

INSURANCE CORPORATION OF BRITISH COLUMBIA



**STRATEGY FOR IMPROVING INTERSECTION
SAFETY:
IN-SERVICE SAFETY REVIEWS FOR FIVE
INTERSECTIONS**

KAMLOOPS, BRITISH COLUMBIA

**Engineering and
Planning Consultants**



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FOR FIVE INTERSECTIONS**

*ISO 9001 Registered
Quality Assured*

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A. INTRODUCTION

A.1 Background

The 2003 Safer Cities Program is an initiative of the Insurance Corporation of British Columbia (ICBC) to develop a holistic plan to proactively improve safety in a community by targeting various locations for 3E (engineering, education, and enforcement) solutions to road safety issues. The program includes an extensive process of consultation with stakeholders, such as municipalities, local polices, and school districts. Pilot programs are under way on several locations throughout the province, including the City of Kamloops.

Kamloops will also be the pilot site for Safety Conscious Planning, a program developed by ICBC that includes processes and techniques for ensuring that safety is an explicit priority in land-use and transportation planning initiatives. As the majority of urban collisions occur at intersections, developing a strategy for improving intersection safety was considered a key component of this plan.

As part of the Improving Intersection Safety Strategy of Safer Cities Program, In-Service Intersection Site Reviews were performed at five locations within the City. The locations were selected by City staff and Hamilton Associates, and represent a cross-section of various road classifications. This report summarizes the findings of the In-Service Review.

A.2 Study Objectives

The overall intention of this study is to provide stakeholders location-specific road safety concerns at intersections. The results can also be used to identify community-wide safety issues. The stakeholders can then use the summary to identify locations where improvements can be immediately implemented or to identify locations or issues that can be addressed on a system-wide basis.

The specific objectives of this In-Service Review are to:

- review the current physical and operational characteristics at the five study intersections; and
- identify factors that may potentially contribute to collisions at this and other high-crash locations.

A.3 Study Intersections

The five study intersections are located throughout the City, including:

- Valleyview Drive and Highland Road;
- Seymour Street and 3rd Avenue;
- Columbia Street and 5th Avenue;
- Highway 5A and Summit Drive; and,
- 7th Street and Richmond Avenue.

A.4 Method

The reviews followed a systematic method to evaluate the physical, traffic, and human factor characteristics at each location. Site visits, drive-throughs, and walkabouts were conducted at all intersections on Thursday, April 5, 2003 to determine these characteristics. A prompt list was used to review and identify geometric and operational issues. Intersection physical characteristics reviewed included laning, traffic control, sight distances, land use, horizontal and vertical grades, pedestrian facilities, road surface conditions, roadside furniture, and lighting. Traffic characteristics reviewed included qualitative vehicle volume observations, queuing, delays, vehicle speeds, and on-street parking. As well, road user behaviour was observed to identify human factor characteristics that may be contributing to the collision risk.

A.5 Presentation Format

The results of the reviews, including a description of the site, physical and traffic observations, human factor issues, and potential collision causes were summarized, and are presented in the following sections for the five study intersections:

- Section B: Valleyview Drive and Highland Road Intersection
- Section C: Seymour Street and 3rd Avenue Intersection
- Section D: Columbia Street and 5th Avenue Intersection
- Section E: Highway 5A and Summit Drive/Hugh Allen Drive
- Section F: Richmond Avenue and 7th Street
- Section G: Overview of Issues

Section G provides a summary of issues that were common to more than one location. The information provided in these sections will help ICBC and other road safety stakeholders to identify opportunities for safety improvements at these and other Kamloops intersections. With continued cooperation among the stakeholders, the intersections can be made safer for all road users.

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B. VALLEYVIEW DRIVE AND HIGHLAND ROAD INTERSECTION

(a) Physical and Traffic Characteristics

The intersection of Valleyview Drive and Highland Road is located south of the Trans-Canada Highway in the primarily residential Valleyview area of the City. Valleyview Drive is a suburban collector road, and serves as the primary east-west link south of the Trans-Canada Highway. Highland Drive is a north-south suburban arterial road, and provides access to the Trans-Canada Highway to the north and the Juniper Ridge area to the south.

The intersection provides a four-way STOP control and overhead flashing beacons, with dual STOP signs for the north-south approaches. Two through lanes with an exclusive left-turn lane are provided for each Highland Drive approach. One through lane wide enough to allow two vehicles to overtake each other is provided for each Valleyview Drive approach. Marked crosswalks are provided across the east and north legs. Sidewalks are provided, except along the eastbound and southbound exit legs. The east leg provides a gravel shoulder without a curb-and-gutter.

