FEHR PEERS

MEMORANDUM

Date: October 25, 2016

To: Ken Tatsuguchi, P.E. and Nami J.H. Wong, P.E., State of Hawaii Department of Transportation – Highways Division – Planning Branch

From: Rachel Neumann and Netai Basu

Subject: ***Kihei High School Grade Separated Pedestrian Crossing Feasibility Study***

Ref: LA15-2746

This technical memorandum summarizes the results of a grade-separated pedestrian crossing ("GSPC") feasibility study conducted in preparation for the opening of a proposed high school in Kihei, Hawaii on the west coast of the island of Maui. The Hawaii State Department of Transportation ("HDOT") is concerned about school-related impacts to the transportation system. The State Land Use Commission ("Land Use Commission") and Maui County Council have imposed zoning conditions requiring an overpass or underpass be provided to facilitate pedestrian access to the proposed school. DOT has directed this GSC feasibility study to be completed in compliance with Federal Highway Administration ("FHWA") Report # *FHWA/RD-84/082 Warrants for Pedestrian Over and Underpasses* ("FHWA/RD-84/082") as a condition of approval for a District Boundary Amendment necessary to develop the school.

PROJECT DESCRIPTION

Currently, high school-age students from the community of Kihei on the island of Maui attend school in either Kahului or Wailuku. The Hawaii Department of Education (HDOE) has plans to construct a new high school in Kihei to be located mauka of Piilani Highway. The school is projected to open in 2018, with an initial enrollment of 800 students. Full enrollment of 1,650 students is anticipated in 2028. Access to the high school will be provided via a new access roadway off Piilani Highway at the intersection with Kulanihakoi Street.

Within the vicinity of the proposed high school, Piilani Highway is a predominantly four-lane, two-way roadway generally oriented in the north south direction that provides direct access through Kihei. Within the vicinity of the proposed high school, the posted speed limit is 40 miles per hours ("mph") and the design speed is 55 mph. Due to the high speeds of the vehicular traffic, the 8-foot wide shoulders, which were designated as bicycle lanes, are not utilized by bicyclists. There

EXHIBIT 4

are no sidewalks or pedestrian facilities on Piilani Highway. A Pedestrian Route Study ("Ped Route Study") was conducted to address bicycle and pedestrian access and safety issues at the proposed school access roadway. The Ped Route Study recommended a redesign of the intersection at Piilani Highway and Kulanihakoi Street to provide optimum service the highest level of protection for bicycles and pedestrians, including a traffic signal and high-visibility crosswalks at a minimum and a roundabout at a maximum. The Land Use Commission additionally required that a GSC feasibility study be conducted in compliance with the proposed warrants in FHWA/RD-84/082 to examine the feasibility of providing grade-separated non-motorized crossing opportunities from the makai to mauka sides of Piilani Highway. The Waipuilani and Kulanihakoi Gulches, respectively located north and south of the intersection with Kulanihakoi Street, were recommended as preferred GSPC locations, and the feasibility of providing GSPCs at these specific locations will be explored in this memo.

GSPC WARRANTS

FHWA/RD-84/082 identifies the following eight warrants for grade-separated pedestrian over or undercrossings.

1. Pedestrian volume should be a total of over 300 in the 4 highest continuous hour period if vehicle speed is over 40 miles per hour 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 commitment.

An excerpt from FHWA/RD-84/082 summarizing the warrants is included in this memo as Appendix A.

IS A GSPC WARRANTED?

Pedestrian Volumes

The posted speed limit on Piilani Highway is 40 mph, it is located in an urban area, and is not a freeway. Therefore, in order to meet the pedestrian volume warrant, at least 300 or pedestrians must utilize the crossing in the highest continuous four-hour period.

