant interchange" design (if necessary)	This is not considered a viable option as "T" intersection(s) on Highway 2 do not address the primary safety issues. Gap selection would still be a challenge for vehicles entering or departing Highway 2 at TR204.
	2. Replacement of High-Risk Conflict Points	1. J-turn intersections (indirect minor road crossing and left-turns)	A J-turn intersection is not considered a feasible option as the median is not wide enough for a median U-turn lane and large distances would be required for weaving on southbound Highway 2.
		2. Offset "T" intersections (indirect minor road crossing)	This is not considered a viable option as "T" intersection(s) on Highway 2 do not address the primary safety issues. Gap selection would still be a challenge for vehicles entering or departing Highway 2 at TR204 and large distances would be required for weaving on Highway 2.
		3. Jughandle intersections (indirect left-turns)	Jughandles would be required for both northbound and southbound left turns resulting in three intersections replacing the existing intersection. A jug handle intersection would not meet the 1.6 km intersection spacing requirement for Highway 2. Jughandles are typically implemented at signalized intersections to reduce the number of required phases and improve the intersection level of service. The basic implementation of a traffic signal at TR204 would be sufficient to resolve the identified issues.
		4. Other indirect left-turn treatments (Michigan lefts)	Michigan left turn intersections require traffic signal control to allow the minor road through traffic to travel straight through the intersection. They are typically used to reduce phases at signalized urban and suburban intersections to improve operation and level of service. Determined to be inappropriate for Highway 2 / TR204 based on continued through movements from the minor road, and that a traffic signal without the Michigan left turn modifications would likely perform acceptably.
		5. Expressway semi-roundabout intersection (ES-RI)	Semi-roundabout intersections were determined to be inappropriate based on the required speed reduction for implementation of a roundabout style intersection plus significant reconstruction of the Highway 2 approaches, which would be throwaway for the ultimate Highway 2 corridor.
	3. Relocation or Control	1. Provide left/right turn lanes or increase their length	Right and left turn deceleration lanes are provided for both directions on Highway 2 at the intersection. If an option is chosen that maintains the median opening, the northbound left turn lane deceleration lane and taper may require lengthening.
		2. Provide free right turn ramps for exiting expressway traffic	Considering the right turn volumes and the conflicting through volumes, it is not expected that the provision of a free right turn with a lane away would be beneficial for either direction.
		3. Minimize median opening length	Reducing median opening length is not recommended. The existing median opening length meets AT guidelines and is required to accommodate left turn truck movements.
		4. Signalization	The TAC traffic signal warrant is met. Traffic signals control conflict points by alternately assigning right of way to conflicting movements and provide gaps for vehicles to complete movements through the intersection. Installation of a traffic signal would require a speed limit reduction to 80 km/h on Highway 2.
2. Gap Selection Aids	*1. Vehicle Detection (Intersection Sight Distance Enhancements)*	1. Provide clear sight triangles	N/A – Sight triangles are adequate.
		2. Modify horizontal/vertical alignments on intersection approaches	N/A – Horizontal and vertical alignments are satisfactory.

Category	Subcategory	Treatment	Discussion
		3. Realign skewed intersections to reduce or eliminate skew	N/A – Angle of intersection (~90°) is satisfactory.
		4. Move minor road stop line as close to expressway as possible	N/A – Existing stop line placement meets AT guidelines and allows for satisfactory sight lines.
		5. Provide offset right turn lanes	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
		6. Provide offset left turn lanes	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
	2. Judging Arrival Time	1. Intersection decision support system (IDS) or other dynamic device	N/A
		2. Roadside markers/poles (static markers at a fixed distance)	Not considered due to potential for driver misunderstanding.
	3. Merging / Crossing Aids --- *(Promoting Two-Stage Gap Selection)*	1. Provide left turn acceleration lanes (MALs) for merging traffic	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
		2. Provide right turn acceleration lanes for merging traffic	N/A – Existing right-turn acceleration lanes are suitable for the design speed of Highway 2.
		3. Expressway speed zoning/enforcement near intersections	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations. If a traffic signal is considered, a reduced speed limit on Highway 2 would be required.
		4. Widen median to provide for adequate vehicle storage	N/A – The median is wide enough to provide adequate vehicle storage for two-stage gap selection.
		5. Add centerline, yield/stop bars, and other signage in the median	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
		6. Extend left edge lines of expressway across median opening	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
		7. Public education campaign teaching two-stage gap selection	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
3. Intersection Recognition Devices	*1. Intersection Treatments*	1. Provide overhead control beacon reinforcing two-way stop control	N/A – Based on site observations and collision reports, drivers on the minor approaches recognize the intersection and traffic controls.
		2. Provide intersection lighting	N/A – Warranted level of lighting already in place, however, the warrant for full illumination is almost met. If the intersection is signalized, full illumination will be required.
	2. All Approaches	1. Enhanced (overhead/larger/flashing) intersection approach signage	N/A – Flashing red lights currently in place on minor approaches. Intersection awareness not considered an issue on major approaches.
	3. Expressway Approaches	1. Provide diagrammatic freeway-style intersection guide signs	N/A – Intersection awareness not considered an issue on major approaches.
		2. Provide Dynamic WATCH FOR ENTERING TRAFFIC WHEN FLASHING Signs	A dynamic traffic warning system could reduce the speed of Highway 2 vehicles, when activated, resulting in reduced collisions and/or reduced collision severity. A dynamic traffic warning system would not be expected to improve the LOS during peak periods. Intersection Conflict Warning Systems (ICWS) provide dynamic signs, variable message signs and flashers tied to detection systems to provide active warning to traffic on the major road, minor road or both roads at the intersection. There could be benefits realized from the implementation of a system to warn drivers of other traffic at the intersection. Implementation of ICWS on high volume roadways is not beneficial as the reduced traffic gaps result in continuous activation of the system.
		3. Use of a variable median width (wider in intersection vicinity)	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
		4. Change median type in vicinity of intersection	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
	4. Minor Road Approaches	1. Use STOP-AHEAD pavement marking and in-lane rumble strips	Stop sign compliance does not appear to be an issue at this location. STOP AHEAD pavement marking and transverse rumble strips already in place for the west approach.
		2. Provide a stop bar (or a wider one)	N/A – Stop bars currently in place and recognized.
		3. Provide divisional/splitter island at mouth of intersection	An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations. Provision of a divisional/splitter island could be incorporated into a right-in, right-out configuration and/or with a partial median closure.
		4. Provide signage/marking for prevention of wrong-way entry	N/A – Wrong way signage currently in place.

Note: Items highlighted in green are discussed further as potential countermeasures.

Ultimately full closure of the Highway 2 / TR204 intersection would provide the greatest operational and safety benefit to this section of Highway 2. The existing road network on the west side of Highway 2 provides access to interchanges at Highway 7 / Highway 547 (south of Okotoks) and Highway 2A / Highway 522 (north of Okotoks) through Okotoks. On the east side of Highway 2, local road access is only available to the interchange at Highway 2A / Highway 522 (north of Okotoks). It is expected that the adjacent communities and residents would expect upgrades to the service road network to improve access to these interchanges in the event of access restrictions or closures to Highway 2.

The following sections identify options to improve safety for the intersection of Highway 2 and TR204. Note that the improvements and cost estimates do not consider the potential of throwaway costs at the point of implementation of the ultimate improvements. It is recommended that a more thorough review of the proposed improvements be undertaken prior to design of any interim improvement to minimize throwaway, and to consider the benefit of the options relative to the timing of the ultimate improvements.

It is recognized that some of the suggested improvements may divert traffic to other at-grade intersections, and if similar improvements are not considered at those locations, there is the potential that safety and operational issues may be exacerbated. For example, access restrictions at TR204 could potentially divert some traffic movements to TR210 or TR212. The resolution of operational and safety issues at TR204 may require the implementation of similar or alternate measures at adjacent intersections. Ultimately, all of these at-grade accesses would be closed when Highway 2 is upgraded to a freeway. It is expected that implementation of short-term improvements would need to consider improvements and or development of sections of the service road network to provide access north and south to the Highway 7 / Highway 547 and Highway 2A / Highway 522 interchanges. This level of review would be better suited to a functional planning study than a site-specific safety review.

Discussions of specific improvements at the TR204 intersection consider that traffic will be redirected, when necessary, to the interchanges and that alternative route options related to short cutting or U-turns at existing at-grade intersections would be addressed with similar improvements or closure.

The selection and discussion of safety improvement strategies eliminated options that were felt to have significantly higher cost, have potential to result in greater throwaway, and/or not provide a significant advantage over a more economical and efficient solution.

9.1 Signage, Pavement Markings and Rumble Strips

Some actions could be taken to address deficiencies with signs, pavement markings and rumble strips, however, it is expected that they would have a negligible effect on the majority of the collisions occurring at this intersection. These improvements include:

- Repair/replace bent and/or damaged signs and sign posts.
- Complete the breakaway features on sign posts.
- Adjust the placement and spacing of signs to follow “Design Bulletin #82/2014”.

- Adjust the Tourist Oriented Directional signs (Riverbend Campground and the Riverview Bed & Breakfast / On Deck Recreational Facility) on the southbound approach to have 200 m spacing.
- Provide an advance Local Road Name sign on the southbound approach 190 m to 240 m north of the intersection.
- Re-mill the rumble strips on the west approach if an overlay is not planned for the near future.
- At the RR290/TR204 intersection, install Yield sign on southbound RR290 and a Stop sign on westbound RR290.
- Install No Parking signs on the north shoulder of the west approach.

If the intersection is maintained open, the repair of these identified deficiencies could be considered with future maintenance activities or included with other intersection improvements.

9.2 Intersection Conflict Warning System for Highway 2

Dynamic signage could be provided on Highway 2 in advance of the intersection to advise Highway 2 drivers that vehicles are present at the TR204 stop bars. For the purpose of this review the dynamic signage is considered to include a static overhead sign supplemented with flashing beacons. The static sign would provide a “Vehicles Entering When Flashing” message. Loops, radar or video detection equipment would be installed for the TR204 approaches to identify vehicles at the stop bar. Pros and cons are discussed in Table 17.

Table 17: Pros and Cons – Intersection Conflict Warning System for Highway 2

Pros	Cons
• Intersection warning device. • Activated when vehicles present on TR204 approach. • Increase intersection awareness • Prepare approaching drivers to slow down and/or complete evasive maneuvers. • Heightened awareness and potentially reduced perception/reaction time for Highway 2 drivers. • Approaching vehicles may reduce speed when system is active. • Potential reduction in right angle and rear end collisions. • Reduced collision severity for slower moving vehicles on Highway 2. • Potential to install with solar powered flashers and radio communication between the controller and the flashers. • Could be combined with a Traffic Approaching System on TR204. (additional cost)	• Medium implementation cost. • Highway 2 drivers may not recognize flashing beacons or adjust speed / driving behaviour when beacons flashing. • No warrant system to determine when or where a Traffic Entering System should be installed. • Video cameras may not be suitable detection devices if there are visibility issues (fog) on Highway 2. • If system control is completed with relays and/or simple detection control, the system reliability may be reduced resulting in increased down time. • Failed detection would result in continuously flashing beacons. • If beacons are flashing and approaching Highway 2 traffic does not see vehicles on the TR204 approaches, there is potential that local drivers may ignore the system. • When the flashing beacons are not activated, Highway 2 drivers may have a heightened perceived sense of security and increase their speed believing that no traffic is present at the intersection. • In a power outage, the flashers would not activate, however, drivers are expected to be aware of their driving environment and recognize vehicles at the TR204 intersection approaches.

Intersection Conflict Warning System for Highway 2 Estimated Cost: $250,000

9.3 Intersection Conflict Warning System for TR204

A Traffic Approaching System could be provided on the TR204 approaches to advise drivers that vehicles are approaching on Highway 2. For the purpose of this review, a variable message sign (VMS) or electronic sign would be side mounted and supplemented with a “When Flashing” tab and flashing beacons. The VMS or electronic sign would provide a “Traffic Approaching” message when vehicles are detected on Highway 2 by loops, radar or video detection equipment. To minimize confusion, the electronic signs would be blank when there are no identified approaching vehicles on Highway 1. Pros and cons are discussed in Table 18.

Table 18: Pros and Cons – Intersection Conflict Warning System for TR204

Pros	Cons
• Intersection warning device • Activated when vehicles approaching on Highway 2. • Assist drivers to choose appropriate gaps for crossing and turn movements. • Potential reduction in right angle and rear end collisions. • Potential to install with solar powered detection and radio communication between the controller and detection devices. • Could be combined with a Traffic Entering System on Highway 2. (additional cost) 	• Medium implementation cost. • No warrant system to determine when or where Traffic Approaching System should be installed. • Challenging to locate signs within the drivers cone of vision at the stop bar locations on the stop controlled TR204 and median approaches. It is expected that the signs would have to be placed on the far sides of the Highway 2 lanes. Signs for vehicles in the median opening could be blocked by right and left turning vehicles from Highway 2. • Collision severity might not be reduced as system does not provide the potential to alter travel speeds on Highway 2 unless combined with a Traffic Entering System on Highway 2. • Video cameras may not be suitable detection devices if there are visibility issues at the intersection. • If system control is completed with relays and/or simple detection control, the system reliability may be reduced resulting in increased down time. Operational / equipment redundancy should be considered in the system design. • Potential for drivers to become reliant on the system. In the event of system failure or power outage, the system would be inoperable and drivers not knowing the system has malfunctioned might continue to follow the direction of the system and assume there is no approaching traffic. An uninterruptible power supply (UPS) would maintain operation of the system for a period of time but would not continue operation for extended power outages or other types of system failure. • System may not properly report gaps related to very high speed vehicles on Highway 2. • Failed detection would result in continuously flashing beacons. Continuously flashing beacons could confuse drivers who rely on the system and increase delay on the TR204 approaches. • Potential exposure to legal liability in the event that a driver follows the direction of the system and is involved in a collision.

Intersection Conflict Warning System for TR204 Estimated Cost: $200,000 (NOT RECOMMENDED)

ISL does not recommend implementation of a Intersection Conflict Warning System for TR204 based on the high traffic volumes on Highway 2 resulting in reducing potential for the system to identify suitable gaps, the risk associated with drivers becoming reliant on the system to make decisions to enter the intersection and the potential for system malfunction and/or power outage.

9.4 Movement Restrictions

9.4.1 Minor Approach Turn Restrictions

This option would restrict left turn and through movements on the TR204 approaches, and allow unrestricted movement of the left turns from Highway 2. Turn restrictions could be accomplished by either of the following treatments separately, or by a combination of both treatments:

- Develop divisional islands on the minor approaches to restrict left turn and through movements from the minor approaches while continuing to allow left turns from Highway 2 (Figure 11).
- Conversion of the existing median opening to a directional median opening that allows left turns from Highway 2 while restricting minor approach left turn and through movements (Figure 12).

The result of both of these options is the minor approaches would operate as right-in, right-out and the left turns from Highway 2 would continue to be allowed. With no conflicting movements in the median opening, an additional 15 to 20 m would be available in the median opening for left turn vehicle storage.

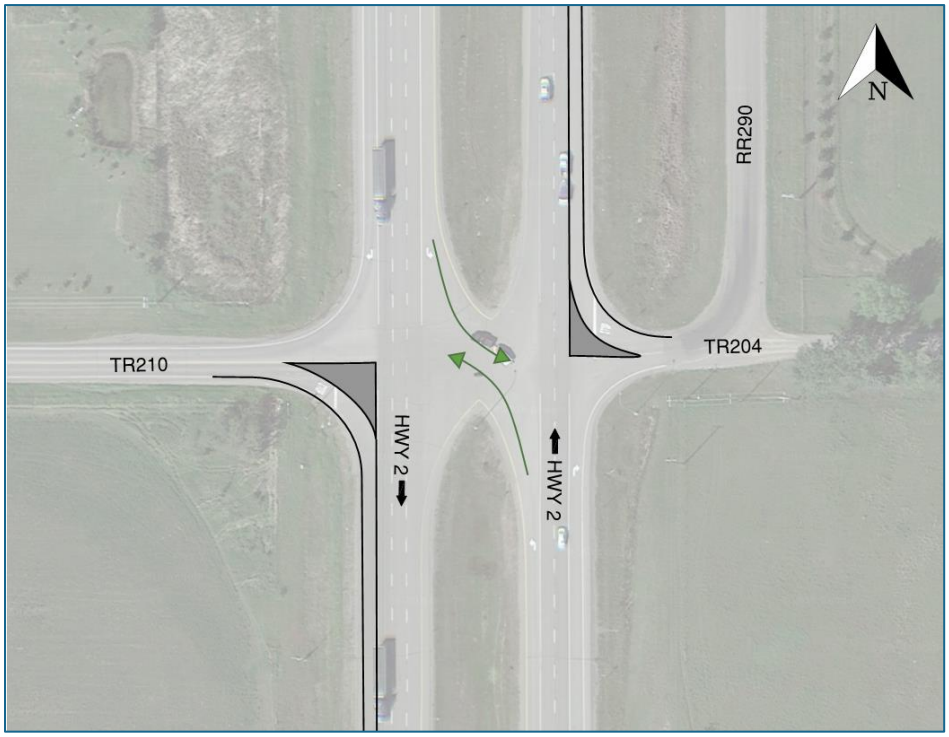


Figure 11: Turn Restrictions Using Divisional Island on Minor Approaches

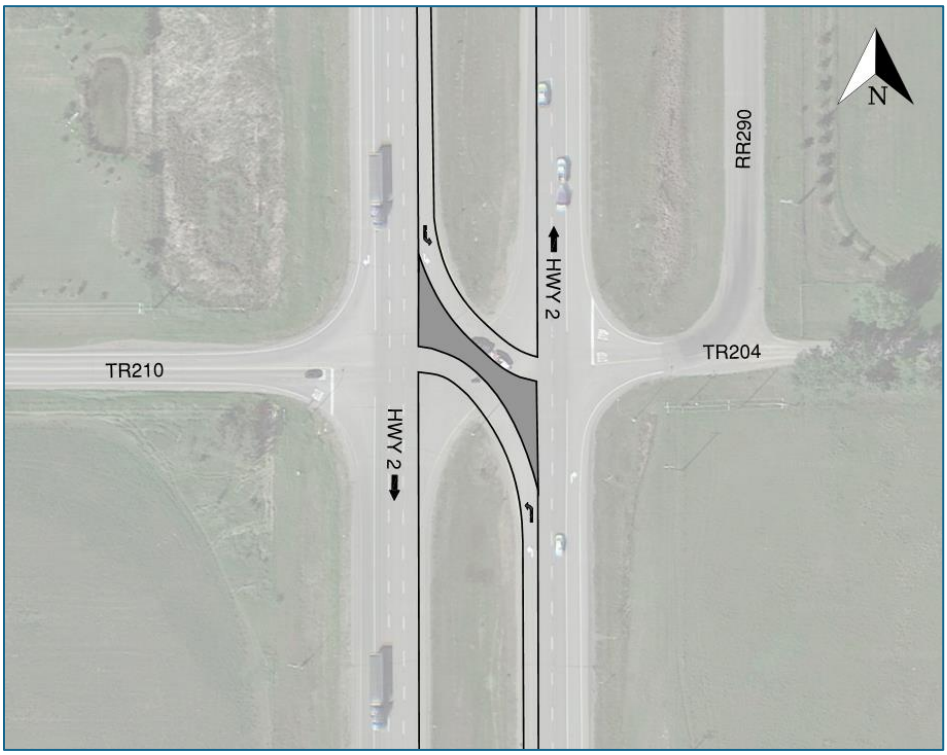


Figure 12: Turn Restrictions Using Directional Median Opening

Restricted movements could be re-routed as follows:

- Eastbound left turn and through movements (combined total up to 104 vehicles in peak hour) would complete a right turn, head south to the Highway 7 / Highway 547 interchange and cross the interchange, and then head north on Highway 2 to continue northbound or complete a right turn at TR204. For these movements, the proposed turn restrictions would result in additional trip length of approximately 5.3 km. Alternately, these movement could use the local road network to travel to Highway 2A and the Highway 2A / Highway 522 interchange to complete the left turn movement or cross Highway 2 to access the acreage residential areas on the east side of Highway 2.
- Westbound left turn and through movements (combined total up to 38 vehicles in peak hour) would complete a right turn, head north to the Highway 2A / Highway 522 interchange and cross the interchange, and then head south on Highway 2 to continue southbound or complete a right turn at TR204. For these movements, the proposed turn restrictions would result in additional trip length of approximately 22.5 km.