There is an uphill vertical curve for the Valleyview Drive approaches in both directions, and a downhill grade along Highland Road in the northbound direction. Horizontal curves exist south and west of the intersection. Lighting is provided along the intersection approaches; however, the intersection itself provides only one lamp standard. Other notable physical features include a retaining wall along the horizontal curve on eastbound approach that may restrict intersection visibility.

Traffic observations indicate that the intersection operates with little delay in the mid-day period. All drivers during the observation duration were observed to obey the STOP signs. No traffic conflicts were observed, and vehicles did not appear to be speeding. Vehicles were observed to park on the shoulder of the eastbound exit leg.

(b) Human Factor Observations

A review of human factors was conducted during the site visit. The following items were noted:

- The horizontal and vertical curves may limit the intersection visibility as a vehicle approaches the intersection. Drivers may enter the intersection without stopping or stop late before the intersection, possibly resulting in angle and rear-end collisions. The intersection conspicuity is likely to decrease at nighttime with the limited intersection lighting.
- The retaining wall on the westbound approach, when combined with the horizontal curve, may reduce the visibility of the westbound STOP sign. Drivers may enter the intersection without stopping or stop late before the intersection, possibly resulting in angle and rear-end collisions.
- The unmarked eastbound and westbound approach lanes are wide enough to allow vehicles to overtake other vehicles stopped on these approaches. As a result, right-turning drivers may overtake the leading vehicles waiting to travel through or turn left at the four-way STOP controlled intersection, and potentially contribute to sideswipe collisions and confusion at the four-way STOP control.
- The wide eastbound and westbound approach lanes may also make the single STOP sign less conspicuous. This may possibly contribute to a high angle and rear-end collision risk.
- It is uncommon for intersection approaches with two through lanes and an exclusive left-turn lane, such as those along the Highland Road approaches, to be provided with a STOP sign control. The relatively high number of approach lanes (10) into the intersection may create confusion about the right-of-way at the four-way STOP control, and result in an increased angle, left-turn, and rear end collision risk.

- Along the eastbound exit leg, there is a lack of a sidewalk and a curb-and-gutter, requiring pedestrians to walk on the gravel shoulder. However, vehicles were also observed to park on the shoulder, possibly forcing pedestrians to walk onto the roadway and increasing the pedestrian collision risk.

(c) Potential Safety Issues

Based on the results of physical, traffic, collision, and human factor observations, the following safety issues were identified, and are shown in TABLE B-1.

(d) Possible Solutions

Possible solutions or improvements to each of the safety issues identified in TABLE B-1 are outlined in TABLE B-2.

TABLE B-1 SAFETY ISSUES – VALLEYVIEW DRIVE AND HIGHLAND ROAD INTERSECTION

<p>1. The intersection visibility may be limited by the presence of horizontal and vertical curves close to the intersection, particularly at nighttime. The retaining wall along the eastbound approach may reduce the visibility of the STOP sign. Drivers may stop late before the intersection, possibly resulting in rear-end collisions.</p>	
<p>2. With wide eastbound and westbound approaches, right-turn drivers may overtake the leading vehicles waiting to travel through or turn left at the intersection, possibly contributing to sideswipe collisions. The wide approach also makes STOP sign less conspicuous, possibly contributing to angle and rear-end collisions.</p>	
<p>3. The number of approach lanes (10) may create confusion about right-of-way at the four-way STOP. This causes driver indecision and impatience, possibly contributing to angle, left-turn and rear-end collisions.</p>	
<p>4. No proper sidewalk and curb-and-gutter along the eastbound exit leg may increase the conflicts between pedestrians and vehicles. The presence of on-street parking further increases the collision risk.</p>	

**TABLE B-2 SOLUTIONS – VALLEYVIEW DRIVE AND HIGHLAND ROAD
INTERSECTION**

1.	<p>There are several treatments that can be considered to improve the visibility of the intersection and to provide drivers with advanced notice of the need to stop including:</p> <ul style="list-style-type: none">• Stop Ahead signs;• Increased intersection lighting; and,• Centre or median mounted Stop signs on the eastbound and westbound approaches.
2.	<p>Providing drivers with guidance on the proper use of the wide road surface at the intersection may reduce variability in driver responses. Painted lanes can be considered on the east and westbound approaches that indicate to drivers how to approach the intersection. Curb-extensions could also be considered, which would also improve intersection visibility. The previously mentioned, median-mounted Stop sign can improve the conspicuity of the signs and can be considered regardless of the final layout of the lanes.</p>
3.	<p>Little can be done to reduce driver confusion at a multi-way stop controlled intersection with a large number of approaches but to provide signals or a roundabout. As the intersection traffic volume increases the driver confusion may also increase. A signal warrant could be conducted for the intersection and, if not currently warranted, revisited on a regular basis. If no such growth is anticipated, and operations would not be significantly impacted, the City may consider reducing the number of approach lanes.</p>
4.	<p>A sidewalk and curb and gutter can be considered for the eastbound exit leg of the intersection to provide separation between pedestrians and vehicular traffic.</p>

