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The San Pablo/I-80 corridor is a "SMART" transportation corridor that extends about 20 miles along the eastern shore of the San Francisco Bay. The corridor uses Intelligent Transportation System (ITS) technologies to increase and enhance transportation mobility.

The goal of the SMART Corridor Plan was to improve vehicle mobility throughout the corridor. Since the plan focused almost exclusively on vehicular traffic, achieving these goals has the potential to raise the risk of injury to pedestrians and bicyclists without thorough analysis of the overall effects of the SMART corridor implementation. This study identifies and describes multiple factors that may affect the behavior of pedestrians, bicyclists and drivers along the corridor. This report focuses on findings for the Berkeley sector. The evaluation utilized multiple types of data collection including vehicle counts, field observations, field inspections, and collision data. Researchers inspected the physical elements of each intersection and observed driver, pedestrian, and bicyclist behavior. Analysis of these data, led to a typology, used to assign context-specific safety interventions, many of which involve engineering and enforcement. The main goal is to ensure that motorists as well as pedestrians and bicyclists should have a sense that all have an equal right to travel in the area. This can be accomplished through clear and consistent signage, a distinctive crosswalk treatment, consistent lighting and other enhancements. Implementation of the recommended countermeasures and follow up analysis are not part of this baseline study. A detailed traffic engineering analysis would be required to produce estimates of costs and benefits, and to determine priorities.

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Pedestrian and Bicycle Safety Evaluation in a SMART Corridor

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University of California Berkeley

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Pedestrian and Bicycle Safety Evaluation in a SMART Corridor

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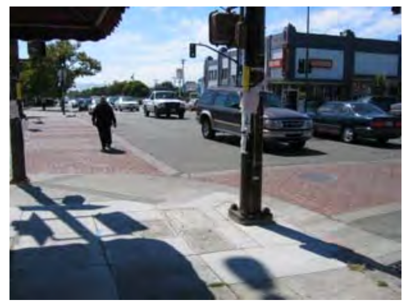
Prepared for The California Department of Transportation






JUNE 2007

Traffic Safety Center
Setting New Directions in Traffic Safety

ABSTRACT

Title: Pedestrian and Bicycle Safety Evaluation in a SMART Corridor

Prepared by:
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Date: June 2007

The San Pablo/I-80 corridor is a "SMART" transportation corridor that extends about 20 miles along the eastern shore of the San Francisco Bay. The corridor uses Intelligent Transportation System (ITS) technologies to increase and enhance transportation mobility.

The goal of the SMART Corridor Plan was to improve vehicle mobility throughout the corridor. Since the plan focused almost exclusively on vehicular traffic, achieving these goals has the potential to raise the risk of injury to pedestrians and bicyclists without thorough analysis of the overall effects of the SMART corridor implementation.

This study identifies and describes multiple factors that may affect the behavior of pedestrians, bicyclists and drivers along the corridor. This report focuses on findings for the Berkeley sector.

The evaluation utilized multiple types of data collection including vehicle counts, field observations, field inspections, and collision data. Researchers inspected the physical elements of each intersection and observed driver, pedestrian, and bicyclist behavior. Analysis of these data led to a typology, used to assign context-specific safety interventions, many of which involve engineering and enforcement.

The main goal is to ensure that motorists as well as pedestrians and bicyclists should have a sense that all have an equal right to travel in the area. This can be accomplished through clear and consistent signage, a distinctive crosswalk treatment, consistent lighting and other enhancements.

Implementation of the recommended countermeasures and follow up analysis are not part of this baseline study. A detailed traffic engineering analysis would be required to produce estimates of costs and benefits, and to determine priorities.

Keywords: Partners for Advanced Transit and Highways California, Pedestrians, Pedestrian Detectors, Risk Analysis, Safety, Traffic Accidents, Traffic Signals, Traffic Signs

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1. EXECUTIVE SUMMARY

1.1. BACKGROUND

The San Pablo/I-80 corridor is a “SMART” transportation corridor that extends about 20 miles along the eastern shore of the San Francisco Bay, from downtown Oakland north to the City of Hercules. The corridor uses Intelligent Transportation System (ITS) technologies, such as video monitoring of intersections, signal timing and the integration of a bus rapid transit,[1] to increase and enhance transportation mobility within and throughout several East Bay communities. However, until recently, there had been no systematic planning for pedestrian and bicycle safety in this corridor. In 2004, California Partners for Advanced Transit and Highways (PATH) at the University of California, Berkeley, received a contract from Caltrans, the California state agency responsible for highway, bridge, and rail transportation planning, construction, and maintenance to analyze pedestrian and bicycle safety for the corridor. The Traffic Safety Center (TSC) at the University of California, Berkeley, performed the research. This document focuses on findings for the Berkeley sector of the corridor. We have provided a general analysis of conditions on San Pablo Avenue affecting pedestrian and bicyclist safety, and a range of possible countermeasures. A detailed traffic engineering analysis would be required to produce estimates of costs and benefits, and to determine priorities.

This report is organized into five sections: (i) methods and data collected, (ii) overall problems and countermeasures, (iii) description of specific intersections, (iv) approaches to countermeasures, and (v) an analysis and detailed description of problems and recommended countermeasures for five zones within the sector that include thirteen intersections. It should be noted that implementation of the recommended countermeasures and follow up analysis are not part of this baseline study.

1.2. METHODS

The evaluation utilized multiple types of data collection including vehicle counts, field observations, field inspections, and collision data.

1.2.1. Collision Data

The Statewide Integrated Traffic Record System (SWITRS) is a computerized database of California motor vehicle collisions maintained by the California Highway Patrol (CHP). SWITRS data were used to reconstruct the circumstances related to collisions at 13 intersections selected for study in the Berkeley sector. Multiple vehicle collisions occurred between 1998 and 2003, including 29 collisions with bicycles and 36 collisions with pedestrians. These numbers may under-represent the risk to pedestrians and bicyclists since official figures only include *reported* collisions and do not include near misses, which—based on our observations—appear to be common at these intersections.

[1] http://www.smartcorridors.com/index.jsp May 9, 2006

1.2.2. Vehicle Counts

Vehicle volumes counts were conducted for signalized intersections along the SMART Corridor for ACCMA by Fehr & Peers transportation consultants in 2003 for a traffic signal prioritization study. Fehr and Peers supplied the report to the Traffic Safety Center. Vehicle counts were available for the signalized intersections, which comprised five of the 13 study intersections. The Fehr and Peers data include vehicle counts for the afternoon peak traffic hours of 4 p.m. to 5 p.m. or 5 p.m. to 6 p.m. for all signalized intersections in the Berkeley sector of the San Pablo/I-80 corridor. These data helped to provide some context for the analysis with descriptions of overall traffic conditions, and confirmed relative rates of vehicle flow at the signalized study intersections. Vehicle count data was not available for other years or for unsignalized intersections.

1.2.3. Field Observations

Researchers made observations at each of the 13 intersections to collect behavioral data on drivers, pedestrians, and bicyclists and their interactions. Observations were made in August of 2004 for one-hour periods during the peak traffic hours of 3 p.m. to 6 p.m. midweek (Tuesdays, Wednesdays, and Thursdays to avoid fluctuations in traffic due to weekend travel effects, a common industry practice). Observations were recorded by Traffic Safety Center staff, graduate student researchers, and University of California Transportation Center (UCTC) graduate student researchers. They observed that many vehicles failed to yield the right-of-way to pedestrians, who were unable to complete crossings during the “Walk” phase, and bicyclists, who had difficulty navigating among vehicles during lane changes.

1.2.4. Field Inspections

Researchers also examined the infrastructure at each intersection and noted signal configuration, signage, pavement markings, adherence to Americans with Disabilities Act (ADA) requirements, and other features. The most frequently noted deficiencies in these areas were: curb ramps that led outside established crosswalk markings, lack of curb ramps, and sidewalk clearance blocked by landscaping or street furniture.

1.3. OVERALL ISSUES AND COUNTERMEASURES

1.3.1. General Assessment

The San Pablo/I-80 corridor was designed to accommodate a high volume of motor vehicle traffic traveling through several communities. With close proximity to, and running parallel to I-80, San Pablo Avenue serves as a by-pass during peak traffic hours. San Pablo appears to be composed of distinctive zones as it passes through different municipalities and neighborhoods.

For the most useful interventions, the unique environmental context of each neighborhood zone needs to be considered. In study zones with a history of collisions between vehicles and pedestrians and bicyclists, potential solutions should address challenges directly by: (i) increasing driver awareness of pedestrians and bicyclists and their right-of-way, (ii) alerting pedestrians and bicyclists to areas of risk, and (iii) improving ease of travel and safety for pedestrians and bicyclists as they cross intersections. A number of conditions were noted that affect safety overall and are as follows:

1.3.1.1. Vehicles Turning Right on Red Light at Signalized Intersections
For vehicles turning right during red lights, the risk occurs to pedestrians crossing during their "walk" phase immediately in front of the vehicles facing the red light. Researchers observed numerous drivers who simply did not stop as required, or who looked only to their left for a gap in the vehicular traffic, rather than where pedestrians were crossing on their right.

1.3.1.2. Right and Left Turns Across Pedestrian Crossings at Signalized Intersections
For vehicles turning right on green lights, the risk occurs when the pedestrian "walk" phase on the crosswalk runs parallel to the initial direction of vehicles that also have a green light. Drivers often failed to yield to pedestrians in the crosswalks. Occasionally, drivers moved very close to pedestrians before stopping, or drivers passed closely behind pedestrians. In many cases, drivers behaved as though they had the right-of-way over pedestrians who also had the green light. When vehicles turn left on green lights, the risks for pedestrians during unprotected left turns are similar, although the pedestrian often can observe the oncoming encroaching motorist.

Vehicles turning right on green also encountered frequent conflicts with bicyclists. Bicyclists traveling straight through an intersection often had to cross the path of right-turning vehicles to proceed.

1.3.1.3. Right Turns Across Pedestrian Crossings at Unsignalized Intersections
Vehicles turning right at unsignalized locations have no restrictions against turning and tend to slow their speed only if the curb radius is small enough to require it. Drivers were often observed violating pedestrian right-of-way.

1.3.1.4. ADA Violations
Berkeley's curb ramps[2] are slowly being updated by Caltrans to meet ADA standards, which require detectable warnings[3] at new curb ramp installations and updates along the corridor. Unfortunately, the curb ramps are diagonal relative to the intersection, which is not the preferred configuration—two ramps are preferred, one for each crosswalk direction. Additionally, there are a number of locations where sidewalk minimum clearance width does not meet the ADA standard of 60 inches, due to obstructions including temporary and fixed objects such as vegetation, street furniture, newspaper racks, and trash cans.

1.3.1.5. High Speed Traffic in Pedestrian Zones
The posted speed limit along the Berkeley study sector is 35 mph, and while researchers did not measure vehicle speeds, drivers appeared to exceed the speed limit at several study intersections. To make right turns at intersections of all types and during all signal phases (red, yellow, green)

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[2] A curb ramp is a combined ramp and landing to accomplish a change in level at a curb, providing street and sidewalk access to wheelchairs, AASHTO, Guide for the Planning, Design and Operation of Pedestrian Facilities, July 2004.pp.124.
[3] Detectable warnings are a standardized surface feature applied to walking surfaces to warn pedestrians of hazards on a sidewalk, such as a curb line or drop-off, AASHTO, July 2004, pp124.

drivers commonly slowed but did not stop, and then accelerated through the crosswalk to fit into the gap in traffic. For drivers moving straight, the distance across several intersections allowed them to accelerate substantially by the time they reached the far crosswalk. Generally, higher vehicle speeds were more likely to be observed at larger intersections, at those with wide lanes, and at those that lacked common traffic controls.

1.3.1.6. Close Proximity of Driveways to Intersection

Several intersections had driveways within 100 feet of the stop bar or crosswalk of an intersection. In heavy vehicle traffic flow areas, this led to conflicts between drivers and pedestrians on sidewalks and/or bicyclists on roadway edges, while drivers were entering and exiting business properties.

1.3.1.7. High Incidence of Jaywalking

Several locations along the study area had crossing gaps (long distances between designated crossings) where existing crosswalks were not meeting the needs of pedestrians for crossing San Pablo Avenue. Jaywalking (generally referring to someone crossing a busy street outside of a designated crosswalk) may increase risk to pedestrians both because motorists pedestrians in the middle of a block and may be traveling at relatively higher speeds, making stopping more difficult.

1.3.1.8. Poor Crosswalk Visibility

The crosswalks at most of the study intersections had only minimal striping with two parallel lines, and many were faded. Unclear markings contribute to driver lack of awareness and failure to comply with pedestrian right-of-way. In addition, although several crossings are part of designated bicycle routes, there is no indication that bicycles are allowed in these crossings.

1.3.1.9. Inadequate medians

Several medians on San Pablo Avenue are inadequate for pedestrian refuge for various reasons including insufficient width, failure to extend to the crosswalk, and failure to meet ADA accessibility requirements.

1.3.1.10. Vehicle Encroachment on Pedestrian Right-of-Way (ROW)

Researchers observed motorists encroaching upon pedestrian and bicyclist right-of-way in intersections, creating a dangerous environment. This problem was exacerbated by conditions discussed above including:

- Turning conflicts
- High vehicle speed
- Poor crosswalk visibility

1.3.1.11. Lack of Way-Finding Signage for Bicyclists

Signage directing pedestrians and bicyclists to common paths or destinations is largely absent. For example, the lack of way-finding system or signs that identify the City of Berkeley's "bicycle boulevard" system4 or the precise location of secondary bicycle routes creates ambiguity about where bicyclists can travel.

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[4] A network of seven bicycle roadways in Berkeley, modified as needed to enhance bicyclists' safety and convenience. http://www.ci.berkeley.ca.us/transportation/Bicycling/BB/BicycleBoulevard.html

1.3.1.12. Lack of Amenities for Bicyclists

At most intersections, bicyclists were observed riding on the sidewalk or traveling in the wrong direction (against traffic) on the street. This practice was reflected in the records of vehicle/bicycle collisions in the area involving bicycles traveling against vehicle traffic flow. Such behavior likely indicates a lack of amenities for bicyclists or the absence of a general feeling of safety on the street.

1.4. ZONE ANALYSIS

A detailed analysis was conducted and a set of recommendations were prepared for each of thirteen study intersections within the five study zones. For each of these intersections, an analysis of conditions contributing to risk for pedestrians and bicyclists was provided, along with specific detailed countermeasures. The analyses are based upon the data sources identified above. For most locations, a tiered set of recommendations has been provided. The first tier includes more general overarching countermeasures recommended to treat problematic conditions encountered along the entire San Pablo/I-80 Corridor in Berkeley. The second tier includes intersection-specific countermeasures where applicable.

1.4.1. Summary of Recommended Countermeasures

1.4.1.1. Tier 1 Recommendations

Overarching recommendations are divided into three groups to address conditions in all intersections, only signalized intersections, or only unsignalized intersections, as follows.

All Intersections

- Upgrade crossings to ADA and MUTCD standards:
    - Upgrade curb ramps: locate curb ramps at intersection, place landing area inside/within crosswalk markings. It is preferable to place two curb ramps per corner, one per sidewalk, rather than one diagonal ramp.
    - Install truncated domes[5] at curb ramps to improve detectability of the boundary between street and sidewalk by pedestrians.
    - Upgrade sidewalks/clearance to 36 inches at a minimum and 60 inches where possible.
- Install more visible crosswalk markings (i.e. ladder or continental design) to decrease conflicts, increase number of motorists yielding to pedestrians, and increase number of pedestrians using crosswalk.
- Update pedestrian crossing zone signs with fluorescent-yellow/green color, providing greater visibility for drivers to see upcoming pedestrian crossing zones.

[5] Truncated domes are small domes with flattened tops used as a detectable warning at curb lines, and transit platforms, AASHTO, July 2004. pp 126.

Signalized Intersections

- Provide advanced warning for using “roving eyes,” which are flashing lights above the crosswalk that resemble animated eyes looking down at the pedestrian. The signal is mounted over a pedestrian crossing, and when activiated, the "roving" eyes remind drivers to watch out for pedestrians. The signal is activated by a pedestrian and indicates, by placement of the pedestrian on the sign (right or left), which direction from which the pedestrian is crossing. Roving eyes are expected to improve motorist respect for pedestrian right-of-way.
- Install countdown signals for pedestrians that include animated eyes which are intended to increase pedestrian awareness of traffic and of time remaining to complete street crossing, increasing compliance, and thereby reducing conflict with vehicles.
- Install pedestrian ”call” buttons for a “walk” signal that confirm that the button has been preseds, so pedestrian know that signals are responding to their presence. Such buttons would likely improve pedestrian compliance.
- Install offset/advance limit lines to reduce pedestrian/driver conflict and decrease the number of vehicles blocking crosswalks by encouraging drivers to stop farther away from the marked crosswalk. The lines should not slow vehicle mobility.

Unsignalized Intersections

- Install “smart” street lighting, triggered by movement on the pavement below. Increased lighting increases visibility of pedestrians and would likely reduce pedestrian/vehicle conflict.
- Install “LOOK” pavement stencils directed at pedestrians at the entrance to crosswalks. The stencils proclaim the warning “LOOK” to warn pedestrians to watch for oncoming traffic, potentially reducing conflicts and increasing awareness.
- Install portable speed trailers near intersections to inform drivers of their speed as they pass through the area, discouraging and potentially reducing the conflicts associated with speeding.

Tier-two recommendations are listed for each specific intersection in Table 1.1.

Table 1.1. Zone Specific Treatments

ZONE	Intersection-Specific Countermeasure
Zone 1	No specific countermeasure assigned
Zone 2	
Intersection1	Restrict RTOR/Install leading pedestrian interval
	Extend median extensions to crosswalk
Intersection 2	Install in-roadway knockdown signs/impactable yield signs
	Install speed trailers (temporary enforcement)
	Install pedestrian-activated flashing beacons
	Install pedestrian-activated flashing lights
	Upgrade/extend median
Zone 3	
Intersection 1	Restrict RTOR/Add Leading pedestrian interval
	Install ample way-finding signage for bicyclists
	Install signs that encourage motorists to “share the road”
	Install signs warning drivers parking on the street to exercise “door zone vigilance”

	Consider/study optimal relocation of bus stops for making connections (or ITS smart timing: provide real time schedule/location of buses)
	Restrict parking at peak hours for vehicle traffic within a one block radius of the intersection
Intersection 2	Install in-roadway knockdown signs/impactable yield signs
	Install speed trailers
	Install pedestrian-activated flashing beacons
	Install pedestrian-activated flashing lights
	Replace landscaping with higher canopy vegetation
Intersection 3	Install in-roadway knockdown signs
	Install pedestrian-activated flashing lights
	Upgrade/extend median
Zone 4	
Intersection 1	Install speed trailers
	Install pedestrian-activated flashing beacons
	Upgrade/extend median
Intersection 2	Install in-roadway knockdown signs/impactable yield signs
	Install speed trailers
	Install pedestrian-activated flashing lights
	Upgrade/extend median
Intersection 3	Upgrade/extend median (pedestrian refuge island)
	Install ample way-finding signage for bicyclists
	Install signs encouraging motorists to “share the road”
	Install signs warning drivers parking on the street to exercise “door zone vigilance”
	Restrict parking at peak hours within 1-block radius of the intersection
Zone 5	
Intersection 1	Install ample way-finding signage for bicyclists
	Install signs encouraging motorists to “share the road”
Intersection 2	Install in-roadway knockdown signs/impactable yield signs
	Install speed trailers
	Install pedestrian-activated flashing beacons
	Install pedestrian-activated flashing lights
Intersection 3	Install in-roadway knockdown signs/impactable yield signs
	Install speed trailers
	Install pedestrian-activated flashing beacons
	Install pedestrian-activated flashing lights
Intersection 4	Replace landscaping with higher canopy vegetation
	Install in-roadway knockdown signs
	Install speed trailers
	Install pedestrian-activated flashing beacons

While these proposed countermeasures are expected to improve pedestrian and bicycle safety along the Berkeley sector of the corridor, a before-and-after evaluation should be conducted in which countermeasures are installed to determine their effectiveness. It would also be beneficial for the City of Berkeley to continue monitoring pedestrian and bicyclist safety problems as Caltrans continues to make improvements and perform maintenance along the San Pablo Avenue.