Synchro analysis results based on the HCM 2010 TWSC procedure are shown in Table 19 and Table 20. Synchro reports are provided in Appendix F.

Table 19: AM Peak Hour Synchro Results – Minor Approach Turn Restrictions

Performance Measure	Northbound			Southbound			Eastbound	Westbound
	L	T	R	L	T	R	R	R
LOS	D	--	--	B	--	--	D*	C*
Delay (s)	27.8	--	--	14.7	--	--	34.8	17.1
V/C	0.29	--	--	0.10	--	--	0.65	0.16
95% Queue (veh)	1.1	--	--	0.3	--	--	4.3	0.6
Intersection LOS / Delay (s)	A / 3.1							

* The minor approaches were considered to be Yield controlled for this analysis. If the right turns were considered to be free flow, the LOS would increase to "A"

Table 20: PM Peak Hour Synchro Results – Minor Approach Turn Restrictions

Performance Measure	Northbound			Southbound			Eastbound	Westbound
	L	T	R	L	T	R	R	R
LOS	E	--	--	B	--	--	C*	C*
Delay (s)	38.9	--	--	15.0	--	--	23.7	16.4
V/C	0.42	--	--	0.10	--	--	0.38	0.09
95% Queue (veh)	1.9	--	--	0.3	--	--	1.7	0.3
Intersection LOS / Delay (s)	A / 1.9							

* The minor approaches were considered to be Yield controlled for this analysis. If the right turns were considered to be free flow, the LOS would increase to "A"

All movements except for the northbound left and eastbound right movements operate at LOS of 'C' or better. Although Synchro indicates the northbound left turn experiences an unacceptable LOS of 'E' in the PM peak hour, restricting the minor approach left turn and through movements may be a viable interim improvement option when the following is considered:

- In the PM peak hour, the delay for the northbound left turn is only slightly greater (3.9 s) than LOS 'D'.
- Traffic volumes analysed in this scenario represent a worst-case scenario where all of the current eastbound traffic continues to use the intersection even after minor approach left turn and through movements are restricted. After turn restrictions are in place, a significant proportion of the eastbound left turn vehicles would likely use an alternative route (Highway 2A), which would result in better LOS at the intersection.
- Restricting the minor approach left turn and through movements removes all conflicting traffic flows in the median opening and simplifies the task of completing a highway left turn.
- Without conflicting vehicles in the median opening, the Highway 2 left turn vehicles are able to immediately enter the median opening, choose an appropriate gap and cross to TR204.

When Highway 2 traffic volumes reach a point where highway left turns no longer have a sufficient number of safe gaps, highway left turns could be restricted by fully closing the median opening. Based on current traffic volumes, the northbound left turn would operate at a LOS "E",

however, less than a 10% increase in southbound traffic volumes would result in a LOS "F" suggesting a potential lifespan of approximately five (5) years.

Considering the illumination warrant for this improvement, the warrant score and associated lighting recommendation is dependent on whether the channelization is painted or raised. Results for the illumination warrant are provided in Table 21 and warrant worksheets are included in Appendix F. A collision frequency of 1.0 was used in each scenario. A collision frequency of 2.0 would result in an additional 30 points.

Table 21: Illumination Warrant – Minor Approach Turn Restrictions

Scenario	Warrant Points	Lighting Warranted	Upgrades Required?
Painted Channelization	236	Delineation Lighting	No
Raised Channelization	296	Full Illumination	**Yes**

For the painted channelization scenario, delineation lighting is warranted, however, the 236 points is just four (4) points shy of warranting full illumination. If raised channelization were considered, the points would increase to 296 and full illumination would be warranted.

Estimated costs are provided in Table 22. Although the geometric review identified potential improvements for the northbound left turn lane and taper, cost estimates for these improvements are not provided as the expected lifespan associated with the northbound left turn lane is short (less than 5 years).

Table 22: Estimated Costs – Minor Approach Turn Restrictions

Improvement	Option	Cost
Divisional Islands on Minor Approaches	Painted channelization Raised channelization	$10,000 $180,000
Directional Median Opening	Painted channelization Raised channelization	$15,000 $190,000
Intersection Lighting *(required with raised channelization options)*	Full Illumination	$400,000

At minimum, this option requires either divisional islands on the minor approaches or a directional median opening. To discourage restricted movements, raised divisional islands should be installed on either the minor approaches or as part of a directional median opening. The minimum cost for implementing this option is estimated to be in the range of $580,000, which would include raised divisional islands on the minor approaches and full illumination.

Pros and cons for minor approach turn restrictions are discussed in Table 23.

Table 23: Pros and Cons – Minor Approach Turn Restrictions

Pros	Cons
• Reduced conflicting traffic movements in the median. • Simplified driving task for highway left turns. • Reduces crossing conflicts. • Reduces merge/diverge conflicts. • Reduced “Right Angle”, and “Rear End” collisions. • Maintains free flow movement for north-south traffic on Highway 2 (~93% of total entering traffic). • Aligns well with the ultimate plan to close the intersection and develop Highway 2 into a freeway facility. • Provides additional storage space for left turn movements.	• Eliminates minor approach left turn and through movements. • Additional travel distance and time for restricted/re-routed movements. • Roadway hazards introduced with raised channelization. • Medium implementation cost. • Collision statistics included three (3) “Right Angle” collisions related to vehicles travelling from the median opening and interacting with Highway 2 through vehicles. Maintaining the median open for left turns from Highway 2 could result in further right angle collisions related to vehicles crossing from the median opening to TR204. • Drivers on the TR204 approaches with a desire to cross or make a left turn may complete a right turn and then an illegal U-turn at an emergency / maintenance median crossover. • Drivers on Highway 2 with a desire to make a left turn onto TR204 might complete an illegal U-turn at an emergency / maintenance median crossover to access the right in. • Increased enforcement may be required at the emergency / maintenance median crossovers. • Maintenance crossovers adjacent to the interchanges may need to be closed to direct traffic to the interchange to complete a U-turn. This will increase travel times for maintenance vehicles.

9.4.2 Full Median Closure

This option would restrict left turns on Highway 2 approaches as well as left turn and through movements on the TR204 approaches. Turn restrictions would be accomplished with complete closure of the median opening, and a painted right-in, right-out divisional island on the minor approaches. A sketch of the full median closure option is provided in Figure 13.

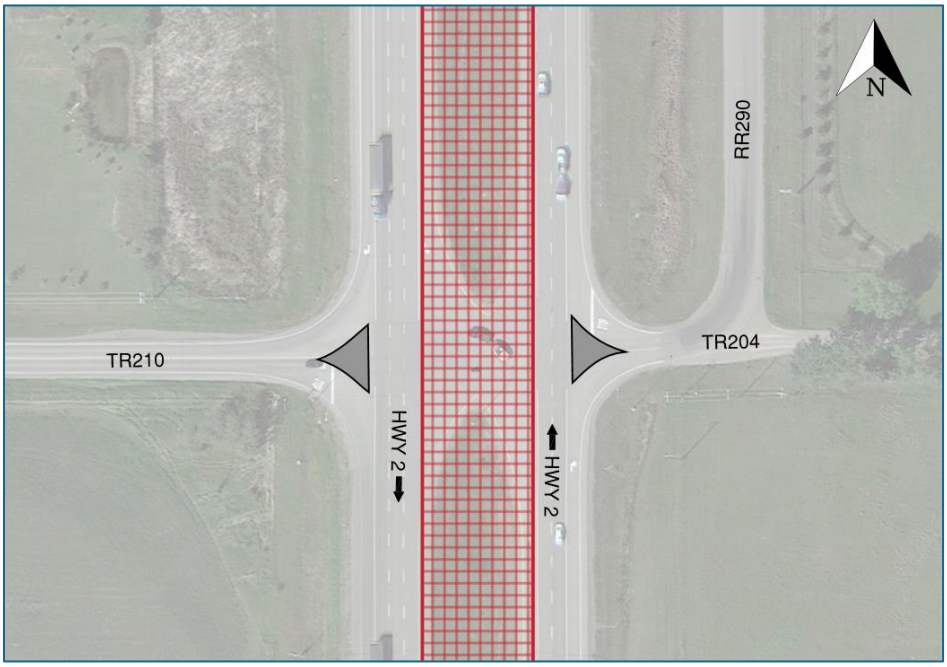


Figure 13: Full Median Closure

Minor approach left turn and through movements could be re-routed in the same way described for the Minor Approach Turn Restrictions option. Highway left turns could be re-routed as follows:

- Northbound left turns (up to 60 vehicles in peak hour) would use the Highway 7 / Highway 547 interchange. For this movement, closure of the median could result in an additional trip length of approximately 9.1 km.
- Southbound left turns (only one (1) vehicle in AM or PM peak hour) would first head south to the Highway 7 / Highway 547 interchange, cross the interchange and then head north on Highway 2 to complete a right turn onto TR204. For this movement, closure of the median would result in additional trip length of approximately 5.3 km.

Synchro analysis results for the HCM 2010 TWSC procedure are shown in Table 24 and Table 25. Synchro reports are provided in Appendix F.

Table 24: AM Peak Hour Synchro Results – Full Median Closure

Performance Measure	Northbound		Southbound		Eastbound	Westbound
	T	R	T	R	R	R
LOS	--	--	--	--	D*	C*
Delay (s)	--	--	--	--	34.8	17.1
V/C	--	--	--	--	0.65	0.16
95% Queue (veh)	--	--	--	--	4.3	0.6
Intersection LOS / Delay (s)	A / 2.5					

* The minor approaches were considered to be Yield controlled for this analysis. If the right turns were considered to be free flow, the LOS would increase to "A"

Table 25: PM Peak Hour Synchro Results – Full Median Closure

Performance Measure	Northbound		Southbound		Eastbound	Westbound
	T	R	T	R	R	R
LOS	--	--	--	--	C*	C*
Delay (s)	--	--	--	--	23.7	16.4
V/C	--	--	--	--	0.38	0.09
95% Queue (veh)	--	--	--	--	1.7	0.3
Intersection LOS / Delay (s)	A / 1.0					

* The minor approaches were considered to be Yield controlled for this analysis. If the right turns were considered to be free flow, the LOS would increase to "A"

All movements except for the eastbound right movement operate at LOS of 'C' or better. The overall LOS is improved compared to the Minor Approach Turn Restrictions option.

Implementation of a median closure would eliminate the need for illumination as each minor approach would be restricted to right-in, right-out and would only connect with a one-way direction of Highway 2. Considering the potential warrant points, delineation lighting is only required where it is desirable to illuminate pedestrians or cross street traffic and neither of these conditions would be present for the right-in, right-out intersections.

It is recommended that full closure of the median be paired with painted islands on the minor approaches to direct traffic. The cost for these improvements is estimated to be in the range of $180,000.

Pros and cons for full median closure are discussed in Table 26.

Table 26: Pros and Cons – Full Median Closure

Pros	Cons
• Eliminates all crossing conflicts. • Reduces merge/diverge conflicts. • Eliminates “Right Angle” collisions. • Reduces “Rear End” collisions. • Reduced collision severity. • Aligns well with the ultimate plan to close the intersection and develop Highway 2 into a freeway facility. • Basic implementation has relatively low implementation cost.	• Eliminates left turns from Highway 2. • Eliminates minor approach left turn and through movements. • Additional travel distance and time for restricted/re-routed movements. • Drivers on the TR204 approaches with a desire to cross or make a left turn may complete a right turn and then an illegal U-turn at an emergency / maintenance median crossover. • Drivers on Highway 2 with a desire to make a left turn onto TR204 might complete an illegal U-turn at an emergency / maintenance median crossover to access the right in. • Increased enforcement may be required at the emergency / maintenance median crossovers. • Maintenance crossovers adjacent to the interchanges may need to be closed to direct traffic to the interchange to complete a U-turn. This will increase travel times for maintenance vehicles.

9.5 Traffic Signal

A traffic signal is potentially a cost-effective short-term solution to resolve conflicts and congestion at the intersection. The following enhancements are required with a traffic signal:

- Full illumination of the intersection.
- Reduced speed limit of 80 km/h on Highway 2.
- Advance warning flashers.

Synchro analysis results for a traffic signal are shown in Table 27 and Table 28. For this option, an exclusive eastbound right turn lane was added on the west approach. Synchro reports are provided in Appendix F.

Table 27: AM Peak Hour Synchro Results – Traffic Signal

Performance Measure	Northbound			Southbound			Eastbound		Westbound
	L	T	R	L	T	R	LT	R	LTR
LOS	A	C	A	A	B	A	D	A	C
Delay (s)	9.2	20.1	0.1	8.7	15.0	1.1	54.2	5.7	32.3
V/C	0.25	0.76	0.03	0.19	0.54	0.09	0.74	0.22	0.28
95% Queue (m)	6.0	160.4	0.0	1.8	83.2	0.6	13.4	5.5	11.1
Intersection LOS / Delay (s)	B / 18.8								

Table 28: PM Peak Hour Synchro Results – Traffic Signal

Performance Measure	Northbound			Southbound			Eastbound		Westbound
	L	T	R	L	T	R	LT	R	LTR
LOS	A	B	A	A	A	A	D	A	D
Delay (s)	5.9	11.5	0.1	4.8	8.9	1.4	53.3	5.6	38.2
V/C	0.27	0.65	0.03	0.16	0.46	0.17	0.48	0.26	0.31
95% Queue (m)	5.8	106.2	0.0	1.1	61.7	4.3	15.1	2.8	9.7
Intersection LOS / Delay (s)	B / 10.7								

With a traffic signal, all movements operate with an acceptable LOS, however, the eastbound left/through movement has LOS of D, which is the maximum acceptable threshold for AT, in both the AM and PM peak hours.

The estimated cost for a traffic signal including full illumination and advanced warning flashers is in the range of $800,000.

Pros and cons for a traffic signal are discussed in Table 29.

Table 29: Pros and Cons – Traffic Signal

Pros	Cons
• Alternately assigns right of way between conflicting movements. • Does not restrict any traffic movements. • Reduced collision severity due to lower speed and potential protected left turns. • Reduced sight distance requirements. • Reduced deceleration / acceleration lane length requirements. • Traffic signal and advance warning flashers work as an intersection recognition device for Highway 2 drivers.	• Does not meet the intent of a freeway / expressway roadway classification. • Drivers may not expect to encounter a traffic signal on a freeway / expressway, especially in a rural area. • Improved operation may result in increased minor approach traffic volumes. • Implementation of traffic signal could make future closure of the intersection more difficult due to public expectations. • "Rear End", "Side Swipe" and "Fixed Object" collisions may increase. • Safety implications related to potential red light running. • Introduction of fixed hazards (poles) within the clear zone. • Speed limit reduction to 80 km/h. • Medium implementation cost.

9.6 Summary

The most prevalent type of collision at the TR204 intersection are "Right Angle" collisions occurring in southbound Highway 2. The collision information suggests drivers are stopping before entering the intersection but are proceeding when it is unsafe. This suggests that gap selection is challenging for drivers.

An Intersection Conflict Warning System for Highway 2 could be considered as a short term measure to advise drivers on Highway 2 of potential vehicles entering from TR204. The warning system could increase driver awareness and potentially result in vehicles slowing as they approach the intersection with the result that collision severity could be decreased.

Ultimately, the development of Highway 2 to a freeway will resolve the safety issues identified at this intersection. In the meantime, there are several options that can be considered to reduce conflicts and improve safety at the intersection. These options include a traffic signal, partial median closure, and full median closure. These options resolve identified safety and operational issues at the TR204 intersection, however, they have the potential to introduce new operational and safety issues on the Highway 2 corridor and at adjacent at-grade intersections. Specifically, the partial and full median closure options may require implementation of similar measures at adjacent intersections as well as other steps to eliminate the potential for illegal use of adjacent median crossovers for U-turns.

A traffic signal could provide satisfactory traffic operations and safety for the intersection, however, a traffic signal is not necessarily the best solution for a freeway or a remote high-volume section of highway. Although there are traffic signals on the highway just south of Calgary, they

are a significant distance north of TR204 and drivers are not typically expecting a speed zone reduction or a traffic signal while travelling in a freeway environment. Implementation of a traffic signal could impact highway efficiency and increase “Rear End”, ”Side Swipe” and ”Fixed Object” collisions. A traffic signal at this location could potentially draw more traffic to the intersection and make future closure of the intersection more difficult. The unexpected speed reduction for Highway 2 drivers could introduce a continued enforcement issue. From the perspective of Highway 2 users, there are better options to improve safety on this stretch of Highway 2 as there are alternate local road connections for the adjacent developed areas. For these reasons, a traffic signal is not recommended at the TR204 intersection.

Restricting minor road left turn and through movements is a viable short or medium-term solution that AT could consider to improve safety and traffic operations. This option is relatively inexpensive and imposes less turn restrictions than full closure of the median, however, gap selection would continue to be a challenge for highway left turns and severe “Right Angle” collisions could still occur. This option may also attract illegal U-turns to the intersection if similar measures are implemented at adjacent at-grade intersections. When Highway 2 traffic volumes reach a point where highway left turns no longer have a sufficient number of safe gaps, highway left turns could be restricted by fully closing the median opening. Based on a review of traffic volumes, it is expected that the highway left turns could be allowed for approximately five (5) years before the LOS decreases to LOS “F”.

