WALKING SECURITY INDEX

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Walking Security Index

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A. EXECUTIVE SUMMARY

The Final Report of the Walking Security Index Project consists of seven sections.

- **Section A** provides an overview of the Final Report, and highlights the topics that are of central importance to better serving and promoting pedestrians' security - - safety, comfort, convenience - - at signalized intersections in Ottawa-Carleton.
- **Section B** provides a context for subsequent sections by reviewing the study origins and purpose, describing the study scope and methodology, and outlining the organization of the Final Report.
- **Section C** discusses the process and criteria used to derive the variables to recommend for inclusion in audit forms and/or indexes used to assist in defining, measuring, and evaluating pedestrians' security expectations and experiences at signalized intersections. A total of 19 essential variables and 19 high priority variables are identified for inclusion in the final specification of WSI variables for audit form, index, and intersection modification assessment purposes.
- **Section D** presents a total of ten indexes which are designed to assist in describing, measuring and evaluating the feature and performance characteristics of signalized intersections from the pedestrians' security perspective. Numeric examples are included to demonstrate the ease of index implementation, and the possibilities for extension of the indexes.
- **Section E** contains a total of 17 intersection recommendations. The recommendations are derived by combining findings from the literature, and from comments made by the three groups of experts - - elected officials, professional staff, ordinary citizens - - who participated in the Project. The recommendations represent the changes and initiatives required in order for signalized intersections in Ottawa-Carleton to meet the basic security needs of pedestrians.
- **Section F** concludes the main text of the Final Report in a two-stage summary. First, the findings on variables, indexes and intersection modifications are connected to the WSI Project's terms of reference. And, second, several "next steps" involving continued WSI-related research, and the implementation of study findings and recommendations in day-to-day operations are briefly discussed.
- **Section G** contains the references cited in the Final Report.

The remainder of the Final Report consists of the Appendices, which contain the details upon which the sections in the main text are based, and the Acknowledgments.

B. STUDY BACKGROUND AND OBJECTIVES

1. Study Origin and Purposes

The origin and purpose of this study are presented in the proposal which describes the Walking Security Index (WSI) Project (Wellar, 1996a, 1996b). For ease of access to the pertinent parts of the proposal, Table 1 presents the terms upon which approval of the Project by the Regional Municipality of Ottawa-Carleton was based.

In the preceding phase of the research, emphasis was on specifying the variables to operationalize the concepts – safety, comfort, convenience – which are principal components of the Walking Security Index (WSI). The purpose of that part of the project is discussed in Interim Report 5 (Wellar, 1997e) and is summarized as follows:

> To identify and classify the variables which elaborate safety, comfort, and convenience, and are candidates for inclusion in the set of variables selected to operationalize the Index (Wellar, 1997e, 2).

The Final Report constitutes the final phase of the WSI Project.* As such, it is a culmination of all research activities undertaken to date, including those represented in the Interim Reports and other publications produced as part of Project documentation. Details in those respects are contained in Appendix A.

As can be seen in Appendix A, the abstracts, executive summaries and conclusions of the background reports are published in their entirety. These materials put the Final Report in its research design context, and provide a foundation for its direction and content.

In regard to the objectives of the Final Report, they can be expressed as three related tasks that reflect the convergence of research activities undertaken over the course of the WSI Project.

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*In the interests of space, Final Report is used in the text for ***Walking Security Index***, which is the title of the final report on the Walking Security Index Project.

1. Selecting the variables which are deemed most appropriate for defining and measuring the expectations and experiences that pedestrians associate with safety, comfort, convenience while traversing signalized intersections in Ottawa-Carleton;
2. Naming the features, conditions, restrictions, etc. to associate with the selected variables in order to achieve pedestrians' expectations about safety, comfort, convenience while traversing signalized intersections in Ottawa-Carleton;
3. Organizing and relating the variables in audit tables, algebraic equations, and other formulations to create an index (or indexes) to serve the objectives outlined in the terms of reference for the Project (Table 1):
    a) The index (or indexes) contributes to describing, explaining and/or predicting the state or level of safety, comfort, convenience expected and experienced by pedestrians traversing signalized intersections in Ottawa-Carleton;
    b) The index (or indexes) provides guidance for elected officials, professional staff and citizens regarding the intersection, driver and pedestrian feature and performance variables which, upon modification, are most likely to contribute to achieving the state or level of safety, comfort, convenience that pedestrians expect to experience while traversing signalized intersections in Ottawa-Carleton.*
    c) The index (or indexes) and associated forms developed to assess intersection performance provide a benchmark or means against which to measure and evaluate proposals that involve modifying intersection feature or performance characteristics, drivers' attitudes and behaviors, and pedestrians' attitudes and behaviors.

Finally, in overviewing the origin and purpose of the WSI Project, it is necessary to recall and emphasize that there are two "realities" which are pertinent to the study process, to the study sponsor (RMOC), and to all the users of signalized intersections:

- Existing reality (experiences)
- Preferred reality (expectations)

The significance of the two realities to the study may be summarized as follows:

1. The **origin** of the WSI Project is due to **differences** between the existing reality of experience and the preferred reality of expectation regarding pedestrians' security (safety, comfort, convenience).

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* In order to avoid undue repetition, the reader is asked to bear in mind that throughout this document our interest is in pedestrians' expectations and experiences involving **signalized intersections**.

Table 1. Terms of Reference for the Walking Security Index (WSI) Project

1. The Walking Security Index (WSI) Project shall contribute a pedestrian's perspective on the level of security (safety, comfort, convenience) engendered by intersections and intersection design (new, modified) under different road network and traffic situations in Ottawa-Carleton.

2. The Walking Security Index (WSI) Project shall be designed to:

a) Improve understanding of pedestrian navigation, flow, and storage patterns and behaviours at regional intersections. Three related research initiatives are central to realizing the goal of improved understanding, and they are summarized as follows: i) to better and more completely identify the variables involved in pedestrian decisions and activities; ii) to better specify the relationships among the variables which describe pedestrian decisions and activities; and iii) to better describe and explain the relations between pedestrians and vehicle operators. An important part of this work is to investigate whether the WSI is an appropriate instrument for representing pedestrian interests, using level of service (LOS) for vehicle operators as the basis of comparison.

b) Obtain pedestrians' views on the factors that directly and indirectly affect their sense of security (safety, comfort, convenience, other) at intersections.

c) Identify hazards and constraints affecting safe, comfortable and convenient pedestrian movement at intersections.

d) Identify generic and site-specific intersection modifications that serve and promote pedestrian security (safety, comfort, convenience, other).

3. The Walking Security Index (WSI) Project shall be designed with all due regard for the sampling, observational, statistical and operational conditions of methodologically sound research, and all due regard for the real-world, action-oriented obligations of the Transportation Department, RMOC. In designing the Project, regard shall be given to :

a) Prior index-type studies on walking security reported in the learned and popular literature, and especially documentation involving related research-action activities, situations or events in Ottawa-Carleton.

b) Relevant sections or portions of the Regional Official Plan, Regional Transportation Master Plan, and/or related reports thereof.

c) Other pertinent documentation on index construction involving regard for and representation of values and attitudes, with emphasis on "the pedestrian perspective".

d) Impending initiatives within RMOC and/or other agencies (eg, Ministry of Transportation Ontario (MTO), Transportation Association of Canada (TAC)) that could affect when, where and how pedestrians' views on walking security could or should be incorporated in intersection design (new, modified).

Source: Wellar (1996b, p.37)

2. The **purpose** of the WSI Project is to generate findings and recommendation which may assist in **overcoming the differences** between pedestrians' existing reality (experience) and their preferred reality (expectation) on matters of security (safety, comfort, convenience) at signalized intersections.

The Project's background materials (illustrated in Appendix A) reveal that there are numerous findings and recommendations which could be presented for consideration. However, it is the intent of the Final Report to provide a basis for action wherever the supporting evidence is sufficient, and to set aside for the time being those initiatives or options that appear to require additional research and reflection.

Consequently, a concerted effort was made to derive suggestions for modifications which satisfy the following general criteria.

1. **Pertinence.** That is, the proposed modifications directly contribute to closing the gap between experience and expectation.

2. **Support.** That is, the proposed modifications are favored by the parties (elected, professional, citizen) responsible for taking the steps necessary to make the proposed modifications operational.

3. **Low degree of difficulty.** That is, the recommendations involving variables, indexes or modifications do not appear to pose unreasonable difficulties in terms of legal, institutional, technological, technical, financial or other concerns that affect policy, planning and program decisions in Ottawa-Carleton.[1]

In anticipation that the criteria used to select variables and construct index formulations might themselves be subject of debate, a brief elaboration of this fundamental topic is included in the Final Report. The interested reader is referred to Appendix B for a detailed discussion of variable evaluation (and selection) criteria.

2. Study Scope and Methodology

In principle, the scope of the final phase of the project is as broad as the terms of reference suggest (Table 1). In practice, however, the scope of this phase has been defined and bounded in two significant respects.

First, the scope is limited to the research undertaken and the documentation produced in previous phases. And, second, it is impractical to revisit in detail all the research activities and documents associated with the previous phase. Hence, those research activities and documents, which were all duly approved by the contracting agency (Regional Municipality of Ottawa-Carleton) are taken as givens, and are used as building blocks to be incorporated into the Final Report.

There is an exception to the rule in this regard, however, which involves the responses of the groups of experts (elected officials, professional staff, ordinary citizens) to the lists of variables that were assembled and circulated for comment.*

As noted in Interim Report 5, circumstances arose which caused us to conclude Interim Report 5 before we had an opportunity to review the groups of experts' comments about:

1. Variables to **add** to the respective lists;
2. Variables to **delete** from the respective lists;
3. Variables to **revise** to make the meaning clearer;
4. Variables to regard as **high priority** for inclusion in the Index.

Since these comments are central to the findings and conclusions presented in the Final Report, it is necessary that they be documented. And, because of their importance, it would have been preferred if the comments and discussion of the comments could have been the focus of a separate, "stand alone" interim report.

However, schedule and resource constraints required that we proceed directly to preparation of the Final Report. Consequently, the experts' comments and discussion of the comments are presented in Appendix D and Appendix E.

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*The contribution of elected, professional and lay (citizen) experts to the WSI Project are discussed in detail in Interim Report 5 (Wellar, 1997e).

Insofar as the scope of the Final Report is concerned, then, it is bounded by the several tasks remaining to complete the WSI Project:

1. Selecting the variables which best elaborate the concepts of pedestrian security (safety, comfort, convenience);

2. Describing the variables' associated features, conditions, characteristics, - - such as type and location of signs, number and types of signal operations, size and complexity of intersections - -, which are most likely to contribute to enhanced safety, comfort, convenience for pedestrians while crossing signalized intersections;

3. Specifying an index or indexes - - in tabular, algebraic, or other formulations - - that can be used: a) to describe and measure intersection features and performance; and, b) to evaluate the need for, or consequences of, infrastructure and behavioral (driver, pedestrian) modifications.

In regard to methodology, the Final Report is largely an exercise in synthesizing the findings from prior WSI Project research initiatives and associated reports. We hasten to add here that while the first-order findings derived from fieldwork tend to underpin the research process, due regard is given to second-order findings such as those which are derived from literature reviews, and from the opinions of elected, professional and lay experts.

The exception to the general rule of conducting a synthesis for the Final Report is found in Appendix D and Appendix E which deal with comments on the lists of variables presented as candidates for inclusion in the Index. As noted, those discussions are of an analysis nature since they involve critiquing the variables and associated comments on a variable-by-variable basis.

And, as concluding observations on methodology, two related research design factors warrant emphasizing. First, the research objectives are **client-driven**, which places a high premium on operationally useful results.[2] Therefore, the approach adopted for the Final Report falls within the realm of cataloguing, and matters of hypothesizing and theorizing are largely set aside for consideration in more appropriate venues.[3]

Second, the research design of the project takes full, explicit account of the real-world situation of Ottawa-Carleton in which the study has been undertaken, and readers are advised accordingly. That is, the purpose of the study is to suggest ways and means of moving from what is to what should be, while also having regard for real-world constraints, limitations, etc. of the locality in which the findings and recommendations are to apply.

As a result, although several changes are proposed which involve doing new things in new ways, a conscious effort is made in the Final Report to focus on initiatives that involve incremental rather than radical adjustments. However, and this point cannot be over-emphasized, **if** it appears that a seemingly radical change involving infrastructure design, or driver or pedestrian behavior is needed to radically change the status of pedestrian security for the better in Ottawa-Carleton, then such a change is pursued.

3. Organization of the Final Report

The Final Report consists of two equally important and inter-dependent parts, the main text and the appendixes. Their respective contributions are outlined as follows.

Upon completion of Section B which provides a context for the findings and recommendations that follow, the Final Report addresses its first of two major tasks. That is, to present the variables selected for inclusion in the Walking Security Index (or Indexes), and/or in the associated "audit forms" which may be used to conduct assessments of particular intersections.[4]

The discussion of variables (Section C) is a synthesis of findings from the review of various literatures, of conclusions from fieldwork observations and analysis, and of observations and recommendations by the experts (elected, professional, citizen) who provided feedback on the lists of candidate variables circulated for comment. The outcome of the synthesis is a derived set of variables that are deemed "best fit" for ascertaining whether expectations about pedestrians' security (safety, comfort,

convenience) at signalized intersections in Ottawa-Carleton are met.*

Then, after naming the derived variables, a rationale is presented to explain: a) why a variable is included; and, b) how it affects the connection between the existing reality (experience) and the preferred reality (expectation) of pedestrian security. The intent of this segment is to provide a substantive foundation for future debates about:

1) The relative merits of variables which are on the lists contained in Section C of the Final Report; and,
2) The pertinence and completeness of the descriptions and rationale used to justify the presence of a variable on a list in Section C.

In Section D, attention is focused on the formulation of an index that can be used to define, measure, and assess pedestrians' security in conceptual and operational terms, and which is applicable generically (all intersections) or specifically (some intersections). Issues and choices related to the design and application of indexes were discussed in the background reports, so the approach taken in Section D is to present the formulations which are deemed to best satisfy the criteria noted above in Section B.1 and elaborated in Appendix B.

As the reader will observe upon reading Section D, several *caveats* are associated with the index formulations. And, there is good reason for caution. That is, the very complicated reality of a large, complex intersection, traversed by hundreds of vehicles and pedestrians per hour, can be obscured or discounted by use of simplified representations such as indexes.[5]

On the one hand, then, Section D illustrates our regard for the crude but seemingly popular KISS principle - - keep it simple, stupid - - by seeking to minimize the number or complexity of variables contained in the formulations. On the other hand, however,

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*Best fit" refers to the criteria of **pertinence, support,** and **degree of difficulty** used to select the variables (Recall Section B.1, and see Appendix B for details).

Section D illustrates our higher regard for the fact that these formulations deal with keeping pedestrians free from care or cure, which is the essence of security (Wellar, 1997b).

The "bottom-line", then, is that in this project we do not sacrifice pedestrians' security - - safety, comfort, convenience - - in order to produce simple but potentially counter-productive means of defining, measuring and assessing their expectations and experiences at signalized intersections. And, we hasten to add, it appears that the experts - - elected, professional, citizen - - who participated in the study would agree with that decision.

Then, in Section E, the main text presents a selection of proposed intersection modifications. In terms of process, they are derived by combining the "messages" from the literature reviews, fieldwork projects, feedback on prior WSI Project reports, and the suggestions received from elected officials, professional staff, and area residents. And, the criteria of **pertinence, support** and **degree of difficulty** are again applied in making decisions about which intersection modifications to recommend.

It is important to emphasize here the high degree of interdependency among variables, indexes and modifications. As a result, and in the event that modifications do occur, then it follows that new or different variables and indexes will likely be required to describe, measure and evaluate the impacts of the initial and subsequent modifications. That is, by way of brief elaboration, the variables and indexes presented in *Walking Security Index* are pertinent to the **current** intersection situation in Ottawa-Carleton. The future situation could be quite different, however, if recommended modifications are adopted in whole or in part. Hence, and due to the interdependency noted above, the modifications could create a need for new or different variables or indexes to account for the effects.

The main text is concluded by a Summary (Section F). We begin by recalling the connections between the terms of reference and the findings and recommendations involving the variables, indexes and proposed intersection modifications. Then, the

reminder is given that while the WSI Project involves client-driven, applied research, responsibility for acting on the findings and recommendations is broadly distributed. That is, action in response to the research is within the purview of the Regional Municipality of Ottawa-Carleton, **and** the parties interested in pedestrians' security - - elected officials, professional staff, ordinary citizens.

In the remainder of the Final Report a number of appendixes are presented. The intent is to provide as much background material as is deemed necessary to produce a reasonably self-contained Final Report. And, further, we want to provide all readers a full indication of the research activities and documentation behind the findings and recommendations.[6]

The appendices are presented in Section H. Their contributions to the Final Report are summarized as follows.

- Appendix A contains the abstracts, executive summaries, and conclusions from WSI Project publications, and provides an overview of the initiatives, participants, activities, etc. which lead to the findings and recommendations contained in the Final Report.

- Appendix B discusses the decision criteria used to evaluate variables for inclusion in audit forms, indexes, and/or intersection modification proposals.

- Appendix C contains the initial specification of variables identified as candidates to define pedestrians' security (safety, comfort, convenience).

- Appendix D is a detailed account of the response of elected officials, professional staff, and ordinary citizens to the initial specification of variables. Although this research is at a preliminary stage, it is an important first step towards what might be termed "enlightened consensus": all the interested parties achieve a shared understanding of the relative importance of different variables to pedestrians' security expectations and experiences.

- Appendix E presents the results of applying a decision rule to the initial specification of variables in order to derive a "culled" set of variables. This was a necessary stop in order to methodologically move from 212 candidate variables and sub-variables to a more refined, operational set of basic variables.

- Finally, in Appendix F, the many contributors to ***Walking Security Index*** - - the Final Report on the Walking Security Index Project - - are acknowledged.

4. Notes

1. The "low degree of difficulty" criterion is used **strictly in a relative sense**, since virtually any non-trivial, transportation-related modification undertaken in Ottawa-Carleton at present involves some difficulties. That is, there tend to be costs, trade-offs, frictions, uneven benefits, etc. associated with modifications to policies, plans or programs, as well as to real-world modifications involving roadways and intersections, the transitway, rail lines, etc. Hence, it is emphasized that this criterion involves judgements about **relative** degree of difficulty, and the choices made favor modifications that are less rather than more difficult to implement.

2. As a rule, all methodologically designed research seeks to add to knowledge, or to add to ways and means of continuing to add to knowledge (Ackoff, 1953). There is an important distinction between **client-driven** and **curiosity-driven** research, however, which may be summarized as follows. Client-driven research is based on questions, issues, approaches, etc. which are set by the person, agency, etc. that pays for or otherwise sponsors the research program or project. In the case of curiosity-driven research, however, the questions, problems, issues, etc. behind the inquiry are set by the researcher(s). This important topic was further discussed by the Principal Investigator (and several students) at the 1998 meetings of the Canadian Association of Geographers in June, and will be examined in detail at the Applied Geography Conference in October. Readers interested in receiving abstracts and details of the presentations are invited to contact the Principal Investigator.

3. The distinctions and connections among cataloguing, hypothesizing, and theorizing were discussed at a preliminary level in several preceding WSI Project publications (Wellar, 1995, 1996a, 1997a, 1997c, 1997d). As a result, we do not repeat that discussion here. It is appropriate to observe, however, that as research on pedestrian security continues there will likely be both increasing need and opportunity to move beyond exploratory research into the domain of confirmatory research. Should that occur, then the hypothesizing and theorizing elements will assume increased importance, which in turn means a requirement to refer to the substantial body of learned literature on the logical structures of scientific inquiry.

4. For further discussions and examples of "audit forms" see, for example, Mitchell (1996), Ste. Marie and Cockerton (1996), and Wellar (1996b, 1997c and 1997e).

5. In several Interim Reports (Wellar, 1996a, 1996b, 1997c) we discuss various advantages and disadvantages, strengths and weaknesses, etc. associated with index use. For further, indicative readings on this topic see, for example, Allan (1975), Bailey (1987), James and James (1968), New York Times (1997), Sheldon and Moore (1968), and Smith and Wellar (1992).

6. The primary "reader" for whom this document is intended is, of course, the Regional Municipality of Ottawa-Carleton and the Mobility Services Division, Environment and Transportation Department, in particular. However, experience to date makes it clear that elected officials, professionals, and ordinary citizens from Ottawa-Carleton and elsewhere will also be reading the Final Report. A concern in this regard is that some readers may not refer to the original, background documents, and might thereby misconstrue the contents of either or both of the background reports or the ***Walking Security Index***. Since it appears fair to say that the WSI Project has increased both the scope and depth of knowledge about various aspects of pedestrians' security, it is appropriate that the caution be over-emphasized. That is, it is highly recommended that anyone seriously interested in the methodology, findings and recommendations of the WSI Project review **all** the pertinent documentation.

C. SPECIFICATION OF WALKING SECURITY VARIABLES

1. Objectives of the Variable Specification Process

The variable specification process has been designed to serve three related objectives.

First, to identify and classify all the **candidate variables** that **could** be used to **conceptually define** pedestrian safety, comfort, convenience.

Second, to identify and classify all the **selected variables** that **should** be used to **operationally define** pedestrian safety, comfort and convenience, which collectively comprise pedestrian security.*

Third, to name the **essential variables** that **must** be included in **evaluations** and **decisions** regarding intersection features, performance characteristics, and modification proposals that affect pedestrians' security.

The first part of the variable specification task is captured in the project publications leading up to the Final Report. They are indicatively summarized in Appendix A, which contains the executive summary and conclusion section of each Project publication.

As for the objectives of the activities undertaken during that research, they had a common theme: to elicit from the literature (learned, popular, legal, regulatory, professional, interest group), from groups of experts (elected, professional, lay), and from fieldwork projects, any ideas, notions, thoughts, suppositions, opinions or concepts on how to define and measure pedestrians' experiences and expectations in regard to safety, comfort, convenience and, collectively, security.

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* The various literatures also contain various spellings for a number of variables that are of interest to this project. In the event of differences, and where possible, the *Highway Traffic Act* (Province of Ontario, 1997) is used as the final authority in the Final Report.

The product of the background work on variables that could be considered as candidates for WSI purposes is represented by Tables 3, 4, 5, 6, and 7 in Interim Report 5 (Wellar, 1997e). Those tables contain a total of 212 candidate variables and sub-variables, which are allocated as follows among the categories developed to organize the specification of variables:

1. Infrastructure Features (54)
2. Vehicular Traffic Features (54)
3. Pedestrian Traffic Features (30)
4. Infrastructure Performance Measures (25)
5. User (Behavior) Performance Measures for Vehicles, Drivers, Pedestrians (49).

In regard to the first objective of the variables specification process, it is met by the lists of candidate variables.

The second objective of the variables specification process - - to select the variables that should be used for operational purposes, viz., audit forms and indexes - - is met by Tables 2 and 3 which follow Part 3 in this section. And, the third objective of naming the essential variables for inclusion in intersection evaluations and decisions is also represented in those tables.

Due to the fact that the derivation of the selected and named variables is a major methodological consideration, the process of deriving the WSI variables is made explicit in Part 2.

2. Derivation of Selected Walking Security Variables

a. Background Research - - Initial Specification of Variables

Derivation of the set of walking security variables to prescribe for inclusion in audit forms and/or indexes formally began with the first investigations into the literature, consultations with experts, and experiences during fieldwork. In particular, there was an abiding interest from the outset in any candidate variables that satisfied such criteria as:

1. They receive frequent mention;
2. They are mentioned by multiple sources;
3. They are used in both questions and answers;
4. They are treated as both problem and solutions;
5. They are mentioned/discussed with a sense of passion or urgency, involving any or all of the following emotions: fear, anger, resentment, frustration, loathing;
6. They are associated with situations, circumstances, perceptions, etc., in which there appear to be victims, and the victims are seemingly without any recourse to righting wrongs;
7. They are mentioned/discussed with a sense of satisfaction, pleasure, enjoyment, and rising expectations about bettering or enhancing a situation;
8. They are supported by methodologically-based, empirical research.

As the reader may be aware, those kinds of criteria are commonly employed in applied research conducted by or for public agencies, or on issues of public interest. Their purposes or contributions may be illustrated by the following brief comments.[1]

An obvious reason for the appeal of criteria 1 and 2 is that they can be used to "play-the-numbers-game" to ascertain what is popular (or unpopular) with the voters or groups of voters. A more important reason for their value to this study, which began with many unknowns, is that they are expansive and open-ended in scope. And, criteria 3 and 4 provide an appropriate, open-minded, open-ended perspective for an inquiry such as the Walking Security Index Project which explores new subject matter.

The most important contributors to this study, however, are criteria 5, 6, 7, and 8. Those criteria induced and sustained a motivation to carefully and creatively deal with written materials, participants, and fieldwork data for the duration of the project. The reasons behind the need to be careful and creative are documented in the background publications, including several articles in the *Proceedings* of the pedestrians' safety conference.[2]

At the risk of over-simplification, it appears that the perplexing situation represented by criteria 5, 6, 7 and 8, and the numerous references, may be outlined in a compare and

contrast format:

> On the one hand, the pedestrian mode of travel is the oldest mode of travel, the most widely used mode of travel, the most frequently used mode of travel, and is the only mode that can be practiced and is encouraged to be practiced by people of all ages throughout their lifetimes. Perversely, however, pedestrians as a group are the trip-makers who are most susceptible, most vulnerable, and most likely to be in need of care or cure while travelling. And especially while traversing signalized intersections.
>
> On the other hand, and despite what is known or should be known about the substantial differences between pedestrians' experiences and expectations, it appears that a number of significant issues, questions, and alternatives are being investigated as original research in this study during a 1994-1998 timeframe. Further, were it not for the determination and support of several elected officials and members of the Transportation Environment Action Plan - Community Advisory Group, even this modestly-funded study likely would not have taken place.[3]

The overriding salient point, therefore, is that the criteria provided an ever-present reminder of what is at stake and who is at risk, and the need to be as methodologically rigorous as conditions and skills permit. As a result, throughout the process of the initial specifications (Interim Report 5, Wellar, 1997e), attention was paid to **all** the variables that **could** be candidates (criteria 1-8) and **all** the variables that appear to represent the spirit and essence (**should, must**) of pedestrian security (criteria 6, 7, 8 and 5).

b. Synthesis Research - - Final Specification of Variables

As noted above in section C1, the objective of the current specification is to identify and classify: 1) all the **selected variables** that **should** be used to **operationally define** pedestrian safety, comfort, convenience: and, 2) the **essential variables** that **must** be included in evaluations and decisions about intersection modifications that affect pedestrians' security.

The process of deriving the variables for the final specification combines several cataloguing, analyzing and synthesizing activities.

1. Responses by the groups of experts (elected, professional, citizen) to the materials circulated as part of Interim Report 5 research are tabulated. The results are shown in Appendix D as Tables D-1, D-2, D-3, D-4, and D-5, and represent the experts' collective views on variables to include in the final specifications.

2. The variables that received an "accepted in principle", "accepted in principle and practice", or "supported by WSI research" rating during the initial specification phase are culled from Tables 3, 4, 5, 6 and 7 in interim Report 5. They are presented in Appendix E.

   To this stage in the process, relatively straightforward decision rules are employed to establish whether a variable in the initial specification is "surviving". That is, deciding whether the variable is still under consideration for the final specification involves choosing a cut-off point or level, and then keeping or cutting the variables accordingly.

3. The third stage of the variable derivation process combines the experts' ratings (Appendix D) and the assessments based on WSI research (Appendix E), which necessitates using a decision rule that can relate "apples and oranges" or "alphas and numerics". That is, the A, BA, B and C of the assessments need to be related to the number of groups of experts (1, 2, or 3) supporting a variable.

For this synthesis activity, the decision rule is readily illustrated by means of a schematic and an associated description of the row and column entries (Figure 1). As indicated, the variables are assigned to groups I, II, or III, and the logic of the decision rule is as follows for each class.

Figure 1. Merging of Assessments from WSI Project Research and Views of Experts to Identify Selected Variables for the Final Specification

		Level of Expert Support		
		3	2	1
Assessment	A	I	I	I
	BA	I	II	III
	B	I	II	III
	C	I	II	III

Where,

Assessment = research findings about the connection between a variable and walking security components (safety, comfort, convenience).

A	=	connection accepted in principle and practice
BA	=	connection moving from B to A
B	=	connection accepted in principle
C	=	connection supported by WSI Project Research

Expert Support = number of groups of experts (elected, professional, citizen) supporting inclusion of a variable in the final specification of walking security variables.

Cell Entries = ratings to assign to variables based on assessments and views of experts.

I = variables that receive highest ratings; in operational terms, they should already be included in RMOC policies, plans and programs that affect expectations and experiences of pedestrians.

II = variables that receive higher ratings; in operational terms, they should be under pro-active consideration for immediate inclusion in RMOC policies, plans and programs that affect expectations and experiences of pedestrians.

III = variables that receive high ratings; in operational terms, they should be under pro-active consideration for inclusion in modification-type projects (eg. traffic calming) so that they can be subjected to methodologically-based empirical study.

Group 1 Variables

Variables in this group are ranked as high priority by the three groups of experts, and by the assessments done over the course of the Project. As a result, it appears appropriate to rate these variables as **essentials** for inclusion in the final specification.

Group II Variables

Variables in this class are supported by two of the three groups of experts, and their assessments indicate a strong degree of connection with pedestrians' safety, comfort, convenience. As a result, it appears reasonable that these variables be seriously considered for inclusion in the final specification. In operational terms, serious consideration means that these variables **should be** explicitly considered in terms of the practical implications of their being included in or excluded from policies, plans, or programs of RMOC that affect pedestrians' security expectations and experiences.

Group III Variables

Variables in this class are supported by one of the groups of experts, and their assessments indicate a strong degree of connection with pedestrians' safety, comfort and convenience. Hence, a sufficient basis exists to consider them for inclusion in the final specification. In operational terms, the variables **could be** contained in the research issues, problems or questions contained in proposals, and evaluations or impact assessments of projects that affect pedestrians' expectations and in experiences. The intent of this rule is to subject Group III Variables to empirical studies which are designed to ascertain whether these variables should move to Group II and, subsequently, to Group I standing.

The fourth and final stage of the variable derivation process is to "run" the Group I, II, and III variables through an evaluation filter. As discussed in Appendix B, both general and particular evaluation criteria are used, and are labeled as shown in Figure 2.

Figure 2. Evaluation Criteria Used in the Final Phase of WSI Variable Specification

General Evaluation Criteria	Particular Evaluation Criteria
Pertinence Support Degree of Difficulty	Enforceability Data Availability

The purpose of using such an evaluation filter is to attempt to ensure that what should be done is, and what should not be done is not. Specifically, the intent here is to attempt to ensure that the final specification includes the variables that it must or should (I, II), and excludes those that do not belong in the specification. The five evaluation criteria deemed necessary and sufficient to "check out" the final specification of Walking Security Index variables are briefly overviewed, and readers are referred to Appendix B for further discussion.[4]

- **Pertinence** requires establishing that the variable materially contributes to defining, measuring, assessing, etc. walking security (safety, comfort, convenience).
- **Support** requires establishing that a variable has "friends in court", advocates, protagonists, etc. who will push or pull to have the variable receive its (deemed) due regard.
- **Degree of Difficulty** takes into account the various conduits, barriers or obstacles to change - -political, institutional, cultural, technological, technical, etc. - - and relates them to the same kinds of means and opportunities of achieving change.
- **Enforceability** recognizes that, insofar as pedestrian security is involved, police in Ottawa-Carleton will in all likelihood have to continue to lay charges against those who contravene relevant Acts, By-laws, etc. The value of this criterion is as a reminder that if any (new) variables are introduced which (could) involve a police action, then the variables must be subject to observation or attestation in such a manner that arrests and convictions can be achieved on the evidence obtained. The challenge, then, is to establish that values for the proposed variables lend themselves to being acquired through human observation, or by mechanical devices such as cameras and other recording devices.
- **Data availability**, that is having and having access to observations (values) on variables, is a matter of fundamental concern if RMOC anticipates mounting and maintaining an information system capable of performing analysis-synthesis types of relationship studies on the status, trends, etc. of pedestrians' security in Ottawa-

Carleton. Indeed, Interim Report 4 - - which was not in the original project design - - was produced in recognition of the operational significance which database development holds for the audit form and index aspects of the applied research (Wellar, 1997a).

As a result, a judicious effort was made to identify pertinent variables that did not involve a monitoring dimension, or that did not appear to entail a high degree of difficulty of data maintenance. This criterion therefore serves the useful function of requiring one last review of the variables to minimize the risk of proposing an unreasonably burdensome data availability or acquisition problem.

3. Final Specification of Walking Security Variables

The final specification of variables for the (current) WSI Project is presented in Tables 2 and 3. As shown, the variables named as essential (the "musts") are listed in Table 2, and those designated as high priority for operational purposes (the "shoulds") are in Table 3. Two remarks about the contents of the tables may help to ensure that they are understood as intended.

1. Emphasis here is on generic variables. For particular intersections, variables in the "could" group (see Appendix C) might well be more appropriate.

2. The categories of variables represented by the table headings used in Interim Report 5 are retained. That occurs because no challenges arose in regard to the categories, and because the categories were supported by members of the groups of experts involved in the reviews of variables.

A **summary reason** is provided for each variable to account for its inclusion in the final specification. The reason for putting emphasis on summary is two-fold. First, for many of the variables there is a large, published literature. It would be redundant and unduly costly to reproduce extant details. And, second, many of the variables have been the subject of detailed discussion in previous WSI Project reports, which are available to interested readers.

In addition to giving a summary reason for including each variable, an attribute is also associated with or prescribed for some of them. That is done for established variables

which are currently not functioning as intended or expected, and for new variables whose intended role or purpose depends upon certain conditions being met.

The attribute aspect is, of course, exceedingly important, and a brief word of clarification may be instructive. The attributes of variables directly affect the contributions which they make to pedestrians' safety, comfort, convenience. And, concomitantly, the attributes of the variables also directly affect the infrastructure of intersections, the use of intersections by vehicle operators, cyclists and pedestrians, and the behavior of vehicle operators, cyclists and pedestrians.

Due, therefore, to the importance of variable attributes, and the need to have those attributes instituted in order to match pedestrians' experiences to their expectations, any attribute modifications that might be contentious are elaborated in Section E which examines proposed intersection modifications in detail.

4. Comments on Group I (Essential) Variables

Although the variables named in Table 2 are the final specification for this Project, in reality they are initial approximations of what is needed to make informed evaluations and decisions regarding intersection modifications. That qualification is made explicit because, as noted above, a significant amount of the research behind the variables is original to this study. Hence, further testing is required before the variables can be properly regarded as confirmed. It is to be expected, therefore, that the list of Group I (essential) variables could undergo changes as circumstances change.

Insofar as the immediate situation is concerned, however, the variables in Table 2 are the result of what appears to be a methodologically robust derivation process. Consequently, it appears fair to suggest that proposed modifications to Table 2 **must** be based on a similar process if they are to be considered as credible alternatives.