2. INTRODUCTION

2.1. BACKGROUND

The San Pablo/I-80 corridor is a "SMART" transportation corridor extending approximately 20 miles from downtown Oakland to the City of Hercules along the eastern shore of the San Francisco Bay. The corridor uses Intelligent Transportation System (ITS) technologies, such as video monitoring of intersections, signal timing and the integration of bus rapid transit[6] to increase and enhance transportation mobility within and throughout several East Bay communities. Until recently, there was no systematic planning for pedestrian and bicycle safety along this corridor. In 2004, California Partners for Advanced Transit and Highways (PATH) at the University of California at Berkeley received a contract from Caltrans to conduct a pedestrian and bicycle safety analysis of the corridor. The Traffic Safety Center at the University of California, Berkeley, conducted the research. This document focuses on the analysis and results for the Berkeley sector of the corridor.

2.2. THE SAN PABLO AVENUE/I-80 SMART CORRIDOR

The San Pablo corridor was selected for two principle reasons. First, San Pablo Avenue is a major arterial in the San Pablo/I-80 corridor, with multiple access points to the highway. It also connects several residential communities with shopping and eating areas and business sites. Second, the Alameda County Congestion Management Agency (ACCMA) whose primary responsibility is to coordinate transportation planning, funding and other congestion management activities for the county of Alameda implemented the SMART Corridor Plan (as part of the East Bay SMART Corridors Program) between January 2003 and spring 2004. The goal of the SMART Corridor Plan was to improve vehicle mobility throughout the corridor, and its detailed goals included:

- Increasing roadway efficiency for vehicles and transit service.
- Supporting a multi-modal transportation system, personal vehicles, commercial vehicles and public transit.
- Reducing vehicle travel time and improving traffic flow.
- Enhancing emergency response time and incident (accident) removal.[7]

Since the plan focused almost exclusively on facilitating vehicular traffic throughout the corridor, achieving these goals may raise the risk of injury to pedestrians and bicyclists without thorough analysis of the overall effects of the SMART corridor implementation.

According to ACCMA, the East Bay SMART Corridors Program consists of two major arterial corridors in the east bay portion of the San Francisco Bay Area — the San Pablo Avenue and the Hesperian/International/E. 14th Boulevard corridors. The intention of the SMART Corridors Program was to plan and implement a multi-modal advanced transportation management system along two corridors: the San Pablo Avenue /I-80 corridor and the I-880 corridor.[8]

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[6] http://www.smartcorridors.com/index.jsp
[7] http://www.accma.ca.gov/pdf/2002_2003_annual_report.pdf pp12.
[8] http://www.accma.ca.gov/pages/smart.shtml April 8, 2006.

The SMART Corridor concept is driven by the assumption that better management of vehicle traffic congestion, improved incident and emergency response, increased vehicle mobility, and overall increased efficiency and management of roadways and transit “can be achieved through Intelligent Transportation Systems (ITS) technologies, such as wireless communication devices for infrastructure (signal)-vehicle communication, dynamic message signs, traffic cameras, vehicle detection systems, emergency vehicle signal preemption systems, and transit signal priority systems.[9] The general goals of SMART corridors are summarized below.[10]

Enhance Local Arterial Operations

- Improve traffic signal coordination and reduce vehicle traffic delays.
- Improve collection and dissemination of current vehicle travel conditions.
- Provide accurate and timely information about the corridors to the transportation managers (municipalities) and to the public (via SMART corridor website).

Enhance Freeway/Arterial Operation

- Minimize the intrusion of freeway traffic onto local streets due to freeway congestion and freeway incidents (accidents or slowdowns)
- Proactively manage traffic already diverted from the freeway to minimize its impact on local arterial roadways, and return regional traffic back to the freeway as soon as possible.
- Provide rapid response to and clearing of incidents on both the freeway and surface streets.

Improve Transit Operations

- Improve on-time performance of public transit services.
- Reduce the travel times for public transit buses.
- Provide accurate and timely bus arrival information to riders

Facilitate Interagency Coordination

- Improve sharing of resources between transportation agencies
- Manage transportation operations (i.e. transit, signal timing, incident management) along the corridors.

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[9] http://www.accma.ca.gov/pages/smart.shtml April 8, 2006.
[10] http://www.accma.ca.gov/pages/smart.shtml April 8, 2006.

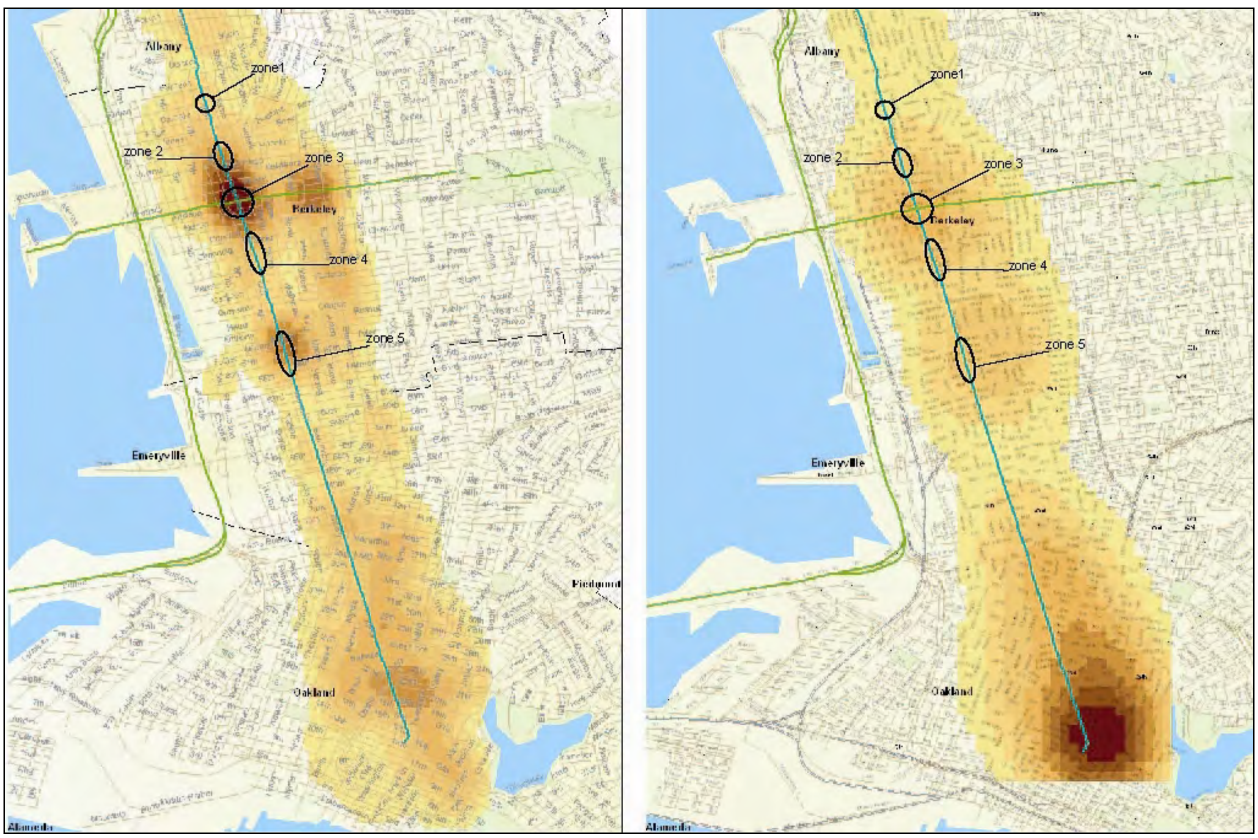
Figure 2.1. San Pablo Avenue SMART Corridor

These goals imply a very high level of planning and coordination in which the corridor is conceptualized and operated as an integrated system to enhance vehicle traffic. SMART corridors, if successful, hold the promise of great increases in coordinated and efficient mobility of vehicles.

2.3. THE STUDY AREA

The portion of the San Pablo Corridor in Berkeley is a 2.3-mile stretch of San Pablo Avenue. The five zones having the most significant historical crash activity and the largest crash densities were ultimately chosen as the “target zones” for field observations. These zones all incorporate intersections along or within one block of San Pablo Avenue in Berkeley. Pedestrian and bicyclist crash densities are shown in Figures 2.2 and 2.3. The intersections are listed by zone in Table 2.1.

Figure 2.2 (on left): Bicycle Crash Density, San Pablo Ave., (1998-2003)
Figure 2.3 (on right): Pedestrian Crash Density, San Pablo Ave., (1998-2003)
Darker areas indicate high collision desnsities



Source: US Census, SWITRS 1998-2003

Table 2.1: Study Intersections by Zone on the SMART Corridor in Berkeley, California

Zone 1	*Point Zone*
Intersection 1	San Pablo Ave. and Gilman St. **(S)**
Zone 2	*Linear North-South Zone*
Intersection 1	San Pablo Ave. and Cedar St. **(S)**
Intersection 2	San Pablo Ave. and Virginia St.
Zone 3	*Linear South and West Zone*
Intersection 1	San Pablo Ave. and University Ave. **(S)**
Intersection 2	University Ave. and 10th St.
Intersection 3	San Pablo Ave. and Addison St.
Zone 4	*Linear North-South Zone*
Intersection 1	San Pablo Ave. and Bancroft Way
Intersection 2	San Pablo Ave. and Channing Way
Intersection 3	San Pablo Ave. and Dwight Way **(S)**
Zone 5	*Linear North-South Zone*
Intersection 1	San Pablo Ave. and Ashby Ave. **(S)**
Intersection 2	San Pablo Ave. and Haskell St.
Intersection 3	San Pablo Ave. and 67th St.
Intersection 4	San Pablo Ave. and 65th St.

(S) = signalized

Each intersection was selected for study because it was identified as a productive target for pedestrian and bicycle-safety improvements. Study intersections were selected based upon visual clustering of pedestrian and bicycle crashes with vehicles along the corridor using Geographic Information Systems (GIS) software, a system capable of integrating, storing, editing, analyzing, and displaying geographically referenced information. Zones were created based on clusters of these historical crashes from 1998-2003, measured by both proximity to one another and number of crashes over time.

Traffic counts of motor vehicles were taken at signalized intersections along the corridor from the Fehr and Peers San Pablo Avenue Signal Coordination Project (2003). Fehr & Peers is a transportation consulting firm hired by ACCMA to collect the traffic counts at all signalized intersections along the corridor in order to inform signal coordination. The counts show a general pattern of high vehicle volumes, typical of an urban arterial.

Traffic Safety Center field observations were limited to intersections selected for study during August 2004. Scattered concentrations of high pedestrian volumes are shown in Table 3.1, with the highest being in Zone 3. Bicyclist volumes were higher at unsignalized intersections, particularly Zone 4. The remaining areas of high volume counts (both pedestrian and bicyclist) were scattered throughout the study area and thus could not be characterized by zone.
Land uses along the corridor were varied and ranged from shopping and retail centers, large and small employment centers, and recreational trails, to residential developments.

Historical collision data from 1998-2003 document a significant number of vehicle collisions with pedestrians and bicyclists. Forty percent of all such collisions along the entire San Pablo/ I-80 corridor occurred at Berkeley intersections, which constitute only 25 % of study intersections within the corridor. The existing vehicle traffic volume, pedestrian and bicycle patterns, and projected improvement in traffic flow due to SMART Corridor enhancements indicate a potential for conflicts among different types of road users. Additionally, the low pedestrian and bicycle volumes relative to the number of vehicles at several of these intersections indicate that drivers may not expect to encounter pedestrians and bicyclists and may drive in ways that create more risk for conflicts and collisions with pedestrians and bicyclists.

The goals of the current study are to:

- Evaluate the safety, perception of safety, and ease of use of the San Pablo Corridor in Berkeley for pedestrians and bicyclists.
- Propose measures to improve safety and ease of use for pedestrians and bicyclists in the area.

3. METHODS

3.1. CONCEPTUAL FRAMEWORK

This study identifies and describes multiple factors that may affect the behavior of pedestrians, bicyclists and drivers ("the users") at the study intersections. The physical character of intersections provides visual cues for motorists, pedestrians and bicyclists behavior. Examples include travel lanes, median and sidewalk widths, crosswalk character, signage, and traffic controls. Visual cues affect the speed of vehicle travel and the awareness of all users of their environment. The users (i.e. pedestrians, bicyclists and drivers) react first to the physical elements of the intersection and then react to one another, creating a dynamic environment. This environment can affect the users' actual and perceived safety at intersections. Potential collisions could be mitigated by physical interventions (i.e. countermeasures) to the intersection.

Researchers inspected the physical elements of each intersection and made observations about how each intersection was used by pedestrians and bicyclists, noting interactions and conflicts between motorized (drivers) and non-motorized (pedestrian and bicyclists) modes of transportation. Analysis of these data led to a typology, which was used to assign context-specific interventions to improve the safety of the intersection for pedestrians and bicyclists.

3.2. DATA COLLECTED

The evaluation utilized data from four main sources:

- Collision data
- Traffic volume
- Observations of drivers, pedestrians and bicyclists
- Field survey of physical infrastructure and land use

3.2.1. Collision Data

The Statewide Integrated Traffic Record System (SWITRS), a computerized collision database maintained by the California Highway Patrol (CHP), was used to reconstruct collision data at the study intersections.

SWITRS reported multiple collisions at the 13 study intersections in Berkeley between 1998 and 2003, with a total of 29 bicycle collisions and 36 pedestrian collisions with vehicles. These numbers likely underestimate the extent of such collisions since they only include reported incidents. Thus the risk for pedestrians and bicyclists is likely higher than official reports suggest.

Of the thirteen intersections, Ashby and San Pablo Avenues showed the highest numbers of both bicycle and pedestrian collisions. Over the six years studied, the intersection of Ashby and San Pablo had five vehicle collisions with pedestrians and six vehicle collisions with bicyclists. The intersection of University and San Pablo had four collisions of each type. Other intersections tended to have a predominance of one type of crash over the other.

Figure 3.1: Vehicle Collisions with Pedestrians and Bicyclists by Intersection Along the San Pablo Corridor in Berkeley, CA (SWITRS, 1998-2003)

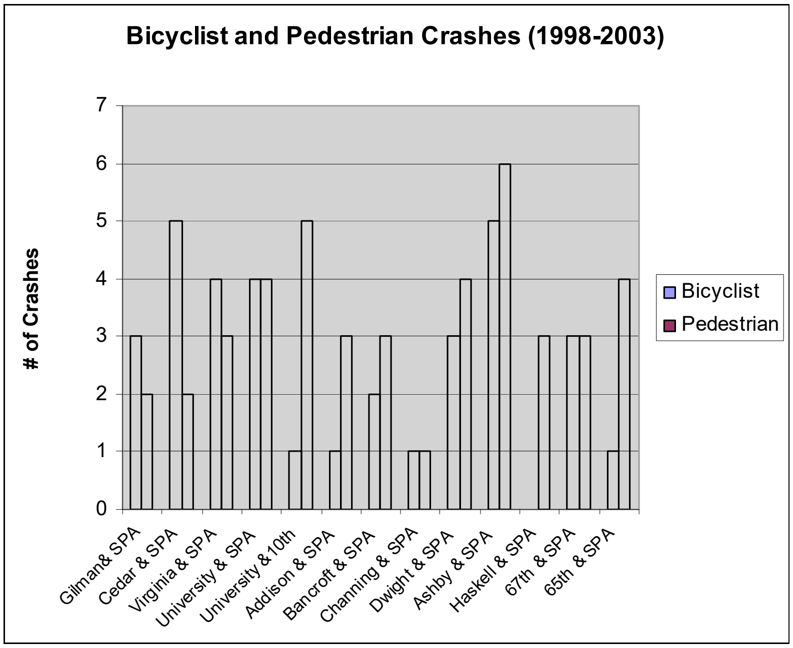


Table 3.1: Number of Vehicle Collisions with Pedestrians and Bicyclists by Intersection and Study Zone along the San Pablo Corridor in Berkeley (SWITRS, 1998-2003)

STUDY ZONE	STUDY INTERSECTIONS ALONG SAN PABLO CORRIDOR*	Vehicle Collisions	
		With Bicyclists	With Pedestrians
1	Gilman& San Pablo	3	2
2	Cedar & San Pablo	5	2
	Virginia & San Pablo	4	3
3	University & San Pablo	4	4
	University &10th	1	5
	Addison & San Pablo	1	3
4	Bancroft & San Pablo	2	3
	Channing & San Pablo	1	1
	Dwight & San Pablo	3	4
5	Ashby & San Pablo	5	6
	Haskell & San Pablo	0	3
	67th & San Pablo	3	3
	65th & San Pablo	1	4

3.2.2. Vehicle Volume

Vehicle volumes were supplied by Fehr and Peers[11] and include 2003 counts for the afternoon peak of 4 to 5 p.m. or 5 to 6 p.m. at all signalized intersections for the Berkeley section of the San Pablo corridor. The vehicle volumes at the signalized intersections are shown in Table 3.2.

Table 3.2: Vehicle Volume Counts at Signalized Intersections

Signalized Intersection	PM Peak Hour Vehicle Count [12]
Gilman & San Pablo	3285
Cedar & San Pablo	3564
University & San Pablo	4296
Dwight & San Pablo	3314
Ashby & San Pablo	3369

Based on these data, there were significantly higher counts of vehicles at the intersections of University and San Pablo Ave. and relatively high but, slightly less significant counts at Cedar and San Pablo Ave. These intersections provide important origin destination connections as well as direct connections to the freeway, which may be responsible in part for the higher volume. These data also provide some context for the analysis with descriptions of overall traffic conditions, and confirmed relative rates of vehicle flow at the signalized study intersections with typical high urban arterial traffic flow. Vehicle count data was not available for other years or for unsignalized intersections.

3.2.3. Field Observations

Researchers made observations at each of the 13 intersections to collect behavioral data on drivers, pedestrians, and bicyclists and their interactions. Observations were made in August of 2004 for a one-hour period during peak traffic hours of 3 p.m. to 6 p.m. midweek (Tuesdays, Wednesdays, and Thursdays to avoid fluctuations in traffic due to weekend travel effects, a common industry practice). Observations were recorded by TSC staff, graduate student researchers, and University of California Transportation Center (UCTC) graduate student researchers.

Data collection forms for pedestrians and bicyclists are included in Appendix A.

[11] San Pablo Avenue Signal Coordination Project. Fehr and Peers, 2003.
[12] Fehr and Peers, 2003.

