Chinatown
One-Way Street Conversion Study
Final Report

Prepared for:
City of Oakland

Submitted by:

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

180 Grand Avenue, Suite 250
Oakland, CA 94612

Phone: (510) 839-1742; Fax: (510) 839-0871
www.dowlinginc.com
Contact: Mark Bowman

May 6, 2009

May 6, 2009

Mr. Mohamed Alaoui, P.E.
City of Oakland Public Works Agency
250 Frank H. Ogawa Plaza, Suite 4344
Oakland, CA 94612

Subject: Chinatown One-Way Street Conversion Study P05114.014

Dear Mohamed:

Dowling Associates is pleased to submit the Draft Report for the Chinatown One-Way Street Conversion Study. Please contact me if you have questions or comments.

Sincerely,

Dowling Associates, Inc.

[Sent Via Email]

Mark Bowman, P.E.
Principal

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Executive Summary

Dowling Associates conducted the Chinatown One-Way Street Conversion Study for the City of Oakland to address whether it would be advisable to convert certain streets in Chinatown from one-way traffic operations to two-way operations. The study addresses the likely impacts to motor vehicle operations and to the safety of operations for pedestrians, bicyclists and transit users.

The study addresses the advisability of converting the following two streets from one-way operations to two-way operations:

- Harrison Street from 8th Street to 10th Street
- Additional conversion of 10th Street from Madison Street to Webster Street

Existing conditions in the corridor are shown in Figure 1.

Figure 1: Chinatown One-Way Conversion Study Area

A summary of the findings of the study is provided in Table 1.

Table 1: Chinatown Streets: One Way Conversion to Two-Way Traffic

Issue	Harrison Street	10th Street	Notes
Vehicle Access to Properties	Largely unaffected.	Largely unaffected.	Parking direction would be reoriented.
Traffic Service	Minimal effects.	Expected to be similar.	No analysis of 10th Street conversion.
Travel Speeds	6% to 7% higher on Webster Street.	Expected to be similar.	No analysis of 10th Street conversion.
Vehicle Queuing	Improvements on Webster St.; no effect on Harrison St.	Expected to be similar.	No analysis of 10th Street conversion.
Vehicle, Pedestrian and Bicycle Safety	Potential accident increases of 10 to 50 percent on Harrison St. and decrease of 6 to 7 percent on Webster St.	Potential accident increases of 10 to 50 percent on 10th St. and small decrease on other nearby streets.	Based on experiences of before and after studies in other cities.
Pedestrian Accessibility	Largely unaffected.	Largely unaffected.	
Bicycle Accessibility	Slight improvement.	Slight improvement.	More direct access.
Freight and Passenger Loading	Minimal effects. No double parking was observed.	Freight loading required in median. Effect on safety is unknown.	Freight loading areas would be available.
Parking	No change.	No change.	Actual counts
Transit Operations	Largely unaffected.	Largely unaffected.	No transit stops on either street.
Garbage Pickup	Rerouting required. Potential traffic blockages.	Rerouting required. Potential traffic blockages.	Similar to operations on Alice and Jackson Streets.
Emergency Vehicle Access	Slight improvement.	Slight improvement.	More direct access.

Additional discussion of study findings is provided in the Conclusions section on page 21.

Introduction

A quantitative analysis of traffic operations was provided for the conversion of Harrison Street to two-way operations. A qualitative assessment was provided for the conversion of 10th Street to two-way operations.

The study area (shown in Figure 2) includes the following streets:

- Webster Street from 11th Street to 8th Street
- Harrison Street from 7th Street to 11the Street
- Alice Street between 9th and 10th Streets
- Jackson and Madison Streets between 9th and 11th Streets
- 8th Street from Alice Street to Webster Street
- 9th, 10th, and 11th Streets between Webster and Madison Streets

Data Collection and Documentation

Previous studies prepared for the study area were reviewed. Those studies included:

- *Revive Chinatown Community Transportation Plan* (CHS Consulting Group 2004)

- *Downtown Transportation and Parking Plan* (Dowling Associates 2002)

- *Transportation Analysis for: 226 13th Street Development Project* (Dowling Associates 2006)

- *Measure DD Implementation Project EIR* (LSA Associates 2007)

- *Transportation Analysis for: 188 11th Street Residential Project* (Dowling Associates 2005)

- *Oak to Ninth Avenue Project Draft EIR* (ESA 2006)

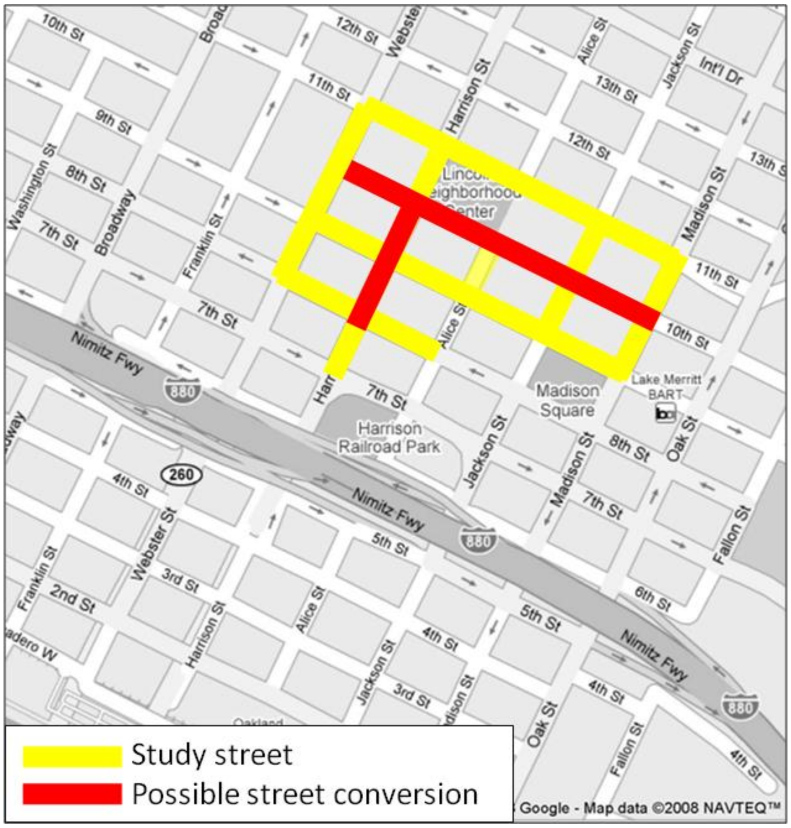

Figure 2: Chinatown One-Way Conversion Study Area

New traffic data for motor vehicles, pedestrians and bicycles were collected for the a.m. and p.m. peak periods at the study intersections along Webster and Harrison Streets. Traffic data at the other study intersections were gathered from available sources including the other studies conducted in the project vicinity by Dowling Associates and others. The traffic data were adjusted to provide a balance between traffic volumes leaving one intersection and the traffic volumes arriving at the next intersection. The adjusted peak hour motor vehicle traffic volumes are shown in Figure 3 and in Appendix A.

Field Review

Dowling Associates staff performed a field review of the study streets, took photos, and measured and inventoried existing conditions. Street widths were measured and constraints that might affect the one-way conversion were noted. Field review data included:

1. Street dimensions
2. Parking spaces
3. Bus stops
4. Traffic controls
5. Visibility obstructions
6. Impediments to pedestrian travel
7. Impediments to bicycle travel
8. Double parking

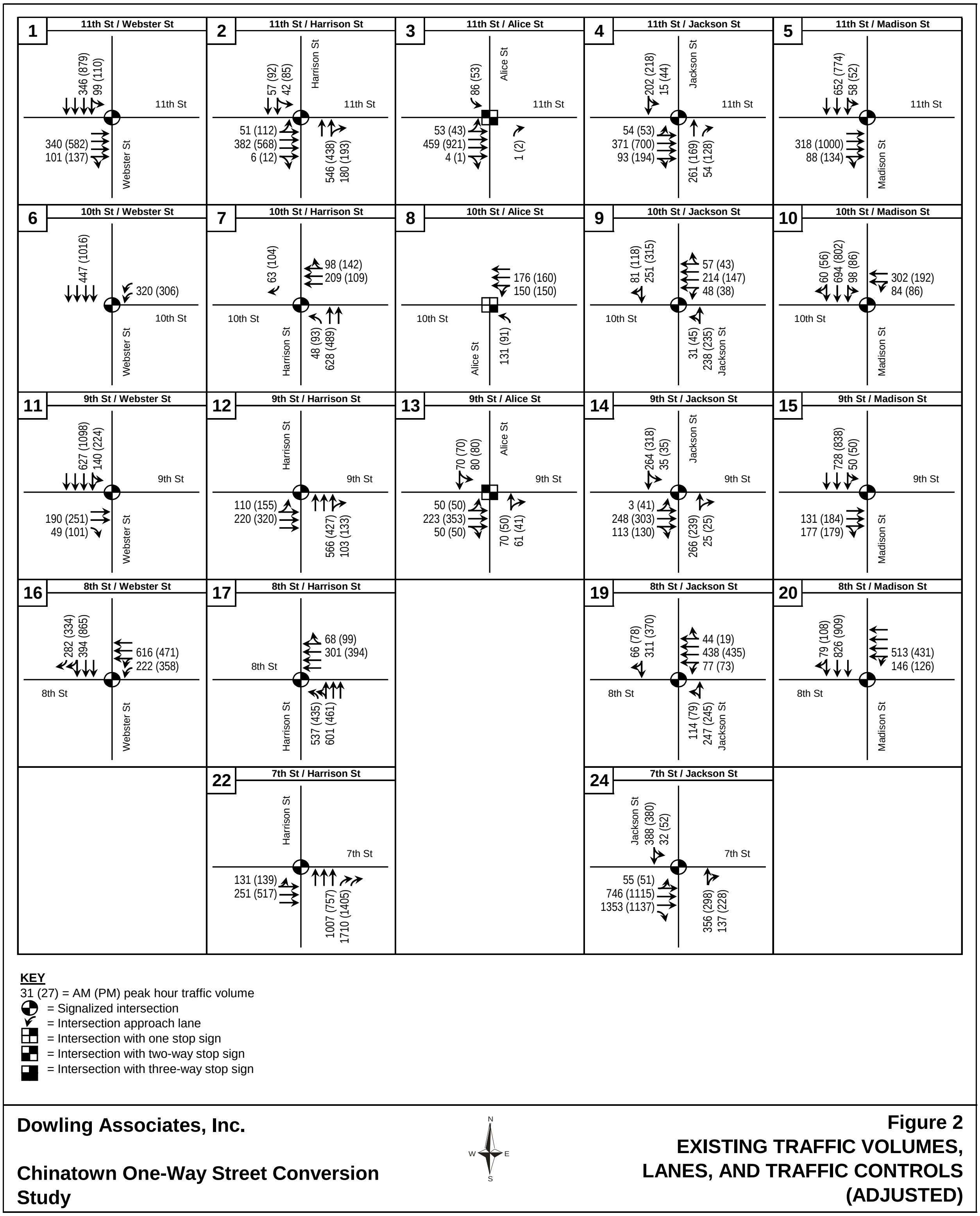

Figure 3: Existing Traffic Volumes, Lanes, and Traffic Controls (Adjusted)

An exhibit showing the coverage area for existing conditions is provided in Figure 4 and as an attachment as a larger exhibit. Photos of the study area streets are also shown as an attachment. The aerial photo base for Figure 4 does not show the recent modifications to intersections on Webster Street, which are now designed with bulb outs at the intersection corners and now operate with an exclusive pedestrian traffic signal phase.

Figure 4: Existing conditions overview (a larger version is shown as an attachment)

The existing conditions exhibit shows the width of streets from curb to curb, the number and type of parking spaces on each block, bus stop locations (in green), and locations where double parking was observed during the field review. The types of intersection traffic controls are shown in Figure 3 and in the photo exhibit attachment. No visibility obstructions were observed for motorists; however, merchant displays were observed that created an impediment to pedestrian access (as shown in Figure 5) and obstructions to bicycle and motor vehicle travel were observed where vehicles are double parked (as shown in Figure 5 and Figure 6).

Figure 5: 10th Street sidewalk just west of Harrison Street

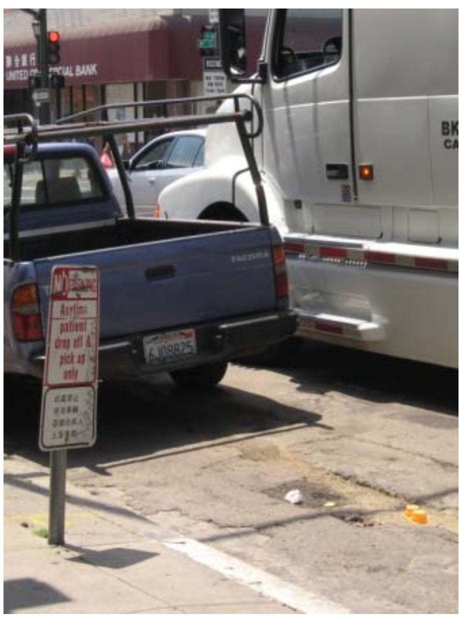

Figure 6: Double parking on Webster St. north of 8th St.

Research on One-Way Conversions

Dowling Associates performed a search of available literature with a purpose to:

- Document the experience of other cities that have converted from one-way to two-way operations and identify advantages and disadvantages of the two traffic circulation concepts.

- Document the experiences of cities that have converted from two-way to one-way and compare it to the experiences of the former group.

- Document empirical studies that demonstrate a reduction in vehicle speeds through lane reduction in high density urban areas.

A summary of research findings is provided in Appendix D. More than seventeen of the articles and studies considered converting two-way streets to one-way streets. Five were on converting one-way streets to two-way streets.

Much of the research that has been published regarding street conversions addresses conversion of two-way streets to one-way operations, documenting the trend in the latter half of the 20th century to expand the traffic carrying capacity of central business districts. The application of one-way street systems was applied in some cases outside the urban core resulting in undesirable quality-of-life issues in areas more sensitive to traffic impacts.

The recent trend has been to convert one-way street systems back to two-way operations as a means of calming traffic primarily to improve the quality of life in residential areas. This trend is also being applied more broadly and there are transportation professionals who now advocate two-way streets for practically all conditions including central business districts.

The author's assessment is that street systems should be designed to address the needs of the area being served. One-way street systems may be appropriate in highly developed central business districts where it is important to accommodate motor vehicle traffic and maintain good service for pedestrians and bicyclists. Two-way street systems may be more appropriate in less highly developed central business districts and especially in low and medium density residential areas where the emphasis is placed more on livability than serving traffic. A combination of one-way streets and two-way streets may be effectively employed to concentrate motor vehicles toward streets intended to accommodate vehicles and to provide protection for streets designed to emphasize use by non-motorized modes of travel. The key to success is to implement a street system that best fits the needs of the specific area under consideration recognizing that one system does not fit all conditions.

Several studies show that one-way streets increase capacity in a range of 20 to 30 percent above equivalent two-way streets. This additional capacity can be important in a dense urban core. Studies conducted in congested urban areas generally showed that one-way streets reduce accidents. Other studies indicate that slower speeds typically found on two-way streets in residential areas improve safety.

One-way streets keep streets narrow and allow simpler signal phasing, both of which contribute to short traffic signal cycle lengths and short pedestrian crossings. Therefore, in urban commercial settings, one-way streets can be more convenient for pedestrians because pedestrians have shorter wait times for a pedestrian signal and are less exposed to conflicts with vehicles as they cross the street.

One-way street systems limit the number of motor vehicle movements at intersections and simplify decision making for motorists, bicyclists and pedestrians, especially the elderly and those with special mobility needs. This simplification of decision making may be more important in chaotic urban conditions than in less confusing lower density development areas.

Two-way streets provide a more direct path to and from destinations than one-way streets and allow access without driving around the block. Some studies indicated that one-way streets are less convenient for transit and emergency response; however, this effect may be somewhat offset by lower delays traveling along one-way streets.

No clear link has been established between the type of street system – one-way or two-way – and economic viability. One key finding of the research is that cities that have had the most successful conversions have been the ones where the both the community and technical staff were in agreement and/or where the project was initiated by requests from the community.

Most of the studies on the effects of lane reduction involved implementation of road diets: conversion from four-lane two-way streets with two through lanes in each direction and no left-turn lanes to three-lane streets with one through lane in each direction and a center median that accommodates left turning movements. One study indicated that reducing lane width reduces the capacity of a roadway but also nearly always reduced accident rates.

Potential for Converting Streets to Two-Way Operations

Dowling Associates performed a quantitative analysis of the impacts of converting Harrison Street from one-way operations to two-way operations between 8th Street and 10th Street. A qualitative assessment was also made of the potential to convert 10 Street to two-way operations between Madison Street to Webster Street. Levels of service were estimated for the conversion of Harrison Street to two-way operations. Service levels were not estimated for the additional conversion of 10th Street.

The figures below and the attached plan-size graphics show the two options. Figure 7 (and Exhibit 3) shows a schematic representation of existing conditions prepared using the Synchro software package.

The following factors were considered in the evaluation of conversion from one-way to two-way operations with respect to:

1. Number and width of vehicle lanes
2. Vehicle access to properties
3. Traffic service and vehicle queuing (Harrison Street conversion only)
4. Vehicle, pedestrian and bicycle safety
5. Pedestrian and bicycle accessibility
6. Freight and passenger loading
7. Parking
8. Transit operations
9. Garbage pickup
10. Emergency vehicle access

Extension of Two-Way Operations on Harrison Street

Figure 8 (and Exhibit 4) shows a concept that would extend two-way traffic operations from 10th Street south to 8th Street. This concept would add one southbound through lane on Harrison Street between 10th and 8th Streets. Space for the new southbound through lane would be provided by removing one northbound through lane along this section of Harrison Street. The removal of the northbound lane would be accomplished by converting the northbound Harrison Street shared through-left turn lane at 8th Street to a left-turn only lane. Between 9th and 10th Streets, end-to-end left-turn lanes would be provided. One geometric issue that is raised by this concept is the challenge of providing an adequate radius for traffic to flow from westbound 10th Street to southbound Harrison Street. This challenge may be resolved by pushing the stop line for the northbound Harrison Street traffic southward.

A new southbound lane on Harrison Street is expected to attract traffic from Webster Street and other streets in the immediate vicinity of the project. The changes in traffic flow expected to result from the two-way conversion of Harrison Street and the traffic volumes that would be expected after conversion are shown in Appendix A. Approximately 10 percent of the traffic on Webster Street would be diverted to southbound Harrison Street during the a.m. peak hour and approximately 6 percent would be diverted during the p.m. peak hour.

Additional Conversion of 10th Street to Two-Way Operations

Figure 9 (and Exhibit 5) shows a concept for converting 10th Street to two-way operations (in addition to converting Harrison Street to two-way operations). This concept was developed to determine the feasibility of converting the section of 10th Street between Harrison and Webster Streets to two-way operations. Conversion of this section of 10th Street to two-way operations would require modifications to the lanes and traffic controls as far east as Madison Street in order to transition between the four-lane one-way westbound 10th Street on the east end to the three-lane, two-way section at the west end. Conversion of 10th Street to two-way operations would reduce the design challenge described above for the conversion of Harrison Street alone.

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Chinatown One-Way Street Conversion Study

Figure 6
SCHEMATIC OF EXISTING CONDITIONS

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Figure 7
TWO-WAY HARRISON STREET

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Chinatown One-Way Street Conversion Study

Figure 8
TWO-WAY HARRISON STREET AND 10TH STREET

Number and Width of Vehicle Lanes

The number of lanes for both conversion options is discussed above and is illustrated in Figure 8 and Figure 9, in Exhibits 4 and 5, and on the traffic volume figures in Appendix A.

Vehicle Access to Properties

Vehicle access to properties would be largely unaffected.

Harrison Street Conversion

The parking along the west side of Harrison Street would be reoriented from north facing to south facing. Access to the west side of Harrison Street would require motorists to approach from the north instead of from the south as they must do now.

Additional 10th Street Conversion

The parking along the south side of 10th Street would be reoriented from west facing to east facing. Access to the south side of 10th Street would require motorists to approach from the west instead of from the east as they must do now.

Traffic Service

For the conversion of Harrison Street, the traffic levels of service (LOS) at study intersections along Webster and Harrison Streets were analyzed for the a.m. and p.m. peak hours using methodologies described in the Highway Capacity Manual.[1] The LOS for signalized and unsignalized intersections is defined in terms of delay. Delay is a complex measure and is dependent upon a number of variables. The most basic of these is the number of vehicles in the traffic stream, but for signalized intersections, delay is also dependent on the quality of signal progression, the signal cycle length, and the "green" ratio for each approach or lane group. The LOS criteria for signalized intersections are shown in The quantitative analysis of traffic operations included evaluation of service levels at the following intersections.

- 11th St / Webster St
- 11th St / Harrison St
- 10th St / Webster St
- 10th St / Harrison St
- 9th St / Webster St
- 9th St / Harrison St
- 8th St / Webster St
- 8th St / Harrison St
- 7th St / Harrison St

Table 2.

[1] *Highway Capacity Manual, 2000.* Transportation Research Board.

The quantitative analysis of traffic operations included evaluation of service levels at the following intersections.

- 11th St / Webster St
- 11th St / Harrison St
- 10th St / Webster St
- 10th St / Harrison St
- 9th St / Webster St
- 9th St / Harrison St
- 8th St / Webster St
- 8th St / Harrison St
- 7th St / Harrison St

Table 2: Level of Service Criteria – Signalized Intersections

Level of Service (LOS)	Average Delay (seconds/vehicle)	Description
A	≤ 10	Very Low Delay: This level of service occurs when progression is extremely favorable and most vehicles arrive during a green phase. Most vehicles do not stop at all.
B	> 10 and < 20	Minimal Delays: This level of service generally occurs with good progression, short cycle lengths, or both. More vehicles stop than at LOS A, causing higher levels of average delay.
C	> 20 and < 35	Acceptable Delay: Delay increases due to only fair progression, longer cycle lengths, or both. Individual cycle failures (to service all waiting vehicles) may begin to appear at this level of service. The number of vehicles stopping is significant, though many still pass through the intersection without stopping.
D	> 35 and < 55	Approaching Unstable Operation/Significant Delays: The influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, or high volume/capacity ratios. Many vehicles stop, and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.
E	> 55 and < 80	Unstable Operation/Substantial Delays: These high delay values generally indicate poor progression, long cycle lengths, and high volume/capacity ratios. Individual cycle failures are frequent occurrences.
F	> 80	Excessive Delays: This level, considered unacceptable to most drivers, often occurs with over-saturation (that is, when arrival traffic volumes exceed the capacity of the intersection). It may also occur at nearly saturated conditions with many individual cycle failures. Poor progression and long cycle lengths may also contribute significantly to high delay levels.
Source: Transportation Research Board, *Highway Capacity Manual*, Washington, D.C., 2000, pages 10-16 and 16-2.		

The levels of service and delays at intersections on the street system are shown in Table 3. Detailed calculations are shown in Appendix B.

