Lafayette Downtown Traffic Study

for

Moraga Road Corridor

Prepared For:

City of Lafayette

January 8, 1998

Dowling Associates

Transportation Engineering • Planning • Research • Education

A California Corporation

Dowling Associates, Inc.
Transportation Engineering • Planning • Research • Education

January 8, 1998

Mr. Tony Coe
Public Works Services Manager
City of Lafayette
P.O. Box 1968 3675 Mt. Diablo Blvd., Suite 210
Lafayette, CA 94549-1968

SUBJECT: Lafayette Downtown Traffic Study P970056

Dear Tony:

We are transmitting the study report for the Lafayette Downtown Traffic Study. The report includes three technical memoranda which focus on the following specific elements of the project:

- Pedestrian and Bicycle Study
- Traffic Operations Anlysis
- Supplemental Traffic Studies

In addition, we are reporting on some additional items we were asked to resolve after our last meeting with the GPAC. Since that meeting, we have refocused our attention on what needs to be done to make Moraga Road function efficiently and support the City's plan to enhance the business climate downtown.

We have evaluated two total-system alternatives for Moraga Road (with variations):

I. Five lanes (four through lanes plus a two-way left-turn lane -TWLTL) north of Brook Street. This alternative would require removal of parking and bike lanes along Moraga Road to avoid widening the street and taking property.

II. Modified TWLTL (one southbound, two northbound through lanes north of Brook Street) with the following three options at Brook/School Street:

   A. Two southbound through lanes (existing conditions at Brook/School Streets). Moraga Road from Brook Street south would remain as it is today.

   B. One southbound through lane; one southbound dedicated left turn lane. From Brook Street to School Street the southbound inside through lane would be converted to a left turn only lane for School Street.

   C. Two southbound through lanes; one southbound dedicated left turn lane. The existing roadway would have to be widened between Brook and School Streets; property would have to be acquired.

180 Grand Avenue • Suite 995 • Oakland, CA 94612 • (510) 839-1742 • FAX (510) 839-0871
E-mail: traffic@dowlinginc.com

Figures showing the alternatives for Moraga Road north of Brook Street and the options for the Brook/School Street section are shown as attachments to this letter.

The analysis of the Brook/School Street options was performed first, and yielded results that helped us develop a long-range strategy for improving Moraga Road. The technical analysis of the Brook/School Street area is summarized below:

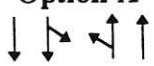
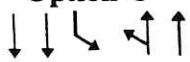
Brook/School Street Segment
Intersection Levels of Service and Delay (in seconds)

Option	Option A		Option B		Option C	
	LOS	Delay	LOS	Delay	LOS	Delay
AM Peak Hour	D	35.5	D	31.5	C	19.9
PM Peak Hour	C	17.6	F	High	C	16.2

The analysis showed that converting the southbound inside through lane to a left turn lane to serve School Street (Option B) would cause a traffic operations failure during the PM peak hour. The conclusion from this is that Moraga Road would have to be widened to accommodate installation of a dedicated southbound left-turn lane for School Street.

A summary of the attributes of the Options for the Brook/School Street segments is shown below:

Moraga Road Alternatives Summary
Brook/School Street Segment

Impact	Option A 	Option B 	Option C 
Congestion	Moderate	Highly Congested	Uncongested
Safety	Left Turns from Through Lane NB & SB	Left Turns from Through Lane NB	Left Turns from Through Lane NB
Property Required ?	No	No	Yes

This analysis also pointed out another consideration. If a single lane southbound cannot work effectively at Brook and School Streets, it may not work at other locations where signals may be needed in the future. If the downtown business activity grows and generates more traffic, a signal may become required at the Moraga Boulevard intersection, and the modified TWLTL alternative (Alternative 2) may not work effectively.

A summary of the attributes of the alternatives for Moraga Road north of Brook Street is shown below:

Moraga Road Alternatives
North of Brook Street

	Existing Conditions	Alternative 1 Five Lanes	Alternative 2 Modified TWLTL
Potential for Congestion Relief	None	High	Moderate
Traffic Flow	Through Traffic Impeded by Left-Turning Vehicles	Through Traffic Unimpeded	Through Traffic Unimpeded NB Merge Required SB
Ability to Accommodate Future Traffic Signal	Moderate	High	Low
Safety	Left Turns from Through Lane	Turning Vehicle Storage Provided	Turning Vehicle Storage Provided
Bike Lanes	Substandard - Should be Removed	Removed	Removed
Parking	Maintained	Move to Off-Street Location	Maintained

Long-Range Plan

We recommend the five-lane alternative (Alternative 1) be implemented north of Brook Street to serve the long-term needs for downtown circulation as well as regional mobility. If the funds are available, we also recommend providing five lanes between Brook Street and School Street (Alternative 2C).

Unfortunately, the five-lane alternative would require removal of the parking along the west side of Moraga Road. Although no parking study has been performed, it has been stated that the short supply of parking inhibits the economic potential of the downtown. If this is the case, alternative parking will need to be provided to accommodate the long-term transportation needs for downtown.

We also recommend the City immediately begin looking for a location in the downtown to provide significant parking: either a large surface parking area or areas, if available; or a location for a parking structure. The City should explore the possibility of using Measure C sales tax funding to replace the parking that would be displaced by implementing the five-lane alternative within the existing right-of-way. It seems to be a legitimate use of Measure C funds to move the required on-street parking to an off-street location to allow for expansion of the roadway capacity within the existing right-of-way. This would be a cheaper solution than widening Moraga Road to provide the needed capacity.

Interim Plan

A strategy will need to be developed for Moraga Road to cover the period until the five-lane alternative can be implemented. There are three basic options for an interim plan:

1. Do nothing (a short to mid-term strategy)
2. Install the modified TWLTL concept (a mid-term strategy)
3. Install the five-lane alternative and remove the on-street parking before additional parking is obtained elsewhere (a mid-term strategy)

There are advantages and disadvantages to all three alternatives. Doing nothing would require no capital to implement and would preserve the parking, but would not improve the capacity or safety of Moraga Road.

Installing the modified TWLTL concept would require some capital expenditure and would preserve the parking and improve traffic safety, but would not provide a significant improvement in capacity.

Installing the five-lane alternative before alternative parking is provided would also require some capital expenditure and would improve safety and capacity, but would reduce the parking supply in an area that is short of parking already.

Selecting among these three options is beyond the purview of the traffic consultant and must be decided by public officials who represent the various constituents potentially affected.

Removal of the bike lanes along Moraga Road is recommended for all three options. Three transportation studies have now recommended removal of the bike lanes north of Brook/School Streets: the Lamorinda Transportation Study, the Downtown Feasibility Study, and this Moraga Road Transportation Study. Although it would be desirable to have bike lanes along Moraga Road, providing them would require widening Moraga Road and taking commercial property adjacent to the street. An alternative route for bicycles has been proposed in the Pedestrian/Bicycle Study for this project. The bike route plan modifications are illustrated on an attached figure.

Other recommendations from our study are to not install new traffic signals along Moraga Road until such time as signal warrants are met and there has been a demonstrated need for a signal. At present, no new traffic signals are warranted and it is unlikely that the warrants will be satisfied near-term, depending upon the pace of development in the areas served by Moraga Road.

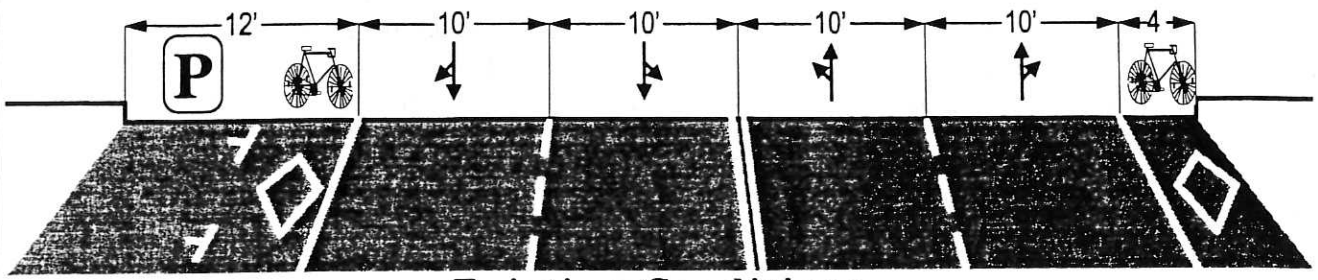
We have also recommended removal of some of the crosswalks across Moraga Road to improve pedestrian safety in the corridor. Additional detailed conclusions and recommendations are contained at the beginning of each of the three technical memoranda that follow this letter.

We look forward to discussing the results of our study with City Staff and the appropriate committees. Please call if you have questions or comments.

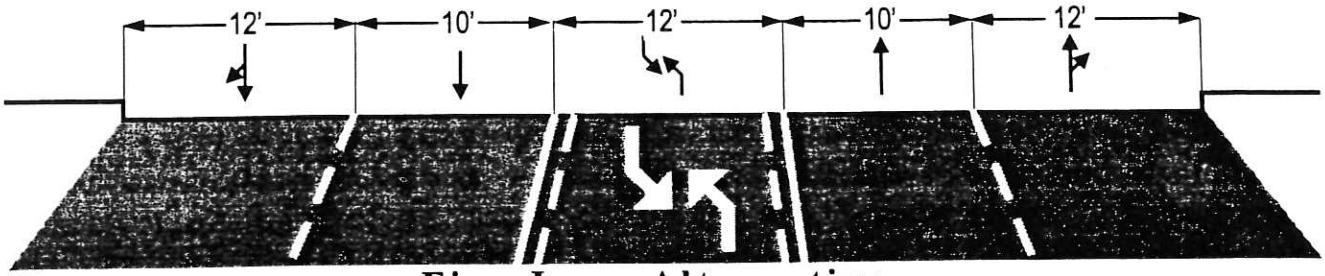
Sincerely,
Dowling Associates, Inc.

Mark A. Bowman
Principal

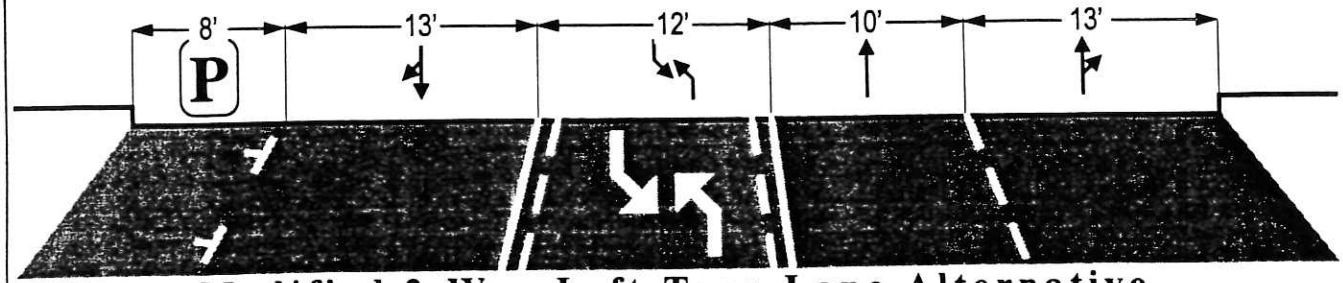
c:_active projects\lafayette\moraga rd\document\tech memo summary letter.doc



