School Transport Walking Hazard Assessment Guidelines

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Abstract

School busing is a controversial issue. Typically, schools use a distance-based approach to determine eligibility for busing. Children living within a certain distance of the school are expected to be able to walk, and are therefore not considered eligible for school bus service.

Problems arise for the administrators of busing when safety hazards exist which require special consideration. Currently, there are few tools available for evaluating the potential risks to child pedestrians and determining where busing should be provided to address safety concerns. Given this situation, the Ottawa Student Transportation Authority (OSTA) commissioned a study to develop a methodology for consistently, fairly and transparently evaluating hazards along the route to school.

This paper provides details on the recommended methodology for evaluating where school bus service should be provided – essentially where there are legitimate traffic safety hazards that present a barrier to children walking to school. While originally intended to evaluate eligibility for busing, the warrant system also provides a basis for prioritizing improvements to the walking environment. The methodology is based on a two-part framework which draws on extensive safety research and feedback on similar warrant systems in the US:

1. **Absolute warrants** are used to identify situations which are deemed to present such a significant risk to students that busing is automatically warranted if no alternative routes exist.

2. **Combination warrants** account for the cumulative impact of multiple hazards along the route to school. To apply the combination warrant, “hazard points” are assigned; where the two greatest hazards have a combined score of 100 points or greater, busing is considered to be warranted.

The evaluation methodology provides a quantifiable, defensible and transparent system for evaluating child pedestrian safety to inform decision making and encourage active modes of transportation amongst students.

1. Introduction

The Ottawa Student Transportation Authority (OSTA) was established in 2007 to manage and deliver student transportation services for the Ottawa-Carleton District School Board and the Ottawa Catholic School Board. As the school boundaries for each board typically overlap, combining the delivery of transportation services allows for better integration and coordination of school busing. In total, OSTA provides bus transportation for over 60,000 students each day.

Prior to 2007, each school board was responsible for its own transportation services. Eligibility for busing was established based on the walking distance to school; students living beyond the specified 'eligibility distance' received busing, all other students were expected to walk. Over time, eligibility zones were modified to include the busing of students impacted by real or perceived safety hazards. Since these eligibility zones were established independently, two neighbouring schools in different boards could have very different school busing requirements despite similar enrollment boundaries.

With OSTA taking on responsibility for school bus service across both boards, a process of harmonizing the transportation policies of the two boards was undertaken. As part of this process, it was recognized that inconsistencies in the eligibility zones for the two boards were creating inequity and inefficiency in the delivery of transportation services. It was also recognized that any effort to modify the eligibility zone boundaries would need a fair and consistent approach for evaluating traffic safety hazards that might trigger the need for busing.

Currently, there are few tools available for evaluating the potential risks to child pedestrians and determining where busing should be provided to address safety concerns. As a result, a study was undertaken to develop a methodology for consistently, fairly and transparently evaluating hazards along the route to school. The methodology identifies areas where school bus service would not normally be provided based on the defined eligibility distance, but is nonetheless required due to the presence of legitimate traffic safety hazards. The proposed evaluation framework is expected to achieve a three-fold benefit:

1) By systematically identifying traffic hazards, important health and safety objectives can be realized - children receive busing if a hazard is deemed to exist (addressing safety), but are encouraged to walk or cycle to school if the route is considered to be sufficiently safe (improving health).
2) By providing bus service to only those students who truly need it, OSTA can improve operating efficiency, ensuring that busing is a sustainable and viable option for meeting transportation needs.
3) By clearly delineating areas where school bus service will not be provided, targeted actions can be taken on a school, neighbourhood, and city level to encourage students living in these areas to explore active transportation options.

In developing the evaluation process, an effort was made to ensure that the methodology:

- Recognizes the limitations of child pedestrians
- Reflects sound engineering principles and is based on accepted guidelines by recognized transportation agencies and authorities

- Identifies opportunities for mitigation of safety hazards in partnership with the City and other stakeholders, so that as many children as possible can walk to school
- Uses readily available data, is simple to apply through the use of checklists and other tools, and can be easily communicated to parents

This paper describes the initial phase of work which focused on developing the preliminary evaluation framework. Subsequent phases of work will involve testing the methodology and applying it across Ottawa to assess traffic safety hazards for children walking to school.

2. Benefits of Walking to School

The journey to school is an important one for both children and parents. Encouraging travel by active modes results in numerous personal and societal benefits:

- Children between the ages of 5 and 11, as well as youth aged 12-17 are encouraged to achieve 60 minutes of exercise daily according to the Public Health Agency of Canada [1]. **Children who walk to school are shown to experience higher overall levels of physical activity**, even if only a small portion of the activity comes from the trip itself [2]. In addition, children who are encouraged to be active are more likely to carry these good habits over into adulthood [3].
- Obesity among children is a growing concern. Every additional **hour spent in a car per day is associated with a 6% increase in the likelihood of obesity**, while each additional **kilometer walked per day is associated with a 4.8% reduction in the likelihood of obesity** [4].
- An Ontario Walkability Study of more than 6000 students found that **nearly 75% of children surveyed would prefer to walk or cycle to school regularly** [5]. Such results indicate that policies to encourage active modes are actually aligned with the wishes of students themselves.
- As the number of pedestrians along a given corridor increases, driver awareness also improves which results in safer conditions. That is, **as more students are encouraged to walk, safety is improved for all**.
- The number one trigger of asthma attacks is air pollution, which can be at least partially attributed to emissions from motor vehicles. Alarmingly, **asthma is the leading cause of school absenteeism** in Canada [6]. By reducing the number of vehicles on the road, and particularly the congestion surrounding school zones, air pollution can be minimized.

It is ultimately the role of the community, school, parents and municipality to encourage, wherever it is safe to do so, walking and cycling to school. Any changes to school bus routing thus present an opportunity for the broader school community to work together to achieve an increase in walking and cycling activity.

3. Challenges in Evaluating Safety

Safety is a paramount consideration in accommodating mobility needs – whether for pedestrians, cyclists, car drivers, or passengers. While professionals and decision makers may strive for the highest level of safety, what constitutes safe is not always well understood or defined. As noted in the TAC *Geometric Design Guide for Canadian Roads*:

> It is impossible to make a road completely safe, if by “safe” we mean a road on which we can guarantee that there will never be a collision. We can, however, design a road to provide a reasonable level of safety. Just what is a reasonable level of safety, when we take into account the cost required to build it, is a matter of experience and judgment. In short, the notion of a “safe” (or collision-free) road is a myth. Design should be viewed instead as a process that can result in a road being ‘more safe’ or ‘less safe’. [7, pg. 1.1.1.2]

Although it is impossible to assess absolute safety, for the purposes of evaluating school busing requirements, it is necessary to make a final conclusion about whether a particular walking route is “safe enough”. While collision data is frequently used to examine safety for motor vehicles, collision data for pedestrians is not always as meaningful because the associated pedestrian volume is not always known, making it difficult to assess exposure. In addition, collisions involving pedestrians tend to be rare. Just because no collisions were observed does not imply a safe situation, particularly if pedestrians are avoiding areas they know to be dangerous. Thus, while collision data is important, other indicators must be used as well to predict the potential for future collisions.