Table 3.3 Observed Vehicle, Pedestrian and Bicyclist Counts at Peak Afternoon Hours by Intersection and Zone Along the San Pablo Corridor in Berkeley, CA, (2003-2004)

Zone	Intersection	Peak Vehicles*	Pedestrian Count**	Bike Count **
1	Gilman	**3285**	142	30
2	Cedar	**3564**	118	33
	Virginia	NA	76	21
3	University	**4296**	349	11
	10th	NA	145	4
	Addison	NA	262	25
4	Bancroft	NA	72	45
	Channing	NA	52	60
	Dwight	**3314**	137	39
5	Ashby	**3639**	128	25
	Haskell	NA	28	10
	67th	NA	73	25
	65th	NA	123	36

*Collected by Fehr & Peers (2003), made available by University of California Transportation Center.[13]
**Collected by Traffic Safety Center August, 2004.

Behavioral data collected for pedestrians by researchers under the supervision of TSC staff included:

- Leg of intersection/crosswalk used by pedestrian
- Whether the pedestrian was alone or part of a group
- Age group and gender of pedestrian
- Whether the pedestrian pushed the pedestrian signal button (if applicable)
- Pedestrian signal phase at time of pedestrian entry into crosswalk (Walk, Flashing Don't Walk, Solid Don't Walk)
- Pedestrian signal phase at time of pedestrian exit from crosswalk
- Whether the pedestrian crossed outside of the crosswalk
- Whether the pedestrian walked, ran (due to discomfort or fear of traffic), or aborted their crossing (due to change in signal or oncoming traffic)
- Vehicle presence and movement
- Vehicle violation (e.g. violation of pedestrian right-of-way, or running a red light)
- Conflicts with vehicle, including:
    - Pedestrian changed gait or stride to avoid perceived/real threat,
    - Vehicle stops or swerves to avoid a pedestrian

[13] Fehr and Peers, 2003.

Behavioral data collected for bicyclists by trained researchers under the supervision of the Traffic Safety Center staff included:

- Leg of intersection used by bicyclist
- Whether the bicyclist was alone or part of a group
- Age group and gender of bicyclist
- Signal phase at time of bicyclist entry into intersection (Green, Yellow, or Red)
- Signal phase at time of bicyclist exit from intersection
- Starting direction of travel
- Ending lane and direction of travel
- Turning direction (if any)
- Starting and ending lane of travel (or sidewalk)
- Bicyclist violation (running a red light or violating another vehicle's right-of-way)
- Vehicle presence and movement
- Vehicle violation (e.g. violation of pedestrian right-of-way, or running a red light)
- Presence and type of conflict with vehicle, including
    - Cyclist changed braked or swerved to avoid perceived/real threat
    - Vehicle stops or swerves to avoid a bicyclist

Due to the relative rarity of vehicle collisions with pedestrians or bicyclists and the difficulty in identifying significant changes in crash rates within approximately one year after implementation of countermeasures, we gathered information on surrogate measures for vehicle collisions with pedestrians or bicyclists. It should be noted that implementation of the recommended countermeasures and follow up analysis are not part of this baseline study.

Researchers documented the following behaviors as surrogate measures:

- Vehicle encroachment ("movement") on pedestrian or bicyclist right-of-way was defined as a vehicle moving into the crosswalk without fully blocking the crosswalk or forcing the pedestrian to change direction or move out of the way.
- Vehicle violation of pedestrian or bicyclist right-of-way included a clear violation of the pedestrian or bicyclist right-of-way, such as blocking a crosswalk or making a right turn in front of a bicyclist or pedestrian.
- Vehicle conflicts with pedestrians and bicyclists were defined by either a pedestrian or bicyclist changing his or her speed or direction to avoid a perceived or real threat, or a vehicle stopping or swerving to avoid a pedestrian or bicyclist.
- Pedestrians running or aborting their crossing indicated that pedestrian signal timing was not sufficient, or crossing distance was too long.

Observations included many occurrences of vehicles failing to yield the right-of-way, pedestrians unable to complete crossings during the "Walk" phase, and bicyclists having difficulty navigating among vehicles changing lanes.

3.2.4. Field Inspection of the Intersections

Parallel to field observations, in August 2004, TSC staff inspected the infrastructure at each intersection using a standardized form. Information was collected from each leg of the intersection and up to 100 feet of the approach, including signal configuration, signage, pavement markings, adherence to ADA requirements, and other features. Types of information collected included:

- Pavement Markings/Striping: type and condition
  - Crosswalk (parallel, ladder)
  - Advance limit lines (yielding)
- Lane configuration (number and type of lanes in each direction)
- One-way streets
- Traffic signals (signalized, unsignalized (stop), uncontrolled)
- Traffic restrictions (e.g. no right turn on red, no U-turn)
- Pedestrian signals and countdown signals
- Pedestrian-safety signs
- Detectable boundary[14] between sidewalk and street
  - Truncated domes[15]
  - Textured pavement
- Parking locations
- Street light locations
- Possible sight obstructions
- Curb ramps[16]
- Temporary or permanent items protruding into travel routes (vegetation, trash cans, etc)
- Sidewalk width/clearance
- Driveway locations (distance from intersection)
- Posted speed limits
- Bus stop locations
- Median islands
- Adjacent land uses

The staff was instructed to take measurements and note presence or absence of features contributing to the overall transportation infrastructure for each location. The staff assessed many deficiencies in these areas, the most frequent being: curb ramps that led outside established crosswalk markings, lack of curb ramps, and sidewalk clearance blocked by landscaping or street furniture.

[14] Detectable warnings are a standardized surface feature applied to walking surfaces to warn pedestrians of hazards on a sidewalk, such as a curb line or drop-off, AASHTO, July 2004. pp124.
[15] Truncated domes are small domes with flattened tops used as a detectable warning at curb lines, and transit platforms, AASHTO, July 2004. pp126.
[16] A curb ramp is a combined ramp and landing to accomplish a change in level at a curb, providing street and sidewalk access to wheelchairs, AASHTO, July 2004. pp124.

4. OVERALL PROBLEMS AND COUNTERMEASURES

4.1. PROBLEMS

Several problems are common to the study area as a whole and have an impact on safety for pedestrians and bicyclists at all intersections within the Berkeley sector of the San Pablo Corridor. These include:

- Turning conflicts with pedestrians at marked crossings
- ADA and MUTCD Violations
  - Curb ramps outside of the crosswalk markings
  - Lack of detectable boundaries between sidewalk and street
  - Sidewalks blocked by landscaping or street furniture
- High-speed traffic in pedestrian crossing areas
- Jaywalking
- Close proximity of driveways to intersections
- Poor crosswalk visibility
- Inadequate median width for pedestrian refuge
- Driver encroachment on pedestrian right-of-way
- Lack of way-finding signage for bicyclists
- Lack of amenities for bicyclists (e.g. bike lanes, bike boxes, way finding)

4.1.1. Turning Conflicts For Pedestrians at Marked Crossings

The predominant safety problem at intersections studied was the violation of pedestrian right-of-way by right- and left-turning vehicles. The risk for pedestrians occurs from: (i) right turns on red, (ii) right turns on green, (iii) right-turns at a non-signalized crossings, and (iv) unprotected left turn phases, where pedestrians get a walk signal against potential left-turning vehicles. During a protected left-turn phase for vehicles, pedestrians get a "Don't Walk" signal for the duration of left-turn green arrow. Such conflicts were typical of the movements preceding vehicle collisions with pedestrians at crosswalks as shown in the historical SWITRS data.

For vehicles turning right during red lights, the risk occurs to pedestrians who cross in their "Walk" phase immediately in front of the vehicles facing the red light. Observed drivers often did not stop as required, or when they did stop, they tended to look to their left for a gap in the traffic rather than to the right where pedestrians were crossing.

For vehicles turning right during green lights, the risk occurs because the pedestrian "Walk" phase coincides with the green light for the vehicle. Often, drivers simply did not yield to pedestrians, moved very close to them before stopping, or proceeded very closely behind them. In many cases, drivers seemed to presume the right-of-way. Right turns on green also provided bicycle–driver conflicts when bicyclists, who were navigating straight through an intersection, had to cross the path of right-turning vehicle to proceed.

The risks for pedestrians when drivers are making left turns without an exclusive left turn signal phase are similar to those for right-turn conflicts, although the pedestrian typically has the benefit of facing the oncoming/encroaching motorist.

For right turns at unsignalized intersections, drivers are required to observe the right-of-way of pedestrians in the crosswalk, and must stop for them. However, drivers are often unfamiliar with the law and attempt to drive in front of or behind pedestrians when they perceive an adequate gap, frequently cutting off the pedestrian. If there are no pedestrians in the crosswalk drivers have no restrictions from turning and tend to slow their speed only when the curb radius is small enough to require it.

4.1.2. ADA and MUTCD Violations

Other significant problems observed were violations of the ADA and Architectural Barriers Act (ABA) Accessibility Guidelines for Buildings and Facilities.[17] The most frequent violation was the location of curb ramps outside of crosswalk markings on San Pablo Avenue, which may force pedestrians to enter the street at a place outside of a crosswalk, where motorists may not expect them and may not see them. This situation is especially dangerous for persons with disabilities and pedestrians with strollers who use the ramps.

Most intersections did not have any detectable warnings or truncated domes to indicate the transition from sidewalk to intersection. According to Americans with Disabilities Act Accessibility Guidelines (ADAAG)[18] "Detectable warnings shall consist of raised truncated domes with a diameter of nominal 0.9 in (23 mm), a height of nominal 0.2 in (5 mm) and a center-to-center spacing of nominal 2.35 in (60 mm) and shall contrast visually with adjoining surfaces, either light-on-dark, or dark-on-light."[19] The truncated domes are typically placed relatively close together and can be detected by one's feet or when using a cane. The domes are placed at a two-foot long strip at the curb line for the full width of a ramp or walkway to warn of proximal vehicular traffic or a grade change.[20] While Berkeley intersections were not in violation at the time of the study, when upgraded to MUTCD standards, they will be required to have truncated domes installed at the landing of the curb ramp to signalize the entry way or direction to the crosswalk.

Obstructions on sidewalks, such as landscaping and street furniture, can reduce the effective width of passage, which can be particularly problematic for persons with disabilities and pedestrians with strollers. The ADA standards require a minimum sidewalk clearance of 36 inches but recommends 60 inches to permit passage of two wheelchairs side by side.[21]

Caltrans is currently addressing some of the curb-ramp and crosswalk upgrades as part of corridor-wide upgrades concurrently with the ACCMA SMART Corridor improvements (eg. bus rapid transit signal prioritization). However, assessment of the full extent of recent improvements is outside the scope of this project.

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[17] http://www.access-board.gov/ada-aba/final.pdf

[18] ADAAG provides scoping and technical specifications for new construction and alterations undertaken in the public right-of-way. AASHTO, July 2004. pp123.

[19] *Draft Guidelines for Accessible Public Rights of Way*, United States Architectural and Transportation Barriers Compliance Board, Washington, DC, June 2002. http://www.access-board.gov/adaag/html/adaag.htm#4.29.2

[20] AASHTO July 2004,, p88.

[21] AASHTO, July 2004, p58.

4.1.3. High Speed Traffic in Pedestrian Zones

The speed limit along the majority of study area was 35 mph (one school was located within the Berkeley study at zone 2). While not explicitly measured, vehicle speeds appeared to exceed the speed limit at several locations. While making right turns, drivers commonly slowed, but they did not always stop (i.e. yield properly to pedestrians), typically accelerating across the crosswalk to fit in the gaps in traffic. In general, it appeared that higher speeds were facilitated by wide lanes, large intersections, and lack of traffic controls that characterize some intersections in the area.

4.1.4. Close Proximity of Driveways to Intersection

Several intersections in the study area had driveways within 100 feet of the stop bar or crosswalk. This could lead to pedestrian/driver conflict on sidewalks and bicyclist/driver conflict on the streets and sidewalks for motorists entering and exiting businesses in heavy traffic areas.

4.1.5. High Incidence of Jaywalking

In several locations, where existing crosswalks were not meeting the needs for the pedestrians needing to reach destinations on the opposite side of San Pablo Ave. (origin and destination pairs), jaywalking was observed. Jaywalking increases risk because motorists may not expect pedestrians midblock and may be traveling at relatively higher speeds, making sudden stopping difficult.

4.1.6. Poor Crosswalk Visibility

The majority of the crosswalks in the study area have only minimal striping consisting of two parallel lines, and many of these are faded, making them less visible to drivers. In addition, although several crossings are part of bicycle routes, there is no indication that bicycles are allowed in these crossings.

4.1.7. Inadequate Medians

Several medians were inadequate for pedestrian refuge due to inadequate width, failure to extend to the crosswalk, and failure to meet ADA requirements for accessibility (i.e. entrance to protected median at grade, minimum width 60”).

4.1.8. Vehicle Encroachment on Pedestrian Right-of-Way

Researchers observed motorists encroaching upon pedestrian and bicyclist right-of-way in several intersections, which can lead to a perception of increased danger for pedestrians. This problem was exacerbated by previously discussed conditions including:

- Turning conflicts
- High vehicle speed
- Poor crosswalk visibility

4.1.9. Lack of Way-Finding Signage for Bicyclists

Signage directing pedestrians and bicyclists to common paths or destinations is generally lacking. For example, few markings indicate the bicycle boulevard system or the precise location of secondary bicycle routes, creating ambiguity about where bicyclists can travel.

4.1.10. Lack of Amenities for Bicyclists

At most intersections, bicyclists were observed riding on the sidewalk or traveling in the wrong direction (against traffic) on the street. This practice was reflected in the records of vehicle/bicycle collisions in the area involving bicycles traveling against vehicle traffic flow. This bicyclist behavior likely indicates a lack of amenities for bicyclists or general feeling of lack of safety on the street. On some streets (e.g. Shattuck Ave.) in Berkeley bicyclists are prohibited from traveling on the sidewalk. On San Pablo Ave. there are several locations where the sidewalk was too crowded with pedestrians to accommodate bicyclists. In the cases where we did observe bicyclists on the sidewalk, we saw it as a surrogate measure for the sense of danger or risk on the street for the bicyclists. This risk can be compounded if bicyclists cross against traffic in crosswalks and turning drivers do not expect to encounter them.

4.2. COUNTERMEASURES TO MITIGATE PEDESTRIAN AND BICYCLIST RISK

The selection of recommended countermeasures is based on observed behavior of pedestrians, bicyclists, and drivers, analysis of existing infrastructure and review of potential countermeasures.

A wide range of potential countermeasures is recommended to illustrate a variety of options. Countermeasures are organized into two categories: a minimum set of lower-cost and simpler “basic treatments” that should be applied, and a set of “additional items,” which are often more costly or complex, that should also be considered.

In this section, the safety concerns and potential countermeasures are summarized.

4.2.1. Overall Goals

The San Pablo Corridor in Berkeley parallels I-80. The corridor was designed to accommodate a high volume of motor vehicle traffic within and through Berkeley. With close proximity to the freeway, and a significant number of regional commercial destinations, there is an “automobile mentality” in the area that raises concerns about safety for pedestrians and bicyclists. General goals of the countermeasures are to (i) increase drivers’ awareness of pedestrians and bicyclists and their right-of-way, (ii) alert pedestrians and bicyclists to areas of risk, and (iii) improve ease of travel and crossing intersections for pedestrians and bicyclists.

Meeting these goals requires a vigorous application of available countermeasures, many of which involve engineering and enforcement. One goal is to ensure that motorists as well as pedestrians and bicyclists should have a sense that all have an equal right to travel in the area. This can be accomplished through a clear, consistent pattern of signage, a distinctive crosswalk treatment, consistent lighting and other enhancements that will make the area more inviting for pedestrians and bicyclists, while providing cues to drivers that the intersections are shared spaces.

Recommendations for countermeasures (summarized in Table 4.1) drew upon planning practice and several state of the practice publications and resources including:

- Traffic Calming State of the Practice by Reid Ewing (1999)
- AASHTO's Guide for the Planning, Design and Operation of Pedestrian Facilities (2004)
- Walkinginfo.org, a comprehensive resource on pedestrian issues (tools, checklists, policies, data, plans, and photographs) maintained by the Pedestrian and Bicycle Information Center at the University of North Carolina, Chapel Hill.

Table 4.1. Safety Concerns and Countermeasures

Issue	Potential Countermeasures to Achieve Goals
Vehicle Turning Right During Red Light Across Pedestrian Crossing	• Recessed stop bars • Signs indicating "Stop on red before proceeding" and "Yield to pedestrians" • Experimental pedestrian-triggered in-roadway lighting • Pedestrian triggered electronic signs indicating "Yield to pedestrians" or "No right turn on red." • A pedestrian warning sign accompanied by two amber flashing signal beacons • No right turn on red (RTOR) SIGNS
Vehicle Turning Right or Left During Green Light Across Pedestrian Crossing	• Passive warning signs (fixed roadside) clearly indicating the pedestrian right-of-way • Leading pedestrian interval (pedestrian- crossing phase begins prior to the vehicle green phase to give pedestrians a head start) • Experimental pedestrian triggered in-roadway lighting or electronic signs indicating "Yield to pedestrians" • A pedestrian warning sign accompanied by two amber flashing signal beacons
Vehicle Turning Right or Left at Unsignalized Intersection Across Pedestrian Crossing	• Pedestrian triggered in-roadway lighting, • Electronic signs or overhead beacons indicating "Yield to pedestrian"

Lack of ADA and MUTCD Compliance on Sidewalks and Ramps at Intersections	• Bringing curb ramps into compliance
	    • Placing within crosswalk openings
	• Distinguishing borders between sidewalk and intersection
	    • Installing truncated domes at crossing entrances
	• Bringing sidewalk width/clearance into compliance

Excessive Vehicle Speed and Conflict While Turning Across a Pedestrian Crossing	• Reduced turning radii. By squaring off curb to minimum allowable radius for class majority (85th percentile) anticipated class of vehicle to slow turning vehicles and reduce pedestrian crossing distance • Warning/Enforcement: • Radar speed trailers in select locations

	• For right turns on red, enforcing full vehicle stop before proceeding on red

Close Proximity of Driveways to Intersection	• Moving driveways to secondary streets
	• Measures to enhance awareness for pedestrians:
	  • Driveway crossing signs
	  • Pavement texture change
	• Measures to enhance awareness for motorists/bicyclists:
	  • Pedestrian crossing zone sign (on sidewalk)
	  • Pedestrian in roadway knockdown/impactable yield signs (in crosswalk)

High Incidence of Jaywalking	• Enhancing current crossings, making them more easily accessible thus attractive to pedestrians. • Make safer with in-pavement lighting or pedestrian overhead beacon, special crosswalk paving • Legitimize unmarked crossings: making safer by installing pedestrian crossing signs to warn motorist of potential crossing zone
Poor Crosswalk Visibility	• Greatly enhanced crosswalk and other pavement markings • In paths where both bicycles and pedestrians are allowed, separate (sidewalk/multi-use recreational path) pathways for pedestrians and bicyclists should be marked as drivers do not expect bicyclists traveling opposite of traffic
Inadequate Medians	• Lengthen median to connect with the marked crosswalk • Widen median to 48 inch minimum • Make medians ADA accessible (entrance to protected median at grade, minimum width 60”)
Vehicle Encroachment on Pedestrian Right-of-Way (ROW)	• Moving vehicle stop limit lines several feet short of crosswalk • Enforcement of stopping for red lights before turning right

Lack of Way-Finding Signage	• Marking bicycle routes with a consistent treatment and way-finding signage.
	  • In-roadway markings and coloring on bicycle routes,
	  • Distinctive signage both marking the route and directing bicyclists to it

Lack of Amenities for Bicyclists	• “Share-the–road” awareness signs directed at drivers • Intersection parking restrictions for 100 feet from the intersection for all vehicles at rush hour • Intersection bicycle boxes, to provide space to bicycles to wait at intersections for the signal to change

4.2.2. Countermeasures

Countermeasures include changes to signage and lighting, physical infrastructure (including upgrades to meet ADA requirements), signal timing, and enforcement of traffic-safety laws. Each of these countermeasures can help to make the intersections safer.