No existing pedestrian counts across Piilani Highway at Kulanihakoi Street were available for review during the preparation of this report. For the purposes of this analysis, it was assumed that pedestrian activity at this location is today not present, as there are no existing nearby destinations mauka of Piilani Highway, nor are sidewalks or crossing facilities provided. Therefore, there is no baseline pedestrian volume and all future estimates rely exclusively on school-generated trips assumed to occur during school opening and dismissal times.

In testimonial response to the *Kihei High School Petition for Land Use District Boundary Amendment*, HDOT estimated that 20 percent of Kihei high school students would walk to the proposed school. No data about existing Maui student journey-to-school mode splits is available to support this estimate. Additionally, future development in Kihei is expected to fuel the dramatic growth in the student population between 2018 and 2028, and much of this development is planned for mauka of Piilani Highway. Students drawn from developments mauka of Piilani Highway would likely access the school from a future roadway planned even further inland of the school site, from other planned direct connections, or via sidewalks on the east side of Piilani Highway, meaning that the pool of students who may utilize grade-separated crossings to get to school is much smaller than the total school population. Thus, it is very likely that a 20 percent pedestrian mode split at the proposed school represents an overestimate.

Future pedestrian volume estimates were prepared for this analysis based on a five, 10, and 20 percent student pedestrian mode split. Staff/visitor pedestrian volume estimates were calculated based on American Community Survey 2013 5-year estimate Journey-to-Work data for Kihei CDP (Census-Designated Place). Total student, staff, and visitor numbers for the proposed high school were based on the traffic impact analysis report ("TIAR") prepared by Wilson Okamoto Corporation for Group 70 in 2014. The volumes presented below still likely represent an overestimate as they assume that all students, staff, and visitors originate makai of Piilani Highway.

As illustrated in Table 1, the pedestrian volume warrant is not met in 2018 under any likely conditions. In 2028, at least 18 percent of students must walk to school in order to meet the pedestrian volume warrant.

TABLE 1. Pedestrian Volumes by Student Mode Split

Year	Enrollment	Pedestrian Volumes by Student Mode Split		
		5%	10%	20%
2018	800	41	81	161
2028	1,650	85	168	333

Vehicle Volumes

As Piilani Highway is located in an urban area and the posted speed limit is 40 mph, to meet the vehicle volume warrant, vehicle volumes on Piilani Highway at Kulanihakoi Street must equal or exceed 10,000 vehicles within the same four-hour period as the highest pedestrian volumes occur, or 35,000 vehicles in an entire 24-hour day.

Since no baseline pedestrian counts exist, there was no pre-determined four-hour period in which to measure the 10,000 vehicles. Based on vehicle counts collected in the TIAR prepared by Group 70, the highest four-hour period for vehicles occurs between 1:30 and 5:30 PM, encompassing the school dismissal period during which school-related pedestrian volumes could be expected to peak.

Existing counts indicate that Piilani Highway carries fewer than 8,700 vehicles during the highest four-hour period, and just over 32,000 vehicles per day. The TIAR estimated ambient traffic growth along Piilani Highway for both 2018 and 2028. In 2018, Piilani Highway can be expected to carry just over 9,500 vehicles during the highest four-hour period and just under 34,700 vehicles per day. In 2028, Piilani Highway can be expected to carry just over 15,500 vehicles during the highest four-hour period and more than 55,000 vehicles per day.

The vehicle volume warrant is not met in 2018, and is met in 2028.

Distance to the Nearest Safe Crossing

The intersection of Piilani Highway and Kulanihakoi Street is side-street stop-controlled. Traffic traveling north and south on Piilani Highway is uncontrolled and does not stop. No marked crossing across Piilani Highway is provided. The nearest existing marked crossings across Piilani Highway are located 0.96 miles away at Ohukai Road in the north and 0.75 miles away at Piikea Avenue in the south.

The intersection of Piilani Highway and Kulanihakoi Street is planned to be signalized ahead of the proposed school's opening. The intersection improvement is assumed, for this analysis, to include marked pedestrian crossings. If the intersection is improved as planned, the warrant regarding safe crossing distances is not met. Should the intersection improvement not occur, the nearest marked crossings will continue to be located more than 600' from the proposed school driveway. Under such conditions, the warrant regarding safe crossing distances is met.