In developing the methodology, every effort was made to develop an objective and consistent evaluation process which seeks to determine whether an unacceptable level of risk is faced by a child walking to school under normal conditions. However, it is important to note that the goal of the evaluation process was to objectively assess the requirement for busing. Simply because a hazard is not deemed to require busing is not an explicit endorsement of the safety of a child pedestrian walking along a given route.

4. Child Pedestrians

Evaluating traffic safety around schools requires an understanding of how children view their surroundings and interact with traffic. Child pedestrians have unique perceptions of the world around them, and developmental factors play an important role in influencing their abilities to safely navigate the demands of intersections and roads.

According to the *SafeKids Canada Child Pedestrian Injuries Report 2007-2008*, child pedestrian injuries are a leading cause of injury-related death for Canadian children aged 14 years and younger [8]. A review of collision data provides insight into the most frequent types of collisions involving children.

The City of Toronto’s *Pedestrian Collision Study* found that almost half of all pedestrian collisions occur at an intersection, based on data from 2002/2003 [9]. Midblock locations were found to account for a further 22% of collisions. The data suggests that child pedestrians are over-represented in both midblock collisions and collisions at pedestrian cross-overs, as well as certain types of intersection collisions. Figure 1 provides more detailed information about the action of child pedestrians at the time of collision, based on national collision data from Transport Canada [referenced in 8]. According to this figure, intersections present the greatest risk to child pedestrians. This is not surprising as intersections are the most complicated elements in a transportation network, with multiple conflicting movements. It is therefore crucial that a methodology which evaluates safety for children gives careful consideration to crossings.

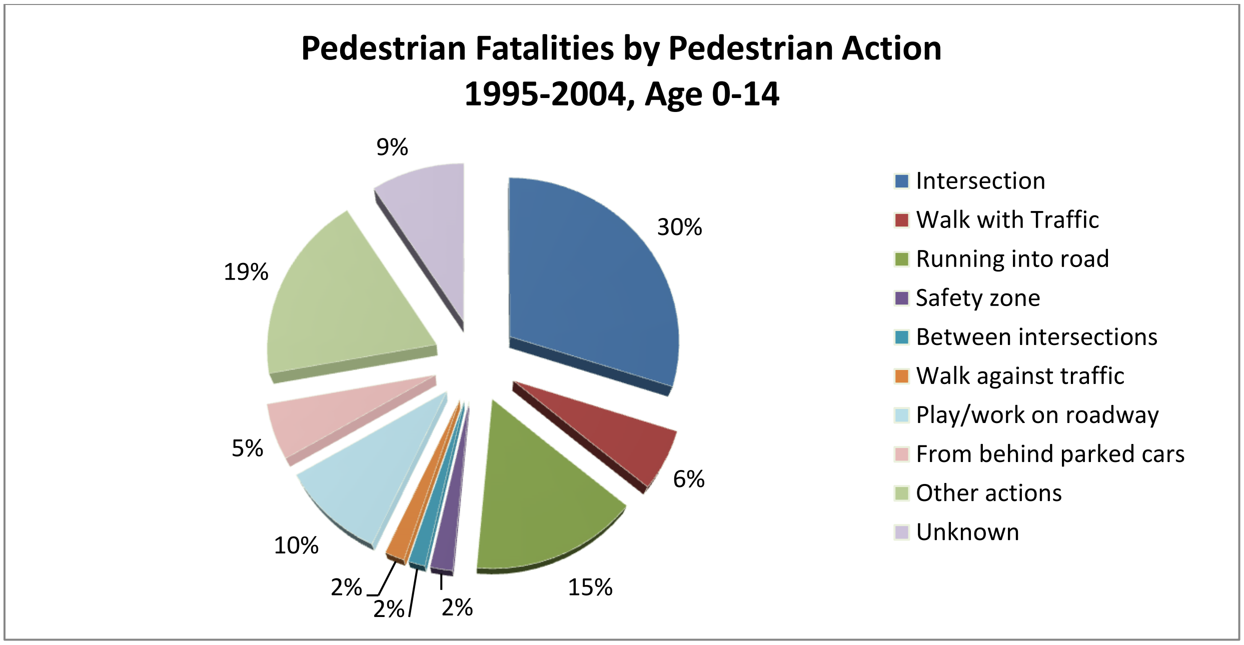

Figure 1 – Pedestrian Fatalities by Pedestrian Action, Age 0-14

There are a wide range of physical, psychological, and behavioural characteristics of children which tend to increase their risk for pedestrian collisions [10,11,12,13,14,15,16]:

- Children have difficulty detecting traffic. Their small size not only makes them **less visible to drivers** but also **less able to see oncoming vehicles**, especially when parked cars impede their vision. In addition, **the field of vision of children is one-third narrower than that of adults**. As a result, children have a restricted capacity for using information in their peripheral vision. Children under the age of 8 also have **difficulty judging the direction and importance of various traffic sounds**, such as sirens. Consequently, they may turn the wrong way searching for a sound, missing important information.
- Children have **difficulty conceptualizing speed and distance**, which in turn makes it difficult to judge safe gaps in traffic. Because their sense of perception is different from that of adults, children may think large cars move more quickly than small cars, or that narrow streets are less dangerous than wide streets. This distorted view of traffic motion is particularly dangerous in light of children's **limited understanding of the physics of a moving vehicle**, and the time and distance required to stop.
- Although children may have been taught to cross the street safely**, they can be easily distracted and may respond impulsively**. Children also tend to be impatient, and may have trouble waiting for stoplights to change or for cars to stop at a crosswalk before they step out onto the road.
- **Children need more time to process information and react than adults**, and may be overwhelmed by the complexity of traffic. When confronted with a potentially hazardous situation, they fall back on prescriptive rules, easily remembered but not always appropriate.
- **Children cannot understand the driver's point of view** and expect adults to look out for them. They believe that others see what they see and do not realize that drivers may

be unaware of their presence. **Children also lack a sense of vulnerability**, and do not understand that a car can seriously hurt or kill them.