Table 2. Group I (Essential) Variables for Intersection Modification Evaluation and Decisions that Affect Pedestrians' Security*

Variable Name and Justification
Infrastructure Features
1. **Number of lanes** (I.10) - directly affects vehicle volumes, unpredictability and variations of movement, and amount and extent of pedestrians' exposure to traffic
2. **Speed** (I.11) - directly affects driver reaction times, vehicle stopping difficulties, severity of injury, and inability of pedestrians to react/avoid, especially children and seniors
3. **Roadway Grade** (I.20) - directly affects starting/stopping of vehicles, encroachments due to sliding, and especially due to snow/ice conditions
4. **Turning lanes** (I.24) - permissive left turns are a cause of uncertainty and rash actions by drivers, which directly affect pedestrians' security in every respect
5. **Curb cuts proximal to intersections** (I.36) - affects behaviors of drivers using cuts, and drivers of through traffic, which affects pedestrians' security
6. **Stop bar distance from crosswalk** (I.47) - amount of separation affects number of collisions, conflicts and encroachments, which affects pedestrians' security
7. **Clear sight lines** (I.61) - obstruction of views of drivers and pedestrians on approaches to intersections creates an "opportunity" for collisions and conflicts
Vehicle Traffic Features
8. **Vehicle volumes: peak hours** (V.10) - directly affect potential interactions with pedestrians, relations among drivers and vehicles, likelihood of collisions and conflicts, and pedestrians' security in every respect
9. **Vehicles by type** (V.15) - cars, buses, trucks have different dynamics as to intersection use among vehicles, and in terms of impacts on safety, comfort and convenience of pedestrian intersection users
10. **Distribution of trips by purpose: personal/establishment/drinking** (V.36) - alcohol consumption negatively affects drivers' abilities to properly guide vehicles into and through intersections, which directly affects pedestrians' security
11. **Distribution of vehicles through crosswalk by direction** (V.47) - both left-and-right turn vehicle movements through crosswalks can compromise pedestrians' security, and especially at intersections with high pedestrian and vehicle volumes

Pedestrian Traffic Features
12. Pedestrian volumes: peak hours (P.10) - directly affect potential interactions with vehicles, behaviors of vehicle operators, and effects on pedestrians' security
13. Pedestrian by age groups (P. 34) - children and seniors are most likely candidates to have security compromised, and may require that special measures be taken to serve and promote their security needs
Infrastructure Performance Measures
14. Right turn on red (IM.10) - prohibitions at one location may affect pedestrians' security at other intersections, so "transfer" of vehicle-based problems requires that pedestrians have adequate time to clear, and especially in winter when clothing, footwear, and walking conditions affect mobility
15. Signage (IM.20) - the quality and location of signs that inform drivers of crosswalks, schools, etc. are fundamental to serving and promoting pedestrians' security
16. Ice/snow/slush removal (IM.28) - mobility and dignity require that sidewalks and crosswalks be at least as clean for pedestrians as roadways are for vehicle operators, and especially for children and seniors
Vehicle, Driver, Pedestrian (User) Behavior Measures
17. Pedestrian-vehicle collisions (UM. 10) - this variable represents a direct measure of the incidence of "contacts" which compromise pedestrians' security
18. Pedestrian-vehicle conflicts (UM.12) - participation in and concerns about conflicts with vehicles directly affects pedestrians' security, and especially if conflicts involve vehicles at speeds of 40 or more kph
19. Vehicle moving violations (UM.14) - all of the associated violations - - speeding, running lights, blocking traffic, and encroaching stop bars, crosswalks and sidewalks - - compromise pedestrians' security in every respect

* Variable names and ID's (eg., P.10, IM.28) are from Tables C-1, C-2, C-3, C-4, and C-5 in Appendix C.

Moreover, it is important to make explicit that the variables in Table 2 constitute what might be called a "bare bones" listing. By way of explanation, the 19 variables in Table 2 are what remains from an initial set of 212 variables and sub-variables. To make it to the Group I array, variables were required to "survive" the literature, the views of experts, and the five evaluation criteria.

Finally, the variables in Table 2 may satisfy the condition of **necessary.** However, by no means can they be deemed **sufficient** for tasks that involve robustly defining, measuring, and evaluating the relationship between pedestrians' security expectations and experiences. Which brings us to the high priority variables that expand and elaborate the essential variables, and are needed in order to paint a more complete pedestrians' security picture of Ottawa-Carleton's signalized intersections.

5. Comments on Group 2 (High Priority) Variables

The Group II Variables extend, elaborate, add emphasis to, complement, etc. the Group I Variables. The intent behind these variables is to assist in moving thoughts and actions on pedestrians' security beyond the essential (minimal) to the preferred (optimal). Our objectives regarding Group II Variables may be summarized as follows.

The essential variables deal with what must be known or done, and for which resources must be allocated in order to ascertain that which must be known, or achieve what must be done. In comparison, the high priority variables with their "should" dimension call attention to the need to have regard for a **preferred** aspect of the pedestrian mode of movement.

As such, the high priority variables play a role in serving notice to the Regional Municipality of Ottawa-Carleton, and their message is the following. After dealing with the essential variables, which includes ensuring that the proper databases are fully operational, there is a set of high priority variables awaiting similar consideration in order to properly serve and promote pedestrians' security.

Table 3. Group II (High Priority) Variables for Operationally Defining Pedestrian Security at Signalized Intersections*

Variable Name and Justification
Infrastructure Features
1. **Cut-off channels** (I.18) - directly affects traffic volumes, collision/conflict opportunities, aggressive driving
2. **Channel island size** (I.19) - can be used to control/calm traffic, provide haven for pedestrians
3. **Roadway surface conditions** (I.21) - irregular surface (holes, cracks) may slow traffic, but may cause incidents, especially for bicycles; smooth surfaces promote excessive speed
4. **Traffic calmers** (I.28) - directly affect vehicles volumes and speeds and, hence, pedestrians' security
5. **Sidewalk corner size** (I.34) - inadequate size causes "spillover" onto sidewalks and roadways and deviations from crosswalk paths, and especially for visually impaired and blind pedestrians
Vehicular Traffic Features
6. **Vehicle volumes: off-peak hours** (V.14) - depending upon the presence of stores, playgrounds, high-density developments, proximity to transit station, etc., off-peak traffic volumes could significantly affect pedestrians' security
7. **Distribution of trips by journey origin and destination** (V.23) - in order to ascertain whether solutions are local or regional, it is necessary to know whether the problem traffic is local or regional
8. **Distribution of trips by purpose: personal/school** (V.29) - vehicle trips to and from schools are a significant portion of the vehicular traffic traversing regional intersections in the vicinity of schools at all levels; reduction in bus programs could increase the number of such vehicle trips
Pedestrian Traffic Features
9. **Pedestrian volumes: off-peak hours** (P.14) - depending upon the presence of stores, playgrounds, high-density development, proximity to transit stations, off-peak volumes could involve substantial numbers of pedestrians

Infrastructure Performance Measures
10. **Curbing height and condition** (IM.18 and IM.19) - helps separate vehicles and pedestrians, but may cause problems for visually impaired and mobility impaired pedestrians
11. **Signage** (IM.21) - support for signage is qualified by seeming failure to function as intended (ignored by some drivers, some cyclists, and some pedestrians), resulting in requests for a new/different signage approach
12. **Water drainage** (IM.24) - standing water due to design, or ice/snow build-up, directly affects pedestrians' security
Vehicle, Driver, Pedestrian (User) Behavior Measures
13. **Vehicle-vehicle collisions** (UM.11) - collisions among vehicles point to design or behavioral problems that could involve pedestrians as innocent by-standers
14. **Vehicle-vehicle conflicts** (UM.13) - conflicts among vehicles point to design or behavioral problems that could involve pedestrians as innocent by-standers
15. **Vehicles change lane in intersection** (UM.22) - lane changes induce (other) driver reactions and expose pedestrians to effects of drivers "wheeling and dealing" in the midst of moving vehicles
16. **Vehicles change course** (UM.23) - drivers tend to change course in order to avoid stopping or yielding, which compromises pedestrians' security
17. **Vehicles accelerate through crosswalk** (UM.24) - puts pedestrians at risk who may not have been seen by the driver, or who may enter roadway beyond the crosswalk markings, with children and teens most likely to be the victims
18. **Pedestrians delayed** (UM.31) - lights timed to move vehicles treat pedestrians as "second-class citizens" and are a *de facto* (and not acceptable) denial of pedestrians' security
19. **Need by pedestrians to take evasive action to avoid collisions/conflicts** (UM. 33/34) - observations and complaints on this variable point to the need to modify behavior(s), or intersection design, to serve and promote pedestrians' security

* Variable names and ID's (eg. UM.33/34) are from Tables C-1, C-2, C-3, C-4, and C-5 in Appendix C.

6. Comments on Group III (Residual) Variables

The variables not selected as Group I or Group II variables are those which are characterized as residuals. These variables could be relevant for examining or modifying particular intersections or behaviors. Or, they could become generically relevant as a result of legislative, technical or other changes that affect how pedestrians are "treated" when traversing signalized intersections.

There are a number of residual variables, and they can be identified by interested readers by reference to Tables C-1, C-2, C-3, C-4, and C-5 in Appendix C.

7. A Final Comment on the Selected Variables

During the study numerous opinions were encountered about the variables to include in the walking security audits and indexes. In order to openly and fairly deal with the various points of view, and be seen to have done so, a transparent and rigorous variable derivation process was needed. Such a process has been inherent in the WSI Project from the outset, as evidenced by the (published) Interim Reports and the numerous Project meetings over the years. The variable derivation process is outlined in Part 2.

In the discussion of the process, and the status of the variables, a qualification was made explicit. That is, since there is a considerable amount of original research in the study, some of the variables are closer to the exploratory than the confirmatory end of the research spectrum. Hence, it is appropriate to caution that further testing is needed in order to more confidently establish which variables belong on the lists.

Such a qualification does not mean, however, and should not be taken to imply, that variables can be shuffled into or out of lists as one might do with a deck of cards. That is, the variables on the lists, whether at the exploratory or confirmatory end, were derived via a process that had evaluation criteria and decision rules. It is reasonable to expect therefore, out of respect for the groups of experts who contributed to this study, that any changes to the lists will be the result of a similarly open and rigorous derivation process.

8. Notes

1. For further discussion of pedestrian security-related criteria, indicators, pointers, etc. that are used in the public policy/plan/program process, see, for example: Atkins (1989), City of Ottawa (1994), Firth (1980), Hass-Klau (1980), Hemmens (1968), Khristy (1994), RMOC (1995a, 1995b, 1997a, 1997b), Sheflin (1996), Smith and Wellar (1992), TRB (1991a, 1991b), Wellar (1994, 1996c, 1996d, 1997c), Wellar and Harris (1992), and Zegeer *et al* (1985).

2. Illustrations of the "balancing act" between being careful and being creative are presented in all the Interim Reports, which are listed in the References (Wellar 1996a, 1997a, 1997b, 1997e; Wellar and Froelich, 1996). In addition, the following publications also make valuable contributions to identifying and choosing among the variables that could, should and must be used for intersection evaluation and decision purposes: Barkow (1996), Braaksma (1996), Harrel (1991), Khristy (1994), Knoblauch *et al* (1985), Malinsky (1996), Mitchell (1996), Poulton (1982), RMOC (1975), Robertson and Carter (1988), Rodgers (1974), Sarker (1993), Schnablegger (1996), Sheflin (1996), Ste. Marie and Cockerton (1996), TRB (1991a, 1991b), Thompson (1996), Tolley (1990), Walljasper (1998), Wellar (1994, 1995, 1996b, 1996c), and Zegeer (1980).

3. The following individuals warrant recognition for their contributions of time, expertise, energy and encouragement when choices were being debated and decisions made at Committee and Council, Regional Municipality of Ottawa-Carleton, about whether to fund and then about whether to continue the WSI Project: Regional Councillor Diane Holmes and Regional Councillor Jacques Legendre; and, Alayne McGregor, Linda Hoad and Peter Martin, members, Transportation Environment Action Plan-Community Advisory Group, Regional Municipality of Ottawa-Carleton, (TEAP-CAG).

4. The evaluation criteria of pertinence, support and degree of difficulty are generally applicable to reviews of existing or proposed policies, plans, programs and projects. However, they emerged as serious concerns before the Project was funded, and

continued to be abiding concerns for its duration. As for enforceability and data availability, they also received attention from start to finish among members of the groups of experts working on the project. It appears eminently reasonable, therefore, to proceed on the premise that for the purpose of an in-process evaluation, with an emphasis on oversight, the five evaluation criteria are necessary and sufficient *vis-a-vis* the Project's terms of reference (Table 1).

D. SPECIFICATION OF THE WALKING SECURITY INDEX (WSI)

1. Purposes of the Walking Security Index (WSI) as an Instrument for Representing Pedestrians' Expectations of Safety, Comfort, Convenience

The purposes of the Index were defined in large part when the proposed study was approved for funding by the Regional Municipality of Ottawa-Carleton in 1995 (Wellar, 1995). And, they were further defined and refined over the course of the study as findings and recommendations were published and reviewed, and accepted, revisited or modified.

With special reference to term 2a) in the terms of reference (Table 1), the operational purposes of the Walking Security Index as an instrument for representing pedestrians' security interests can be expressed as follows:

- To provide a means of **better describing** the walking security experience of pedestrians at signalized intersections;
- To provide a means of **better explaining** why pedestrians' experiences differ from their expectations in regard to security;
- To provide a means of **better predicting** the consequences for pedestrians' security that are likely to occur as a result of intersection infrastructure modifications and/or changes in the behaviors of users (vehicle operators, cyclists, pedestrians);
- To provide a means of **better evaluating** the consequences for pedestrians' security that are likely to arise from proposed modifications to signalized intersections, infrastructures, and/or to the behaviors of intersection users (pedestrians, vehicle operators, cyclists).

In preparation for this final phase activity, several basic pieces of fundamental research were conducted:

- Literature reviews on index construction in general and in regard to transportation index design and implementation in particular were completed;
- Various approaches to index construction relevant to this study were identified;
- Reports were published in order to receive feedback on methodology, on whether what was being undertaken had been tried elsewhere and, if so, whether it had failed or succeeded; and,
- The Walking Security Index variables that were initially specified for inclusion in an index or audit form were subsequently subjected to review by three groups of experts (electeds, professionals, citizens). Then, the variables were "run through a filter" which used the criteria of pertinence, support, degree of difficulty, enforceability, and data availability as a last check on the variables specified for index and/or audit form purposes (Section C).

With the final specification of variables in place, all the parts have been assembled for specification of the Index. As indicated and acknowledged, however, the range of options at our disposal (and that of RMOC) is so large and diverse that it is appropriate to regard these formulations as indicative and illustrative rather than definitive and comprehensive.

The reason for modesty in this regard should become evident very quickly, when it is appreciated that there are 19 essential and 19 high priority variables in the final specification. That number of variables is sufficient to create many dozens of reasonable formulations. Moreover, many additional formulations are possible by introducing such real-world context variables as land use densities and patterns, and the socioeconomic characteristics of pedestrians and vehicle operators.

Further, the approach adopted is consistent with how the research program has unfolded to date. Specifically, the formulations are pragmatic and are based on the following two central premises:

- The instrument (Index) is to be used to describe, explain, predict and evaluate walking security matters in Ottawa-Carleton "as is". In other words, the Index is designed and used to reflect and deal with current realities. In the event of fundamental changes, such as the installation of red-light cameras, a huge police presence at intersections, or a massive increase in gasoline prices, then it is likely that some of the formulations would be over-taken by events.

- The instrument (Index) is to be used to describe, explain, predict and evaluate walking security matters in Ottawa-Carleton under the conditions of changes to intersection infrastructure features, or to the performance of vehicle operators and pedestrians. The point being made is that if "wrongs" are found to exist, then it is presumed that the necessary steps will be taken to correct them.

And, as a closing context remark, it is recognized that readers are likely to have different backgrounds and, hence, a different appreciation for formulations that are qualitative (text), quantitative (numeric), or visual (graphic) in nature.[1] Indeed, to be blunt, there is substantial evidence that strictly mathematical formulations would seriously fail the variable criteria tests of pertinence, support and degree of difficulty.[2] And, on the other hand, a totally word-based formulation might require four or five pages of text, some of it tedious and mind-numbing in detail, to elaborate a relatively simple algebraic formula.

Since it is clear, therefore, that differences among readers comes with the territory for this topic, the formulations and the relationships among variables are considered as explicitly as resources permit. And, in addition, references are provided for readers who wish to examine additional materials on the respective formulations. As for readers who are better equipped in technical terms, they are asked to bear with the interpretations done for those who may benefit from relationships and operations on variables being simplified in order to help achieve broader understanding of the formulations.

2. Walking Security Index Formulations

Due to the numerous variables under consideration, and the substantial body of suggestions made by elected officials, professional staff, individuals and community

associations, many formulations could be presented. In order to focus on those which must and should be selected, however, the following criteria are applied to identify the formulations that might be termed the **most appropriate** for implementation:

1. They best satisfy the study's terms of reference;
2. They are best supported by research findings derived during the course of the study;
3. They best satisfy the conditions of pertinence, support and degree of difficulty, which are presented in Section C in the discussion of decision support criteria;
4. They do not create new enforceability issues, and do not entail new or substantially different enforceability activities (Section C);
5. They are relatively transparent in terms of what is measured, and how; and;
6. They can be implemented using currently available data, or data that can be readily obtained through technical, technological, and human resources which are already engaged in database development and maintenance activities at the Region (Section C).

As the reader will observe, the formulations are generally presented in order of increasing complexity.* We proceed from very basic, two-variable linear relationships to relationships that are cumulative, non-linear, and consist of six or more variables. Several graphics are presented to illustrate fundamental concepts, and a brief selection of references is included for consideration by readers who wish to investigate the logic behind the formulations.

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* The relationships among complexity, reliability and utility, which are central to many sensitivity analysis studies, have been borne in mind during the process of specifying the formulations. It appears clear that all the formulations are easily within the 'technical purview' of the Regional Municipality of Ottawa-Carleton and, for that matter, any of the experts who participated in the WSI Project.

Before presenting the formulations selected for consideration by RMOC, the reader is reminded that the Final Report is based on a number of background reports. The summaries which overview those reports are contained in Appendix A. It is strongly recommended that, at a minimum, all the summaries be reviewed prior to reading this section. The point of concern is that lack of regard for the details behind the variables and relationships could cause the formulations to be misconstrued.

A. Vehicle-Pedestrian Interaction Potential (V-PIP) Index

The V-PIP Index is formulated as follows:

$$\textbf{V-PIP} = \textbf{\# of vehicles/hr} \bullet \textbf{\# of pedestrians/hr} \qquad (1)$$

The value of this index is that it provides a general indication of the **potential** amount of interaction -- collisions, conflicts, delays -- between vehicles and pedestrians.* On the basis of the premise that increased amounts of interaction likely mean that pedestrians' security (safety, comfort, convenience) is diminished, then the V-PIP Index may be used to rank interactions according to the likelihood that pedestrians' security expectations involving safety, comfort, convenience are not being met.

As illustrated by Figure 3, the relationship expressed is an inverse. That is, the higher the number of potential interactions, the lower pedestrians' security. Several observations about the V-PIP formulation are needed to ensure that it is perceived and used as intended, and as supported by the evidence. These observations include the following.

1. The V-PIP Index provides a **relative** ranking or rating among the intersections. It does **not** provide an **absolute** determination as to whether pedestrians' expectations about security are being met or served at any signalized intersection.

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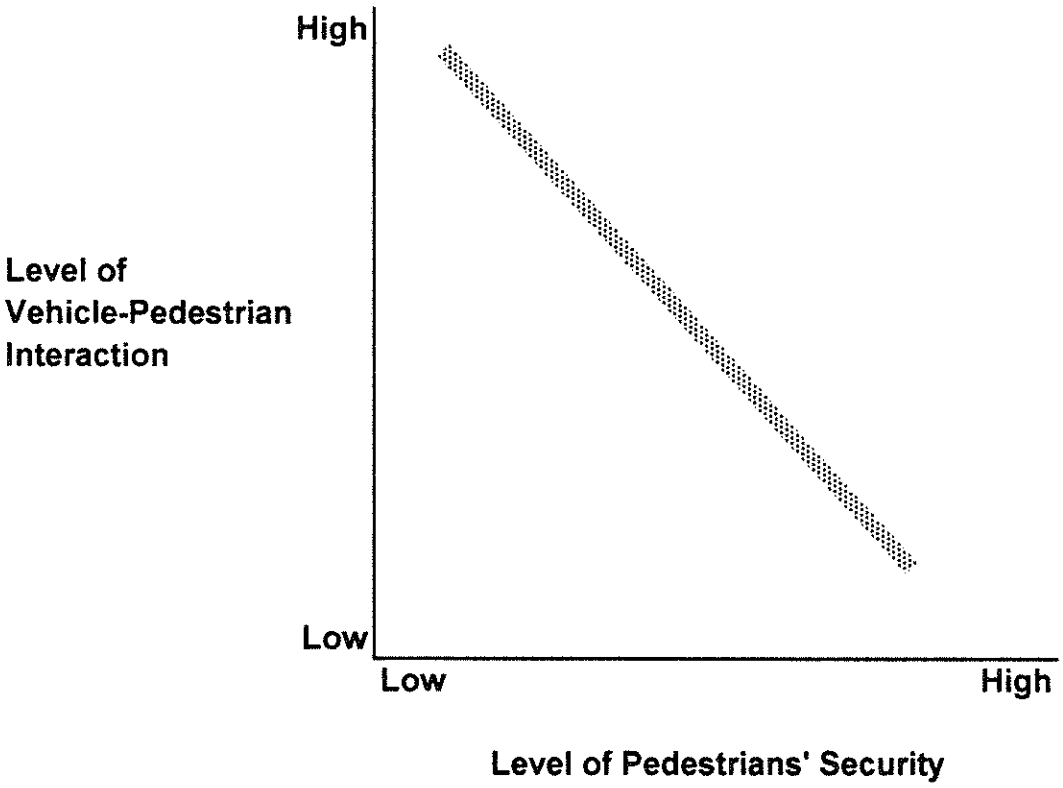
*The formulations throughout this section are based on hourly volumes of vehicles and pedestrians, but can be modified to deal with longer time spans.

Figure 3. Illustration of Relationship Between Vehicle-Pedestrian Interaction and Pedestrians' Security.



2. Although they are identical in construction, there is a notable, conceptual difference between the V-PIP Index and indexes that simply relate numbers of vehicles and numbers of pedestrians. By way of illustration, the 'Priority Index' used in Ottawa-Carleton (RMOC, 1993; Wellar, 1995) and the 'Hazard Exposure Index' used in North York (1979) both calculate a product from the v • p (vehicles x pedestrians) combination.[3] In the case of the V-PIP, however, there is **explicit regard** for **potential interactions**. That is, V-PIP explicitly recognizes that actual interactions could be much less than potential interactions, and especially when large numbers of vehicles and/or pedestrians are involved in the counts.

   To illustrate the point -- and elaboration is deemed necessary since a current practice is being questioned -- consider the following numerical example.

   An hour's traffic of 800 vehicles and 600 pedestrians potentially involves 800 • 600 = 480,000 interactions. However, for that to actually occur every vehicle must interact with every pedestrian within the hour, which is physically impossible. The inclusion of the qualifier 'potential' is important, therefore, because it allows for relative ratings to be made, which also makes it clear that the interaction value is not real or actual. Rather, the number is merely an indication of how interactive an intersection could be if every moving entity (vehicles, pedestrians) encounters every other moving entity.

3. The V-PIP Index provides **forewarning information** about the vehicle-pedestrian relationship in general, and about changes at each signalized intersection for which vehicle and pedestrian count data are available. As a result, the V-PIP Index is useful as an operational tool for ascertaining changes in potential interaction levels.

4. The V-PIP index attaches equal weights to vehicles and pedestrians. As a result, such diverse combinations of vehicles and pedestrians as 50 • 400, 100 • 200, 200 • 100 and 400 • 50 all yield the same product. That is, V-PIP = 20,000 in all cases. The lack of discrimination between numbers of vehicles and numbers of pedestrians points out the strength-weakness aspect of such a formulation: that is, while the computations are easy, the results are not discerning in regard to the composition of the interactions. Table 4 and Figure 4 illustrate the concern behind the V-PIP Index's lack of discrimination.

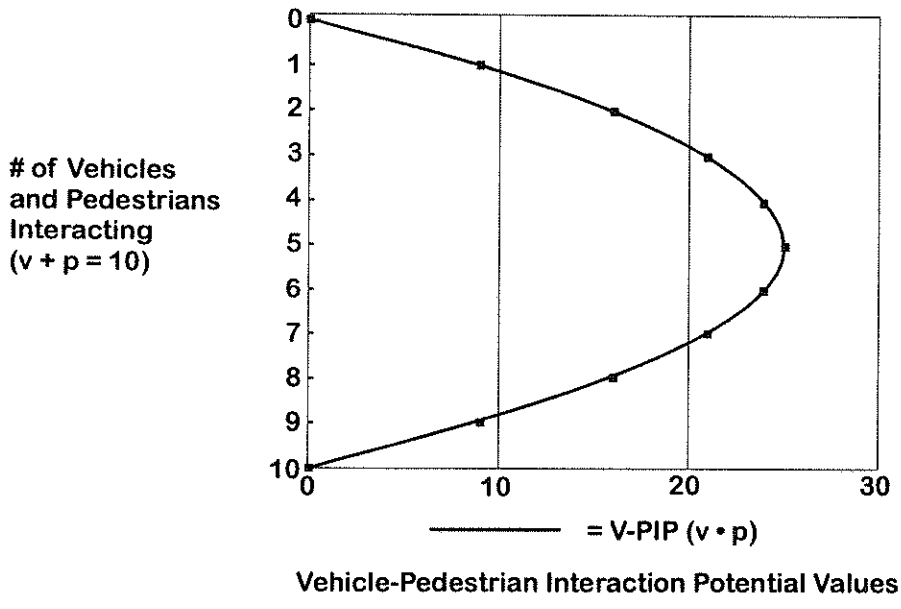
As shown in Table 4, and using a total of 10 vehicles and pedestrians (i.e., v + p = 10), the interaction value of 16 is obtained when v • p = 8 X 2, or v • p = 2 X 8. And, V-PIP = 21 for v • p = 7 • 3 and 3 • 7. Similarly, but in schematic form in Figure 4, the V-PIP Index curve is a symmetrical parabola and the same values result for the reciprocals.

It appears fair to suggest, however, that pedestrians' security (safety, comfort, convenience) is **not** generally regarded as being equivalent in those two situations.[4]

Table 4. Numeric Illustration of How Different Combinations of Numbers of Interacting Vehicles and Pedestrians Yield the Same Interaction Potential Values

v	•	p	V-PIP Index
0	•	10	0
1	•	9	9
2	•	8	16
3	•	7	21
4	•	6	24
5	•	5	25
6	•	4	24
7	•	3	21
8	•	2	16
9	•	1	9
10	•	0	0

Figure 4. Graphic Illustration of How Different Combinations of Numbers of Interacting Vehicles and Pedestrians Yield the Same Interaction Potential Values



Hence, care must be exercised when using this formulation, and the qualifier term "potential" assists in reminding us to exercise due discretion in that regard.

B. Weighted Vehicle-Pedestrian Interaction Potential (WV-PIP) Index

Following from observation 4 above, the WV-PIP formulation is based on the premise that, *ceteris paribus*, a pedestrian's security is more likely to be adversely affected by vehicles than by pedestrians. The interpretation of the premise is a two-part conditional statement. First, as the pedestrian share of intersection users declines and the vehicle share increases, the level of security experienced by pedestrians declines. And second, the associated implication is that an adjustment factor is needed to give "more weight" to vehicles (than to pedestrians) in order to capture the differential impact.

In order to benefit from existing research, several literature reviews were undertaken for studies that had already addressed the matter of an adjustment factor. As of this writing, however, no ready-made solution of a methodologically robust nature had been located that could be directly imported to express the differential relationship noted. Therefore, the straightforward procedure of squaring the vehicle counts is adopted for the formulation for the following reasons:

1. This procedure serves the purpose of effectively differentiating between the impact of vehicles and pedestrians on pedestrians' security;
2. While the official or learned literature documents have not yet been obtained for inclusion in the Final Reports' references, the Principal Investigator has been told of instances/locations where a weighted formulation is used.[6]
3. The premise behind the formulation can be readily demonstrated both numerically and graphically.

The weighted formulation is therefore termed the WV-PIP Index, and is expressed as follows:

$$\textbf{WV-PIP} = \#\ \text{of vehicles}^2/\text{hr} \bullet \#\ \text{of pedestrians/hr} \qquad (2)$$

Table 5 and Figure 5 illustrate the differences between the V-PIP Index and the WV-PIP Index. It is noted that **the scale of the x-axis has been changed** between Figure 4 and Figure 5 to accommodate the larger (product) numbers resulting from the squaring procedure. It is emphasized, however, that the change in scale has no bearing on **the substantive point being demonstrated**. That is, when the vehicle component is weighted by values greater than 1.0 then the resulting numbers and associated graphic effectively discriminate between the effects of vehicles and pedestrians on pedestrians' security. In this case, both Table 5 and Figure 5 demonstrate how the higher product values from WV-PIP (that is, $V^2 \bullet p$) give due recognition to the impact of an increased proportion of vehicles on pedestrians' security.

C. Weighted Passenger Car Equivalent-Pedestrian Interaction Potential (WPCE-PIP) Index

This index recognizes that there are differences in the impacts that different kinds of vehicles have on pedestrians' security. As the reader may recall, the inability of the V-PIP Index to discriminate among vehicle types was noted as being a limitation of that index (Section 2a, endnote 1).

In the formulation of the WPCE-PIP Index, the concept of passenger car equivalent (pce) is used to take into account the different impacts that cars, trucks, and buses have on intersection performance and, hence, on pedestrians' security.* The adjustment values are those currently in use by the Regional Municipality of Ottawa-Carleton (RMOC, 1995):

automobile = 1.0 passenger car equivalent;
heavy vehicle = 1.7 passenger car equivalent; and,
bus = 1.7 passenger car equivalent.

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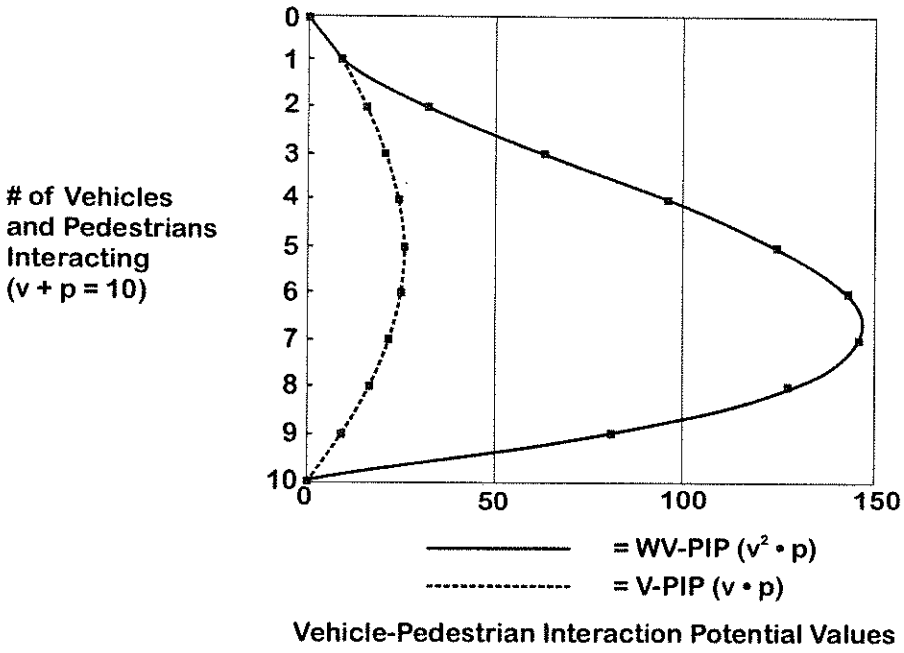
*In some texts and jurisdictions, the terms passenger car unit (pcu) or passenger car unit equivalent (pcue) are used.

Table 5. Comparison of Values Generated By the V-PIP and WV-PIP Index.

(v= 0 - 10; p = 10 - 0; v + p = 10)

v	•	p	V-PIP Index	WV-PIP Index
			v • p	v^2 • p
0	•	10	0	0
1	•	9	9	9
2	•	8	16	32
3	•	7	21	63
4	•	6	24	96
5	•	5	25	125
6	•	4	24	144
7	•	3	21	147
8	•	2	16	128
9	•	1	9	81
10	•	0	0	0

Figure 5. Graphic Illustration of Relationship Between Interacting Vehicles and Pedestrians and Interaction Potential Values When Index is Weighted (WV-PIP) and Not Weighted (V-PIP).



It merits putting on record for future reference that questions were raised with Regional Staff regarding the equivalents. Points of concern include the following:

1. Tractor trailers, with long boxes and 18 wheels are not distinguished from dump trucks with short boxes and 10 wheels;
2. Articulated buses are not distinguished from regular buses; and,
3. The equivalency factor of 1.7 appears to be on the low side even when limited to operational and timing standards for signalized intersections. When the 1.7 factor is applied to impacts on pedestrians' safety, comfort and convenience, it appears to decidedly understate the case, and especially regarding the impacts of tractor trailers and articulated buses.

In the present circumstances, it is appropriate to use the factors in place since the study design is based on what is, and not on what should be. On its face, however, the current scheme appears to be in need of modification in order that the true impacts of different kinds of vehicles can be more accurately measured. In that regard, consideration could be given to adopting the relatively discriminating pcu/veh regime contained in Table 1-2 of the *Canadian Capacity Guide* (Teply *et al.*, 1995).

With those qualifying remarks in place, the WPCE-PIP Index is formulated as follows:

$$\textbf{WPCE-PIP} = \textbf{\# of passenger car equivalents}^2\textbf{/hr} \bullet \textbf{\# of pedestrians/hr} \qquad (3)$$

The added value of using passenger car equivalent is demonstrated by the case studies presented for illustrative purposes in Table 6. As shown in Case 1, it is obvious from observation that the WPCE-PIP Index yields very different outputs as a function of type of vehicle: from 2,500,000 for all automobiles to 7,225,000 for all trucks or all buses.

And, as shown by Cases 2, 3, and 4, there are readily observable differences in formulation outputs when there are even relatively minor changes in the composition of vehicle mix.

Further, the distinctions are even more apparent if the vehicle and pedestrian numbers used in the formulation represent the totals for 8-, 10- or 12-hour counts. A very important attribute of the WPCE-PIP Index, therefore, is that it is sensitive to the mix of vehicular

traffic, and especially when the mix contains a larger proportion of vehicles in the non-automobile class with its 1.0 factor.

Moreover, as a related consideration that is introduced above, it needs to be noted that legitimate questions can be raised about the 1.7 factor used by the RMOC, and the fact that RMOC does not assign different factors to regular and articulated buses. Further refinements by RMOC in those domains would lead to even more definitive rankings (among intersections) by the WPCE-PIP Index.

In addition to the question about vehicle equivalencies, there is another aspect of equivalency that needs to be made explicit before leaving the discussion of adjustment factors. That is, substantial evidence was accumulated during WSI Project fieldwork which suggests that an adjustment factor is needed to account for differences among pedestrians' perceptions about their security at signalized intersections. And, it was further found, generally speaking, that differences in perceptions about intersection features, traffic conditions, etc. can be assigned to one of three or four age groups, that is, children/youth, adults, and seniors (Wellar, 1995; Wellar and Froelich, 1996).