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C. SEYMOUR STREET AND 3RD AVENUE INTERSECTION

(a) Physical and Traffic Characteristics

The intersection of Seymour Street and 3rd Avenue is located in the city centre area with Central Business District (CBD) commercial land use. Seymour Street is an eastbound one-way town centre arterial, while 3rd Avenue is a northbound one-way town centre arterial. Both roadways provide access and circulation within the CBD area. There is a downhill grade in the northbound direction along 3rd Avenue.

Similar to other CBD intersections, buildings are typically constructed up to the sidewalk, thus providing limited setback from the road. Commercial signs and lights, along with other visual clutter were also noted near the intersection. The northbound view along 3rd Avenue is dominated by a yellow pedestrian bridge crossing a railway several blocks north of the intersection.

Both Seymour Street and 3rd Avenue provide two wide through lanes and on-street parking close to the intersection. An exclusive eastbound left-turn lane and a northbound right-turn lane are also provided for Seymour Street and 3rd Avenue respectively. The intersection operates with a two-phase signal control with pedestrian push buttons. One primary signal head with a 300-millimetre red display and 200-millimetre amber and green displays, and one secondary signal head with 200-millimetre displays are provided for the approaches.

Alley lanes close to the intersection access 3rd Avenue north and south of the intersection. Parking lot entrances and exits access Seymour Street close to the intersection to the east and west.

The wide cross-section and one-way streets may encourage speeding and lane-changing on Seymour Street. Typical to other intersections in a city centre, pedestrian activity is high. On-street parking is well utilized in the area.

(b) Human Factor Observations

A review of human factors was conducted during the site visit, and the following items were noted:





- One-way travel and three travel lanes may contribute to high vehicles speeds and heavy lane changing, possibly resulting in a high sideswipe and rear-end collision risk.
- Typically, at least two primary signal heads are provided for approaches with three lanes, such as the eastbound and northbound approaches. The relative inconspicuity of the signal displays may result in vehicles either entering the intersection during red or late amber intervals or suddenly stopping before entering the intersection. An increased risk of angle or rear-end collisions may result. High vehicle speeds and the northbound downhill grade may also reduce the capability of drivers to stop effectively.
- Short building setbacks, the visual clutter created by the yellow pedestrian bridge and the various advertisement signs and lights at the intersection may reduce the intersection conspicuousness. The potential visibility obstruction by a large vehicle traveling through the intersection may further reduce the signal conspicuousness. A higher risk of angle or rear-end collisions may result. Because of the proximity of conflicting vehicles in curb lanes of one-way streets, and the restricted crossing sight distance, a review of the all-red phase should be considered.
- On-street parking is provided close to the intersection. During a parallel parking manoeuvre, following vehicles might need to suddenly stop, possibly resulting in an increased rear-end and sideswipe collision risk, especially on the exit legs of the intersection.
- The alleyways and parking lot accesses are located close to the intersection. Turning manoeuvres into and out of these alleyways and accesses further intensify the complicated turning movements at the intersection, resulting in an increased collision risk.

- The relatively short setback of the buildings from the roadway results in reduced sight distance of crossing pedestrians, as well as limited storage area for pedestrians, especially in the northeast corner. The heavy pedestrian activity at the intersection further increases the potential for pedestrian collisions.

(c) Potential Collision Causes

Based on the results of physical, traffic, collision, and human factor characteristics, safety issues were identified, and are shown in TABLE C-1.

TABLE C-1 SAFETY ISSUES – SEYMOUR STREET AND 3RD AVENUE INTERSECTION

1.	High vehicle speeds and wide cross-sections in the northbound and eastbound directions may contribute to risky lane change manoeuvres, resulting in risk of side-swipe and rear-end collisions.	
2.	With a single primary signal head and limited sight distance due to short building setback, drivers travelling behind a heavy truck may have limited signal head visibility, possibly contributing to angle and rear-end collisions. The downhill grade in the northbound direction combined with the yellow bridge and visual clutter further reduces signal head visibility.	
3.	With on-street parking close to the intersection approach, turning vehicles might have to stop if parallel parking manoeuvres occur in the exit lanes, possibly resulting in rear-end and side-swipe collisions. Vehicle entering and exiting the back lanes close to the intersection also increase the collision risks.	
4.	The reduced sight distance to crossing pedestrians due to limited building setback may contribute to the conflicts between vehicles and pedestrians. The limited storage area for pedestrians in the northeast corner and heavy pedestrian activities in the downtown area further increase the potential collision risks.	