Given these limitations, the National Safe Kids Campaign recommends that children under the age of ten be accompanied by adults or older children when crossing the street [15]. Likewise, Safe Kids Canada recommends that children under the age of eleven be supervised when dealing with traffic, since younger children generally do not have the ability to make safe decisions on their own [16]. As noted in the literature, teaching children about traffic safety has only limited potential to reduce child pedestrian injuries:

> While children as young as nine years may be able to learn the skills to cross the street, it is unlikely, because of their cognitive, perceptual and behavioral abilities, that they can be relied upon to use those skills, especially when they are engrossed in play. Interacting with traffic is complex, and the necessary abilities are not fully developed in children until age 11 to 12 years [10, pg. 71]

The above findings highlight an important issue when evaluating the various traffic hazards encountered by child pedestrians: for children below a certain age, few routes are likely to be safe enough to walk to school alone. When designing an evaluation framework, it is therefore important to define the target age group for which safety is to be assessed. To avoid a situation where nearly all young children receive busing, the framework should be tailored to children who are old enough to walk to school independently; if a route is deemed to be sufficiently safe for this target age group, then it is also considered to be a viable route for younger students under the presumption that they will be accompanied by someone older. This latter assumption speaks to the need to educate parents. As with any issue related to child safety, it is ultimately the parent's responsibility to decide on the capabilities of their children. Even if a route does not meet the warrants for school bus service, parents should not interpret such results as an endorsement of the route safety. Instead, they must assess for themselves whether it is appropriate for their child to walk to school unaccompanied, given their child's level of development and the traffic situation to be encountered.

For the proposed evaluation framework, the age of eleven was selected as the 'design age' for assessing safety hazards. While children of all ages are encouraged to walk to school, adequate supervision is assumed for all children below the age of eleven.

5. Literature Review Findings

There is little technical guidance on identifying 'hazard zones' where school bus service should be provided to address traffic safety concerns. Only a few states in the U.S. appear to have documented, in-practice warrants for establishing walking hazards including New York, New Mexico, Pennsylvania, Florida, Idaho and Illinois. In addition, several U.S. school boards have developed strategies for assessing busing requirements.

The majority of the approaches include similar measures for evaluating pedestrian safety, including:

- Traffic volume (both along roads and at intersections)
- Speed limit
- Type of intersection control
- Size/function of the road e.g. width, number of lanes, functional classification
- Type of pedestrian facility provided along the road e.g. sidewalk, shoulder, etc.

- Railroad crossing characteristics e.g. number of trains using the tracks during walk-to-school periods, speed of trains, number of tracks in use, type of protection, etc.

A number of additional factors were only found in one or two of the strategies, but were felt to have merit:

- Judgement Points – used to take into account the “on the ground” conditions observed during the site visit which may not be adequately captured in the evaluation framework
- Length of hazardous section
- Streets with high accident frequency during the periods when children walk to school
- Physical or visual obstructions along the walking route

Generally all of the approaches studied took a reactive approach to the issue of hazards. The evaluation criteria were utilized in response to requests from parents, school boards and other organizational bodies, rather than as a proactive evaluation of walking zones. Florida is the only state which makes reference to correcting the hazard in cooperation with local government to minimize busing requirements.

Walkability checklists were also reviewed, and generally found to include similar factors related to pedestrian safety. The main differences between the hazard evaluation frameworks used for assessing school bus requirements and the more general walkability checklists lie in the interpretation of factors which are not easily quantified. These include: crime/perception of crime and unsavoury characters, cleanliness of pedestrian facilities, provision of pedestrian amenities (such as benches or shade trees), nearby land uses, and driver behaviour.

6. Proposed Methodology

It is clear from the literature review that while there is no standard approach for systematically evaluating the safety of child pedestrians, there are several factors which are consistently identified as correlating with the safety of a particular facility.

While there are numerous measures of safety and walkability, the approach in developing the proposed methodology for the OSTA was to use as few indicators as possible, while still capturing the key measures influencing safety. This is important for the usefulness of the warrant system given that:

- The methodology is intended to be transparent and consistent. Complicated warrant systems are not easily followed or understood, particularly by non-technical audiences.
- An evaluation methodology with extensive data requirements and which is extremely time-consuming to implement is not efficient. By minimizing data requirements, the approach can be applied effectively to evaluate hazards in a thorough but timely manner.
- The methodology is designed to be as objective as possible. Many of the factors related to walkability are qualitative and require a subjective evaluation, which may impact the integrity of the evaluation process. Other factors relate more the quality of the walking environment, and have limited impact on safety. As a result, such factors were not included in the evaluation framework.

Details of the proposed methodology are provided in the following sections, including the overall structure of the framework, as well as the various measures used to assess safety.

6.1 Hazard Evaluation Framework

Several of the approaches examined in the literature make use of a scoring system for evaluating hazards. The shortcoming of this approach is that conditions which are considered to have an unacceptable level of risk may not score high enough to warrant busing. In contrast, an absolute safety test is not able to deal well with conditions where there may be multiple hazards which are cumulatively contributing to an increased exposure to risk but which may individually fail to meet 'absolute' warrants.

While many warrant systems also consider the number of children using a particular route or crossing (such as the system used in Ottawa to evaluate the need for school crossing guards, or the Ministry of Transportation of Ontario's pedestrian signal warrants), this type of warrant is felt to be inappropriate for the purposes of determining the need for hazard busing. Even if there is only one child walking a particular route to school which is deemed to be unsafe, that child should be eligible for busing.

Given the above considerations, the proposed methodology is based on a two-part framework (refer to Figure 2):

1. **Absolute warrants** are used to identify situations which are deemed to present such a significant risk to student pedestrians that busing is automatically warranted if no alternative routes exist.

2. **Combination warrants** account for the cumulative impact of multiple hazards along the route to school. While each hazard in isolation may be insufficient to automatically warrant busing, in combination, these hazards may contribute to a level of safety that is less than desirable. To apply the combination warrant, "hazard points" are assigned to reflect the relative risk; where the two greatest hazards have a combined score of 100 points or greater, busing is considered to be warranted.

If a particular route is deemed to require busing, alternative routes are evaluated. If no feasible alternatives exist, then school bus service is recommended to address safety concerns.

Similar to other approaches documented in the literature, the proposed methodology considers three types of potential hazards:

1. Travel along roads and paths (corridors)
2. Travel across roads (crossings)
3. Railroad crossings

For each type of hazard, the key factors influencing safety were identified to provide a rationale and basis for developing evaluation measures. The evaluation framework for corridors, crossings, and railroads is described in the following sections.

