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WARRANTS FOR PEDESTRIAN OVER AND UNDERPASSES

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16. Abstract

The purpose of this research was to develop warrants for pedestrian over and underpasses or grade separated pedestrian crossings (GSPCs). Currently there are no established nationally acceptable warrants to serve as standards in deciding whether or not to build a GSPC.

This research was conducted by first performing a literature review of existing practices and assessment of the state-of-the-practice to identify general types of warrants and existing warrants. A panel of advisors was formed to evaluate the practicality of the existing and candidate warrants. A behavioral study was conducted to ascertain pedestrians' perceptions of risks and inconvenience associated with use of sample GSPCs. Candidate warrants were developed and validated by contigency table and chi-square analyses of site characteristics of sample GSPCs.

Proposed warrants were developed from the candidate warrants consisting of threshold warrants for pedestrian volume, vehicle volume, and distance to nearest "safe" alternative crossing. In addition, requirements for at-grade roadway crossing barriers, artificial lighting, site topography to minimize elevation changes, nearby pedestrian-generating land use(s), and available funding were included. Seattle's priority ranking system (warrant) was proposed as a tool to prioritize potential GSPC sites for planning purposes based on pedestrian and vehicle volume, accidents, and other site characteristics.

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1.0 PURPOSE

The purpose of this research is to establish warrants which will consider factors that influence the effective use of pedestrian over and underpasses or grade separated pedestrian crossings (GSPCs). Currently there are no established nationally acceptable warrants to serve as standards in deciding whether or not to build a GSPC.

2.0 INTRODUCTION

There are cases where GSPCs have been built for situations that did not need them. Ultimately, these GSPCs have been abandoned or removed. The GSPCs that satisfy a particular need tend to be effectively utilized. The need for a GSPC may exist such as on a safe route to and from school where better alternative routes are not possible. An example of a GSPC built to satisfy a need is an overpass between Eleanor Roosevelt High School and the planned community of Greenbelt, MD. This overpass is over four (4) lanes of high speed traffic on the Baltimore-Washington Parkway. An overpass is the only means to walk safely to the school from the community. Additionally, there may be a greater demand anticipated because of planned development or a proposed transportation network.

The need for a GSPC may be present, but certain factors may prevent it from being effectively utilized. In Omaha, NE, the walkway structure of some safe route to school overpasses is an open grid. The open grid is excellent for snow removal in that snow simply falls through the grid down to the roadway. However, pedestrians feel uneasy seeing moving vehicles and feeling the vibrations of the walkway. This type of factor discourages usage even with an existing need for the GSPC. The impact on the usage will vary with the desirability of the location and the alternatives present.

2.1 Research Approach

The objective of the research is to develop and validate warrants which can provide a basis for determining when GSPCs would most likely be successful and well-utilized by pedestrians. In order to accomplish this objective,

The third part, section 6.0, included the development and validation of criteria and warrants for installation of GSPCs. Criteria and warrants were developed from the synthesis of those factors that influence the utilization of GSPCs. The factors were selected from potential criteria in section 3.0, existing warrants in section 4.0, and analysis of site data from 20 of the 40 sample GSPC sites used for criteria/warrant development. The site data anaylsis process identified those criteria and warrants that are most frequently associated with successful GSPC installations. Site characteristics, pedestrian usage/nonusage volumes, and volume of vehicular traffic conflicting with pedestrian movements from the second part were analyzed with contigency table and chi-square hypothesis testing technique in this part. Twelve (12) candidates warrants were derived or adopted from existing ones. The panel of advisors was asked to comment on the candidate warrants in the same manner as they did for the existing warrants.

The fourth part, section 7.0, included the validation of candidate warrants to assure that they provide a basis for determining when a GSPC installation would most likely be successful. Four methods were used to evaluate the candidate warrants: study of behavioral patterns from section 5.0, contigency table and chi-square analyses of site characteristics from the other 20 sample GSPC sites, comparison of candidate warrants with corresponding site characterstics of the GSPC sites, and evaluation of comments given by the panel of advisors on existing and candidate warrants. These warrants must be simple and straightforward in order to be useful to transportation professionals. The proposed warrants were recommended to help predict the real world experience if a GSPC would be built.

2.2 Summary of Findings

The high cost of construction for GSPCs, between $40,000 and 250,000, limits their use as pedestrian vehicle separators except where funding is available and political influence/policy decisions favor their installation. Therefore, there are few established quantitative warrants for GSPCs. San Diego, CA developed threshold warrants (i.e., with minimum pedestrian and vehicular volume levels), and Seattle, WA developed a priority ranking system

(i.e., assigning points to measurable characteristics such as volume and accidents). Most jurisdictions use system-type warrants (i.e., based on master plans).

Warrants were developed and validated as described in section 2.1 above and the following summarizes the proposed warrants:

1. Pedestrian volume should be a total of over 300 in the 4 highest continuous hour period if vehicle speed is over 40 mph and the proposed sites are in urban areas and not over or under a freeway. Otherwise, pedestrian volume should be a total of over 100 pedestrians in the 4 highest continuous hour period.

2. Vehicle volume should be over 10,000 in the same 4 hour period used for the pedestrian volume warrant or ADT over 35,000 if both vehicle speed is over 40 mph and the proposed sites are in urban areas. If the two conditions are not met, vehicle volume should be over 7,500 in 4 hours or ADT over 25,000.

3. A proposed site should be at least 600 feet from the nearest alternative "safe" crossing. A "safe" crossing is where a traffic control device stops vehicles to create adequate gaps for pedestrians to cross. Another "safe" crossing is an existing over or underpass near the proposed one.

4. A physical barrier to prohibit at-grade crossing of the roadway is desirable as part of overpass or underpass design plan.

5. Artificial lighting should be provided to reduce potential crime against users of underpasses and overpasses. It may be required to light underpasses 24 hours a day and overpasses all night.

6. Topography of the proposed site should be such that elevation changes are minimal to users of overpasses and underpasses and construction costs are not excessive. Elevation change is a factor effecting the convenience of the users.

7. A specific need should exist or be projected for a GSPC based on existing or proposed land use(s) adjoining the proposed site which generate pedestrian trips. These land use(s) should have direct access to the GSPC.

8. Funding for construction of the pedestrian overpass or underpass must be available prior to construction committment.

3.0 LITERATURE REVIEW

A list of available literature which pertains to criteria and warrants for GSPCs was compiled as the first part of this research. A computer literature search via the Highway Research Information Service was made, and applicable literature from miscellaneous sources were collected such as US DOT library. The compiled literature was reviewed to identify relevant literature, which then was divided into three categories: directly relevant, indirectly relevant, and useful background literature. The directly relevant literature discusses specific criteria and warrants for pedestrian over and underpasses. The indirectly relevant literature deals with warrants for pedestrian signals, crosswalks, sidewalks and other pedestrian treatments. The useful background literature provided general GSPC design and installation criteria such as ramp slope for wheel chairs, lighting for underpasses, line-of-sight through underpasses and on ramps. Also, the background literature was used to identify which cities had or were currently planning or installing GSPCs. Appendix A contains a bibliography of literature divided into sections A-1, A-2, and A-3 for each category. A brief description of the significance of the directly relevant literature follows each bibliographical listing in Appendix A-1.