Existing Conditions



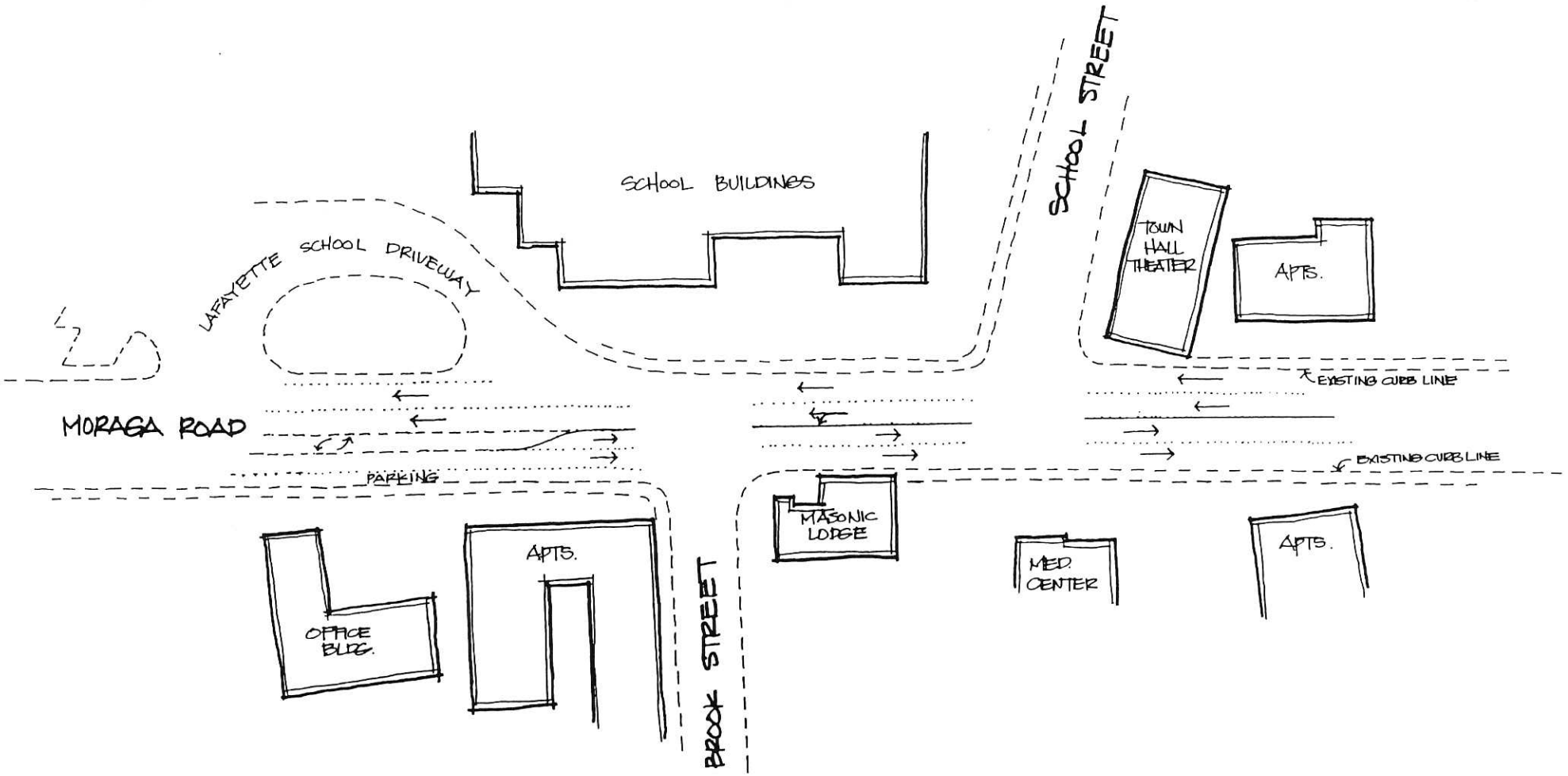
Five-Lane Alternative



Modified 2-Way Left-Turn Lane Alternative

Moraga Road Alternatives

N

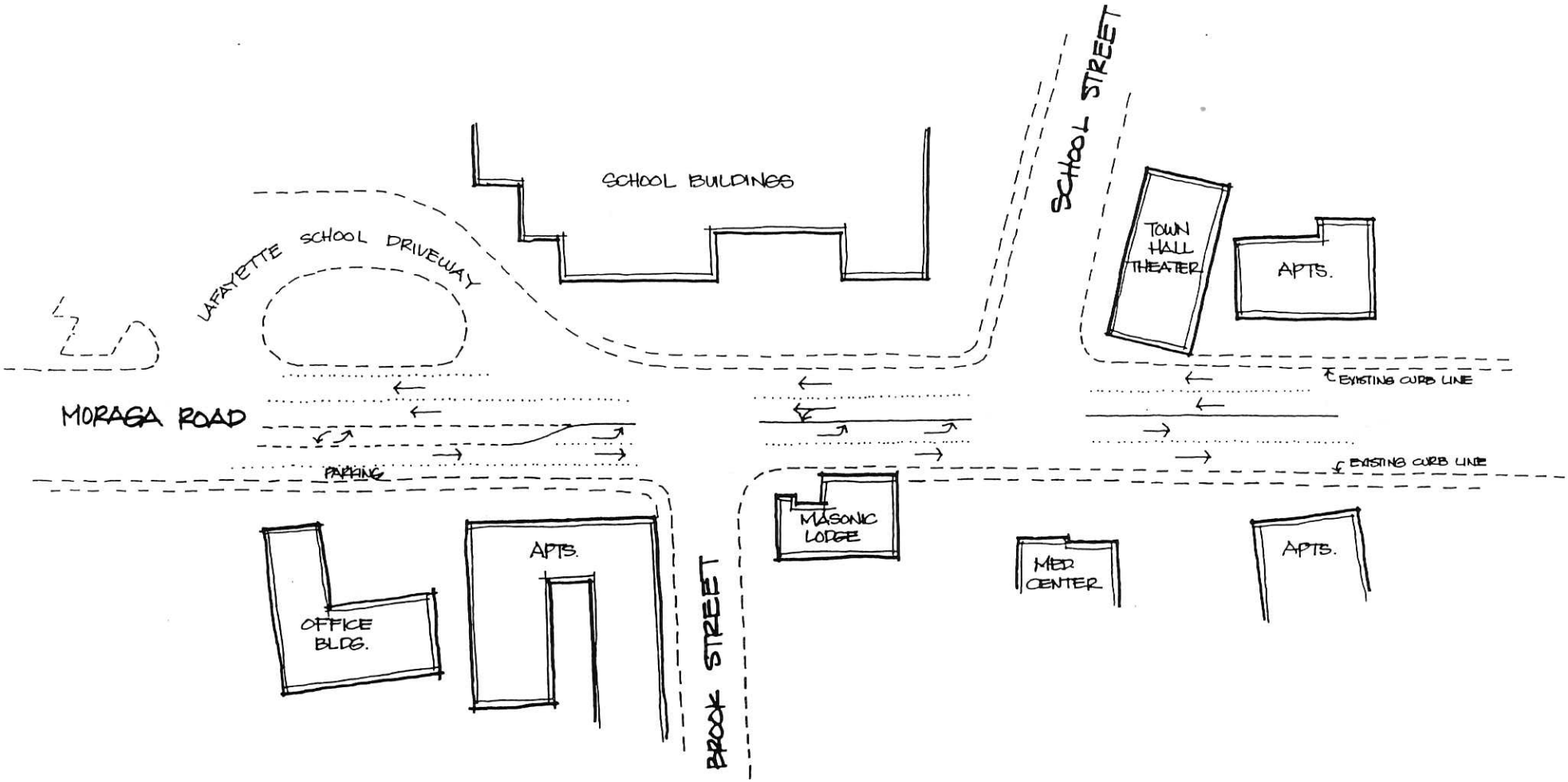


NTS

MORAGA ROAD - OPTION A

MODIFIED TWLTL
2 THRU LANES @ BROOK STREET

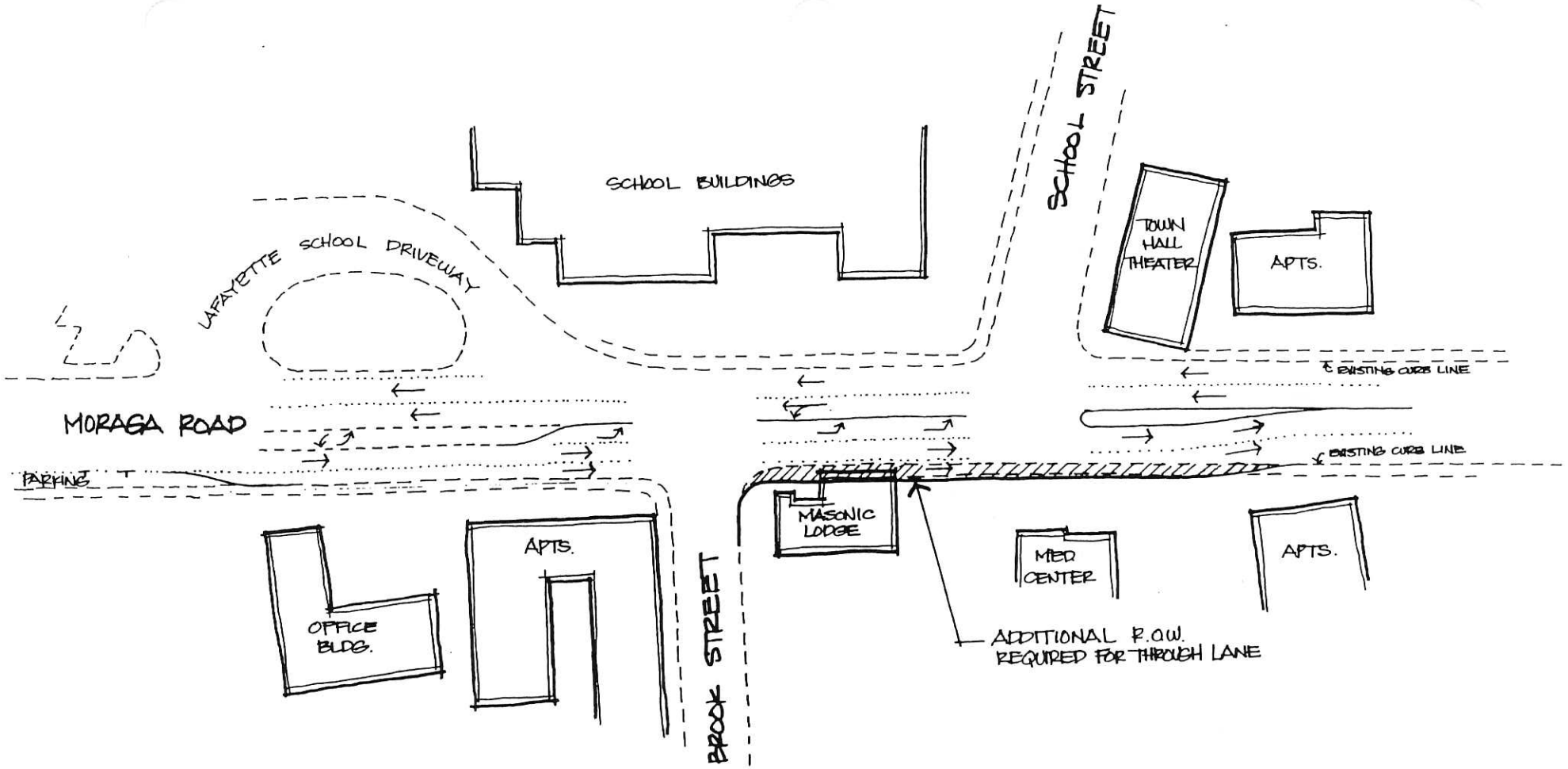
McGILL MARTIN SELF, Inc.
Civil Engineering Land Planning Surveying
Community Development Public Policy Finance Construction Management



MORAGA ROAD - OPTION B

MODIFIED TWLTL
DEDICATED LEFT TURN LANE

McGill Martin Self, Inc.
Civil Engineering Land Planning Surveying
Community Development Public Policy Finance Growth Management
8 Orinda Way Suite 100A Orinda, CA 94563-1513 Tel: 510 254 8850 Fax: 510 254 1353

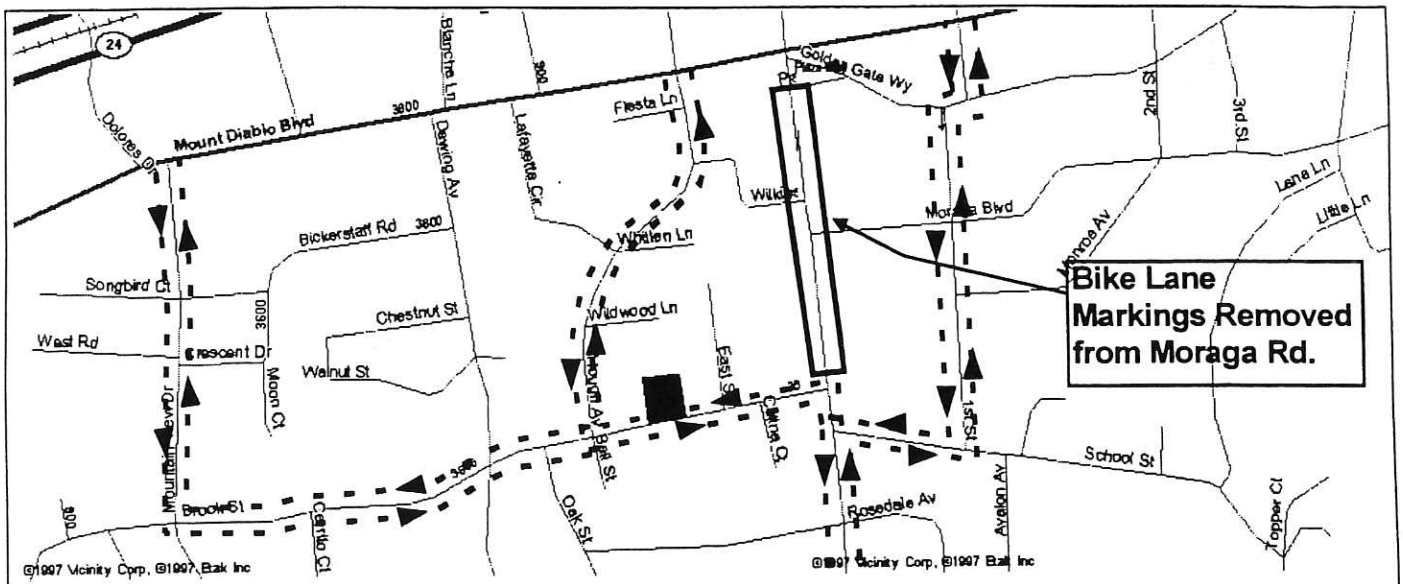


NTS.

MORAGA ROAD - OPTION C

MODIFIED TWLTL
DEDICATED LEFT TURN LANE
AND 2 THRU LANES.

McGILL MARTIN SELF, INC.
Civil Engineering Land Planning Surveying
Community Development Public Policy Finance Growth Management
1 Orinda Way Suite 300A Orinda, CA 94563-2313 Tel: 510 254 6830 Fax: 510.254.3333



Proposed Bike Route Changes
for Moraga Road

Contents

Technical Memorandum I
Pedestrian and Bicycle Study

Introduction

The Lafayette Downtown Feasibility Study (DFS) recommended a comprehensive analysis of pedestrian and bicycle issues along the Moraga Road corridor. This report is the culmination of a study to accomplish the goals of the DFS. The Pedestrian and Bicycle Study for Moraga Road addressed two major issues:

1. The level of pedestrian/bicycle activity in the corridor.
2. The potential need for pedestrian/bicycle facilities to accommodate the demand.

The report assesses the potential need for:

- crosswalk removal or relocation
- maintaining adequate routes to school
- relocating existing bus stops to better serve pedestrians
- providing a median refuge island for pedestrians and bicyclists
- a strategically located pedestrian signal
- a grade separated pedestrian/bicycle crossing near the elementary school
- provision of other pedestrian facilities including sidewalks, walkways, paths, etc.

The report contains a summary of the study conclusions, followed by a more detailed discussion of the pedestrian/bicycle data collected during the study, the evaluation of existing pedestrian and bicycle use, and the need for improvements to the ped/bike facilities or other street improvements that would benefit pedestrian and bicycle mobility and safety. The discussion is provided in the context of other improvements that are being considered to improve traffic operations and safety in the Moraga Road corridor.

Figures that illustrate the alternatives are provided at the end of the report along with backup calculations and data.

Summary of Recommendations 15 Recommendations

1. All of the five existing painted crosswalks at unsignalized locations on Moraga Road north of St. Mary's Road should be removed to protect pedestrians from a false sense of security. Legal crosswalks would still exist at the unsignalized intersections even if not painted. At midblock locations, it would no longer be legal for pedestrians to cross.
2. If the community insists that some of the painted crosswalks across Moraga Road be retained, the crossing at the Plaza Way intersection should be considered first. This crosswalk had the highest number of pedestrians (of the unsignalized crosswalks), and most of the pedestrians were adults.
3. If the community insists that another painted crosswalk be retained, the crossing at Moraga Boulevard should be considered as the second candidate. This crosswalk had about half the pedestrian activity of the Plaza Way crosswalk, and three-quarters of the pedestrians were school-aged children, so we would discourage retention of the painted crosswalk. A pedestrian signal may be justified at this location in the future (see recommendation number 8, below).
4. If it is decided to retain any of the unsignalized, painted crosswalks across Moraga Road, we recommend that the City consider making it/them more visible by using recessed pavement lighting similar to the treatment on Mt. Diablo Boulevard at the Park Hotel.
5. At Moraga Road, the existing routes to school appear to be adequate and should be retained. We do not recommend removal of the traffic signal and consolidation of pedestrian crossings at School Street, as recommended in the DFS. We are concerned that school-age children would still be legally permitted to cross at Brook Street without the protection of a traffic signal.
6. The bus stops along Moraga Road appear to provide adequate service to pedestrians and should be retained.
7. A median refuge island is recommended only if the decision is made to widen Moraga Road.
8. We do not recommend installation of a pedestrian traffic signal at any point along Moraga Road at this time. The total number of pedestrians counted between Brook Street and Mt. Diablo Boulevard were less than half the number required to satisfy the pedestrian signal warrant. Pedestrian volumes should be checked periodically to evaluate the potential future need for such a signal.
9. Installation of a grade separated pedestrian crossing is not considered to be cost-effective at the present time.
10. We recommend widening the sidewalk along the elementary school's frontage to approximately eight feet (toward the school).

11. A pedestrian facility (sidewalk or path) that connects from St. Mary's Road to Old Jonas Hill Road is recommended, consistent with the DFS. The street lighting along this segment of the roadway should also be evaluated.

12. Because of the inability to provide standard bike lanes north of School Street, the existing striped lanes should be removed, consistent with the DFS and the Lamorinda Traffic Study. We also recommend that the pavement be repaired or replaced in the areas where deterioration has occurred.

13. Until such time as Moraga Road is widened, we recommend creating a new bike route system north of School Street that involves splitting the current Moraga Road route into eastern and western forks. For bicycle traffic to or from the east side of Moraga Road, the new route would utilize First Street and School Street. For bicycle traffic to or from the west side of Moraga Road, the new route would utilize Brook Street to Hough Avenue for access to downtown, and Brook Street to Mountain View Drive for access to points west.

14. On First Street, we recommend construction of a Class 1 bike path, consistent with Caltrans standards. We also recommend adding standard width Class 2 bike lanes to the portion of Moraga Road south of School Street wherever sufficient width exists to provide at least a five-foot lane.

15. At the Brook Street intersection, the City should consider installing internally illuminated signs indicating "No Left Turn" during the appropriate hours.

