Human-centred Pedestrian Safety Evaluation Program: User Guide for Technical Tools

A technical user's guide for the analytical tools developed for setting investment priorities in pedestrian safety in the City of Ottawa.

January 2010

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Background

Pedestrians, and other vulnerable road users, represent an important part of the overall road safety picture. Vulnerable road user[1] fatalities in Canada claimed 567 lives in the year 2000 – a figure that represents almost 20% of all road fatalities in our country. Of these, 367 involved pedestrians. In addition, over 13,700 people suffered some level of personal injury.

Almost 70% of the pedestrian fatalities took place in urban areas, and two-thirds were killed at intersections. Even though crash involvement rates for persons 65 years of age and over are lower than for most other age groups, seniors are much more vulnerable to serious injury or death when struck by a motor vehicle than younger pedestrians[2]. In Canada, over one-third of all pedestrian fatalities involve a senior citizen. This constitutes a substantial over-representation of this group.

In its “Pedestrian Crossing Control Manual”, the Transportation Association of Canada (TAC) states:

> *Pedestrian crossings present one of the greatest challenges for the traffic and safety engineering communities.* [3]

Kenneth Ogden, in his seminal work on road safety engineering, further reinforces this view:

> *Pedestrians, bicyclists, and other vulnerable road users require specific consideration in traffic design and management, particularly from a road safety viewpoint.* [4]

1.2 The City of Ottawa Context

The walking mode of travel represents an important component of overall travel demand in the City of Ottawa. Estimates of walking trip activity prepared for the City as part of another project indicate that in 2001, pedestrians accounted for over 81 million person trips in the course of the year, or almost 12% of all travel demand in the City. The vast majority of these trips took place in the urbanized area of the City, with about 40% occurring in the peak periods and almost 58% happening in off-peak times.[5] This figure approaches the 15% daily mode share captured by public transit in the City. Given this

---

[1] Vulnerable road users (VRU) include pedestrians, cyclists, and in-line skaters. In addition, within the pedestrian group, special consideration is usually necessary in dealing with the needs of seniors, persons with disabilities (including manual and motorized wheelchair users), and children.
[2] Zegeer, CV. Seiderman, C. Lagerwey, P. Cynecki, M. Ronkin, M. Schneider, R. “Pedestrian Facilities Users Guide: Providing Safety and Mobility”. Federal Highway Administration. McLean. VA. 2001. p.12.
[3] Transportation Association of Canada. “Pedestrian Crossing Control Manual”. Ottawa. Canada. 1998. p. 1.
[4] Ogden, KW. “Safer Roads: A Guide to Road Safety Engineering”. Avebury Technical. Aldershot, England. 1996. p. 365.
[5] Projections based on City of Ottawa data and prepared for the 2003 Cost of Travel update project.

fact, it is not surprising that community interest in pedestrian safety issues is significant in the City.

1.3 Goals and Objectives

The overall goal of the work proposed in this document is to help improve the ability of the City to address pedestrian road safety issues, and in particular, to identify high-priority locations based on readily available, easily collected data and input from members of the community. The prioritization methodology contained herein helps to define a process that can be used for programming pedestrian safety investments explicitly and proactively in a consistent and defensible manner, without necessarily relying on reactive responses to pedestrian collisions or public complaints. The process is taken a step further by providing a tool to help city staff identify candidate countermeasures and obtain guidelines for the application of these countermeasures as part of a detailed engineering study carried out at locations identified through the prioritization and public consultation process.

More specifically, the objectives of this project include the need to:

- Improve the understanding of the relationship of pedestrian needs and safety issues in the context of signalized and non-signalized intersection operations;

- Develop an overall approach to programming road safety improvements oriented specifically to pedestrian needs at signalized and non-signalized intersections, and providing – as part of its structure – a vehicle for community-based, proactive input to the identification of intersections requiring detailed study;

- Help identify candidate countermeasures at intersections slotted for pedestrian safety improvements based on design and operational characteristics and provide heuristic guidance on the appropriate application of those countermeasures.

1.4 The pedestrian safety evaluation process

The pedestrian safety evaluation process has been designed as two separate work streams to be carried out by city staff and community committees, respectively. The work streams are generally carried out independently and concurrently, with pre-defined interfaces to maintain communications between the two parties and to ensure the needs of each are being satisfied.

Responsibilities of city staff include the following:

- Maintaining and expanding the database of intersections under consideration;

- Collecting, inputting, and updating the required data for each intersection as necessary;

- Programming pedestrian safety improvements based on budget allocations, the calculated Pedestrian Safety Index from the prioritization tool, collision history, public input, political pressure, and any other considerations that may be necessary;

- Identifying candidate countermeasures and conducting detailed engineering studies for the programmed intersections to determine the most appropriate and most effective improvements on a site-by-site basis;

- Design and implement the improvements.