Signage and Lighting:
Signage can alert drivers, pedestrians and bicyclists to potential hazards. However, sign use and movement should be judiciously employed, as overuse may result in noncompliance. Additionally, excessive signage can clutter the roadway, causing confusion.[22] Signs may be more effective with appropriate lighting and when activated by pedestrians. In general, in-pavement, streetlights and beacons can be effective alternatives to constant lighting, particularly at night and if triggered by pedestrian or bicyclist presence. Proper street lighting can have a beneficial effect on the safety and comfort of pedestrians. Lighting should not only highlight the presence of intersections, but mark mid-block crossings.[23]

Physical Infrastructure Changes:
One of the most effective ways to change driver, pedestrian and bicyclist behavior is by making physical changes to the roadway environment. Adding medians, extending curbs, and tightening turns does not rely on the presence of pedestrians or bicyclists to be effective in changing driver behavior. Such countermeasures also affect behavior day and night.

In addition, a distinctive crosswalk treatment would improve driver awareness of pedestrians and bicyclists and mark the area as a shared space. The pattern should be highly visible day and night. Potential treatments could include wide bold ladder stripes, texture, color, lighting, and bicycle route symbols where applicable.

In his study, Reid Ewing noted that the most compelling effect of traffic calming is improved traffic safety. By slowing traffic, eliminating conflicting movements, and sharpening drivers' attention, traffic calming may result in fewer and less severe collisions.[24]

Law Enforcement:
Enforcement of traffic safety laws, particularly for drivers, is critical to making intersections safer for all users, especially the preservation of pedestrian right-of-way. Well-publicized enforcement campaigns are often effective in deterring careless and reckless driving. Campaigns usually involve public education programs that encourage drivers to share the roadway with pedestrians and bicyclists, combined with strategically installed traffic control devices.[25] Most importantly, by enforcing the traffic code, the police lend credibility to traffic laws, traffic control devices, legal right-of-way, and traffic safety educational programs.

Municipalities can use various strategies to implement enforcement campaigns to protect pedestrians and bicyclists. These include increased police presence around school zones, residential neighborhoods, and other areas with high pedestrian activity; "pedestrian sting" operations that involve police officers in civilian clothing; and high-profile, mass media campaigns to introduce change and help set the public agenda.[26]

ADA Requirements:

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[22] Walkinginfo.org April 10, 1006.
[23] AASHTO, July 2004, pp 89.
[24] Reid Ewing, Traffic Calming, State of the Practice (ITE: 1999), 109.
[25] www.walkinginfo.org April 10, 2006.
[26] www.walkinginfo.org April 10, 2006.

The Americans with Disabilities Act Accessibilities Guidelines (ADAAG) provide scoping and technical specifications for new construction and alterations undertaken in areas of public right-of-way.[27] A majority of the study intersections failed to meet basic ADA requirements regarding curb ramp requirements, and some failed due to landscaping and street-furniture blocking the travel path on sidewalks. Per ADA guidelines, curb ramps must be installed at all intersections and midblock locations where pedestrian crossings exist, as mandated by federal legislation (1973 Rehabilitation Act and ADA1990). Curb ramps must have a slope of no more than 1:12 [must not exceed 25.4 mm/0.3 m (1 in/ft) or a maximum grade of 8.33 percent], and a maximum slope on any side flares of 1:10.[28]

Researchers noted that pushbuttons were not always located close to the curb ramps, and very few ramps had detectable boundaries between the street and sidewalk. The ADAAG specifies that detectable warnings are to be installed at a 2.0 ft strip at the top of the curb ramp for the full width of the ramp or walk.[29] Sidewalks and walkways should be kept clear of poles, signposts, newspaper racks, and other obstacles that could block the path, obscure a driver's view or pedestrian visibility, or become a tripping hazard. All other ADA requirements for the intersections appear to have been in compliance for the study intersections. ADA upgrades should be made as the intersections are upgraded.

4.2.3. Intersection Taxonomy

An intersection taxonomy system was developed to classify the groupings of intersections that comprise the Berkeley sector of the San Pablo Avenue Corridor in a consistent manner, to define the relationships between the infrastructure and the behavior of drivers, pedestrians, and bicyclists. A further goal was to measure the consistency between infrastructure, behavior, and historical crash data for the intersections. The intersection taxonomy is outlined below.

Traffic Flow Characteristics

- Automobile Average Daily Traffic (AADT)
- Estimated Average speed

- Infrastructure characteristics:
    - Traffic control: Signal, stop, no control
    - Roadway/crossing environment and/or deficiencies
        - Roadway width, where applicable: insufficient crossing time
        - Sidewalk clearance, ADA compliance
        - Driveways, curb cuts (distance from intersection)
        - Excessive distance between crossings (more than two blocks without a marked crossing)
        - Unsuitable median refuge (too narrow, doesn't connect to crosswalk)

[27] AASHTO, July 2004, pp 123.
[28] *Draft Guidelines for Accessible Public Rights of Way*, United States Architectural and Transportation Barriers Compliance Board, Washington, DC, June 2002. http://www.access-board.gov/adaag/html/adaag.htm#4.8
[29] AASHTO, July 2004, pp 88.

Observed Behavior

- Pedestrian
- Bicyclist
- Driver

Finally, historical data on collisions between vehicles and pedestrians or bicyclists was used to identify typical crash types and conflicts. Based on the physical taxonomy that was constructed for each of the intersections from infrastructure deficiencies, user characteristics and historical crash data, ‘profiles’ of intersections were formulated that recommended a number of appropriate countermeasures. The countermeasures were drawn from field practice and established industry resources such as those listed in section 4.2.1. Countermeasures were recommended for the individual intersections, for study zones, and where applicable, for the entire San Pablo Corridor in Berkeley. The taxonomy matrix is shown in Appendix B.

5. ZONE ANALYSIS

5.1. ZONE 1

Zone 1 is a single intersection at San Pablo Avenue and Gilman Street.

Figure 5.1: Aerial Photo Zone 1 and Intersections

5.1.1. Observed Land Use

The land use in Zone 1 is primarily commercial with convenience stores, restaurants, automobile service, and a gas station in the vicinity. A shopping center with a national chain store is located immediately south of the intersection. The land use to the east of San Pablo on Gilman transitions to single and multi-family residential use, while the western side is primarily commercial and industrial as Gilman approaches Interstate 80.

5.1.2. Gilman Street and San Pablo Avenue

5.1.2.1. Traffic Characteristic/Control

The traffic flow at on San Pablo at Gilman is heavy and travels at a relatively high speed, often above 45 mph. The intersection is controlled by a traffic signal with an eastbound and westbound left turn phase and dedicated left-turn lanes.

Traffic during the afternoon peak was an estimated 3300 vehicles,[30] 140 pedestrians,[31] and 30 bicyclists per hour. Vehicle counts were the summation of all approaches at the intersection (Gilman and San Pablo), and pedestrian and bicyclist counts were for all crossings.

5.1.2.2. Roadway/Crossing Characteristics

There are four through-travel lanes, two in each direction and one turning lane on San Pablo and three through-travel lanes on Gilman (2 western approach, 1 eastern approach). The boundary between sidewalk and street on all sides of the intersection was generally undetectable, and all sides of the brick paved crosswalk were unevenly worn and visually difficult to distinguish from the roadway. A large number of bicyclists were observed using this intersection, however there were few amenities to serve them such as paths, signs, or signals. Many pedestrian crossings were made outside of the intersection or against the signal, suggesting that the current intersection (facility) was not meeting their needs.

5.1.2.3. Observed Intersection Behavior

- Drivers were observed encroaching upon pedestrians in the crosswalk
- 18% of pedestrians observed walked against the "Don't Walk" signal
- Bicyclists were observed riding on the sidewalk
- Bicyclists were observed riding on the wrong side of the road, against traffic. At this intersection, there is a history of collisions between vehicles and bicyclists riding in the wrong direction.

5.1.2.4. Crash Typology

Three collisions between vehicles and bicyclists, and two between vehicles and pedestrians were reported for this intersection between 1998 and 2003 (Figure 3). Two bicycle crashes occurred in the proximity of the intersection, but over 100 feet from the crosswalk. The pedestrian crashes were located outside of the crosswalk. One involved a jaywalking pedestrian and a straight moving vehicle (p1). The second involved a left-turning vehicle that violated the traffic signal and struck an eastbound pedestrian (p2).

The bicycle crashes were mainly concentrated on or near the northeast corner of Gilman. Two of the bicycle crashes occurred outside of the intersection in a place where bicyclists would be cut off by merging or turning traffic. The bicycle crash events involved bicyclists riding in the wrong direction, against vehicle traffic, hitting a stopped vehicle, and entering traffic. The crash types and previous movements are illustrated in Figure 5.2.

[30] Peak hour vehicle flow data provided at all intersections by Fehr and Peers, 2003.
[31] Pedestrian and bicyclist counts taken for one hour, between the afternoon peak hours of 3-6 p.m. Tuesday-Thursday at each intersection unless otherwise noted. Counts taken by study author and TSC staff.

Figure 5.2. San Pablo Avenue and Gilman Street

5.1.2.5. Intersection Summary Analysis

The intersection is dominated by north-south automobile traffic along San Pablo with a west-to-east squeeze conflict, as a lane drop occurs when Gilman changes from commercial/industrial to residential. A busy shopping center with a regional draw is located to the southwest of the intersection and has entrances on Gilman to the north and San Pablo to the south, which results in traffic backups and conflicts on the sidewalks, driveways, and at a bus stop. A gas station is located on the southwest corner, with entrances and exits located close to the intersection on each side. Gilman also leads to I-80/580 to the west and to and a Target Superstore to the west and north, which draws additional traffic through the intersection. All of this contributes to a very active intersection with vehicles, pedestrians, and bicyclists.

5.1.2.6. Recommended Countermeasures (Intersection Specific)

The risks for this intersection should be addressed by the general countermeasures recommended for all intersections and signalized intersections.

The risks include:

- High rates of jaywalking
- Close proximity of driveways to intersection

- Poor crosswalk visibility
- Vehicle encroachment on pedestrian right-of-way (ROW)
- Lack of bicycling amenities

5.2. ZONE 2

Zone 2 is a linear single block zone on San Pablo Avenue bounded by Cedar Street and Virginia Street and selected for its high concentration of pedestrian and bicyclist crashes.

Figure 5.3: Aerial Photo Zone 2 and Intersections

5.2.1. Observed Land Use

The land use in this area is primarily commercial with businesses including pet supplies, bakeries, gas stations, and restaurants in the vicinity. San Pablo Avenue at Cedar St. has a fine grain pedestrian scale (tightly spaced buildings with shallow setbacks) with a large variety of storefronts and building facades abutting the sidewalk, with regular street tree planting that gives a feeling of enclosure and safety at this location moving south on San Pablo Ave. toward Virginia. However, south of Virginia, the land use transitions to a higher proportion of residential with more driveway curb cuts on the sidewalks. The land use to the east is primarily residential and to the west is mixed commercial and residential.

5.2.2. Cedar Street and San Pablo Avenue

5.2.2.1. Traffic Characteristics/Control

The traffic flow on San Pablo Avenue at Cedar is heavy and travels at a relatively high speed, often above 45 mph. The intersection is controlled by a traffic signal and multi-directional left turn phases. The posted speed is 35 MPH.

Traffic during the afternoon peak was an estimated 3500 vehicles, 118 pedestrians, and 34 bicyclists per hour.

5.2.2.2. Roadway/Crossing Characteristics

There are four through-travel lanes on San Pablo, two in each direction and two through travel lanes on Cedar, one in each direction. Cedar's lane configuration is complex and potentially confusing on the eastern approach. It splits into two streets just east of the intersection, with Hopkins to the north and Cedar to the South. There were several ADA concerns, including a lack of ADA-compliant curb ramps on crosswalk exits on the northeast, northwest, and southwest corners, and the nearest sidewalk access points for pedestrians were corner business driveways. The southeast crosswalk end curb ramp was in compliance for slope and ramp landing, however it was not contained within the crosswalk markings. The southwest sidewalk was cluttered with unmounted newspaper boxes that could easily be sent into disarray when loaded and unloaded, obstructing the sidewalk. Another concern was the close proximity of driveway entrances to the intersection on the northwest, southwest, and southeast sides, which could lead to pedestrian/driver conflict on sidewalks and bicyclist/driver conflict as motorists enter or exit businesses in heavy traffic areas. There were medians on the east and west sides on Cedar that were unsuitable for pedestrian refuge because they did not extend into the crosswalk. Also, the boundary between sidewalk and street was generally undetectable, and the brick-paved crosswalk was unevenly worn and visually difficult to distinguish from the roadway pavement.

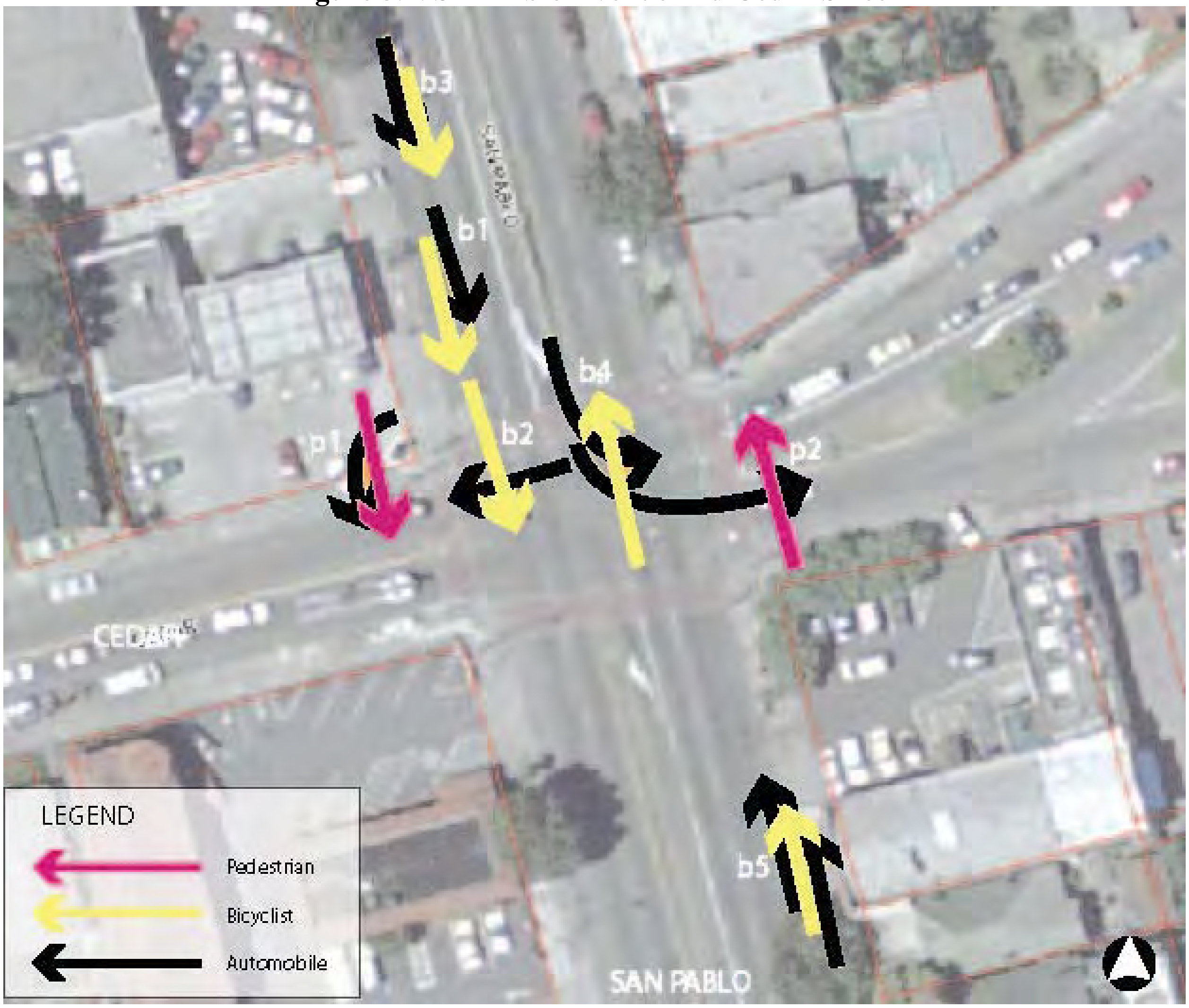
5.2.2.3. Observed Behavior

- Drivers were observed regularly encroaching upon pedestrians in the crosswalk in the intersection.
- 26% of pedestrians observed walked against the signal; i.e., they, began crossing at flashing "Don't Walk" or during the "Don't Walk" signal.
- Bicyclists were observed riding on the sidewalk suggesting a lack of amenities, such as bicycle lanes and intersection bicycle boxes.

5.2.2.4. Crash Typology

Collisions between vehicles and five bicyclists, and vehicles and two pedestrians were reported for this intersection between 1998 and 2003. The crash types and previous movements are illustrated in Figure 5.4.

Figure 5.4. San Pablo Avenue and Cedar Street



The majority of the crashes appeared to be concentrated in the northwestern quadrant and approach to the intersection. The pedestrian crashes involved a driveway crossing and a left-turning vehicle violation of pedestrian ROW in a crosswalk

The bicyclist crashes involved vehicles entering traffic, bicycles hitting stopped cars, and vehicles cutting-off bicyclists via turning or lane changes.

5.2.2.5. Intersection Summary Analysis

The Cedar-San Pablo Intersection was distinguished by its high level of vehicle traffic of 3500 vehicles per hour at the afternoon peak in 2003, high numbers of pedestrians and bicyclists, and poor ADA compliance for curb ramps and crosswalks. There were many local business attractors that brought vehicles, pedestrians and bicyclists into potential conflict within 100 feet of the intersection.

5.2.2.6. Recommended Countermeasures (Intersection Specific)

- Restrict RTOR/Leading Pedestrian interval: reduces conflict, increases use of pedestrian call button, increases numbers of drivers yielding to pedestrians, and reduces pedestrian delay. However, may reduce intersection level of service (LOS) by increasing vehicle wait time.
- Median extensions to crosswalk (pedestrian refuge islands): reduce conflict, reduce number of trapped pedestrians, increase number of pedestrians using crosswalk.

5.2.3. Virginia Street and San Pablo Avenue

5.2.3.1. Traffic Characteristics/Control

The traffic flow on San Pablo Avenue at Virginia is moderate to intermittent and appeared to be at moderate speeds of 30-45 mph. San Pablo Ave. is uncontrolled at this location, and Virginia St. is controlled with a stop sign.

Traffic during the afternoon peak included 76 pedestrians and 21 bicyclists per hour. (No vehicle counts were made at this or any other unsignalized intersections).