The associated consequence, which is both far-reaching and profound in its political, social and economic implications, is summarized as follows. First, given the differences among pedestrians' perceptions about their security, it is "inappropriate" to make decisions or take actions involving intersections without having taken into account the differences among the pedestrians using intersections.[7]

And, second, children and seniors have a direct interest in, and are directly affected by signalized intersections that are near homes, schools, playgrounds, and seniors' complexes, if the intersections are part of school, recreation and leisure walk routes, or if they otherwise impact on the mobility and security of children and seniors. It again follows, therefore, that it would be "inappropriate" to make decisions or take actions of a modification-type without using an adjustment factor that accounted for differences among pedestrians.

Table 6. Illustration of the Discriminatory Power of the Weighted Passenger Car Equivalent-Pedestrian Interaction Potential (WPCE-PIP) Index *vis-à-vis* the Weighted Vehicle-Pedestrian Interaction Potential Index.
(In all cases, # of pedestrians = 100, total # of vehicles = 500).*

Case 1 100 Pedestrians 500 Vehicles WV-PIP = 500^2 • 100 = 250,000 • 100 = 2,500,000 WPCE-PIP = $(500 \times 1.0)^2$ • 100 = 250,000 • 100 = 2,500,000 (automobiles only) WPCE -PIP = $(500 \times 1.7)^2$ • 100 = 722,500 • 100 = 7,225,000 (trucks only) WPCE-PIP = $(500 \times 1.7)^2$ • 100 = 722,500 • 100 = 7,225,000 (buses only)
Case 2 100 Pedestrians 400 Automobiles 50 Trucks 50 Buses WPCE -PIP = $((400 \times 1.0) + (50 \times 1.7) + (50 \times 1.7))^2$ • 100 = 3,249,000
Case 3 100 Pedestrians 300 Automobiles 100 Trucks 100 Buses WPCE -PIP = $((300 \times 1.0) + (100 \times 1.7) + (100 \times 1.7))^2$ • 100 = 4,096,000
Case 4 100 Pedestrians 200 Automobiles 100 Trucks 200 Buses WPCE -PIP = $((200 \times 1.0) + (100 \times 1.7) + (200 \times 1.7))^2$ • 100 = 5,041,000

*Adjustment factors used to calculate passenger car equivalents are:

- passenger car, minivan, pick-up truck = 1.0;
- dump trucks and tractor trailers = 1.7;
- buses = 1.7 (RMOC, 1995b).

Insofar as the WSI Project's terms of reference are concerned, however, in-depth research to design an adjustment factor which accounts for differences among pedestrians was not included. As a result, resources were not allocated to develop such an adjustment factor, nor was it a topic that was explicitly included in the literature searches and reviews. Hence, the WPCE-PIP Index should be considered as a formulation in progress. In particular, the independent variable - - # of pedestrians - - should be refined to take into account differences among pedestrians. It appears that a three-class system (youth, adult, senior) would be reasonable, with additional classes to be added if research findings justify that a higher order of definition is required to represent pedestrians' interests.

In anticipation of questions arising, it is further suggested that what might be called the pedestrian age or life-cycle adjustment factor have a basis of adult = 1.0. An interview-style project would appear to be an appropriate approach for developing the adjustment factors for youth and seniors.

Regarding the operationalization of the indexes in this section, there may be readers who are uneasy about the day-to-day implications of the formulations, numbers, graphics, data etc. A discussion of the *degree of difficulty* criterion associated with using the indexes may therefore be helpful.

As noted at the outset of this section, the formulations move through a relatively simple to relatively complex process. However, the degree of difficulty associated with employing the WPCE-PIP Index is minimally higher than for the other indexes. Moreover, to the extent that any additional difficulty arises, it largely resides in the development of the database on the traffic mix at signalized intersections. And, in reality, that is a task which is more mundane than complicated since it can be achieved by relatively 'low-tech' devices and means, including counts by students who are engaged in the Region's summer work program.

With regard to the computations, they are easily performed by electronic means for any of the indexes once the values for the variables or components of the formulations have

been entered. Indeed, these kinds of computations are among those which can be performed by currently available IS/GIS application packages (Wellar, 1997; Wellar and Soroko, 1997). And, that general comment certainly holds in this particular case because the computational capability needed to transform pertinent data into pertinent information via the WPCE-PIP is well-established at the Region.[8]

Before presenting the next type of formulation, it may be useful to provide a summary comment on the three related indexes discussed above in Sections 2a, 2b and 2c. In brief, it appears clear that the WPCE-PIP Index is vastly superior to the WV-PIP Index and the V-PIP Index, and can be made even more discriminating with some fine-tuning adjustments. The benefits associated with having such a relatively powerful means for calculating potential vehicle-pedestrian interactions are suggested as being apparent and persuasive. As for costs, none have been identified which are not 'part-and-parcel' of operating a large urban region with a highly-developed, multi-modal transportation system that is experiencing competition among users of signalized intersections.

D. Quality of Infrastructure Condition (QIC) Index

The purpose of the QIC Index (or QICI) is to provide an assessment of whether intersection features involving infrastructure construction and maintenance meet pedestrians' security expectations. As illustrated by the variables presented in Table 7, interest here is in the impact(s) on pedestrians' security caused by conditions which may involve intersections directly (their construction features) and indirectly (their maintenance features).

The formulation of this index is in the nature of a checklist. In general, the larger the number of negative findings, the greater the need for remedial measures. It warrants noting, however, that in some locations it may be sufficient for one negative finding to point to a need for prompt, corrective action. A case in point could be the presence of large accumulations of snow or ice at intersections used by seniors and/or pedestrians with physical disabilities.

Table 7. Quality of Intersection Condition (QIC) Index: Checklist of Core Variables for Assessing Intersection Construction and Maintenance.

ID	Variable Names for Intersection Construction or Maintenance Features*	Condition Met?		
		Yes	No	Partial
		(+1)	(-1)	(-.5)
1	Sidewalk corner capacity			
2	Height of curbing			
3	Condition of curbing			
4	Sidewalk width			
5	Sidewalk curb condition			
6	Roadway surface conditions			
7	Median (refuge) capacity			
8	Median (refuge) condition			
9	Traffic calmers			
10	Channel island capacity			
11	Crosswalk capacity			
12	Crosswalk signed and painted			
13	Stop bar painted and signed			
14	Pedestrian signage			
15	No sight line obstruction			
16	Street furniture proximal to sidewalk corner			
17	Ice/snow/slush removal			
18	Water drainage			
	Totals =			
	Overall Assessment = (Yes - No) - Partial =			

*The variable names are selected from Section C, and the list of variables contained in Appendix C, as well as Tables 3-7 in Interim Report 5 (Wellar, 1997e). As shown, a 'direction' may be given for the variables to illustrate the preferred or expected conditions that are necessary in order to achieve pedestrians' security expectations.

Insofar as weighting the variables is concerned, two factors combine to discount moving to that level of sophistication at this time. First, we have not accumulated sufficient evidence to confidently propose an all-purpose, generic weighting scheme. That is, and based on feedback received to date, it appears that the weights could vary as a function of an intersection's location in the regional road network, the composition of the pedestrian population, the season of the year, and the nature of the intersection surroundings. Estimating the significance of those nuances is currently not within our purview and, hence, it is inappropriate to assign weights until such time as the needed empirical evidence has been assembled.

Second, this is a task that would likely be better performed by community associations, school advisories, and other groups having day-to-day-familiarity with intersection construction and maintenance problems. Clearly, they are the interested parties who are best positioned to make this index operational by providing needed data on periodic and/or event-triggered bases.

The core variables selected for inclusion in the QIC Index are presented in Table 7. These are deemed to be the basic or fundamental audit-type variables that should be included in all checklist assessments of intersection feature conditions related to construction and maintenance matters. It is again emphasized that the checklist of condition variables is indicative rather than comprehensive, since the latter type of listing is better prepared on an intersection-by-intersection basis. And, it is again suggested that the 'list-preparers' be community groups which have an intimate, feet-on-the-ground understanding of the intersections in their neighborhoods.

It appears that this kind of straightforward, cataloguing-type index is an effective and efficient means of monitoring construction and maintenance features of intersections.

Further, the checklist design makes it an easy and unambiguous instrument to use. It is therefore anticipated that pedestrians themselves will assist in administering and perhaps modifying the core checklist.

In regard to its implementation, the QIC Index is based on observations made during on-site inspections. There are several ways that sound data acquisition programs could be instituted with little if any cost to the Region. First, it is likely that a significant portion of the data acquisition activity could be undertaken by such groups as community associations and school advisories. Many of them have expressed an interest in contributing to the increased security of pedestrians, and this seems to be an excellent way of encouraging broad public involvement.

Second, several hundred students in the Geography Program, University of Ottawa, have been productively engaged in various types of WSI Project studies as part of course assignments. It is anticipated that increased emphasis on client-driven, applied research experience could result in additional course assignments being designed to assist in testing and/or implementing the QIC Index.

Further, discussions with several high school teachers indicate that students from high schools in the Region could become engaged in on-site inspections. As one teacher noted, this kind of involvement might help make them more aware of what they are driving into when they get behind the steering wheel of a car or truck.

E. Intersection Pedestrian Challenge-Features (IPC-F) Index

This section on WSI formulations contains a substantial amount of background discussion before the IPC-F Index formulation is presented. There are two related, compelling reasons for going into such detail in the Final Report.

First, several aspects of the IPC-F Index appear to be original to the WSI Project. As a result, it is necessary that the 'full story' behind those aspects be as explicit as needed to make the case for the associated recommendations.

Second, the IPC-F Index incorporates several major departures from conventional principles and practices in the fields of transportation engineering, traffic engineering, and transportation planning. Further, since aspects of the formulations also appear to depart from 'conventional wisdom,' it is even more necessary that the reasons behind the

departures be as explicit as needed to make the case behind the formulations.

In regard to the connection between the index and the terms of reference (Table 1) for the WSI Project, the IPC-F Index is designed to provide guidance on questions and discussions about:

1. whether intersection modifications are needed to achieve pedestrians' security expectations;
2. whether proposed modifications affect pedestrians' security; and,
3. how pedestrians' security is likely to be affected by intersection modifications.

The IPC-F Index is therefore pertinent to many parts of the terms of reference, but especially parts 1, 2a, 2b, 2c, and 2d.

By way of introducing the research behind the IPC-F Index, a brief reference to an historical context is necessary. That is, over the years a variety of instruments, devices and procedures have been used to guide decisions about whether an intersection needed to be "improved". And, chief among those instruments, devices and procedures to assist decision-making are what are termed "warrants" and "level of service (LOS) ratings." This section of the Final Report examines the terms "improve", "warrants", and "LOS" from the perspective of pedestrians' security expectations and, based upon that perspective, presents the IPC-F Index as the preferred means for performing intersection modification needs assessments.

As indicated, and as will be discussed in more detail below, a long history is attached to *improve*, *warrants*, and *LOS* in the urban transportation field. The evidence appears to be conclusive, however, that these terms and the philosophy which they represent are under serious challenge, and that a new, more suitable means is required to assess policies, plans or programs affecting intersection characteristics. The following observations and references, mainly taken from previous WSI project reports, appear sufficient to explain why these changes have occurred.

Improve

The term "improve" or "improvement" has largely disappeared from municipal documents in Ottawa-Carleton, and has been replaced by "modify" or "modification". To summarize a longer commentary on this significant change of language (Wellar, 1996b, 1997c), "improve" is a value-laden term which is used improperly when the action involved does not **benefit all the affected parties**.

By way of illustration, widening an intersection from four to eight lanes might enable more cars to flow through, but it creates an adverse situation for pedestrians. Pure and simple, a widening is a modification, but it is not necessarily an "improvement".

In the context of pedestrian security, then, a means is required to assist in deciding whether intersections need to be modified in order for pedestrians' security expectations to be met, and to assess the proposed modifications in terms of their intended and unintended consequences for pedestrians' security. The relationship involved, therefore, is a classic case of cause and effect, which requires that the variables in the IPC-F Index formulation make a direct contribution to pedestrians' security.

Warrants

Various criteria, collectively referred to as 'warrants', have been developed over the years to assist in making decisions about modifications to intersection geometry, signage, signaling, etc. In order to help ensure that the pertinence of warrants to IPC-F Index design and implementation is clear, several definitions are presented and briefly discussed. To introduce this topic, we begin with a non-technical definition:

> **Warrant** - anything that authorizes a person or an action
> (*Reader's Digest Oxford Complete Wordfinder*, 1996, p. 1735).

In the broader context of transportation planning, traffic engineering, and land use development in Ottawa-Carleton, warrants would encompass an array of procedures, directives, regulations, etc. that are used by municipalities when they conduct intersection

performance reviews. Within the context of the WSI Project, however, our interests are focused on the particulars which comprise the warrants. That is, our emphasis is on the criteria or variables, combinations of variables, and decision rules governing the variables.[9] Hence, the administration of the warrants during intersection reviews is the focus of our attention.

At this point, it is necessary to turn to technical documentation. These are the documents which contain the definitions that identify or specify the variables, combinations of variables, and decision rules associated with the warrants used in Ottawa-Carleton. Again, our scope is effectively limited to Ottawa-Carleton, and we focus on matters directly pertaining to WSI Project variables and index formulations. As a result, the discussion is limited to as few definitions and elaborations as are necessary to illustrate why and how consideration of warrants in both the conceptual and operational aspects is pertinent to the design and implementation of the IPC-F Index.

The first set of definitions and elaborations of warrants are taken from the *Manual of Uniform Traffic Control Devices* (MOT, 1985). This report sets the terms of reference for provincial roads and other roads which come within provincial purview, so it is a useful 'umbrella' for examining the local municipality documents selected for consideration.

The provincial materials are from part B.203 Installation Warrants for Traffic Control Signals (MOT, 1985):

1. "The installation of traffic control signals at any location will be justified and will probably prove beneficial when any one of the following warrants, vehicular volume, vehicular delay, accident or pedestrian, is completely satisfied" (p. B2-3).

   Comment: As indicated, warrants pertaining to vehicular volume, vehicular delay, accidents or pedestrians may be used in deciding whether the installation of traffic signals will be justified.

2. "In the application of these warrants the following principles must be observed: Only vehicles entering the intersection -- whether they turn right, go straight

through or turn left -- should be considered. If the right turns are channelized by means of physical islands, they are not considered to enter the intersection and therefore should not be in any warrant calculations" (p. B2-3).

Comment: The empirical evidence for the Laurier-Nicholas intersection makes it overwhelmingly clear (Wellar, 1995; Wellar and Froelich, 1996), as do comments from users of various intersections with channelized right turns, that an intersection modification needs assessment procedure which does not have regard for channels is ignoring a **major**, negative force affecting pedestrians' security.

3. "Right turns are not considered as traffic crossing the artery, therefore, they should be deleted from the combined pedestrian and vehicle volume in the Delay to Cross Traffic Warrant" (p. B2-3).

   Comment: Right turns -- whether on green or on red -- directly affect pedestrians' safety, comfort and convenience, so this principle is wanting in regard to capturing the interaction potential between vehicles and pedestrians.

4. B. 2.03.03 Accident Hazard [Warrant]

   "The installation of traffic signals will seldom be justified on the accident warrant alone and it should be remembered that their operation may even increase the intersection accident rate due to rear-end collisions etc. caused directly or indirectly by the signal operation" (p. B2-4).

   Comment: The explanation associated with this warrant is narrowly confined as written in that it deals solely with accidents among vehicles ("rear-end collisions") and ignores pedestrians, even though pedestrians are mentioned in the first quotation taken from the *Manual* (MOT, 1985).

5. B. 2.03.04 Combination Warrant

"Signals may occasionally be justified where no one warrant is satisfied, but two or more are satisfied to the extent of 80% or more of the stated values, particularly if other important factors are present such as:

i. Sudden change from rural conditions to those of an urban business district;
ii. An extreme width of roadway which pedestrians must cross;
iii. Predominance of small children or handicapped pedestrians such as blind, aged or crippled adults who need to cross the roadway" (p. B2-4).

Comment: While the warrant is somewhat sensitive to the pedestrians' situation, factor ii specifies "extreme width of roadway", and factor iii requires that those who have difficulty crossing the intersection constitute a "predominance" of the pedestrian population. Among all the literature reviewed to date, no other official text comes to mind which is as prejudicial in favor of the interests of vehicle operators, and against the interests of pedestrians.

The next set of definitions and elaborations are taken from the *Report on the Application of Multi-Way Stop Control Devices for the City of Ottawa and the Regional Municipality of Ottawa-Carleton* (RMOC, 1975).

1. "City of Ottawa Council, in dealing with recently approved multi-way STOP control in the Glebe study area, approved the development of a policy to regulate further usage of this control on streets under the jurisdiction of the City of Ottawa. Since many requests of this type have been received dealing with Regional Roads, the following policy has been developed to ensure a co-ordinated [sic] and consistent review of further requests for multi-way STOP control on streets under the jurisdiction of the Regional Municipality of Ottawa-Carleton and the City of Ottawa.

   In addition to warrants for the use of multi-way STOP control, a number of further recommendations are made to improve driver observance of this type of control and minimize certain disadvantages inherent in its use" (p. 1).

Comment: At the risk of belaboring the obvious, the modification -- using multi-way STOP control -- was initiated to deal with problems caused by vehicle operators, who in turn created further problems due to lack of proper observance of this type of control.

2. "During periods of peak traffic demand the traffic congestion and delays on Carling Avenue and Woodroffe Avenue encouraged motorists to travel through Whitehaven via Georgina Drive.

   In an effort to alleviate this problem, the City of Ottawa erected a barricade across Georgina Drive at Winnington Avenue on August 15, 1972. This measure was quickly proven inadequate as it resulted in a severe loss of convenience to residents of this area and shifted traffic problems to neighbouring streets" (p. 2).

   Comment: This observation on the impact of a barricade is especially pertinent to the WSI Project because of the use of the term **convenience**, and severe 'loss of convenience' at that, to describe the "hardship" experienced by vehicle operators -- not pedestrians -- residing in Whitehaven.

3. "In many instances it [multi-way STOP control] has been installed at locations where an unacceptably high accident frequency continues despite the use of less restrictive measures. Other common intersection problems which have occurred include:

   a. poor observance of existing intersection control and related accident hazard
   b. unacceptable delay to minor street traffic
   c. incurable visibility problems
   d. balanced traffic volumes, but not large enough to warrant the installation of traffic control signals
   e. very large or unbalanced turning movements
   f. pedestrian crossing difficulties" (p. 5).

Comment: Although "pedestrian crossing difficulties" (f) are noted as being a common intersection problem, the remainder of the report is largely silent on the topic of why and how multi-way STOP control as an intersection modification instrument affects pedestrians' security.

4. "As with other types of traffic control, multi-way STOP control must be used with discretion if maximum effectiveness is to be realized. The following factors should therefore be considered to ensure reasonable application of this device:

   a) Distance to Nearest Traffic Control
   This factor should be considered in order to avoid a proliferation of unnecessary traffic control devices which would encourage poor driver observance. Further, when such installations are considered as a speed reduction measure, the spacing of control devices has a considerable effect on the net result...In cases where this type of control is provided as a pedestrian priority device the spacing should correspond to the pedestrian requirements" (p. 13).

   Comment: While the elaboration of the 'distance to nearest traffic control' factor refers to the control as a *pedestrian priority device*, and to *pedestrian requirements*, most of the report speaks to the higher priority of keeping the traffic on arterials moving efficiently. Discussion of factor c) which follows is a case in point about the abiding emphasis in the *Manual* on expediting the flow of vehicular traffic.

5. "c) Road Classification
   Since the primary objective of the arterial road system is to ensure unrestricted traffic flow, it is obvious that multi-way STOP control on an arterial roadway would conflict with this objective. Furthermore, the implementation of multi-way STOP control on arterial routes results in reduced capacity, increased delay and may contribute to increases in traffic on adjacent non-arterial routes" (p. 13).

Comment: The singular focus of the discussion on vehicular traffic flow overlooks the urban reality of Ottawa-Carleton. Even then (1975), there were many arterial road intersections that were being used by pedestrians, cyclists, and different kinds of vehicular traffic. In many parts of Ottawa-Carleton, for many hours of the day, **unrestricted** traffic flow did not exist, and does not exist today.

6. From Section 5, Impact of Multi-way Stop Control.
"DISCOURAGE VEHICULAR TRAFFIC...Multi-way STOP control, when used at key locations along a roadway, can lead to greater travel time and therefore make the route undesirable to motorists. For this measure to be effective, it is essential that alternate unrestricted routes be available, otherwise the frequent STOP control leads to driver frustration and numerous undesirable affects [sic], principally noise and speeding."

   Comment: The concern about a modification that 'bothers' vehicle operators is largely a symptom of a long-ago time when 'the car was king', and references to 'unrestricted traffic flow' and 'unrestricted routes' were part of the transport supply management argument. On the evidence, times have changed considerably and drivers who engage in hostile or anti-social behavior are increasingly being called to account. Hence, any selfish attitudes held by drivers or drivers' advocates can be deeply discounted as an intersection modification needs assessment consideration. In other words, it is time to give pedestrians their due regard in terms of expectations, and to modify the expectations of vehicle operators "downwards".

The final document that is discussed in this segment of Section D is *Policy: Installation of Stop Controls, Yield Controls and Multi-Way Stop Controls at Roadway Intersections* (City of Ottawa, 1994). There are two aspects of the City of Ottawa report that are especially pertinent to this discussion on the principles and practices associated with warrants.

First, the 1994 report finds that there is need to change the warrants system that was in place.

> Developing a New Warrant System
>
> It was the desire of the Department of Engineering and Works that any new system of assessing the multi-way stop controls applications should, at the least, be aimed at addressing the shortfalls of the current warrant system - namely addressing community concerns and perceptions.
>
> The current City of Ottawa warrant system has concentrated on the collection and analysis of objective or quantifiable data including traffic volume, pedestrian crossing volumes, and accidents frequencies. Since these warrants have been oriented to the application of intersection control to designate right-of-way, there has been a need for intersections to meet relatively high traffic volume and accident frequency levels.
>
> While the current warrant system does a more reasonable job in addressing intersection control for higher volume roadways (e.g.: Collector and Major Collector Roads), its relevance to lower volume roadways, and to the concerns of local residents is doubtful. This is due to the current warrant systems reliance on quantifiable data, whereby more subjective opinions and insights of those residents most affected by the traffic patterns under study are not taken into account (City of Ottawa, 1994, p. 69).

Comment: The emphasis on the new system being capable of addressing **community** concerns and perceptions reflects the political dimension. That is, 'the community' made known to elected officials that the existing system of specifying and applying warrants did not adequately take into account the views of residents (voters). The WSI Project also recognizes the importance of "community", but it appears that our approach is considerably more definitive. Specifically, pedestrians and community associations are considered to constitute a body of lay experts, and their opinions play a direct role in deciding which variables to use and how to relate them in an index formulation. In general, however, there is a strong philosophical and political connection between that report and this one, in that both point out the need for something new or different with regard to warrants.

Second, in the section 'Impacts of Multi-Way Stop Controls (p. 67-69)', the following topics are discussed:

- Traffic Safety
- Traffic Volume
- Traffic Speeds
- Compliance
- Energy Use and Air Pollution
- Noise
- Cycling

Comment: Nowhere in the section is the matter of impacts on pedestrians specifically addressed. Indeed, the pedestrian mode of movement is rarely mentioned in the report.
It appears fair to suggest that, in general, warrants have tended to assign the highest priority to the movement of vehicles, and to have little or no real regard for pedestrians' safety, comfort, convenience. Consequently, vehicle-serving warrants are, *de facto*, an inappropriate means to use in decisions that bear directly on pedestrians' security.

An even stronger reason for rejecting the use of warrants as presently construed, however, is provided by the Regional Official Plan (1997), and the Regional Master Transportation Plan (RMOC, 1997). Both documents attach the **highest priority to the walking mode and the lowest priority to the vehicular mode of transportation**. The message taken from the consensus position of elected officials, professional staff and ordinary citizens is that the current emphasis of warrants on moving vehicles has been overtaken by events. Instead, what is required is a new means for assessing intersection modification needs.

The final background item to discuss before presenting the IPC-F Index is level of service (LOS), a concept and phrase which came into use in the transportation field some 30-35 years ago (HRB, 1965; TRB, 1991).

As previously discussed (Wellar, 1996b, 1997c), **LOS emphasis has been on promoting the convenience and comfort of vehicle operators and their passengers.** And, the associated problem *vis-à-vis* making the Walking Security Index Project findings

operational is obvious: when moving vehicle LOS criteria or standards are used as **the** basis for decisions on modifications, the discussion and subsequent results are not likely to serve pedestrians' security (Atkins, 1989; Harrel, 1991; Hass-Klau, 1990; Khristy, 1994; Poulton, 1982; RMOC, 1995b, 1997a, 1997b; Robertson and Carter, 1988; Sarkar, 1993; Schnobleggar, 1996; Sheflin, 1996; TRB, 1991a, 1991b; Wellar, 1975, 1994, 1996c, 1997b, 1997c; Zegeer, 1980, 1985). Hence, on first principles the old-style LOS argument is not acceptable if pedestrians' security expectations are to be satisfied, and a new or different approach is needed to assist in intersection modification decisions.

Indeed, serious challenges have been raised about LOS in the broader context of transportation demand management (TDM) and alternative transportation strategies. The following comment on LOS as a criterion for measuring or evaluating transportation system performance - - including signalized intersection performance - - is especially relevant to our research on new or different walking security index formulations (TRB, 1991, p. 177):

> Level-of-Service Measures
>
> The use of the LOS criterion in system evaluation can lead to wrong policy decisions, because it does not provide information about nonautomobile modes (transit, bicycling, walking) and HOVs. Congestion itself may not be bad, and may in fact be necessary for success of TDM strategies. The LOS criterion should therefore be replaced with a criterion or set of criteria that addresses all modes, environmental objectives, and urban form issues. The criteria should measure person mobility rather than vehicle mobility, and should include standardized consideration of performance with respect to environmental, social, and economic efficiency objectives.

Before presenting the IPC-F Index, several premises upon which it is based need to be made transparent and explicit.

First, Ottawa-Carleton is a metropolitan region with a mature, multi-modal transportation system. As a result, while questions can be raised about the levels of use that cars, trucks, buses, cyclists and pedestrians make of intersections, it remains as a basic principle that intersections must continue to serve the transportation needs of **all**

residents and visitors in Ottawa-Carleton. Indeed, that point was frequently made, albeit resignedly in some cases, by the pedestrians who were interviewed during the survey and re-survey studies done at the Laurier Avenue-Nicholas Street intersection (Wellar, 1995; Wellar and Froelich, 1996).

The consequence of this principle is that while pedestrian security would be enhanced if there were no other modes of transport, and no roads or intersections to move vehicles, that is not the reality with which we are dealing. As a result, the scoring system developed for this index is based on the understanding that it is standard practice for intersections to consist of multiple lanes, many of which allow for turning movements and bi-directional traffic flows.

The challenge in formulating this index, therefore, involves the **threshold concept** noted above in the discussion about warrants. That is, we need to identify the critical junctures at which intersection design or operational features, primarily intended to serve the other modes, have an unacceptable impact on the reasonable expectations that pedestrians hold in regard to their security.

Second, it is intended that the index provide guidance as to the need for and nature of intersection modifications that are conducive to achieving pedestrians' security. As a result, the scoring system is constructed so as to produce an early and sharp warning about current or impending situations that need modification if pedestrians' security is to be achieved.

And, along that same line of reasoning, the index is designed to yield an early and sharp warning about proposed modifications that are likely to jeopardize pedestrians' security. As such, a design principle for the scoring system is that it not err by understating the degree to which modification-type variables and attributes negatively affect pedestrians' security.

Third, the IPC-F Index could be formulated in a checklist format similar to that for the Quality of Infrastructure Condition (QIC) Index discussed above in Section D-d.

Preliminary tests of a checklist approach in this case indicate, however, that due to the large number of variables and the wide range of values associated with the variables, the 'solution' gets very messy. Further, the various values assigned to independent variables may not represent nor be the result of independent events. That is, the values assigned to one variable could be determined or affected by the values assigned to another variable for a very good reason: the level of pedestrian security achieved by an intersection is the combined product of many variables, some of which may interact to yield a combined result which is greater or less than the sum of its parts.

As a result of those considerations, it appears that the formulation of this index should be of the commutative type where the order of independent variables does not affect the output quantity (index score). And, it should rank intersections in terms of the challenge to pedestrian security that is caused by intersection features.

In recognition of all the points of context given above, the intersection pedestrian challenge-features (IPC-F) Index is therefore formulated as follows:

$$\textbf{IPC-F} = \textbf{NLR} \bullet \textbf{NTLTR} \bullet \textbf{IGR} \bullet \textbf{DTFR} \bullet \textbf{NCR} \qquad \textbf{(4)}$$

Where,

IPC-F = intersection score on challenge to pedestrian security that is caused by intersection features
NLR = number of lanes rating
NTLTR = number of turn lanes by type rating
IGR = intersection geometry rating
DTFR = direction(s) of traffic flow rating
NCR = number of channels adjacent to intersection rating.

The rating system for the IPC-F Index variables is presented in Table 8. As with previous rating systems (e.g. Table 7), the values (for variables) are based on comments received throughout the study from elected officials, professional staff, and especially pedestrians, on the degree to which differences in the attributes of variables (e.g., 8 lanes versus 16 lanes) affect pedestrians' security.

Table 8. Variables and Rating System for the Intersection Pedestrian Challenge - Features (IPC-F) Index.

Number of Lanes Rating (NLR) System ≤ 8 lanes = 1.0 9-12 lanes = 1.5 13-16 lanes = 2.0 17-21 lanes = 3.0 > 21 lanes = 4.0
Number of Turn Lanes By Type Rating (NTLTR) System 0 turn lanes = 1.0 1 protected turn = 1.25 2 protected turns = 1.50 3-4 protected turns = 2.00 > 4 protected turns = 3.00 1 permissive turn = 1.50 2 permissive turns = 3.00 3 permissive turns = 4.00 > 3 permissive turns = 6.00
Intersection Geometry Rating (IGR) System All 90° angles = 1.0 1 non-90° angle = 1.25 2 non-90° angles = 1.50 3 non-90° angles = 2.0 4 non-90° angles = 3.0
Intersection Slope Rating (ISR) System All roadway approaches ≤ 4° = 1.0 1 approach > 4° = 1.25 2 approaches > 4° = 1.50 3 approaches > 4° = 2.00 4 approaches > 4° = 3.00
Direction of Traffic Flow Rating (DTFLR) System All legs 1-way = 1.0 1 leg 2-way = 1.25 2 legs 2-way = 1.50 3 legs 2-way = 1.75 4 legs 2-way = 2.0
Number of Channels Adjacent to Intersection Rating (NCR) System 0 channels = 1.0 1 channel = 1.25 2 channels = 1.50 3 channels = 2.0 4 channels = 3.0

In order to help ensure that the nature of the IPC-F Index and the logic behind the ratings systems are properly construed, several explanatory remarks are presented.

First, there may well be other variables that should be included in this Index. However, these are the variables which are supported by evidence acquired to date. The inclusion of other variables for which we do not have sufficient supporting evidence would diminish the robustness of the formulation.

Second, the values assigned are estimates, and are used in a relative sense. They are not presented as absolutes, and it is inappropriate for them to be construed as absolutes.

Third, the use of a quantification procedure -- assigning numbers -- does not mean that we are in the realm of so-called "hard science" (Ackoff, 1953; Bailey, 1987; Bowler, 1992; Christensen, 1991; Committee on the Conduct of Research, 1994; Walizer and Wienir, 1978; Wellar and Harris, 1992). Rather, the assignment of numbers is done in order to enhance the operational aspect of the Index, since computations involving many variables and values can be more efficiently performed via the use of numbers than by the use of qualitative terms.

Further, the assignment of numbers also has the advantage of increasing the flexibility or room to maneuver in regard to the range of values that can be assigned to variables, and to the range of values that the product can attain when variables are combined. This is not to say, of course, that a qualitative procedure could not be used, even with a commutative or combinatorial-type formulation. One cost of such a procedure, however, is that interpreting the outcome can be very difficult when the product is a synthesizing term that represents all the other terms used to represent the values of variables, or variable attributes in the index formulation.

Fourth, and very importantly, it is emphasized that there is room to differ about the numeric values assigned to the variable attributes. For example, it is reasonable to argue that the values for the slope (IS) variable should be higher in the winter than in the summer when the likelihood of skidding is higher. Or, that the values for the turning lane

variable (NTLTR) should be higher or lower for the numbers of permitted or permissive turns. The fact remains, however, that this formulation is a construct which has been developed for consideration by the Regional Municipality of Ottawa-Carleton. As a result, detailed discussions about the particulars of the construct are properly pursued if and when implementation of the IPC-P Index is contemplated in principle. Should that occur, then it would be appropriate at that time to go into the details about whether to have regard for left turns only, or both left and right turns.

An illustration of the Intersection Pedestrian Challenge-Features (IPC-F) Index in operation is presented in Table 9. Eight intersections are used to demonstrate how this Index ranks the intersections in terms of the walking environment that they create for pedestrians.

Bearing in mind **all** the *caveats* and conditions presented earlier to mitigate against misconstruing the outcomes, the following comments on Table 9 indicate how the IPC-F Index provides guidance regarding needed or proposed intersection modifications.

1. On a scale measuring intersections along the friendly-to-hostile spectrum, Woodroffe/Lenester/Georgina (Intersection A) is friendly and Carling/Iroquois (Intersection F) is hostile. By way of brief description, Woodroffe/Lenester/ Georgina is relatively small, square, has no slope and no channels. By comparison, Carling/Iroquois is much larger, no angles are square, the intersection is at the bottom of a hill, multiple turns are permissive, and it has a large channel and large channel island.

2. Intersection C (Kirkwood/Merivale) is a relatively small intersection, but its high level of slope and irregular geometry make for what is locally referred to as a "scary situation" for pedestrians.