Physical Barriers

A physical barrier to prohibit at-grade crossing of the roadway is desirable as part of the grade separated crossing design plan.

No physical barrier will exist at Kulanihakoi Street to prevent at-grade pedestrian crossings. Even if marked pedestrian crossings are not including in the previously described intersection improvement, the planned signalization of the intersection will in fact facilitate at-grade crossings. Therefore, the physical barrier warrant is not met in either study year.

Lighting

Lighting GSPCs along Waipuilani and/or Kulanihakoi Gulch is feasible. Thus, while GSPC facilities have yet to be designed, the lighting warrant is met.

Topography

United States Geological Survey ("USGS") quadrangle maps for the Kihei area were obtained. The maps indicate that Waipuilani and Kulanihakoi Gulches, which are located between a half and three-quarters of a mile from the coast, have elevations between 20 and 40 feet above sea level. The level of detail of the map is 20 feet. The exact topography of the gulches is not available at this time, but it is likely that elevation changes are gentle enough to provide a grade-separated crossing. Based on this assumption, the topography warrant is met. More detailed information is needed to verify this assumption.

Adjacent Land Uses

Existing or projected adjoining land uses to the GSPC should generate pedestrian trips, and should have direct access to the planned GSPC. Uses such as a school are generally high pedestrian generators.

For planning purposes, HDOE estimates that one high school student is generated from approximately six single-family homes or twenty multi-family units. Residential development immediately makai of Piilani Highway is primarily single-family, with some multi-family development further makai. It would require approximately 2,000 single-family homes adjacent to the GSPC to generate the 300 students necessary to meet the pedestrian warrant assuming a

pedestrian mode split for those students of 100% (which is not realistic but is used here to define the limits of the warrant evalaution). Adjacent is assumed to mean within a ½-mile travel distance from the school, as this is generally acknowledged to be a reasonable walking distance. Based on an aerial review, it does not appear that 2,000 single-family homes exist adjacent to the proposed GSPC. Additionally, given that the pedestrian mode split for student journeys to school is typically far less than 50%, the number of housing units required to generate 300 student pedestrians is in actual fact far greater than 2,000 single-family homes. Although some multi-family units exist in this area, the student generation rate for this type of housing is lower and the use of single-family homes for this calculation provides the highest number of potential pedestrians.

The discontinuous and disconnected nature of the roadway network makai of Piilani Highway means that, unless a robust pedestrian network is developed in addition to the GSPC, relatively few students will have direct access to the GSPC.

Mauka of Piilani Highway, the opening of the proposed school in 2018 ensures that the adjoining land use warrant is met. Makai of Piilani Highway, however, low residential density and a disconnected roadway network do not meet this warrant in 2018.

Funding

No funding has been committed for construction of the GSPC at this time. The funding warrant is not currently met, but may be met in the future.

GSPC PHYSICAL FEASIBILITY

Detailed cross-sectional elevation drawings of either Waipuilani or Kulanihakoi Gulch were not available for review during preparation of this report. Therefore, when assessing GSPC physical feasibility, it was assumed that no vertical clearance is currently available at either gulch.

GSPC design requirements were determined based on the 2001 FHWA report *Designing Sidewalks and Trails for Access: Best Practices Design Guide* ("FHWA 2001") and the 2004 American Association of State Highway and Transportation Officials ("AASHTO") *Guide for the Planning, Design, and Operation of Pedestrian* Facilities ("AASHTO 2004").

Undercrossings require provision of 10' of vertical clearance, measured from the top of the floor to the bottom of the ceiling. Pathways must be a minimum of 16' wide. Ramp slope cannot exceed an 8.33% grade, equal to one foot of landing for every inch of rise. Five foot deep landings must be provided for every 30" of ramp rise.

