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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, criteria were developed and validated which determine whether a GSPC would be effectively utilized. Based on these criteria, warrants were developed and validated.

The research was divided into four parts. The first part was a state-of-the-art review consisting of two subparts: a literature review and an assessment of current practices. The literature review, section 3.0, involved an examination of available sources of information on potential criteria and warrants for GSPCs. A warrant is considered more quantitative and specific than a criteria which is qualitative and less specific. The useful literature was grouped by level of applicability to GSPC warrants and listed in the bibliography in Appendix A. The potential criteria for GSPCs were summarized. The different types of warrants were identified as threshold, priority ranking (i.e., assigned points or exposure indexes), economic, system, policy, and political.

The assessment of the current practices, section 4.0, evaluated the state-of-the-practice through an analysis of literature and discussions with research, state, and local transportation professionals representing different regions of the United States. Each type of warrant was discussed along with a list of existing warrants. A panel of advisors, consisting of five (5) transportation professionals from different cities, was asked to comment on the existing warrants for GSPCs. The ease of application (i.e., complexity, data requirements, etc.) and appropriateness (i.e., reasonable pedestrian or vehicular volume levels) for these warrants were assessed from their comments. The assessment was used as a validation tool in the fourth part, section 7.0, where the comments of the panel of advisors were summarized.

In the second part, behavioral perceptions of risks and convenience were collected and analyzed for emerging patterns in section 5.0. These patterns were used to develop candidate warrants. Informal inquiries of pedestrians were conducted to obtain their perceptions at 37 of 40 sample GSPC sites in five cities. At the same time, site characteristics data were collected at all 40 GSPC sites including pedestrian usage/nonusage volume and spot vehicle counts.

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

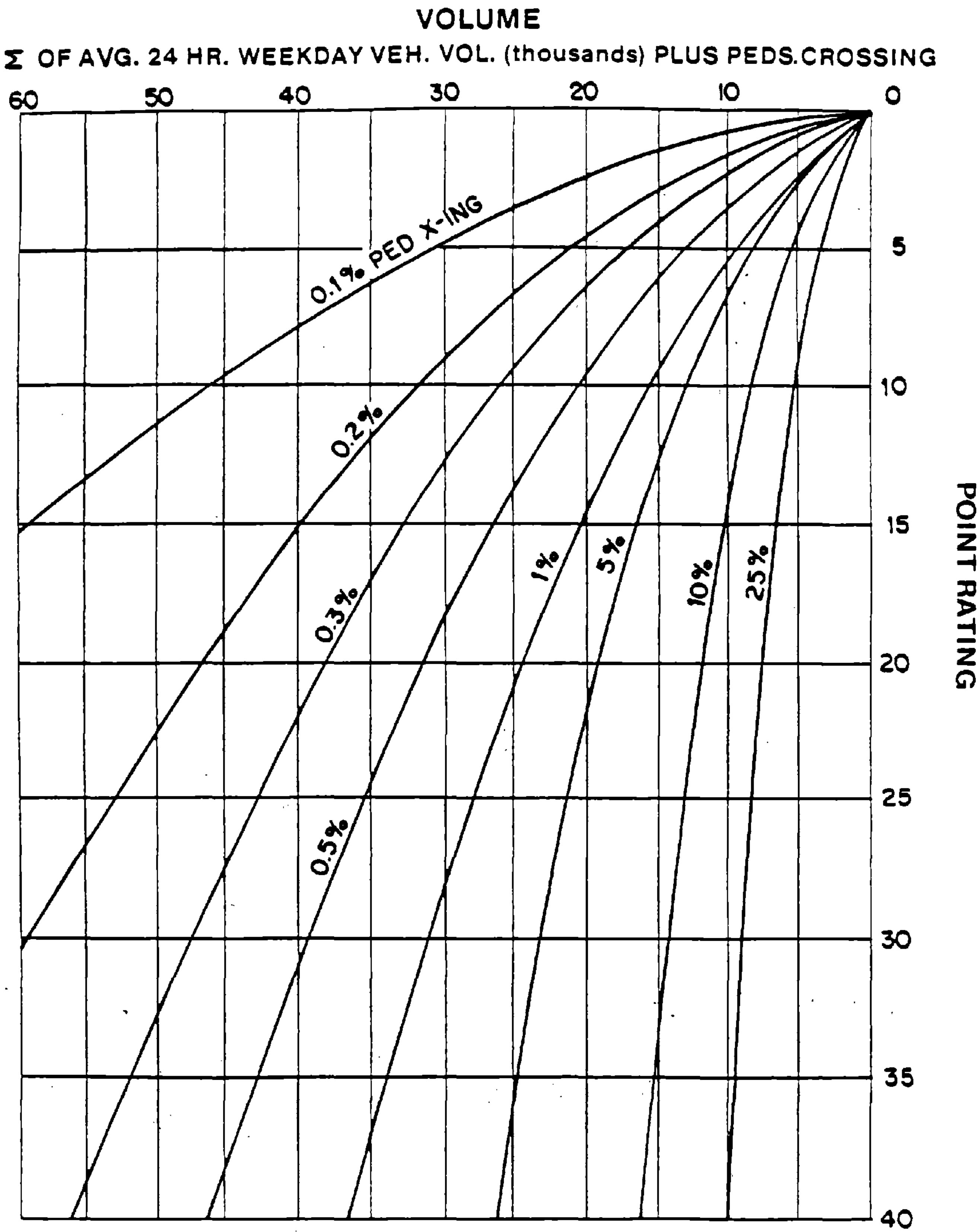

FIGURE 1

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.

TABLE 6: OVERPASS AND UNDERPASS SITES

REGION	OVERPASS		UNDERPASS	
	SUCCESSFUL	UNSUCCESSFUL	SUCCESSFUL	UNSUCCESSFUL
Midwest	Foothills Pkwy & Emerson Ditch (Boulder) Foothills Pkwy & Sioux Dr (Boulder) Center Rd & 48th St (Omaha) W Center Rd & 108th St (Omaha) NW Radial & 56th St (Omaha) Saddle Creek Rd & 50th St (Omaha) 72nd St & Western Ave (Omaha)	W Center Rd & 87th St (Omaha)* Dodge St & Happy Hollow (Omaha)	Broadway & Univ of CO (Boulder) Broadway & Viele Ditch (Boulder) 28th St & E Aurora Ave (Boulder) 28th St & College Ave (Boulder) NW Radial & 52nd St (Omaha)	
West	N Aurora Ave & 130 St N (Seattle) Montlake Blvd NE near Pacific St (southerly) (Seattle)	Empire Way S & Rainier Ave S (Seattle) Holman Rd N & 13th Ave NW (Seattle)	E Marginal Way S & 16th Ave S (Seattle) (northerly) E Marginal Way S & 16th Ave S (southerly) (Seattle) 16th Ave S & E Marginal Way S (Seattle)	Aurora Ave N & N 79th Ave (Seattle)

* No behavioral data collected at this site.

TABLE 6: OVERPASS AND UNDERPASS SITES (Continued)

REGION	OVERPASS		UNDERPASS	
	SUCCESSFUL	UNSUCCESSFUL	SUCCESSFUL	UNSUCCESSFUL
East	Balt-Washington Pkwy & Maisel St (Baltimore) Broening Hwy & GM Plant (Baltimore)* I-170 & Carrolton Ave (Baltimore)* Northern Pkwy & Mt Pleasant Golf Course (Baltimore) George Washington Pkwy southernmost to Key Bridge (Glen Echo, MD) Balt-Washington Pkwy near Greenbelt Rd (Greenbelt, MD) Rt 50 & Jackson St (Arlington, VA) Rt 395 at Shirlington Cir (Arlington, VA) Rt 495 at Wakefield Park (Fairfax Co, VA) Rt 495 north of Rt 66 (Fairfax Co, VA)	Northern Pkwy near Clearspring Ave (Baltimore) Rt 395 EB Ramp & Kenmore Ave (Alexandria, VA)	Centerway Dr near Thomas Farm Rd (Gaithersburg, MD) Rt 50 west of Glebe Rd (Arlington, VA) Rt 395 & 24th St (Dolly Madison Apts) (Arlington, VA)	Shady Grove Rd & Mill Run Rd (Gaithersburg, MD) Stedwick Rd near Mont Village Mall (Gaithersburg, MD) Watkins Mill Rd near Watkins Mill Elem School (Gaithersburg, MD)

* No behavioral data collected at this site.

The term "user" (or "nonuser") in this report is defined as a pedestrian who uses (does not use) a GSPC more frequently than crossing the roadway at-grade (or using a GSPC). Fifty five (55) nonuser inquiries and 207 user inquiries were obtained. This reflected the small number of nonusers counted in the 8 hour pedestrian count at all GSPC sites. The total pedestrians counted were 15,203 users and 1,792 nonusers (11%).

5.1 Emerging Patterns

The behavioral studies were conducted to gather data including demographic, trip generation, crossing frequency, and pedestrians' perceptions of risks and inconvenience. The database of 262 informal inquiries was split into two subsets: user and nonuser inquiries. Each variable of the inquiries was grouped into like categories (i.e., origins/destinations, such as home and work; and age range groupings). Refer to Table 7 for a list of the categories and the ranges of frequency responses to the informal inquiries. Contingency table analyses were performed for each category of each variable. For each, a table compared each subset of users and nonusers against the range of responses for each category. A chi-square hypothesis test was performed to determine the degree of the dependency of the user/nonuser subset against each category. The dependency was expressed as the probability that emerging patterns were statistically significant by the value of the chi-square distribution. The range of chi-square values was established as the degree of dependency as follows:

- None at 0.0 to 1.4
- Slight at 1.5 to 5.0
- Regular at 5.1 to 10.0
- High at over 10.0

In most cases, the emerging patterns from the analyses above confirmed the expected results--that if it is safe to cross at-grade on the roadway, pedestrians will do so. The breakdown of these patterns for users and nonusers is outlined in Table 8 for each category. The patterns are described as follows:

1. Age - The 13-18 year old age group tend to be nonusers.

2. Sex - No patterns.

TABLE 7:
RANGES OF BEHAVIORAL CATEGORIES

CATEGORY	RANGE
General:	
° City -	5 Cities
° GSPC Site -	37 Sites (22 Over/15 Underpasses)
° User/Nonuser -	207 Users/55 Nonusers
Demographic:	
1. Observed Age -	8%(1-12), 18%(13-18), 35%(19-29), 33%(30-59) & 6%(Over 59 yrs old)
2. Sex -	59% Males/41% Females
Trip Generation:	
3. Origin/Destination -	45% Home, 1% Work, 22% School, 14% Car, 5% Bus, 4% Shopping, 3% Social, & 6% Recreational
4. Distance from Home -	45%(1-3 blocks), 43%(4 bl to 1 mi), & 12%(1-8 miles)
Crossing Frequency:	
5. Crossing on GSPC or At-grade -	60% Daily, 32% Weekly, & 8% Less
6. Using GSPC -	8% Never, 52% Daily, 30% Weekly, & 10% Less
7. Crossing At-grade* -	49% Never, 16% Daily, 23% Weekly, & 12% Less
Pedestrians' Perceptions:	
8. Reason(s) for Using GSPC -	(1) Traffic: Unspecified, light/heavy volume, Low/High speed, & adequate/no acceptable gaps (2) Safety: Unspecified, fear of crime, & not dangerous
9. Reason(s) for Not Using GSPC -	Same (1) Traffic & (2) Safety reasons as for "Using GSPC"
10. Danger(s) for Not Using GSPC -	Same (1) Traffic reasons as for "Using GSPC"
11. Convenience of Using GSPC -	Same (2) Safety reasons as for "Using GSPC"
12. Inconvenience of Using GSPC -	Same (2) Safety reasons as for "Using GSPC"
13. Additional Comments by Pedestrians -	Positive: Safety, convenience, good design of GSPC, good lighting, & good line-of-sight (no hiding places for undesirable characters) Negative: GSPC not needed (safe to cross road), crime threat (poor lighting or line-of-sight), poor maintenance (graffiti or debris), pedestrian-bicycle conflicts, & poor design of GSPC

*At-grade refers to crossing the roadway at street level and applies to nonusers.

TABLE 8: PATTERNS OF BEHAVIOR*

CATEGORY	PATTERNS: USER	PATTERNS: NONUSER
Sample Size:	207	55
Demographic:		
1. Observed Age -	No patterns	13-18 year old age group
2. Sex -	No patterns	No patterns
Trip Generation:		
3. Origin/Destination -	Work trips (slight)	Shopping trip (slight)
4. Distance from Home -	No patterns	Over 1 mile
Crossing Frequency:		
5. Crossing on GSPC or At-grade -	No patterns	Weekly or less (slight)
6. Using GSPC -	Twice & once daily (high)	Weekly or less
7. Crossing At-grade -	No patterns	Twice daily to weekly (high to slight)
Pedestrians' Perceptions:		
8. Reason(s) for Using GSPC -	Heavy traffic (slight)	Convenience
9. Reason(s) for <u>Not</u> Using GSPC -	Better for joggers & bicyclists and safe to cross at-grade (slight)	No patterns
10. Danger(s) of <u>Not</u> Using GSPC -	No patterns	Safe to cross at-grade
11. Convenience of Using GSPC -	No patterns	Heavy traffic
12. Inconvenience of Using GSPC -	Lack of traffic (slight)	No patterns
13. Additional Comments by Pedestrians -	No patterns	Poor design

* Qualitative ranges of the probability that the patterns were statistically significant:
- Slight: 1.5 to 5.0 elemental chi-square value
- Regular: 5.1 to 10.0 elemental chi-square value
- High: Over 10.0 elemental chi-square value

If indication is not given for a pattern, regular probability applies.

3. Origin/destination - There were slight patterns of users going or coming from work and patterns of nonusers to and from shopping trips.

4. Distance from home - The distance of over 1 mile emerged due to the impact of bicyclists and joggers on the nonuser subset.

5. Frequency crossing on GSPC or at-grade* - There was no statistical significance between the frequency of user or nonusers crossing on a daily basis. The less frequent or occasional pedestrians who cross at-grade did make an impact.

6. Frequency using GSPC - Users would utilize a GSPC regularly and nonusers less frequently. This confirms that the subjects were grouped properly into user and nonuser subsets.

7. Frequency crossing at-grade - Likewise, nonusers would cross at-grade regularly. The more frequently a nonuser crosses a roadway, the greater the tendency to use a GSPC rather than to cross at-grade.

8. Reason(s) for using GSPC - As expected, nonusers value their convenience, and heavy traffic does influence use of GSPC.

9. Reason(s) for not using GSPC - The trend of thought for users is if it is safe to cross at-grade, they will not use the GSPC. Joggers and bicylists again favor nonuse when possible and safe.

10. Danger(s) of not using GSPC - Nonusers tend to feel there is no real danger when crossing at-grade.

11. Convenience of using GSPC - No clear reason from users, but nonusers tend to feel it is safer to use a GSPC if there is heavy traffic.

12. Inconvenience of using GSPC - Similar as above, nonusers will not use GSPC if there is light traffic.

13. Additional comments by pedestrians - Only the comment of "poor design" by nonusers emerged as a pattern.

The overall result of the analysis of behavioral patterns was to confirm that pedestrians will use a GSPC if there is heavy traffic. Otherwise, there is a tendency to not use a GSPC especially for pedestrians crossing less frequently at a site and for joggers and bicyclists. The fact that only 11 percent of the total pedestrians counted were nonusers is a tribute to good design of the sample GSPC sites.

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*At-grade refers to crossing the roadway at street level and applies to nonusers.

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 warrants are used to predict if a potential GSPC will be well-utilitized. As discussed in Section 2.1 of this report, criteria differ from warrants in that criteria tend to be qualitative and less specific rather than quantitative. An example of a criterion is that the presence of an alternative "safe" crossing of a roadway near a GSPC would tend to diminish its usage. An example of a corresponding warrant would be "safe" alternatives within 400 feet of a proposed GSPC would reduce its usage. The development of criteria and warrants are interdependent activities since the same process that might identify nearby alternative "safe" crossings as a criterion might also indicate 400 feet as the limit of influence. In this report, the term criteria/warrant development will be used to refer to the combined criteria and warrant development activity.

As discussed in section 3.1 of this report, only over and underpasses across highways and freeways are dealt with in this report. Generally the difference between freeway and highway crossings is that the option for pedestrians to cross a freeway at-grade is not available and pedestrians have to use a GSPC.

Two general sources were used to generate potential criteria and warrants. One source was existing warrants for GSPCs as discussed in section 4.1 of this report and for related pedestrian treatments such as traffic signals, adult crossing guards, and midblock crosswalks listed in Appendix C. The other source was analysis of emerging patterns from site characteristics data collected at sample GSPC sites. The data consists of behavioral patterns discussed in section 5.0 and site characteristics (including pedestrian volume and spot vehicle counts).

Site characteristics data include the surrounding environment, GSPC design features, roadway features (being crossed by the GSPC), alternative "safe" crossing, vehicle volume on roadway and pedestrian volume. Refer to Table 25 in Appendix D for a list of site characteristics and the range of values collected at the 40 GSPC sites. Actual pedestrian volume and spot vehicle counts corresponding to the same hours of the pedestrian counts were collected as part of the site characteristics data. The vehicles conflicting with pedestrian crossing at-grade movements were counted in the spot vehicle count. Figures 3 and 4 in Appendix F show the vehicle/pedestrian volume and site characteristics data collection forms.

Site data were collected at forty (40) GSPC sites, listed in Table 6, in 5 cities from different geographical regions of the continental United States. The cities selected have or still build GSPCs. The cities and the type of warrants utilized in each city are as follows:

- Baltimore, MD - System Warrant
- Boulder, CO - System Warrant
- Omaha, NE - Priority Ranking Warrant (Exposure Index)
- Seattle, WA - Priority Ranking Warrant (Assigned Points)
- Washington, DC - System Warrant

Refer to section 3.3 of this report for discussion of different types of warrants.

The pedestrian user and nonuser counts were employed as indicators of the degree of "success" or utilization of a GSPC. A primary definition was developed to measure "success" with two additional definitions to employ if one or more GSPC sites have equal values of the primary measure:

- Primary Measure

  Ratio of users to the total pedestrians (both users and nonusers) (utilizing 8 hour values)

- Additional Measures

  1. Total number of users in the highest 8 hours of pedestrian activity
  2. Total number of nonusers in the highest 8 hours of pedestrian activity

If two or more GSPC sites have the same ratio of users to total pedestrians, the site with the larger number of users was considered more successful. If two or more GSPC sites have the same number of users and ratio, the one with the smaller number of nonusers was considered more successful.

The sample GSPC sites were broken down by region (i.e., east, midwest, and west) and by over or underpass. Each site was ranked by the proportion of users to total pedestrians. A 1.00 ratio means no nonusers were counted when pedestrian volume was collected. In this report, the terms "successful", "moderate", and "unsuccessful" were used to differentiate the degree of success and were based on the following:

Degree of Success	Ratio of Users to Total Pedestrians	No. of GSPC Sites
Successful	0.95 to 1.00	20
Moderate	0.55 to 0.94	13
Unsuccessful	0.01 to 0.54	7

The range of the frequency distribution for values of the ratio of users to total pedestrians was examined. The cutoff points of 0.54 and 0.94 were established since there were no ratios between 0.55 and 0.63 and between 0.95 to 0.96. Refer to Table 26 in Appendix D for the corresponding value of each measure for all GSPC sites.

The 40 GSPC sites were randomly stratified into two sets of 20 sites. They were stratified by balancing the number of overpasses, underpasses, and the ratio of users to total pedestrians for each set. One set was used to develop criteria/warrants, while the other was used to validate warrants. Where there were similar types of sites with very close ratios of users to total pedestrians, the similar GSPC sites would be randomly selected for each set. The 25 overpasses and 15 underpasses sites were stratified into two sets of 13 overpasses and 7 underpasses and 12 overpasses and 8 underpasses. The sites were stratified based on the ratio of users to total pedestrians such that the distribution between each set was 10 vs. 10 successful sites, 7 vs. 6 moderate sites, and 3 vs. 4 unsuccessful sites. The former numbers of GSPC sites were used for the development of criteria/warrants in this s/ction, while the latter were used for validation of warrants in section 7.0 of this report. Refer to Table 27 in Appendix D for a list of the randomly stratified GSPC sites.

6.1 Potential Criteria/Warrants from Existing Warrants

In addition to existing warrants for GSPCs, other warrants were reviewed for other pedestrian treatments including traffic signals based on pedestrian demands, school crossing guards (adult and safety patrol), and midblock crosswalks. Sample existing warrants for other pedestrian treatments are described in Appendix C. These were established warrants for cities, counties, and states which indicates when an installation of a traffic signal, crossing guard, or crosswalk is most effective. Usually these warrants were developed to protect children walking to and from school. An example would be Denver, CO* which established warrants for stop signs and traffic signals based on ADT and the number of lanes. The related warrants adopted in the MUTCD are also included in Appendix C.