3.1 Findings of Literature Review

GSPCs have advantages over alternative solutions of preventing pedestrian-vehicle conflicts since:

- GSPCs eliminate conflicts between vehicles and pedestrians when utilized by pedestrians.
- There is no roadway capacity loss or vehicle speed reduction resulting from use of an existing GSPC compared with the popular alternative of a pedestrian traffic signal. Pedestrians and vehicles have their own right-of-way instead of sharing a portion of the roadway.
- Total delay for pedestrians and motorists can be reduced in many cases. Although pedestrians' crossing time may increase if they have to ascend and descend GSPCs ramps or steps, pedestrians no longer have to wait for gaps in vehicular traffic. Vehicles do not have to slow down or stop for pedestrians.

Despite these advantages, GSPCs are not commonly built due mainly to their high construction costs. It has been reported in various literature references that GSPCs cost from $40,000 to $250,000. The cost of special design features, such as ramps to permit access to GSPCs for the handicapped, has increased the construction cost and has further discouraged their installation. Most GSPCs are built because funding is available from the federal government or they were as part of an existing transportation master plan. The FHWA typically funds GSPC construction associated with roadway projects when a community is disrupted by a new roadway, usually a freeway. The term freeway in this research will refer to a roadway for through traffic with full or partial access control, with speed limits above 40 mph, and generally with grade separations at major intersections. In some cases, GSPCs may be built because of citizen requests after a freeway is built, but usually GSPCs are built as part of freeway projects. Pedestrians usually have a choice when a GSPC is across a highway (a roadway other than a freeway) since they may cross a highway at-grade or at a nearby traffic signal instead of using the GSPC. The term highway in this research will refer to a local, collector, or arterial roadway without access control and with intersections at-grade with the roadway. Currently most GSPCs being built are over freeways or built as part of a safe route to school program, especially for elementary school children. Generally most GSPCs are overpasses. Underpasses tend to be unsuccessful because of the threat of crime to users and drainage problems. Skyways connecting buildings in dense downtown areas are also being built as part of transportation master plans. Given the unique circumstances for which skyways are built, they will not be addressed in this research.

3.2 Criteria Identified

The applicable literature was reviewed for any criteria which might influence the use or nonuse of GSPCs. These criteria were grouped into categories to be used in the third part of this report. Criteria which influence utilization of GSPCs were developed in the third part. The list of criteria appears in Table 1. While list of criteria is not comprehensive, it does list major factors influencing utilization of GSPCs. Freeways and highways are influenced by different criteria. These criteria may act individually or interact in different ways, for example:

TABLE 1:
LIST OF POTENTIAL CRITERIA FOR GSPCs

CONVENIENCE

Activity center (pedestrian traffic generator) nearby GSPC
Height to ascend/descend on GSPCs' ramps or steps
Additional distance to travel using GSPC compared with crossing roadway at-grade
Accessibility for the handicapped (and blind)

ALTERNATIVE "SAFE" CROSSINGS INSTEAD OF GSPCs

Traffic signal - with pedestrian heads, pedestrian pushbuttons, advanced/delay green
Pedestrian/school crosswalk - marked, unmarked, signed
School crossing guard - adult, student safety patrol

FEASIBILITY OF INSTALLATION

Right-of-way (ROW) available for ramps for GSPC
Funding available to build GSPC

PEDESTRIAN SAFETY

Perception of risk
Preventable accidents - fatality and injuries (5 year period)
Conflicts between vehicles and pedestrians

TABLE 1:
LIST OF POTENTIAL CRITERIA FOR GSPCs (Continued)

VEHICULAR TRAFFIC OPERATIONS

Acceptable gaps in traffic (1 per minute average)
Volume of potential pedestrians using a GSPC
Volume of vehicles - low, moderate, high
Percent of truck/buses - low, moderate, high
Speed of vehicles - less than 20 mph, 20-35 mph, over 35 mph
Directional traffic flow - one-way, two-way
Vehicle turning movements conflicting with pedestrian movements

ROADWAY GEOMETRICS

Distance to cross roadway or to median
Number of moving traffic lanes to cross to other side of the roadway
Number of moving traffic lanes to cross to refuge island (median)
Presence of pedestrian raised refuge median (4 feet minimum)
Sight distance - good, moderate, poor
Freeway - usually no alternative "safe" crossing
Highway - major artery, collector, local street

ADJOINING LAND USES

Elementary school/nursery school/day care center
Jr/sr high school or college
Central business district (CBD)
Residential to recreational
Residential to shopping/transportation terminal (i.e., bus stop)
Residential to residential
Office/factory to parking lot/bus stop
Office/factory to shopping

TABLE 1:
LIST OF POTENTIAL CRITERIA FOR GSPCs (Continued)

PLANS

Adopted master plan - pedestrian, bicycle, horse trails
Compatibility with esthetic character of environment
Proposed plans - pedestrian, bicycle, horse path
Community continuity - cohesion, disruption

DESIGN FEATURES AFFECTING USAGE

Physical barrier to prohibit at-grade crossing
Topography of surrounding land
Litter control - routine cleaning
Lighting for underpasses and overpasses
Signing to entrance to GSPCs
Climate - sun glare, snow
Drainage (underpasses) - adequate, inadequate
Crime - clear view up ramps or through underpass and no hidden areas
Handicapped accessible - ramp slope, ramp length, and hand rails
Esthetic design

COST FACTORS

Construction cost - ROW acquisition, foundation, materials, labor
Maintenance and operation cost - litter control, lighting, graffiti removal
Vehicle delay/fuel consumption if traffic light vs. GSPC - increase, decrease, no change
Roadway capacity if traffic light vs. GSPC - increase, decrease, no change
Accident cost of injuries
Accident cost of fatalities
Tax receipts (increased due to desirable business location near GSPC in form of tax base, property value, and business activity)
Pedestrian delay reduction

- Pedestrians will use or not use a GSPC depending upon their perception of the risks. Lack of acceptable safe gaps in traffic is motivation to use a GSPC in order to avoid being hit by moving vehicles while crossing the roadway at-grade. A dark underpass could be perceived as a crime risk which is more dangerous than an accident threat. Therefore, pedestrians would generally choose to cross the roadway at-grade rather than use such an underpass.

- If it is possible and more convenient to cross a highway at-grade, pedestrians generally will not use GSPCs. Therefore, available gaps in vehicular traffic become significant to give pedestrians a margin of safety between themselves and oncoming traffic.

- If a traffic signal is near a GSPC and there is not heavy turning movement towards the at-grade crossing location, safe gaps in traffic will be available for pedestrians to cross the highway at-grade. Many GSPCs that are well-utilized and are near traffic signals have barriers installed along the roadway to discourage at-grade crossings. In other cases, there are natural grade differences in the area terrain at the GSPC site. In Akron, OH and Boulder, CO, it is more convenient to use GSPCs because of this grade difference. In a few instances where the GSPC was planned with the roadway construction, the grade through an underpass was kept flat while the roadway grade was changed.