For the purposes of this analysis, it was assumed that the entirety of the required 10' of vertical clearance will need to be excavated at either gulch. In order to provide 10' of vertical clearance, 140' of ramp will need to be provided on either side of Piilani Highway, including a minimum of four landings. Sufficient public right-of-way is available on both sides of Piilani Highway to

accommodate the required ramp lengths and USGS quadrangle maps suggest that the topography does not preclude ramp construction. Detailed engineering surveys will be required to determine ultimate feasibility.

Overcrossings require provision of 16' of vertical clearance above street grade, measured from the top of the roadway to the bottom of the overcrossing bridge ceiling. Pathways must be a minimum of 16' wide. Ramp slope cannot exceed an 8.33% grade, equal to one foot of landing for every inch of rise. Five foot deep landings must be provided for every 30" of ramp rise.

For the purposes of this analysis, it was assumed that Piilani Highway is at-grade. In order to provide 16' of vertical clearance, 227' of ramp will need to be provided on either side of Piilani Highway, including a minimum of six landings. Sufficient public right-of-way is available on both sides of Piilani Highway to accommodate the required ramp lengths and USGS quadrangle maps suggest that the topography does not preclude ramp construction. Detailed engineering surveys will be required to determine ultimate feasibility.

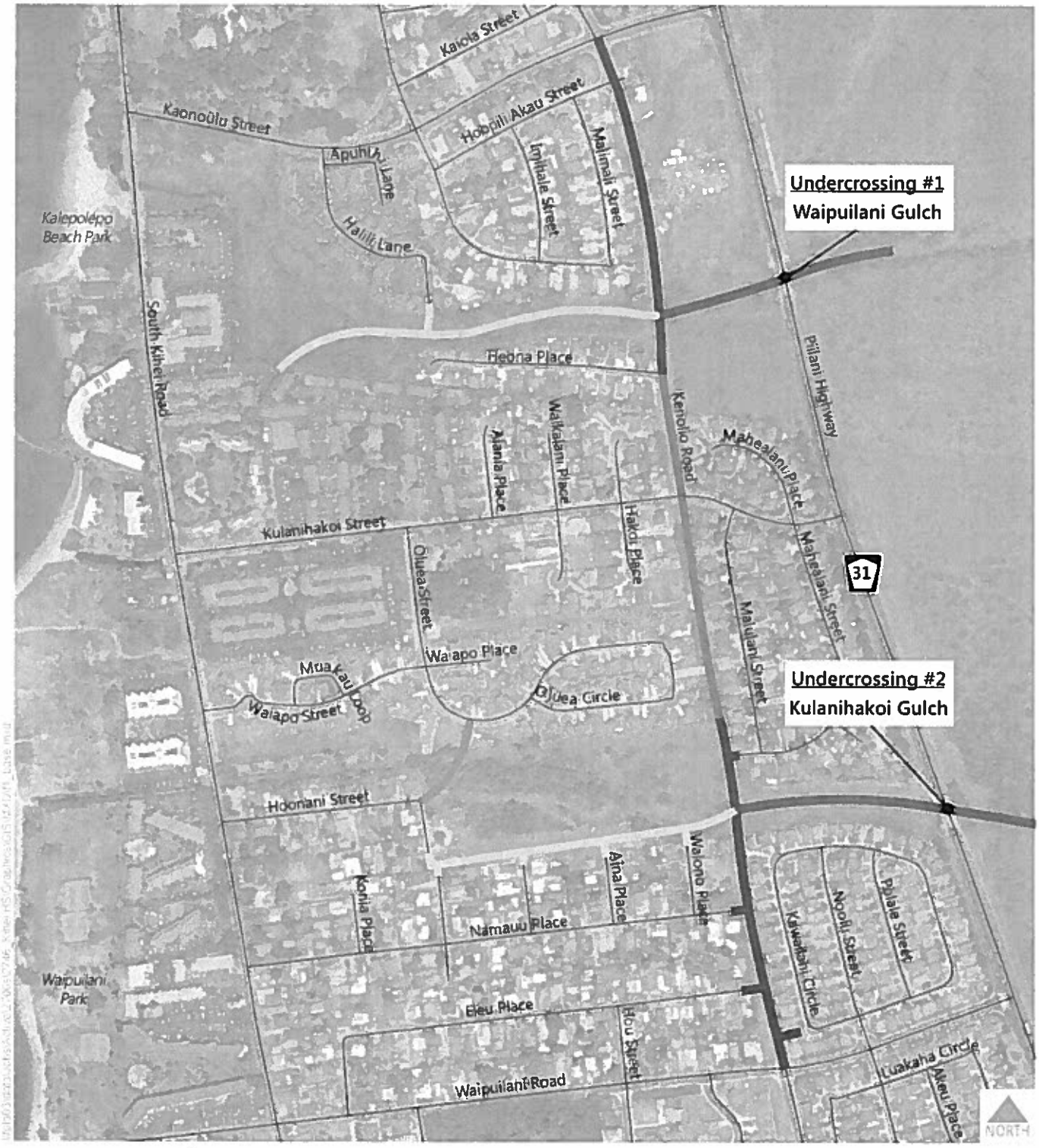
Undercrossings are generally preferred to overcrossings as they require shallower slopes and thus shorter ramp lengths, which results in both reduced construction costs and easier access for those with mobility challenges If an overcrossing were selected as the preferred configuration, the ideal location for its placement is at the intersection with Piilani Highway and Kulanihakoi Street to provide the most direct connection and serve the greatest number of pedestrians and cyclists. A detailed feasibility analysis for this location has not been conducted, but an aerial review indicates that there is insufficient right-of-way available makai of Piilani Highway to land the ramps connecting residential neighborhoods to the overcrossing.