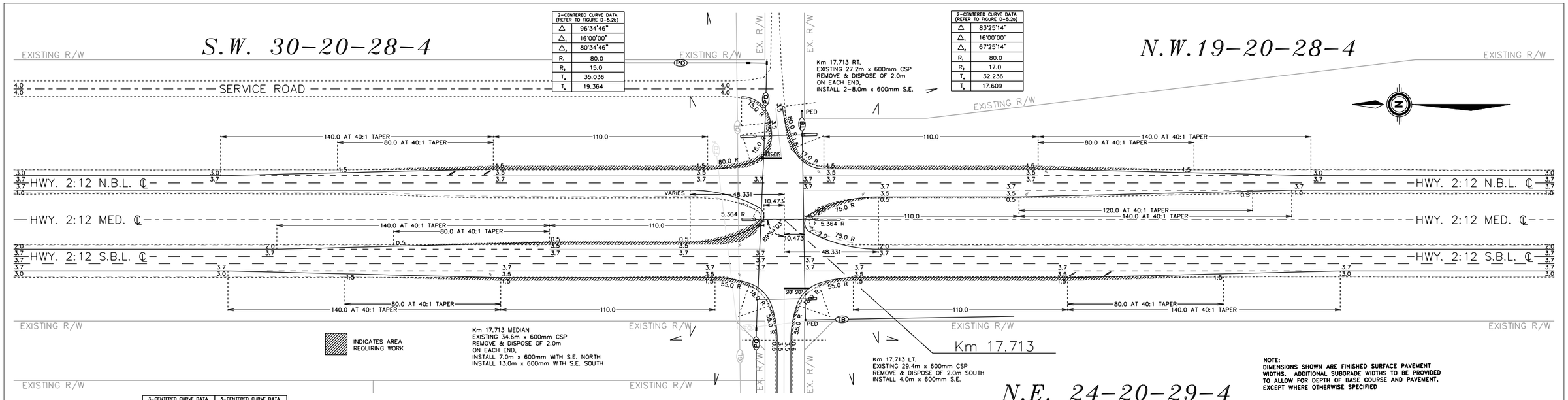
Full closure of the median opening appears to offer the most significant safety benefit, has relatively low implementation costs, and aligns best with the ultimate plan to develop the corridor to a freeway. This option would eliminate all crossing conflicts and “Right Angle” collisions, and would significantly reduce the number of conflict points. This option is considered a viable medium to long-term solution and includes improvements related to the ultimate closure of the TR204 intersection approaches (to be implemented when required). Steps will need to be considered to eliminate potential for illegal U-turns at adjacent median crossovers.

ISL recommends that AT initiate full closure of the median opening including, but not limited, to the following:

- Improvements / upgrades required for closure of the median opening.
- Improvements / upgrades required for the TR204 approaches.
- Improvements / upgrades required to eliminate potential for illegal U-turns at adjacent median crossovers.
- Public consultation as necessary for the next steps of safety improvements.

Appendix A

As-Built Drawings



2-CENTERED CURVE DATA (REFER TO FIGURE D-5.2b)	
Δ	96°34'46"
Δ_1	16°00'00"
Δ_2	80°34'46"
R_1	80.0
R_2	15.0
T_1	35.036
T_2	19.364

2-CENTERED CURVE DATA (REFER TO FIGURE D-5.2b)	
Δ	83°25'14"
Δ_1	16°00'00"
Δ_2	67°25'14"
R_1	80.0
R_2	17.0
T_1	32.236
T_2	17.609

3-CENTERED CURVE DATA (REFER TO FIGURE D-5.2a)		3-CENTERED CURVE DATA (REFER TO FIGURE D-5.2a)	
Δ	90°05'53"	Δ	89°54'07"
Δ_1	18°55'29"	Δ_1	18°55'29"
Δ_2	52°14'56"	Δ_2	52°03'09"
R_1	55.0	R_1	55.0
R_2	18.0	R_2	18.0
P	2.000	P	2.000
X	2.973	X	2.973
T	32.034	T	31.966
T_1	20.034	T_1	19.966
T_2	14.196	T_2	14.128

NOTE:
DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT, EXCEPT WHERE OTHERWISE SPECIFIED

	BY	DATE
TITLE SEARCH DATE		
SURVEYED	D.W.	08/04
DESIGNED	M.L.O.	08/04
CHECKED	K.J.B.	08/04
DRAWN	M.L.O.	08/04

No.	REVISIONS	BY	DATE
6			/ /
5			/ /
4			/ /
3			/ /
2			/ /
1			/ /

CONSULTANT
JOB No. | PLAN No.
EAGLE ENGINEERING CORP.

PERMIT TO PRACTICE
PERMIT TO PRACTICE
EAGLE ENGINEERING CORP.
Signature Original Signed
Date December, 2004
PERMIT NUMBER: P 6063
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

DESIGNER
PROFESSIONAL ENGINEER OF ALBERTA
ORIGINAL STAMPED AND SIGNED
BY: K. BIDDLE
DATE December, 2004

CHECKER
PROFESSIONAL ENGINEER OF ALBERTA
ORIGINAL STAMPED AND SIGNED
BY: S. BIDDLE
DATE December, 2004

PLAN SHOWING INTERSECTIONAL TREATMENT AT JCT. HWY. 2:12 & E-W R/A 6.5 Km EAST OF OKOTOKS

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
SOUTHERN	IN-1277B-1-P	HWY. 2:12	6963/04	1 of 1

Alberta TRANSPORTATION

10m 0 20m HORIZONTAL

PLAN DESCRIPTION
INT 1277B
HWY. 2:12 & E-W R/A
6.5 Km E. OF OKOTOKS

PROCESS | DATE | BY
TO IDMS
TO OJS
MICROFILMED

BAR CODE

PLAN No. IN-1277B-1-P
PLAN LOCATION HWY. 2:12
CONTRACT No. 6963/04
GRAPHICS FILE

COORDINATE DATA
LOCAL
BASE LONGITUDE

Appendix B

Traffic Data

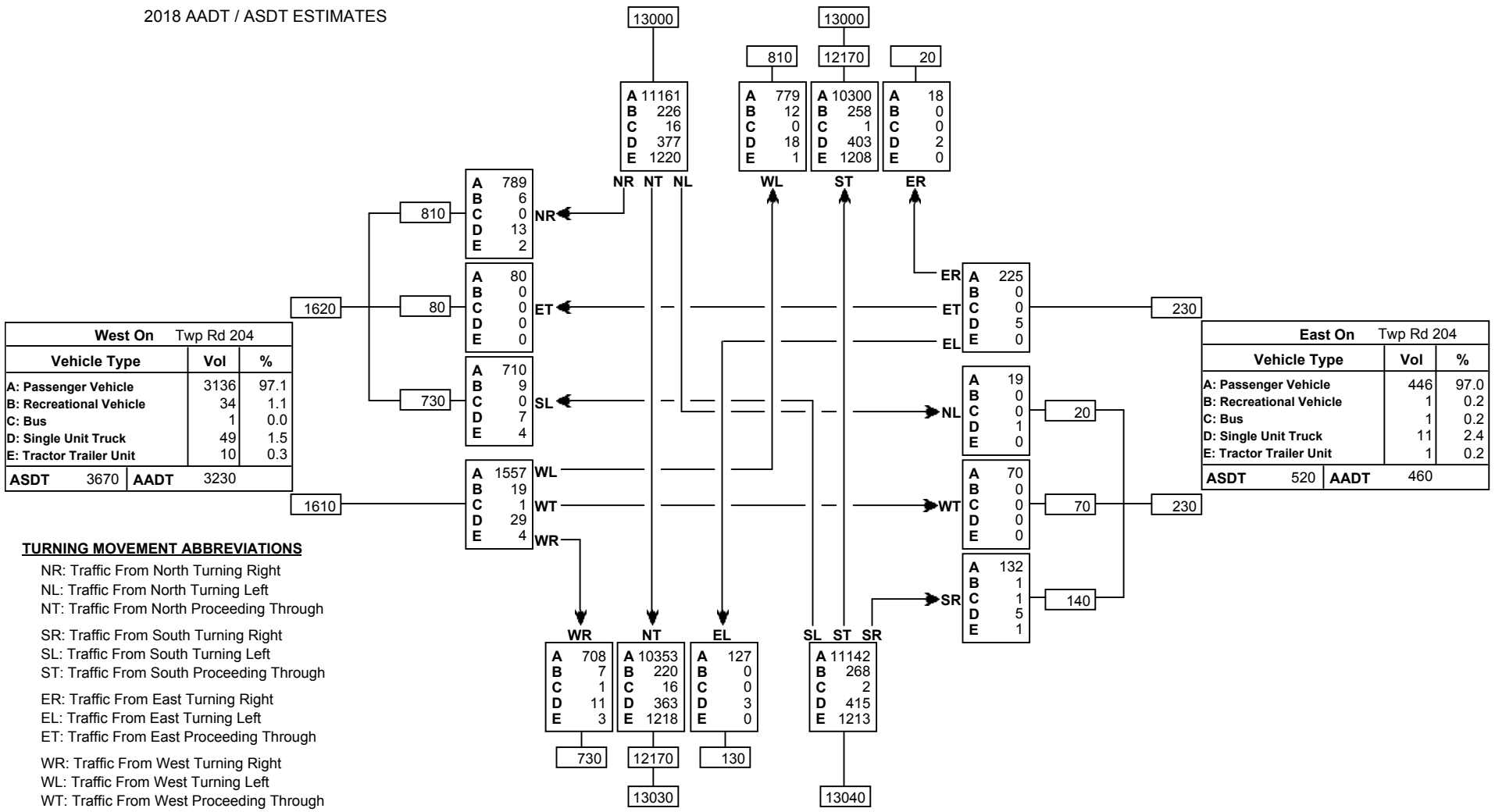
Turning Movement Summary Diagram

ISL Engineering and Land Services Ltd.

Reference No.: 1000590

Intersection of:
2 & TWP RD 204 (370 AVE E)

2018 AADT / ASDT ESTIMATES



North On 2		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	22258	85.6
B: Recreational Vehicle	496	1.9
C: Bus	17	0.1
D: Single Unit Truck	800	3.1
E: Tractor Trailer Unit	2429	9.3
ASDT 29550	**AADT** 26000	

West On Twp Rd 204		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	3136	97.1
B: Recreational Vehicle	34	1.1
C: Bus	1	0.0
D: Single Unit Truck	49	1.5
E: Tractor Trailer Unit	10	0.3
ASDT 3670	**AADT** 3230	

East On Twp Rd 204		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	446	97.0
B: Recreational Vehicle	1	0.2
C: Bus	1	0.2
D: Single Unit Truck	11	2.4
E: Tractor Trailer Unit	1	0.2
ASDT 520	**AADT** 460	

South On 2		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	22330	85.7
B: Recreational Vehicle	495	1.9
C: Bus	19	0.1
D: Single Unit Truck	792	3.0
E: Tractor Trailer Unit	2434	9.3
ASDT 29630	**AADT** 26070	

TURNING MOVEMENT ABBREVIATIONS

NR: Traffic From North Turning Right
NL: Traffic From North Turning Left
NT: Traffic From North Proceeding Through

SR: Traffic From South Turning Right
SL: Traffic From South Turning Left
ST: Traffic From South Proceeding Through

ER: Traffic From East Turning Right
EL: Traffic From East Turning Left
ET: Traffic From East Proceeding Through

WR: Traffic From West Turning Right
WL: Traffic From West Turning Left
WT: Traffic From West Proceeding Through

TURNING MOVEMENT ABBREVIATIONS

AADT: Annual Average Daily Traffic
Average daily traffic expressed as vehicles per day fo
period of January 1 to December 31 (365 days)

ASDT: Average Summer Daily Traffic
Average daily traffic expressed as vehicles per day fo
period of May 1 to September 30 (153 days)

ISL Engineering and Land Services Ltd.

Reference No.: 1000590

Intersection of:
2 & TWP RD 204 (370 AVE E)

2018 a.m. 100th Highest Hour ESTIMATES

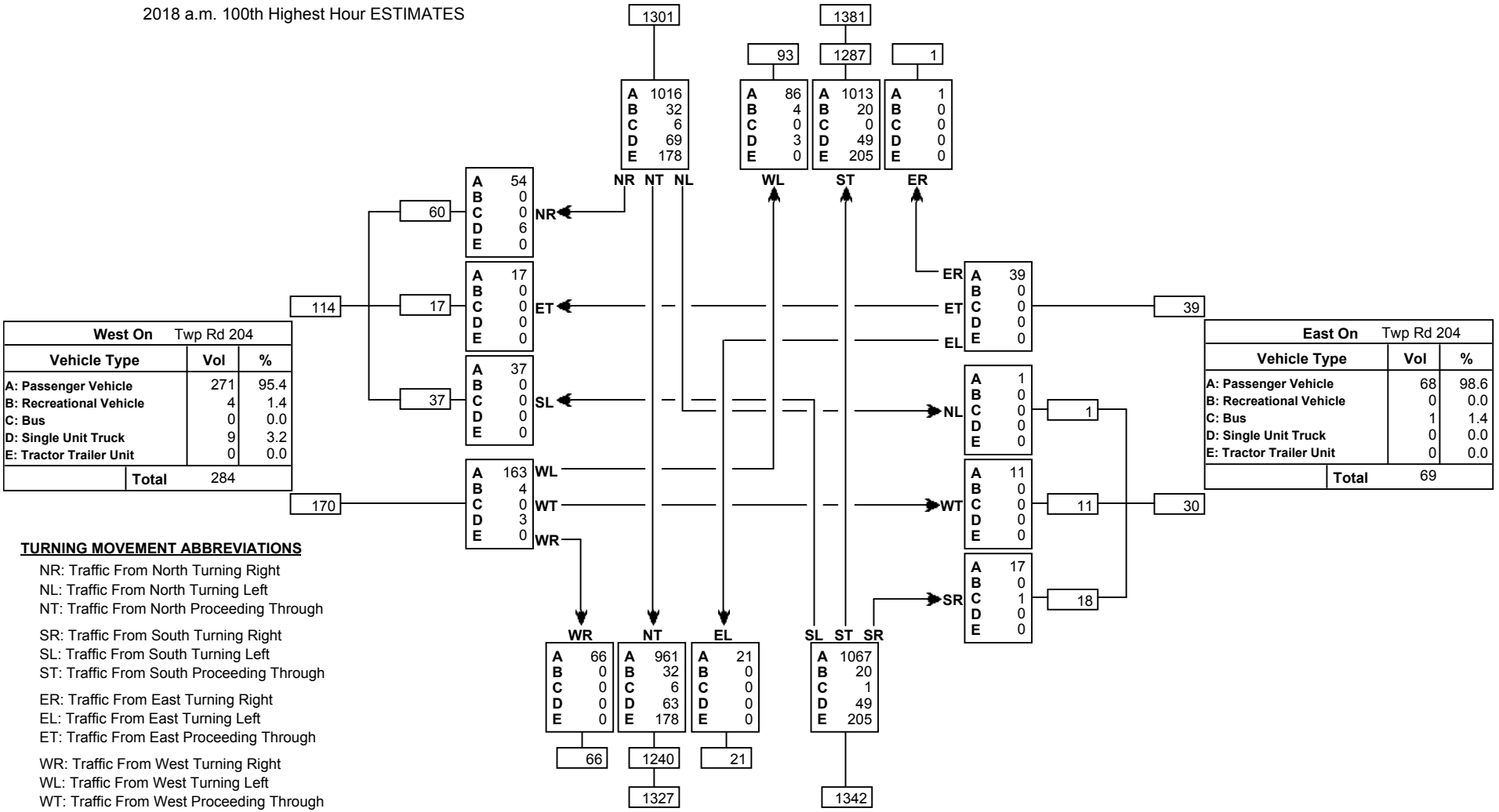
Turning Movement Summary Diagram

North On 2		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	2116	78.9
B: Recreational Vehicle	56	2.1
C: Bus	6	0.2
D: Single Unit Truck	121	4.5
E: Tractor Trailer Unit	383	14.3
Total	2682	

West On Twp Rd 204		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	271	95.4
B: Recreational Vehicle	4	1.4
C: Bus	0	0.0
D: Single Unit Truck	9	3.2
E: Tractor Trailer Unit	0	0.0
Total	284	

East On Twp Rd 204		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	68	98.6
B: Recreational Vehicle	0	0.0
C: Bus	1	1.4
D: Single Unit Truck	0	0.0
E: Tractor Trailer Unit	0	0.0
Total	69	

South On 2		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	2115	79.2
B: Recreational Vehicle	52	1.9
C: Bus	7	0.3
D: Single Unit Truck	112	4.2
E: Tractor Trailer Unit	383	14.3
Total	2669	



TURNING MOVEMENT ABBREVIATIONS

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EL: Traffic From East Turning Left
ET: Traffic From East Proceeding Through

WR: Traffic From West Turning Right
WL: Traffic From West Turning Left
WT: Traffic From West Proceeding Through

ISL Engineering and Land Services Ltd.