Data Collection

The data collection program for this study involved counting pedestrians and bicyclists. Pedestrians were counted traveling along Moraga Road and crossing Moraga Road. The counting methodology may have resulted in double counting pedestrians who cross more than one leg of the same intersection, but our observations were that nearly all pedestrians at the Moraga/School/Brook crossings crossed only a single leg of any intersection.

All bicyclists were counted, regardless of direction or whether on the street or sidewalk. In addition to the volume of pedestrians and bicyclists, a distinction was made between adults and school age children.

Study Times and Limits. The pedestrian and bicycle counts were conducted during three peak periods of a typical weekday, 7:30-8:30 AM, 2:45-3:45 PM, and 5:00-6:00 PM. The counts were conducted on Thursday, November 6, 1997, which was approximately 10 days following the change to Pacific Standard Time. The importance of the time change is that the morning peak period occurred in full daylight. In full daylight, parents would be more likely to allow their children to walk or ride to school. Pedestrian and bicycle activity during the summer would be lower during peak periods related to school activity; however, the activity during other periods of

the day (not covered in this study) would likely be higher. After the counts were in progress, we learned that the elementary school had let out at 2:30, so we caught primarily the pedestrian activity from the middle school (on School Street) during that time period. Based on our observations, the pedestrian activity related to the elementary school appeared to be significantly lower than that related to the middle school.

The observation area included the Moraga Road/Mt. Diablo Boulevard intersection on the north, and extended south to the marked crosswalk near the Moraga Road/Tanglewood Drive/Hamlin Road intersection.

Summary of Counts. The results of the pedestrian and bicycle counts are shown in Figures 1-4 at the end of this report. Figures 1-3 show the northern portion of our study area, from Mt. Diablo Boulevard to St. Mary's Road. Each of the three figures shows a different hour of counts. Figure 4 covers the southernmost portion of our study area for all three study periods.

By far, the heaviest pedestrian volumes occur at the Brook-School intersections, where 136 pedestrians (116 of them children) were counted from 7:30-8:30 and 99 pedestrians (72 of them children) were counted from 2:45-3:45. A moderate amount of pedestrian activity was observed at Moraga Road/Mt. Diablo Boulevard, with 56 pedestrians during the morning hour, 43 during the afternoon hour, and 37 during the evening hour. It should be noted that 17 of the 37 pedestrians counted during the 5:00-6:00 PM hour were school-age children crossing as a group approximately 2-3 minutes before 6:00. We do not have information as to whether this occurrence was a one-time event or if it occurs regularly.

Bicycle traffic was primarily concentrated at the Brook-School intersections during all hours counted, although a few cyclists were counted at Mt. Diablo. Throughout the corridor, there were a total of 53 school age cyclists and 26 adult cyclists.

Crossing Guards' Observations. At the Brook Street intersection, one crossing guard was on duty from 8:00-8:30 AM, and another was on duty from 2:30-3:00 PM. Conversations with the guards revealed that violations of the left- and right-turning restrictions for vehicles are common. The right-turn restriction, which prohibits right-turns-on-red during typical school crossing hours, is of particular concern with respect to pedestrian activity in the crosswalk across Brook Street[1]. The crossing guards reported that many of the violations take place while pedestrians are in the crosswalk. Also, vehicles often block the crosswalks across Moraga Road when the downstream queue builds to that intersection (from Mt. Diablo for northbound traffic and from School Street for southbound traffic) and vehicles move through the intersection before there is enough room available for them.

[1] The pedestrians cross all legs of the Moraga/Brook/School intersections during an exclusive pedestrian phase, so the right-turn restrictions were apparently implemented to ensure that no vehicle movements at all would occur while pedestrians are crossing.

Evaluation

Use of Facilities as Intended

One of our tasks was to determine whether pedestrians and cyclists are using the facilities appropriately. In summary, we found that the facilities are used appropriately.

We observed that there were few crossings of Moraga Road made outside of the existing marked crosswalks. Specifically, we observed only 8 such crossings during the three hours of observations, or approximately 2% of all crossings.

Virtually all school age bicyclists rode exclusively on the sidewalks. While this is not an explicitly recommended practice by Caltrans, Caltrans recognizes the safety benefits for young, inexperienced cyclists, and generally accepts it as a reasonable use of the facility. When crossing streets, most of them walked their bikes within the marked crosswalks (often at the explicit instructions of the crossing guards). Conversely, virtually all of the adult cyclists were observed riding in the street.

Assessment of Need for Various Modifications

The need for new facilities and modifications to existing facilities were assessed based on our observations and data collected for this study.

Marked Crosswalks.

The California Vehicle Code defines a crosswalk as:

a) "That portion of a roadway included within the prolongation . . . of sidewalks . . . ."

b) "Any portion of a roadway distinctly indicated for pedestrian crossing by lines or other markings on the surface."

There is growing concern in the traffic engineering profession that marked crosswalks at locations where vehicles are only required to stop for pedestrians (uncontrolled) may be less safe than no marked crosswalks. The reason for the concern is that pedestrians may feel a false sense of security upon entering the crosswalk and are more likely to be struck by a vehicle. Engineers supporting this notion argue that without a marked crosswalk, pedestrians tend to assume that vehicles won't see them, so they act with significantly more caution. Also, at intersections motorists are more aware that pedestrians may be crossing.

This safety issue is particularly evident when the roadway being crossed includes more than one lane in each direction, like Moraga Road. In such cases, a vehicle in one lane may stop for a pedestrian, but the vehicle in the adjacent lane may not, often because the driver's vision is blocked by the stopped vehicle. Even if legally right, a pedestrian will incur significantly more serious injury than the vehicle and/or driver that strikes him/her.

Several cities have considered removing marked crosswalks at similar locations, and at least one, Campbell (near San Jose), has actually removed several of them. Some cities have eliminated crosswalks at non-signalized locations after repaving or overlaying streets, and only reinstall marked crosswalks based on citizen requests.

The marked crosswalks relevant to this discussion are the uncontrolled crossings of Moraga Road at Plaza Way, Moraga Boulevard, O'Connor-Rosedale, and the two midblock crosswalks between Plaza and Moraga Boulevard. The pedestrian and bicycle demand at these unsignalized painted crosswalks are summarized below.

Location	Number of Crossings During Three Hours Observed		
	Adults	Students	Total
Plaza Way	37	3	40
Midblock Crosswalk South of Plaza Way	17	2	19
Midblock Crosswalk North of Moraga Blvd.	17	11	28
Moraga Blvd.	5	16	21
O'Connor-Rosedale	3	2	5

Based on the above discussion of pedestrian safety and on the volumes of pedestrians crossing Moraga Road at the marked, unsignalized crosswalks, our first recommendation would be to remove all of the five existing unsignalized crosswalks north of St. Mary's Road. Pedestrians have other opportunities to cross Moraga Road at marked crossings that are controlled by traffic signals. Additionally, pedestrians would still be legally permitted to cross at Plaza Way, Moraga Boulevard, and O'Connor-Rosedale according to the provisions of the California Vehicle Code, as described above.

If the community insists that one or more of the crosswalks be retained, we recommend the crossing be retained at the Plaza Way intersection. This recommendation is based on the fact that the crosswalk would be legal whether marked or not according to the California Vehicle Code, almost all of the people crossing at this location were adults, the existing demand is highest of all at this location, and the future demand is most likely to increase at this location.

There are current plans to add new stores to some of the currently empty space in the Fiesta Square Shopping Center, on the west side of Moraga Road. The level of pedestrian activity at the northern portion of the corridor is likely to increase once the new stores open.

Both midblock crosswalks should be removed for safety reasons, as described above, and the crosswalk at the O'Connor/Rosedale intersection should be removed because of low demand.

We also recommend removal of the crosswalk across Moraga Road at the Moraga Boulevard intersection. Although there is a relatively high demand for the unsignalized crossing at Moraga Boulevard, most of the users at this location were children, who should be crossing the street at signalized crosswalks (more discussion of this issue is contained in the following section). Discussion of a potential pedestrian crossing traffic signal is included in a separate section below.

If it is decided to retain any of the marked unsignalized crosswalks, we recommend that the City consider making it/them more visible by using recessed pavement lighting similar to the treatment on Mt. Diablo Boulevard at the Park Hotel. The crosswalk treatment should be transparent to pedestrians and should not include colors or textures that would convey a false sense of security to pedestrians. The accident experience at any marked unsignalized crosswalks that are retained should be monitored to determine if the crosswalk markings should be removed in the future.

Routes to School and Safety for Children. Our observations of the routes taken by students indicate that the existing patterns appear to be adequate for the most part. Within our observation area, most school age pedestrians arrived at the Brook/School intersections from the residential area west of Moraga Road via Brook Street. **Very few pedestrians were observed arriving from areas south of School Street or north of Brook Street.**

At the pedestrian crossing at Brook Street, school crossing guards were observed during the peak periods for school children. The school crossing guards ensured that the children crossed only during the pedestrian phase of the signal[2]. The visibility of the guards, who used hand-held stop signs, also contributed to the safety of pedestrian and bicycle operations for non-school users.

One safety concern for school children is related to the queuing that occurs behind the traffic signals - this issue is discussed below under Left-turn Restrictions at Brook Street. Another safety concern is that some students cross (legally) at the marked, unsignalized crosswalks. These crosswalks are not needed for children's routes to school (they can and should cross at the signalized crossings).

The DFS recommended that the traffic signal a Brook Street be removed, all left turning movements be prohibited, and the pedestrian crossings be consolidated at School Street. We do not concur with this recommendation. From our field observations, we are concerned that school age pedestrians would continue to cross Moraga Road to the elementary school, even if crossing guards

[2] The guards pushed the pedestrian push button (PPB) whenever children arrived, which is often a problem where young pedestrians cross without crossing guards. According to the Caltrans *Traffic Manual* (Chapter 10 - School Area Pedestrian Safety, General Provisions), less than half of school-age pedestrians will push the PPB to cross, but will cross during gaps in traffic (without a crossing guard present).

Both midblock crosswalks should be removed for safety reasons, as described above, and the crosswalk at the O'Connor/Rosedale intersection should be removed because of low demand.

We also recommend removal of the crosswalk across Moraga Road at the Moraga Boulevard intersection. Although there is a relatively high demand for the unsignalized crossing at Moraga Boulevard, most of the users at this location were children, who should be crossing the street at signalized crosswalks (more discussion of this issue is contained in the following section). Discussion of a potential pedestrian crossing traffic signal is included in a separate section below.

If it is decided to retain any of the marked unsignalized crosswalks, we recommend that the City consider making it/them more visible by using recessed pavement lighting similar to the treatment on Mt. Diablo Boulevard at the Park Hotel. The crosswalk treatment should be transparent to pedestrians and should not include colors or textures that would convey a false sense of security to pedestrians. The accident experience at any marked unsignalized crosswalks that are retained should be monitored to determine if the crosswalk markings should be removed in the future.

Routes to School and Safety for Children. Our observations of the routes taken by students indicate that the existing patterns appear to be adequate for the most part. Within our observation area, most school age pedestrians arrived at the Brook/School intersections from the residential area west of Moraga Road via Brook Street. **Very few pedestrians were observed arriving from areas south of School Street or north of Brook Street.**

At the pedestrian crossing at Brook Street, school crossing guards were observed during the peak periods for school children. The school crossing guards ensured that the children crossed only during the pedestrian phase of the signal[2]. The visibility of the guards, who used hand-held stop signs, also contributed to the safety of pedestrian and bicycle operations for non-school users.

One safety concern for school children is related to the queuing that occurs behind the traffic signals - this issue is discussed below under Left-turn Restrictions at Brook Street. Another safety concern is that some students cross (legally) at the marked, unsignalized crosswalks. These crosswalks are not needed for children's routes to school (they can and should cross at the signalized crossings).

The DFS recommended that the traffic signal a Brook Street be removed, all left turning movements be prohibited, and the pedestrian crossings be consolidated at School Street. We do not concur with this recommendation. From our field observations, we are concerned that school age pedestrians would continue to cross Moraga Road to the elementary school, even if crossing guards

[2] The guards pushed the pedestrian push button (PPB) whenever children arrived, which is often a problem where young pedestrians cross without crossing guards. According to the Caltrans *Traffic Manual* (Chapter 10 - School Area Pedestrian Safety, General Provisions), less than half of school-age pedestrians will push the PPB to cross, but will cross during gaps in traffic (without a crossing guard present).

Grade Separated Pedestrian Crossing. In order for this type of structure to be cost effective, there should be sufficient volume to warrant a signal at a location where adding a signal would destroy the traffic flow. As stated above, none of the currently uncontrolled crossings has nearly enough pedestrian volume to meet the relevant signal warrant. The existing controlled crossings at Brook and School Streets might be candidates for a grade separated crossing, but there appears to be only moderate inefficiency inherent in the existing signal system (related to Moraga Road traffic) to warrant consideration of such an expensive structure.

Other Pedestrian or Bicycle Facilities. Many school age bicyclists were observed riding on the sidewalk near the school. We observed that conflicts with bicycles and pedestrians were common. While none of these young pedestrians or cyclists were seen to be forced off of the sidewalk into the street, it appeared to be a reasonable possibility. This situation is particularly evident where the construction area fence forms a complete barrier at the back edge of the sidewalk opposite Brook Street. We therefore **recommend widening the sidewalk along the school's street frontage to approximately eight feet.** However, it should be noted that Caltrans, which recommends against *encouraging* bicycles to ride on the sidewalk (although states that such activity by children is acceptable), recommends against very wide sidewalks because of the potential for higher bicycle speeds. There is probably not enough right-of-way available for this widening, so the City would have to obtain it or convince the school district to construct the wider sidewalk on its property.

Another issue is how to accommodate pedestrians and bicyclists along the segment of Moraga Road south of St. Mary's Road. **The DFS recommended provision of a 5-foot wide sidewalk or path on the west side of Moraga Road from St. Mary's Road to Tanglewood Drive, and on the east side from Rosedale Avenue to Old Jonas Hill Road.** Despite the low pedestrian volumes observed in this area, **we concur with the DFS recommendation.** This facility could be either a concrete sidewalk or an asphalt path separated by an asphalt berm. As part of the pedestrian facility, the lighting along this segment of the roadway should be evaluated.

Bicycle Issues. We observed almost no bicyclists using the Moraga Road bike lanes. It is prudent, however, to note that we do not know if this observation is caused by a low basic demand for bicycle travel or a low volume at this location because of poor facilities.

The existing northbound bike lane is four feet wide, which is narrower than the current Caltrans standard of 1.5 meters, or almost five feet. One of the primary concerns relevant to Moraga Road is ensuring that cyclists have sufficient space between the bike lane stripe and the lip of the gutter (the seam where the AC pavement and concrete gutter meet). The southbound bike lane stripe defines a space of about 12 feet, which cyclists must share with parked cars. Regardless of the location of parallel parking stripes, parked cars take up about eight feet, leaving only about four feet of effective bike lane width.

Both the DFS and the Lamorinda Traffic Study recommended removal of the bike lanes north of School Street. We concur with the recommendations of the previous two studies and providing a wide curb lane for motor vehicles. By removing the striping for bike lanes that are too narrow, cyclists will ride where they feel it is safe. Given the low volume of cyclists, vehicle traffic will not be hindered significantly if one has to drive around an occasional cyclist. During peak periods, motor vehicles often travel at or below bicycle speeds, which is safer for cyclists. During non-peak periods, motor vehicles in the right lane encountering a cyclist will have room to either change to the left lane or move to the left edge of the right lane, possibly even moving temporarily over the lane stripe. We also recommend that the the pavement be inspected and repairs made in the areas where deterioration has occurred.