5.2.3.2. Roadway/Crossing Characteristics

San Pablo Avenue has four through-travel lanes and Virginia has two through-travel lanes. There is a southbound left-turn lane on San Pablo Ave. Virginia is a marked east-west bicycle boulevard. Lack of ADA compliance included crosswalks on the north, south, east and west sides of the intersection. Each curb ramp was located outside of the crosswalk and intersection. There were medians to the north and south of the intersection on San Pablo. The northern median was landscaped (about four feet wide) and did not extend to the crosswalk. Two double yellow lines extend from the median to the northern crosswalk and as a result, this median was not suitable for a pedestrian refuge. The southern median, which was about 12 feet wide and reached the southern edge of the crosswalk, was suitable for a pedestrian refuge. However, it was not ADA compliant (no wheelchair access for the median — ramp or at-grade with a cut curb opening to allow the crosswalk to pass through it).

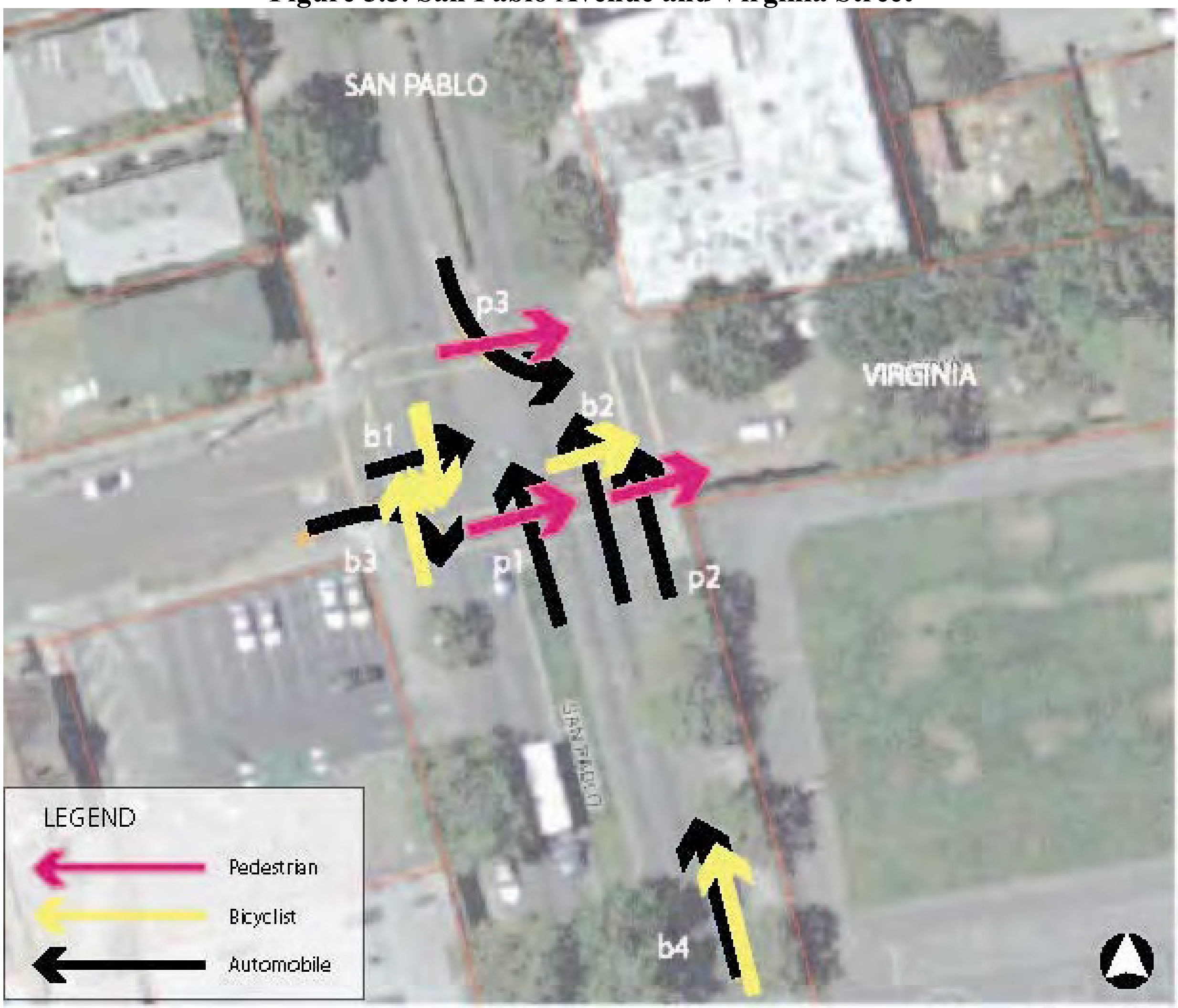
5.2.3.3. Observed Behavior

- Motorists were observed encroaching upon pedestrians in the crosswalk.
- Approximately 33% of pedestrians observed crossed against the signal.
- Bicyclists were observed riding on the sidewalk.
- Bicyclists were observed riding on wrong side of the road against traffic. At this intersection, there is a history of collisions between vehicles and bicyclists riding in the wrong direction.

5.2.3.4. Crash Typology

There were collisions between vehicles and four bicyclists, and between vehicles and three pedestrians reported for this intersection between 1998 and 2003. The crashes appeared to concentrate on the southern end of the intersection (Figure 5). The pedestrian crashes were in the intersection involving eastbound pedestrians. Two involved straight moving northbound vehicles (p1, p2) and the other was a left-turning southbound vehicle (p3). The pedestrian crashes involved eastbound pedestrians, two straight moving vehicles and one left-turning vehicle. The bicycle crashes involved bicyclists in each direction. One bicyclist was moving against traffic, one hit a stopped vehicle, and the others were riding perpendicular to traffic in the intersection. The crash types and previous movements are illustrated in figure 5.5.

Figure 5.5. San Pablo Avenue and Virginia Street



5.2.3.5. Intersection Summary Analysis

This intersection is characterized by intermittent high-speed traffic with no traffic control on San Pablo Avenue and stop-sign control on both Virginia approaches. Additionally, this is a bicycle boulevard[32] crossing with a high level of bicycle traffic.

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[32] Bicycle boulevards in Berkeley are comprised of roadways modified as needed to enhance bicyclists' safety and convenience (http://www.ci.berkeley.ca.us/transportation/Bicycling/BB/BicycleBoulevard.html).

5.2.3.6. Recommended Countermeasures (Intersection Specific)

- In-roadway knockdown (impactable yield) signs, passive awareness: increases awareness, reduces conflict.
- Speed trailers: discourages speeding, reduces conflict.
- Pedestrian activated flashing beacons: reduces conflict, increases use of crosswalks.
- Pedestrian activated flashing lights: reduces conflict, increases use of crosswalks.
- Upgraded/extended median (pedestrian refuge island): reduce conflict, reduce number of trapped pedestrians, increase number of pedestrians using crosswalk.

5.3. ZONE 3

Zone 3 is a right-angled zone beginning at 10th Street and University Avenue, moving east along University to San Pablo Avenue, heading south and terminating at Addison Street.

Figure 5.6: Aerial Photo Zone 3 and Intersections

5.3.1. Observed Land Use

The land use in this zone is predominantly commercial. There are a number of international shops, restaurants, and general convenience stores, served primarily by pedestrian access. The northeast corner of the zone has a shopping center, with a national drug store chain. The shopping center has a large parking lot with vehicle entry and exit points on University and San Pablo Avenues. However, their placement allows sufficient room for bus stops and pedestrian access on each corner. The land use is primarily commercial on University and San Pablo, but at Addison and further south, the land use transitions to residential within one block of San Pablo Avenue on the eastern side and mixed use commercial, light industrial, and residential on the western side.

5.3.2. University Avenue and San Pablo Avenue

5.3.2.1. Traffic Characteristics/Control

The traffic flow on San Pablo Avenue at University is heavy with moderate to high-speed traffic flow (30 to 45 mph). The intersection is controlled by a traffic signal and multi-directional left turn phases.

Traffic during the afternoon peak included an estimated 4300 vehicles, 300 pedestrians, and 11 bicyclists per hour.

5.3.2.2. Roadway/Crossing Characteristics

Both San Pablo and University Avenues have four through travel lanes and a left turn and right turn lane in each direction. The brick-paved crossings were wearing unevenly and are being replaced as part of Caltrans upgrade of the corridor. There was no detectable boundary between pedestrian and street environments. The curb ramps and sidewalks appeared to be ADA compliant. However the sidewalks contained a significant number of obstructions on the sidewalk including street furniture and clutter. There were bus stops on every corner. No facilities were provided for bicycle traffic.

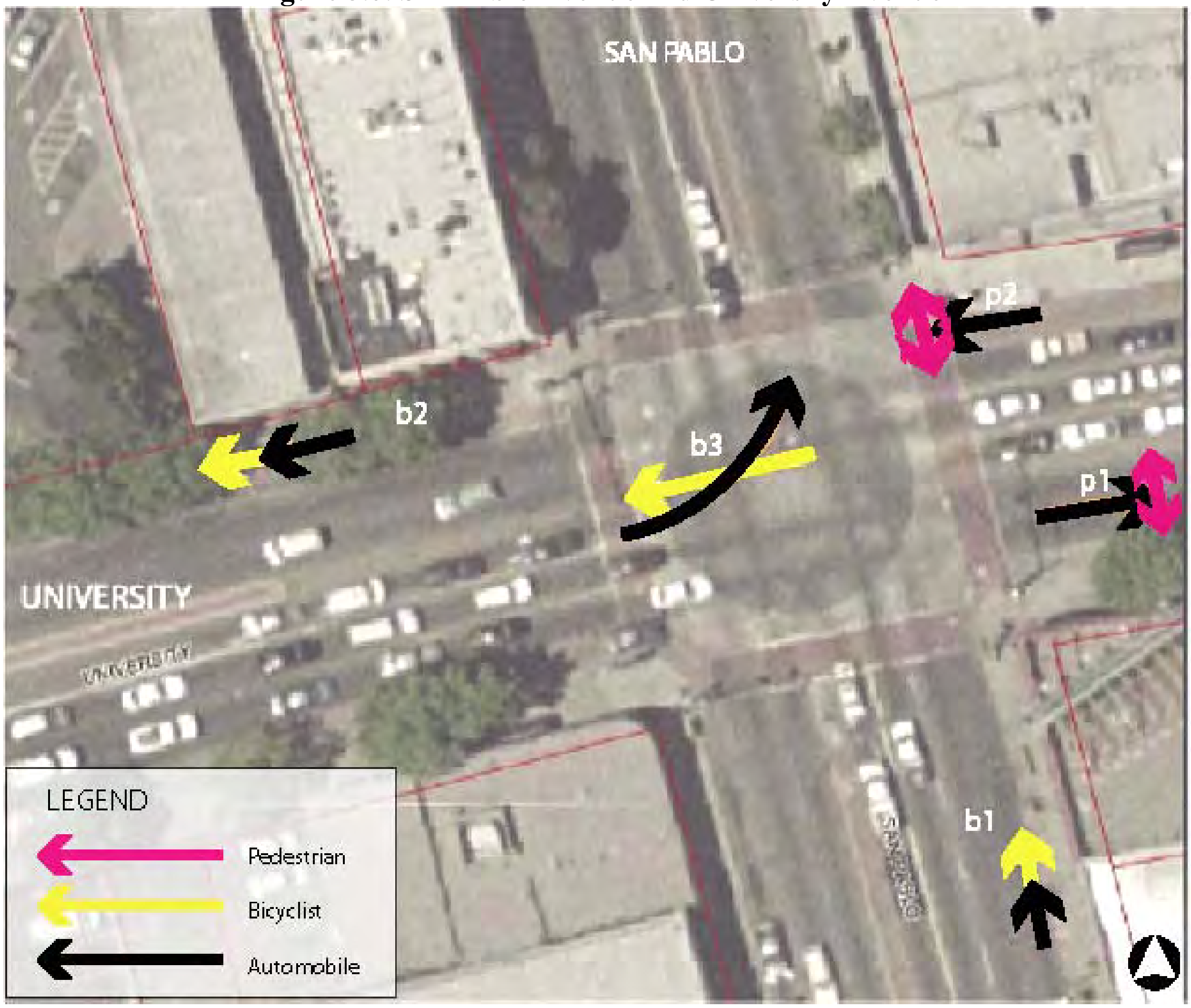
5.3.2.3. Observed Behavior

- Motorists were observed to encroach upon pedestrian space in the crosswalk.
- Jaywalking (crossing against the signal or outside of the crosswalk) was relatively low (7% of observed pedestrians at the intersection).
- Bicyclists were observed riding on the sidewalk.
- Bicyclists were observed riding on the wrong side of the road against traffic. At this intersection, there is a history of collisions between vehicles and bicyclists riding in the wrong direction.

5.3.2.4. Crash Typology

Vehicle collisions with four bicyclists and, and vehicle collisions with four pedestrians were reported at this intersection between 1998 and 2003; however, there was no common pattern among the crashes. Two pedestrian crashes were more than 100 feet from the intersection. The crashes involved pedestrian violations such as jaywalking and walking under the influence. The bicycle crashes involved bicyclists hitting stopped vehicles and bicyclists riding against traffic. The crash types and previous movements for these collisions are illustrated in Figure 5.7.

Figure 5.7. San Pablo Avenue and University Avenue



5.3.2.5. Intersection Summary Analysis

The intersection at San Pablo and University Avenues is at a confluence of two high capacity arterial roadways with bus stops for multiple bus lines located on each corner. The intersection is characterized both by the highest vehicle and pedestrian volumes for all Berkeley intersections studied. Despite low bicyclist volumes, the rate of vehicle collisions with bicycles was high given their relative exposure. One conclusion might be that the bicyclists who use this intersection are most likely there because it is a destination (there are several shops and restaurants at this intersection); otherwise they would use the nearby bicycle route network, which would allow riders to negotiate an easier, less congested route to their destination.

The shear volume of pedestrians and vehicle congestion at the intersection may combine to make the environment slightly safer for pedestrians by influencing drivers to travel at lower speeds, due to the increased awareness of a shared environment and the overall reduced capacity of the intersection. One significant source for vehicle/pedestrian conflicts are the bus stops on opposing corners of the intersection, making connections difficult, and leading to frequent jaywalking. Also, there is little space dedicated to bicyclists (e.g. shared lane, bike lane, special turning lane and/or bike box), who frequently ride through the intersection, This contributes to the most common bicycle crash type: a bicycle hitting a stopped car, as bicyclists are forced to ride too close to parked vehicles. Additionally, way-finding (i.e. navigational system of signs) is not provided to help bicyclists locate the nearby bicycle boulevard system, the use of which could alleviate many of these issues for some bicyclists.

5.3.2.6. Recommended Countermeasures (Intersection Specific)

- Restricting RTOR/Addition of leading pedestrian interval (LPI): reduces conflict, increases use of pedestrian call button, increases number of drivers yielding to pedestrians, reduces pedestrian delay; however, may slightly reduce intersection (driver) LOS during restriction.
- Ample signage (way-finding) for bicyclists to guide them to the alternative bicycle network.
- Installation of visible signs encouraging motorist to “share the road” and warning of approaching bicycle boulevard intersection.
- Installation of signs warning drivers about street parking and “door zone vigilance” to watch for frequent bicyclists in/near the parking lane.
- Placement of bus stops (or ITS smart timing — synchronizing AC Transit schedules) to allow sufficient time for riders to connect with buses on opposite corners of the intersection.
- Restriction of street parking at peak hours within a one-block radius of the intersection. Delivery parking on southeast side on San Pablo Ave. causes traffic conflicts and potential backing issues with bicycles and pedestrians (where traffic backs up into Addison crosswalk, encouraging pedestrian jaywalking and bicyclist weaving).

5.3.3. University Avenue and 10th Street

5.3.3.1. Traffic Characteristics/Control

The traffic flow on University at 10th is moderate to high speed ranging 30-45 mph. University Ave. has no traffic controls at this location, but cross traffic at 10th Street is controlled with a stop sign.

Traffic for the afternoon peak was estimated to include 145 pedestrians and 4 bicyclists per hour.

5.3.3.2. Roadway/Crossing Characteristics

At this intersection, University has four through-travel lanes and 10th Street has two through-travel lanes. There is a left-turn lane from both the eastern and western approaches on University Ave. There are marked crosswalks on the north, south, east and west sides of the intersection. The east side of the intersection has a 10-foot wide landscaped median abutting the crosswalk which is suitable for a pedestrian refuge. The median narrows to the east as it approaches San Pablo to accommodate the northbound left-turn lane. The landscaping reduced visibility for westbound motorists approaching the intersection at University and 10th Street.

On the west side of the intersection on University Ave. there is a two-foot wide median abutting to the crosswalk and the northbound left-turn lane. This median is bulbed-out further west at 9th

Street with landscaping and street trees; however, it is too narrow for a pedestrian refuge at 10th and University.

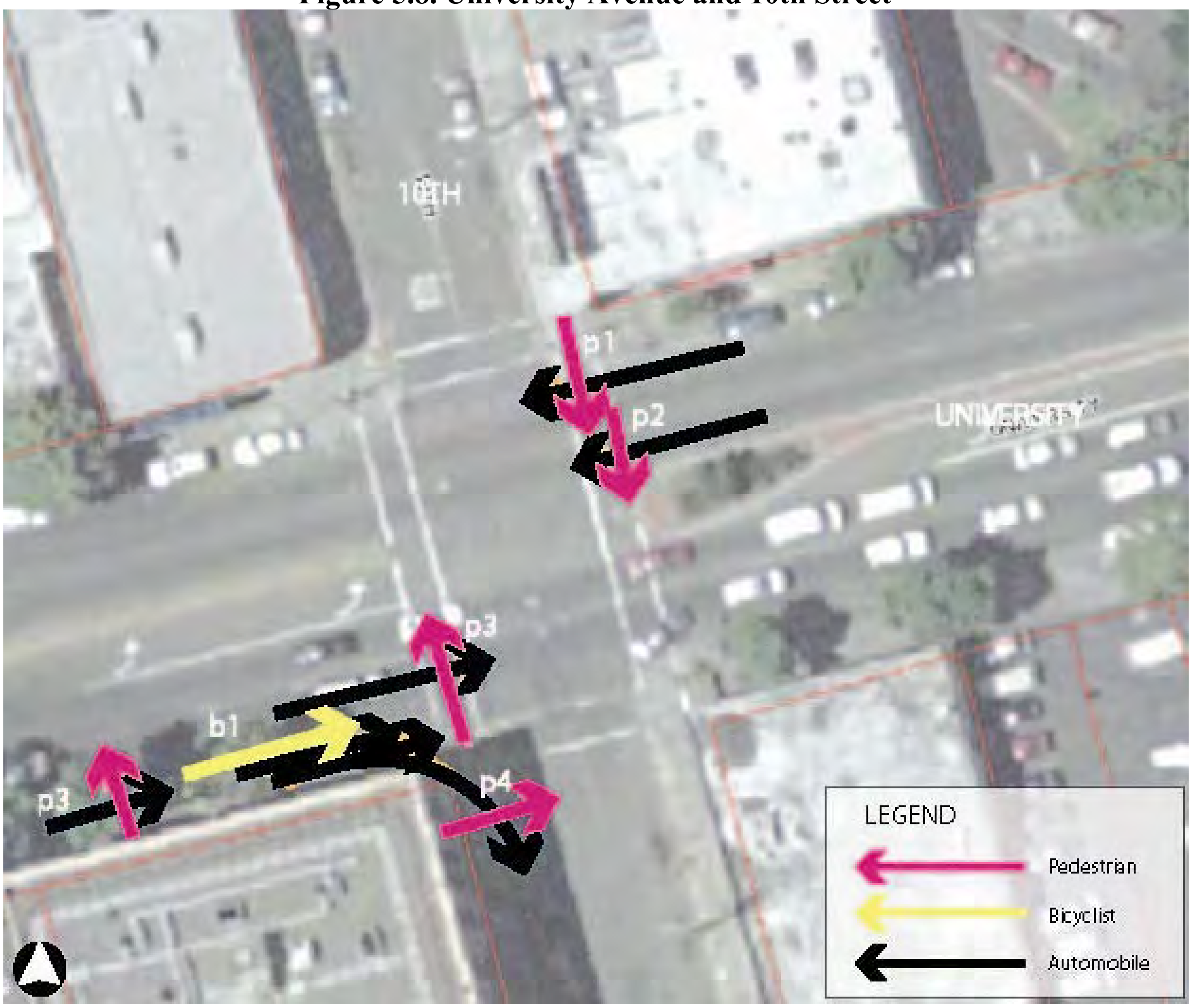
5.3.3.3. Observed Behavior

- Motorists were observed encroaching upon pedestrians in the crosswalk.
- 12% of pedestrians were observed jaywalking
- Bicyclists were observed riding on the sidewalk

5.3.3.4. Crash Typology

There were five pedestrian crashes and one bicycle crash reported to SWITRS for this intersection in the past six years. The crash types and previous movements are illustrated in figure 5.8.