Criteria/warrants were synthesized from those which are common among the existing warrants for GSPC listed in Tables 2, 3, 4, and 5, and potential criteria identified in Table 1. Table 9 lists the synthesized criteria/warrants along with their sources. The criteria were broken down by specific factors common to existing warrants such as pedestrian volume, ADT, and distance to the nearest alternative "safe" crossing. Some of these criteria/warrants were further examined as part of site characteristics analysis in section 6.2 of this report.

The synthesized criteria/warrants were analyzed by comparing what percentage of the sample GSPC sites had similar site characteristics to those specified by each synthesized criteria/warrant. For example, among the successful GSPC sites, there should be a high percentage of sites satisfying a strong warrant/criteria; while among the unsuccessful sites, there should be a low percentage. The results are shown in Table 10. Only the pedestrian volume warrant of over 100 pedestrians in 4 hours had the appropriate distribution of percentages: 85 percent for successful, 38 percent for moderate, and 14 percent for unsuccessful GSPC sites. The distribution of percentages for the pedestrian volume warrant of over 300 pedestrians in 4 hours was less than 36 percent for each degree of success. Some of these synthesized criteria/warrants are part of established warrants used as candidate warrants in part four of this report, section 7.0, even though this analysis shows them individually as weak indicators of well-utilized GSPCs.

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*Warrants printed in reference A-2/#24 of Bibliography A-2.

TABLE 9:
SYNTHESIZED CRITERIA/WARRANTS

<u>Highway Applications</u>

• Barrier to Prevent At-grade Crossing	(San Diego (SD) & AASHTO)
• Distance to Alternative "Safe" Crossing:	
-greater than 400 ft	(SD-safety patrol)
-greater than 600 ft	(Wisc. & Caltrans)
-greater than 660 ft	(Ohio)
-greater than 700 ft	(Toronto-crosswalk)
-greater than 750 ft	(SD)
-greater than 2,640 ft	(Wash State)
• Marked Crosswalk	(Seattle and NJ)
• Elementary School Nearby	(Seattle)
• Pedestrian Volume (1 hr total):	
-greater than 110	(Proposed MUTCD-ped signal)
• Pedestrian Volume (2 hr total):	
-greater than 90	(Proposed MUTCD-ped signal)
• Pedestrian Volume (4 hr total):	
-greater than 300	(SD)
-greater than 100	(Wash State)
-greater than 60	(Proposed MUTCD-ped signal)
• Pedestrian Delay:	
-greater than 60 sec ped delay & 5 preventable accidents in 3 consecutive yrs	(Canada)
• ADT-given the no. of lanes and raised median:	
-ADT > 14,400 if lanes = 2 & no median	(Denver-ped signal)
-ADT > 8,000 if lanes = 3 & no median	(Denver-ped signal)
-ADT > 5,250 if lanes ≥ 5 & no median	(Denver-ped signal)
-ADT > 20,800 if lanes = 4 & raised median	(Denver-ped signal)
-ADT > 11,000 if lanes ≥ 5 & raised	(Denver-ped signal)
-ADT > 35,000	(Omaha)
• Vehicle volume (1 hr total)*:	
-greater than 1,440 if lanes = 1 or 2 & no median	(Denver-ped signal)
-greater than 800 if lanes = 3 & no median	(Denver-ped signal)
-greater than 525 if lanes ≥ 5 & no median	(Denver-ped signal)
-greater than 1,100 if lanes ≥ 5 & raised median	(Denver-ped signal)
• Vehicle Volume (2 hr total):	(Caltrans-crossing guard)

-greater than 350/hr for 2 hrs if urban and pedestrian volume > 40/hr
-greater than 300/hr for 2 hrs if rural and pedestrian volume > 30/hr

*Developed for Denver, CO to derive ADT values (see reference A-2/#24)

TABLE 9:
SYNTHESIZED CRITERIA/WARRANTS (Continued)

Highway Applications (Continued)

• Vehicle Volume (4 hr total): -greater than 3,000	(SD)
• Vehicle Volume-for any 8 hrs & speed<40 mph: -greater than 600 & pedestrian volume > 150 if no median -greater than 1,000 & pedestrian volume > 150 if raised median or for any highest 8 hrs & speed > 40 mph: -greater than 600 & pedestrian volume > 105 if no median -greater than 1,000 & pedestrian volume > 105 if raised median	(MUTCD-ped signal)
• Vehicle Volume (8 hr total): -greater than 300/hr and ped volume > 75 for any 8 hrs	(Illinois-crosswalks)
• Inadequate Sight Distance	(Mass & Ohio)
• Land Use Development	(Mass & Omaha & SD)
• Median (at least 4 ft): -raised -at-grade	 (Mass) (Mass)
• R = (time to cross using GSPC)/(time to cross at-grade) R < 0.75	(Reference A-1/#23)
• R = (distance using GSPC)/(distance crossing at-grade) R < 0.75	
• Number of Acceptable Gaps: -60 gaps in an hour	(Canada & MUTCD)
• Street Width: -curb to curb -no. of lanes	(Seattle)
• Land Use - Jr/Sr high school nearby	(Mass)

Freeway Applications

• Pedestrian Volume (2 hr total): -greater than 200	(Wash State)
• Distance to Nearest Alternative "Safe" Crossing: -greater than 2,640 -greater than 5,200	(Wash State)

TABLE 10:
PERCENT OF GSPC SITES SATISFYING SYNTHESIZED CRITERIA/WARRANTS

• Vehicle Volume (1 hour total):

Vehicle Volume	Refuge Median	Number of Lanes	PERCENT OF GSPC SITES* Successful	Moderate	Unsuccessful
- Over 1,440	Present	1 or 2	40%	62%	14%
- Over 1,100	None	4 or More	25%	23%	43%
- Over 1,000	Present	N/S	40%	62%	0%
- Over 1,000	None	N/S	35%	31%	57%
- Over 800	Present	3	40%	62%	0%
- Over 525	Present	4 or More	40%	62%	0%

• Vehicle Volume (4 hour total):

	Successful	Moderate	Unsuccessful
- Over 3,000	95%	92%	71%

• Average Daily Traffic (ADT):

ADT	Refuge Median	Number of Lanes	Successful	Moderate	Unsuccessful
- Over 35,000	N/S	N/S	20%	8%	0%
- Over 20,000	Present	4	40%	62%	43%
- Over 14,400	None	2	0%	0%	14%
- Over 11,000	Present	5 or More	40%	62%	43%
- Over 8,000	None	3	10%	0%	0%
- Over 5,250	None	5 or More	25%	23%	57%

• Pedestrian Volume (4 hour total):

	Successful	Moderate	Unsuccessful
- Over 300	35%	8%	0%
- Over 100	85%	38%	14%

N/S = Not Specified

* Percentage of all successful GSPC sites in the criteria/warrant development set of sample GSPCs satisfying a synthesized criteria/warrant. Likewise, all of the moderate or unsuccessful sites were compared with each criteria/warrant.

Since the validation process was applied for the entire candidate set of warrants and since other individual warrants were strong indicators, these established warrants were not discarded and were validated in section 7.0.

6.2 Potential Criteria/Warrants from Site Characteristics

Site characteristics data were collected at sample GSPC sites to compare them to potential criteria/warrants. The comparison was used as an indicator of how well a criteria/warrant predicted that a GSPC would be well-utilized.

As was performed for the behavioral patterns (in section 5.1 of this report), the data were grouped, analyzed by contingency table analysis, and tested for independence utilizing the chi-square test of each datum against each degree of "success" of GSPC (or utilization). The grouped data for each characteristic is found in Table 28 in Appendix E. The emerging patterns were indicators of under-utilized or well-utilized GSPCs and are summarized in Table 11. For the most part, the obvious patterns emerged. Characteristics associated with under-utilized GSPCs were as follows:

1. Over/under local or collector street.
2. Over/under one or two lanes of moving traffic.
3. Speed limit is under 35 mph.
4. A large refuge median is present which is over 4 feet wide.
5. An alternative "safe" crossing is less than 250 feet away from a proposed GSPC.
6. Average daily traffic (ADT) of the roadway crossed is less than 14,500.
7. Vehicle volume corresponding to the 8 highest pedestrian traffic hours is less than 10,000.
8. Vehicle volume corresponding to the 4 highest pedestrian traffic hours is less than 3,000.
9. Pedestrian volume is less than 100 in an 8 hour period.
10. Pedestrian volume is less than 30 in a 4 hour period.

TABLE 11: SUMMARY OF STATISTICAL ANALYSIS FOR DEVELOPMENT

CHARACTERISTIC	PREDICTOR		
	Successful	Moderate	Unsuccessful
• Surrounding Environment:			
1. Land Use Category -	Residential (Res)	Res/Educational Res/Commercial Industrial/Commercial	Res/Recreational
2. Land Use Density -	Heavy	Light & Medium	____
3. Policy of Nearby School on Use of GSPC -	.... No Pattern Emerged		
• GSPC Design Features:			
4. Artificial Lighting -	.... No Pattern Emerged		
5. Pedestrian Barrier*-	.... No Pattern Emerged		
6. Access/Approach to GSPC -	At-grade	Ramp & Steps	____
7. Distance to Travel Using GSPC (ft) -	Over 400	1 to 400	____
8. Distance to Travel At-grade (ft) -	Over 200	1 to 200	____
9. Ratio of Distance Using GSPC to Crossing At-grade -	Freeway Site **	0.01 to 1.01 & Over 1.50	1.01 to 1.50
• Roadway Features (being crossed):			
10. Type of Roadway -	Freeway	Major Arterial	Local/Collector
11. Number of Lanes -	3/4	Over 4	1/2
12. Refuge Median Width (ft) -	Over 25 & Freeway Site	1 to 3 & Over 10	4 to 10
13. Speed Limit (mph) -	45/55	35/40	25/30
14. Truck Route -	.... No Pattern Emerged		

* Physical barrier forcing pedestrians to use a GSPC

** Freeways sites were considered separately since no at-grade crossing is reasonably possible

TABLE 11: SUMMARY OF STATISTICAL ANALYSIS FOR DEVELOPMENT (Continued)

CHARACTERISTIC	PREDICTOR		
	Successful	Moderate	Unsuccessful
• Alternative "Safe" Crossing:			
15. Distance from GSPC (ft) -	Over 700	251 to 750 & 0 (Immediately next to)	1 to 250
16. Type of Alternative -	.... No Pattern Emerged		
17. Type of Signal Hardware (if traffic signal) -	____	Heads/Push-buttons	Pedestrian Heads
18. Type of Pavement Markings (if traffic signal) -	.... No Pattern Emerged		
• Vehicle Volume on Roadway:			
19. Average Daily Traffic -	Over 35,000	14,401 to 35,000	1 to 14,400
20. Corresponding*** 8 highest hrs -	Over 20,000	10,001 to 20,000	1 to 10,000
21. Corresponding*** 4 highest hrs -	Over 20,000	3,001 to 20,000	1 to 3,000
22. Corresponding*** highest hr -	Over 3,000	1 to 3,000	____
• Pedestrian Volume:			
23. User Volume (8 highest hrs) -	Over 1,000	101 to 1,000	0 to 100
24. User Volume (4 highest hrs) -	Over 300	31 to 300	0 to 30
25. User Volume (highest hr) -	Over 10	____	0 to 10

*** Vehicle traffic which conflicts with at-grade crossings at each site and corresponds to the same hour of the day as the occurrence of the highest pedestrian volume

Characteristics associated with well-utilized GSPCs were as follows:

1. Heavy density development.

2. A pedestrian barrier is essential to encourage use of GSPC and enhances safety especially across highways. Pedestrians who really want to cross at-grade can be very resourceful as indicated by the lack of patterns in Table 11.

3. Distance to cross at-grade is over 200 feet.

4. Distance on a proposed GSPC would be over 400 feet.

5. At-grade access/approach to a GSPC instead of a ramp or steps is proposed for a GSPC.

6. A proposed GSPC crossing a freeway where at-grade crossings are not reasonably possible would be better utilized than across a highway.

7. If not crossing a freeway, a 3 or 4 lane highway.

8. Speed limit is over 40 mph.

9. Nearest alternative "safe" crossing is over 750 feet.

10. Average daily traffic is over 35,000.

11. Vehicle volume corresponding to the 8 highest pedestrian traffic hours is over 20,000.

12. Vehicle volume corresponding to the 4 highest pedestrian traffic hours is over 20,000.

13. Vehicle volume corresponding to the highest pedestrian traffic hour is over 3,000.

14. Pedestrian volume is over 1,000 in 8 hours.

15. Pedestrian volume is over 300 in 4 hours.

16. Pedestrian volume is over 10 in 1 hour.

For the land use categories, there was a strong statistical significance that adjoining residential land use was associated with successful GSPC sites. There were weak indications that the other categories of land uses were associated with moderate or unsuccessful sites. To better understand the relationship between adjoining land use and the degree of "success" of GSPCs, another type of analysis was performed. Each category of land use was compared with the land uses near sample GSPC sites. The percentages of all successful sites, as well as all moderate and unsuccessful sites near each category of land use were determined. The analysis results are shown in Table 12 in a similar manner as in Table 10. All land uses were weak indicators in that the distribution of percentages was generally balanced between successful, moderate and unsuccessful GSPC sites rather than high for successful, lower for moderate, and near zero for unsuccessful sites. These overall results confirm those in Table 11 for land use categories, site characteristic number 1. Therefore, land use was not considered as a criterion.

6.3 Candidate Warrants

Twelve candidate warrants were derived or considered from existing GSPC warrants. Four threshold warrants were derived from the analysis of site characteristics data while three existing warrants were considered from San Diego, CA and the proposed MUTCD pedestrian warrant for traffic signals. Existing priority ranking warrants were also considered in the form of exposure indexes from Victoria, Australia and Omaha, NE, and in the form of assigned points warrants from Seattle, WA; Massachusetts; and New Jersey. Refer to Tables 13, 14, and 15 for a description of these warrants.

For the derived candidate warrants in Table 13, threshold values for the vehicle volume, pedestrian volume, distance to nearest "safe" crossing, vehicle speed, and number of lanes were developed from Table 11. Some of the individual derived threshold warrants were developed based on values from existing threshold warrants. The pedestrian volume threshold from San Diego (#1) and the Derived Candidate (4 hour) is a total of over 300 pedestrians in 4 hours for both. The ADT threshold of over 35,000 vehicles was similar for the San Diego (#2) warrants and Derived Candidate (ADT). In addition, all but the proposed MUTCD signal warrants were derived or established (i.e., San Diego) for GSPCs. The proposed MUTCD warrants by Zegeer were developed for traffic signals based on pedestrian demand. The current MUTCD warrants require a pedestrian volume of at least 150 pedestrians per hour on the highest volume crosswalk crossing the major street for each of any 8 hours. The proposed warrant reduced the currently high volume requirement to a reasonable value of 60 pedestrians for each of any 4 hours. Refer to Table 23 in Appendix C for Zegeer's proposed warrant.

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 uiversity)	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%

TABLE 13: CANDIDATE THRESHOLD WARRANTS

WARRANT	SOURCE: Derived Candidate (ADT)	Derived Candidate (8 hour)	Derived Candidate (4 hour)	Derived Candidate (1 hour)	San Diego CA (#1)	San Diego CA (#2)	Proposed MUTCD for Traf Signal
Vehicle Volume:	ADT over 35,000	Over 20,000 in 8 hrs	Over 20,000 in 4 hrs	Over 3,000 in 1 hr	Over 3,000 in 4 hrs	ADT over 35,000	Less than 60 adequate gaps in an hr
Pedestrian Volume:	Over 1,000 in 8 hrs	Over 1,000 in 8 hrs	Over 300 in 4 hrs	Over 10 in an hr	Over 300 in 4 hrs	Over 100 in 4 hrs	Over 110 in an hr or*
Nearest "Safe" Crossing:	750 ft	750 ft	750 ft	750 ft	750 ft	Traffic Signal	Not Specified
Vehicle Speed:	Over 40 mph	Over 40 mph	Over 40 mph	Over 40 mph	Over 30 mph	Not Specified	Not Specified
Land Use Development:	High Density	High Density	High Density	High Density	Substantial	Not Specified	Not Specified
Physical Barrier to Prohibit At-grade Crossing:	Yes (& no refuge median)	Yes (& no refuge median)	Yes (& no refuge median)	Yes (& no refuge median)	Yes (& no refuge median)	Yes (& no refuge median)	Not Specified
No. of Lanes:	Over 2	Over 2	Over 2	Over 2	Not Specified	Over 70 ft	Not Specified

*Over 90 ped in each of any 2 hrs or 60 ped in each of any 4 hrs

TABLE 14: CANDIDATE (PRIORITY RANKING) EXPOSURE INDEXES

WARRANT	SOURCE		
	Victoria, Australia		Omaha, NE
Vehicle Volume (V):	Over 750 in an hr	Over 1,000 in a hr	(ADT/10,000)
Pedestrian Volume (P):	Children	Children	Children in the morning
Vehicle Speed (S):	Not Specified	Not Specified	(Speed/30 mph)
Roadway:	If 2-Way & undivided	If 2-Way & divided	No. of lanes: K = 1 if 2 K = 2 if 3 or 4 K = 3 if 5 or more
Minimum Value:	V x P >100,000	V x P >280,000	None
Index:	V x P	V x P	V x P x S x K

TABLE 15: CANDIDATE ASSIGNED POINTS (PRIORITY RANKING) WARRANTS

WARRANT	SOURCE: Seattle, WA	Mass DPW	NJ DOT
Total Points:	Up to 100	Up to 100	Up to 200
Vehicle/Pedestrian Volume:	Up to 40 pts (See Figure 1)	Up to 40 pts (See Figure 1)	Up to 80 pts
Accidents:	Up to 15 pts (5 pts per correctable ped accident)	Up to 15 pts (5 pts per correctable ped accident)	Not Specified
Adult Crossing Guard:	If present, 10 pts	If present, 10 pts*	School crossing protection, up to 20 pts
Crosswalk:	If present for school, 10 pts	If present for school, 10 pts*	If present for school, 10 pts
Nearby School:	If elementary, 10 pts	If elementary, 10 pts* If Jr/Sr high, only 5 pts*	Not Specified
Refuge Median:	If raised, less 4 pts If at-grade, less 2 pts	If raised, less 4 pts* If at-grade, less 2 pts*	Not Specified
Others:	-Up to 15 pts: • Sight Distance • Land Use development • 2 pts per 10 ft of roadway width (included as part of the 15 pts)	- Up to 15 pts:* • Sight distance • Land use development - 2 pts per 10 ft of roadway width* * All factors combined, up to 45 pts	- Poor sight distance, up to 50 pts - Distance to "safe" alternative crossing, up to 30 pts - Others, up to 10 pts

Both exposure indexes and assigned points systems are priority ranking warrants to select the best possible sites for proposed GSPCs. The exposure index from Victoria, Australia in Table 14 sets a minimum index value below which a proposed GSPC is not warranted. The other priority ranking warrants do not specify such minimum index value or assigned points total. The assigned point ranking warrants from Massachusetts and from New Jersey in Table 15 were developed based on Seattle's priority ranking warrant. Massachusetts' warrant is almost identical except that 5 points are assigned when a junior or senior high school is nearby a GSPC. New Jersey's warrant system quantified some of the individual warrants with graphs. Points for sight distance, distance to the nearest alternative "safe" crossing, and school crossing protections are read from graphs which eliminates engineering judgment but requires more field data. New Jersey's warrants do not consider refuge medians, correctable pedestrian-vehicle accidents, or presence of nearby schools.

7.0 VALIDATION OF CANDIDATE WARRANTS

In part four, the candidate warrants were validated to find out how well the warrants predicted if a GSPC site would be successful.

The candidate warrants were validated by four methods:

1. Study of pedestrian perceptions of risk and inconvenience (behavioral study).
2. Comparison of candidate warrants with corresponding site characterics of sample GSPC sites.
3. Contingency table/chi-square analyses for site characteristics of validation GSPC sites similar to the analysis for criteria/warrant development.
4. Evaluation of comments from the panel of advisors on usefulness and ease of application of candidate warrants.

The first validation method was discussed in section 5.2 of this report, the latter three are discussed in the following sections.

Individual proposed candidate warrants were developed from those warrants of each candidate group that was determined to be valid.