Several alternatives are being considered for modification of the motor vehicle travel lanes on Moraga Road. Cross sections of the existing conditions and some of the alternatives being considered for Moraga Road are shown in Figure 5 at the end of this report. The primary goal of the Moraga Road alternatives is to provide a two-way left-turn lane, which would remove turning traffic from the through traffic. Some of these alternatives would eliminate bike lanes on Moraga Road.

As a more comprehensive solution to bike routes in this area, we recommend creating a new route system that could be considered the "Lafayette Bike Route 'Y'." The concept is to have the Moraga Road route diverge into two routes at the Brook-School intersections to avoid the narrower and busier portion of Moraga Road north of there:

- The bike route south of School Street would remain as is.
- For bicycle traffic to or from the east side of Moraga Road, the new route would utilize First Street and School Street.
- For bicycle traffic to or from the west side of Moraga Road, the new route would utilize Brook Street and Hough Drive to access downtown, and Brook Street to Mountain View Drive for access to points west.

The new divergent bike routes could be established with minimal cost by using signs to create Class 3 bike routes where no bike lanes exist. On First Street, we recommend construction of a Class 1 bike path, consistent with Caltrans standards; currently, there is only one very wide bike lane on the east side of First Street.

We also recommend adding standard width Class 2 bike lanes to the portion of Moraga Road south of School Street wherever sufficient width exists to provide at least a five foot lane (e.g., a cross section of 5-foot bike lanes, 11-foot curb lanes and 10-foot center lanes for the 52-foot roadway width south of Brook Street).

Left-turn Restrictions at Brook Street. The school crossing guards observed violations of the northbound left-turn prohibition at Brook Street, as discussed above. We are concerned that such

violations could contribute to the potential for vehicle/pedestrian conflicts at the intersection. The time limits on the prohibition may contribute to the potential for violations by drivers. The restrictions are only in effect from 7:00 AM to 4:00 PM. Enforcement of the prohibition would be improved by prohibiting the left-turning movement at all times. This would also eliminate confusion for those who may violate the restriction inadvertently. Prohibition of the maneuver at all times would create inconvenience for residents at times when the restriction is not needed.

We recommend a compromise solution, which would involve installing internally illuminated signs indicating "No Left Turn" during the appropriate hours. Similar signs operate on Park Street in Alameda and on Main Street in Walnut Creek. We recommend that the signs be illuminated continuously during the applicable hours.

Dowling Associates, Inc.

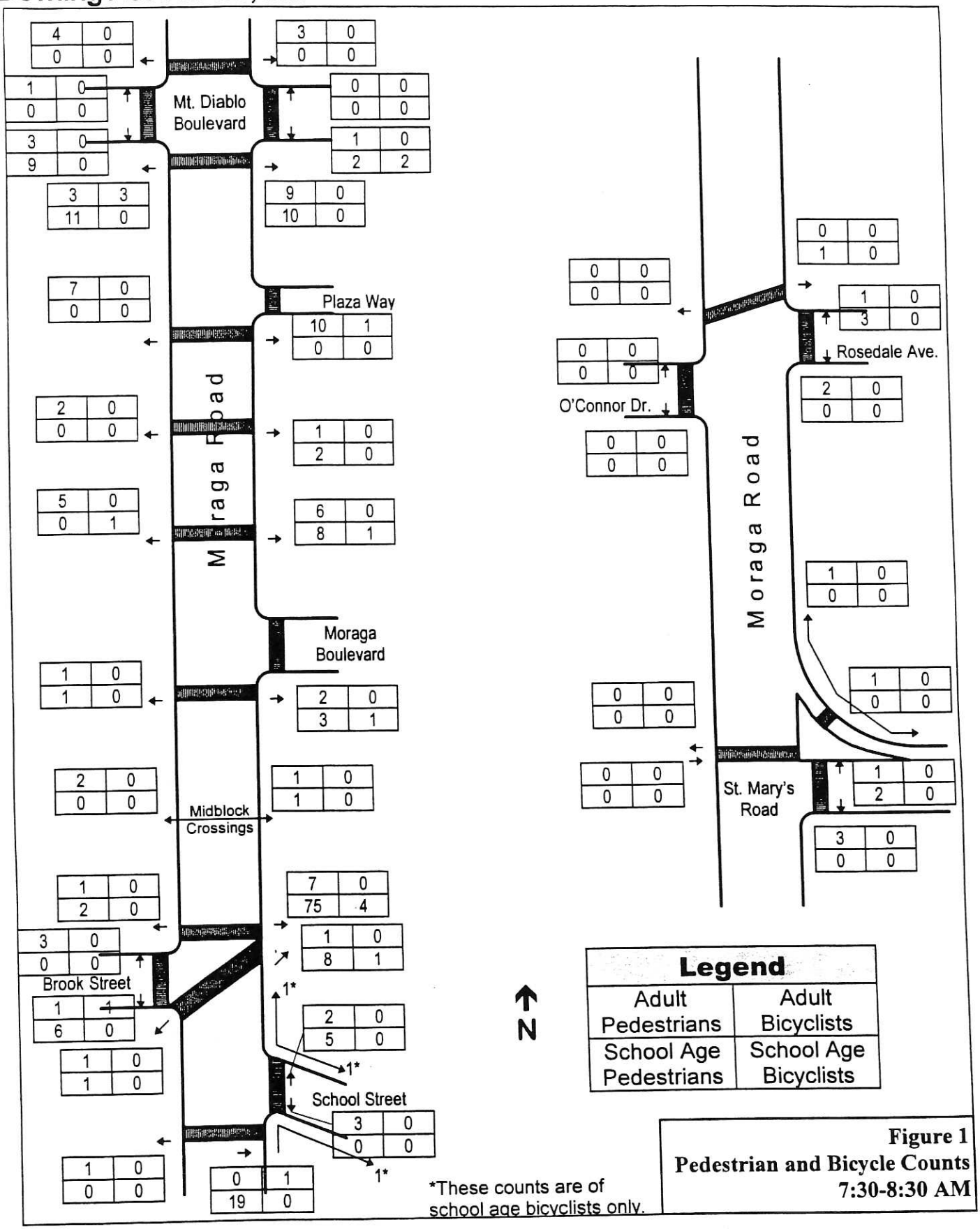
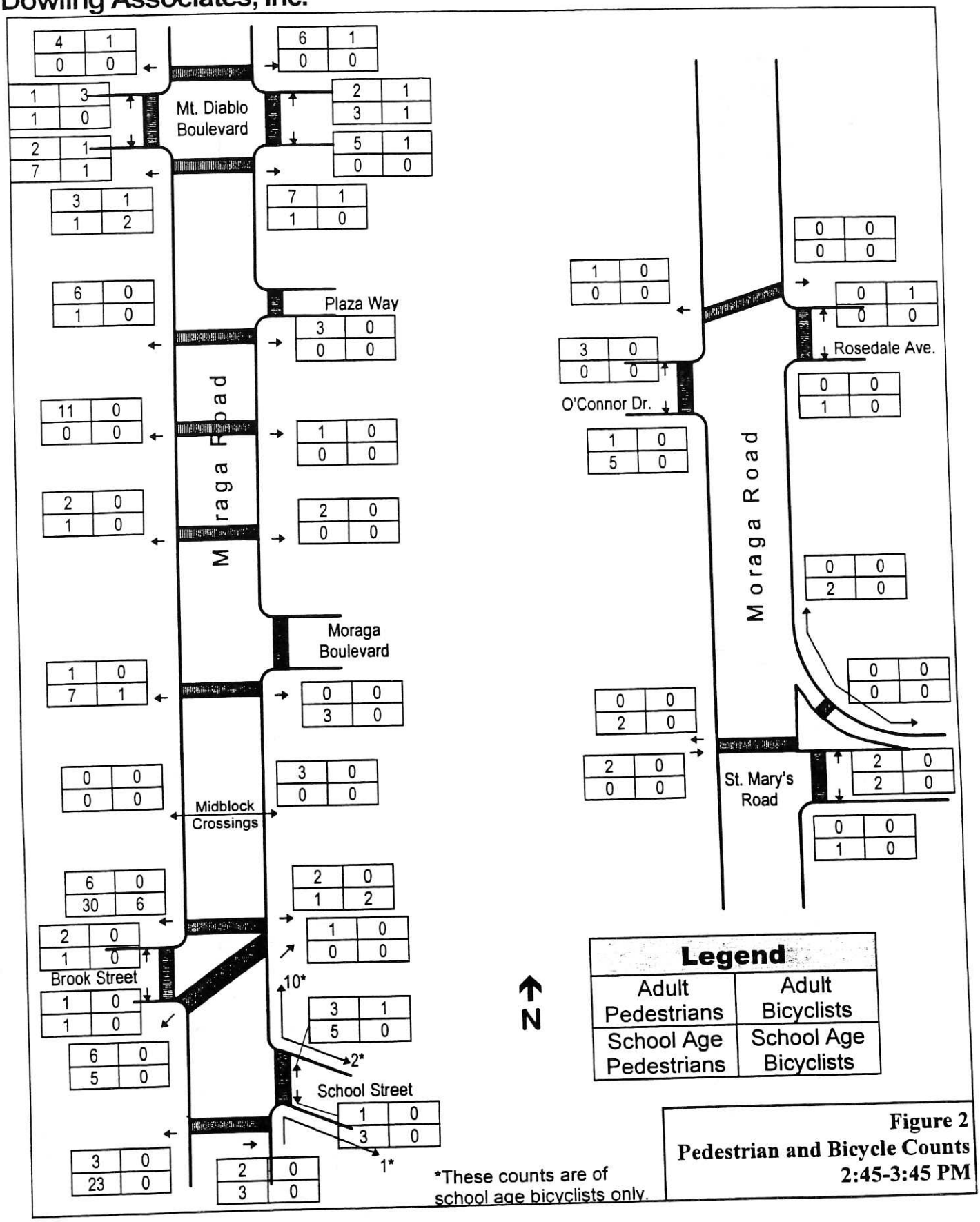


Figure 1
Pedestrian and Bicycle Counts
7:30-8:30 AM

Dowling Associates, Inc.



*These counts are of school age bicyclists only.

Figure 2
Pedestrian and Bicycle Counts
2:45-3:45 PM

Dowling Associates, Inc.