3. Intersection H (Bank/Walkley) is a large, sloped, multi-turn, channelized intersection which is ranked as very hostile to pedestrians' security. A walkabout of the intersection and the one at Carling/Iroquois may be instructive for anyone wondering

Table 9. Application of the Intersection Pedestrian Challenge-Features (IPC-F) Index.
IPC-F = NLR • NTLTR • IGR • ISR • DTFR • NCR*

Intersection Location	IPC-F Value
Intersection A: Woodroffe Avenue and Lenester Avenue/Georgina St. NLR = 1.5; NTLTR = 1.0; IGR = 1.0; ISR = 1.0; DTFR = 2.0; NCR = 1.0 IPC-F = 1.5 • 1.0 • 1.0 • 1.0 • 2.0 • 1.0 = 3.0	3.0
Intersection B: Laurier Avenue and Elgin Street NLR = 3.0; NTLTR = 4.5; IGR = 1.0; ISR = 1.0; DTFR = 2.0; NCR = 1.0 IPC-F = 3.0 • 4.5 • 1.0 • 1.0 • 2.0 • 1.0 = 27.0	27.0
Intersection C: Kirkwood Avenue and Merivale Road NLR = 2.0; NTLTR = 3.5; IGR = 1.25; ISR = 2.0; DTFR = 1.75; NCR = 1.0 IPC-F = 2.0 • 3.5 • 1.25 • 2.0 • 1.75 • 1.0 = 30.7	30.7
Intersection D: Laurier Avenue and Nicholas Street NLR = 3.0; NTLTR = 2.5; IGR = 1.0; ISR = 1.25; DTFR = 2.0; NCR = 3.0 IPC-F = 3.0 • 2.5 • 1.0 • 1.25 • 2.0 • 3.0 = 56.3	56.3
Intersection E: Rideau Street and King Edward Avenue NLR = 3.0; NTLTR = 3.0; IGR = 1.25; ISR = 1.25; DTFR = 2.0; NCR = 1.0 IPC-F = 3.0 • 3.0 • 1.25 • 1.25 • 2.0 • 1.0 = 56.3	56.3
Intersection F: Baseline Road and Greenbank Road NLR = 4.0; NTLTR = 3.0; IGR = 1.0; ISR = 1.25; DTFR = 2.0; NCR = 3.0 IPC-F = 4.0 • 3.0 • 1.0 • 1.25 • 2.0 • 3.0 = 90.0	90.0
Intersection G: Carling Avenue and Iroquois Road NLR = 4.0; NTLTR = 4.0; IGR = 3.0; ISR = 1.25; DTFR = 2.0; NCR = 1.5 IPC-F = 4.0 • 4.0 • 3.0 • 1.25 • 2.0 • 1.5 = 180.0	180.0
Intersection H: Bank Street and Walkley Road NLR = 4.0; NTLTR = 3.0; IGR = 1.0; ISR = 3.0; DTFR = 2.0; NCR = 3.0 IPC-F = 4.0 • 3.0 • 1.0 • 3.0 • 2.0 • 3.0 = 216	216

* Where,
NLR = Number of Lanes Rating
NTLTR = Number of Turn Lanes By Type Rating
IGR = Intersection Geometry Rating
ISR = Intersection Slope Rating
DTFR = Direction of Traffic Flow Rating
NCR = Number of Channels Adjacent to Intersection Rating

whether they are worthy of the big (bad) numbers relative to the other intersections for which the Intersection Pedestrian Challenge-Features Index is calculated.

4. Intersection D (Laurier and Nicholas) and Intersection E (Baseline/Greenbank) received the same score of 56.3, even though they are assigned different values for the NTLTR, IGR, and NCR variables. Since both intersections are assigned pejorative nicknames by local users (i.e. "Fear and Loathing" at Laurier and Nicholas; "Intersection from Hell" at Rideau and King Edward), it appears that the IPC-F Index performs well in terms of reconciling differences to produce an accurate rating on what intersections have in common *vis-à-vis* pedestrians' security.

Based on the examples given above, the following kinds of guidance or advice can be elicited from the IPC-F Index:

1. Due to their size, intersections G and H are candidates to be modified 'downwards'. That is, they constitute hostile environments for pedestrians and action could legitimately be asked for or taken to modify one or several aspects of these intersections.
2. For reasons of slope and geometry, intersection C is a candidate for modification in order to satisfy pedestrians' expectations about safety, comfort, convenience. As can be seen via on-site inspection, this intersection is seriously lacking in its regard for pedestrians' security, and the score of 30.7 appears to accurately capture the problems experienced by pedestrians at this small but "scary" site.
3. The variable that is largely responsible for driving up the rating for intersection B (Laurier/Elgin) is the turn lane variable at a rating of 4.5. That is the highest (worst) NTLTR score among the intersections used as examples, and it highlights a common complaint made by pedestrians: even with turn restrictions for some hours, the large number of turn lanes makes Laurier/Elgin a "mess" for pedestrians. The point of guidance here, perhaps, is that this intersection needs to be "simplified" by way of turn restrictions.
4. Channels are a strongly pro-vehicle means of moving traffic, but they are broadly deemed to be hostile to pedestrians. Since it appears to be the channels at Laurier/Nicholas, Carling/Iroquois and Bank/Walkley that most contribute to making life difficult for pedestrians at those locations, it occurs that: a) some or all of the channels could be closed or modified; or, b) the rating system should be adjusted upwards to better reflect the very negative impact that channels have on pedestrians' security.

5. Various combinations of variables and scores can result in the same ratings. Examination of the variables using a sensitivity analysis-type approach provides a clear, numeric indication of which variables need to be changed, and by how much, to generate ratings consistent with pedestrians' expectations.

Further refinement of the ratings system would yield even more definitive measures and advice on how to best modify intersection features to achieve pedestrians' security objectives. Clearly, the IPC-F Index provides a very substantive, flexible means for asking informed questions and making informed decisions in regard to intersection feature modifications.

F. Basic Walking Security (BWS) Index

As discussed in detail in this and prior WSI Project reports, the security expected and experienced by pedestrians is affected by both the structural and functional aspects of intersections. In brief, **it is the mix of intersection traffic features and performance characteristics which affects pedestrians' security, comfort and convenience.** To this point in Section D, a number of indexes have been presented which reflect various elements or components which make up the mix of structural and functional considerations. And, while each of those indexes serves a useful purpose, none of them presents "the big picture" which is needed to provide information and guidance for effective decisions and actions that involve intersection modifications.

The design of the Basic Walking Security Index (BWSI) is intended to combine both structural and functional variables in one formulation. There are several premises, *caveats*, etc. that need to be explicitly noted, however, before the index is presented.

1. The descriptor 'Basic' is most appropriate. Only a small proportion of the candidate variables are included, and no claim about comprehensiveness or completeness can be made or is made.[10]

2. This formulation is a first approximation. There are numerous other variables which could reasonably and legitimately be included on the basis of documentation provided in earlier WSI Project Reports. However, for reasons of complexity, data

availability, and operational constraints, no productive purpose is served by "throwing in every pertinent variable".[11]

3. Since the (potential) amount of interaction between vehicles and pedestrians directly affects pedestrians' security, it is a matter of basic logic that the WPCE-PIP Index be part of a composite formulation. As noted above, however, the contribution of the WPCE-PIP Index will increase substantially for all those intersections that are 'fine-tuned' by means of a pedestrian age or life-cycle adjustment factor.

4. Since the physical configuration of an intersection directly affects pedestrians' security expectations and experiences, it is a matter of basic logic that the IPC-F Index be part of a composite formulation. And, as shown in Section D - *E,* it is also basic logic that vehicle-oriented features based on "warrants", "improvements" and "LOS" cannot be taken as givens. Instead, **more *and different* research is required to ensure that proper classes, weights, etc. have been assigned from the perspective of pedestrians' security**.

5. The BWSI formulation combines numbers that could be 6, 7, 8 or more digits in length. Bearing in mind that the numbers serve rating or ranking purposes, their value is properly regarded as being relative rather than absolute. However, should consideration be given to such procedures as taking square roots or 'knocking off zeroes', then the reader is advised that the integrity of the formulation could be put at risk for no apparent methodological or technical benefit.

With those background remarks as context, the following formulation is proposed as a means of measuring and evaluating how well pedestrians' security expectations are matched by experiences at signalized intersections in Ottawa-Carleton:

$$\mathbf{BWS = (WPCE\text{-}PIP) \bullet (IPC\text{-}F)} \qquad \mathbf{(5)}$$

Where,

BWS = a composite index score (number) that ranks signalized intersections according to the likelihood that pedestrians' security expectations are matched by experiences.

WPCE-PIP = an index score (number) that represents the quantity of potential interactions between pedestrians or vehicles (expressed as passenger car units) at signalized intersections.

IPC-F = an index score (number) that represents the magnitude of challenge to pedestrians' security caused by intersections' features.

The WPCE-PIP and IPC-F components are developed in detail above in Section D-e and D-f, so there is no useful purpose in repeating that discussion. However, there are several matters of interpretation and explanation involving the BWS side of the formulation that will need to be made explicit.

First, the Basic Walking Security Index (BWSI) is a derived index. That is, it combines the WPCE-PIP and IPC-F indexes. For all intents and purposes, then, the amount of effort involved in deriving BWS scores for intersections is trivial after the WPCE-PIP and IPC-F values have been calculated.

Second, the BWS Index, like any index, yields a number that represents a synthesis of values associated with two or more variables. As a result, care must be exercised to use the scores as intended, that is, as a means for ranking or rating intersections on a **relative** basis. In other words, it is totally inappropriate to use an index score for an intersection in isolation from index scores from other intersections.

Third, the same or very similar BWS Index scores can result from very different combinations of scores from the WPCE-PIP and IPC-F Indexes. It is therefore incumbent upon the user of the BWS Index to exercise due diligence when examining the BWS Index scores. Of particular concern, given the long history of index abuse and misuse, is that the analysis-synthesis of BWSI scores not be done outside the context of the WPCE-PIP and IPC-F scores. Indeed, given that one set of scores is a derived product of the scores, there does not seem to be any apparent good grounds for presenting the BWSI scores without the WPCE-PIP and IPC-F scores as supporting evidence.

The three matters of interpretation and explanation noted above are not particular to the BWS Index. Rather, they are part of the broader set of reservations and complaints

about index abuse and misuse that arose during discussions with community association groups and members, and other ordinary citizens, in Ottawa-Carleton. Their concerns dealt with differences between how indexes are intended and designed to be used, and how they could be or might be used in a manipulative way by vested interests.

Those kinds of concerns impact on the public's perception of indexes, and on the credibility or cynicism attached to index scores. As a result, it is appropriate to address them directly as part of the explanation about the intent, design, and proper use of the Basic Walking Security Index.

The origin of community complaints about index abuse and misuse in many cases appears to reside in experiences with Ontario Municipal Board (OMB) panels. And, the nature of the complaint is the seeming sanctity accorded evidence from "expert witnesses" recognized by the panel members. As a case in point, let us briefly consider the level of services (LOS) index critically discussed above in Section D-e.

Although under challenge for years on technical, planning and political grounds, OMB panels in Ottawa-Carleton are perceived to have had a great deal of time for "experts" treating different LOS schemes and scores as if they had an absolute truth aspect to them. However, and the evidence on this is demonstrably overwhelming, whatever value LOS scores have is by definition **relative**. That occurs because the LOS rating system is relative (A to F), and because the basis of the ratings involves making comparisons among intersections in order to give meaning to the LOS ratio for any intersection. Further, in regard to LOS or any index score, it is illogical in the extreme to proceed as if an index itself specifies the significance to attach to a score. Rather, the user or proponent, if following proper procedure, decides or defines what a score means **relative** to what other scores mean (Allan, 1975; Bailey, 1987; New York Times (1997); Sheldon and Moore, 1986; Simon, 1978).

Moreover, and this point was made on a number of occasions, it appears that few community groups in Ottawa-Carleton have had much success in arguing the case for pedestrians at OMB hearings. Rather, the argument which is seen to have tended to

carry the day is that of proposed road and intersection widenings on behalf of moving more vehicles faster. Period.

There are, therefore, two parts to the concern of ordinary citizens that need to be addressed in setting out the intended and designed purpose of the BWS Index.

First, by way of context, it is necessary that the Ontario Municipal Board, as well as Regional Committees and Council and other entities that affect pedestrians' security, have **all due regard** for the Official Plan and the Transportation Master Plan, Regional Municipality of Ottawa-Carleton (Malinsky and Wellar, 1998; RMOC, 1997a, 1997b). And, we specifically refer to those sections of the Plans which speak to the matter of serving and promoting the needs of pedestrians. Upon achieving due regard for pedestrians' expectations in principle, then it is logical to consider use of the indexes to achieve pedestrians' security in practice.

The intended and designed purpose of the BWS Index is to generate **relative** rankings or ratings of intersection features and performance from the perspective of pedestrians' security. The implications of the rankings or ratings in terms of modification decisions and actions is a political-technical matter to be worked out by elected officials, professional staff, and the citizens of Ottawa-Carleton. Towards that end, the Basic Walking Security Index is a means of "putting all the cards on the table", so to speak, since it includes a large number of variables with room for others to be added as necessary.

And, very importantly, only a few, basic arithmetical operations are required to yield the rankings or ratings. There are no polynomials, no quadratic functions, no coefficients of determination to compute. As a result, there is no role or need for "rocket science experts" to calculate and interpret what it all could mean or might mean.

In other words, there appears to be no mysticism in the numbers generated, nor in how they are generated. Hence, there is no apparent reason for OMB-type expert witnesses to propound on the meanings of the numbers, or their relation to the Official Plan and

Transportation Master Plan (RMOC, 1997a, 1997b). Rather, the Basic Walking Security Index scores seem to speak for themselves - - on a relative basis - - and elected officials, professional staff, and area citizens appear fully competent to use the scores as one of the inputs affecting decisions and actions on intersection modifications.

It is necessary to explicitly acknowledge and emphasize here that comments on the transparency and ease of use are not the result of field testing the BWS Index. Rather, the comments represent the Principal Investigator's impressions as to how the Index will be perceived and received by elected officials, professional staff and ordinary citizens.

As a result, and although the impressions are based on many encounters, discussions, etc. over several years, they could be in error about the level of technical expertise needed to use the Basic Walking Security Index as intended. This is a matter for serious consideration by the Regional Municipality of Ottawa-Carleton, therefore, since only the client or contracting agency is in position to evaluate whether the formulation satisfies the degree of difficulty criteria (Section C and Appendix B).

Finally, at the operational level, a body of rules or procedures will be needed to organize and use the BWS Index scores. In brief, the Index scores are data, and decisions and actions will need to be taken on how to **transform those data into information and knowledge for policy, plan and program purposes**. This point serves as an explicit reminder that actual implementation of the BWS Index depends totally on the elected officials, professional staff, and ordinary citizens of Ottawa-Carleton to make it serve and promote pedestrians' security.

G. Aggressive Driving Indexes

The formulations in this sub-section address the threat to pedestrians' security that is caused by what is labeled 'aggressive driving' for the purposes of this report. Other terms and descriptors used to refer to what we call aggressive driving and drivers include 'road rage', 'road hog', and numerous profane terms and phrases of disparagement to characterize the opposite of defensive, safety-first, after-you-driving.[12]

Interest in this aspect of pedestrians' security began with the channelization study (Wellar, 1995), and the re-study (Wellar and Froelich, 1996). During interviews many pedestrians made reference to aggressive drivers at the channel and at signalized intersections. However, since the general phenomenon of aggressive driving was not part of the terms of reference for those studies, nor the WSI Project, on-site, empirical evidence was not accumulated in a methodologically designed manner. As a result, we do not have a robust body of empirical data at our disposal to justify proposing aggressive driving indexes.[13]

Instead, the case for suggesting this kind of index is based on the large number of newspaper accounts that report on aggressive driver incidents in Ottawa-Carleton and elsewhere. Specifically, we have gone from a limited collection of such articles, several of which were published in Interim Report 1 (Wellar, 1996a), to many dozens of articles indicating widespread, worsening problems of seemingly epidemic proportions in this region and elsewhere.

Based on both the amount of coverage given the topic, therefore, and the fact that this literature appears to satisfy all the variable selection criteria (Section C and Appendix B), several aggressive driving indexes are presented for consideration.

The first aggressive driving formulation, which has three parts, involves the widely- and frequently-complained about act of "running the lights". This formulation is expressed as follows:

$$\textbf{Aggressive Driving: Red (ADR) Index} = \frac{\textbf{\# of vehicles through on red/hr}}{\textbf{total \# of vehicles/hr}} \quad (6)$$

$$\textbf{Aggressive Driving: Amber (ADA) Index} = \frac{\textbf{\# of vehicles through on amber/hr}}{\textbf{total \# of vehicles/hr}} \quad (7)$$

$$\textbf{Aggressive Driving: Red and Amber (ADRA) Index} = \frac{\textbf{\# of vehicles through on red + amber/hr}}{\textbf{\# of vehicles/hr}} \quad (8)$$

The magnitude and level of anger, irritation, etc. associated with this form of aggressive

driving behavior has been discussed in previous reports (Wellar, 1995, 1996a, 1996c). And, it is further elaborated in the report investigating newspaper coverage of the topics considered during the WSI Project (Wellar, 1998). The point of common concern, noted in interviews and in media reports, is that aggressive driving behavior shows disregard for the right of pedestrians to be free from care or cure when (legally) crossing an intersection.

Among the specific reasons for creating the aggressive driving indexes (red, amber, red + amber) are the following:

1. Drivers in the aggressive mode are, in real or perceived terms, more likely to be watching for other vehicles than to be on the look-out for pedestrians;

2. Drivers running the lights may accelerate their vehicles in advance of the intersection, in the approach, or in the intersection itself. Any of these actions makes it more difficult for vehicles to be stopped quickly when pedestrians are in the roadway. Further, it is more difficult for pedestrians to comprehend the situation, decide upon a course of action, and then take evasive action with a vehicle accelerating towards him or her at a higher-than-expected rate of speed;

3. Drivers running the lights often do so in "packs". That is, two, three, four or more drivers proceed through on the red or amber with minimal headway (distance between rear and front bumpers) between them.

   This "pack action" poses major risks to pedestrians' security, and especially in large, complicated intersections where pedestrians may be in the crosswalk while cars are tail-gating to get through. And, pedestrians' security is also threatened when road conditions are hazardous due to rain, snow or ice, and braking is more difficult to achieve. Intersections which are cases in point here include Carling/Iroquois, Merivale/Kirkwood, Bank/Walkley and Rideau/King Edward (Table 8, Section D-d) which have sloped road segments approaching the intersection.

In addition to running the lights, there are several other behaviors of drivers that are rated as aggressive because they put pedestrians at risk. Or, they impose an undue care or cure burden upon pedestrians. While a number of such behaviors could be elicited from the lists of variables in Tables C-1 to C-5, Appendix C, the following index represents an

aggressive driver behavior that is substantively supported by evidence acquired over the course of the WSI Project.

Aggressive Driving: Fail-to-Yield (ADFY) Index =

$$\frac{\text{\# of vehicles that fail to yield to peds/hr}}{\text{total \# of vehicles/hr}} \quad (9)$$

The fail-to-yield index applies in all those crosswalk and channel situations where vehicle operators engage in the following kinds of behaviors that threaten pedestrians' security:

- Race through crosswalks on either side of the intersection in order to "beat" pedestrians to the mid-way point;
- "Nose into" crosswalks, even when pedestrians are on a walk signal, so as to stop pedestrians from walking and allow one's vehicle to be driven through; and,
- Proceed into and through channel crosswalks with no actual regard for pedestrians who are waiting to cross, who are starting across, or who have not yet completed crossing.

These kinds of fail-to-yield behaviors were noted in the original study of the Laurier-Nicholas channelization problem (Wellar, 1995), and have been confirmed and re-confirmed without exception via interviews, meetings with community associations, and responses to the lists of variables by elected officials and lay experts.

There appears to be no question, therefore, about the need for including aggressive driving indexes among the many indexes that are pertinent to the WSI Project terms of reference contained in Table 1. And, it appears, there are no indexes which are as effective or efficient - - they require very few variables, and measure major impacts - - in making the case for undertaking the modifications necessary to achieve pedestrians' reasonable expectations about their security at signalized intersections.

3. Other Walking Security Index Formulations

The numerous WSI variables listed in Section C can be combined in even more numerous ways to create a very large number of credible indexes. Indeed, for **each** type

of variable list, it is possible to formulate more indexes than are presented in Section D of the Final Report.

It was not the intent, however, nor were sufficient resources allocated, to develop an exhaustive array of indexes. Rather, our focus is on formulations that meet the terms of reference (Table 1), advance the field of research on pedestrians' security, and are supported by the evidence acquired over the course of the project. As a result, the ten indexes presented above are those which mark the completion of the index specification task.

In addition to the fully-specified indexes, however, there are a number of formulations under consideration that could be termed "works-in-progress". These are formulations which are at various stages of development, but must (temporarily) remain works-in-progress due to lack of resources (financial, time) to bring them to full specification.

Among the various indexes that are prime candidates for further research, there appear to be two which are especially noteworthy. First, an index titled *Intersection Pedestrian Challenge - Performance (IPC-P)* would be extremely pertinent. That occurs, obviously, because it picks up on the features-performance theme that has been present throughout the study. Moreover, it would cover off the functional component of the structural-functional approach to defining intersections discussed previously (Wellar,1996b, 1997a, 1997b).

Further, within the category of "works-in-progress", are relationships and index ideas proposed by professional staff, elected officials and citizens. These suggestions arrived late in the study schedule, and were not subjected to in-depth examination due to time and resource constraints. It is reasonable to expect, however, that the search for "better" indexes has likely just begun.

Second, from a global or "big picture" perspective, it would be instructive to conceptualize a comprehensive, multi-variable index that combined all the pertinent feature (structural) and performance (functional) variables. The formulation might best be set up in both the

checklist and equation formats for *compare and contrast* purposes, and to provide guidance on implementation opportunities and challenges.

This index is tentatively titled *Intersection Modification Needs Assessment (IMNA) -- Pedestrians' Perspective*. The purpose of the index would be to identify **feature and performance** aspects of signalized intersections that require modification in order to meet pedestrians' security (safety, comfort, convenience) expectations.

It is appropriate to close this reference to other indexes by noting two *caveats*. First, **more methodologically designed research is needed to explore and confirm whether introducing and combining more variables yields more and better information on the status of pedestrians' expectations and experiences in Ottawa-Carleton**. Anything less not only perpetuates the inequities of the past, but will likely lead to worsening the already wide, unsatisfactory gap between pedestrians' security experiences and their legitimate expectations. Based on responses to Project activities and reports, it appears that a solid foundation of concepts, methodologies, variables and index formulations is now in place to support additional, **robust** research, which builds on and extends the results achieved to date.

Second, and as discussed by the Principal Investigator at the 1998 Conference, Association of American Geographers, the importance of the **spatial aspect** to traffic movement was recognized decades ago in the 1965 edition of the *Highway Capacity Manual* (HRB, 1965).

The WSI Project continued that tradition, but only in a **limited** way. That is, a number of variables are identified which can be represented as points, lines or polygons. Hence, the spatial aspect is recognized, but largely at the geo-referencing level for purposes of description (Wellar, 1997a; Wellar and Soroko, 1997).

A remaining research task, which was outside the purview of the current study, is to formally investigate why and how the spatial factor affects pedestrians' security throughout Ottawa-Carleton. Towards that end, consideration needs to be given to

hypothesizing-theorizing types of investigations in order for the index formulations to achieve operational, real-world applicability.

4. Notes

1. The pertinence of qualitative, quantitative and visualization procedures to the design, development, implementation and monitoring of a WSI-based capability in Ottawa-Carleton goes far beyond appreciating index formulations. That is, the procedures are generally pertinent to how we transform existing reality to data, data to information, information to knowledge, and knowledge to preferred reality. As a result, this brief reference to the three procedures understates their fundamental significance to the entire process of moving the WSI from an idea and concept to an operational reality.

2. Sources of evidence as to the widespread antipathy towards mathematics and statistics include university classes, municipal council and committee meetings, Ontario Municipal Board hearings, and check-out counters in drugstores. Many people of all ages appear to be "numerically-challenged", which suggests the need to supplement numeric formulations with textual and graphic descriptions.

3. The Hazard Exposure Index (HEI) was adopted by North York (Council) in 1979 as a means of evaluating requests and making reasoned decisions involving sidewalks. Similarities between the HEI and WSI initiatives include the following: active involvement of electeds, professionals, and ordinary citizens in deliberations; and, common regard for many of the variables, to the point of referring to a category of essential variables that "really" measure what is happening between vehicles and pedestrians. For newspaper coverage of the reception given to the HEI initiative see, for example, the following issues of the *Toronto Star:* August 9, 1979; and September 6, 18 and 20, 1979.

4. A related problem involves making distinctions among cars, heavy trucks, buses, and articulated buses when calculating intersection loadings, capacity, level of service

(LOS), etc. The associated argument is that due to differences in size, maneuverability, etc. they do not all have the same impact on, for example, intersection capacity, service volumes, and levels of service. Hence, adjustment factors are used to 'correct' for the differences so that vehicle units or some other common metric can be used. In the WSI situation, the challenge is to develop a formulation which adjusts for the different impacts that vehicles and pedestrians have on pedestrians' security, comfort, convenience.

5. The foundation for adopting this premise extends as far back as the initial channelization study (Wellar, 1995), and has been reinforced by additional fieldwork and literature search findings (Wellar, 1996c, 1997c, 1997d; Wellar and Froelich, 1996). Preliminary investigation of the premise as a research hypothesis was supported, but questions arose and continue to arise, about the levels at which different effects are experienced, and whether there are differences in effects as they relate to the safety, comfort and convenience of pedestrians, respectively. For operational purposes, then, and assuming that population-type studies are not necessary nor advisable, it would be appropriate for RMOC or other interested parties to transform investigation of **research hypotheses** to investigation of **statistical hypotheses** in order to more precisely ascertain the effects of different vehicle and pedestrian loadings on pedestrians' security.

6. The use of weighted formulations was discussed following a presentation by the Principal Investigator on the Walking Security Index Project, at the 1998 Conference of the Association of American Geographers, in Boston, March 25-29. One such formulation is $p \cdot v^2$ which is apparently used in the U.K.

7. The term "inappropriate" covers a variety of associated terms including immoral, unethical, unfeeling, irresponsible, unconscionable, etc. Readers interested in further elaboration of 'inappropriate' need only attend a municipal council or committee meeting, or neighborhood association meeting, which has a troublesome or dangerous intersection on the agenda. When the affected residents are adamantly

forceful about long overdue changes being made, they make use of many terms to characterize those who are seen to be unresponsive or insensitive to residents' needs or wishes.

8. This unqualified statement about the Region's computational capabilities being sufficient to implement any of the indexes is based on previous and current reviews of numerous documents containing similar formulations. There is, in the Principal Investigator's opinion, no question whatsoever about the Region's capability to effectively and efficiently undertake any and all tasks associated with implementing and maintaining the indexes at levels commensurate with pedestrians' expectations.

9. An example of a decision rule, or of a decision rule in action, is setting a threshold or target limit for traffic volume which, upon being reached, provides grounds for installing signals. One of the more common and sometimes hotly contested warrant situations involves decisions about whether traffic volume or other considerations justify putting stop signs on collector roads in residential neighborhoods.

10. This acknowledgment is intended to inform readers that many relationships remain to be investigated and, by extension, they are invited to build on, critique, vary, etc. the lines of inquiry presented in both the Interim Reports and the Final Report of the WSI Index Project.

11. This line of reasoning is well-established in statistics, and is illustrated by judicious use of such techniques as analysis of variance. In the former case, when an appropriate sampling system is used there is little or no information gain from adding to the sample size. And, in the latter case, there may be little or no information benefit achieved from the addition of marginal variables which account for ever-decreasing amounts of variance.

12. For more discussion of terms used to describe pedestrians' feelings about aggressive drivers and driving, see pages 28-33 and Table YQ5 (p.32) in the original channelization study (Wellar, 1995).

13. Assignments in several courses (GEG 2306 - Urban Geography, and GEG 3104 - Research Methods) in 1997 included a fieldwork component whereby students observed the incidence of aggressive driving at selected intersections. Their observations are deemed to be more than sufficient to establish that aggressive driving does occur at signalized intersections in many parts of Ottawa-Carleton, and that empirical grounds to justify proposing this kind of index could be readily achieved via study of either the population or a systematic sample of signalized intersections.

E. RECOMMENDATIONS FOR INTERSECTIONS THAT SERVE AND PROMOTE BASIC NEEDS OF PEDESTRIANS

1. Origin of Recommendations

In the Projects' terms of reference (Table 1), term 2d) states that the Walking Security Index (WSI) Project shall be designed to:

> Identify generic and site-specific intersection modifications that serve and promote pedestrian security (safety, comfort, convenience, other).

The proposals presented in this section respond to term of reference 2d). However, and as the term "basic" in the heading might suggest, our attention is on the primary or high-priority recommendations that are deemed to serve and promote "basic needs". Other important but less urgent modifications are left for attention in subsequent studies.

2. Criteria for Selecting "Basic Needs" Modifications

As the reader may be aware, the Regional Municipality of Ottawa-Carleton has long been a recipient of modification (or "improvement") proposals. By way of recent example, both the Official Plan review (RMOC, 1997a) and the Transportation Master Plan review (RMOC, 1995a, 1997b) generated a large and diverse number of proposals for transportation system changes, with many of them related to pedestrians' safety, comfort, convenience, and related considerations.

It is the express intent of this section to not replicate the laundry-list approach that is frequently used to collate outpourings of wishes on matters of public interest. Instead, the proposals are based on the criteria previously used to select variables and to specify index formulations.

To recall the criteria (see Section 2b and Appendix B for discussion) they are:

1. Pertinency
2. Support
3. Degree of difficulty
4. Enforceability
5. Data availability.

In terms of their application, the ideal proposals are those for which pertinency and support are highest, and for which problems involving degree of difficulty (legal, technical, etc), enforceability, and data availability are lowest.

Finally, in regard to criteria used to select the proposed modifications, there is the matter of "do-ability" or "manageability". That is, if too many proposals are made, the risk increases that nothing will get done.[1] Hence, emphasis here is on basic needs, that is, the modifications that must be undertaken and which, if undertaken, are likely to make significant contributions to enhanced security of pedestrians in Ottawa-Carleton.[2]

3. Proposed Basic Intersection Modifications

A total of 17 modifications are proposed, and the essential reasons behind their selection are presented. Since it is not our task to produce a comprehensive manual on modifications, readers seeking details about the whats, whys, and hows of the proposals are invited to review the Interim Reports and the references cited in the reports.

A. Install Red-Light Cameras

As of this writing, two kinds of cases have been made with regard to red-light cameras. First, they are an exemplary modification in regard to all the selection criteria. Indeed, insofar as pedestrian security is concerned, it appears clear that the installation of red-light cameras is the single-most effective, efficient, equitable and economic means of serving and promoting pedestrians' security in Ottawa-Carleton.

In brief, it is expected that cameras which "catch" vehicle operators illegally proceeding through on red lights and amber lights, or operators illegally traversing stop lines and crosswalks, will have a dramatic, uplifting effect on pedestrians' security. And, conversely, it is also anticipated that cameras which record pedestrians engaging in illegal acts may also prevent pedestrians from being the authors of their own misfortune.

As for the second part of the case to make with regard to cameras, it is that arguments in opposition appear to be without foundations in law or logic. Moreover, no arguments

have yet been encountered which refute any of the criteria used to select the proposed modifications.[3]

The first recommended modification, then, is that red-light cameras be installed at intersections at the earliest opportunity. And, in regard to which locations should receive highest priority, it is suggested that the Basic Walking Security Index formulation be used to assist in the process of decision-making.

B. Install Camera Radar and Strictly Enforce the 60 KPH Maximum

A repeated complaint is that too many drivers choose to accelerate rather than slow down when using intersections, and that too many vehicles exceed the speed limit. The associated request is increased enforcement, with photo radar proposed as the most effective, efficient way of dealing with what is regarded as a major threat to pedestrians' security.

As for the reference to 60 kph as a **maximum** posted speed in the vicinity of intersections, it seems (to pedestrians) that vehicle operators tend to regard the posted speed limit as some kind of average, or perhaps a number to which you can add 5, 10 or 15 kph or more and not be ticketed.

The problem, of course, is that intersections are far and away the most complicated parts of a road system, have the least tolerance for driver error, and are precisely where errors in judgement by individual vehicle operators and combinations of vehicle operators, are most likely to occur.[4] Hence, when the design speed of 60 kph is exceeded by one or more drivers, then the higher the likelihood that errors occur and pedestrians' security is compromised, to the point of loss of life!

The recommended modification of installing photo radar, and regarding 60 kph as the maximum tolerated speed, serves the initial purpose of ascertaining whether strict enforcement by photo radar provides grounds for retaining the 60 kph posted speed - - **as a maximum** - - in the vicinity of signalized intersections. And, it appears that no more than a month-long trial would be required to make that determination. Should the

trial finding be that strict enforcement does not serve the objective of having the posted speed respected as a maximum, then reduction of the posted speed to 50 kph **with an attendant increase in penalties** suggests itself as the next logical step in preventing vehicle speeds from putting pedestrians' security at risk.

C. Increase Separation of Stop Lines/Stop Bars from Crosswalks

For all the reasons given in previous reports, it is recommended that stop lines/stop bars be separated from crosswalks by a minimum of six (6) metres. Quite simply, it is unsafe, uncomfortable, inconvenient, and generally unnecessary for pedestrians to have to deal with vehicle operators who approach intersections at excessively high rates of speeds, at speeds which are inappropriate for conditions, who use vehicles as instruments of intimidation, etc.

Upon inspection of many sites across Ottawa-Carleton, and weighing the recommendation against the criteria for proposed selection, this modification meets all the conditions. Further, it appears that it has not been countered to date by reason of law or logic. Hence, it is recommended that the separation distance between stop lines/ stop bars and crosswalks be a minimum of six (6) metres.

D. Adjust Light Cycle Duration on the Green Phases.

As intersections get larger, more time is required by all pedestrians to cross them, and especially by seniors and children. Moreover, conditions of snow and ice, and heavier winter clothing and footwear, also add to the length of time required by pedestrians to cross intersections. The proposed modification for correcting this problem is that the light signal allow more time for pedestrian crossings. That is, the duration of time allowed to cross needs to be extended, and especially for locations and times that involve crossings by children and seniors.

E. Remove Pedestrian Walk Signals: Pilot Study

Interviews with drivers indicate that many drivers use the pedestrian walk signals as a basis for deciding whether and when to speed up as they approach intersections. Rarely, it appears, do the signals communicate the message to slow down and stop. Conversely, and curiously, the pedestrian signals appear to have little or no actual utility for pedestrians! It is therefore recommended that a pilot study be instituted for the purpose of **ascertaining the actual contribution made to pedestrian security (safety, comfort, convenience) by pedestrian traffic signals.**

F. Increase and Vigorously Enforce Crosswalk and Stop Line/Stop Bar By-Laws

The "Rules of the Road" part of the *Highway Traffic Act* (Province of Ontario, 1997) includes several sections - - 136 (1), 140 (1), 140 (2), 140 (3), 144(5), and 144 (7) - -, which stipulate that vehicle operators **shall** or **must** have regard for stop lines, crosswalk lines or other roadway markings that indicate where vehicle stops are to be made, and the conditions under which vehicles are to proceed.

Moreover, the same or similar by-laws and language are part of the day-to-day operations of the police force in Ottawa-Carleton.

Since these rules of the road have status in the *Highway Traffic Act* and in municipal by-laws, several reasonable expectations follow:

1. That the rules and by-laws will be duly respected by vehicle operators.

2. That violators will be apprehended, charged, prosecuted and, if found guilty, dealt with according to the law of the matter.

Insofar as the current regard for stop lines or crosswalk lines is concerned, an hour's fieldwork yields dozens of violations per hour, and many hundreds over the course of an 8-hour count. Indeed, it is not unusual to repeatedly observe lead vehicles stopped at a signal to be over the stop lines.

And, insofar as enforcement is concerned, it appears to range between minimal and non-existent. Indeed, throughout the entirety of the WSI Project, which involved dozens of fieldworkers, no one reported seeing or hearing about a driver being "pulled over" for a stop line or crosswalk violation.[5]

The three-part rationale or argument behind this proposed modification may be summarized as follows.

1. Pedestrians have the right to expect that the stipulations of provincial and municipal regulations, that is, laws and by-laws, are being respected by vehicle operators. That is frequently not the case at present in Ottawa-Carleton, with the result that pedestrians' security suffers.