7.1 Comparison of Candidate Warrants with GSPC Sites

The candidate warrants were validated by comparing each warrant in Tables 13, 14, and 15 with the corresponding characteristic of GSPC sites. As discussed in section 6.2 of this report, a subset of half of the sites were used for warrant validation and are listed in Table 27 of Appendix D. For the threshold warrants, the percentage of all successful sites as well as moderate and unsuccessful GSPC sites satisfying each individual warrant within each set was determined. The percent for each candidate set was the lowest percent value for any individual warrant in a set. If a particular set or individual warrant was an ideal indicator that a proposed GSPC would be well-utilized, the resultant percentages would be 100 percent for successful sites, 50 percent for moderate sites, and 0 percent for unsuccessful sites. Refer to Table 16 for the percentage of GSPC sites satisfying the threshold candidate warrants.

The existing threshold warrant from San Diego, CA (#2) was closest to the ideal indicator with 50 percent for successful sites, 17 percent for moderate sites, and 0 percent for unsuccessful sites. The proposed MUTCD pedestrian warrant for traffic signals was a good indicator for successful and moderate GSPC sites with over 70% each but inconsistent for unsuccessful sites with 50 percent. The rest of the candidate sets of warrants were poor indicators. Within the strong and weak candidate sets of warrants, some individual warrants were found to be good indicators. The vehicle volume warrant of ADTs over 35,000 was good although it was also found to be in the weak Derived Candidate (ADT) warrants and the strong San Diego, CA (#2) candidate warrants. The pedestrian volume of over 300 in a 4 hour period was a good predictor but in the poor set of Derived Candidate (4 hour) and San Diego, CA (#1) warrants. Individual warrants such as the above were combined for a proposed candidate warrant in section 7.4 of this report.

Validation of the candidate exposure index and assigned points ranking warrants was performed differently than for the threshold warrants. The subset of validation GSPC sites was initially ranked as a basis of comparison against the resultant rankings when applying the priority ranking candidate warrants in Tables 14 and 15. The validation sites were ranked according to

TABLE 16: PERCENT OF GSPC SITES SATISFYING CANDIDATE THRESHOLD WARRANTS

WARRANT	CANDIDATE THRESHOLD WARRANTS																				
	Derived Candidate (ADT)			Derived Candidate (8 hr)			Derived Candidate (4 hr)			Derived Candidate (1 hr)			San Diego CA(#1)			San Diego CA(#2)			Proposed MUTCD for Traf Signal		
	Suc	Mod	Uns*	Suc	Mod	Uns	Suc	Mod	Uns	Suc	Mod	Uns	Suc	Mod	Uns	Suc	Mod	Uns	Suc	Mod	Uns
Vehicle Volume:	50	17	0	40	0	25	20	0	0	50	0	0	100	83	75	50	17	0	-	-	-
Pedestrian Volume:	10	0	0	10	0	0	40	17	0	100	100	75	40	17	0	60	50	25	70	83	50
Nearest "Safe" Crossing:	50	0	0	50	0	0	50	0	0	50	0	0	50	0	0	60	67	75	-	-	-
Vehicle Speed:	70	17	0	70	17	0	70	17	0	70	17	0	100	83	75	-	-	-	-	-	-
Land Use Development:	0	17	0	0	17	0	0	17	0	0	17	0	70	67	75	-	-	-	-	-	-
Physical Barrier to Prohibit At-grade Crossing:	70	50	0	70	50	0	70	50	0	70	50	0	70	50	0	70	50	0	-	-	-
No. of Lanes:	100	100	75	100	100	75	100	100	75	100	100	75	100	100	75	-	-	-	-	-	-
Lowest % Satisfying:	0	0	0	0	0	0	0	17	0	0	0	0	40	0	0	50	17	0	70	83	50

* Suc = Successful or 0.95 to 1.00 ratios of users to total pedestrians
Mod = Moderate or 0.55 to 0.94 ratios of users to total pedestrians
Uns = Unsuccessful or 0.01 to 0.54 ratios of users to total pedestrians
"-" = Not specified by candidate warrants

the ratio of users to total pedestrians. If the ratio was equal for two or more sites, the total number of users of the GSPC was employed to break the tie. Refer to Table 30 of Appendix F for the twenty (20) comparative ranking of these sites. When applying Victoria, Australia's exposure index, highest one hour vehicle volume was multiplied by pedestrian volume for an index value. A site must have an index value exceeding a threshold of 100,000 for divided highways or 280,000 for undivided highways to be considered a potential GSPC site. The sites were ranked from the highest index value of 2,081,000 to the lowest of 2,300. As expected, the 16th to the 20th lowest ranked sites were below the minimum index threshold value according to this index. Inconsistent with this pattern, the 10th lowest ranked site out of 20 sites by this index was also below the minimum index threshold. An explanation would be that the 10th ranked site by the Victoria's index was the 17th ranked site by ratio of users to total pedestrians. Overall, the mean variation between the ranking based on ratio of users to total pedestrians and the Victoria's exposure index was 4.5 places with a standard deviation of 3.9. Table 31 of Appendix F lists the values of vehicle and pedestrian volumes and index values for each GSPC site. Table 17 gives the resultant rankings when applying Victoria's exposure index along with the results of the four other priority ranking warrants.

Application of Omaha's exposure index was similar to Victoria's only in that vehicle volume was multiplied by pedestrian volume. Also, there were several differences. Omaha's index utilized ADT in lieu of the highest one hour vehicle volume used by Victoria's index. Additional factors for vehicle speed and number of lanes were also multiplied by these volumes in order to compute the index value. Instead of establishing a minimum threshold value for the total index value like Victoria's index, the values for vehicle ADT and speed were divided by a threshold value (i.e., 10,000 ADT and 30 mph) to compute a ratio. If the ratio is less (or more) than 1.0, the individual exposure value reduces (or increases) the total index values. According to results from the validation of threshold warrants, ADT is a better indicator than hourly vehicle volume. The mean variation between the rankings based on ratio of user to total pedestrians and based on Omaha's index was 5.2 with a standard deviation of 4.5. The simpler Victoria's exposure index with hourly vehicle volume compares slightly better than Omaha's index when based on

TABLE 17:
RESULTANT RANKING WHEN APPLYING CANDIDATE WARRENTS

	GSPC SITES RANKED BY RATIO	VICTORIA AUST	OMAHA NE	SEATTLE WA	MASS DPW	NEW JERSEY DOT
• Successful						
1	Foothills Pkwy & Sioux Dr (Boulder)	11	15	12/13/14	10/11	7
2	16th Ave S near E Marginal Way S (Seattle)*	2	7	9	9	10
3	Balt-Wash Pkwy near Greenbelt Rd (Wash Metro)	8	8	3	3	1/2/3
4	Rt 50 West of Glebe Rd (Wash Metro)*	15	13	5/6/7	5/6/7	11
5	Rt 395 & 24th St (D Madison Apts) (Wash Metro)*	9	5	5/6/7	5/6/7	5
6	Rt 495 at Wakefield Park (Wash Metro)	4	3	5/6/7	5/6/7	1/2/3
7	28th St & E Aurora Ave (Boulder)*	3	4	4	4	6
8	Broadway south of Regency Dr (Boulder)*	5	9	2	2	4
9	E Marginal Way S near 16th S (South) (Seattle)*	1	2	8	8	8
10	W Center Rd & 108th St (Omaha)	12	12	11	14/5	17
• Moderate						
11	Centerway Dr near Thomas Farm School (Wash Metro)*	19	18	20	20	19
12	Broening Hwy at GM Plant (Baltimore)	6	11	12/13/14	16	13
13	Saddle Creek Rd & 50th St (Omaha)	13	16	10	12	14
14	Holman Rd N & 13th Ave NW (Seattle)	17	17	16/17	17	16
15	Balt-Wash Pkwy & Maisel St (Baltimore)	14	1	1	1	1/2/3
16	72nd St & Western Ave (Omaha)	16	14	15	13	12
• Unsuccessful						
17	Center Rd & 48th St (Omaha)	10	10	12/13/14	10/11	15
18	Watkins Mills Rd near school (Wash Merto)*	20	20	19	19	20
19	Rt 495 EB Ramp & Kenmore Rd (Wash Metro)	18	19	18	18	18
20	Empire Way S & Rainier Ave S (Seattle)	7	6	16/17	14/15	9

* Underpass GSPC site (all others sites are overpasses).

rankings by the ratio of users to total pedestrians. Table 32 of Appendix F lists the values of vehicle ADT, pedestrian volume, speed, lane factors, and index values for each GSPC site.

The candidate assigned points type of priority ranking warrants of Seattle and Massachusetts were analyzed together since the only difference is 5 additional points assigned in the Massachusetts' warrant if a junior or senior high school is near the proposed GSPC. The points were assigned for each ranking warrant element including:

1. Vehicle/pedestrian volume (see Figure 1)
2. Correctable accidents
3. Adult crossing guard
4. Crosswalk present at site
5. Elementary school near site
6. Refuge median present (negative points)
7. Roadway width
8. Adequacy of sight distance
9. Vehicle speed
10. Nearness of alternative crossing

The overall mean variations between the rankings by ratio of users to total pedestrians and rankings based on Seattle's and Massachusetts' priority ranking warrants were 4.15 and 4.45, respectively. The standard deviations were 4.4 and 4.5, respectively. These mean variations were slightly less than those for the exposure indexes at 4.5 for Victoria's and 5.2 for Omaha's index. The additional consideration of nearby junior and senior high schools of Massachusetts' warrant only increased the mean variation by 7% while the standard deviation was almost identical. Refer to Table 33 of Appendix F for the points assigned to each warrant element and totals for each GSPC site.

New Jersey's ranking warrant was analyzed like Seattle's and Massachusetts' with points assigned for each warrant element. New Jersey's warrant included peak hour/delay factors and did not include correctable accidents. The remainder of the warrant elements was similar to Seattle's and Massachusetts' warrants. New Jersey's warrant quantified points assignments with figures and curves which standardized points determination while requiring more extensive data collection and time to apply. Seattle's and Massachusetts' priority ranking warrants used only the figure shown in Figure 1 of this report. The overall mean variation between the rankings by ratio of users to total pedestrians and rankings based on New Jersey's warrant was 4.2 with a standard deviation of 3.6. The mean variation was equal to Seattle's warrant although the standard deviation was slightly lower for New Jersey's warrant. Table 34 of Appendix F lists the points assigned to each warrant element and shows totals for New Jersey's priority ranking warrant.

None of the exposure indexes or assigned points ranking warrants had a mean (ranking) variation of less than 4.0. Table 18 summarizes the mean variation and standard deviation for each warrant by degree of success. Another type of comparison was employed to evaluate differences between rankings of sites based on the ratio of users to total pedestrians and by the candidate warrants. This comparison was used to calculate the percent of GSPC sites within 2 rankings of those based on the ratio of users to total pedestrians. For all of the candidate priority ranking warrants, under 60 percent of the sites were not within 2 rankings of those based on the ratio. The range was from 35 percent to 55 percent for all GSPC sites with the assigned points ranking warrants having the higher percentages. Seattle's assigned points warrant had the highest percent at 55 percent which also was one of the lowest mean variations. The breakdown of percent sites within 2 rankings by successful, moderate, and unsuccessful GSPC sites did not result in any trends. Table 18 includes this evaluation.

In summary, individual warrants within different threshold warrants were validated as good indicators of a successful GSPC. Only the candidate warrants from San Diego, CA (#2) were determined to be a valid set. The priority ranking warrants in the form of an exposure index or assigned points system had moderate success being on the average 4 rankings off when compared against rankings based on the ratio of users to total pedestrians. The assigned points warrants, particularly Seattle's warrant, were slightly better at indicating successful GSPCs than exposure indexes.

7.2 Modification by Site Characteristics

Candidate warrants were validated by the same procedure as used for criteria/warrants development in section 6.2 of this report. Site characteristics data were analyzed for emerging patterns by a contingency table/

TABLE 18:
VARIATION* OF RANKINGS FROM RATIO OF USERS TO TOTAL PEDESTRIANS RANKINGS

	Victoria Australia			Omaha NE			Seattle WA			Massachusetts DPW			New Jersey DOT		
	$\bar{x}$	s	W/in^2	$\bar{x}$	s	W/in^2	$\bar{x}$	s	W/in^2	$\bar{x}$	s	W/in^2	$\bar{x}$	s	W/in^2
Successful Sites:	4.9	3.6	30%	5.1	4.0	30%	4.1	4.7	60%	4.2	4.8	50%	3.9	3.0	50%
Moderate Site:	3.0	3.3	50%	5.0	4.4	33%	4.9	4.0	50%	5.3	5.2	17%	4.8	4.6	50%
Unsuccessful:	5.8	5.5	50%	5.8	6.2	50%	3.1	2.8	50%	3.9	3.5	50%	4.0	4.7	50%
All GSPC Sites:	4.5	3.9	40%	5.2	4.5	35%	4.2	4.4	55%	4.5	4.5	40%	4.2	3.6	50%

* $\bar{x}$ = Mean variation
s = Standard deviation
W/in^2 = Percent of GSPC sites within 2 rankings of those based on the ratio of users to total pedestrians

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.

TABLE 19: SUMMARY OF STATISTICAL ANALYSIS FOR VALIDATION

CHARACTERISTIC	PREDICTOR		
• Surrounding Environment:	Successful	Moderate	Unsuccessful
1. Land Use Category -	Industrial/ Commercial Residential/ Educational Residential/ Recreational	Residential	Residential/ Commercial
2. Land Use Density -	.... No Pattern Emerged		
3. Policy of Nearby School on Use of GSPC -	____	Passive & None	Active
• GSPC Design Features:			
4. Artificial Lighting -	Adequate	None	____
5. Pedestrian Barrier -	.... No Pattern Emerged		
6. Access/Approach to GSPC -	____	At-grade & Steps	Ramp
7. Distance to Travel Using GSPC (ft) -	Over 400	151 to 400	1 to 150
8. Distance to Travel At-grade (ft) -	Over 200	1 to 50 & 101 to 200	51 to 100
9. Ratio of Distance Using GSPC to Crossing At-grade -	0.01 - 0.74 & 1.51 to 2.00 & Freeway Site	0.75 to 1.00	1.01 to 1.50 & Over 2.00
• Roadway Features (being crossed):			
10. Type of Roadway -	Freeway	Major Arterial & Local/Collector	____
11. Number of Lanes -	6	3 to 5	1/2 & Over 6
12. Refuge Median Width (ft) -	11 to 25	Freeway Site & 1 to 10 & Over 25	____
13. Speed Limit (mph) -	Over 40	____	Under 45
14. Truck Route -	.... No Pattern Emerged		

TABLE 19: SUMMARY OF STATISTICAL ANALYSIS FOR VALIDATION (Continued)

CHARACTERISTIC	PREDICTOR		
	Successful	Moderate	Unsuccessful
• Alternative "Safe" Crossing:			
15. Distance from GSPC (ft) -	Over 400	1 to 251	251 to 400
16. Type of Alternative -	Road Over/ Underpass	Traffic Signal	____
17. Type of Signal Hardware, (if traffic signal) -	Ped Heads & Push-buttons	Ped Heads Only & Neither	____
18. Type of Pavement Markings (if traffic signal) -	Crosswalk	Stopline & No Markings	____
• Vehicle Volume on Roadway:			
19. Average Daily Traffic -	Over 25,000	14,401 to 25,000	1 to 14,400
20. Corresponding* 8 highest hours -	Over 15,000	10,001 to 15,000	1 to 10,000
21. Corresponding* 4 highest hours -	Over 7,500	3,001 to 7,500	1 to 3,000
22. Corresponding* highest hour -	Over 2,000	1,501 to 2,000	1 to 1,500
• Pedestrian Volume:			
23. User Volume (8 highest hrs) -	____	Over 60	0 to 60
24. User Volume (4 highest hrs) -	Over 800	0 to 800	____
25. User Volume (highest hr) -	.... No Pattern Emerged		

* Conflicting vehicular traffic to pedestrian movements if crossing at-grade and corresponding to the same hours of the day as the highest pedestrian values.

TABLE 20: DIFFERENCES BETWEEN VALIDATION AND DEVELOPMENT PREDICTORS

CHARACTERISTIC/PREDICTOR*	Validation (Table 19)			Development (Table 11)		
	Suc	Mod	Unsuc	Suc	Mod	Unsuc
• Surrounding Environment:						
1. Land Use Category						
- Residential (Res)		X		X		
- Res/Educational	X				X	
- Res/Commercial			X		X	
- Res/Recreational	X					X
- Industrial/Comm'l	X				X	
2. Land Use Density						
- Heavy		X		X		
3. Policy of Nearby School on Use of GSPC - Active			X		X	
• GSPC Design Features:						
4. Artificial Lighting						
- Adequate	X				X	
- Inadequate	X				X	
6. Access/Aproach to GSPC - At-grade		X				
- Ramp			X		X	
7. Distance to Travel Using GSPC (ft) -			1-150	X	1-150	
8. Distance to Travel At-grade (ft) -			51-100		51-100	
9. Ratio of Distance Using GSPC to Crossing At-grade -	0.01-0.74 1.51-2.0		Over 2.0		.01-0.74 Over 1.5	
• Roadway Features:						
10. Type of Roadway						
- Local/Collector		X				X
11. Number of Lanes -	6	3/4	Over 6	3/4	Over 5	
12. Refuge Median Width						
- Freeway Site		X		X		
- Width (ft)	11-25				11-25	
13. Speed Limit (mph) -			35-40		35-40	

* Characteristics and predictors not listed were the same for validation and development.

TABLE 20:
DIFFERENCES BETWEEN VALIDATION AND DEVELOPMENT PREDICTORS (Continued)

CHARACTERISTIC/PREDICTOR*	Validation (Table 19)			Development (Table 11)		
	Suc	Mod	Unsuc	Suc	Mod	Unsuc
• Alternative "Safe" Crossing:						
15. Distance from GSPC (ft) -	401-750	1-250	251-400		251-750	1-250
17. Type of Signal Hardware (if traffic signal)						
- Ped Head/ Pushbuttons	X				X	
- Ped Head only		X				X
18. Type of Pavement Markings (if traffic signal)						
- Crosswalk	X				X	
• Vehicle Volume:						
19. Average Daily Traffic (1,000 veh) -	25-35				25-35	
20. Corresponding** 8 highest hrs (1,000 veh) -	15-20				15-20	
21. Corresponding** 4 highest hrs (1,000 veh) -	7.5-20				7.5-20	
22. Corresponding** highest hr (1,000 veh) -	2-3		1-1.5		1-1.5 & 2-3	
• Pedestrian Volume:						
23. User Volume (8 highest hrs) -		Over 60		Over 100		60-100
24. User Volume (4 highest hrs) -		0-30 & 301-800		301-800		0-30
25. User Volume (highest hr) -		Over 0		Over 10		0-10

** Conflicting vehicular traffic to pedestrian movements if crossing at-grade and corresponding to the same hours of the day as the highest pedestrian values.

4. Artificial Lighting - This tends to be present at moderate or successful GSPC sites and not present as unsuccessful sites.

6. Access/Approach to GSPC - An at-grade approach would not necessarily influence utilization of a GSPC. Other convenience and safety factors are more influential in encouraging utilization.

7. Distance to Travel Using GSPC - Shorter distances of 100 to 150 feet tend to be characteristic of moderate to unsuccessful GSPCs. Most likely this would be because it is easier to cross at-grade at these sites.

8. Distance to Travel At-grade - Same as Distance to Travel Using GSPC, number 7 above.

9. Ratio of Distance Using GSPC to Crossing At-grade - Ratios under 2.0 tend to be an indicator of moderate to successful GSPCs. This ratio reflects the amount of inconvenience pedestrians will tolerate. Surprisingly, the results show pedestrians would walk twice the distance to use a GSPC.

10. Type of Roadway - GSPCs over local or collector streets tend to be moderate to unsuccessful GSPCs.

11. Number of Lanes - The number of lanes of moving traffic would not be a validate indicator of a well-utilized GSPC.

12. Refuge Median Width - GSPCs over freeways tend to be moderate to successful. Large medians are indicators of major highways with high traffic volumes. The presence of an 11 to 25 feet median is not an independent indicator of the degree of successful utilization of GSPCs.

13. Speed Limit - GSPCs tend to be moderate to successful if the speed limit of the roadway crossed is over 35 mph.

15. Nearest Alternative "Safe" Crossing - Alternative "safe" crossing(s) less than 700 feet tend to indicate successful GSPCs.

17. Type of Signal Hardware - This characteristic influence on GSPC utilization could not be assumed based on the differences between analyses for validation and development.

18. Type of Pavement Markings - Same as Types of Signal Hardware, number 17 above.

19 to 22. Vehicle Volume on Roadway - For each volume count duration, the medium to high volume ranges indicated moderate to successful GSPCs instead of only moderate utilization for criteria/warrant development.

23 to 25. Pedestrian Volume - For each volume count duration, the validation analysis indicated that the upper ranges of pedestrian volume influence moderate utilization. For the criteria/warrant development, the tendency was to influence successful utilization.