(d) Possible Solutions

Possible solutions or improvements to each of the safety issues identified in TABLE C-1 are outlined in TABLE C-2.

**TABLE C-2 SOLUTIONS – SEYMOUR STREET AND 3RD AVENUE
INTERSECTION**

1.	There are some treatments that can be considered for reducing vehicle speeds, which can result from having wide cross-sections, including: <ul style="list-style-type: none">• Provide curb bulbs at the intersection• Provide wide painted parking lanes, narrowing the through lanes;• Introducing progression; and,• Enforcement.
2.	To increase the conspicuity of the signal heads there are several treatments that can be considered including: <ul style="list-style-type: none">• Provide an overhead primary signal head for each travel lane;• Install 300mm bulbs for each of the lights on the primary signal heads; and,• Provide backboards for all signal lights and consider placing a fluorescent retro reflective strip on the backboards to help them stand out from any background visual clutter.
3.	Parking can be restricted farther back from the intersection to reduce conflicts between turning and parking vehicles. Eliminating an additional parking stall on each approach may provide the necessary room.
4.	To increase the pedestrian storage area and pedestrian visibility some of the treatments that have already been discussed can be considered, including: <ul style="list-style-type: none">• Curb bulbs can be installed at the intersection to increase both pedestrian storage and visibility. This treatment has the added benefit of reducing pedestrian exposure by shortening the crossing distance; and,• Restricting parking farther back from the intersection will increase pedestrian visibility, though it will not improve storage.

D. COLUMBIA STREET AND 5TH AVENUE INTERSECTION

(a) Physical and Traffic Characteristics

The intersection of Columbia Street and 5th Avenue is located south of the city centre area. Columbia Street is an east-west town centre arterial providing access between the Trans-Canada Highway and the city centre, and provides numerous signalized intersections. 5th Avenue is a north-south town centre collector providing local access. The intersection is located between two signalized intersections: 4th Avenue to the west and 6th Avenue to the east.

The major infrastructure near the intersection is the Royal Inland Hospital located southwest of the intersection. A government building (Ministry of Forest Regional Office) to the south, a motel on the northeast quadrant, and a family restaurant on the northwest quadrant are also located at the intersection.

The intersection provides a two-way STOP control, with Columbia Street as the major street. STOP signs are provided for both the northbound and southbound approaches. A special crosswalk (marked crosswalk with overhead illuminated signs and push-button flashing lights) is provided at a slight oblique angle across Columbia Street at the west leg. A warning sign alerting drivers of the special crosswalk is installed for the westbound direction, but was noticeably absent in the eastbound direction. It was noted that the crosswalk pavement markings were faded during the site observations, and may be difficult to notice during wet surface conditions.

There is also a STOP sign at a hospital access for southbound vehicles south of the intersection. As a result, southbound through vehicles would encounter a STOP sign crossing Columbia Street, quickly followed by a STOP sign at the hospital access.

Columbia Street provides two straight and wide travel lanes in each direction, while 5th Avenue provides one wide travel lane in each direction. On the north leg of the intersection, on-street parking close to the intersection is provided for both the northbound and southbound direction. It was noted that the road surface at the southwest corner of the intersection was uneven.

Traffic observations were performed during the site visit, and indicate that vehicle speeds along Columbia Street seem relatively high. As well, a significant pedestrian crossing demand during lunch hours is expected.

(b) Human Factor Observations

A review of human factors was conducted, and the following items were noted:

- The sightline of westbound vehicles for southbound drivers was found to be partially obscured by a hotel sign at the northeast corner. When combined with the relatively high vehicle speeds along Columbia Street, northbound drivers may have difficulty in judging the crossing gap. As a result, there may potentially be an increase in the angle, left-turn, and rear-end collision risk.
- The wide northbound and southbound approach lanes may make the single STOP sign less conspicuous, and possibly contribute to angle, sideswipe, and rear-end collisions. The STOP sign for southbound drivers at the hospital access south of the study intersection may further confuse southbound drivers, potentially increasing the collision risk.

- The faded oblique crosswalk pavement markings, in conjunction with the uneven road surface near the southwest corner of the intersection, may reduce the visibility of the marked crosswalk. As mentioned previously, Columbia Street provides two straight and wide travel lanes in each direction. Columbia Street also provides a traffic signal control at 4th Avenue and 6th Avenue, as well as at 3rd Avenue. With the numerous traffic signals along Columbia Street, the expectancy of an unsignalized intersection may be low. Drivers along Columbia Street may not expect vehicles and pedestrians crossing or entering the intersection, resulting in an increased rear-end, angle, left-turn, and pedestrian collision risk.