6.2 Corridor Evaluation Framework

The corridor evaluation framework (refer to Figure 3) deals with the evaluation of conditions where a pedestrian is travelling along a street, either directly on the roadway, or using a sidewalk, shoulder or pathway. All sections of the walking route are evaluated using the evaluation framework. If any section meets the ‘absolute safety’ warrant, busing is considered to be justified (as long as no alternative routes exist). If none of the sections meet the absolute warrants, hazard points are assigned. The section with the highest hazard points is used in evaluating the combination warrant. If there are multiple types of treatments along a corridor (i.e. a shoulder and a sidewalk), the evaluation of the worst case section first will help to quickly capture the maximum risk exposure. The evaluations cover the following situations:

- No sidewalks or shoulders for more than 30m [Will trigger absolute safety warrant]
- Shoulders
- Sidewalks
- Pathways

It is important to note that walking facilities must be evaluated in the direction in which they are intended to be used as laid out in the Highway Traffic Act. This has implications when evaluating alternatives, as it may be necessary to cross over to the other side of the road to face oncoming traffic when walking on the shoulder. In this case, the crossing must also be evaluated for safety. A similar situation would exist where sidewalks are provided on only one side of the road.

General Considerations

Safety along road corridors is influenced by a number of factors, including the degree of separation from moving traffic, visibility of pedestrians, and presence of driveways. The speed of traffic is also important, as higher speeds require longer braking distances for a driver to respond, and are more likely to result in a serious or fatal injury should a collision occur.

Key safety indicators included in the evaluation framework are briefly discussed below.

Separation from Traffic

Separation from traffic is most closely related to collisions occurring head-on or from behind. Should a driver swerve to avoid an obstacle or lose control of the vehicle and veer off course, the separation between pedestrians and vehicles will be a key factor in whether a collision occurs, and the resulting severity.

- **Sidewalks** - Sidewalks provide a segregated travel corridor for pedestrians. It has been found that streets with no sidewalks have 2.6 times more pedestrian collisions than expected based on exposure [17]. Although the presence of sidewalks provides a high degree of safety for pedestrians, the quality of the sidewalk also plays a role.

  Evaluation of sidewalk facilities was based primarily on the degree of separation from traffic (including both the boulevard width and sidewalk width), as it relates to the posted speed limit. Sidewalks below the desired minimum width with no boulevard therefore represent the worst condition. However, since sidewalks generally provide a high level of accommodation for pedestrian travel along a road, narrow sidewalks on their own were not considered sufficiently unsafe to automatically trigger the need for busing.

- **Shoulders** - If a pedestrian is walking along a shoulder, the width of the shoulder will essentially define the separation from traffic unless roadside barriers are provided. For high speed or high volume roads, shoulder widths which do not meet the minimum requirements set out in the *TAC Geometric Design Guide* [7] were deemed to present a significant safety hazard, and are therefore considered to meet the absolute warrants for the provision of hazard busing. Other shoulder conditions may or may not pose a serious hazard depending on the speed and volume of traffic using the road, and the evaluation methodology was designed accordingly.

- **No Walking Facilities** - This situation arises where no shoulders or sidewalks are available and a child is forced to travel on the road itself. The separation from traffic in this case is non-existent. Consequently, this was considered to meet the 'absolute safety' warrant for hazard busing.
- **Pathways** - For the purposes of this project, a pathway was defined as a winter-maintained, off-road facility intended for walking or cycling. An asphalt path in the boulevard parallel to a road is not considered a pathway, but would instead be evaluated as a sidewalk. Since pathways are segregated from the roadway and do not follow along the path of a road, they are not subject to encroachment by vehicular traffic and are therefore considered safe from traffic conflicts (except at roadway crossings, which are evaluated separately).

Accesses

Accesses and driveways pose a risk to pedestrians due to the potential for conflicts with exiting and entering vehicles. Commercial accesses are generally considered to be more dangerous than residential driveways as they typically have higher traffic volumes and are located on busier roads with higher demands on drivers' attention. However, residential accesses also present a safety risk, particularly where drivers back out of the driveway. Within the evaluation framework, points are assigned based on the access density, with commercial accesses weighted more heavily.

6.3 Crossing Evaluation Framework

The crossing evaluation framework (refer to Figure 4) is intended for evaluating crossings of collector and arterial streets. All crossings along the route are evaluated. Similar to the corridor evaluation, if any crossing meets the 'absolute safety' warrant, busing is considered to be justified (as long as no feasible alternative exists). If none of the crossings meet the absolute warrants, hazard points are assigned for use in the combination warrant. The following crossings are considered in the evaluation framework:

- Uncontrolled Intersection & Midblock Crossings
- Multi-Way Stops (all crossings) / Two-Way Stops (crossings on minor leg)
- Signalized Intersections

General Considerations

In assessing safety, a predictive approach has been adopted; the methodology examines measures that are known to influence safety in an effort to assess the potential *future* risk to child pedestrians. However, it is also important to consider past experience. Accordingly, collision data is used as an initial verification that the crossing does not pose a proven risk to pedestrians. Any location with 2 or more pedestrian collisions in the previous three years is considered to warrant hazard busing. Other factors considered at all crossings include:

- **Sight Distance** - If the available sight distance is less than the required sight distance (due to an obstacle such as a tree or building), then the driver may not be able to stop in time if a child is crossing the road, posing a serious safety concern. Consequently, sight distance is an essential requirement no matter which type of crossing is being considered. If there is insufficient visibility such that drivers cannot see a pedestrian in the crossing and vice versa, then the crossing is considered to meet the absolute safety warrant for the provision of hazard busing.

- **Presence of Adult Crossing Guards** - Adult crossing guards are felt to provide an improvement in both real and perceived safety at crossings. According to the Institute of Transportation Engineers, "crossing guards and increased enforcement are the best measures for child pedestrian safety [14, pg. 46]." For the evaluation methodology, the presence of crossing guards was felt to improve safety to the extent that school busing is not required, regardless of the crossing characteristics.

Uncontrolled Intersection & Midblock Crossings

The main issue associated with uncontrolled crossings relates to the availability of gaps in the traffic stream to allow the pedestrian to cross safely. The number of crossing opportunities at an uncontrolled crossing is a function of several factors, including the traffic volume, operation of adjacent traffic control devices, and the crossing width.

The TAC *Pedestrian Crossing Control Manual* [13] contains a series of charts which relate the number of pedestrian crossing opportunities per hour to the hourly traffic volume for different road cross-sections. According to this manual, where there are greater than 120 crossing opportunities per hour, no special treatment for pedestrians is warranted. Based on this cut-off value, the corresponding hourly volume on the roadway was used as a threshold for determining whether school bus service should be provided.

In the case of child pedestrians, it was felt that no more than two lanes of traffic should be crossed in an uncontrolled situation without assistance. Based on the crossing distance for a two-lane road, the TAC Manual suggests a maximum traffic threshold of 800 veh/hr to ensure at least 120 crossing opportunities per hour. This threshold was then adjusted downward (to 500 veh/hr) to provide an additional margin of safety for child pedestrians – if the traffic volume is greater than 500 veh/hr, the crossing is deemed to meet the absolute safety warrant for the provision of hazard busing. At all lower-volume crossings, hazard points are assigned for use in the combination warrant.