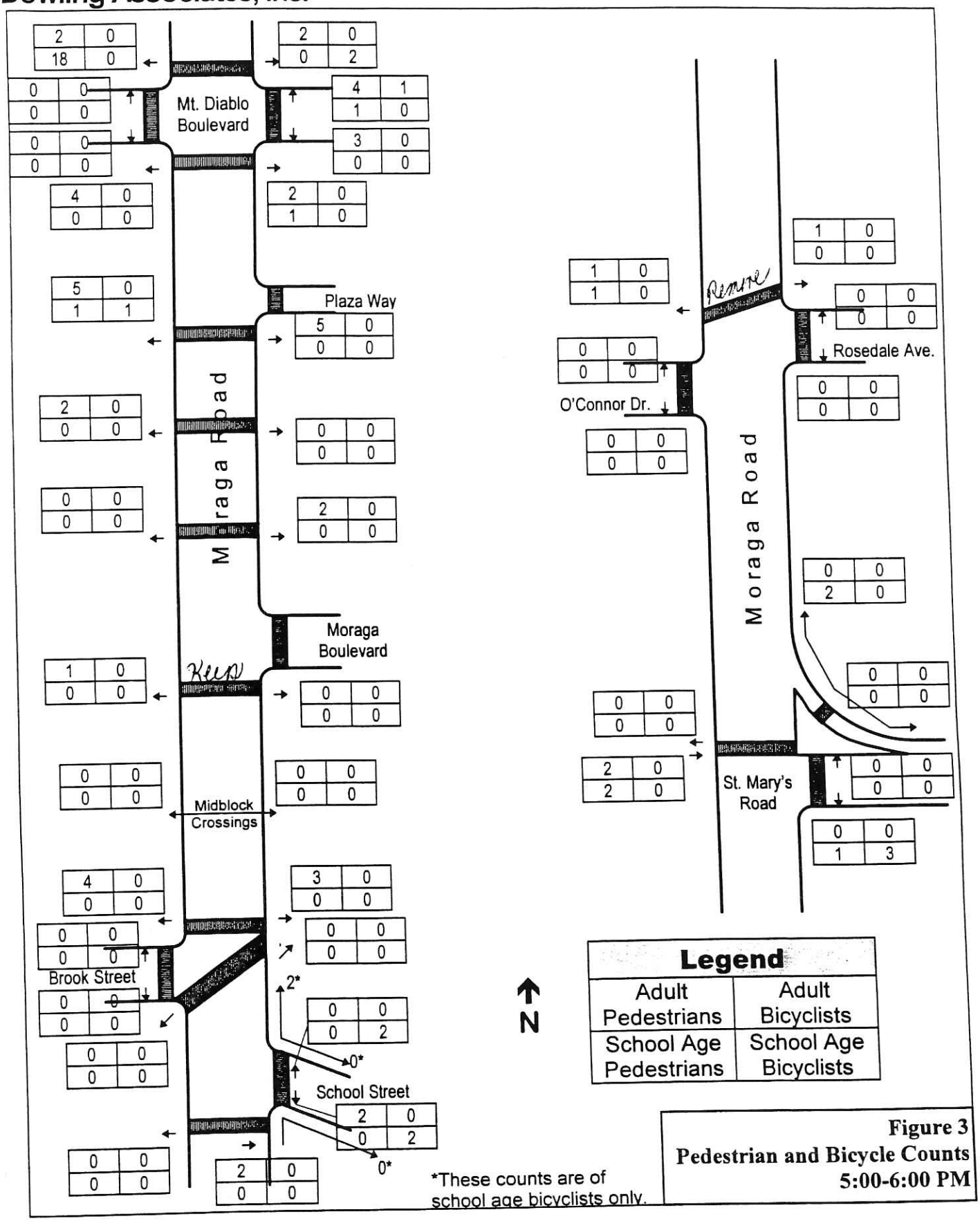


Figure 3
Pedestrian and Bicycle Counts
5:00-6:00 PM

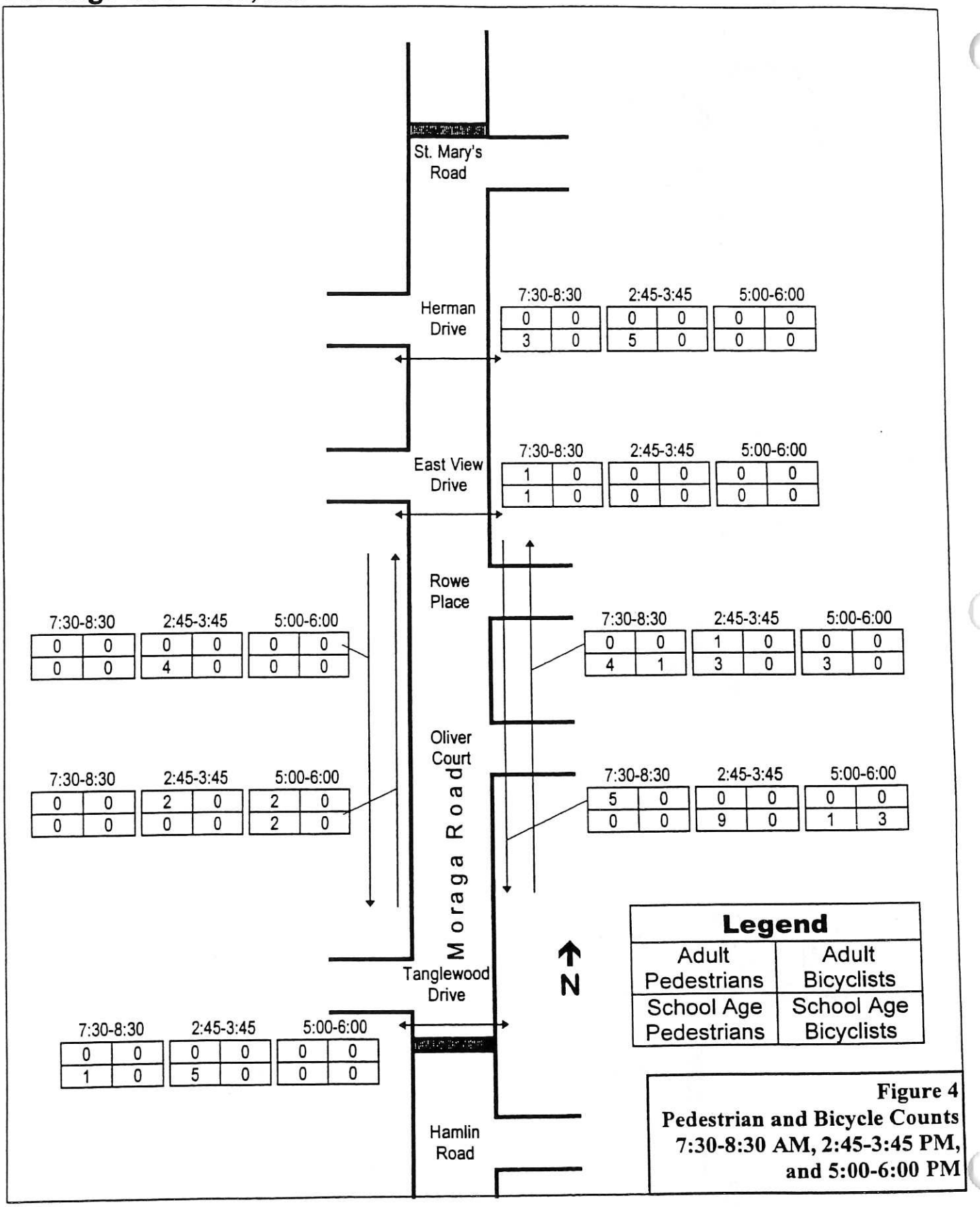
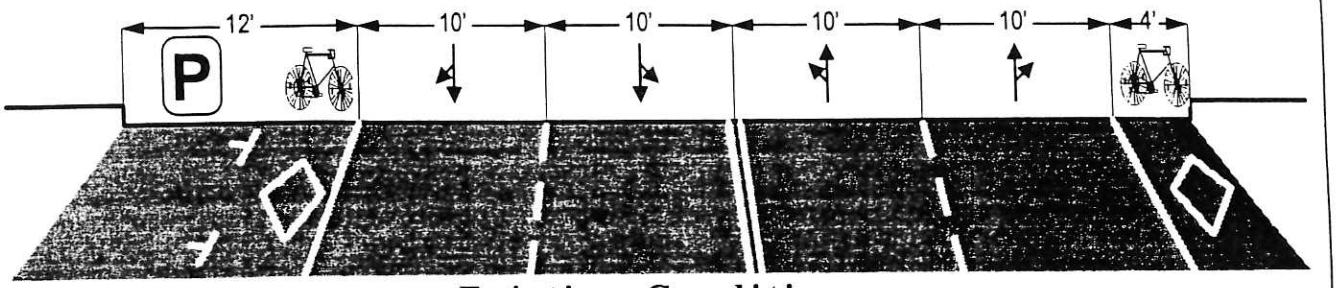
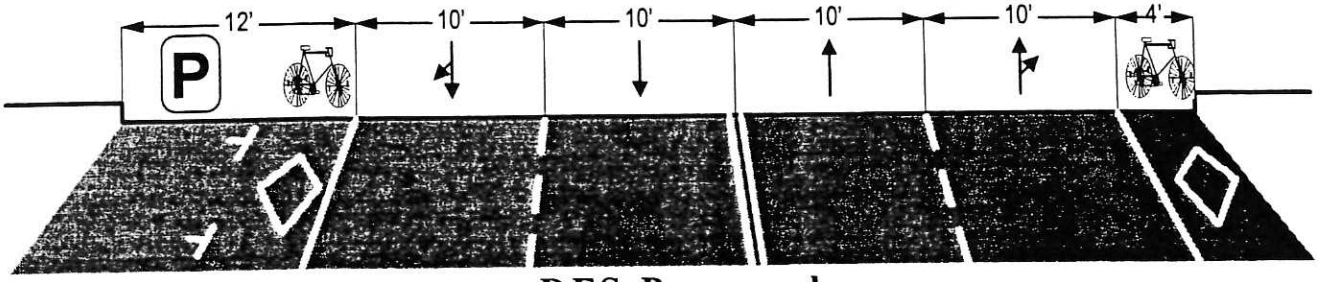


Figure 4
Pedestrian and Bicycle Counts
7:30-8:30 AM, 2:45-3:45 PM, and 5:00-6:00 PM

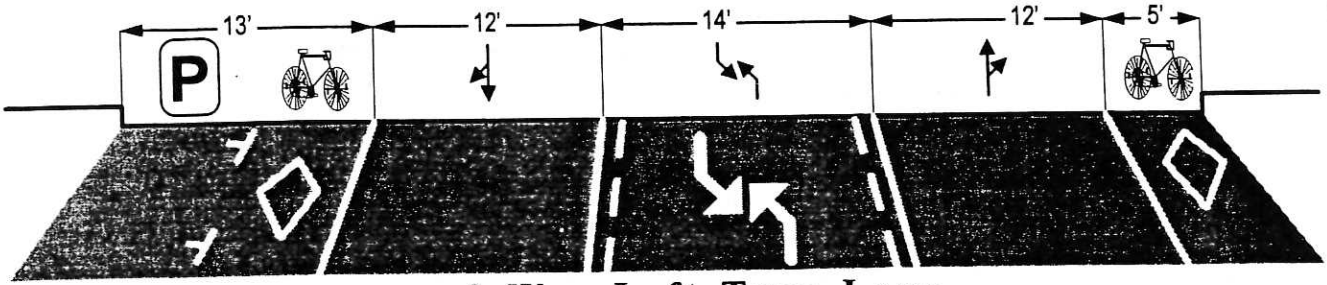


Existing Conditions

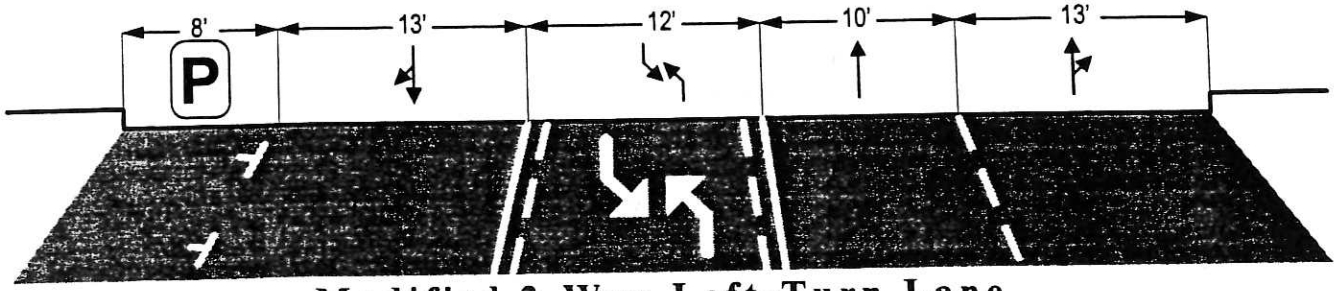


DFS Proposal

(no left turns at Moraga Blvd. or Brook St.)



2-Way Left-Turn Lane



Modified 2-Way Left-Turn Lane

NORTH

Figure 5
Moraga Road Cross Sections

Technical Memorandum II
Traffic Operations Analysis

Introduction

Moraga Road is a heavily traveled arterial extending from downtown Lafayette to the Moraga City limits. The section of Moraga Road from Mt. Diablo Boulevard to St. Mary's Road has four lanes with left turning movements allowed from the inside through lane into the numerous public streets and driveways along the corridor. The Downtown Feasibility Study (DFS) recommended several modifications to improve traffic operations, including:

- Removal of the traffic signal at Brook Street and consolidation of the pedestrian crossings at School Street
- Prohibition of all left turning movements at Brook Street and Moraga Boulevard
- Addition of lanes at the Mt. Diablo Boulevard / Moraga Road intersection

In subsequent studies conducted by Dowling Associates and McGill Martin Self, alternative refinements to the DFS proposals for the Mt. Diablo Boulevard / Moraga Road intersection were evaluated. The recommended alternative for the Mt. Diablo Boulevard / Moraga Road intersection provided the number of lanes proposed in the DFS, with one significant exception.

It was recommended that the traffic signal at the intersection be modified and the single northbound right turn lane be retained. (The DFS report had suggested adding a second northbound right turn lane on Moraga Road between Mt. Diablo Boulevard and Plaza Drive). To make the single right turn lane function effectively, a new traffic signal head would be installed to allow the northbound right turning movement to occur concurrently with the westbound left turning movement. The benefits of the revised plan were demonstrated by a computer simulation of both alternatives.

Another element of the post-DFS studies was the preliminary evaluation of alternatives for modifying the travel lanes along Moraga Road. This evaluation yielded two alternatives identified as having the potential to improve traffic operations on Moraga Road. This short list of alternatives included:

- The DFS alternative (modified, as described above), and
- A two-way left-turn lane alternative with one through lane in each direction, bicycle lanes, and parking north of Brook Street.

The City requested a more in-depth study of these two alternatives including a computer simulation of traffic operations along Moraga Road. This report summarizes the results of the additional evaluation results of the short-listed Moraga Road alternatives. The report contains a summary of the study conclusions, followed by a more detailed discussion of the traffic simulation, and traffic operations at the critical intersections. Figures that illustrate the alternatives are provided at the end of the report along with backup calculations and data.

Summary of Conclusions

The DFS alternative (illustrated in the figure at the end of the report) would constrain access to residences and businesses by prohibiting all left turning movements at Moraga Boulevard and at Brook Street. It also requires the remaining left-turning traffic to continue to turn from a through traffic lane.

The two-way left-turn lane alternative would provide a refuge area for traffic to wait for a gap in traffic while making a left turn and for traffic entering Moraga Road from side streets and driveways.

The two-way left-turn lane alternative would require two lanes of traffic to merge into one lane at each end of the two-way left-turn lane section.

The traffic simulation showed no significant differences in traffic operations in the southbound direction for the two alternatives.

For the northbound direction, the two-way left-turn lane alternative resulted in significantly lower travel speeds and greater congestion during the morning peak period than the DFS alternative. Traffic queues for the two-way left-turn lane alternative would extend from Mt. Diablo Boulevard through the St. Mary's intersection, and beyond, during the morning peak period.

Traffic operations at the signalized intersections would be essentially the same for the DFS and the two-way left-turn lane alternatives. Some additional delay would occur for the two-way left-turn lane alternative but the additional delay would be so small as to be imperceptible by the traveling public.

A compromise alternative could be developed that offers many of the advantages of both alternatives with few of the disadvantages of either alternative. **The compromise alternative would provide two lanes in the northbound direction, one lane in the southbound direction, and a two-way left-turn lane between the through lanes.** This alternative (illustrated in the figure at the end of the report) would allow the parking on the west side of Moraga Road to be retained but would require bike lane striping to be removed on both sides of Moraga Road.

In a study of bicycle and pedestrian activity along Moraga Road, almost no bicyclists were observed during three hours (7:00-8:00 AM, 2:45-3:45 PM, and 5:00-6:00 PM) on a partly cloudy school day (no rain had been forecast). The bicycle and pedestrian study will be submitted at a later date.

Traffic Simulation Results

Traffic simulation runs were performed for the morning and evening peak hour conditions for the following scenarios:

- Existing baseline conditions .....(EX-AM and EX-PM)
- DFS alternative modified as described in the introduction..(DFS-AM and DFS-PM)
- two-way left-turn lane alternative .....(LT-AM and LT-PM)

The existing baseline conditions scenario includes existing conditions plus the added lanes and signal modifications that have already been approved for the Moraga Road and Mt. Diablo Boulevard intersection. The previously approved improvements include an additional through lane in the eastbound and southbound directions, and the addition of a new traffic signal head to allow the northbound right turning movement to occur concurrently with the westbound left turning movement.

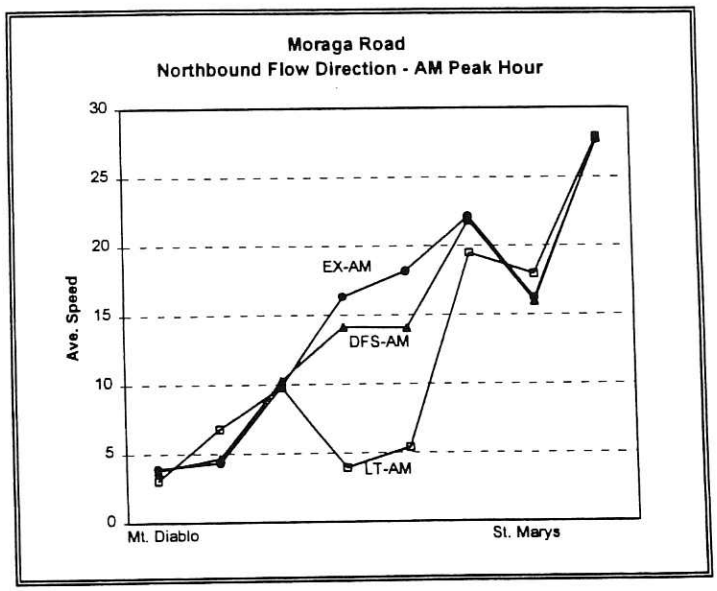
The DFS alternative includes the modifications described for the existing baseline conditions scenario at the Mt. Diablo Boulevard intersection plus the left-turning prohibitions at Moraga Boulevard and at Brook Street. This is essentially the same set of recommendations made in the DFS study except that the new traffic signal head would be provided to allow the northbound right turning movement to occur concurrently with the westbound left turning movement. The DFS report had suggested adding a second northbound right turn lane on Moraga Road between Mt. Diablo Boulevard and Plaza Drive.

For the two-way left-turn alternative, the southbound traffic would merge into a single lane shortly south of the Mt. Diablo Boulevard intersection, continuing to Brook Street, at which point the two southbound lanes would resume. Northbound traffic would merge into a single lane just north of Brook Street, continuing to Plaza drive, where multiple lanes for the approach to Mt. Diablo Boulevard would begin.

Five simulation runs were performed for each scenario and the average speeds were computed for each of the analysis scenarios. The travel speed data are shown in the graphs and in the table at the end of the report. The significant findings of the traffic simulation are summarized below.

Morning Peak Hour

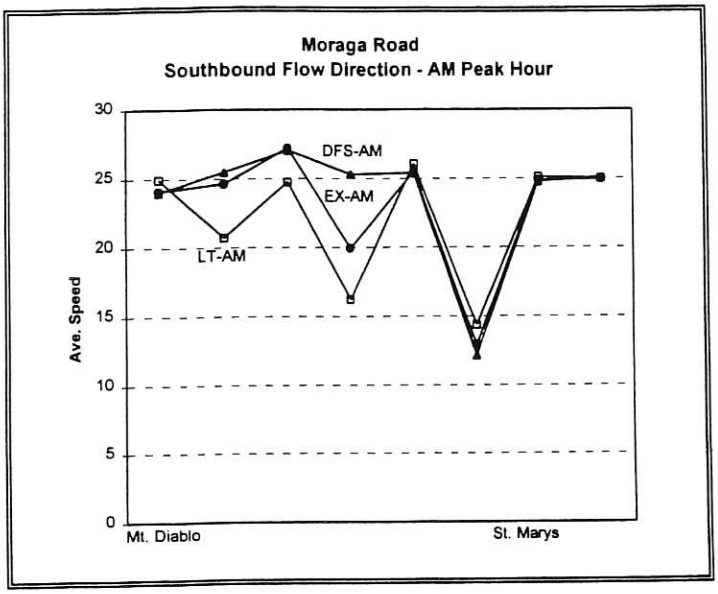
Northbound: The DFS alternative shows slightly slower northbound speeds than existing baseline conditions for the section of Moraga Road from just north of Brook Street to South of School Street. It should be noted again that these alternatives are the same at the Mt. Diablo Boulevard intersection. For the two-way left-turn lane alternative, the section from Moraga Boulevard to south of School Street shows a significantly lower average travel speed for the northbound direction of travel. This indicates increased congestion for the two-way left-turn lane alternative. Speed reductions in the range of up to 10 mph are indicated.