- Across freeways, there are usually no alternatives for pedestrians to cross except by using a GSPC. Although some pedestrians do cross freeways at-grade, criteria such as convenience and traffic gaps are apparently not as significant. The freeway and its access control barriers restrict pedestrians from crossing at-grade. Criteria such as community disruption and severance become significant.

3.3 Types of Warrants Identified

Based on the literature review, six general types of warrants for GSPCs were identified: threshold, priority ranking, economic, system, policy, and political. The first three are quantitative, and the next three are qualitative. In some cases, political pressure to establish a qualitative policy generates a system plan and thus quantitative threshold or priority ranking warrants are developed. No general sequence or combination of types of warrants is prevalently followed, and development varies within each particular jurisdiction. Only the first four types of warrants were investigated in this report due to the diversity of politics in jurisdictions across the United States and of policies implemented as a result of political actions.

A description of each type of warrant[1] from the most to least quantitative follows:

1. Threshold Warrants - This type of warrant is based on a set of warrants of which all or a combination of individual warrants must be satisfied. Discussions of threshold warrants in the literature review referred to the minimum pedestrian volume warrant for traffic signals in the Manual on Uniform Traffic Control Devices (MUTCD) as a GSPC warrant. Examples of threshold warrants for GSPCs would be vehicular volume, pedestrian volume, vehicle speed, acceptable pedestrian gaps in traffic, preventable accidents, and distance to nearest alternative "safe" crossing (usually a traffic signal). Some professional judgments are still required for such qualitative factors as future land use patterns which could generate pedestrian activity, feasibility of alternatives to a GSPC, and feasibility of GSPC construction.

2. Priority Ranking Warrants: This approach for developing warrants is also known as a point warrant. Factors affecting the need for and potential utilization of GSPCs are either selected and assigned point weights or combined to form of an exposure index. For the former, quantitative factors are assigned points according to their numerical value (i.e., pedestrian or vehicular volume) while qualitative criteria are assigned points based on professional judgments. The latter ranking system, exposure indexes, measures the interaction between pedestrians, vehicles, and possibly site characteristics (i.e., vehicle speed) usually by multiplying their respective values together.

   The assigned points type of ranking system is becoming a popular method to warrant GSPCs and was found to be used in at least three states: Washington, New Jersey, and Massachusetts. This type of priority ranking system has been recommended in a number of

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1 Swan, S; Sgourakis, A; Deleuw, C., Effective Treatments of Over and Under crossing for Use by Bicyclists, Pedestrians and the Handicapped - Literature Review, FHWA-RD-78-142, October, 1980.

professional articles including the Institute of Transportation Engineer's Technical Committee 4E-A Report in 1972 (reference A-1/#9 in the bibliography).

3. Economic Warrants: This type of warrant includes the benefit-cost, cost effectiveness, annual cost, or present worth comparisons of the construction and maintenance costs of GSPCs with alternatives such as traffic signal installations. The benefits are usually reduced pedestrian hazards (in terms of preventable pedestrian injuries and fatalities) and reduced vehicle and pedestrian delay. The National Cooperative Highway Research Program (NCHRP) Report 189 Quantifying the Benefits of Separating Pedestrians and Vehicles (reference A-1/#6) and the followup report NCHRP 240 A Manual to Determine Benefits of Separating Pedestrians and Vehicles (reference A-1/#19) present economic methodologies to analyze GSPCs. Economic warrants are difficult to use especially since monetary values for pedestrian injury, death and delay must be used with great care to obtain reasonable conclusions.

4. System Warrants: This is actually a case by case evaluation of a GSPC at a specific site to determine how well a GSPC fits into the overall transportation system or master plan. The GSPC is evaluated on a generally qualitative basis concerning existing and proposed conditions. Where a threshold warrant specifies a vehicle volume, the system warrant may require "high" vehicle volumes or speeds. This requires the transportation professional to determine whether or not the vehicular volume or speed at a particular site is a "high" value. Most of the available literature was found to provide general qualitative criteria for system warrants.

5. Policy Warrants: GSPCs may be "warranted" in that they are built as a result of an established policy. Many cities have policies to improve pedestrian safety by separating pedestrian circulation patterns from the vehicular right-of-way. In addition, GSPCs have been warranted as part of an established policy to provide a safe route to and from school in lieu of a pedestrian/school traffic

signal and/or adult crossing guards. Quantifiable warrants have been developed to support the policy warrants to provide safe routes to and from school in Omaha, NE.

6. Political Warrants: This is not a warrant per se but is the result of political lobbying of or by the local legislature or the result of the prerogative of a strong politician. The political influence can contribute to development of another type of warrant which in turn may result in building a GSPC or contribute to a GSPC being built without applying any other type of warrant. This "warrant" varies greatly with the degree of political insulation that local transportation planning departments have from their legislative body and executive hierarchy.

4.0 STATE-OF-THE-PRACTICE REVIEW

The state-of-the-practice, subpart two of part one, was assessed through discussions with transportation professionals at the state and local level. A comprehensive survey of local jurisdictions or practitioners was not attempted. An initial list of professional contacts was generated from those cities that have active pedestrian safety programs. The cities were identified in the literature review and from professional contacts. The cities, counties, and states contacted are summarized in Appendix B.

4.1 Local Practices - Warrants Used

There are three basic types of warrants currently used in the United States. Some jurisdictions use quantitative threshold warrants, others use priority ranking systems (either assigned points or exposure index) while others use system warrants. Summaries of existing threshold, assigned points (priority ranking) warrants, exposure indexes (priority ranking warrants), and system warrants are shown in Tables 2, 3, 4, and 5.

A panel of advisors was formed to provide comments concerning the ease of application (i.e., complexity, data requirements, etc.) and appropriateness of the existing warrants for GSPCs. Their comments provided insight to local

TABLE 2: EXISTING THRESHOLD WARRANTS

Source:	San Diego CA (#1)	Washington State DOT
Reference No.*:	A-1/#20	A-1/#2
Date:	1971	1978
Application:	All conditions below should be met for unsignalized locations:	For fully controlled access freeways, must meet warrants A(1) & A(2) plus warrants (B(1) & B(2)) or C below:
Major Street Vehicle Volume per Period	Exceeds 3,000 in continuous 4 highest hrs	N/S
Minor Street Vehicle Volume per Period	Less than 125 in the same continuous 4 hrs	N/S
Pedestrian Volume per Period	Exceeds 300 in the same cont. 4 hrs (1 child under 12 yrs equals 2.5 pedestrians)	Warrant B(1): Exceed 200 2 hrs period
Accidents	N/S	N/S
Nearest "Safe" Crossing (ft)	750 or more (traffic signal)	Warrant B(2): For 85% of pedestrian users, 1/2 mile or more
Vehicle Speed (mph)	Exceeds 30 mph (85% highest speed)	N/S
Sight Distance	N/S	N/S
Feasible to Install	N/S	Warrant A(1): "Feasible from an engineering standpoint"
Land Use Development	"Substantially developed" "Traffic patterns and volume stabilized"	N/S
Physical Barrier to Prohibit At-grade Crossing	"Feasible to prohibit pedestrian from crossing the major street,..."	N/S
Economic	"For a 10 yr period, ... less expensive than a traffic signal"	Warrant C: Economic cost due to community disruption by severing adjoining land uses is more than the cost of a GSPC
Road Geometry	N/S	N/S
Others	None	Warrant A(2): "No possibility of changes in bus routes... which would eliminate the need for such structure..."