RECOMMENDATIONS

In 2018, when the proposed high school is projected to open, no GSPC warrants are definitively met. Warrant #3, the warrant regarding safe crossing distances, is met only if planned improvements are not made. Warrants # 5 and 8, regarding lighting and funding, are not currently met but may be met by 2018 depending on future planning. In 2028, however, primary warrants regarding pedestrian and vehicle volumes at the proposed high school access driveway either are met or may be met depending on student pedestrian mode split. Therefore, the need for a GSPC should be viewed as long-term.

It is likely that constructing a GSPC at either Waipuilani or Kulanihakoi Gulch is physically feasible, however a detailed engineering survey is recommended to determine ultimate feasibility. Without a survey, the preferability of constructing a GSPC in one gulch over another cannot be determined. Waipuilani Gulch is located approximately 750' north of the proposed high school access driveway, and Kulanihakoi Gulch is located approximately 1,250' south of the driveway. Priority should ultimately be given to the GSPC that would facilitate the maximum number of pedestrian crossings based on adjacent student residential density and pedestrian network connectivity. A

GSPC should augment, rather than replace, an at-grade crossing opportunity, by facilitating crossings for students originating from disconnected neighborhoods to the north and south of the proposed high school access driveway. In order to be effective, the GSPC cannot be constructed in isolation, but must be part of a robust pedestrian network providing connectivity that the existing vehicle roadway network does not. The higher the level of connectivity, the higher the GSPC use and attendant student pedestrian mode split. Development of such a network will require interagency coordination between HDOE, future Kihei High School administrators, Kihei transportation and planning officials, HDOT, the County of Maui, and other agencies, and should take into account planned improvements including completion of the Liloa Drive extension and the Hawaii Statewide Bikeway Network. An example of a robust network that would facilitate the highest use rate is illustrated in Figure 1, below.



Bike/Ped GSC Undercrossing
Required
Preferred

Liloa Drive Extension
Required
Preferred

New Bike/Ped Pathway
Preferred

Figure 1

Kihei High School

APPENDIX A

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.