2. Vehicle operators are, quite simply, breaking the law ands getting away with it. Following the logic of the so-called "broken windows theory", it appears that disrespecting stop lines and crosswalks may be an important first step in the process of committing increasingly serious moving violations, as illustrated by the following stages of anti-social or aberrant driver behavior:[6]

Stage i:	Ignore stop lines, crosswalk lines, roadway markings.
Stage ii:	Drive through yield signs and stop signs.
Stage iii:	Exceed speed limits.
Stage iv:	Run amber lights.
Stage v:	Run red lights.
Stage vi:	Ignore pedestrian walk lights.
Stage vii;	Ignore pedestrians.
Stage viii;	Be the cause of _____.[7]

3. The law and law enforcement are flouted, with the overall result being an increasing disregard for the rules of the road, as well as the interests of other members of society who are directly and indirectly affected by drivers who choose to operate outside the bounds of civilized authority.

These three topics will be further elaborated in the report on newspaper coverage of pedestrians security matters (Wellar, 1998a). And, further evidence will be given on the importance of this modification proposal to pedestrians' security.

For the present, however, it should suffice to emphasize that feedback from pedestrians, and parents of children who walk frequently, includes a reference to the "lawlessness" of drivers who do not stop their vehicles at the stop lines, or who drive into crosswalks which are legally occupied by pedestrians. It appears evident, therefore, that if pedestrian security is a goal to be achieved in Ottawa-Carleton, then a key, first step towards that goal is increased and vigorous enforcement of by-laws involving crosswalks, stop lines/stop bars, and other roadway markings.

As to the active monitoring of crosswalks and stop lines/stop bars for violations, this also appears to be an excellent candidate for camera surveillance. And, insofar as priorities are concerned, the indexes presented in Section D - - when used with data on intersections traversed by children and seniors - - provide guidance as to the intersections most in need of attention.

G. Restrict Right Turns on Red: Pilot Program

There are a number of intersections in Ottawa-Carleton at which (permitted) right turns on red appear to significantly affect pedestrians' security. The types of intersections involved include the following:

1. Those on regional road sections that carry relatively large volumes of relatively fast-moving traffic, and which require that drivers accelerate rapidly in order to "cut in" to the flow. The problem for pedestrians is that vehicle operators are more likely to be watching out for oncoming vehicles and less likely to be watching out for pedestrians. Examples of this kind of intersection include: Banner Road and Greenbank Road; the intersection between Fairlawn Plaza and Carlingwood Mall on Carling Ave.; Iris Street and Woodroffe Ave.; and, Fifth Ave and Bronson Ave.

2. Those with relatively heavy volumes of pedestrian traffic across all legs of the intersection. The frequent result is that drivers facing a red light "push in" as a means of getting through the intersection when they see what may appear to be a steady stream of pedestrians on the greens. Examples of this type of intersection include: Elgin St. and Laurier Ave.; Sussex Ave. and Rideau St; King Edward Ave. and Laurier Ave.; Richmond Road and Churchill Ave.; Elgin St and Somerset St; and Kent St and Slater St.

In both of those types of circumstances the safety, comfort and convenience of pedestrians is frequently and regularly compromised by drivers seeking to enhance their comfort and convenience at the expense of pedestrians. The modification of restricting right turns at high pedestrian volume intersections, as demonstrated in Cincinnati, Ohio, could be an effective and efficient means of dealing with a problem that appears likely to persist and worsen unless a corrective action of this nature is taken.[8]

It is therefore recommended that a broad-based pilot program of restricted rights on red be undertaken. Candidate intersections include those mentioned above, as well as intersections that community associations, school advisories, and other affected parties might choose to nominate for the pilot program.

H. Modify Light-Cycles: Eliminate Delays from Red to Green

The current signalling procedure of having all lights on red has gone far beyond the intended purpose of allowing vehicle operators who entered on a green phase to clear without encountering oncoming vehicles. Now, the "down-time" or "no-vehicles-on-green" has turned to a perverse purpose. That is, aggressive drivers use this gap to proceed through on the amber or red, accelerating as necessary in the approach or in the intersection to "beat" the drivers now awaiting a green light.

Using the indexes presented in Section D for guidance as to priorities, it is recommended that the Region institute a six-month program of reducing and removing red-to-green delays at all signalized regional road intersections in Ottawa-Carleton. It is noted that

consideration was given to excepting signalized intersections which are part of OC Transpo bus routes.[9] The problem, of course, is that the exceptions would also be available to vehicle operators, whose (bad) behavior caused the modification to be proposed. Hence, it appears that the no exception rule is advisable.

I. Petition the Government of Ontario for a Change to Section 140 of the Highway Traffic Act in Order to Properly Recognize the Risk to Pedestrians in Channel Crossovers.

In sections 140 (1) and 140 (2) of the *Act* (Province of Ontario, 1997), the text contains the phrase "the half of the roadway". However, the fact is that if the channel is single-lane, then there tend to be no markings to indicate where "the half of the roadway" is located.

As a case in point, there are no such lane markings on the four channel lanes at the Laurier Avenue-Nicholas Street intersection. Nor does the Principal Investigator recall any single-lane channels anywhere in Ottawa-Carleton which are marked so as to indicate to both drivers and pedestrians where their respective halves of the channel are located.

Moreover, and this concern is derived from repeated observations at various intersections in Ottawa-Carleton, there is a very real element of risk attached to the rule of the road represented by sections 140 (1) and 140 (2). That is, in an un-marked channel which is wide enough to accommodate tractor trailers, many drivers seem to take their half "out of the middle", which puts pedestrians at either end of a crossover at risk or, at best, makes them uneasy. Further, some drivers approach at a rate of speed which is sufficiently excessive that they appear to have difficulty figuring out - - at a moment's notice - - exactly where the pedestrians are in the crossover.

It is therefore proposed that the Regional Municipality of Ottawa-Carleton consider petitioning that this part of the *Highway Traffic Act* be modified to more accurately reflect the need for vehicle operators to stop when pedestrians are in the crossover of a channel lane. Specifically, it is proposed that a sub-section be added which speaks explicitly to

the matter of un-marked channels, and that language regarding "half of the roadway" be expressly excluded.

J. Modify Posted and Painted Roadway Signage: Yield to Pedestrians.

The posted yield to pedestrian signage currently in use in Ottawa-Carleton appears to have little meaning for drivers and pedestrians alike. Indeed, a significant study finding is that some pedestrians walk past these posted signs and do not even notice them (Wellar, 1995; Wellar and Froelich, 1996). What, then, is the likelihood that drivers moving at a much faster rate give these signs their intended regard? It appears that "nil" is a reasonable response.

As for painted roadway signage that seeks to encourage drivers to yield, or attempts to inform them that pedestrians are likely to be crossing ahead, it appears to be equally ineffectual. The communication which follows in Figure 6 speaks eloquently to the signage problem, and the need for research to solve it.

It is recommended, therefore, that the Region bring this matter to the attention of appropriate professional and technical bodies for the purpose of: a) confirming whether others have found posted pedestrian signage to serve and promote pedestrians' security; and b) precipitating needed research or other actions that may be necessary to bring about needed changes - - whether generic or specific - - to increase the effectiveness of this type of signage in Ottawa-Carleton.

K. Change Yield to Pedestrian Signs to Stop Signs: Pilot Program.

Drivers who do not respect "yield" signs are in violation of the *Highway Traffic Act* and municipal by-laws. Worse, however, from the perspective of the WSI Project, these drivers are negatively affecting pedestrians' security when the signs specifically involve yielding to pedestrians at, for example, crosswalks in channels or channel lanes.

Figure 6. Correspondence Regarding the Need for More Effective Signage to Alert Drivers to Yield to Pedestrians at Crosswalks

TOWN OF EXETER

10 FRONT STREET EXETER, NH 03833-2792 (603) 778-0591

September 12, 1996

Barry Wellar. Professor
Faculty of Arts and Geography
University of Ottawa
165 Waller St.
P. O. Box 450, Stn. A
Ottawa, Ontario K1N 6N5
Canada

Dear Professor Wellar:

Thank you so much for the case study you provided me with your letter of August 6, received on September 11th. (I'm sure both postal services would blame the other for the crummy service)

In any event the information is most interesting. I particularly enjoyed the reference to the concerns over inconveniencing the motorist and the demand to maintain traffic flow. My limited research on the issue of crosswalks seems to suggest that highway engineers only view them as impediments and that the transportation system would be best if we did away with people on foot. I found this kind of narrow thinking at its narrowest in a finding in a Federal Highway Administration study that reported, without comment, that the frequency of pedestrian injuries was highest in cross walks! Little wonder that I've had such a hard time in researching what I thought was a rather straight forward issue.

That brings me to my request. In your research, and I recognize that nothing short of stop signs at cross walks are the preferred method for pedestrians, have you found a "best" way to sign crosswalks. We have tried signs; large, small, above, beside and on the ground, black and white, three colors, and nothing seems to work particularly better than the other. We are even considering using the "sharks teeth", so commonly used in Scandinavia, to alert drivers to yield at crosswalks.

With the complaints from pedestrians growing, and recognizing that I'm not going to put stop signs at each cross walks, I'm looking to find a way to mark them that is best. Any research on this issue that you may be aware of will be appreciated.

Again thanks for the help.

Please let me know when "Perspectives on Pedestrian Safety" is available, I'd like a copy for our Public Works library.

Sincerely,

George N. Olson
Town Manager

One problem with the yield approach is that it is frequently argued to be a matter of interpretation, or differences of opinion arise, about whether a driver needed to yield or not, and whether in fact he or she did yield or not. Further, it appears that many drivers tend to regard the yield to pedestrians sign as a cue that they may need to be ready to step on the accelerator in order to "beat" pedestrians to the crosswalk.

Finally, while it appears that installation of "yield to pedestrians" signs may have an initial, intended impact on drivers, the impact apparently rapidly dissipates for regular users of intersections with that signage.

The summary observation on yield to pedestrians signage, therefore, is that it does not effectively serve the interests of pedestrians. Rather, such signage appears to be yet another of the many instruments that was created to "keep the traffic moving", but which negatively affects other intersection users as a consequence.

It is therefore proposed that the Region use the WSI Project indexes, and inputs from community associations and other groups, as part of a pilot program to strategically and selectively replace yield to pedestrian signs by stop signs. It is noted that such a modification serves a two-fold purpose. First, **requiring a stop** as opposed to **encouraging a yield** dramatically raises the prospect of achieving pedestrians' security. And second, in regard to enforcement, it appears that violation of a stop by-law is much more readily pursued (arrest, prosecution, conviction) than violation of a yield by-law, and particularly if **cameras** are installed at high-incidence, channelized intersections such as the one at Laurier and Nicholas.

L. Modify Roadway Marking Materials: Paint

A current complaint, and one that is readily turned into an excuse by drivers, is that painted markings no longer exist or are not clearly visible. That occurs due to various forces, including weathering, traffic wear-and-tear, removal by snowplow blades, etc. If the Region intends to continue using paint for roadway markings, then it is recommended that it seek out a supplier whose product is more durable than the one presently in use.

Further, and in anticipation of increased camera surveillance of intersections, it would be appropriate to obtain a paint mix that is susceptible to being photographed by intersection cameras.

M. Provide Proper Maintenance

It is irritating, to say the least, for pedestrians to have to plow through snow, climb over snowbanks, inch through deep slush, slip on ice, or wade through water, in order to get off the sidewalk, across the relatively clean roadway and back onto the sidewalk.

However, it is galling to the point of infuriating for pedestrians when they receive what was referred to as "the double whammy": 1) the roads are neat for cars, and the sidewalks near intersections are a mess for pedestrians; and 2) the sidewalks near intersections are a mess because the snow, slush, and ice are moved by plows from the roads to the sidewalks, in order to accommodate vehicle operators at the expense of those who walk.

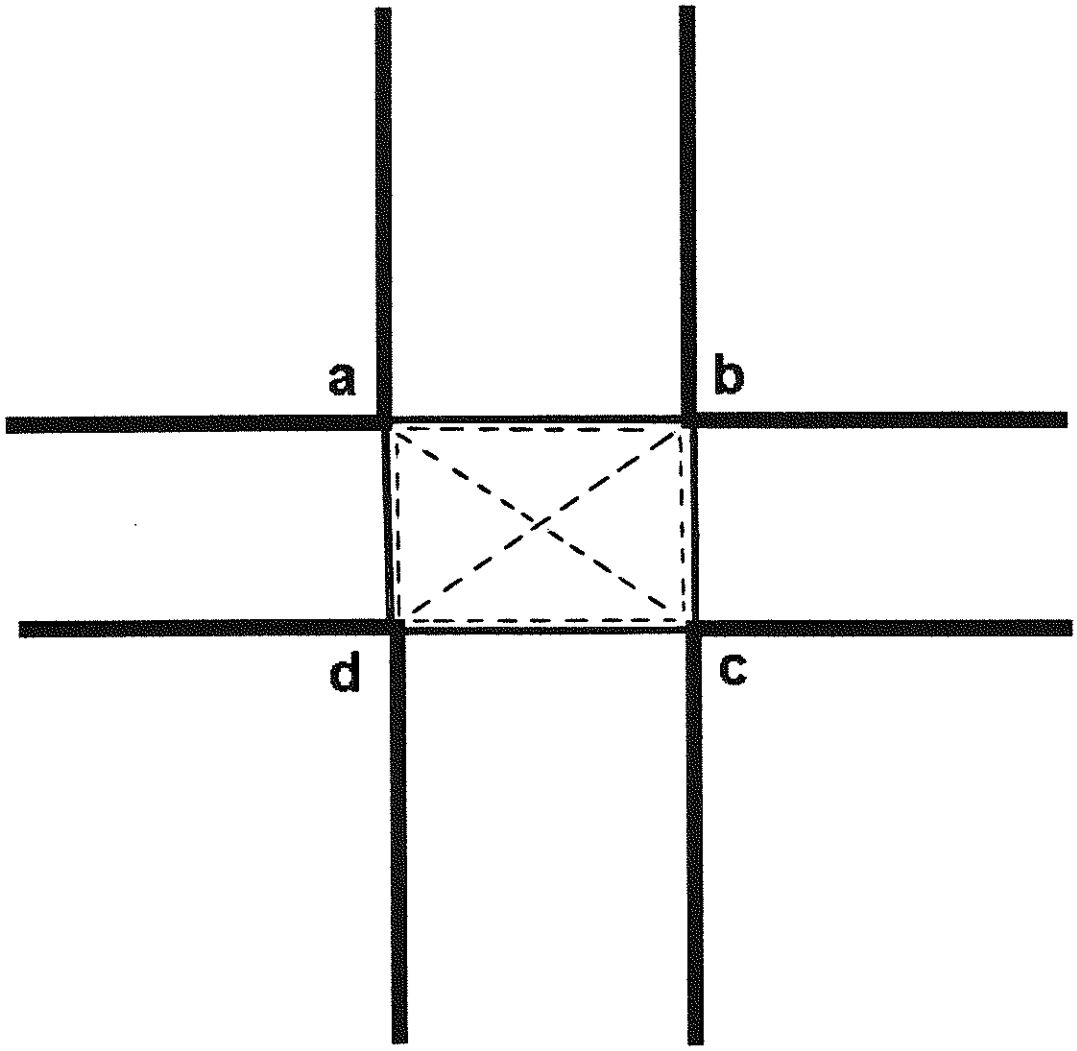
It appears fair to say that pedestrians have the right to expect that intersections will be maintained in a manner that allows for safety, comfort and convenience of passage. That expectation is not being met, and this modification - - provide proper intersection maintenance for all users - - makes explicit a frequently-voiced complaint of pedestrians in Ottawa-Carleton.

N. "Desire-Line Walking": Pilot Project

Many pedestrian crossings are of a two-leg or two-side nature. That is, and as illustrated by Figure 7, in order to get from corner a to corner c the pedestrian is required to get there via corner b (ab and bc) or d (ad and dc), following the solid lines. However, and as illustrated by the dashed line, there is an alternative route that goes directly from a to c.

The two-leg travel pattern is not only a longer route than going via the diagonal (ac), but it exposes pedestrians to vehicular traffic that is entering and exiting the intersection in the lanes on the two sides (ab and bc, or ad and dc) being traversed.

Figure 7. Illustration of "Desire-Line Walking"



_____ = Current path for pedestrians

- - - - - - - - = "Desire-line" path for pedestrians

The argument is made, therefore, that walking the perimeter is not serving pedestrians' interests. That is, pedestrians' safety, comfort, convenience is better served and promoted by means of "desire-line walking" which allows pedestrians to traverse the intersection in a preferred pattern (shortest path) without having to deal with moving vehicles.

This system is in use in a number of cities, including Denver, Colorado. Based on careful study of a high-use intersection in Denver over a 4-day period in 1996, discussions with pedestrian groups, reviews of the literature, and comments on the lists of variables, it appears that the "desire-line walking" approach merits consideration on a trial project basis in Ottawa-Carleton.

In regard to selecting intersections for the pilot project, several criteria are suggested as being pertinent to the deliberations:

1. The intersections rank in the "top 10" for the following indexes; V-PIP; WV- PIP; WPCE-PIP; IPC-F; BWS; ADFY.
2. The intersection (s) has (have) more than 11 lanes;
3. Turn restrictions are in place;
4. In the absence of data to apply the index criterion, more than 10% of pedestrians are observed to cross two approaches (go "kitty-corner").

As for an initial candidate for the desire-line pilot project, it occurs that the Elgin Street - Laurier Avenue intersection could be an instructive place to begin. This locale is popularly known to be cursed by pedestrians and drivers alike, and is the site of readily observable conflicts among pedestrians and vehicle operators. It therefore lends itself as a reasonable test case for the desire-line walking proposal.

O. Ensure Adequate Lighting from the Pedestrians' Perspective

Concerns were frequently raised that lighting needs to be improved in order to ensure that pedestrians who are at, or are approaching the edge of the roadway, are clearly visible to oncoming vehicle operators, **and** to vehicle operators in a queue waiting to make a turn.

The implications of this proposed modification is that the Region first establish that lighting levels are up to standard at all signalized intersections, and to then ascertain whether the standard itself is acceptable for today's vehicular and pedestrian traffic, by season of the year.

P. Ensure Adequate Sight Lines from the Pedestrians' Perspective

There are several sight line matters at issue. First, complaints were lodged about signs in bus shelters that are proximal to crosswalks. If the signs are opaque, then the views of drivers and pedestrians are obscured. And, if the signs are "eye-catching", then drivers may be looking at the signs rather than in the direction of a crosswalk that could have pedestrians in it or entering it, just several metres away.

Second, concerns were raised about bushes, street furniture, nearby flashing lights, utility poles, and other objects which affect vehicle operators' views of intersections and of pedestrians.

It appears to be something that goes without saying, but clear sight lines are necessary if pedestrians' security is not to be compromised or jeopardized. Hence, as a matter of first principle, obstacles to the sight lines of drivers and pedestrians must be eliminated. In the event that an "audit form" is used or developed to ensure clear sight lines, the lists in Appendix C and D contain variables which are candidates for inclusion on the form.

Q. Modify and Standardize Intersection Features to Eliminate Obstacles and Nasty Surprises that Make Intersection Usage Difficult and Even Dangerous for Pedestrians with Disabilities

This proposal attempts to synthesize the comments and suggestions made by a variety of elected, professional, and lay experts on how to promote and serve the needs of pedestrians with disabilities.[10] It is emphasized that the present discussion is at a very preliminary level, and is intended only as a precursor to the comprehensive study which appears necessary to deal with this difficult matter. The following observations indicate the nature of the problems and needs associated with intersection use by those with

disabilities.

First, pedestrians who are visually impaired have their safety, comfort and convenience compromised when there are no standards or limited standards in place regarding any of the following intersection features:

- height of curbs
- location and design of storm sewer covers and grates
- location of utility poles, sign posts, and street furniture
- location and width of crosswalks
- amount of separation between crosswalks and stop lines
- location, size and slope of ramps.

To the extent that intersections are sensitive to the capabilities of the visually impaired, then obstacles are reduced. And, to the extent that intersections are standardized, then predictability is increased and nasty surprises are decreased. Clearly, it seems, those are very good reasons for ensuring that the circumstances of the visually impaired are incorporated in intersection design and construction criteria.

Second, there are other pedestrians who may have difficulty negotiating intersections, and are also negatively affected by the kinds of obstacles and uncertainties noted above. These pedestrians include people with physical disabilities, those pushing strollers or carriages, and those in wheelchairs, all of whom can experience loss of security for intersection design reasons. Hence, they have an interest in this modification.

And, third, there is another important group that comes to mind, namely the large and growing group of seniors in both the residential and tourist or visitor populations of Ottawa-Carleton. Unless and until it is made easy or easier for seniors to negotiate intersections, then the emphasis on the pedestrian mode in the Official Plan and Transportation Master Plan (RMOC, 1997a, 1997b) remains a principle waiting to be transformed into practice.

4. Other Modifications

Just as there are other variables and indexes which could be presented, there are other modifications which could be proposed. And, there could be modifications which have not been identified, but which satisfy all the selection criteria (pertinence, support, degree of difficulty, data availability, enforceability, and "do-ability"). It is the opinion of the Principal Investigator however, that the modifications identified are those which best respond to the Projects' terms of reference and which, if implemented, are most likely to advance the case of pedestrians' security in Ottawa-Carleton.

Should it occur that other modifications are proposed, then in the interests of consistency it is expected that evaluation of them will include regard for the criteria used to make selections A-Q above. Further, and again in the interests of consistency, it is expected that other modifications will be **derived** from research undertaken as part of the WSI Project, or from a similar, **methodologically** designed inquiry.

5. Notes

1. This statement reflects the fact that elected officials, professional staff, and the public-at-large have an interest in the findings and recommendations of the WSI Project. As a result, in order to assist in ensuring that the debate about modifications is focussed and pragmatic, the proposals are limited to those which are deemed to be most needed and most susceptible to being achieved at present or in the near future.

2. "Significant" is used in the sense that elected officials, professional staff and citizens - - the affected parties - - regard the modifications as essential or high priority.

3. As of mid-April, 1998 the Province of Ontario was giving "mixed signals" as to whether it would allow municipalities to install (red-light) cameras and, if so, whether and what kinds of provincial stipulations might be attached. By early May, 1998, the Ontario Government stated its opposition to cameras, and it was expected that a substantive reason in law or logic would be presented to support the rejection of cameras. As the Final Report goes to the printer, no such reason in law or logic for the Province's

opposition to cameras at signalized intersections had been located. Moreover, in the form of "late-breaking news", a Private Member's Bill (M. Colle, Lib.) appears to have been accepted by all parties. What remains to be seen is the extent, degree, etc. to which principle becomes practice. In the meantime, newspaper articles assembled to date (Wellar, 1998a) indicate overwhelming public support for intersection cameras.

Addendum to endnote 3. The following recommendation of the Transportation Committee, Regional Municipality of Ottawa-Carleton, was "carried" by Regional Council at its meeting of 10 June 1998, and is a "last-minute" addition to the Final Report:

That the Government of Ontario support the installation of red light cameras at high collision intersections to monitor and prosecute owners of vehicles that run red lights.

Source: **The Regional Municipality of Ottawa-Carleton Council Minutes**, No. 14, 10 June 1998, p.20.

By way of brief comment on the recommendation it is clear from the WSI study that "high collision intersections" pose the **gravest threat** to pedestrians' security. However, it is also clear that there are a number of important matters that warrant attention in regard to **achieving the greatest level of security for the greatest number of pedestrians** (and cyclists and other motorists) in Ottawa-Carleton, and frequency of collisions is just one such matter. It appears reasonable to suggest, therefore, that consideration should be given to other variables in Section C, and the indexes in Section D, as part of the red-light camera installation program.

4. Application of the "zero tolerance" rule for speeding intersection traffic - - no ifs, buts, maybes, exceptions - - appears to be gaining in acceptance among drivers and non-drivers alike. The connection made by the public is that higher or excess speeds result in more serious injuries and even death for vehicle operators, but especially for pedestrians who may be totally unprotected from a 1000 kg vehicle moving at 80 kph. As for the radar cameras (or a camera which records both licence plates and speeds),

they not only provide around-the-clock surveillance, but they are excellent "witnesses" when claims are in dispute. The forthcoming report (Wellar, 1998a) on newspaper coverage on this and related topics further explores the "attitudes dimension" of urban transportation, and pedestrians' security in particular.

5. It might be instructive to examine the records of area police forces to ascertain the annual numbers of citations issued for these violations.

6. The "broken window" theory is a variation on a number of maxims such as "spare the rod, spoil the child", a "stitch in time saves nine", "justice delayed is justice denied", and other remonstrations about "nipping things in the bud", and "getting things under control before they get out of hand". By way of analogy, then , breaking windows would be a step on the way to trashing a building, whereas ignoring stop lines is a step on the way to running a red light or running down a pedestrian.

7. Ironically, on April 20, 1998, at 9:14 a.m., while crossing Laurier Avenue on the east side of Elgin Street to deliver copies of correspondence on transportation matters to Regional officials, the Principal Investigator was party to an incident where a driver engaged in stages i, v, vi, and vii. Fortunately, due to a quick reaction whereby a briefcase and bookbag were used to absorb the impact and whack the car, the driver stopped before seriously injuring any pedestrians. A telephone call to Regional Police Services was expeditiously handled by the attending officer.

8. The Principal Investigator was able to study the restricted right turn system in downtown Cincinnati over a span of six days (Saturday-Thursday) in October, 1997. While officials in Cincinnati should be contacted to confirm the impressions formed, it is the Principal Investigator's opinion that the program of designating strategically selected intersections for restricted movement was most conducive to pedestrians' security. As a result, and given that there are already restrictions on movements at some downtown intersections in Ottawa-Carleton, it appears that this proposed modification could be put in place, extensively and very expeditiously, as part of a comprehensive, traffic calming initiative in Ottawa-Carleton.

9. Although there may be many candidates for this dubious distinction, it is suggested that the worst intersection for illegal vehicle blockages (cars, not buses) along the Transitway, and perhaps throughout Ottawa-Carleton, is the Laurier Avenue East intersection. What remains a mystery to the Principal Investigator is why, over some 19 years with two to ten crossings per day, usually five days per week, and more than 40 weeks per year, he has **never seen a ticket being issued to a driver for blocking the buses or pedestrians.** As for the magnitude of the problem, it is not unusual to see dozens of blockages during any peak hour, morning or afternoon.

10. The use of intersections by pedestrians with disabilities appears to be sufficiently complex to warrant a separate study. In the case of the WSI Project, we are able to refer to the problems and needs of those with disabilities in general, but we have not addressed the many particular aspects of being disabled (Government of Canada (nd); Government of Ontario (1989). The report on newspaper coverage (Wellar, 1998a) of pedestrians' security contains several references to excellent articles on the topic, but it appears clear that further, directly pertinent study is needed to ensure that the full range of problems and needs of pedestrians with disabilities are identified.

    Addendum to endnote 10. A "last-minute" communication was received on July 14, 1998 from Regional Councillor D. Holmes, Chair, Transportation Committee, regarding the work of the Audible Pedestrian Signals (APS) Committee, Regional Municipality of Ottawa-Carleton. The work of the APS Committee, which was precipitated by a presentation from blind and visually impaired pedestrians, is especially relevant to the *Walking Security Index* report because of its use of criteria - - many of which are also presented in this document - - to prioritize aps installations.

    (Source: Memorandum of 2 July 1998, **Update-APS Committee**, from C. Rousseau, Co-ordinator, Audible Pedestrian Signals (APS) Committee, to Regional Chair and Members of Council).

F. SUMMARY

1. Three Primary Research Tasks Completed

In order to satisfy the WSI Projects' terms of reference (Table 1), the final phase of the study completed the following three primary research tasks:

1. **Variables** for measuring and evaluating signalized intersection feature and performance characteristics from the perspective of pedestrians' security - - safety, comfort, convenience - - are specified.

2. **Indexes** for ranking and evaluating signalized intersections in terms of their relative regard for pedestrians' security are formulated.

3. **Intersection Modifications** for achieving pedestrians' security are proposed.

In the remainder of the Summary, emphasis is on the outputs of the Project, that is, the derived variables, the derived indexes, and the derived proposals for intersection modifications. Details about the derivation process - - literature searches and reviews, analysis/synthesis of field data (counts, interviews, etc), consultations with experts, etc. - - are contained in the Interim Reports (Appendix A). Therefore, they are not repeated in the Final Report. However, there are several key design principles and a number of methodological considerations that directly affect the outputs, so they are explicitly noted in the Summary.

2. Variable Specification

Section C of the Final Report summarizes the approach adopted to transform more than 200 candidate variables into a preferred or core set of pedestrians' security variables. As discussed, a set of criteria was used to make final decisions about the variables to specify for Walking Security Index purposes, and for other purposes that involve measuring and evaluating intersections from the perspective of pedestrians' security.

Those criteria are as follows:

General Evaluation Criteria	Particular Evaluation Criteria
Pertinence	Enforceability
Support	Data Availability
Degree of Difficulty	

Insofar as the criteria are concerned, they appear to have been appropriate for this study. In particular, it appears that they did not cause us to include variables that have been rejected by the literature. And, conversely, it appears that the criteria did not cause us to reject variables that are accepted by the literature, are in agreement with our empirical research findings, or tend to be supported by the experts who reviewed the lists of variables.

In addition to setting out the variable selection criteria, the final phase provided an opportunity to "test" the categories used to classify variables. As illustrated by Table 2 and Table 3 in Section C, WSI-related variables are allocated among the following categories:

1. Infrastructure Features
2. Vehicle Traffic Features
3. Pedestrian Traffic Features
4. Infrastructure Preference Measures
5. User (Behavior) Performance Measures for Vehicles, Drivers, Pedestrians.

Indications are that these categories contribute to understanding the structural and functional fundamentals of intersections. And, by recognizing both the features and performance aspects, the categories provide both the rationale and the means for postulating and examining relationships among all the factors - - intersection infrastructure, vehicles, drivers, pedestrians - - that affect pedestrians' security.

Finally, the WSI Project recognized that there are three groups of experts whose opinions need to be elicited about the variables to include in the final specification. The groups of experts are elected officials, professional staff, and ordinary citizens, and their legitimacy

can be summarized as follows.

In order for the findings of this study to be implemented, decisions have to be taken and actions must occur. These initiatives involve developing and evaluating public policies, programs, plans and, very importantly, affect the well-being of present and future residents and visitors of Ottawa-Carleton. As a result, it is appropriate that the three designated groups of experts - - elected officials, professional staff and citizens - - be given an opportunity to comment on the lists of variables, and to suggest the priority to be attached to them for audit, index, or modification purposes.

It is the Principal Investigator's impression that the vast majority of the specified variables are consistent with the comments of the vast majority of participating experts. And, it is his further impression that the participating experts did a very commendable job of representing the interests of their respective constituencies. It is therefore concluded that the involvement of elected officials, professional staff and ordinary citizens made a substantial contribution to the validity of the study and the Final Report.

Finally, in regard to variable specification, it is important to emphasize that this is one of relatively few studies investigating the question of which variables to use, conceptually and operationally, to define, measure and evaluate pedestrians' security (safety, comfort, convenience). Further, due to an apparent lack of previous inquiries in some domains, variable specification was both original and exploratory, and established and confirmatory, in the derivation process.

The overriding conclusions about variables specification, therefore, are two-fold:

1. Substantial progress has been made in specifying the variables for defining, measuring and evaluating pedestrians' security expectations and experiences; and,

2. Much remains to be done in order to complete the specification of variables that are **necessary and sufficient** to define, measure and evaluate pedestrians' security expectations and experiences. It appears, however, that the evaluation

criteria, categories of variables, and expert groups employed in the WSI Project warrant consideration for inclusion in such studies.

3. Index Formulation

The index formulation task proved to be more challenging than anticipated. Three reasons in particular account for index formulation difficulties.

1. Very little prior work in the field of pedestrian security was encountered that could be directly adopted or adapted. And, only a limited amount of prior research in the transportation, planning, safety or related fields was found to lend itself to the formulation of indexes representing pedestrians' security matters.

2. The large number of selected variables (Tables 2 and 3 in Section C) and the even larger number of candidate variables (Appendix C and Appendix D) represented the essence of a non-trivial research problem. That is, given all those variables, many choices needed to be made about which combinations of variables to use in which formulations. And, further research questions followed in regard to the kinds of formulations to choose to represent the relationship among variables.

3. Since the evaluation criteria used to select variables apply to index formulation, but in a magnified manner since indexes combine variables, a serious design challenge arises. That is, how does one formulate comprehensive indexes that provide needed information, but do not become incomprehensible to members of any of the groups (elected officials, professional staff, ordinary citizens) interested in pedestrians' security?

Those difficulties notwithstanding, a total of 10 indexes and formulations are discussed in Section D. They are presented as a set in Table 10. Since each index is described in detail in the main text, the summary comments are generic rather than specific.

Table 10. Summary of Walking Security Indexes and Formulations

- Vehicle-Pedestrian Interaction Potential (V-PIP) Index
- Weighted Vehicle-Pedestrian Interaction Potential (WV-PIP) Index
- Weighted Passenger Car Equivalent - Pedestrian Interaction Potential (WPCE-PIP) Index
- Quality of Infrastructure Condition (QIC) Index
- Intersection Pedestrian Challenge - Features (IPC-F) Index
- Basic Walking Security (BWS) Index
- Aggressive Driving: Red (ADR) Index
- Aggressive Driving: Amber (ADA) Index
- Aggressive Driving: Red + Amber (ADRA) Index
- Aggressive Driving: Fail-to-Yield (ADFY) Index

First, to the extent that increased complexity can be tolerated, additional variables and combinations of variables, as well as sub-categories or sub-classes, can be associated with most and likely all the formulations.

Second, the types of formulations presented appear amenable to incorporating most if not all the specified variables (Table 2 and Table 3) in relationships of interest. As a result, they serve as models for additional formulations involving other variables.

Third, none of the formulations involve "rocket science", and all of them appear to be fully within the competency (legal, organizational, technical, financial, etc.) of the Regional Municipality of Ottawa-Carleton to make operational, implement, and maintain.

Fourth, many of the formulations lend themselves to being used or expressed as research and statistical hypotheses. As a result, they provide a basis for empirically testing the formulations for real-world validity and applicability in Ottawa-Carleton and elsewhere, and for creating more finely-tuned formulations.

Fifth, it is appropriate to recall earlier comments on the need and opportunity to extend the current study. As previously acknowledged in Section D, by no means have all the pertinent variables been incorporated in a formulation, nor has research been undertaken to assess whether the formulations developed during the WSI study could benefit from modification. The current WSI Project should therefore be regarded as an opening rather than a closing statement on Walking Security Index formulations.

And, sixth, it appears fair to observe that future research into these kinds of index formulations should have regard for the methodology behind this part of the WSI Project. The expected result of building on what has already been done is that rather than "reinvent the wheel", future research would be designed to: 1) deny or confirm what has been specified; or 2) bring forward new or different index formulations on pedestrians' security expectations and experiences.

4. Intersection Modifications and Other Recommendations

One of the tasks of the WSI Project, as per Part 2 d) of the terms of reference (Table 1) was to identify modifications that serve and promote pedestrians' security (safety, comfort, convenience). That obligation is discharged in Section E, in which proposed modifications are presented. The suggested modifications and a number of other recommendations are assembled as a set in Table 11.