*Refer to Appendix A for annotation of the reference.
N/S = Not Specified

TABLE 2: EXISTING THRESHOLD WARRANTS (Continued)

Source:	San Diego CA (#2)	Omaha NE
Reference No.:	A-1/#10	A-1/#10
Date:	pre 1971	1971
Application:	Signalized locations:	All conditions should be met for unsignalized locations:
Major Street Vehicle Volume per Period	(Existing or future) 35,000 per day	Total exceeds 3,000 in continuous 4 highest hrs
Minor Street Vehicle Volume per Period	N/S	Less than 125 in same continuous 4 hrs
Pedestrian Volume per Period	Exceeds 100 in continuous 4 hrs	Exceeds 300 in the same continuous 4 hrs (1 child under 12 yrs equals 2.5 pedestrian)
Accidents	N/S	N/S
Nearest "Safe" Crossing (ft)	N/S	750 or more (traffic signal)
Vehicle Speed (mph)	N/S	Exceeds 30 mph (85 percentile)
Sight Distance	N/S	N/S
Feasible to Install	N/S	N/S
Land Use Development	N/S	"Substantially developed and traffic patterns ... stabilized"
Physical Barrier to Prohibit At-grade Crossing	Yes	N/S
Economic	N/S	"Feasible"
Roadway Geometry	Width exceeds 70 ft	For 10 yr period, less expensive than traffic signal
Others	None	None

TABLE 2: EXISTING THRESHOLD WARRANTS (Continued)

Source:	Ohio DOT	Wisconsin DOT
Reference No.:	A-1/#15	A-1/#2
Date:	1981	1977
Application:	Overpasses "in urban areas outside the CBD":	To be considered in analysis of need:
Major Street Vehicle Volume per Period	Exceeds 600 per hr for any 8 hrs of an average day without a raised median (4 ft or wider) or exceeds 1,000 per hr with a raised median *	Exceeds 600 per hr for any 8 hrs of an average day without a raised median (4 ft or wider) or exceeds 1,000 per hr with a raised median *
Minor Street Vehicle Volume per Period	N/S	N/S
Pedestrian Volume per Period	"Substantial desire ... exist" Exceeds 150 per hr for the same 8 hrs as above on highest crosswalk *	"High degree of interest" Exceeds 150 per hr for the same 8 hrs as above on highest crosswalk *
Accidents	N/S	"Pedestrian accident problems evident"
Nearest "Safe" Crossing (ft)	Exceeds 660 or more	Exceeds 600 or more
Vehicle Speed (mph)	N/S	"Significant hazard to pedestrians"
Sight Distance	If "limited", MUTCD vehicle and pedestrian volume requirements can be waived	N/S
Feasible to Install	"Physical conditions permit construction"	"Practical to construct... within existing physical conditions"
Land Use Development	N/S	N/S
Physical Barrier to Prohibit At-grade Crossing	"Pedestrians can be prevented from crossing at-grade"	"Prevent pedestrians from crossing at-grade"
Economic	N/S	N/S
Roadway Geometry	N/S	N/S
Others	No "reasonable alternative" is available	No reasonable alternatives and "organized groups expressed a high degree of interest"
	* Minimum pedestrian warrant for traffic signals in the MUTCD	* Minimum pedestrian warrant for traffic signals in the MUTCD

TABLE 2: EXISTING THRESHOLD WARRANTS (Continued)

Source:	Article by N. Szwed (ARRB/DOT Pedestrian Conf.)
Reference No.:	A-1/#23
Date:	1978
Application:	Considerations to establish need:
Major Street Vehicle Volume per Period	Exceeds 1,000 per hour
Minor Street Vehicle Volume per Period	N/S
Pedestrian Volume per Period	"Magnitude of desire for GSPC" Exceeds 300 per hour (Protecting young children)
Accidents	"Records should be checked" Accident history should "not usually vary substantially or be revealing"
Nearest "Safe" Crossing (ft)	Not near traffic signal which creates traffic gaps
Vehicle Speed (mph)	"High speed"
Sight Distance	N/S
Feasible to Install	N/S
Land Use Development	N/S
Physical Barrier to Prohibit At-grade Crossing	Minimize at-grade crossings
Economic	Cost effectiveness, but procedure "can be difficult"
Roadway Geometry	No median present
Others	* No alternative to reroute or relocate pedestrians' destination * "Esthetic effect" of GSPC * "Intrusion of private abutting properties"

TABLE 3: EXISTING ASSIGNED POINTS (PRIORITY RANKING) WARRANTS

Source:	SEATTLE WA	ITE
Reference No.*:	A-1/#14	A-1/#9
Date:	1969	1972
Application:	Up to 100 points (pts):	Freeway applications: (up to 100 pts):
Vehicle/Pedestrian Volume	Up to 40 pts (See Figure 1)	Up to 40 pts (See Figure 1)
Accidents	Up to 15 pts, 5 pts per correctable ped accident in a 5 yr period	Up to 15 pts, 5 pts per accident
Marked School Crossing	10 pts, if present	10 pts, if present
Elementary School	10 pts, if nearby	10 pts, if nearby
Jr/Sr High School	N/S	N/S
Adult Crossing Guard	10 pts, if present	10 pts, if present
Sight Distance	----	----
Land Use Development	---- 15 pts plus extra points for street width below**	---- 15 pts
Improve Vehicle Speed & Capacity	N/S	----
Nearest "Safe" Crossing	N/S	N/S
Street Width	** included as extra pts such that 2 pts per 10 ft of width are added	2 pts per 10 ft of width
Raised Median (Min 4 ft)	Less 4 pts, if present	Less 4 pts, if present
At-grade Median (Min 4 ft)	Less 2 pts, if present	Less 2 pts, if present
Others	None	None

*Refer to Appendix A for annotation of the reference.
N/S = Not Specified

TABLE 3: EXISTING ASSIGNED POINTS (PRIORITY RANKING) WARRANTS (Continued)

Source:	NJ DOT	Massachusetts DPW
Reference No.:	A-1/#3	A-1/#2
Date:	1975	1975
Application:	Highways using a series of charts (200 pts system):	"Non-limited access highways" (100 pts system & build GSPC if over 75 pts):
Vehicle/Pedestrian Volume	Up to 80 pts (or 40 pts times 2 if 120 sec average ped delay in their peak hr)	Up to 40 pts (Refer to Figure 1)
Accidents	N/S	Up to 15 pts, 5 pts for each correctable ped accident in a 5 yr period
Marked School Crossing	Up to 30 pts (considers crossing time**)	10 pts, if present
Elementary School	N/S	10 pts, if nearby
Jr/Sr High School	N/S	5 pts, if nearby
Adult Crossing Guard	Up to 30 pts (or alternative passive or active protection considering pedestrian volume)	10 pts, if present
Sight Distance	Up to 50 pts (based on speed* & pedestrian crossing time **)	---- Up to 15 pts if sight distance deficiencies or if potential increase in traffic
Land Use Development	Up to 70 pts considering pedestrian volume	----
Improve Vehicle Speed & Capacity	* Speed incorporated into sight distance chart	N/S
Nearest "Safe" Crossing	Up to 30 pts (considering pedestrian volume)	N/S
Street Width	** Used to determine pedestrians' crossing time for school & crossing pts	2 pts per 10 ft of width
Raised Median (Min 4 ft)	N/S	Less 4 pts, if present
At-grade Median (Min 4 ft)	N/S	Less 2 pts, if present