Figure 5.8. University Avenue and 10th Street



The reported collisions between vehicles and pedestrians or bicyclists at the intersection of University Avenue and 10th Street were concentrated on the southwest and northeast corners and approaches to the intersection. Pedestrian crashes occurred in instances of vehicles moving straight through the intersection, or approaching the intersection, and turning right. In most cases the vehicle violated the pedestrian right-of-way. The single bicycle crash involved straight moving vehicles approaching the intersection.

5.3.3.5. Intersection Summary Analysis

This is the first intersection west of the intersection of San Pablo and University Avenues, and it is unsignalized. Approaching motorists seemed unaware of the upcoming intersection and pedestrian crossing. After moving west on University and leaving the intersection with San Pablo, vehicles were observed increasing speed and then stopping quickly to use the 10th Street intersection to make U-turns. This practice made the eastern crosswalk particularly hazardous for pedestrians where visibility is limited due to the landscaping on the median. There were two pedestrian crashes in the eastern crossing in the previous 6 years.

5.3.3.6. Recommended Countermeasures (Intersection Specific)

- In-Roadway Knockdown Signs (impactable yield), passive awareness: increases awareness, reduces conflict.
- Speed Trailers: discourages speeding, reduces conflict.
- Pedestrian Activated Flashing Beacons: reduces conflict, increases use of crosswalks.
- Pedestrian Activated Flashing Lights: reduces conflict, increases use of crosswalks, however, could reduce pedestrian awareness.
- Replacing landscaping with higher canopy species to improve crosswalk visibility.

5.3.4. Addison Street and San Pablo Avenue

5.3.4.1. Traffic Characteristics/Control

The intersection of San Pablo Avenue and Addison Street is comprised of two T-intersections perpendicular to San Pablo Avenue. One segment of Addison Street intersects San Pablo Avenue on its west side (southern intersection). North of this intersection, Addison then continues from the east side of San Pablo (northern intersection). The northern intersection is unsignalized but controlled by a stop sign. San Pablo Avenue has no traffic controls at this part of the intersection. The southern intersection is controlled with a traffic signal.

Traffic for the afternoon peak was estimated to include 262 pedestrians and 25 bicyclists per hour.

5.3.4.2. Roadway/Crossing Characteristics

Northern Intersection

The vehicular traffic on the northern Addison intersection was bi-directional, with vehicles entering and exiting from local commercial establishments on Addison. There were two pedestrian crossings originating from the northeast corner of the intersection. The northern crossing cut through the median at grade, but it did not meet the sidewalk at the available curb ramp on either end. Similarly, the eastern crossing did not meet a curb ramp at either end of the crosswalk. Several pedestrians with strollers were observed struggling with the curbs and weaving out of the crosswalks to access the sidewalks. There was a 10-foot median separating the north and southbound vehicle traffic on San Pablo Ave. The median brought an abrupt end to westbound vehicular traffic on Addison, which was forced to turn right onto San Pablo.

Southern Intersection

At the southern intersection, to continue eastbound on Addison, drivers had to make a left turn onto San Pablo and then an immediate right turn onto Addison. There were three crossings in the intersection on the north, west and south sides. The crosswalk markings were parallel and yellow. There were no curb ramps at the ends of any crosswalks. The northern crosswalk ended in the post office driveway for postal vehicles. The driveway was graded/ramped for use by vehicles, but it seemed to be a dangerous mix of uses in an area that should be exclusively pedestrian. The southern and western crossings had curb ramps to the south of the crosswalk that required pedestrians to exit the crosswalk to use them. There was a 10-foot wide landscaped median on the northern side of the intersection that was suitable as a refuge. The southern side had a median that ended 20 to 25 feet south of the intersection from which two rows of double yellow lines extended that separated the left-turn lane from the southbound traffic.

5.3.4.3. Observed Behavior

- Motorists were observed encroaching upon pedestrians in the crosswalk in both the north and south intersections.
- 19% of pedestrians were observed jaywalking between the two intersections.
- Bicyclists were observed riding on the sidewalk.
- Bicyclists were observed riding on the wrong side of the road against traffic. There has been a history of crashes in this intersection with bicyclists riding in the wrong direction.

5.3.4.4. Crash Typology

There were vehicle collisions with three pedestrians, and vehicle collisions with one bicyclist reported for this intersection in the past six years. The crashes appeared to be concentrated at the eastern side of the southern intersection and approach. It is not clear by the data provided whether the crashes occurred in the proximity of the northern or southern Addison crossing. The pedestrian crashes occurred in the intersection with vehicles stopping or proceeding straight, they occurred outside of the crosswalk between a vehicle backing up and two eastbound pedestrians. The bicycle crash occurred with a northbound vehicle entering traffic. The crash types and previous movements are illustrated in figure 5.9.

5.3.4.5. Intersection Summary Analysis

The pedestrian and bicycle traffic at this intersection is quite high as there are many destinations on both the eastern and western sides of San Pablo Ave. Vehicle traffic was observed to back up into the northern intersection from San Pablo Ave. and University forcing pedestrians to weave through stopped and slow-moving vehicles. Other hazards included the post office driveway and shared crosswalk end/curb ramp at the northeast corner of the southern crosswalk. A significant hazard was the lack of ADA curb ramps at the end of each of the crosswalks. Currently, pedestrians, wheelchairs and strollers are forced to exit the crosswalk in order to gain access to the sidewalk from the street.

5.3.4.6. Recommended Countermeasures

Northern Intersection:

- In-roadway knockdown signs (impactable yield), passive awareness: increases awareness, reduces conflict; however, may give pedestrian false sense of security.
- Pedestrian activated flashing lights: reduces conflict, increases use of crosswalks, could reduce pedestrian awareness.

Southern Intersection:

- Upgraded/extended median (pedestrian refuge island): reduce conflict, reduce number of trapped pedestrians, increase number of pedestrians using crosswalk.

Figure 5.9. San Pablo Avenue and Addison Street

5.4. ZONE 4

This is a north-south linear two-block zone along San Pablo Avenue beginning at Bancroft Way, encompassing Channing Way and terminating at Dwight Way.

Figure 5.10: Aerial Photo Zone 1 and Intersections

5.4.1. Observed Land Use

This zone had mixed use including commercial and residential areas, with commercial, retail and professional services primarily on San Pablo Avenue, and residential areas within a block east and west. A pleasant pedestrian-scale retail shopping and restaurant district began in the southern end of the zone and extended about two blocks south.

5.4.2. Bancroft Way and San Pablo Avenue

5.4.2.1. Traffic Characteristics/Control

The vehicle traffic flow on San Pablo at Bancroft was low to moderate and traveled at moderate speeds ranging from 30-45 mph. While San Pablo Avenue had no traffic controls at this location, Bancroft was controlled with a stop sign.

Traffic for the afternoon peak was estimated to include 72 pedestrians and 42 bicyclists per hour.

5.4.2.2. Roadway/Crossing characteristics

There are four through travel lanes on San Pablo and two through travel lanes on Bancroft. Crosswalks are located on all four sides of the intersection. The markings are parallel and white. The crosswalks ends are captured by ADA-compliant curb ramps on the northeast, southeast and southwest ends. The remaining curb ramps are located outside of the intersection and are not ADA compliant. An additional pedestrian risk is created by the close proximity of driveways close to the intersection on San Pablo on the southeast and southwest. Also, bus stops are located on the northeast and northwest corners of San Pablo, adding to the complexity of the interactions between users at the intersection.

There are four-foot wide landscaped medians on the northern and southern sides of the intersection on San Pablo. The medians do not extend to the crosswalks, however, and two double yellow lines extend from the median to the crosswalk to separate the north and southbound traffic on both sides of the intersection. Neither median is suitable as a pedestrian refuge.

5.4.2.3. Observed Behavior

- Motorists were observed encroaching upon pedestrians in the crosswalk.
- About 14% of pedestrians were observed crossing outside of the crosswalk.
- Bicyclists were observed riding on the sidewalk.

5.4.2.4. Crash Typology

There were vehicle collisions with three pedestrians, and vehicle collisions with two bicyclists reported for this intersection between 1998 and 2003. The majority occurred in the eastern section of the intersection and approach. Pedestrian crashes included both driver and pedestrian violations, with straight-moving vehicles inside the intersection as well as a vehicle entering traffic from a parking lot.

The bicycle crashes involved straight-moving and turning vehicles against straight-moving bicycles. The crash types and previous movements are illustrated in Figure 5.11.

5.4.2.5. Intersection Summary Analysis

The intersection at San Pablo and Bancroft is characterized by high vehicle and bicycle traffic and an absence of traffic signals. The crash history has shown a risk for collisions between vehicles making uncontrolled left-turns onto Bancroft and northbound and southbound pedestrians. The infrastructure poses a risk for conflicts between drivers and pedestrians and bicyclists, with several driveways cutting through the sidewalk close to the intersection.

Figure 5.11. San Pablo Avenue and Bancroft Way

5.4.2.6. Recommended Countermeasures (Intersection Specific)

- Speed trailers: discourages speeding, reduces conflict.
- Pedestrian activated flashing beacons: reduces conflict, increases use of crosswalks, however, could reduce pedestrian awareness.
- Upgraded/extended median (pedestrian refuge island): reduce conflict, reduce number of trapped pedestrians, increase number of pedestrians using crosswalk.

5.4.3. Channing Way and San Pablo Avenue

5.4.3.1. Traffic Characteristics/Control

The traffic flow on San Pablo at Channing is low to moderate with moderate speed ranging from 30-45mph. San Pablo Avenue has no traffic controls at this location, while Channing is controlled with a stop sign.

Traffic for afternoon peak was estimated to include 52 pedestrians and 60 bicyclists per hour.

5.4.3.2. Roadway/Crossing Characteristics

There are four through travel lanes on San Pablo and two through travel lanes on Channing. There are no dedicated left turn lanes, and there are time periods during which left-turns were prohibited. Crosswalks exist on all four sides of the intersection. However, this intersection is not ADA compliant since the curb ramps are not contained by the crosswalk markings. Additionally, sidewalk access is obstructed by landscaping and street furniture. There re 10-foot wide landscaped medians on San Pablo on the north and south sides of the intersection, which are suitable as pedestrian refuges. However, they are not at grade and are therefore not ADA compliant.

5.4.3.3. Observed Behavior

- Motorists were observed encroaching upon pedestrians in the crosswalk.
- 23% of pedestrians were observed outside of the crosswalk.
- Bicyclists were observed riding on the sidewalk.
- Bicyclists were observed riding on the wrong side of the road against the traffic. There is a history of collisions at this intersection between vehicles and bicyclists riding in the wrong direction.

5.4.3.4. Crash Typology

One vehicle collision with a pedestrian, and three vehicle collisions with bicycles were reported between 1998 and 2003. The pedestrian/vehicle crash occurred about 30 feet outside of the intersection on San Pablo Ave., with two northbound vehicles and a westbound pedestrian. The pedestrian/bicycle collision involved a westbound pedestrian and a northbound bicyclist on San Pablo over 100 feet from the intersection. The crash types and previous movements are illustrated in Figure 5.12.

5.4.3.5. Intersection Summary Analysis

The intersection at San Pablo Avenue and Channing was characterized by low volume high-speed traffic, with no traffic control on San Pablo Avenue, which left pedestrians unprotected in crossing. In addition, vehicles encroached on eastern and western crosswalks. Additionally, sidewalks were blocked on Channing by furniture or landscaping, and every curb ramp was outside of crosswalk markings, forcing pedestrians to exit the crosswalk and enter the street to access the sidewalk.

5.4.3.6. Recommended Countermeasures (Intersection Specific)

- In-roadway knockdown signs, passive awareness: increases awareness, reduces conflict; however, may give pedestrian false sense of security.
- Speed trailers: discourages speeding, reduces conflict.
- Pedestrian activated flashing lights: reduces conflict, increases use of crosswalks; could reduce pedestrian awareness.
- Upgraded/extended median (pedestrian refuge island): reduce conflict, reduce number of trapped pedestrians, increase number of pedestrians using crosswalk.

Figure 5.12. San Pablo Avenue and Channing Way

5.4.4. Dwight Way and San Pablo Avenue

5.4.4.1. Traffic Characteristics/Control

The traffic flow on San Pablo at Dwight was heavy and moved at relatively high speeds, often above 45 mph. The intersection was controlled by a traffic signal, and north- and southbound left turn signals. Traffic during the afternoon peak included an estimated 3300 vehicles, 137 pedestrians, and 39 bicyclists per hour.

5.4.4.2. Roadway/Crossing characteristics

San Pablo has four through-travel lanes (2 per direction) and one turning lane, while Dwight has three through-travel lanes (total, 2 westbound, 1 eastbound). The boundary between sidewalk and street at the intersection is generally undetectable, and the brick- paved crosswalk is unevenly worn and visually difficult to distinguish from the roadway. There are crosswalks on all sides of the intersection, all of which are paved with brick. The curb ramps are diagonal, requiring the pedestrian to enter the intersection before entering the crosswalk, thereby increasing exposure —also directing the vision impaired away from the crosswalk. The curb ramp landings are contained by the crosswalk markings on each side. There are bus stops on both Dwight and San Pablo on the northeast and northwest corners of the intersection. There are medians on San Pablo on the north and south sides of the intersection that stopped several feet short of the intersection. Both are unsuitable for pedestrian refuge.

5.4.4.3. Observed Behavior

- Motorists were observed encroaching on upon pedestrians in the crosswalk.
- There is a relatively low incidence of jaywalking at 4%.
- Bicyclists were observed riding on the sidewalk.
- Bicyclists were observed riding on the wrong side of the road. There has been a history of vehicle collisions at this intersection with bicyclists riding in the wrong direction.

5.4.4.4. Crash Typology

Vehicle collisions with four pedestrians, and vehicle collisions with three bicyclists were reported between 1998 and 2003. The majority occurred in the northwest corner of the intersection and approach. Pedestrian crashes involved straight-moving and left-turning vehicles and included both driver and pedestrian violations. Two bicycle crashes involved a stopped or parked car with straight moving bicyclists, and one involved a right-turning vehicle into a bicycle traveling the wrong way against traffic. The crash types and previous movements are illustrated in figure 5.13.

5.4.4.5. Intersection Summary Analysis

The intersection at Dwight is characterized by a combination of heavy vehicle, pedestrian and bicycle traffic. The intersection is home to a number of retail and restaurant establishments, as well as bus stops and parallel parking, which makes the use pattern complex and prone to user conflict. There is a history of conflict between left-turning vehicles and north and southbound pedestrians and between bicycles and stopped vehicles.

5.4.4.6. Recommended Countermeasures (Intersection Specific)

- Upgraded/extended median (pedestrian refuge island): reduce conflict, reduce number of trapped pedestrians, increase number of pedestrians using crosswalk.
- Ample signage for bicyclists to guide them to alternative bicycle network, two blocks the west of this intersection.
- Signs encouraging motorist to “share the road” and warning of approaching bicycle boulevard intersection.
- Signs warning motorist parking on the street about “door zone vigilance.”

Figure 5.13. San Pablo Avenue and Dwight Way

5.5. ZONE 5

Zone 5 is a linear five-block zone running north and south along San Pablo Avenue that encompasses a total of four study intersections. Zone 5 runs from the intersection of San Pablo with Ashby Avenue south to include intersections with Haskell Street, 67th Street, and 65th Street in Oakland. The intersections were considered to be part of an important pattern of historical pedestrian crashes in the area were selected to describe a comprehensive picture of the concerns in this zone.

Figure 5.14: Aerial Photo Zone 5 and Intersections

5.5.1. Observed Land Use
The land use in this zone is primarily commercial with some office space. The land use transitions to residential within one block of San Pablo Avenue on the eastern side and mixed use commercial, light industrial, and some residential on the western side.

5.5.2. Ashby Avenue and San Pablo Avenue

5.5.2.1. Traffic Characteristics/Control
The traffic flow on San Pablo Avenue at Ashby is heavy volume and travels at a relatively high speed, often greater than 45 mph. The intersection is controlled by a traffic signal with an eastbound and westbound left turn phase.

Traffic for the afternoon peak was estimated to include 3600 vehicles, 128 pedestrians, and 25 bicyclists per hour.