As the reader may be aware, intersection modification is a popular topic. That is, and as demonstrated by letters to editors, calls to talk-show hosts, opinings at neighbourhood meetings, and representations made during Official Plan, Ontario Municipal Board, rezoning, and other hearings, there seems to be no end of suggestions on why, how, when and where signalized intersections should be modified. And, it appears fair to infer, there is no end of suggestions because there are a variety of things perceived to be wrong or going wrong at intersections, and in the immediate vicinity of intersections, in many parts of Ottawa-Carleton.

Table 11. Summary of Proposed Intersection Modifications that Serve and Promote Basic Needs of Pedestrians*

- Install photo (red-light) cameras
- Install camera radar and strictly enforce the 60 kph maximum
- Increase separation of stop lines/stop bars from crosswalks
- Adjust light cycle duration on the green phases
- Remove pedestrian walk signals: Pilot study
- Increase enforcement of crosswalk and stop line/stop bar by-laws
- Restrict right turns on red: Pilot program
- Modify light cycles: eliminate delays from red to green
- Petition the Government of Ontario for a change to Section 140 of the *Highway Traffic Act* in order to properly recognize the risks to pedestrians in channel crossovers
- Change yield to pedestrian signs to stop signs: Pilot program.
- Modify posted and painted roadway signage: yield to pedestrians
- Modify roadway marking materials: paint
- Provide proper maintenance
- Ensure adequate lighting from the pedestrians' perspective
- Ensure adequate sight lines from the pedestrians' perspective
- Modify and standardize intersection features so as to eliminate obstacles and nasty surprises that make intersection usage difficult and even dangerous for pedestrians with disabilities

* The summary list is an "at-a-glance" overview of the recommendations made to promote and serve pedestrians' security at signalized intersections in Ottawa-Carleton. The details behind the recommendations are contained in Section E, and readers are counselled to have due regard for those details when referring to Table 11 in part or in whole.

In comparison, therefore, to the dozens of proposed modifications that may appear in a major newspaper in a month, the 17 proposals listed in Table 11 make a very modest contribution to the large **quantity** of suggestions currently in circulation. However, and as noted in Section E, our focus has been on generics. Hence, it is anticipated that more proposals for modifications involving specific intersections will ensue as a result of the Final Report being distributed to , for example, elected officials, community associations, and school advisories.

Finally, in regard to focus, emphasis throughout the WSI Project was on methodological rigor. As a result, we are more interested in the **quality** of the modification proposals than their number. It appears fair to say, therefore, that by drawing on various literatures, by engaging in observation and interview fieldwork, and by eliciting the views of elected officials, professional staff, and ordinary citizens, the WSI Study approach of methodologically deriving the modification proposals fully satisfies the Project's terms of reference.

5. Next Steps

The Final Report identifies a number of research needs and research opportunities, as do the Interim Reports. Further, the research questions and issues raised are both client-driven and curiosity-driven, in terms of their origins and purposes to be served.[1] It therefore appears fair to say the research program and design behind the WSI Project has spawned the makings of a rich research and action agenda on the topic of pedestrians' security.

Insofar as known research projects that build on or extend the current WSI Projects are concerned, two are especially pertinent. First, the study to examine newspaper coverage of pedestrians' security and related topics has already begun (Wellar, 1998a). It is intended that this project provide a comprehensive overview of pedestrians' security topics, advocates, initiatives, etc. as reported in newspapers. Further, the terms of reference include designing the outline of a "system" for effectively and efficiently accessing both hard copy and electronic versions of newspaper articles on pedestrians'

security.

Second, the Project Director of an on-going study for the U.S. National Highway Traffic Safety Administration (NHTSA) that is looking into ways of reducing pedestrian injury and fatalities through controlling vehicle speed, has inquired about the WSI Project and reports.[2] Examination of the Synopsis for the NHTSA study - - "Literature Review on Vehicle Travel Speeds and Pedestrian Injuries" - - suggests that the NHTSA interest in countermeasures is met at least in part by the variables, indexes and modifications presented in *Walking Security Index*. Hence, it is reasonable to expect that WSI materials submitted for the NHTSA study could stimulate examination of WSI Project documents by a number of U.S. agencies.

In addition, it appears that other WSI-oriented research projects are under way or are impending at different localities and institutions (governments, universities) in Canada. These next steps had their origins in meetings, exchanges of materials, discussions, correspondence, etc. over the past several years between the Principal Investigator and individuals and groups with interests in pedestrians' security. Indications are that a number of individuals and groups are using or could use WSI Project variables, indexes and proposed intersection modifications in their projects.

As for next steps at the operational level, that is a matter for the client (Regional Municipality of Ottawa-Carleton) to attend to regarding study findings and recommendations. And, in addition, it is a matter to be considered by all the parties - - elected officials, professional staff, ordinary citizens, and the media - - who have an interest in the day-to-day state of pedestrians' security expectations and experiences at signalized intersections in Ottawa-Carleton.[3]

6. Notes

1. Client-driven research is based on questions, issues, approaches, etc. being set by the person, agency, etc. that pays for or otherwise sponsors a research program or project. Curiosity-driven research consists of inquiries that are undertaken to add to

knowledge, or to add to ways and means of continuing to add to knowledge. These activities are undertaken as part of the search for truth, and the research questions and issues are derived by, rather than given to the researcher. Readers interested in further discussion of the two research domains in the context of the WSI Project are invited to contact the Principal Investigator.

2. In a communication to the Principal Investigator, comments and questions about the WSI Project are raised by Dr. William Leaf, PRG Inc., who is Project Director for the U.S. National Highway Traffic Safety Administration study. Interest in the WSI Project arose from a presentation by Dr. B. Wellar on the pedestrian security study (WSI Project) at the Traffic Calming Session, 1997 Transportation Research Board Conference in Washington, DC.

3. This is an appropriate place to insert the reminder that the "direct client" for this report is the Regional Municipality of Ottawa-Carleton (RMOC). That is the case because RMOC engaged the Principal Investigator, through the University of Ottawa, to undertake the WSI Project. In reality, however, all aspects of the *Walking Security Index,* including the proposed modifications, could be considered by anyone - - elected official, professional staff member, ordinary citizen - - in Ottawa-Carleton or elsewhere who reads the report, which is a public document.

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H. APPENDICES

Appendix A. Abstracts, Executive Summaries, and Conclusions of Selected WSI Project Reports and Associated Publications

Published documents which contain the foundations upon which the Final Report is based include a field study report on channelization, five Interim Reports, the proceedings of a conference on pedestrian safety, several articles in professional or technical association proceedings, material presented at professional or lay meetings, and many newspaper articles. And, in addition to the published reports, project documentation includes more than 200 reports by students who have participated in the WSI Project via assignments in Geography courses at the University of Ottawa (GEG 2306 and 3110, Urban Geography; GEG 3104, Methods of Geographical Research; GEG 3311, Political Geography; GEG 3313, Planning Methodology; and GEG 4313, Planning Principles and Techniques).

The documentation selected for re-publication is limited to materials which have been subjected to review by the client (Regional Municipality of Ottawa-Carleton), or by external professional or technical experts. In the case of the RMOC reviews, they pertain to documents that were approved for publication. Hence, they can be deemed pertinent to the Project's terms of reference and, consequently, to the Final Report.

As for the reviews by external experts (elected, professional, lay), there has not been sufficient opportunity for either the elected officials or citizens to prepare detailed, comprehensive responses to the research undertaken or outlined. As a result, the views of elected or lay experts on project reports, newspaper articles, communications to and from community associations, and communications to and from elected officials, are not deemed sufficiently robust to be included in Appendix A.

Professional experts, on the other hand, are accustomed to providing "rapid turnaround", frequently in response to queries from elected officials or senior officials who have an immediate need-to-know. The documents of note are several papers that were critically assessed before, while, or after being presented at professional or technical association meetings.

Finally, in regard to the amount of text being re-published, it is limited to abstracts, executive summaries and conclusions or variations thereof. Those sections appear to be sufficient to put the Final Report in context, and to indicate the whys and hows behind the development and derivation of the *Walking Sexurity Index*. Readers in need of further details are invited to examine the original documents.

a. ***Design and Pre-Testing of a Survey Instrument to Measure Pedestrian Levels of Safety and Comfort: A Case Study of the Channelized Cut-Off from Laurier Avenue East to Nicholas Street South, Ottawa, Ontario.*** Barry Wellar. Ottawa, ON: Regional Municipality of Ottawa-Carleton and the University of Ottawa. 1995.

Executive Summary

The following selected summary comments provide a thematic overview of the project and report.

The data base for this study of the pedestrian-vehicle situation at the Laurier E. to Nicholas S. cut-off includes: historical materials (text, numeric tabulations, videos) provided by the Regional Municipality of Ottawa-Carleton; survey data on vehicle and pedestrian counts and behaviours, 0700h - 1800h, April 6, 1995; and survey data from a stratified, systematic random sample of 454 pedestrians (212 females, 242 males, which is an exact proportionate match of the April 6, 1996 population count) who were interviewed between 0700h and 1800h during weekdays in late March and early April, 1995.

Critical findings regarding the pedestrian-vehicle situation are:

1. Pedestrians interviewed overwhelmingly agree (90 per cent) that the cut-off represents a safety problem that requires correction.

2. The cause of the problem is generally seen to be the many vehicle operators who do not yield to pedestrians, and who thereby ignore the Highway Traffic Act, pedestrian signs, and pedestrian pavement markings, all of which combine to ineffectually "instruct" vehicle operators to yield to pedestrians.

3. A vast majority of the sampled pedestrians are opposed to further "doses" of signs, markings, and related "passive or do-nothing remedies".

4. The initial modification proposed by survey respondents is a STOP -- sign or signal -- which is so positioned as to ensure that drivers and not pedestrians suffer any consequences that arise from an active intervention to deal with drivers as the problem source.

5. Should the STOP fail to perform effectively -- a one-year trial is appropriate -- then it is necessary to close the cut-off, because that appears to be the only remaining means to control drivers who jeopardize pedestrians at this location.

6. The survey instrument developed for this study performed exceedingly well during the pre-test. It should be more broadly tested in the Region as the basis for a walking security index that measures pedestrians' sense of safety, comfort and convenience at intersections.

Summary Findings and Recommendations

Cut-off Concerns and Modifications

The purpose of this section is to present and briefly discuss the general themes or lessons, learned that emerge from the study. This entails considering the Yes-side and No-side questions and responses as separate sets, and in combination. In the interests of space, and because the details contained in the previous sections are readily available to the reader, the particulars behind the findings are not repeated.

First, there is a gender and age-group agreement across the sample that a problem exists at the cut-off. That is, the cut-off is perceived as a source of concern to pedestrians because too many vehicle operators fail to yield to pedestrians who are in, entering, or are about to enter the pedestrian cross-walk.

Second, the most recent attempt (in 1993) by RMOC to address this longstanding problem – by introducing pedestrian crossing signs and markings – had initial, limited success.

The general view of the sampled respondents is, however, that more or different pedestrian-based signs or markings will not increase either the sense or the reality of increased pedestrian safety. That view is derived from the pedestrian experience that such "passive" devices become ineffectual over time. And, worse, they become potentially dangerous because they (may) create a false sense of security among pedestrians.

Third, many pedestrians are concerned that remedies to problems created by vehicle operators are not directed at the cause, but instead try to manipulate the effect.

By way of illustration, signs, markings and even blinking lights do not and cannot control vehicle operators who choose (by the hundreds, every day) to violate the pedestrian right to safe passage. On the other hand, however, pedestrians perceive that they are supposed to be grateful for (so-called) remedies that do not work in their interest, but which enable drivers to continue "business as usual". This was characterized by many respondents as adding insult to injury.

As for measures that force or tend to force drivers from invading pedestrian space, the concern is that they will not be employed because they interrupt traffic flow. The concern of pedestrians, then, is theat the following kinds of remedies are precluded from the outset: a tighter turning radius (it would preclude 18-wheelers), a right angle turn (inconveniences drivers), a narrow cut-off (vehicles cannot squeeze through or take evasive action when pedestrians are also in the cut-off, or the cross-walk), and a stop for vehicles (whether sign or signal light) would inconvenience their operators.

The critical findings therefore, are that: a safety problem is seen to exist by almost 90 per cent of the survey sample; a vast majority of respondents are opposed to further doses of previous remedies (signs, markings); and the overwhelming consensus is that whatever proposed remedy is tried next it must deal directly with the cause of the problem. That is, vehicle operators who do not yield to pedestrians, despite the fact of a traffic law, signs, and markings that "instruct" them to do so.

Two proposed modifications that directly address pedestrian concerns emerge from the survey.

First, a **STOP** -- whether by sign or signal -- is seen by many pedestrians as a necessary condition for achieving a sense of pedestrian safety at the cut-off. As for its location, the STOP needs to be on Laurier Avenue, before the cut-off, and its effective operation appears to be based on vehicles not proceeding into the cut-off until there is no

opportunity for a conflict with pedestrians.

As for the second modification, it is of the "when all else fails" variety. That is, if the STOP -- whether sign or light -- goes the way of previous signs and markings and ceases to perform as intended and expected, then the cut-off needs to be closed.
Whichever modification is chosen, it is appropriate that it be evaluated in terms of its effect on pedestrians. The present project, including the tapes, field reports and this report, constitute a substantive basis for such a before-after (impact) study.

Validity of the Survey Instrument

Review of all the field reports, student research papers (Urban Geography, GEG 3310), and a selection of the (cassette) interview tapes indicates that in very large measure the questionnaires served their intended purpose: all the questions were similarly asked and perceived; the survey team was able to organize the questions and replies in a coherent manner; and, the questions and responses directly addressed the objectives of the project's Terms of Reference.

Moreover, and very importantly, the stratified, systematic random sample of pedestrians selected for the interviews participated with enthusiasm, candour, and attentiveness. It is reasonable to therefore find that the questionnaire was of proper length, that the questions asked were pertinent, and that the manner of survey administration -- using cassette recorders -- was well-received by the interviewees.

The summary judgment regarding the survey instrument is that the pre-test was successful, and that it should now be tested under different vehicular traffic, road network, and pedestrian situations throughout Ottawa-Carleton.

b. Walking Security Index (WSI) Project: Literature Search, Outreach and Research Design Activities. Interim Report 1. Barry Wellar. Ottawa, ON: Regional Municipality of Ottawa-Carleton and the University of Ottawa. 1996.

Purpose of Interim Report 1

The purpose of this report (Interim Report I) is to identify and summarize the activities undertaken in Phase 1 of the Project, which began at the conclusion of contract negotiations in September 1995. The context for Interim Report I is the Terms of Reference for the Walking Security Index (WSI) Project, which are presented in Appendix A.

Following from the Terms of Reference, the activities reported on are grouped into three general categories:

1. Literature Search and Review;
2. Outreach Activities;
3 . Research Design.

Each activity category is briefly discussed in terms of what was done, products derived, and implications for future WSI Project-related activities.

Literature Search and Review

Four kinds of literature are pertinent to the Walking Security Index project:

- ❑ learned
- ❑ popular
- ❑ legal/regulatory/professional, and
- ❑ interest group.

This section first considers progress to date in surveying and reviewing the learned literature which is the traditional start-point for methodological inquiries. Consideration is then given to the popular literature, the legal, regulatory, and professional literature, and the interest group literature, each of which has contributions to make to the design and implementation of a Walking Security Index (WSI).

Learned Literature

The critical finding from the learned literature search and review is that, based on the journals, proceedings and texts encountered to date, the WSI Project does not duplicate research already done at the conceptual, design or implementation stages. That finding has two critical design and budget implications. First, because of the apparent originality of the Walking Security Index concept, the learned literature is unlikely to contain materials that specify how to construct the index. And second, due to the lack of prior research of this type, there appears to be no escaping the need to conduct **basic index design and pre-test studies** prior to "real-world" implementation of the index in an operational environment.

The learned literature search and review established four additional, important findings.

First, there are numerous ways of constructing indexes. Hence, specifying the index which best expresses the concept of "walking security" (safety, comfort, convenience) in both the structural and functional senses is a genuine research problem. That is, choice is involved regarding both the ***structure*** of the index and its ***functionality*** (variables and relationships), so logic (rather than mere opinion) is required to give the index credibility.

Second, there is a growing body of learned literature on pedestrians. However, it appears that much of the literature and associated studies are exploratory rather confirmatory, with a heavy emphasis on description rather than explanation. Moreover, it also appears that the amount, intensity, and disciplinary cumulativeness of pedestrian literature pales severely in comparison to that on drivers and their cars and trucks.

Third, there is great diversity and numerous perspectives present in the pedestrian literature. That occurs because the pedestrian population is diverse, as are the factors, situations, and circumstances that affect feelings and choices about whether to walk, when, and where.

And, fourth, our decision to regard **safety, comfort and convenience as aspects of security** appears to be supported by the planning literature, and the literature on

pedestrians and traffic. Absence of theory or prior research in this regard requires, however, that we avoid premature judgements about general concepts. Hence, we are obliged to continue the "literature watch" to ensure that we are focusing attention on the key factors affecting pedestrians' sense of well-being, that is, their **sense of security.**

It is generally found, therefore, that while the learned literature has much to offer the Walking Security Index (WSI) project, there appears to be no well-worn path to follow in designing and pre-testing the index. As a result the lessons of this literature are two-fold, and are of a caveat nature:

1. Analysis of the learned literature did not yield an index that we could simply "plug into" the pedestrian-roadway expression or equation of Ottawa-Carleton. As a result, the WSI project is required to engage in the difficult, higher-order task of synthesis in order to create the index. And,

2. Design and implementation of an index to represent pedestrians' sense of well-being, whether real or perceived, is not a simple, mechanical, deterministic exercise. As such the research design of the project is faced with a major challenge: how to transform a complex concept into an operational measure that can be readily understood and implemented.

Outreach Initiatives

Due to the real-world implications of the project, an outreach component is included in the research design. The purpose of the outreach component is to establish a mechanism for eliciting and receiving opinions, feedback, and advice from individuals and groups whose interests and expertise related to pedestrian security (safety, comfort, convenience) are based on practical experience.

Research Design

The activities undertaken to date have yielded findings, outcomes, or products that support the original research design. As a result, no substantive changes of a methodological nature to the project' s research plan are contemplated. The one "glitch-type" adjustment to be made is to devise a means for obtaining representations from residents whose regional councillors do not accept the invitation to participate in the study.

For reasons of limited time and financial resources, it is not possible to survey RMOC residents as to their views. Alternatively, it is appropriate and necessary to design a sampling procedure to help overcome councillors' non-participation. Regrettably, this approach not only consumes resources (energy, time, money), but it precludes directly working at the level of political parameters (that can be attached to elected officials in a controlled, directed research setting) which affect the state of pedestrian security (safety, comfort, convenience) in Ottawa-Carleton. However, under the circumstances there may be no alternative but to take the nonpreferred route in order to ensure that all Ottawa-Carleton wards are heard on this region-wide matter.

c. ***Perspectives on Pedestrian Safety.*** Proceedings of the 1996 Ottawa-Carleton Pedestrian Safety Conference. Barry Wellar (editor). Ottawa, ON: Regional Municipality of Ottawa-Carleton and the Pedestrian Safety Conference Committee. 1996.

Background and Introduction to Perspectives on Pedestrian Safety

Abstract. This paper provides a context for the papers in the Proceedings by briefly reviewing events leading up to the Conference, and then outlining the structure of the Conference and the organization of the perspectives.

Historique et Introduction Aux Perspectives Sur la Sécurité des Pietons

Résumé. Cet exposé dessine le contexte des communications présentées dans les Actes en passant brièvement en revue les événements qui ont mené à la Conférence. Il esquisse ensuite la structure de la Conférence et l'agencement des différentes perspectives.

Conference Origins

The origins of the Conference lie in the proposals, recommendations, requests and actions of an entity known as "TEAP-CAG," which stands for Transportation Environment Action Plan - Community Advisory Group. Without recounting the history of TEAP-CAG, it is appropriate to recognize the roots underlying the conference and, subsequently, the Proceedings.

Operating within the purview of the Transportation Department, Regional Municipality of Ottawa-Carleton (RMOC), TEAP had an explicit mission-oriented purpose: to explore and promote opportunities and means to increase travel by walking, cycling and transit as the preferred alternatives (in that order) over trips by private automobiles. And, towards that end, members of CAG proposed initiatives, evaluated and ranked initiatives, critiqued documents, made recommendations about funding levels and priorities, and so on.

The topic of a Pedestrian Safety Conference was raised as a possible TEAP-CAG

initiative in 199394, and again in 1994-95, but program support, that is, funding, was not secured from RMOC until February 1996. And, as a coincidental matter of importance that warrants noting here, TEAP was "discontinued" by RMOC in February 1996.

Conference Structure and Organization of the Proceedings

In the interests of completeness, the Final Program for the Pedestrian Safety Conference held April 27, 1996 at the Ottawa-Carleton Centre, Regional Municipality of Ottawa-Carleton, is reproduced in Table 1. (Note: Tables 1, 2 and 3 appear at the end of the paper.)

As illustrated, in a very brief span of time a number of perspectives involving a variety of safety topics, situations, and constituencies were presented. The purpose of the Opening Plenary, given that this was the first conference of its kind in Ottawa-Carleton, was to **broadly explore** safety-related issues, problems, concerns, initiatives, remedies, etc.

The primary function of the Walking Workshops and Panel Discussions was to provide an opportunity for participants to pursue matters raised during the Plenary presentations. They were intended, in effect, as means to elaborate and debate the ideas, facts, opinions, and other points introduced by the Plenary speakers. And, as one might expect, those sessions also presented a forum for all participants to introduce new content for consideration, and to thereby add to the substance of the deliberations. Again in the interests of completeness, Tables 2 and 3 (at the end of the paper) contain descriptions of the workshops and panels, respectively.

In addition to the traditional sessions of the opening plenary, panels, and workshops, however, this conference also contained a plenary of a different order. That is, it offered a wrap-up or closing plenary consisting of rapporteurs' reports. The value of such a session is that it pulls together the overriding messages sent and received, and tends to give attendees a more comprehensive and coherent sense of what has transpired overall, and especially for those sessions which they did not attend.

For future reference, however, let me explicitly note that this benefit has a cost: a

rapporteur-based closing plenary is very difficult to organize and to implement. We are therefore **greatly indebted** to the rapporteurs for their verbal reports given at the conference, and written reports prepared for the Proceedings.

Conclusion

The Preface provides a context for and introduction to Perspectives on Pedestrian Safety. It is anticipated that the document will prove useful in two respects in particular.

First, the papers and reports contain numerous ideas, talking points, research findings, etc. which are pertinent to discussions, debates, and decisions affecting pedestrian safety. Hence, the Proceedings is a resource for ordinary citizens, elected officials, professional staff, and interest groups seeking reasons and ways and means to enhance pedestrian safety. And, second, it is likely that additional conferences, seminars, workshops, etc. will be held in this area and elsewhere on the topic of pedestrian safety and related matters. The availability of the Proceedings means that a pertinent reference document is in place to build on, and to thereby accelerate the attainment of enhanced pedestrian safety.

d. Pedestrian Perspectives on Intersection Performance: A Case Study Report on Channelization. Barry Wellar. 1996 *URISA Proceedings*, 187-201.

Abstract. This paper presents the methodology, findings, and recommendations of an in-depth investigation into problems at the "busiest" intersection in Ottawa-Carleton, Canada. By means of vehicle and pedestrian counts, video-taped and direct observation of behaviors, and a sample of 454 interviews with pedestrians it is ascertained that: 1), passive devices such as pedestrian signs, yield signs, or zebra markings are not sufficient to give pedestrians a satisfactory sense of safety and comfort; and 2), the appropriate modifications are a STOP, and then removal of the channel if vehicle operators do not comply. The paper also outlines the status of a follow-on project to design and test a walking security index (WSI) to measure intersection performance from a pedestrian perspective across Ottawa-Carleton; and introduces The Theory of Sprawl-Induced Aberrant Driver Behavior.

Conclusion

The research project and report (Wellar, 1995) discussed in the paper make a very substantial contribution to the body of empirical data on pedestrians' views about traffic conditions and driver behavior.

Clearly, insofar as Ottawa-Carleton is concerned, pedestrians are taking increased exception to being put at risk by careless and in-a-hurry vehicle operators. And, most important, a case is being built for designing pedestrian security (safety, comfort, convenience) directly into roadway and intersection configurations at the first instance.

Over the next few months the research moves into the heart of the project, that is, the index design phase. This includes variable selection and pre-testing in an operational setting; specifying the GIS application that incorporates roadway, traffic and pedestrian entities, attributes and relations (over space and time); and, undertaking an extensive outreach program involving a variety of public and vested interest groups.

Field observations in Ottawa-Carleton, consultations with planners in many localities in a number of centres, and examination of the literature on aberrant driver behavior- running red lights, speeding up to get through the ambers, rolling through stop signs, ignoring pedestrians, etc.--suggests that a number of causal factors may be at work. As a means of organizing this part of the research, the **Theory of Sprawl Induced Aberrant Driver Behavior** is proposed to describe, explain, and predict the incidence and causes of illegal and anti-social driver choices in Ottawa-Carleton. In the coming months hypotheses will be framed and tested using police reports and data collected at a sample of intersections in Ottawa-Carleton. And, findings will be related as appropriate to the Regional Official Plan review that is now in progress.

e. ***Findings from a Field Re-Survey of the Laurier and Nicholas Cut-Off Channel (E → S) and Implications for the Walking Security Index Project.*** Barry Wellar and Ingrid Froelich. Interim Report 2. Ottawa, ON: Regional Municipality of Ottawa-Carleton and the University of Ottawa. 1996.

Executive Summary

Interim Report 2 deals with several fundamental links between the 1995 Laurier- Nicholas Channelization Study and the Walking Security Index (WSI) Project now in progress. The nature and implications of the links are summarized as follows:

1. Legitimate concerns raised about the quality of the 1995 database for the variables vehicle pedestrian conflicts, vehicles changing course, and pedestrian delays have been resolved via a field re-survey. It has been confirmed by means of detailed instructions, and more focussed reporting burdens, that high quality observations can be recorded for these variables. As a result, it is appropriate to consider including these variables in the practical (operational) research design of the WSI, and to incorporate the 1996 re-survey data into the Region's database for this location.

2. Concern regarding the criteria used to measure and define conflicts, and other related factors affecting pedestrians' sense of security (safety, comfort, convenience) were successfully examined by the re-survey. As a result, Interim Report 2 contains a number of findings and recommendations that provide guidance for changing the nature of the definitions and measurement of variables contained in the RMOC form, "Instructions for Field Surveys at Right-Turn Cut-Offs."

3. In response to findings from the 1995 Channelization Report, and their confirmation during the 1996 re-visit to the cut-off, a pilot study was undertaken to explore the degree and extent of stop bar, crosswalk, and right-turn-on-red infractions at selected intersections in different areas of Ottawa-Carleton.

As a result of the pilot study activity (that emerged during the re-survey project) a set of observation instructions were tested, a survey form was critiqued and modified, and several variables were confirmed as potential elements of the Walking Security Index. That pilot study work will now serve as the basis for two related tasks: 1) conducting more

extensive observation-recording trial runs at an increased number of regional road intersections; and 2) designing a region-wide, pedestrian security database which is needed to operationalize the Walking Security Index.

Summary

Recommendations to Mobility Services Division, RMOC, Regarding Disposition of 1995 and 1996 Field Surveys of the (SW) Right-Turn Cut-Off, Laurier Avenue at Nicholas Street, Ottawa-Carleton

The purpose of this section is to present selected recommendations to the Mobility Services Division, Department of Environmental and Transportation, RMOC. The recommendations flow from the 1995 and 1996 observations and data recording experiences of the channelization and WSI Projects. Our interest is to report on lessons learned as a result of the experimentation that was undertaken as part of the research design of the 1995 survey and the 1996 re-survey.

First, we recommend that the Division give consideration to amending the form "Instructions for Field Surveys at Right-turn Cut-Offs." It is our finding that the instructions are incomplete in terms of the variables employed, and in regard to the definitions or explanations attached to the variables.

Second, it was out repeated experience in 1995 and 1996 that for most of the peak hours (A.M., noon, P.M.), for all days of the week, the crosswalk/channel situation is very complex. As a result, we recommend the use of automatic traffic recorders (ATRs) where the observations involve simple volume counts of vehicles. With that time-consuming task taking care of, observers could focus attention on variables that require "interpretations" of what is happening. Such variables include behaviours on the parts of the vehicle operators and pedestrians.

Third, forming judgements about conflicts, delays, changed courses, acceleration of pace, etc. frequently require that the observers track the paths of vehicles and/or pedestrians. It is our finding that an overload (on observers) can occur very quickly in this location. As a result, it is our recommendation that the Division not undertake nor

support surveys at this location that try to obtain observations "on the cheap" by asking observers to take on more than they can effectively handle.

Rather, we suggest that the Division ensure that future surveys begin with the assignment loads that we found worked by the end of the second set of Group counts on October 31. These are illustrated in Appendix A. Then, and especially if the Division's observers have received substantial training in the activity, the burden could be increased.

Our point of concern here is to ensure that the condition of integrity between our 1995 and 1996 data and any future channel and/or crosswalk data is met. To satisfy that objective, any error that occurs needs to be on the side of an under-assignment of tasks. For this location, with its obvious problems and complexities, it would be imprudent and even reckless to think otherwise.

Fourth, we believe that a substantial degree of robustness exists with respect to the data set assembled for this location during the channelization project, and by means of the current re-survey. It is therefore our recommendation that the tables and text presented in the report be adopted as part of the Region's "official" data set and state of knowledge for the cut-off.

And, fifth, we believe that the 1996 re-survey confirms a central channelization study finding: namely, that while the 1993-94 modifications may have initially achieved modest gains involving pedestrians' concerns (safety, comfort, convenience), those gains have largely dissipated over time.

It is our summary recommendation, therefore, that the Mobility Services Division and the Region have all due regard at the earliest for the pedestrian-sensitive conclusions and recommendations of the channelization study (Wellar, 1995). In particular, and to ensure that no doubt arises about the direction to which evidence points we are as explicit as words allow: **a full stop (light or sign) is required to better ensure pedestrians' security - their safety, comfort and convenience - while they are at or in SW crosswalk at Laurier and Nicholas.**

Incorporating Field Re-Survey Data and Findings on Vehicle-Pedestrian Conflicts, Changed Vehicle Courses, and Pedestrian Delays in the WSI Research Project.

As noted above in Section B-I, this research report proceeded in parallel with writing the research report on specifying the concepts and variables to comprise the Walking Security Index (Wellar, 1997). The purpose of this section is to highlight the data and findings from the re-survey that appear pertinent to the formulation, testing and validation of the WSI.

First, emphasis on safety, comfort and convenience as principal components of the WSI appears to be generally supported by the re-survey observations. Indeed, there do not appear to be any contradictions in evidence with the principal components thesis advanced explicitly by Wellar (1995) in the WSI project, and implicitly by the 1996 conference that brought in safety, comfort, convenience considerations via the plenary papers, field workshops, panels, and rapporteurs' reports (Wellar, 1996).

Second, the re-survey generated considerable *prima facie* support for the thesis that there are substantive connections between the WSI components (safety, comfort, convenience) and such re-survey variables as vehicle-pedestrian conflicts, vehicles changing course, and pedestrian delays. It was fortuitous that conditions allowed for this work to be done at this time, since the re-survey provided an extremely valuable and timely check on the WSI project's research design methodology.

Third, the re-survey provided an opportunity to "pre-test" some of the variables that are candidates to constitute the principal components of safety, comfort and convenience. Moreover the re-survey proved to be very instructive in terms of documenting the need to critically question some accepted practices in this field.

Fourth, the critique of the form "Instructions for Field Surveys at Right-Turn Cut-Offs" also proved to be a productive research activity. It is our finding that much remains to be done to fully specify and measure how vehicle-pedestrian conflicts, changed vehicle courses, and pedestrian delays affect pedestrians' sense of safety, comfort and convenience. In other words, and referring back to Interim Report 1 (Wellar, 1996), **there is a compelling**

need to inventory and critique all the pertinent legal, regulatory and professional literature in terms of what is said and what is not said about selecting the appropriate variables to constitute the index.

Finally, as part of the GEG 3104 assignment workload, an important spin-off project was completed which centred around two variables and associated problems that surfaced during the 1995 channel study, and which have re-surfaced on numerous occasions in the interim:

1. Vehicles are not stopping before the slop bars Instead, when braking is complete the vehicles are beyond the stop bars to the point of encroaching upon, intruding into, or even extending across or over the crosswalks. And,

2. Vehicle operators "nose," "zip," or "barge" into crosswalks, including those which are directly in front as well as those at a right or left 90° angle. The situation of issue here is that this behavior occurs even when the crosswalks are already occupied by pedestrians! Or, they are about to be occupied by pedestrians before the vehicle operators would get there if the operators were obeying the rules of the road on full stops, defensive driving, and yields.

It was ascertained via field surveys at various signalized intersections in Ottawa- Carleton that these "misbehaviours" do indeed occur, and that they can be observed and recorded. Hence, the spin-off project served as a pilot study for designing a field form, and for making and recording observations on two more variables that are candidates for inclusion in the Walking Security Index.

Since this was a spin-off project it is not discussed in further detail here. Rather, it is noted for the record that 25 term papers were completed for this assignment, and that pertinent data and findings will be included in future WSI reports as appropriate.

f. ***Safety, Comfort and Convenience as Principal Components of the Walking Security Index: Initial Specification.*** Interim Report 3. Barry Wellar. Ottawa, ON: Regional Municipality of Ottawa-Carleton and the University of Ottawa. 1997.

Executive Summary

Interim Report 3 makes the case for specifying first, that security is an essential component of well-being, and second, that safety, comfort and convenience are principal components of security. In the context of the Walking Security Index Project, and its focus on pedestrians, the relationship advanced is that pedestrian safety, pedestrian comfort, and pedestrian convenience in combination are necessary if not sufficient conditions to achieve pedestrian security.

With due regard for the applied implications of the Index being implemented, emphasis has been placed on making the research process as robust as circumstances permit. The following research methods, research techniques and research operations are among those employed in conducting inquiries and producing findings on the relationship between pedestrians' security, safety, comfort, convenience.

- Searches and reviews of the learned, popular, legal, regulatory, professional, public interest group, private interest group and academic literature for discussions and references pertaining to the WSI as a construct, and to combinations of key words contained in the terms of reference.
- Content analysis and content synthesis of the literature selected for review.
- Field surveys, including both exploratory and confirmatory site activities.
- Interviews with pedestrians, professional staff, elected officials, and student participants.
- Presentations and publications in both professional and popular venues to make the applied research as transparent and available as circumstances permit.

The central finding of Interim Report 3 is that safety, comfort and convenience can be methodologically justified as necessary conditions of security, and that the contents of Interim Report 3 fully support specifying the variables and formulating the Walking Security Index in operational terms.

Summary

Safety, Comfort and Convenience as Principal Components of Pedestrian Security: Lessons from the Driver-Oriented Road Transport Literature

Various bodies of literature were found to support the emphasis put on pedestrian security, safety, comfort and convenience. Indeed, no body of literature -- learned, professional, legal, regulatory, public interest, vested interest, academic -- in whole or in part opposed pedestrians being provided with facilities, services and environments that make walking a safe, comfortable and convenient experience.