Responsibilities of community committees include the following:

- Supplement the data collection efforts of the city;

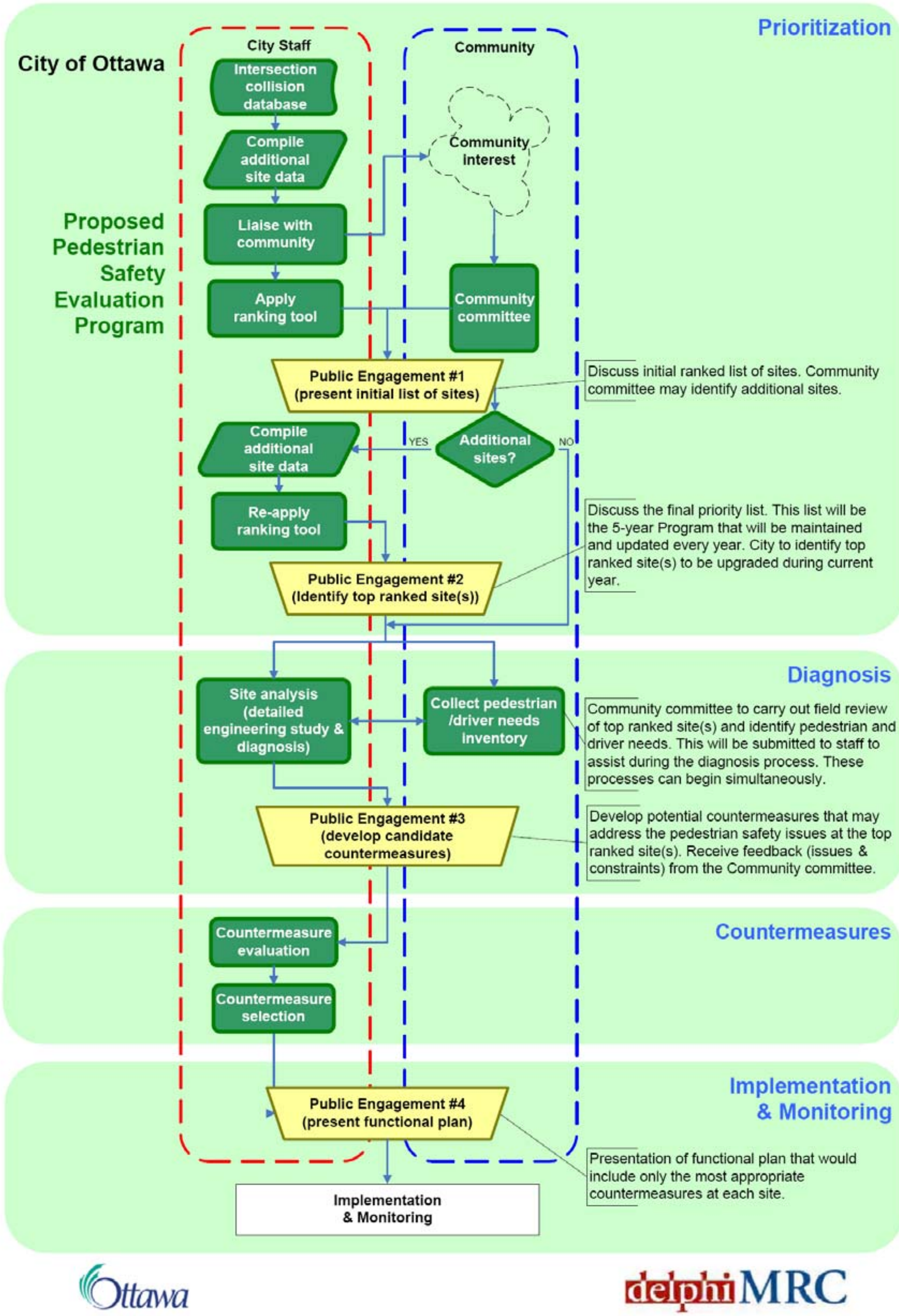
- Review the list of improvement priorities identified by city staff and provide input regarding sites that may have been overlooked;

- With detailed guidance in the form of a prompt list or formal document, conduct a review of pedestrian and driver needs for the intersections programmed for improvements within their community in upcoming years;

- Provide feedback to the city regarding proposed countermeasures and design improvements.

The complete human-centered pedestrian safety evaluation process is demonstrated graphically in Figure 1 on the following page.

Figure 1: Pedestrian safety evaluation process



2 PRIORITIZATION TOOL USER GUIDE

2.1 Background

The City of Ottawa pedestrian safety evaluation process utilizes a prioritization methodology developed by the U.S. Department of Transportation Federal Highway Administration (FHWA) that is known as the Pedestrian Intersection Safety Index (Ped ISI). This methodology calculates a safety index value for each crossing at an intersection, enabling users to identify intersections and intersection approach legs that are likely to be a safety concern for pedestrians and should therefore receive priority for undergoing pedestrian-oriented safety improvements. Using observable characteristics such as traffic control, land use, speeds, volumes, and cross-section design, the methodology produces a safety index score with higher scores indicating a greater priority and need for further investigation.

The tool has been designed to prioritize intersections based on the composite safety index of the intersection as a whole, however supplemental indices for individual crossings within each intersection leg provide an indication of how each crossing is expected to operate from a pedestrian safety perspective. In addition, the capacity to document a 5-year collision history of both fatal and injury pedestrian collisions at each intersection was added to the process. While this collision history does not directly impact the mathematical prioritization process – a process that is based on a regression analysis of a number of design and operational characteristics of the intersection and their impact on pedestrian safety performance – it provides users of the tool with a means to compare the historical pedestrian collision performance of each intersection with the calculated safety index and adjust priorities to account for extenuating circumstances not captured by the model, if one feels this is appropriate. Pedestrian collisions tend to be relatively rare occurrences leading to sporadic data with very small sample sizes which in turn limits the ability of a practitioner to draw collisions based on collisions alone, however the incorporation of this additional collision information (if available) will provide city staff with value-added data with which to make decisions.