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 priority ranking system is given below as presented by Roy W. Morse and M. R. Mitchell in Priority Study, Pedestrian Overpasses (September, 1968, pages 6 to 8):

> Seattle's priority ranking system gives the primary weight to measurable characteristics common to all proposed GSPC sites (i.e., vehicle and pedestrian volume to a 40 points maximum, accident experience to a 15 points maximum, and miscellaneous and sight distance factors to a maximum of 45 points of the total ranking system.)
>
> Vehicle and Pedestrian Volume
>
> The interrelationship between volume of vehicles crossed and volume of pedestrians gives a nearly infinite number of combinations. Standard measures of volume have been used as parameters. Average daily traffic was chosen with the basic assumption that typical traffic distribution exists for all sites.
>
> The relationship between a low volume of pedestrians crossing a high volume of vehicular traffic, compared to a relatively high volume of pedestrians crossing a low volume of vehicular traffic, is shown in Figure 1. This set of curves is patterned after the empirical systems used for signal priority studies. There are three basic systems used for traffic signal priority studies: the Detroit System, the New York System, and the Nomogram System. The Nomogram System was found to be the most adaptable to the similar problem of pedestrian overpasses and underpasses (Figure 2). For example, the maximum point value, 40 points (Figure 1), would be given for a site with 36,000 ADT and 360 pedestrians crossing (1 percent), or to a site with 16,000 ADT and 1,600 pedestrians crossing (10 percent). This empirical system is of course not the absolute answer but a tool for comparison of several proposed sites. Additional factors and differences can be accounted for under "Miscellaneous Factors".
>
> Accident Experience
>
> A check of all proposed GSPC sites under study in Seattle was made to determine the number of correctable pedestrian accidents at each location which would not have occurred if the pedestrian had been on the proposed underpass or overpass. The maximum number of accidents occurring at any site during the previous five-year period was three. Nineteen intersections experienced one accident each, sixteen had two accidents, and five crossings had three accidents each. Five points were given for each correctable accident with no distinction made for severity of accident.
>
> Miscellaneous Factors
>
> This measure was developed to allow engineering judgment to compensate for variables which are difficult to weigh by the above measures of the priority ranking system. In general, 10 points were given for a marked school crossing, 10 additional points if an elementary school crossing, 10 additional points if an adult guard is present, 15 points for sight distance problems, various factors for potential growth, wide crossings,

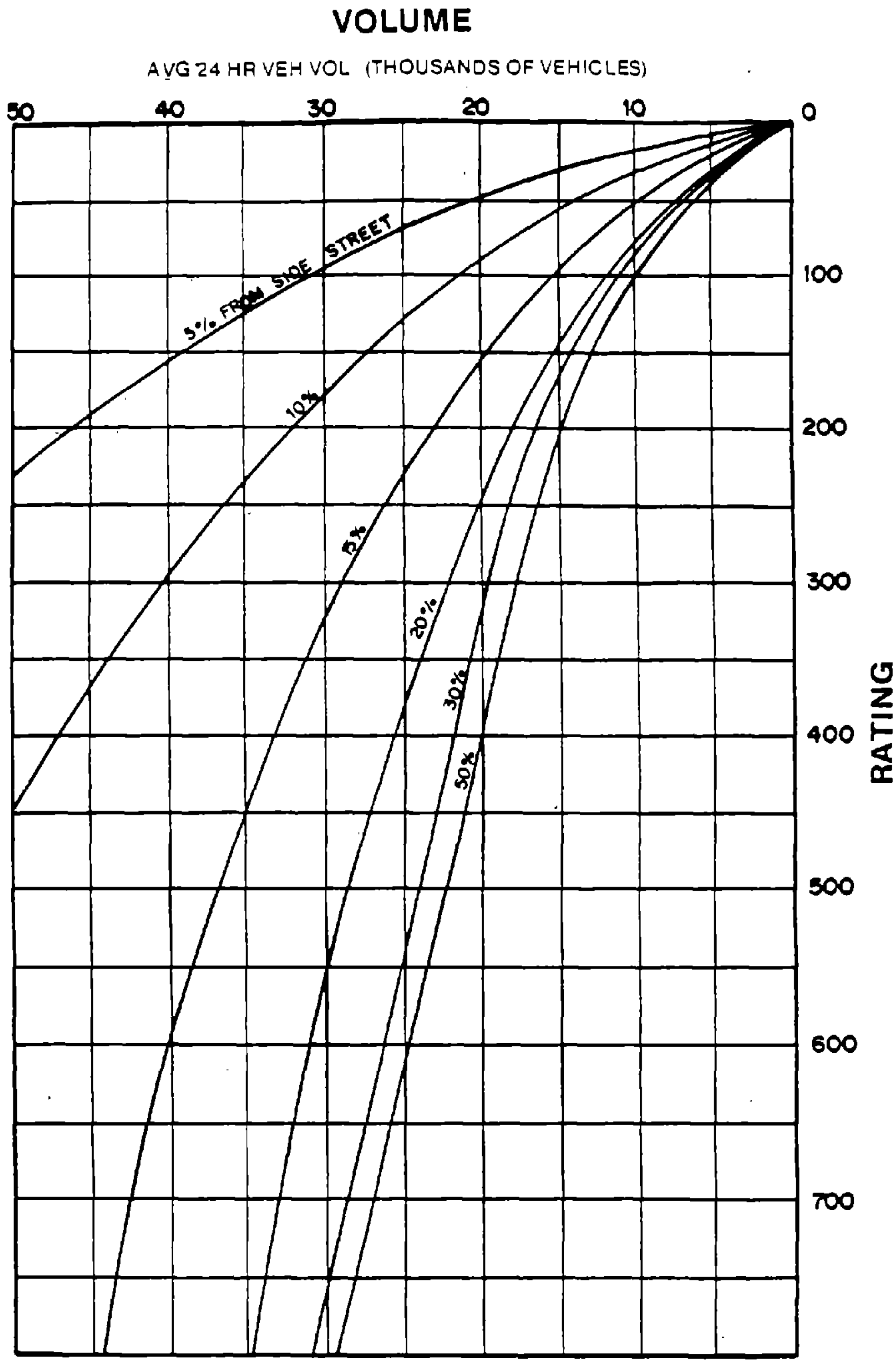

FIGURE 2

NOMOGRAPH SYSTEM

etc., 2 points for each 10 feet of street width. However, deduct 4 points from the total if a raised median/pedestrian island exists or deduct 2 points for a pedestrian refuge area other than raised.

APPENDIX A

BIBLIOGRAPHY OF LITERATURE REVIEW

Appendix A-1

Directly Relevant Literature on Pedestrian Over and Underpass Criteria and Warrants

Appendix A-2

Indirectly Relevant Literature on Pedestrian Signals, Crosswalks, Sidewalks, and Other Roadway Pedestrian Design Elements

Appendix A-3

Useful Background Literature on Pedestrian Over and Underpasses

Appendix A-1

Bibliography of Directly Relevant Literature on Pedestrian Over and Underpass Criteria and Warrants

1. American Association of State Highway and Transportation Officials, A Policy on Design of Urban Highways and Arterial Streets, 1st ed., Washington, D.C., 1973, pages 422-429.

   This reference deals with general criteria concerning GSPC's location and design and is influential in the state-of-the-practice given its stature as a national standard for highway design.

2. Arnold, E.D. Jr. and Robins, Roni, Planning for Pedestrians within the Highway Environment, Virginia Highway Research Council, August, 1980.

   A comprehensive survey of all the states and 33 cities and urbanized counties is summarized to determine existing practices used as warrants for pedestrian treatments. It summarizes warrants for GSPCs used in California, Massachusetts, New Jersey, Ohio, Washington, and Wisconsin as well as warrants for sidewalks, crosswalks, pedestrian traffic signals, and school crossing guards used by different jurisdictions.

3. Batz, Thomas, Powers, John, Manrodt, John, and Hollinger, Richard. Pedestrian Grade Spearation Locations - A Priority Ranking System, NJDOT Report No. 75-006-7712, New Jersey Department of Transportation, December, 1975.

   This report describes the development of a priority ranking system for New Jersey DOT. "The system is based on subjective weights applied to parameters which are measured in the field."

4. Braun, Ronald L. and Roddin Marc F., "Benefits of Separating Pedestrians and Vehicles," Proceedings of the Fourth National Seminar on Planning Design and Implementation of Bicycle and Pedestrian Facilities, American Society of civil Engineers, New York, NY, 1976, pages 406-425.

   The article summarized NCHRP Report 189 or reference number 6 below. The authors present techniques to measure social, environmental, and economic impacts of GSPCs with weighed scales. The impact of such factors as grade changes, lighting, sight distance, vehicular volume, traffic speed, and noise are discussed.

5. Braun, Ronald R. and Roddin, Marc F., "Evaluating Pedestrian-Oriented Facilities," SRI International, Arlington, VA, October, 1977.

   This article is similar to reference number 4 above with minor changes. The impact of accident threats was quantified to include medium weights. The space per person values for the pedestrian density and level of service tables were revised.

Appendix A-1 (Continued)

Bibliography of Directly Relevant Literature on
Pedestrian Over and Underpass Criteria and Warrants

6. Braun, Ronald R. and Roddin, Marc F., Quantifying the Benefits of Separating Pedestrians and Vehicles, National Cooperative Highway Research Program (NCHRP) Report 189, Washington, D.C., 1978.

This NCHRP report provides a complex system for ranking GSPCs and other pedestrian treatments. It quantitatively scores and ranks 36 different factors influencing the usage of GSPCs.

7. Federal Highway Administration, Manual on Uniform Traffic Control Devices for Streets and Highways, 1978.

This manual presents pedestrian warrants for traffic signals which have been adopted by some local transportation professionals for GSPC warrants. It is a national standard for warrants of traffic control devices.

8. Gulino, R.J. and Van Gelder, W.G., Priority Study Pedestrian Overpasses, Seattle Engineering Department, Seattle, WA, March, 1970.

This study describes a priority ranking system and applies it to 100 potential GSPC locations. Thirty (30) top ranked, proposed GSPC sites and 27 existing GSPCs are described in the study.

9. Institute of Transportation Engineers, "Pedestrian Over Crossings - Criteria and Priorities," Traffic Engineering, October, 1972, pages 34-39 and 68.

This ITE report discusses economic, system, threshold (it uses the term "point"), and priority ranking warrants and recommends a priority ranking system similar to that used by Seattle, WA.

10. Klatt, Richard, "Determination of Priorities for Pedestrian Overpasses," Traffic Engineering Division, Omaha, NE, March 1975.

This report evaluates Omaha's priority rating (ranking) system for GSPCs and compares it with other warrant systems.

11. Klatt, Richard and Barrett, Jim, "Pedestrian Overpasses Usage Study," Traffic Engineering Division, Omaha, NE, 1968.

This report gives the history of the funding sources, determination, and construction costs for GSPCs in Omaha. Usage and nonusage data are summarized by age group and hour of the day.

Appendix A-1 (Continued)

Bibliography of Directly Relevant Literature on Pedestrian Over and Underpass Criteria and Warrants

12. LaBaugh, William C., III and Demetsky, Michael J, "Pedestrian Planning in Suburban Areas - A State-of-the-Art Review," Volume I of Development of Guidelines for Accomodating Safe and Desirable Pedestrian Activity within the Highway Environment, December, 1974.

This paper gives detailed criteria on the effectiveness of GSPCs and unit cost data for economic analyses.

13. Montgomery County, MD, Department of Public Works, A Study of Pedestrian Overpasses and Underpasses, March, 1963.

This study discusses Montgomery County's position on justifying construction of GSPCs. Also included are the policy and political criteria that Montgomery County, MD, as well as nine other jurisdictions (i.e., Chicago, New Jersey, Los Angelos, New York, etc.), use in justifying GSPCs.

14. Morse, Roy W. and Mitchell, M.R., Priority Study, Pedestrian Overpasses, Seattle Engineering Department, Seattle, WA, September, 1968.

This study reviews the priority ranking system in Seattle and applies the system for proposed and existing GSPCs on a citywide basis. It is comprehensive with site characteristics, weekly ADTs, 16 hour pedestrian volume, and cost breakdowns for the GSPC sites. The engineering basis behind the priority ranking system is discussed.

15. Ohio DOT, Location and Design Manual, Section 406.1, October, 1981.

Section 406.1 of this manual establishes installation and design guidelines for various pedestrian treatments including GSPCs as well as curb ramps, walkways on bridges, and sidewalks.

16. Perfater, Michael A. and Demetsky, Michael J., "Pedestrian Attitudes and Behavior in Suburban Environments," Development for Accommodating Safe and Desirable Pedestrian Activity Within the Highway Environment, Volume II, March, 1975.

This report examines user and nonuser perceptions associated with GSPCs. It includes case studies of nine over and underpasses in Virginia.

17. Puerto Rico, Study to Select the Factors to be Considered to Determine the Necessity to Install a Pedestrian Overpass, March, 1980.

This study conducted research on quantitative criteria for installation of GSPCs. The New Jersey priority ranking system was used to evaluate twelve (12) GSPCs in Puerto Rico.

Bibliography of Directly Relevant Literature on
Pedestrian Over and Underpass Criteria and Warrants

18. Reilly, E.F., Hollinger, R.L., and Warren S., "Cost-Utility Analysis," New Jersey Department of Transportation, June, 1974.

This analysis develops a technique to measure the value or usefulness of several GSPC designs. It is a systematic approach similar to benefit-cost analysis techniques but derives utility values to measure intangible factors instead of quantifiable factors (i.e., dollars).

19. Roddin, Marc F., A Manual to Determine Benefits of Separating Pedestrians and Vehicles, NCHRP Report 240, November, 1981.

This NCHRP report simplified NCHRP Report 189 or reference number 6 for use as a technical user guide. The number of variables was reduced from 36 to 27, and scoring procedure for evaluation of some variables was simplified. A simpler warrant was developed using 10 variables for pedestrian facilities which separate pedestrians and vehicles.

20. San Diego, City of, School Pedestrian Safety Policies and Warrants, May, 1980.

This document serves as standards and warrants for GSPCs as well as signs, markings, traffic signals, safety patrols, and sidewalks related to the safe route to and from schools.

21. Seattle Engineering Department, Pedestrian Overpass Study, December, 1975.

This study is an updated version of the Priority Study, Pedestrian Overpasses or reference number 14.

22. Swan, S., Sgourakis, A. and De Leuw, C., Effective Treatments of Over and Undercrossings for Use by Bicyclists, Pedestrians, and Handicapped - A Literature Review, Report No. FHWA-RD-78-142, October, 1980.

This FHWA report reviews the state-of-the-art of GSPCs. It specifies design criteria for the handicapped and bicyclists. A comprehensive bibliography is included.

23. Szwed N., "Grade Separated Pedestrian Crossings," Joint Australian Road Research Board/Department of Transport Pedestrian Conference, November, 1978.

This article describes criteria, warrants, and design considerations for GSPCs from Australia. It is interesting in that it is a perspective on warrants for GSPCs other than from the United States.

Appendix A-1 (Continued)

Bibliography of Directly Relevant Literature on Pedestrian Over and Underpass Criteria and Warrants

24. Zaidel, Algarishi A. and Katz, A., "Factors Affecting the Use of Pedestrian Overpasses," Proceedings, International Conference on Pedestrian Safety, Volume I, Haifa, Israel, December, 1976.

This paper was presented at the International Conference on Pedestrian Safety in Haifa, Israel. It gives pedestrian perceptions on the use of GSPCs as well as design criteria that influence GSPC usage.

Appendix A-2

Bibliography of Indirectly Relevant Literature on Pedestrian Signals, Crosswalks, Sidewalks and Other Roadway Pedestrian Design Elements

1. Anne Arundel County, MD, School Sidewalk Study, Bureau of Road Operations, Department of Public Works, April, 1973.
2. Box, Paul C. and Alroth, Willard A., "Assembly, Analysis and Application of Data on Warrants for Traffic Control Signals, Part III," Traffic Engineering, January, 1968.
3. California DOT, "Manual Change Transmittal," No. M83-21 for Chapter 10 of Traffic Manual, "School Area Pedestrian Safety," (Section 10-04), July, 1983.
4. California, State of, Highway Transportation Agency, Department of Public Works, "School Crossing Protection - Signs, Signals and Devices," 1971.
5. Cedar Falls, IA, Mayor's Advisory Committee on Sidewalks, "Sidewalk Study," February, 1973.
6. Columbia, MO, "Manual for School Crossing Control for the City of Columbia, MO," undated.
7. DeLeuw, C., Danielson, F., Kudlick, W., and Swan, S., Effective Treatments of Over and Undercrossings for Use by Bicyclists, Pedestrians and the Handicapped," FHWA-RD-79-70, January, 1981.
8. Federal Highway Administration, Design of Urban Streets, FHWA-TS-80-204, pages 13-1 to 13-6, January, 1980.
9. Freedman, M., Janoff M.S., Koth B.W., and McCunney, W., Fixed Illumination for Pedestrian Protection, FHWA-RD-76-9, December, 1975.
10. Greenhorne & O'Mara, Inc., "Preliminary Sidewalk Construction, Maintenance, Assessment Study for Howard County, Maryland," November, 1974.
11. Herms, Bruce F., Pedestrian Crosswalk Study, Accidents in Painted and and Unpainted Crosswalks, Project PS 69-2-001, August, 1970.
12. Institute of Transportation Engineers, "A Program for School Crossing Protection," Rev. 1971.
13. Institute of Transportation Engineers, Transportation and Traffic Engineering Handbook, pages 220-226, 1976.
14. International Association of Chief of Police and Institute of Transportation Engineers, "Report on Warrants for Traffic Officers at School Intersections," September, 1947.

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Bibliography of Indirectly Relevant Literature on
Pedestrian Signals, Crosswalks, Sidewalks
and Other Roadway Pedestrian Design Elements

15. Lawton, Lawrence, "Traffic Control in the Vicinity of School Zones," Reprinted from Traffic Engineering, March - April, 1974.

16. Lincoln, Nebraska, Sidewalks a Program for Lincoln, Nebraska, December, 1974.

17. Massey, S.A., "Mathematical Determination of Warrants for Pedestrian Crossings," Traffic Engineering, September, 1962, pages 19-21.

18. Ockert, Charles W., "Criteria to be Used in Developing Warrants for an Interchange at a Major Isolated Rural Intersection," Warrants for Highway - Highway Grade Separation, Northwestern University, Evanston, IL, November, 1965.

19. Perkins, David D. and Datta, Tapan K., Priority Analysis: For Community-wide Pedestrian Safety Projects, presented at Transportation Research Board Meeting, 1977.

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22. San Diego, City of, "School Area Pedestrian Safety," Traffic Manual, August, 1979.

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24. URS Company, School Crossing Safety Study, prepared for the City and County of Denver, September, 1981.

25. Wilbur Smith and Associates, Sidewalks: Warrants and Relationships to Pedestrian Safety - Charlotte, NC, October, 1977.

26. Strok, W., "Warrant for School Traffic," Traffic Engineering, May, 1962, pages 16-20.

27. Zegeer, Charles V., Khasnabis, Shehamay, and Fegan, John C., Development of an Improved Pedestrian Warrant for Traffic Signals.

Appendix A-3

Bibliography of Useful Background Literature on Pedestrian Over and Underpasses

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2. Cameron, Ronald M., "Pedestrian Volume Characteristics," Traffic Engineering, January, 1977.

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5. Drake, Peggy L., "Application of Priority Accessible Networks: An Approach to Planning and Providing Access Improvements for Pedestrians Who are Elderly or Handicapped," Presented at 62nd Annual Meeting of the Transportation Research Board, January, 1983.

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12. Kennedy, Norman, "Pedestrian Control," Fundamentals of Traffic Engineering, 8th Ed., 1973, pages 21.1-21.8.

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Pedestrian Over and Underpasses

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25. Swan, Sherrill, "Treatments of Overpasses and Undercrossings for the Disabled: Early Report on the State-of-the-Art," Road User Information Needs, Pedestrian Movement, A Bicycle Travel Patterns, 1978, pages 18-20.

26. Templer, John A., Development of Priority Accessible Networks - An Implementation Manual, Report No. FHWA-IP-80-8, January, 1980.

27. Templer, John A. and Wineman, Jean D., The Feasibility of Accommodating Physically Handicapped Individuals on Pedestrian Over and Under-Crossings, Report No. FHWA-RD-79-146, September, 1980.

Appendix A-3 (Continued)

Bibliography of Useful Background Literature on
Pedestrian Over and Underpasses

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29. Vallette, Gerald R. and McDivitt, Judith A., Model Pedestrian Safety Program User's Manual, October, 1977.

30. Vallette, Gerald R. and McDivitt, Judith A., Pedestrian Safety Programs-A Review of the Literature and Operational Experience, Report No. FHWA-RD-80-190, January, 1981.