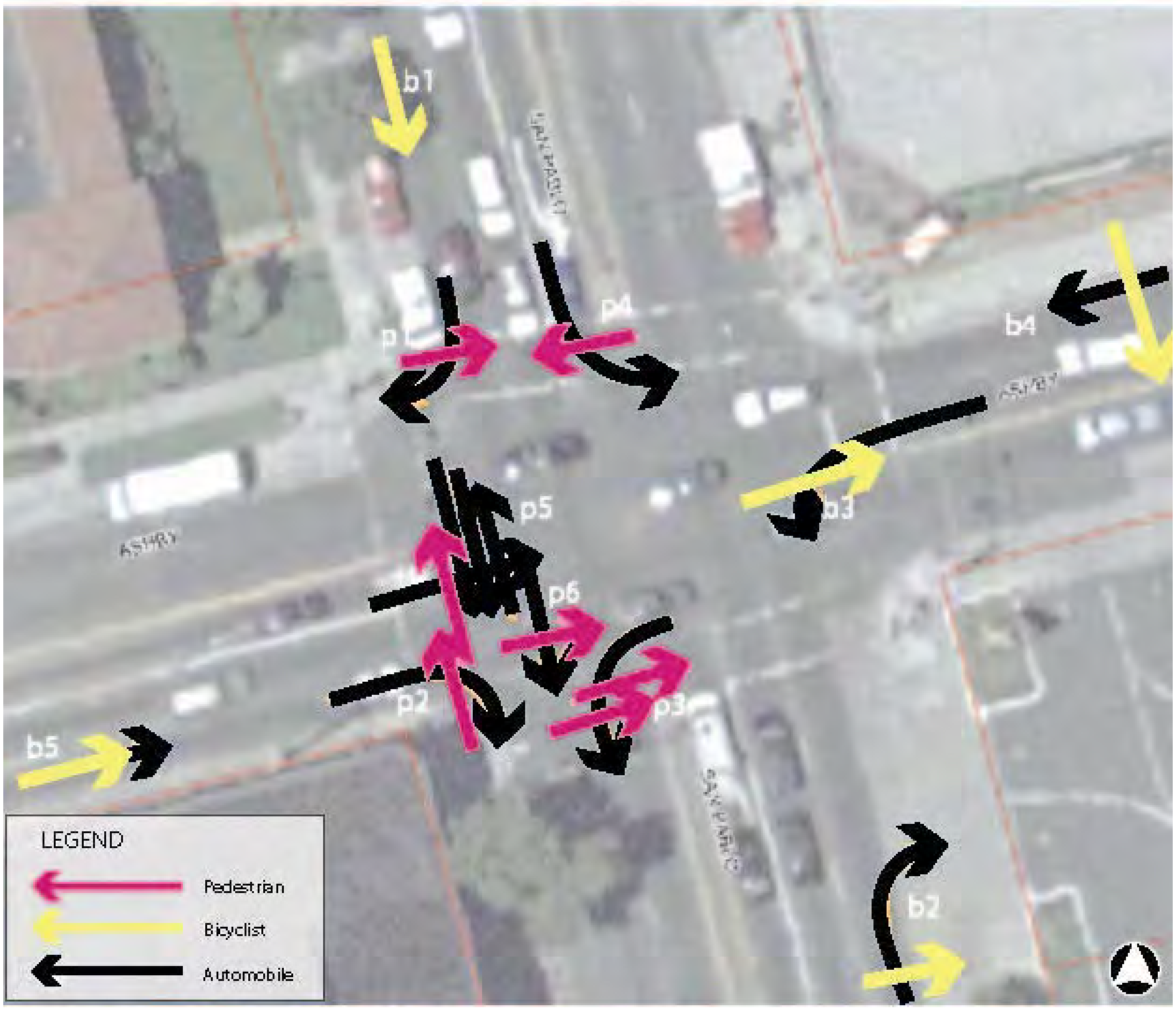
5.5.2.2. Roadway/Crossing Characteristics
There are crosswalks on all four sides of the intersection, with diagonal curb ramps at each landing area fully contained within the markings. There are several businesses in the area (particularly on the northeast, northwest and southwest corners of the intersection) that contribute to foot traffic. Additionally, there are bus stops on the northeast and southwest corners of Ashby and the northeast and southwest corners of San Pablo that generate additional foot traffic. However, this intersection is not ADA compliant. On Ashby, the southeast sidewalk is cluttered with obstructions and is barely wide enough even when clear for the passage of ambulatory pedestrians. The northeast sidewalk is wider but also cluttered with poorly placed benches and trashcans, most likely placed to serve the bus patrons.

5.5.2.3. Observed Behavior
- Motorists were observed encroaching upon pedestrians in the crosswalk.
- Approximately 21% of pedestrians observed walked against the signal.
- Bicyclists were observed riding on the sidewalk and on the wrong side of the road against traffic. There has been a history at this intersection of vehicle collisions with bicyclists riding in the wrong direction.

5.5.2.4. Crash Typology
Vehicle collisions with six pedestrians, and vehicle collisions with five bicyclists were reported for this intersection between 1998 and 2003. The majority of these were clustered on the southwest corner of the intersection. Pedestrian crashes involved right-turning, left-turning, straight-moving and stopped vehicles. Most pedestrian crashes resulted from vehicle violations.

Three of five bicycle crashes occurred outside of the intersection. Two bicyclists were struck while riding on the wrong side of the road against traffic. The bicycle crashes involved right-turning, left-turning, straight-moving and stopped vehicles. Most bicycle crashes involved bicyclist violations. The crash types and previous movements are illustrated in the figure 5.15.

Figure 5.15. San Pablo Avenue and Ashby Avenue



5.5.2.5. Intersection Summary Analysis

The Ashby intersection was characterized by high speed and high volume vehicle traffic, with 75% of the vehicle flow, 50% of the pedestrians and 200% of the bicycles observed at the intersection of San Pablo and University Avenues. This combination of factors lower volumes of motor vehicles with lower pedestrian volume, generally leads to a higher speed mix due to less congestion. The majority of crashes occurred in the southwest corner of the intersection and typically involved turning vehicles. Similar numbers of pedestrians and bicyclists were involved in collisions with vehicles; however, a significant number of pedestrian crashes involved multiple pedestrians.

5.5.2.6. Recommended Countermeasures (Intersection Specific)

- Ample signage for bicyclists to guide them to the alternative bicycle network, two blocks the west of this intersection.
- Signs encouraging motorist to “share the road” and warning of approaching bicycle boulevard intersection.

5.5.3. Haskell Street and San Pablo Avenue

5.5.3.1. Traffic Characteristics/Control

The intersection of Haskell and San Pablo is a T-Intersection located two blocks south of Ashby and San Pablo. Haskell Street is located on the eastern side of San Pablo and is controlled by a stop sign. San Pablo is uncontrolled at this intersection.

Traffic for the afternoon peak included an estimated 28 pedestrians, and 10 bicyclists per hour.

5.5.3.2. Roadway/Crossing characteristics

There are four through-travel lanes on San Pablo and two through-travel lanes on Haskell. The majority of the foot traffic is concentrated around the liquor store on the northeast corner and the second-hand arts and crafts store on the western side of the intersection. There is a marked northern and unmarked eastern crossing at this location. There are ADA-compliant curb ramps on the eastern side of the northern crossing and both sides of the eastern crossing. On the western side, the crosswalk markings end at a full curb, with no curb ramp and there is no ADA available access. The curb ramps on the eastern crossing east of the stop limit line ahve no crosswalk markings.

5.5.3.3. Observed Behavior

- Motorists were observed encroaching upon pedestrians in the crosswalk.
- 31% of pedestrians observed walked outside of the crosswalk.
- Bicyclists were observed riding on the sidewalk.

5.5.3.4. Crash Typology

There were vehicle collisions with three pedestrians reported for this intersection between 1998 and 2003. Two were determined to be the fault of the pedestrian. Pedestrian crashes involved vehicles backing up, a pedestrian jaywalking and an improper passing maneuver by a vehicle. The crash types and previous movements are illustrated in Figure 5.16 below.

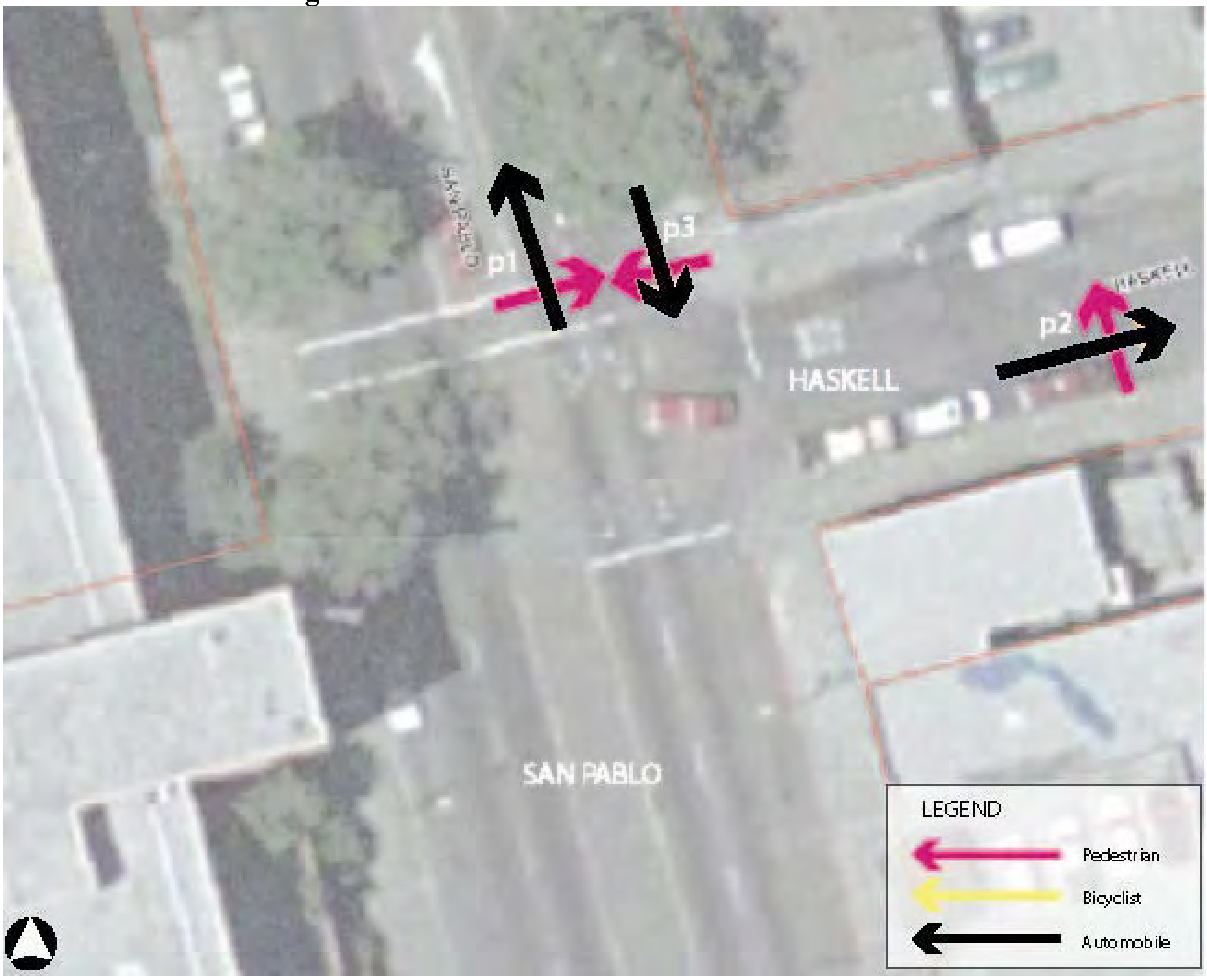
5.5.3.5. Intersection Summary Analysis

The intersection of Haskell and San Pablo is characterized by uncontrolled intermittent high speed vehicle traffic on San Pablo Ave., and high levels of east-west jaywalking. Additionally, the lack of an ADA compliant curb ramp/crosswalk on the western end of the east-west crossing forces pedestrians using ambulatory devices to continue along the street until they reach the next access point either at 67th Street or Folger Ave.

5.5.3.6. Recommended Countermeasures (Intersection Specific)

- In-roadway knockdown signs (impactable yield), passive awareness: increases awareness, reduces conflict.
- Speed trailers: discourages speeding, reduces conflict.
- Pedestrian activated flashing beacons: reduces conflict, increases use of crosswalks; could reduce pedestrian awareness.
- Pedestrian activated flashing lights: reduces conflict, increases use of crosswalks; could reduce pedestrian awareness.

Figure 5.16. San Pablo Avenue and Haskell Street



5.5.4. 67th Street and San Pablo Avenue

5.5.4.1. Traffic Characteristics/Control

The intersection of San Pablo Avenue and 67th Street is comprised of two T-intersections. In the northern intersection, 67th Street intersects with the west side of San Pablo Avenue. Sixty-seventh Street continues from a more southern intersection from the east side of San Pablo Avenue. San Pablo Avenue has no traffic controls on either intersection with 67th. Sixty-seventh Street is controlled by a stop sign on both the northern and southern intersections.

Traffic for the afternoon peak included an estimated 73 pedestrians and 25 bicyclists per hour.

5.5.4.2. Roadway/Crossing Characteristics

San Pablo Avenue has four through-travel lanes at both intersections with 67th Street. On 67th Street, there are two through-traffic lanes at the northern intersection and one at the southern intersection.

The northern intersection between 67th Street and San Pablo has a marked crossing on the northern side and an unmarked crossing on the western side. At the southern approach to the intersection, a central lane opens up on San Pablo to become a left-turn lane for traffic onto 67th Street, prior to the crosswalk. The central lane continues south as a bi-directional turning lane (could be used as a turning lane into neighboring properties) to the southern portion of the intersection. In the northern intersection, the northern crosswalk lines are faded. The western end has a diagonal curb ramp with a landing within the crosswalk lines, and the eastern end of the crosswalk ends in a driveway that is partially outside of the crosswalk lines. The western crossing has diagonal curb ramps on both ends.

The southern intersection has a marked southern crossing and an unmarked eastern crossing. On San Pablo Avenue, there is a left-turn lane for traffic turning onto 67th eastbound. 67th Street becomes a one-way eastbound roadway at the southern intersection and then narrows to one lane. There are diagonal curb ramps on both sides of the unmarked eastern crossing and the southern marked crossing. At the southern intersection with 67th Street, there is a 12 foot landscaped median on San Pablo Ave., running southward. The landscaping obscures visibility of pedestrians.

5.5.4.3. Observed Behavior

- Motorists were observed encroaching upon pedestrians in the crosswalk.
- 25% of pedestrians were observed outside of the crosswalk.
- Bicyclists were observed riding on the sidewalk.
- Bicyclists were observed riding on the wrong side of the road against traffic. There has been a history of vehicle collisions with bicyclists riding in the wrong direction at this intersection.

5.5.4.4. Crash Typology

Vehicle collisions with three pedestrians, and vehicle collisions with three bicyclists were reported for this intersection between 1998 and 2003. Pedestrian crashes involved straight-moving vehicles and were at or within ten feet of the intersection. Bicycle crashes involved right-turning vehicles and were concentrated on the southeastern side of the intersection. The crash types and previous movements are illustrated in figure 5.17.

5.5.4.5. Intersection Summary Analysis

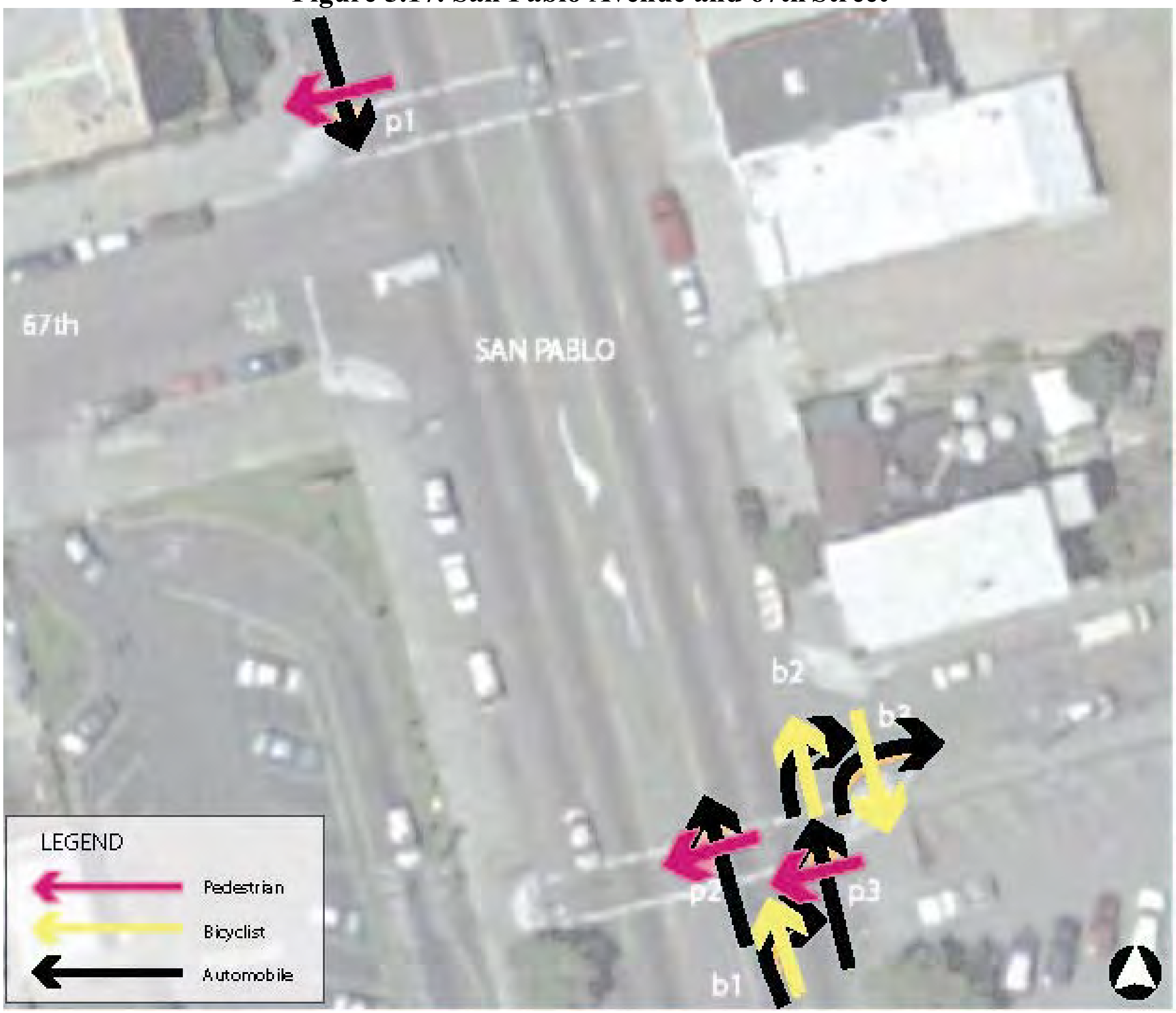
The intersection of San Pablo Avenue and 65th Street was characterized by low volume high-speed vehicle traffic on San Pablo Avenue that was uncontrolled by traffic signals. In the northern intersections, there was a high amount of vehicle traffic due to movement in and out of a parking lot and a drive-thru of fast food restaurant on the northwest corner.

At the southern intersection, motorists turning left onto 67th Street seemed unaware of pedestrians. Also, a significant number of east-west pedestrian crossings were observed, generated by the fast food restaurant on the west side of intersection. Additionally, there is a history of vehicle collisions between straight-traveling northbound vehicles with pedestrians and right-turning vehicles with bicyclists.

5.5.4.6. Recommended Countermeasures (Intersection Specific)

- Replace landscaping with higher canopy vegetation to improve crosswalk visibility.
- In-roadway knockdown signs, passive awareness: increases awareness, reduces conflict; however, may give pedestrian false sense of security.
- Speed trailers: discourages speeding, reduces conflict.
- Pedestrian activated flashing beacons: reduces conflict, increases use of crosswalks; could reduce pedestrian awareness.

Figure 5.17. San Pablo Avenue and 67th Street



5.5.5. 65th Street and San Pablo (on Oakland/Berkeley border)

5.5.5.1. Traffic Characteristics/Control

The traffic flow at 65th Street was low with moderate speeds ranging from 30 to 45 mph. San Pablo Avenue was uncontrolled at this intersection, and 65th was controlled with a stop sign.

Traffic for the afternoon peak was estimated at 123 pedestrians and 36 bicyclists per hour.

5.5.5.2. Roadway/Crossing characteristics

There are four through-travel lanes on San Pablo Avenue and two through-travel lanes on 65th Street. San Pablo includes a central left-turn lane in both southbound and northbound directions. There re marked crossings on the north, south and east sides of the intersection. Curb ramps on each corner are ADA compliant, and are contained in available crosswalk markings. A bus stop is located on San Pablo the northwest side of the intersection, and there are businesses that generate significant foot traffic on the southeast and southwest corners of the intersection. There are narrow medians on the north and south sides of the intersection that are designed to separate traffic and to provide northbound and southbound left-turn lanes. They are not suitable as pedestrian refuges.