The Ped ISI was developed using data from urban and suburban intersections with the following characteristics:

- 3-leg and 4-leg intersections;
- Signalized, 4-way stop, and 2-way stop controlled intersections;
- Traffic volumes ranging from 600 to 50,000 vehicles per day;
- One-way and two-way roadways;
- One to four through lanes per approach;
- Posted speed limits from 15 to 45 mph (24.1 and 72.4 km/h).

The Ped ISI is applied most appropriately at intersections that meet the above criteria. Safety index values that are produced for intersections with characteristics outside these ranges should only be used with the understanding that the models were not developed using intersections of that type.

2.2 Key steps

The City of Ottawa Ped ISI prioritization tool is quite straightforward and easy to use. An input data sheet is provided where the user enters the required data for each intersection, a series of internal calculations are performed, and an output sheet summarizes the results and allows the user to sort based on a variety of criteria. One needs only to determine what intersections will be evaluated in the process, gather and input the data, review and sort the resulting Ped ISI values, compare Ped ISI values with collision history (if desired), and set the final priorities for the pedestrian safety improvement program. More direction on the individual steps is provided below.

Select sites to evaluate – Due to time and resource constraints and the extensive number of signalized and unsignalized intersections within the jurisdiction of the City of Ottawa, it is obviously impractical to include all intersections in the Ped ISI prioritization process. A decision must be made by the City regarding which intersections to include initially upon launching the program, and what criteria would be used to expand the inclusion of intersections considered in future years. One recommendation would be to initially evaluate all intersections that have experienced fatal or injury pedestrian collisions in the latest 5 years for which data is available. Community input, public complaints, Council suggestions, and ongoing collision occurrences could then dictate which intersections are added to the list in subsequent years of the program.

Gather data – Users of the Ped ISI tool will need to gather data on geometric and operational characteristics of each intersection and crosswalk. This can be done either through historical databases, GIS or digital mapping, design drawings, or brief field visits. A list of specific data requirements is provided in Section 2.3.

Calculate Ped ISI index values – The City of Ottawa Ped ISI tool is spreadsheet-based and the administrator of the tool will ensure that the most up-to-date data available is entered into the “master” version of the tool for each intersection (subordinate or “rover” versions of the tool may be made to facilitate data entry for field crews and must not be confused with the master version). Upon input of the data, the Ped ISI is automatically calculated for each approach leg of each intersection and for each intersection as a whole based on the regression model. A safety index value of 1.0 represents a relatively low-risk intersection and an index value of 6.0 represents a high-risk intersection.

Prioritize sites – The City of Ottawa Ped ISI prioritization tool allows the user to sort by Ped ISI values and by a combination of community name and Ped ISI values. Sites with the highest Ped ISI value generally indicate the highest pedestrian safety risk and require further investigation. Users are cautioned, however, that a high Ped ISI does not necessarily indicate a high risk location and a low Ped ISI does not necessarily indicate a low risk location. No model can account for all factors and interaction of factors nor the full extent of extenuating circumstances that may exist at particular intersections and the use of local knowledge, collision history, and engineering judgement is encouraged to further refine the prioritization process. The City of Ottawa Ped ISI tool simply provides a way to prioritize locations that may warrant further investigation.

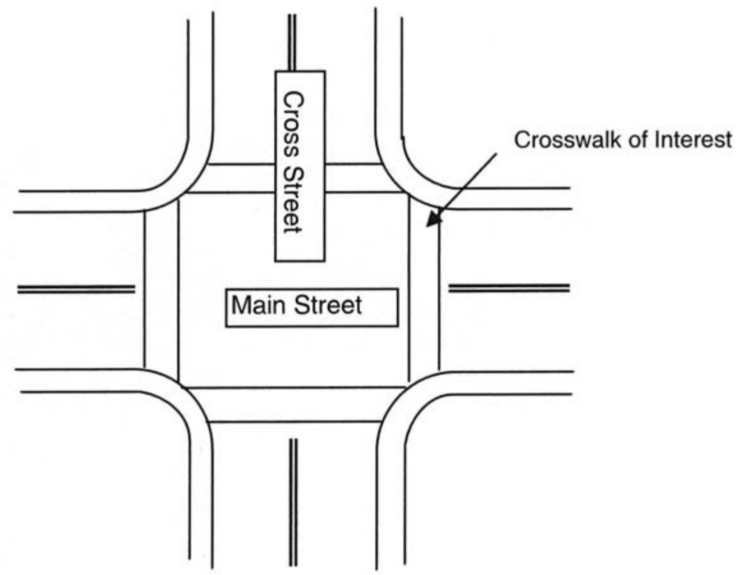
2.3 Data requirements and input variables

A list of data required for the Ped ISI tool is shown in Table 1 and an illustration of a typical intersection showing the crossing of interest is shown in Figure 2.