Reference No.: 1000590

Intersection of:
2 & TWP RD 204 (370 AVE E)

2018 p.m. 100th Highest Hour ESTIMATES

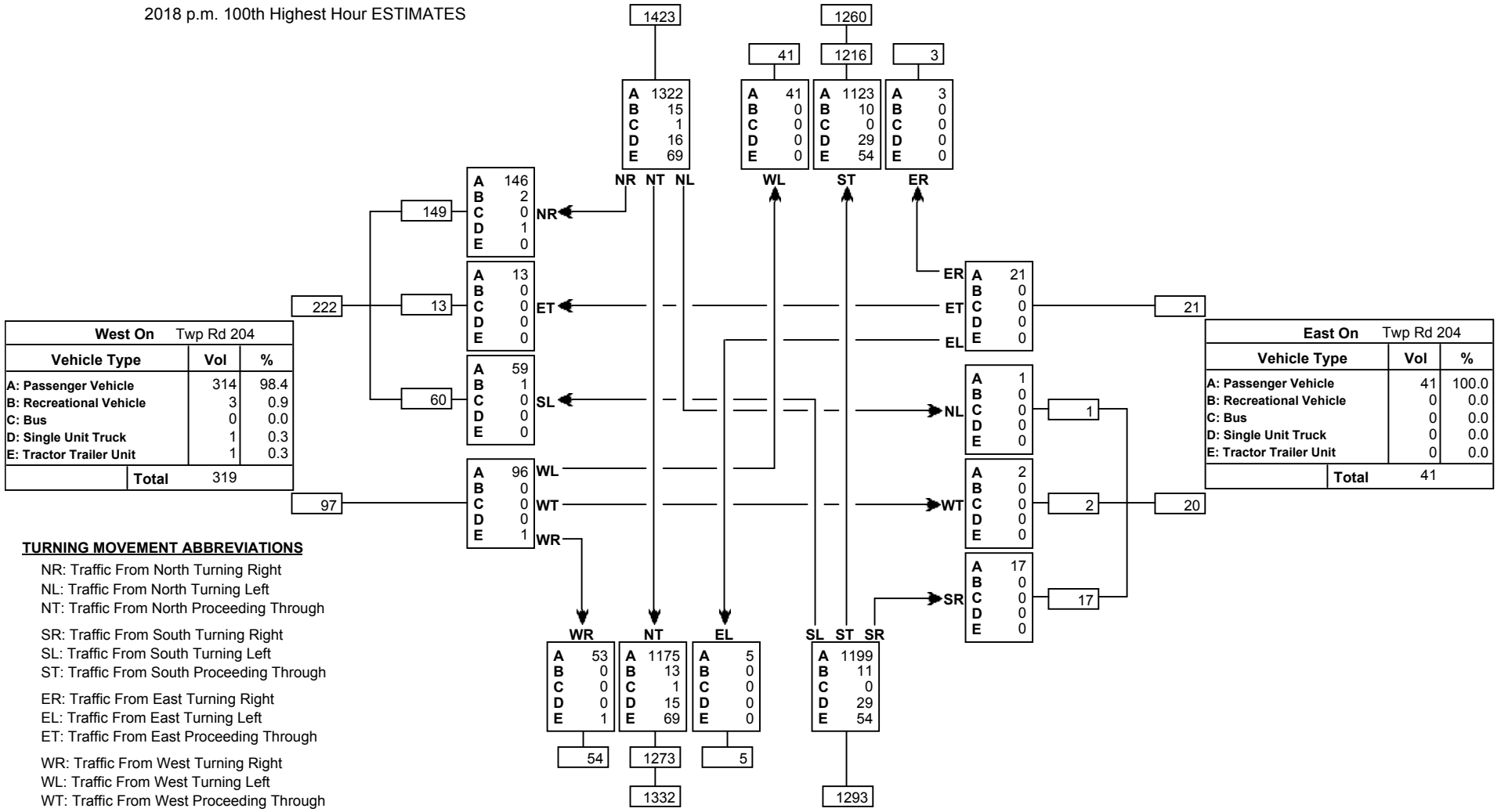
Turning Movement Summary Diagram

North On 2		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	2489	92.8
B: Recreational Vehicle	25	0.9
C: Bus	1	0.0
D: Single Unit Truck	45	1.7
E: Tractor Trailer Unit	123	4.6
Total	2683	

West On Twp Rd 204		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	314	98.4
B: Recreational Vehicle	3	0.9
C: Bus	0	0.0
D: Single Unit Truck	1	0.3
E: Tractor Trailer Unit	1	0.3
Total	319	

East On Twp Rd 204		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	41	100.0
B: Recreational Vehicle	0	0.0
C: Bus	0	0.0
D: Single Unit Truck	0	0.0
E: Tractor Trailer Unit	0	0.0
Total	41	

South On 2		
Vehicle Type	**Vol**	**%**
A: Passenger Vehicle	2432	92.6
B: Recreational Vehicle	24	0.9
C: Bus	1	0.0
D: Single Unit Truck	44	1.7
E: Tractor Trailer Unit	124	4.7
Total	2625	



TURNING MOVEMENT ABBREVIATIONS

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ER: Traffic From East Turning Right
EL: Traffic From East Turning Left
ET: Traffic From East Proceeding Through

WR: Traffic From West Turning Right
WL: Traffic From West Turning Left
WT: Traffic From West Proceeding Through

Appendix C

NESS Report

Report Notes

Report Name	Hwy 2 and TR 204 Safety
Segments	ALL
Collision Year Range	2012-2016
LRS Provided to Create the Report	Not provided
Intersections Provided to Create the Report	1277-HIGHWAY 2:12 AND TOWNSHIP ROAD 204

Report Contents

Intersection Summary Report

LRS	Intersection Site #	Description	Type
2:12 L1 17.677	1277	HIGHWAY 2:12 AND TOWNSHIP ROAD 204	AG

Width Safety Report

Report Notes

Number of results found 2

Collision Cost in $/km (M) over 5 years

Collision Rate in C/100MVKM

Collision rate is calculated as (sum total collisions over 5 years * 100 Mil) / (sum of AADT history for the same 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * $9,120,367) + (sum of collisions involving a serious injury * $66,744) + (sum of collisions involving a minor injury * $66,744) + (sum of the property damage only collisions * $5,851)/km)

		Existing			Collision Frequency				Total Rate			Non Animal Rate			Collision Cost (M)			Safety	Region
LRS	Len	WAADT	Width	Paved Y/N	Total	Fatal	Injury	Non Animal	Actual	BM	Δ	Actual	BM	Δ	Actual	BM	Δ	Issues	
2:12 L1 11.250 - 19.960	8.71	22,560	16.30	Y	104	1	26	66	60.6	48.3	***-12.3***	38.5	36.7	***-1.7***	1.298	1.010	***-0.288***	Yes	1
2:12 R1 17.210 - 19.480	2.27	26,310	11.40	Y	19	0	7	14	36.4	52.6	16.2	26.8	49.8	23.0	0.237	0.816	0.579	~~No~~	1

Intersection Report

Report Notes

Number of results found 1

The number of collisions in this report are collisions at and near the intersection and are collisions within the intersection polygon in TIMS

For details on individual collisions, see the "Collision Details" section within Excel report

The Signalization Work Activity Trigger is Traffic Score (TS) > 79 or TS >= 60 with 5 or more angle collisions

Interchange Trigger - Signalization trigger met on Level 1 divided highway with 100+ km/h, or left turn volume >= 700 vehicles per hour

Collision Cost in $ (M) over 5 years

Collision Rate in C/100MEV

Intersection collision rate is calculated as (sum of intersection collisions over 5 years * 100 Mil) / (sum of AADT entering over 5 years * 365.25)

Collision cost is calculated as (sum of collisions involving a fatality * $9,120,367) + (sum of collisions involving a serious injury * $66,744) + (sum of collisions involving a minor injury * $66,744) + (sum of the property damage only collisions * $5,851)

Va, Vo and Vl in VPH

LT & RT Length in m

Pk = Peak Hour

Year LT = Scheduled Year of Left Turn Lane Construction

Year LTR = Scheduled Year of Left Turn Lane Reconstruction

Year RT = Scheduled Year of Right Turn Lane Construction

Year RTR = Scheduled Year of Right Turn Lane Reconstruction

INT #:1277 LRS: 2:12 L1 17.677

Location: HIGHWAY 2:12 AND TOWNSHIP ROAD 204

Lv 2 Work Activity Summary | Lv 3 Work Activity Summary

Major Road Details

Int. Type: AG
Service Class: LV 1
Posted Speed: 110
Lit: Y Sig: N Div: Y Radius:

TMD Ref:
Maj Rd: 2-NB/SB
Min Rd:

Veh/day	Growth
26,310	1.9%

Collision Frequency				Collision Rate				Collision Cost	
Total	Fatal	Inj	Non-An	Total	BM	Non-An	BM	Cost (in $M)	BM
40	1	15	36	***86.2***	69.8	***77.6***	69.6	***10.262***	1.752

Approach	LT Lane	LT Len	LT BM	RT Lane	RT Len	RT BM	Chan	Yr LT	Vo	Vl	BM	Va	Undiv BM	Pk	Yr RT	RT AADT	Yr Chan
2-NB	Y	213	210	Y	***81***	210	N										
2-SB	Y	***53***	210	Y	239	210	N										

Yr Signal	TS	Ang. Coll	Yr IC	TS	LT vph	Yr Light.	Day	Night	N/D Col%	Near VC
		14					30	9	30.00	Y

Horizontal Curve Report

Report Notes

Number of results found 0

Collision Cost in $/km (M) over 5 years

Collision Rate in C/100MVKM

Collision rate is calculated as (sum total collisions over 5 years * 100 Mil) / (sum of AADT history for the same 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * $9,120,367) + (sum of collisions involving a serious injury * $66,744) + (sum of collisions involving a minor injury * $66,744) + (sum of the property damage only collisions * $5,851)/km)

e in %

Deflection Angle in degrees

			Geometric Analysis						Collision Frequency				Safety Analysis				Work Activity Year		Region
LRS	Len	Exist WAADT	Type	Actual	BM	Δ	Defl Angle	Int On Curve	Total	Fatal	Injury	Non Animal	Type	Actual	BM	Δ	Safety Assess	Recon	
No data found																			

Vertical Curve Report

Report Notes

Number of results found 0

Gradient in %

Collision Rate in C/100MVKM

Collision rate is calculated as (sum segment collisions over 5 years * 100 Mil) / (sum of AADT 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * $9,120,367) + (sum of collisions involving a serious injury * $66,744) + (sum of collisions involving a minor injury * $66,744) + (sum of the property damage only collisions * $5,851)/km)

					K-Value					Running Speed			Total Collision Rate				Region
LRS	Len	Existing WAADT	Type	Grad	k	3R4R BM	Δ	NC BM	Δ	Estimated	Design	Δ	H Curve	INT	WA Year	Heavy Truck %	
2:12 L1 17.290 - 17.808	0.518	26,310	CREST		125	50	75	130	***-5***	120	120	0		***-16.4***		14.6	1
2:12 L1 17.808 - 18.404	0.596		TAN	0.10													1
2:12 R1 16.981 - 17.463	0.482		TAN	2.60													1
2:12 R1 17.463 - 17.884	0.421		CREST		162												1
2:12 R1 17.884 - 18.253	0.369		TAN	0.00													1

Collision Summary

Report Notes

For details on individual collisions, see 'Collision Details' section within the Collision Summary worksheet in the Excel version of this report

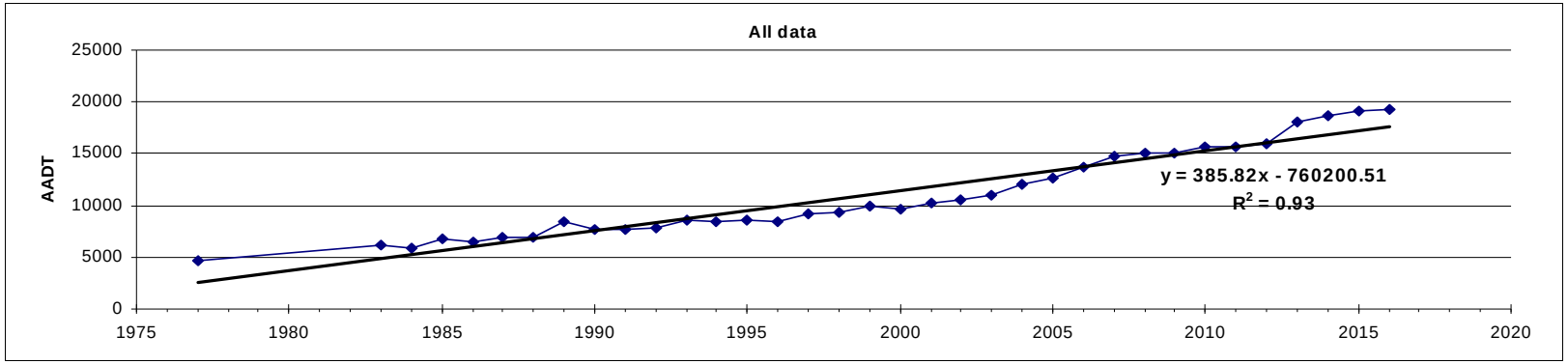
	Total				Roadway				Intersection			
Event	Fatal	Injury	Property Damage Only	Total	Fatal	Injury	Property Damage Only	Total	Fatal	Injury	Property Damage Only	Total
BACKING	0	0	0	0	0	0	0	0	0	0	0	0
HEAD ON	0	0	0	0	0	0	0	0	0	0	0	0
LEFT TURN - ACROSS PATH	0	1	0	1	0	0	0	0	0	1	0	1
OFF ROAD LEFT	0	0	1	1	0	0	0	0	0	0	1	1
OFF ROAD RIGHT	0	1	3	4	0	0	0	0	0	1	3	4
OTHER	0	0	1	1	0	0	0	0	0	0	1	1
PASSING - LEFT TURN	0	0	0	0	0	0	0	0	0	0	0	0
PASSING - RIGHT TURN	0	0	0	0	0	0	0	0	0	0	0	0
REAR END	0	3	6	9	0	0	0	0	0	3	6	9
RIGHT ANGLE	1	9	4	14	0	0	0	0	1	9	4	14
SIDESWIPE - OPPOSITE DIRECTION	0	0	0	0	0	0	0	0	0	0	0	0
SIDESWIPE SAME DIRECTION	0	1	4	5	0	0	0	0	0	1	4	5
STRUCK OBJECT	0	0	1	1	0	0	0	0	0	0	1	1
UNKNOWN	0	0	0	0	0	0	0	0	0	0	0	0
ANIMAL	0	1	4	5	0	1	0	1	0	0	4	4
TOTAL	**1**	**16**	**24**	**41**	**0**	**1**	**0**	**1**	**1**	**15**	**24**	**40**

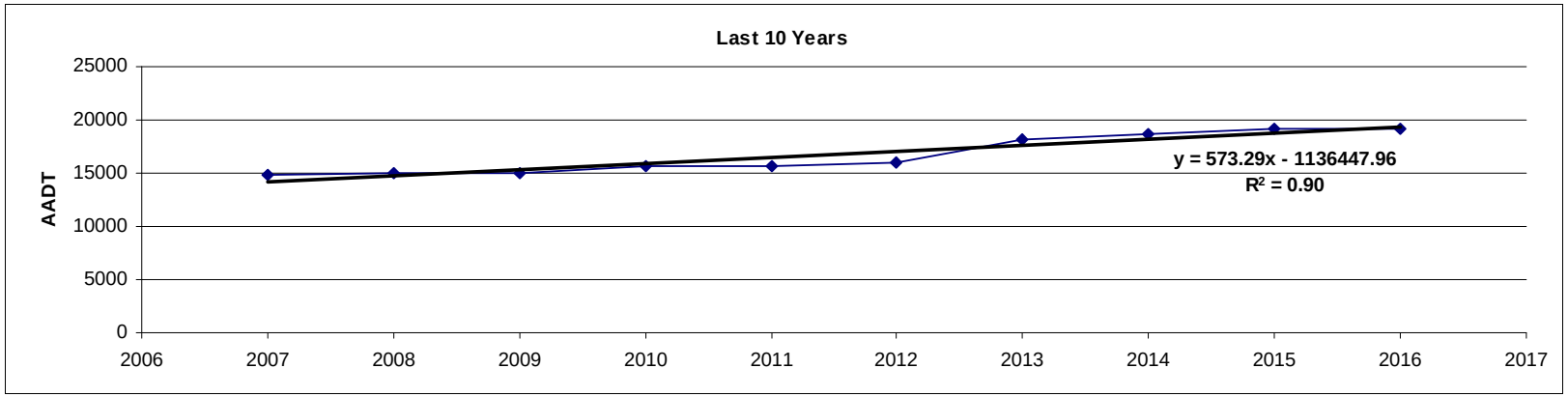
Traffic Growth

Table of ATR's included within the report by location

Hwy	CS	Label	From	To	ATR #
2	12	L1	15.382	19.600	60021260

ATR NUMBER: 60021260 2:12:L1 km 11.185 4.3 KM S 2 & 7 & 547 ALDERSYDE





Growth rate	Since	Two points	Diff to historical	linear regression	Diff to historical	r square
Historical:	1977	1.94		2.19		0.929
20 yrs:	1997	2.76	0.82	2.98	0.79	0.974
10 yrs:	2007	2.56	0.62	2.97	0.78	0.902
5 yrs:	2012	4.27	2.33	3.85	1.66	0.806

Other Calculation	Two points	Diff to historical	linear regression	Diff to historical	r square
Start yr:					
End yr:					
# yr:					

Year	AADT	ASDT	% diff
2016	19,247	21,424	11.3
2015	19,150	21,207	10.7
2014	18,607	20,422	9.8
2013	18,114	20,731	14.4
2012	15,963	17,775	11.4
2011	15,697	17,531	11.7
2010	15,664	17,245	10.1
2009	15,030	16,947	12.8
2008	14,987	16,485	10
2007	14,808	16,247	9.7

INT Collision History

Report Notes

Number of results found	1

This Section includes details on the collision history for selected intersections.

INT # **1277-1** INT type AT GRADE - TYPE UNKNOWN Region: SOUTHERN REGION INT Effective Date: 01-Oct-00

Location: **HIGHWAY 2:12 AND TOWNSHIP ROAD 204** Classification: LV 1 Signalized: N Last paved yr: 2007 Divided: Y

Posted speed: 110 Lit: Y Last paved road name: 2 TM number:

NESS Safety Calculations (2012 - 2016)

	Actual	BM	Deltas
Total rate:	86.232	69.8	-16.4
Non animal rate:	77.608	69.6	-8
Collision cost ($ x M):	10.262	1.752	-8.51

Total (ani + non ani)		Non-animal	2012	2013	2014	2015	2016
# Daytime:	30	Daytime	7	2	4	12	4
# Nightime:	9	Nightime		3	1		2
		Unknown					1

Modify Outliners for Non Animal Collision

	2012	2013	2014	2015	2016
F and Maj Inj.	1	0	3	1	2
Min. Inj.	1	1	1	1.3	2
Non ani	5	5	5	8.6	7

Three Similar Collisions Over Five Yrs Period

(excluding off road and animal collision)

Year: 2016

Prim. evt.: REAR END (9), RIGHT ANGLE (14), SIDESWIPE:SAME DIR. (5),

Collision Frequency Over Last 15 Yrs

Severity - non ani.	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	**Last 5 yrs**
FATAL													1			**1**
MAJOR	1	1									3		2	1	2	**8**
MINOR			1		1				1		1	1	1	2	2	**7**
PDO	2	1	2	1	2	2	1	3	3	1	3	4	1	9	3	**20**
TOTAL	**3**	**3**	**4**	**2**	**3**	**3**	**1**	**3**	**5**	**1**	**9**	**6**	**6**	**12**	**7**	**40**
TOTAL-non ani.	**3**	**2**	**3**	**1**	**3**	**2**	**1**	**3**	**4**	**1**	**7**	**5**	**5**	**12**	**7**	**36**

Collision Summary Last 5 Yrs (2012 - 2016)

(Non animal collisions)

Month	Freq	Hour	AM	PM	Weekday	Freq
Jan:	3	0:	3	1	Mon:	13
Feb:	4	1:		3	Tue:	4
Mar:	10	2:		1	Wed:	3
Apr:	2	3:	1	3	Thu:	4
May:	3	4:		1	Fri:	4
Jun:	1	5:		1	Sat:	3
Jul:	4	6:	1	2	Sun:	4
Aug:	2	7:		2	unknown:	1
Sep:	1	8:	1			
Oct:	3	9:	1	1		
Nov:	2	10:	1			
Dec:		11:	12			
unknown:	1	unknown:	1			

INT polygon yr: 31-Mar-2017

Collision event	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	**Last 5 yrs**
ANIMAL		1	1	1		1			1		2	1	1			**4**
BACKING					1											**0**
HEAD ON																**0**
LEFT TURN:ACROSS PATH											1					**1**
OFF ROAD LEFT	1	1							1			1				**1**
OFF ROAD RIGHT		1										1	1	1	1	**4**
OTHER					1									1		**1**
PASSING:LEFT TURN																**0**
PASSING:RIGHT TURN																**0**
PEDESTRIAN																**0**
REAR END	1		2			1	1	2			1			7	1	**9**
RIGHT ANGLE	1					1		1	2	1	5	2	4	1	2	**14**
SIDESWIPE:OPP DIR																**0**
SIDESWIPE:SAME DIR			1	1	1				1					2	3	**5**
STRUCK OBJECT												1				**1**
UNKNOWN																**0**

*The number of collision in this report are collisions at and near the intersection and is calculated using intersection polygon in TIMS.