Cause: The single northbound lane is a bottleneck which limits the flow of traffic between Brook Street and Mt. Diablo Boulevard. The slow travel speeds from the lane reduction to south of St. Mary's Road are caused by the merge from two lanes to one. North of Moraga Boulevard , travel speeds are slightly higher than for the other alternatives because the lane reduction acts as a meter. North of the lane reduction, traffic flows smoothly in the single northbound lane.

Although this limiting effect could be viewed as desirable by some, it is attained at the expense of significant additional delay for northbound traffic and blockages of driveways and intersections in this section of Moraga Road.

The DFS alternative shows slower speeds than existing conditions from Brook Street to School Street. At first, this seemed to be inconsistent with expectations because the traffic signal at Brook Street would be removed for the DFS alternative. In reality, the traffic signal would meter traffic approaching the Mt. Diablo Boulevard intersection. Without the signal at Brook Street to meter the traffic, the queue from Mt. Diablo Boulevard would grow quicker. This queue would extend through Brook and School Streets, resulting in slower average speeds in that section.



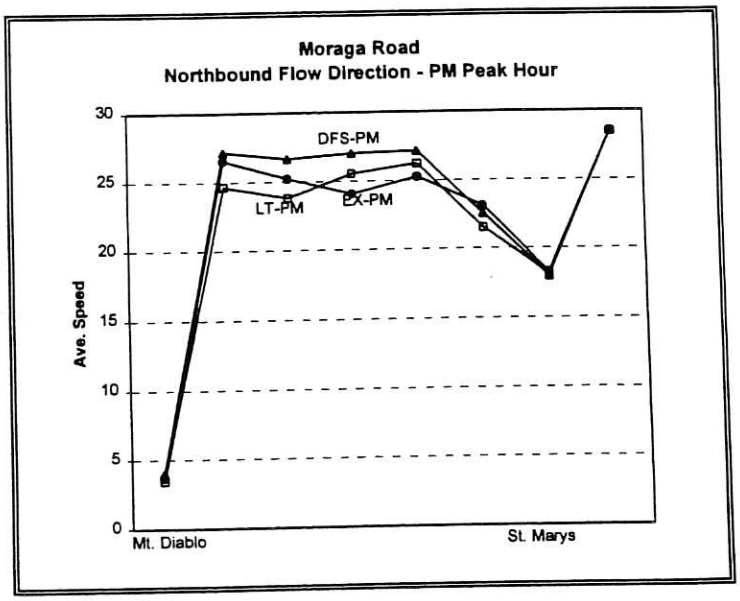
Southbound: There is little difference between the travel speeds for the existing baseline and DFS alternatives except at Brook Street where the DFS plan would remove the traffic signal and all left turning movements would be prohibited. The two-way left-turn lane alternative shows a reduction in average travel speed, which indicates increased congestion. Speed reductions in the range of up to 5 mph are indicated.

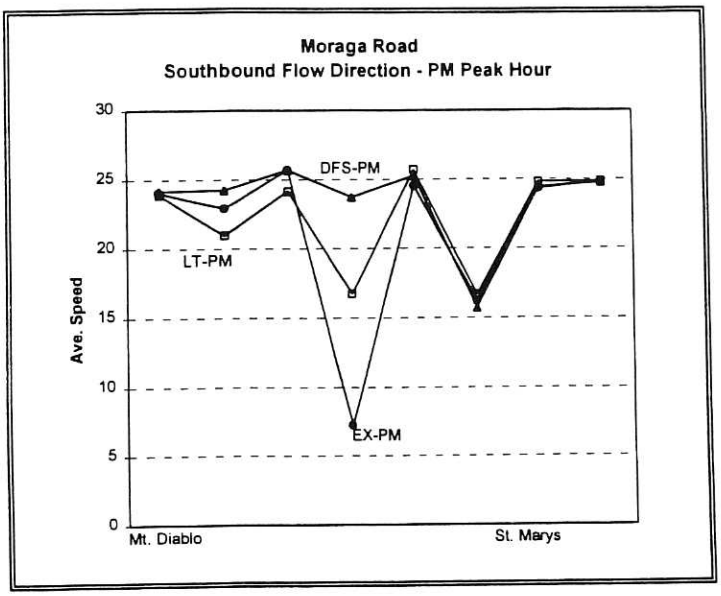
Cause: Parking maneuver interference appears to be the primary cause for this condition. There is also minor merge delay as the two southbound lanes from the Mt. Diablo Boulevard intersection merge into a single lane.

The amount of delay caused by parking maneuvers is probably overstated by the simulation, because the number of parking maneuvers would be less frequent than the minimum value allowed by the simulation (15 maneuvers per hour per block, where a block is defined by adjacent driveways). Additionally, the nature of a two-way left-turn lane is such that through vehicles could actually bypass most parking maneuvers without being significantly delayed.

Evening Peak Hour

Northbound: There is no significant difference between the average speeds with and without the two-way left-turn treatment for all scenarios. This is due to the lower traffic volumes in the northbound direction during the evening commuter peak.





Southbound: There is little difference between the travel speeds for the existing baseline and DFS alternatives except at Brook Street where the DFS plan would remove the traffic signal and all left turn movements would be prohibited. The two-way left turn lane alternative shows a very slight reduction in travel speed, which indicates some increased congestion; however, speed reductions in the range of up to 7 mph are indicated in this case.

Cause: Again, parking maneuver interference appears to be the primary cause for the increased congestion for the two-way left-turn lane alternative between Mt. Diablo Boulevard and Brook Street.

Conclusion: A modified two-way left-turn lane alternative could be developed that would provide the benefits of having a two-way left-turn lane without incurring the excessive delays identified in this study. A second through lane could be provided in the northbound direction to prevent excessive queuing for that direction. The modified two-way left-turn lane alternative is illustrated in the figure at the end of the report. This modification would require removal of the bicycle lanes along both sides of Moraga Road.

The bicycle lanes on Moraga Road are substandard with four feet (4') of width instead of the Caltrans five foot (5') standard width. For the northbound bike lane, the substandard bike lane is adjacent to the right curb. The southbound bicycle lane is located between parallel on-street parking spaces and a 10-foot through travel lane. Southbound motor vehicle traffic would be closer to the bike lane than if at least a standard 12-foot through lane were provided.

A bicycle and pedestrian study being conducted in conjunction with this study showed almost no bicycle traffic in the bike lanes along Moraga Road. It is unclear whether the lack of bicycle traffic is a result of light demand or if cyclists avoid riding in the area because of the substandard conditions.

The decision of whether or not to pursue the modified two-way left-turn lane alternative involves consideration of the following attributes:

- Any two-way left-turn lane alternative would provide better access to residential streets and businesses than the DFS alternative.
- Any two-way left-turn lane alternative would provide improved safety by providing a storage area for left-turning traffic out of the stream of through traffic. This improvement would be offset to a minor extent by the potential for accidents in the area where the two southbound lanes merge into one lane.
- The DFS alternative would provide slightly better service than base conditions for traffic in the southbound direction.
- The *modified* two-way left-turn lane alternative would require elimination of the substandard bike lanes on both sides of Moraga Road.

Intersection Operations Analysis

Two intersections were analyzed using Highway Capacity Manual (TRB 1994) techniques to determine if the two-way left-turn lane alternative would cause a reduction in capacity at intersections along Moraga Road. The intersections analyzed in this manner are located at Mt. Diablo Boulevard and at Brook Street. The results of this analysis are summarized below.

The reduction from two lanes to one in the southbound direction just south of the Mt. Diablo Boulevard intersection would be required for both the two-way left-turn lane alternative and the *modified* two-way left-turn lane alternative. The lane reduction for northbound traffic just north of Brook Street would only be required for the two-way left-turn lane alternative that has one through lane in each direction.

Mt. Diablo Boulevard: The merge from two lanes to one lane in the southbound direction would cause a reduction in the capacity of the two left turn lanes that serve the traffic movement from westbound Mt. Diablo Boulevard to southbound Moraga Road. The efficiency of the outside left turn lane is expected to be reduced by the downstream lane drop. Motorists making the left turning maneuver would tend to use the inside turn lane, which would not require a merge maneuver downstream. Motorists in the outside turn lane would have to merge.

It was assumed that the two lane section on Moraga Road would extend about 250 feet south of the Mt. Diablo Boulevard intersection. A forty percent (40%) reduction in the capacity of the outside left turn lane was made for the calculation of level of service for the two-way left-turn lane alternative. The forty percent reduction assumes that for every 5 vehicles that choose the inside left turn lane, only three vehicles would choose the outside left turn lane. This is a conservative assumption because traffic would most likely distribute more equally. Additional delay experienced at the lane reduction on Moraga Road was evaluated in the analysis of travel speeds on Moraga Road.

The analysis showed the level of service would not change if the two-way left-turn lane alternative were implemented. The average delay per vehicle at the intersection would increase by 1.3 seconds per vehicle during the morning peak hour and by 0.6 seconds during the evening peak hour. This additional delay would not be perceptible by the traveling public.

Brook Street: The merge from two lanes to one lane in the northbound direction would cause a reduction in the capacity of the two through lanes for the northbound approach to the Brook Street intersection. Motorists traveling north on Moraga Road would tend to use the inside through lane, which would not require a merge maneuver downstream. Motorists in the outside lane would have to merge. Again, a forty percent (40%) reduction in the capacity of the outside through lane was made at this intersection for the two-way left-turn lane alternative. This is considered to be a conservative assumption.

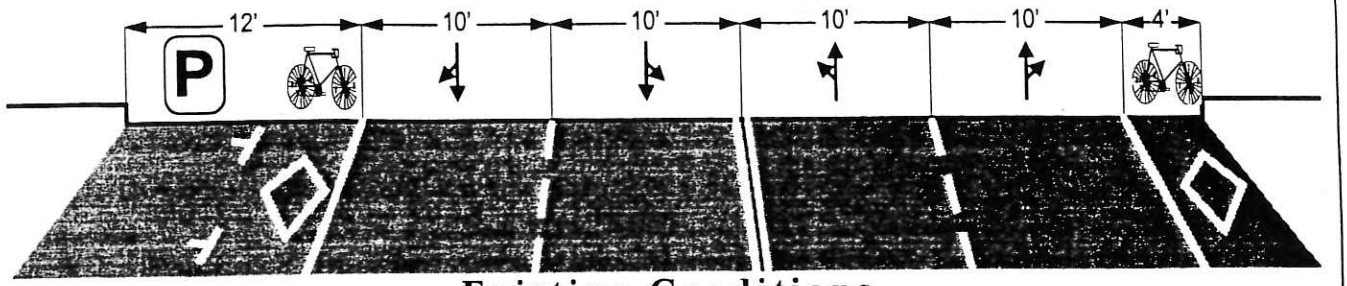
A comparison was made to the level of service for existing baseline conditions at this intersection. (The DFS alternative would not have a traffic signal at Brook Street). Although there would be a slight increase in the overall delay at this intersection for the two-way left-turn lane alternative, the level of service would not change. The average delay per vehicle at the intersection would increase by 0.6 seconds per vehicle during the morning peak hour and by 0.3 seconds during the evening peak hour. The additional delay at the intersection would not be perceptible to the traveling public.

Table 1
Intersection Operations Summary

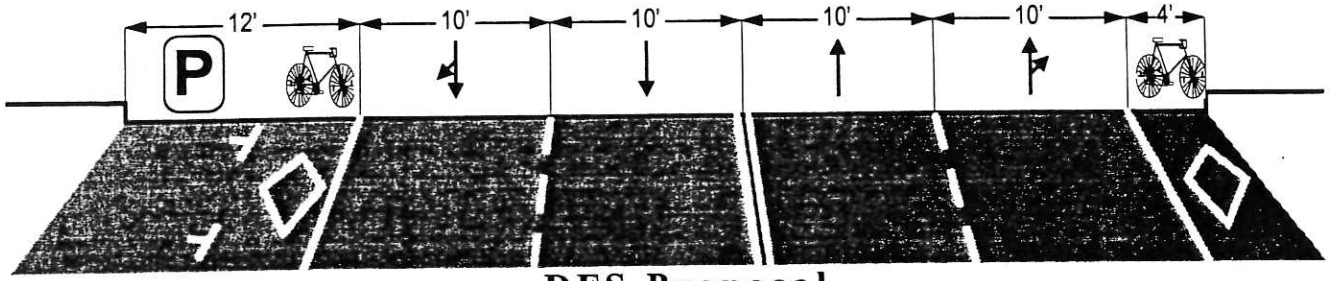
	AM Peak Hour				PM Peak Hour			
	Existing Baseline		TWLTL		Existing Baseline		TWLTL	
Intersection	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
Mt. Diablo Boulevard	C	16.9	C	18.2	C	18.5	C	19.2
Brook Street	A	3.4	A	4.0	B	8.1	B	8.4

TWLTL = Two-way left turn lane alternative
LOS = Level of service
Delay is expressed in terms of seconds of delay for the average vehicle.

Dowling Associates, Inc.

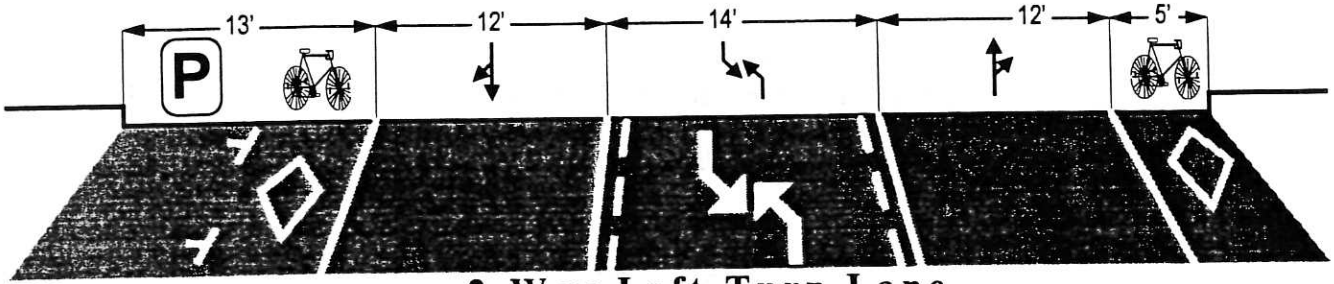


Existing Conditions

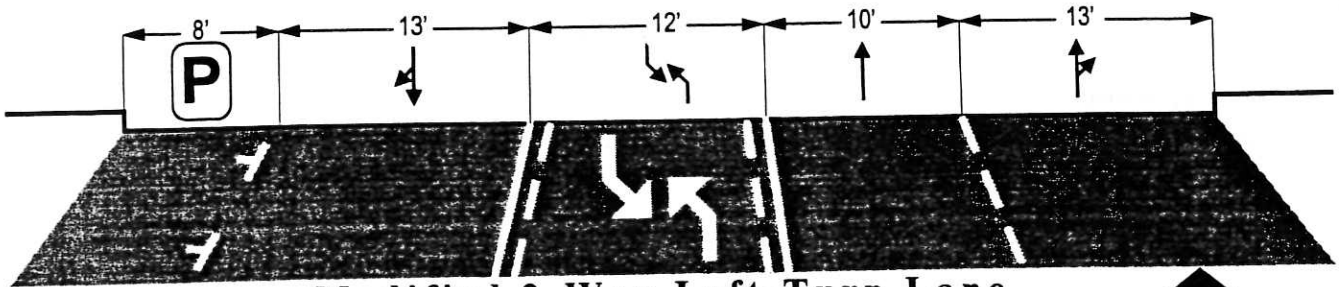


DFS Proposal

(no left turns at Moraga Blvd. or Brook St.)