APPENDIX B

TABLE 22:
SUMMARY OF CITIES AND ORGANIZATIONS CONTACTED

East Coast	Midwest	West Coast
Local Jurisdictions	**Local Jurisdictions**	**Local Jurisdictions**
• Alexandria, VA	• Akron, OH	• San Diego, CA
• Arlington County, VA	• Austin, TX	• San Francisco, CA
• Atlanta, GA	• Boulder, CO	• Seattle, WA
• Baltimore, MD	• Cedar Rapids, IA	
• Fairfax County, VA	• Dallas, TX	
• Montgomery County, MD	• Lansing, MI	
• Nassau County, NY	• New Orleans, LA	
• New York, NY	• Omaha, NE	
• Philadelphia, PA	• Wichita, KN	
• Prince George's County, MD		
• West Palm Beach, FL		
State/Federal Agencies	**State Agencies**	**State Agencies**
• Florida Department of Transportation	• Ohio Department of Transportation	None
• Maryland State Highway Administration	• Texas Department of Highways and Public Transportation	
• National Park Service		
• Virginia Department of Highways and Transportation		

APPENDIX C

A SAMPLE OF OTHER WARRANTS FOR PEDESTRIAN TREATMENTS

TABLE 23:
PEDESTRIAN TRAFFIC SIGNAL WARRANTS

Source:	MUTCD	MUTCD
Reference No.*:	A-1/#7	A-1/#7
Date:	1978	1978
Application:	Intersection school crossing:	Midblock school crossing (nonintersection):
Major Street Vehicle Volume per Period	Exceeds 600 or more per hr, or 1,000 or more per hr if raised median*(over 3 ft) (for each of any 8 hrs)	Exceeds 600 or more per hr, or 1,000 or more per hr if raised median* (over 3 ft) (for each of any 8 hrs)
Pedestrian Volume per Period	150 or more per hr* for same 8 hrs as above	150 or more per hr* for same 8 hrs as above
Accidents	N/S	N/S
Nearest "Safe" Crossing (ft)	N/S	150 or more (Crosswalk)
Vehicle Speed (mph)	*Exceeds 40 mph or**	*Exceeds 40 mph or**
Sight Distance	N/S	N/S
Feasible to Install	N/S	N/S
Land Use Development	**May reduce vehicle and pedestrian volumes by 70% if isolated community of less than 10,000	**May reduce vehicle and pedestrian volumes by 70% if isolated community of less than 10,000
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S
Economic	N/S	N/S
Roadway Geometry	N/S	N/S
Others	None	Curbside parking prohibited 100 ft before and 20 ft after crossing

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

TABLE 23:
PEDESTRIAN TRAFFIC SIGNAL WARRANTS (Continued)

Source:	Zegeer (Proposed MUTCD)	MUTCD
Reference No.:	A-2/#27	A-1/#7
Date:	1983	1978
Application:	Intersection and midblock:	School crossing:
Major Street Vehicle Volume per Period	(Less than 60 adequate gaps in traffic per hr)	"No. of adequate gaps in the traffic stream during the period when children are using the crossing is less than the no. of minutes in the same period."
Pedestrian Volume per Period	Exceeds 60 per hr for any 4 hrs, exceeds 90 per hr for any 2 hrs, or exceeds 110 per hr for the peak hr	N/S
Accidents	N/S	N/S
Nearest "Safe" Crossing (ft)	N/S	N/S
Vehicle Speed (mph)	N/S	N/S
Sight Distance	N/S	N/S
Feasible to Install	N/S	N/S
Land Use Development	N/S	N/S
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S
Economic	N/S	N/S
Roadway Geometry	N/S	N/S
Others	None	None

TABLE 23:
PEDESTRIAN TRAFFIC SIGNAL WARRANTS (Continued)

Source:	San Diego CA	Columbia MO
Reference No.:	A-1/#20	A-2/#6
Date:	1980	Unknown
Application:	Priority ranking system (warranted if location receives at least 30 of 50 total pts) (for elementary school children):	For school areas:
Major Street Vehicle Volume per Period	2 pts if 70 to 99 per period plus 1 pt extra for each 100 additional vehicles, up to 10 pts. The period is the average of any 2 hrs daily when children are present	Exceeds 500 vph for any 2 hrs when children cross
Pedestrian Volume per Period	1 pt if 35 to 49 per period plus 1 pt extra for each 25 additional pedestrians, up to 10 pts. The period is the same period as above	N/S
Accidents	N/S	N/S
Nearest "Safe" Crossing (ft)	600 ft or more and within 35 ft where children cross the street	At a painted crosswalk
Vehicle Speed (mph)	1 pt for every 2 miles over 25 mph, up to 10 pts (Speed "not affected by school children crossing the street")	N/S
Sight Distance	10 pts if sight distance less than: 200 ft if approach speed 30 mph 275 ft if approach speed 40 mph 350 ft if approach speed 50 mph	N/S
Feasible to Install	N/S	N/S
Land Use Development	N/S	N/S
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S

TABLE 23:
PEDESTRIAN TRAFFIC SIGNAL WARRANTS (Continued)

Source:	San Diego CA	Columbia MO
Reference No.:	A-1/#20	A-2/#6
Date:	1980	Unknown
Application:	Priority ranking system (warranted if location receives at least 30 of 50 total pts) (for elementary school children):	For school areas:
Economic	N/S	N/S
Roadway Geometry	Street width from curb to curb or edge of shoulder: 2 pts if less than 40 ft 5 pts if 40 to 59 ft 10 pts if 60 ft or more	N/S
Others	None	None

TABLE 23:
PEDESTRIAN TRAFFIC SIGNAL WARRANTS (Continued)

Source:	Canada	Caltrans
Reference No.:	A-2/#27	A-2/#4
Date:	1966	1971
Application:	Specifies:	Specifies:
Major Street Vehicle Volume per Period	(Exceeds 60 sec delay for ped to cross in 4 highest hrs)	Over 500 per any 2 hrs when children cross*
Minor Street Vehicle Volume per Period	N/S	N/S
Pedestrian Volume per Period	Exceeds 60 per hr for the same 4 highest hrs	100 school age children in 2 hrs* or 500 all day*
Accidents	Exceeds 5 correctable accidents in 3 consecutive yrs, each involving personal injury or PDO over $100	N/S
Nearest "Safe" Crossing (ft)	1,000 or more (traffic signal)	600 or more (controlled crossing)
Vehicle Speed (mph)	N/S	(1) Reduce by 70%, if over 40 mph
Sight Distance	N/S	(2) Reduce by 70%, if less than required safe stopping sight distance
Feasible to Install	N/S	N/S
Land Use Development	N/S	(3) Reduce by 70%, if rural environment
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S
Economic	N/S	N/S
Roadway Geometry	"Suitable for Signalization"	N/S
Others	None	*Reduce by 70% if (1), (2), or (3) applies

TABLE 23:
PEDESTRIAN TRAFFIC SIGNAL WARRANTS (Continued)

Source:	Denver CO
Reference No.:	A-2/#24
Date:	1981
Application:	Nonsignalized intersections, midblock crosswalk or additional pederstrian signal phase:
Major Street Vehicle Volume per Period	<u>No. of Lanes</u> <u>ADT exceeds*</u> 3 14,400 4 8,000 5 or more 5,250 4 20,000 6 or more 11,000
Pedestrian Volume per Period	N/S
Accidents	N/S
Nearest "Safe" Crossing (ft)	200 or more (if midblock)
Vehicle Speed (mph)	N/S
Sight Distance	N/S
Feasible to Install	N/S
Land Use Development	N/S
Physical Barrier to Prohibit At-grade Crossing	N/S
Economic	N/S
Roadway Geometry	** Applicable if raised median is present
Others	*If not midblock, no. of acceptable gaps in an hr less than 60

TABLE 24:
OTHER RELATED EXISTING WARRANTS

Source:	San Diego CA	Columbia MO
Reference No.*:	A-1/#20	A-2/#6
Date:	1980	Unknown
Application:	School safety patrol establishment depends upon:	Adult crossing guard if satisfies (A) and (B):
Major Street Vehicle Volume per Period	"Vehicular traffic...consistently reaches a volume which does not provide a gap of sufficient duration...on the average of approximately once a minute." (i.e., if 50 ft street, over approximately 200 vph for the largest groups and over 375 vph for small groups of peds)	B1 = Hourly volume of traffic crossing crosswalk during school crossing periods* B2 = Four times the no. of 3 axle or larger vehicles B3 = Four times the no. of turning vehicles crossing the crosswalk
Pedestrian Volume per Period	"The number of children crossing the street justifies the patrol being on the corner."	B4 = Hourly volume of school children crossing in crosswalk
Accidents	N/S	N/S
Nearest "Safe" Crossing (ft)	400 or more	N/S
Vehicle Speed (mph)	Not above 35 mph	* = If exceeds 30 mph, increase vehicle volume 20%
Sight Distance	"Adequate chance to observe traffic approaching the crossing."	N/S
Feasible to Install	N/S	N/S
Land Use Development	N/S	N/S
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S
Economic	N/S	N/S
Roadway Geometry	No "more than 2 lanes of moving traffic in each direction."	(A) Minimum of 6 lanes at an intersection or 4 lanes at midblock locations

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

(Continued on the Next Page)

TABLE 24:
OTHER EXISTING RELATED WARRANTS (Continued)

Source:	San Diego CA	Columbia MO
Reference No.:	A-1/#20	A-2/#6
Date:	1980	Unknown
Application:	School safety patrol establishment depends upon:	Adult crossing guard if satisfies (A) and (B):
Others	None	(B) Minimum volume factor (B) exceeds 1600 where: B = (B1) + (B2) + (B3) + (B4)

TABLE 24:
OTHER EXISTING RELATED WARRANTS (Continued)

Source:	Illinois DOT	Toronto Canada
Reference No.:	A-1/#2	A-1/#2
Date:	1975	Unknown
Application:	Crosswalk:	Crosswalk:
Major Street Vehicle Volume per Period	Exceeds 300 vph for each of any 8 hrs for the day	Not where "cross street or turning movements are excessive"
Pedestrian Volume per Period	Exceeds 75 per hr for the same 8 hrs	Exceeds 100 per hr in each of any 8 hrs in which 10 or more wait
Accidents	N/S	N/S
Nearest "Safe" Crossing (ft)	N/S	700 or more (traffic signal or crosswalk)
Vehicle Speed (mph)	N/S	Under 40 mph
Sight Distance	N/S	"Good visibility of pedestrians"
Feasible to Install	N/S	N/S
Land Use Development	N/S	N/S
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S
Economic	N/S	N/S
Roadway Geometry	N/S	4 lanes or less & Avoid offset intersection locations
Others	Urban signalized intersection	"Unsuitable where advertising sign and other objects are overpowering and distractions to motorists."

TABLE 24:
OTHER EXISTING RELATED WARRANTS (Continued)

Source:	Caltrans	International Association of Chiefs of Police
Reference No.:	A-2/#4	A-2/#14
Date:	1971	1947
Application:	Midblock crosswalk:	Crosswalk for children:
Major Street Vehicle Volume per Period	N/S "Material conflict between vehicles and students crossing or where students could not otherwise recognize the proper place to cross."	Max vehicle volume (permitting adequate gaps for pedestrians to cross):

Street Width (ft)	Single Person or Small Group	Large Group (30 to 40 Child)
25 -	1,000	400
30 -	750	350
40 -	500	250
50 -	350	200
60 -	250	150
80 -	150	80
100 -	80	50

Pedestrian Volume per Period	N/S	N/S
Accidents	N/S	N/S
Nearest "Safe" Crossing (ft)	600 or more (intersection)	N/S
Vehicle Speed (mph)	N/S	N/S
Sight Distance	N/S	N/S
Feasible to Install	N/S	N/S
Land Use Development	N/S	N/S
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S
Economic	N/S	N/S
Roadway Geometry	N/S	N/S
Others	None	$\frac{Vph}{1,000}$ x (No. Children) > 30 Y

TABLE 24:
OTHER EXISTING RELATED WARRANTS (Continued)

Source:	Columbia MO	FHWA-RD-76-9
Reference No.:	A-2/#6	A-2/#9
Date:	Unknown	1975
Application:	Stop sign at school crosswalk:	Crosswalk illumination:
Major Street Vehicle Volume per Period	Exceeds 250 vph	Exceeds in at least 3 nights: 1,000 veh/night-major arterial 500 veh/night-collector 200 veh/night-local street
Pedestrian Volume per Period	N/S	50 ped/night if local street or residential area & 100 ped/night all other locations
Accidents	N/S	3 preventable accidents if improved visibility
Nearest "Safe" Crossing (ft)	At a painted crosswalk	N/S
Vehicle Speed (mph)	N/S	N/S
Sight Distance	N/S	Such that "pedestrians cannot be seen until motorist is within the normal safe stopping distance to the crosswalk."
Feasible to Install	N/S	N/S
Land Use Development	N/S	N/S
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S
Economic	N/S	N/S
Roadway Geometry	N/S	N/S
Others	None	Less than 1.5 times the IES prescribed roadway illumination and a min of 2 night ped accidents in 4 yrs

IES = Illuminating Engineering Society

TABLE 24:
OTHER EXISTING RELATED WARRANTS (Continued)

Source:	Howard County* MD	AASHTO*
Reference No.:	A-2/#2	A-1/#1
Date:	1974	1954
Application:	Sidewalks:	Sidewalks:
Major Street Vehicle Volume per Period	Sides of Street with Sidewalks / Vph / Ped one / 30 to 100 / (1) one / Over 100 / (2) both / 30 to 100 / (3) both / Over 100 / (4)	Sides of Street with Sidewalks / Vph / Ped one / 30 to 100 / (1) one / Over 100 / (2) both / 30 to 100 / (3) both / Over 100 / (4)
Pedestrian Volume per Period	(1) = 150 ped/day (A) (2) = 100 ped/day (A) (3) = 500 ped/day (B) (4) = 300 ped/day (C)	(1) = 150 ped/day (A) (2) = 100 ped/day (A) (3) = 500 ped/day (B) (4) = 300 ped/day (C)
Accidents	N/S	N/S
Nearest "Safe" Crossing (ft)	N/S	N/S
Vehicle Speed (mph)	Over 30 mph, if over 50 mph, decrease by: (A) 50 ped/day (B) 200 ped/day (C) 100 ped/day	Over 30 mph, if over 50 mph, decrease by: (A) 50 ped/day (B) 200 ped/day (C) 100 ped/day
Sight Distance	N/S	N/S
Feasible to Install	N/S	N/S
Land Use Development	N/S	N/S
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S
Economic	N/S	N/S
Roadway Geometry	N/S	N/S
Others	None	None

*Both Howard County, MD and AASHTO have the same warrant

TABLE 24:
OTHER RELATED EXISTING WARRANTS (Continued)

Source:	Caltrans	Strok (British Columbia Dep't of Hwys)
Reference No.:	A-2/#4	A-2/#26
Date:	1971	1962
Application:	Adult crossing guard:	Safety patrol:
Major Street Vehicle Volume per Period	Exceeds 350 per hr of any two hrs or 300 per hr if rural conditions	Exceeds 500 vph
Pedestrian Volume per Period	40 or more per hr for the same hrs above or 30 or more if rural conditions	N/S
Accidents	N/S	N/S
Nearest "Safe" Crossing (ft)	600 or more (traffic signal, stop sign or GSPC)	At marked crossing
Vehicle Speed (mph)	N/S	Over 30 mph
Sight Distance	N/S	N/S
Feasible to Install	N/S	N/S
Land Use Development	N/S	N/S
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S
Economic	N/S	N/S
Roadway Geometry	If stop sign controlled intersection, exceeds 500 vph of an over four lane undivided highway. If signalized intersection, exceeds 300 vph of turning vehicle towards where children cross or undivided width longer than 80 ft.	N/S
Others	None	None

TABLE 24:
OTHER RELATED EXISTING WARRANTS (Continued)

Source:	San Diego CA	San Diego CA
Reference No.:	A-2/#11	A-2/#11
Date:	1967	1980
Application:	Marked crosswalk: (satisfy warrants A1 to A4 and rate 16 pts from 28 total pts from warrants B1, B2, & B3)	Crosswalk if at least 16 of 25 pts:
Major Street Vehicle Volume per Period	B1= 2 pts if 4-4.99 avg gap per 5 min 4 pts if 3-3.99 avg gap per 5 min 6 pts if 2-2.99 avg gap per 5 min 8 pts if 1-1.99 avg gap per 5 min 10 pts if 0-0.99 avg gap per 5 min	2 pts if 4-4.99 avg gap per 5 min* 4 pts if 3-3.99 avg gap per 5 min* 6 pts if 2-2.99 avg gap per 5 min* 8 pts if 1-1.99 avg gap per 5 min* 10 pts if 0-0.99 avg gap per 5 min*
Pedestrian Volume per Period	A1 = Exceeds 11 per peak hr B2 = 2 pts if 11 to 30 per hr 4 pts if 31 to 60 per hr 6 pts if 61 to 91 per hr 8 pts if 91 to 100 per hr 10 pts if over 100 per hr	1 pt if 11 to 30 per peak hr 2 pts if 31 to 60 per peak, hr 3 pts if 61 to 90 per peak hr 4 pts if 91 to 100 per peak hr 5 pts if over 100 per peak hr
Accidents	N/S	** = "accident history"
Nearest "Safe" Crossing (ft)	N/S	400 or more (at an intersection)
Vehicle Speed (mph)	A2 = under 45 mph	1 pt if 50 to 55 mph 3 pts if 20 to 25 mph 3 pts if 40 to 45 mph 5 pts if 30 to 35 mph
Sight Distance	A3 = "Not less than 200 ft approaching each direction"	N/S
Feasible to Install	N/S	N/S
Land Use Development	N/S	** = "Adjacent ground and buildings and pedestrian generators"
Physical Barrier to Prohibit At-grade Crossing	N/S	N/S

(Continued on next page)

TABLE 24:
OTHER RELATED EXISTING WARRANTS (Continued)

Source:	San Diego CA	San Diego CA
Reference No.:	A-2/#11	A-2/#11
Date:	1967	1980
Application:	Marked crosswalk: (satisfy warrants A1 to A4 and rate 16 pts from 28 total pts from warrants B1, B2, & B3)	Crosswalk if at least 16 of 25 pts:
Economic	N/S	N/S
Roadway Geometry	B3 = 2 pts if clarify pedestrian movements across complex intersection 2 pts if channelized into shorter path 2 pts if pedestrian seen better by motorists 2 pts if pedestrian exposed to fewer vehicles	** = "intersection layout"
Others	A4 = "Must have adequate crosswalk lighting" *Average gap= $\frac{\text{Total usable gaps(sec)}}{\text{Street width x 12/4.0 fps}}$	Engineering judgment, up to 5 pts for (**) *Average gap= $\frac{\text{Total usable gaps(sec)}}{\text{Street width x 12/4.0 fps}}$

fps = feet per second (use a value of 4.0 in San Diego)

APPENDIX D

GRADE SEPARATED PEDESTRIAN CROSSING (GSPC) STUDY SITES

SESSION	HOUR	AM or PM	FACILITY USERS*								FACILITY NON USERS*									VEHICLE VOLUME			
			AGE					Handi-capped	Bikes	Minutes Sampled	AGE					Handi-capped	Bikes	Minutes Sampled	Con-flicts	Vehicles Counted	Trucks Counted	One or Both Directions?	Minutes Sampled
			0-5	6-12	13-18	19+	60+				0-5	6-12	13-18	19+	60+								
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
10																							
11																							
12																							

* Facility users are those pedestrians or bicyclists who use the overpass or underpass. Facility non-users are those who cross the road in the vicinity of the facility (i.e., signalized intersection or another overpass).

PEDESTRIAN AND TRAFFIC VOLUMES

City, State ______________________

Location ______________________

FIGURE 3

FIGURE 4:
OVERPASS/UNDERPASS SITE CHARACTERISTICS

City, State ______________________________

Location ______________________________

Facility Type: |__| Overpass |__| Underpass

Overpass Type: |__| Overpass, covered |__| Overpass, enclosed by fence

|__| Overpass, side fence |__| Overpass, not covered & no fence

Access: |__| Both Ramps |__| Both Steps |__| Ramp and Steps

Barrier Crossed: |__| Limited Acess highway/freeway |__| Highway, nonfreeway

|__| Railroad |__| Other, specify ______________

Artificial Lighting: |__| None |__| Present, but not adequate

|__| Present, apparently adequate

User Group:

|__| Elementary |__| Jr. High School

|__| College/University |__| Sr. High School

|__| Adults |__| Elderly (55 years or older)

|__| Handicapped, wheelchair bound |__| Handicapped, no wheelchair

|__| Blind |__| Bicyclists |__| Joggers

Land Use: Indicate approximate percentage of each type of land use within 1/2 mile of the facility -

Land Use Category	One Side (A)	Other Side (B)
School		
Residential		
Recreational		
Commercial		
Offices/Factory		
Transportation Terminal		
Others		
Total, All Categories		

FIGURE 4:
OVERPASS/UNDERPASS SITE CHARACTERISTICS (CONTINUED)

Describe type and location (with respect to the facility) of school(s): |__| Elementary |__| Jr. High |__| Sr. High |__| College

---

Describe nature of residental area(s): |__| Single family houses |__| Multi-family houses |__| Garden apts. |__| High rise apts.