(c) Potential Collision Causes

Based on the results of physical, traffic, collision, and human factor characteristics, the following safety issues at the Columbia Street and 5th Avenue intersection were identified, and are shown in TABLE D-1.

(d) Possible Solutions

Possible solutions or improvements to each of the safety issues identified in TABLE D-1 are outlined in TABLE D-2.

**TABLE D-1 SAFETY ISSUES – COLUMBIA STREET AND 5TH AVENUE
 INTERSECTION**

<p>1. Southbound left-turn driver's crossing sight distance to westbound vehicles was limited by the hotel sign at the northeast corner. High vehicle speeds on Columbia Avenue means that northbound drivers have difficulty in judging the crossing gap, potentially resulting in angle, left-turn and rear-end collisions.</p>	
<p>2. The visibility of the southbound STOP sign may be limited by wide approach lane, possibly resulting in angle, rear-end and side-swipe collisions. The STOP sign at the entrance to the hospital facility may further add to driver confusion. On-street parking close to the intersection also reduces the sign and intersection visibility.</p>	
<p>3. The combination of faded diagonal crosswalk pavement markings and uneven road surface may reduce the visibility of the marked crosswalk, especially during wet pavement conditions, and increase the collision risks between pedestrians and east-west vehicles. Heavy crossing pedestrian demand during lunch periods further increases the collision risks.</p>	
<p>4. With wide intersection approaches and traffic signals at 4th Avenue and 6th Avenue, eastbound and westbound drivers may miss the STOP-controlled intersection at 5th Avenue, possibly resulting in rear-end, angle, left-turn and pedestrian-related collisions.</p>	

**TABLE D-2 SOLUTIONS – COLUMBIA STREET AND 5TH AVENUE
INTERSECTION**

1.	To improve the visibility for southbound left turning drivers the private hotel sign may need to be relocated, immediately or with re-development. To reduce the prevailing speeds along Columbia Avenue a speed enforcement or education campaign can be conducted. Longer term solutions to any speeding issues that may exist along Columbia Avenue could be identified through a detailed review of the speed characteristics of the roadway.
2.	To increase the visibility of both the intersection and the Stop sign the following treatments can be considered: <ul style="list-style-type: none">• Restrict parking farther back from the intersection;• Install a median mounted or over-sized Stop sign;• Upgrade the sign sheeting, fluorescent sheeting typically stands out better than regular sheeting during daylight conditions;• Provide a curb-extension on this leg; or,• Install STOP ahead signage. To reduce confusion regarding the Stop sign for the hospital facility a method of restricting the visibility of the sign such as a hood could be considered.
3.	To reduce collision risks between pedestrians and vehicles the following treatments can be considered: <ul style="list-style-type: none">• To help ensure that the painted crosswalks remain visible they should be repainted on a regular basis. Crosswalks on high volume roadways may fade quickly and so benefit from being repainted once or twice a year;• Advanced crosswalk warning signs can be installed on the eastbound approach to warn drivers of the crosswalk; and,• The painted crosswalk can be reviewed to ensure that it is providing the shortest path across the roadway.
4.	To improve the visibility and provide warning of the Stop controlled side street (5 th Avenue) several treatments can be considered including: <ul style="list-style-type: none">• Transitioning the white skip lines to a solid line on the intersection approaches;• Providing an advanced street name sign on the intersection approaches; and,• Removing or relocating any signs that may restrict visibility and add to the visual clutter at the intersection.

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E. HIGHWAY 5A AND SUMMIT DRIVE/HUGH ALLEN DRIVE INTERSECTION

(a) Physical and Traffic Characteristics

The intersection of Highway 5A and Summit Drive/Hugh Allen Drive is a skewed intersection located in the mainly residential Upper Sahali area of the City. Highway 5A is a north-south provincial highway providing connection between Kamloops and the City of Merritt. Summit Drive/Hugh Allen Drive is an east-west suburban arterial that provides access between a residential neighbourhood, the city centre, and the provincial highway system. There are uphill vertical grades in the southbound and westbound direction, as well as a horizontal curve on the west leg. Some shrubbery is located close to the intersection on the northeast and southwest corners.

All approaches provide two through lanes. The Highway 5A approaches also provide exclusive left- and right-turn lanes. The Summit Drive westbound approach also provides a channelized right-turn lane. The right-turn lanes provide YIELD-control, but do not provide an acceleration section on the exit leg nor delineation at the end of the right-turn lane. The intersection operates with a two-phase signal control with pedestrian push button activation phase. Highway 5A provides posted speed limits of 70 and 80 kilometres per hour, as well as advance warning flashers on the approaches.