2-Way Left-Turn Lane



Modified 2-Way Left-Turn Lane

NORTH

Table 4
Average Speed (mph)*

	Southbound Flow Direction						Northbound Flow Direction					
Link Name (& Node Numbers)	EX-AM	DFS-AM	LT-AM	EX-PM	DFS-PM	LT-PM	EX-AM	DFS-AM	LT-AM	EX-PM	DFS-PM	LT-PM
s/o Mt Diablo (1-2)	24.1	24.0	24.9	24.0	24.2	23.9	3.9	3.8	3.0	3.7	4.0	3.5
n/o Wilkinson Ln (5-6)	24.6	25.5	20.7	22.9	24.2	21.0	4.3	4.6	6.8	26.5	27.1	24.6
s/o Moraga Blvd (9-10)	27.2	27.0	24.7	25.7	25.7	24.1	9.8	10.2	9.8	25.2	26.6	23.8
n/o Brook St (11-12)	19.9	25.3	16.2	7.2	23.7	16.7	16.3	14.1	3.9	24.0	27.0	25.5
s/o School St (15-16)	25.5	25.4	26.1	24.5	25.2	25.7	18.2	14.0	5.4	25.2	27.1	26.2
n/o St. Marys (17-18)	12.9	12.1	14.3	16.2	15.7	16.6	22.1	21.8	19.5	23.1	22.5	21.5
s/o St. Marys (18-19)	24.8	24.7	25.1	24.3	24.4	24.8	16.2	16.0	17.9	18.2	18.0	18.1
n/o Old Jonas Hill Rd (19-20)	24.9	25.0	24.9	24.8	24.7	24.8	27.7	27.8	27.9	28.5	28.5	28.5

* Average of five simulation runs for each case shown.

Technical Memorandum III
Supplemental Traffic Studies

Introduction

The section of Moraga Road from St. Mary's Road to the south Lafayette city limits is a winding two-lane arterial in hilly terrain with numerous intersecting residential streets and driveways. The Lafayette Downtown Feasibility Study (DFS) evaluated several of the major access points along the corridor and made several recommendations. A summary of the DFS recommendations are as follows:

- Hamlin Road and Tanglewood Drive Intersection - Do not install a traffic signal; monitor traffic volumes and accidents to determine if a signal may be warranted in the future.
- Silver Springs Road / Mt. View Drive / Old Jonas Hill Road Intersections - Provide traffic signal to control all three side streets; rebuild bus stop and improve pedestrian Access.
- Madrone Drive Intersection - Do not install a southbound left turn lane; monitor traffic volumes and accidents to determine if a left turn lane may be warranted in the future.

Dowling Associates was asked to conduct additional studies to determine if the recommendations in the DFS could be supported or if alternative strategies should be considered. The additional studies were designed to provide:

- A general overview of traffic signal warrants, with specific emphasis on the peak hour warrant and the accident warrant.
- A field investigation of the intersections to determine if there might be other factors that might create the need for improvements, such as signalization or other traffic control measures.
- A study of the potential need for a left turn lane for the southbound Moraga Road approach to Madrone Drive.

This report summarizes the results of the studies for south Moraga Road. The report contains a summary of the study conclusions, followed by a more detailed discussion of the analysis of signal warrants and traffic operations at the critical intersections. Figures that illustrate the alternatives are provided at the end of the report along with backup calculations and data.

Summary of Conclusions

1. Neither the accident experience or peak hour volume warrants for a traffic signal have been satisfied.

2. None of the other traffic signal warrants are likely to be satisfied at any of the study intersections.

3. No other factors were identified that would justify installation of a traffic signal, and no traffic signals are recommended.

4. Average vehicle delays are relatively high during the evening peak hour for some of the side streets that intersect Moraga Road, but the high delays affect few motorists. The 11 vehicles on Tanglewood Drive experience an average delay of 32 seconds each. The 2 vehicles on Mountain View Drive experience an average delay of 31 seconds each.

5. The number of accidents at the study intersections is relatively low, although Madrone Drive has had more accidents than the others.

6. Poor visibility may be contributing to accidents at the Madrone Drive intersection.

7. Sight distances for motorists waiting to enter Moraga Road are less than desirable for many of the cross streets and driveways along Moraga Road. The greatest deficiency (for the intersections studied) is at Madrone Drive. Although the sight distances are less than normally provided, the accident study did not show an unusual number of collisions.

8. The vegetation at all intersections and driveways should be kept pruned to prevent additional reduction in the substandard sight distances.

9. If frequent blockages of the intersections from Hamlin Road to Old Jonas Hill Road occur, install "Keep Clear" pavement markings and supplemental signs at the intersections.

10. The following improvements should be made at the Madrone Drive intersection:

    - Repair or replace the side road ahead warning sign for southbound traffic.
    - Replace the Madrone Drive street name sign with a standard sign.
    - Install a street light at the intersection.

Traffic Signal Warrant Analysis

The analysis of traffic signal warrants looked at all the eleven signal warrants described in the Caltrans Traffic Manual. The warrants are listed below:

1. Minimum Vehicle Volume
2. Interruption of Continuous Traffic
3. Minimum Pedestrian Volume
4. School Areas
5. Progressive Movement
6. Accident Experience
7. Systems Warrant
8. Combination of Warrants
9. Four Hour Volume Warrant
10. Peak Hour Delay Warrant
11. Peak Hour Volume Warrant

The warrant analysis was performed for Warrant Number 6 (accident experience) and Warrant Number 11 (peak hour volume warrant). These two warrants were studied analytically because the required data were generally available. A general overview of the other warrants was also performed to determine if additional data should be collected for additional studies.

The accident experience warrant studies were based on traffic accident report summaries form the statewide traffic accident database (SWITRS) provide by the Lafayette Police Department. The peak hour volume warrant studies were based on traffic volumes collected for the DFS. The accident and traffic volume data are provided at the end of the report.

The Caltrans Traffic Manual states that "the installation of a traffic signal should be considered if one or more of the warrants . . . are met." The logical converse of this statement is that if none of the signal warrants are met, the installation of a traffic signal should not be considered. It is therefore necessary to demonstrate that one or more of the warrants be satisfied before installing a traffic signal. The discussion below describes the evaluation of signal warrants on south Moraga Road.

Warrant 6: Accident Experience

There are several conditions required to satisfy the accident experience warrant. The primary condition is that five or more reported accidents of types susceptible to correction by traffic signals have occurred within a 12-month period, each accident involving personal injury or property damage to an apparent extent of $500 or more. None of the intersections on south Moraga Road satisfy those requirements.

The reported accidents that occurred between January 1, 1994, and June 30, 1997, were studied. A figure showing the type and location of accidents is shown at the end of this report. A summary of the accident history at each intersection (or group of intersections that would be controlled by one signal) is shown below.

Hamlin Road and Tanglewood Drive Intersection - One injury accident involving a pedestrian occurred at Tanglewood Drive in November 1995. One vehicle damage accident occurred at Hamlin Road in July 1996. Both accidents would have been prevented by a traffic signal; however, there were only two accidents within the 12-month period. Installation of a traffic signal could result in a greater number of other types of accidents, and is not recommended based on the accident experience at the intersection.

Silver Springs Road / Mt. View Drive / Old Jonas Hill Road Intersections - Five accidents were reported at this location during the 3 ½ year period studied. Two of those accidents would have been prevented by a traffic signal. No accidents have been reported since August 1995. The accident experience warrant is not satisfied at this location.

Madrone Drive Intersection - During the 3 ½ year period studied, seven accidents were reported, only two of which would have been prevented by a traffic signal. One of those accidents occurred in April 1996 and the other occurred in April 1997. The accident experience warrant is not satisfied at this location.

The review of the accident data indicated that five of the seven accidents at the Madrone Drive intersection occurred at night. This points to the possibility of addressing visibility/lighting as a means of improving safety at this intersection. The other two study locations already have street lights in place.

Warrant 11: Peak Hour Volume Warrant

Satisfaction of the peak hour volume warrant would require 100 vehicles approaching Moraga Road from any single-lane side street approach. The closest any of the intersections comes to satisfying this warrant is at Silver Springs Road, which serves 59 approaching vehicles during the AM peak hour. Hamlin Road ranks next with 45 vehicles, followed by Old Jonas Hill Road at 27, Tanglewood Drive at 25, and Madrone Drive at 5.

It could be argued that the traffic volumes for Silver Springs Road and Old Jonas Hill Road could be combined because they would be served by the same traffic signal. Dowling Associates does not consider this to be a valid argument because the two approaches would most likely be served by separate signal phases as suggested in the DFS. Even if the two phases were served concurrently, the requirement for a two-lane side street approach should be applied, and 150 vehicles per hour

would be required to satisfy the warrant. The combined traffic volumes at Silver Springs Road and Old Jonas Hill Road would total 86 vehicles.

The conclusion from this evaluation is that none of the intersections currently warrant the installation of a traffic signal based on the peak hour volume warrant. It is also unlikely that the peak hour warrant would be satisfied unless additional development occurs that would generate additional side street traffic.

Other Warrants

It is unlikely that conditions at any of the study intersections would satisfy any of the other traffic signal warrants. The DFS indicated that all of the side street traffic approaching Moraga Road between Old Jonas Hill Road and St. Mary's Road could be considered to satisfy Warrant 2: Interruption of Continuous Traffic. The DFS approach is a liberal interpretation of the Caltrans requirements. Even if this interpretation is applied, the total peak hour side street traffic volume in the area would be 131 during the AM peak hour and 62 during the PM peak hour for the westbound approaches to Moraga Road. It is unlikely that the combined side-street traffic would exceed the required 100 vehicles per hour for 8 hours of an average day, as required by the warrant.

Intersection Operations

To supplement the evaluation of signal warrants, an analysis of traffic operations at the study area intersections was performed. The operations analysis was performed based on the volumes collected for the DFS. The DFS traffic volume data, which were collected on different days, were adjusted for consistency. The adjusted traffic volumes are shown at the end of the report.

Traffic volumes were not available for the Madrone Drive intersection, so traffic volumes were developed from *Trip Generation, 6th Edition* (Institute of Transportation Engineers 1997). The nine homes served by Madrone Drive would generate 7 trips during the AM peak hour and 9 trips during the PM peak hour. This traffic was distributed to the roadway network according to prevailing travel patterns and directional distributions contained in *Trip Generation*.

The traffic operations analysis is summarized in Table 2. The intersections operate at acceptable levels of service, generally. The side street movements at unsignalized intersections often operate at LOS E when the main street carries significant traffic volumes. The operations analysis showed the eastbound traffic movements operate at LOS E for Tanglewood Drive and Mountain View Drive during the PM peak hour. Although the delay is relatively high for the eastbound approaches to these intersections, no more than 11 vehicles are affected at any of the intersections during the PM peak hour.

A test was conducted to determine how much the traffic volumes would have to increase to cause the level of service to drop to LOS F. The analysis showed that traffic volumes would have to increase by 35 percent during the AM peak hour and by 15 percent during the PM peak hour for any of movements at any of the intersections to operate at LOS F (more than 45 seconds of average delay for vehicles on any approach). The operation of some movements at LOS F at an intersection does not necessarily justify installation of a traffic signal. It is relatively common for some movements to operate at LOS F and still not satisfy traffic signal warrants.

Table 2: Summary of Intersection Operations

Intersection			AM Peak Hour		PM Peak Hour	
			LOS	Delay	LOS	Delay
Hamlin/Tanglewood/Moraga Rd						
Northbound	Left	Turn	A	3.5	B	6.0
Southbound	Left	Turn	B	5.1	A	4.4
Eastbound			D	20.2	E	32.2
Westbound			C	10.6	C	16.0
Silver Springs/Mt. View/Moraga Rd			na	na	na	na
Northbound	Left	Turn	A	4.9	A	4.4
Southbound	Left	Turn	D	21.0	E	30.8
Eastbound			B	8.6	B	7.3
Westbound						
Old Jonas Hill / Moraga Rd						
Northbound	Left	Turn	na	na	na	na
Southbound	Left	Turn	A	4.6	A	4.2
Eastbound			C	17.5	na	na
Westbound			B	7.1	B	9.5
Madrone / Moraga Rd						
Southbound	Left	Turn	A	4.6	A	4.1
Westbound			B	8.1	C	12.0

Note: "na" indicates no traffic volumes were observed for the traffic movement.

Field Investigation

A field investigation was conducted to determine if other factors might create the need for a traffic signal or other improvements to improve mobility and safety. The field investigation was conducted during the PM peak hour. It has been reported that northbound traffic sometimes queues back through the Spring Hill Road intersection during the AM peak hour. Although not confirmed by observation, this observation is assumed to be true.

A summary of sight distances for the approaches to the intersections are shown in Table 3. The seconds of visibility required are based on the critical gaps described in the Highway Capacity Manual. The critical gap is the amount of gap time in the traffic stream that most motorists would enter. The critical gap was used to identify the bare minimum time motorists would need to complete a maneuver. The American Association of State Highway and Transportation Officials (AASHTO 1990) recommends sight distances about one-third greater than the critical gaps shown in the table.

Hamlin Road and Tanglewood Drive Intersection -

Hamlin Road is located about a hundred feet south of the Tanglewood Drive intersection. A pedestrian crosswalk is provided across Moraga Road on the north side of Tanglewood Drive. A street light is located at the Hamlin Road intersection. Vehicles waiting to enter Moraga Road from Tanglewood Drive have over 500 feet of sight distance to the north. The sight distance to the south is only about 200 feet. The limited sight distance to the south provides only about 5.5 seconds of visibility for oncoming vehicles. The critical gap for traffic entering the northbound traffic stream is 6.5 seconds.

Vehicles waiting to enter Moraga Road from Hamlin Road have about 300 feet of sight distance in both directions. This results in about 5.8 seconds of sight time in each direction. The critical gap is about 6.5 for to the north for the left turn from Hamlin Road.

Silver Springs Road / Mt. View Drive / Old Jonas Hill Road Intersections -

The sight distance for northbound vehicles turning from Moraga Road into Mountain View Drive provides about 4.9 seconds for the turning maneuver. This is 0.1 second less than the normal critical gap. The sight distance from Mountain View Drive to the north on Moraga Road is about 200 feet, or 3.9 seconds of travel time for oncoming traffic. The critical gap for traffic entering Moraga Road is 5.5 also seconds.

The sight distance from Silver Springs Road to the north on Moraga Road is about 300 feet, or 5.8 seconds of travel time for oncoming traffic. This is about 0.7 seconds less than the critical gap for the left turn onto Moraga Road.