(Continued on Next Page)

TABLE 3: EXISTING ASSIGNED POINTS (PRIORITY RANKING) WARRANTS (Continued)

Source:	NJ DOT	Massachusetts DPW
Reference No.:	A-1/#3	A-1/#2
Date:	1975	1975
Application:	Highways using a series of charts (200 pts system):	"Non-limited access highways" (100 pts system & build GSPC if over 75 pts):
Others	Judgment 10 pts	If 48-75 pts, consider further such factors as: 1)severity of accidents, 2)peak hrs of ped correspond to vehicle hrs, 3)community support enough to acquire ROW for GSPC's footings and abutments, and 4) alternative solutions

TABLE 4: EXISTING EXPOSURE INDEXES (PRIORITY RANKING WARRANTS)

Source:	Victoria Australia		Omaha NE
Reference No.*:	A-1/#22		A-1/#10
Date:	(Before 1978)		1975
Application:	For two-way undivided highways:	For two-way divided highways:	Hazard Index (I) I = (V/10,000) x P x (S/30) x K where V, P, S, & K are:
Major Street Vehicle Volume per Period	750 per hr	1,000 per hr	V = Average Daily Traffic (ADT)
Pedestrian Volume per Period	Vehicles times no. of children exceeds 100,000	Vehicles times no. of children exceeds 280,000	P = Children and ped count in the morning crossing peak period
Accidents	N/S	N/S	N/S
Nearest "Safe" Crossing (ft)	N/S	N/S	N/S
Vehicle Speed (mph)	N/S	N/S	S = Speed limit
Sight Distance	N/S	N/S	N/S
Feasible to Install	N/S	N/S	Structure feasible to build engineering design and in physical location
Land Use Development	N/S	N/S	N/S
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S	N/S
Economic	N/S	N/S	Economically justified in long range if compared with other traffic controls
Roadway Geometry	N/S	N/S	K = 1 if 2 lanes K = 2 if 3 or 4 lanes K = 3 if 5 or more
Others	None	None	*Not possible to reroute school children *Conditions require permanent school crossing

* Refer to Appendix A for annotation of the reference.
N/S = Not Specified

TABLE 5: EXISTING SYSTEM WARRANTS

Source:	Washington State DOT	AASHTO
Reference No.*:	A-1/#2	A-1/#1
Date:	1978	1973
Application:	For partially or non-controlled access highways, must meet warrant A plus warrants B or C described below:	"Provided where pedestrian volume, traffic volume and other conditions favor their use.":
Major Street Vehicle Volume per Period	A traffic signal would be oversaturated with the combined major and minor street vehicle and pedestrian volume	"Traffic volume ... favor their (GSPCs) use"
Minor Street Vehicle Volume per Period	A traffic signal would be oversaturated with the combined major and minor street vehicle and pedestrian volume	N/S
Pedestrian Volume per Period	A traffic signal would be oversaturated with the combined major and minor street vehicle and pedestrian volume	"Heavy peak pedestrian movements"
Accidents	N/S	N/S
Nearest "Safe" Crossing (ft)	Warrant B(2): For 85% of pedestrian users, 1/2 mile or more	N/S
Vehicle Speed (mph)	N/S	N/S
Sight Distance	N/S	N/S
Feasible to Install	Warrant A(1): "Feasible from an engineering standpoint"	N/S
Land Use Development	N/S	N/S
Physical Barrier to Prohibit At-grade Crossing	N/S	"Fences may be required to prevent pedestrian crossing the arterial in spite of separations"
Economic	Warrant B(1): Yearly cost of GSPC is less than installing and maintaining a traffic signal	N/S
Roadway Geometry	N/S	N/S
Others	Warrant A(2): No possibility of changes in bus routes... which would eliminate the need for such structure..."	"Where cross streets are terminated" over freeways

* Refer to Appendix A for annotation of the reference.
N/S = Not Specified

practical experiences dealing with warrants and installation of GSPCs. The panel of advisors consisted of the following transportation professionals:

1. Mr. David Fielder - Akron, OH
2. Mr. Thomas Hannan - Baltimore, MD
3. Mr. Bruce Herms - San Diego, CA
4. Mr. J. Vincent O'Connor - Alexandria, VA
5. Mr. William Marconi - San Francisco, CA

In addition to their comments on existing warrants, the panel was asked for their comments on candidate warrants developed in section 6.3 of this report. Their comments were summarized in section 7.3.

The state-of-the-practice for each type of warrant including the disadvantages of economic warrants is discussed below:

Threshold Warrants

The city of San Diego developed quantitative warrants in 1971 in response to a school pedestrian safety policy. Pedestrian and vehicle threshold values are fixed at a realistic level. Four (4) continuous rather than the highest 8 hours of volume data are required. Children are weighted to be equal to 2.5 adult pedestrians. This reduces the requirement of 300 pedestrians per 4 hour period to 120 school children. The threshold warrant includes relevant criteria such as distance to nearest traffic signal and specifies physical barriers to prevent pedestrians from crossing at-grade. A ten-year economic analysis is also stipulated to compare the cost effectiveness of a GSPC to a traffic signal installation.

Assigned Points (Priority Ranking) Warrant

In 1969, the city of Seattle, WA, developed a priority system to rank and justify potential GSPCs. New Jersey, Massachusetts, and the Institute of Transportation Engineers have adopted priority ranking systems which are versions of Seattle's system with minor modifications. The priority ranking system permits flexibility in evaluating pedestrian volume and conflicting vehicle volume. Figure 1 shows the point rating curves used by Seattle's ranking warrant. If the combined average daily traffic (ADT) for pedestrians