Although direct measurements of gap availability have been used in other methodologies for assessing safety (such as the City of Ottawa's School Crossing Guard warrants), a simpler approach was adopted for evaluating school busing requirements. Given the effort required to conduct a gap study at each unprotected pedestrian crossing that a child might use en route to school, the methodology uses traffic volume as a surrogate measure of gap availability, reducing data collection requirements considerably.

In developing the evaluation methodology, consideration was also given to the type of treatment at uncontrolled crossings, and whether the crossing is marked or unmarked. While there are specific crosswalk configurations which have been found to improve visibility at pedestrian crossings, overall conclusive evidence on the safety benefits of such treatments is difficult to find. A major U.S. study of over 1000 crosswalks found no relation between the number of pedestrian crashes and the crosswalk location, speed limit, direction of traffic flow, crosswalk condition, or crosswalk marking pattern [cited in 18]. There is also the issue of who has the right-of-way at a marked crosswalk. According to the City of Ottawa Traffic and Parking By-law No. 2003-530, pedestrians must yield to vehicular traffic at crosswalks:

> Except where traffic control signals are in operation or where traffic is being controlled by a constable, no pedestrian shall cross a highway without yielding the right-of-way to all vehicles upon the roadway" (Part A-IX.90.)

Given that pedestrians at marked crosswalks in Ontario must yield to traffic, the presence of pavement markings and signage at midblock crossings is not considered to improve pedestrian crossing safety. In fact, it can be argued that such treatments provide a false sense of security and create confusion amongst drivers and pedestrians as to who has the right-of-way. The *Ontario Traffic Manual* echoes this sentiment:

> Marked crosswalks with painted pavement markings are not recommended at uncontrolled crossings as they create a false sense of confidence on the part of pedestrians, particularly children, who may enter the crossing expecting that approaching drivers will see them and stop [19, pg. 48].

In the proposed evaluation framework, the number of hazard points assigned at an uncontrolled crossing is based solely on the speed limit at the crossing and conflicting traffic volume; the impact of pavement markings or other specialized crosswalk treatments is not considered.

Multi-Way Stops (all crossings) / Two-Way Stops (crossings on minor leg)

The main issue with stop-controlled crossings relates to driver compliance. In theory, multi-way stops present the ideal situation for pedestrians as all drivers must come to a complete stop before entering the intersection, allowing pedestrians to cross safely. One study found that pedestrian collisions declined by 25 percent when traffic signals were converted to all-way stops at low-volume urban intersections [20]. However, safety issues can arise where there are multiple lanes of traffic which reduce the visibility of pedestrians, where many drivers consistently fail to come to a complete stop, or where high speeds and poor sightlines at the intersection create a safety concern.

Consequently, crossings of roads controlled by stop signs are not deemed to warrant hazard busing on their own. However, factors such as the crossing width (number of lanes), vehicle approach speed and the angle of the intersection can all contribute to situations which are ‘less desirable’ from a safety perspective and are thus accounted for in the evaluation framework.

While the compliance rate at stop signs is known to influence safety and has been used in other evaluation systems (such as the City of Ottawa’s School Crossing Guard warrants), compliance is not considered in the proposed methodology given the associated data collection requirements.

Signalized Intersections

At signalized intersections, the main concern relates to conflicts between pedestrian and vehicle movements occurring at the same time, as well as illegal movements by pedestrians and drivers. While it is recognized that children may have low patience and may be tempted to proceed regardless of the pedestrian display, and may also be less observant of vehicles making illegal manoeuvres, such behavioural characteristics are not specifically addressed in the proposed methodology. It is assumed that any children old enough to walk alone have sufficient skill to correctly navigate signalized intersections, and that signalized crossings on their own are not sufficient to justify hazard busing.

In terms of conflicts, the following situations are of particular concern:

- Right turns on red
- Right turns on green
- Left turns on green (unprotected movement)

Research suggests that left turn collisions involving pedestrians are more prevalent than right-turn collisions, with one study showing a 60-40 split between left and right-turn collisions respectively [21]. However, rather than consider each turning movement individually, the total volume of traffic entering the intersection was selected as a surrogate measure of the potential for pedestrian-vehicle conflicts. Several research studies have documented the relationship between the number of vehicle-pedestrian collisions per intersection and the overall traffic entering the intersection [22]. Such findings suggest that the proposed approach provides a reasonable basis for assessing school bus requirements.

As well as the total volume of traffic, the evaluation also considers the *treatment* of left and right turns. If left turns are not protected (i.e. a vehicle may turn left while a pedestrian is crossing in the crosswalk with a walk indication), there is a greater risk of conflicts and additional points are awarded accordingly. With regards to right-turn movements, there is conflicting evidence on the relative safety of different treatment types. A recent NCHRP project concluded that right turn channelization is significantly safer for pedestrians than conventional right-turn lanes, based on 7 years of data for 395 intersection approaches in Toronto [23]. However, a report by the FHWA claims that the higher speeds and potentially longer crossing distances associated with right turn channelization could lead to an increase in both the number and severity of pedestrian crashes [24]. The proposed evaluation framework conservatively recognizes that there may be a corresponding increase in risk if pedestrians must cross a right turn channelization with a high volume of right turning vehicles.

Similar to multi-way stops, a signalized intersection is not deemed to present an absolute safety concern. Additional factors such as crossing width (number of lanes), vehicle speed and the angle of the intersection will, however, contribute to situations which are less than desirable, and are therefore considered in the evaluation process.

Another measure that has been used to assess safety at signalized intersections is the number of conflicts, where a conflict is defined as a situation where the safety of a pedestrian is genuinely compromised by the failure of a motorist to provide the right-of-way, resulting in either the pedestrian or vehicle having to take evasive action. Although this measure has merit, it was not included in the proposed methodology since conflicts are not easily measured, and involve some degree of subjectivity in determining whether a conflict has in fact occurred.

6.4 Railway Crossings

The safety of railway crossings is dependent on a number of factors, such as the type of protection provided at the crossing (lights, gates, etc.), number of tracks being crossed, and level of train activity. While such factors have been used in other jurisdictions to assess the suitability of a crossing for students, a simpler, more conservative approach was adopted for the OSTA framework - any student crossing a mainline, at-grade railway track is considered to be eligible for hazard busing, regardless of the type of protection provided. Such an approach reflects the high level of risk associated with railway crossings (both perceived and real), the difficulty in obtaining information on train activity (which is likely to change over time), and the relatively few at-grade railway crossings in Ottawa used by students.