Table 3: Summary of Intersection Sight Distances and Times (Estimated)

Intersection Approach	North Sight Line Available Feet	North Sight Line Available Seconds	North Sight Line Critical Gap Seconds	South Sight Line Available Feet	South Sight Line Available Seconds	South Sight Line Critical Gap Seconds
Hamlin/Tanglewood/Moraga Rd						
Northbound Left Turn	500	9.7	5.0			
Southbound Left Turn				300	5.8	5.0
Eastbound	500	9.7	5.5	200	***3.9***	6.5
Westbound	300	***5.8***	6.5	300	5.8	5.5
Silver Springs/Mt. View/Moraga Rd						
Northbound Left Turn	250	***4.9***	5.0			
Southbound Left Turn				500	9.7	5.0
Eastbound	200	***3.9***	5.5	350	6.8	6.5
Westbound	300	***5.8***	6.5	500	9.7	5.5
Old Jonas Hill / Moraga Rd						
Northbound Left Turn	400	7.8	5.0			
Southbound Left Turn				300	5.8	5.0
Eastbound	300	5.8	5.5	250	***4.9***	6.5
Westbound	500	9.7	6.5	400	7.8	5.5
Madrone / Moraga Rd						
Southbound Left Turn				200	***3.9***	5.0
Westbound	300	***5.8***	6.5	150	***2.9***	5.5

Note: Bold italics indicates deficient sight lines.

At the driveway across from Old Jonas Hill Road, the sight distance to the north on Moraga Road is about 250 feet, or 4.9 seconds of travel time for oncoming traffic. This is about 0.6 seconds less than the critical gap for the left turn onto Moraga Road. There are no other sight distance restrictions for traffic on Old Jonas Hill Road or the driveway across from Old Jonas Hill Road.

Madrone Drive Intersection -

The sight distances at Madrone Drive are severely restricted. Drivers making a left turn from Moraga Road into Madrone Drive have about 200 feet of sight distance, or about 3.9 seconds of travel time for oncoming vehicles - about 1.1 seconds less than the critical gap.

Drivers exiting from Madrone Drive onto Moraga Road also have a severely restricted sight distance. The available sight time of about 5.8 seconds to the north is about 0.7 seconds less than the critical gap. The sight time to the south is only about 2.9 seconds, or 2.6 seconds less than the critical gap.

During the field investigation, it was observed that the grade on Madrone Drive approaching Moraga Road is steep and could result in a need for a larger gap in traffic than would otherwise be required. It was also difficult to locate the Madrone Drive intersection at night. The warning sign, that indicated to southbound traffic that the intersection is ahead, was not very visible. The sign's reflectivity was low and the sign appeared to be leaning as if it had been struck. The street name sign at the intersection is also difficult to read at night because of its non-standard design.

Although the sight distances are less than normally provided, the accident study did not show an unusual number of collisions of a type that would be expected to result from inadequate sight distances. This condition could change and points to the need for monitoring of accidents in the future. Solving the sight distance restrictions would require extensive redesign of Moraga Road and would be likely to result in substantial environmental impacts.

Recommendations

Based on the studies conducted for south Moraga Road, the following actions are recommended:

The vegetation at all intersections and driveways should be kept pruned to prevent additional sight distance restrictions.

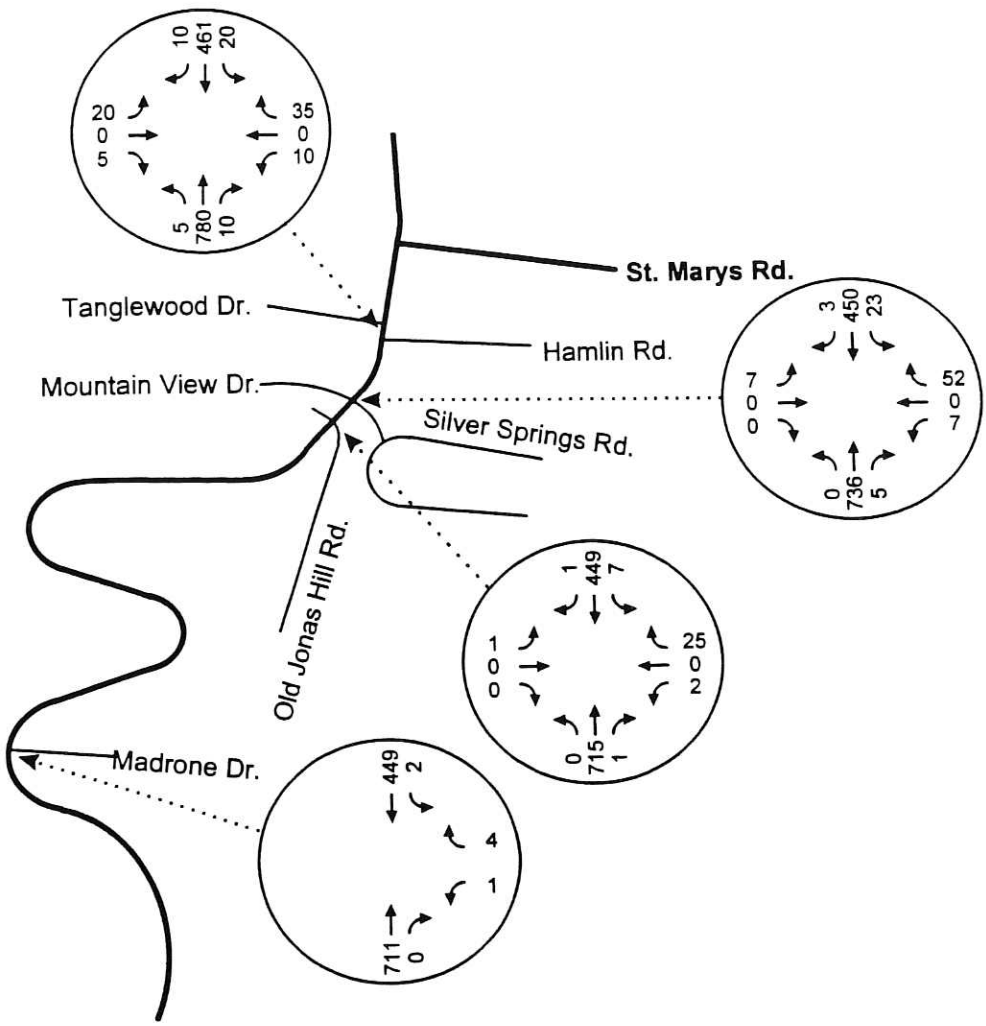
Hamlin Road and Tanglewood Drive Intersection - **Do not install a traffic signal**; monitor traffic volumes and accidents to determine if a signal may be warranted in the future. This recommendation is consistent with the DFS. If frequent blockages of the intersections occur because of northbound traffic queues, "Keep Clear" pavement markings and supplemental signing may be justified.

Silver Springs Road / Mt. View Drive / Old Jonas Hill Road Intersections - **Do not install a traffic signal**; monitor traffic volumes and accidents to determine if a signal may be warranted in the future. This recommendation is different from the DFS, which recommended installation of a traffic signal. A traffic signal is not justified either by signal warrants or safety considerations, and could actually increase the accident rates at the intersections. If the City wishes to install some type of improvement at these intersections, a flashing beacon could be installed to supplement the side road signs on Moraga Road; however, the accident study does not indicate the need for a flashing beacon. If frequent blockages of the intersections occur because of northbound traffic queues, "Keep Clear" pavement markings and supplemental signing may be justified.

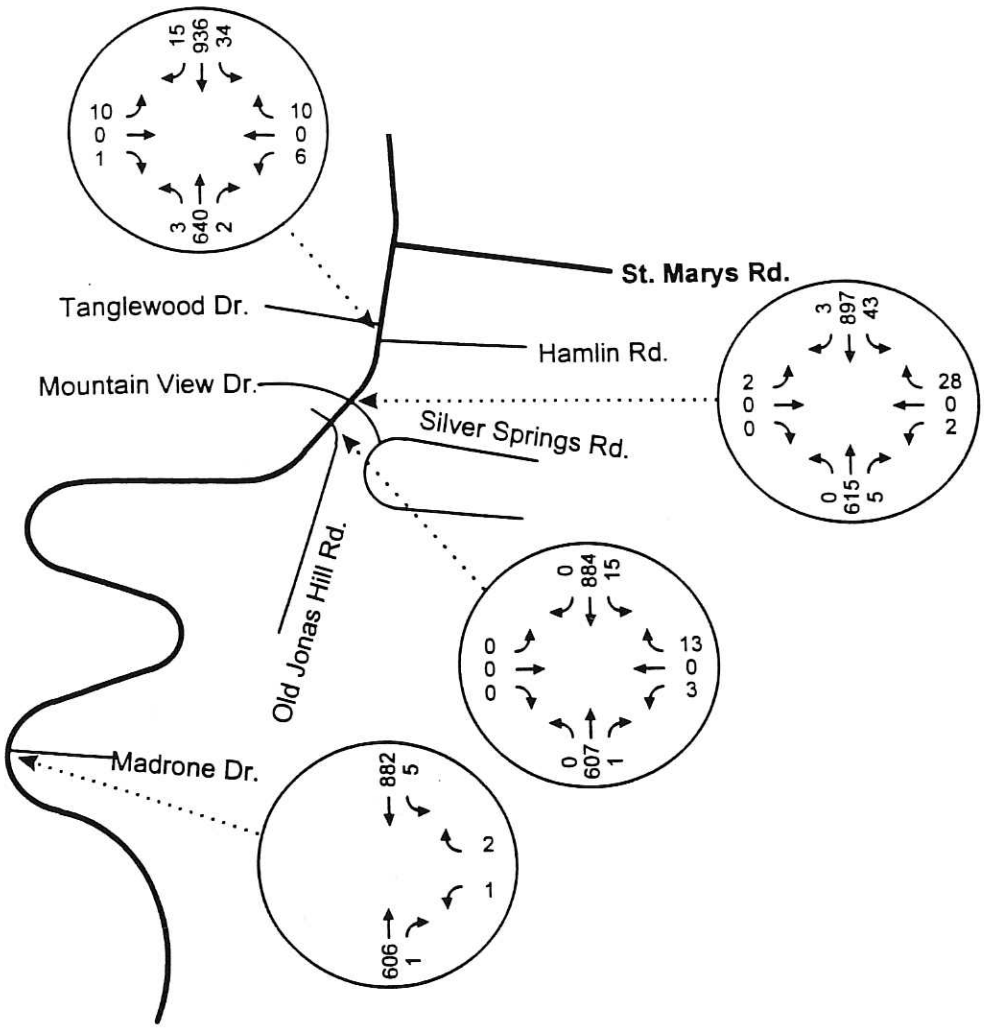
Madrone Drive Intersection - Do not install a southbound left turn lane; monitor traffic volumes and accidents to determine if a left turn lane may be warranted in the future. This recommendation is consistent with the DFS. Improvements that should be made include the following:

- Repair or replace the side road ahead warning sign for southbound traffic.
- Replace the Madrone Drive street name sign with a standard sign.
- Install a street light at the intersection.

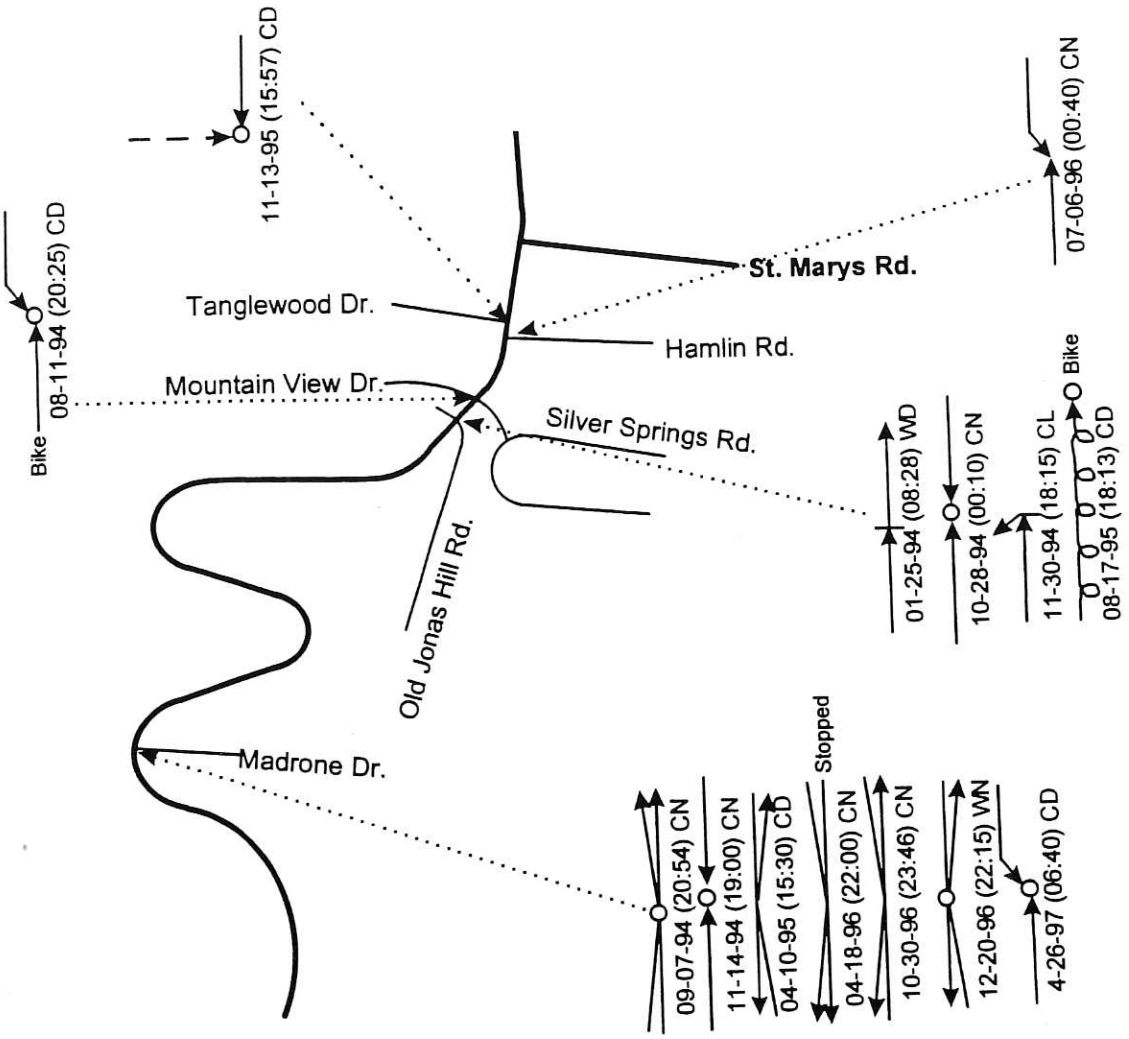
Traffic accidents should be monitored along Moraga Road to determine if additional measures may be required in the future.



AM Peak hour Traffic Volumes



PM Peak hour Traffic Volumes

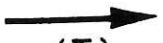


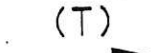
Note: Please see next page for key to collision diagram symbols.

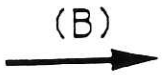
Accident Summary (01/01/94 to 06/30/97)

Key to Collision Diagram Symbols

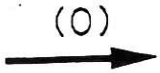
Vehicle Type


Automobile


(T) Truck


(B) Bus

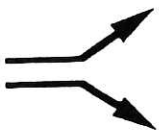

(M) Motorcycle


(O) Other


Pedestrian


Uninvolved

Vehicle Movement


Left

Right


Straight


Backing

Severity


PDO


Injury


Fatal

Accident Type


Rear-End


Head-On


Angle


Sideswipe, Same Direction


Sideswipe, Opposite Direction


Out of Control


Collision with Fixed Object

Road Surface

C	Dry, Clear
W	Wet
S	Snowy, Icy
O	Other

Lighting

D	Daylight
N	Dark, No Lights
L	Dark with Street Lights