Table 1: Ped ISI prioritization tool input variable definitions

Data Input	Data Format	Notes
Signal controlled crossing	0 = no 1 = yes	This variable is 1 if movements of vehicles and pedestrians at the crossing of interest are controlled by a traffic signal.
Stop-controlled crossing	0 = no 1 = yes	This variable is 1 if vehicle traffic on the leg with the crossing of interest must stop for a stop sign.
Number of lanes	1, 2, 3, 4, etc.	This variable is the number of through lanes in both directions on the street being crossed at the crossing of interest, not including exclusive turn lanes. At the stem of 3-leg T-intersections which has no through lanes in one or both directions, turning lanes are included.
Speed	85^{th} percentile operating speed and posted speed limit (km/h)	This variable is the 85^{th} percentile operating speed of vehicles approaching the crossing of interest. If different operating speeds are recorded in opposing directions, an average value should be input for both directions / crossings of interest. In the absence of operating speed information, the posted speed limit or an estimate of the 85^{th} percentile speed is used.
Traffic Volume	Average daily traffic volume	This variable is the ADT on the street being crossed, in both directions of travel. Average 24-hour volumes for each turning movement from City of Ottawa count sheets should be used to derive an ADT for each approach leg individually, as ADT can vary substantially between two opposing intersection legs on the same street, especially if one is one-way and the other is two-way.
Land Use	0 = residential area 1 = commercial area	This variable is 1 if the predominant land use of the surrounding area is commercially developed. Commercial development is defined as retail shops, banks, restaurants, gas stations, and other service oriented businesses that tend to generate high pedestrian volumes.

Figure 2: Typical intersection and location for crossing of interest



2.4 Output and results

The City of Ottawa Ped ISI prioritization tool will produce a pedestrian intersection safety index for every crosswalk as well as an intersection as a whole. This will provide an indication of high-risk crossings and high-risk intersections that warrant further review based on the design and operational characteristics addressed in the model. Figures 3 and 4 provide an example of inputs specified by the user and the resulting list of countermeasures suggested by the tool.

This space intentionally left blank

Figure 3: Prioritization tool – sample input sheet

Community	Intersection		Map Location ID	X Coord	Y Coord	Intersection Control (City Database)	*Commercial Area?	Crosswalk	Street Crossed / Intersection Approach						Speed (km/h)		5-year Pedestrian Collision History				Pedestrian Safety Index	
	Street 1	Street 2							Name	*Stop Controlled?	*Signal Controlled?	# Through Lanes	ADT (vpd)	ADT Count Year	85th Percentile	Posted Speed	Period	Fatal	Injury	Collisions / Year	Crossing Ped ISI	Intersection Ped ISI
Somerset	Albert St	Bank St					1	E	Albert St	0	1	3	6,097	2009		50	From			0.00	2.35	2.17
								W	Albert St	0	1	3	6,360			50	1999				2.35	
								N	Bank St	0	1	2	2,831			50	To				1.99	
								S	Bank St	0	1	2	3,158			50	2004				1.99	
Gloucester-Southgate	Albiod Rd	Bridle Path Dr					0	N	Albion Rd	0	1	2	8,962	2009	68	50	From			0.00	1.99	2.03
								S	Albion Rd	0	1	2	10,186		68	50					2.00	
								W	Bridle Path Dr	0	1	3	5,992			50	To				2.11	
River	Baseline Rd	Prince of Wales Dr					0	W	Baseline Rd	0	1	6	28,599	2009	81	60	From			0.00	3.60	3.13
								E	Heron Rd	0	1	6	36,318		81	60					3.64	
								N	Prince of Wales Dr	0	1	4	22,181			60	To				2.65	
								S	Prince of Wales Dr	0	1	4	17,288			60					2.62	
Capital	Bronson Ave	University Rd					0	N	Bronson Ave	0	1	6	41,389	2009	85	70	From			0.00	3.72	2.86
								S	Bronson Ave	0	1	6	38,914		85	70					3.70	
								W	University Rd	0	1	2	8,246			70	To				2.01	
								E	Sunnyside Ave	0	1	2	4,805			70					1.99	
Gloucester-South Nepean	Crestway Dr	Cresthaven Dr					0	W	Crestway Dr	0	1	2	6,330	2009	56	40	From			0.00	1.84	1.74
								E	Crestway Dr	0	1	2	4,139		56	40					1.83	
								N	Cresthaven Dr	0	1	2	3,688			40	To				1.65	
								S	Cresthaven Dr	0	1	2	2,541			40					1.64	
Orleans	Jeanne D'Arc Blvd	OR 174 EB Ramps					1	N	Jeanne D'Arc Blvd	0	1	4	17,636	2009		60	From			0.00	2.86	2.50
								S	Jeanne D'Arc Blvd	0	1	4	22,533			60					2.89	
								W	OR 174 EB Off-Ramp	0	1	3	11,111			60	To				2.49	
								E	OR 174 EB On-Ramp	0	1	1	2,102			60					1.77	
Somerset	Kent St	Albert St					1	N	Kent St	0	1	4	10,663	2009		50	From			0.00	2.71	2.53
								S	Kent St	0	1	4	10,997			50					2.71	
								W	Albert St	0	1	3	8,328			50	To				2.36	
								E	Albert St	0	1	3	7,994			50					2.36	
Rideau-Vanier	King Edward Ave	Laurier Ave					1	N	King Edward Ave	0	1	2	11,580	2009		50	From			0.00	2.04	2.37
								S	King Edward Ave	0	1	2	12,317			50					2.05	
								W	Laurier Ave	0	1	4	9,608			50	To				2.70	
								E	Laurier Ave	0	1	4	7,751			50					2.69	
Rideau-Vanier	King Edward Ave	Rideau St					1	N	King Edward Ave	0	1	4	19,537	2009		50	From			0.00	2.76	2.73
								S	King Edward Ave	0	1	4	12,553			50					2.72	
								W	Rideau St	0	1	4	13,191			50	To				2.72	
								E	Rideau St	0	1	4	11,195			50					2.71	
Kitchissippi	Richmond Rd	Churchill Ave					1	W	Richmond Rd	0	1	2	12,457	2008	47	50	From			0.00	2.02	2.03
								E	Richmond Rd	0	1	2	10,077		47	50					2.00	
								N	Churchill Ave	0	1	2	13,298			50	To				2.06	
								S	Churchill Ave	0	1	2	8,514			50					2.03	
Bay	Richmond Rd	McEwan Ave					0	W	Richmond Rd	0	1	2	14,480	2009		50	From			0.00	1.82	1.80
								E	Richmond Rd	0	1	2	14,052			50					1.82	
								N	McEwen Ave	0	1	2	2,882			50	To				1.75	
																50						
Knoxdale-Merivale	Woodroffe Ave	Slack Rd					0	N	Woodroffe Ave	0	1	4	19,870	2009	91	80	From			0.00	2.99	2.92
								S	Woodroffe Ave	0	1	4	21,789		91	80					3.00	
								E	Slack Rd	0	1	4	7,079			80	To				2.79	