5.5.5.3. Observed Behavior

- Motorists were observed encroaching upon pedestrians in the crosswalk.
- Jaywalking was high with about 41% of pedestrians observed outside of the crosswalk.
- Bicyclists were observed riding on the sidewalk.
- Bicyclists were observed riding on the wrong side of the road against traffic. There has been a history at this intersection of vehicle collisions with bicyclists riding in the wrong direction.

5.5.5.4. Crash Typology

Vehicle collisions with four pedestrians, and vehicle collisions with one bicyclist were reported for this intersection between 1998 and 2003. Pedestrian crashes involved straight-moving, left-turning and right-turning vehicles. In all cases, the drivers were at fault. The bicycle crash involved a bicyclist traveling on the wrong side of the road with a right-turning vehicle. The crash types and previous movements are illustrated in figure 5.18.

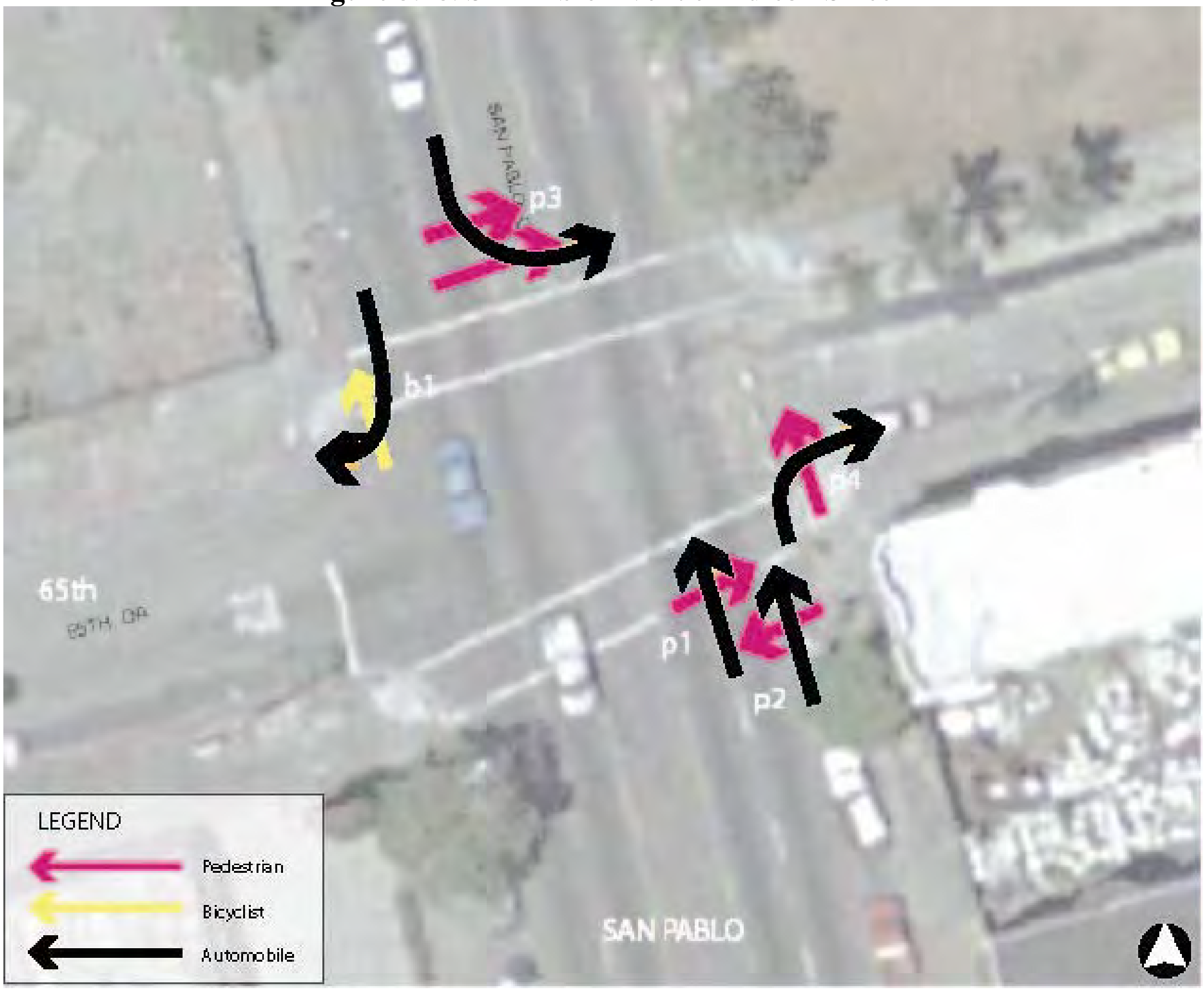
5.5.5.5. Intersection Summary Analysis

The intersection of San Pablo Avenue and 65th Street was characterized by low-volume high-speed vehicle traffic on San Pablo, which had no traffic control. There is a significant amount of jaywalking and loitering at the intersection due to a liquor store and other business activities at the corner. Additionally, while there were high volumes of bicyclists observed at this location, there were no amenities to serve them.

5.5.5.6. Recommended Countermeasures (Intersection Specific)

- Median extensions to crosswalk (pedestrian refuge islands): reduce conflict, reduce number of trapped pedestrians, increase number of pedestrians using crosswalk.
- In-roadway knockdown signs (impactable yield), passive awareness: increases awareness, reduces conflict; may give pedestrian false sense of security.
- Speed trailers: discourages speeding, reduces conflict.
- Pedestrian activated flashing beacons: reduces conflict, increases use of crosswalks; could reduce pedestrian awareness.

Figure 5.18. San Pablo Avenue and 65th Street



5.6. GENERAL COUNTERMEASURE RECOMMENDATIONS:

There were many similarities among intersections and zones that warranted similar countermeasure treatments. Those treatments, which were not specific to a particular intersection, were organized into overarching recommendations in three categories: "all intersections," "signalized intersections," and "unsignalized intersections." A detailed traffic engineering analysis would be required to produce estimates of costs and benefits, and to determine priorities.

5.6.1. All Intersections

- General upgrade of crossings to MUTCD and ADA standards:
    - Upgrade of curb ramps, with crosswalk catchments.
    - Installation of truncated domes at curb ramps to increase detectability of the boundary between street and sidewalk.

  - Upgrade sidewalks/clearance.
- More visible crosswalk markings (ladder/continental): decrease conflicts, increases numbers of motorist yielding to pedestrians, increase number of pedestrians using crosswalk.
- Updated fluor-yellow pedestrian crossing zone signs.

5.6.2. Signalized Intersections:

- Advanced warning for motorists, such as roving eyes (i.e., flashing lights above the crosswalk that resemble animated eyes looking down at the pedestrian to notify drivers that a pedestrian is trying to cross); reduces conflict, improves motorist compliance; but may decrease pedestrian awareness of vigilance.
- Countdown signals with animated eyes for pedestrians: improves awareness, reduces conflict, improves information, improves compliance.
- Call buttons that confirm the press: improves pedestrian compliance, improves information.
- Offset/advance stop lines: reduces pedestrian/driver conflict, decreases the number of drivers that block the crosswalk, should not impact vehicle mobility.

5.6.3. Unsignalized intersections:

- Smart Lighting (i.e., street lighting that responds to movement or trigger): increases visibility, reduces conflict.
- Pavement stencils: reduce conflicts, increase pedestrian awareness.
- Portable speed trailers: discourage speeding, reduce conflict.

APPENDIX A:
SAMPLE DATA SHEETS

Accessibility Survey Checklist
Intersection:
Date:

	Crossing/Corridor:		North:	South:		East:	West:
1	Confirm striping, xwalk& advance limit lines (clear(C) or faded (F))	E / W			N / S		
	Number of Lanes	E / W			N / S		
	Lane Configuration (Left Turn) (count of lanes)	E / W			N / S		
	Lane Config (Through) (count of lanes)	E / W			N / S		
	Lane Config (Right Turn) (count of lanes)	E / W			N / S		
2	One-Way (y/n)	E / W			N / S		
	Traffic Signals (and restrictions), Signalized (y/n)	E / W			N / S		
	Left-turn Phase (y/n)	E / W			N / S		
	No Right Turn on Red Restriction (y/n)	E / W			N / S		
	No U-Turn (y/n)	E / W			N / S		
	Pedestrian signal head (y/n)	E / W			N / S		
	Pedestrian signal head, countdown (y/n)	E / W			N / S		
3	Bike detector/inductive loop (y/n)	E / W			N / S		
4	Ped signal timing (4ft/sec), 2.5 ft/sec covers 95 of peds (N/A)	E / W			N / S		
5	Street crossing design should ensure that the boundary between the sidewalk and the street is detectable. Pedestrian crossing information should be available to all users. (**tactile strips**, etc.) (y/n)	E / W			N / S		
6	Level of ped traffic outside crosswalk or against signal (N/A)	E / W			N / S		
7	Parking locations & Approx locations from intersection, meters & towaways (distance, ft)	E / W			N / S		
8	Street light exist/adequate (y/n)	E / W			N / S		
9	Possible sight (LOS) obstructions (y/n)	E / W			N / S		
10	ADA compliant curb ramps, w>=3ft, cross slope 2%, level landing (y/n)	E / W			N / S		
11	Is foot of a curb **ramp** contained within the **crosswalk markings** (y/n)?	E / W			N / S		
12	Do Street furniture, plantings, and other fixed items protrude into travel routes? (y/n) (Bad for vision	E / W			N / S		
13	Sidewalks passable for wheelchairs? w>=3ft, 5ft (60 in) turning/passing (mobility)	E / W			N / S		
14	Sidewalk obstructions, plantings furniture, etc. inhibit ped and wheelchair mobility? 3ft-5ft (y/n)	E / W			N / S		
15	Curb return radius <20 ft? encourage high speed and ramp crossing (y/n)	E / W			N / S		
16	Driveway entrances within 100 ft of intersection (y/n)	E / W			N / S		
17	Posted speed limits nearby? Where?	E / W			N / S		
18	Are Pedestrian facilities on and along sidewalks accessible? Signal actuating buttons, drinking fountains, telephones, kiosks, and other pedestrian elements should meet accessibility criteria for approach and maneuvering space, reach range, and controls and operation. (y/n/NA)	E / W			N / S		
19	Bus stop locations (shelters, other struct. If within 100 feet y/n, otherwise no)	E / W			N / S		
	Existing median (size) ? (in feet)	E / W			N / S		
20	Is median suitable for a refuge? (y/n)	E / W			N / S		
21	Possible 4ft median insert w/10ft lanes (lane reduction) (y/n)?	E / W			N / S		
22	Potential for curb bulbs (driveways, bus stops, utilities, drains, poles)	E / W			N / S		
23	Adjacent land uses (up to 2 blocks away) Residential, Commercial, Industrial, School, Government (R, C, I, S, G) comma delimited	E / W			N / S		

Pedestrian Form

Pedestrian Behavior Form

Location: Corner: Observer:

Date: Time Start: End: Weather:

	Ped Observation					Begin Crossing			Finish Crossing							
X walk Leg	Number	(A=Alone; G=group)	Sex (M/F)	Age (A-D)*	Press'd PED button	W	FRH/FDW	R-FDW	W	RH/FDW	RH/DW	Out of crosswalk	Ped Action (R A W)**	Vehicle? If yes, movement (L R T)***	Vehicle violation? ****	P-V Conflict (1) If yes, Type (1 or 2)***
	1															
	2															
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	57															
	58															
	59															
	60															

*A=0-9, B=10-17, C=18-54, D=55+U, **Run, Abort, Walk

***(1)Ped changed gait or stride to avoid perceived/real threat, (2) Vehicle stops or swerves to avoid a pedestrian

***Vehicle near/encroaching on PED during which maneuver Left, Right, Through/Straight

****Vehicle violation: vehicle violates ped ROW, and/or breaks traffic law (e.g. runs red light)

Bicyclist Form

Bicyclist Behavior Form

Location:

Date: Time Start: End:

Observer:

Weather:

Cross Leg	Number	S=single, G=Group	Sex (M/F)	Age (A-D)	Begin Crossing G	Begin Crossing Y	Begin Crossing R	Finish Crossing G	Finish Crossing Y	Finish Crossing R	Start Dir N,S,E,W	End Dir N,S,E,W	Turn L, R, T	Start Lane 1,2,3,4 of # (or LMR)	End Lane 1,2,3,4 of # (or LMR)	Cyclist Violation ****	Vehicle ? If yes, movement (L, R, T)	Vehicle Violation ****	B-V Conflict (1) If yes, Type (1 or 2)***	Notes
	1																			
	2																			
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*A=0-9, B=10-17, C=18-64, D=65+/

***(1)Cyclist changed/braked or swerved to avoid perceived/real threat. (2) Vehicle stops or swerves to avoid a cyclist

****Ran a red light or violated another vehicle's ROW

APPENDIX B:
TAXONOMY MATRIX

Intersection Taxonomy	Pedestrian Risk	Bicyclist Risk	CounterMeasures	SPA & GILMAN	SPA & CEDAR	SPA & VIRGINIA	SPA & UNIV	SPA & 10TH	SPA & ADDISON (N)	SPA & ADDISON (S)	SPA & BANCROFT	SPA & CHANNING	SPA & DWIGHT	SPA & ASHBY
Traffic Characteristics														
Volume - Heavy (>25,000)				X	X		X		X	X			X	X
Volume - Medium (10,000-25,000)								X						
Volume - Light (<10,000)											X	X		
Speed - High (>45)	Unfriendly pedestrian environment	Unfriendly bicycling environment exposure	Enforce speed limit	X	X			X						
Speed - Low/Med (30-45)							X		X	X	X	X	X	X
Speed - Low (<30)														
High Pedestrian Volume	Exposure, lack of space, maneuverability		Widen sidewalks and crosswalks at interse accommodate flow, streamline crossings, automat				X						X	
High Bicyclist Volume		lack of space/ motorist awareness	Bike loop detector, narrow traffic lanes to 6 ft bike lane, Bicycle box a limit line, Stu			X								
Traffic Control														
Signalized														
Insufficient crossing time	Exposure		Medians or bulbouts to shorten crossing di Leading Pedestrian Interval (L Pedestrian sign											
Long Wait Time	Encourages jaywalking		Pedestrian pushbutton, quick feedback				X							
Excessive time between crossings	Increases possibility of jaywalking impatience, if timing app ped sees a g		Pedestrian pushbutton, quick feedback						X					
Unsignalized/Uncontrolled	Potentially long wait times for safe gap	Potentially long wait times for safe gap	In-pavement stencils, widen/lengthen med crosswalk for pedestrian refug			X		X	X		X	X		

Intersection Taxonomy	Pedestrian Risk	Bicyclist Risk	CounterMeasures	SPA & GILMAN	SPA & CEDAR	SPA & VIRGINIA	SPA & UNIV	SPA & 10TH	SPA & ADDISON (N)	SPA & ADDISON (S)	SPA & BANCROFT	SPA & CHANNING	SPA & DWIGHT	SPA & ASHBY
Roadway/Crossing Characteristics														
				(Secondary Street)										
Number of through travel lanes in t directions				3	2	2	4	2	2	2	2	2	2	4
Lack of ADA compliance: curb ram crossings (existence, loca	Inaccessible to handicapped pedestrians		One curb ramp per cross walk direction. A compliance: move inside cross ramp slope 1:12, sid		X				X	X		X		X
Lack of ADA compliance: sidewalk obstructions: landscaping	Inaccessible to handicapped pedestrians		Remove obstructions, standardize street fi inches minimum clear path i				X					X		X
Lack of detectable street/sidewalk	Decreases awareness of crossing zone		Install detectable warnings: truncated dom curbramps	X		X	X	X	X	X	X	X	X	
Driveway entrance/exits close to intersections	Pedestrian/vehicle sidewalk confli potential	conflicts with motorists at intersections	move entrances to greater than 50 feet fro or to secondary/side street		X						X			
User-Amenity mismatch: pedestria destination)	origins and destinations not conne easy obvious path lead exposure		mid-block crosswalk	X									X	
User-Amenity mismatch: bicyclists destination)		no room for bikes at bike destin, leads to crowding/con and approa	Bike box at intersection, bike signal conductive bike				X							X
Long Street Crossing	Exposure		Median or bulbouts to shorten crossing dis Pedestrian signal head count											
Excessive distance between crossings	increases possibility of jaywalking spatial mismatch of ped destination		Consider mid-block crossing with safety aı such as in-pavement lighting c striping											
Complex/confusing intersection design		conflicts with motorists at intersection	Turn restriction, driveway entrance restrictions		X				X	X				
Median NOT suitable for refuge			Widen /extend median to crosswalk								X			X
Crosswalk is faded/worn/undetectable			Update crosswalk markings, continental style	X										
Bikelane/bikeway/recreational path		Depending on facility, there mi more exposure	Wayfinding to bike "routes", share the roac increase awareness for mot			X						X		

Intersection Taxonomy	Pedestrian Risk	Bicyclist Risk	CounterMeasures	SPA & GILMAN	SPA & CEDAR	SPA & VIRGINIA	SPA & UNIV	SPA & 10TH	SPA & ADDISON (N)	SPA & ADDISON (S)	SPA & BANCROFT	SPA & CHANNING	SPA & DWIGHT	SPA & ASHBY
Observed Behavior														
Motorist														
Vehicle encroachment on pedestri (crossing)	reduces pedestrian perception of intersection		Advance limit lines, traffic enforcement	X	X	X	X	X	X	X	X	X	X	X
Lack of awareness of ped/motorist environment	exposure/lack of visibility, environ incongruence with local		Widen sidewalk, place crosswalk and ped warning bollard , replace low l higher canopy t mot					X	X		X			
Pedestrian														
Jaywalking			Improved pedestrian amenities: frequent crosswalks, pedestrian activat	18%	26%	33%	5%	12%	19%	19%	14%	23%	4%	21%
Bicyclist														
Bicycling wrongway		bicyclist feels threatened by exi street environment, fe against traffic	Bike amenities at intersection: bike box, si bike lane if possible, "share th	X		X	X		X	X		X	X	X
Bicycling on sidewalk		bicyclist feels threatened by exi street environment, fe sidewalks, i in	Bike amenities at intersection: bike box, si bike lane if possible, "share th	23%	18%	16%	7%	9%	11%	11%	13%	2%	6%	14%
Crash/Conflict History														
Straight moving conflict, motorist/ped/bike	from red-light running, jaywalking, due to poor signal timin crossing, ins	a vehicle or cyclist violation of red-light	Enforcement: red light running, advance li Yield to ped signs		X	X	X	X	X	X	X	X		X
Right turning conflict, motorist/ped/bike	vehicles violating pedestrian ROW turn on non-restricted r	vehicles violating bicyclist ROW right turn on non-restric	Advance limit lines to prevent encroachme crosswalks, right turn on red re	X		X		X						X
Left turning conflict, motorist/ped/bike	vehicles violating pedestrian ROW turn on non-exclusive le	vehicles violating bicyclist ROW turn on non-exclusive l	Leading pedestrian interval (LPI), for left t phase. Animated eyes/in-p peds of on-con	X	X	X	X							X
Pre(or post)-intersection bike confl change/merge/door zo etc.)		no room for bikes at bike destin leads to crowding/con and approa	Bike loop detector, narrow traffic lanes to 6 ft bike lane	X	X	X	X	X	X	X	X	X		X