Describe type and location of recreational facility(ies): ______

Describe nature of commercial area: |__| Local stores |__| Regional shopping center |__| Public utility offices

---

Describe type and scale of office/factories: |__| Office |__| Light small scale industry |__| Major Industry

---

Describe transportation terminal: |__| Bus stop |__| Train station

---

Describe others: |__| School guards |__| Safety patrol |__| None but school policy |__| None, no school policy

---

General Maintenance: |__| Clean, no litter
|__| Fairly clean, small amounts of debris
|__| Dirty, moderate amounts of debris
|__| Very dirty, extensive debris

Structural Condition: |__| Well maintained
|__| Adequately maintained
|__| Poorly maintained

Distance from Facility: |__|__|__|__| (ft)

Nearest Safe Crossing: |__| Signalized intersection
|__| Overpass
|__| Underpass
|__| Other, specify ______________

FIGURE 4

OVERPASS/UNDERPASS SITE CHARACTERISTICS (CONTINUED)

Crossing Distances: |__|__|__| Using facility

|__|__|__| Cross at-grade, not using facility

|__|__|__| Horizonal distance on structure

|__|__|__| Vertical rise/fall, one side

|__|__|__| Vertical rise/fall, other side

If Freeway or Highway -

Grade of Roadway: |__| At-grade |__| Elevated |__| Depressed

Vehicle Speed: |__|__| Post speed limit |__|__| Floating car

Vehicle Volume: |__|__|__|__|__|__| ADT

|__|__|__|__| AM to |__|__|__|__| PM Peak Hour (of Pedestrian Use)

|__|__|__|__| AM to |__|__|__|__| PM Peak Hour Duration (1/4 hour periods)

Vehicle Mix: |__| 0 - 3% Buses & trucking, not including vans and pickups (SU)

|__| 4 - 9%

|__| Over 10%

Roadway Cross Section:

	Side A One Direction	Side B Other Direction
Number of Lanes		
Outside Shoulder Width (ft)		
Inside Shoulder Width (ft)		
Median Width (ft)		
Lane Width (ft)		
Total, Cross Section (ft)		

Describe type of median: |__| Raised Grass |__| NJ barrier

|__| Fence |__| Raise concrete |__| At-grade grass

FIGURE 4:
OVERPASS/UNDERPASS SITE CHARACTERISTICS (CONTINUED)

If Highway -.

Directional Flow: [ ] Two-way [ ] One-way

Functional Classification: [ ] Major Artery [ ] Minor Artery

Principal Financial Source to Construct Highway:
[ ] Local-city, county, township
[ ] State
[ ] Federal
[ ] Private developer

Traffic Control: [ ] None [ ] Yield sign [ ] Stop sign [ ] Signal

Pavement Markings: [ ] Pedestrian crosswalks [ ] Stoplines [ ] Both [ ] None

Signal Equipment:
[ ] Signal with pedestrian heads and pushbuttons
[ ] Signal with pedestrian heads only
[ ] Signal without heads or pushbuttons

TABLE 25
RANGES OF SITE CHARACTERISTICS

CHARACTERISTIC	RANGE
General:	
No. of Cities	5 Cities
No. of GSPC Sites	40 Sites
Surrounding Environment:	
Land Use Category*	Residential, Commercial, Industrial, Educational, or Recreational
Land Use Density	Light, Medium, or High
Policy of Nearby School on Use of GSPC	Active (Adult or Safety Patrol Stationed at GSPC), Passive (Encourage to Use but No Guards) or None
GSPC Design Features:	
Over or Underpass	25 Over and 15 Underpasses
Artificial Lighting	Adequate, Inadequate, or None
Pedestrian Barrier (Difficulty to Cross)	Easily (Raised Grass/Concrete Median), Some Difficulty (NJ Barrier), or Great Effort (Fence)
Access/Approach to GSPC	At-grade, Ramp, or Steps
Distance to Travel Using GSPC	92 to 3092 feet
Distance to Travel At-grade (not Using GSPC)	42 to 823 feet
Ratio of Distance Using GSPC to Crossing At-grade	0.39 to 5.90
Roadway Features (being crossed):	
Type of Roadway	Freeway, Major Arterial, or Collector/Local
Number of Lanes	2 to 16 lanes**
Refuge Median Width	3 to 21 feet
Speed Limit	25 to 55 mph
Truck Route	Yes or No

*Land use categories:
- Primary Educational (i.e., day care, elementary)
- Secondary Educational (i.e., Jr/Sr high, college/university)
- Recreation Center (i.e., YMCA, swimming pool, park, golf course)
- Commercial (i.e., restaurant, gasoline station, regional shopping center)
- Offices (i.e., public utility, hospital, light industry)
- Industrial (Medium and heavy)
- Old Age Home
- Residential (i.e., single family, multi-family)
- Bus Stop
- Parking Lot

**Rt 395 at Shirlington Circle in Arlington County, VA has 16 lanes where there are two sets of 3 lane service roads, a 2 lane HOV road, two 1 lane ramps, and two sets of 3 lane through traffic.

TABLE 25:
RANGES OF SITE CHARACTERISTICS (Continued)

CHARACTERISTIC	RANGE
Alternative "Safe" Crossing:	
Distance from GSPC	Immediately Next to GSPC to Greater than 1 mile
Type of Alternative	Traffic Signal or Roadway Over/Underpass
Type of Signal Hardware (if traffic signal)	Pedestrian Signal, Pushbutton, or None
Type of Pavement Markings (if traffic signal)	Crosswalk, Stopline, or None
Vehicle Volume on Roadway:	
Average Daily Traffic	11,800 to 186,700
Corresponding** 8 highest hrs	2,800 to 68,900 veh/8 hrs
Corresponding** 4 highest hrs	1,200 to 40,700 veh/4 hrs
Corresponding** highest hr	700 to 12,270 veh/hr
Pedestrian Volume:	
User - 8 highest hrs	7 to 2,507 ped/8 hrs
Nonuser - 8 highest hrs	0 to 441 ped/8 hrs
User - 4 highest hrs	3 to 1,947 ped/4 hrs
Nonuser - 4 highest hrs	0 to 257 ped/4 hrs
User - highest hr	3 to 970 ped/hr
Nonuser - highest hr	0 to 137 ped/hr
Ratio of GSPC Users to Total Pedestrians (Users & Nonusers) (from 8 hr values)	0.26 to 1.00 (No nonusers)

** = Vehicle traffic which conflicts with at-grade pedestrian crossings at each site and corresponds to the same hours of the day as the occurrence of the highest pedestrian volume.

TABLE 26: MEASURES OF SUCCESS FOR GSPC* SITES

REGION	OVERPASS RATIO	OVERPASS LOCATION	OVERPASS # USERS	OVERPASS # NONUSERS	UNDERPASS RATIO	UNDERPASS LOCATION	UNDERPASS # USERS	UNDERPASS # NONUSERS
East	100%	I-170 & Carrolton Ave (Baltimore)	402	0	100%	Rt 50 west of Glebe Rd (Arlington, VA)	85	0
	100%	Balt-Wash Pkwy near Greenbelt Rd (Greenbelt, MD)	183	0	100%	Rt 395 & 24th St (Dolly Madison Apts) (Arlington, VA)	81	0
	100%	Rt 495 north of Rt 66 (Fairfax Co, VA)	60	0	94%	Centerway Dr near Thomas Farm Rd (Gaithersburg, MD)	49	3
	100%	Geo. Wash. Pkwy Pkwy southernmost to Key Bridge (Glen Echo, MD)	48	0	50%	Watkins Mills Rd near Watkins Mills Elementary School (Gaithersburg, MD)	7	7
	100%	Rt 395 at Shirlington Circle (Arlington, VA)	47	0	44%	Shady Grove Rd & Mill Run Rd (Gaithersburg, MD)	11	14
	100%	Rt 495 at Wakefield Park (Fairfax Co, VA)	27	0	26%	Stedwick Rd near YWCA at Mont Village Mall (Gaithersburg, MD)	9	25
	99%	Rt 50 & Jackson St (Arlington, VA)	74	1				
	94%	Northern Pkwy near Clearspring Ave (Baltimore)	78	5				
	83%	Broening Hwy at GM Plant (Baltimore)	341	68				
	73%	Balt-Wash Pkwy & Maisel St (Baltimore)	939	346				
	69%	Northern Pkwy & Mt Pleasant Golf Course (Baltimore)	133	60				
	49%	Rt 395 EB Ramp & Kenmore Rd (Alexandria, VA)	59	61				

*All numerical values reflect 8 hour totals

TABLE 26: MEASURES OF SUCCESS FOR GSPC* SITES (Continued)

	OVERPASS				UNDERPASS			
REGION	RATIO	LOCATION	# USERS	# NONUSERS	RATIO	LOCATION	# USERS	# NONUSERS
Midwest	100%	Foothills Pkwy & Sioux Dr (Boulder)	983	0	100%	28th St College Ave (Boulder)	214	0
	100%	Foothills Pkwy near Emerson Ditch (Boulder)	371	0	99.7%	28th St & E Aurora Ave (Boulder)	1260	4
	97%	W Center Rd & 108th St (Omaha)	88	3	99.7%	Broadway south of Regency Dr (Univ of Co) (Boulder)	694	2
	82%	NW Radial & 56th St (Omaha)	184	40	98%	Broadway near Viele Ditch (Boulder)	120	2
	81%	Saddle Creek Rd & 50th St (Omaha)	248	60	72%	NW Radial & 52th St (Omaha)	191	36
	72%	72nd St & Western Ave (Omaha)	126	48				
	64%	W Center Rd & 87th St (Omaha)	362	200				
	54%	Center Rd & 48th St (Omaha)	124	106				
	34%	Happy Hollow & Dodge St (Omaha)	82	157				

*All numerical values reflect 8 hour totals

TABLE 26: MEASURES OF SUCCESS FOR GSPC* SITES (Continued)

	OVERPASS				UNDERPASS			
REGION	RATIO	LOCATION	# USERS	# NONUSERS	RATIO	LOCATION	# USERS	# NONUSERS
West	100%	Montlake Blvd NE near Pacific St (Seattle)	1907	0	100%	16th Ave S near E Marginal Way S (Seattle)	914	0
	92%	Aurora Ave N & 130th St N (Seattle)	208	18	99%	E Marginal Way S near 16th Ave S (Northerly) (Seattle)	2507	13
	77%	Holman Rd N & 13th Ave NW (Seattle)	79	24	98%	E Marginal Way S near 16th Ave S (Southerly) (Seattle)	1568	36
	42%	Empire Way S & Rainier Ave S (Seattle)	313	441	69%	Aurora Ave N & N 79th St (Seattle)	27	12

*All numerical values reflect 8 hour totals

TABLE 27: RANDOMLY STRATIFIED GSPC SITES*

CITY	DEVELOP CRITERIA/WARRANT	VALIDATE WARRANT
Baltimore, MD	• I-170 & Carrolton Ave (O/P) • Northern Pkwy near Clearspring Ave (O/P) • Northern Pkwy & Mt Pleasant Golf Course (O/P)	• Broening Hwy at GM Plant (O/P) • Balt-Wash Pkwy & Maisel St (O/P)
Boulder, CO	• 28th & College Ave (U/P) • Broadway near Viele Ditch (U/P) • Foothills Pkwy near Emerson Ditch (O/P)	• 28th St & E Aurora Ave (U/P) • Broadway south of Regency Dr (Univ of CO) (U/P) • Foothills Pkwy & Sioux Dr (O/P)
Omaha, NE	• Happy Hollow & Dodge St (O/P) • W Center Rd & 87th St (O/P) • NW Radial & 56th St (O/P) • NW Radial & 52nd St (U/P)	• Center Rd & 48th St (O/P) • 72nd St & Western Ave (O/P) • Saddle Creek Rd & 50th St (O/P) • W Center Rd & 108th St (O/P)
Seattle, WA	• E Marginal Way S near 16th Ave S (Northerly) (U/P) • Aurora Ave N & N 79th St (U/P) • Aurora Ave N & 130th St N (O/P) • Montlake Blvd NE near Pacific St (O/P)	• E Marginal Way S near 16th Ave S (Southerly) (U/P) • Holman Rd N & 13th Ave NW (O/P) • Empire Way S & Rainier Ave S (O/P) • 16th Ave S near E Marginal Way S (U/P)

*O/P = Overpass
U/P = Underpass

TABLE 27: RANDOMLY STRATIFIED GSPC SITES (Continued)

CITY	DEVELOP CRITERIA/WARRANT	VALIDATE WARRANT
Washington, DC Metropolitan Area	• Rt 395 at Shirlington Circle (Arlington, VA) (O/P) • Shady Grove Rd & Mill Run Rd (Gaithersburg, MD) (U/P) • Rt 50 & Jackson St (Arlington, VA) (O/P) • Rt 495 North of Rt 66 (Fairfax Co, VA) (O/P) • George Washington Pkwy southernmost to Key Bridge (Glen Echo, MD) (O/P) • Stedwick Rd near YMCA at Mont Village Mall (Gaithersburg, MD) (U/P)	• Rt 395 & 24th St (Dolly Madison Apts) (Arlington, VA) (U/P) • Watkins Mill Rd near Watkins Mill Elementary School (Gaithersburg, MD) (U/P) • Rt 50 west of Glebe Rd (Arlington, VA) (U/P) • Balt-Wash Pkwy near Greenbelt Rd (Greenbelt, MD) (O/P) • Rt 495 at Wakefield Park (Fairfax Co, VA) (O/P) • Centerway Dr near Thomas Farm Rd (Gaithersburg, MD) (U/P) • Rt 395 EB Ramp & Kenmore Ave (Alexandria, VA) (O/P)

APPENDIX E

CRITERIA/WARRANT DEVELOPMENT

AND VALIDATION STATISTICAL RESULTS

KEY TO TABLES

Letter (Number)

• Letter Code -

Degree of Success	User Volume 8 hour	4 hour	1 hour	Nonuser Volume 8 hour	4 hour	1 hour
S - Successful	Over 300	Over 200	Over 200	1-10	1-10	1-10
M - Moderate	61-300	61-200	31-200	11-40	11-40	11-20
U - Unsuccessful	1-60	1-60	1-30	Over 40	Over 40	Over 20
0 - Freeway Site	-	-	-	Zero	Zero	Zero
* - No Pattern	*	*	*	*	*	*

• Definition of degree of success from section 6.2 of this report -

Degree of Success	Ratio of Users to Total Pedestrians
Successful	0.95 to 1.00
Moderate	0.55 to 0.94
Unsuccessful	0.01 to 0.54

• Number Code -

Probability that the patterns were statistically signicant was based on the chi-square element distribution, [(expected value-observed value) square]. The higher values of the chi-square elements indicate stronger statistical significances.

TABLE 28: CRITERIA/WARRANT DEVELOPMENT STATISTICAL RESULTS

CHARACTERISTIC	STATISTICAL RESULTS				
• Surrounding Environment:					
1. Land Use Category -	Residential (Res.)	Commercial/ Industrial	Res./ Comm'l	Res./ Educ.	Res./ Recreatial
User Volume (8 hr)	S(11)	S/M(3)	U(4)	S/M(3)	U(7)
Nonuser Volume (8 hr)	S(2)	M(5)	S(1)	U(7)	M/U(6)
Ratio Users to Total Ped (8 hr)	S(3)	*	*	S/M(1)	U(1)
Predictor	S(7)	M(*)	M(*)	M(1)	U(1)
2. Land Use Density -	Light	Medium	Heavy		
User Volume (8 hr)	U(2)	*	S(10)		
Nonuser Volume (8 hr)	S(1)	M(2)	0(2)		
Ratio Users to Total Ped (8 hr)	S(1)	M(1)	S(1)		
Predictor	M(*)	M(1)	S(6)		
3. Policy of Nearby School on Use of GSPC -	Active	Passive	None		
User Volume (8 hr)	M(1)	S(5)	S(1)		
Nonuser Volume (8 hr)	*	U(5)	S(1)		
Ratio Users to Total Ped (8 hr)	U(3)	M(1)	*		
Predictor	*	M(1)	S(1)		
• GSPC Design Features:					
4. Artificial Lighting -	None	Inadequate	Adequate		
User Volume (8 hr)	S(2)	U(4)	M(1)		
Nonuser Volume (8 hr)	M/U(2)	S(4)	U(6)		
Ratio Users to Total Ped (8 hr)	M(1)	U(4)	S(1)		
Predictor	M(1)	*	M(*)		
5. Pedestrian Barrier -	Present	Not Present			
User Volume (8 hr)	S(19)	*			
Nonuser Volume (8 hr)	U(6)	*			
Ratio Users to Total Ped (8 hr)	*	*			
Predictor	M(*)	*			
6. Access/Approach to GSPC -	At-Grade	Ramp	Steps		
User Volume (8 hr)	U(0)	M(3)	U(2)		
Nonuser Volume (8 hr)	S(4)	U(3)	M(5)		
Ratio Users to Total Ped (8 hr)	S(1)	*	M(3)		
Predictor	S(1)	*	M(3)		

TABLE 28: CRITERIA/WARRANT DEVELOPMENT STATISTICAL RESULTS (Continued)

CHARACTERISTIC	STATISTICAL RESULTS					
• GSPC Design Features (Cont'd):						
7. Distance to Travel Using GSPC (ft) -	1-150	151-200	201-250	251-300	301-400	Over 400
User Volume (8 hr)	U(7)	M/U(3)	S/M(3)	*	S(11)	U(19)
Nonuser Volume (8 hr)	M(4)	M(5)	S(3)	M(2)	U(3)	O(10)
Ratio Users to Total Ped (8 hr)	M(0)	U(3)	S(2)	*	M(2)	S(4)
Predictor	M(0)	M(3)	S(2)	*	M(2)	S(4)
8. Distance to Travel At-grade (ft) -	1-50	51-100	101-200	201-400	Over 400	
User Volume (8 hr)	M(3)	M/U(1)	*	S/M(2)	U(11)	
Nonuser Volume (8 hr)	S/M(0)	S/M(0)	M(4)	S/M(1)	O(7)	
Ratio Users to Total Ped (8 hr)	U(3)	M(4)	U(3)	*	S(3)	
Predictor	*	M(1)	*	S(0)	S(3)	
9. Ratio of Distance Using GSPC to Crossing At-grade -	Freeway Site	0.01-0.74	0.75-1.00	1.01-1.50	1.51-2.00	Over 2.00
User Volume (8 hr)	U(29)	M(4)	M(7)	U(11)	M(*)	M(6)
Nonuser Volume (8 hr)	O(9)	M/U(1)	M(10)	M(2)	U(7)	M(2)
Ratio Users to total Ped (8 hr)	S(3)	S(1)	M(2)	U(11)	M(1)	M(2)
Predictor	S(3)	M(2)	M(8)	U(11)	M(1)	M(2)
• Roadway Features (being Crossed):						
10. Type of Roadway -	Freeway	Major Arterial	Local/Collector			
User Volume (8 hr)	U(11)	*	U(10)			
Nonuser Volume (8 hr)	O(7)	*	M(2)			
Ratio Users to Total Ped (8 hr)	S(3)	M(1)	U(10)			
Predictor	S(3)	*	U(10)			
11. Number of Lanes -	1/2	3/4	5	6	Over 6	
User Volume (8 hr)	U(11)	S(7)	M(7)	S(4)	U(4)	
Nonuser Volume (8 hr)	M(2)	O(4)	U(3)	M(4)	O(2)	
Ratio Users to Total Ped (8 hr)	U(11)	S(1)	U(1)	M(2)	*	
Predictor	U(11)	S(1)	M(1)	M(2)	*	
12. Refuge Median Width (ft) -	None(0)	3	4-11	11-25	Over 25	
User Volume (8 hr)	S(3)	*	M(2)	*	U(11)	
Nonuser Volume (8 hr)	M(1)	M(2)	U(16)	M/U(1)	O(7)	
Ratio Users to Total Ped (8 hr)	U(3)	M(12)	*	*	S(3)	
Predictor	M(2)	M(2)	U(*)	*	S(3)	

TABLE 28: CRITERIA/WARRANT DEVELOPMENT STATISTICAL RESULTS (Continued)