Figure 4: Prioritization tool – sample output sheet

Community	Intersection		Map Location ID	X Coord	Y Coord	ADT Count Year	Collisions / Year	Intersection PSI
	Street 1	Street 2						
Bay	Richmond Rd	McEwan Ave				2009		1.80
Capital	Bronson Ave	University Rd				2009		2.86
Gloucester-South Nepean	Crestway Dr	Cresthaven Dr				2009		1.74
Gloucester-Southgate	Albiod Rd	Bridle Path Dr				2009		2.03
Kitchissippi	Richmond Rd	Churchill Ave				2008		2.03
Knoxdale-Merivale	Woodroffe Ave	Slack Rd				2009		2.92
Orleans	Jeanne D'Arc Blvd	OR 174 EB Ramps				2009		2.50
Rideau-Vanier	King Edward Ave	Rideau St				2009		2.73
Rideau-Vanier	King Edward Ave	Laurier Ave				2009		2.37
River	Baseline Rd	Prince of Wales Dr				2009		3.13
Somerset	Kent St	Albert St				2009		2.53
Somerset	Albert St	Bank St				2009		2.17

While this methodology provides a consistent and defensible framework for prioritizing locations for pedestrian safety improvements, it is reiterated that the Ped ISI index values have limitations as they are based on a regression model that considers only factors that have been shown through research to have a statistically significant relationship to safety performance. This index should not constitute an indiscriminate and concrete prioritization of locations for improvement – rather it should be used in conjunction with detailed study, local knowledge, collision history, and engineering judgement to produce a finalized program of prioritized safety improvement locations.

2.5 Starting a new year

At the end of each year the priority list will require updating. The manager of the program must archive a copy of the "master" file from the previous year. Next, the following steps will have to be taken to update the "master" file at the start of the new year:

- Retain all the intersections from the previous year;
- Remove the sites that were subject to safety improvement in the previous year;
- Remove the sites that were subject to rehabilitation, etc.;
- Review the most recent collision statistics and add sites that experienced fatalities (if they are not already on the priority list);
- Update the priority list with new site data such as new traffic counts, lane configuration changes, new traffic signals, etc.;
- Execute the priority tool to get an initial list of ranked sites;
- Meet with the various community committees to discuss the preliminary ranked list and gather their comments and input.

3 THE COUNTERMEASURE SELECTION TOOL

3.1 Introduction

Once a practitioner has carried out a detailed engineering study, reviewed information submitted by the community group (based on the pedestrian and driver needs assessment), and diagnosed the issues, the countermeasure selection tool can be used to generate a list of candidate countermeasures. The City of Ottawa countermeasure selection tool concept is based on the countermeasures and application guidelines provided in FHWA's PEDSAFE Pedestrian Safety Guide and Countermeasure Selection System and other similar resources. PEDSAFE has a strong technical foundation, uses readily available data as input to the tool, and lends easily to a spreadsheet-based program. We have enhanced the tool by including additional countermeasures gleaned from an extensive literature search carried out on behalf of the City of Ottawa. In total, over 60 pedestrian-oriented safety countermeasures are considered by this tool. The complete database of countermeasures and their respective categories are shown in Table 4.