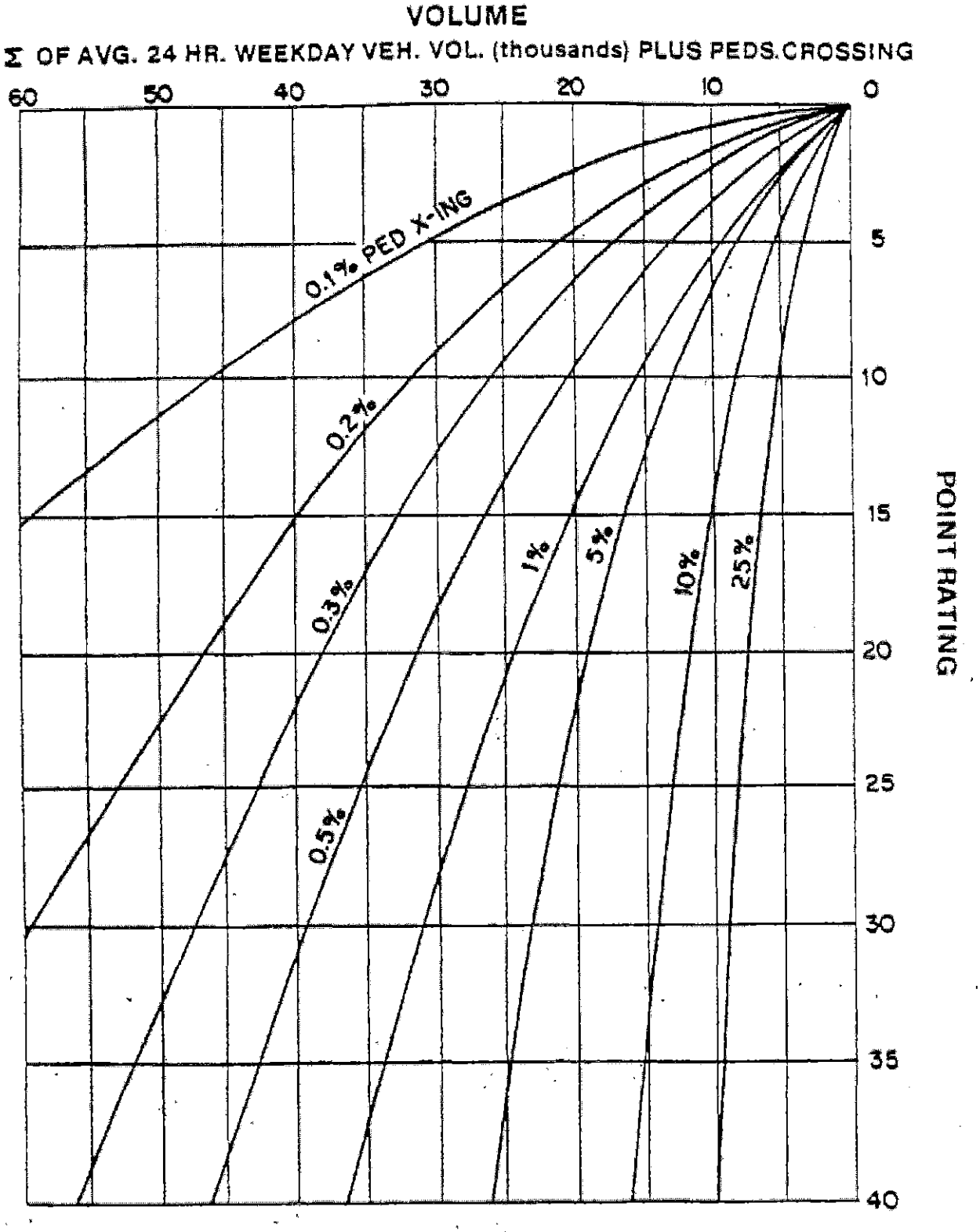

FIGURE 1

PEDESTRIAN OVERPASS STUDY VOLUME POINT RATING

and vehicles is 53,000 and pedestrians represent 0.2 percent of this combined total, 25 points will be rated for that location. But for 25 percent pedestrians out of a combined 8,000 ADT for pedestrians and vehicles, the same 25 points is assigned. Therefore, small pedestrian volume crossing heavy traffic is considered to be equally as important as heavy pedestrian volume with light traffic. Other criteria such as number of preventable accidents and highway width are also assigned points. The combination of these factors is a little over 50 percent of the total ranking points. Additional criteria are refuge median, sight distance, land use development, and presence of a school crossing.

Exposure Index (Priority Ranking Warrant)

The city of Omaha, NE uses an exposure index as a means to determine the necessity for building a GSPC at a proposed school crossing. It was originally developed in 1968 and considered vehicle ADT, vehicle speed, and volume of children. The index was modified in 1972 to include a factor for street width. Instead of simply multiplying these values together as done with Victoria's index, vehicle ADT and speed are used as ratios. ADT is divided by 10,000, and speed by 30 mph. These values are minimums. When the actual ADT or speed is below them, the index value would be reduced since the ratio would be less than 1.0. Street width was handled by multiplying the index product by a factor of 1, 2 or 3 depending on the number of traffic lanes.

Economic Warrants

The first and most obvious disadvantage with economic warrants is the difficulty to assess the cost of pedestrian benefits such as the dollar value of a life saved or an injury avoided. There are several problems with the safety portion of the typical economic warrant. Signalizing a location instead of providing a GSPC may save pedestrian-vehicle accidents but may produce rearend or other accidents. These must be forecasted or predicted. Signalizing a location produces speed-change cycles that must be factored into the analysis which requires the prediction of volume and gasoline prices. Prediction of accidents saved or caused, volume, and prices creates credibility gaps and "room for argument."

Other elements of the economic analysis aggravate the credibility gap. These include the design life of the signal and GSPC, maintenance costs, interest rate (which also must be predicted) and salvage values. Economic analysis generally produces large dollar values to compare alternatives such as the signal vs. GSPC. This further removes the economic analysis as a decisionmaking tool from the category of "readily understandable" for the layperson. Ultimately, the political decisionmaker must present the decision and the applied warrants to the laypersons to whom he/she is responsible.

In some cases an economic analysis is complicated by a difficult design. In any case, significant design and cost information must be gathered and analyzed in order to be related to benefits in the economic analysis and warrant procedure. Preliminary design alternatives and costs are frequently controversial and many times leave a credibility gap.

A specific example of a defensibly straightforward economic warrant used in Washington State is whether the cost of taking property at a location of a proposed GSPC is more expensive than building a GSPC structure. With this warrant, those affected may argue that the "severance" (i.e., roadway dividing a community where a group of residents is cutoff from community recreational facilities) is clear and extreme. The opposition may be able to argue that the community has average availability and access and that the severance is not clear and extreme. The cost of land required to provide similar facilities may be controversial. Any number of controversies with such economic warrants have arisen and can be expected in future applications.

System Warrants

Most jurisdictions use qualitative system-type warrants based on an urban master plan for separating pedestrians and vehicles. Cities and counties such as Minneapolis, MN; New Orleans, LA; Baltimore, MD; San Francisco, CA; Akron, H; Boulder, CO and Prince George's County, MD have master plans incorporating GSPCs. Others like Omaha, NE build GSPCs as part of a safe route to school program/policy. However, many safe route to school programs use actuated pedestrian signals in lieu of GSPCs (i.e., Denver, CO).

Many cities which use system warrants do not generate threshold or priority ranking warrants to aid in selecting locations of GSPCs. Some jurisdictions adopt system-type criteria from AASHTO's Red Book (reference A-1/#1). An example would be the statement on page 425 of the Red Book that "on many freeways, highway overpasses for cross streets may be limited to three to five block intervals." Others use quantitative warrants developed for pedestrian traffic signals, usually the MUTCD's minimum pedestrian volume warrant (section 4C-5 of the MUTCD).