CHARACTERISTIC	STATISTICAL RESULTS					
• Roadway Features (being crossed) (Cont'd):						
13. Speed Limit (mph) -	25/30	35	40	45	45/55	
User Volume (8 hr)	U(10)	M(4)	*	*	U(19)	
Nonuser Volume (8 hr)	M(2)	M/U(5)	S/M(2)	O(2)	O(10)	
Ratio Users to Total Ped (8 hr)	U(10)	M(5)	*	*	S(4)	
Predictor	U(10)	M(5)	*	S(*)	S(4)	
14. Truck Route -	Yes	No				
User Volume (8 hr)	*	M(1)				
Nonuser Volume (8 hr)	*	S/M(1)				
Ratio Users to Total Ped (8 hr)	M(1)	M(1)				
Predictor	*	M(*)				
• Alterative "Safe" Crossing:						
15. Distance from GSPC (ft) -	Zero (0)	1-250	251-400	401-750	751-2640	Over 2640
User Volume (8 hr)	*	U(19)	S(3)	S(11)	M(1)	U(19)
Nonuser Volume (8 hr)	M(5)	M(5)	S(19)	U(10)	S(4)	O(5)
Ratio Users to Total Ped (8 hr)	U(2)	U(3)	*	M(2)	S(4)	S(2)
Predictor	M(*)	U(3)	S(10)	M(2)	S(4)	S(2)

16. Type of Alternative -	Traffic Signal	Roadway Over/Underpass
User Volume (8 hr)	*	U(32)
Nonuser Volume (8 hr)	*	O(4)
Ratio Users to Total Ped (8 hr)	*	S(1)
Predictor	*	M(*)

17. Type of Signal Hardware (if traffic signal) -	None	Pedestrian Heads	Heads & Pushbuttons
User Volume (8 hr)	M(2)	M/U(2)	M/U(1)
Nonuser Volume (8 hr)	M(1)	U(12)	*
Ratio Users to Total Ped (8 hr)	U(3)	*	M(1)
Predictor	M(1)	U(*)	M(1)

18. Type of Pavement Markings (if traffic signal) -	Crosswalk	Stopline (Vehicle)	Both
User Volume (8 hr)	M(*)	M/U(*)	U(*)
Nonuser Volume (8 hr)	S/M(*)	*	S(*)
Ratio Users to Total Ped (8 hr)	M/U(*)	U(*)	M(*)
Predictor	M(*)	M(*)	*

TABLE 28: CRITERIA/WARRANT DEVELOPMENT STATISTICAL RESULTS (Continued)

CHARACTERISTIC	STATISTICAL RESULTS						
• Vehicle Volume on Roadway:							
19. Average Daily Traffic (1,000 veh) -	0-14.4	14.4-20.8	20.8-25	25-35	35-60	Over 60	
User Volume (8 hr)	U(10)	S(3)	M(*)	M(*)	S(11)	U(19)	
Nonuser Volume (8 hr)	M(2)	U(6)	*	U(3)	S(2)	O(5)	
Ratio Users to Total Ped (8 hr)	U(10)	S/M(1)	M/U(3)	M/U(2)	S(3)	S(2)	
Predictor	U(10)	M(1)	M(*)	M(2)	S(3)	S(2)	
20. Corresponding** 8 highest hours (1,000 veh/8 hrs)-	0-6	6-10	10-12.5	12.5-15	15-20	20-40	Over 40
User Volume (8 hr)	U(3)	*	M(12)	M/U(3)	M(2)	U(3)	U(19)
Nonuser Volume (8 hr)	S(0)	M/U(3)	M(2)	M(16)	S/M(1)	O(5)	O(5)
Ratio Users to Total Ped (8 hr)	U(3)	U(1)	M(4)	M/U(1)	M/U(2)	S(2)	S(2)
Predictor	U(3)	U(1)	M(4)	M(1)	M(2)	S(2)	S(2)
21. Corresponding** 4 highest hours (1,000 veh/4 hrs)-	0-3	3-7.5	7.5-10	10-20	Over 20		
User Volume (4 hr)	U(5)	M(2)	S/M(3)	S(5)	U(1)		
Nonuser Volume (4 hr)	M(1)	*	M(3)	O(1)	O(2)		
Ratio Users to Total Ped (8 hr)	U(3)	S/M(2)	M(2)	S(3)	S(2)		
Predictor	U(4)	M(2)	M(3)	S(4)	S(2)		
22. Corresponding** highest hour (vph) -	1-600	601-1,500	1,501-2,000	2,001-3,000	Over 3,000		
User Volume (1 hr)	M(1)	M(1)	M/U(1)	U(1)	*		
Nonuser Volume (1 hr)	S(0)	S(0)	M/U(5)	S(1)	S(3)		
Ratio Users to Total Ped Ped (8 hr)	*	*	M/U(2)	S/M(1)	S(5)		
Predictor	M(1)	M(1)	*	M(*)	S(4)		
• Pedestrian Volume:							
23. User Volume (8 highest hrs) -	1-30	31-60	61-100	101-300	301-1,000	Over 1,000	
Nonuser Volume (8 hr)	M(7)	O(7)	U(2)	M/U(6)	M/U(3)	S/M(1)	
Ratio Users to Total Ped (8 hr)	U(11)	S(3)	M/U(1)	M(4)	S/M(1)	S(3)	
Predictor	U(2)	*	U(1)	M(5)	M(2)	S(2)	

** = Vehicle traffic which conflicts with at-grade crossings at each site and corresponds to the same hours of the day as the occurrence of the highest pedestrian volumes.

TABLE 28: CRITERIA/WARRANT DEVELOPMENT STATISTICAL RESULTS (Continued)

CHARACTERISTIC	STATISTICAL RESULTS						
• Pedestrian Volume (Cont'd):							
24. User Volume (4 highest hrs) - Nonuser Volume (4 hr)	1-30 / M(1)	31-60 / S(2)	61-100 / M/U(6)	101-200 / M/U(0)	201-300 / M/U(0)	301-800 / S/M(0)	Over 800 / S/M(0)
Ratio Users to Total Ped (8 hr)	U(4)	M/U(1)	M(4)	M(2)	M/U(1)	S(1)	S(2)
Predictor	U(2)	*	M(*)	M(1)	M(*)	S(0)	S(0)
25. User Volume (highest hr) - Nonuser Volume (1 hr)	1-9 / S(0)	10-20 / S(0)	21-30 / S(0)	31-50 / M(1)	51-100 / M(1)	101-250 / U(2)	Over 250 / U(2)
Ratio Users to Total Ped (8 hr)	U(7)	S(2)	S/M(1)	S/M(1)	*	S/M(1)	S/M(1)
Predictor	*	S(1)	S(0)	M(1)	*	*	*

TABLE 29: WARRANT VALIDATION STATISTICAL RESULTS

CHARACTERISTIC	STATISTICAL RESULTS				
• Surrounding Environment:					
1. Land Use Category -	Residential (Res)	Commercial/ Industrial	Res/ Comm'l	Res/ Educational	Res/ Recreat'l
User Volume (8 hr)	U/M(6)	S(10)	M/U(1)	M/S(1)	M(3)
Nonusers Volume (8 hr)	S(2)	M(3)	U(5)	S(2)	S(3)
Ratio Users to Total Ped (8 hr)	*	S/M(1)	U(2)	*	S(1)
Predictor	*	S(6)	U(3)	S(1)	S(0)
2. Land Use Density -	Light	Median	Heavy		
User Volume (8 hr)	M/U(3)	*	S(3)		
Nonuser Volume (8 hr)	S(3)	M(*)	U(10)		
Ratio Users to Total Ped (8 hr)	*	*	M(3)		
Predictor	*	*	M(*)		
3. Policy of Nearby School on Use of GSPC -	Active	Passive	None		
User Volume (8 hr)	M(1)	S(3)	*		
Nonuser Volume (8 hr)	U(3)	U(8)	*		
Ratio Users to Total Ped (8 hr)	U(*)	M(3)	*		
Predictor	U(2)	M(*)	*		
• GSPC Design Features:					
4. Artificial Lighting -	None	Inadequate	Adequate		
User Volume (8 hr)	S/M(2)	U(5)	S(3)		
Nonuser Volume (8 hr)	U(4)	S(5)	M(1)		
Ratio Users to Total Ped (8 hr)	M(1)	*	S(1)		
Predictor	M(1)	S(1)	S(2)		
5. Pedestrian Barrier -	Present	Not Present			
User Volume (8 hr)	*	*			
Nonuser Volume (8 hr)	*	*			
Ratio User to Total Ped (8 hr)	*	*			
Predictor	*	*			
6. Access/Approach to GSPC -	At-Grade	Ramp	Steps		
User Volume (8 hr)	U(2)	S/M(2)	M(6)		
Nonuser Volume (8 hr)	S(4)	U(1)	M(1)		
Ratio Users to Total Ped (8 hr)	*	U(1)	S/M(2)		
Predictor	M(*)	U(1)	M(3)		

TABLE 29: WARRANT VALIDATION STATISTICAL RESULTS (Continued)

CHARACTERISTIC	STATISTICAL RESULTS					
• GSPC Design Features (Cont'd):						
7. Distance to Travel Using GSPC (ft) -	1-150	151-200	201-250	251-300	301-400	Over 400
User Volume (8 hr)	U(16)	M(2)	M(*)	M(1)	U(*)	M(10)
Nonuser Volume (8 hr)	S(9)	M(6)	S(2)	U(1)	M(3)	S(10)
Rates Users to Total Ped (8 hr)	U(2)	M(7)	M(1)	U(1)	*	S(3)
Predictor	U(3)	M(5)	M(0)	U(1)	M(*)	S(3)
8. Distance to Travel At-grade (ft) -	1-50	51-100	101-200	201-400	Over 400	
User Volume (8 hr)	*	U(2)	M(1)	M(*)	M(10)	
Nonuser Volume (8 hr)	M(8)	U(7)	M(*)	S(1)	S(10)	
Ratio Users to Total Ped (8 hr)	*	M(1)	*	*	S(3)	
Predictor	M(*)	U(4)	M(*)	S(0)	S(3)	
9. Ratio of Distance Using GSPC to Crossing At-grade -	Freeway Site	0.01-0.74	0.75-1.00	1.01-1.50	1.51-2.00	Over 2.00
User Volume (8 hr)	M(3)	S(5)	*	U(6)	S(2)	U(6)
Nonuser Volume (8 hr)	S(10)	S(1)	*	U(13)	S(2)	M(2)
Ratio Users to Total Ped (8 hr)	S(3)	S/M (1)	*	U(13)	M(1)	U(4)
Predictor	S(4)	S(1)	*	U(11)	S(2)	U(4)
• Roadway Features (being crossed):						
10. Type of Roadway (being crossed) -	Freeway		Major Arterial		Local/Collector	
User Volume (8 hr)	M(1)		S(1)		U(3)	
Nonuser Volume (8 hr)	S(5)		U(2)		S/M(4)	
Ratio Users to Total Ped (8 hr)	S/M(2)		*		M/U(3)	
Predictor	S(3)		M(*)		*	
11. Number of Lanes -	1/2	3/4	5	6	Over 6	
User Volume (8 hr)	U(16)	M(2)	*	S(1)	M(2)	
Nonuser Volume (8 hr)	U(6)	S(2)	M(5)	S(1)	U(3)	
Ratio Users to Total Ped (8 hr)	U(6)	M(2)	U(1)	S(1)	U(2)	
Predictor	U(9)	M(1)	M(3)	S(1)	U(1)	
12. Refuge Median Width (ft) -	0(None)	1-3	4-11	11-25	Over 25	
User Volume	M(2)	M(2)	M(2)	S(3)	M(1)	
Nonuser volume (8 hr)	M(4)	M(1)	S(1)	S(3)	M(1)	
Ratio Users to Total Ped (8 hr)	U(7)	S/M(1)	M(1)	S(3)	S/M(1)	
Predictor	M(*)	M(1)	M(1)	S(3)	M(1)	

TABLE 29: WARRANT VALIDATION STATISTICAL RESULTS (Continued)

CHARACTERISTIC — STATISTICAL RESULTS

• Roadway Features (being crossed)(Cont'd):

13. Speed Limit (mph) -	25/30	35	40	45	50/55
User Volume (8 hr)	U(16)	U(1)	S(5)	M(4)	M(1)
Nonuser Volume (8 hr)	S(9)	U(8)	U(4)	S(2)	S(5)
Ratio Users Total Ped (8 hr)	U(2)	M(3)	U(2)	S(4)	S/M(2)
Predictor	U(*)	U(3)	U(*)	S(2)	S(2)

14. Truck Route -	Yes	No
User Volume (8 hr)	M(1)	U(3)
Nonuser Volume (8 hr)	U(1)	S(3)
Ratio Users to Total Ped (8 hr)	*	*
Predictor	M(*)	M(*)

• Alternative "Safe" Crossing:

15. Distance from GSPC (ft) -	Zero (0)	1-250	251-400	401-750	751-2640	Over 2640
User Volume (8 hr)	S(2)	M(*)	U(16)	M(*)	M(3)	M(3)
Nonusers Volume (8 hr)	M(5)	U(1)	U(3)	S(2)	O(3)	O(10)
Ratio Users to Total Ped (8 hr)	M(1)	M(3)	U(2)	S(1)	S(1)	S(3)
Predictor	M(3)	M(*)	U(6)	S(1)	S(1)	S(3)

16. Type of Alternative -	Traffic Signal	Roadway Over/Underpass
User Volume (8 hr)	S/M(1)	M(5)
Nonuser Volume (8 hr)	U(1)	O(8)
Ratio Users to Total Ped (8 hr)	*	S(2)
Predictor	M(*)	S(2)

17. Type of Signal Hardware (if traffic signal) -	None	Pedestrian Heads	Heads & Pushbuttons
User Volume (8 hr)	M(2)	*	M(5)
Nonuser Volume (8 hr)	U(1)	*	S(7)
Ratio Users to Total Ped (8 hr)	M(2)	*	S(2)
Predictor	M(2)	*	S(2)

18. Type of Pavement Markings (if traffic signal) -	Crosswalk	Stopline(Vehicle)	Both
User Volume (8 hr)	S(4)	M(1)	M(3)
Nonuser Volume (8 hr)	*	M/U(1)	S(1)
Ratio Users to Total Ped (8 hr)	S/M(1)	*	*
Predictor	S(2)	M(1)	M(*)

TABLE 29: WARRANT VALIDATION STATISTICAL RESULTS (Continued)

CHARACTERISTIC / **STATISTICAL RESULTS**

- Vehicle Volume on Roadway:

19. Average Daily Traffic (1,000 veh) -

Average Daily Traffic (1,000 veh)	0-14.4	14.4-20.8	20.8-25	25-35	35-60	Over 60
User Volume (8 hr)	U(19)	S(3)	M(2)	M(1)	S(3)	M(3)
Nonuser Volume (8 hr)	S(4)	U(6)	M(6)	S(4)	U(1)	O(10)
Ratio Users to Total Ped (8 hr)	U(7)	U(1)	M(1)	S/M(1)	S/M(1)	S(3)
Predictor	U(7)	M(*)	M(2)	S(1)	S(1)	S(3)

20. Corresponding ** 8 highest hours (1,000 veh/8 hrs) -

Corresponding ** 8 highest hours (1,000 veh/8 hrs)	0-6	6-10	10-12.5	12.5-15	15-20	20-40	Over 40
User Volume (8 hr)	U(15)	U(2)	S(16)	M(2)	S(7)	M(1)	M(2)
Nonuser Volume (8 hr)	S(9)	U(26)	M(6)	U(4)	S(1)	U(1)	O(7)
Ratio Users to Total Ped (8 hr)	U(2)	U(4)	S(2)	S/M(3)	S(2)	*	S(2)
Predictor	U(2)	U(10)	S(7)	M(3)	S(3)	M(*)	S(2)

21. Corresponding ** 4 highest hours (1000 veh/4 hrs) -

Corresponding ** 4 highest hours (1000 veh/4 hrs)	0-3	3-7.5	7.5-10	10-20	Over 20
User Volume (4 hr)	U(8)	M(2)	S(3)	*	*
Nonuser Volume (4 hr)	S(5)	M(2)	M(1)	*	O(3)
Ratio Users to Total Ped (8 hr)	U(2)	U(2)	M(1)	S(1)	S(2)
Predictor	U(2)	M(1)	M(0)	S(*)	S(2)

22. Corresponding ** highest hour (vph) -

Corresponding ** highest hour (vph)	1-600	601-1,500	1,501-2,000	2,001-3,000	Over 3,000
User Volume (1 hr)	M/U(1)	U(2)	S/M(2)	*	M(2)
Nonuser Volume (1 hr)	U(2)	U(3)	M(4)	*	O(4)
Ratio Users to Total Ped (8 hr)	M(3)	U(13)	M(5)	S(3)	S(5)
Predictor	M(0)	U(6)	M(4)	S(*)	S(3)

** Vehicle traffic which conflicts with at-grade crossings at each site and correspond to the same hour of the day as the occurrence of the highest pedestrian values.

TABLE 29: WARRANT VALIDATION STATISTICAL RESULTS (Continued)

• Pedestrian Volume:

23. User Volume (8 highest hrs) -	1-30	31-60	61-100	101-300	301-1,000	Over 1,000
Nonuser Volume (8 hr)	S(5)	U(2)	S/M(2)	M(*)	U(3)	M(15)
Ratio Users to Total Ped Ped (8 hr)	U(6)	U(2)	S(1)	*	*	S(1)
Predictor	*	U(2)	S(1)	M(*)	U(*)	M(8)

24. User Volume (4 highest hrs) -	1-30	31-60	61-100	101-200	201-300	301-800	Over 800
Nonuser Volume (4 hr)	S(2)	S(2)	M(3)	*	*	*	*
Ratio Users to Total Ped (8 hr)	U(6)	*	M(1)	S/M(1)	U(2)	S(1)	S(1)
Predictor	M(*)	S(*)	M(2)	M(*)	U(*)	S(*)	S(*)

25. User Volume (highest hr) -	1-9	10-20	21-30	31-50	51-100	101-250	Over 250
Nonuser Volume (1 hr)	S/M(*)	S/M(*)	S(1)	S(1)	S/M(*)	U(2)	U(2)
Ratio Users to Total Ped (8 hr)	U(6)	U(2)	M(10)	S(3)	*	*	S(2)
Predictor	U(*)	M(*)	M(5)	S(2)	M(*)	U(*)	M(*)

APPENDIX F

COMPARISON OF CANDIDATE

WARRANTS WITH VALIDATION

OVER/UNDERPASSES

TABLE 30:
RANKING OF GSPC SITES FOR VALIDATION

	GSPC SITE	RATIO	USER	NONUSER*
1	Foothills Pkwy & Sioux Dr (Boulder)	100%	983	0
2	16th Ave S near E Marginal Way S (Seattle)	100%	914	0
3	Balt-Wash Pkwy near Greenbelt Rd (Wash Metro)	100%	183	0
4	Rt 50 West of Glebe Rd (Wash Metro)	100%	85	0
5	Rt 395 & 24th St (D Madison Apts) (Wash Metro)	100%	81	0
6	Rt 495 at Wakefield Park (Wash Metro)	100%	27	0
7	28th St & E Aurora Ave (Boulder)	99.7%	1260	4
8	Broadway south of Regency Dr (Boulder)	99.7%	694	2
9	E Marginal Way S near 16th S (South) (Seattle)	98%	1568	36
10	W Center Rd & 108th St (Omaha)	97%	88	3
11	Centerway Dr near Thomas Farm School (Wash Metro)	94%	49	3
12	Broening Hwy at GM Plant (Baltimore)	83%	341	68
13	Saddle Creek Rd & 50th St (Omaha)	81%	248	60
14	Holman Rd N & 13th Ave NW (Seattle)	77%	79	24
15	Balt-Wash Pkwy & Maisel St (Baltimore)	73%	939	346
16	72nd St & Western Ave (Omaha)	72%	126	48
17	Center Rd & 48th St (Omaha)	54%	124	106
18	Watkins Mills Rd near school (Wash Metro)	50%	7	7
19	Rt 495 EB Ramp & Kenmore Rd (Wash Metro)	49%	59	61
20	Empire Way S & Rainier Ave S (Seattle)	42%	313	441

* For reader information and not used as a tie breaker when the ratios of users to total pedestrians are equal