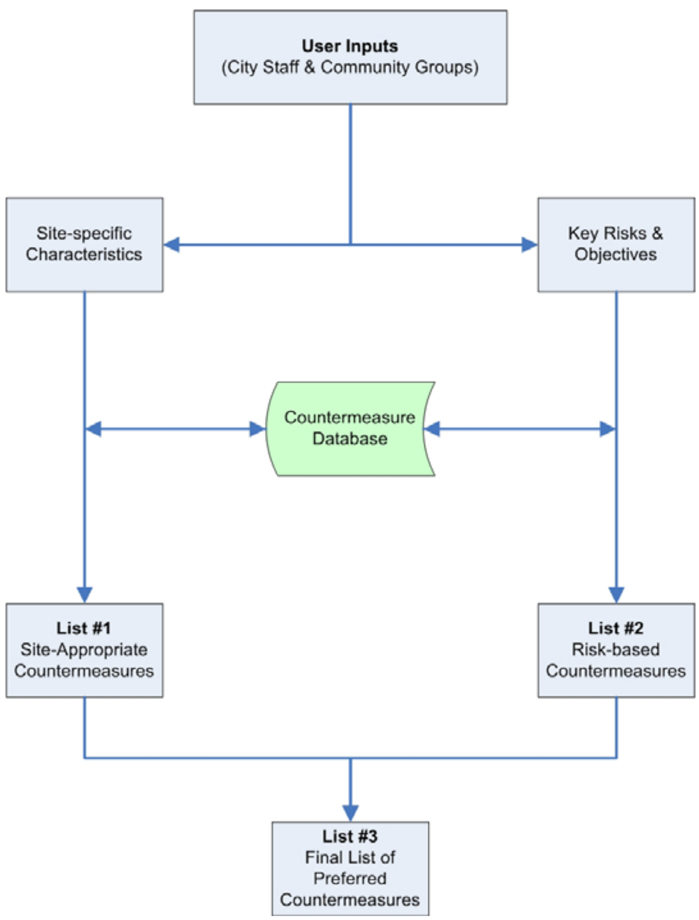
The FHWA's PEDSAFE considers two types of data inputs upon generating candidate countermeasures for a given site – crash type groups and performance objectives. Crash type groups represent the prevalent types of pedestrian-vehicle collisions and are analogous to vehicle collision configurations. Examples include multiple threat, turning vehicle, through vehicle, bus-related, etc. Performance objectives relate to diagnosed problems with design or operational characteristics at the intersection, which are expected to emerge from a detailed engineering study and through a pedestrian and vehicle needs assessment. Examples include excessive vehicle speed, poor right-of-way compliance, poor visibility and sightlines, etc. Due to the sparsity of pedestrian collision data and the general lack of details regarding events leading up to pedestrian collisions in collision databases, we have elected to focus on performance objectives in the City of Ottawa countermeasure selection system. A complete list of the potential performance objectives are outlined in Table 3.

Within the tool, we have supplemented the performance objective inputs used to help narrow down the list of appropriate countermeasures from the database of potential countermeasures with site-specific operational and design characteristic inputs specified by the user. These site-specific characteristics, which are outlined in detail in Table 2, help to eliminate countermeasures that are not appropriate given the configuration of the site. For example, many traffic calming measures may not be appropriate on high speed, high volume streets; signal-related countermeasures do not apply at unsignalized intersections, etc. The "performance objective criteria" and the design and operational "exclusion criteria" are based on a combination of the heuristic guidelines for each countermeasure in the literature, situations to which particular countermeasures are generally applied in practice, and expert judgement. Upon discussion with city officials and throughout ongoing application of the tool, it may be desirable to modify these criteria in keeping with city policies and best practices.

To use the tool, the practitioner fills in the requisite characteristics about the road, intersection, and crossing of interest on the input sheet. The user then defines the key performance objectives or risk factors that exist at the intersection – in other words, the undesirable design and operational factors that may exist at the site and towards which countermeasures should be targeted. A single performance objective or multiple objectives may be selected. The tool is then run and a series of countermeasures are suggested on a results summary sheet. The countermeasures are listed based on category groupings of countermeasures so that similar countermeasures are reported together. A separate list of countermeasures is generated for each performance objective specified. In some cases where multiple performance objectives are specified, the same countermeasure may appear more than once, suggesting that the countermeasure may be appropriate for helping to address several different risks present.

Once again it is stressed that these lists of countermeasures represent those that appear most appropriate to the site based on the characteristics and performance objectives specified after being filtered from the full list of pedestrian countermeasures in the database. Careful consideration of each countermeasure is still necessary to determine its appropriateness in context with the site and other countermeasures being considered. Also, the fact that a given countermeasure is not suggested does not necessarily mean that it can not be applied effectively to the site. In any case, compatible systems of countermeasures should be developed and implemented according to the detailed application guidelines that are provided in the documentation accompanying this tool. The lists of countermeasures provided by this tool are intended to provide a starting point for this process.

Figure 5: The countermeasure selection process



3.2 Key steps

Gather data – Users of the countermeasure selection tool will need to gather site characteristic information and identify key safety risks that need to be addressed. The majority of the input data for the tool will likely have been gathered as part of the detailed engineering study (DES) and the community group's pedestrian and driver needs assessment. A list of specific data requirements is provided in Section 5.3.3.

Calculate Candidate Countermeasures – Based on the data entered into the tool an initial list of candidate countermeasures is produced based on both the countermeasures' appropriateness for the site characteristics and the risks that need to be addressed.

Detailed Consideration of Countermeasures – Starting with the initial lists of countermeasures provided by the tool, a practitioner gives careful consideration to each, considers other countermeasures if necessary, and develops a final system of countermeasures that are compatible with the site and with each other that will be designed and implemented based on the application heuristics provided in the documentation and best practices of the industry.

3.3 Data requirements and input variables

The countermeasure selection tool requires user inputs from two perspectives: the site-specific characteristics (e.g. design features, vehicle and pedestrian volumes, operating speeds, etc.) and site-specific safety risks that need to be addressed (e.g. the need to reduce vehicle speeds, improve visibility, etc.). The user input variables and a brief explanation of each is provided in Tables 2 and 3, respectively.