Dedicated left-turn lanes are provided on the northbound and southbound legs, but not on the east-west approaches.

(b) Human Factor Observations

A review of human factors was conducted, and the following items were noted:





- There are long distances between signalized intersections along all approaches, especially Highway 5A when combined with the vertical grades, and lack of accesses, this may contribute to relatively high speeds. The expectancy of a signalized intersection may therefore be low, resulting in the observed vehicles entering the intersection during the red interval or stopping abruptly at the intersection. These traffic characteristics may result in angle and rear-end collisions.
- The vertical grades and the horizontal curve make the intersection less conspicuous, and reduce signal head visibility, which may contribute to angle, left-turn opposing and rear-end collisions.
- The limited delineation at the exits of the channelized right-turn lanes may result in drivers assuming that an acceleration lane is provided, resulting in the sudden braking and an increase in rear-end collision risk with following vehicles. Bushes on the northeast corner may obscure stopped westbound right-turning vehicles and pedestrians as a westbound driver approaches the intersection, and further increase the rear-end collision risk.
- The combination of the relatively high vehicle speeds along Highway 5A, the sharp angle of the right-turn lane, and the westbound uphill grade reduces the visibility of northbound through vehicles and increases the difficulty for the right-turn drivers in judging available gaps.
- The skewed intersection layout resulted in eastbound and westbound left-turning vehicles requiring more time to complete turns. When combined with the lack of exclusive eastbound and westbound left-turn lanes, the left-turn collision risk increases, especially if the intergreen time is short.
- Drivers waiting to turn left in the shared left and through lanes on the east and west approaches may block the view of conflicting through vehicles for opposing left-turn drivers. This may contribute to left-turn opposing and secondary side-swipe and rear-end collisions.

- The intersection operates with a two-phase signal control. Should left-turn traffic volumes be high, the lack of a northbound and southbound left-turn phase combined with the relatively high vehicle speeds along Highway 5A could result in an increased left-turn opposing collision risk.

(c) Potential Collision Causes

Based on the results of physical, traffic, collision, and human factor characteristics, the following safety issues at the Highway 5A and Summit Drive/Hugh Allen Drive were identified, and are shown in TABLE E-1.

TABLE E-1 SAFETY ISSUES – HIGHWAY 5A AND SUMMIT DRIVE/HUGE ALLEN DRIVE INTERSECTION

1.	With long distances to the nearest signals for all approaches, drivers build up speed, entering the intersection during the red stage or stopping abruptly at the intersection, possibly resulting in angle and rear-end collisions. Horizontal and vertical curves close to the intersection further reduce the intersection conspicuity.	
2.	With limited delineation at the exits of channelized right-turn lanes, right-turn drivers assume an acceleration lane is provided, resulting in stop-and-go conditions and possibly causing rear-end collisions with following vehicles. Bushes on the northeast corner reduced the visibility of the westbound right-turn lane.	
3.	High vehicle speed on Highway 5A, sharp angle of the channelized lanes and westbound uphill grade increase the difficulty for right-turn drivers in judging available gaps.	
4.	The lack of left-turn phase for the north-south directions and the absence of exclusive left-turn lanes on the east-west approaches may increase the potential left-turn collision risks. The skewed intersection layout increases the turning paths of left-turn vehicles and left-turn collision risks if the intergreen time is short.	

(d) Possible Solutions

Possible solutions or improvements to each of the safety issues identified in TABLE E-1 are outlined in TABLE E-2.

TABLE E-2 SOLUTIONS – HIGHWAY 5A AND SUMMIT DRIVE/HUGE ALLEN DRIVE INTERSECTION

1.	To help prevent drivers from entering the intersection during the red stage, or from having to stop abruptly, the intergreen time of the signal phasing can be reviewed to ensure that it suits the intersection. This review could consider the prevailing vehicle speeds along the roadway as well as the posted speed.
2. & 3.	There are several methods of improving the safety of the right turn lanes including: <ul style="list-style-type: none">• Adding continuity lines at the ends of the channelized right turns, in conjunction with the existing YIELD signs, may confirm to drivers that they must yield to approaching traffic. The YIELD signs could be relocated closer to the yield point, and dual or oversize YIELD signs could also be considered.• Installing acceleration lanes may reduce the variability in speeds between merging vehicles and improve the operation of the channelized right turn. If pedestrian and cross-street volumes are high, re-aligning the channelized right turn so that the skew is not so great and visibility of cross-street traffic is improved. Trimming the brush in the northeast corner of the intersection may improve visibility for the channelized right turn.
4.	The signal phasing at the intersection can be reviewed, due to the speeds along the roadways and the skew of the intersection, permissive left turn phasing may not be ideal. The review could look into the possibility of adding a protected left turn phase and removing the permissive left turns. Left turn lanes can also be considered for the east / west roadway, possibly within the existing pavement width.