TABLE 31:
VICTORIA'S EXPOSURE INDEX RANKING

RANKING	GSPC SITE	(V)* VEHICLE VOLUME	(P)* PEDESTRIAN VOLUME	TWO-WAY	DIVIDED/ UNDIVIDED	INDEX (VxP)	INDEX RANKING
1	Foothills Pkwy & Sioux Dr (Boulder)	2,490	68	X	D	169,320	11
2	16th Ave S near E Marginal Way S (Seattle)**	2,060	284	X	UD	585,040	2
3	Balt-Wash Pkwy near Greenbelt Road (Wash Metro)	4,525	55	X	D	248,875	8
4	Rt 50 West of Glebe Rd (Wash Metro)**	4,211	25	X	D	105,275	15
5	Rt 395 & 24th St (D Madison Apts) (Wash Metro)**	12,270	20	X	D	245,400	9
6	Rt 495 at Wakefield Park (Wash Metro)	8,280	45	X	D	372,600	4
7	28th St & E Aurora Ave (Boulder)**	3,250	162	X	UD	526,500	3
8	Broadway south of Regency Dr (Boulder)**	2,740	123	X	D	337,020	5
9	E Marginal Way S near 16th S (South) (Seattle)**	2,100	991	X	UD	2,081,100	1
10	W Center Rd & 108th St (Omaha)	2,528	50	X	D	126,400	12
11	Centerway Dr near Thomas Farm School(Wash Metro)**	305	32	X	D	9,760(NG)	19
12	Broening Hwy at GM Plant (Baltimore)	1,664	187	X	UD	311,168	6
13	Saddle Creek Rd & 50th St (Omaha)	1,849	64	X	D	118,336	13
14	Holman Rd N & 13th Ave NW (Seattle)	2,122	31	X	UD	65,782(NG)	17
15	Balt-Wash Pkwy & Maisel St (Baltimore)	310	372	X	D	115,320	14
16	72nd St & Western Ave (Omaha)	1,536	47	X	D	72,192(NG)	16
17	Center Rd & 48th St (Omaha)	1,815	111	X	UD	201,465(NG)	10
18	Watkins Mills Rd near school (Wash Metro)**	455	5	X	UD	2,275(NG)	20
19	Rt 495 EB Ramp & Kenmore Rd (Wash Metro)	700	30	No	UD	21,000(NG)	18
20	Empire Way S & Rainier Ave S (Seattle)	1,400	217	X	UD	303,800	7

* 1 hr total for vehicle and pedestrian (users and nonusers) volumes
** Underpass GSPC site (all other sites are overpasses)
NG = No good in that index is less than 100,000 for divided roadways or index is less than 280,000 for undivided roadways

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TABLE 32:
OMAHA'S EXPOSURE INDEX RANKING

RANKING	GSPC SITE	V (ADT/10^k)	(P)* PEDESTRIAN VOLUME	(S) SPEED (MPH/30)	NO.OF LANES	K FACTOR	INDEX (VxPxSxK)	INDEX RANKING
1	Foothills Pkwy & Sioux Dr (Boulder)	23.4	68	1.50	4	2	4,774	15
2	16th Ave S near E Marginal Way S (Seattle)**	18.6	284	1.33	4	2	14,051	7
3	Balt-Wash Pkwy near Greenbelt Rd (Wash Metro)	68.4	55	1.83	4	2	13,769	8
4	Rt 50 West of Glebe Rd (Wash Metro)**	55.4	25	1.50	8	3	6,233	13
5	Rt 395 & 24th St (D Madison Apts) (Wash Metro)**	186.7	20	1.83	10	3	20,500	5
6	Rt 495 at Wakefield Park (Wash Metro)	134.9	45	1.83	6	3	33,327	3
7	28th St. & E Aurora Ave (Boulder)**	36.1	162	1.50	6	3	26,317	4
8	Broadway south of Regency Dr (Boulder)**	29.0	123	1.17	5	3	12,520	9
9	E Marginal Way S near 16th S (South) (Seattle)**	18.6	991	1.33	5	3	73,546	2
10	W Center Rd & 108th St (Omaha)	28.7	50	1.50	5	3	6,458	12
11	Centerway Dr near Thomas Farm School(Wash Metro)**	6.6	32	0.83	4	2	351	18
12	Broening Hwy at GM Plant (Baltimore)	18.6	187	1.17	4	2	8,139	11
13	Saddle Creek Rd & 50th St (Omaha)	16.6	64	1.17	5	3	3,729	16
14	Holman Rd N & 13th Ave NW (Seattle)	24.7	31	1.17	5	3	2,688	17
15	Balt-Wash Pkwy & Maisel St (Baltimore)	50.7	372	1.83	6	3	103,544	1
16	72nd St & Western Ave (Omaha)	29.7	47	1.33	3	3	5,570	14
17	Center Rd & 48th St (Omaha)	19.1	111	1.33	5	3	8,459	10
18	Watkins Mills Rd near school (Wash Metro)**	6.8	5	0.83	5	3	85	20
19	Rt 495 EB Ramp & Kenmore Rd (Wash Metro)	11.8	30	1.17	2	1	152	19
20	Empire Way S & Rainier Ave S (Seattle)	16.5	217	1.33	13	3	14,286	6

* 1 hr total for vehicle and pedestrian (users and nonusers) volumes
** Underpass GSPC site (all other sites are overpasses)

TABLE 33:
SEATTLES'/MASSACHUSETTS' PRIORITY RANKING WARRANTS

RANKING	GSPC SITE	VEHICLE PEDESTRIAN VOLUME**	CORRECTABLE ACCIDENTS	ADULT CROSSING GUARD	CROSS WALK	ELEM SCHOOL	LESS FOR REFUGE MEDIAN	SUB TOTAL POINT
1	Foothills Pkwy & Sioux Dr (Boulder)	20(24/0.9%)	5 (1)	-	-	10***	(-4)	3
2	16th Ave S near E Marginal Way S (Seattle)*	37(20/4.7%)	-	-	-	-	--	37
3	Balt-Wash Pkwy near Greenbelt Rd (Wash Metro)	40(69/0.25%)	-	-	-	10***	--	50
4	Rt 50 West of Glebe Rd (Wash Metro)*	25(55/0.15%)	5 (1)	-	10	-	--	40
5	Rt 395 & 24th St (D Madison Apts) (Wash Metro)*	40(187/0.05%)	-	-	-	-	--	40
6	Rt 495 at Wakefield Park (Wash Metro)	40(135/0.2%)	-	-	-	10	--	40
7	28th St. & E Aurora Ave (Boulder)*	40(37/2.7%)	-	-	10	-	(-4)	46
8	Broadway south of Regency Dr (Boulder)*	40(30/2.5%)	-	-	10	10***	(-4)	56
9	E Marginal Way S near 16th S (South) (Seattle)*	40(20/7.9%)	--	-	-	-	(-2)	38
10	W Center Rd & 108th St (Omaha)	14(29/0.3%)	-	-	10	10	(-4)	30
11	Centerway Dr near Thomas Farm School(Wash Metro)*	3(7/0.8%)	-	-	-	10	(-4)	9
12	Broening Hwy at GM Plant (Baltimore)	19(19/2.2%)	-	-	10	-	--	29
13	Saddle Creek Rd & 50th St (Omaha)	17(17/1.8%)	-	-	10	10	(-2)	35
14	Holman Rd N & 13th Ave NW (Seattle)	12(25/0.4%)	5 (1)	-	-	10	(-2)	25
15	Balt-Wash Pkwy & Maisel St (Baltimore)	40(52/2.5%)	15 (3)	-	-	10	--	65
16	72nd St & Western Ave (Omaha)	25(30/0.8%)	-	-	-	10***	(-2)	33
17	Center Rd & 48th St (Omaha)	13(19/0.9%)	-	10	-	10***	--	33
18	Watkins Mills Rd near school (Wash Metro)*	2(7/0.2%)	-	-	-	10	--	12
19	Rt 495 EB Ramp & Kenmore Rd (Wash Metro)	8(12/1.0%)	5 (1)	-	10	***	--	23
20	Empire Way S & Rainier Ave S (Seattle)	27(17/4.4%)	-	-	-	***	(-2)	25

* Underpass GSPC site (all other sites are overpasses)

** Points from Table 34 where in parentheses the first value is the combined ADT and 8 hr pedestrian (users and nonusers) volume in units of 1,000s and second value is the percent of pedestrian volume to the combined volume

*** Junior/senior high school present, therefore add 5 points for Massachusetts DPW's assigned point warrant only

TABLE 33:
SEATTLES'/MASSACHUSETTS' PRIORITY RANKING WARRANTS (Continued)

RANKING	GSPC SITE	ROAD(1) WIDTH	POOR SIGHT DISTANCE	LAND USE(2) DEVELOP'T	HIGH(3) SPEED	ALTERNATIVE CROSSING	TOTAL(4) OTHER
1	Foothills Pkwy & Sioux Dr (Boulder)	7	-	-	6(45)	-	13
2	16th Ave S near E Marginal Way S (Seattle)*	6	-	8	4(40)	-	15
3	Balt-Wash Pkwy near Greenbelt Rd (Wash Metro)	6	-	-	20(55)	5(none)	15
4	Rt 50 West of Glebe Rd (Wash Metro)*	11	12	4	6(45)	-	15
5	Rt 395 & 24th St (D Madison Apts) (Wash Metro)*	14	-	4	10(55)	5(none)	15
6	Rt 495 at Wakefield Park (Wash Metro)	9	-	-	10(55)	5(none)	15
7	28th St. & E Aurora Ave (Boulder)*	9	-	4	6(45)	-	15
8	Broadway south of Regency Dr (Boulder)*	9	12	4	2(35)	-	15
9	E Marginal Way S near 16th S (South) (Seattle)*	7	-	8	4(40)	-	15
10	W Center Rd & 108th St (Omaha)	7	-	4	6(45)	-	15
11	Centerway Dr near Thomas Farm School(Wash Metro)*	6	-	-	-	-	6
12	Broening Hwy at GM Plant (Baltimore)	6	-	8	2(35)	-	15
13	Saddle Creek Rd & 50th St (Omaha)	7	-	4	2(35)	-	13
14	Holman Rd N & 13th Ave NW (Seattle)	7	6	4	2(35)	-	15
15	Balt-Wash Pkwy & Maisel St (Baltimore)	7	-	8	10(55)	-	15
16	72nd St & Western Ave (Omaha)	5	-	-	4(40)	-	9
17	Center Rd & 48th St (Omaha)	7	-	5	4(40)	-	11
18	Watkins Mills Rd near school (Wash Metro)*	7	6	-	-	-	13
19	Rt 495 EB Ramp & Kenmore Rd (Wash Metro)	3	-	4	2(35)	-	9
20	Empire Way S & Rainier Ave S (Seattle)	16	-	8	2(40)	-	15

* Underpass GSPC site (all other sites are overpasses)
(1) 2 points for each 10 feet of roadway width
(2) 8 points for heavy development and 4 points for median development
(3) 2 points for 35 mph and 2 additional points for each 5 mph above 35 mph
(4) Up to 15 points maximum

TABLE 33:
SEATTLES'/MASSACHUSETTS' PRIORITY RANKING WARRANTS (Continued)

RANKING	GSPC SITE	SEATTLE TOTAL POINTS	SEATTLE RANKING	MASS TOTAL ** POINTS	MASS RANKING
1	Foothills Pkwy & Sioux Dr (Boulder)	44	12/13/14	49**	10/11
2	16th Ave S near E Marginal Way S (Seattle)*	52	9	52	9
3	Balt-Wash Pkwy near Greenbelt Rd (Wash Metro)	65	3	70**	3
4	Rt 50 West of Glebe Rd (Wash Metro)*	55	5/6/7	55	5/6/7
5	Rt 395 & 24th St (D Madison Apts) (Wash Metro)*	55	5/6/7	55	5/6/7
6	Rt 495 at Wakefield Park (Wash Metro)	55	5/6/7	55	5/6/7
7	28th St. & E Aurora Ave (Boulder)*	61	4	61	4
8	Broadway south of Regency Dr (Boulder)*	71	2	76**	2
9	E Marginal Way S near 16th S (South) (Seattle)*	53	8	53	8
10	W Center Rd & 108th St (Omaha)	45	11	45	14/15
11	Centerway Dr near Thomas Farm School(Wash Metro)*	15	20	15	20
12	Broening Hwy at GM Plant (Baltimore)	44	12/13/14	44	16
13	Saddle Creek Rd & 50th St (Omaha)	48	10	48	12
14	Holman Rd N & 13th Ave NW (Seattle)	40	16/17	40	17
15	Balt-Wash Pkwy & Maisel St (Baltimore)	80	1	80	1
16	72nd St & Western Ave (Omaha)	42	15	47**	13
17	Center Rd & 48th St (Omaha)	44	12/13/14	49**	10/11
18	Watkins Mills Rd near school (Wash Metro)*	25	19	25	19
19	Rt 495 EB Ramp & Kenmore Rd (Wash Metro)	32	18	37**	18
20	Empire Way S & Rainier Ave S (Seattle)	40	16/17	45**	14/15

* Underpass GSPC site (all other sites are overpasses)
** Add five points for junior/senior high school for Massachusetts DPW's warrant

TABLE 34:
NEW JERSEY'S PRIORITY RANKING WARRANTS

RANKING	GSPC SITE	ADT FOR PEDESTRIAN[1]	ADT FOR VEHICLE[2]	TOTAL VOLUME	% PED	PED-VEH POINTS[3]	PEAK HR DELAY FACTOR	SUB TOTAL POINTS
1	Foothills Pkwy & Sioux Dr (Boulder)	250	23,400	23.7	1.06%	20	0.12	40
2	16th Ave S near E Marginal Way S (Seattle)*	1,030	18,600	19.6	5.25%	37	0.20	74
3	Balt-Wash Pkwy near Greenbelt Rd (Wash Metro)	225	68,400	68.6	0.33%	40	0.15	80
4	Rt 50 West of Glebe Rd (Wash Metro)*	105	55,400	55.5	0.19%	25	0.12	50
5	Rt 395 & 24th St (D Madison Apts) (Wash Metro)*	95	186,700	186.8	0.05%	40	0.15	80
6	Rt 495 at Wakefield Park (Wash Metro)	335	134,900	135.2	0.25%	40	0.15	80
7	28th St. & E Aurora Ave (Boulder)*	1,215	36,100	37.3	3.26%	40	0.12	80
8	Broadway south of Regency Dr (Boulder)*	835	29,000	29.8	2.80%	40	0.20	80
9	E Marginal Way S near 16th S (South) (Seattle)*	1,685	18,600	20.3	8.31%	40	0.20	80
10	W Center Rd & 108th St (Omaha)	110	28,700	28.8	0.38%	14	0.20	28
11	Centerway Dr near Thomas Farm School(Wash Metro)*	55	6,600	6.7	0.83%	3	0.06	6
12	Broening Hwy at GM Plant (Baltimore)	455	18,600	19.1	2.39%	19	0.20	38
13	Saddle Creek Rd & 50th St (Omaha)	370	16,600	17.0	2.18%	17	0.20	34
14	Holman Rd N & 13th Ave NW (Seattle)	115	24,700	24.8	0.46%	12	0.08	24
15	Balt-Wash Pkwy & Maisel St (Baltimore)	1,460	50,700	52.2	2.80%	40	0.15	80
16	72nd St & Western Ave (Omaha)	270	29,400	29.7	0.90%	25	0.04	50
17	Center Rd & 48th St (Omaha)	195	19,100	19.3	1.01%	13	0.20	26
18	Watkins Mills Rd near school (Wash Metro)*	20	6,800	6.8	0.29%	2	0.00	4
19	Rt 495 EB Ramp & Kenmore Rd (Wash Metro)	140	11,800	11.9	1.17%	8	0.08	16
20	Empire Way S & Rainier Ave S (Seattle)	895	16,500	17.4	5.15%	27	0.20	54

* Underpass GSPC site (all other sites are overpasses)

(1) 8 highest hours of pedestrian volume (users and nonusers) plus one half of the difference between the 8 hour and 4 hour volume values (to account for the lower volumes during the 16 hours remaining in a typical day)

(2) ADT value

(3) From Table 33

TABLE 34:
NEW JERSEY'S PRIORITY RANKING WARRANTS (Continued)

RANKING	GSPC SITE	ROAD WIDTH	SPEED (MPH)	DESIRED SIGHT DISTANCE	SIGHT(1) DISTANCE POINTS	PED(2) XING TIME	XING(1) MAX GR	NO.OF(3) SCHOOL CHILDREN
1	Foothills Pkwy & Sioux Dr (Boulder)	71	45	1,150	11	25	-	276
2	16th Ave S near E Marginal Way S (Seattle)*	60	40	875	-	22	1	-
3	Balt-Wash Pkwy near Greenbelt Rd (Wash Metro)	64	55	1,250	4	23	-	140
4	Rt 50 West of Glebe Rd (Wash Metro)*	107	45	1,750	17	34	0	-
5	Rt 395 & 24th St (D Madison Apts) (Wash Metro)*	138	55	2,500	1	42	-	46
6	Rt 495 at Wakefield Park (Wash Metro)	88	55	1,750	9	29	-	86
7	28th St. & E Aurora Ave (Boulder)*	92	45	1,550	-	30	5	14
8	Broadway south of Regency Dr (Boulder)*	86	35	1,100	-	29	5	74
9	E Marginal Way S near 16th S (South) (Seattle)*	66	40	975	-	24	1	-
10	W Center Rd & 108th St (Omaha)	69	45	1,150	-	24	5	92
11	Centerway Dr near School(Wash Metro)*	58	25	550	5	22	-	67
12	Broening Hwy at GM Plant (Baltimore)	63	35	800	-	23	5	-
13	Saddle Creek Rd & 50th St (Omaha)	69	35	900	-	24	5	112
14	Holman Rd N & 13th Ave NW (Seattle)	66	35	850	11	24	-	84
15	Balt-Wash Pkwy & Maisel St (Baltimore)	78	55	1,550	9	27	-	524
16	72nd St & Western Ave (Omaha)	48	40	700	11	19	-	68
17	Center Rd & 48th St (Omaha)	66	40	950	-	24	5	242
18	Watkins Mills Rd near school (Wash Metro)*	66	25	600	9	24	-	12
19	Rt 495 EB Ramp & Kenmore Rd (Wash Metro)	30	35	375	-	15	2	44
20	Empire Way S & Rainier Ave S (Seattle)	162	40	2,500	-	17	3	446

(1) See reference A-1/#3 in Appendix A
(2) Pedestrian crossing time equals (road width/4 fps) plus 7 clearance
(3) 0-18 yr old children time 2 (including users and nonusers)

TABLE 34:
NEW JERSEY'S PRIORITY RANKING WARRANTS (Continued)

RANKING	GSPC SITE	XING PROTECTION	SCHOOL XING PROTECTION POINTS	DISTANCE TO "SAFE" ALT'TIVE	DISTANCE TO "SAFE" ALT'TIVE POINTS	UNIQUENESS POINTS	TOTAL POINTS	RANKING
1	Foothills Pkwy & Sioux Dr (Boulder)	None	30	1,000	13	-	94	7
2	16th Ave S near E Marginal Way S (Seattle)*	(Signal)	-	0	-	10	85	10
3	Balt-Wash Pkwy near Greenbelt Rd (Wash Metro)	None	24	5,000	20	-	128	1/2
4	Rt 50 West of Glebe Rd (Wash Metro)*	(Signal)	-	1,600	15	-	82	11
5	Rt 395 & 24th St (D Madison Apts) (Wash Metro)*	None	13	4,225	20	-	114	5
6	Rt 495 at Wakefield Park (Wash Metro)	None	19	6,500	20	-	128	1/2/3
7	28th St. & E Aurora Ave (Boulder)*	(Signal)	4	445	17	-	106	6
8	Broadway south of Regency Dr (Boulder)*	(Signal)	11	680	20	-	116	4
9	E Marginal Way S near 16th S (South) (Seattle)*	(Signal)	-	0	0	10	91	8
10	W Center Rd & 108th St (Omaha)	Guard/Sgl	9	0	0	-	42	17
11	Centerway Dr near School(Wash Metro)*	None	17	80	0	-	28	19
12	Broening Hwy at GM Plant (Baltimore)	(Signal)	-	242	3	10	56	13
13	Saddle Creek Rd & 50th St (Omaha)	(Signal)	12	0	0	-	51	14
14	Holman Rd N & 13th Ave NW (Seattle)	(Signal)	9	0	0	-	44	16
15	Balt-Wash Pkwy & Maisel St (Baltimore)	(Signal)	20	379	19	-	128	1/2/3
16	72nd St & Western Ave (Omaha)	(Signal)	8	0	0	-	69	12
17	Center Rd & 48th St (Omaha)	Guard/Sgl	15	0	0	-	46	15
18	Watkins Mills Rd near school (Wash Metro)*	Guard	2	275	0	-	15	20
19	Rt 495 EB Ramp & Kenmore Rd (Wash Metro)	(Signal)	11	519	2	-	31	18
20	Empire Way S & Rainier Ave S (Seattle)	(Signal)	25	195	4	-	86	9

* Underpass GSPC site (all other sites are overpasses)