*Cost of PDO collision had increased from $1,000 to $2,000 in 2011

INT Collision Direction

Report Notes

Number of results found 1

This Section contains information about the direction of collisions occurring at selected intersections.

INT #: 1277 LOCATION: HIGHWAY 2:12 AND TOWNSHIP ROAD 204

2012 - 2016 Collision Objects: Vehicle 1 and 2 Travel Direction Summary

All non animal:	**NB**	NE	**EB**	SE	**SB**	SW	**WB**	NW	U
FATAL			1		1				
MAJOR	1		5		8		1		
MINOR	7		3		4				
PDO	4		5		23				2
Total	12	0	14	0	36	0	1	0	2

Right angle	**NB**	NE	**EB**	SE	**SB**	SW	**WB**	NW	U
FATAL			1		1				
MAJOR			5		6		1		
MINOR	2		3		1				
PDO			3		4				1
Total	2	0	12	0	12	0	1	0	1

Left turn across path	**NB**	NE	**EB**	SE	**SB**	SW	**WB**	NW	U
FATAL									
MAJOR									
MINOR	1				1				
PDO									
Total	1	0	0	0	1	0	0	0	0

Rear end	**NB**	NE	**EB**	SE	**SB**	SW	**WB**	NW	U
FATAL									
MAJOR					2				
MINOR	2				2				
PDO	2		2		8				
Total	4	0	2	0	12	0	0	0	0

Other collisions	**NB**	NE	**EB**	SE	**SB**	SW	**WB**	NW	U
BACKING	0	0	0	0	0	0	0	0	0
HEAD ON	0	0	0	0	0	0	0	0	0
OFF ROAD LEFT	0	0	0	0	0	0	0	0	1
OFF ROAD RIGHT	1	0	0	0	3	0	0	0	0
OTHER	1	0	0	0	0	0	0	0	0
PASSING:LEFT TURN	0	0	0	0	0	0	0	0	0
PASSING:RIGHT TURN	0	0	0	0	0	0	0	0	0
PEDESTRIAN	0	0	0	0	0	0	0	0	0
SIDESWIPE:OPP DIR	0	0	0	0	0	0	0	0	0
SIDESWIPE:SAME DIR	2	0	0	0	8	0	0	0	0
STRUCK OBJECT	1	0	0	0	0	0	0	0	0
UNKNOWN	0	0	0	0	0	0	0	0	0

Collision with no dir. data # coll

*U: unknown direction

Appendix D

Site Photographs

Looking toward the intersection from the north approach right turn lane.

View of the north approach from the median.

Looking toward the intersection from the north approach left turn lane.

View of the south approach from the median opening.

View of the west approach from the median opening.

Looking toward the intersection from the south approach.

Advance Local Road Name sign on the south approach.

Looking toward the intersection from the south approach left turn lane.

Looking toward the intersection from the south approach right turn lane.

View of the south approach from the outside shoulder.

View of the north approach from the median opening.

View of the east approach from the median opening.

Looking toward the intersection from the Rumble Strips sign on the west approach.

The Rumble Strips sign has significant damage (shotgun damage) to the sign face.

Transverse rumble strips on the west approach are worn in the wheel paths.

Looking toward the intersection from the Stop Ahead sign and word marking on the west approach.

View to the south from the eastbound stop line.

Looking west towards the west approach from intersection.

There is evidence that vehicles have been pulling off the pavement and stopping on the north shoulder.

Looking towards the intersection from the west approach.

There is evidence that vehicles have been pulling off the pavement and stopping on the north shoulder.

Looking south from the Stop Ahead sign on RR291 (east approach).

Looking southwest toward the intersection from the bend on the east approach.

Pavement deterioration is evident along the inside of the bend and the area adjacent to the pavement appears to be heavily travelled.

Looking toward the intersection from the east approach.

The right STOP word marking is fading.

The Stop sign and flashing red light on the east approach.

The Stop sign is installed on a double-wide wood post that appears to have been installed recently.

View to the south from the westbound stop line.

View to the north from the eastbound stop line.

Looking toward the east approach from Highway 2.

The east leg of the TR204/RR291 intersection functions as a multi-parcel country residential access.

Although traffic operations, appearance, and signage suggest that it is a private access, it is shown as a public roadway on MD of Foothills maps.

Looking north from the TR204/RR291 intersection.

The intersection is uncontrolled and the north and west legs operate as a single continuous route with a 90° bend.

Looking towards the intersection from the north approach.

A queue of four (4) vehicles on the west approach wait for vehicles in the median opening to clear.

Flowers on the southwest street light pole appear to be a memorial marker.

Flowers on the west approach Stop Line sign appear to be a memorial marker.

The power distribution cabinet (PDC) for the illumination system.

Rust on top of the illumination system PDC.

Missing access louvre on the side of the illumination system PDC.

Street light pole base in southwest corner of intersection (Pole #17035312).

Street light pole base in south median (Pole #17035338).

Street light pole base in southeast corner of intersection (Pole#17035338).

Appendix E

Operational Analysis

Intersection	
Int Delay, s/veh	0.6

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	93	11	66	21	17	10	37	1287	18	10	1240	60
Future Vol, veh/h	93	11	66	21	17	10	37	1287	18	10	1240	60
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	-	-	Stop	-	-	Stop	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	1100	-	1100	1100	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	66	25	80	75	46	88	59	92	65	25	90	75
Heavy Vehicles, %	4	2	3	2	2	10	3	15	6	5	15	3
Mvmt Flow	141	44	83	28	37	11	63	1399	28	40	1378	80

Due to an error reported storage lengths are 10 times larger than those entered into Synchro.

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	2301	2982	689	2177	2982	699	1378	0	0	1399	0	0
Stage 1	1458	1458	-	1524	1524	-	-	-	-	-	-	-
Stage 2	843	1524	-	653	1458	-	-	-	-	-	-	-
Critical Hdwy	7.03	6.54	7.16	6.99	6.54	7.1	5.36	-	-	4.2	-	-
Critical Hdwy Stg 1	7.38	5.54	-	6.54	5.54	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.58	5.54	-	6.74	5.54	-	-	-	-	-	-	-
Follow-up Hdwy	3.69	4.02	3.93	3.67	4.02	3.4	3.13	-	-	2.25	-	-
Pot Cap-1 Maneuver	~ 28	~ 14	331	36	~ 14	364	254	-	-	469	-	-
Stage 1	~ 95	192	-	121	179	-	-	-	-	-	-	-
Stage 2	312	179	-	396	192	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	-	~ 10	331	-	~ 10	364	254	-	-	469	-	-
Mov Cap-2 Maneuver	-	~ 10	-	-	~ 10	-	-	-	-	-	-	-
Stage 1	~ 71	176	-	91	135	-	-	-	-	-	-	-
Stage 2	165	135	-	204	176	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s			1	0.4
HCM LOS	-	-		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	254	-	-	-	-	469	-	-
HCM Lane V/C Ratio	0.247	-	-	-	-	0.085	-	-
HCM Control Delay (s)	23.8	-	-	-	-	13.4	-	-
HCM Lane LOS	C	-	-	-	-	B	-	-
HCM 95th %tile Q(veh)	0.9	-	-	-	-	0.3	-	-

Notes			
~: Volume exceeds capacity	$: Delay exceeds 300s	+: Computation Not Defined	*: All major volume in platoon

Intersection	
Int Delay, s/veh	0.7

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	41	10	54	10	13	10	60	1216	17	10	1273	149
Future Vol, veh/h	41	10	54	10	13	10	60	1216	17	10	1273	149
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	-	-	Stop	-	-	Stop	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	1100	-	1100	1100	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	81	50	80	63	50	75	79	82	44	25	87	77
Heavy Vehicles, %	4	2	3	2	2	10	3	15	6	5	15	3
Mvmt Flow	51	20	68	16	26	13	76	1483	39	40	1463	194

Due to an error reported storage lengths are 10 times larger than those entered into Synchro.

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	2449	3178	732	2310	3178	741	1463	0	0	1483	0	0
Stage 1	1543	1543	-	1635	1635	-	-	-	-	-	-	-
Stage 2	906	1635	-	675	1543	-	-	-	-	-	-	-
Critical Hdwy	7.03	6.54	7.16	6.99	6.54	7.1	5.36	-	-	4.2	-	-
Critical Hdwy Stg 1	7.38	5.54	-	6.54	5.54	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.58	5.54	-	6.74	5.54	-	-	-	-	-	-	-
Follow-up Hdwy	3.69	4.02	3.93	3.67	4.02	3.4	3.13	-	-	2.25	-	-
Pot Cap-1 Maneuver	~ 22	~ 10	310	29	~ 10	341	230	-	-	435	-	-
Stage 1	82	175	-	103	157	-	-	-	-	-	-	-
Stage 2	286	157	-	383	175	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	-	~ 6	310	-	~ 6	341	230	-	-	435	-	-
Mov Cap-2 Maneuver	-	~ 6	-	-	~ 6	-	-	-	-	-	-	-
Stage 1	55	159	-	69	105	-	-	-	-	-	-	-
Stage 2	138	105	-	238	159	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s			1.3	0.3
HCM LOS	-	-		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	230	-	-	-	-	435	-	-
HCM Lane V/C Ratio	0.33	-	-	-	-	0.092	-	-
HCM Control Delay (s)	28.2	-	-	-	-	14.1	-	-
HCM Lane LOS	D	-	-	-	-	B	-	-
HCM 95th %tile Q(veh)	1.4	-	-	-	-	0.3	-	-

Notes			
~: Volume exceeds capacity	$: Delay exceeds 300s	+: Computation Not Defined	*: All major volume in platoon

Intersection	
Int Delay, s/veh	3.1

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	170	0	0	39	37	1380	29	10	1261	77
Future Vol, veh/h	0	0	170	0	0	39	37	1380	29	10	1261	77
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	-	-	Yield	-	-	Yield	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	1100	-	1100	1100	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	88	88	80	88	88	70	59	92	65	25	90	75
Heavy Vehicles, %	2	2	3	2	2	2	3	15	4	5	15	2
Mvmt Flow	0	0	213	0	0	56	63	1500	45	40	1401	103

Due to an error reported storage lengths are 10 times larger than those entered into Synchro.

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	-	-	701	-	-	750	1504	0	0	1545	0	0
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy	-	-	7.16	-	-	6.94	5.36	-	-	4.2	-	-
Critical Hdwy Stg 1	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-	-	-	-	-	-	-
Follow-up Hdwy	-	-	3.93	-	-	3.32	3.13	-	-	2.25	-	-
Pot Cap-1 Maneuver	0	0	325	0	0	354	220	-	-	411	-	-
Stage 1	0	0	-	0	0	-	-	-	-	-	-	-
Stage 2	0	0	-	0	0	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	-	-	325	-	-	354	220	-	-	411	-	-
Mov Cap-2 Maneuver	-	-	-	-	-	-	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	34.8	17.1	1.1	0.4
HCM LOS	D	C		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	220	-	-	325	354	411	-	-
HCM Lane V/C Ratio	0.285	-	-	0.654	0.157	0.097	-	-
HCM Control Delay (s)	27.8	-	-	34.8	17.1	14.7	-	-
HCM Lane LOS	D	-	-	D	C	B	-	-
HCM 95th %tile Q(veh)	1.1	-	-	4.3	0.6	0.3	-	-

Intersection	
Int Delay, s/veh	1.9

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	97	0	0	21	60	1257	19	10	1278	162
Future Vol, veh/h	0	0	97	0	0	21	60	1257	19	10	1278	162
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	-	-	Yield	-	-	Yield	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	1100	-	1100	1100	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	88	88	82	88	88	71	79	82	44	25	87	77
Heavy Vehicles, %	2	2	3	2	2	2	3	15	4	5	15	2
Mvmt Flow	0	0	118	0	0	30	76	1533	43	40	1469	210

Due to an error reported storage lengths are 10 times larger than those entered into Synchro.

Major/Minor	Minor2		Minor1			Major1				Major2		
Conflicting Flow All	-	-	735	-	-	767	1679	0	0	1576	0	0
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy	-	-	7.16	-	-	6.94	5.36	-	-	4.2	-	-
Critical Hdwy Stg 1	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-	-	-	-	-	-	-
Follow-up Hdwy	-	-	3.93	-	-	3.32	3.13	-	-	2.25	-	-
Pot Cap-1 Maneuver	0	0	309	0	0	345	180	-	-	400	-	-
Stage 1	0	0	-	0	0	-	-	-	-	-	-	-
Stage 2	0	0	-	0	0	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	-	-	309	-	-	345	180	-	-	400	-	-
Mov Cap-2 Maneuver	-	-	-	-	-	-	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	23.7	16.4	1.8	0.3
HCM LOS	C	C		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	180	-	-	309	345	400	-	-
HCM Lane V/C Ratio	0.422	-	-	0.383	0.086	0.1	-	-
HCM Control Delay (s)	38.9	-	-	23.7	16.4	15	-	-
HCM Lane LOS	E	-	-	C	C	B	-	-
HCM 95th %tile Q(veh)	1.9	-	-	1.7	0.3	0.3	-	-

Intersection	
Int Delay, s/veh	2.5

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations			↱			↱		↑↑	↱		↑↑↑	↱
Traffic Vol, veh/h	0	0	170	0	0	39	0	1380	29	0	1261	77
Future Vol, veh/h	0	0	170	0	0	39	0	1380	29	0	1261	77
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	-	-	Yield	-	-	Yield	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	1100	-	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	88	88	80	88	88	70	88	92	65	88	90	75
Heavy Vehicles, %	2	2	3	2	2	2	2	15	4	2	15	2
Mvmt Flow	0	0	213	0	0	56	0	1500	45	0	1401	103

Due to an error reported storage lengths are 10 times larger than those entered into Synchro.

Major/Minor	Minor2		Minor1			Major1			Major2			
Conflicting Flow All	-	-	701	-	-	750	-	0	0	-	-	0
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy	-	-	7.16	-	-	6.94	-	-	-	-	-	-
Critical Hdwy Stg 1	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-	-	-	-	-	-	-
Follow-up Hdwy	-	-	3.93	-	-	3.32	-	-	-	-	-	-
Pot Cap-1 Maneuver	0	0	325	0	0	354	0	-	-	0	-	-
Stage 1	0	0	-	0	0	-	0	-	-	0	-	-
Stage 2	0	0	-	0	0	-	0	-	-	0	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	-	-	325	-	-	354	-	-	-	-	-	-
Mov Cap-2 Maneuver	-	-	-	-	-	-	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	34.8	17.1	0	0
HCM LOS	D	C		

Minor Lane/Major Mvmt	NBT	NBR	EBLn1	WBLn1	SBT	SBR
Capacity (veh/h)	-	-	325	354	-	-
HCM Lane V/C Ratio	-	-	0.654	0.157	-	-
HCM Control Delay (s)	-	-	34.8	17.1	-	-
HCM Lane LOS	-	-	D	C	-	-
HCM 95th %tile Q(veh)	-	-	4.3	0.6	-	-

Intersection	
Int Delay, s/veh	1

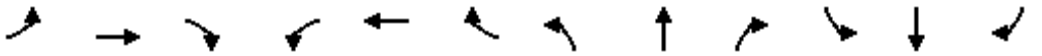
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	97	0	0	21	0	1257	19	0	1278	162
Future Vol, veh/h	0	0	97	0	0	21	0	1257	19	0	1278	162
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	Yield	-	-	Yield	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	1100	-	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	88	88	82	88	88	71	79	82	44	25	87	77
Heavy Vehicles, %	2	2	3	2	2	2	2	15	4	2	15	2
Mvmt Flow	0	0	118	0	0	30	0	1533	43	0	1469	210

Due to an error reported storage lengths are 10 times larger than those entered into Synchro.

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	-	-	735	-	-	767	-	0	0	-	-	0
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy	-	-	7.16	-	-	6.94	-	-	-	-	-	-
Critical Hdwy Stg 1	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-	-	-	-	-	-	-
Follow-up Hdwy	-	-	3.93	-	-	3.32	-	-	-	-	-	-
Pot Cap-1 Maneuver	0	0	309	0	0	345	0	-	-	0	-	-
Stage 1	0	0	-	0	0	-	0	-	-	0	-	-
Stage 2	0	0	-	0	0	-	0	-	-	0	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	-	-	309	-	-	345	-	-	-	-	-	-
Mov Cap-2 Maneuver	-	-	-	-	-	-	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	23.7	16.4	0	0
HCM LOS	C	C		

Minor Lane/Major Mvmt	NBT	NBR	EBLn1	WBLn1	SBT	SBR
Capacity (veh/h)	-	-	309	345	-	-
HCM Lane V/C Ratio	-	-	0.383	0.086	-	-
HCM Control Delay (s)	-	-	23.7	16.4	-	-
HCM Lane LOS	-	-	C	C	-	-
HCM 95th %tile Q(veh)	-	-	1.7	0.3	-	-



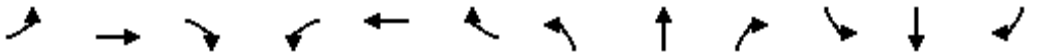
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	93	11	66	21	17	10	37	1287	18	10	1240	60
Future Volume (vph)	93	11	66	21	17	10	37	1287	18	10	1240	60
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (m)	0.0		30.0	0.0		15.0	110.0		110.0	110.0		110.0
Storage Lanes	0		1	0		0	1		1	1		1
Taper Length (m)	7.5			7.5			30.0			30.0		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.91	1.00
Frt			0.850		0.980				0.850			0.850
Flt Protected		0.963			0.982		0.950			0.950		
Satd. Flow (prot)	0	1767	1568	0	1773	0	1752	3139	1524	1719	4510	1568
Flt Permitted		0.727			0.790		0.148			0.118		
Satd. Flow (perm)	0	1334	1568	0	1426	0	273	3139	1524	214	4510	1568
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			104		8				120			120
Link Speed (k/h)		80			80			80			80	
Link Distance (m)		443.3			364.3			628.3			632.6	
Travel Time (s)		19.9			16.4			28.3			28.5	
Peak Hour Factor	0.66	0.25	0.80	0.75	0.46	0.88	0.59	0.92	0.65	0.25	0.90	0.75
Heavy Vehicles (%)	4%	2%	3%	2%	2%	10%	3%	15%	6%	5%	15%	3%
Adj. Flow (vph)	141	44	83	28	37	11	63	1399	28	40	1378	80
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	185	83	0	76	0	63	1399	28	40	1378	80
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(m)		0.0			0.0			30.0			30.0	
Link Offset(m)		0.0			0.0			0.0			0.0	
Crosswalk Width(m)		4.8			4.8			4.8			4.8	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (k/h)	25		15	25		15	25		15	25		15
Turn Type	Perm	NA	Perm	Perm	NA		pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8			2		2	6		6
Detector Phase	4	4	4	8	8		5	2	2	1	6	6
Switch Phase												
Minimum Initial (s)	10.0	10.0	10.0	10.0	10.0		5.0	20.0	20.0	5.0	20.0	20.0
Minimum Split (s)	18.0	18.0	18.0	18.0	18.0		11.0	26.5	26.5	11.0	26.5	26.5
Total Split (s)	31.0	31.0	31.0	31.0	31.0		11.0	58.0	58.0	11.0	58.0	58.0
Total Split (%)	31.0%	31.0%	31.0%	31.0%	31.0%		11.0%	58.0%	58.0%	11.0%	58.0%	58.0%
Maximum Green (s)	23.0	23.0	23.0	23.0	23.0		5.0	51.5	51.5	5.0	51.5	51.5
Yellow Time (s)	5.0	5.0	5.0	3.5	3.5		5.0	5.0	5.0	5.0	5.0	5.0
All-Red Time (s)	3.0	3.0	3.0	4.5	4.5		1.0	1.5	1.5	1.0	1.5	1.5
Lost Time Adjust (s)		0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)		8.0	8.0		8.0		6.0	6.5	6.5	6.0	6.5	6.5
Lead/Lag							Lead	Lag	Lag	Lead	Lag	Lag
Lead-Lag Optimize?							Yes	Yes	Yes	Yes	Yes	Yes
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Recall Mode	None	None	None	None	None		None	Max	Max	None	Max	Max

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Act Effct Green (s)		17.3	17.3		17.3		57.6	54.2	54.2	56.4	52.0	52.0
Actuated g/C Ratio		0.19	0.19		0.19		0.62	0.59	0.59	0.61	0.56	0.56
v/c Ratio		0.74	0.22		0.28		0.25	0.76	0.03	0.19	0.54	0.09
Control Delay		54.2	5.7		32.3		9.2	20.1	0.1	8.7	15.0	1.1
Queue Delay		0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		54.2	5.7		32.3		9.2	20.1	0.1	8.7	15.0	1.1
LOS		D	A		C		A	C	A	A	B	A
Approach Delay		39.2			32.3			19.2			14.1	
Approach LOS		D			C			B			B	
Queue Length 50th (m)		33.9	0.0		11.3		3.8	111.6	0.0	2.4	61.0	0.0
Queue Length 95th (m)		13.4	5.5		11.1		6.0	160.4	0.0	1.8	83.2	0.6
Internal Link Dist (m)		419.3			340.3			604.3			608.6	
Turn Bay Length (m)			30.0				110.0		110.0	110.0		110.0
Base Capacity (vph)		335	472		364		250	1842	943	212	2538	935
Starvation Cap Reductn		0	0		0		0	0	0	0	0	0
Spillback Cap Reductn		0	0		0		0	0	0	0	0	0
Storage Cap Reductn		0	0		0		0	0	0	0	0	0
Reduced v/c Ratio		0.55	0.18		0.21		0.25	0.76	0.03	0.19	0.54	0.09

Intersection Summary

Area Type: Other
Cycle Length: 100
Actuated Cycle Length: 92.4
Natural Cycle: 80
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 18.8 — Intersection LOS: B
Intersection Capacity Utilization 59.4% — ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 3: Hwy 2 & TR204



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	41	10	54	10	13	10	60	1216	17	10	1273	149
Future Volume (vph)	41	10	54	10	13	10	60	1216	17	10	1273	149
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (m)	0.0		30.0	0.0		15.0	110.0		110.0	110.0		110.0
Storage Lanes	0		1	0		0	1		1	1		1
Taper Length (m)	7.5			7.5			30.0			30.0		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.91	1.00
Frt			0.850		0.968				0.850			0.850
Flt Protected		0.965			0.986		0.950			0.950		
Satd. Flow (prot)	0	1773	1568	0	1746	0	1752	3139	1524	1719	4510	1568
Flt Permitted		0.752			0.877		0.148			0.133		
Satd. Flow (perm)	0	1381	1568	0	1553	0	273	3139	1524	241	4510	1568
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			104		13				120			194
Link Speed (k/h)		80			80			80			80	
Link Distance (m)		443.3			364.3			628.3			632.6	
Travel Time (s)		19.9			16.4			28.3			28.5	
Peak Hour Factor	0.81	0.50	0.80	0.63	0.50	0.75	0.79	0.82	0.44	0.25	0.87	0.77
Heavy Vehicles (%)	4%	2%	3%	2%	2%	10%	3%	15%	6%	5%	15%	3%
Adj. Flow (vph)	51	20	68	16	26	13	76	1483	39	40	1463	194
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	71	68	0	55	0	76	1483	39	40	1463	194
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(m)		0.0			0.0			30.0			30.0	
Link Offset(m)		0.0			0.0			0.0			0.0	
Crosswalk Width(m)		4.8			4.8			4.8			4.8	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (k/h)	25		15	25		15	25		15	25		15
Turn Type	Perm	NA	Perm	Perm	NA		pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8			2		2	6		6
Detector Phase	4	4	4	8	8		5	2	2	1	6	6
Switch Phase												
Minimum Initial (s)	10.0	10.0	10.0	10.0	10.0		5.0	20.0	20.0	5.0	20.0	20.0
Minimum Split (s)	18.0	18.0	18.0	18.0	18.0		11.0	26.5	26.5	11.0	26.5	26.5
Total Split (s)	19.0	19.0	19.0	19.0	19.0		11.0	70.0	70.0	11.0	70.0	70.0
Total Split (%)	19.0%	19.0%	19.0%	19.0%	19.0%		11.0%	70.0%	70.0%	11.0%	70.0%	70.0%
Maximum Green (s)	11.0	11.0	11.0	11.0	11.0		5.0	63.5	63.5	5.0	63.5	63.5
Yellow Time (s)	5.0	5.0	5.0	3.5	3.5		5.0	5.0	5.0	5.0	5.0	5.0
All-Red Time (s)	3.0	3.0	3.0	4.5	4.5		1.0	1.5	1.5	1.0	1.5	1.5
Lost Time Adjust (s)		0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)		8.0	8.0		8.0		6.0	6.5	6.5	6.0	6.5	6.5
Lead/Lag							Lead	Lag	Lag	Lead	Lag	Lag
Lead-Lag Optimize?							Yes	Yes	Yes	Yes	Yes	Yes
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Recall Mode	None	None	None	None	None		None	Max	Max	None	Max	Max

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Act Effct Green (s)		10.5	10.5		10.5		72.7	70.8	70.8	71.6	68.7	68.7
Actuated g/C Ratio		0.11	0.11		0.11		0.75	0.73	0.73	0.74	0.71	0.71
v/c Ratio		0.48	0.26		0.31		0.27	0.65	0.03	0.16	0.46	0.17
Control Delay		53.3	5.6		38.2		5.9	11.5	0.1	4.8	8.9	1.4
Queue Delay		0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		53.3	5.6		38.2		5.9	11.5	0.1	4.8	8.9	1.4
LOS		D	A		D		A	B	A	A	A	A
Approach Delay		30.0			38.2			11.0			8.0	
Approach LOS		C			D			B			A	
Queue Length 50th (m)		13.8	0.0		8.0		3.3	98.4	0.0	1.7	52.8	0.0
Queue Length 95th (m)		15.1	2.8		9.7		5.8	106.2	0.0	1.1	61.7	4.3
Internal Link Dist (m)		419.3			340.3			604.3			608.6	
Turn Bay Length (m)			30.0				110.0		110.0	110.0		110.0
Base Capacity (vph)		157	271		189		282	2298	1148	255	3202	1169
Starvation Cap Reductn		0	0		0		0	0	0	0	0	0
Spillback Cap Reductn		0	0		0		0	0	0	0	0	0
Storage Cap Reductn		0	0		0		0	0	0	0	0	0
Reduced v/c Ratio		0.45	0.25		0.29		0.27	0.65	0.03	0.16	0.46	0.17

Intersection Summary			
Area Type:	Other		
Cycle Length: 100			
Actuated Cycle Length: 96.7			
Natural Cycle: 75			
Control Type: Semi Act-Uncoord			
Maximum v/c Ratio: 0.65			
Intersection Signal Delay: 10.7		Intersection LOS: B	
Intersection Capacity Utilization 63.4%		ICU Level of Service B	
Analysis Period (min) 15			

Splits and Phases: 3: Hwy 2 & TR204

Appendix F

Warrants

Alberta Transportation - Traffic Signal Warrant Analysis

Main Street (name)	**Highway 2**	**Direction (EW or NS)**	**NS**	**Road Authority:**	**Alberta Transportation**
Side Street (name)	**TR204**	**Direction (EW or NS)**	**EW**	**City:**	**4.1 km E of Okotoks, AB**
Quadrant / Int #	**1277**	**Comments**	**6-Hour Peak: 2.80 x (AM + PM DHV)**	**Analysis Date:**	**2018 Nov 16, Fri**
for Warrant Calculation Results, please hit 'Page Down'	**CHECK SHEET**			**Count Date:**	**2018 100th Highest Hour**
				Date Entry Format:	(yyyy-mm-dd)

Lane Configuration		Excl LT	Th & LT	Through	Th+RT+LT	Th & RT	Excl RT	UpStream Signal (m)	# of Thru Lanes
Highway 2	NB	1		2			1	9,999	2
Highway 2	SB	1		3			1	9,999	3
TR204	WB				1				
TR204	EB				1				
Are the TR204 WB right turns significantly impeded by through movements? (y/n)							y		
Are the TR204 EB right turns significantly impeded by through movements? (y/n)							y		

Demographics		
Elem. School/Mobility Challenged	(y/n)	n
Senior's Complex	(y/n)	n
Pathway to School	(y/n)	n
Metro Area Population	(#)	28,900
Central Business District	(y/n)	n

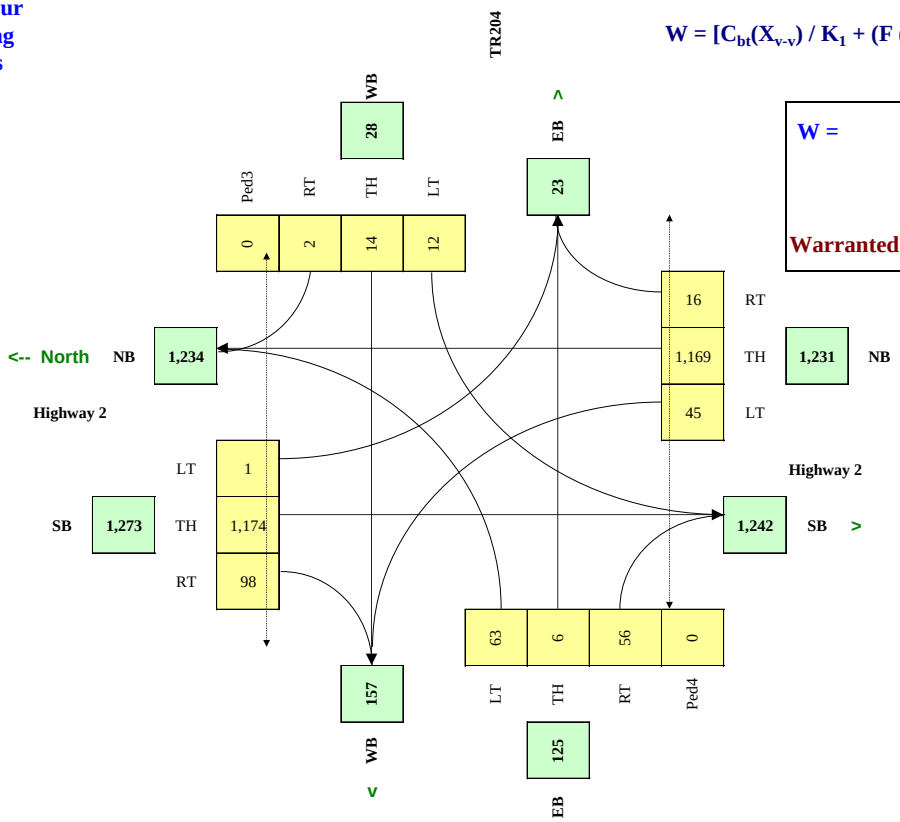
Other input		Speed (Km/h)	Truck %	Bus Rt (y/n)	Median (m)
Highway 2	NS	110	14.0%	n	30.3
TR204	EW		3.0%	n	

Set Peak Hours

Traffic Input	**NB**			**SB**			**WB**			**EB**			**Ped1 NS**	**Ped2 NS**	**Ped3 EW**	**Ped4 EW**
	LT	**Th**	**RT**	**LT**	**Th**	**RT**	**LT**	**Th**	**RT**	**LT**	**Th**	**RT**	**W Side**	**E Side**	**N Side**	**S Side**
press 'Set Peak Hours' Button to set the peak hour periods	272	7015	98	6	7043	586	73	84	11	376	36	336	0	0	0	0
Total (6-hour peak)	**272**	**7,015**	**98**	**6**	**7,043**	**586**	**73**	**84**	**11**	**376**	**36**	**336**	**0**	**0**	**0**	**0**
Average (6-hour peak)	**45**	**1,169**	**16**	**1**	**1,174**	**98**	**12**	**14**	**2**	**63**	**6**	**56**	**0**	**0**	**0**	**0**

Average 6-hour Peak Turning Movements

$$W = [C_{bt}(X_{v\text{-}v}) / K_1 + (F\,(X_{v\text{-}p})\,L) / K_2] \times C_i$$



W = **174** **174** **0**

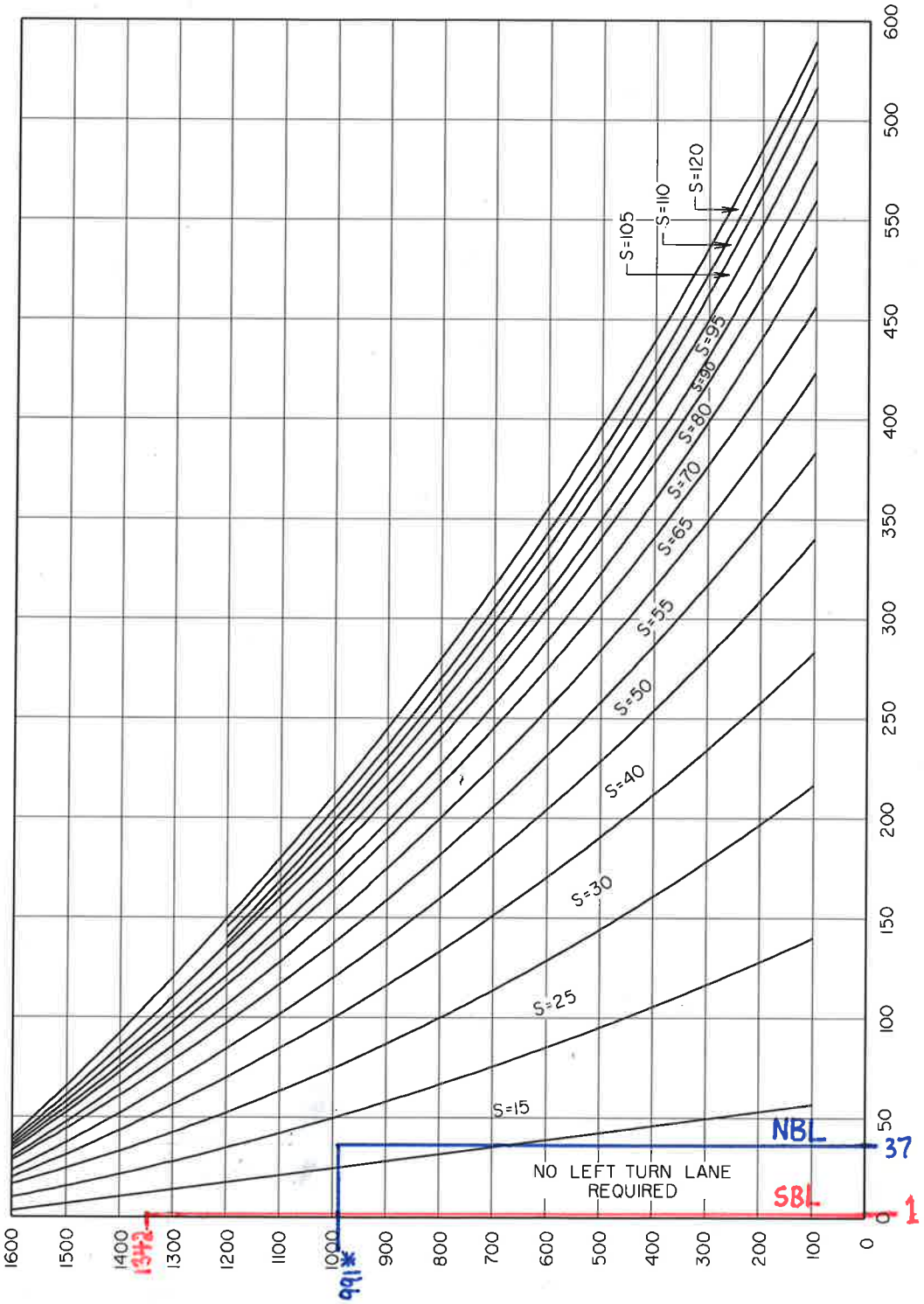
Veh ***Ped***

Warranted

RESET SHEET

Hwy 2 at TR 204
AM 100th Highest Hour Traffic Volumes
(2018)