F. RICHMOND AVENUE AND 7TH STREET INTERSECTION

(a) Physical and Traffic Characteristics

The intersection of Richmond Avenue and 7th Street is located in the North Shore area of the City. Both Richmond Avenue and 7th Street are suburban collector roads. While providing access for local residents, the two roads together also provide a bypass to congestion along 8th Street. The land use at the study intersection is primarily residential.

The intersection provides four-way STOP control. The eastbound and northbound approaches provide one wide travel lane with sidewalks and curb-and-gutter. The westbound and southbound approaches provide an undelineated lane with gravel shoulders. The lane width of the approaches is wide enough to allow two vehicles to wait side by side. Marked crosswalks are provided across the north, south, and east legs of the intersection. There is shrubbery at the southwest corner of the intersection.

Lighting is generally provided along the intersection approaches and at the intersection. However, the luminaires appear to be spaced far apart, which may result in limited visibility at nighttime. Numerous utility poles are located close to the intersection and the roadside.

Traffic observations indicate that the predominant turning movements are the northbound left-turns and the eastbound right-turns. These movements coincide with vehicles bypassing congestion along 8th Street, as well as potential delays at the 8th Street and Tranquille Road intersection. No demarcation was provided between the roadway and a wide paved shoulder where vehicles parked.

(b) Human Factor Observations





A review of human factors was conducted, and the following items were noted:

- Based on the traffic patterns observed, traffic queues and vehicle delays are expected during the peak periods for the high volumes of eastbound right turns and northbound left turns, which may contribute to rear-end collisions. Drivers may not anticipate through vehicles in these directions. Angle, left-turn, and rear-end collisions may result.
- The shrubbery at the southwest corner of the intersection reduces crossing sight distance, further contributing to the risk of angle collisions.
- The presence of utility poles close to the roadway increases the risk of fixed object collisions. The wide cross-section, utility poles, shrubbery and queues of vehicle limit the visibility of the STOP signs. The limited street lighting along the approaches may further increase the risk of collisions at nighttime.
- Sidewalks and curb-and-gutters are not provided along the north and east legs of the intersection, requiring pedestrians to walk along the shoulder. When combined with vehicles parking on these shoulders, pedestrians may be forced to walk onto the roadway, increasing the risk of collisions involving pedestrians.

(c) Potential Collision Causes

Based on the results of physical, traffic, collision, and human factor characteristics, the following safety issues were identified at the Richmond Avenue and 7th Street intersection, and are shown in TABLE F-1.

TABLE F-1 SAFETY ISSUES – RICHMOND AVENUE AND 7TH STREET INTERSECTION

1.	With heavy northbound left-turn and eastbound right-turn traffic volumes, during the peak hours, traffic queues and considerable vehicle delays are expected. Impatient northbound and eastbound through drivers may overtake the traffic queue and enter the intersection, possibly contributing angle, left-turn and rear-end collisions.	
2.	Due to heavy eastbound right-turn traffic and the row of trees near the southwest corner, eastbound drivers have limited visibility of STOP sign, and opposing traffic, possibly contributing rear-end and angle collisions.	
3.	The presence of the utility poles (hydro pole and STOP sign pole) increases the collision risk for westbound vehicles hitting the fixed objects. The limited street lighting at the intersection might further increase the collision frequency at nighttime.	
4.	Lack of continuity between crosswalks and sidewalks at the east leg lead the pedestrians to use the roadway and increase the collision risks between pedestrian and vehicles. On-street parking at the undefined pull-out areas further increases the collision risks.	

(d) Possible Solutions

Possible solutions or improvements to each of the safety issues identified in TABLE F-1 are outlined in TABLE F-2.

TABLE F-2 SOLUTIONS – RICHMOND AVENUE AND 7TH STREET INTERSECTION

1.	To address the issue of having drivers jump the queue at the intersection painted lanes can be utilized to delineate the proper use of the road surface at the intersection. This may reduce driver frustration and increase the operational capacity and safety of the intersection. The City may wish to review if the traffic volumes on Richmond are appropriate to its network classification. If not, traffic calming measures such as curb extensions, and traffic circles may be appropriate to help reduce both volumes and the risk of angle collisions. Treatments at the intersection of 7 th Street and Tranquille Road to the south may also be effective. Such measures should be undertaken only as part of an area-wide traffic calming plan, in consultation with the residents.
2.	To increase visibility at the intersection and the visibility of the traffic control devices the row of trees in the southwest corner of the intersection could be trimmed. The curb extensions discussed above would also address this issue.
3.	To reduce the potential negative effects of having utility poles in close proximity to the roadway, the more hazardous installations can be considered for mitigation measures such as: <ul style="list-style-type: none">• Remove the poles and running the services underground; or,• Relocate the poles to less hazardous locations. Additional lighting at the intersection may also reduce the frequency of collisions as night.
4.	There are several treatments that can be considered to improve pedestrian safety at and around the intersection, they include: <ul style="list-style-type: none">• Provide continuous sidewalks along the intersecting roadways;• Provide crosswalks with let-downs that line up with the sidewalks; and,• Install curb and gutter at the edge of the roadway to provide physical separation between pedestrians and vehicular traffic.