Policy Warrants

Policy warrants vary from community to community based on localized needs. In Omaha and San Diego, concern for school children safety has led to quantitative warrants (i.e., exposure index and threshold warrants, respectively). Baltimore, MD and New Orleans, LA developed a downtown skyway system to separate pedestrian traffic from vehicles. The skyways were built as part of a master plan or system warrant. Boulder, CO and Prince George's County, MD have a policy for pathways for joggers and bicyclists. Established master plans were developed as result of their policies on pathways.

Political Warrants

Political influence into the decisionmaking process vary depending on the level of insulation the transportation professionals have within each local governmental hierarchy. Ideally, citizen concerns should be heard and addressed in a rational manner based on engineering standards. This is not practical in most cases as every situation in each community has its own unique problems requiring a solution acceptable to the major political influences.

4.2 Deficiencies with Current Warrants

The problem with many current warrants is that they are cumbersome to apply and may not always utilize reasonable quantitative values such as pedestrian volume. The volume of pedestrians who might use a GSPC cannot be accurate accurately projected. Pedestrian volumes specified in the MUTCD are

unreasonably high when applied in rural or suburban locations and usually can only be met in large cities. Revised minimum pedestrian volume warrants for traffic signals were proposed for the MUTCD via research by Zegeer in 1983 (reference A-2/#27). The requirement of at least 150 pedestrians per hour for any 8 hours of an average day was reduced to 60 pedestrians per hour in any 4 hours, 90 in any 2 hours, or 110 in the peak hour. The priority ranking system of Seattle, WA resolves this inflexible pedestrian volume requirement by establishing a weighted ratio of vehicle to pedestrian volume in the form of a chart shown in Figure 1. This figure is discussed in section 4.1 of this report under assigned points (priority ranking) warrants. Seattle's priority ranking system which has been adopted by other jurisdictions provides assigned points for different criteria. Assigned points ranking systems often require cumbersome data collection procedures and require the use of engineering judgment concerning factors such as sight distance adequacy, pedestrian/vehicle volume growth and other factors. Other warrants specify economic analysis to justify GSPC installations. GSPCs can rarely be economically justified, especially since current recommendations for handicapped accessibility (i.e., ramps) increase their cost. In addition, ramps often increase the walking distance on a GSPC which creates further inconvenience for the nonhandicapped user.

5.0 BEHAVIORAL PATTERNS

In part two, perceptions of risk and inconvenience were collected by conducting informal inquiries of random subjects to ascertain behavioral patterns. The data collection involved inquiries of users and nonusers of a GSPC at 37 sites. Only 37 instead of all 40 GSPC sites were involved due to restrictions in collecting inquiry data at three sites. The 40 GSPC sites were a sample of existing GSPCs in Baltimore, MD; Boulder, CO; Omaha, NE; Seattle, WA; and Washington, DC. See Table 6 for a list of all 40 GSPC sites. The three GSPC sites where behavioral data could not be collected are shown by asterisks on Table 6. The determination of successful and unsuccessful GSPCs were made based on actual pedestrian counts. Details are discussed in section 6.0 of this report.

There were other interesting reasons or comments received in small numbers and resulting in no emerging patterns. These comments and in parentheses, the number of times they were given, were as follows:

* Better for joggers (21)
* Better for bicyclists (16)
* Crime threat (i.e., poor lighting, hidden corners where undesirable characters can hide, etc.) (15)
* Dislike GSPC (i.e., poor design, unclean) (14)
* Like GSPC design (13)
* Obey signs and or parents (8)
* Dislike climbing steps (6)

5.2 Derived Criteria

From these emerging patterns of perceptions, several criteria evolved as predictors for under-utilized or well-utilized GSPCs. Criteria for under-utilized GSPCs were as follows:

* Roadway being crossed has a low traffic volume
* A junior or senior high school (serving 13-18 year old age group) near a proposed GSPC
* Shopping area(s) near a proposed GSPC
* Proposed GSPC to serve jogging or bicycle trails or routes

Criteria for well-utilized GSPCs were as follows:

* Convenience in terms of being easier, shorter, or quicker to use a GSPC
* Roadway being crossed has a heavy traffic volume
* Trips to or from work where the employer encourages use of a GSPC

6.0 DEVELOPMENT OF CRITERIA AND WARRANTS

This section, part three, discusses the development of criteria and warrants for grade separated pedestrian crossings (GSPCs). Criteria and

TABLE 12:
PERCENT OF GSPC SITES NEARBY EACH CATEGORY OF LAND USE

LAND USE	PERCENT OF GSPC SITES		
	Successful	Moderate	Unsuccessful
• Educational (Daycare, elementary)	18%	31%	29%
• Educational (Junior/senior high, college university)	17%	13%	23%
• Residential			
1. Single-Family Housing	35%	62%	43%
2. Multi-Family Housing	22%	11%	19%
3. Housing for the Elderly	5%	0%	
4. All Housing	21%	19%	20%
• Recreational	5%	6%	10%
• Commercial	10%	15%	10%
• Office/Light Industry	3%	2%	4%
• Median/Heavy Industry	10%	4%	0%
• Bus Stop	20%	46%	29%
• Parking Lot	20%	8%	0%

chi-square analyses. The warrant validation subset of sample GSPC sites was used as in section 7.1. The results of the contingency table/chi-square analyses are shown in Table 29 of Appendix E. For each site characteristic, the statistical results were broken down for different measures of success (i.e., user volume, nonuser volume, and ratio of users to total pedestrians). The former two measures of success were analyzed with 1, 4, and 8 hour user and nonuser pedestrian volume data. The successful, moderate, or unsuccessful degrees of GSPC utilization were determined for each measure of success. The summary of this analysis is shown in Table 19. Different patterns for many of the characteristics emerged when the results of analysis for validation were compared with that for criteria/warrant development. These differences are illustrated in Table 20. Site characteristics with the same patterns for criteria/warrant development and validation were not listed in Table 20 or discussed below. For each characteristic, the following describes the differences and their influence on utilization of GSPCs (as numbered in Table 19):

1. Land Use Categories - As discussed in section 6.2 and reaffirmed by this analysis, none of the land uses were good indicators of well-utilized GSPCs. There were differences in emerging patterns between development and validation for land use categories. Despite these differences, the conclusions were the same. Refer to Table 13 in section 6.2 for detailed analysis of land use categories.

2. Land Use Density - No pattern emerged, and therefore land use should not be considered as a warrant.

3. Policy of Nearby School on Use of GSPC - There were minor differences for schools with active policies. To better understand the patterns, the percent of GSPC sites nearby a school practicing a particular policy was evaluated by the degree of success. The results of this additional analyses of school policy on use of GSPCs is shown below:

SCHOOL POLICY	PERCENT OF GSPC SITES		
	Successful	Moderate	Unsuccessful
* Active (Adult/student crossing guard)	5%	4%	14%
* Passive (Policy; but no enforcement)	0%	15%	0%
* No Established Policy	3%	46%	29%

No patterns emerged for either active, passive, or no policy. If the GSPC design is not convenient to use, active or passive encouragement would not make it successful.