Table 3: Intersection Levels of Service

Intersection	Peak Hour	Existing Conditions		Two-Way Harrison		Change in Delay²
		LOS¹	Delay²	LOS¹	Delay²	
11th St & Webster St	AM	B	10.6	B	10.4	-0.2
	PM	B	13.1	B	12.7	-0.4
11th St & Harrison St	AM	B	16.4	B	16.3	-0.1
	PM	B	13.0	B	13.3	0.3
10th St & Webster St	AM	A	4.6	C	21.8	17.2
	PM	A	8.0	A	8.3	0.3
10th St & Harrison St	AM	A	8.5	A	7.9	-0.6
	PM	A	9.2	A	8.6	-0.6
9th St & Webster St	AM	C	24.4	C	23.4	-1.0
	PM	C	30.8	C	28.1	-2.7
9th St & Harrison St	AM	A	4.8	A	5.6	0.8
	PM	A	6.4	A	6.9	0.5
8th St & Webster St	AM	B	18.1	B	16.5	-1.6
	PM	C	26.7	B	17.9	-8.8
8th St & Harrison St	AM	A	6.4	A	6.4	0.0
	PM	A	7.4	A	7.5	0.1
7th St & Harrison St	AM	B	11.3	B	11.3	0.0
	PM	B	10.1	B	10.1	0.0
NB Harrison Right Turn Movement & Pedestrian Crossing	AM	B	11.2	B	11.2	0.0
	PM	A	4.3	A	4.3	0.0

Source: Dowling Associates, Inc., 2008

¹ LOS = Level of Service

² Delay = Average Delay in seconds

The conversion of Harrison Street to two-way operations would result in minor changes to levels of service and delay, but would not cause any intersections to operate below the City's Level of Service (LOS) E standard for Downtown. The change in LOS at the intersection of 10 and Webster during the a.m. peak hour occurs as a result of a change in the progression factor for traffic heading westbound on 10th Street. This result was produced using the Synchro HCM method but is not evident using the Synchro Percentile Delay method. The change in delay and LOS is not expected to be realized but could not be overridden in the software used for the analysis.

The levels of service and travel speeds along the Webster and Harrison Street are shown in Table 4.

Table 4: Corridor Levels of Service

Roadway	Peak Hour	Existing Conditions		Two-Way Harrison		Percent Change in Speed
		LOS[1]	Corridor Speed (mph)	LOS[1]	Corridor Speed (mph)	
Southbound Webster Street	AM	E	7.3	E	7.8	7%
	PM	F	6.3	F	6.7	6%
Northbound Harrison Street	AM	E	8.4	E	8.2	-2%
	PM	E	8.6	E	8.5	-1%
Southbound Harrison Street[2]	AM	E	8.8	D	9.3	6%
	PM	E	8.4	E	8.6	2%

Source: Dowling Associates, Inc., 2008

[1] LOS = Level of Service

[2] Corridor lengths for Existing Conditions and Two-Way Harrison Conversion are different for the southbound movement.

Speeds are a measure of level of service for roadway corridors. Conversion of Harrison Street to two-way operations is expected to increase travel speeds on Webster Street by 6 to 7 percent during and will reduce northbound speeds on Harrison Street by 1 to 2 percent. Speeds are shown as increasing on southbound Harrison Street; however, the lengths of the southbound segments are different for the two alternatives and are therefore not directly comparable.

Vehicle Queuing

Vehicle queues were evaluated to determine if conversion to two-way operations on Harrison Street would result in queues that would exceed the available vehicle storage capacity. The analysis did not assess the effects of double parking that often results in queuing problems, particularly on Webster Street. Actual vehicle queues resulting from double parking may be greater than those reported in the summary of the analysis. The conversion of Harrison Street to two-way operations would remove some southbound traffic from Webster Street and reduce congestion and queuing that may result from double parking. A summary of the analysis is provided in Appendix B and is described below.

Some vehicle queues exceed the available storage capacity during current peak hour conditions as follows:

- The vehicle queue for the southbound through movement on Webster Street at 9th Street exceeds the available storage capacity during the p.m. peak hour. Conversion of Harrison Street to two-way operations would reduce the amount of the queue overflow but would not eliminate it.

- The vehicle queue for the southbound right-turning movement on Webster Street at 8th Street also exceeds the storage capacity during the p.m. peak hour. Conversion of Harrison Street to two-way operations would eliminate the queue overflow at this location.

- The vehicle queue for the northbound right turning movement on Harrison Street at 7th Street exceeds the storage capacity during both the a.m. and p.m. peak hours. Conversion of Harrison Street to two-way operations would not affect vehicle queues for this movement.

Vehicle, Pedestrian and Bicycle Safety

Harrison Street Conversion

Conversion of Harrison Street to two-way operations could increase the number of accidents in the area, although the outcome is uncertain. All modes of travel encounter fewer potential conflicts with motor vehicles on one-way streets in comparison to two-way streets. However, conversion to two-way operations would reduce the potential need for motor vehicle recirculation to find parking and would generally result in lower traffic speeds.

A study conducted in 2005 showed that conversion of one-way streets to two-way operations in Denver, Indianapolis and Lubbock, Texas, increased accident rates by 25 to 37 percent. Conversely, conversion of two-way streets to one-way operations reduced accidents in Sacramento, Portland and the State of Oregon reduced accidents by 10 to 51 percent.[2] A 1998 study showed that one-way streets at downtown intersections had 22 to 25 percent fewer accidents.[3] Other studies show similar results for motor vehicle accidents and also indicate that conversion to two-way operations increased the number of pedestrian accidents.

If the experiences of the cities documented in these prior studies are applicable to Chinatown, we would expect the conversion of Harrison Street to increase the number of accidents on Harrison Street by between 10 and 50 percent. In addition, the number of pedestrian accidents would be expected to increase although the amount of the likely increase is unknown. On the other hand, removal of traffic from Webster Street is expected to reduce the number of accidents there by approximately 6 to 7 percent.

Additional 10th Street Conversion

Conversion of 10th Street to two-way operations could also increase the number of accidents, although, similar to Harrison Street, the outcome is uncertain. Similar principles regarding safety discussed for Harrison Street conversion would also apply to 10th Street.

If the experiences of the cities documented in the studies cited above are applicable to Chinatown, we would expect the conversion of 10th Street to increase the number of accidents on 10th Street by between 10 and 50 percent. In addition, the number of pedestrian accidents would be expected to increase although the amount of the likely increase is unknown. On the other hand, removal of traffic from other streets in the area is expected to reduce the number of accidents there by a lesser amount.

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[2] Cunneen M., O'Toole R., *No Two-Ways About It: One-Way Streets are Better than Two-Way, Center for the American Dream,* 2005.
[3] Stemley J. J., *One-Way Streets Provide Superior Safety and Convenience* , 1998.

Pedestrian and Bicycle Accessibility

Pedestrian accessibility would not be significantly affected by conversion of Harrison Street or 10th Street to two-way operations. Bicycle accessibility should be slightly improved by providing more direct access to destinations in Chinatown.

Freight and Passenger Loading

Harrison Street Conversion

Freight and passenger loading would not be significantly affected by converting Harrison Street to two-way operations. Double parking for freight and/or passenger loading was observed along Webster Street, Alice Street, and 8th and 10th Streets. No double parking was observed along Harrison Street, so conversion of Harrison Street to two-way operations is not expected to have a significant effect on freight and passenger loading.

Additional 10th Street Conversion

Conversion of 10th Street to two-way operations would require freight loading to occur in the striped median between the through lanes of traffic on 10th Street in the block between Harrison and Webster Streets, where double parking was observed.

Allowing freight loading in the striped median may result in reduced levels of safety; however, this may not necessarily be the case. Peak hour traffic volumes along 10th Street are approximately 300 vehicles per hour (a relatively low volume of traffic). At low street volumes, freight vehicles parked in the median may result in slower vehicle speeds, which would tend to improve safety.

Parking

No change to the number of parking spaces is anticipated for either alternative.

Harrison Street Conversion

As mentioned above, conversion of Harrison Street to two-way operations would require reorientation of parking along the west side of Harrison Street from north facing to south facing.

Additional 10th Street Conversion

Similarly, conversion of 10th Street to two-way operations would require reorientation of parking along the south side of 10th Street from west facing to south facing.

Transit Operations

Transit operations would be largely unaffected by conversion of either street to two-way operations. City staff reviewed the concepts for conversion of Harrison Street and 10th

Street and found that there are no apparent conflicts with the Bus Rapid Transit (BRT) project proposed by AC Transit.[4]

Harrison Street Conversion

AC Transit Route 314 operates along Harrison Street but does not stop in the section where conversion is being considered.

Additional 10th Street Conversion

AC Transit route 59 operates along one block of 10th Street and also does not stop in the section where conversion is being considered.

Garbage Pickup

Waste Management provides residential and commercial waste collection service in Chinatown. Garbage pickup is provided using carts for residential and commercial customers. Recycling service is also provided.

Harrison Street Conversion

Waste collection along the east side of Harrison Street would be largely unaffected by conversion of Harrison Street to two-way operations. Conversion would reduce the number of northbound lanes along the two block section that would be converted. Currently there are three northbound lanes and conversion to two-way operations would reduce the number to two lanes. When waste collection vehicles stop in one lane to serve customers, other vehicles may pass in the adjacent two lanes. Conversion to two-way operations would leave only one lane for passage of a stopped waste collection vehicle. This situation currently exists on Harrison Street north of 10th Street.

The conversion of Harrison Street to two-way operations would require rerouting of waste collection trucks from northbound to southbound to serve customers along the west side of Harrison Street. There would only be one southbound lane on Harrison Street between 10th and 8th Streets. Waste collection vehicles could completely block southbound traffic flow during collection times. A maximum of approximately one vehicle per minute is expected to be traveling southbound on Harrison Street in the section that would be converted during waste pickup times. This situation currently exists on Alice and Jackson Streets.

Additional 10th Street Conversion

Waste collection along both sides of 10th Street would be affected. The conversion of 10th Street to two-way operations would require rerouting of waste collection trucks from westbound to eastbound to serve customers along the south side of 10th Street. There would only be one lane on 10 Street in the westbound direction west of Alice Street. There would only be one land in the eastbound direction from Webster Street to Madison Street. Waste collection vehicles could completely block traffic flow at those locations during

[4] Source: Bruce Williams, Senior Transportation Planner, personal communication with Iris Starr on March 31, 2009.

collection times. Traffic volumes on 10th Street after conversion are expected to be comparable to those on Jackson Street, where a similar condition currently exists.

Emergency Vehicle Access

Conversion of Harrison Street and 10th Street to two-way operations would provide a slight improvement with regard to emergency vehicle access. The conversion would have little effect on delays along emergency vehicle travel routes.

Harrison Street Conversion

Two-way conversion of Harrison Street would provide an additional direct route of travel for emergency vehicles accessing the area along Harrison Street from the north.

Additional 10th Street Conversion

Two-way conversion of 10th Street would provide an additional direct route of travel for emergency vehicles accessing the area along 10th Street from the west.

Conclusions

In summary, the conversion of Harrison Street from one-way to two-way operations is considered to be feasible based on an assessment of many factors. Harrison Street currently has the available capacity to be converted to two-way operations without causing any significant traffic operational problems. That assessment is based on an analysis of existing conditions and does not consider potential future changes that may increase traffic volumes in the area.

Based on the research of the experiences of other cities, conversion of Harrison Street to two-way operations is likely to reduce the capability of Harrison Street to serve future traffic volumes. The analysis showed that converting Harrison Street to two-way operations would shift 6 to 10 percent of traffic away from Webster Street and thereby reduce the potential for congestion.

The research also indicates that conversion of Harrison Street to two-way operations is likely to reduce travel speeds along the section of street that is converted. Our analysis showed travel speeds on Harrison Street would not be significantly affected by the two-way conversion. The analysis showed that travel speeds along the study portion of Webster Street would be expected to increase by 6 to 7 percent but would remain below 8 mph.

If the experiences of the cities documented in prior studies are applicable to Chinatown, we would expect the conversion of Harrison Street to increase the number of accidents on Harrison Street by between 10 and 50 percent and the number of pedestrian accidents would also be expected to increase. On the other hand, removal of traffic from Webster Street is expected to reduce the number of accidents there by approximately 6 to 7 percent.

One geometric issue is raised by converting Harrison Street, only, to two-way operations. This action would create a challenge of providing an adequate radius for traffic to flow from westbound 10th Street to southbound Harrison Street. This challenge may be resolved by pushing the stop line for the northbound Harrison Street traffic southward or by converting 10th Street to two-way operations.

Converting 10th Street to two-way operations between Harrison and Webster Streets would require modifications to the lanes and traffic controls on 10th Street as far east as Madison Street in order to transition between the four-lane one-way section on the east end to the three-lane, two-way section at the west end.

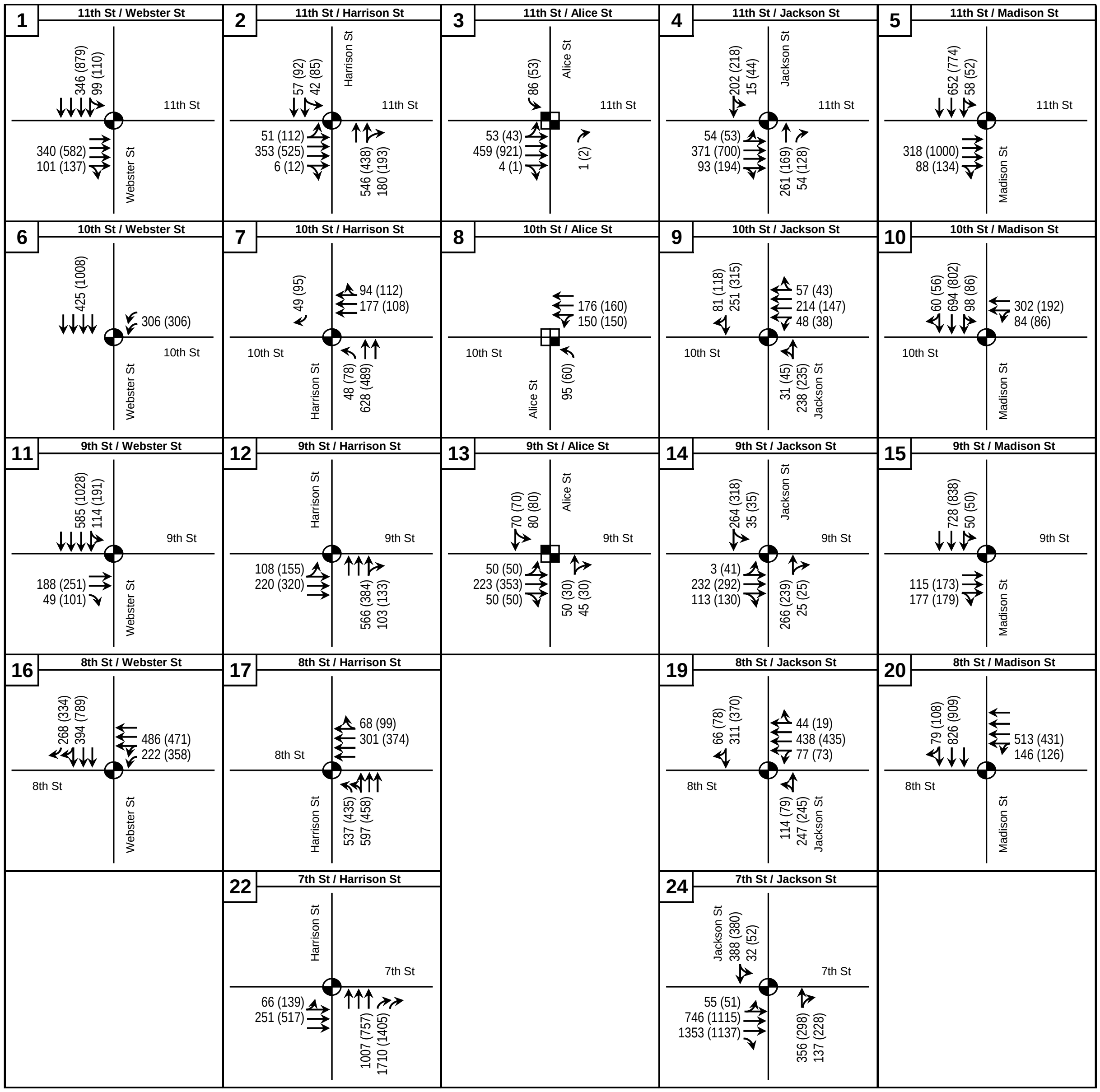
Although conversion of Harrison Street to two-way operations would require changes to access and parking, the effects on the following factors would be minimal:

- Vehicle access to properties
- Traffic levels of service
- Pedestrian accessibility
- Freight and passenger loading
- Parking
- Transit operations
- Garbage pickup

Vehicle queues on Webster Street would be reduced by converting Harrison Street to two-way operations. Bicycle accessibility should be slightly improved by providing more direct access to destinations in Chinatown, and emergency vehicle access would also be slightly improved.

Public participation is an important element of any program for converting streets from one-way to two way operations. Cities that have had the most successful conversions have been the ones where the both the community and technical staff were in agreement and/or where the project was initiated by requests from the community.

APPENDIX A – Traffic Volumes



KEY

31 (27) = AM (PM) peak hour traffic volume

= Signalized intersection

= Intersection approach lane

= Intersection with one stop sign

= Intersection with two-way stop sign

= Intersection with three-way stop sign

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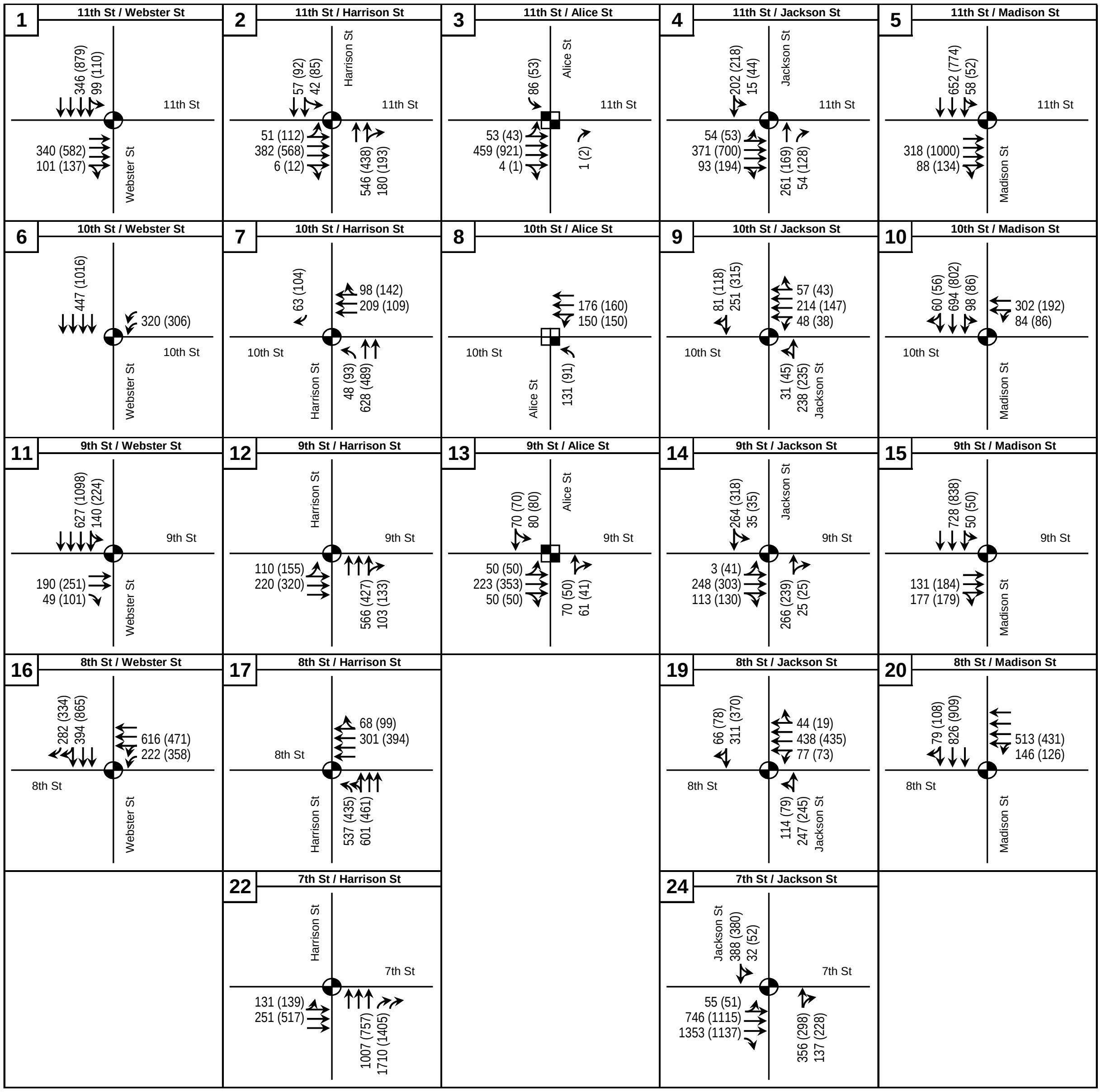
N W E S

Figure A-1
EXISTING TRAFFIC VOLUMES, LANES, AND TRAFFIC CONTROLS (UN-ADJUSTED)



KEY

31 (27) = AM (PM) peak hour traffic volume

= Signalized intersection

= Intersection approach lane

= Intersection with one stop sign

= Intersection with two-way stop sign

= Intersection with three-way stop sign

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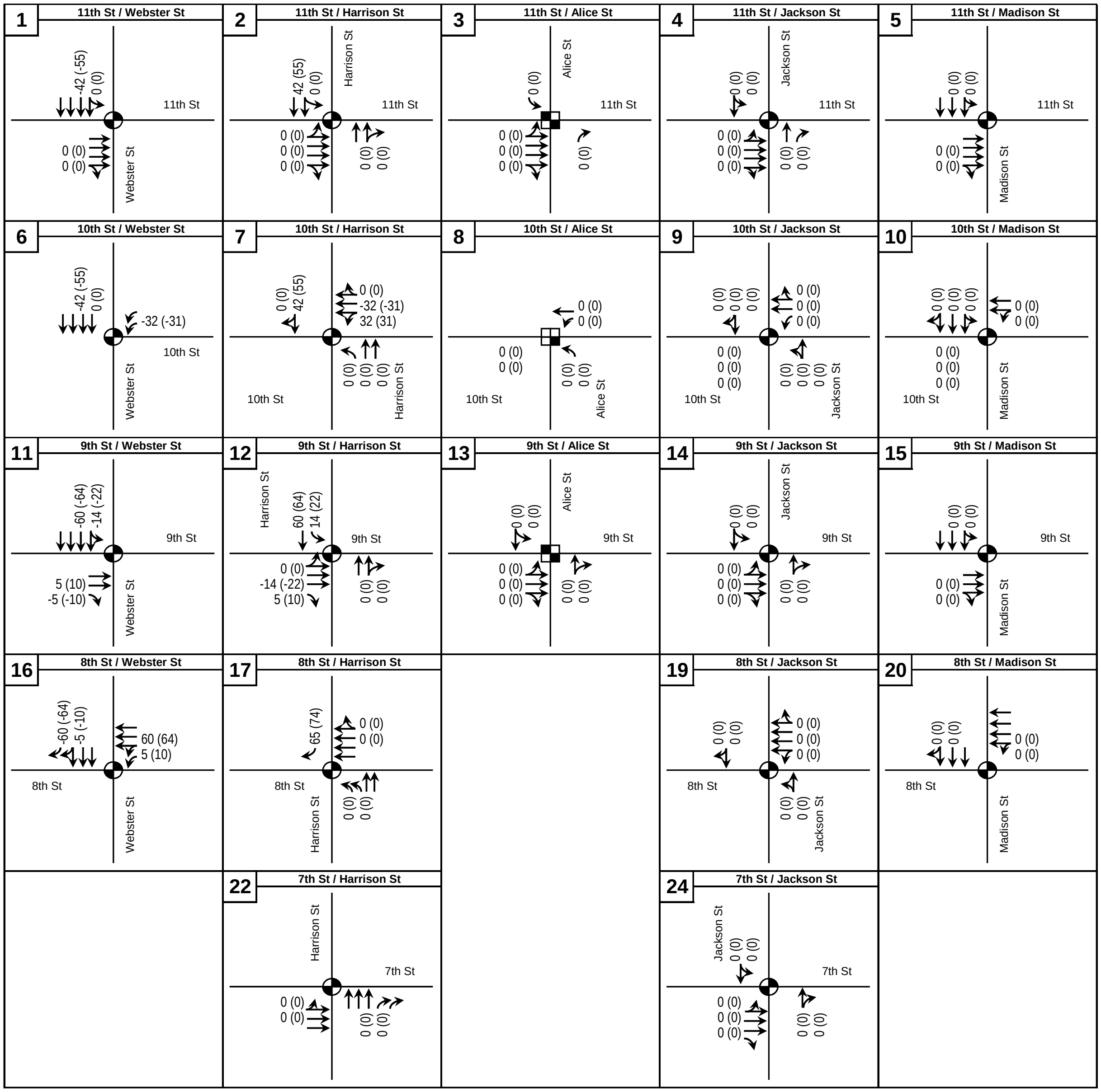
Figure A-2
EXISTING TRAFFIC VOLUMES, LANES, AND TRAFFIC CONTROLS (ADJUSTED)



KEY

31 (27) = AM (PM) peak hour traffic volume

= Signalized intersection

= Intersection approach lane

= Intersection with one stop sign

= Intersection with two-way stop sign

= Intersection with three-way stop sign

Note: Traffic volume changes are shown only at the intersections along Webster and Harrison Streets, which were analyzed quantitatively.

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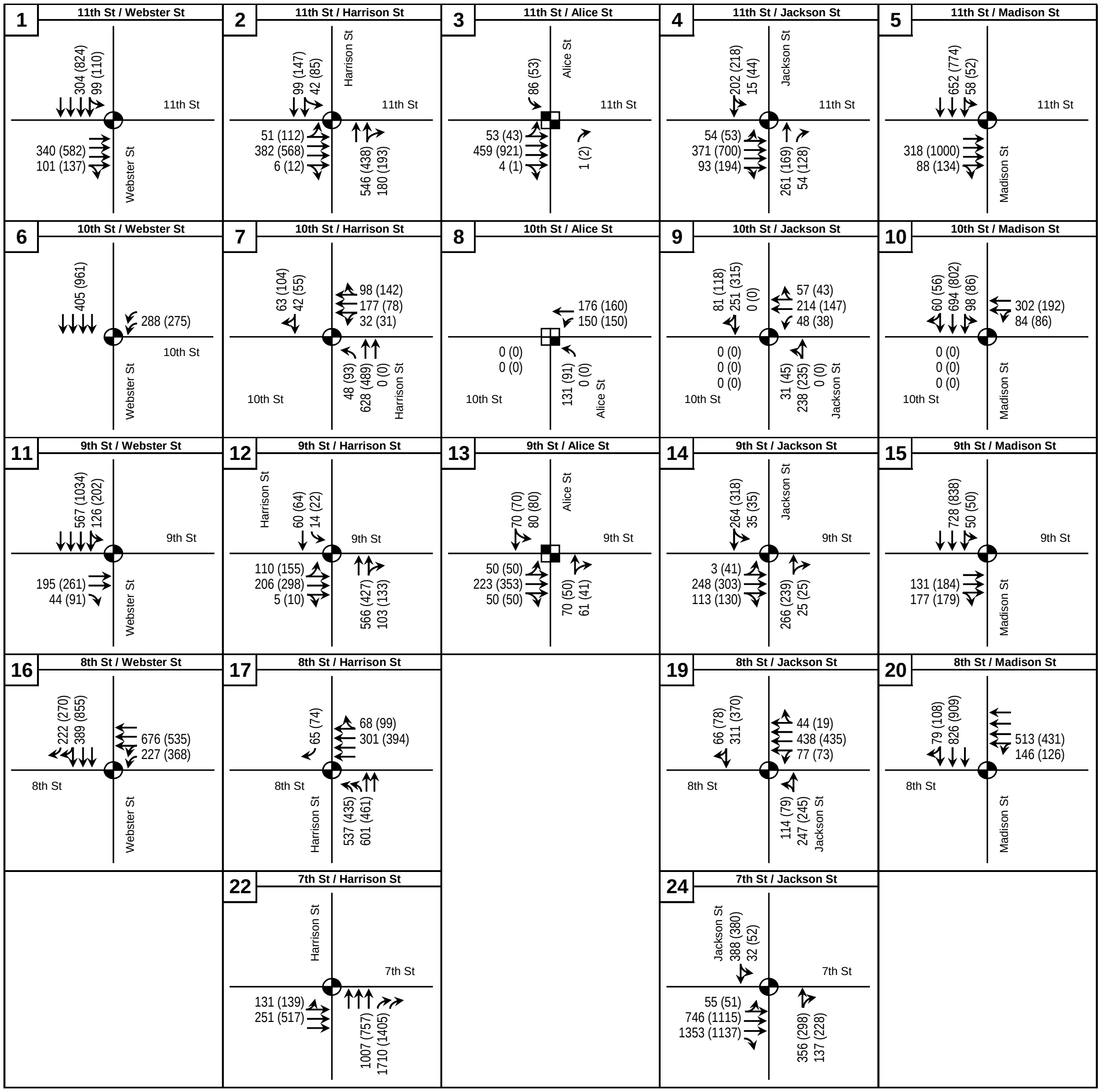
Figure A-3
CHANGES TO TRAFFIC VOLUMES, LANES, AND TRAFFIC CONTROLS FOR CONVERSION OF HARRISON ST.



KEY

31 (27) = AM (PM) peak hour traffic volume

= Signalized intersection

= Intersection approach lane

= Intersection with one stop sign

= Intersection with two-way stop sign

= Intersection with three-way stop sign

Note: Traffic volume changes are shown only at the intersections along Webster and Harrison Streets, which were analyzed quantitatively.

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Figure A-4
TRAFFIC VOLUMES, LANES, AND TRAFFIC CONTROLS AFTER CONVERSION OF HARRISON ST.

Chinatown One-Way Street Conversion Study
Existing Motor Vehicle Traffic Volumes (AM Peak Hour)

	Northbound			Southbound			Eastbound			Westbound			Count Date
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	
1	0	0	0	99	346	0	0	340	101	0	0	0	Tuesday, November 18, 2008
2	0	546	180	42	57	0	51	353	6	0	0	0	Tuesday, November 18, 2008
3	0	0	1	86	3	0	53	459	4	0	0	0	14th & Jackson Study 2006
4	0	261	54	15	202	0	54	371	93	0	0	0	14th & Jackson Study 2006
5				58	652			318	88				Measure DD 2005
6	0	0	0	0	425	0	0	0	0	306	0	0	Tuesday, November 18, 2008
7	48	628	0	0	0	49	0	0	0	0	177	94	Thursday, November 13, 2008
8	95									150	176		
9	31	238			251	81				48	214	57	11th & Jackson Study 2005
10				98	694	60				84	302		Measure DD 2005
11	0	0	0	114	585	0	0	188	49	0	0	0	Tuesday, November 18, 2008
12	0	566	103	0	0	0	108	220	0	0	0	0	Thursday, November 13, 2008
13		50	45	80	70		50	223	50				
14		266	25	35	264		3	232	113				
15				50	728			115	177				
16	0	0	0	0	394	268	0	0	0	222	486	0	Tuesday, November 18, 2008
16	0	0	0	0	590	193	0	0	0	303	644	0	Oak to Ninth 2005
16	0	0	0	0	728	181	0	0	0	240	789	0	Downtown Study 2001
17	537	597	0	0	0	0	0	0	0	0	301	68	Thursday, November 13, 2008
17	545	646	0	0	0	0	0	0	0	0	499	70	Downtown Study 2001
18													
19	114	247			311	66				77	438	44	Oak to Ninth 2005
20					826	79				146	513		Measure DD 2005
21	0	0	0	201	802	0	0	575	296	0	0	0	Downtown Study 2001
22	0	1007	1710	0	0	0	66	251	0	0	0	0	Thursday, November 13, 2008
22	0	1075	1308	0	0	0	126	597	0	0	0	0	Downtown Study 2001
22	0	305	31	17	267	0	48	650	30	0	0	0	Downtown Study 2001
24	0	356	137	32	388	0	55	746	1353	0	0	0	

= Estimated
= Calculated

Chinatown One-Way Street Conversion Study
Existing Motor Vehicle Traffic Volumes (PM Peak Hour)

	Northbound			Southbound			Eastbound			Westbound			Count Date
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	
1	0	0	0	110	879	0	0	582	137	0	0	0	Tuesday, November 18, 2008
2	0	438	193	85	92	0	112	525	12	0	0	0	Tuesday, November 18, 2008
3	0	0	2	53	0	0	43	921	1	0	0	0	14th & Jackson Study 2006
4	0	169	128	44	218	0	53	700	194	0	0	0	14th & Jackson Study 2006
5				52	774			1000	134				Measure DD 2005
6	0	0	0	0	1008	0	0	0	0	306	0	0	Tuesday, November 18, 2008
7	78	489	0	0	0	95	0	0	0	0	108	112	Thursday, November 13, 2008
8	60									150	160		
9	45	235			315	118				38	147	43	11th & Jackson Study 2005
10				86	802	56				86	192		Measure DD 2005
11	0	0	0	191	1028	0	0	251	101	0	0	0	Tuesday, November 18, 2008
12	0	384	133	0	0	0	155	320	0	0	0	0	Thursday, November 13, 2008
13		30	30	80	70		50	353	50				
14		239	25	35	318		41	292	130				
15				50	838			173	179				
16	0	0	0	0	789	334	0	0	0	358	471	0	Tuesday, November 18, 2008
16	0	0	0	0	922	368	0	0	0	390	507	0	Oak to Ninth 2005
16	0	0	0	0	1204	424	0	0	0	270	746	0	Downtown Study 2001
17	435	458	0	0	0	0	0	0	0	0	374	99	Thursday, November 13, 2008
17	335	1199	0	0	0	0	0	0	0	0	680	162	Downtown Study 2001
18													
19	79	245			370	78				73	435	19	Oak to Ninth 2005
20					909	108				126	431		Measure DD 2005
21	0	0	0	266	1156	0	0	653	383	0	0	0	Downtown Study 2001
22	0	757	1405	0	0	0	139	517	0	0	0	0	Thursday, November 13, 2008
22	0	1260	1399	0	0	0	263	673	0	0	0	0	Downtown Study 2001
22	0	234	131	25	275	0	66	943	1005	0	0	0	Downtown Study 2001
24	0	298	228	52	380	0	51	1115	1137	0	0	0	

= Estimated
= Calculated

Chinatown One-Way Street Conversion Study
Existing Pedestrian Volumes

	Intersection	AM Peak Hour						PM Peak Hour					
		North Leg	East Leg	South Leg	West Leg	NW-SE Diagonal	SW-NE Diagonal	North Leg	East Leg	South Leg	West Leg	NW-SE Diagonal	SW-NE Diagonal
1	11th St / Webster St	75	87	69	91			115	152	119	142		
2	11th St / Harrison St	53	227	41	63			144	294	124	125		
6	10th St / Webster St	113	184	4	0			319	184	4	0		
7	10th St / Harrison St	191	198	138	201			219	204	268	247		
11	9th St / Webster St	111	126	177	129	140	40	171	312	412	320	330	170
12	9th St / Harrison St	121	77	155	246			228	169	163	446		
16	8th St / Webster St	66	121	131	92	105	31	127	198	212	205	200	106
17	8th St / Harrison St	154	44	158	88			158	52	296	225		
22	7th St / Harrison St	30	54	18	36			68	26	22	51		
23	Harrison NB Right					54						26	

= Estimated

Chinatown One-Way Street Conversion Study
Existing Bicycle Volumes

	Intersection	AM Peak Hour						PM Peak Hour					
		North Leg	East Leg	South Leg	West Leg	NW-SE Diagonal	SW-NE Diagonal	North Leg	East Leg	South Leg	West Leg	NW-SE Diagonal	SW-NE Diagonal
1	11th St / Webster St	2	7	5	10			3	4	13	4		
2	11th St / Harrison St	19	6	8	2			28	19	5	6		
6	10th St / Webster St	4	11	4	0			5	11	0	4		
7	10th St / Harrison St	5	2	4	10			5	5	13	8		
11	9th St / Webster St	1	1	7	6	0	0	4	8	5	7	0	0
12	9th St / Harrison St	8	3	10	6			4	16	21	9		
16	8th St / Webster St	5	9	1	0	2	0	12	7	2	1	0	1
17	8th St / Harrison St	4	6	5	5			6	6	4	6		
22	7th St / Harrison St	21	8	5	2			8	11	8	4		
23	Harrison NB Right					8						11	

= Estimated

APPENDIX B – Traffic Queues

Queue Summary for Existing Conditions

Intersection	Measure Description	Turning Movement									
		EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBL	SBT	SBR
11th St & Webster St	Storage Length (ft)	300								200	
	AM Queue (ft)	27								43	
	PM Queue (ft)	54								113	
11th St & Harrison St	Storage Length (ft)	300					200			200	
	AM Queue (ft)	26					#181			29	
	PM Queue (ft)	36					140			49	
10th St & Webster St	Storage Length (ft)			300						200	
	AM Queue (ft)			0						27	
	PM Queue (ft)			34						62	
10th St & Harrison St	Storage Length (ft)				300	70	200				
	AM Queue (ft)				30	1	134				
	PM Queue (ft)				21	7	116				
9th St & Webster St	Storage Length (ft)	300	300							190	
	AM Queue (ft)	74	52							144	
	PM Queue (ft)	95	101							271	
9th St & Harrison St	Storage Length (ft)	300					200				
	AM Queue (ft)	28					11				
	PM Queue (ft)	m53					11				
8th St & Webster St	Storage Length (ft)			300	300					190	190
	AM Queue (ft)			#236	168					13	174
	PM Queue (ft)			#273	167					29	m#290
8th St & Harrison St	Storage Length (ft)				300	190	190				
	AM Queue (ft)				29	133	0				
	PM Queue (ft)				37	108	9				
7th St & Harrison St	Storage Length (ft)	300					200				
	AM Queue (ft)	38					100				
	PM Queue (ft)	61					73				
Harrison RT & Ped	Storage Length (ft)							300			
	AM Queue (ft)							#446			
	PM Queue (ft)							#331			

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

Queue Summary for Two-Way Harrison Option

Intersection	Measure Description	Turning Movement									
		EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBL	SBT	SBR
11th St & Webster St	Storage Length (ft)	300								200	
	AM Queue (ft)	27								39	
	PM Queue (ft)	53								106	
11th St & Harrison St	Storage Length (ft)	300					200			200	
	AM Queue (ft)	26					#181			39	
	PM Queue (ft)	36					140			63	
10th St & Webster St	Storage Length (ft)			300						200	
	AM Queue (ft)			0						24	
	PM Queue (ft)			39						58	
10th St & Harrison St	Storage Length (ft)				300	70	200			200	
	AM Queue (ft)				30	m7	66			25	
	PM Queue (ft)				21	36	90			22	
9th St & Webster St	Storage Length (ft)	300	300							190	
	AM Queue (ft)	75	25							83	
	PM Queue (ft)	98	37							239	
9th St & Harrison St	Storage Length (ft)	300					200		70	200	
	AM Queue (ft)	30					11		6	15	
	PM Queue (ft)	m55					15		8	17	
8th St & Webster St	Storage Length (ft)			300	300					190	190
	AM Queue (ft)			52	174					9	29
	PM Queue (ft)			60	113					25	m67
8th St & Harrison St	Storage Length (ft)				300	190	190				190
	AM Queue (ft)				29	0	10				1
	PM Queue (ft)				37	0	13				0
7th St & Harrison St	Storage Length (ft)	300					200				
	AM Queue (ft)	38					100				
	PM Queue (ft)	61					73				
Harrison RT & Ped	Storage Length (ft)							300			
	AM Queue (ft)							#446			
	PM Queue (ft)							#331			

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

APPENDIX C – Level of Service Calculations

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	340	101	0	0	0	0	0	0	99	346	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		3.5									3.5	
Lane Util. Factor		0.86									0.86	
Frpb, ped/bikes		0.99									1.00	
Flpb, ped/bikes		1.00									0.99	
Frt		0.97									1.00	
Flt Protected		1.00									0.99	
Satd. Flow (prot)		5425									5561	
Flt Permitted		1.00									0.99	
Satd. Flow (perm)		5425									5561	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	370	110	0	0	0	0	0	0	108	376	0
RTOR Reduction (vph)	0	50	0	0	0	0	0	0	0	0	71	0
Lane Group Flow (vph)	0	430	0	0	0	0	0	0	0	0	413	0
Confl. Peds. (#/hr)	38		35	35		38	46		44	44		46
Confl. Bikes (#/hr)			7									17
Parking (#/hr)		20									20	
Turn Type										Perm		
Protected Phases		2									4	
Permitted Phases										4		
Actuated Green, G (s)		32.5									20.5	
Effective Green, g (s)		32.5									20.5	
Actuated g/C Ratio		0.54									0.34	
Clearance Time (s)		3.5									3.5	
Lane Grp Cap (vph)		2939									1900	
v/s Ratio Prot		c0.08										
v/s Ratio Perm											0.07	
v/c Ratio		0.15									0.22	
Uniform Delay, d1		6.8									14.0	
Progression Factor		1.00									1.00	
Incremental Delay, d2		0.1									0.3	
Delay (s)		6.9									14.3	
Level of Service		A									B	
Approach Delay (s)		6.9			0.0			0.0			14.3	
Approach LOS		A			A			A			B	

Intersection Summary			
HCM Average Control Delay	10.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.17		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	7.0
Intersection Capacity Utilization	35.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	51	382	6	0	0	0	0	546	180	42	57	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						3.5			3.5	
Lane Util. Factor		0.86						0.95			0.95	
Frpb, ped/bikes		1.00						0.97			1.00	
Flpb, ped/bikes		1.00						1.00			0.99	
Frt		1.00						0.96			1.00	
Flt Protected		0.99						1.00			0.98	
Satd. Flow (prot)		5474						2848			2955	
Flt Permitted		0.99						1.00			0.70	
Satd. Flow (perm)		5474						2848			2119	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	55	415	7	0	0	0	0	593	196	46	62	0
RTOR Reduction (vph)	0	3	0	0	0	0	0	54	0	0	0	0
Lane Group Flow (vph)	0	474	0	0	0	0	0	735	0	0	108	0
Confl. Peds. (#/hr)	27		21	21		27	32		114	114		32
Confl. Bikes (#/hr)			27						8			
Bus Blockages (#/hr)	0	25	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)		20						10			10	
Turn Type	Perm									Perm		
Protected Phases		2						4			4	
Permitted Phases	2									4		
Actuated Green, G (s)		32.0						20.5			20.5	
Effective Green, g (s)		32.0						20.5			20.5	
Actuated g/C Ratio		0.53						0.34			0.34	
Clearance Time (s)		4.0						3.5			3.5	
Lane Grp Cap (vph)		2919						973			724	
v/s Ratio Prot								c0.26				
v/s Ratio Perm		0.09									0.05	
v/c Ratio		0.16						0.76			0.15	
Uniform Delay, d1		7.2						17.5			13.7	
Progression Factor		0.82						1.00			1.00	
Incremental Delay, d2		0.1						5.4			0.4	
Delay (s)		6.0						23.0			14.1	
Level of Service		A						C			B	
Approach Delay (s)		6.0			0.0			23.0			14.1	
Approach LOS		A			A			C			B	

Intersection Summary			
HCM Average Control Delay	16.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	56.4%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	320	0	0	0	0	447
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width	14	10	10	10	10	10
Total Lost time (s)	3.0					3.0
Lane Util. Factor	0.97					0.86
Frpb, ped/bikes	1.00					1.00
Flpb, ped/bikes	1.00					1.00
Frt	1.00					1.00
Flt Protected	0.95					1.00
Satd. Flow (prot)	3296					5682
Flt Permitted	0.95					1.00
Satd. Flow (perm)	3296					5682
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	348	0	0	0	0	486
RTOR Reduction (vph)	224	0	0	0	0	0
Lane Group Flow (vph)	124	0	0	0	0	486
Confl. Peds. (#/hr)	4	113		92	92	
Confl. Bikes (#/hr)		8				
Parking (#/hr)	20					20
Turn Type						
Protected Phases	2					1
Permitted Phases						
Actuated Green, G (s)	16.0					23.0
Effective Green, g (s)	16.0					23.0
Actuated g/C Ratio	0.36					0.51
Clearance Time (s)	3.0					3.0
Lane Grp Cap (vph)	1172					2904
v/s Ratio Prot	c0.04					c0.09
v/s Ratio Perm						
v/c Ratio	0.11					0.17
Uniform Delay, d1	9.7					5.9
Progression Factor	0.25					1.00
Incremental Delay, d2	0.2					0.1
Delay (s)	2.6					6.0
Level of Service	A					A
Approach Delay (s)	2.6		0.0			6.0
Approach LOS	A		A			A

Intersection Summary			
HCM Average Control Delay	4.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.14		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	25.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	0	209	98	48	628	0	0	0	63
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	10	10	16	12	10	10	10	14
Total Lost time (s)					4.0		4.0	4.0				4.0
Lane Util. Factor					0.91		1.00	0.95				1.00
Frpb, ped/bikes					0.97		1.00	1.00				0.92
Flpb, ped/bikes					1.00		0.94	1.00				1.00
Frt					0.95		1.00	1.00				0.86
Flt Protected					1.00		0.95	1.00				1.00
Satd. Flow (prot)					4014		1594	3274				1344
Flt Permitted					1.00		0.95	1.00				1.00
Satd. Flow (perm)					4014		1594	3274				1344
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	227	107	52	683	0	0	0	68
RTOR Reduction (vph)	0	0	0	0	57	0	28	0	0	0	0	36
Lane Group Flow (vph)	0	0	0	0	277	0	24	683	0	0	0	32
Confl. Peds. (#/hr)	96		69	69		96	101		99	99		101
Confl. Bikes (#/hr)						9			2			10
Parking (#/hr)					30		10	10				10
Turn Type							Perm					custom
Protected Phases					2			1				
Permitted Phases							1					1
Actuated Green, G (s)					16.0		21.0	21.0				21.0
Effective Green, g (s)					16.0		21.0	21.0				21.0
Actuated g/C Ratio					0.36		0.47	0.47				0.47
Clearance Time (s)					4.0		4.0	4.0				4.0
Lane Grp Cap (vph)					1427		744	1528				627
v/s Ratio Prot					c0.07			c0.21				
v/s Ratio Perm							0.02					0.02
v/c Ratio					0.19		0.03	0.45				0.05
Uniform Delay, d1					10.0		6.5	8.1				6.6
Progression Factor					1.00		0.72	0.88				1.00
Incremental Delay, d2					0.3		0.1	0.9				0.2
Delay (s)					10.3		4.7	8.0				6.7
Level of Service					B		A	A				A
Approach Delay (s)		0.0			10.3			7.8			6.7	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.34		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	44.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	190	49	0	0	0	0	0	0	140	627	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	11	11	11	10	10	10	10	10	10	10	10	10
Total Lost time (s)		4.0	4.0								4.0	
Lane Util. Factor		0.95	1.00								0.86	
Frpb, ped/bikes		1.00	0.81								1.00	
Flpb, ped/bikes		1.00	1.00								0.97	
Frt		1.00	0.85								1.00	
Flt Protected		1.00	1.00								0.99	
Satd. Flow (prot)		3165	1052								5484	
Flt Permitted		1.00	1.00								0.99	
Satd. Flow (perm)		3165	1052								5484	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	207	53	0	0	0	0	0	0	152	682	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	207	53	0	0	0	0	0	0	0	834	0
Confl. Peds. (#/hr)	146		179	179		146	155		153	153		155
Confl. Bikes (#/hr)			8									7
Parking (#/hr)		10	10								20	
Turn Type			Perm							Perm		
Protected Phases		2									1	
Permitted Phases			2							1		
Actuated Green, G (s)		27.0	27.0								29.0	
Effective Green, g (s)		27.0	27.0								29.0	
Actuated g/C Ratio		0.30	0.30								0.32	
Clearance Time (s)		4.0	4.0								4.0	
Lane Grp Cap (vph)		950	316								1767	
v/s Ratio Prot		c0.07										
v/s Ratio Perm			0.05								0.15	
v/c Ratio		0.22	0.17								0.47	
Uniform Delay, d1		23.6	23.2								24.4	
Progression Factor		1.00	1.00								0.97	
Incremental Delay, d2		0.5	1.1								0.9	
Delay (s)		24.1	24.4								24.5	
Level of Service		C	C								C	
Approach Delay (s)		24.2			0.0			0.0			24.5	
Approach LOS		C			A			A			C	

Intersection Summary			
HCM Average Control Delay	24.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	34.0
Intersection Capacity Utilization	53.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	110	220	0	0	0	0	0	566	103	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	12	12	12	13	12	12	12	12
Total Lost time (s)		4.0						3.0				
Lane Util. Factor		0.91						0.91				
Frpb, ped/bikes		1.00						0.99				
Flpb, ped/bikes		0.98						1.00				
Frt		1.00						0.98				
Flt Protected		0.98						1.00				
Satd. Flow (prot)		4597						4845				
Flt Permitted		0.98						1.00				
Satd. Flow (perm)		4597						4845				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	120	239	0	0	0	0	0	615	112	0	0	0
RTOR Reduction (vph)	0	50	0	0	0	0	0	58	0	0	0	0
Lane Group Flow (vph)	0	309	0	0	0	0	0	669	0	0	0	0
Confl. Peds. (#/hr)	61		78	78		61	123		39	39		123
Confl. Bikes (#/hr)			18						9			
Parking (#/hr)		20						10				
Turn Type	Perm											
Protected Phases		2						1				
Permitted Phases	2											
Actuated Green, G (s)		18.0						20.0				
Effective Green, g (s)		18.0						20.0				
Actuated g/C Ratio		0.40						0.44				
Clearance Time (s)		4.0						3.0				
Lane Grp Cap (vph)		1839						2153				
v/s Ratio Prot								c0.14				
v/s Ratio Perm		0.07										
v/c Ratio		0.17						0.31				
Uniform Delay, d1		8.7						8.1				
Progression Factor		0.91						0.35				
Incremental Delay, d2		0.2						0.4				
Delay (s)		8.1						3.1				
Level of Service		A						A				
Approach Delay (s)		8.1			0.0			3.1			0.0	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	4.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.24		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	7.0
Intersection Capacity Utilization	44.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	222	616	0	0	0	0	0	394	282
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						0.97	0.88
Flpb, ped/bikes				0.87	1.00						1.00	1.00
Frt				1.00	1.00						0.96	0.85
Flt Protected				0.95	1.00						1.00	1.00
Satd. Flow (prot)				1046	4234						3984	949
Flt Permitted				0.95	1.00						1.00	1.00
Satd. Flow (perm)				1046	4234						3984	949
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	241	670	0	0	0	0	0	428	307
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	0	217	694	0	0	0	0	0	566	169
Confl. Peds. (#/hr)	101		134	134		101	114		129	129		114
Confl. Bikes (#/hr)						6						9
Parking (#/hr)				10	10						10	10
Turn Type				Perm								Perm
Protected Phases					2						1	
Permitted Phases				2								1
Actuated Green, G (s)				27.0	27.0						29.0	29.0
Effective Green, g (s)				27.0	27.0						29.0	29.0
Actuated g/C Ratio				0.30	0.30						0.32	0.32
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				314	1270						1284	306
v/s Ratio Prot											0.14	
v/s Ratio Perm				c0.21	0.16							c0.18
v/c Ratio				0.69	0.55						0.44	0.55
Uniform Delay, d1				27.8	26.4						24.1	25.1
Progression Factor				0.89	0.89						0.15	0.21
Incremental Delay, d2				11.3	1.6						1.0	6.4
Delay (s)				36.0	25.1						4.6	11.7
Level of Service				D	C						A	B
Approach Delay (s)		0.0			27.7			0.0			6.3	
Approach LOS		A			C			A			A	

Intersection Summary			
HCM Average Control Delay	18.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	34.0
Intersection Capacity Utilization	53.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	0	301	68	537	601	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	10	10	10	11	10	10	10	10
Total Lost time (s)					3.5		4.0	4.0				
Lane Util. Factor					0.86		0.86	0.86				
Frpb, ped/bikes					0.98		1.00	1.00				
Flpb, ped/bikes					1.00		0.97	0.99				
Frt					0.97		1.00	1.00				
Flt Protected					1.00		0.95	0.99				
Satd. Flow (prot)					5335		1171	4309				
Flt Permitted					1.00		0.95	0.99				
Satd. Flow (perm)					5335		1171	4309				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	327	74	584	653	0	0	0	0
RTOR Reduction (vph)	0	0	0	0	49	0	88	88	0	0	0	0
Lane Group Flow (vph)	0	0	0	0	352	0	216	845	0	0	0	0
Confl. Peds. (#/hr)	77		79	79		77	44		22	22		44
Confl. Bikes (#/hr)						9			11			
Bus Blockages (#/hr)	0	0	0	0	18	0	0	0	0	0	0	0
Parking (#/hr)					20		10	10				
Turn Type							Perm					
Protected Phases					2			1				
Permitted Phases							1					
Actuated Green, G (s)					15.5		22.0	22.0				
Effective Green, g (s)					15.5		22.0	22.0				
Actuated g/C Ratio					0.34		0.49	0.49				
Clearance Time (s)					3.5		4.0	4.0				
Lane Grp Cap (vph)					1838		572	2107				
v/s Ratio Prot					c0.07							
v/s Ratio Perm							0.18	0.20				
v/c Ratio					0.19		0.38	0.40				
Uniform Delay, d1					10.4		7.2	7.3				
Progression Factor					1.00		0.91	0.48				
Incremental Delay, d2					0.2		1.7	0.5				
Delay (s)					10.6		8.3	4.0				
Level of Service					B		A	A				
Approach Delay (s)		0.0			10.6			5.1			0.0	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	6.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.31		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	47.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	131	251	0	0	0	0	0	1007	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	11	11	11	12	12	12	12	12	12	12	12	12
Total Lost time (s)		3.0						5.0				
Lane Util. Factor		0.91						0.91				
Frpb, ped/bikes		1.00						1.00				
Flpb, ped/bikes		1.00						1.00				
Frt		1.00						1.00				
Flt Protected		0.98						1.00				
Satd. Flow (prot)		4573						5085				
Flt Permitted		0.98						1.00				
Satd. Flow (perm)		4573						5085				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	142	273	0	0	0	0	0	1095	0	0	0	0
RTOR Reduction (vph)	0	16	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	399	0	0	0	0	0	1095	0	0	0	0
Confl. Peds. (#/hr)	15		9	9		15	18		27	27		18
Confl. Bikes (#/hr)			26						10			
Parking (#/hr)		10										
Turn Type	Perm											
Protected Phases		2						1				
Permitted Phases	2											
Actuated Green, G (s)		20.4						16.6				
Effective Green, g (s)		20.4						16.6				
Actuated g/C Ratio		0.45						0.37				
Clearance Time (s)		3.0						5.0				
Vehicle Extension (s)		2.0						2.0				
Lane Grp Cap (vph)		2073						1876				
v/s Ratio Prot								c0.22				
v/s Ratio Perm		0.09										
v/c Ratio		0.19						0.58				
Uniform Delay, d1		7.4						11.4				
Progression Factor		1.00						1.00				
Incremental Delay, d2		0.2						1.3				
Delay (s)		7.6						12.8				
Level of Service		A						B				
Approach Delay (s)		7.6			0.0			12.8			0.0	
Approach LOS		A			A			B			A	

Intersection Summary			
HCM Average Control Delay	11.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	41.1%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	WBL	WBR	NBL	NBR	SEL	SET	SER	NWL	NWT	NWR
Lane Configurations										
Volume (vph)	0	0	0	1710	0	0	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	12	12	12	12	12	12
Total Lost time (s)				4.0						
Lane Util. Factor				0.88						
Frpb, ped/bikes				1.00						
Flpb, ped/bikes				1.00						
Frt				0.85						
Flt Protected				1.00						
Satd. Flow (prot)				2787						
Flt Permitted				1.00						
Satd. Flow (perm)				2787						
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	1859	0	0	0	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	0	1859	0	0	0	0	0	0
Confl. Peds. (#/hr)							36	36		
Turn Type				custom						
Protected Phases				6						
Permitted Phases				6						
Actuated Green, G (s)				33.4						
Effective Green, g (s)				33.4						
Actuated g/C Ratio				0.74						
Clearance Time (s)				4.0						
Vehicle Extension (s)				2.0						
Lane Grp Cap (vph)				2069						
v/s Ratio Prot				c0.67						
v/s Ratio Perm										
v/c Ratio				0.90						
Uniform Delay, d1				4.5						
Progression Factor				1.00						
Incremental Delay, d2				6.7						
Delay (s)				11.2						
Level of Service				B						
Approach Delay (s)	0.0		11.2			0.0			0.0	
Approach LOS	A		B			A			A	

Intersection Summary			
HCM Average Control Delay	11.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.90		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	11.6
Intersection Capacity Utilization	63.2%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	582	137	0	0	0	0	0	0	110	879	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		3.5									3.5	
Lane Util. Factor		0.86									0.86	
Frpb, ped/bikes		0.99									1.00	
Flpb, ped/bikes		1.00									0.99	
Frt		0.97									1.00	
Flt Protected		1.00									0.99	
Satd. Flow (prot)		5439									5599	
Flt Permitted		1.00									0.99	
Satd. Flow (perm)		5439									5599	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	633	149	0	0	0	0	0	0	120	955	0
RTOR Reduction (vph)	0	6	0	0	0	0	0	0	0	0	38	0
Lane Group Flow (vph)	0	776	0	0	0	0	0	0	0	0	1037	0
Confl. Peds. (#/hr)	58		60	60		58	71		76	76		71
Confl. Bikes (#/hr)			16									8
Parking (#/hr)		20									20	
Turn Type										Perm		
Protected Phases		2									4	
Permitted Phases										4		
Actuated Green, G (s)		32.5									20.5	
Effective Green, g (s)		32.5									20.5	
Actuated g/C Ratio		0.54									0.34	
Clearance Time (s)		3.5									3.5	
Lane Grp Cap (vph)		2946									1913	
v/s Ratio Prot		c0.14										
v/s Ratio Perm											0.19	
v/c Ratio		0.26									0.54	
Uniform Delay, d1		7.4									16.0	
Progression Factor		1.00									1.00	
Incremental Delay, d2		0.2									1.1	
Delay (s)		7.6									17.1	
Level of Service		A									B	
Approach Delay (s)		7.6			0.0			0.0			17.1	
Approach LOS		A			A			A			B	

Intersection Summary			
HCM Average Control Delay	13.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	7.0
Intersection Capacity Utilization	37.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	112	568	12	0	0	0	0	438	193	85	92	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						3.5			3.5	
Lane Util. Factor		0.86						0.95			0.95	
Frpb, ped/bikes		1.00						0.95			1.00	
Flpb, ped/bikes		0.99						1.00			0.98	
Frt		1.00						0.95			1.00	
Flt Protected		0.99						1.00			0.98	
Satd. Flow (prot)		5405						2768			2917	
Flt Permitted		0.99						1.00			0.62	
Satd. Flow (perm)		5405						2768			1854	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	122	617	13	0	0	0	0	476	210	92	100	0
RTOR Reduction (vph)	0	4	0	0	0	0	0	84	0	0	0	0
Lane Group Flow (vph)	0	748	0	0	0	0	0	602	0	0	192	0
Confl. Peds. (#/hr)	72		62	62		72	63		147	147		63
Confl. Bikes (#/hr)			33						19			6
Bus Blockages (#/hr)	0	25	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)		20						10			10	
Turn Type	Perm									Perm		
Protected Phases		2						4			4	
Permitted Phases	2									4		
Actuated Green, G (s)		32.0						20.5			20.5	
Effective Green, g (s)		32.0						20.5			20.5	
Actuated g/C Ratio		0.53						0.34			0.34	
Clearance Time (s)		4.0						3.5			3.5	
Lane Grp Cap (vph)		2883						946			633	
v/s Ratio Prot								c0.22				
v/s Ratio Perm		0.14									0.10	
v/c Ratio		0.26						0.64			0.30	
Uniform Delay, d1		7.6						16.6			14.5	
Progression Factor		0.78						1.00			1.00	
Incremental Delay, d2		0.2						3.3			1.2	
Delay (s)		6.1						19.9			15.7	
Level of Service		A						B			B	
Approach Delay (s)		6.1			0.0			19.9			15.7	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM Average Control Delay	13.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	59.6%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	306	0	0	0	0	1016
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width	14	10	10	10	10	10
Total Lost time (s)	3.0					3.0
Lane Util. Factor	0.97					0.86
Frpb, ped/bikes	1.00					1.00
Flpb, ped/bikes	1.00					1.00
Frt	1.00					1.00
Flt Protected	0.95					1.00
Satd. Flow (prot)	3296					5682
Flt Permitted	0.95					1.00
Satd. Flow (perm)	3296					5682
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	333	0	0	0	0	1104
RTOR Reduction (vph)	46	0	0	0	0	0
Lane Group Flow (vph)	287	0	0	0	0	1104
Confl. Peds. (#/hr)	4	319		92	92	
Confl. Bikes (#/hr)		5		15		
Parking (#/hr)	20					20
Turn Type						
Protected Phases	2					1
Permitted Phases						
Actuated Green, G (s)	16.0					23.0
Effective Green, g (s)	16.0					23.0
Actuated g/C Ratio	0.36					0.51
Clearance Time (s)	3.0					3.0
Lane Grp Cap (vph)	1172					2904
v/s Ratio Prot	c0.09					c0.19
v/s Ratio Perm						
v/c Ratio	0.25					0.38
Uniform Delay, d1	10.2					6.7
Progression Factor	1.04					1.00
Incremental Delay, d2	0.5					0.4
Delay (s)	11.1					7.1
Level of Service	B					A
Approach Delay (s)	11.1		0.0			7.1
Approach LOS	B		A			A

Intersection Summary			
HCM Average Control Delay	8.0	HCM Level of Service	A
HCM Volume to Capacity ratio	0.32		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	33.9%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	0	109	142	93	489	0	0	0	104
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	10	10	16	12	10	10	10	14
Total Lost time (s)					4.0		4.0	4.0				4.0
Lane Util. Factor					0.91		1.00	0.95				1.00
Frpb, ped/bikes					0.94		1.00	1.00				0.91
Flpb, ped/bikes					1.00		0.92	1.00				1.00
Frt					0.92		1.00	1.00				0.86
Flt Protected					1.00		0.95	1.00				1.00
Satd. Flow (prot)					3728		1569	3274				1324
Flt Permitted					1.00		0.95	1.00				1.00
Satd. Flow (perm)					3728		1569	3274				1324
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	118	154	101	532	0	0	0	113
RTOR Reduction (vph)	0	0	0	0	88	0	54	0	0	0	0	60
Lane Group Flow (vph)	0	0	0	0	184	0	47	532	0	0	0	53
Confl. Peds. (#/hr)	110		134	134		110	124		102	102		124
Confl. Bikes (#/hr)						18			5			8
Parking (#/hr)					30		10	10				10
Turn Type							Perm					custom
Protected Phases					2			1				
Permitted Phases							1					1
Actuated Green, G (s)					16.0		21.0	21.0				21.0
Effective Green, g (s)					16.0		21.0	21.0				21.0
Actuated g/C Ratio					0.36		0.47	0.47				0.47
Clearance Time (s)					4.0		4.0	4.0				4.0
Lane Grp Cap (vph)					1326		732	1528				618
v/s Ratio Prot					c0.05			c0.16				
v/s Ratio Perm							0.03					0.04
v/c Ratio					0.14		0.06	0.35				0.09
Uniform Delay, d1					9.8		6.6	7.6				6.7
Progression Factor					1.00		1.75	1.07				1.00
Incremental Delay, d2					0.2		0.2	0.6				0.3
Delay (s)					10.0		11.7	8.8				6.9
Level of Service					B		B	A				A
Approach Delay (s)		0.0			10.0			9.2			6.9	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	9.2	HCM Level of Service	A
HCM Volume to Capacity ratio	0.26		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	45.9%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	251	101	0	0	0	0	0	0	224	1098	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	11	11	11	10	10	10	10	10	10	10	10	10
Total Lost time (s)		4.0	4.0								4.0	
Lane Util. Factor		0.95	1.00								0.86	
Frpb, ped/bikes		1.00	0.66								1.00	
Flpb, ped/bikes		1.00	1.00								0.95	
Frt		1.00	0.85								1.00	
Flt Protected		1.00	1.00								0.99	
Satd. Flow (prot)		3165	859								5333	
Flt Permitted		1.00	1.00								0.99	
Satd. Flow (perm)		3165	859								5333	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	273	110	0	0	0	0	0	0	243	1193	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	273	110	0	0	0	0	0	0	0	1436	0
Confl. Peds. (#/hr)	336		456	456		336	410		406	406		410
Confl. Bikes (#/hr)			9									15
Parking (#/hr)		10	10								20	
Turn Type			Perm							Perm		
Protected Phases		2									1	
Permitted Phases			2							1		
Actuated Green, G (s)		27.0	27.0								29.0	
Effective Green, g (s)		27.0	27.0								29.0	
Actuated g/C Ratio		0.30	0.30								0.32	
Clearance Time (s)		4.0	4.0								4.0	
Lane Grp Cap (vph)		950	258								1718	
v/s Ratio Prot		0.09										
v/s Ratio Perm			c0.13								0.27	
v/c Ratio		0.29	0.43								0.84	
Uniform Delay, d1		24.1	25.3								28.3	
Progression Factor		1.00	1.00								0.96	
Incremental Delay, d2		0.8	5.1								4.8	
Delay (s)		24.9	30.4								32.0	
Level of Service		C	C								C	
Approach Delay (s)		26.5			0.0			0.0			32.0	
Approach LOS		C			A			A			C	

Intersection Summary			
HCM Average Control Delay	30.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	34.0
Intersection Capacity Utilization	53.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	155	320	0	0	0	0	0	427	133	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	12	12	12	13	12	12	12	12
Total Lost time (s)		4.0						3.0				
Lane Util. Factor		0.91						0.91				
Frpb, ped/bikes		1.00						0.98				
Flpb, ped/bikes		0.97						1.00				
Frt		1.00						0.96				
Flt Protected		0.98						1.00				
Satd. Flow (prot)		4540						4723				
Flt Permitted		0.98						1.00				
Satd. Flow (perm)		4540						4723				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	168	348	0	0	0	0	0	464	145	0	0	0
RTOR Reduction (vph)	0	43	0	0	0	0	0	81	0	0	0	0
Lane Group Flow (vph)	0	473	0	0	0	0	0	528	0	0	0	0
Confl. Peds. (#/hr)	114		82	82		114	223		85	85		223
Confl. Bikes (#/hr)			25						25			
Parking (#/hr)		20						10				
Turn Type	Perm											
Protected Phases		2						1				
Permitted Phases	2											
Actuated Green, G (s)		18.0						20.0				
Effective Green, g (s)		18.0						20.0				
Actuated g/C Ratio		0.40						0.44				
Clearance Time (s)		4.0						3.0				
Lane Grp Cap (vph)		1816						2099				
v/s Ratio Prot								c0.11				
v/s Ratio Perm		0.10										
v/c Ratio		0.26						0.25				
Uniform Delay, d1		9.0						7.8				
Progression Factor		0.99						0.47				
Incremental Delay, d2		0.3						0.3				
Delay (s)		9.3						4.0				
Level of Service		A						A				
Approach Delay (s)		9.3			0.0			4.0			0.0	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	6.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.26		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	7.0
Intersection Capacity Utilization	45.9%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	358	471	0	0	0	0	0	865	334
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						0.98	0.75
Flpb, ped/bikes				0.74	0.94						1.00	1.00
Frt				1.00	1.00						0.99	0.85
Flt Protected				0.95	0.99						1.00	1.00
Satd. Flow (prot)				895	3936						4140	811
Flt Permitted				0.95	0.99						1.00	1.00
Satd. Flow (perm)				895	3936						4140	811
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	389	512	0	0	0	0	0	940	363
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	0	218	683	0	0	0	0	0	1013	290
Confl. Peds. (#/hr)	217		259	259		217	256		252	252		256
Confl. Bikes (#/hr)						14						8
Parking (#/hr)				10	10						10	10
Turn Type				Perm								Perm
Protected Phases					2						1	
Permitted Phases				2								1
Actuated Green, G (s)				27.0	27.0						29.0	29.0
Effective Green, g (s)				27.0	27.0						29.0	29.0
Actuated g/C Ratio				0.30	0.30						0.32	0.32
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				269	1181						1334	261
v/s Ratio Prot											0.24	
v/s Ratio Perm				c0.24	0.17							c0.36
v/c Ratio				0.81	0.58						0.76	1.11
Uniform Delay, d1				29.1	26.7						27.4	30.5
Progression Factor				0.87	0.88						0.17	0.21
Incremental Delay, d2				21.8	2.0						2.4	76.0
Delay (s)				47.3	25.4						7.1	82.3
Level of Service				D	C						A	F
Approach Delay (s)		0.0			30.7			0.0			23.9	
Approach LOS		A			C			A			C	

Intersection Summary			
HCM Average Control Delay	26.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.97		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	34.0
Intersection Capacity Utilization	53.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	0	394	99	435	461	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	10	10	10	11	10	10	10	10
Total Lost time (s)					3.5		4.0	4.0				
Lane Util. Factor					0.86		0.86	0.86				
Frpb, ped/bikes					0.98		1.00	1.00				
Flpb, ped/bikes					1.00		0.92	0.98				
Frt					0.97		1.00	1.00				
Flt Protected					1.00		0.95	0.98				
Satd. Flow (prot)					5310		1115	4237				
Flt Permitted					1.00		0.95	0.98				
Satd. Flow (perm)					5310		1115	4237				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	428	108	473	501	0	0	0	0
RTOR Reduction (vph)	0	0	0	0	71	0	34	34	0	0	0	0
Lane Group Flow (vph)	0	0	0	0	465	0	202	704	0	0	0	0
Confl. Peds. (#/hr)	79		148	148		79	113		26	26		113
Confl. Bikes (#/hr)						10						12
Bus Blockages (#/hr)	0	0	0	0	18	0	0	0	0	0	0	0
Parking (#/hr)					20		10	10				
Turn Type							Perm					
Protected Phases					2			1				
Permitted Phases							1					
Actuated Green, G (s)					15.5		22.0	22.0				
Effective Green, g (s)					15.5		22.0	22.0				
Actuated g/C Ratio					0.34		0.49	0.49				
Clearance Time (s)					3.5		4.0	4.0				
Lane Grp Cap (vph)					1829		545	2071				
v/s Ratio Prot					c0.09							
v/s Ratio Perm							c0.18	0.17				
v/c Ratio					0.25		0.37	0.34				
Uniform Delay, d1					10.6		7.2	7.0				
Progression Factor					1.00		0.74	0.64				
Incremental Delay, d2					0.3		1.8	0.4				
Delay (s)					10.9		7.1	4.9				
Level of Service					B		A	A				
Approach Delay (s)		0.0			10.9			5.5			0.0	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	7.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.32		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	47.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	139	517	0	0	0	0	0	757	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	11	11	11	12	12	12	12	12	12	12	12	12
Total Lost time (s)		3.0						5.0				
Lane Util. Factor		0.91						0.91				
Frpb, ped/bikes		1.00						1.00				
Flpb, ped/bikes		0.99						1.00				
Frt		1.00						1.00				
Flt Protected		0.99						1.00				
Satd. Flow (prot)		4595						5085				
Flt Permitted		0.99						1.00				
Satd. Flow (perm)		4595						5085				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	151	562	0	0	0	0	0	823	0	0	0	0
RTOR Reduction (vph)	0	36	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	677	0	0	0	0	0	823	0	0	0	0
Confl. Peds. (#/hr)	34		11	11		34	26		13	13		26
Confl. Bikes (#/hr)			16						15			
Parking (#/hr)		10										
Turn Type	Perm											
Protected Phases		2						1				
Permitted Phases	2											
Actuated Green, G (s)		21.2						15.8				
Effective Green, g (s)		21.2						15.8				
Actuated g/C Ratio		0.47						0.35				
Clearance Time (s)		3.0						5.0				
Vehicle Extension (s)		2.0						2.0				
Lane Grp Cap (vph)		2165						1785				
v/s Ratio Prot								c0.16				
v/s Ratio Perm		0.15										
v/c Ratio		0.31						0.46				
Uniform Delay, d1		7.4						11.3				
Progression Factor		1.00						1.00				
Incremental Delay, d2		0.4						0.9				
Delay (s)		7.8						12.2				
Level of Service		A						B				
Approach Delay (s)		7.8			0.0			12.2			0.0	
Approach LOS		A			A			B			A	

Intersection Summary			
HCM Average Control Delay	10.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	37.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	WBL	WBR	NBL	NBR	SEL	SET	SER	NWL	NWT	NWR
Lane Configurations										
Volume (vph)	0	0	0	1405	0	0	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	12	12	12	12	12	12
Total Lost time (s)				4.0						
Lane Util. Factor				0.88						
Frpb, ped/bikes				1.00						
Flpb, ped/bikes				1.00						
Frt				0.85						
Flt Protected				1.00						
Satd. Flow (prot)				2787						
Flt Permitted				1.00						
Satd. Flow (perm)				2787						
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	1527	0	0	0	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	0	1527	0	0	0	0	0	0
Confl. Peds. (#/hr)							24	24		
Turn Type				custom						
Protected Phases				6						
Permitted Phases				6						
Actuated Green, G (s)				35.2						
Effective Green, g (s)				35.2						
Actuated g/C Ratio				0.78						
Clearance Time (s)				4.0						
Vehicle Extension (s)				2.0						
Lane Grp Cap (vph)				2180						
v/s Ratio Prot				c0.55						
v/s Ratio Perm										
v/c Ratio				0.70						
Uniform Delay, d1				2.4						
Progression Factor				1.00						
Incremental Delay, d2				1.9						
Delay (s)				4.3						
Level of Service				A						
Approach Delay (s)	0.0		4.3			0.0			0.0	
Approach LOS	A		A			A			A	

Intersection Summary			
HCM Average Control Delay	4.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	9.8
Intersection Capacity Utilization	52.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	340	101	0	0	0	0	0	0	99	304	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		3.5									3.5	
Lane Util. Factor		0.86									0.86	
Frpb, ped/bikes		0.99									1.00	
Flpb, ped/bikes		1.00									0.99	
Frt		0.97									1.00	
Flt Protected		1.00									0.99	
Satd. Flow (prot)		5425									5548	
Flt Permitted		1.00									0.99	
Satd. Flow (perm)		5425									5548	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	370	110	0	0	0	0	0	0	108	330	0
RTOR Reduction (vph)	0	50	0	0	0	0	0	0	0	0	71	0
Lane Group Flow (vph)	0	430	0	0	0	0	0	0	0	0	367	0
Confl. Peds. (#/hr)	38		35	35		38	46		44	44		46
Confl. Bikes (#/hr)			7									17
Parking (#/hr)		20									20	
Turn Type										Perm		
Protected Phases		2									4	
Permitted Phases										4		
Actuated Green, G (s)		32.5									20.5	
Effective Green, g (s)		32.5									20.5	
Actuated g/C Ratio		0.54									0.34	
Clearance Time (s)		3.5									3.5	
Lane Grp Cap (vph)		2939									1896	
v/s Ratio Prot		c0.08										
v/s Ratio Perm											0.07	
v/c Ratio		0.15									0.19	
Uniform Delay, d1		6.8									13.9	
Progression Factor		1.00									1.00	
Incremental Delay, d2		0.1									0.2	
Delay (s)		6.9									14.2	
Level of Service		A									B	
Approach Delay (s)		6.9			0.0			0.0			14.2	
Approach LOS		A			A			A			B	

Intersection Summary			
HCM Average Control Delay	10.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.16		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	7.0
Intersection Capacity Utilization	35.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	51	382	6	0	0	0	0	546	180	42	99	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						3.5			3.5	
Lane Util. Factor		0.86						0.95			0.95	
Frpb, ped/bikes		1.00						0.97			1.00	
Flpb, ped/bikes		1.00						1.00			0.99	
Frt		1.00						0.96			1.00	
Flt Protected		0.99						1.00			0.99	
Satd. Flow (prot)		5474						2849			2984	
Flt Permitted		0.99						1.00			0.73	
Satd. Flow (perm)		5474						2849			2200	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	55	415	7	0	0	0	0	593	196	46	108	0
RTOR Reduction (vph)	0	3	0	0	0	0	0	54	0	0	0	0
Lane Group Flow (vph)	0	474	0	0	0	0	0	735	0	0	154	0
Confl. Peds. (#/hr)	27		21	21		27	32		114	114		32
Confl. Bikes (#/hr)			27						6			2
Bus Blockages (#/hr)	0	25	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)		20						10			10	
Turn Type	Perm									Perm		
Protected Phases		2						4			4	
Permitted Phases	2									4		
Actuated Green, G (s)		32.0						20.5			20.5	
Effective Green, g (s)		32.0						20.5			20.5	
Actuated g/C Ratio		0.53						0.34			0.34	
Clearance Time (s)		4.0						3.5			3.5	
Lane Grp Cap (vph)		2919						973			752	
v/s Ratio Prot								c0.26				
v/s Ratio Perm		0.09									0.07	
v/c Ratio		0.16						0.76			0.20	
Uniform Delay, d1		7.2						17.5			14.0	
Progression Factor		0.82						1.00			1.00	
Incremental Delay, d2		0.1						5.4			0.6	
Delay (s)		5.9						23.0			14.6	
Level of Service		A						C			B	
Approach Delay (s)		5.9			0.0			23.0			14.6	
Approach LOS		A			A			C			B	

Intersection Summary			
HCM Average Control Delay	16.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	56.2%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	288	0	0	0	0	405
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width	14	10	10	10	10	10
Total Lost time (s)	3.0					3.0
Lane Util. Factor	0.97					0.86
Frpb, ped/bikes	1.00					1.00
Flpb, ped/bikes	1.00					1.00
Frt	1.00					1.00
Flt Protected	0.95					1.00
Satd. Flow (prot)	3296					5682
Flt Permitted	0.95					1.00
Satd. Flow (perm)	3296					5682
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	313	0	0	0	0	440
RTOR Reduction (vph)	202	0	0	0	0	0
Lane Group Flow (vph)	111	0	0	0	0	440
Confl. Peds. (#/hr)	4	113		92	92	
Confl. Bikes (#/hr)		8				
Parking (#/hr)	20					20
Turn Type						
Protected Phases	2					1
Permitted Phases						
Actuated Green, G (s)	16.0					23.0
Effective Green, g (s)	16.0					23.0
Actuated g/C Ratio	0.36					0.51
Clearance Time (s)	3.0					3.0
Lane Grp Cap (vph)	1172					2904
v/s Ratio Prot	c0.03					c0.08
v/s Ratio Perm						
v/c Ratio	0.09					0.15
Uniform Delay, d1	9.7					5.8
Progression Factor	4.53					1.00
Incremental Delay, d2	0.2					0.1
Delay (s)	44.0					5.9
Level of Service	D					A
Approach Delay (s)	44.0		0.0			5.9
Approach LOS	D		A			A

Intersection Summary			
HCM Average Control Delay	21.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.13		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	25.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	32	177	98	48	628	0	0	42	63
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	10	10	10	10	10	10	14	10
Total Lost time (s)					4.0		4.0	4.0			4.0	
Lane Util. Factor					0.91		1.00	0.95			1.00	
Frpb, ped/bikes					0.97		1.00	1.00			0.95	
Flpb, ped/bikes					0.99		0.94	1.00			1.00	
Frt					0.95		1.00	1.00			0.92	
Flt Protected					0.99		0.95	1.00			1.00	
Satd. Flow (prot)					3952		1326	3056			1740	
Flt Permitted					0.99		0.68	1.00			1.00	
Satd. Flow (perm)					3952		954	3056			1740	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	35	192	107	52	683	0	0	46	68
RTOR Reduction (vph)	0	0	0	0	57	0	0	0	0	0	36	0
Lane Group Flow (vph)	0	0	0	0	277	0	52	683	0	0	78	0
Confl. Peds. (#/hr)	96		69	69		96	101		99	99		101
Confl. Bikes (#/hr)						9						10
Parking (#/hr)					30		10	10				10
Turn Type				Perm			Perm					
Protected Phases					2			1			1	
Permitted Phases				2			1					
Actuated Green, G (s)					16.0		21.0	21.0			21.0	
Effective Green, g (s)					16.0		21.0	21.0			21.0	
Actuated g/C Ratio					0.36		0.47	0.47			0.47	
Clearance Time (s)					4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)					1405		445	1426			812	
v/s Ratio Prot								c0.22			0.04	
v/s Ratio Perm					0.07		0.05					
v/c Ratio					0.20		0.12	0.48			0.10	
Uniform Delay, d1					10.0		6.8	8.2			6.7	
Progression Factor					1.00		0.50	0.74			1.00	
Incremental Delay, d2					0.3		0.5	1.0			0.2	
Delay (s)					10.4		3.9	7.2			6.9	
Level of Service					B		A	A			A	
Approach Delay (s)		0.0			10.4			6.9			6.9	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	7.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.36		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	48.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	195	44	0	0	0	0	0	0	126	567	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	11	11	11	10	10	10	10	10	10	10	10	10
Total Lost time (s)		4.0	4.0								4.0	
Lane Util. Factor		0.95	1.00								0.86	
Frpb, ped/bikes		1.00	0.81								1.00	
Flpb, ped/bikes		1.00	1.00								0.97	
Frt		1.00	0.85								1.00	
Flt Protected		1.00	1.00								0.99	
Satd. Flow (prot)		3165	1052								5484	
Flt Permitted		1.00	1.00								0.99	
Satd. Flow (perm)		3165	1052								5484	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	212	48	0	0	0	0	0	0	137	616	0
RTOR Reduction (vph)	0	0	34	0	0	0	0	0	0	0	45	0
Lane Group Flow (vph)	0	212	14	0	0	0	0	0	0	0	708	0
Confl. Peds. (#/hr)	146		179	179		146	155		153	153		155
Confl. Bikes (#/hr)			8									7
Parking (#/hr)		10	10								20	
Turn Type			Perm							Perm		
Protected Phases		2									1	
Permitted Phases			2							1		
Actuated Green, G (s)		27.0	27.0								29.0	
Effective Green, g (s)		27.0	27.0								29.0	
Actuated g/C Ratio		0.30	0.30								0.32	
Clearance Time (s)		4.0	4.0								4.0	
Lane Grp Cap (vph)		950	316								1767	
v/s Ratio Prot		c0.07										
v/s Ratio Perm			0.01								0.13	
v/c Ratio		0.22	0.05								0.40	
Uniform Delay, d1		23.6	22.4								23.7	
Progression Factor		1.00	1.00								0.95	
Incremental Delay, d2		0.5	0.3								0.7	
Delay (s)		24.2	22.6								23.3	
Level of Service		C	C								C	
Approach Delay (s)		23.9			0.0			0.0			23.3	
Approach LOS		C			A			A			C	

Intersection Summary			
HCM Average Control Delay	23.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.32		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	34.0
Intersection Capacity Utilization	53.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	110	206	5	0	0	0	0	566	103	14	60	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	12	12	12	12	12	10	10	10
Total Lost time (s)		4.0						3.0		3.0	3.0	
Lane Util. Factor		0.91						0.95		1.00	1.00	
Frpb, ped/bikes		1.00						0.99		1.00	1.00	
Flpb, ped/bikes		0.98						1.00		0.99	1.00	
Frt		1.00						0.98		1.00	1.00	
Flt Protected		0.98						1.00		0.95	1.00	
Satd. Flow (prot)		4574						3179		1637	1739	
Flt Permitted		0.98						1.00		0.31	1.00	
Satd. Flow (perm)		4574						3179		526	1739	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	120	224	5	0	0	0	0	615	112	15	65	0
RTOR Reduction (vph)	0	3	0	0	0	0	0	33	0	0	0	0
Lane Group Flow (vph)	0	346	0	0	0	0	0	694	0	15	65	0
Confl. Peds. (#/hr)	61		78	78		61	123		39	39		123
Confl. Bikes (#/hr)			18						3			6
Parking (#/hr)		20						10				
Turn Type	Perm									Perm		
Protected Phases		2						1			1	
Permitted Phases	2									1		
Actuated Green, G (s)		18.0						20.0		20.0	20.0	
Effective Green, g (s)		18.0						20.0		20.0	20.0	
Actuated g/C Ratio		0.40						0.44		0.44	0.44	
Clearance Time (s)		4.0						3.0		3.0	3.0	
Lane Grp Cap (vph)		1830						1413		234	773	
v/s Ratio Prot								c0.22			0.04	
v/s Ratio Perm		0.08								0.03		
v/c Ratio		0.19						0.49		0.06	0.08	
Uniform Delay, d1		8.8						8.9		7.1	7.2	
Progression Factor		0.83						0.41		0.73	0.72	
Incremental Delay, d2		0.2						1.1		0.5	0.2	
Delay (s)		7.5						4.7		5.7	5.4	
Level of Service		A						A		A	A	
Approach Delay (s)		7.5			0.0			4.7			5.5	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	5.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	7.0
Intersection Capacity Utilization	48.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	227	676	0	0	0	0	0	389	222
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						0.98	0.88
Flpb, ped/bikes				0.87	1.00						1.00	1.00
Frt				1.00	1.00						0.97	0.85
Flt Protected				0.95	1.00						1.00	1.00
Satd. Flow (prot)				1046	4235						4057	949
Flt Permitted				0.95	1.00						1.00	1.00
Satd. Flow (perm)				1046	4235						4057	949
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	247	735	0	0	0	0	0	423	241
RTOR Reduction (vph)	0	0	0	155	4	0	0	0	0	0	34	101
Lane Group Flow (vph)	0	0	0	67	757	0	0	0	0	0	481	48
Confl. Peds. (#/hr)	101		134	134		101	114		129	129		114
Confl. Bikes (#/hr)						6						9
Parking (#/hr)				10	10						10	10
Turn Type				Perm								Perm
Protected Phases					2						1	
Permitted Phases				2								1
Actuated Green, G (s)				27.0	27.0						29.0	29.0
Effective Green, g (s)				27.0	27.0						29.0	29.0
Actuated g/C Ratio				0.30	0.30						0.32	0.32
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				314	1271						1307	306
v/s Ratio Prot											c0.12	
v/s Ratio Perm				0.06	0.18							0.05
v/c Ratio				0.21	0.60						0.37	0.16
Uniform Delay, d1				23.5	26.8						23.5	21.8
Progression Factor				1.05	0.86						0.08	0.20
Incremental Delay, d2				1.5	2.0						0.7	1.0
Delay (s)				26.3	25.1						2.7	5.5
Level of Service				C	C						A	A
Approach Delay (s)		0.0			25.3			0.0			3.3	
Approach LOS		A			C			A			A	

Intersection Summary			
HCM Average Control Delay	16.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	34.0
Intersection Capacity Utilization	53.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	0	301	68	537	601	0	0	0	65
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	10	10	11	11	10	12	12	12
Total Lost time (s)					3.5		4.0	4.0				4.0
Lane Util. Factor					0.86		0.97	0.95				1.00
Frpb, ped/bikes					0.98		1.00	1.00				0.96
Flpb, ped/bikes					1.00		0.97	1.00				1.00
Frt					0.97		1.00	1.00				0.86
Flt Protected					1.00		0.95	1.00				1.00
Satd. Flow (prot)					5335		2979	3165				1542
Flt Permitted					1.00		0.95	1.00				1.00
Satd. Flow (perm)					5335		2979	3165				1542
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	327	74	584	653	0	0	0	71
RTOR Reduction (vph)	0	0	0	0	49	0	171	0	0	0	0	36
Lane Group Flow (vph)	0	0	0	0	352	0	413	653	0	0	0	35
Confl. Peds. (#/hr)	77		79	79		77	44		22	22		44
Confl. Bikes (#/hr)						9			6			5
Bus Blockages (#/hr)	0	0	0	0	18	0	0	0	0	0	0	0
Parking (#/hr)					20		10	10				
Turn Type							Perm					custom
Protected Phases					2			1				
Permitted Phases							1					1
Actuated Green, G (s)					15.5		22.0	22.0				22.0
Effective Green, g (s)					15.5		22.0	22.0				22.0
Actuated g/C Ratio					0.34		0.49	0.49				0.49
Clearance Time (s)					3.5		4.0	4.0				4.0
Lane Grp Cap (vph)					1838		1456	1547				754
v/s Ratio Prot					c0.07			c0.21				
v/s Ratio Perm							0.14					0.02
v/c Ratio					0.19		0.28	0.42				0.05
Uniform Delay, d1					10.4		6.8	7.4				6.0
Progression Factor					1.00		0.73	0.54				1.00
Incremental Delay, d2					0.2		0.4	0.8				0.1
Delay (s)					10.6		5.5	4.8				6.1
Level of Service					B		A	A				A
Approach Delay (s)		0.0			10.6			5.1			6.1	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	6.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.33		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	51.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	131	251	0	0	0	0	0	1007	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	11	11	11	12	12	12	12	12	12	12	12	12
Total Lost time (s)		3.0						5.0				
Lane Util. Factor		0.91						0.91				
Frpb, ped/bikes		1.00						1.00				
Flpb, ped/bikes		1.00						1.00				
Frt		1.00						1.00				
Flt Protected		0.98						1.00				
Satd. Flow (prot)		4573						5085				
Flt Permitted		0.98						1.00				
Satd. Flow (perm)		4573						5085				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	142	273	0	0	0	0	0	1095	0	0	0	0
RTOR Reduction (vph)	0	16	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	399	0	0	0	0	0	1095	0	0	0	0
Confl. Peds. (#/hr)	15		9	9		15	18		27	27		18
Confl. Bikes (#/hr)			26						10			
Parking (#/hr)		10										
Turn Type	Perm											
Protected Phases		2						1				
Permitted Phases	2											
Actuated Green, G (s)		20.4						16.6				
Effective Green, g (s)		20.4						16.6				
Actuated g/C Ratio		0.45						0.37				
Clearance Time (s)		3.0						5.0				
Vehicle Extension (s)		2.0						2.0				
Lane Grp Cap (vph)		2073						1876				
v/s Ratio Prot								c0.22				
v/s Ratio Perm		0.09										
v/c Ratio		0.19						0.58				
Uniform Delay, d1		7.4						11.4				
Progression Factor		1.00						1.00				
Incremental Delay, d2		0.2						1.3				
Delay (s)		7.6						12.8				
Level of Service		A						B				
Approach Delay (s)		7.6			0.0			12.8			0.0	
Approach LOS		A			A			B			A	

Intersection Summary			
HCM Average Control Delay	11.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	41.1%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	WBL	WBR	NBL	NBR	SEL	SET	SER	NWL	NWT	NWR
Lane Configurations										
Volume (vph)	0	0	0	1710	0	0	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	12	12	12	12	12	12
Total Lost time (s)				4.0						
Lane Util. Factor				0.88						
Frpb, ped/bikes				1.00						
Flpb, ped/bikes				1.00						
Frt				0.85						
Flt Protected				1.00						
Satd. Flow (prot)				2787						
Flt Permitted				1.00						
Satd. Flow (perm)				2787						
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	1859	0	0	0	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	0	1859	0	0	0	0	0	0
Confl. Peds. (#/hr)							36	36		
Turn Type				custom						
Protected Phases				6						
Permitted Phases				6						
Actuated Green, G (s)				33.4						
Effective Green, g (s)				33.4						
Actuated g/C Ratio				0.74						
Clearance Time (s)				4.0						
Vehicle Extension (s)				2.0						
Lane Grp Cap (vph)				2069						
v/s Ratio Prot				c0.67						
v/s Ratio Perm										
v/c Ratio				0.90						
Uniform Delay, d1				4.5						
Progression Factor				1.00						
Incremental Delay, d2				6.7						
Delay (s)				11.2						
Level of Service				B						
Approach Delay (s)	0.0		11.2			0.0			0.0	
Approach LOS	A		B			A			A	

Intersection Summary			
HCM Average Control Delay	11.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.90		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	11.6
Intersection Capacity Utilization	63.2%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	582	137	0	0	0	0	0	0	110	824	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		3.5									3.5	
Lane Util. Factor		0.86									0.86	
Frpb, ped/bikes		0.99									1.00	
Flpb, ped/bikes		1.00									0.99	
Frt		0.97									1.00	
Flt Protected		1.00									0.99	
Satd. Flow (prot)		5439									5595	
Flt Permitted		1.00									0.99	
Satd. Flow (perm)		5439									5595	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	633	149	0	0	0	0	0	0	120	896	0
RTOR Reduction (vph)	0	8	0	0	0	0	0	0	0	0	40	0
Lane Group Flow (vph)	0	774	0	0	0	0	0	0	0	0	976	0
Confl. Peds. (#/hr)	58		60	60		58	71		76	76		71
Confl. Bikes (#/hr)			16									8
Parking (#/hr)		20									20	
Turn Type										Perm		
Protected Phases		2									4	
Permitted Phases										4		
Actuated Green, G (s)		32.5									20.5	
Effective Green, g (s)		32.5									20.5	
Actuated g/C Ratio		0.54									0.34	
Clearance Time (s)		3.5									3.5	
Lane Grp Cap (vph)		2946									1912	
v/s Ratio Prot		c0.14										
v/s Ratio Perm											0.17	
v/c Ratio		0.26									0.51	
Uniform Delay, d1		7.3									15.7	
Progression Factor		1.00									1.00	
Incremental Delay, d2		0.2									1.0	
Delay (s)		7.6									16.7	
Level of Service		A									B	
Approach Delay (s)		7.6			0.0			0.0			16.7	
Approach LOS		A			A			A			B	

Intersection Summary			
HCM Average Control Delay	12.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.36		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	7.0
Intersection Capacity Utilization	36.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	112	568	12	0	0	0	0	438	193	85	147	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						3.5			3.5	
Lane Util. Factor		0.86						0.95			0.95	
Frpb, ped/bikes		1.00						0.95			1.00	
Flpb, ped/bikes		0.99						1.00			0.98	
Frt		1.00						0.95			1.00	
Flt Protected		0.99						1.00			0.98	
Satd. Flow (prot)		5405						2768			2950	
Flt Permitted		0.99						1.00			0.64	
Satd. Flow (perm)		5405						2768			1925	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	122	617	13	0	0	0	0	476	210	92	160	0
RTOR Reduction (vph)	0	4	0	0	0	0	0	84	0	0	0	0
Lane Group Flow (vph)	0	748	0	0	0	0	0	602	0	0	252	0
Confl. Peds. (#/hr)	72		62	62		72	63		147	147		63
Confl. Bikes (#/hr)			33						19			6
Bus Blockages (#/hr)	0	25	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)		20						10			10	
Turn Type	Perm									Perm		
Protected Phases		2						4			4	
Permitted Phases	2									4		
Actuated Green, G (s)		32.0						20.5			20.5	
Effective Green, g (s)		32.0						20.5			20.5	
Actuated g/C Ratio		0.53						0.34			0.34	
Clearance Time (s)		4.0						3.5			3.5	
Lane Grp Cap (vph)		2883						946			658	
v/s Ratio Prot								c0.22				
v/s Ratio Perm		0.14									0.13	
v/c Ratio		0.26						0.64			0.38	
Uniform Delay, d1		7.6						16.6			15.0	
Progression Factor		0.78						1.00			1.00	
Incremental Delay, d2		0.2						3.3			1.7	
Delay (s)		6.1						19.9			16.6	
Level of Service		A						B			B	
Approach Delay (s)		6.1			0.0			19.9			16.6	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM Average Control Delay	13.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	59.6%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	288	0	0	0	0	961
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width	14	10	10	10	10	10
Total Lost time (s)	3.0					3.0
Lane Util. Factor	0.97					0.86
Frpb, ped/bikes	1.00					1.00
Flpb, ped/bikes	1.00					1.00
Frt	1.00					1.00
Flt Protected	0.95					1.00
Satd. Flow (prot)	3296					5682
Flt Permitted	0.95					1.00
Satd. Flow (perm)	3296					5682
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	313	0	0	0	0	1045
RTOR Reduction (vph)	53	0	0	0	0	0
Lane Group Flow (vph)	260	0	0	0	0	1045
Confl. Peds. (#/hr)	4	319		92	92	
Confl. Bikes (#/hr)		5		15		
Parking (#/hr)	20					20
Turn Type						
Protected Phases	2					1
Permitted Phases						
Actuated Green, G (s)	16.0					23.0
Effective Green, g (s)	16.0					23.0
Actuated g/C Ratio	0.36					0.51
Clearance Time (s)	3.0					3.0
Lane Grp Cap (vph)	1172					2904
v/s Ratio Prot	c0.08					c0.18
v/s Ratio Perm						
v/c Ratio	0.22					0.36
Uniform Delay, d1	10.1					6.6
Progression Factor	1.24					1.00
Incremental Delay, d2	0.4					0.3
Delay (s)	13.0					6.9
Level of Service	B					A
Approach Delay (s)	13.0		0.0			6.9
Approach LOS	B		A			A

Intersection Summary			
HCM Average Control Delay	8.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.30		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	33.1%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	32	78	142	93	489	0	0	55	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	10	10	10	10	10	10	14	10
Total Lost time (s)					4.0		4.0	4.0			4.0	
Lane Util. Factor					0.91		1.00	0.95			1.00	
Frpb, ped/bikes					0.94		1.00	1.00			1.00	
Flpb, ped/bikes					0.98		0.93	1.00			1.00	
Frt					0.92		1.00	1.00			0.99	
Flt Protected					0.99		0.95	1.00			1.00	
Satd. Flow (prot)					3619		1301	3056			1965	
Flt Permitted					0.99		0.72	1.00			1.00	
Satd. Flow (perm)					3619		981	3056			1965	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	35	85	154	101	532	0	0	60	3
RTOR Reduction (vph)	0	0	0	0	88	0	0	0	0	0	2	0
Lane Group Flow (vph)	0	0	0	0	186	0	101	532	0	0	61	0
Confl. Peds. (#/hr)	110		134	134		110	124		102	102		124
Confl. Bikes (#/hr)						18			5			8
Parking (#/hr)					30		10	10				10
Turn Type				Perm			Perm					
Protected Phases					2			1			1	
Permitted Phases				2			1					
Actuated Green, G (s)					16.0		21.0	21.0			21.0	
Effective Green, g (s)					16.0		21.0	21.0			21.0	
Actuated g/C Ratio					0.36		0.47	0.47			0.47	
Clearance Time (s)					4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)					1287		458	1426			917	
v/s Ratio Prot								c0.17			0.03	
v/s Ratio Perm					0.05		0.10					
v/c Ratio					0.14		0.22	0.37			0.07	
Uniform Delay, d1					9.9		7.1	7.7			6.6	
Progression Factor					1.00		0.90	0.98			1.00	
Incremental Delay, d2					0.2		1.0	0.7			0.1	
Delay (s)					10.1		7.4	8.3			6.7	
Level of Service					B		A	A			A	
Approach Delay (s)		0.0			10.1			8.1			6.7	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.27		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	46.5%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	261	91	0	0	0	0	0	0	202	1034	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	11	11	11	10	10	10	10	10	10	10	10	10
Total Lost time (s)		4.0	4.0								4.0	
Lane Util. Factor		0.95	1.00								0.86	
Frpb, ped/bikes		1.00	0.66								1.00	
Flpb, ped/bikes		1.00	1.00								0.95	
Frt		1.00	0.85								1.00	
Flt Protected		1.00	1.00								0.99	
Satd. Flow (prot)		3165	859								5344	
Flt Permitted		1.00	1.00								0.99	
Satd. Flow (perm)		3165	859								5344	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	284	99	0	0	0	0	0	0	220	1124	0
RTOR Reduction (vph)	0	0	69	0	0	0	0	0	0	0	39	0
Lane Group Flow (vph)	0	284	30	0	0	0	0	0	0	0	1305	0
Confl. Peds. (#/hr)	336		456	456		336	410		406	406		410
Confl. Bikes (#/hr)			9									15
Parking (#/hr)		10	10								20	
Turn Type			Perm							Perm		
Protected Phases		2									1	
Permitted Phases			2							1		
Actuated Green, G (s)		27.0	27.0								29.0	
Effective Green, g (s)		27.0	27.0								29.0	
Actuated g/C Ratio		0.30	0.30								0.32	
Clearance Time (s)		4.0	4.0								4.0	
Lane Grp Cap (vph)		950	258								1722	
v/s Ratio Prot		c0.09										
v/s Ratio Perm			0.03								0.24	
v/c Ratio		0.30	0.12								0.76	
Uniform Delay, d1		24.2	22.8								27.3	
Progression Factor		1.00	1.00								0.95	
Incremental Delay, d2		0.8	0.9								3.0	
Delay (s)		25.0	23.7								29.0	
Level of Service		C	C								C	
Approach Delay (s)		24.7			0.0			0.0			29.0	
Approach LOS		C			A			A			C	

Intersection Summary			
HCM Average Control Delay	28.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	34.0
Intersection Capacity Utilization	53.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	155	298	10	0	0	0	0	427	133	22	64	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	12	12	12	12	12	10	10	10
Total Lost time (s)		4.0						3.0		3.0	3.0	
Lane Util. Factor		0.91						0.95		1.00	1.00	
Frpb, ped/bikes		1.00						0.98		1.00	1.00	
Flpb, ped/bikes		0.97						1.00		0.98	1.00	
Frt		1.00						0.96		1.00	1.00	
Flt Protected		0.98						1.00		0.95	1.00	
Satd. Flow (prot)		4506						3100		1613	1739	
Flt Permitted		0.98						1.00		0.37	1.00	
Satd. Flow (perm)		4506						3100		629	1739	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	168	324	11	0	0	0	0	464	145	24	70	0
RTOR Reduction (vph)	0	5	0	0	0	0	0	66	0	0	0	0
Lane Group Flow (vph)	0	498	0	0	0	0	0	543	0	24	70	0
Confl. Peds. (#/hr)	114		82	82		114	223		85	85		223
Confl. Bikes (#/hr)			25						16			9
Parking (#/hr)		20						10				
Turn Type	Perm									Perm		
Protected Phases		2						1			1	
Permitted Phases	2									1		
Actuated Green, G (s)		18.0						20.0		20.0	20.0	
Effective Green, g (s)		18.0						20.0		20.0	20.0	
Actuated g/C Ratio		0.40						0.44		0.44	0.44	
Clearance Time (s)		4.0						3.0		3.0	3.0	
Lane Grp Cap (vph)		1802						1378		280	773	
v/s Ratio Prot								c0.18			0.04	
v/s Ratio Perm		0.11								0.04		
v/c Ratio		0.28						0.39		0.09	0.09	
Uniform Delay, d1		9.1						8.4		7.2	7.2	
Progression Factor		0.94						0.56		0.77	0.78	
Incremental Delay, d2		0.3						0.8		0.6	0.2	
Delay (s)		8.9						5.5		6.1	5.9	
Level of Service		A						A		A	A	
Approach Delay (s)		8.9			0.0			5.5			6.0	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	6.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.34		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	7.0
Intersection Capacity Utilization	46.5%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	368	535	0	0	0	0	0	855	270
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						0.99	0.75
Flpb, ped/bikes				0.74	0.94						1.00	1.00
Frt				1.00	1.00						1.00	0.85
Flt Protected				0.95	0.99						1.00	1.00
Satd. Flow (prot)				895	3980						4210	811
Flt Permitted				0.95	0.99						1.00	1.00
Satd. Flow (perm)				895	3980						4210	811
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	400	582	0	0	0	0	0	929	293
RTOR Reduction (vph)	0	0	0	168	50	0	0	0	0	0	3	179
Lane Group Flow (vph)	0	0	0	72	692	0	0	0	0	0	955	85
Confl. Peds. (#/hr)	217		259	259		217	256		252	252		256
Confl. Bikes (#/hr)						14						8
Parking (#/hr)				10	10						10	10
Turn Type				Perm								Perm
Protected Phases					2						1	
Permitted Phases				2								1
Actuated Green, G (s)				27.0	27.0						29.0	29.0
Effective Green, g (s)				27.0	27.0						29.0	29.0
Actuated g/C Ratio				0.30	0.30						0.32	0.32
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				269	1194						1357	261
v/s Ratio Prot											c0.23	
v/s Ratio Perm				0.08	0.17							0.10
v/c Ratio				0.27	0.58						0.70	0.33
Uniform Delay, d1				24.0	26.7						26.7	23.1
Progression Factor				1.21	0.85						0.12	1.28
Incremental Delay, d2				2.4	2.0						2.1	2.2
Delay (s)				31.4	24.7						5.3	31.7
Level of Service				C	C						A	C
Approach Delay (s)		0.0			26.4			0.0			11.0	
Approach LOS		A			C			A			B	

Intersection Summary			
HCM Average Control Delay	17.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	34.0
Intersection Capacity Utilization	53.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	0	394	99	435	461	0	0	0	74
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	10	10	11	11	10	12	12	12
Total Lost time (s)					3.5		4.0	4.0				4.0
Lane Util. Factor					0.86		0.97	0.95				1.00
Frpb, ped/bikes					0.98		1.00	1.00				0.91
Flpb, ped/bikes					1.00		0.92	1.00				1.00
Frt					0.97		1.00	1.00				0.86
Flt Protected					1.00		0.95	1.00				1.00
Satd. Flow (prot)					5310		2836	3165				1468
Flt Permitted					1.00		0.95	1.00				1.00
Satd. Flow (perm)					5310		2836	3165				1468
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	428	108	473	501	0	0	0	80
RTOR Reduction (vph)	0	0	0	0	71	0	65	0	0	0	0	41
Lane Group Flow (vph)	0	0	0	0	465	0	408	501	0	0	0	39
Confl. Peds. (#/hr)	79		148	148		79	113		26	26		113
Confl. Bikes (#/hr)						10			6			6
Bus Blockages (#/hr)	0	0	0	0	18	0	0	0	0	0	0	0
Parking (#/hr)					20		10	10				
Turn Type							Perm					custom
Protected Phases					2			1				
Permitted Phases							1					1
Actuated Green, G (s)					15.5		22.0	22.0				22.0
Effective Green, g (s)					15.5		22.0	22.0				22.0
Actuated g/C Ratio					0.34		0.49	0.49				0.49
Clearance Time (s)					3.5		4.0	4.0				4.0
Lane Grp Cap (vph)					1829		1386	1547				718
v/s Ratio Prot					c0.09			c0.16				
v/s Ratio Perm							0.14					0.03
v/c Ratio					0.25		0.29	0.32				0.05
Uniform Delay, d1					10.6		6.9	7.0				6.0
Progression Factor					1.00		0.60	0.67				2.67
Incremental Delay, d2					0.3		0.5	0.5				0.1
Delay (s)					10.9		4.6	5.2				16.3
Level of Service					B		A	A				B
Approach Delay (s)		0.0			10.9			4.9			16.3	
Approach LOS		A			B			A			B	

Intersection Summary			
HCM Average Control Delay	7.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.30		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	50.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	139	517	0	0	0	0	0	757	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	11	11	11	12	12	12	12	12	12	12	12	12
Total Lost time (s)		3.0						5.0				
Lane Util. Factor		0.91						0.91				
Frpb, ped/bikes		1.00						1.00				
Flpb, ped/bikes		0.99						1.00				
Frt		1.00						1.00				
Flt Protected		0.99						1.00				
Satd. Flow (prot)		4595						5085				
Flt Permitted		0.99						1.00				
Satd. Flow (perm)		4595						5085				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	151	562	0	0	0	0	0	823	0	0	0	0
RTOR Reduction (vph)	0	36	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	677	0	0	0	0	0	823	0	0	0	0
Confl. Peds. (#/hr)	34		11	11		34	26		13	13		26
Confl. Bikes (#/hr)			16						15			
Parking (#/hr)		10										
Turn Type	Perm											
Protected Phases		2						1				
Permitted Phases	2											
Actuated Green, G (s)		21.2						15.8				
Effective Green, g (s)		21.2						15.8				
Actuated g/C Ratio		0.47						0.35				
Clearance Time (s)		3.0						5.0				
Vehicle Extension (s)		2.0						2.0				
Lane Grp Cap (vph)		2165						1785				
v/s Ratio Prot								c0.16				
v/s Ratio Perm		0.15										
v/c Ratio		0.31						0.46				
Uniform Delay, d1		7.4						11.3				
Progression Factor		1.00						1.00				
Incremental Delay, d2		0.4						0.9				
Delay (s)		7.8						12.2				
Level of Service		A						B				
Approach Delay (s)		7.8			0.0			12.2			0.0	
Approach LOS		A			A			B			A	

Intersection Summary			
HCM Average Control Delay	10.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	37.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	WBL	WBR	NBL	NBR	SEL	SET	SER	NWL	NWT	NWR
Lane Configurations										
Volume (vph)	0	0	0	1405	0	0	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	12	12	12	12	12	12
Total Lost time (s)				4.0						
Lane Util. Factor				0.88						
Frpb, ped/bikes				1.00						
Flpb, ped/bikes				1.00						
Frt				0.85						
Flt Protected				1.00						
Satd. Flow (prot)				2787						
Flt Permitted				1.00						
Satd. Flow (perm)				2787						
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	1527	0	0	0	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	0	1527	0	0	0	0	0	0
Confl. Peds. (#/hr)							24	24		
Turn Type				custom						
Protected Phases				6						
Permitted Phases				6						
Actuated Green, G (s)				35.2						
Effective Green, g (s)				35.2						
Actuated g/C Ratio				0.78						
Clearance Time (s)				4.0						
Vehicle Extension (s)				2.0						
Lane Grp Cap (vph)				2180						
v/s Ratio Prot				c0.55						
v/s Ratio Perm										
v/c Ratio				0.70						
Uniform Delay, d1				2.4						
Progression Factor				1.00						
Incremental Delay, d2				1.9						
Delay (s)				4.3						
Level of Service				A						
Approach Delay (s)	0.0		4.3			0.0			0.0	
Approach LOS	A		A			A			A	

Intersection Summary			
HCM Average Control Delay	4.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	9.8
Intersection Capacity Utilization	52.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

APPENDIX D – Research on One-Way Conversions

180 Grand Avenue, Suite 250
Oakland, CA 94612
www.dowlinginc.com

510.839.1742
510.839.0871 fax
traffic@dowlinginc.com

Dowling Associates, Inc.

Date: December 19, 2008

Memorandum

To: Mohamed Alaoui, City of Oakland

From: Senanu Ashiabor and Mark Bowman, P.E.

Reference #: City of Oakland On-Call P05117.14

Subject: Chinatown One-Way Street Conversion Study: Task 4: Research on One-Way Conversions

Introduction

This Memo is a summary of the literature search performed by Dowling Associates to:

- Document the experience of cities that have converted from one-way to two-way operations and identify advantages and disadvantages of the two traffic circulation concepts.
- Document the experiences of cities that have converted from two-way to one-way and compare it to the experiences of the former group.
- Document empirical studies that demonstrate a reduction in vehicle speeds through lane reduction in high density urban areas.

For the review we searched the National Transportation Library's Transportation Research Information Services (TRIS), the University of California, Berkeley's library catalog and Google's Transportation Meta Search and Google Scholar search engines. A complete list of the twenty-seven journal articles and engineering reports and studies relevant to the topic are listed in Appendix A.

Summary of Findings

More than seventeen of the articles and studies concerned/advocated for converting two-way streets to one-way streets. Five were on converting one-way streets to two-way streets. The paucity of information of converting to two-way streets is not surprising, since that trend begun in the early 1990s while converting to one-way streets have been in effect from the 1950s.

The key arguments advanced for converting two-way streets to one-way streets are based on capacity, safety, cost and convenience. Specifically:

- Capacity: several studies show implementing one-way streets increase the capacity in a range from 20 to 30 percent above equivalent two-way street.

- Safety: several of the studies record a reduction in the accident rate when converting from two-way to one-way traffic operations.
- Cost: most conversions have been justified based on the fact that converting to one-way street system is cheaper than widening the existing network.
- Convenience: one-way streets are easier to cross for pedestrians (at least mid-block and across), and are easier on the elderly.

In an interesting twist the arguments for converting from one-way to two-way also focus on safety and convenience, in addition to accessibility and environmental issues.

- Safety: slower speeds on two-way streets make it easier for pedestrians to cross.
- Convenience: two-way street networks are easier to navigate compared to one-way networks (which are confusing to non-locals).
- Accessibility: businesses on both sides of the street can be accessed with less driving around the block.
- Downtown environment: reduced speeds lead to a much calmer and pedestrian friendly downtown environment.

The studies on lane reduction reduced focused more on accident rates than vehicle speeds. The implicit assumption driving most studies was that reduced vehicle speeds results in a reduction in vehicle to vehicle and vehicle pedestrian accident rates. Hence most studies tend to focus on accident rates.

Our general finding from the review is there is limited technical guidance on when or where to implement two-way or one-way street systems. Hence, the decision to convert has been made on a case-by-case basis. The cities that have had the most successful conversions have been the ones where the both the community and technical staff were in agreement. The level of agreement is generally enhanced in cases where the city council and technical staff effectively marketed the project to the community, or where the project was initiated by requests from the community.

Impacts of Converting Two-Way Streets to One-Way Streets

Olympia, Washington: A Study of Vehicle Traffic and Business Trends Before and After One-Way Streets (1950): After their 1949 earthquake the City Council implemented a temporary one-way street system on State Avenue and Forth Avenue as the debris was being cleared. Based on a feasibility study by the Traffic Engineering Division of the State Highway Department that a one-way road could potentially enhance the capacity of the existing two-way configuration by 30% a one-way system was implemented on State Avenue and Forth Avenue. Downtown business men opposed the report's recommendations claiming it would affect the business economy and create a safety hazard.

A 'before and after study' from April 1948 to April 1951 examined highway volumes and sales figures to assess the impact of implementation of the one-way system. The data collected showed traffic on State and Forth Avenue increased from 18,100 to 18,400 and then 18,600 over the three year period. The accident rate initially increased from 10.9 to 11.5 and then dropped to 10 accidents per million vehicle miles over the same period. The initial increase in accident rate was attributed to the time it took people to adjust and litigation associated with the business community that delayed installing of appropriate signage in the first year of operations of the one-way system. Retail sales data revealed a downward trend of businesses in Olympia, but sales on businesses on one-way street declined less than those on two-way streets. State sales declined by 4.5%, and sales on two-way streets in Olympia declined by 1.3% while one-way streets business sales increased 1.8%. In general the sales data indicated the one-way system did not have a negative impact on businesses as claimed by the merchants that opposed the plan.

San Jose, California: Utility of One-way Streets in Downtown San Jose, California (1953): This was and engineering report by Faustman, a consultant, recommending Almaden Street and Vine Street be converted to one-way streets. Faustman's analysis involved comparing existing volumes on selected streets with Highway Capacity Manual[1] values. Streets in the study were Almaden, San Fernando, San Carlos, Vine, Fourth and Vine Streets, and Auzerais Avenue. The final recommendation was to install a one-way traffic system on Almaden Street (northbound) and Vine Street (southbound) due to their high volume to capacity ratio. The other streets were to be maintained as two-way streets until congestion levels in the future necessitated implementing one-way systems.

City of Albany, California: Feasibility of One-way Streets in the City of Albany, California (1956): Faustman conducted a study for the city based on traffic volumes. The volume to capacity ratios showed that Higuera and Marsh Streets were close to capacity. As they were next to each other this was an ideal configuration for implementing a one-way system. The reports recommendation was converting Marsh and Monterey Street to one-way north bound streets, and Higuera and Palm to one-way south-bound streets. Google Earth images of the streets shows Higuera and Marsh streets are still operated as one-way streets today. Monterey is a two-way with widened left-turn and right turn pockets at various intersections.

San Luis Obispo, California: Feasibility of One-way Streets in the City of San Luis Obispo, California (1957): The study looked at traffic volumes, mid-block and intersection accident data, curb parking and inventory on to consider implementing a one-way street system. Existing traffic volumes were below Highway Capacity Manual[2] capacity of 600 vehicles per hour. Hence conversion to a one-way street was not warranted on that basis. Relatively high accident rates were observed in mid-block sections of the study area. In addition restricted movement due to the parking conditions in the study area was also noted. Based on these two observations the consultant recommended implementing one-way street system, and prohibiting parking on one side of the street. The issue of impacts on business was not considered critical as there was no significant business activity going on in the study area at that time.

[1] 1950 Highway Capacity Manual

[2] 1950 Highway Capacity Manual

Washington DC: Accelerated D.C. Highway Program and One-way Street Plan (1962): The Special Committee on Traffic in the House of representatives considered objections raised by the Police and Fire Departments to a plan by the D.C. Highway Department to convert an additional 16 miles of two-way streets to one-way streets. The Police and Fire Departments contented that the plan unnecessarily increased their travel time, and negatively impacted their ability to perform their services. D.C. bus companies also opposed the scheme because they felt it unnecessarily burdened their patrons and operations. They argued it would a) involve altering and inconveniencing riding habits of 200,000 daily bus passengers, b) eliminating many curb zones for passengers, c) triple bus congestion in certain areas, d) triple the number of buses forced to use certain streets.

The Special Committee also noted the fact that 1) some the roads to be converted had just been widen, 2) the scheme would unnecessarily make travel tenuous for the numerous non-locals that visited the capital every year, 3) very little consideration appeared to have been given by the Highway Department to the concerns raised by the Police and Fire Departments, and 4) no compelling studies justifying the plan were presented to the committee. Based on these the committee recommend a temporary freeze on the implementation of the project until more substantial justification could be provided, and necessary measures had been take to address the concern raised by of the Police and Fire Departments. This appears to be a case where the Highway Department spent minimal effort in coordination with relevant stakeholders. A classical case of how transportation related projects can get bogged down in controversy and political wrangling if critical stakeholders are ignored.

Helena, Montana: Economic Analysis of One-Way Couplet: Helena (1967): A 'before and after' study from 1959 to 1966 looked at economic indicators, traffic volumes and accidents data to assess the impact of the Prospect Avenue couplet on the economy. The couplet was constructed over a two-year period from fall of 1960 till July 1962. Six years after construction traffic volume had grown by 87% above pre-construction period on the couplet compared to 39% at a nearby location on Montana Avenue. Accident rates of 141 per 10 million vehicle miles on the couplets were comparable to 144 for the major streets in Great Falls, Montana. The land use trend showed increased and extensive development of commercial properties around the couplets, with abutting property values increasing over eight times from 1959 to 1966 compared to non-abutting properties in the same area. Forty-five business establishments moved to the couplets abutting property from 1960-1965. Forty percent of 58 business owners that had located to the area indicated they did so based on expected growth potential from construction of the couplet. More than 90 % of the business owners interviewed said they preferred the one-way couplet to a two-way system on 11th Avenue. Overall, the study showed construction of the couplet had led to economic growth in the couplet area, and the couplet was favored by both residents and businesses in the area.

Bismarck, North Dakota: Economic and Traffic Effects of Bismarck's 7th and 9th Streets One-Way (1983)*:* A 'before and after' economic study of the conversion of 7th and 9th Streets in Bismarck-Mandan, North Dakota into a one-way pair. The study could not unearth any conclusive significant impacts on land use due to the project. Though residential property sales increased the first year after the project they quickly readjusted back to pre-construction levels. The same phenomenon was observed in the average sale price.

The average daily traffic on 7th Street grew from 2,400 vehicles per day to 10,200. Traffic on 9th Street however decreased slightly from 11,500 to 10,200. The fivefold increase on 7th Street was not unexpected, because it was a local street before the project while 9th Street was an arterial before the project. Despite the increased traffic volume accident data showed both a decrease in the number of accidents per million vehicle miles, and a decrease in the percent of severe accidents for the one-way pair. The number of pedestrian accidents also decreased after implementation of the one-way system. Overall one-way system brought increased flow at higher speeds with a reduction in both delays and accidents. The project was favorably accepted by the public from the attitudinal survey, and survey respondents indicated a desire for more one-way street conversions in Bismarck

Jerusalem: Safety of one-way urban streets (1990)*:* Assessed safety of one-way and two-way streets in downtown Jerusalem using accident data. Streets were classified into locals, arterials and collectors. The accident rate was always higher for one-way streets than two-way streets. In non-CBD areas the mid-block pedestrian accident rate on one-way streets is 1.5 times that of two-way streets, and 1.24 times for vehicle accidents. The intersection accident rate ratios increased to 4.65 and 3.96 for pedestrians and vehicles respectively. In CBD areas the mid-block pedestrian accident rate on one-way streets is 0.99 that of two-way streets, and 1.43 times for vehicle accidents. Indicating the pedestrian accident rate is lower in the CBD. The study also notes that the high accident rates in non-CBD's are concentrated at the non-signalized intersections.

This study is referred to by both proponents and opponents of one-way streets to justify their positions. Opponents of one-way systems use it to indicate one-way networks are unsafe, while proponents point to the small sample size and that it does not apply to CBD's. The study has some caveats; the authors note the relatively sample size of accidents in the CBD area. They also note the doubtful finding that speeds on one-way streets were slightly lower than two-way streets. The data seems to suggest there are more accidents on two-way streets that have lower speeds than one-way streets. There is also the question of transferability of the results to situations in the U.S.

No Two-Ways About It: One-Way Streets are Better than Two-Way (2005): The author quotes from published studies in Denver, Portland, Indianapolis, Lubbock (Texas) and Sacramento to show converting one-way streets to two-way streets reduced safety by increasing accident rates. A few of his sources are anecdotal and some of the studies date back to the 1950s. A summary of some of the studies he refers to are listed below:

- City of Denver: Accident rates increased 37% with converting one-way to two-way streets (One-way Street Monitoring Study: Phase 1 Conversion Report, 1990)
- Indianapolis: 33% increase in accident rates
- Lubbock (Texas): 12% decrease in traffic with 25% more accidents and 34% increase in property damage (City of Lubbock, "Main & 10th Street Accident Analysis Before and After Study, 1998)

He cites studies that show that converting two-streets to one-way not only increased speeds and reduced stops but also led in some cases to a 38% decrease in accidents.

- Sacramento: 14% fewer accidents thought traffic increased by 17% (Faustman, Improving Traffic Access to the Sacramento Business District, 1950)
- Portland study: 51% reduction in accidents at intersections and 37% fewer between intersections (Fowler, One-Way Grid System of Portland Oregon, 1953)
- Olympia: Business on one-way streets are doing better than comparable business on two-way streets (Faustman, 1952)
- Oregon State Highway Department study: 10% fewer accidents and 23% more traffic

The authors posit that City Councils are adopting a wrong approach by allowing Planners instead of Engineers to make judgment calls about which kind of road system is safer. Though he has data to support his position, his analysis is focused on downtown and central business districts and the conclusions may not be applicable to residential neighborhoods.

One-Way Streets Provide Superior Safety and Convenience (1998): A review of the various issues associated with converting between one-way and two-way streets. The author favors maintaining one-way streets. The paper is targeted at addressing issues raised by downtown revitalization advocates to convert one-way streets back to two-way streets. Some of the disadvantages of one-way streets raised mentioned are:

- Infrequent users are confused by the system: true, however these users are usually a small proportion of the populace visiting downtown
- Transit operators face long and circuitous routes that increase fuel costs and wear and tear on transit vehicles; and impose long walks for passengers and confusion about location of transit stops
- Emergency vehicles face more crowded intersections and longer trips: in a well designed one-way system emergency vehicles are less likely to have to make maneuvers like driving in opposite direction of traffic flow
- Merchants complain one-way systems adversely affect traffic: argues that studies have shown this concern to be unfounded

The three major advantages of one-way streets are safety, capacity and convenience.

- Safety: Substantially reduced vehicle to vehicle and vehicle to pedestrian conflicts at one-way intersections enhances safety (Wiley reported 25% reduction in intersection accidents, and Karagheuzoff reported 22%), also one-way systems are easier on elderly drivers and pedestrians (Robert 1995)
- Capacity: the elimination of left-turning movement conflicts reduces congestion, and when combined with progressive signal timing plans significantly increases capacity of one-way streets in the range of 22 to 33% over two-way streets

Convenience: installation of mid-block crossings reduces pedestrian travel time and distance, also one-way systems can have both left-turn-on-red and right-turn-on-red, and conversion of two-way to one-way comes at a minimal cost.

Impacts of Converting One-Way Streets to Two-Way Streets

Conversion of Streets from One-way to Two-way Operation (2000): The conclusion of this study review was that "the single most important factor in successful conversion from one-way to two-way operations is a meaningful public involvement process (supported by straightforward technical studies) and that articulated guidelines for such conversions (e.g., threshold volumes) do not seem to exist." The study involved both a literature review, and survey of practitioners. The literature review went as far back as Canning and Eldridge studies in 1937. They found the key arguments advanced for converting two-way streets to one-way in the literature are; low cost of implementation (relative to street widening), increased capacity, decrease in number of stops, increased speed of vehicles, perceived safety (pedestrians face traffic from only one direction), reduction in accidents, and ease of maintaining signal progression. On the negative side the is the issue of driver confusion (especially for non-local drivers), disruptive impact of business operations on affected and neighborhood streets, pedestrians being forced to cross more lanes of traffic.

Lubbock , Texas: Converting Back to Two-Way Streets in Downtown Lubbock (1998): A review of the conversion couplets on Main Street and 10th Street in Lubbock to two-way streets based on an initiative started by locals and merchants the CBD. The factors in favor of conversion were "1) Less confusion for motorists, especially visitors, 2) Improved access to properties, and 3) Reduced travel distance to destination." The reasons against converting to a two-way system were 1) Approximate cost of $50,000, 2) Increased congestion, 3) Resulting poor signal progression, 4) Small town look, 5) Difficulty in converting back to one-way in the future.

The town voted to go ahead with the conversion and it was completed in March 30, 1995. Before and after data showed a slight increase in congestion, and accidents increased from 45 to 52 on Main Street and 48 to 64 on 10th Street. The City Traffic Engineer pointed out that four intersections removed on 10th street might be responsible for the increase in accidents on that street. Though most of the reasons against the conversion materialized, the City Engineer reported public was happy with the conversion. The community was so pleased with the outcome; the city plans to convert another pair of one-way streets, Buddy Holly Avenue and Texas Avenue, to two-way streets.

Traffic Issues for Smaller Communities (1998): A qualitative treatment of traffic issues for smaller communities. The author proposes that the objective driving development of traffic networks should be different from busy downtown areas. The propose that small communities need among others, 1) Low operating speeds on main streets, 2) An attractive environment, 3) A simple understandable traffic system and by implication fewer one-way streets.

Downtown Streets: Are We Strangling Ourselves on One-Way Networks (2000)*:* Makes the case for converting one-way streets to two-way streets to make downtowns and cities more livable. The authors acknowledge the usual arguments made in favor of one-way streets, increased speed, better signal progression, reduced delay and fewer conflicting movements. They however take the position that the needs of non-vehicle travelers (pedestrians, transit) are largely ignored when using the above metrics. They propose evaluating the network in terms of

- Capacity: acknowledge converting to two-way streets may reduce traffic by 10-20% (actual studies put the figure closer to 30%)
- Out-of-direction travel: contend that one-way systems increase turning movements in a range of 120-160% compared to two-way networks (from analysis of a single network, not based on empirical data)
- Travel Speed: contends that slower vehicular travel speeds are safer for pedestrians
- Pedestrian measures of effectiveness: addressing street crossing from the network level pedestrians face more different types of street configurations patterns to cross in a two-way network than in a one-way network (analysis is skewed, based solely on schematics of network and not interviews or observations of pedestrians)
- Eclipsing of storefront exposure: at intersections on one-way street networks, stores on adjacent street on the side of the direction of travel are eclipsed from sight of traveling vehicles.

The authors contend that evaluation of one-way to two-way street conversion projects should use multiple criteria including those raised above. Comment: Positions will be more compelling if backed with empirical data. Example, examine accident level data for comparable one-way and two-way networks to see if pedestrian vehicular collusions actually increase.

Lane Reduction and Vehicle Speeds in High Density Urban Areas

Relationship Between Lane Width and Speed: Review of Relevant Literature: The consensus of the review was that 1) speed reductions ranged from 3 to 1 mile per hour for lane narrowing projects, 2) minimal impact on operations of buses and trucks, 3) Projects with narrower lanes nearly always reduced accident rates; reported accident reductions ranging from 20 to 50 % (Howard, NCHRP Report 330). In terms of capacity streets lanes narrower than 12 feet reduce the capacity of a roadway. Streets with 11' lanes have 3% less capacity than 12' lanes. Likewise, 10' lane streets have 7% less capacity.

Evaluation of Lane Reduction "Road Diet" Measures and their Effects on Crashes and Injuries: The report focus more on accident data than speeds, but the implicit assumption is that reduction in accident rates is due to reductions in speeds from the road diet. Data for the study was collected from a subset of 12 road diets (2,068 crashes) and 25 comparison sites (8,556 crashes). The key findings of this study are that: 1) Crash frequencies at road diets in the after period were approximately 6 percent lower than at the corresponding comparison sites. 2) Crash rates did not change significantly from the before period to the after period. Although crash rates were lower at road diets than at comparison sites, road diets did not perform better or worse (from the before period to the after period) relative to comparison sites. 3) Road diet conversions did not affect crash severity. 4) Road diet conversions did not result in a significant change in crash types.

The results appear to indicate that if speeds actually reduced on the road diet projects, the reduced speeds did not translate into significant reduction in crashes.

Case Study: Road Diet; The Conversion of Main Street in Butler, Pennsylvania: The study was based on interviews conducted with the Pennsylvania Department of Transportation representatives, transportation consultants, resource agencies, local officials, downtown business owners, and residents of the City of Butler. The issues the road diet project were meant to address were 1) Truck Traffic: improve slow moving heavy truck traffic on Main Street. 2) Congestion: reduced general congestion, due to large traffic volumes, 3) Insufficient Lane Widths: congestion effects were being exacerbated by insufficient lane widths leading to many ‘side-swipe accidents’. 4) Inside lanes became Left Hand Turn Lanes: Inside /Left lanes on acted as a *defacto* left-hand turn-lane blocking faster moving traffic behind them. 5) Drag racing between lights: Drivers frequently accelerate rapidly between lights, attempting to “beat” the adjacent vehicle. 6) Aesthetics: Too much traffic on Main Street. Downtown traffic was heavy. Overall, Main Street traffic had created an “unpleasant” environment in the downtown corridor. The final study recommended reducing Main Street to three lanes from four at a cost of $47,000. A combination of restriping and retiming of traffic signals would provide for improved operations along Main Street.

The final outcome was an efficient three lane configuration that has increased lane widths, eliminated drag racing and weaving, improved vehicular and pedestrian safety, and changed the aesthetic of Main Street from “highway” to “Hometown Street”. Critics would point out that trucks are still present and congestion at peak times can still be a problem, but again, these are not problems that road diet is designed to solve. A road diet program will improve access, safety and operations without negatively effecting road capacity or LOS but, it will do nothing to reduce traffic volumes or alter vehicle mix.

Four-Lane to Three-Lane Conversions: This was a study of 15 conversion and 15 comparison sites with 10 years of annual data on citywide crash rates. The conversion and comparison sites had traffic volumes ranging from 2,000 to 17,400 annual daily traffic (ADT) from 1982–2004 and were mostly located in smaller urbanized areas (ranging in population from 1,169 to 198,682 according to the 2000 Census). The final results showed 1) Potential for a 25 percent reduction in crash frequency per mile and a 19 percent reduction in crash rate. 2) A 34 % reduction in the number of all injury crashes and lower severity of the crashes that do occur. 3) Less involvement of age groups that are traditionally at risk—drivers 25 and under and 65 and older, 4) A significant reduction in the number of crash types related to left turns and stopped traffic.

The authors refer to previous research by Huang et al., that evaluated 12 conversion sites and 25 comparison sites in Washington and California, showed less benefit. Their research showed an average crash frequency that was only 6 percent lower on the conversion sites versus the comparison sites. They also found that crash rates did not change from before to after, that crash severities were not affected, and that crash types did not change significantly.

Other Relevant Studies

Vital Signs: Circulation in the Heart of the City – An Overview of Downtown Traffic (1998)*:* A discussion of how community goals, improved understanding and technology have impacted development of the downtown network, including one-way streets. The author claims the debate has always been how to improve the economic environment of the CBD. The issue is in the 1950s the perception was that "'traffic congestion is what keeps shoppers away from downtown' hence congestion was the problem and economic decline the symptom.", while in the 1990s economic decline is the problem and high volume traffic at high speeds is a symptom of the problem. The author points out that no clear link has been established between one-way streets and economic viability. The Olympia Washington (1952) study that sought to establish this link was inconclusive. The author questions whether a clear link can be established between the direction and speed with which traffic is traveling and the level of economic vibrancy downtown. Until that link is clear it is hard to either reject or accept the push to change from one-way to two-way streets as an attempt to revitalize downtowns.

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Appendix A: Summary of References

No.	Author/Date	Title/Summary
1	Highway Research Board, 1949	Highway Research Board, Bulletin No. 32, *One-Way Streets: Panel Discussion Held at the Twenty-Ninth Annual Meeting* A 1950 forum discussion on one-way streets. Comments from engineers and planners from several States in the U.S. **Philadelphia**: Implementing one-way streets has led to improved flow, and experience in Charleston showed a 26% increase in speed. Problems with narrow streets and complaints from merchants about loss of business. In general residents are accepting and demanding more one-way systems in Philadelphia. **West Virginia:** Floating car studies showed all forms of delay expect those related to signals are reduced significantly with implementation of one-way street systems. **Baltimore**: Improved flow with installation of one-way systems. Notice land use adjacent to one-way streets changing gradually from residential to professional developments, noted 10 to 15% decrease in accidents. Suggested businesses should be encouraged to provide additional of-street parking to minimize impacts of converting to one-way. **Texas**: Noted 36% decrease in accident rates and 24% decrease in property damage incidents. In addition delay reduced by 35% on streets converted to one-way. **Detroit:** Installed innovative mid-block signal systems that are still under evaluation. **New York:** Reported moderate improvement in speed on newly converted one-way streets, even though progressive signal systems had not been installed. **New Hampshire:** Floating car survey showed 30% improvement in speed. Accident rate increased 2.5 times in first two months after one-way system installed and then dropped back to normal after that. The system had also significantly eliminated left-turn conflicts and concentrated flow on one-way streets. **Sacramento:** facing opposition to implementing one-way system from business community.
2	Bugge, W. A, 1952	*A Study of Vehicle Traffic and Business Trends Before and After One-Way Streets in Olympia, Washington:* The one-way street system in Washington started as a temporary measure after their earthquake in April 1949. The streets under discussion were State Avenue and Forth Avenue. Both streets run East-West through downtown of the City of Olympia. Prior to the earthquake each street had two-way traffic with parallel parking on each side of the street. The earthquake dumped rubble from adjacent building unto the roadways forcing the City Council to temporarily mandate one-way travel on both streets. During the period after the earthquake the Traffic Engineering Division of the State Highway Department was asked to conduct a study of the feasibility of implementing a one-way system along the two roads. The study found that a one-way road could potentially enhance the capacity of the existing two-way configuration by 30%. The study also recommended prohibiting parking on one side of the street during peak hours. The final report recommended improved signage and progressively time traffic signals to reduce accidents and congestion. The report's recommendations were opposed by

		downtown business men on the basis it would affect the business economy and create a safety hazard. The study examined highway volumes on the streets a year before and two years after the implementation of the one-way system. Data collected showed that traffic on two streets increased from 18,100 to 18,400 and then 18,600 over that three year period. The accident rate however initially increased from 10.9 to 11.5 and then dropped to 10 accidents per million vehicle miles over the same period. The study attributed the initial increase in accidents to the time it took people to adjust to the system. Also due to the litigation associated with the concerns of business community appropriate signage was not installed till much later in the first year, even thought the one-way system was in operation. The 9% drop in accident rate on the two roads compared favorably with a 25% increase in accidents in the whole city of Olympia. Comparisons of before and after data showed a decrease in non-intersection accidents while intersection related accident rates remained constant. The number of persons injured also dropped significantly. There was a drop in pedestrian related accidents over the first year and then an increase in the second year that could not be explained. Head-on collisions increased slightly while parking related accidents decreased. The study analyzed retail sales data for 84 selected establishments over the same three year period. Analysis showed that while there was a general downward trend of business in Olympia, the sales on businesses on one-way street declined less than those on two-way streets. Comparing 1949 and 1948 sales data, State sales figures were only 95.5% of the previous year, and those for two-way streets in the city of Olympia were 98.7% while one-way streets increased at 101.8%. On the contrary the data showed that 67% on business in Olympia that were experiencing a downward trend in sales volume “Before” the one-way system and an upward trend “After” were located on the one-way streets. While 80% of business that had an upward trend “Before” and a downward trend “After” were located on two-way streets. The comparison may not be fair given that the one-way streets are located downtown and are likely to be less affected by any general downward turn. It does show though that the implementation of the one-way system does not necessarily have negative impact on business as claimed by the merchants that opposed the plan.
3	Quinton Engineers, 1953	*Proposed System of One-Way Streets and its Relationship to Traffic Movement and Business Activity: Central Business District, City of San Diego*: In order to alleviate increasing congestion and delay in downtown San Diego Quinton Engineers conducted a study to develop a one-way street network system for the city. The one-way system was chosen because it would potentially 1) reduce delay and increase capacity, 2) allow progressive signal timing, 3) reduce traffic accidents, 4) ease curb parking, 5) facilitate turning movements, 6) improve pedestrian circulation and reduce headlight glare. The study

		also recommended prohibition of parking on selected streets during peak hours if it was found to be necessary during project implementation. The was an extensive one-way system bounded by Market Street on the south, Ash Street on the north, Pacific Highway and Cabrillo Freeway on the west and east respectively. The project was to be implemented in three phases. No before and after study evaluation report was found for the project.
4	Faustman, J. D, 1953	*Utility of One-way Streets in Downtown San Jose, California*: In the San Jose study the Consultant made their recommendation based on traffic data collected for selected streets in an earlier study. The analysis was done by comparing existing volumes on the street with Highway Capacity Manual[3] values. The streets in the study were Almaden, San Fernando, San Carlos, Vine, Fourth and Vine Streets, and Auzerais Avenue. The Consultant recommended installing a one-way traffic system on Almaden Street (northbound) and Vine Street (southbound). The other streets were to be maintained as two-way streets until congestion levels in the future necessitated implementing one-way systems.
5	Faustman, J. D, 1956	*Feasibility of One-way Streets in the City of Albany, California*: For the San Luis Obispo study the Consultant concentrated on traffic volumes. A spatial plot of existing traffic volumes was over projected capacity values from the Highway Capacity Manual[4]. The plot showed that Higuera and Marsh Streets were close to capacity. As they were next to each other this was an ideal configuration for implementing a one-way system. Two other alternatives to improve traffic flow were considered and rejected. The first was to widen the streets to 64 feet from 40 feet and keep the existing two lanes of parking. This was rejected on the based on the cost of acquiring additional right of way in a business district and the additional hazard associated with widening roads. The other alternative of prohibiting parking at peak hours (4 to 6pm) was rejected due to enforcement costs and issues. The Consultant pointed that even if feasible just one vehicle parked and not towed will substantially degrade the capacity of the link. Based on the fact that the projected capacity was likely to be exceeded within two or three years it was suggested Marsh and Monterey Street be converted to one-way north bound streets, and Higuera and Palm be converted to one-way in the south-bound direction. An inspection of Google Earth images of the streets shows Higuera and Marsh streets are still operated as one-way streets today. Monterey is a

[3] 1950 Highway Capacity Manual

[4] 1950 Highway Capacity Manual

<table>
<tr><td></td><td></td><td>two-way with widen left-turn and right turn pockets at various intersections.</td></tr>
<tr><td>6</td><td>Faustman, J. D
1957</td><td>Feasibility of One-way Streets in the City of San Luis Obispo, California, The study looked at traffic volumes, mid-block and intersection accident data, curb parking and inventory on project study area. The project area was bounded by the area between Madison and Stannage Avenues (inclusive). The bounding intersections on Madison were Buchan and Clay Streets, and for Stannage were Dartmouth Street and Brighton Avenue.
The arguments extended in the study to justify implementing a one-way system were,
Increase in capacity
Accident reduction by:
Minimizing vehicle conflicts
Reducing conflict between vehicles and pedestrians
Eliminating head-on collisions
Eliminating headlight glare
Low cost relative to expanding existing street to carry the same volume of traffic
Easier and faster to install than widening existing street
Flexibility in meeting changing traffic conditions?
On the other hand the disadvantages are: 1) Long and circuitous travel and traffic patterns, 2) Confusion to non-locals, 3) Eliminating turning movements at some intersections leads to increased turning volumes at others, 4) Disruptive effect on business depending on drive-in traffic.
The Consultant found traffic volumes were below existing Highway Capacity Manual[5] capacity of 600 vehicles per hour. Hence conversion to a one-way street was not warranted on that basis. Relatively high accident rates were observed in mid-block sections of the study area. In addition restricted movement due to the parking conditions in the study area was also noted. Based on these two observations the consultant recommended implementing one-way street system, and prohibiting parking on one side of the street. The issue of impacts on business was not considered critical as there was no significant business activity going on in the study area at that time.</td></tr>
<tr><td>7</td><td>Special Committee on Traffic, Committee on the</td><td>Accelerated D.C. Highway Program and One-way Street Plan: The committee considered objections raised by the Police and Fire Departments to a plan by the D.C. Highway Department to convert an additional 16 miles of two-way streets to one-way streets. The reasons advanced by the Highway</td></tr>
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[5] 1950 Highway Capacity Manual

	District of Columbia, 1962	Department were to 1) increase capacity, safety, and speed, and 2) negligible cost of switching from two-way to one-way streets. The Police and Fire Departments contented that the plan unnecessarily increased their travel time, and hence negatively impacted their ability to perform their services. The D.C. bus companies also opposed the scheme because they felt it unnecessarily burdened their patrons and operations. They argued it would a) involve altering and inconveniencing riding habits of 200,000 daily bus passengers, b) many curb zones for passengers would be eliminated, c) bus congestion would be tripled in certain areas, d) triple the number of buses would be forced to use certain streets if the plan was adopted. The committee voiced objection to the scheme, based on the fact that 1) some the road to be converted had just been widen, 2) the scheme would unnecessarily make travel tenuous for the numerous non-locals that visited the capital every year, 3) very little consideration appeared to have been given by the Highway Department to the concerns raised by the Police and Fire Departments, and 4) no compelling studies justifying the plan were presented to the committee. Based on these the committee recommend a temporary freeze on the implementation of the project until more substantial justification could be provided, and necessary measures had been take to address the concern raised by of the Police and Fire Departments. In this case there appears to have been little preparation by the Highway Department in developing the plan. The above goes to show that proposal to convert one-way streets to two-way streets or vice versa can easily get bogged down in controversy and political wrangling if critical stakeholders are ignored.
8	Rybakoff G., Rigler R, 1967	*Economic Analysis of One-Way Couplet: Helena*: A 'before and after' analysis looked at selected economic indicators, traffic volumes and accidents data to assess the impact of the Prospect Avenue couplet on the economy. The couplet was constructed over a two-year period from fall of 1960 till July 1962. The study collected data from 1959 to 1966. The economic indicators used were "1) change in land use, 2) Land and property valuations, 3) Building permits and valuations, 4) Number and type of Business enterprises, and 5) Employment statistics.". The couplet was approximately one mile long and runs eastbound on 11th Avenue and westbound on Prospect Avenue. Six years after construction traffic volume had grown by 87% above pre-construction period on the couplet compared to 39% at a nearby location on Montana Avenue. Credible before accident data was unavailable. Accident rates of 141 per 10 million vehicle miles on the couplets were comparable to 144 for the major streets in Great Falls, Montana. The land use trend showed increased and extensive development of commercial properties around the couplets, with abutting property values increasing over eight times from 1959 to 1966 compared to non-abutting properties in the same area. Forty-five

		business establishments moved to the couplets abutting property from 1960-1965. Forty percent of 58 business owners that had located to the area indicated they did so based on expected growth potential from construction of the couplet. More than 90 % of the business owners interviewed said they preferred the one-way couplet to a two-way system on 11th Avenue. Overall, the study showed construction of the couplet had led to economic growth in the couplet area, and the couplet was favored by both residents and businesses in the area.
9	Enustun N., 1969	*Study of the Operational Aspects of One-Way and Two-Way Streets:* A 'before and after' study of one-way traffic operations in the cities of Lansing and Kalamazoo in Michigan. The study focused on traffic volumes on the streets and did not involve the analysis of any accident data. Analysis of data collected showed average speeds had increased on all the routes converted to one-way. The average speed in Kalamazoo had increased from 18.1 to 23.1 mph and from 25.3 to 28.2 mph in Lansing. Average number of stops in some sections of the study area had dropped from 6.3 to 1.0. Delay in one case dropped from 71 to 11 seconds per mile. Fifteen-minute afternoon peak traffic leaving traffic sections of the study area was observed to have increased by 74%, compared to the 17% increase for the 24 hour total. It was also noted that increased gaps in traffic on the one-way streets made it easier for traffic on side streets to turn unto the one-way streets.
10	Cameron J. W., Johnson K. D., 1983	*Economic and Traffic Effects of Bismarck's 7th and 9th Streets One-Way:* This was initiated as a 'before and after' economic study for the conversion of 7th and 9th Streets in Bismarck-Mandan, North Dakota into a one-way pair. Traffic runs southbound on 7th and northbound on 9th Street. The one-way corridor was 1.5 miles long, and opened to traffic in fall 1978. According to the report the land use changes from residential in the north, to business in the central and commercial in the south. The study collected data on economic impacts, traffic volumes, turning movements, travel time and delay. In addition noise data was collected, and an attitudinal survey was administered to the public. The study could not unearth any conclusive significant impacts on land use due to the project. Though residential property sales increased the first year after the project they quickly readjusted back to pre-construction levels. The same phenomenon was observed in the average sale price. The price deceased by about $2000 the year after the project compared to a control area away from the project and then reset after the first year. The major impacts observed on the project were traffic related. The average daily traffic on 7th Street grew from 2,400 vehicles per day to 10,200. Traffic on 9th Street however decreased slightly from 11,500 to 10,200. The fivefold increase on 7th Street was expected though, because it was a local street before the project while 9th Street was an arterial before the project. Despite the large volume increases and increased turning movements the accident data did not show degradation in safety. The accident

		analysis revealed a both a decrease in the number of accidents per million vehicle miles, and a decrease in the percent of severe accidents for the one-way pair. The accident rate on 7th Street decreased from 34.71 to 23.44, and that for 9th Street decreased from 19.83 to 19.46. Over the same period the accident rates on cross streets decreased but their s accidents increased. The number of pedestrian accidents also decreased after implementation of the one-way system. Overall from a traffic and safety perspective the one-way system brought increased flow at higher speeds with a reduction in both delays and accidents. The project was reported to be favorably accepted by the public from the attitudinal survey, and survey respondents indicated a desire for more one-way street conversions in Bismarck.
11	Hocherman, I., A. S. Hakkert, and J. Bar-Ziv., 1990.	*Safety of one-way urban streets:* Assessed safety of one-way and two-way streets in Jerusalem using accident data. They compared data for both streets in and outside the Central Business District (CBD). Streets were classified into locals, arterials and collectors. Based on all the data tabulated the accident rate was always higher for one-way streets than two-way streets. In non-CBD areas the mid-block pedestrian accident rate on one-way streets is 1.5 that of two-way streets, and 1.24 times for vehicle accidents. The intersection accident rate ratios increase to 4.65 and 3.96 for pedestrians and vehicles respectively. In CBD areas the mid-block pedestrian accident rate on one-way streets is 0.99 that of two-way streets, and 1.43 times for vehicle accidents. Indicating the pedestrian accident rate is lower in the CBD. The study also notes that the high accident rates in non-CBD's are concentrated at the non-signalized intersections. Their study is widely referred to by both proponents and opponents of one-way streets to justify their positions. Opponents of one-way systems use it to indicate one-way networks are unsafe, while proponents point to the small sample size and that it does not apply to CBD's. The study has some caveats; the authors note the sample size of accidents in the CBD was relatively small. They also note the doubtful finding that speeds on one-way streets were slightly lower than two-way streets. Hence, the data seems to suggest there are more accidents on two-way streets that have lower speeds than one-way streets. There is also the question of transferability of the results to situations in the U.S.
16	Hart J., 1998	*Converting Back to Two-Way Streets in Downtown Lubbock*: Discusses the conversion of the couplets on Main Street and 10th Street in Lubbock to two-way streets. The conversion was done based on an initiative started by locals and merchants the CBD. The factors in favor of conversion were "1) Less confusion for motorists, especially visitors, 2) Improved access to properties, and 3) Reduced travel distance to destination.". Given that Lubbock is a medium sized city of 200,000 people the traffic volumes on downtown streets is around 600 vehicles per hour, the first reason does not appear that critical. The reasons against converting to a two-way system were 1) Approximate cost of $50,000, 2)

		Increased congestion, 3) Resulting poor signal progression, 4) Small town look, 5) Difficulty in converting back to one-way in the future. The town voted to go ahead with the conversion and it was completed in March 30, 1995. Before and after data collected showed a slight increase in congestion, however accidents increased from 45 to 52 on Main Street and 48 to 64 on 10th Street. The City traffic engineer pointed out that four intersections removed on 10th street might be responsible for the higher increase in accidents on that street. Though most of the reasons against the conversion materialized, the City Engineer reported public was happy with the conversion. The project was so well accepted the city was planning to convert another pair of one-way streets, Buddy Holly Avenue and Texas Avenue, to two-way streets.
12	Forbes, G., 1998	*Vital Signs: Circulation in the Heart of the City – An Overview of Downtown Traffic:* A discussion of how community goals, improved understanding and technology have impacted development of the downtown network, including one-way streets. It claims the debate has always been how to improve the economic environment of the CBD. The issue is in the 1950s the perception was that "'traffic congestion is what keeps shoppers away from downtown' hence congestion was the problem and economic decline the symptom.", while in the 1990s economic decline is the problem and high volume traffic at high speeds is a symptom of the problem. The author points out that no clear link has been established between one-way streets and economic viability. The Olympia Washington (1952) study that sought to establish this link was inconclusive. The author questions whether a clear link can be established between the direction and speed with which traffic is traveling and the level of economic vibrancy downtown. Until that link is clear it is hard to either reject or accept the push to change from one-way to two-way streets as an attempt to revitalize downtowns.
13	Stemley J. J., 1998	*One-Way Streets Provide Superior Safety and Convenience*: A review of the various issues associated with converting between one-way and two-way streets. The author favors maintaining two-way streets. The paper is targeted at addressing issues raised by downtown revitalization advocates to convert one-way streets back to two-way streets. Some of the disadvantages of one-way streets raised and addressed are • Infrequent users are confused by the system: admits it is true, however it does not take long to learn the system and these users are usually a small proportion of the populace visiting downtown • Transit operators face long and circuitous routes leading to more fuel use, wear and tear on transit vehicles, longer walks for passengers and confusion about location of transit stops • Emergency vehicles face more crowded intersections and longer trips: author argues that in a

		well designed one-way system emergency vehicles are less likely to have to make maneuvers like driving in opposite direction of traffic flow • Merchants complain one-way systems adversely affect traffic: argues that studies have shown this concern to be unfounded The three major advantages of one-way streets highlighted are safety, capacity and convenience. • Safety: Substantially reduced vehicle to vehicle and vehicle to pedestrian conflicts at one-way intersections enhances safety (Wiley reported 25% reduction in intersection accidents, and Karagheuzoff reported 22%), also one-way systems are easier on elderly drivers and pedestrians (Robert 1995, Intersection Design for Older Driver and Pedestrian Safety) • Capacity: the elimination of left-turning movement conflicts reduces congestion, and when combined with progressive signal timing plans significantly increases capacity of one-way streets in the range of 22 to 33% over two-way streets Convenience: installation of mid-block crossings reduces pedestrian travel time and distance, also one-way systems can have both left-turn-on-red and right-turn-on-red, conversion of two-way to one-way comes at a minimal cost.
14	Edwards J., 1998	*Traffic Issues for Smaller Communities*: A qualitative treatment of traffic issues for smaller communities. The author proposes that the objective driving development of traffic networks should be different from busy downtown areas. The propose that small communities need among others, 1) Low operating speeds on main streets, 2) An attractive environment, 3) A simple understandable traffic system and by implication fewer one-way streets.
15	Lyles R. W., Faulkner C. D., Syed A. M., July 2000	*Conversion of Streets from One-way to Two-way Operation*: One of the most comprehensive documentations of the issues related to one-way/two-way street conversions. The final conclusion of the review was that 'the single most important factor in successful conversion from one-way to two-way operations is a meaningful public involvement process (supported by straightforward technical studies) and that articulated guidelines for such conversions (e.g., threshold volumes) do not seem to exist'. The review involved both a literature review, and survey of practitioners. The literature review went as far back as Canning and Eldridge studies in 1937. The the key arguments advanced for converting two-way streets to one-way in the literature are; low cost of implementation (relative to street widening), increased capacity, decrease in number of stops, increased speed of vehicles, perceived safety (pedestrians face traffic from only one direction), reduction in accidents, and ease of maintaining signal progression. On the negative side the is the issue of driver confusion (especially for non-local drivers),

		disruptive impact of business operations on affected and neighborhood streets, pedestrians being forced to cross more lanes of traffic.
16	Walker G., Kulash W., McHugh B., 2000	*Downtown Streets: Are We Strangling Ourselves on One-Way Networks:* Makes the case for converting one-way streets to two-way streets in order to make downtowns and cities more livable. The authors acknowledge the usual arguments made in favor of one-way streets, increased speed, better signal progression, reduced delay and fewer conflicting movements. They however take the position that the needs of non-vehicle travelers (pedestrians, transit) are largely ignored when using the above metrics. They propose evaluating the network in terms of • Capacity: acknowledge converting to two-way streets may reduce traffic by 10-20% (actual studies put the figure closer to 30%) • Out-of-direction travel: contend that one-way systems increase turning movements in a range of 120-160% compared to two-way networks (from analysis of a single network, not based on empirical data) • Travel Speed: contends that slower vehicular travel speeds are safer for pedestrians • Pedestrian measures of effectiveness: addressing street crossing from the network level pedestrians face more different types of street configurations patterns to cross in a two-way network than in a one-way network (analysis is skewed, based solely on schematics of network and not interviews or observations of pedestrians) • Eclipsing of storefront exposure: at intersections on one-way street networks, stores on adjacent street on the side of the direction of travel are eclipsed from sight of traveling vehicles. The authors contend that evaluation of one-way to two-way street conversion projects should use multiple criteria including those raised above. Comment: Positions will be more compelling if backed with empirical data. Example, examine accident level data for comparable one-way and two-way networks to see if pedestrian vehicular collusions actually increase.
17	Parsons Transportation Group, 2003	*Relationship Between Lane Width and Speed: Review of Relevant Literature:* The consensus of the review was that 1) speed reductions ranged from 3 to 1 mile per hour for lane narrowing projects, 2) minimal impact on operations of buses and trucks, 3) Projects with narrower lanes nearly always reduced accident rates; reported accident reductions ranging from 20 to 50 % (NCHRP Report 330). In terms of capacity streets lanes narrower than 12 feet reduce the capacity of a roadway. Streets with 11' lanes have 3% less capacity than 12' lanes. Likewise, 10' lane streets have 7% less capacity than 12' lane streets; and 9' lane streets have 10% less capacity than 12' lane streets.
18	FHWA: in ITE Journal, 2005	*Evaluation of Lane Reduction "Road Diet" Measures and their Effects on Crashes and Injuries:* The report focus more on accident data than speeds, but the implicit assumption is that reduction in

		accident rates is due to reductions in speeds from the road diet. Data for the study was collected from a subset of 12 road diets (2,068 crashes) and 25 comparison sites (8,556 crashes). The key findings of this study are that: 1) Crash frequencies at road diets in the after period were approximately 6 percent lower than at the corresponding comparison sites. 2) Crash rates did not change significantly from the before period to the after period. Although crash rates were lower at road diets than at comparison sites, road diets did not perform better or worse (from the before period to the after period) relative to comparison sites. 3) Road diet conversions did not affect crash severity. 4) Road diet conversions did not result in a significant change in crash types. The results appear to indicate that if speeds actually reduced on the road diet projects, the reduced speeds did not translate into significant reduction in crashes.
19	Cunneen M., O'Toole R., 2005	*No Two-Ways About It: One-Way Streets are Better than Two-Way, Center for the American Dream*: A scathing attack on the trend of converting one-way streets to two-way streets. The author quotes numerous studies that show that converting one-way streets to two-way streets has consistently resulted in increased accidents and increased congestion. Though a few of his source are anecdotal, he quotes from published studies in Denver, Portland, Indianapolis, Lubbock (Texas) and Sacramento that found converting one-way to two-way streets reduced safety by increasing accident rate. • City of Denver: Accident rates increased 37% with converting one-way to two-way streets (One-way Street Monitoring Study: Phase 1 Conversion Report, 1990) • Indianapolis: 33% increase in accident rates () • Lubbock (Texas): 12% decrease in traffic with 25% more accidents and 34% increase in property damage (City of Lubbock, "Main & 10th Street Accident Analysis Before and After Study, 1998) He cites studies that show that converting two-streets to one-way not only increased speeds and reduced stops but also led in some cases to a 38% decrease in accidents. • Sacramento: 14% fewer accidents thought traffic increased by 17% (Faustman, Improving Traffic Access to the Sacramento Business District, 1950) • Portland study: 51% reduction in accidents at intersections and 37% fewer between intersections (Fowler, One-Way Grid System of Portland Oregon, 1953) • Olympia: Business on one-way streets are doing better than comparable business on two-way streets (Faustman, 1952) • Oregon State Highway Department study: 10% fewer accidents and 23% more traffic He posits that City Councils are adopting a wrong approach by allowing Planners instead of Engineers to make judgment calls about which kind of road system is safer. Though he has data to support his position, his analysis is focused on downtown and central business

		districts and the conclusions may not be applicable to residential neighborhoods.
20	Raykes, J., Watts, D., 2006	*Case Study: Road Diet; The Conversion of Main Street in Butler, Pennsylvania:* The study was based on interviews conducted with the Pennsylvania Department of Transportation representatives, transportation consultants, resource agencies, local officials, downtown business owners, and residents of the City of Butler. The issues the road diet project were meant to address were 1) Truck Traffic: improve slow moving heavy truck traffic on Main Street. 2) Congestion: reduced general congestion, due to large traffic volumes, 3) Insufficient Lane Widths: congestion effects were being exacerbated by insufficient lane widths leading to many 'side-swipe accidents'. 4) Inside lanes became Left Hand Turn Lanes: Inside /Left lanes on acted as a defacto left-hand turn-lane blocking faster moving traffic behind them. 5) Drag racing between lights: Drivers frequently accelerate rapidly between lights, attempting to "beat" the adjacent vehicle. 6) Aesthetics: Too much traffic on Main Street. Downtown traffic was heavy. Overall, Main Street traffic had created an "unpleasant" environment in the downtown corridor. The final study recommended reducing Main Street to three lanes from four at a cost of $47,000. A combination of restriping and retiming of traffic signals would provide for improved operations along Main Street. The final outcome was an efficient three lane configuration that has increased lane widths, eliminated drag racing and weaving, improved vehicular and pedestrian safety, and changed the aesthetic of Main Street from "highway" to "Hometown Street". Critics would point out that trucks are still present and congestion at peak times can still be a problem, but again, these are not problems that road diet is designed to solve. A road diet program will improve access, safety and operations without negatively effecting road capacity or LOS but, it will do nothing to reduce traffic volumes or alter vehicle mix.
21	Center for Transportation Research and Education, Iowa State University, 2006	*Four-Lane to Three-Lane Conversions:* This was a study of 15 conversion and 15 comparison sites with 10 years of annual data on citywide crash rates. The conversion and comparison sites had traffic volumes ranging from 2,000 to 17,400 annual daily traffic (ADT) from 1982–2004 and were mostly located in smaller urbanized areas (ranging in population from 1,169 to 198,682 according to the 2000 Census). The final results showed 1) Potential for a 25 percent reduction in crash frequency per mile and a 19 percent reduction in crash rate. 2) A 34 % reduction in the number of all injury crashes and lower severity of the crashes that do occur. 3) Less involvement of age groups that are traditionally at risk—drivers 25 and under and 65 and older, 4) A significant reduction in the number of crash types related to left turns and stopped traffic. The authors refer to previous research by Huang et al., that evaluated 12 conversion sites and 25

		comparison sites in Washington and California, showed less benefit. Their research showed an average crash frequency that was only 6 percent lower on the conversion sites versus the comparison sites. They also found that crash rates did not change from before to after, that crash severities were not affected, and that crash types did not change significantly.