The most compelling literature in support of pedestrian safety, comfort and convenience, however, was found to be the road transport literature in advocacy of motorized vehicle transport.

For decades the road transport literature used the terms safety, comfort and convenience to describe and evaluate the level of service experienced by motorized vehicle operators and their passengers. That literature thereby makes a major contribution to establishing the conceptual pertinency of: security to well-being in general, and the pertinency of pedestrian safety, comfort and convenience to pedestrian security in particular for the following reason:

> All users of all modes of transportation have the right to expect and receive equitable regard and treatment.

The argumentation on behalf of those who ride in motorized vehicles is therefore pertinent to those who walk, and can be directly adopted as a matter of principle.

It is with regard to the implementation of the Index, however, that the lessons from the driver-oriented road transport literature take on real-world significance. That is, from the standpoint of fairness, and reasonableness, people who walk have the same entitlements to well-being as those who drive or ride. The fact that the entitlements have not been equitably distributed over the past number of decades does not negate the principle, of course, but instead illustrates how much "catching up" needs to be done to provide pedestrians with appropriate facilities and environments.

Security: Necessary But Not Necessarily Sufficient to Ensure Well-Being

The overriding concept of security was presented (back in 1994-95) as the driving rationale behind a project to develop an index that measures intersection performance from the pedestrian perspective. The concept of security -- which means free from care and cure -- is deemed necessary and appropriate for this project. It is emphasized, however, that security is not presented as being sufficient to measure every aspect of intersection performance that affects pedestrians' well-being in real or perceived terms.

Safety, Comfort and Convenience: Necessary But Not Necessarily Sufficient to Define Security

In Section C, principles and definitions are presented to explain how safety, comfort and convenience are related to and constitute security. The definitions of the proposed principal components are summarized as follows.

- Pedestrian safety is the condition of pedestrians being free from physical harm while walking.
- Pedestrian comfort is the condition of pedestrians being free from mental and emotional duress while walking.
- Pedestrian convenience is the condition that pedestrians are treated equitably in regard to the provision of, means to, and use of transportation facilities and services.

And, in the interests of preventing mis-interpretations, the caveat noted in Part 2 about the necessary-sufficient distinction needs to be repeated. That is, for the purposes of this project, safety, comfort and convenience were presented to and accepted (by RMOC) as necessary and appropriate measures of pedestrian security. Consequently, their elaboration in Interim Report 3 proceeded on that understanding.

Conversely, however, no claim or even suggestion is made that safety, comfort and convenience are sufficient to define security in its structural and functional totality. As indicated above, the sufficiency matter is beyond the purview of this project. We would, of course, be most interested in being apprised of dissertations, theses, or other documents which report on methodologically or epistemologically rigorous investigations into this

important topic.

Specifying the Variables to Operationalize the Principal Components: Next Steps

It is intended that the initial specification of WSI variables occur within several months of Interim Report 3 being finalized. Major research activities to be undertaken include the following:

1. Synthesize the findings from the literature reviews, fieldwork projects, responses to presentations, and discussions with interested groups.

2. Compile a "long list" of candidate variables for each principal component (safety, comfort, convenience).

3. Elicit feedback on the "long list" from Regional staff, municipal staff, community associations, and other interested parties as to the "short list" of preferred variables for each principal component (safety, comfort, convenience).

4. Synthesize the "short list" recommendations and specify the variables which appear to best operationalize the principal components of the Walking Security Index.

Staying the Methodological Course

The reasons for adopting and respecting a methodologically rigorous research design are presented earlier in this report, and in preceding WSI Project reports. As a result, they do not need repeating here. What does warrant noting, however, is the occasional sharp or blunt message which reminds us of the costs of foregoing rigour and engaging in "loose" research. A current, high-visibility reason for staying the methodological course lies in the "rough" reception given to the Human Development Index report published annually by the United Nations (U.N.).

As Wellar (1996) noted in his critique of the 1996 report, and Coyne (1997) observed in his column discussing the 1997 Index, there are serious errors of omission and commission in whats, whys and hows of the Index. The unfortunate chain of events involved may be summarized as follows: since the methodology upon which the Index is

based is flawed, the robustness of the Index is damaged; consequently, the outputs of the Index, and the interpretations of the outputs, are flawed.

The message taken, therefore, from the U.N. and other experiences is that having regard for the precepts of methodological inquiry throughout the Project is a course that needs to be stayed.

g. ***Capability of IS/GIS - Based Intersection Applications to Implement the Walking Security Index (WSI): A Preliminary Status and Prospects Assessment.*** Interim Report 4. Barry Wellar. Ottawa, ON: Regional Municipality of Ottawa-Carleton and University of Ottawa. 1997.

Executive Summary

Interim Report 4 addresses an apparent weakness in the literature on pedestrian security d and information, intersection databases, and information system/geographic information system (IS/GIS) intersection applications. The weakness identified via numerous electronic and paper searches is that the literature lacks substantive documentation on: **a) how best to integrate intersection feature and performance data** in an IS/GIS application; **and b) how best to generate pedestrian security information** for policy, plan, program and project purposes from an IS/GIS-based intersection application.

The purpose of Interim Report 4 is two-fold: first, to advise the Regional Municipality of OttawaCarleton on the implications of these findings for implementation of the Walking Security Index (WSI); and second, to provide the Municipality with suggestions as to how it might deal with the apparent literature gap and associated real-world problems.

Interim Report 4 is constructed around a paper accepted for presentation at the 1997 Urban and Regional Information System Association Conference. "Integrating Intersection Feature and Performance Data Using the Walking Security Index (WSI) Model " (Wellar and Soroko, 1997) combines findings from the WSI Project and a GIS software evaluation project. The paper is presented in Appendix A.

As context for the Wellar-Soroko paper, Interim Report 4 examines two matters that directly bear on how effectively the IS/GIS-based application is developed and implemented:

1. The critical contribution of the WSI Model to the definition/specification of the intersection application; and,

2. The need for a municipal survey of IS/GIS intersection applications to identify what remains to be done to achieve the data integration and information generation objectives.

Conclusion

The approach of this paper, given its URISA setting, is to emphasize the outputs and the use of an IS/GIS application for discussions and decisions affecting the security of pedestrian movement. In addition, however, we refer to previous research for substantive direction: achieving the desired outputs and uses is based on designing and operationalizing an IS/GIS application that has due regard for the Walking Security Index as a model for integrating intersection feature and performance data.

It is our general finding that much research and development remains to be undertaken, and validated, throughout this application domain. In that regard we hasten to add that we find no evidence that a technological solution (IS/GIS software package) is either at hand or even imminent. However, a survey of selected agencies is planned as part of the WSI Project to guard against the open literature not fully reporting on the status and prospects of this IS/GIS challenge and opportunity.

h. Walking Security Index Variables: Initial Specification. Interim Report 5. Barry Wellar. Ottawa, ON: Regional Municipality of Ottawa-Carleton at the University of Ottawa. 1997.

Executive Summary

Interim Report 5 contains the initial specification of variables that have been identified as candidates for inclusion in the Walking Security Index (WSI). A total of 212 variables and sub-variables are named, and are categorized and enumerated as follows:

1. Infrastructure Features (54)
2. Vehicular Traffic Features (54)
3. Pedestrian Traffic Features (30)
4. Infrastructure Performance Measures (25)
5. User (Behavior) Performance Measures for Vehicles, Drivers, Pedestrians (49).

In the first instance, the purpose of these variables is to elaborate the concepts of security, safety, comfort, and convenience as they pertain to the experience of pedestrians at signalized intersections. Based on the available evidence, all the named variables are pertinent to one or more of the concepts. And, due to the relatively exhaustive lists of variables and sub-variables that have been assembled, it appears that the concepts have been defined as fully as needed to permit an initial specification of the Index.

Second, the lists of variables may also serve an immediate, important function of a very practical nature. That is, it appears that they could be used by elected officials, professionals, community groups, and other interested parties wishing to perform "audits" of signalized intersections.

The remaining WSI Project task is to design the Index, based on a selection of the specified variables. Towards that end the lists of variables in Appendix A are being circulated among elected experts, professional experts, and lay experts for comments on the pertinency of the variables to pedestrians' security (safety, comfort, convenience).

Summary

Procedures for Deriving the Candidate Variables

Consistent with the methodology of previous WSI studies, Interim Report 5 is based on a combination of research activities. These include cataloguing, analyzing and synthesizing observations and findings obtained in literature searches (various literatures, from learned to popular), field surveys, interviews, and consultations. In addition, preliminary circulation of candidate variables among groups of experts (elected, professional, lay), beginning with the 1996 pedestrian safety conference (Wellar, 1996d), provided feedback to the effect that the research was "on the right track."

Categories of Variables

In all the literature encountered - learned, popular, legal, regulatory, professional, and interest group--there appears to be a common tendency towards gross simplification of intersection dynamics and interactions. And, similarly, there appears to be a tendency towards gross simplifications and non-substantiable claims as to what is or is not pertinent to pedestrians' expectations about their security (safety, comfort, convenience) while crossing signalized intersections or channels of regional roads.

To clarify and structure this dialogue to (more) productive purposes, five categories of variables are used to organize the discussion. The categories are:

1. Intersection Features
2. Vehicle Traffic Features
3. Pedestrian Traffic Features
4. Infrastructure Performance Measures
5. User (Behavior) Performance Measures for Vehicles, Drivers, Pedestrians.

As noted above in Section C, these categories are based on classifying intersection feature and performance characteristics in terms of their structural and functional properties. It is a Project finding that the structural-functional approach is a most effective means of specifying the variables that elaborate the concepts of safety, comfort, and convenience. Indeed, and based on the research completed to date, it appears

reasonable to conclude that the structural-functional approach established itself as a *sine qua non* for both research and actual projects that involve taking into account intersection modification or assessment variables.

Rating the "State of Knowledge and Regard" Concerning the Connection Between WSI Variables and Concepts

In the apparent absence of prior research in this domain, it was necessary to develop a system for rating the connections between WSI variables and concepts. Bearing in mind prior Project literature searches and reviews, and having due regard to the "inexactness" which is appropriately associated with this field of inquiry, a rating system with nine classes was devised. The classes, which rate the state of knowledge and regard between variables and concepts, are as follows:

A	=	connection accepted in principle and practice
B	=	connection accepted in principle but not in practice
C	=	connection supported by WSI research
D	=	connection not sufficiently investigated
BA	=	connection moving between B and A status
CA	=	A-type connection in question
CB	=	B-type connection in question
CD	=	WSI-based original research needed
Other	=	validation research needed.

Using the Variables: As Check-Lists for Audits, and for Input to the Walking Security Index

A total of 212 variables and sub-variables have been identified as candidates for inclusion in the Index. Over the course of the next several months, those variables and combinations of variables contained in Tables 3, 4, 5, 6, and 7 will be studied for their significance to the WSI.

As readers will note upon examining Appendix A, the opinions of three bodies of experts--elected, professional, lay--are being sought to assist in the deliberations.

Finally, the check-lists are deemed to serve an immediate, real-world purpose. That is, they can be used to "check-out" intersections in terms of their features, and their performance characteristics, as they pertain to pedestrians' safety, comfort, and convenience. In that regard it is noted that other variables which are significant to particular intersections, traffic situations, etc. can be added to the current lists to increase the lists' applicability at given locations.

Next Steps

The major, remaining activity to complete the WSI Project is to propose the structure and content of the Walking Security Index. Review of responses to Appendix A, and a final round of consultations with index design experts (resources permitting) are planned for completion by early December, with the Final Report to be submitted to RMOC by the end of December, 1997.

An Interim Report containing media articles and comments has been under active consideration for many months. However, this activity will not be undertaken unless and until it is ascertained that the expenditures of time and finances will not jeopardize completion of the Final Report on or before the scheduled due date.

Appendix B. Variable Evaluation Criteria

1. Background

The use of criteria to assist in evaluating options and making choices was discussed in several background reports (Wellar, 1997b, 1997c, 1997e) and, most recently, in Section B-2 of this document. In the latter case, it was noted that the general criteria of pertinence, support and ease are deemed to be of paramount importance when making suggestions about modifications that are likely to be acted upon to close the gap between experiences and expectations involving pedestrian security.

So that readers know the basis upon which the variables were selected for inclusion in the audit form(s) and/or index(es), the criteria employed are made explicit. Readers should also be apprised, however, that since much of the research is both original and exploratory there will likely be both need and opportunity to bring other criteria to bear on how to make choices about the variables to select and not select.

2. Evaluation Criteria -- General

a. Pertinence

If changes in the values of candidate variables significantly affect pedestrians' expectations or experiences involving their security, then those variables are pertinent to defining, measuring, and evaluating the situations of pedestrians while using signalized intersections. Variables for which changes in values do not have such an effect are not pertinent and, hence, are not appropriately considered for inclusion in the audit form(s) or index(es).

b. Support

Variables for which there is consensus among the experts (elected, professional, lay), the literature, and project fieldwork are obviously candidates for inclusion in the audit form(s) and the index(es). For the far more numerous cases where unanimity does not exist, however, one or more of the sources of support must be seen to be making or representing a sufficiently robust case on behalf of the variable(s) in question. That is,

since change is not likely to occur without advocacy, one or more of the "players" must be pushing or pulling on behalf of a variable in order for it to be deemed to have support.

The exception in this regard would be a new or different variable that emerged during the course of the project. If, on the basis of the Principal Investigator's judgement, it appears very likely to receive robust support by one of the expert groups (elected, professional, lay) in the foreseeable future, that is, within the next several years, then such a variable is deemed to satisfy the support criterion.

c. Degree of Difficulty

The premise behind this criterion is that, *ceteris paribus*, a variable is more likely to be instituted, modified, respected, etc. if the required action is relatively easy or benign, rather than challenging or disruptive in political, legal, institutional, financial, technological, technical, and related terms.

In the former case, the sense of ease could be due to familiarity, repetition of previous, marginal changes, acceptance of an idea whose time has come, etc. And, in the latter case, examples of actions likely to be relegated to the challenging category would be those wherein the variables involve major such obstacles or counter forces as: complicated changes in legislation; large, costly and disruptive structural changes to the existing regional road network; the creation of new signaling system technologies to accommodate changes in intersection performance requirements; and, a profound adjustment of attitudes and behaviors among the populations of vehicle operators, pedestrians, elected officials, or professional staff.

The fact of the matter remains, however, that in perceiving or assessing degrees of ease or difficulty as a criterion for selecting variables, there is a real-world context that provides guidance. And, reference to the spatial aspect is especially instructive. That is, Ottawa-Carleton is an urbanized region of some 750,000 residents, much of the area inside the Greenbelt is 'built-up,' and a multi-modal transportation system that provides for travel in the walk, cycle, transit and vehicle modes is largely in place. And, of direct pertinence to the understanding of this criterion, the movement of all modes of traffic on regional roads

throughout Ottawa-Carleton is facilitated and regulated by some 800 signalized intersections.

The point of emphasis, therefore, is that a large amount of action and interaction involving cars, trucks, bases, bikes, drivers and pedestrians occurs, minute-by-minute, hour-by-hour, day-by-day, in a relatively confined space. And, to compound the situation, two perversities appear to be at work. First, no evidence has been found to suggest that any of the modes is tending towards reducing its demand on signalized intersections in Ottawa-Carleton. And, second, no evidence has been found to support the notion that turning more land area over to intersections would relieve congestion, or alleviate the other ills afflicting intersection performance in Ottawa-Carleton.

Clearly, then, a realistic perception of the difficulty criterion requires that discussions and choices be put in their proper context. Specifically, in order to match pedestrians' experiences to expectations in regard to security, it is required that change occurs. Further, change could occur with respect to any or all of the following: intersection infrastructure features; vehicular traffic features; pedestrian traffic features; and the performance aspects of intersections, vehicular traffic, drivers, and pedestrians.

As the last paragraph demonstrates, the easy-difficult spectrum is complicated because there may be choices to be made between or among the various forces and players affecting pedestrians' security. As a result, the reasons used to evaluate variables for the difficulty criterion are made as explicit and detailed as the background research permits.

3. Evaluation Criteria -- Particular

The distinction between the general criteria above and the particular criteria which follow is primarily due to their "authorship". That is, the general criteria tend to be applicable to any and all proposed initiatives involving change, and they have a long history of use and acceptance. The criteria regarded as particular, however, were elaborated during consultations with elected, professional and/or lay experts who participated in the WSI Project, and especially during the review of the lists of variables (Interim Report 5, Wellar, 1997). For reasons of origin and participant recognition alone, these criteria warrant serious consideration.

Even more importantly, however, in terms of the robustness of findings and recommendations about variables, the feedback from experts contains what might be termed a "bonus". That is, their responses and inputs provide an indication of the likely "reception" that will be given to the variables proposed for the audit form(s) and index(es). Such participation and advice provides early warnings or signals about the pertinence, support, and degree of difficulty associated with the variables.

Further, such participation and advice also helps reduce the number of iterations that the form(s) and index(es) might go through before the essentials finally emerge. That is, those affected (electeds, professional staff, citizens/pedestrians) made their views known during the process, rather than after a product was presented as a *fait accompli* and then subjected to debate. As a result, the learning and acceptance curves for the findings and recommendations should be flatter (easier to climb) for all who have participated in the variables specification process.

Two evaluation criteria of the "particular" category emerged for use in making recommendations about which variables to include in the pedestrian security audit form(s) and index(es). These particular criteria are labeled *enforceability* and *data availability*, and they specifically address matters raised by WSI Project participants.

a. Enforceability

The focus of attention in regard to enforceability involves features or performance variables that are intended to control or regulate intersection use, and the behavior of intersection users. A variable is deemed enforceable to the degree that it serves two functions or meets two conditions, in particular:

1. It compels observance by intersection users, that is, vehicle operators/owners, cyclists, pedestrians; and,
2. It lends itself to the arrest and conviction of intersection users (vehicle operators/owners, cyclists and pedestrians) who do not properly observe the regulation associated with a feature or performance variable.

There are various sources of *enforceable variables*, including the *Highway Traffic Act*, regional and city by-laws, and driving school information sheets. Examples of familiar,

enforceable variables include signal lights, signs (stop, stop line, yield, kph, etc.) and road markings (dividing lines, crosswalks, stop bars, etc.). The distinguishing characteristic of these variables is that failure to observe the associated regulations could be cause for arrest and prosecution under the terms of the relevant law or by-law.

Insofar as their connection to pedestrian security is concerned, enforceable variables may be pertinent to each of the components of security, that is, *safety*, *comfort*, *convenience*. However, in operational terms, enforcement of relevant laws and by-laws currently refers only to the safety component. As a result, that is the only component for which an enforcement variable needs to be pertinent in order to be recommended as an audit form or index variable.

Finally, expertise as to the enforceability of variables falls very much within the purview of Ottawa-Carleton Regional Police Services, since that agency is responsible for the enforcement of laws and by-laws regulating use of and behavior on regional roads, including signalized intersections. We are therefore very appreciative of the feedback from the Traffic Services Section and Constable Amerjit Sahota in their reviews of the lists of variables. And, we are especially indebted to Constable Sahota for his insights and suggestions about the operational importance of enforceability when recommending variables for the walking security audit form(s) and index(es).

b. Data Availability

This criterion has a particular relevance to the WSI Project for several reasons. First, and as indicated by the lists of variables circulated as part of the research for Interim Report 5 (Wellar, 1997e), the potentially large number of pertinent variables translates into a potentially large data burden. Hence, it is appropriate to question whether the data needed to "feed" a WSI-based intersection feature and performance application of that magnitude and complex functionality are available, and can be maintained at needed operational levels (Wellar, 1997a; Wellar and Soroko, 1997).

At an operational, pragmatic level, then, data availability is a legitimate concern. There is, however, a second consideration about data availability which appears to be even more germane to the variable specification task which is the focus of Section C in the main text of the Final Report. That is, questions about data availability are logically examined **after** two other leading questions have been raised and answered:

1. What needs to be known and is not known?;
2. How is the needed knowledge to be acquired?

Moreover, in the current IS/GIS environment at the RMOC, which appears similar to that of many urban/regional governments across North America, there is a bundle of fundamental, building-block questions about data ➔ information ➔ knowledge transformations that (logically) require being dealt with before answers to questions of data availability can be of much practical value.

Further, to recall the Project's terms of reference (Table 1, Section B), emphasis in this particular study is clearly on identifying and relating the variables which elaborate the concepts of pedestrian security (safety, comfort, convenience). The implication of this second consideration, it appears, is that both the terms of reference and the principles of information systems and knowledge base development **reject** data availability as an overriding concern.

In the face of this *impasse*, an accommodation needs to be reached: that is, data availability is a useful real-world test of practicality, but it must operate without stifling the higher purpose of specifying the (pertinent) variables that should be in the audit forms or indexes. The following two observations about the variables and associated data appear sufficient to demonstrate why and how the accommodation can be arranged, and why it should be adopted by the RMOC.

First, variables that pertain to features or structural matters are likely to warrant only

minimal database development attention. By way of illustration, adoption of a recommendation to locate stop bars six metres from crosswalks does not, in and of itself, entail building and maintaining a sophisticated database for that variable. Similarly, accepting that the duration of cycles should reflect the realities of the seasons -- it takes longer for pedestrians to cross the road in winter than in summer -- or that sidewalk corners should be kept clear of ice and snow, are not data availability concerns.

Fortunately, there are a number of feature variables which involve minimal data burdens, but which are pertinent to bridging the gap between pedestrians' experiences and expectations regarding their security (safety, comfort, convenience). As a result, ensuring that all the pertinent features/structural variables are identified and adopted for use in the audit forms is a major step towards operationalizing WSI concepts without incurring a data burden.

Second, variables that pertain to performance or functional matters could warrant substantial database development attention. This occurs because it is these variables which would constitute the data elements, information elements and knowledge elements of an IS/GIS to: 1) monitor, measure and assess intersection performance and functionality over time and space; and 2) provide guidance for decision makers in regard to potential modifications.

As indicated in Section C, there are a number of performance variables which are pertinent to the audit forms and indexes. And, as demonstrated by the associated discussions (and previous reports: Wellar, 1997a, 1997c, 1997e, Wellar and Soroko, 1997), there may be substantial challenges involved in monitoring, measuring and assessing the changes in performance variables.

The positive aspect of the complexity problem is that it reinforces the need to focus on what needs to be known, and the means of knowing, before engaging in data acquisition, processing, storing, retrieving, etc. activities. As a result, the criterion of data availability is

relevant to variable selection and recommendation process because it emphasizes the need to restrict the index formulation(s) to what might be termed **primary performance variables.**

Appendix C. Initial Specification of Variables Associated With Pedestrian Security (Safety, Comfort, Convenience)

Interim Report 5 (Wellar, 1997e) discusses the derivation of the variables contained in the initial specification. And, very importantly, it presents an assessment of the degree to which the connection between concepts (security, safety, comfort, convenience) and variables appears to be accepted in principle and in practice. The tables in Interim Report 5, which summarize the connections between concepts and variables, and the status of acceptance of the connections (principle-practice), are repeated here for easier cross-reference with other tables in the Final Report. Readers wishing more details about the nature of connections, assignment of cell entries, etc. are referred to the original document (Wellar, 1997e).

Table C-1. Intersection feature and performance variables associated with pedestrian security: Infrastructure features

Infrastructure Features		Associated WSI Component *		
ID	Variable Name	Safety	Comfort	Convenience
I.10	Number of lanes	B	B	B
I.11	Posted speed of approach lanes	BA	BA	BA
I.12	30 kph	A	A	A
I.13	40 kph	A	A	A
I.14	50 kph	D	D	D
I.15	60 kph	D	D	D
I.16	80 kph	A	A	A
I.17	Roadway width	B	B	B
I.18	Cut-off channel lane(s)	C	C	C
I.19	Channel island size	C	C	C
I.20	Roadway grade (of approaches)	BA	BA	BA
I.21	Roadway surface conditions	B	B	B
I.22	Number of left turn lanes	B	B	B
I.23	Permissive	B	B	B
I.24	Protected	B	B	B
I.25	Simultaneous	B	B	B
I.26	Median (refuge) size	B	B	B
I.27	Median (refuge) condition	B	B	B
I.28	Traffic calmers proximal to intersection	BA	BA	BA
I.29	Roadway bumps	BA	BA	BA
I.30	Roadway humps	BA	BA	BA
I.31	Rumble strips	BA	BA	BA
I.32	Ceramic Buttons	D	D	D
I.33	Sidewalk width	B	B	B
I.34	Sidewalk corner size	B	B	B
I.35	Sidewalk curb condition	B	B	B
I.36	Curb cut(s) proximal to intersection	B	B	B
I.37	Crosswalk elevated	B	B	B
I.38	Crosswalk signed and painted	C	C	C
I.39	Crosswalk width	CB	CB	CB
I.40	"Desire-line" crosswalk design	B	B	B

Source: Wellar (1997e, pp.22-23).

Table C-1. Intersection feature and performance variables associated with pedestrian security: Infrastructure features (continued)

Infrastructure Features		Associated WSI Component *		
ID	Variable Name	Safety	Comfort	Convenience
I.41	Dedicated bicycle lane	D	D	D
I.42	Curb divider	B	B	B
I.43	Painted line	D	D	D
I.44	Stop bar	A	A	A
I.45	Painted	BA	BA	BA
I.46	Painted and signed	B	B	B
I.47	Stop bar distance from crosswalk	C B	C B	C B
I.48	Pedestrian signage	C B	C B	C B
I.49	Pedestrian zone ahead sign	C B	C B	C B
I.50	Yield to pedestrian sign	C B	C B	C B
I.51	Pedestrian zone painted on roadway	C B	C B	C B
I.52	Pedestrian-activated signals	C B	C B	C B
I.53	Visual	C B	C B	C B
I.54	Visual and audible	C B	C B	C B
I.55	Protective pedestrian posts	D	D	D
I.56	At/on crosswalks	D	D	D
I.57	At/on traffic island	D	D	D
I.58	At/on median	D	D	D
I.59	LED indicating wait time for walk signal	B	B	B
I.60	Street furniture proximal to sidewalk corner	B	B	B
I.61	Sightline obstructions	B	B	B
I.62	For vehicle operators	B	B	B
I.63	For pedestrians	B	B	B

* The cell entries depict concept-variable connections as follows:
A = accepted in principle and practice;
B = accepted in principle but not in practice;
C = supported by WSI Project research;
D = not sufficiently investigated;
BA = moving between B and A status;
CA = A-type connection in question;
CD = WSI-based research needed;
Other letter combinations = validation research needed.

Source: Wellar (1997e, pp. 22-23).

Table C-2. Intersection feature and performance variables associated with pedestrian security: Vehicular traffic features

Vehicular Traffic Features		Associated WSI Component *		
ID	Variable Name	Safety	Comfort	Convenience
V.10	Traffic volumes, peak hours	CB	CB	CB
V.11	A.M. (7-9)	B	B	B
V.12	Noon (11-1)	B	B	B
V.13	P.M. (3-6)	B	B	B
V.14	Traffic volumes, off-peak hours	B	B	B
V.15	Percentage of vehicles by type	B	B	B
V.16	Car/van	B	B	B
V.17	Heavy truck	B	B	B
V.18	Transit (bus)	B	B	B
V.19	Transit (rail)	D	D	D
V.20	Passenger	D	D	D
V.21	Freight	D	D	D
V.22	Bicycle	B	B	B
V.23	Distribution of trips by journey origin and destination	CB	CB	CB
V.24	Local	CB	CB	CB
V.25	Regional	CB	CB	CB
V.26	Extra-regional	CB	CB	CB
V.27	Distribution of trips by purpose: personal	CD	CD	CD
V.28	Work	CD	CD	CD
V.29	School	C	C	C
V.30	Business	CD	CD	CD
V.31	Shop	C	C	C
V.32	Recreation/leisure	D	D	D
V.33	Medical/health	D	D	D
V.34	Entertainment	D	D	D
V.35	Dining	D	D	D
V.36	Drinking	A	A	A
V.37	Dining and drinking	D	D	D
V.38	Sports	D	D	D
V.39	Theatre	D	D	D

Table C-2. Intersection feature and performance variables associated with pedestrian security: Vehicular traffic features (continued)

Vehicular Traffic Feature		Associated WSI Component *		
ID	Variable Name	Safety	Comfort	Convenience
V.40	Distribution of trips by purpose: commercial	C	C	C
V.41	Delivery of goods	C	C	C
V.42	Delivery of people	C	C	C
V.43	Distribution of trips by purpose: public	A	C	C
V.44	Fire	A	C	C
V.45	Police	A	C	C
V.46	Works	C	C	C
V.47	Distribution of vehicle movements through crosswalk by direction	BA	C	C
V.48	Straight	A	C	C
V.49	Straight and left turn	A	C	C
V.50	Straight and right turn	A	C	C
V.51	Straight and left and right turn	A	C	C
V.52	Peak hour gaps for cut-off channel	B	C	C
V.53	A.M. (7-9)	B	C	C
V.54	Noon (11-1)	B	C	C
V.55	P.M. (3-6)	B	C	C
V.56	Percentage of drivers by gender	CB	CB	CB
V.57	Male	CB	CB	CB
V.58	Female	CB	CB	CB
V.59	Percentage of drivers by age group	BA	BA	BA
V.60	Youth (16-25)	CB	CB	CB
V.61	Young adult (26-35)	CB	CB	CB
V.62	Mature adult (36-54)	CB	CB	CB
V.63	Seniors (55+)	CB	CB	CB

* The cell entries depict concept-variable connections as follows:

A= accepted in principle and practice; B = accepted in principle but not in practice,

C = supported by WSI Project research; D = not sufficiently investigated;

BA = moving between B and A status; CA = A-type connection in question;

CD = WSI-based research needed;

Other letter combinations = validation research needed.

Source: Wellar (1997e, pp. 25-26).

Table C-3. Intersection feature and performance variables associated with pedestrian security: Pedestrian traffic features

Pedestrian Traffic Features		Associated WSI Component*		
ID	Variable Name	Safety	Comfort	Convenience
P.10	Pedestrian volumes, peak hours	CB	CD	CD
P.11	A.M. (7-9)	CB	CD	CD
P.12	Noon (11-1)	CB	CD	CD
P.13	P.M. (3-6)	CB	CD	CD
P.14	Pedestrian volumes, off-peak hours	CD	CD	CD
P.15	Distribution of trips by journey origin-destination	CB	CD	CD
P.16	Within neighborhood	CB	CD	CD
P.17	Outside neighborhood	D	D	D
P.18	Distribution of trips by purpose	CB	CD	CD
P.19	Work	B	C	C
P.20	School	CB	CB	CB
P.21	Business	BD	BD	BD
P.22	Shop	BD	BD	BD
P.23	Recreation/leisure	B	B	B
P.24	Medical/health	B	B	B
P.25	Entertainment	D	D	D
P.26	Dining	D	D	D
P.27	Drinking	B	B	B
P.28	Dining and drinking	D	D	D
P.29	Sports	D	D	D
P.30	Theatre	D	D	D
P.31	Percentage of pedestrians by gender	CB	BCD	BCD
P.32	Male	CB	BCD	BCD
P.33	Female	CB	BCD	BCD
P.34	Percentage of pedestrians by age group	B	BCD	BCD
P.35	Child (12 and under)	BA	CD	CD
P.36	Youth (13-20)	B	CD	CD
P.37	Young adult (21-29)	B	CD	CD
P.38	Adult (30-54)	B	CD	CD
P.39	Senior (55 and over)	BA	CD	CD

* Cell entry meanings are noted at the bottom of Table C-1 and Table C-2

Source: Wellar (1997e, p. 28).

Table C-4. Intersection feature and performance variables associated with pedestrian security: Infrastructure performance measures

Infrastructure Performance Measures		Associated WSI Component*		
ID	Variable Name	Safety	Comfort	Convenience
IM.10	Right turn on red permitted	CB	CB	CB
IM.11	Sidewalk corner capacity	BA	CB	CB
IM.12	Crosswalk capacity	B	CD	CD
IM.13	Pedestrian clearance period	CB	CB	CB
IM.14	Pedestrian clearance interval	CB	CB	CB
IM.15	Duration of "walk" signal	CB	CB	CB
IM.16	Duration of "flashing hand" signal	CB	CB	CB
IM.17	Stop bar and crosswalk separation	BCD	BCD	BCD
IM.18	Height of curbing	CD	CD	CD
IM.19	Condition of curbing	CB	CB	CB
IM.20	Signage (yield, stop, ped x-ing, etc.)	ACD	CD	CD
IM.21	Signage location	BCD	CD	CD
IM.22	Roadmarking visibility	BCD	CD	CD
IM.23	Roadmarking location	BCD	CD	CD
IM.24	Water drainage	B	BCD	BCD
IM.25	On roadway	A	CB	CB
IM.26	At/on sidewalk	B	BCD	BCD
IM.27	At/on median or refuge	B	BCD	BCD
IM.28	Ice/snow/slush removal	B	BCD	BCD
IM.29	On roadway	A	BCD	BCD
IM.30	At/on sidewalk corner	B	BCD	BCD
IM.31	At/on median or refuge	B	BCD	BCD
IM.32	Air pollution	BA	CB	CD
IM.33	Ground-based ozone levels	BA	CB	CD
IM.34	Noise levels	BA	CB	CD

* The cell entries depict concept-variable connections as follows:
A= accepted in principle and practice; B = accepted in principle but not in practice,
C = supported by WSI Project research; D = not sufficiently investigated;
BA = moving between B and A status; CA = A-type connection in question;
CD = WSI-based research needed;
Other letter combinations = validation research needed.

Source: Wellar (1997e, p. 30).