7.3 Comments of the Panel of Advisors

The panel of advisors was asked to review the existing warrants for GSPCs in section 4.1 of this report and the twelve candidate warrants from section 6.3. They were asked for their comments on the ease of application, reasonableness, and completeness of the warrants. The practical experience given by the advisors provided insight into local practices. The comments were as follows:

1. Vehicle Volume - There should be values set for urban and nonurban sites as well as high-speed (over 40 mph) and low-speed roadways. An example of the latter would be vehicle volumes of 500 vph if over 40 mph and 1,000 vph if under 40 mph.

2. Pedestrian Volume - The same type of comment was given as for vehicle volume above. An example would be over 1,000 pedestrians per 8 hours in urban areas and over 300 pedestrians per 4 hours in rural areas.

3. Vehicle Speed - It should be used as a factor to vary the vehicular and pedestrian volume levels.

4. Nearest Alternative "Safe" Crossing - This could be based on maximum walking distance of school children established by the local school board.

5. Pedestrian Barrier - This was considered necessary to prevent at-grade crossings.

6. Roadway Geometry - Wide roadways could be a warrant because the timing of an alternative traffic signal must be increased for the pedestrian walk phase while the main street green time decreased. Intersection capacity is usually reduced when main street time is decreased. Also, this could be considered a warrant for complex intersections. One advisor warned that wide roadways require longer GSPCs to span the roadway which increase construction costs.

7. Topography of the proposed site should be such that elevation changes are minimal to users to GSPCs and construction cost is not excessive.

Correctable accidents, sight distance, surrounding land use, and economic justification were not mentioned as necessary to warrant a GSPC. The major criteria if a GSPC is to be built is available funding. Another important consideration suggested was the topography of the proposed site. The topography should lend itself to easy access to the GSPC with minimal elevation changes. An example of favorable topography would be a GSPC over a depressed

freeway. The construction cost would be less at such sites. Assigned points ranking warrants were mentioned as planning tools to identify suitable sites. Threshold warrants were indicated as useful in justifying installation of GSPCs to the public.

7.4 Proposed Warrants for Pedestrian Over and Underpasses

The validation results of each of the four methods from sections 5.2, 7.1, 7.2 and 7.3 in this report were summarized in Table 21. The results were in general agreement except for roadway width or number of lanes. A wide roadway was a valid warrant according to the result of the validation of site characteristics data and the panel of advisors but not according to comparisons of warrants to characteristics of sample GSPC sites. Land use could be a conditional warrant if a GSPC connects the site of a major employer(s) to a parking lot and if the employer enforces its use. Artificial lighting and a pedestrian barrier should be required. The vehicle and pedestrian volumes should be varied with the vehicle speed and urban versus rural sites.

Based on results of these validations, the following were the proposed candidate warrants for over and underpasses or grade seperated pedestrian crossings (GSPCs):

1. The concept of a 4 hour pedestrian volume was preferred by the panel of advisors since it is easier to collect than 8 hours of data and only major urban centers generate 8 hours of heavy pedestrian volume. The total of 300 pedestrians in 4 hours from San Diego's (#1) warrant was too high for many potential sites. The total of 300 pedestrians in 4 hours was reduced to 100 for roadways with vehicle speed under 45 mph, in nonurban areas, and over/under freeway sites.

2. For vehicle volume, two units of volume were chosen. From validation of San Diego's (#2) warrant, "ADT over 35,000" was a good indicator of successful GSPCs by comparing this candidate warrant to GSPC site characteristics. ADT data are usually readily available to transportation agencies. Four hour vehicle volume was selected as it directly corresponds to the duration of pedestrian volume data. Volume units of 4 and 8 hours were favored over ADT values by the panel of advisors. The 3,000 vehicle volume in 4 hours from San Diego's (#1) warrant was increased to 10,000. The value of 3,000 was too low as it was satisfied by almost every sample validation GSPC site, including successful, moderate, and unsuccessful sites.

TABLE 21: SUMMARY OF VALIDATION RESULTS FOR CANDIDATE WARRANTS

WARRANT	COMPARING WARRANTS TO GSPC SITES	BEHAVIORAL STUDY	VALIDATION OF SITE DATA	COMMENTS FROM PANEL OF ADVISORS
Vehicle Volume:	ADT over 35,000	Heavy traffic	Relative to other factors	1,000 vph (reduce as below*) Over 20,000 in 8 hrs (urban)
Pedestrian Volume:	Over 300 in 4 hrs	Not studied	Relative to other factors	Over 1,000 in 8 hrs (urban) Over 300 in 4 hrs (rural)
Nearest "Safe" Crossing:	750 ft or more	Not studied	Not analyzed	Max walking distance of school children
Vehicle Speed:	Over 40 mph	Not significant	Over 35 mph	*Reduce volumes if over 40 mph by 50%
Land Use Development:	Not valid	No Jr/Sr high school present	Sites with a major employer where the GSPC connects to the parking lot and sites over freeways	Not significant
Physical Barrier to Prohibit At-grade Crossing:	Required	Not studied	Not analyzed	Required
No. of Lanes:	Not valid	Not studied	Wide roadway and shorter to cross using the GSPC.	Wide roadway
Others:	None	If major employer, enforces utilization of GSPC	Artificial lighting is required	*Available funding source *Topography where there is minimal change of elevation for pedestrians

As suggested by the panel of advisors, both ADT and 4 hour vehicle volumes were reduced for roadways with lower speeds and in nonurban areas.

3. The value of 750 feet or more to the nearest alternative "safe" crossing was considered too far as only 50 percent of the successful validation GSPC sites met this candidate warrant. The value of 600 feet was the lowest value from the existing threshold warrants for GSPCs. Refer to Table 3 under Wisconsin DOT for the source of the 600 feet value.

4. Physical pedestrian barriers are recommended to ensure proper use of GSPCs at highway (nonfreeway) sites. High-speed freeways have fences at the edge of their right-of-way.

5. The presence of artificial lighting at successful and moderately successful GSPC sites emerged as a pattern during validation of site characteristics data.

6. Topography of the proposed GSPC site can affect the convenience to user and cost of contruction. The behavioral study in section 5.0 of this report reaffirmed the common sense conclusion that a GSPC must be convenient to use. Convenience means easier, faster, and more direct route for the users without walking up and down grades.

7. Special needs of adjoining land use(s) has been the most common reason to build GSPCs. These needs were addressed in the system-type warrants discussed in section 3.3 of this report. Typical land uses having access via a GSPC would be elementary schools, parks, recreation centers, and major employment centers. Usually these land uses connect to parking lots or another part of a facility. The important criteria in the proposed warrant is "directness". The GSPC must be located where a pedestrian wants to cross in order to be convenient.

8. Without funding sources, a GSPC cannot be built. This is why GSPCs over or under freeways were built more often than over or under highways.

The candidate exposure index and assigned points ranking warrants were analyzed in section 7.1 of this report. The validation results for these candidate ranking warrants were similar. These warrants ranked the sample validation GSPC sites from 4.0 to 4.5 places off from the ranking according to the ratio of users to total pedestrians. The best set of ranking warrants was Seattle's. It is recommended as suggested by the panel of advisors to use Seattle's priority ranking warrants to prioritize potential GSPC sites for planning purposes. The proposed threshold warrants should be used to determine if a proposed overpass or underpass should be built. Seattle's