6.5 Acceptable Alternatives

The provision of hazard busing under both the absolute and combination warrants is contingent on the availability of alternative routes; as long as there is a feasible alternative which is sufficiently safe for walking to school, hazard busing is not considered to be warranted. In order for an alternative to be considered feasible, the detour length must be such that the total distance walked to school is less than the eligibility distance used to define school bus boundaries. While back-tracking to make use of a safer crossing, or travelling out of the way to take advantage of sidewalk facilities, may be inconvenient (and is certainly undesirable), the route is still considered to be acceptable as long as the overall walking distance does not exceed the maximum distance that other children are asked to walk to school.

6.6 Security Issues and Temporary Conditions

Although the evaluation process focuses exclusively on traffic hazards, it is recognized that issues related to personal security may occasionally arise. To address such cases, the guidelines recommend that a process be put in place to evaluate requests for busing on a case-by-case basis.

There may also be situations where temporary hazards exist, for example, due to construction activity. The proposed evaluation framework can be equally applied in such situations to determine the need for hazard busing, recognizing that busing would only be provided as long as the temporary conditions exist.

7. Application of the Framework

7.1 Scope of Application

The hazard evaluation framework is intended solely for evaluating collector and arterial streets. Local streets are assumed to be adequate for travel by children, unless there is sufficient evidence to indicate otherwise. According to the proposed guidelines, local streets may be considered for evaluation if the volume of traffic exceeds a pre-defined threshold during the time when children are walking to/from school.

7.2 Evaluation Process

The evaluation process is carried out with the help of flowcharts and forms. To start, information is gathered to assist with the identification of potential walking routes. Key data requirements at this stage include the road classification, presence of any adult crossing guards, and location of winter-maintained paths. As part of the pre-evaluation phase, a site visit is required. To assist in the site visit, a number of data collection forms are available. In identifying potential walking routes to evaluate, a strategic approach is recommended; for a given catchment area, begin the evaluation with the route that appears to be the safest; if this route does not meet the warrants for busing, no additional routes need to be evaluated.

To apply the methodology, each route is split into crossings and corridor sections with similar walking facilities (shoulders, sidewalks, paths etc.). To minimize the evaluation effort, the most hazardous crossings / sections would typically be evaluated first, to quickly identify whether the “absolute” or “combination” safety warrants will be met. If the warrants are not met, the remaining crossings / sections would be evaluated using the appropriate framework to confirm the worst-case conditions for applying the safety warrants.

An example site visit and evaluation form is shown in Figure 5.

7.3 Data Requirements

The data requirements for each type of evaluation will vary depending on the types of hazards under investigation. Ideally, all traffic information should correspond to the time when children are travelling to/from school. A summary of the key data requirements is provided in Table 1.

Table 1 – Data Requirements for Corridors & Crossings

Data Required	Corridors			Crossings		
	Sidewalk	Shoulder	No Facility	Unprotected	Stop Control	Signal
Separation from traffic	X	X				
Speed limit	X	X		X	X	
Number of lanes		X		X	X	X
Traffic count data[1]		X		X		X
Section length	X	X	X			
Collision history[2]				X	X	X
Sight distance				X	X	X

[1] Manual count required at unprotected crossings; use City of Ottawa data for signals
[2] Obtained from City of Ottawa

8. Benefits

The proposed evaluation framework has a number of benefits:

- It provides a systematic, defensible and quantitative method for evaluating traffic safety hazards and associated school bus requirements, ensuring that the results are unbiased and fair.
- It promotes consistency in the evaluation of safety hazards to protect the integrity of the decision making process.
- It relies on a series of check-lists and forms, allowing the evaluation to be carried out by OSTA staff who may not have a background in traffic engineering or safety.
- It is based on a thorough review of the literature, and reflects the latest research on pedestrian safety.
- It offers the opportunity to rank hazardous routes in order of priority. While not intended for this purpose, this inherent flexibility ensures that busing is provided where it is most needed in the event that financial constraints limit the amount of busing that can be provided.

9. Recommendations & Next Steps

This paper reports on an evaluation framework that was developed for the Ottawa Student Transportation Authority to assess the need for school bus service to address traffic safety concerns. The methodology as proposed reflects experience in other jurisdictions as well as standards, guidelines, and best practices related to safety. The methodology was tested against several traffic scenarios to ensure the results were generally consistent with other evaluation frameworks; however, no real-world testing was undertaken as part of the initial phase of work described in this paper. As a result, in the final report for this phase, it was recommended that the OSTA test the methodology at several schools and carefully review the assignment of hazard points to ensure the results accurately reflect the perceived level of risk as determined by a traffic professional. Based on this review, minor tweaking of the point system may be required. Such review and refinement is considered important given the wide range of conditions likely to be encountered in the field and the challenges inherent in evaluating multiple hazards in combination.

In the spring of 2012, OSTA initiated the process of applying the evaluation framework across all of the schools under its jurisdiction. Results are expected to be announced in time for the start of the 2014 school year.

10. Acknowledgements

This paper draws from the final report on the proposed school transport walking hazard assessment guidelines, prepared in October 2011 by Morrison Hershfield Ltd. on behalf on the Ottawa Student Transportation Authority. The section on the limitations of child pedestrians owes much of its content to an earlier 2002 study by Morrison Hershfield Ltd. entitled “Adult School Crossing Guard Program and School Zone Traffic Safety Program Policy Development”, prepared for the City of Ottawa.