Table 2: Countermeasure selection tool site-specific characteristic inputs

Data Input	Data Format	Notes
Type of traffic control	Signalized, Unsignalized	This variable indicates whether the intersection traffic control is with a traffic signal or with stop signs.
Pedestrian volume	High, Low	This variable indicates the pedestrian crossing volume at the intersection and crossing of interest. A high volume is categorized as more than 1,200 per day, and low is less than 1,200 per day.
Vehicle volume	High, Low	This variable indicates whether the vehicular volume on the main street at the crossing of interest is high or low.
Operating speed	High, Low	This variable indicates whether the 85th percentile operating speed of vehicles on the main street at the crossing of interest is high (70km/h or more) or low (less than 70km/h).
Number of lanes	<4, 4+	This variable indicates whether the number of through lanes on the main street at the crossing of interest is less than four, or four or more

		lanes, considering both directions of travel.
On-street parking	Yes, No	This variable identifies whether or not there is on-street parking upstream of the crossing of interest.
Illumination present	Yes, No	This variable identifies whether or not illumination is provided at the intersection and crossing of interest.
Land use	Commercial CBD, Residential, Other	This variable indicates the type of land use surrounding the intersection and crossing of interest.
Target population	All pedestrians, Elderly/children, Special needs	This variable identifies whether or not any vulnerable pedestrian groups are expected to be routinely using the intersection and crossing of interest.
School area	Yes, No	This variable indicates whether the intersection and crossing of interest are in the vicinity of a school.

The second set of user inputs are identified in Table 3. These inputs require the user to simply select the safety risks identified in the detailed engineering study. While any number of risks can be specified, identifying the two or three most important safety risks or performance objectives generally yields the most meaningful results.

Table 3: Countermeasure selection tool safety risk inputs (i.e. performance objectives)

Data Input	**Notes**
Reduce vehicle speeds	This variable is selected if the user needs to address risks associated with excessive operating speeds. Examples include reducing intersection curb radii or traffic calming treatments like raised intersections.
Improve sightlines and visibility	This variable is selected if the user needs to address risks associated with limited or blocked sightlines between drivers and pedestrians. Example treatments include curb extensions, removing on-street parking and street furniture, and installing median refuge islands.
Reduce vehicular volume	This variable is selected if the user needs to address risks associated with inappropriately high traffic volumes. Example treatments include reducing the number of through travel lanes (i.e. a road diet), or traffic calming treatments such as speed humps, chokers, or chicanes.
Reduce pedestrian exposure	This variable is selected if the user needs to address risks associated with pedestrian exposure at long crosswalks. Example treatments include signalization enhancements (i.e. a

	scramble or exclusive pedestrian phase), or a pedestrian refuge (i.e. channelization island or centre median).
Improve pedestrian access and mobility	This variable is selected if the user needs to address risks associated with pedestrian access and mobility in the vicinity of a crosswalk. Example treatments include enhancements to crossing signals and signs, proper design of sidewalks and refuge areas, or a crossing guard.
Vehicle and pedestrian right-of-way compliance	This variable is selected if the user needs to address risks associated with right-of-way compliance issues where drivers don't yield to pedestrians or pedestrians disregard crossing signals. Example treatments include improved crosswalk markings or improved enforcement activities.
Reduce high risk behaviour	This variable is selected if the user needs to address risks associated with unnecessary or inappropriate risk-taking by pedestrians or drivers. Example treatments include automatic pedestrian detection (as opposed to push buttons), or adding pedestrian signals and markings at unmarked crosswalks being used by pedestrians.

Once both sets of user inputs have been entered into the tool, the pedestrian-oriented safety countermeasures that are common to both the site-specific criteria and site-specific risk objectives are returned. Table 4 outlines the full database of countermeasures that may be returned based on the inputs specified, grouped by categories for reporting convenience.