FIGURE D-8.6c WARRANTS FOR LEFT TURN LANES AND STORAGE REQUIREMENTS FOR FOUR-LANE DIVIDED HIGHWAYS



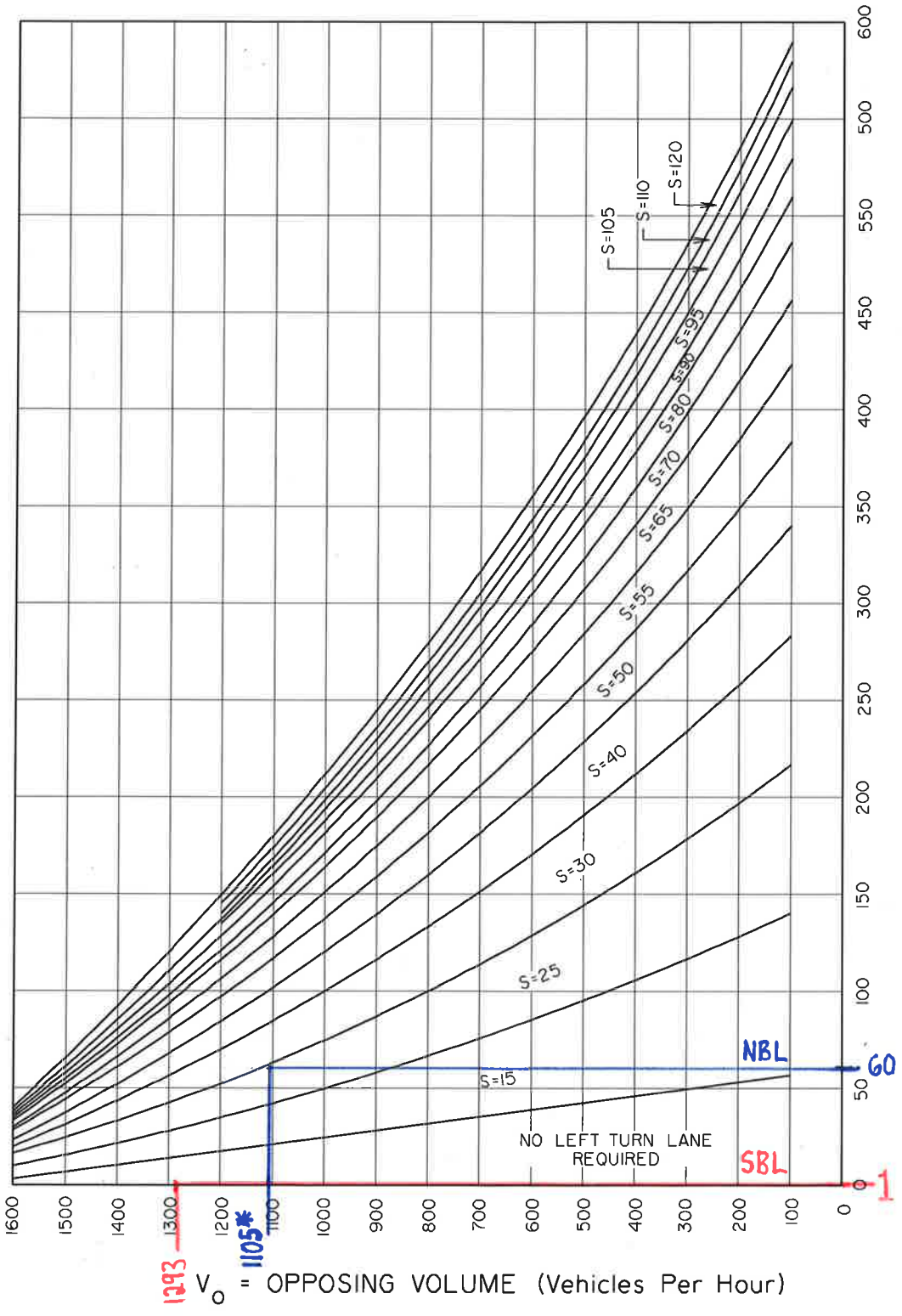
* Adjusted opposing volume for NBL as the left turns cross 3 lanes and the chart is based on left turns crossing 2 lanes. Adjusted opposing volume to only include through volumes from the 2 right-most through lanes plust the left and right turns. Assumed a 40/35/25 split (right to left) for lane utilization.

V_O=1+1240(0.40+0.35)+60
V_O=991

GRAPHICS FILE: DEI:[200.221]debxd86.mgn

Hwy 2 at TR204
PM 100th Highest Hour Traffic Volumes
(2018)

FIGURE D-8.6c WARRANTS FOR LEFT TURN LANES AND STORAGE REQUIREMENTS FOR FOUR-LANE DIVIDED HIGHWAYS



* Adjusted opposing volume for NBL as the left turns cross 3 lanes and the chart is based on left turns crossing 2 lanes. Adjusted opposing volume to only include through volumes from the 2 right-most through lanes plus the left and right turns. Assumed a 40/35/25 split (right to left) for lane utilization.

V_O=1+1273(0.40+0.35)+149
V_O=1105

GRAPHICS FILE: DEI:[200,221]debxd86.man

Illumination of Isolated Rural Intersections
LIGHTING WARRANT SPREADSHEET

This spreadsheet is to be used in conjunction with *Illumination of Isolated Rural Intersections* , Transportation Association of Canada, February 2001.

Please enter information in the cells with yellow background

INTERSECTION CHARACTERISTICS

Highway 2	Main Road
Township Road 204	Minor Road
Okotoks, AB	City/Town

Date January 4, 2019

Other Existing Conditions
Scenario: Collision Frequency of 1.0

GEOMETRIC FACTORS

	Value	Rating	Weight	Comments	Check	Score
Channelization Rating	Descriptive	3		Refer to Table 1(A) to determine rating value	OK	
Presence of raised channelization? (Y / N)	n				OK	
Highest operating speed on raised, channelized approach (km/h)	0		5		OK	
Channelization Factor					OK	15
Approach Sight Distance on most constrained approach (%)	100	0	10	Relative to the recommended minimum sight distance	OK	0
Posted Speed limit (in 10's of km/h)	80				OK	
Radius of Horizontal Curve (m)	20			Enter "T" for tangent (no horizontal curve at the intersection)	OK	
Posted Speed Category =		0				
Posted Speed Category =		0				
Posted Speed Category =	C	4				
Posted Speed Category =		0				
Horizontal Curvature Factor		4	5		OK	20
Angle of Intersection (10's of Degrees)	90	0	5		OK	0
Downhill Approach Grade (x.x%)	0.0	0	3	Rounded to nearest tenth of a percent	OK	0
Number of Intersection Legs	4	2	3	Number of legs = 3 or more	OK	6
					Geometric Factors Subtotal	**41**

OPERATIONAL FACTORS

Is the intersection signalized ? (Y/ N)	n			Calculate the Signalization Warrant Factor		
AADT on Major Road (2-way)	26070	4	10	Either Use the two AADT inputs **OR** the Descriptive Signalization Warrant (Unused values should be set to Zero) Refer to Table 1(B) for description and rating values for signalization warrant.	OK	40
AADT on Minor Road (2-way)	3230	4	20		OK	80
Signalization Warrant	Descriptive	0	30		OK	0
					OK	
Night-Time Hourly Pedestrian Volume	0	0	10	Refer to Table 1(B), note #2, to account for children and seniors	OK	0
Intersecting Roadway Classification	Descriptive	4	5	Refer to Table 1(B) for ratings.	OK	20
Operating Speed or Posted Speed on Major Road (km/h)	110	4	5	Refer to Table 1(B), note #3	OK	20
Operating Speed on Minor Road (km/h)	80	3	5	Refer to Table 1(B), note #3	OK	15
					Operational Factors Subtotal	**175**

ENVIRONMENTAL FACTOR

Lighted Developments within 150 m radius of intersection	0	0	5	Maximum of 4 quadrants	OK	0
					Environmental Factor Subtotal	**0**

COLLISION HISTORY

Average Annual night-time collision frequency due to inadequate lighting (collisions/yr, rounded to nearest whole #)	1.0	1	15	Enter **either** the annual frequency (See Table 1(C), note #4) **OR** the number of collisions / MEV	OK	15
OR						
Collision Rate over last 3 years, due to inadequate lighting (/MEV)	0	0	0	(Unused values should be set to Zero)	OK	0
Is the average ratio of **all** night to day collisions >= 1.5 (Y/N)	n	0			OK	
					OK	
					Collision History Subtotal	**15**

Check Intersection Signalization:
Intersection is not Signalized

ILLUMINATION WARRANTED
DELINEATION LIGHTING TO ILLUMINATE PEDESTRIANS OR CROSS STREET TRAFFIC

SUMMARY

Geometric Factors Subtotal	41
Operational Factor Subtotal	175
Environmental Factor Subtotal	0
Collision History Subtotal	15
TOTAL POINTS	**231**

Illumination of Isolated Rural Intersections
LIGHTING WARRANT SPREADSHEET

This spreadsheet is to be used in conjunction with *Illumination of Isolated Rural Intersections* , Transportation Association of Canada, February 2001.

Please enter information in the cells with yellow background

INTERSECTION CHARACTERISTICS

Highway 2	Main Road
Township Road 204	Minor Road
Okotoks, AB	City/Town

Date January 4, 2019

Other Existing Conditions
Scenario: Collision Frequency of 2.0

GEOMETRIC FACTORS

	Value	Rating	Weight	Comments	Check	Score
Channelization Rating	Descriptive	3		Refer to Table 1(A) to determine rating value	OK	
Presence of raised channelization? (Y / N)	n				OK	
Highest operating speed on raised, channelized approach (km/h)	0		5		OK	
Channelization Factor					OK	15
Approach Sight Distance on most constrained approach (%)	100	0	10	Relative to the recommended minimum sight distance	OK	0
Posted Speed limit (in 10's of km/h)	80				OK	
Radius of Horizontal Curve (m)	20			Enter "T" for tangent (no horizontal curve at the intersection)	OK	
Posted Speed Category =		0				
Posted Speed Category =		0				
Posted Speed Category =	C	4				
Posted Speed Category =		0				
Horizontal Curvature Factor		4	5		OK	20
Angle of Intersection (10's of Degrees)	90	0	5		OK	0
Downhill Approach Grade (x.x%)	0.0	0	3	Rounded to nearest tenth of a percent	OK	0
Number of Intersection Legs	4	2	3	Number of legs = 3 or more	OK	6
					Geometric Factors Subtotal	**41**

OPERATIONAL FACTORS

Is the intersection signalized ? (Y/ N)	n			Calculate the Signalization Warrant Factor		
AADT on Major Road (2-way)	26070	4	10	Either Use the two AADT inputs **OR** the Descriptive Signalization Warrant (Unused values should be set to Zero) Refer to Table 1(B) for description and rating values for signalization warrant.	OK	40
AADT on Minor Road (2-way)	3230	4	20		OK	80
Signalization Warrant	Descriptive	0	30		OK	0
					OK	
Night-Time Hourly Pedestrian Volume	0	0	10	Refer to Table 1(B), note #2, to account for children and seniors	OK	0
Intersecting Roadway Classification	Descriptive	4	5	Refer to Table 1(B) for ratings.	OK	20
Operating Speed or Posted Speed on Major Road (km/h)	110	4	5	Refer to Table 1(B), note #3	OK	20
Operating Speed on Minor Road (km/h)	80	3	5	Refer to Table 1(B), note #3	OK	15
					Operational Factors Subtotal	**175**

ENVIRONMENTAL FACTOR

Lighted Developments within 150 m radius of intersection	0	0	5	Maximum of 4 quadrants	OK	0
					Environmental Factor Subtotal	**0**

COLLISION HISTORY

Average Annual night-time collision frequency due to inadequate lighting (collisions/yr, rounded to nearest whole #)	2.0	3	15	Enter **either** the annual frequency (See Table 1(C), note #4) **OR** the number of collisions / MEV	OK	45
OR						
Collision Rate over last 3 years, due to inadequate lighting (/MEV)	0	0	0	(Unused values should be set to Zero)	OK	0
Is the average ratio of **all** night to day collisions >= 1.5 (Y/N)	n	0			OK	
					OK	
					Collision History Subtotal	**45**

Check Intersection Signalization:
Intersection is not Signalized

FULL ILLUMINATION WARRANTED

SUMMARY

Geometric Factors Subtotal	41
Operational Factor Subtotal	175
Environmental Factor Subtotal	0
Collision History Subtotal	45
TOTAL POINTS	**261**

TABLE 1(A) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: GEOMETRIC FACTORS

Classification Factor	Rating 0	1	2	3	4	Weight		Score (Rating x Weight)
channelization	none	right and/or left turn lanes on minor approach only	right turn lane(s) only on major leg(s)	left turn lane(s) on major leg(s)	left and right turn lanes on all legs	raised and operating speed less than 70 km/h on at least one channelized approach OR raised and operating speed 70 km/h or more on at least one channelized approach OR painted only	15 20 5	
approach sight distance on the most constrained approach (relative to recommended minimum intersection sight distance)	100% or more	75% - 99%	50% - 74%	25% - 49%	<25%	10		
horizontal curvature (radius) at or immediately before intersection on any leg for posted speed limit of:								
110 km/h	tangent	>1,800m	1,150 to 1,800m	750 to 1,150m	<750m			
90 or 100 km/h	tangent	>1,400m	950 to 1,400m	600 to 950m	<600m			
70 or 80 km/h	tangent	>950m	550 to 950m	340 to 550m	<340m			
60 km/h	tangent	>575m	320 to 575m	190 to 320m	<190m	5		
angle of intersection OR offset intersection	90° angle	80° or 100° angle	--	70° or 110° angle	<70° or >110° OR offset intersection	5		
downhill approach grades at or immediately before intersection on any leg	<3.0%	3.1 to 3.9% and meets design guidelines for type and speed of road	4.0 to 4.9% and meets design guidelines for type and speed of road	5.0 to 7.0% and meets design guidelines for type and speed of road	>7.0% OR exceeds maximum gradient for the type and speed of road	3		
number of legs	--	3	4	5	6 or more	3		
						SUBTOTAL (Geometric Factors)		

TABLE 1(B) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: OPERATIONAL FACTORS

Classification Factor	Rating 0	1	2	3	4	Weight	Score (Rating x Weight)
IF THE INTERSECTION IS SIGNALIZED, ILLUMINATION IS WARRANTED.							
IF THE INTERSECTION IS NOT SIGNALIZED, points should be calculated on the basis of *either* the AADT factor *or* the signalization warrant factor:							
either							
AADT (2-way)[1]:							
on major road and	<1,000	1,000 to 2,000	2,000 to 3,000	3,000 to 5,000	>5,000	10	
on minor road	<500	500 to 1,000	1,000 to 1,500	1,500 to 2,000	>2,000	20	
or signalization warrant[1]	intersection not signalized and volume-based signal warrant is less than 20% satisfied	intersection not signalized and volume-based warrant is 20% to 40% satisfied	intersection not signalized and volume-based warrant is 40% to 60% satisfied	intersection not signalized and volume-based warrant is 60% to 80% satisfied	intersection not signalized and volume-based warrant is over 80% satisfied	30	
regular night-time hourly pedestrian volume[2]	no pedestrians	up to 10	10 to 30	30 to 50	over 50	10	
intersecting roadway classifications	no primary road involved	primary/rural major, primary/rural minor, or primary/designated community access	primary/secondary	primary/primary	intersection includes divided highway	5	
operating speed or posted speed limit on major road[3]	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5	
operating speed or posted speed limit on minor road[3]	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5	
						SUBTOTAL (Operational Factors)[1]	

NOTES 1. If the intersection is not signalized, the user should choose *EITHER* the AADT factor *OR* the signalization warrant factor. The points from either factor, but not both factors, may be used in the warrant points calculation.

2. The number of certain types of vulnerable pedestrians should be factored to reflect their increased need for visibility. The number of child pedestrians (ages 12 and under) should be multiplied by 2, and the number of senior pedestrians (ages 65 and over) should be multiplied by 1.5.

3. 85th percentile night-time speed should be used if available. Otherwise, the posted speed limit may be used.

TABLE 1(C) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: ENVIRONMENTAL AND COLLISION FACTORS

Classification Factor	Rating 0	1	2	3	4	Weight		Score (Rating x Weight)
ENVIRONMENTAL FACTOR								
lighted development within 150m radius of intersection	--	in one quadrant	in two quadrants	in three quadrants	in four quadrants	5		
						SUBTOTAL (Environmental Factors)		
COLLISION HISTORY								
average annual night-time collision frequency[4] or rate over last 3 years (only collisions potentially attributable to inadequate lighting)	0 collisions per year	Scenario Collision Frequency of 1.0 1 collision per year	--	Scenario Collision Frequency of 2.0 2 collisions per year	3 or more per year OR at least 1.5 collisions per million entering vehicles per year *and* an average ratio of all night to day collisions of at least 1.5.	1 or 2 collisions per year	15	
						3 or more collisions per year OR rate≥1.5 collisions/MEV	30	
						SUBTOTAL (Collision History)		
						Geometric Factors Subtotal (Table 1(A))		
						Operational Factors Subtotal (Table 1(B))		
						Environmental Factors Subtotal (Table 1(C))		
						Collision History Subtotal (Table 1(C))		
						TOTAL POINTS		

NOTE: 4. reported collisions, rounded to nearest whole number

Illumination of Isolated Rural Intersections
LIGHTING WARRANT SPREADSHEET

This spreadsheet is to be used in conjunction with *Illumination of Isolated Rural Intersections* , Transportation Association of Canada, February 2001.