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Hazard Evaluation Flowchart

Ottawa Student Transportation Authority

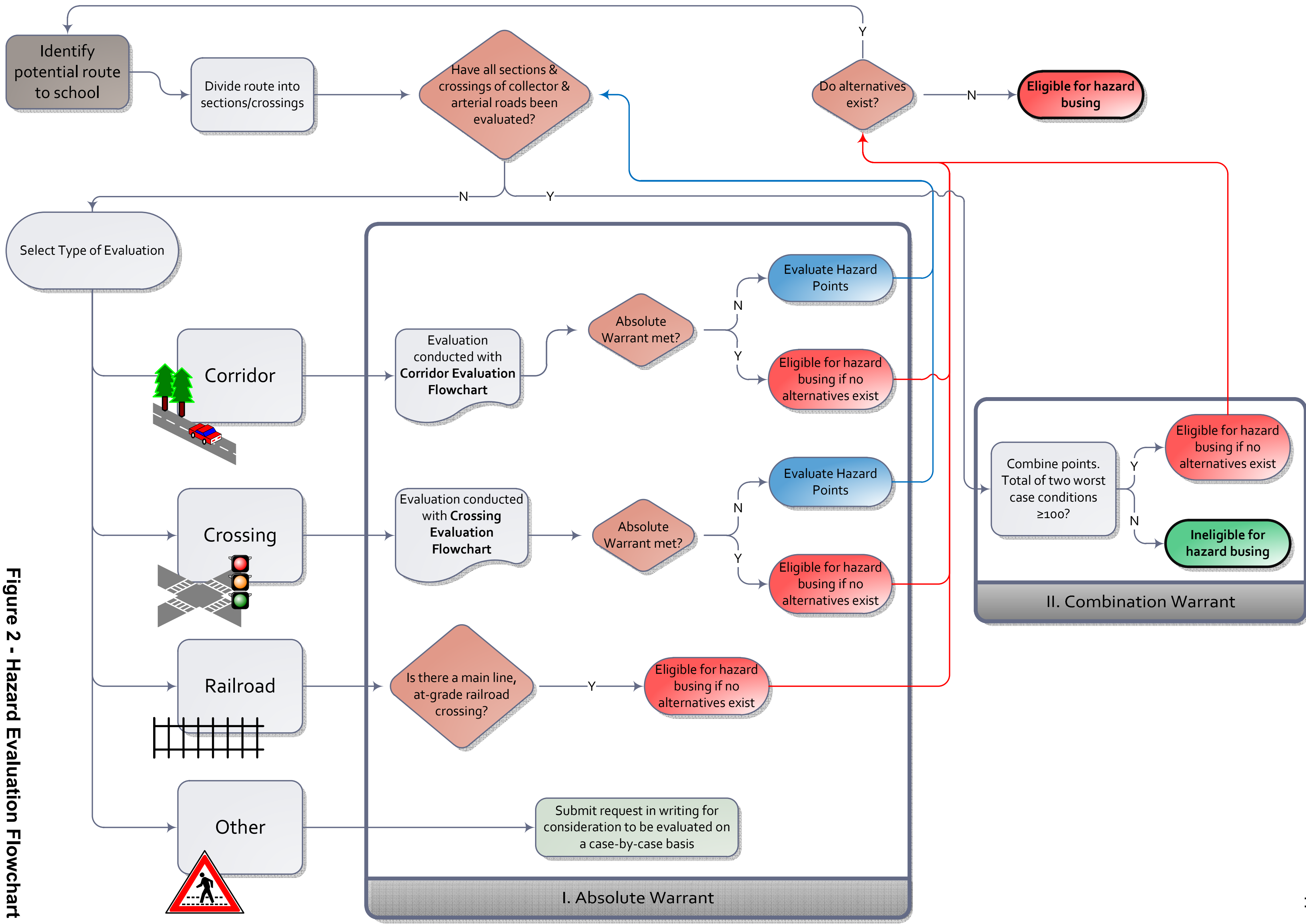


Figure 2 - Hazard Evaluation Flowchart

Corridor Evaluation Flowchart

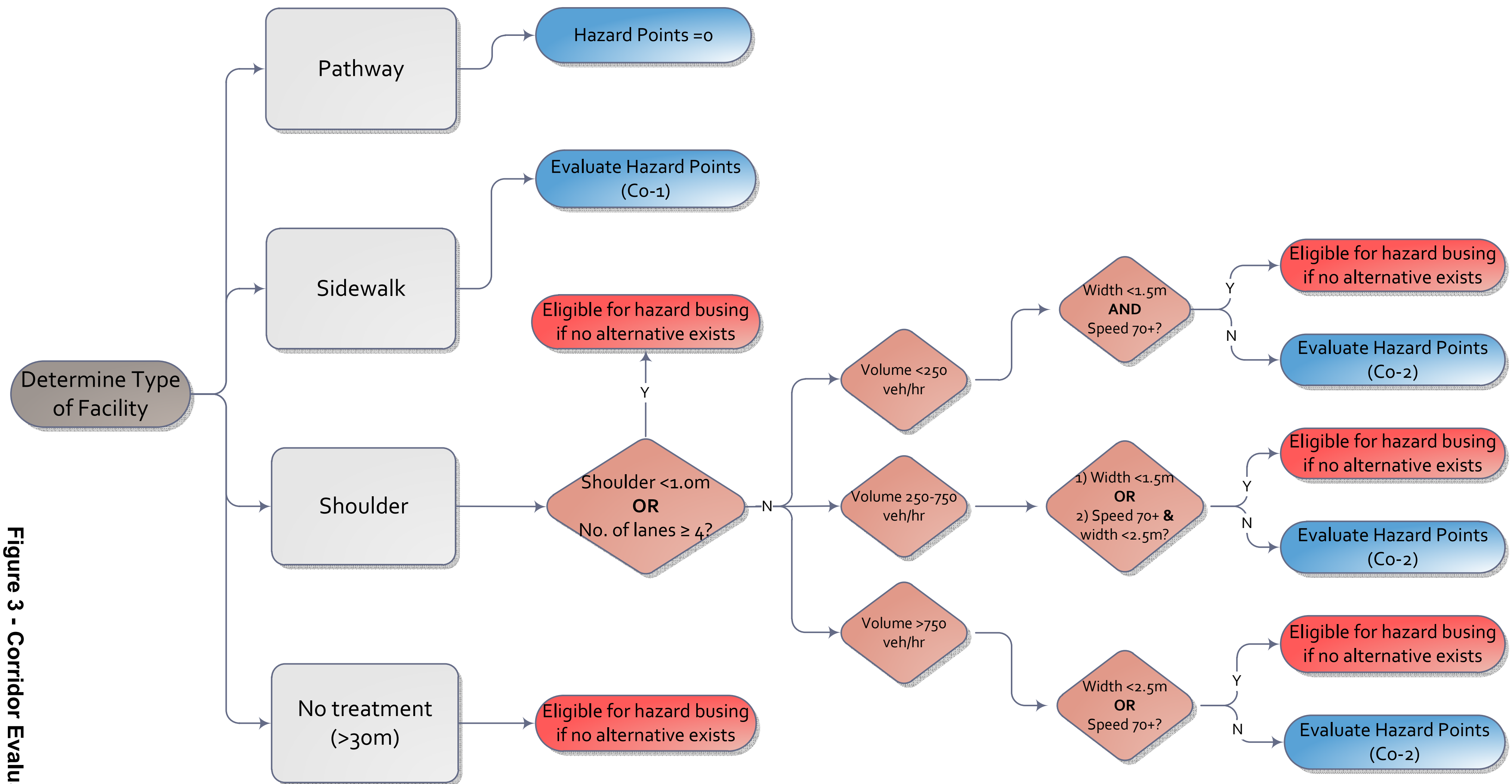


Figure 3 - Corridor Evaluation Flowchart

This flowchart is intended for evaluation of arterial and collector roads as part of the Hazard Evaluation Framework.