Table 4: Categorized countermeasures considered in tool

Category		Countermeasure
Signals & signs	1	Install a traffic signal at an unsignalized intersection
	2	Install pedestrian signal heads
	3	Install countdown pedestrian signal heads
	4	Increase pedestrian signal symbol size (for crossing distances greater than 30m increase symbol height)
	5	Increase signal phase time (assume a reduced walking speed of 0.9m/s)
	6	Implement a scramble pedestrian phase
	7	Implement an exclusive pedestrian phase (pedestrian "walk" indication with no concurrent vehicle "green" phase)
	8	Implement a leading pedestrian interval (LPI) signal phase
	9	Implement two-stage / partial crossing
	10	Ensure pedestrian push buttons and related signage is located appropriately (if applicable)
	11	Install accessible pedestrian signals (APS) & push buttons
	12	Implement automatic pedestrian detection at signalized crossings
	13	Provide advance left turn phase for vehicles (with "don't walk" indication for pedestrians)
	14	Install supplementary signage (e.g. additional crossing info, watch for pedestrians, look both ways, etc.)
	15	Install supplementary signage at school crossings (e.g. advance warning, flashing beacons)
Pedestrian facility design	16	Install raised pedestrian crosswalk
	17	Install texturized / coloured crosswalk pavement
	18	Install enhanced crosswalk pavement markings (e.g. zebra, ladder, zig zag)
	19	Provide advance yield markings at crosswalks or increase the setback
	20	Add or enhance illumination at crosswalk area
	21	Install curb extensions / bulb outs
	22	Install median refuge island
	23	Prohibit pedestrian crossing (physical barrier)
	24	Ensure pedestrian sidewalk / refuge at ends of crosswalk is adequate
	25	Ensure sidewalk continuity to/from crosswalk location is adequate
	26	Install properly designed mountable curb-cut ramps
Intersection design	27	Install neighbourhood mini-circle roundabout
	28	Install a raised intersection
	29	Install a modern roundabout at intersection
	30	Provide illumination at intersection
	31	Reduce curb radii at intersection
	32	Install turn lane channelization and refuge ("pork chop") islands
	33	Improve right turn slip lane design
	34	Remove sightline obstructions (e.g. vegetation, utility poles, street furniture)
Roadway design	35	Remove curb parking adjacent to crosswalk
	36	Relocate transit stop to far-side of intersection
	37	Reduce lane widths
	38	Reduce number of lanes on roadway (e.g. road diets, redistribute right-of-way to suit needs of all road users)
	39	Install bicycle lanes (provides buffer, improves visibility, and may reduce speed due to narrower lanes)
	40	Introduce on-street parking ("side friction" may reduce vehicle speeds)
	41	Address access management concerns at/adjacent to crosswalk
	42	Convert one-way street to two-way flow (may reduce vehicle speeds)
	43	Convert two-way street to one-way flow (simplifies pedestrian workload)
Traffic calming / speed management	44	Install speed hump/table on approach to crosswalk
	45	Install chicanes on approach to crosswalk
	46	Install chokers on approach to crosswalk
	47	Install serpentine street on approach to crosswalk
	48	Implement woonerf (street for living)
	49	Install neighbourhood gateway/identity treatment
	50	Implement landscaping/streetscape improvements
	51	Implement special street paving treatments to reduce speed
Traffic management	52	Install traffic diverters
	53	Prohibit right-turn-on-red
	54	Prohibit vehicle turning movements
	55	Implement a partial street closure at an intersection leg (i.e. make one-way at intersection)
	56	Implement a full closure at an intersection leg (i.e. convert 4-leg intersection to 3-leg, consider pedestrian street)
Maintenance / awareness / education / enforcement	57	Install red light cameras
	58	Install speed monitoring feedback signs
	59	Increase enforcement
	60	Implement a crossing guard
	61	Relocate parent pick-up/drop-off areas away from school crosswalks
	62	Maintain crosswalk pavement markings
	63	Sidewalk and crosswalk maintenance

3.4 Output and results

Figures 4 and 5 provide an example of inputs specified by the user and the resulting list of countermeasures suggested by the tool.

Figure 6: Countermeasure selection tool - sample input sheet

Site-specific road / intersection / crossing characteristics

Traffic Control	Unsignalized
Pedestrian Volume	Low
Vehicular Volume	High
Operating Speed	Low
Number of Lanes to Cross	< 4
On-Street Parking Present	No
Illumination Present	Yes
Land Use	Residential
Target Population Group	Elderley/children
School In Area?	No

Risk factors / performance objectives identified through field audit process

Risk factor 1	Reduce vehicle speeds
Risk factor 2	Improve sightlines and visibility
Risk factor 3	Reduce vehicular volume
Risk factor 4	
Risk factor 5	
Risk factor 6	
Risk factor 7	

Run Results

Figure 7: Countermeasure selection tool – tabulated results summary sheet

		Reduce Vehicle Speeds	Improve Sightlines and Visibility	Reduce Vehicular Volume	Reduce Pedestrian Exposure	Improve Pedestrian Access & Mobility	Vehicle & Pedestrian Right-Of-Way Compliance	Reduce High Risk Behaviour
Signals & signs	Install a traffic signal at an unsignalized intersection							
	Install pedestrian signal heads							
	Install countdown pedestrian signal heads				√			
	edestrian signal symbol size (for crossing distances greater than 30m increase symbol height from 150mm/6in to 225mm/9in)							
	Increase signal phase time (assume a reduced walking speed of 0.9m/s)							
	Implement a scramble pedestrian phase							
	Implement an exclusive pedestrian phase (pedestrian "walk" indication with no concurrent vehicle "green" phase)							
	Implement a leading pedestrian interval (LPI) signal phase		√		√			
	Implement two-stage / partial crossing				√			
	Ensure pedestrian push buttons and related signage is located appropriately (if applicable)							
	Install accessible pedestrian signals (APS) & push buttons							
	Implement automatic pedestrian detection at signalized crossings							
	Provide advance left turn phase for vehicles (with "don't walk" indication for pedestrians)							
	Install supplementary signage (e.g. additional crossing info, watch for pedestrians, look both ways, etc.)		√					
	Install supplementary signage at school crossings (e.g. advance warning, flashing beacons)							

Managing the electronic files that are produced over the course of a year for each community will require a strict protocol to prevent the loss of data. The tool is intended to be executed for each site and there may be more than one version for a given site. Therefore the file naming convention will be important and we suggest – as a starting point – that the two street names be included in the file name as well as a community name/code and year. All of the files should be archived electronically and it is suggested that hard copies of the input/output sheets for each site also be filed in a common location.

Ottawa

delphiMRC