Please enter information in the cells with yellow background

INTERSECTION CHARACTERISTICS

Highway 2	Main Road
Township Road 204	Minor Road
Okotoks, AB	City/Town

Date January 7, 2019

Other Minor Approach Turn Restrictions Option
Scenario: Painted Channelization

GEOMETRIC FACTORS

	Value	Rating	Weight	Comments	Check	Score
Channelization Rating	Descriptive	4		Refer to Table 1(A) to determine rating value	OK	
Presence of raised channelization? (Y / N)	n				OK	
Highest operating speed on raised, channelized approach (km/h)	0		5		OK	
Channelization Factor					OK	20
Approach Sight Distance on most constrained approach (%)	100	0	10	Relative to the recommended minimum sight distance	OK	0
Posted Speed limit (in 10's of km/h)	80				OK	
Radius of Horizontal Curve (m)	20			Enter "T" for tangent (no horizontal curve at the intersection)	OK	
Posted Speed Category =		0				
Posted Speed Category =		0				
Posted Speed Category =	C	4				
Posted Speed Category =		0				
Horizontal Curvature Factor		4	5		OK	20
Angle of Intersection (10's of Degrees)	90	0	5		OK	0
Downhill Approach Grade (x.x%)	0.0	0	3	Rounded to nearest tenth of a percent	OK	0
Number of Intersection Legs	4	2	3	Number of legs = 3 or more	OK	6
					Geometric Factors Subtotal	**46**

OPERATIONAL FACTORS

Is the intersection signalized ? (Y/ N)	n			Calculate the Signalization Warrant Factor		
AADT on Major Road (2-way)	27830	4	10	Either Use the two AADT inputs **OR** the Descriptive Signalization Warrant (Unused values should be set to Zero) Refer to Table 1(B) for description and rating values for signalization warrant.	OK	40
AADT on Minor Road (2-way)	3230	4	20		OK	80
Signalization Warrant	Descriptive	0	30		OK	0
					OK	
Night-Time Hourly Pedestrian Volume	0	0	10	Refer to Table 1(B), note #2, to account for children and seniors	OK	0
Intersecting Roadway Classification	Descriptive	4	5	Refer to Table 1(B) for ratings.	OK	20
Operating Speed or Posted Speed on Major Road (km/h)	110	4	5	Refer to Table 1(B), note #3	OK	20
Operating Speed on Minor Road (km/h)	80	3	5	Refer to Table 1(B), note #3	OK	15
					Operational Factors Subtotal	**175**

ENVIRONMENTAL FACTOR

Lighted Developments within 150 m radius of intersection	0	0	5	Maximum of 4 quadrants	OK	0
					Environmental Factor Subtotal	**0**

COLLISION HISTORY

Average Annual night-time collision frequency due to inadequate lighting (collisions/yr, rounded to nearest whole #)	1.0	1	15	Enter **either** the annual frequency (See Table 1(C), note #4) **OR** the number of collisions / MEV	OK	15
OR						
Collision Rate over last 3 years, due to inadequate lighting (/MEV)	0	0	0	(Unused values should be set to Zero)	OK	0
Is the average ratio of **all** night to day collisions >= 1.5 (Y/N)	n	0			OK	
					OK	
					Collision History Subtotal	**15**

Check Intersection Signalization:
Intersection is not Signalized

ILLUMINATION WARRANTED
DELINEATION LIGHTING TO ILLUMINATE PEDESTRIANS OR CROSS STREET TRAFFIC

SUMMARY

Geometric Factors Subtotal	46
Operational Factor Subtotal	175
Environmental Factor Subtotal	0
Collision History Subtotal	15
TOTAL POINTS	**236**

Illumination of Isolated Rural Intersections
LIGHTING WARRANT SPREADSHEET

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Please enter information in the cells with yellow background

INTERSECTION CHARACTERISTICS

Highway 2	Main Road	**Date**	January 7, 2019
Township Road 204	Minor Road	**Other**	Minor Approach Turn Restrictions Option
Okotoks, AB	City/Town		Scenario: Raised Channelization

GEOMETRIC FACTORS

	Value	Rating	Weight	Comments	Check	Score
Channelization Rating	Descriptive	4		Refer to Table 1(A) to determine rating value	OK	
Presence of raised channelization? (Y / N)	y				OK	
Highest operating speed on raised, channelized approach (km/h)	80		20		OK	
Channelization Factor					OK	80
Approach Sight Distance on most constrained approach (%)	100	0	10	Relative to the recommended minimum sight distance	OK	0
Posted Speed limit (in 10's of km/h)	80				OK	
Radius of Horizontal Curve (m)	20			Enter "T" for tangent (no horizontal curve at the intersection)	OK	
Posted Speed Category =		0				
Posted Speed Category =		0				
Posted Speed Category =	C	4				
Posted Speed Category =		0				
Horizontal Curvature Factor		4	5		OK	20
Angle of Intersection (10's of Degrees)	90	0	5		OK	0
Downhill Approach Grade (x.x%)	0.0	0	3	Rounded to nearest tenth of a percent	OK	0
Number of Intersection Legs	4	2	3	Number of legs = 3 or more	OK	6
					Geometric Factors Subtotal	**106**

OPERATIONAL FACTORS

Is the intersection signalized ? (Y/ N)	n			Calculate the Signalization Warrant Factor		
AADT on Major Road (2-way)	27830	4	10	Either Use the two AADT inputs **OR** the Descriptive Signalization	OK	40
AADT on Minor Road (2-way)	3230	4	20	Warrant (Unused values should be set to Zero) Refer to Table	OK	80
Signalization Warrant	Descriptive	0	30	1(B) for description and rating values for signalization warrant.	OK	0
					OK	
Night-Time Hourly Pedestrian Volume	0	0	10	Refer to Table 1(B), note #2, to account for children and seniors	OK	0
Intersecting Roadway Classification	Descriptive	4	5	Refer to Table 1(B) for ratings.	OK	20
Operating Speed or Posted Speed on Major Road (km/h)	110	4	5	Refer to Table 1(B), note #3	OK	20
Operating Speed on Minor Road (km/h)	80	3	5	Refer to Table 1(B), note #3	OK	15
					Operational Factors Subtotal	**175**

ENVIRONMENTAL FACTOR

Lighted Developments within 150 m radius of intersection	0	0	5	Maximum of 4 quadrants	OK	0
					Environmental Factor Subtotal	**0**

COLLISION HISTORY

Average Annual night-time collision frequency due to inadequate lighting (collisions/yr, rounded to nearest whole #)	1.0	1	15	Enter **either** the annual frequency (See Table 1(C), note #4)	OK	15
OR				**OR** the number of collisions / MEV		
Collision Rate over last 3 years, due to inadequate lighting (/MEV)	0	0	0	(Unused values should be set to Zero)	OK	0
Is the average ratio of **all** night to day collisions >= 1.5 (Y/N)	n	0			OK	
					OK	
					Collision History Subtotal	**15**

Check Intersection Signalization:
Intersection is not Signalized

FULL ILLUMINATION WARRANTED

SUMMARY

Geometric Factors Subtotal	106
Operational Factor Subtotal	175
Environmental Factor Subtotal	0
Collision History Subtotal	15
TOTAL POINTS	**296**

HIGHWAY 2 & TWP RD 204
Minor Approach Turn Restrictions Option

TABLE 1(A) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: GEOMETRIC FACTORS

Classification Factor	Rating 0	1	2	3	4	Weight		Score (Rating x Weight)
channelization	none	right and/or left turn lanes on minor approach only	right turn lane(s) only on major leg(s)	left turn lane(s) on major leg(s)	left and right turn lanes on all legs	raised and operating speed less than 70 km/h on at least one channelized approach OR	15	
						raised and operating speed 70 km/h or more on at least one channelized approach OR	20	Scenario: Raised Channelization
						painted only	5	Scenario: Painted Channelization
approach sight distance on the most constrained approach (relative to recommended minimum intersection sight distance)	100% or more	75% - 99%	50% - 74%	25% - 49%	<25%	10		
horizontal curvature (radius) at or immediately before intersection on any leg for posted speed limit of:								
110 km/h	tangent	>1,800m	1,150 to 1,800m	750 to 1,150m	<750m			
90 or 100 km/h	tangent	>1,400m	950 to 1,400m	600 to 950m	<600m			
70 or 80 km/h	tangent	>950m	550 to 950m	340 to 550m	<340m			
60 km/h	tangent	>575m	320 to 575m	190 to 320m	<190m	5		
angle of intersection OR offset intersection	90° angle	80° or 100° angle	--	70° or 110° angle	<70° or >110° OR offset intersection	5		
downhill approach grades at or immediately before intersection on any leg	<3.0%	3.1 to 3.9% and meets design guidelines for type and speed of road	4.0 to 4.9% and meets design guidelines for type and speed of road	5.0 to 7.0% and meets design guidelines for type and speed of road	>7.0% OR exceeds maximum gradient for the type and speed of road	3		
number of legs	--	3	4	5	6 or more	3		
						SUBTOTAL (Geometric Factors)		

TABLE 1(B) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: OPERATIONAL FACTORS

Classification Factor	Rating 0	1	2	3	4	Weight	Score (Rating x Weight)
IF THE INTERSECTION IS SIGNALIZED, ILLUMINATION IS WARRANTED.							
IF THE INTERSECTION IS NOT SIGNALIZED, points should be calculated on the basis of *either* the AADT factor *or* the signalization warrant factor:							
either							
AADT (2-way)[1]:							
on major road and	<1,000	1,000 to 2,000	2,000 to 3,000	3,000 to 5,000	>5,000	10	
on minor road	<500	500 to 1,000	1,000 to 1,500	1,500 to 2,000	>2,000	20	
or signalization warrant[1]	intersection not signalized and volume-based signal warrant is less than 20% satisfied	intersection not signalized and volume-based warrant is 20% to 40% satisfied	intersection not signalized and volume-based warrant is 40% to 60% satisfied	intersection not signalized and volume-based warrant is 60% to 80% satisfied	intersection not signalized and volume-based warrant is over 80% satisfied	30	
regular night-time hourly pedestrian volume[2]	no pedestrians	up to 10	10 to 30	30 to 50	over 50	10	
intersecting roadway classifications	no primary road involved	primary/rural major, primary/rural minor, or primary/designated community access	primary/secondary	primary/primary	intersection includes divided highway	5	
operating speed or posted speed limit on major road[3]	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5	
operating speed or posted speed limit on minor road[3]	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5	
						SUBTOTAL (Operational Factors)[1]	

NOTES 1. If the intersection is not signalized, the user should choose *EITHER* the AADT factor *OR* the signalization warrant factor. The points from either factor, but not both factors, may be used in the warrant points calculation.

2. The number of certain types of vulnerable pedestrians should be factored to reflect their increased need for visibility. The number of child pedestrians (ages 12 and under) should be multiplied by 2, and the number of senior pedestrians (ages 65 and over) should be multiplied by 1.5.

3. 85th percentile night-time speed should be used if available. Otherwise, the posted speed limit may be used.

TABLE 1(C) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: ENVIRONMENTAL AND COLLISION FACTORS

Classification Factor	Rating 0	1	2	3	4	Weight		Score (Rating x Weight)
ENVIRONMENTAL FACTOR								
lighted development within 150m radius of intersection	--	in one quadrant	in two quadrants	in three quadrants	in four quadrants	5		
						SUBTOTAL (Environmental Factors)		
COLLISION HISTORY								
average annual night-time collision frequency[4] or rate over last 3 years (only collisions potentially attributable to inadequate lighting)	0 collisions per year	1 collision per year	--	2 collisions per year	3 or more per year OR at least 1.5 collisions per million entering vehicles per year *and* an average ratio of all night to day collisions of at least 1.5.	1 or 2 collisions per year	15	
						3 or more collisions per year OR rate≥1.5 collisions/MEV	30	
						SUBTOTAL (Collision History)		
						Geometric Factors Subtotal (Table 1(A))		
						Operational Factors Subtotal (Table 1(B))		
						Environmental Factors Subtotal (Table 1(C))		
						Collision History Subtotal (Table 1(C))		
						TOTAL POINTS		

NOTE: 4. reported collisions, rounded to nearest whole number

Illumination of Isolated Rural Intersections
LIGHTING WARRANT SPREADSHEET

This spreadsheet is to be used in conjunction with *Illumination of Isolated Rural Intersections* , Transportation Association of Canada, February 2001.

Please enter information in the cells with yellow background

INTERSECTION CHARACTERISTICS

Highway 2	Main Road	**Date**	January 7, 2019
Township Road 204	Minor Road	**Other**	Traffic Signal Option
Okotoks, AB	City/Town		

GEOMETRIC FACTORS

	Value	Rating	Weight	Comments	Check	Score
Channelization Rating	Descriptive	3		Refer to Table 1(A) to determine rating value	OK	
Presence of raised channelization? (Y / N)	n				OK	
Highest operating speed on raised, channelized approach (km/h)	0		5		OK	
Channelization Factor					OK	15
Approach Sight Distance on most constrained approach (%)	100	0	10	Relative to the recommended minimum sight distance	OK	0
Posted Speed limit (in 10's of km/h)	80				OK	
Radius of Horizontal Curve (m)	20			Enter "T" for tangent (no horizontal curve at the intersection)	OK	
Posted Speed Category =		0				
Posted Speed Category =		0				
Posted Speed Category =	C	4				
Posted Speed Category =		0				
Horizontal Curvature Factor		4	5		OK	20
Angle of Intersection (10's of Degrees)	90	0	5		OK	0
Downhill Approach Grade (x.x%)	0.0	0	3	Rounded to nearest tenth of a percent	OK	0
Number of Intersection Legs	4	2	3	Number of legs = 3 or more	OK	6
					Geometric Factors Subtotal	**41**

OPERATIONAL FACTORS

Is the intersection signalized ? (Y/ N)	y			Illumination is Warranted		
AADT on Major Road (2-way)	26070	4	10	Either Use the two AADT inputs **OR** the Descriptive Signalization	OK	40
AADT on Minor Road (2-way)	3230	4	20	Warrant (Unused values should be set to Zero) Refer to Table	OK	80
Signalization Warrant	Descriptive	0	30	1(B) for description and rating values for signalization warrant.	OK	0
					OK	
Night-Time Hourly Pedestrian Volume	0	0	10	Refer to Table 1(B), note #2, to account for children and seniors	OK	0
Intersecting Roadway Classification	Descriptive	4	5	Refer to Table 1(B) for ratings.	OK	20
Operating Speed or Posted Speed on Major Road (km/h)	110	4	5	Refer to Table 1(B), note #3	OK	20
Operating Speed on Minor Road (km/h)	80	3	5	Refer to Table 1(B), note #3	OK	15
					Operational Factors Subtotal	**175**

ENVIRONMENTAL FACTOR

Lighted Developments within 150 m radius of intersection	0	0	5	Maximum of 4 quadrants	OK	0
					Environmental Factor Subtotal	**0**

COLLISION HISTORY

Average Annual night-time collision frequency due to inadequate lighting (collisions/yr, rounded to nearest whole #)	1.0	1	15	Enter **either** the annual frequency (See Table 1(C), note #4)	OK	15
OR				**OR** the number of collisions / MEV		
Collision Rate over last 3 years, due to inadequate lighting (/MEV)	0	0	0	(Unused values should be set to Zero)	OK	0
Is the average ratio of **all** night to day collisions >= 1.5 (Y/N)	n	0			OK	
					OK	
					Collision History Subtotal	**15**

Check Intersection Signalization:
Intersection is Signalized

FULL ILLUMINATION WARRANTED

SUMMARY

Geometric Factors Subtotal	41
Operational Factor Subtotal	175
Environmental Factor Subtotal	0
Collision History Subtotal	15
TOTAL POINTS	**231**

HIGHWAY 2 & TWP RD 204
Traffic Signal Option

TABLE 1(A) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: GEOMETRIC FACTORS

Classification Factor	Rating 0	1	2	3	4	Weight		Score (Rating x Weight)
channelization	none	right and/or left turn lanes on minor approach only	right turn lane(s) only on major leg(s)	left turn lane(s) on major leg(s)	left and right turn lanes on all legs	raised and operating speed less than 70 km/h on at least one channelized approach OR raised and operating speed 70 km/h or more on at least one channelized approach OR painted only	15 20 5	
approach sight distance on the most constrained approach (relative to recommended minimum intersection sight distance)	100% or more	75% - 99%	50% - 74%	25% - 49%	<25%	10		
horizontal curvature (radius) at or immediately before intersection on any leg for posted speed limit of:								
110 km/h	tangent	>1,800m	1,150 to 1,800m	750 to 1,150m	<750m			
90 or 100 km/h	tangent	>1,400m	950 to 1,400m	600 to 950m	<600m			
70 or 80 km/h	tangent	>950m	550 to 950m	340 to 550m	<340m			
60 km/h	tangent	>575m	320 to 575m	190 to 320m	<190m	5		
angle of intersection OR offset intersection	90° angle	80° or 100° angle	--	70° or 110° angle	<70° or >110° OR offset intersection	5		
downhill approach grades at or immediately before intersection on any leg	<3.0%	3.1 to 3.9% and meets design guidelines for type and speed of road	4.0 to 4.9% and meets design guidelines for type and speed of road	5.0 to 7.0% and meets design guidelines for type and speed of road	>7.0% OR exceeds maximum gradient for the type and speed of road	3		
number of legs	--	3	4	5	6 or more	3		
						SUBTOTAL (Geometric Factors)		

TABLE 1(B) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: OPERATIONAL FACTORS

Classification Factor	Rating 0	1	2	3	4	Weight	Score (Rating x Weight)
IF THE INTERSECTION IS SIGNALIZED, ILLUMINATION IS WARRANTED.							
IF THE INTERSECTION IS NOT SIGNALIZED, points should be calculated on the basis of *either* the AADT factor *or* the signalization warrant factor:							
either AADT (2-way)[1]:							
on major road and	<1,000	1,000 to 2,000	2,000 to 3,000	3,000 to 5,000	>5,000	10	
on minor road	<500	500 to 1,000	1,000 to 1,500	1,500 to 2,000	>2,000	20	
or signalization warrant[1]	intersection not signalized and volume-based signal warrant is less than 20% satisfied	intersection not signalized and volume-based warrant is 20% to 40% satisfied	intersection not signalized and volume-based warrant is 40% to 60% satisfied	intersection not signalized and volume-based warrant is 60% to 80% satisfied	intersection not signalized and volume-based warrant is over 80% satisfied	30	
regular night-time hourly pedestrian volume[2]	no pedestrians	up to 10	10 to 30	30 to 50	over 50	10	
intersecting roadway classifications	no primary road involved	primary/rural major, primary/rural minor, or primary/designated community access	primary/secondary	primary/primary	intersection includes divided highway	5	
operating speed or posted speed limit on major road[3]	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5	
operating speed or posted speed limit on minor road[3]	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5	
					SUBTOTAL (Operational Factors)[1]		

NOTES 1. If the intersection is not signalized, the user should choose *EITHER* the AADT factor *OR* the signalization warrant factor. The points from either factor, but not both factors, may be used in the warrant points calculation.

2. The number of certain types of vulnerable pedestrians should be factored to reflect their increased need for visibility. The number of child pedestrians (ages 12 and under) should be multiplied by 2, and the number of senior pedestrians (ages 65 and over) should be multiplied by 1.5.

3. 85th percentile night-time speed should be used if available. Otherwise, the posted speed limit may be used.

TABLE 1(C) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: ENVIRONMENTAL AND COLLISION FACTORS

Classification Factor	Rating 0	1	2	3	4	Weight		Score (Rating x Weight)
ENVIRONMENTAL FACTOR								
lighted development within 150m radius of intersection	--	in one quadrant	in two quadrants	in three quadrants	in four quadrants	5		
						SUBTOTAL (Environmental Factors)		
COLLISION HISTORY								
average annual night-time collision frequency[4] or rate over last 3 years (only collisions potentially attributable to inadequate lighting)	0 collisions per year	1 collision per year	--	2 collisions per year	3 or more per year OR at least 1.5 collisions per million entering vehicles per year *and* an average ratio of all night to day collisions of at least 1.5.	1 or 2 collisions per year	15	
						3 or more collisions per year OR rate≥1.5 collisions/MEV	30	
						SUBTOTAL (Collision History)		
						Geometric Factors Subtotal (Table 1(A))		
						Operational Factors Subtotal (Table 1(B))		
						Environmental Factors Subtotal (Table 1(C))		
						Collision History Subtotal (Table 1(C))		
						TOTAL POINTS		

NOTE: 4. reported collisions, rounded to nearest whole number

ISL Engineering and Land Services

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