Crossing Evaluation Flowchart

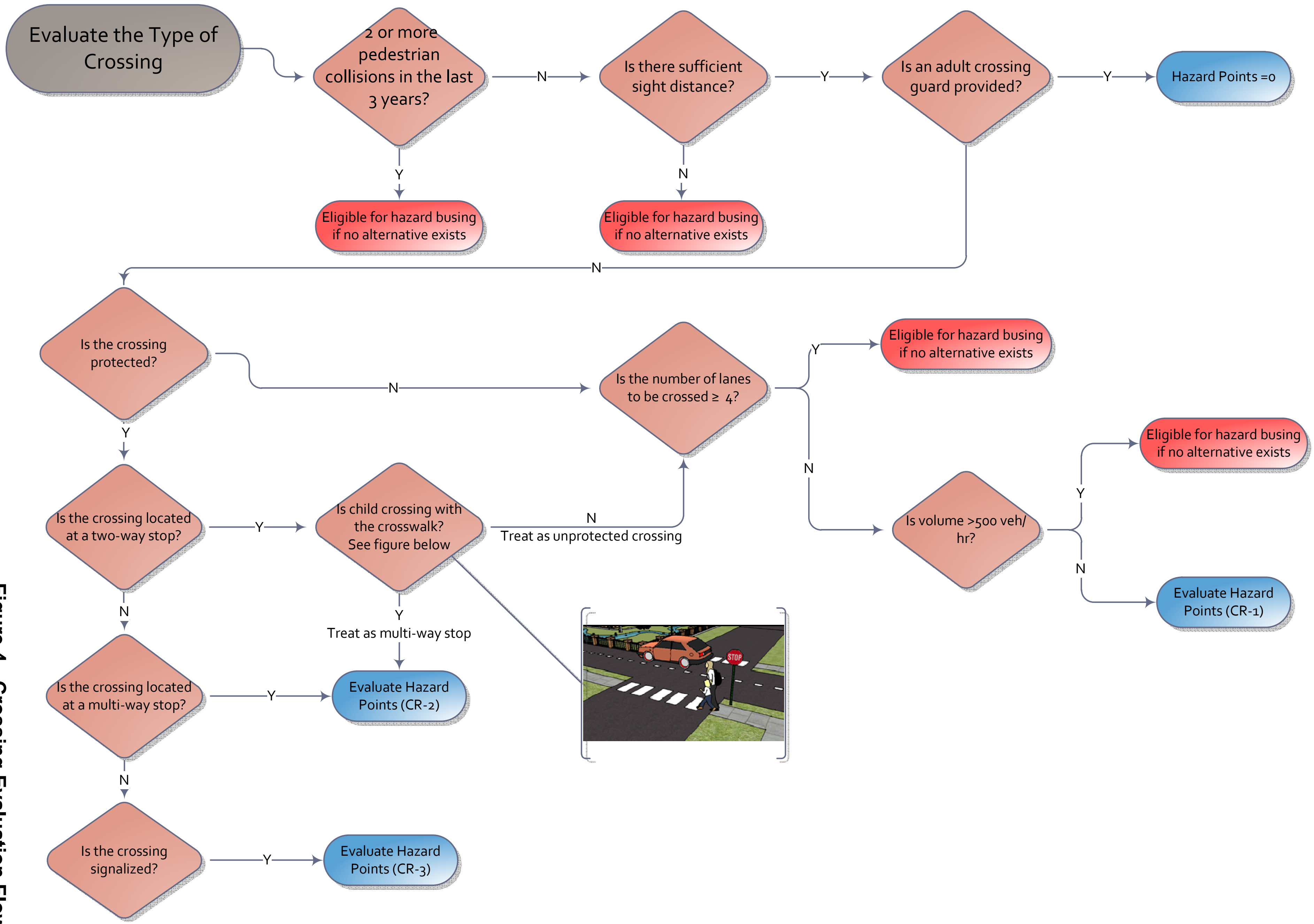


Figure 4 - Crossing Evaluation Flowchart

This flowchart is intended for evaluating crossings of arterial and collector roads as part of the Hazard Evaluation Framework.

Figure 5 - Sample Data Collection & Evaluation Forms

Site Visit Data Collection Form - Corridor Sections

School: ______________________ Date: __________

Location: ______________ Section Length ________ m

Select Facility Type below:

Sidewalks ○ Complete this section: **Speed Limit:** ________ km/hr

Accesses – Look at the frequency and density of accesses along the section. Access points may include driveways to houses, businesses and stores. Indicate in chart.

	Typical Access Frequency		
Type of Access	**None**	**Some (1-2/100m)**	**Many (3+/100m)**
Commercial / Industrial			
Residential			

Width – Beginning from the edge of the road, or curb if one is provided, measure out until the edge of the far side of the sidewalk. If the width varies, measure the width for a typical section.

________ m

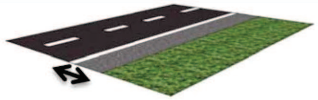
Route Consistency – Are there short sections (<30m) without walking facilities or that are substantially worse than the average condition evaluated? Y ○ N ○

Shoulders ○ Complete this section: **Speed Limit:** ________ km/hr

Number of Lanes on Roadway: 2 ○ 3 ○ 4+ ○

Note: If number of lanes is 4+, it is not necessary to collect further data

Width – Beginning from the edge of the road, measure out until the edge of the shoulder. If the width varies, measure the width for a typical section.



________ m

Route Consistency – Are there short sections (<30m) without walking facilities or that are substantially worse than the average condition evaluated? Y ○ N ○

Volume – Count the number of vehicles for the given section in both directions during the one-hour period when children are most likely to be walking to school (See *Traffic Count Form*). ________ veh/hr

Pathway ○

Notes:

CO-1 Sidewalk Evaluation Form

School: ______________________

Section Location: ______________ Section Length: ____ m

Access / Driveways

Assign points based on the table below. If more than one access type applies, choose the type which would result in the highest point value.

	Typical Access Frequency		
Type of Access	None	Some (1-2/100m)	Many (3+/100m)
Commercial / Industrial / Parking Lot	0	5	10
Residential	0	5	

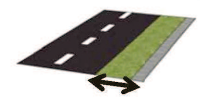
Examples:

None Some Residential Many Commercial

☐ pts

Separation from Traffic

Assign points based on the table below.*



Speed Limit (km/hr)	**Separation Distance (m)**			
	<1.5	1.5-2.0	2-4.5	+4.5
40 or less	10	5	0	0
50	25	15	10	0
60+	30	25	15	0

*If a roadside barrier is provided to shield the sidewalk, assign 0 pts.

☐ pts

Route Consistency

Are there short sections (<30m) without walking facilities or that are substantially worse than the average condition evaluated?

If *Y-assign 10 points*. If *N-assign 0 points*. Y ○ N ○ ☐ pts

Subtotal

Enter the sum of the boxes above. ☐ pts

Total

For section lengths > 400m, multiply subtotal by 1.5.
For sections lengths < 400m, multiply subtotal by 1.0. ☐ pts