G. OVERVIEW OF ISSUES

From the five in-service intersection safety reviews, the following issues were identified which may be common to other intersections in Kamloops:

- Signal head visibility;
- Wide approach lanes and on-street parking make STOP signs less visible;
- Natural features reduce intersection visibility and intersection turning sight distance;
- Issues related to downtown one-way streets;
- High vehicle speeds; and
- Right-of-way confusion at four-way STOP-controlled intersections.

These issues are discussed in further detail below.

a) Signals Less Conspicuous

Various factors contributed to reduce the conspicuous-ness of traffic signals. At downtown intersections, only one primary signal head was provided for three lanes of traffic. The primary signal head would be outside the cone of vision for drivers in the curb lane.



FIGURE G-1 PRIMARY SIGNAL HEAD OUTSIDE OF DRIVER'S CONE OF VISION (Also note how secondary signal head blends into buildings in the background.)

At many locations, traffic signals had 300 millimetre red indicators, but 200 millimetre indicators for the amber and green lenses. On some secondary signal heads, all of the lenses were 200 millimetres, and backplates were generally not provided. On a background of dark foliage, secondary signal heads without backplates may be difficult to see. With less conspicuous signal heads, drivers may notice the indications late, possibly contributing to rear-end, angle and left-turn opposing collisions.

b) Wide Approach Lanes Make Stop Signs Less Visible

Wide approach lanes, and the presence of parked vehicles (especially large vehicles such as mini-vans or trucks) may make the STOP sign less conspicuous. Drivers may notice the STOP sign late, or not at all, possibly contributing to angle and rear-end collisions. Wide lanes can also lead to lane use confusion and sideswipe collisions.



FIGURE G-2 STOP SIGN IS OUTSIDE THE DRIVER'S PRIMARY CONE OF VISION

c) Natural Features

Because of the topography of the Kamloops area, numerous intersections had vertical curves and horizontal curves on the intersection approaches. Such features can reduce the visibility of the intersection ahead, reduce crossing sight distance, or make traffic control devices less conspicuous. At other locations, roadside vegetation further reduced stopping or crossing sight distance. Drivers may not anticipate the need to stop, or may stop late, contributing to rear-end and angle collisions.



**FIGURE G-3 CURVED APPROACH
MEANS THAT SIGNAL HEADS ARE TO
THE DRIVER'S LEFT, BLOCKED BY
OTHER SIGNALS AND LESS VISIBLE
UNTIL THE LAST MINUTE**

d) Issues Related to Downtown One-Way Streets

While only one intersection was reviewed in the one-way street network that forms the downtown core, numerous issues were noted that may also occur at other downtown intersections.

These issues include: high pedestrian demand and narrow sidewalks; clearance intervals; lack of building setback reduces crossing sight distance and pedestrian visibility; visual clutter reducing signal visibility, parking close to the intersection. These issues were all discussed in detail in SECTION C.



FIGURE G-4 TYPICAL DOWNTOWN INTERSECTION WITH VISUAL CLUTTER, REDUCED CROSSING SIGHT DISTANCE, AS WELL AS PEDESTRIAN AND PARKING ACTIVITY

e) Right-of-Way Confusion at STOP-controlled intersections

A high number of approach lanes, unbalanced traffic volumes, and presence of pedestrians can create confusion about right-of-way at a four-way STOP. This causes driver impatience and erratic turning manoeuvres, and can potentially contribute to angle, left-turn crossing and rear-end collisions.



FIGURE G-5 MULTIPLE APPROACH LANES MEAN THAT DRIVERS MAY HAVE DIFFICULTY REMEMBERING WHO HAS THE RIGHT-OF-WAY

f) High Vehicle Speeds

Long distances between intersections, and accesses, downhill grades, one-way streets and wide cross-sections can all provide drivers with the opportunity to pick up speed on their approach to intersections, possibly contributing to off-road and rear-end collisions.



**FIGURE G-6 INTERSECTION SPACING
MAY CONTRIBUTE TO HIGHER SPEEDS**

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