Table C-5. Intersection feature and performance variables associated with pedestrian security: Vehicle, driver, pedestrian (user) behavior measures

Vehicle, Driver, Pedestrian Behavior Measures		Associated WSI Component *		
ID	Variable Name	Safety	Comfort	Convenience
UM.10	Pedestrian-vehicle collisions	A	A	CB
UM.11	Vehicle-vehicle collisions	CD	CA	CD
UM.12	Pedestrian-vehicle conflicts	CB	A	A
UM.13	Vehicle-vehicle conflicts	CD	CA	CD
UM.14	Vehicle moving violations	BA	CA	CA
UM.15	Exceeding the speed limit	BA	CA	CD
UM.16	Running red	BA	CA	CA
UM.17	Running amber	BA	CA	CA
UM.18	Blocking vehicle traffic	CB	CA	CA
UM.19	Crosswalk encroachment	CB	CB	CA
UM.20	Stop bar encroachment	CB	CB	CA
UM.21	Sidewalk encroachment	CB	CB	CA
UM.22	Vehicles change lane in intersection	A	A	A
UM.23	Vehicles change course	A	A	A
UM.24	Vehicles accelerate through crosswalk	A	A	A
UM.25	Drivers engage in aggressive behaviour	C	A	C
UM.26	Wave fist/give finger	C	A	C
UM.27	Yell/swear	C	A	C
UM.28	Spin/squeal tires	B	A	C
UM.29	Honk horn	C	A	C
UM.30	Pedestrians delayed	CA	CA	A
UM.31	At signalized corners	CA	CA	A
UM.32	At cut-off channels	CA	CA	A
UM.33	Pedestrians' concerns about oncoming traffic causes pedestrians to take evasive action	A	A	A
UM.34	To avoid collisions with vehicles	A	A	A
UM.35	To avoid conflicts with vehicles	C	A	A
UM.36	Pedestrian-pedestrian collisions	BD	BD	BD
UM.37	Pedestrian-pedestrian conflicts	BD	BD	BD
UM.38	Personal injury incidents	A	A	D
UM.39	Falls	A	A	D
UM.40	Slips/stumbles	A	A	D

Table C-5. Intersection feature and performance variables associated with pedestrian security: Vehicle, driver, pedestrian (user) behavior measures (continued)

Vehicle, Driver, Pedestrian Behavior Measures		Associated WSI Component *		
ID	Variable Name	Safety	Comfort	onvenience
UM.41	Pedestrian moving violations	CA	CD	A
UM.42	Against lights	CA	D	A
UM.43	Outside crosswalk	CA	D	A
UM.44	"Jay-walking"	CA	CB	A
UM.45	"Desire-line walking"	CA	CB	A
UM.46	Any of the above, no vehicles involved	CA	A	A
UM.47	Pedestrians' behaviour: defensive	A	A	A
UM.48	Wait for traffic to clear	A	D	A
UM.49	Wait for traffic to stop	A	D	A
UM.50	Wait for pedestrian group to form	CD	A	A
UM.51	Alter walk speed	A	A	A
UM.52	Alter walk path	A	A	A
UM.53	Pedestrians' behaviour: offensive	A	BCD	ACD
UM.54	Do not signal intent	A	BCD	CA
UM.55	"Barge" into traffic	A	BCD	CA
UM.56	Gesture/yell at drivers	A	BCD	CD
UM.57	Assault vehicles	A	BCD	CD
UM.58	Gesture/yell at other pedestrians	A	BCD	CD

* The cell entries depict concept-variable connections as follows:
A = accepted in principle and practice;
B = accepted in principle but not in practice;
C = supported by WSI Project research;
D = not sufficiently investigated;
BA = moving between B and A status;
CA = A-type connection in question;
CD = WSI-based research needed;
Other letter combinations = validation research needed.

Source: Wellar (1997e, pp. 33-34).

Appendix D. Responses of Elected, Professional and Lay Experts to the Initial Specification of WSI Candidate Variables

As discussed in Appendix A of Interim Report 5 (Wellar, 1997e), circumstances prevented circulating the lists of candidate variables among experts prior to publishing the initial specification in Interim Report 5. The express purpose of Appendix D in the Final Report, therefore, is to take into account the feedback received from experts who responded to the Cover Letter presented in Figure D-1.

Paragraph four of the Cover Letter addresses the matter which is of interest here. Specifically, the elected, professional and lay experts were invited to comment on the lists in terms of variables to:

1. **add**;
2. **delete**;
3. **revise**; and,
4. regard as **high priority**.

Readers interested in the details behind the Cover Letter or the experts included in the circulation are referred to Appendix A of Interim Report 5 (Wellar, 1997e).

As shown by Table D-1, a "comment" column was provided for the experts to advise us in regard to their **add, delete, revise,** and **high priority** positions. The listing of variables circulated among the experts is the same as that contained in Tables C-1, C-2, C-3, C-4 and C-5 in Appendix C, so only one sheet of the lists is repeated for illustrative purposes.

Variables Proposed for Addition, Deletion, Revision

There were only a limited number of suggestions about variables to add, delete, or revise. And, there were no variables or attributes of variables for which there was consensus between or among groups of experts as to needed additions, deletions or revisions. Rather, respondents appeared to put their time and energy into dealing with the candidate variables circulated for their attention.

Figure D-1. Text of cover letter used to invite comment on the lists of WSI candidate variables

Re: Walking Security Index (WSI) Project: Specifying the Variables

As you may be aware, the Walking Security Index Project is now in the phase of specifying the variables for inclusion in the Index. Your participation in this phase of the project is invited, and I look forward to receiving your comments as one of the "Elected Experts" selected for the survey.

By way of brief background and orientation, Interim Report 3 (completed in June, 1997) identified three types of experts on the subject of pedestrian security:

3. "Elected Experts" (politicians)
4. "Professional Experts" (engineers, planners, police, etc)
5. "Lay Experts" (ordinary citizens who walk, roller blade, ride transit, drive vehicles)

As our research clearly shows, each group of experts contributes to defining and achieving the levels of pedestrian safety, pedestrian comfort, and pedestrian convenience experienced at signalized intersections. Your feedback, from an "Elected Experts" perspective, is therefore a very important input to this phase of the WSI Project.

In regard to the enclosed lists, the following are among the kinds of suggestions that will be especially valuable:

1. variables to **add** to the respective lists;
2. variables to **delete** from the respective lists;
3. variables to **revise** to make the meaning clearer;
4. variables to regard as **high priority** for inclusion in the Index.

In all cases, specific suggestions will be most appreciated.

Again, I look forward to receiving your comments, which may be written directly on the forms, or on the backs of the forms if more space is needed. Please include a telephone number in the event that clarifications are required.

Please submit the comments at your earliest convenience. The Final Report is scheduled for completion by December 1997, and I would very much like to have your comments when completing the final specification of WSI variables for inclusion in the Index.

Table D-1. Example of form used to elicit views of experts on candidate WSI variables

Infrastructure Features		Comments
ID	Variable Name	
I.10	Number of lanes	
I.11	Posted speed of approach lanes	
I.12	30 kph	
I.13	40 kph	
I.14	50 kph	
I.15	60 kph	
I.16	80 kph	
I.17	Roadway width	
I.18	Cut-off channel lane(s)	
I.19	Channel island size	
I.20	Roadway grade (of approaches)	
I.21	Roadway surface conditions	
I.22	Number of left turn lanes	
I.23	Permissive	
I.24	Protected	
I.25	Simultaneous	
I.26	Median (refuge) size	
I.27	Median (refuge) condition	
I.28	Traffic calmers proximal to intersection	
I.29	Roadway bumps	
I.30	Roadway humps	
I.31	Rumble strips	
I.32	Ceramic Buttons	
I.33	Sidewalk width	
I.34	Sidewalk corner size	
I.35	Sidewalk curb condition	
I.36	Curb cut(s) proximal to intersection	
I.37	Crosswalk elevated	
I.38	Crosswalk signed and painted	
I.39	Crosswalk width	
I.40	"Desire-line" crosswalk design	

There were insightful comments made by the respondents, however, that pertain to the add, delete and revise options. And, there are lessons to be learned by this "open process" whereby participants are given an opportunity to freely express their views. As a result, it is appropriate that we comment on the feedback received in order to provide a more complete record on the experts' responses to the Cover Letter and lists of candidate variables.

a. Variables Proposed for Addition

Discussions with respondents indicate that the proposed additions can be both generic and specific in regard to origins and intended application. That is, the variable(s) may arise from experiences at intersections in general or at one or more intersections in particular. And, the variables may be intended for use in an index which applies to intersections in general, and/or in the list of variables used to perform a 'security audit' at particular intersections.

As a summary comment, no suggestion of the addition variety was received that was compelling insofar as the variable evaluation criteria are concerned. We hasten to emphasize that this is not a criticism of the experts, nor is it surprising in view of earlier experiences with inviting suggestions on how to current problems at the Laurier-Nicholas intersection (Wellar, 1995). Rather, it is likely more reasonable to expect **proposals for additions** to be both more numerous, and more substantive, after the candidate and selected WSI variables have been subjected to exposure for several years.

b. Variables Proposed for Deletion

A small number of variables were proposed for deletion. The reason behind the proposals to delete was essentially the same. That is, two or more of the variables represent very similar intersection features or performance measures, and thereby create redundancy in the lists.

The "advice" from the respondents to delete several of the variables or sub-variables is generally accepted without argument. That occurs because choice was built into the lists (e.g. by using different terms as descriptors). We can now refine the lists based on the feedback from experts as to their preferences.

For those cases where similar variables are in both a feature **and** a performance list, however, what might be called a redundancy argument is not deemed to hold. That is,

each of these lists must be self-contained to (attempt to) minimize errors of omission or oversight by users when they make decisions about variables. Hence, while readers of the lists may occasionally have a sense of 'seeing double,' the Regional Municipality of Ottawa-Carleton (which is the Project Client) should feel reassured about the methodological robustness of the Project's research process. This oversight prevention measure is an example of WSI Project rigor.

c. Variables Proposed for Revision

The proposals for revisions to variables tended to deal with using 'better' terminology, that is, to use an extra word or two to clarify the meaning of a variable, to use terms which more precisely define those aspects of a concept which are to be represented by the variables etc. In other words, the proposals for revisions are consistent with many of the comments or criticisms commonly associated with the general problem of defining complex phenomena.

Further, the proposals for revisions are consistent with what might be expected due to differences among respondents. That is, the elected officials, professionals, and ordinary citizens (constituting our groups of experts) differ in education, training, work obligations and experience, and so on. As a result, it is to be expected that there will be differences in perceptions as to what is meant by *pedestrian security*, and in the choices of phrases or terms used to give operational meaning to the concepts of security, safety, comfort and convenience.

There is no surprise, therefore, in the fact that revisions were proposed. What is somewhat surprising, however, is the relatively small number of variables that have been "flagged" for attention. This is an important methodological point, and a word of caution is necessary. That is, and as noted previously (Wellar, 1996a, 1996c, 1997b, 1997e), the WSI Project appears to be engaged in applied research that has a substantial original component. The consequent point of caution, and one which cannot be over-emphasized, is that despite the WSI Project publications to date, including the Final Report, research in this field is still more exploratory than confirmatory. The message taken from the limited number of proposals to revise, therefore, is that while we appear to be moving toward consensus, it is advisable to be prudent and modest in claims made about agreements.

There are, after all, five lists of variables with 54, 54, 30, 25 and 49 variables in the initial specification (Appendix C). Clearly, then, it would be most imprudent and immodest to surmise that, after only one round of consultation, any and all sources of disagreement among the bodies of experts had been identified and resolved. It appears most appropriate, therefore, that the proposals for revision be regarded as feedback on the preliminary specification, with the clear understanding that additional rounds are required list-by-list before any claims about consensus are warranted.

In closing this comment on revisions, two remarks may be instructive as future points of reference. First, as noted above, comments or suggestions about revisions tended to involve clarifications, or the use of more precise language. By way of illustration, Infrastructure Features variable I.55 in Table C-1, Appendix C, is currently expressed as 'Protective pedestrian posts'. The technically appropriate term, however, appears to be 'bollards', as in 'Protective pedestrian bollards'. An informal survey quickly revealed, however, that the term 'bollards' is not part of "everyday language" of either elected or lay experts -- which brings us to the second contextual remark.

That is, considerable effort went into the avoidance of jargon in the lists, and the feedback received indicates that we have been very successful in that regard. However, for those occasions that call for specific, technical terms - - which may not be part of the everyday language of everyone who reads the *Walking Security Index* - - we proceed to use the terms in the revised lists. However, to the extent that space allows, we include descriptors that may assist members of all groups of experts to better comprehend those variables which were flagged during the first round of responses to the initial specification of WSI variables.

Variables to Regard as High Priority

Tables D-2, D-3, D-4, D-5, and D-6 contain the "high priority" ratings assigned by the elected, professional and lay experts who commented on the lists of candidate variables.

As discussed in Section C, the ratings by the experts were a basic input to decisions about which variables to assign to the Group I (essential), Group 2 (high priority) and Group 3 (residual) categories.

In the interests of explicitness, it is emphasized that a ✓ in a cell does not necessarily mean that consensus was achieved.

Rather, and this is the limit to which a project of this type can reasonably aspire, a ✓ means that the group (s) tended to support assigning a variable a high priority rating. It would require considerably more resources than those available to the WSI Project to definitively measure the support or opposition associated with individual variables and sets of variables.

Table D-2. Variables in the initial specification assigned a high priority by experts: Infrastructure features

Infrastructure Features		Expert Groups in Support		
ID	Variable Name	Elected	Professional	Lay
I.10	Number of lanes	✓	✓	✓
I.11	Posted speed of approach lanes	✓	✓	✓
I.12	30 kph			
I.13	40 kph			
I.14	50 kph			
I.15	60 kph			
I.16	80 kph			
I.17	Roadway width	✓		✓
I.18	Cut-off channel lane(s)	✓		✓
I.19	Channel island size			
I.20	Roadway grade (of approaches)	✓	✓	✓
I.21	Roadway surface conditions	✓		✓
I.22	Number of left turn lanes	✓		✓
I.23	Permissive	✓	✓	✓
I.24	Protected			
I.25	Simultaneous			✓
I.26	Median (refuge) size	✓		✓
I.27	Median (refuge) condition			✓
I.28	Traffic calmers proximal to intersection	✓		✓
I.29	Roadway bumps			
I.30	Roadway humps			
I.31	Rumble strips			
I.32	Ceramic Buttons			
I.33	Sidewalk width			
I.34	Sidewalk corner size	✓		✓
I.35	Sidewalk curb condition			
I.36	Curb cut(s) proximal to intersection			✓
I.37	Crosswalk elevated			
I.38	Crosswalk signed and painted			✓
I.39	Crosswalk width			
I.40	"Desire-line" crosswalk design			✓

Table D-2. Variables in the initial specification assigned a high priority by experts: Infrastructure features (continued)

Infrastructure Features		Expert Groups in Support		
ID	Variable Name	Elected	Professional	Lay
I.41	Dedicated bicycle lane			
I.42	Curb divider			
I.43	Painted line			
I.44	Stop bar	✓	✓	✓
I.45	Painted			
I.46	Painted and signed	✓	✓	✓
I.47	Stop bar distance from crosswalk	✓	✓	✓
I.48	Pedestrian signage			✓
I.49	Pedestrian zone ahead sign			✓
I.50	Yield to pedestrian sign			✓
I.51	Pedestrian zone painted on roadway			
I.52	Pedestrian-activated signals			
I.53	Visual			
I.54	Visual and audible			
I.55	Protective pedestrian posts			
I.56	At/on crosswalks			
I.57	At/on traffic island			
I.58	At/on median			
I.59	LED indicating wait time for walk signal			
I.60	Street furniture proximal to sidewalk corner			
I.61	Sight line obstructions	✓	✓	✓
I.62	For vehicle operators			✓
I.63	For pedestrians			✓

Table D-3. Variables in the initial specification assigned a high priority by experts: Vehicular traffic features

Vehicular Traffic Features		Expert Groups In Support		
ID	Variable Name	Elected	Professional	Lay
V.10	Traffic volumes, peak hours	✓	✓	✓
V.11	A.M. (7-9)			
V.12	Noon (11-1)			
V.13	P.M. (3-6)			
V.14	Traffic volumes, off-peak hours	✓		✓
V.15	Percentage of vehicles by type	✓	✓	✓
V.16	Car/van	✓		✓
V.17	Heavy truck	✓		✓
V.18	Transit (bus)	✓		✓
V.19	Transit (rail)			
V.20	Passenger			
V.21	Freight			
V.22	Bicycle			
V.23	Distribution of trips by journey origin and destination	✓	✓	✓
V.24	Local			
V.25	Regional	✓		✓
V.26	Extra-regional			
V.27	Distribution of trips by purpose: personal			
V.28	Work			
V.29	School		✓	✓
V.30	Business			
V.31	Shop			✓
V.32	Recreation/leisure			
V.33	Medical/health			
V.34	Entertainment			
V.35	Dining			
V.36	Drinking	✓	✓	✓
V.37	Dining and drinking	✓		✓
V.38	Sports			
V.39	Theatre			

Table D-4. Variables in the initial specification assigned a high priority by experts: Pedestrian traffic features

Pedestrian Traffic Features		Expert Groups In Support		
ID	Variable Name	Elected	Professional	Lay
P.10	Pedestrian volumes, peak hours	✓	✓	✓
P.11	A.M. (7-9)			
P.12	Noon (11-1)			
P.13	P.M. (3-6)			
P.14	Pedestrian volumes, off-peak hours	✓		✓
P.15	Distribution of trips by journey origin-destination			
P.16	Within neighborhood			
P.17	Outside neighborhood			
P.18	Distribution of trips by purpose			
P.19	Work			
P.20	School			
P.21	Business			
P.22	Shop			
P.23	Recreation/leisure			
P.24	Medical/health			
P.25	Entertainment			
P.26	Dining			
P.27	Drinking			
P.28	Dining and drinking			
P.29	Sports			
P.30	Theatre			
P.31	Percentage of pedestrians by gender			
P.32	Male			
P.33	Female			
P.34	Percentage of pedestrians by age group	✓	✓	✓
P.35	Child (12 and under)	✓	✓	✓
P.36	Youth (13-20)			
P.37	Young adult (21-29)			
P.38	Adult (30-54)			
P.39	Senior (55 and over)	✓	✓	✓

Table D-5. Variables in the initial specification assigned a high priority by experts: Infrastructure performance measures

Infrastructure Performance Measures		Expert Groups In Support		
ID	Variable Name	Elected	Professional	Lay
IM.10	Right turn on red permitted	✓	✓	✓
IM.11	Sidewalk corner capacity			
IM.12	Crosswalk capacity			
IM.13	Pedestrian clearance period			✓
IM.14	Pedestrian clearance interval			
IM.15	Duration of "walk" signal			✓
IM.16	Duration of "flashing hand" signal			
IM.17	Stop bar and crosswalk separation			✓
IM.18	Height of curbing			✓
IM.19	Condition of curbing			✓
IM.20	Signage (yield, stop, ped x-ing, etc.)	✓	✓	✓
IM.21	Signage location	✓		✓
IM.22	Roadmarking visibility			
IM.23	Roadmarking location			
IM.24	Water drainage	✓	✓	✓
IM.25	On roadway	✓	✓	✓
IM.26	At/on sidewalk	✓		✓
IM.27	At/on median or refuge			✓
IM.28	Ice/snow/slush removal	✓	✓	✓
IM.29	On roadway	✓	✓	✓
IM.30	At/on sidewalk corner	✓		✓
IM.31	At/on median or refuge			✓
IM.32	Air pollution			✓
IM.33	Ground-based ozone levels			✓
IM.34	Noise levels			✓

Table D-6. Variables in the initial specification assigned a high priority by experts: Vehicle, driver, pedestrian (user) behavior measures

Vehicle, Driver, Pedestrian Behavior Measures		Expert Groups In Support		
ID	Variable Name	Elected	Professional	Lay
UM.10	Pedestrian-vehicle collisions	✓	✓	✓
UM.11	Vehicle-vehicle collisions	✓		✓
UM.12	Pedestrian-vehicle conflicts	✓		✓
UM.13	Vehicle-vehicle conflicts			✓
UM.14	Vehicle moving violations	✓	✓	✓
UM.15	Exceeding the speed limit	✓	✓	✓
UM.16	Running red	✓	✓	✓
UM.17	Running amber	✓	✓	✓
UM.18	Blocking vehicle traffic			✓
UM.19	Crosswalk encroachment			✓
UM.20	Stop bar encroachment			✓
UM.21	Sidewalk encroachment			✓
UM.22	Vehicles change lane in intersection	✓	✓	✓
UM.23	Vehicles change course	✓	✓	✓
UM.24	Vehicles accelerate through crosswalk	✓	✓	✓
UM.25	Drivers engage in aggressive behaviour			✓
UM.26	Wave fist/give finger			
UM.27	Yell/swear			
UM.28	Spin/squeal tires			
UM.29	Honk horn			
UM.30	Pedestrians delayed	✓		✓
UM.31	At signalized corners			✓
UM.32	At cut-off channels			✓
UM.33	Pedestrians' concerns about oncoming traffic causes pedestrians to take evasive action	✓		✓
UM.34	To avoid collisions with vehicles	✓	✓	✓
UM.35	To avoid conflicts with vehicles	✓		✓
UM.36	Pedestrian-pedestrian collisions			
UM.37	Pedestrian-pedestrian conflicts			
UM.38	Personal injury incidents			✓
UM.39	Falls			✓
UM.40	Slips/stumbles			✓

Table D-6. Variables in the initial specification assigned a high priority by experts: Vehicle, driver, pedestrian (user) behavior measures (continued)

Vehicle, Driver, Pedestrian Behavior Measures		Expert Groups In Support		
ID	Variable Name	Elected	Professional	Lay
UM.41	Pedestrian moving violations		✓	
UM.42	Against lights			
UM.43	Outside crosswalk			
UM.44	"Jay-walking"			
UM.45	"Desire-line walking"			
UM.46	Any of the above, no vehicles involved			
UM.47	Pedestrians' behaviour: defensive	✓		
UM.48	Wait for traffic to clear	✓		✓
UM.49	Wait for traffic to stop	✓		✓
UM.50	Wait for pedestrian group to form	✓		
UM.51	Alter walk speed	✓		✓
UM.52	Alter walk path	✓		✓
UM.53	Pedestrians' behaviour: offensive		✓	
UM.54	Do not signal intent		✓	
UM.55	"Barge" into traffic		✓	
UM.56	Gesture/yell at drivers		✓	
UM.57	Assault vehicles		✓	
UM.58	Gesture/yell at other pedestrians			

Appendix E. Variables Culled from Initial Specification Based on Finding a Substantive Connection Between Variables and the Safety, Comfort, Convenience Components of Security.

The assessment of concept-variable connections in Section D, Interim Report 5 (Wellar, 1997e) covers a wide range of possibilities:

A = connection accepted in principle and practice
B = connection accepted in principle
C = connection supported by WSI research
D = connection not sufficiently investigated
BA = connection moving from B to A
CA = A-type connection in question
CB = B-type connections in question
CD = WSI-based original research needed
Other = validation research needed

Among the range of assessments the following are deemed appropriate, **at this time**, for moving from the initial to the final specification: **A, B, BA,** and **C.**

The phrase **at this time** has dimension to it which needs to be made explicit, so that our intent is not misconstrued.

The WSI Project is client-driven rather than curiosity-driven, and a schedule is attached to the study. As a result of the time constraint, and financial constraints, there are limits on how many and which kinds of topics can be investigated, in what manner, and so on. Hence, limits must be imposed on the investigation into connections between concepts and variables associated with pedestrians' safety, comfort and convenience.

In the case of connections among concepts and variables in the WSI Project, it appears fair to say that investigations are at a very early stage. And, future research could uncover important variables and connections that are not identified in the current study. The phrase **at this time** therefore points to an operational necessity, and also "props the door open" for other researchers to not only check out the A, B, BA and C assessments, but to inquire into the D, CA, CB, CD and other validations as well.

As for the distribution of assessments among the WSI components (safety, comfort, convenience), a question arises about the number of cells that need to contain an A, B, BA, or C assessment in order for the variable to be culled from the initial specification.

The answer to that question requires a rule, which is as follows: Decisions about assessments are obliged to have regard for the conditions discussed in Section D.2 concerning the process of deriving Walking Security Index variables.

In particular, there is a demonstrated need to exercise care and creativity, and to be expansive and open-ended, when specifying the variables for a research product that is more at the exploratory than confirmatory stage of development. That occurs, as noted in D.2, because a number of the issues, questions, relationships, etc. that are discussed appear to be receiving original, methodologically-based research attention. Hence, it seems appropriate to err on the side of "potentially significant" for these exploratory assessments, and to anticipate that subsequent confirmatory assessments will move the arrays of variables closer to what might be termed "only the necessary essentials".

As a result of that decision rule, any variable assigned an A, B, BA or C assessment is culled for consideration as a final specification variable.

It is important to emphasize in closing, however, that being culled from the lists in Appendix C was not sufficient to guarantee inclusion in either the list of essential or high priority variables, or in any of the indexes. Nor, on the other hand, did being left out of the cull necessarily exclude a variable from further consideration.

That occurred because the variable selection process was designed to avoid errors of omission or commission, as follows:

1. The expertise of elected officials, professional staff and area residents was involved in selecting and ranking variables; and,

2. The evaluation criteria (pertinence, support, degree of difficulty, enforceability, data availability) provided a five-layer filter to help ensure the operational utility of recommendations.

Appendix F. Acknowledgments

Many individuals and organizations contributed to the Interim Reports and the Final Report of the WSI Project. In the case of the Interim Reports, each contained an acknowledgments appendix in which the contributors were recognized on a report-by-report basis.

For the Final Report, two types of acknowledgments are in order. First, it is appropriate to recognize those who made substantive contributions to the contents and production of the document. And, second, recognition is given to individuals and organizations who "answered the bell" when asked for guidance, advice, support, or other kinds of assistance needed to bring the WSI Project to a productive conclusion.

I am therefore pleased to acknowledge the contributions of the following individuals and groups to the Final Report of the Walking Security Index Project.

Project Assistants
Tammy McAnaul, Honours Program, and Erin Novakowski, Ph.D. Candidate, Department of Geography, University of Ottawa, processed the text of the Final Report. We are most appreciative of the energy and skills that they brought to bear in the physical production of the document.

Editorial Advisor
The Final Report was edited by Marjorie Wellar. Her numerous suggestions are most appreciated, and the many improvements that she made to the language and logic of the text are gratefully acknowledged.

Elected Officials
At the political level a number of officials provided invaluable assistance. Recognition is due first and foremost to Regional Councillors Diane Holmes, Jacques Legendre, Alex Munter, and Alex Cullen (now MPP, Ottawa West). They helped make the Project a reality, supplied political support as necessary, and served as a "sounding board" on matters involving the policy aspects of the Project.

In addition, a debt of gratitude is owed to the elected officials who raised policy-relevant questions, reviewed the lists of variables, encouraged their constituents to participate in the Project, and made materials and personnel available to the Principal Investigator and the (student) research assistants: Councillors Wendy Byrne, Linda Davis, Clive Doucet,

Brian McGarry, and Madeleine Meilleur, Regional Municipality of Ottawa-Carleton; Mayor Merle Nicholds, City of Kanata; Councillor Ron Kolbus, City of Ottawa; Councillor John Adams, City of Toronto; and, Councillor Maggi Fimia, Metro King County (State of Washington).

Professional Staff

At the professional level, special thanks are due to Grant Malinsky and John Buck, Mobility Services Division, Transportation and Environment Department, Regional Municipality of Ottawa-Carleton. They provided technical and administrative support, made needed data and documentation available throughout the duration of the Project, and gave timely feedback on operational and other questions about implementing Project recommendations.

A number of other professionals in the region contributed to the Final Report by providing data, reports, and advice. Of particular importance however, was the involvement of professional staff in the review specification of WSI variables. We are pleased to acknowledge the contributions of the following professionals and agencies to the Final Report.

Regional Municipality of Ottawa-Carleton

Philippe Landry, Traffic Operations Branch, Environment and Transportation Department
Paul Jordan, Development Approvals Division, Planning and Development Approvals Department
John McKenzie, Development Approvals Division, Planning and Development Approvals Department
Harry Beere, Development Approvals Division, Planning and Development Approvals Department

Ottawa-Carleton Regional Police Service

Constable Amerjit Sahota, Traffic Services Section

Ottawa-Carleton Transit Commission

Helen Gault, Planning and Development
Norm Inglis, Safety and Training
Carolyn Richardson, Safety and Training

City of Gloucester

Dale Philpotts, Traffic Operations, Operations and Fire

Rodney Pitchers, Traffic Operations, Operations and Fire

City of Kanata

Jim Miskelly, Traffic Coordinator

Town of Exeter (NH)

George Olson, Town Manager

The professionals listed are those whose names were on correspondence, on returned survey forms, on faxes, or were brought to our attention by supervisors or colleagues. And, many of them also assisted by way of telephone discussions involving various alternative transportation and walking security matters. It is very much regretted if we have inadvertently overlooked any member of the professional community who assisted in the variable review process, or otherwise made a substantive contribution to the Final Report.

Ordinary Citizens

A debt of gratitude is owed to members of the public who contributed to the Final Report by suggesting intersections and problems that needed study, by proposing variables to include in WSI formulations, and by setting priorities for the variables to include in index formulations.

These area residents brought a real world perspective to bear on the research process and recommendations, which helped ensure the day-to-day relevance of the study. And, very importantly, they demonstrated the importance of involving lay experts in an applied research project that has public policy, plan and program implications at the neighborhood, community and regional scales.

The ordinary citizens, or lay experts as we refer to them in this study, who made important contributions to the Final Report are as follows:

- John Blatherwick (Woodpark Community Association)
- Linda Hoad (Federation of Citizens' Associations (Ottawa), and former member, Transportation Environment Action Plan - Community Advisory Committee)
- L.P. Johnson (Glebe Community Association)

- Peter Martin (Action Sandy Hill, and former member, Transportation Environment Action Plan - Community Advisory Group)
- Carole Noël (Dalhousie Community Association)
- Pat Steenberg (Glebe Community Association)
- Francis Tanner (Carlington)
- Chuck Williamson (Dow's Lake Residents' Association).

Media

All branches of the media - - print, radio, television - - in Ottawa-Carleton contributed to the production of *Walking Security Index*. They did so by reporting on issues, problems and initiatives that affect pedestrians' secuirty, by raising awareness about the WSI Project. We are therefore pleased to recognize the media for the fair and reasonable coverage given to the study.

Research Assistants

During the Winter and Fall Semesters in 1997, the Principal Investigator included WSI Project-related assignments in several courses taught in the Geography Program, University of Ottawa. These assignments required students to conduct literature searches, undertake fieldwork, assemble, analyze and synthesize data, make observations on the connections between intersection feature and performance variables, and propose priorities for variables to include in the lists and index formulations in the Final Report.

These students performed as Research Assistants, and their important contributions are hereby acknowledged on a course-by-course basis.

GEG 2306 - Urban Geography (Winter, 1997)		
Jonathan Addy	Jacqueline Dumas	Richard Matakovic
Marissa Aiello	Sylvestre Fink	Tammy McAnaul
Sjoerd Attema	Scott Frake	Guillermo Munoz
Izabela Aurelson	Gabriela Freyenmuth	Lanny Murphy
Michelle Ball	Kimberly Gamble	Jed Narraway
Mark Bracko	Michael Gravelle	Laura Peddie
Dawn Burnett	Darlene Hiscott	Genevieve Raymond
Peter Cech	Christopher Hugenholtz	Alicia Roberge
Allison Cook	Reid Kelsey	David Ross
Heather Davidson	Scott Kendall	David Rubeli
Tony De Iuliis	René Lajzerowicz	Leslie Seibel
Rodrigo Diaz	Sonia Lanoë	Trevor Smith
Janet Dignem	Jean Lefebvre	Christopher Spruyt
Andrew Digney	Quoc Luu	Martin Vesely

GEG 2306 - Urban Geography - (Fall 1997)		
Kathryn Beaulieu	Steven Forest	Kenneth Parlee
Sean Bourque	Chinelo Furlow	Laura Schacht
Monic Buettner	Jeffery Hirvonen	Jacqueline Schwass
Michael Butler	Frank Ieraci	Jennifer Taylor
Tara Coultish	Isabelle Lessard	Catherine Vander meulen
Paige Dampier	Jennifer Lewis	Wai Mei Wong
Cheryl Day	Miguel Madeira	Erin Wooler
Douglas Dizgun	Sandra McDonell	
Kirvin Dyer	Ian Morris	

GEG 3104 - Methods of Geographical Research (Fall 1997)		
Sjoerd Attema	Karin Frederking	Richard Matakovic
Mark Bracko	Martin Gamache	Lanny Murphy
Monic Buettner	Kimberly Gamble	David Ross
Brian Cheguis	Michael Gravelle	Jacqueline Schwass
Ian Cochrane	Jason Hockley	Peter Shuttleworth
Martin Connolly	Christopher Hugenholtz	Trevor Smith
Kimberly Denison	Reid Kelsey	Christopher Spruyt
Janet Dignem	Scott Kendall	Kathleen Tracey
Scott Frake	Lisa MacPherson	Erin Wooler

GEG 3311 - Political Geography (Fall 1997)	
Mark Bracko Andrew Digney	Donald Easy David Ross

GEG 4313 - Planning Practice and Techniques (Winter 1997)		
Brian Cheguis Andrew Digney Andrew Doi	Sylvestre Fink Anne Lamoureux Lysa Levasseur	Tammy McAnaul Peter Reed Marc Rivet

A word of collective thanks is therefore due to all who contributed to the completion of the Final Report of the Walking Security Index Project. Clearly, the high level of representation achieved allowed us to undertake a study and submit a report which are far more robust, comprehensive, and pertinent than would have been the case without that assistance.

Walking Security Index Publications

We are pleased to provide the following information on publications from the Channelization Project (1994-1995), the Pedestrian Safety Conference (1995-1996), and the Walking Security Index (WSI) Project (1995-1998).

1. ***Design and Pre-Testing of a Survey Instrument to Measure Pedestrian Levels of Safety and Comfort: A Case Study of the Channelized Cut-Off from Laurier Avenue East to Nicholas Street South, Ottawa, Ontario.*** Barry Wellar, July 1995. 95 pages. Cost : $10.00.

2. ***Walking Security Index Project: Literature Search, Outreach and Research Design Activities.*** Interim Report 1. Barry Wellar, April 1996. 75 pages. Cost: $9.00.

3. ***Perspectives on Pedestrian Safety. Conference Proceedings.*** Barry Wellar, editor, August 1996. 143 pages. Cost $20.00.

4. "Pedestrian Perspectives on Intersection Performance: A Case Study Report on Channelization". Barry Wellar, in ***1996 Annual URISA Conference Proceedings***, 181-201. Cost $2.00.

5. ***Findings from a Field Re-Survey of the Laurier and Nicholas Cut-Off Channel (E→S), and Implications for the Walking Security Index.*** Interim Report 2. Barry Wellar and Ingrid Froelich, December 1996. 69 pages. Cost $8.00.

6. ***Capability of IS/GIS-Based Intersection Applications to Implement the Walking Security Index (WSI): A Preliminary Status and Prospects Assessment.*** Interim Report 4. Barry Wellar, April 1997. 31 pages. Cost: $4.00.

7. ***Safety, Comfort, and Convenience as Principal Components of the Walking Security Index: Initial Specification.*** Interim Report 3. Barry Wellar, June 1997. 71 pages. Cost: $8.00.

8. ***Walking Security Index Variables: Initial Specification.*** Interim Report 5. Barry Wellar, November 1997. 56 pages. Cost: $8.00.

9. ***Walking Security Index.*** Final Report. Barry Wellar. July 1998. 191 + vi pages. Cost: $ 25.00

Anyone requiring further details about existing or impending publications are invited to contact Prof. Wellar by e-mail (wellarb@uottawa.ca), fax (613-562-5145), or regular mail.

(See over for publication order form)

Order Form
Walking Security Index Publications

Please make cheques payable to the University of Ottawa, c/o Prof. Barry Wellar, Department of Department of Geography, University of Ottawa, Ottawa, Ontario, CANADA, K1N 6N5.

Order Form: Pedestrian Security, Safety, etc. Publications				
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1	Design and Pre-Testing of a Survey Instrument		10.00*	
2	WSI Project: Literature Search		9.00*	
3	Perspectives on Pedestrian Safety		20.00*	
4	Channelization Case Study Report (in 1996 URISA Proceedings)		2.00	
5	Field Re-Survey Findings		8.00*	
6	IS/GIS Applications		4.00	
7	Principal Components of the WSI		8.00*	
8	WSI Variables: Initial Specification		8.00*	
9	Final Report		25.00*	
			Postage and Handling	
			Total	

* For each of the texts marked by * add $2.00 for postage and handling. Contact Prof. Wellar in regard to postage and handling charges for bulk orders, and for the cost of a complete set of WSI publications.

Name:	
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City:	
Province/State:	Postal Code: