Lake Street/4th Street/Central Avenue

Intersection Control Evaluation (ICE)
Report

City of Madera

Lake Street/4th Street/Central Avenue

Intersection Control Evaluation (ICE) Report

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1. Introduction

1.1 Purpose

This document has been prepared to present the results of a conceptual alternatives analysis performed by Omni-Means for the City of Madera in support of the Intersection Control Evaluation (ICE) process. The analysis evaluates potential alternative improvements at the Lake Street/4th Street/Central Avenue intersection. Though this intersection is not on the state highway system, this analysis has been conducted consistent with guidelines provided in Caltrans Traffic Operations Policy Directive 13-02 for intersection improvements on the state highway system.

The purpose of the study is to identify viable alternatives (project) to improve safety, reduce delay, and enhance mobility for all travel modes at the intersection of Lake Street/4th Street/Central Avenue. The project would improve traffic circulation, access, and safety for all modes of transportation. It would relieve anticipated future traffic congestion associated with planned development in the City and improve local traffic circulation.

The intersection of Lake Street/4th Street/Central Avenue is located in the northeast quadrant of the City of Madera, in the urbanized City limits, south of the Fresno River, east of SR 99 and northwest of Highway 145. Although this intersection currently does not experience severe delay or congestion, traffic forecast data shows this intersection reaching an LOS of E in the PM peak hour by the year 2040. There are five approaches to the intersection (as shown in Figure 1) and the 5-legged nature of this intersection presents unique design challenges.

Figure 1: Study Area

This document contains a description of the following sections consistent with the Caltrans ICE document guidelines including:

- Screening Objectives;
- Screening Criteria;
- Capacity Assessment/Analysis;
- Footprint Development & Assessment;
- Safety Considerations
- Life-Cycle Costs; and
- Recommendations & Documentation.

1.2 Project Setting/ Land Use

The intersection of Lake Street/4th Street/Central Avenue is located in the northeast quadrant of the City of Madera, east of SR 99 and northwest of Highway 145. Lake Street serves as a north-south arterial in the City. About half a mile to the southwest Lake Street intersects Sunrise Avenue, and at the study intersection Lake Street turns and continues due north well beyond the City limits. The southwest leg of 4th Street is an arterial and has an interchange with SR 99 about half a mile southwest of the study intersection. The northeast leg of 4th Street is a local road that terminates at Flume Street after one block. Central Avenue is an east/west collector street that extends from H Street to Lake Street.

The primary land use directly adjacent to the study intersection is single family residential. Centennial Park is located northeast of the intersection at the end of 4th Street. It includes a pool, youth and community center, and a community garden. City of Madera Fire Station #6 is located north of the study intersection on Lake Street. Although there are residential homes located at each corner of the intersection, there are not a significant number of driveways. Most properties in this area have their access off of an alley that serves as a communal driveway for an entire block of houses. This will result in minimal impacts to property access, even if there are other property impacts around the intersection. There is also a significant heavy vehicle presence at this intersection during the morning peak hour.

Lake Street crosses the Fresno River approximately 400 feet north of the study intersection. The bridge at this location is a constraint and any impacts to it should be avoided.

2. Screening Objectives

In August 2013, Caltrans issued Traffic Operations Policy Directive (TOPD) 13-02 regarding Intersection Control Evaluation (ICE). According to this directive, all proposals to install or modify intersection control on state highways must consider all three intersection control strategies (traffic signal, yield control roundabout, and all-way stop control) and the supporting design configurations during the ICE screening process. Consistent with the intent of this Directive, the objective of this report is to determine which of these intersection control strategies are context-appropriate, practical to implement, and merit further consideration.

2.1 Project Analysis Scenarios

This section contains a brief description of the time frames for which the traffic operations analysis was conducted. The project design alternatives (discussed within the next section) were analyzed for Existing Year (Year 2017) and Design Year (Year 2040) conditions. The analysis was

conducted for both the AM and PM peak hour conditions. The peak hour turning movement volumes are summarized on Figure 2.

Comparing the traffic data, the AM and PM peak hours are fairly balanced, but there are about 10% more vehicles entering the intersection in the PM peak hour. Northbound Lake Street and eastbound 4th Street have significantly more vehicles in the PM peak hour than in the AM Peak Hour. The other three legs are more balanced between the two peak hours.

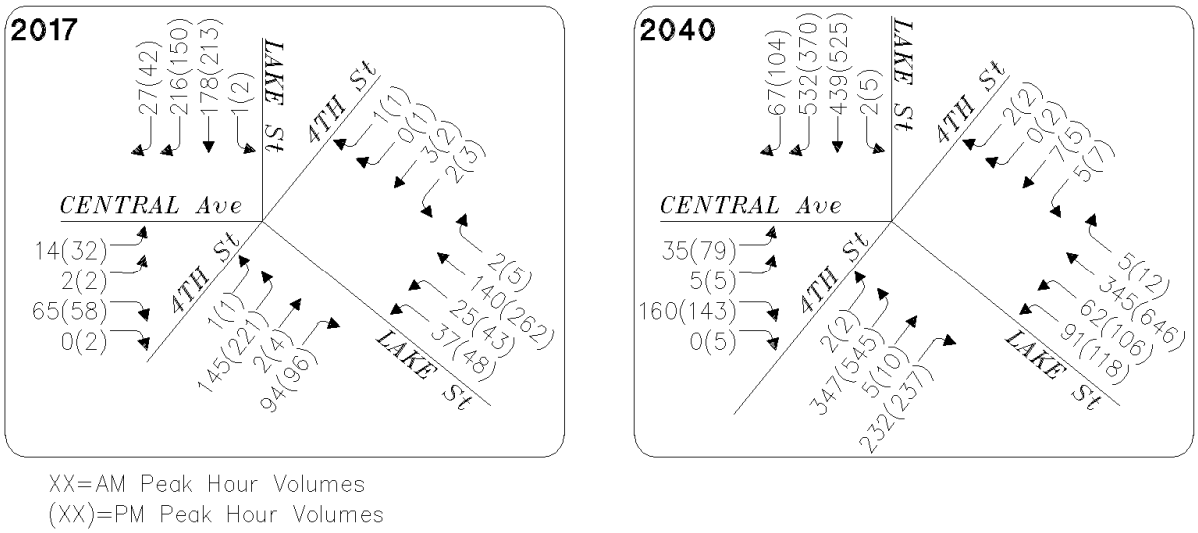

Figure 2: Peak Hour Traffic Volumes

A comparison of volumes by directionality (NB and SB on the corridor) indicated that, in general, the northbound traffic volumes (northbound Lake Street and 4th Street) are higher than the southbound Lake Street volumes. This trend is more significant in the PM peak hour.

One of the primary objectives of TOPD 13-02 is to balance the needs of all modes and users with system performance goals. For that reason, volumes for pedestrians and bicycles were also collected and analyzed. There were 6 cyclists using the study intersection during the AM peak hour and 10 in the PM peak hour. In the AM peak hour, about half of the cyclists were approaching from Central Avenue. In the PM peak hour, about half were approaching from the northeast leg of 4th Street. About 24 pedestrians used the intersection during the AM peak hour and about 27 pedestrians in the PM peak hour. Pedestrians cross on each leg of the intersection during both peak hours.

2.1.1 Existing Year (2017)

Traffic volumes collected in February 2017 during both AM and PM peak hours are utilized in this study. Pedestrian, cyclist, and truck volumes were measured as part of the counts, and peak hour factors were determined. These volumes were used as a base line for future year projections. See Figure 2 for a summary of the turning movement volumes for the study intersection.

2.1.2 Design Year (2040)

Omni-Means received year 2035 forecast volumes from the Madera County Transportation Commission (MCTC) Regional Travel Demand Model (RTDM) on February 22, 2017. The forecast volumes were link-based volumes; therefore, Omni-Means converted the existing traffic

count data to approach volumes, in order to compare them to the data provided by MCTC. The growth rates between the existing traffic counts and MCTC's 2035 traffic forecast volumes were calculated for each leg of the intersection and were found to be about 4%.

As a 4%/year growth rate seemed high, Omni-Means requested existing year volumes that were used in the MCTC RTDM. Omni-Means received the requested 2017 link based traffic volumes from the RTDM and determined that these traffic volumes had an average annual growth rate of about 0-1.1% between the RTDM's 2017 and 2035 volumes. Based on this determination, Omni-Means used a 1% annual growth rate applied on the existing turning movements' counts to the year 2040. See Figure 2 for the forecasted 2040 traffic volumes.

2.2 Project Design Alternatives

This study analyzes three alternatives. The first is a No Build Alternative that assumes existing lane geometrics and all-way stop control. The second alternative is signalization with modified lane geometrics. The third alternative is a yield-control roundabout with modified lane geometrics.

2.2.1 No Build Alternative

The No-Build Alternative leaves the existing lane geometrics and all-way stop-control in place.

2.2.2 Traffic Signal Alternative

With this alternative, the intersection is signalized and the lane geometrics have been modified to accommodate the Design Year volumes. The northeast leg of 4th Street will be terminated at the alley, and the intersection will only feature 4 legs. The Signal Alternative lane geometrics can be found on Figure 3 and is provided in Appendix B of this report.

2.2.3 Roundabout Alternative

This alternative would replace the intersection with a modern single lane roundabout designed to accommodate the Design Year traffic forecast volumes. The northeast leg of 4th Street will be terminated at the alley, and the intersection will only feature 4 legs. The Roundabout Alternative layout shown on Figure 4 and is provided in Appendix C of this report.

3. Screening Criteria

The traffic operations for the No-Build Alternative, Signal Alternative, and Roundabout Alternative were analyzed for the AM and PM peak hours under existing (2017) and design (2040) year conditions.

Both the No-Build and Signal Alternatives were analyzed using Synchro 9 and SimTraffic analysis software. Synchro 9 is a macroscopic analysis and optimization application that reports the Level of Service (LOS) and delay as per the Highway Capacity Manual (HCM) 2010 methodologies. SimTraffic is a traffic micro-simulation application that individually tracks and records each vehicle in the model simulating real world conditions. SimTraffic was used to record queuing characteristics for the No-Build and Traffic Signal Alternatives.

SIDRA analysis software was used for the Roundabout Alternative to determine the LOS, volume to capacity ratio (V/C), delay, and the 95th percentile queues. The volume to capacity ratio (V/C) compares roadway demand (vehicle volume) with roadway carrying capacity. A V/C of 1.00 indicates that a roadway facility is operating at full capacity.

3.1 Traffic Operations Analysis

Traffic operations have been quantified through the determination of LOS. LOS is a qualitative measure of traffic conditions, whereby a letter grade "A" through "F" is assigned to an intersection or roadway segment representing progressively worsening traffic conditions. LOS definitions for different types of intersection controls are outlined in Table 1.

TABLE 1
LEVEL-OF-SERVICE (LOS) CRITERIA

LOS	Type of Flow	Delay	Maneuverability	Stopped Delay/Vehicle	
				Signal/ Rndbt	Unsig-nalized
A	Stable Flow	Very slight delay. Progression is very favorable, with most vehicles arriving during the green phase not stopping at all.	Turning movements are easily made, and nearly all drivers find freedom of operation.	< 10.0	< 10.0
B	Stable Flow	Good progression and/or short cycle lengths. More vehicles stop than for LOS A, causing higher levels of average delay.	Vehicle platoons are formed. Many drivers begin to feel somewhat restricted within groups of vehicles.	>10.0 and < 20.0	>10.0 and < 15.0
C	Stable Flow	Higher delays resulting from fair progression and/or longer cycle lengths. Individual cycle failures may begin to appear at this level. The number of vehicles stopping is significant, although many still pass through the intersection without stopping.	Back-ups may develop behind turning vehicles. Most drivers feel somewhat restricted	>20.0 and < 35.0	>15.0 and < 25.0
D	Approaching Unstable Flow	The influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, or high volume-to-capacity ratios. Many vehicles stop, and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.	Maneuverability is severely limited during short periods due to temporary back-ups.	>35.0 and < 55.0	>25.0 and < 35.0
E	Unstable Flow	Generally considered to be the limit of acceptable delay. Indicative of poor progression, long cycle lengths, and high volume-to-capacity ratios. Individual cycle failures are frequent occurrences.	There are typically long queues of vehicles waiting upstream of the intersection.	>55.0 and < 80.0	>35.0 and < 50.0
F	Forced Flow	Generally considered to be unacceptable to most drivers. Often occurs with over saturation. May also occur at high volume-to-capacity ratios. There are many individual cycle failures. Poor progression and long cycle lengths may also be major contributing factors.	Jammed conditions. Back-ups from other locations restrict or prevent movement. Volumes may vary widely, depending principally on the downstream back-up conditions.	> 80.0	> 50.0

In the City's General Plan Circulation and Infrastructure Element, Policy CI-22 states that "in the Downtown District (as defined in the Land Use Element of this General Plan), the City shall seek to maintain LOS D." This intersection is located within the Downtown District; therefore, LOS "D"

is assumed to represent the appropriate LOS target.

In addition to providing acceptable LOS and delay, a goal of the build alternatives will be to reduce standing queues on all approaches.

3.2 Analysis Factors

The following criteria are incorporated in the analysis in order to most accurately reflect intersection operating conditions:

- The peak hour factor (PHF) was calculated based on data from the traffic counts collected in February 2017. The PHF represents how constant vehicle volumes are during the peak hour and is equal to the peak hour volume divided by 4 times the peak 15-minute volume. A PHF of 0.81 was used for the AM peak hour, and a PHF of 0.98 was used for the PM peak hour.
- Truck percentages were calculated based on data from counts collected in February 2017. The AM peak hour experiences about 4% heavy vehicles, and about 1% in the PM peak hour.
- SIDRA software includes an environmental factor that modifies capacity reflecting driver response times, standard of intersection geometry, visibility, operating speeds, vehicle sizes, pedestrian interference, parking, buses stopping, etc. For the analysis performed for this report, an environmental factor of 1.02 was used for roundabout analysis.

4. Capacity Assessment/Analysis – Existing Intersection (5-Leg)

Section 4 includes a capacity assessment and analysis of the existing 5-legged Lake Street/4th Street/Central Avenue intersection for the No Build Alternative as well as for a Traffic Signal Alternative and for a Roundabout Alternative. Each alternative is evaluated under both Existing (2017) and Design Year (2040) conditions. LOS worksheets for each alternative are provided in Appendix A.

4.1 No Build Analysis

The following section summarizes the traffic operations analysis and results for the No-Build Alternative under Existing (2017) and Design Year (2040) conditions. LOS worksheets for each analysis condition are provided in Appendix A.

4.1.1 Existing Year (2017)

Tables 2A and 2B present the Existing Condition peak hour intersection LOS and delay for the No Build Alternative.

TABLE 2A
NO BUILD - EXISTING YEAR (2017) AM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	Delay (sec)[2]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection	***10.2***	***B***	**--**	
Northbound Lake Street Left/Thru/Right	9.9	A	350	75
Southbound Lake Street Left/Thru	15.9	B	660	190
Southbound Lake Street Right			65	20
Eastbound 4th Street Left	7.4	A	60	50
Eastbound 4th Street Thru			320	10
Eastbound 4th Street Right			75	40
Eastbound Central Avenue Left/Thru/Right	11.5	B	445	70
Westbound 4th Street Left/Thru/Right	8.4	A	325	25

1.V/C ratio not available for 5-leg AWSC intersection.

2. Traffic Operation outputs calculated using SimTraffic simulation results.

As shown in Table 2A, the No Build Alternative is currently providing acceptable intersection LOS and delay for the study intersection during the AM peak hour. The No Build Alternative has acceptable 95th percentile queues for all movements.

TABLE 2B
NO BUILD - EXISTING YEAR (2017) PM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	Delay (sec)[2]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection	***14.8***	***B***	**--**	
Northbound Lake Street Left/Thru/Right	18.2	B	350	170
Southbound Lake Street Left/Thru	20.1	C	660	175
Southbound Lake Street Right			65	20
Eastbound 4th Street Left	12.5	C	**60**	**75**
Eastbound 4th Street Thru			320	20
Eastbound 4th Street Right			75	35
Eastbound Central Avenue Left/Thru/Right	13.2	C	445	75
Westbound 4th Street Left/Thru/Right	5.8	A	325	30

1.V/C ratio not available for 5-leg AWSC intersection.

2. Traffic Operation outputs calculated using SimTraffic simulation results.

As shown in Table 2B, the No Build Alternative is currently providing acceptable intersection LOS and delay the study intersection during the PM peak hour. The No Build Alternative has acceptable 95th percentile queues for all movements, except for the following:

- The queue for the eastbound 4th Street left-turn exceeds the available storage.

4.1.2 Design Year (2040)

Tables 3A and 3B present the Design Year Condition peak hour intersection LOS and delay for the No Build Alternative.

TABLE 3A
NO BUILD - DESIGN YEAR (2040) AM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	Delay (sec)[2]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection	***23.0***	***C***	**--**	
Northbound Lake Street Left/Thru/Right	15.1	B	350	125
Southbound Lake Street Left/Thru	**42.3**	**E**	660	420
Southbound Lake Street Right			**65**	**195**
Eastbound 4th Street Left	10.6	B	**60**	**70**
Eastbound 4th Street Thru			320	20
Eastbound 4th Street Right			75	50
Eastbound Central Avenue Left/Thru/Right	12.7	B	445	90
Westbound 4th Street Left/Thru/Right	8.0	A	325	20

1.V/C ratio not available for 5-leg AWSC intersection.

2. Traffic Operation outputs calculated using SimTraffic simulation results.

As shown in Table 3A, the No Build Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the AM peak hour. The projected 95th percentile queues are accommodated for all movements, except for the following:

- The projected queue for the southbound Lake Street right-turn exceeds the available storage.
- The queue for the eastbound 4th Street left-turn exceeds the available storage.

TABLE 3B
NO BUILD - DESIGN YEAR (2040) PM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	Delay (sec)[2]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection	***43.4***	***E***	**--**	
Northbound Lake Street Left/Thru/Right	**53.4**	**F**	**350**	**380**
Southbound Lake Street Left/Thru	**59.6**	**F**	660	415
Southbound Lake Street Right			**65**	**240**
Eastbound 4th Street Left	**39.7**	**E**	**60**	**125**
Eastbound 4th Street Thru			320	260
Eastbound 4th Street Right			**75**	**135**
Eastbound Central Avenue Left/Thru/Right	15.2	B	445	70
Westbound 4th Street Left/Thru/Right	14.0	B	325	30

1.V/C ratio not available for 5-leg AWSC intersection.

2. Traffic Operation outputs calculated using SimTraffic simulation results.

As shown in Table 3B, the No Build Alternative is not projected to provide acceptable intersection LOS or delay for the study intersection during the PM peak hour. The projected 95th percentile

queues are accommodated for all movements, except for the following:

- The projected queue for the northbound Lake Street exceeds the available storage and would spill back into the intersection of 5th Street.
- The projected queue for the southbound Lake Street right-turn lane exceeds the available storage.
- The queues for the eastbound 4th Street left-turn and right-turn lanes exceed the available storages.

4.2 Traffic Signal Analysis

This section provides a summary of the AM and PM peak hour intersection operations associated with installation of a traffic signal with the existing 5-legged intersection under Existing Year (2017) and Design Year (2040) conditions. LOS worksheets for each analysis condition and lane geometrics used for this analysis are provided in Appendix A.

4.2.1 Existing Year (2017)

Tables 4A and 4B show the projected volume/capacity (V/C) ratio, delay, LOS, and 95th percentile queues for Existing Year conditions during AM and PM peak hour conditions, respectively.

TABLE 4A
SIGNAL - EXISTING YEAR (2017) AM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio[1]	Delay (sec)[1]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection	***0.46***	***20.4***	***C***	**--**	
Northbound Lake Street Left	0.43	17.7	B	200	30
Northbound Lake Street Thru/Right				350	65
Southbound Lake Street Left	0.49	18.8	B	100	0
Southbound Lake Street Thru				660	105
Southbound Lake Street Right				200	135
Eastbound 4th Street Left	0.39	22.8	C	150	40
Eastbound 4th Street Left				320	110
Eastbound 4th Street Thru/Right				320	25
Eastbound Central Avenue Left/Thru/Right	0.52	28.8	C	445	85
Westbound 4th Street Left	0.01	21.3	C	100	0
Westbound 4th Street Thru/Right				325	10

1.Traffic Operation outputs calculated using Synchro 9 (Queues/Signalized Intersection Summary - HCM 2000)

As shown in Table 4A, the Traffic Signal Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the AM peak hour. The Traffic Signal Alternative has acceptable 95th percentile queues for all movements.

TABLE 4B
SIGNAL - EXISTING YEAR (2017) PM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio[1]	Delay (sec)[1]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection	***0.45***	***20.2***	***C***	**--**	
Northbound Lake Street Left/Thru/Right	0.47	18.0	B	200	105
Northbound Lake Street Thru/Right				350	155
Southbound Lake Street Left	0.44	18.8	B	100	5
Southbound Lake Street Left/Thru				660	100
Southbound Lake Street Right				200	60
Eastbound 4th Street Left	0.44	22.2	C	150	40
Eastbound 4th Street Left				320	145
Eastbound 4th Street Thru/Right				320	25
Eastbound Central Avenue Left/Thru/Right	0.50	28.2	C	445	85
Westbound 4th Street Left	0.01	20.3	C	100	5
Westbound 4th Street Thru/Right				325	15

1.Traffic Operation outputs calculated using Synchro 9 (Queues/Signalized Intersection Summary - HCM 2000)

As shown in Table 4B, the Traffic Signal Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the PM peak hour. The Traffic Signal Alternative has acceptable 95th percentile queues for all movements.

4.2.2 Design Year (2040)

Tables 5A & 5B show the projected volume/capacity (V/C) ratio, delay, LOS, and 95th percentile queues for Design Year conditions during AM and PM peak hour conditions, respectively.

TABLE 5A
SIGNAL - DESIGN YEAR (2040) AM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio[1]	Delay (sec)[1]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection	***0.56***	***25.7***	***C***	**--**	
Northbound Lake Street Left	0.53	21.9	C	200	95
Northbound Lake Street Thru/Right				360	155
Southbound Lake Street Left	0.63	24.2	C	100	5
Southbound Lake Street Thru				660	125
Southbound Lake Street Right				200	155
Eastbound 4th Street Left	0.51	29.4	C	150	115
Eastbound 4th Street Left				320	65
Eastbound 4th Street Thru/Right				320	15
Eastbound Central Avenue Left/Thru/Right	0.50	31.8	C	445	90
Westbound 4th Street Left	0.02	27.0	C	100	0
Westbound 4th Street Thru/Right				325	15

1.Traffic Operation outputs calculated using Synchro 9 (Queues/Signalized Intersection Summary - HCM 2000)

As shown in Table 5A, the Traffic Signal Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the AM peak hour. The Traffic Signal Alternative

has acceptable 95th percentile queues for all movements. Although the intersection delay and LOS are acceptable, they are worse than those projected for the No Build Alternative. The main long-term benefit of the Traffic Signal Alternative is the reduction in 95th percentile queues and delay on the southbound Lake Street approach.

TABLE 5B
SIGNAL - DESIGN YEAR (2040) PM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio[1]	Delay (sec)[1]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection	***0.55***	***26.4***	***C***	**--**	
Northbound Lake Street Left/Thru/Right	0.49	21.6	C	200	110
Northbound Lake Street Thru/Right				360	260
Southbound Lake Street Left	0.55	25.1	C	100	5
Southbound Lake Street Left/Thru				660	150
Southbound Lake Street Right				200	130
Eastbound 4th Street Left	0.60	31.0	C	150	110
Eastbound 4th Street Left				320	200
Eastbound 4th Street Thru/Right				320	45
Eastbound Central Avenue Left/Thru/Right	0.52	34.2	C	445	140
Westbound 4th Street Left	0.02	27.0	C	100	10
Westbound 4th Street Thru/Right				325	15

1.Traffic Operation outputs calculated using Synchro 9 (Queues/Signalized Intersection Summary - HCM 2000)

As shown in Table 5B, the Traffic Signal Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the PM peak hour. The Traffic Signal Alternative also has acceptable 95th percentile queues for all movements. For the design year PM peak hour, the Traffic Signal Alternative operates better than the No Build Alternative by reducing intersection delay from 43.4 seconds to 26.4 seconds and eliminates all 95th percentile queuing impacts.

4.3 Roundabout Analysis

This section provides a summary of the AM and PM peak hour intersection operations associated with installation of a roundabout with the existing 5-legged intersection under Existing Year (2017) and Design Year (2040) conditions. LOS worksheets for each analysis condition and lane geometrics used for this analysis are provided in Appendix A.

4.3.1 Existing Year (2017)

Tables 6A and 6B show the projected volume/capacity (V/C) ratio, delay, LOS, and 95th percentile queues for Existing Year conditions during AM and PM peak hour conditions, respectively.

TABLE 6A
ROUNDABOUT - EXISTING YEAR (2017) AM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio	Delay (sec)	Level of Service[1]	Available Storage	95th Percentile Queue (ft)
Intersection	***0.49***	***7.4***	***A***	**--**	
Northbound Lake Street	0.23	5.4	A	350	35
Southbound Lake Street	0.49	9.1	A	660	100
Eastbound 4th Street	0.30	6.7	A	320	50
Eastbound Central Avenue	0.13	6.0	A	445	20
Westbound 4th Street	0.01	4.1	A	325	0

1.Lane LOS values are based on average delay and v/c ratio per lane.

As shown in Table 6A, the Roundabout Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the AM peak hour. The Roundabout Alternative has acceptable 95th percentile queues for all movements.

TABLE 6B
ROUNDABOUT - EXISTING YEAR (2017) PM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio	Delay (sec)	Level of Service[1]	Available Storage	95th Percentile Queue (ft)
Intersection	***0.44***	***7.4***	***A***	**--**	
Northbound Lake Street	0.44	8.5	A	350	80
Southbound Lake Street	0.36	7.1	A	660	60
Eastbound 4th Street	0.34	7.0	A	320	55
Eastbound Central Avenue	0.11	5.1	A	445	15
Westbound 4th Street	0.01	4.6	A	325	0

1.Lane LOS values are based on average delay and v/c ratio per lane.

As shown in Table 6B, the Roundabout Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the PM peak hour. The Roundabout Alternative has acceptable 95th percentile queues for all movements.

For both the AM and PM peak hours, the Roundabout Alternative operates better than the No Build Alternative by improving LOS from B to A and significantly reducing the 95th percentile queues.

4.3.2 Design Year (2040)

Tables 7A & 7B show the projected volume/capacity (V/C) ratio, delay, LOS, and 95th percentile queues for Design Year conditions during AM and PM peak hour conditions, respectively.

TABLE 7A
ROUNDABOUT - DESIGN YEAR (2040) AM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio	Delay (sec)	Level of Service[1]	Available Storage	95th Percentile Queue (ft)
Intersection	***0.67***	***10.5***	***B***	**--**	
Northbound Lake Street	0.67	14.0	B	350	195
Southbound Lake Street	0.31	6.6	A	660	50
Eastbound 4th Street	0.42	8.9	A	320	75
Eastbound Central Avenue	0.20	8.2	A	445	35
Westbound 4th Street	0.01	4.5	A	325	0

1.Lane LOS values are based on average delay and v/c ratio per lane.

As shown in Table 7A, the Roundabout Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the AM peak hour. The Roundabout Alternative has acceptable 95th percentile queues for all movements. The Roundabout Alternative is projected to improve the design year intersection LOS from a C to a B and reduces the projected queues.

TABLE 7B
ROUNDABOUT - DESIGN YEAR (2040) PM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio	Delay (sec)	Level of Service[1]	Available Storage	95th Percentile Queue (ft)
Intersection	***0.60***	***10.3***	***B***	**--**	
Northbound Lake Street	0.60	12.6	B	350	150
Southbound Lake Street	0.49	9.5	A	660	95
Eastbound 4th Street	0.47	9.5	A	320	85
Eastbound Central Avenue	0.17	6.4	A	445	25
Westbound 4th Street	0.02	5.6	A	325	0

1.Lane LOS values are based on average delay and v/c ratio per lane.

As shown in Table 7B, the Roundabout Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the PM peak hour. The Roundabout Alternative has acceptable 95th percentile queues for all movements. The Roundabout Alternative is projected to improve the design year intersection LOS from a E to a B and reduces the projected queues.

5. Build Alternatives Footprint Development & Assessment

The following section summarizes the development of preliminary concept layouts of both a Traffic Signal Alternative and for a Roundabout Alternative. The layouts are useful for preliminary right-of-way needs for each alternative and also to illustrate truck-turning movements. The lane geometry for the alternatives is the same for all analysis scenarios and include terminating the northeast leg of 4th Street at the alley in advance of the intersection. Termination of this leg was discussed with and agreed to by the City.

5.1 Traffic Signal Alternative

The Traffic Signal Alternative features converting the intersection of Lake Street/4th Street/Central Avenue from a 5-way all-way stop-control to a 4-way traffic signal as shown in Figure 3. The Lake Street bridge over the Fresno River will be retained with no impacts to the structure. In order to accommodate the design vehicle turning movements, all five curb returns will need to be reconstructed. Other intersection lane geometrics improvements are illustrated in Figure 3 and are listed below:

- The northbound 4th Street approach shows the existing left-turn lane eliminated, and the existing through lane converted to a left-turn lane.
- The northbound Lake Street approach features a narrow median with a separate left-turn lane and a shared through/right-turn lane.
- The southbound 4th Street approach is terminated at the alley in advance of the intersection.
- The southbound Lake Street approach remains two lanes at the intersection.
- Central Avenue remains a single lane approach.
- The traffic signal footprint encroaches beyond the right-of-way on the northwest corner of Central Avenue and Lake Street.

5.1.1 Traffic Signal Performance Checks

The following design criteria were used to analyze the geometrics and safety performance of the proposed Traffic Signal Alternative:

- The “WB-40” design vehicle from the American Association of State Highway and Transportation Officials (AASHTO) Geometric Design of Highways and Streets, 5th Edition (updated 2004), shall be accommodated on all movements.
- The “S-BUS-40” design vehicle from the American Association of State Highway and Transportation Officials (AASHTO) Geometric Design of Highways and Streets, 5th Edition (updated 2004), shall be accommodated on all movements.

Exhibits illustrating the truck turns for each condition are provided in Appendix B.

Traffic Signal Alternative: Preliminary Layout

LEGEND:

- EXISTING RIGHT-OF-WAY AND PROPERTY LINES
- PROPOSED IMPROVEMENTS
- RIGHT-OF-WAY IMPACTS
- ESTIMATED LIMITS FOR NEW PAVEMENT SECTION

LAKE Street

CONSTRUCT 25' RADIUS RETURN. CONSTRUCT RAMP TO ADA STANDARDS

CONSTRUCT SIDEWALK CONNECTION

ELBOW ENDING 4TH STREET INTO THE ALLEY.

4TH Street

CENTRAL Avenue

ø1

ø4 ø4

DEMO 4TH STREET AND PROVIDE LANDSCAPING

CONSTRUCT CURB, GUTTER, AND SIDEWALK TO END 4TH STREET ACCESS.

ø3 ø3

ø2 ø2

RAISED MEDIAN

LAKE Street

4TH Street

ø3 OR ø4 PED ø4 ø8 PED ø1 ø6 PED ø2 ø2 PED

PHASE DIAGRAM

NORTH

0 50

Scale: 1"= 50

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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure 3

Madera, California

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5.2 Roundabout Alternative

The Roundabout Alternative features converting the intersection of Lake Street/4th Street/Central Avenue from a 5-way all-way stop-control to a modern 4-leg single lane roundabout as shown on Figure 4. All approaches to the intersection are shown with shared lane markings, consistent with Madera County 2011 Regional Bicycle Transportation Plan. The Lake Street bridge over the Fresno River will be retained with no impacts to the structure. The roundabout has an inscribed circle diameter of 116' with an 84' diameter central island, 16' circulatory roadway, and an 8' truck apron. The shared-use path has a width of 10' with a minimum landscaped buffer of 3'-5'. Pedestrian crossings are shown a minimum of 20'-25' from the circulatory roadway, and the pedestrian refuges at the splitter islands are at least 6' wide. Other intersection lane geometrics improvements are illustrated in Appendix C and are listed below:

- The roundabout was centered in between the existing structures located on each corner, in order to minimize right-of-way impacts.
- The northbound 4th Street approach shows a wider median, in order to provide speed control on this entry.
- In order to accommodate a right-turning truck, a truck blister was added to the northwest and southern corners of the roundabout. The truck blister is constructed out of the same material as the truck apron and allows the back tires of the truck's trailer to off-track onto it as the truck completes the right turn.
- The approach roadways are shown with splitter islands, which provide necessary deflection and speed control for entering vehicles.
- The roundabout footprint encroaches beyond the right-of-way in four of the five corners with impacts to the adjacent properties. Property impacts could be reduced by modifying the minimum width of the proposed shared-use path and landscape buffer. The National Cooperative Highway Research Program (NCHRP) Report 672 entitled "Roundabouts: An Informational Guide, 2nd edition" is the design guide used to design roundabouts. This guide recommends a shared-use path width of 10’ with 8’ being the minimum, and a landscape buffer of 5’ with 3’ being the minimum. Removing the landscape buffer can be done, but a vertical barrier would be required between the circulatory roadway and the shared-use path, in order to be ADA compliant.
- In addition to direct property impacts due to the construction footprint, there are other property impacts due to sight distance requirements. As illustrated on Figure 4, these property impacts encroach into three corners, and buildings on the west side restrict the available sight distance.

5.2.1 Roundabout Performance Checks

Due to the complexity in the design, several performance checks have been conducted to verify the Roundabout's feasibility. These performance checks meet current Caltrans TOPD 13- 02 and HDM 405.10 which mandates conformance with the National Cooperative Highway Research Program (NCHRP) Report 672 entitled "Roundabouts: An Informational Guide, 2nd edition".

The following design criteria were used to analyze the geometrics and safety performance of the proposed Roundabout Alternative:

- Criteria and methodologies to be consistent with Caltrans DIB 80-01, Caltrans Highway Design Manual, and Report 672 of the National Cooperative Highway Research Program (NCHRP) titled *Roundabouts: An Informational Guide (Second Edition).* This document

Roundabout Alternative: Preliminary Layout

LEGEND:
- EXISTING RIGHT-OF-WAY AND PROPERTY LINES
- PROPOSED IMPROVEMENTS
- PROPERTY IMPACT LIMIT DUE TO SIGHT LINES
- PROPERTY IMPACTS DUE TO GEOMETRIC FOOTPRINT
- PROPERTY IMPACTS DUE TO SIGHT LINES
- LANDSCAPE AREA
- STAMPED CONCRETE TRUCK APRON

LAKE Street
CONSTRUCT SIDEWALK CONNECTION
ELBOW ENDING 4TH STREET INTO THE ALLEY.
4TH Street
TRUCK BLISTER
CENTRAL Avenue
DEMO 4TH STREET AND PROVIDE LANDSCAPING
YIELD
TRUCK BLISTER
4TH Street
LAKE Street

ROUNDABOUT GEOMETRICS:
- INSCRIBED CIRCLE DIAMETER: 116'
- CENTER ISLAND DIAMETER: 84'
- CIRCULATORY WIDTH: 16'
- TRUCK APRON WIDTH: 8'
- SHARED USE PATH WIDTH: 10'
- LANDSCAPE STRIP WIDTH: 3'-5' MINIMUM

NORTH
0 50
Scale: 1"= 50

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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure 4

Madera, California

2264EX007.dwg

supersedes the original roundabout guide published by the FHWA in 2000.

- The “WB-40” design vehicle from the American Association of State Highway and Transportation Officials (AASHTO) Geometric Design of Highways and Streets, 5th Edition (updated 2004), shall be accommodated on all movements. This vehicle shall be accommodated such that the tractor portion of the vehicle does not need to mount any truck aprons.
- The “S-BUS-40” design vehicle from the American Association of State Highway and Transportation Officials (AASHTO) Geometric Design of Highways and Streets, 5th Edition (updated 2004), shall be accommodated on all movements. This vehicle shall be accommodated such that the bus does not need to mount any truck aprons.
- Fast path entry speeds on single lane roundabout approaches should be 25 mph or less.
- Minimum stopping sight distance for posted speed limits should be provided for vehicles approaching roundabout entrances and pedestrian crosswalks.
- View angles for all legs of the roundabout should be no more than 15 degrees.
- Entry angles for all legs of the roundabout should be between 20 and 40 degrees.

Exhibits illustrating the truck turns for each condition and the fastest path analysis, stopping sight and intersection sight distance analysis, and intersection view angle exhibits are provided in Appendix C.

5.2.2 Fastest Path and Vehicle Speed Checks

The “Fastest Path” represents the path that the most aggressive drivers could take through the roundabout and assumes no other traffic to be within the intersection. NCHRP Report 672 indicates that the recommended maximum vehicle entry speeds along the fastest path should be less than 25 mph at urban single-lane roundabouts. NCHRP Report 672 also indicates that the differential speed between consecutive or conflicting projected fast path speeds should be less than 15 mph.

Fastest path speeds are determined for five locations per approach. These include entry speeds (referred to as V1); through movement circulating speeds (V2); exiting speeds (V3); left turn movement circulating speeds (V4); and right turn speeds (V5). A diagram of the described locations is shown in Figure 5.

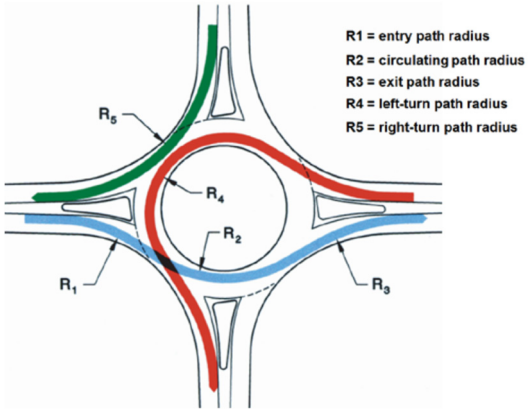


Figure 5 - Fast Path Critical Speed Locations

Fastest path speeds for the Roundabout Alternative are shown in Table 8. Exhibits illustrating the fastest path analysis can be found in Appendix C.

TABLE 8: FASTEST PATH SPEEDS (MPH)

MOVEMENT	NB LAKE STREET (N#)	SB LAKE STREET (S#)	NEB 4TH STREET (NE#)	EB CENTRAL AVENUE (E#)
ENTERING (R1)	21.9	22.4	21.8	20.8
CIRCULATING (R2	22.5	24.4		31.2
EXITING (R3)	31.4	21.7		38.1
LEFT TURN (R4)	14.6		14.8	14.0
RIGHT TURN (R5)		13.4	15.7	15.4

Notes:
All values are in miles per hour
V3 exiting speeds are derived from vehicle acceleration formulas in NCHRP 672
V3 fast path speed measured at exit crosswalk or 100 feet downstream from V2.
N/A = Fastest path speed does not exist for this approach
2% cross-slope assumed for determining Fastest path

As shown in Table 8, the fastest path entering and right-turn speeds are less than the maximum speed of 25 mph for a single lane approach. Therefore, these fastest path speeds are acceptable for this ICE planning document. Because the Roundabout Alternative naturally slows vehicles to 25 mph or less, the vehicle traffic will be quieter than the Traffic Signal Alternative.

5.2.3 Sight Distance

Intersection sight distance differs at roundabouts versus other intersections. Drivers must be able to see potentially conflicting oncoming traffic from the left as they approach the roundabout entry. NCHRP Report 672 provides methodologies to establish the required sight distance triangles for conflicting traffic, as well as pedestrians in crosswalks, for both the entering and circulating vehicle movements. The stopping and intersection sight distance triangles were overlaid onto the proposed Roundabout Alternative to show clear vision areas for the intersection. Sight distance lengths vary according to vehicle fast path vehicle speeds. Intersection sight distances were calculated using a critical headway time t_c of 5.0 seconds, unless noted otherwise.

Table 9 presents the required intersection sight distances with the corresponding sight triangles shown in Appendix C.

TABLE 9: INTERSECTION SIGHT DISTANCE

LEG	APPROACH		CONFLICTING SPEED (MPH)	SIGHT TRIANGLE LENGTH (FT)
NB LAKE STREET	NEB 4TH STREET	ENTERING LEG (D1)	21.8	159.9
	EB CENTRAL AVENUE	CIRCULATING LEG (D2)	14.0	103.0
SB LAKE STREET	NB LAKE STREET	CIRCULATING LEG (D2)	14.6	107.1
NEB 4TH STREET	EB CENTRAL AVENUE	ENTERING LEG (D1)	26.0	183.2*
	SB LAKE STREET	CIRCULATING LEG (D2)	24.4	178.8
EB CENTRAL AVENUE	SB LAKE STREET	ENTERING LEG (D1)	23.4	163.8**

Notes: Intersection Stopping Sight Distance criteria obtained from NCHRP Report 672 with 5 second Critical Headway (tc)
*Critical Headway = 4.8 seconds.
**Critical Headway = 4.77 seconds.

Required stopping sight distances at the entries to the roundabout are provided in Table 10 and

the pedestrian crossing stopping distances are provided in Table 11.

TABLE 10: STOPPING SIGHT DISTANCE TO ENTRY

APPROACH	INITIAL SPEED (MPH)	STOPPING SIGHT DISTANCE (FT)
NB LAKE STREET	35.0	247.3
SB LAKE STREET	35.0	247.3
NEB 4TH STREET	35.0	247.3
EB CENTRAL AVENUE	35.0	247.3

TABLE 11: STOPPING SIGHT DISTANCE TO PEDESTRIAN CROSSING

LEG	APPROACH		CONFLICTING SPEED (MPH)	SIGHT TRIANGLE LENGTH (FT)
NB LAKE STREET	NB LAKE STREET	INITIAL SPEED	35.0	247.3
	NEB 4TH STREET	RIGHT TURN (V5)	15.7	81.8
	EB CENTRAL AVENUE	CIRCULATING SPEED (V2)	26.0	161.0
SB LAKE STREET	SB LAKE STREET	INITIAL SPEED	35.0	247.3
	NB LAKE STREET	CIRCULATING SPEED (V2)	22.2	129.2
NEB 4TH STREET	NEB 4TH STREET	INITIAL SPEED	35.0	247.3
	EB CENTRAL AVENUE	RIGHT TURN (V5)	15.4	79.6
	SB LAKE STREET	CIRCULATING SPEED (V2)	23.4	139.0
EB CENTRAL	EB CENTRAL AVENUE	INITIAL SPEED	35.0	247.3
	SB LAKE STREET	RIGHT TURN (V5)	13.4	66.3

From Tables 9, 10, and 11 and the corresponding figures in Appendix C, the proposed Roundabout Alternative provides sufficient sight distance. Special consideration to landscaping features in the sight triangles will be necessary to ensure proper sight distance at the intersections.

5.2.4 View Angles

The angle between consecutive entries must not be overly acute in order to allow drivers to comfortably turn their heads to the left to view oncoming traffic from the adjacent upstream entry. Guidance from the NCHRP section 6.7.4 recommends a minimum 75° intersection angle (15° view angle). All approaches have view angles that are less than 15°; see Appendix C for the figure showing the view angles.

6. Build Alternatives Capacity Assessment/ Analysis

Section 6 includes a capacity assessment and analysis of the 4-leg Lake Street/4th Street/Central Avenue intersection for the Traffic Signal Alternative and for the Roundabout Alternative. Each alternative is evaluated under both Existing (2017) and Design Year (2040) conditions.

6.1 Traffic Signal Alternative Analysis

This section provides a summary of the AM and PM peak hour intersection operations associated with the Traffic Signal Alternative under Existing Year (2017) and Design Year (2040) conditions. LOS worksheets for each analysis condition and lane geometrics used for this analysis are

provided in Appendix B.

6.1.1 Existing Year (2017)

Tables 12A and 12B show the projected volume/capacity (V/C) ratio, delay, LOS, and 95th percentile queues for Existing Year conditions during AM and PM peak hour conditions, respectively.

TABLE 12A
TRAFFIC SIGNAL ALTERNATIVE - EXISTING YEAR (2017) AM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio[1]	Delay (sec)[1]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection		***23.8***	***C***	**--**	
Northbound Lake Street Thru	0.86	40.0	D	350	160
Northbound Lake Street Left	0.40			200	65
Southbound Lake Street Thru	0.59	17.4	B	400	190
Southbound Lake Street Right	0.39			200	100
Eastbound 4th Street Left	0.67	21.8	C	320	105
Eastbound 4th Street Right	0.08			200	0
Eastbound Central Avenue Left/Thru/Right	0.54	22.6	C	445	65

1.Traffic Operation outputs calculated using Synchro 9 (Queues/Signalized Intersection Summary - HCM 2000)

As shown in Table 12A, the Traffic Signal Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the AM peak hour. The Traffic Signal Alternative has acceptable 95th percentile queues for all movements.

TABLE 12B
TRAFFIC SIGNAL ALTERNATIVE - EXISTING YEAR (2017) PM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio[1]	Delay (sec)[1]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection		***24.3***	***C***	**--**	
Northbound Lake Street Thru	0.74	26.7	C	350	300
Northbound Lake Street Left	0.27			200	90
Southbound Lake Street Thru	0.58	21.8	C	400	145
Southbound Lake Street Right	0.13			200	45
Eastbound 4th Street Left	0.66	23.2	C	320	185
Eastbound 4th Street Right	0.07			200	0
Eastbound Central Avenue Left/Thru/Right	0.57	28.6	C	445	85

1.Traffic Operation outputs calculated using Synchro 9 (Queues/Signalized Intersection Summary - HCM 2000)

As shown in Table 12B, the Traffic Signal Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the PM peak hour. The Traffic Signal Alternative has acceptable 95th percentile queues for all movements.

6.1.2 Design Year (2040)

Tables 13A & 13B show the projected volume/capacity (V/C) ratio, delay, LOS, and 95th percentile

queues for Design Year conditions during AM and PM peak hour conditions, respectively.

TABLE 13A
TRAFFIC SIGNAL ALTERNATIVE - DESIGN YEAR (2040) AM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio[1]	Delay (sec)[1]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection		***28.2***	***C***	**--**	
Northbound Lake Street Thru	0.90	49.7	D	350	220
Northbound Lake Street Left	0.42			200	85
Southbound Lake Street Thru	0.60	21.6	C	400	190
Southbound Lake Street Right	0.56			200	180
Eastbound 4th Street Left	0.57	20.7	C	320	160
Eastbound 4th Street Right	0.09			200	15
Eastbound Central Avenue Left/Thru/Right	0.63	30.6	C	445	95

1.Traffic Operation outputs calculated using Synchro 9 (Queues/Signalized Intersection Summary - HCM 2000)

As shown in Table 13A, the Traffic Signal Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the AM peak hour. The Traffic Signal Alternative has acceptable 95th percentile queues for all movements. Although the intersection delay and LOS are acceptable, they are worse than those projected for the No Build Alternative. The main long term benefit of the Traffic Signal Alternative is the reduction in 95th percentile queues and delay on the southbound Lake Street approach.

TABLE 13B
TRAFFIC SIGNAL ALTERNATIVE - DESIGN YEAR (2040) PM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio[1]	Delay (sec)[1]	Level Of Service	Available Storage	95th Percentile Queue (ft)
Intersection		***38.3***	***D***	**--**	
Northbound Lake Street Thru	0.86	39.5	D	**350**	**375**
Northbound Lake Street Left	0.31			200	115
Southbound Lake Street Thru	0.84	37.4	D	400	290
Southbound Lake Street Right	0.49			200	140
Eastbound 4th Street Left	0.85	38.5	D	320	320
Eastbound 4th Street Right	0.09			200	35
Eastbound Central Avenue Left/Thru/Right	0.63	37.6	D	445	115

1.Traffic Operation outputs calculated using Synchro 9 (Queues/Signalized Intersection Summary - HCM 2000)

As shown in Table 13B, the Traffic Signal Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the PM peak hour. The Traffic Signal Alternative has acceptable 95th percentile queues for all movements except the northbound Lake Street through movement and vehicles queuing on this approach may occasionally back into and block the 5th Street intersection. For the design year PM peak hour, the Traffic Signal Alternative operates better than the No Build Alternative by reducing intersection delay from 43.4 seconds to 38.3 seconds and eliminates 95th percentile queuing impacts except as noted above.

6.2 Roundabout Alternative Analysis

This section provides a summary of the AM and PM peak hour intersection operations associated with the Roundabout Alternative under Existing Year (2017) and Design Year (2040) conditions. LOS worksheets for each analysis condition and lane geometrics used for this analysis are provided in Appendix C.

6.2.1 Existing Year (2017)

Tables 14A and 14B show the projected volume/capacity (V/C) ratio, delay, LOS, and 95th percentile queues for Existing Year conditions during AM and PM peak hour conditions, respectively.

TABLE 14A
ROUNDABOUT ALTERNATIVE - EXISTING YEAR (2017) AM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio	Delay (sec)	Level of Service[1]	Available Storage	95th Percentile Queue (ft)
Intersection	***0.49***	***7.4***	***A***	**--**	
Northbound Lake Street	0.23	5.4	A	350	35
Southbound Lake Street	0.49	9.0	A	660	100
Eastbound 4th Street	0.30	6.7	A	320	50
Eastbound Central Avenue	0.13	5.9	A	445	20

1.Lane LOS values are based on average delay and v/c ratio per lane.

As shown in Table 14A, the Roundabout Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the AM peak hour. The Roundabout Alternative has acceptable 95th percentile queues for all movements.

TABLE 14B
ROUNDABOUT ALTERNATIVE - EXISTING YEAR (2017) PM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio	Delay (sec)	Level of Service[1]	Available Storage	95th Percentile Queue (ft)
Intersection	***0.43***	***7.3***	***A***	**--**	
Northbound Lake Street	0.35	7.0	A	350	60
Southbound Lake Street	0.43	8.4	A	660	80
Eastbound 4th Street	0.33	6.9	A	320	55
Eastbound Central Avenue	0.11	5.1	A	445	15

1.Lane LOS values are based on average delay and v/c ratio per lane.

As shown in Table 14B, the Roundabout Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the PM peak hour. The Roundabout Alternative has acceptable 95th percentile queues for all movements.

For both the AM and PM peak hours, the Roundabout Alternative operates better than the No Build Alternative by improving LOS from B to A and significantly reducing the 95th percentile

queues.

6.2.2 Design Year (2040)

Tables 15A & 15B show the projected volume/capacity (V/C) ratio, delay, LOS, and 95th percentile queues for Design Year conditions during AM and PM peak hour conditions, respectively.

TABLE 15A
ROUNDABOUT ALTERNATIVE - DESIGN YEAR (2040) AM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio	Delay (sec)	Level of Service[1]	Available Storage	95th Percentile Queue (ft)
Intersection	***0.66***	***10.3***	***B***	**--**	
Northbound Lake Street	0.30	6.5	A	350	50
Southbound Lake Street	0.66	13.6	B	660	190
Eastbound 4th Street	0.41	8.7	A	320	75
Eastbound Central Avenue	0.20	8.0	A	445	35

1.Lane LOS values are based on average delay and v/c ratio per lane.

As shown in Table 15A, the Roundabout Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the AM peak hour. The Roundabout Alternative has acceptable 95th percentile queues for all movements. The Roundabout Alternative is projected to improve the design year intersection LOS from a C to a B and reduces the projected queues.

TABLE 15B
ROUNDABOUT ALTERNATIVE - DESIGN YEAR (2040) PM PEAK HOUR TRAFFIC OPERATIONS

Intersection/Approach	V/C Ratio	Delay (sec)	Level of Service[1]	Available Storage	95th Percentile Queue (ft)
Intersection	***0.59***	***10.1***	***B***	**--**	
Northbound Lake Street	0.48	9.2	A	350	90
Southbound Lake Street	0.59	12.3	B	660	145
Eastbound 4th Street	0.46	9.2	A	320	85
Eastbound Central Avenue	0.16	6.3	A	445	25

1.Lane LOS values are based on average delay and v/c ratio per lane.

As shown in Table 15B, the Roundabout Alternative is projected to provide acceptable intersection LOS and delay for the study intersection during the PM peak hour. The Roundabout Alternative has acceptable 95th percentile queues for all movements. The Roundabout Alternative is projected to improve the design year intersection LOS from a E to a B and reduces the projected queues.

7. Safety Considerations

Safety is a key evaluation factor brought forth in the Directive, and one of the goals of the ICE process is to identify projects that will ensure a reasonable level of safety and operational performance for all users.

7.1 Historic Collision Data

Historical collision data for a five-year interval (2011 through 2016) was obtained from the Statewide Integrated Traffic Records System (SWITRS). Table 16 provides the summary of the type of collisions that happened in that time period at the study intersections.

TABLE 16
COLLISION DATA

Intersections	Property Damage Only	Fatal	Injury (Severe)	Injury (Other visible)	Injury (Complaint of Pain)
Lake Street/4th Street/Central Avenue	9	0	0	0	1

As shown in Table 12, there were no fatal or severe injury collisions at the study intersection within the five-year interval. Most collisions resulted in property damage only, but there was one reported injury collision. Of the total 10 collisions, 4 were broadside or head-on collisions.

7.2 Safety Analysis

7.2.1 Crash Modification Factors

The technical report publication titled “Desktop Reference for Crash Reduction Factor” by the Federal Highway Administration (FHWA) documents Crash Modification Factors (CMF). The publication contains CMF values for conversion of an all-way stop control to a roundabout or traffic signal or a traffic signal to a roundabout. The CMF factors for both Total Collisions and Fatal/Severe Injury Collisions are reproduced below:

Total Collisions

- CMF for converting all-way stop control to a roundabout: 72% with +/- 6% standard error
- CMF for converting all-way stop control to a traffic signal: -17%

Fatal/Severe Injury Collisions

- CMF for converting all-way stop control to a roundabout: 88% with +/- 8% standard error.
- CMF for converting all-way stop control to a traffic signal: -23% with +/- 22% standard error.

As can be seen, statistics have shown that, in general, the conversion of a stop-controlled intersection to a signal results in a negative CMF (increase in crashes) for both total number and fatal/severe injury collisions. Conversely, roundabouts have proven to result in fewer total collisions and fewer injury collisions compared to the stop-controlled and signalized intersections they replace.

7.2.2 Number of Conflicting Points

CMF factors do not account for the 5-legged intersection, which needs a detailed examination of conflict point parameters for both the Signal Alternative and Roundabout Alternatives the number of conflicting points within an intersection directly correlates to the risk of an incident, especially at intersections. Conflicting points are locations at which a roadway user can cross, merge, diverge, etc. with another roadway user. A diagram of conflict locations at typical 4-legged intersections are provided in Figure 6.

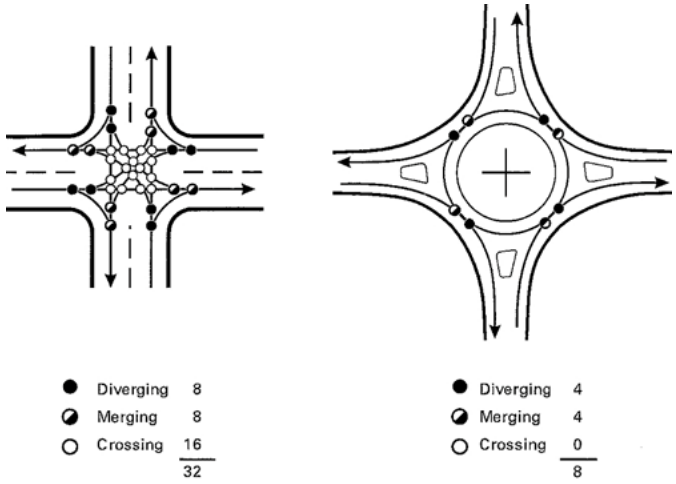


Figure 6 – Typical Conflict Points at Typical Intersections

The number of conflicting points for each of the proposed alternatives are provided below:

Traffic Signal Alternative= **32** Conflicts
Roundabout Alternative=**8** Conflicts

The analysis above illustrates the advantages that the Roundabout Alternative provides by significantly reducing the number of conflict points between vehicles and further justifies the higher CMF values as the exposure to risk is significantly reduced at roundabout intersections.

7.2.3 Reduced Speed Potential and Crash Severity Potential

Typically, the roundabout geometric design requires the driver to reduce the speed in the intersection to 15-25 MPH. Conversely, drivers can travel through a signalized intersection at speeds higher than posted speed limits due to lack of geometric constraints. Due to reduced travel speeds through the intersection and expected reduction in crashes, the Roundabout Alternative is likely to eliminate most severe crash types.

7.2.4 Pedestrian and Bike Safety

Bicycle and pedestrian safety features have been incorporated into the design of both alternatives. The Traffic Signal Alternative includes high-visibility crosswalks and a reconstructed curb ramp. According to the City's Bike Plan, all entering legs to this intersection are identified as Class 3 shared roadways. For this reason, no bike lanes were shown on either concept.

The Roundabout Alternative includes several safety enhancements for both pedestrians and

cyclists. Cyclists have two options when using a roundabout: they can exit the roadway via a bike ramp to use the shared use path with pedestrians, or they can take the lane and ride through the roundabout with the vehicles. Cyclists may feel more comfortable taking the lane due to the slower speeds that a roundabout provides; the average vehicle speed is nearly the same speed as a cyclist. The shared-use path is separated from the circulatory roadway with a landscaped buffer. This buffer screens pedestrians from the moving vehicles and also directs pedestrians to the correct crossing location. The crosswalks are split into two stages with the provision of pedestrian refuges in the splitter island. This means pedestrians only need to cross one direction of traffic at a time and they reduce the amount of sustained time a pedestrian is in potential conflict with motorized vehicles by limiting the length of each crossing.

Compared to the Roundabout Alternative, where a pedestrian only has to cross one lane of traffic at a time, with the Traffic Signal Alternative pedestrians will need to cross up to four lanes of traffic at a time.

8. Alternatives Comparison

8.1 Traffic Signal Alternative

Based on the geometric concept shown on Figure 3 and also provided in Appendix B, the Traffic Signal Alternative has the following potential impacts and considerations:

- The intersection improvements under this alternative would encroach into the adjacent property at the northwest corner of the intersection. Partial or full acquisition of this parcel would be required.
- Reconstructed curb return with ADA compliant pedestrian ramps will be provided on the northwest return.
- The northeast leg of 4th Street will be terminated at the alley and will no longer be part of the intersection. A sidewalk connection will be provided between Lake Street and the existing sidewalk on this leg of 4th Street.
- Approximately 29 on-street parking spaces will be eliminated on the approach roadways to accommodate the additional turn lanes. Eleven of these spaces are part of the northeast leg of 4th Street that will be removed.
- The intersection will be converted from all-way stop control, and a traffic signal will be installed.

8.2 Roundabout Alternative

Based on the geometric concept shown on Figure 4 and also provided in Appendix C, Roundabout Alternative has the following potential impacts and considerations:

- The intersection improvements under this alternative would encroach into the adjacent properties at the corners of the intersection. Partial or full acquisition of each parcel would be required.
- The northeast leg of 4th Street will be terminated at the alley and will no longer be part of the intersection. A sidewalk connection will be provided between Lake Street and the existing sidewalk on this leg of 4th Street.
- Shared-use paths (10') are proposed to be provided on each corner of the intersection with landscaped buffers.
- Approximately 40 on-street parking spaces will be eliminated on the approach roadways

to accommodate the proposed curb alignments. Eleven of these spaces are part of the northeast leg of 4th Street that will be removed.

9. Life-Cycle Analysis

9.1 Collision Costs

Costs associated with each crash type have been quantified using the expected crash reduction (CMF) for the intersection type as noted in the previous section and the number of accidents shown in the Collision history section. Transportation Planning Department of Caltrans provides the costs associated with accident types in Life-Cycle Benefit-Cost Analysis Economic Parameter 2016 webpage (www.dot.ca.gov/hq/tpp/offices/eab/benefit_cost/LCBCAeconomic_parameters.html). The costs are as follows:

- Fatal Accident $10,800,000
- Injury Accident: $148,800
- Property Damage (PDO) Accidents: $9,700
- Average Cost per Accident: $185,600

At the study intersection, there were a total of 10 reported collisions in the 5 year (2011- 2016) period. Out of those 10 collisions, one (1) collision was an injury collision and the remaining collisions were property damage collisions. As such, the total collision cost is calculated to be $236,100 [($148,800 x 1) + ($9,700 x 9)]. The annual collision cost is calculated to be $47,220.

- Using the CRF reduction of 17%, the cost reduction for the Signal Alternative is approximately $8,000/year.
- Using the CRF reduction of 56%, the cost reduction for the Roundabout Alternative is $26,400/year.

Therefore, the Roundabout Alternative will result in lower collision costs when compared to the Signal Alternative.

9.2 Fuel Costs

To calculate the fuel cost for the alternatives, the vehicle operating costs were quantified for the project. The fuel costs (vehicle operating costs) were computed using the delay for the AM and PM peak hour periods for both the Signal and Roundabout alternatives. The output files showing the cost for all alternatives can be found in Appendix D.

The vehicle operating cost parameters were obtained from Life-Cycle Benefit-Cost Analysis Economic Parameters 2016 published by Caltrans. The cost of average fuel price was documented as $3.18 for regular unleaded which was utilized for analysis purpose.

- The average fuel cost for the Signal Alternative is $21,000/year.
- The average fuel cost for the Roundabout Alternative is $20,000/year.

Therefore, it can be concluded that the Roundabout Alternative will result in slightly lower fuel costs when compared to the Traffic Signal Alternative.

9.3 Environmental Costs

To calculate the environmental cost for the alternatives, the greenhouse gas emissions costs were quantified for the project. The fuel costs (vehicle operating costs) were computed using the delay for the AM and PM peak hour periods for both the Signal and Roundabout alternatives. The output files showing the cost for the alternatives can be found in Appendix C. The vehicle operating cost parameters were obtained from Life-Cycle Benefit-Cost Analysis Economic Parameters 2016 published by Caltrans. The cost of Carbon Monoxide (CO) in California urban area was stated to be $80/ton. The cost of Nitrogen Oxide (NOx) in California urban area was stated to be $18,700/ton.

- The average environmental cost for the Signal Alternative is $1,505/year.
- The total environmental cost for the Roundabout Alternative is $1,505/year.

Therefore, it can be concluded that both alternatives will result in the same greenhouse emission costs.

9.4 Capital Costs

9.4.1 Construction Costs

Preliminary estimated construction costs have been developed for both the Traffic Signal Alternative and the Roundabout Alternative with copies of these preliminary cost estimates provided in Appendix B and C. The estimated construction costs for each alternative are provided below.

- **$1.05 Million** for Traffic Signal Alternative
- $**1.62 Million** for Roundabout Alternative

As shown, the construction costs, which represent an initial project capital investment, will be lower for the Traffic Signal Alternative when compared to the Roundabout Alternative.

9.4.2 Right-of-Way Costs

Preliminary ball-park costs for right-of-way were estimated and are provided in Table 17. For this study, $10 per square foot was assumed for partial right of way takes. For the Roundabout Alternative, there are three properties identified in Table 17 as full takes. These full takes are per discussions with the City and are based on property impacts due to both roundabout geometric and sight line impacts. It was also agreed that $250,000 per full take was a reasonable ball-park cost estimate for this study.

TABLE 17
PRELIMINARY RIGHT-OF-WAY IMPACTS AND COSTS

Property	Traffic Signal Alternative (SQFT/COST)	Roundabout Alternative (SQFT/COST)
NW Corner of Lake Street and Central Avenue	160 / $1,600	Full Take / $250,000
SW Corner of Central Avenue and 4th Street	-	Full Take / $250,000
North Side Central Avenue West of Lake Street	-	149 / $1,490
SE Corner of 4th Street and Lake Street	-	392 / $3,920
NE Corner of 4th Street and Lake Street	-	Full Take / $250,000
Estimated Right-of-Way Costs	**$1,600**	**$755,410**

As shown in Table 17, the Roundabout Alternative has a much larger impact on the adjacent properties and results in much greater right-of-way impacts and costs when compared to the Traffic Signal Alternative. These costs also represent and initial project capital investment.

9.5 Other Costs

Besides the collision, environmental and mobility cost, a significant portion of cost associated with both alternatives will be related to its operation & maintenance and pavement rehabilitation costs.

9.5.1 Operation & Maintenance Cost

The maintenance and operation cost for a traffic signal includes providing power service to the signal and street lighting ($1,500 annually), signal retiming ($3,000 every three years), and signal maintenance for power outages/new detector loops/etc. ($1,500 annually) for a total annual cost of $4,000 per year.

The roundabout alternative would incur much lower operation and maintenance costs limited to the cost to power street lighting, which is estimated at $750 annually.

9.5.2 Landscape Maintenance Cost

It is difficult to quantify the landscape maintenance cost at this level since the cost is directly proportional to the area covered by the landscape. Roundabouts typically have a central island covered by landscaping, as well as other landscaping features not typical for a signal.

The landscape maintenance cost is projected to be $1,500 per year for the Roundabout Alternative. The Traffic Signal Alternative is assumed to have no landscaping that will need to be maintained; therefore, a cost of $0 per year per signal was used for landscape maintenance cost.

9.5.3 Pavement Rehabilitation

It is necessary for the function of a roadway to keep the pavement in good condition and maintain roadway striping and markings to assist motorists to navigate through an intersection/corridor safely and efficiently.

Intersections with traffic signals experience a lot of differential loading and pavement heaving

perpendicular to the direction of travel. This is caused by frequent stopping and starting of vehicles at the intersection.

Roundabout intersections experience less severe pavement heaving due to the lack of differential loading, but when heaving does occur at roundabouts, it is typically parallel to the direction of travel and occurs near the outer edge of the roadway, along the curb line. This is caused by the constant angular forces experienced in and near the circulatory roadway. As a result, roundabout intersection do not typically require structural section reconstruction just resurfacing.

Proper maintenance of the roadway profiles and cross slopes also ensure proper drainage flow and friction levels with a vehicle's tires and a roadway is typically resurfaced every 5-10 years. For the purpose of this report pavement rehabilitation is expected to occur in the study area every 8 years.

The costs associated with pavement rehabilitation include removing and reconstructing the roadway structural section, resurfacing, and pavement delineation. Traffic signal rehabilitation projects typically require more structural section reconstruction than roundabout intersections, but roundabout intersections require more labor intensive control when replacing the pavement delineation (striping and markings).

9.6 Service Life

The roundabout and traffic signal alternatives proposed for the ultimate design year are projected to provide equal levels of service for the Design Year 2040; however, the roundabout alternative is projected to operate with lower delays and shorter queues for the Ultimate Design Year than the Traffic Signal Alternative.

It can be concluded that the Roundabout Alternative will provide increased benefit with regards to service life, when compared to the Traffic Signal Alternative.

10. Summary of Findings

The traffic forecast volumes for the Lake Street/4th Street/Central Avenue intersection show growth in this area. The No Build Alternative analysis shows congestion and delay in the design year (2040) indicating that significant improvements would need to be made to the study intersection. Table 18 summarizes and compares the performance for both the Traffic Signal Alternative and the Roundabout Alternative.

TABLE 18
ALTERNATIVE PERFORMANCE COMPARISON

Performance Measure	Traffic Signal Alternative	Roundabout Alternative
Cumulative Condition		
Delay - All approaches LOS "D" or better LOS A rated at 5 and E rated at 1.	2.4 ✓	**4.8** ✓✓
95th % Queue - Adequate queue storage	✓	✓✓
Future Investment Needs		
Service Life – function past the design year	D ✓	**B** ✓✓
Costs		
Operations & Maintenance - Annualized	$3,000	**$1,700** ✓
Collision Costs - Annualized	$150,100	**$100,800** ✓
Delay Costs - Annualized	$36,000	**$11,000** ✓
Fuel Costs - Annualized	$21,000	**$20,000** ✓
Environmental Costs - Annualized	$1,505	$1,505
Capital Costs - Annualized	**$48,000** ✓	$119,000
Truck Accommodations		
Serves design vehicle for all movements	✓	✓
Safety		
Predictive Measures - Greatest crash reduction potential for expected fatal and injury crashes	17%	**56%** ✓
Vehicle Conflicts - The number of potential conflict points that may occur at the intersection based on layout geometry	32	**8** ✓
Pedestrian Safety - Exposure to traffic in terms of number of lanes, conflict points, crossing times, and expected vehicular speeds.	4 35-45 mph	**1** **15-25mph** ✓✓
Bicycle Safety - Exposure to traffic in terms of number of lanes, conflict points, and speed differential		✓
Property Impacts		
Property Impacts	✓✓	
Local Access		
Maintains local access and circulation	✓	✓
Total Performance Measures Met	**8**	**17**

Table 19 provides a summary of the life cycle costs for the two alternatives.

TABLE 19
LIFE CYCLE COST SUMMARY PERFORMANCE COMPARISON

Life Cycle Costs (20 year design)	Traffic Signal Alternative	Roundabout Alternative
Collision and Mobility Costs		
Collision Costs of predicted crashes	$3,002,000	$2,016,000
Delay Costs	$860,000	$260,000
Fuel and GHG Costs	$537,000	$506,000
Project Costs including design, construction and maintenance		
Operations and Maintenance Costs	$60,000	$34,000
Project Costs (including R/W)	$1,172,299	$2,609,802
Total Life Cycle Costs (Opening Year $ - Net Present Value)	**$5,631,299**	**$5,425,802**

11. Conclusions

As shown in Table 18, 17 performance measure points were assigned to the Roundabout Alternative, as compared to 8 for the Traffic Signal Alternative. As shown in Table 19, when compared to the Traffic Signal Alternative, implementation of the Roundabout Alternative will result in lower life cycle costs. Based on these results, the Roundabout Alternative would provide superior performance at a lower overall cost then the Traffic Signal Alternative for the Lake Street/4th Street/Central Avenue intersection.

Appendix

APPENDIX A – CAPICITY ASSESSMENT/ANALYSIS EXISTING 5-LEG INTERSECTION

- NO BUILD ANALYSIS
- SIGNAL ANALYSIS
- ROUNDABOUT ANALYSIS

APPENDIX B – TRAFFIC SIGNAL ALTERNATIVE

- SIGNAL LAYOUT & TRUCK TURN EXHIBITS
- SYNCHRO/SIMTRAFFIC ANALYSIS
- CONSTRUCTION COST ESTIMATE

APPENDIX C – ROUNDABOUT ALTERNATIVE

- ROUNDABOUT LAYOUT, FASTEST PATH, & TRUCK TURN EXHIBITS
- SIDRA 7 ANALYSIS
- CONSTRUCTION COST ESTIMATE

APPENDIX D – BENEFIT/COST RATIO BACK-UP

APPENDIX E – ALTERNATIVES COMPARISON BACK-UP

APPENDIX A – CAPACITY ASSESSMENT/ANALYSIS EXISTING 5-LEG INTERSECTION

NO BUILD ANALYSIS

SIGNAL ANALYSIS

ROUNDABOUT ANALYSIS

APPENDIX A – NO BUILD ANALYSIS

Summary of All Intervals

Run Number	1	2	3	4	5	Avg
Start Time	6:57	6:57	6:57	6:57	6:57	6:57
End Time	7:10	7:10	7:10	7:10	7:10	7:10
Total Time (min)	13	13	13	13	13	13
Time Recorded (min)	10	10	10	10	10	10
# of Intervals	2	2	2	2	2	2
# of Recorded Intervals	1	1	1	1	1	1
Vehs Entered	153	157	163	161	161	159
Vehs Exited	158	156	151	162	160	157
Starting Vehs	10	8	6	11	12	8
Ending Vehs	5	9	18	10	13	9
Travel Distance (mi)	27	27	27	28	28	28
Travel Time (hr)	1.9	1.7	1.7	1.7	1.8	1.8
Total Delay (hr)	0.7	0.5	0.6	0.5	0.6	0.6
Total Stops	155	157	163	160	161	159
Fuel Used (gal)	1.5	1.4	1.4	1.4	1.4	1.4

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Run Number	1	2	3	4	5	Avg
Vehs Entered	153	157	163	161	161	159
Vehs Exited	158	156	151	162	160	157
Starting Vehs	10	8	6	11	12	8
Ending Vehs	5	9	18	10	13	9
Travel Distance (mi)	27	27	27	28	28	28
Travel Time (hr)	1.9	1.7	1.7	1.7	1.8	1.8
Total Delay (hr)	0.7	0.5	0.6	0.5	0.6	0.6
Total Stops	155	157	163	160	161	159
Fuel Used (gal)	1.5	1.4	1.4	1.4	1.4	1.4

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	EBL	EBT	EBR	WBT	WBR2	NBL2	NBL	NBT	NBR	SBT	SBR	SBR2
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	3.8	0.1	3.8	0.1	0.1	0.2	0.2	0.2		0.4	0.5	2.7
Total Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
Total Del/Veh (s)	7.4	4.6	5.3	8.4	1.4	8.6	9.9	9.0		15.9	12.2	3.0
Stop Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
Stop Del/Veh (s)	5.8	2.7	5.7	5.1	1.4	5.5	7.7	5.1		11.6	11.3	3.0

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	SEL2	SEL	SER	All
Denied Delay (hr)	0.0	0.0	0.0	0.1
Denied Del/Veh (s)	0.2		0.1	1.3
Total Delay (hr)	0.0	0.0	0.0	0.5
Total Del/Veh (s)	11.5		7.8	10.2
Stop Delay (hr)	0.0	0.0	0.0	0.4
Stop Del/Veh (s)	9.0		7.3	8.3

Intersection: 2: N Lake St & E 4th St & Central Ave

Movement	EB	EB	EB	WB	NB	SB	SB	SE
Directions Served	<L	T	R	LTR>	<LTR	LTR	>	<LR
Maximum Queue (ft)	47	7	38	26	69	162	16	58
Average Queue (ft)	32	2	20	7	42	99	6	40
95th Queue (ft)	50	10	42	25	76	189	20	70
Link Distance (ft)		362		330	430	406		473
Upstream Blk Time (%)								
Queuing Penalty (veh)								
Storage Bay Dist (ft)	60		75				65	
Storage Blk Time (%)	0		0			20		
Queuing Penalty (veh)	0		0			5		

Summary of All Intervals

Run Number	1	2	3	4	5	Avg
Start Time	6:57	6:57	6:57	6:57	6:57	6:57
End Time	7:10	7:10	7:10	7:10	7:10	7:10
Total Time (min)	13	13	13	13	13	13
Time Recorded (min)	10	10	10	10	10	10
# of Intervals	2	2	2	2	2	2
# of Recorded Intervals	1	1	1	1	1	1
Vehs Entered	193	199	215	191	191	197
Vehs Exited	199	186	196	194	194	193
Starting Vehs	12	6	7	14	18	12
Ending Vehs	6	19	26	11	15	13
Travel Distance (mi)	34	34	36	34	34	35
Travel Time (hr)	2.3	2.6	2.6	2.1	2.4	2.4
Total Delay (hr)	0.9	1.2	1.2	0.7	1.0	1.0
Total Stops	198	199	216	187	193	198
Fuel Used (gal)	1.8	1.8	1.9	1.7	1.8	1.8

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Run Number	1	2	3	4	5	Avg
Vehs Entered	193	199	215	191	191	197
Vehs Exited	199	186	196	194	194	193
Starting Vehs	12	6	7	14	18	12
Ending Vehs	6	19	26	11	15	13
Travel Distance (mi)	34	34	36	34	34	35
Travel Time (hr)	2.3	2.6	2.6	2.1	2.4	2.4
Total Delay (hr)	0.9	1.2	1.2	0.7	1.0	1.0
Total Stops	198	199	216	187	193	198
Fuel Used (gal)	1.8	1.8	1.9	1.7	1.8	1.8

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	EBL	EBT	EBR	WBL	WBT	WBR	WBR2	NBL2	NBL	NBT	NBR	SBT
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	3.5	0.1	3.7		0.1			0.2	0.3	0.2	0.1	0.4
Total Delay (hr)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
Total Del/Veh (s)	12.5	9.0	4.4		5.8			17.4	17.6	18.2	9.5	20.1
Stop Delay (hr)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
Stop Del/Veh (s)	10.9	6.4	4.8		4.0			15.2	15.5	14.1	9.2	16.1

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	SBR	SBR2	SEL2	SEL	SER	SER2	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Denied Del/Veh (s)	0.6	3.1	0.2		0.1		1.3
Total Delay (hr)	0.1	0.0	0.0	0.0	0.0	0.0	0.8
Total Del/Veh (s)	15.8	3.8	13.2	5.6	9.5		14.8
Stop Delay (hr)	0.1	0.0	0.0	0.0	0.0	0.0	0.7
Stop Del/Veh (s)	15.4	3.6	10.8	4.7	9.0		12.6

Total Network Performance

Denied Delay (hr)	0.1
Denied Del/Veh (s)	1.3
Total Delay (hr)	0.9
Total Del/Veh (s)	16.3
Stop Delay (hr)	0.7
Stop Del/Veh (s)	13.1

Intersection: 2: N Lake St & E 4th St & Central Ave

Movement	EB	EB	EB	WB	NB	SB	SB	SE
Directions Served	<L	T	R	LTR>	<LTR	LTR	>	<LR>
Maximum Queue (ft)	71	18	35	26	143	147	16	64
Average Queue (ft)	43	4	10	7	89	91	7	39
95th Queue (ft)	77	22	33	32	169	177	18	75
Link Distance (ft)		351		330	430	406		462
Upstream Blk Time (%)								
Queuing Penalty (veh)								
Storage Bay Dist (ft)	60		75				65	
Storage Blk Time (%)	5	0				26		
Queuing Penalty (veh)	5	0				11		

Network Summary

Network wide Queuing Penalty: 17

Summary of All Intervals

Run Number	1	2	3	4	5	Avg
Start Time	6:57	6:57	6:57	6:57	6:57	6:57
End Time	7:10	7:10	7:10	7:10	7:10	7:10
Total Time (min)	13	13	13	13	13	13
Time Recorded (min)	10	10	10	10	10	10
# of Intervals	2	2	2	2	2	2
# of Recorded Intervals	1	1	1	1	1	1
Vehs Entered	200	211	220	202	203	207
Vehs Exited	193	196	200	204	195	198
Starting Vehs	11	8	9	16	12	12
Ending Vehs	18	23	29	14	20	19
Travel Distance (mi)	34	36	36	35	35	35
Travel Time (hr)	3.4	2.9	3.6	2.4	2.6	3.0
Total Delay (hr)	1.9	1.5	2.1	0.9	1.1	1.5
Total Stops	196	212	219	198	205	205
Fuel Used (gal)	2.0	1.9	2.0	1.8	1.8	1.9

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Run Number	1	2	3	4	5	Avg
Vehs Entered	200	211	220	202	203	207
Vehs Exited	193	196	200	204	195	198
Starting Vehs	11	8	9	16	12	12
Ending Vehs	18	23	29	14	20	19
Travel Distance (mi)	34	36	36	35	35	35
Travel Time (hr)	3.4	2.9	3.6	2.4	2.6	3.0
Total Delay (hr)	1.9	1.5	2.1	0.9	1.1	1.5
Total Stops	196	212	219	198	205	205
Fuel Used (gal)	2.0	1.9	2.0	1.8	1.8	1.9

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	EBL	EBT	EBR	WBT	WBR2	NBL2	NBL	NBT	NBR	SBT	SBR	SBR2
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	3.6	0.1	3.7	0.1		0.3	0.2	0.2	0.1	0.7	0.7	3.1
Total Delay (hr)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.5	0.0
Total Del/Veh (s)	10.6	3.8	7.1	8.0		15.1	12.6	13.7	2.0	42.3	37.5	5.0
Stop Delay (hr)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.4	0.5	0.0
Stop Del/Veh (s)	8.9	2.6	7.3	5.1		12.6	9.9	9.5	2.1	40.2	38.5	4.1

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	SEL2	SEL	SER	All
Denied Delay (hr)	0.0	0.0	0.0	0.1
Denied Del/Veh (s)	0.2	0.1	0.2	1.3
Total Delay (hr)	0.0	0.0	0.1	1.4
Total Del/Veh (s)	12.4	6.6	12.7	23.0
Stop Delay (hr)	0.0	0.0	0.1	1.3
Stop Del/Veh (s)	10.4	5.6	12.1	21.6

Intersection: 2: N Lake St & E 4th St & Central Ave

Movement	EB	EB	EB	WB	NB	SB	SB	SE
Directions Served	<L	T	R	LTR>	<LTR	LTR	>	<LR
Maximum Queue (ft)	61	14	46	16	125	347	83	71
Average Queue (ft)	43	3	22	4	68	219	34	49
95th Queue (ft)	70	22	48	20	123	421	195	90
Link Distance (ft)		362		330	430	406		473
Upstream Blk Time (%)						2		
Queuing Penalty (veh)						0		
Storage Bay Dist (ft)	60		75				65	
Storage Blk Time (%)	3	0				62		
Queuing Penalty (veh)	3	0				21		

Summary of All Intervals

Run Number	1	2	3	4	5	Avg
Start Time	6:57	6:57	6:57	6:57	6:57	6:57
End Time	7:10	7:10	7:10	7:10	7:10	7:10
Total Time (min)	13	13	13	13	13	13
Time Recorded (min)	10	10	10	10	10	10
# of Intervals	2	2	2	2	2	2
# of Recorded Intervals	1	1	1	1	1	1
Vehs Entered	231	245	249	237	230	237
Vehs Exited	225	225	210	222	232	222
Starting Vehs	20	17	20	16	25	18
Ending Vehs	26	37	59	31	23	33
Travel Distance (mi)	39	41	39	40	41	40
Travel Time (hr)	5.4	4.4	5.3	4.0	4.9	4.8
Total Delay (hr)	3.8	2.8	3.7	2.4	3.3	3.2
Total Stops	235	244	242	230	234	237
Fuel Used (gal)	2.7	2.4	2.6	2.3	2.6	2.5

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Run Number	1	2	3	4	5	Avg
Vehs Entered	231	245	249	237	230	237
Vehs Exited	225	225	210	222	232	222
Starting Vehs	20	17	20	16	25	18
Ending Vehs	26	37	59	31	23	33
Travel Distance (mi)	39	41	39	40	41	40
Travel Time (hr)	5.4	4.4	5.3	4.0	4.9	4.8
Total Delay (hr)	3.8	2.8	3.7	2.4	3.3	3.2
Total Stops	235	244	242	230	234	237
Fuel Used (gal)	2.7	2.4	2.6	2.3	2.6	2.5

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	EBL	EBT	EBR	WBL	WBT	WBR	WBR2	NBL2	NBL	NBT	NBR	SBL
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	3.9	0.5	3.7	0.1	0.1			0.5	0.4	0.4	0.1	
Total Delay (hr)	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.8	0.0	0.0
Total Del/Veh (s)	39.7	19.3	11.1	5.6	14.0			52.7	50.4	53.4	27.0	
Stop Delay (hr)	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.8	0.0	0.0
Stop Del/Veh (s)	38.9	17.0	10.8	4.7	10.6			52.0	50.2	51.6	27.3	

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	SBT	SBR	SBR2	SEL2	SEL	SER	SER2	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Denied Del/Veh (s)	0.7	0.8	3.6	0.2	0.1	0.2		1.6
Total Delay (hr)	0.7	0.4	0.0	0.0	0.0	0.0	0.0	3.0
Total Del/Veh (s)	59.6	51.6	6.2	14.7	15.2	13.5		43.4
Stop Delay (hr)	0.7	0.4	0.0	0.0	0.0	0.0	0.0	2.9
Stop Del/Veh (s)	58.2	53.2	5.2	12.4	13.8	12.7		42.5

Total Network Performance

Denied Delay (hr)	0.1
Denied Del/Veh (s)	1.6
Total Delay (hr)	3.1
Total Del/Veh (s)	43.5
Stop Delay (hr)	3.0
Stop Del/Veh (s)	41.9

Intersection: 2: N Lake St & E 4th St & Central Ave

Movement	EB	EB	EB	WB	NB	SB	SB	SE
Directions Served	<L	T	R	LTR>	<LTR	LTR	>	<LR>
Maximum Queue (ft)	99	159	72	30	312	327	154	56
Average Queue (ft)	82	76	33	9	217	235	49	43
95th Queue (ft)	127	262	135	32	380	417	242	69
Link Distance (ft)		351		330	430	406		462
Upstream Blk Time (%)		2			1	2		
Queuing Penalty (veh)		0			0	0		
Storage Bay Dist (ft)	60		75				65	
Storage Blk Time (%)	44	1				78		
Queuing Penalty (veh)	55	3				42		

Network Summary

Network wide Queuing Penalty: 99

APPENDIX A – TRAFFIC SIGNAL ANALYSIS

Movement	EBL2	EBL	EBT	EBR	WBL	WBT	WBR2	NBL2	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	1	145	2	94	2	3	1	37	25	140	2	1
Future Volume (vph)	1	145	2	94	2	3	1	37	25	140	2	1
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	12	16	12	12	13	13	12	12
Total Lost time (s)		4.5	4.5		4.5	4.5			4.5	4.5		4.5
Lane Util. Factor		0.97	1.00		1.00	1.00			1.00	1.00		1.00
Frpb, ped/bikes		1.00	0.98		1.00	1.00			1.00	1.00		1.00
Flpb, ped/bikes		0.99	1.00		0.99	1.00			1.00	1.00		0.99
Frt		1.00	0.85		1.00	0.97			1.00	1.00		1.00
Flt Protected		0.95	1.00		0.95	1.00			0.95	1.00		0.95
Satd. Flow (prot)		3156	1444		1622	1896			1699	1785		1621
Flt Permitted		0.75	1.00		0.68	1.00			0.95	1.00		0.95
Satd. Flow (perm)		2506	1444		1163	1896			1699	1785		1621
Peak-hour factor, PHF	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Adj. Flow (vph)	1	179	2	116	2	4	1	46	31	173	2	1
RTOR Reduction (vph)	0	0	95	0	0	4	0	0	0	1	0	0
Lane Group Flow (vph)	0	180	23	0	2	1	0	0	77	174	0	1
Confl. Peds. (#/hr)	6				9			3				1
Confl. Bikes (#/hr)				1			5				2	
Turn Type	Perm	Perm	NA		Perm	NA		Prot	Prot	NA		Prot
Protected Phases			2			6		3	3	8		7
Permitted Phases	2	2			6							
Actuated Green, G (s)		11.8	11.8		11.8	11.8			6.8	25.5		0.7
Effective Green, g (s)		11.8	11.8		11.8	11.8			6.8	25.5		0.7
Actuated g/C Ratio		0.18	0.18		0.18	0.18			0.11	0.40		0.01
Clearance Time (s)		4.5	4.5		4.5	4.5			4.5	4.5		4.5
Vehicle Extension (s)		3.0	3.0		3.0	3.0			3.0	3.0		3.0
Lane Grp Cap (vph)		462	266		214	349			180	711		17
v/s Ratio Prot			0.02			0.00			c0.05	0.10		0.00
v/s Ratio Perm		c0.07			0.00							
v/c Ratio		0.39	0.09		0.01	0.00			0.43	0.25		0.06
Uniform Delay, d1		22.9	21.6		21.3	21.3			26.8	12.8		31.3
Progression Factor		1.00	1.00		1.00	1.00			1.00	1.00		1.00
Incremental Delay, d2		0.5	0.1		0.0	0.0			1.6	0.2		1.5
Delay (s)		23.5	21.8		21.3	21.3			28.4	13.0		32.8
Level of Service		C	C		C	C			C	B		C
Approach Delay (s)			22.8			21.3				17.7		
Approach LOS			C			C				B		

Intersection Summary			
HCM 2000 Control Delay	20.4	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.46		
Actuated Cycle Length (s)	64.0	Sum of lost time (s)	18.0
Intersection Capacity Utilization	45.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR	SBR2	SEL2	SEL	SER
Lane Configurations						
Traffic Volume (vph)	178	216	27	14	2	65
Future Volume (vph)	178	216	27	14	2	65
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	12	12
Total Lost time (s)	4.5	4.5			4.5	
Lane Util. Factor	1.00	1.00			1.00	
Frpb, ped/bikes	1.00	0.98			1.00	
Flpb, ped/bikes	1.00	1.00			1.00	
Frt	1.00	0.85			0.89	
Flt Protected	1.00	1.00			0.99	
Satd. Flow (prot)	1731	1440			1527	
Flt Permitted	1.00	1.00			0.99	
Satd. Flow (perm)	1731	1440			1527	
Peak-hour factor, PHF	0.81	0.81	0.81	0.81	0.81	0.81
Adj. Flow (vph)	220	267	33	17	2	80
RTOR Reduction (vph)	0	88	0	0	0	0
Lane Group Flow (vph)	220	212	0	0	99	0
Confl. Peds. (#/hr)				8		
Confl. Bikes (#/hr)			1			
Turn Type	NA	Perm		Prot	Prot	
Protected Phases	4			9	9	
Permitted Phases		4				
Actuated Green, G (s)	19.4	19.4			8.0	
Effective Green, g (s)	19.4	19.4			8.0	
Actuated g/C Ratio	0.30	0.30			0.12	
Clearance Time (s)	4.5	4.5			4.5	
Vehicle Extension (s)	3.0	3.0			3.0	
Lane Grp Cap (vph)	524	436			190	
v/s Ratio Prot	0.13				c0.06	
v/s Ratio Perm		c0.15				
v/c Ratio	0.42	0.49			0.52	
Uniform Delay, d1	17.8	18.2			26.2	
Progression Factor	1.00	1.00			1.00	
Incremental Delay, d2	0.5	0.9			2.6	
Delay (s)	18.4	19.1			28.8	
Level of Service	B	B			C	
Approach Delay (s)	18.8				28.8	
Approach LOS	B				C	

Intersection Summary

Summary of All Intervals

Run Number	1	2	3	4	5	Avg
Start Time	6:57	6:57	6:57	6:57	6:57	6:57
End Time	7:10	7:10	7:10	7:10	7:10	7:10
Total Time (min)	13	13	13	13	13	13
Time Recorded (min)	10	10	10	10	10	10
# of Intervals	2	2	2	2	2	2
# of Recorded Intervals	1	1	1	1	1	1
Vehs Entered	178	169	150	150	150	158
Vehs Exited	167	175	153	153	148	159
Starting Vehs	6	18	14	12	5	11
Ending Vehs	17	12	11	9	7	10
Travel Distance (mi)	30	31	27	26	26	28
Travel Time (hr)	2.1	2.1	1.9	1.7	1.8	1.9
Total Delay (hr)	1.0	1.0	0.9	0.8	0.8	0.9
Total Stops	123	124	111	106	115	115
Fuel Used (gal)	1.8	1.8	1.5	1.5	1.5	1.6

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Run Number	1	2	3	4	5	Avg
Vehs Entered	178	169	150	150	150	158
Vehs Exited	167	175	153	153	148	159
Starting Vehs	6	18	14	12	5	11
Ending Vehs	17	12	11	9	7	10
Travel Distance (mi)	30	31	27	26	26	28
Travel Time (hr)	2.1	2.1	1.9	1.7	1.8	1.9
Total Delay (hr)	1.0	1.0	0.9	0.8	0.8	0.9
Total Stops	123	124	111	106	115	115
Fuel Used (gal)	1.8	1.8	1.5	1.5	1.5	1.6

2: N Lake St & E 4th St & Central Ave Performance by approach

Approach	EB	WB	NB	SB	SE	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.1
Denied Del/Veh (s)	0.2	0.1	1.5	2.5	0.2	1.5
Total Delay (hr)	0.2	0.0	0.2	0.3	0.1	0.8
Total Del/Veh (s)	13.8	6.9	21.2	16.0	22.6	16.9
Stop Delay (hr)	0.2	0.0	0.2	0.3	0.1	0.6
Stop Del/Veh (s)	12.1	5.4	17.2	12.7	21.0	14.0

Intersection: 2: N Lake St & E 4th St & Central Ave

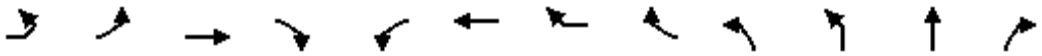
Movement	EB	EB	WB	NB	NB	SB	SB	SB	SE
Directions Served	L	TR	TR>	<L	TR	L	T	R>	<LR
Maximum Queue (ft)	87	23	13	47	100	1	76	92	74
Average Queue (ft)	52	9	3	29	62	0	40	44	42
95th Queue (ft)	105	28	15	52	105	2	86	106	82
Link Distance (ft)	352	352	307		436		387		452
Upstream Blk Time (%)									
Queuing Penalty (veh)									
Storage Bay Dist (ft)				200		100		200	
Storage Blk Time (%)							0		
Queuing Penalty (veh)							1		

Intersection: 2: N Lake St & E 4th St & Central Ave

Phase	2	3	4	6	7	8	9
Movement(s) Served	EBTL	NBL	SBT	WBTL	SBL	NBT	SEL
Maximum Green (s)	31.4	18.5	41.5	31.4	5.0	55.0	20.6
Minimum Green (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Recall	None	None	None	None	None	None	None
Avg. Green (s)	12.0	6.9	14.7	12.0	0.0	20.6	10.5
g/C Ratio	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Cycles Skipped (%)	15	42	8	15	100	42	42
Cycles @ Minimum (%)	0	0	0	0	0	0	0
Cycles Maxed Out (%)	0	0	0	0	0	0	0
Cycles with Peds (%)	8	0	0	0	0	0	8

Controller Summary

Average Cycle Length (s): NA
Number of Complete Cycles : 0



Movement	EBL2	EBL	EBT	EBR	WBL	WBT	WBR	WBR2	NBL2	NBL	NBT	NBR
Lane Configurations												
Traffic Volume (vph)	1	221	4	96	3	2	1	1	48	43	262	5
Future Volume (vph)	1	221	4	96	3	2	1	1	48	43	262	5
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	12	16	12	12	12	13	13	12
Total Lost time (s)		4.5	4.5		4.5	4.5				4.5	4.5	
Lane Util. Factor		0.97	1.00		1.00	1.00				1.00	1.00	
Frpb, ped/bikes		1.00	0.98		1.00	0.99				1.00	1.00	
Flpb, ped/bikes		0.99	1.00		0.99	1.00				1.00	1.00	
Frt		1.00	0.86		1.00	0.93				1.00	1.00	
Flt Protected		0.95	1.00		0.95	1.00				0.95	1.00	
Satd. Flow (prot)		3250	1493		1670	1852				1750	1836	
Flt Permitted		0.76	1.00		0.69	1.00				0.95	1.00	
Satd. Flow (perm)		2583	1493		1215	1852				1750	1836	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	1	226	4	98	3	2	1	1	49	44	267	5
RTOR Reduction (vph)	0	0	78	0	0	1	0	0	0	0	1	0
Lane Group Flow (vph)	0	227	24	0	3	3	0	0	0	93	271	0
Confl. Peds. (#/hr)	6				9				3			
Confl. Bikes (#/hr)				1				5				2
Turn Type	Perm	Perm	NA		Perm	NA			Prot	Prot	NA	
Protected Phases			2			6			3	3	8	
Permitted Phases	2	2			6							
Actuated Green, G (s)		12.8	12.8		12.8	12.8				7.3	24.4	
Effective Green, g (s)		12.8	12.8		12.8	12.8				7.3	24.4	
Actuated g/C Ratio		0.20	0.20		0.20	0.20				0.11	0.38	
Clearance Time (s)		4.5	4.5		4.5	4.5				4.5	4.5	
Vehicle Extension (s)		3.0	3.0		3.0	3.0				3.0	3.0	
Lane Grp Cap (vph)		519	300		244	372				200	704	
v/s Ratio Prot			0.02			0.00				c0.05	c0.15	
v/s Ratio Perm		c0.09			0.00							
v/c Ratio		0.44	0.08		0.01	0.01				0.47	0.39	
Uniform Delay, d1		22.2	20.6		20.3	20.3				26.3	14.2	
Progression Factor		1.00	1.00		1.00	1.00				1.00	1.00	
Incremental Delay, d2		0.6	0.1		0.0	0.0				1.7	0.4	
Delay (s)		22.8	20.7		20.4	20.3				28.0	14.5	
Level of Service		C	C		C	C				C	B	
Approach Delay (s)			22.2			20.3					18.0	
Approach LOS			C			C					B	

Intersection Summary			
HCM 2000 Control Delay	20.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	63.6	Sum of lost time (s)	18.0
Intersection Capacity Utilization	53.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL	SBT	SBR	SBR2	SEL2	SEL	SER	SER2
Lane Configurations								
Traffic Volume (vph)	2	213	150	42	32	2	58	2
Future Volume (vph)	2	213	150	42	32	2	58	2
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	12	12	12	12
Total Lost time (s)	4.5	4.5	4.5			4.5		
Lane Util. Factor	1.00	1.00	1.00			1.00		
Frpb, ped/bikes	1.00	1.00	0.98			0.99		
Flpb, ped/bikes	0.99	1.00	1.00			1.00		
Frt	1.00	1.00	0.85			0.91		
Flt Protected	0.95	1.00	1.00			0.98		
Satd. Flow (prot)	1672	1782	1483			1586		
Flt Permitted	0.95	1.00	1.00			0.98		
Satd. Flow (perm)	1672	1782	1483			1586		
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	2	217	153	43	33	2	59	2
RTOR Reduction (vph)	0	0	91	0	0	0	0	0
Lane Group Flow (vph)	2	217	105	0	0	96	0	0
Confl. Peds. (#/hr)	1				8			
Confl. Bikes (#/hr)				1				1
Turn Type	Prot	NA	Perm		Prot	Prot		
Protected Phases	7	4			9	9		
Permitted Phases			4					
Actuated Green, G (s)	0.7	17.8	17.8			7.7		
Effective Green, g (s)	0.7	17.8	17.8			7.7		
Actuated g/C Ratio	0.01	0.28	0.28			0.12		
Clearance Time (s)	4.5	4.5	4.5			4.5		
Vehicle Extension (s)	3.0	3.0	3.0			3.0		
Lane Grp Cap (vph)	18	498	415			192		
v/s Ratio Prot	0.00	0.12				c0.06		
v/s Ratio Perm			0.07					
v/c Ratio	0.11	0.44	0.25			0.50		
Uniform Delay, d1	31.1	18.8	17.8			26.1		
Progression Factor	1.00	1.00	1.00			1.00		
Incremental Delay, d2	2.7	0.6	0.3			2.0		
Delay (s)	33.9	19.4	18.1			28.2		
Level of Service	C	B	B			C		
Approach Delay (s)		18.8				28.2		
Approach LOS		B				C		

Intersection Summary

Summary of All Intervals

Run Number	1	2	3	4	5	Avg
Start Time	6:57	6:57	6:57	6:57	6:57	6:57
End Time	7:10	7:10	7:10	7:10	7:10	7:10
Total Time (min)	13	13	13	13	13	13
Time Recorded (min)	10	10	10	10	10	10
# of Intervals	2	2	2	2	2	2
# of Recorded Intervals	1	1	1	1	1	1
Vehs Entered	212	211	200	217	199	205
Vehs Exited	207	206	190	207	199	202
Starting Vehs	19	13	11	17	8	12
Ending Vehs	24	18	21	27	8	20
Travel Distance (mi)	37	37	34	37	35	36
Travel Time (hr)	2.7	3.0	2.6	2.9	2.4	2.7
Total Delay (hr)	1.3	1.6	1.3	1.5	1.2	1.4
Total Stops	148	163	153	165	140	154
Fuel Used (gal)	2.2	2.2	2.0	2.2	2.0	2.1

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Run Number	1	2	3	4	5	Avg
Vehs Entered	212	211	200	217	199	205
Vehs Exited	207	206	190	207	199	202
Starting Vehs	19	13	11	17	8	12
Ending Vehs	24	18	21	27	8	20
Travel Distance (mi)	37	37	34	37	35	36
Travel Time (hr)	2.7	3.0	2.6	2.9	2.4	2.7
Total Delay (hr)	1.3	1.6	1.3	1.5	1.2	1.4
Total Stops	148	163	153	165	140	154
Fuel Used (gal)	2.2	2.2	2.0	2.2	2.0	2.1

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	EBL	EBT	EBR	WBL	WBT	WBR	WBR2	NBL2	NBL	NBT	NBR	SBL
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.2	0.5	0.2					3.4	3.6	0.6	0.8	
Total Delay (hr)	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.0	0.0
Total Del/Veh (s)	25.1	19.9	5.0					25.0	25.6	21.6	10.4	
Stop Delay (hr)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0
Stop Del/Veh (s)	21.6	13.7	5.1					22.2	22.6	16.3	8.5	

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	SBT	SBR	SBR2	SEL2	SER	SER2	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Denied Del/Veh (s)	1.0	3.5	3.4	0.2	0.2		1.2
Total Delay (hr)	0.2	0.1	0.0	0.0	0.1	0.0	1.2
Total Del/Veh (s)	20.4	18.0	11.8	24.8	26.2		20.8
Stop Delay (hr)	0.2	0.1	0.0	0.0	0.1	0.0	1.0
Stop Del/Veh (s)	15.3	15.7	10.9	22.1	24.9		17.3

Intersection: 2: N Lake St & E 4th St & Central Ave

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB	SB	SE
Directions Served	<L	L	TR	L	TR>	<L	TR	L	T	R>	<LR>
Maximum Queue (ft)	22	123	32	3	16	63	200	1	110	78	91
Average Queue (ft)	6	79	9	1	4	42	116	0	54	41	53
95th Queue (ft)	38	137	38	5	16	72	218	2	121	88	98
Link Distance (ft)		341	341		307		436		387		438
Upstream Blk Time (%)											
Queuing Penalty (veh)											
Storage Bay Dist (ft)	150			100		200		100		200	
Storage Blk Time (%)		0					3		2		
Queuing Penalty (veh)		0					2		4		

Intersection: 2: N Lake St & E 4th St & Central Ave

Phase	2	3	4	6	7	8	9
Movement(s) Served	EBTL	NBL	SBT	WBTL	SBL	NBT	SEL
Maximum Green (s)	31.4	18.5	41.5	31.4	5.0	55.0	20.6
Minimum Green (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Recall	None	None	None	None	None	None	None
Avg. Green (s)	18.0	8.7	16.6	18.0	0.0	31.4	10.0
g/C Ratio	NA	-0.01	NA	NA	-0.01	-0.01	-0.01
Cycles Skipped (%)	0	13	0	0	100	25	11
Cycles @ Minimum (%)	0	0	0	0	0	0	0
Cycles Maxed Out (%)	0	0	0	0	0	0	0
Cycles with Peds (%)	13	0	11	13	0	0	0

Controller Summary

Average Cycle Length (s): NA
Number of Complete Cycles : 0

Movement	EBL2	EBL	EBT	EBR	WBL	WBT	WBR2	NBL2	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	1	182	3	118	3	4	1	47	31	176	3	1
Future Volume (vph)	1	182	3	118	3	4	1	47	31	176	3	1
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	12	16	12	12	13	13	12	12
Total Lost time (s)		4.5	4.5		4.5	4.5			4.5	4.5		4.5
Lane Util. Factor		0.97	1.00		1.00	1.00			1.00	1.00		1.00
Frpb, ped/bikes		1.00	0.98		1.00	1.00			1.00	1.00		1.00
Flpb, ped/bikes		0.99	1.00		0.98	1.00			1.00	1.00		0.98
Frt		1.00	0.85		1.00	0.97			1.00	1.00		1.00
Flt Protected		0.95	1.00		0.95	1.00			0.95	1.00		0.95
Satd. Flow (prot)		3148	1446		1619	1907			1699	1783		1617
Flt Permitted		0.75	1.00		0.59	1.00			0.95	1.00		0.95
Satd. Flow (perm)		2498	1446		1012	1907			1699	1783		1617
Peak-hour factor, PHF	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Adj. Flow (vph)	1	225	4	146	4	5	1	58	38	217	4	1
RTOR Reduction (vph)	0	0	120	0	0	5	0	0	0	1	0	0
Lane Group Flow (vph)	0	226	30	0	4	1	0	0	96	220	0	1
Confl. Peds. (#/hr)	6				9			3				1
Confl. Bikes (#/hr)				1			5				2	
Turn Type	Perm	Perm	NA		Perm	NA		Prot	Prot	NA		Prot
Protected Phases			2			6		3	3	8		7
Permitted Phases	2	2			6							
Actuated Green, G (s)		14.2	14.2		14.2	14.2			8.5	33.6		0.7
Effective Green, g (s)		14.2	14.2		14.2	14.2			8.5	33.6		0.7
Actuated g/C Ratio		0.18	0.18		0.18	0.18			0.11	0.42		0.01
Clearance Time (s)		4.5	4.5		4.5	4.5			4.5	4.5		4.5
Vehicle Extension (s)		3.0	3.0		3.0	3.0			3.0	3.0		3.0
Lane Grp Cap (vph)		445	257		180	339			181	751		14
v/s Ratio Prot			0.02			0.00			c0.06	0.12		0.00
v/s Ratio Perm		c0.09			0.00							
v/c Ratio		0.51	0.12		0.02	0.00			0.53	0.29		0.07
Uniform Delay, d1		29.6	27.5		27.0	26.9			33.7	15.2		39.2
Progression Factor		1.00	1.00		1.00	1.00			1.00	1.00		1.00
Incremental Delay, d2		0.9	0.2		0.0	0.0			3.0	0.2		2.2
Delay (s)		30.5	27.7		27.1	26.9			36.7	15.4		41.3
Level of Service		C	C		C	C			D	B		D
Approach Delay (s)			29.4			27.0				21.9		
Approach LOS			C			C				C		

Intersection Summary			
HCM 2000 Control Delay	25.7	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	79.7	Sum of lost time (s)	18.0
Intersection Capacity Utilization	50.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR	SBR2	SEL2	SEL	SER
Lane Configurations						
Traffic Volume (vph)	224	272	34	18	3	82
Future Volume (vph)	224	272	34	18	3	82
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	12	12
Total Lost time (s)	4.5	4.5			4.5	
Lane Util. Factor	1.00	1.00			1.00	
Frpb, ped/bikes	1.00	0.98			1.00	
Flpb, ped/bikes	1.00	1.00			1.00	
Frt	1.00	0.85			0.89	
Flt Protected	1.00	1.00			0.99	
Satd. Flow (prot)	1731	1440			1529	
Flt Permitted	1.00	1.00			0.99	
Satd. Flow (perm)	1731	1440			1529	
Peak-hour factor, PHF	0.81	0.81	0.81	0.81	0.81	0.81
Adj. Flow (vph)	277	336	42	22	4	101
RTOR Reduction (vph)	0	85	0	0	0	0
Lane Group Flow (vph)	277	293	0	0	127	0
Confl. Peds. (#/hr)				8		
Confl. Bikes (#/hr)			1			
Turn Type	NA	Perm		Prot	Prot	
Protected Phases	4			9	9	
Permitted Phases		4				
Actuated Green, G (s)	25.8	25.8			13.2	
Effective Green, g (s)	25.8	25.8			13.2	
Actuated g/C Ratio	0.32	0.32			0.17	
Clearance Time (s)	4.5	4.5			4.5	
Vehicle Extension (s)	3.0	3.0			3.0	
Lane Grp Cap (vph)	560	466			253	
v/s Ratio Prot	0.16				c0.08	
v/s Ratio Perm		c0.20				
v/c Ratio	0.49	0.63			0.50	
Uniform Delay, d1	21.7	22.9			30.3	
Progression Factor	1.00	1.00			1.00	
Incremental Delay, d2	0.7	2.6			1.6	
Delay (s)	22.4	25.5			31.8	
Level of Service	C	C			C	
Approach Delay (s)	24.2				31.8	
Approach LOS	C				C	

Intersection Summary

Summary of All Intervals

Run Number	1	2	3	4	5	Avg
Start Time	6:57	6:57	6:57	6:57	6:57	6:57
End Time	7:10	7:10	7:10	7:10	7:10	7:10
Total Time (min)	13	13	13	13	13	13
Time Recorded (min)	10	10	10	10	10	10
# of Intervals	2	2	2	2	2	2
# of Recorded Intervals	1	1	1	1	1	1
Vehs Entered	210	205	199	199	178	199
Vehs Exited	209	209	204	209	180	202
Starting Vehs	19	19	19	17	16	18
Ending Vehs	20	15	14	7	14	13
Travel Distance (mi)	37	37	35	36	31	35
Travel Time (hr)	2.6	2.9	2.5	2.4	2.2	2.5
Total Delay (hr)	1.3	1.5	1.2	1.1	1.1	1.2
Total Stops	136	147	143	143	137	140
Fuel Used (gal)	2.1	2.2	2.0	2.1	1.8	2.0

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Run Number	1	2	3	4	5	Avg
Vehs Entered	210	205	199	199	178	199
Vehs Exited	209	209	204	209	180	202
Starting Vehs	19	19	19	17	16	18
Ending Vehs	20	15	14	7	14	13
Travel Distance (mi)	37	37	35	36	31	35
Travel Time (hr)	2.6	2.9	2.5	2.4	2.2	2.5
Total Delay (hr)	1.3	1.5	1.2	1.1	1.1	1.2
Total Stops	136	147	143	143	137	140
Fuel Used (gal)	2.1	2.2	2.0	2.1	1.8	2.0

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	EBL	EBT	EBR	WBL	WBT	WBR2	NBL2	NBL	NBT	NBR	SBT	SBR
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.2		0.3		0.1		3.8	3.5	0.4	0.3	1.2	3.3
Total Delay (hr)	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.2	0.3
Total Del/Veh (s)	21.8		4.6		14.0		29.3	27.6	15.1	2.6	18.5	19.2
Stop Delay (hr)	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.2	0.2
Stop Del/Veh (s)	18.3		4.4		11.4		26.3	25.1	11.3	1.3	13.7	16.1

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	SBR2	SEL2	SEL	SER	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.1
Denied Del/Veh (s)	3.5	0.3		0.2	1.4
Total Delay (hr)	0.0	0.0	0.0	0.1	1.1
Total Del/Veh (s)	11.7	32.0		25.3	18.4
Stop Delay (hr)	0.0	0.0	0.0	0.1	0.9
Stop Del/Veh (s)	10.4	28.5		23.9	15.2

Intersection: 2: N Lake St & E 4th St & Central Ave

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB	SE
Directions Served	<L	L	TR	L	TR>	<L	TR	T	R>	<LR
Maximum Queue (ft)	6	89	59	3	14	72	121	113	138	87
Average Queue (ft)	1	58	17	1	3	44	74	69	83	53
95th Queue (ft)	8	106	63	5	16	76	132	135	174	96
Link Distance (ft)		352	352		307		436	387		452
Upstream Blk Time (%)										
Queuing Penalty (veh)										
Storage Bay Dist (ft)	150			100		200			200	
Storage Blk Time (%)								2	1	
Queuing Penalty (veh)								7	2	

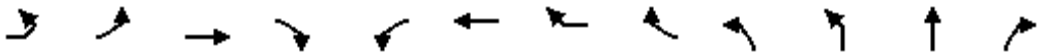
Intersection: 2: N Lake St & E 4th St & Central Ave

Phase	2	3	4	6	7	8	9
Movement(s) Served	EBTL	NBL	SBT	WBTL	SBL	NBT	SEL
Maximum Green (s)	31.4	18.5	41.5	31.4	5.0	55.0	20.6
Minimum Green (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Recall	None	None	None	None	None	None	None
Avg. Green (s)	15.8	8.7	18.4	15.8	0.0	27.7	12.6
g/C Ratio	NA	-0.01	NA	NA	-0.01	-0.01	-0.01
Cycles Skipped (%)	0	33	0	0	100	22	25
Cycles @ Minimum (%)	0	0	0	0	0	0	0
Cycles Maxed Out (%)	0	0	0	0	0	0	0
Cycles with Peds (%)	11	0	0	11	0	0	13

Controller Summary

Average Cycle Length (s): NA

Number of Complete Cycles : 0



Movement	EBL2	EBL	EBT	EBR	WBL	WBT	WBR	WBR2	NBL2	NBL	NBT	NBR
Lane Configurations												
Traffic Volume (vph)	1	278	5	121	4	3	1	1	60	54	329	6
Future Volume (vph)	1	278	5	121	4	3	1	1	60	54	329	6
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	12	16	12	12	12	13	13	12
Total Lost time (s)		4.5	4.5		4.5	4.5				4.5	4.5	
Lane Util. Factor		0.97	1.00		1.00	1.00				1.00	1.00	
Frpb, ped/bikes		1.00	0.98		1.00	0.99				1.00	1.00	
Flpb, ped/bikes		0.99	1.00		0.98	1.00				1.00	1.00	
Frt		1.00	0.86		1.00	0.94				1.00	1.00	
Flt Protected		0.95	1.00		0.95	1.00				0.95	1.00	
Satd. Flow (prot)		3240	1493		1665	1885				1750	1837	
Flt Permitted		0.75	1.00		0.63	1.00				0.95	1.00	
Satd. Flow (perm)		2573	1493		1109	1885				1750	1837	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	1	299	5	130	4	3	1	1	65	58	354	6
RTOR Reduction (vph)	0	0	105	0	0	1	0	0	0	0	1	0
Lane Group Flow (vph)	0	300	30	0	4	4	0	0	0	123	359	0
Confl. Peds. (#/hr)	6				9				3			
Confl. Bikes (#/hr)				1				5				2
Turn Type	Perm	Perm	NA		Perm	NA			Prot	Prot	NA	
Protected Phases			2			6			3	3	8	
Permitted Phases	2	2			6							
Actuated Green, G (s)		16.0	16.0		16.0	16.0				11.8	35.3	
Effective Green, g (s)		16.0	16.0		16.0	16.0				11.8	35.3	
Actuated g/C Ratio		0.19	0.19		0.19	0.19				0.14	0.43	
Clearance Time (s)		4.5	4.5		4.5	4.5				4.5	4.5	
Vehicle Extension (s)		3.0	3.0		3.0	3.0				3.0	3.0	
Lane Grp Cap (vph)		497	288		214	364				249	784	
v/s Ratio Prot			0.02			0.00				c0.07	0.20	
v/s Ratio Perm		c0.12			0.00							
v/c Ratio		0.60	0.10		0.02	0.01				0.49	0.46	
Uniform Delay, d1		30.5	27.5		27.0	27.0				32.7	16.9	
Progression Factor		1.00	1.00		1.00	1.00				1.00	1.00	
Incremental Delay, d2		2.1	0.2		0.0	0.0				1.5	0.4	
Delay (s)		32.5	27.6		27.0	27.0				34.2	17.3	
Level of Service		C	C		C	C				C	B	
Approach Delay (s)			31.0			27.0					21.6	
Approach LOS			C			C					C	

Intersection Summary			
HCM 2000 Control Delay	26.4	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	82.7	Sum of lost time (s)	18.0
Intersection Capacity Utilization	60.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL	SBT	SBR	SBR2	SEL2	SEL	SER	SER2
Lane Configurations								
Traffic Volume (vph)	3	268	189	53	40	3	73	3
Future Volume (vph)	3	268	189	53	40	3	73	3
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	12	12	12	12
Total Lost time (s)	4.5	4.5	4.5			4.5		
Lane Util. Factor	1.00	1.00	1.00			1.00		
Frpb, ped/bikes	1.00	1.00	0.98			0.99		
Flpb, ped/bikes	0.99	1.00	1.00			1.00		
Frt	1.00	1.00	0.85			0.91		
Flt Protected	0.95	1.00	1.00			0.98		
Satd. Flow (prot)	1669	1782	1483			1586		
Flt Permitted	0.95	1.00	1.00			0.98		
Satd. Flow (perm)	1669	1782	1483			1586		
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	3	288	203	57	43	3	78	3
RTOR Reduction (vph)	0	0	89	0	0	0	0	0
Lane Group Flow (vph)	3	288	171	0	0	127	0	0
Confl. Peds. (#/hr)	1				8			
Confl. Bikes (#/hr)				1				1
Turn Type	Prot	NA	Perm		Prot	Prot		
Protected Phases	7	4			9	9		
Permitted Phases			4					
Actuated Green, G (s)	0.7	24.2	24.2			12.7		
Effective Green, g (s)	0.7	24.2	24.2			12.7		
Actuated g/C Ratio	0.01	0.29	0.29			0.15		
Clearance Time (s)	4.5	4.5	4.5			4.5		
Vehicle Extension (s)	3.0	3.0	3.0			3.0		
Lane Grp Cap (vph)	14	521	433			243		
v/s Ratio Prot	0.00	c0.16				c0.08		
v/s Ratio Perm			0.12					
v/c Ratio	0.21	0.55	0.39			0.52		
Uniform Delay, d1	40.7	24.7	23.4			32.2		
Progression Factor	1.00	1.00	1.00			1.00		
Incremental Delay, d2	7.6	1.3	0.6			2.0		
Delay (s)	48.3	26.0	24.0			34.2		
Level of Service	D	C	C			C		
Approach Delay (s)		25.1				34.2		
Approach LOS		C				C		

Intersection Summary

Summary of All Intervals

Run Number	1	2	3	4	5	Avg
Start Time	6:57	6:57	6:57	6:57	6:57	6:57
End Time	7:10	7:10	7:10	7:10	7:10	7:10
Total Time (min)	13	13	13	13	13	13
Time Recorded (min)	10	10	10	10	10	10
# of Intervals	2	2	2	2	2	2
# of Recorded Intervals	1	1	1	1	1	1
Vehs Entered	270	255	256	243	259	256
Vehs Exited	261	247	250	235	276	254
Starting Vehs	15	22	18	14	28	19
Ending Vehs	24	30	24	22	11	21
Travel Distance (mi)	47	44	44	42	47	45
Travel Time (hr)	3.9	3.3	3.3	3.1	4.3	3.6
Total Delay (hr)	2.2	1.7	1.7	1.6	2.5	1.9
Total Stops	202	180	181	168	194	183
Fuel Used (gal)	2.8	2.5	2.6	2.4	3.0	2.7

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Run Number	1	2	3	4	5	Avg
Vehs Entered	270	255	256	243	259	256
Vehs Exited	261	247	250	235	276	254
Starting Vehs	15	22	18	14	28	19
Ending Vehs	24	30	24	22	11	21
Travel Distance (mi)	47	44	44	42	47	45
Travel Time (hr)	3.9	3.3	3.3	3.1	4.3	3.6
Total Delay (hr)	2.2	1.7	1.7	1.6	2.5	1.9
Total Stops	202	180	181	168	194	183
Fuel Used (gal)	2.8	2.5	2.6	2.4	3.0	2.7

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	EBL	EBT	EBR	WBL	WBT	WBR	WBR2	NBL2	NBL	NBT	NBR	SBL
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.3	0.1	0.2	2.5				3.6	3.0	0.7	0.5	
Total Delay (hr)	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.0	0.0
Total Del/Veh (s)	35.2	22.9	6.7	5.7				34.6	34.2	17.4	25.3	
Stop Delay (hr)	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.0	0.0
Stop Del/Veh (s)	30.8	20.3	6.5	4.9				31.4	30.9	13.0	23.5	

2: N Lake St & E 4th St & Central Ave Performance by movement

Movement	SBT	SBR	SBR2	SEL2	SEL	SER	SER2	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Denied Del/Veh (s)	1.1	3.4	3.4	0.1	0.2	0.2		1.2
Total Delay (hr)	0.3	0.2	0.0	0.1	0.0	0.1	0.0	1.8
Total Del/Veh (s)	20.0	21.2	14.0	33.0	59.8	30.6		23.4
Stop Delay (hr)	0.2	0.2	0.0	0.1	0.0	0.1	0.0	1.5
Stop Del/Veh (s)	14.9	18.6	12.4	29.1	56.4	28.5		19.7

Intersection: 2: N Lake St & E 4th St & Central Ave

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB	SB	SE
Directions Served	<L	L	TR	L	TR>	<L	TR	L	T	R>	<LR>
Maximum Queue (ft)	118	173	27	5	9	102	188	2	129	130	124
Average Queue (ft)	42	117	10	1	2	67	124	0	78	64	77
95th Queue (ft)	149	198	32	6	11	122	235	3	136	142	136
Link Distance (ft)		341	341		307		436		387		438
Upstream Blk Time (%)											
Queuing Penalty (veh)											
Storage Bay Dist (ft)	150			100		200		100		200	
Storage Blk Time (%)	0	4					3		4		
Queuing Penalty (veh)	0	6					4		9		

Intersection: 2: N Lake St & E 4th St & Central Ave

Phase	2	3	4	6	7	8	9
Movement(s) Served	EBTL	NBL	SBT	WBTL	SBL	NBT	SEL
Maximum Green (s)	31.4	18.5	41.5	31.4	5.0	55.0	20.6
Minimum Green (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Recall	None	None	None	None	None	None	None
Avg. Green (s)	20.9	10.8	25.8	20.9	0.0	39.6	13.3
g/C Ratio	NA	-0.01	NA	NA	-0.01	NA	NA
Cycles Skipped (%)	0	17	0	0	100	0	0
Cycles @ Minimum (%)	0	0	0	0	0	0	0
Cycles Maxed Out (%)	14	0	0	14	0	0	0
Cycles with Peds (%)	0	0	14	14	0	0	0

Controller Summary
Average Cycle Length (s): NA
Number of Complete Cycles : 0

APPENDIX A – ROUNDABOUT ANALYSIS

LANE SUMMARY

Site: 1 [2017 AM Peak Hour]

4th Street/Lake Street/Central Avenue
2017 AM Peak Hour
Roundabout

Lane Use and Performance	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
SouthEast: North Lake Street													
Lane 1[d]	252	4.0	1092	0.231	100	5.4	LOS A	1.4	36.1	Full	360	0.0	0.0
Approach	252	4.0		0.231		5.4	LOS A	1.4	36.1				
NorthEast: 4th Street													
Lane 1[d]	9	4.0	907	0.010	100	4.1	LOS A	0.0	1.3	Full	325	0.0	0.0
Approach	9	4.0		0.010		4.1	LOS A	0.0	1.3				
North: North Lake Street													
Lane 1[d]	521	4.0	1056	0.493	100	9.1	LOS A	3.9	99.6	Full	730	0.0	0.0
Approach	521	4.0		0.493		9.1	LOS A	3.9	99.6				
West: East Central Avenue													
Lane 1[d]	101	4.0	770	0.131	100	6.0	LOS A	0.8	20.9	Full	450	0.0	0.0
Approach	101	4.0		0.131		6.0	LOS A	0.8	20.9				
SouthWest: 4th Street													
Lane 1[d]	299	4.0	987	0.303	100	6.7	LOS A	1.9	49.1	Full	320	0.0	0.0
Approach	299	4.0		0.303		6.7	LOS A	1.9	49.1				
Intersection	1181	4.0		0.493		7.4	LOS A	3.9	99.6				

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

LANE SUMMARY

Site: 1 [2017 PM Peak Hour]

4th Street/Lake Street/Central Avenue
2017 PM Peak Hour
Roundabout

Lane Use and Performance													
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
SouthEast: North Lake Street													
Lane 1[d]	385	1.0	1063	0.362	100	7.1	LOS A	2.5	61.8	Full	360	0.0	0.0
Approach	385	1.0		0.362		7.1	LOS A	2.5	61.8				
NorthEast: 4th Street													
Lane 1[d]	8	1.0	792	0.010	100	4.6	LOS A	0.1	1.3	Full	325	0.0	0.0
Approach	8	1.0		0.010		4.6	LOS A	0.1	1.3				
North: North Lake Street													
Lane 1[d]	438	1.0	1003	0.436	100	8.5	LOS A	3.2	80.4	Full	730	0.0	0.0
Approach	438	1.0		0.436		8.5	LOS A	3.2	80.4				
West: East Central Avenue													
Lane 1[d]	101	1.0	891	0.113	100	5.1	LOS A	0.7	17.3	Full	450	0.0	0.0
Approach	101	1.0		0.113		5.1	LOS A	0.7	17.3				
SouthWest: 4th Street													
Lane 1[d]	346	1.0	1022	0.339	100	7.0	LOS A	2.2	55.9	Full	320	0.0	0.0
Approach	346	1.0		0.339		7.0	LOS A	2.2	55.9				
Intersection	1277	1.0		0.436		7.4	LOS A	3.2	80.4				

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

LANE SUMMARY

Site: 1 [2040 AM Peak Hour]

4th Street/Lake Street/Central Avenue
2040 AM Peak Hour
Roundabout

Lane Use and Performance	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
SouthEast: North Lake Street													
Lane 1[d]	317	4.0	1032	0.307	100	6.6	LOS A	2.0	52.0	Full	360	0.0	0.0
Approach	317	4.0		0.307		6.6	LOS A	2.0	52.0				
NorthEast: 4th Street													
Lane 1[d]	11	4.0	816	0.014	100	4.5	LOS A	0.1	1.9	Full	325	0.0	0.0
Approach	11	4.0		0.014		4.5	LOS A	0.1	1.9				
North: North Lake Street													
Lane 1[d]	656	4.0	984	0.666	100	14.0	LOS B	7.5	194.1	Full	730	0.0	0.0
Approach	656	4.0		0.666		14.0	LOS B	7.5	194.1				
West: East Central Avenue													
Lane 1[d]	128	4.0	629	0.204	100	8.2	LOS A	1.4	35.7	Full	450	0.0	0.0
Approach	128	4.0		0.204		8.2	LOS A	1.4	35.7				
SouthWest: 4th Street													
Lane 1[d]	375	4.0	902	0.416	100	8.9	LOS A	2.9	74.8	Full	320	0.0	0.0
Approach	375	4.0		0.416		8.9	LOS A	2.9	74.8				
Intersection	1488	4.0		0.666		10.5	LOS B	7.5	194.1				

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

LANE SUMMARY

Site: 1 [2040 PM Peak Hour]

4th Street/Lake Street/Central Avenue
2040 PM Peak Hour
Roundabout

Lane Use and Performance													
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
SouthEast: North Lake Street													
Lane 1[d]	483	1.0	988	0.489	100	9.5	LOS A	3.7	93.8	Full	360	0.0	0.0
Approach	483	1.0		0.489		9.5	LOS A	3.7	93.8				
NorthEast: 4th Street													
Lane 1[d]	10	1.0	656	0.015	100	5.6	LOS A	0.1	2.2	Full	325	0.0	0.0
Approach	10	1.0		0.015		5.6	LOS A	0.1	2.2				
North: North Lake Street													
Lane 1[d]	552	1.0	918	0.601	100	12.6	LOS B	6.0	150.0	Full	730	0.0	0.0
Approach	552	1.0		0.601		12.6	LOS B	6.0	150.0				
West: East Central Avenue													
Lane 1[d]	128	1.0	773	0.166	100	6.4	LOS A	1.1	27.2	Full	450	0.0	0.0
Approach	128	1.0		0.166		6.4	LOS A	1.1	27.2				
SouthWest: 4th Street													
Lane 1[d]	435	1.0	937	0.465	100	9.5	LOS A	3.4	86.0	Full	320	0.0	0.0
Approach	435	1.0		0.465		9.5	LOS A	3.4	86.0				
Intersection	1608	1.0		0.601		10.3	LOS B	6.0	150.0				

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

APPENDIX B – TRAFFIC SIGNAL ALTERNATIVE

SIGNAL LAYOUT & TRUCK TURN EXHIBITS

SYNCHRO/SIMTRAFFIC ANALYSIS

CONSTRUCTION COST ESTIMATE

Traffic Signal Alternative: Preliminary Layout

LEGEND:

- EXISTING RIGHT-OF-WAY AND PROPERTY LINES
- PROPOSED IMPROVEMENTS
- RIGHT-OF-WAY IMPACTS
- ESTIMATED LIMITS FOR NEW PAVEMENT SECTION

LAKE Street

CONSTRUCT 25' RADIUS RETURN. CONSTRUCT RAMP TO ADA STANDARDS

CONSTRUCT SIDEWALK CONNECTION

ELBOW ENDING 4TH STREET INTO THE ALLEY.

4TH Street

CENTRAL Avenue

ø1

ø4 ø4

DEMO 4TH STREET AND PROVIDE LANDSCAPING

CONSTRUCT CURB, GUTTER, AND SIDEWALK TO END 4TH STREET ACCESS.

ø3 ø3

ø2 ø2

RAISED MEDIAN

LAKE Street

4TH Street

ø3 OR ø8 PED ø4 PED ø4 ø1 ø6 PED ø2 ø2 PED

PHASE DIAGRAM

NORTH

0 50

Scale: 1"= 50

1/8/2018 10:04 AM L:\PRJ\2264\2264EX006.DWG

LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

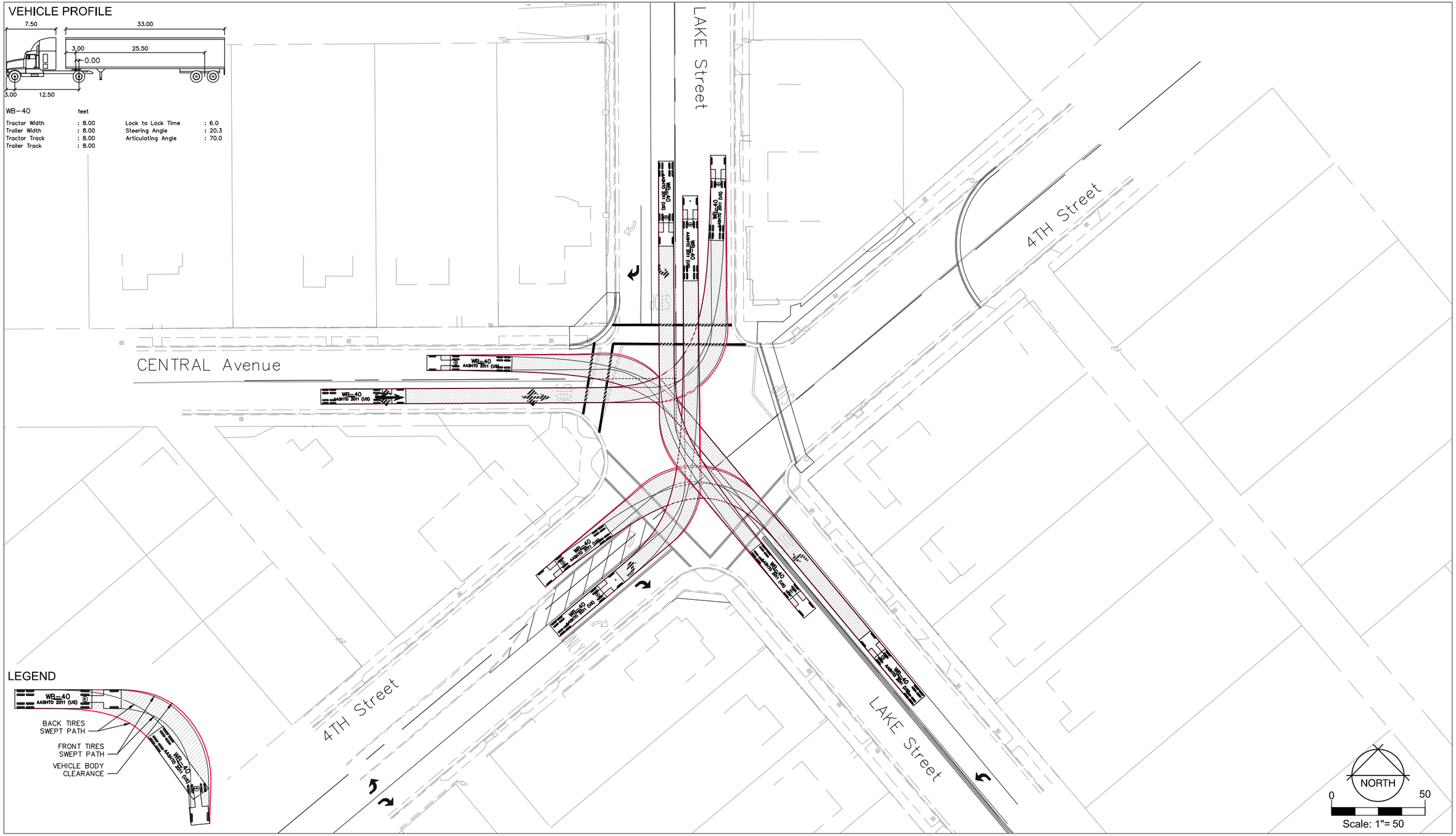
Figure B1

omni·means A GHD Company

Madera, California

2264EX006.dwg

WB-40 Truck Turn (Left-Turn Movement Only)



1/8/2018 10:28 AM L:\PRJ\2264\2264EX006.DWG

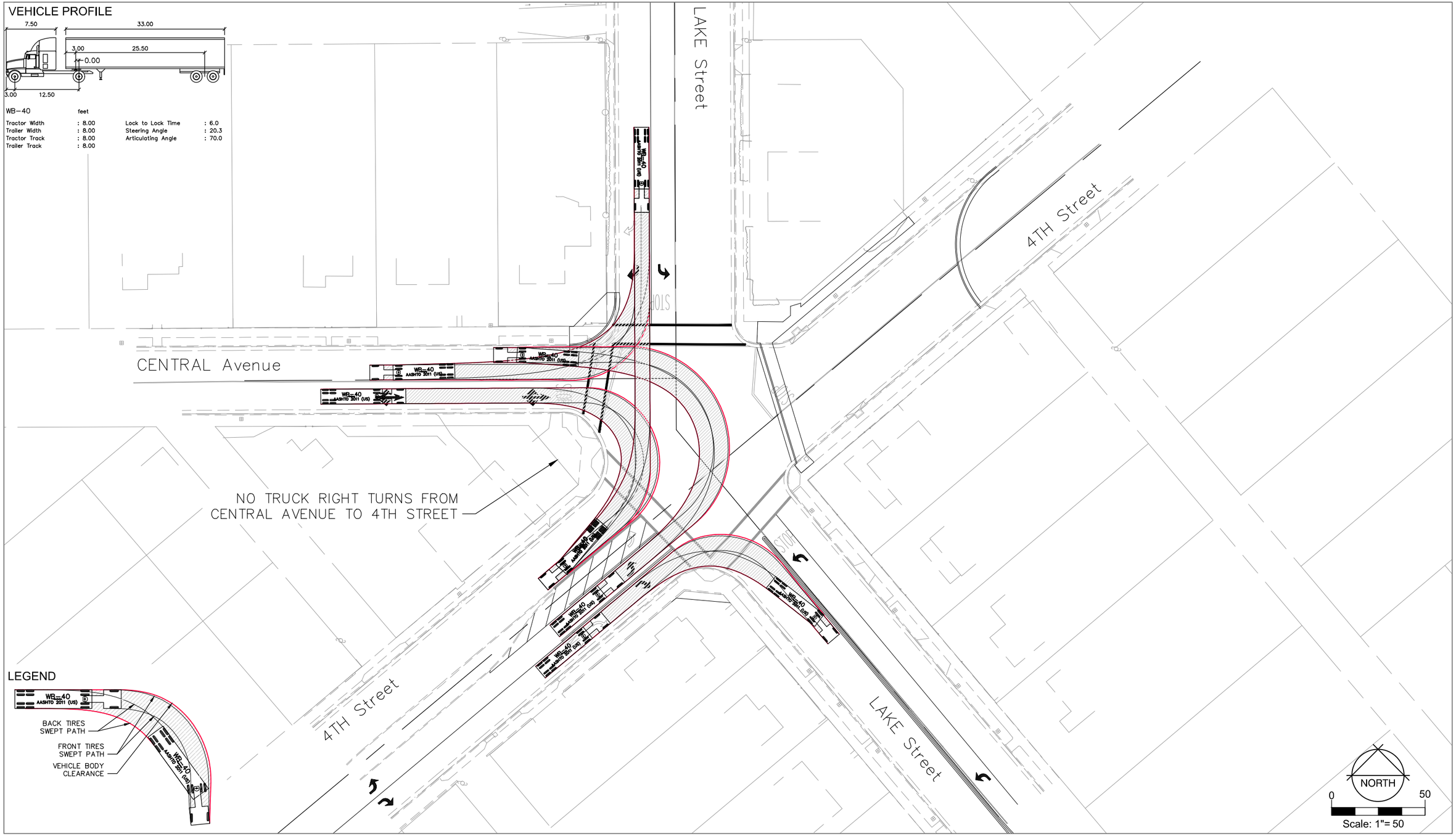
LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure B2

Madera, California

2264EX006.dwg

WB-40 Truck Turn (Right-Turn Movement Only)



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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure B3

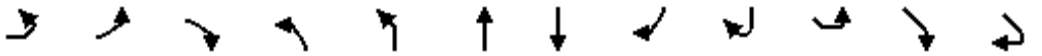
Madera, California

2264EX006.dwg

Lane Group	EBL	EBR	NBL	NBT	SBT	SBR	SEL
Lane Group Flow (vph)	199	128	85	191	243	333	112
v/c Ratio	0.56	0.28	0.28	0.60	0.60	0.69	0.43
Control Delay	31.0	2.9	29.6	38.0	30.1	19.6	31.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	31.0	2.9	29.6	38.0	30.1	19.6	31.3
Queue Length 50th (ft)	67	0	28	66	79	44	39
Queue Length 95th (ft)	158	15	85	#220	189	#182	95
Internal Link Dist (ft)	442			427	397		458
Turn Bay Length (ft)	200		200			200	
Base Capacity (vph)	425	517	344	362	517	563	280
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.47	0.25	0.25	0.53	0.47	0.59	0.40

Intersection Summary

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



Movement	EBL2	EBL	EBR	NBL2	NBL	NBT	SBT	SBR	SBR2	SEL	SER	SER2
Lane Configurations												
Traffic Volume (vph)	1	182	118	47	31	176	224	272	34	18	82	3
Future Volume (vph)	1	182	118	47	31	176	224	272	34	18	82	3
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	13	13	12	12	12	12	12	12
Total Lost time (s)		4.5	4.5		4.5	4.5	4.5	4.5		4.5		
Lane Util. Factor		1.00	1.00		1.00	1.00	1.00	1.00		1.00		
Frpb, ped/bikes		1.00	0.98		1.00	1.00	1.00	0.98		0.99		
Flpb, ped/bikes		0.99	1.00		1.00	1.00	1.00	1.00		1.00		
Frt		1.00	0.85		1.00	1.00	1.00	0.85		0.89		
Flt Protected		0.95	1.00		0.95	1.00	1.00	1.00		0.99		
Satd. Flow (prot)		1629	1439		1699	1788	1731	1439		1508		
Flt Permitted		0.95	1.00		0.95	1.00	1.00	1.00		0.99		
Satd. Flow (perm)		1629	1439		1699	1788	1731	1439		1508		
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)	1	198	128	51	34	191	243	296	37	20	89	3
RTOR Reduction (vph)	0	0	101	0	0	0	0	147	0	0	0	0
Lane Group Flow (vph)	0	199	27	0	85	191	243	186	0	112	0	0
Confl. Peds. (#/hr)	6			3						8		
Confl. Bikes (#/hr)			1						1			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	Perm	Perm	Split	Split	NA	NA	Perm		Prot		
Protected Phases				3	3	3	4			1		
Permitted Phases	2	2	2					4				
Actuated Green, G (s)		12.2	12.2		6.8	6.8	13.3	13.3		6.8		
Effective Green, g (s)		12.2	12.2		6.8	6.8	13.3	13.3		6.8		
Actuated g/C Ratio		0.21	0.21		0.12	0.12	0.23	0.23		0.12		
Clearance Time (s)		4.5	4.5		4.5	4.5	4.5	4.5		4.5		
Vehicle Extension (s)		3.0	3.0		3.0	3.0	3.0	3.0		3.0		
Lane Grp Cap (vph)		348	307		202	212	403	335		179		
v/s Ratio Prot					0.05	c0.11	c0.14			c0.07		
v/s Ratio Perm		c0.12	0.02					0.13				
v/c Ratio		0.57	0.09		0.42	0.90	0.60	0.56		0.63		
Uniform Delay, d1		20.1	18.0		23.3	24.8	19.5	19.3		23.9		
Progression Factor		1.00	1.00		1.00	1.00	1.00	1.00		1.00		
Incremental Delay, d2		2.3	0.1		1.4	35.9	2.5	2.0		6.7		
Delay (s)		22.4	18.1		24.7	60.7	22.1	21.3		30.6		
Level of Service		C	B		C	E	C	C		C		
Approach Delay (s)		20.7				49.7	21.6			30.6		
Approach LOS		C				D	C			C		

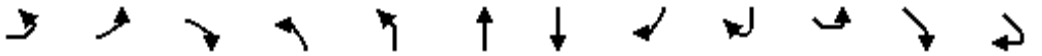
Intersection Summary			
HCM 2000 Control Delay	28.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	57.1	Sum of lost time (s)	18.0
Intersection Capacity Utilization	49.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Lane Group	EBL	EBR	NBL	NBT	SBT	SBR	SEL
Lane Group Flow (vph)	180	116	77	173	220	300	99
v/c Ratio	0.48	0.23	0.25	0.53	0.59	0.61	0.35
Control Delay	24.8	1.0	25.9	33.8	32.6	14.7	25.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	24.8	1.0	25.9	33.8	32.6	14.7	25.2
Queue Length 50th (ft)	49	0	20	49	60	18	28
Queue Length 95th (ft)	107	0	64	#159	#189	#100	65
Internal Link Dist (ft)	442			427	397		458
Turn Bay Length (ft)	200		200			200	
Base Capacity (vph)	442	557	337	355	436	533	279
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.41	0.21	0.23	0.49	0.50	0.56	0.35

Intersection Summary

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



Movement	EBL2	EBL	EBR	NBL2	NBL	NBT	SBT	SBR	SBR2	SEL	SER	SER2
Lane Configurations												
Traffic Volume (vph)	1	145	94	37	25	140	178	216	27	14	65	2
Future Volume (vph)	1	145	94	37	25	140	178	216	27	14	65	2
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	13	13	12	12	12	12	12	12
Total Lost time (s)		4.5	4.5		4.5	4.5	4.5	4.5		4.5		
Lane Util. Factor		1.00	1.00		1.00	1.00	1.00	1.00		1.00		
Frpb, ped/bikes		1.00	0.98		1.00	1.00	1.00	0.98		0.99		
Flpb, ped/bikes		0.99	1.00		1.00	1.00	1.00	1.00		1.00		
Frt		1.00	0.85		1.00	1.00	1.00	0.85		0.89		
Flt Protected		0.95	1.00		0.95	1.00	1.00	1.00		0.99		
Satd. Flow (prot)		1631	1438		1699	1788	1731	1439		1507		
Flt Permitted		0.95	1.00		0.95	1.00	1.00	1.00		0.99		
Satd. Flow (perm)		1631	1438		1699	1788	1731	1439		1507		
Peak-hour factor, PHF	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Adj. Flow (vph)	1	179	116	46	31	173	220	267	33	17	80	2
RTOR Reduction (vph)	0	0	97	0	0	0	0	179	0	0	0	0
Lane Group Flow (vph)	0	180	19	0	77	173	220	121	0	99	0	0
Confl. Peds. (#/hr)	6			3						8		
Confl. Bikes (#/hr)			1						1			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	Perm	Perm	Split	Split	NA	NA	Perm		Prot		
Protected Phases				3	3	3	4			1		
Permitted Phases	2	2	2					4				
Actuated Green, G (s)		7.7	7.7		5.3	5.3	10.2	10.2		5.7		
Effective Green, g (s)		7.7	7.7		5.3	5.3	10.2	10.2		5.7		
Actuated g/C Ratio		0.16	0.16		0.11	0.11	0.22	0.22		0.12		
Clearance Time (s)		4.5	4.5		4.5	4.5	4.5	4.5		4.5		
Vehicle Extension (s)		3.0	3.0		3.0	3.0	3.0	3.0		3.0		
Lane Grp Cap (vph)		267	236		191	202	376	312		183		
v/s Ratio Prot					0.05	c0.10	c0.13			c0.07		
v/s Ratio Perm		c0.11	0.01					0.08				
v/c Ratio		0.67	0.08		0.40	0.86	0.59	0.39		0.54		
Uniform Delay, d1		18.4	16.6		19.3	20.4	16.5	15.7		19.4		
Progression Factor		1.00	1.00		1.00	1.00	1.00	1.00		1.00		
Incremental Delay, d2		6.6	0.1		1.4	28.1	2.3	0.8		3.2		
Delay (s)		25.0	16.7		20.7	48.6	18.8	16.5		22.6		
Level of Service		C	B		C	D	B	B		C		
Approach Delay (s)		21.8				40.0	17.4			22.6		
Approach LOS		C				D	B			C		

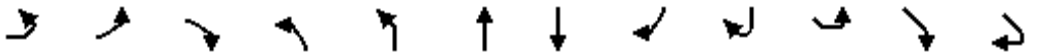
Intersection Summary			
HCM 2000 Control Delay	23.8	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	46.9	Sum of lost time (s)	18.0
Intersection Capacity Utilization	42.8%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Lane Group	EBL	EBR	NBL	NBT	SBT	SBR	SEL
Lane Group Flow (vph)	303	132	124	358	291	263	125
v/c Ratio	0.85	0.30	0.32	0.87	0.84	0.64	0.63
Control Delay	52.8	6.0	28.8	52.1	53.4	21.0	47.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	52.8	6.0	28.8	52.1	53.4	21.0	47.9
Queue Length 50th (ft)	134	0	47	158	132	45	58
Queue Length 95th (ft)	#321	36	113	#377	#290	138	115
Internal Link Dist (ft)	442			427	397		458
Turn Bay Length (ft)	200		200			150	
Base Capacity (vph)	387	461	425	447	362	423	197
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.78	0.29	0.29	0.80	0.80	0.62	0.63

Intersection Summary

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



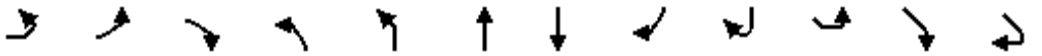
Movement	EBL2	EBL	EBR	NBL2	NBL	NBT	SBT	SBR	SBR2	SEL	SER	SER2
Lane Configurations												
Traffic Volume (vph)	1	278	121	60	54	329	268	189	53	40	73	3
Future Volume (vph)	1	278	121	60	54	329	268	189	53	40	73	3
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	13	13	12	12	12	12	12	12
Total Lost time (s)		4.5	4.5		4.5	4.5	4.5	4.5		4.5		
Lane Util. Factor		1.00	1.00		1.00	1.00	1.00	1.00		1.00		
Frpb, ped/bikes		1.00	0.98		1.00	1.00	1.00	0.98		0.99		
Flpb, ped/bikes		0.99	1.00		1.00	1.00	1.00	1.00		1.00		
Frt		1.00	0.85		1.00	1.00	1.00	0.85		0.91		
Flt Protected		0.95	1.00		0.95	1.00	1.00	1.00		0.98		
Satd. Flow (prot)		1672	1482		1750	1842	1782	1482		1582		
Flt Permitted		0.95	1.00		0.95	1.00	1.00	1.00		0.98		
Satd. Flow (perm)		1672	1482		1750	1842	1782	1482		1582		
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)	1	302	132	65	59	358	291	205	58	43	79	3
RTOR Reduction (vph)	0	0	104	0	0	0	0	123	0	0	0	0
Lane Group Flow (vph)	0	303	28	0	124	358	291	140	0	125	0	0
Confl. Peds. (#/hr)	6			3						8		
Confl. Bikes (#/hr)			1						1			1
Turn Type	Perm	Perm	Perm	Split	Split	NA	NA	Perm		Prot		
Protected Phases				3	3	3	4			1		
Permitted Phases	2	2	2					4				
Actuated Green, G (s)		16.1	16.1		16.9	16.9	14.6	14.6		9.4		
Effective Green, g (s)		16.1	16.1		16.9	16.9	14.6	14.6		9.4		
Actuated g/C Ratio		0.21	0.21		0.23	0.23	0.19	0.19		0.13		
Clearance Time (s)		4.5	4.5		4.5	4.5	4.5	4.5		4.5		
Vehicle Extension (s)		3.0	3.0		3.0	3.0	3.0	3.0		3.0		
Lane Grp Cap (vph)		358	318		394	415	346	288		198		
v/s Ratio Prot					0.07	c0.19	c0.16			c0.08		
v/s Ratio Perm		c0.18	0.02					0.09				
v/c Ratio		0.85	0.09		0.31	0.86	0.84	0.49		0.63		
Uniform Delay, d1		28.3	23.6		24.2	27.9	29.1	26.9		31.2		
Progression Factor		1.00	1.00		1.00	1.00	1.00	1.00		1.00		
Incremental Delay, d2		16.6	0.1		0.5	16.7	16.6	1.3		6.4		
Delay (s)		44.9	23.7		24.7	44.6	45.7	28.1		37.6		
Level of Service		D	C		C	D	D	C		D		
Approach Delay (s)		38.5				39.5	37.4			37.6		
Approach LOS		D				D	D			D		

Intersection Summary			
HCM 2000 Control Delay	38.3	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	18.0
Intersection Capacity Utilization	60.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Lane Group	EBL	EBR	NBL	NBT	SBT	SBR	SEL
Lane Group Flow (vph)	227	98	93	267	182	196	94
v/c Ratio	0.66	0.21	0.27	0.74	0.58	0.45	0.44
Control Delay	33.5	1.0	26.4	40.3	32.3	7.5	32.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	33.5	1.0	26.4	40.3	32.3	7.5	32.0
Queue Length 50th (ft)	69	0	26	81	57	0	30
Queue Length 95th (ft)	183	0	90	#301	146	46	83
Internal Link Dist (ft)	442			427	397		458
Turn Bay Length (ft)	200		200			200	
Base Capacity (vph)	385	500	383	403	335	453	216
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.59	0.20	0.24	0.66	0.54	0.43	0.44

Intersection Summary

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



Movement	EBL2	EBL	EBR	NBL2	NBL	NBT	SBT	SBR	SBR2	SEL	SER	SER2
Lane Configurations												
Traffic Volume (vph)	1	221	96	48	43	262	178	150	42	32	58	2
Future Volume (vph)	1	221	96	48	43	262	178	150	42	32	58	2
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Lane Width	12	12	12	12	13	13	12	12	12	12	12	12
Total Lost time (s)		4.5	4.5		4.5	4.5	4.5	4.5		4.5		
Lane Util. Factor		1.00	1.00		1.00	1.00	1.00	1.00		1.00		
Frpb, ped/bikes		1.00	0.98		1.00	1.00	1.00	1.00		0.99		
Flpb, ped/bikes		0.99	1.00		1.00	1.00	1.00	1.00		1.00		
Frt		1.00	0.85		1.00	1.00	1.00	0.85		0.91		
Flt Protected		0.95	1.00		0.95	1.00	1.00	1.00		0.98		
Satd. Flow (prot)		1677	1482		1750	1842	1782	1515		1583		
Flt Permitted		0.95	1.00		0.95	1.00	1.00	1.00		0.98		
Satd. Flow (perm)		1677	1482		1750	1842	1782	1515		1583		
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	1	226	98	49	44	267	182	153	43	33	59	2
RTOR Reduction (vph)	0	0	78	0	0	0	0	161	0	0	0	0
Lane Group Flow (vph)	0	227	20	0	93	267	182	35	0	94	0	0
Confl. Peds. (#/hr)	6			3						8		
Confl. Bikes (#/hr)			1						1			1
Turn Type	Perm	Perm	Perm	Split	Split	NA	NA	Prot		Prot		
Protected Phases				3	3	3	4	4		1		
Permitted Phases	2	2	2									
Actuated Green, G (s)		11.6	11.6		11.1	11.1	10.0	10.0		5.9		
Effective Green, g (s)		11.6	11.6		11.1	11.1	10.0	10.0		5.9		
Actuated g/C Ratio		0.20	0.20		0.20	0.20	0.18	0.18		0.10		
Clearance Time (s)		4.5	4.5		4.5	4.5	4.5	4.5		4.5		
Vehicle Extension (s)		3.0	3.0		3.0	3.0	3.0	3.0		3.0		
Lane Grp Cap (vph)		343	303		343	361	314	267		165		
v/s Ratio Prot					0.05	c0.14	c0.10	0.02		c0.06		
v/s Ratio Perm		c0.14	0.01									
v/c Ratio		0.66	0.07		0.27	0.74	0.58	0.13		0.57		
Uniform Delay, d1		20.7	18.1		19.3	21.4	21.4	19.6		24.1		
Progression Factor		1.00	1.00		1.00	1.00	1.00	1.00		1.00		
Incremental Delay, d2		4.7	0.1		0.4	7.7	2.6	0.2		4.5		
Delay (s)		25.4	18.2		19.7	29.1	24.0	19.9		28.6		
Level of Service		C	B		B	C	C	B		C		
Approach Delay (s)		23.3				26.7	21.8			28.6		
Approach LOS		C				C	C			C		

Intersection Summary			
HCM 2000 Control Delay	24.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	56.6	Sum of lost time (s)	18.0
Intersection Capacity Utilization	49.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Preliminary Opinion of Costs (Construction Costs Only)

4th Street/Lake Street/Central Avenue Intersection - **Signal Alternative**

City of Madera

1/12/2018

55-4549-03/2264

No.	*Item Description*	*Units*	*Quantity*	*Unit Cost*	*Total*
1	Traffic Control System	LS	1	$60,000.00	$60,000.00
2	Remove Thermoplastic Traffic Stripe	LF	200	$4.25	$850.00
3	Remove Thermoplastic Pavement Marking	SQFT	50	$12.50	$625.00
4	Remove Roadside Sign	EA	10	$155.00	$1,550.00
5	Remove Concrete Sidewalk	SQYD	30	$31.50	$945.00
6	Remove Concrete (Curb & Gutter)	LF	340	$12.50	$4,250.00
7	Roadway Excavation	CY	560	$32.00	$17,920.00
8	Class 2 Aggregate Base	CY	150	$53.00	$7,950.00
9	Hot Mix Asphalt (Type B)	TON	140	$90.00	$12,600.00
10	Minor Concrete (Median Curb)	CY	20	$770.00	$15,400.00
11	Minor Concrete (Curb and Gutter)	CY	10	$355.00	$3,550.00
12	Minor Concrete (Medians)	SQFT	150	$6.00	$900.00
13	Minor Concrete (Sidewalk)	CY	20	$540.00	$10,800.00
14	Thermoplastic Traffic Stripe	LF	1000	$2.00	$2,000.00
15	Thermoplastic Pavement Marking	SQFT	840	$7.00	$5,880.00
16	Landscape	SQFT	7800	$5.00	$39,000.00
17	Signs	EA	20	$380.00	$7,600.00
18	Signals and Lighting	LS	1	$350,000.00	$350,000.00
19	Storm Drain System	LS	1	$50,000.00	$50,000.00
20	Mobilization	LS	1	$53,200.00	$53,200.00
	Subtotal (Construction Costs)				$ 645,020.00
	Minor/ Supplemental Items			30%	$ 194,000.00
	Construction Contingency			25%	$ 210,000.00
	Total Construction Costs				**$ 1,049,020.00**
	Rounded				**$ 1,050,000.00**

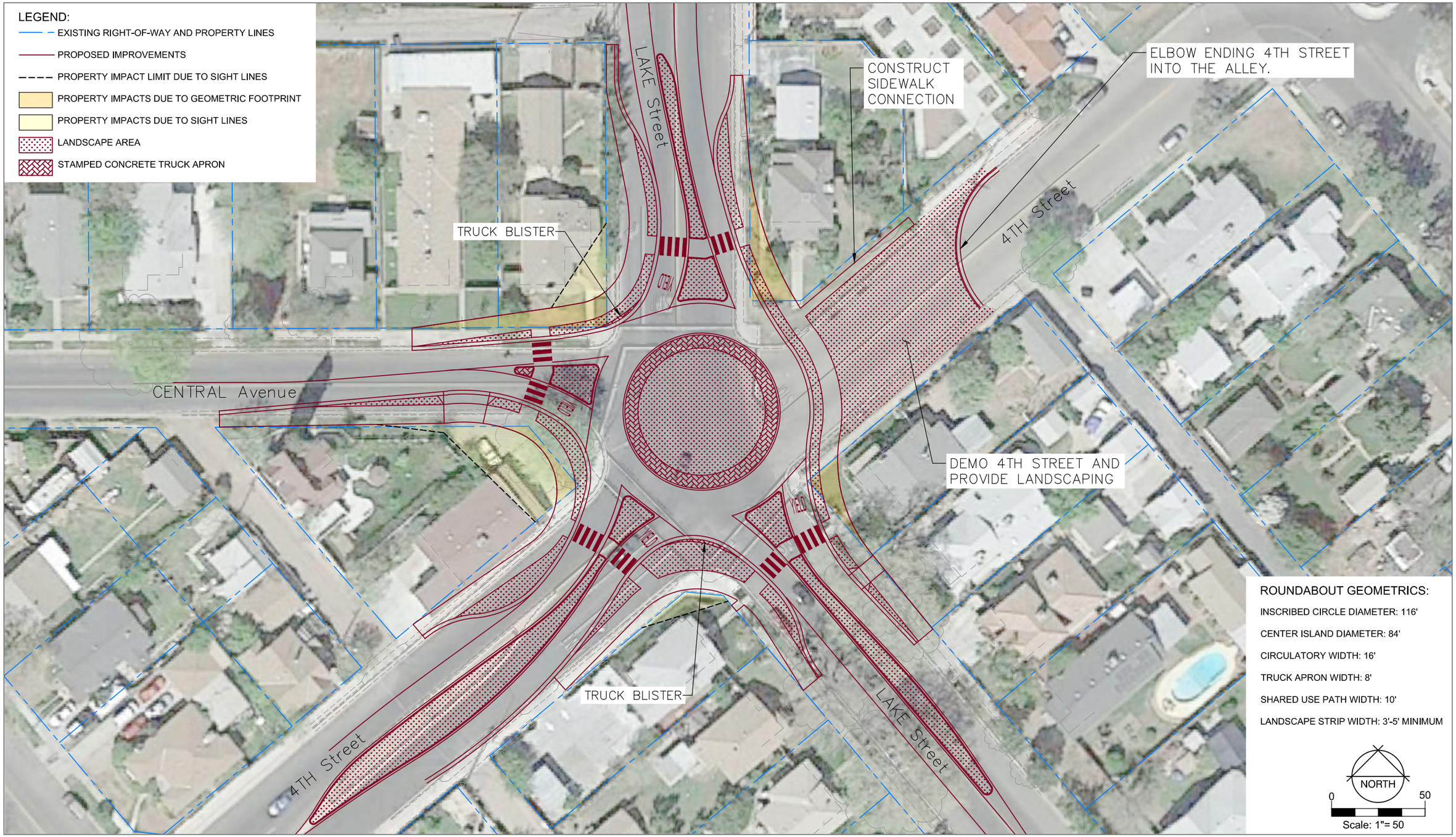
APPENDIX C – ROUNDABOUT ALTERNATIVE

ROUNDABOUT LAYOUT, FASTEST PATH, & TRUCK TURN EXHIBITS

SIDRA 7 ANALYSIS

CONSTRUCTION COST ESTIMATE

Roundabout Alternative: Preliminary Layout



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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure C1

Madera, California

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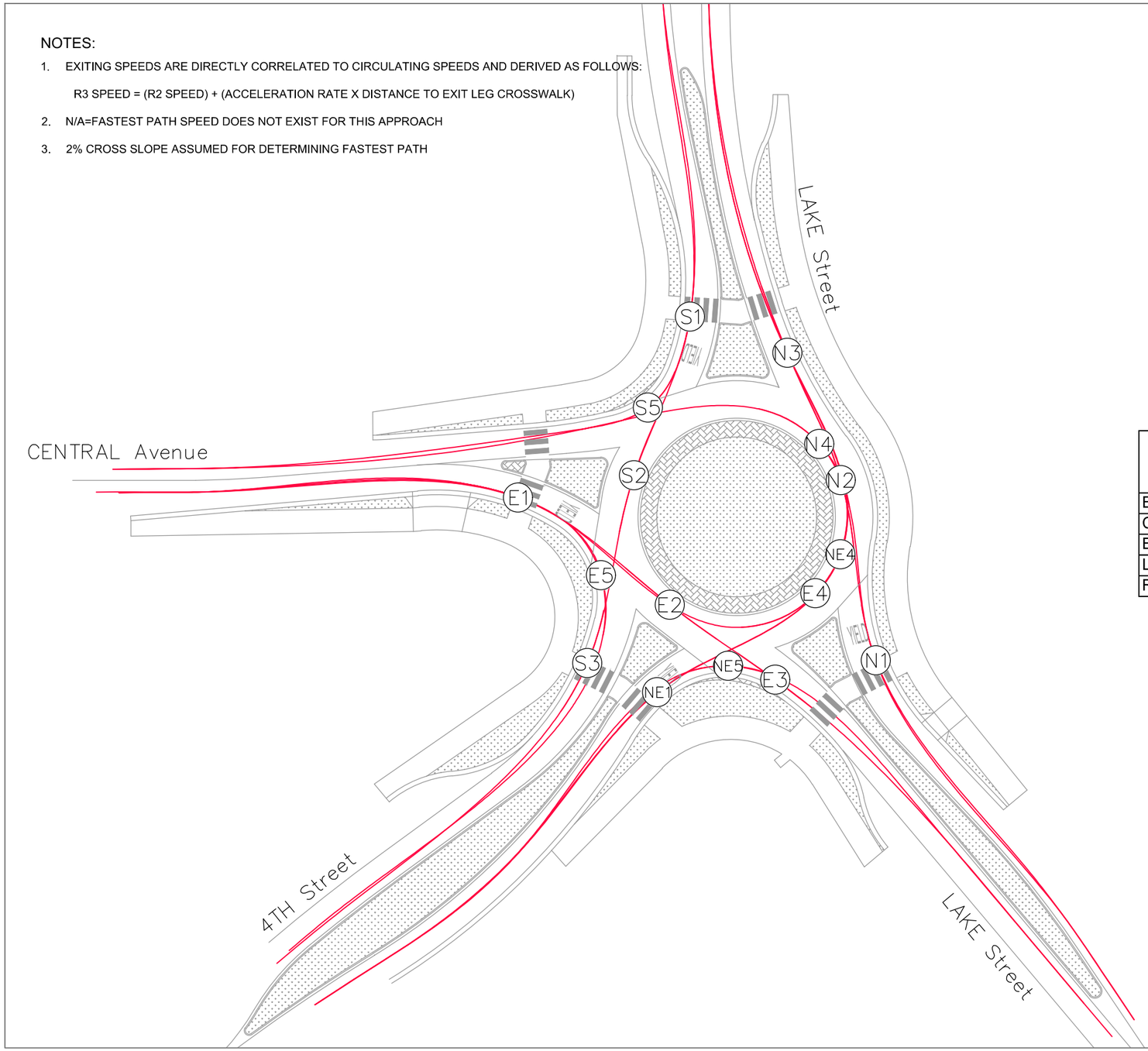
Fastest Path Design

NOTES:

1. EXITING SPEEDS ARE DIRECTLY CORRELATED TO CIRCULATING SPEEDS AND DERIVED AS FOLLOWS:

   R3 SPEED = (R2 SPEED) + (ACCELERATION RATE X DISTANCE TO EXIT LEG CROSSWALK)

2. N/A=FASTEST PATH SPEED DOES NOT EXIST FOR THIS APPROACH
3. 2% CROSS SLOPE ASSUMED FOR DETERMINING FASTEST PATH



FASTEST PATH RADIUS (FT)

MOVEMENT	NB LAKE STREET (N#)	SB LAKE STREET (S#)	NEB 4TH STREET (NE#)	EB CENTRAL AVENUE (E#)
ENTERING (R1)	120.7	128.4	119.1	105.0
CIRCULATING (R2	162.7	202.7		399.4
EXITING (R3)	543.7	118.0		505.0
LEFT TURN (R4)	50.2		51.8	45.2
RIGHT TURN (R5)		33.5	51.3	48.5

FASTEST PATH SPEED (MPH)

MOVEMENT	NB LAKE STREET (N#)	SB LAKE STREET (S#)	NEB 4TH STREET (NE#)	EB CENTRAL AVENUE (E#)
ENTERING (R1)	21.9	22.4	21.8	20.8
CIRCULATING (R2	22.5	24.4		31.2
EXITING (R3)	31.4	21.7		38.1
LEFT TURN (R4)	14.6		14.8	14.0
RIGHT TURN (R5)		13.4	15.7	15.4

NORTH

0 50

Scale: 1"= 50

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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure C2

Madera, California

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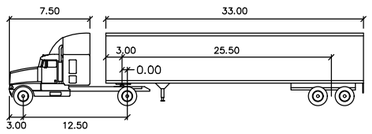
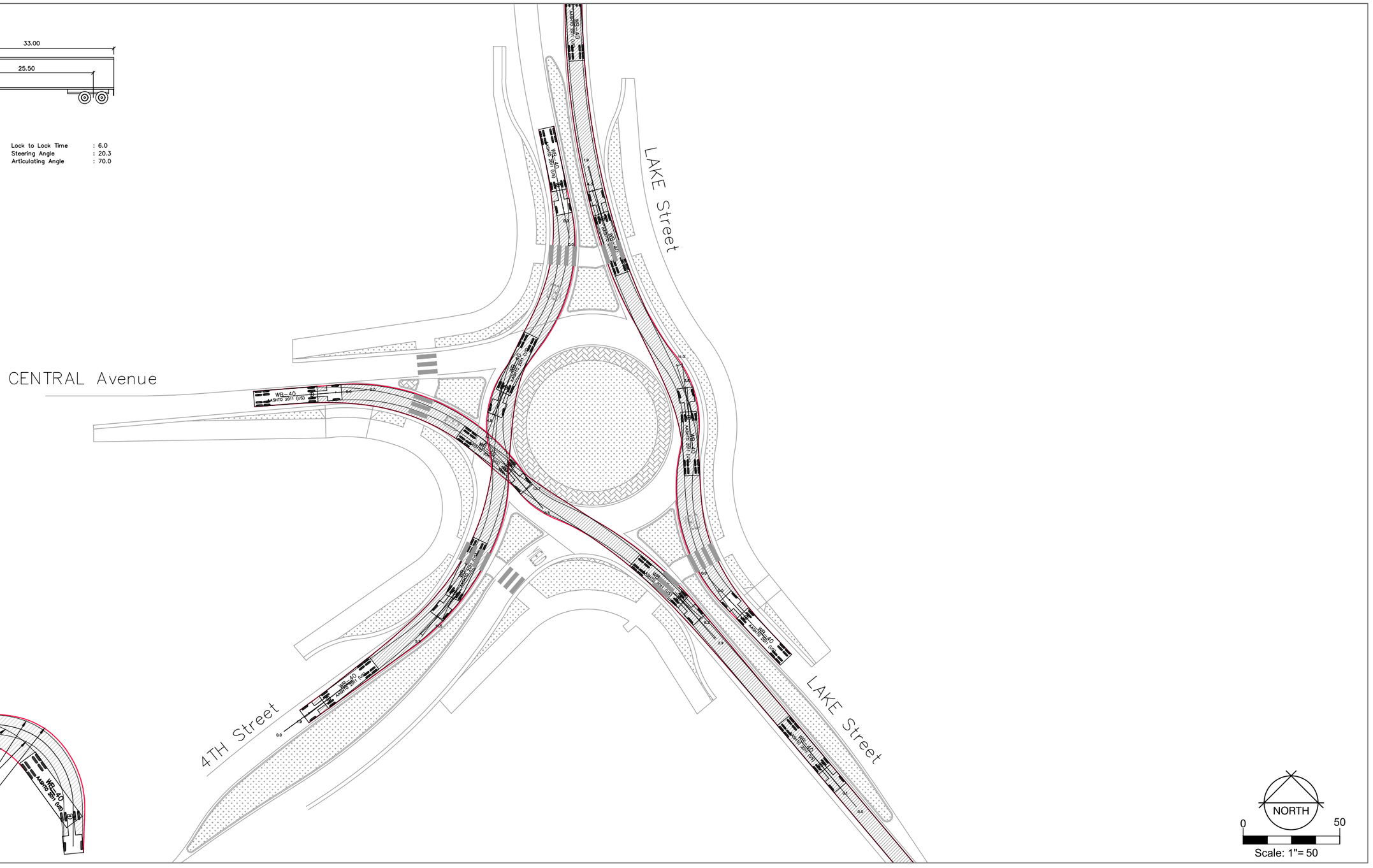
WB-40 Truck Turn (Through Movement Only)

VEHICLE PROFILE

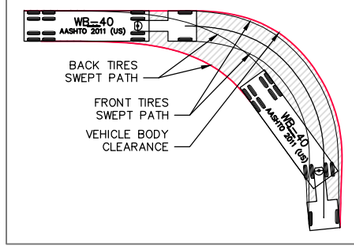


WB–40 feet

Tractor Width	: 8.00	Lock to Lock Time	: 6.0
Trailer Width	: 8.00	Steering Angle	: 20.3
Tractor Track	: 8.00	Articulating Angle	: 70.0
Trailer Track	: 8.00		



LEGEND



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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure C3

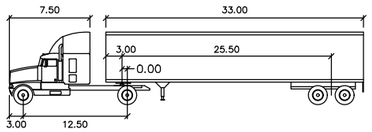
omni·means A GHD Company

Madera, California

2264EX007.dwg

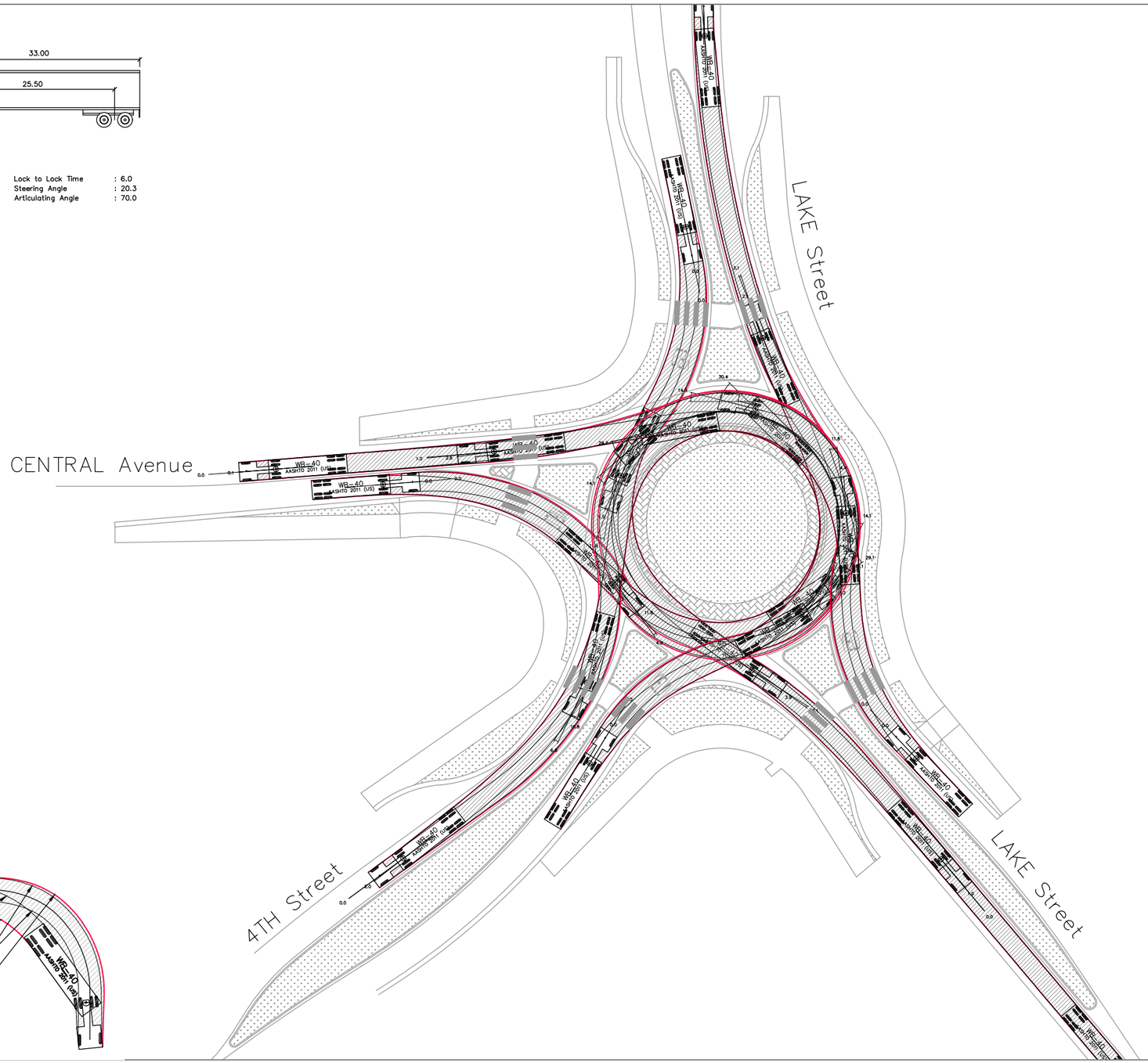
WB-40 Truck Turn (Left-Turn Movement Only)

VEHICLE PROFILE

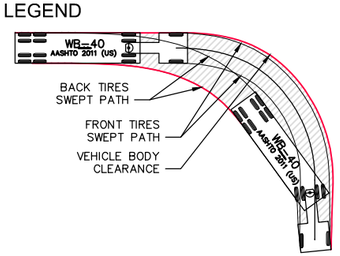


WB–40 feet

Tractor Width	: 8.00	Lock to Lock Time	: 6.0
Trailer Width	: 8.00	Steering Angle	: 20.3
Tractor Track	: 8.00	Articulating Angle	: 70.0
Trailer Track	: 8.00		



LEGEND



NORTH

0 50

Scale: 1"= 50

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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure C4

Madera, California

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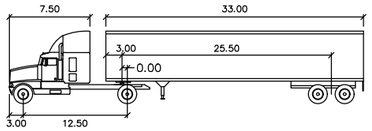
2264EX007.dwg

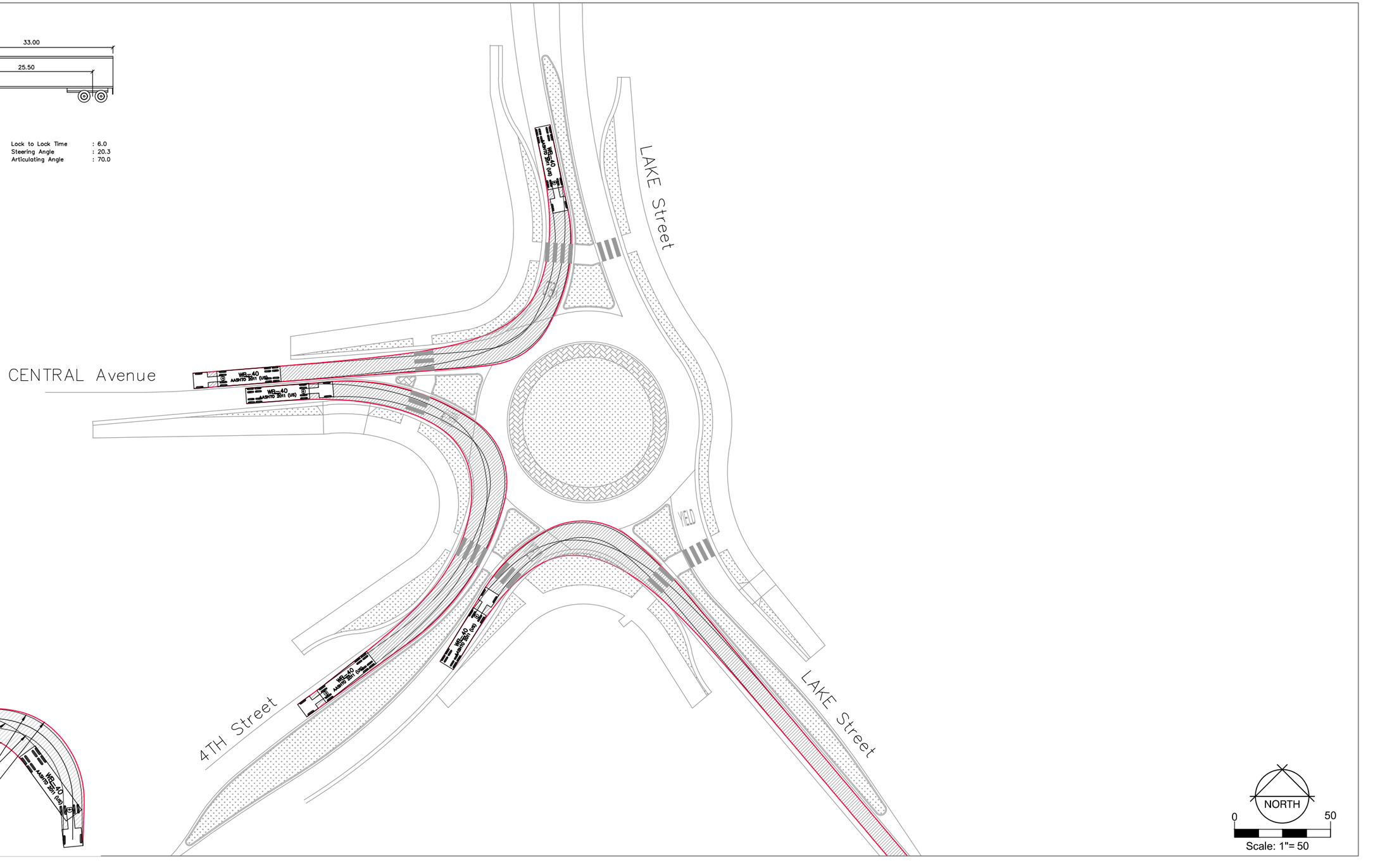
WB-40 Truck Turn (Right-Turn Movement Only)

VEHICLE PROFILE

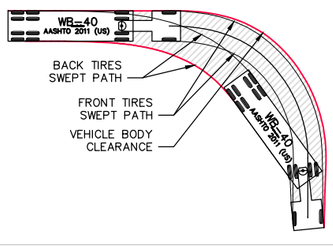


WB–40 feet

Tractor Width	: 8.00	Lock to Lock Time	: 6.0
Trailer Width	: 8.00	Steering Angle	: 20.3
Tractor Track	: 8.00	Articulating Angle	: 70.0
Trailer Track	: 8.00		



LEGEND



NORTH

0 50

Scale: 1"= 50

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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure C5

Madera, California

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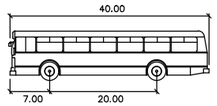
2264EX007.dwg

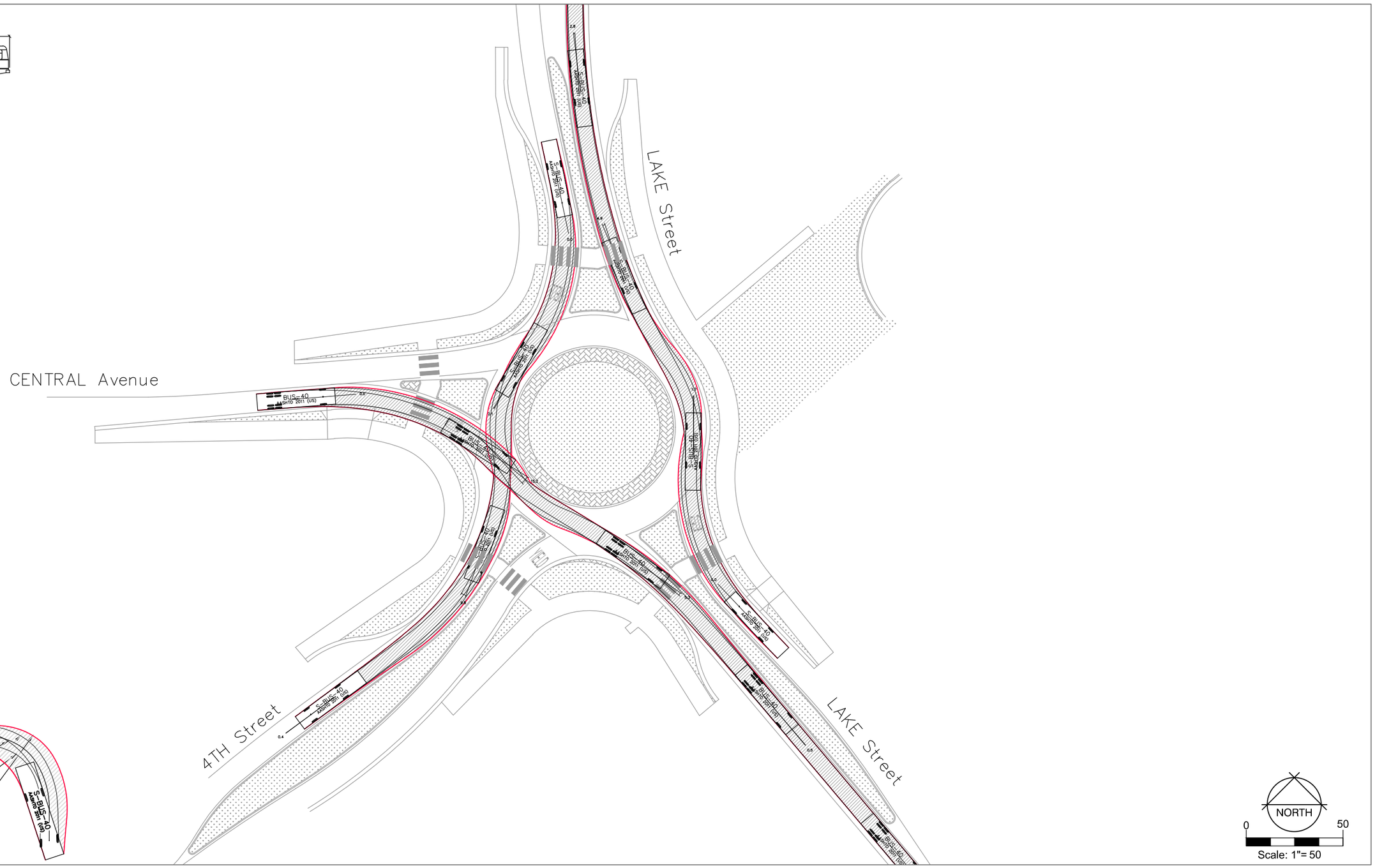
Bus 40 VehicleTurn (Through Movement Only)

VEHICLE PROFILE

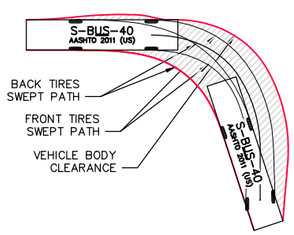


S-BUS-40
feet

Width	: 8.00
Track	: 8.00
Lock to Lock Time	: 6.0
Steering Angle	: 34.4



LEGEND



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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

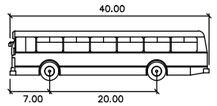
Figure C6

Madera, California

2264EX007.dwg

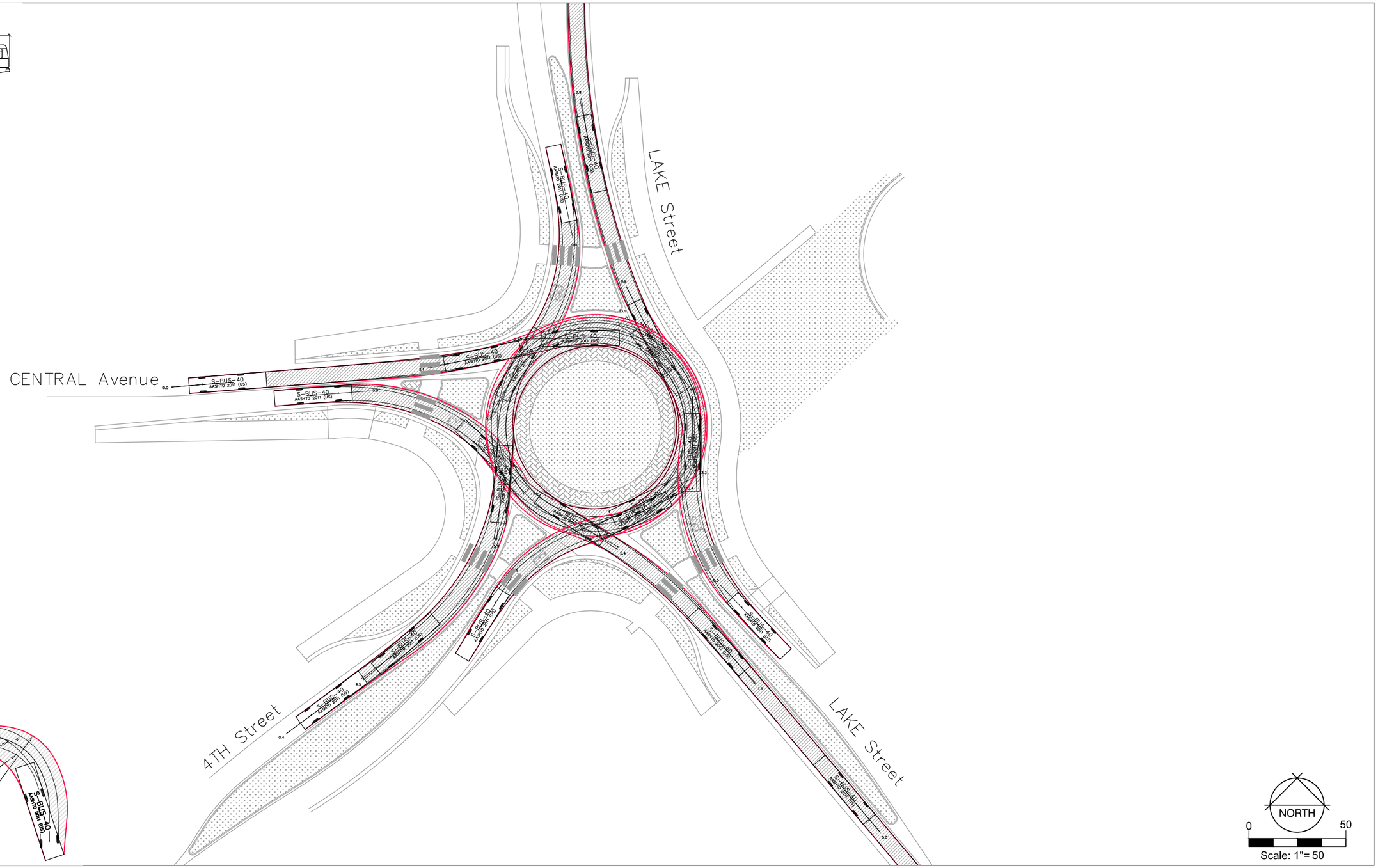
Bus 40 VehicleTurn (Left-Turn Movement Only)

VEHICLE PROFILE

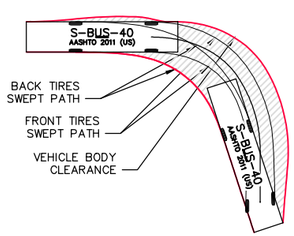


S-BUS-40
feet

Width	: 8.00
Track	: 8.00
Lock to Lock Time	: 6.0
Steering Angle	: 34.4



LEGEND



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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

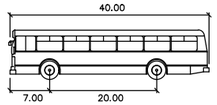
Figure C7

Madera, California

2264EX007.dwg

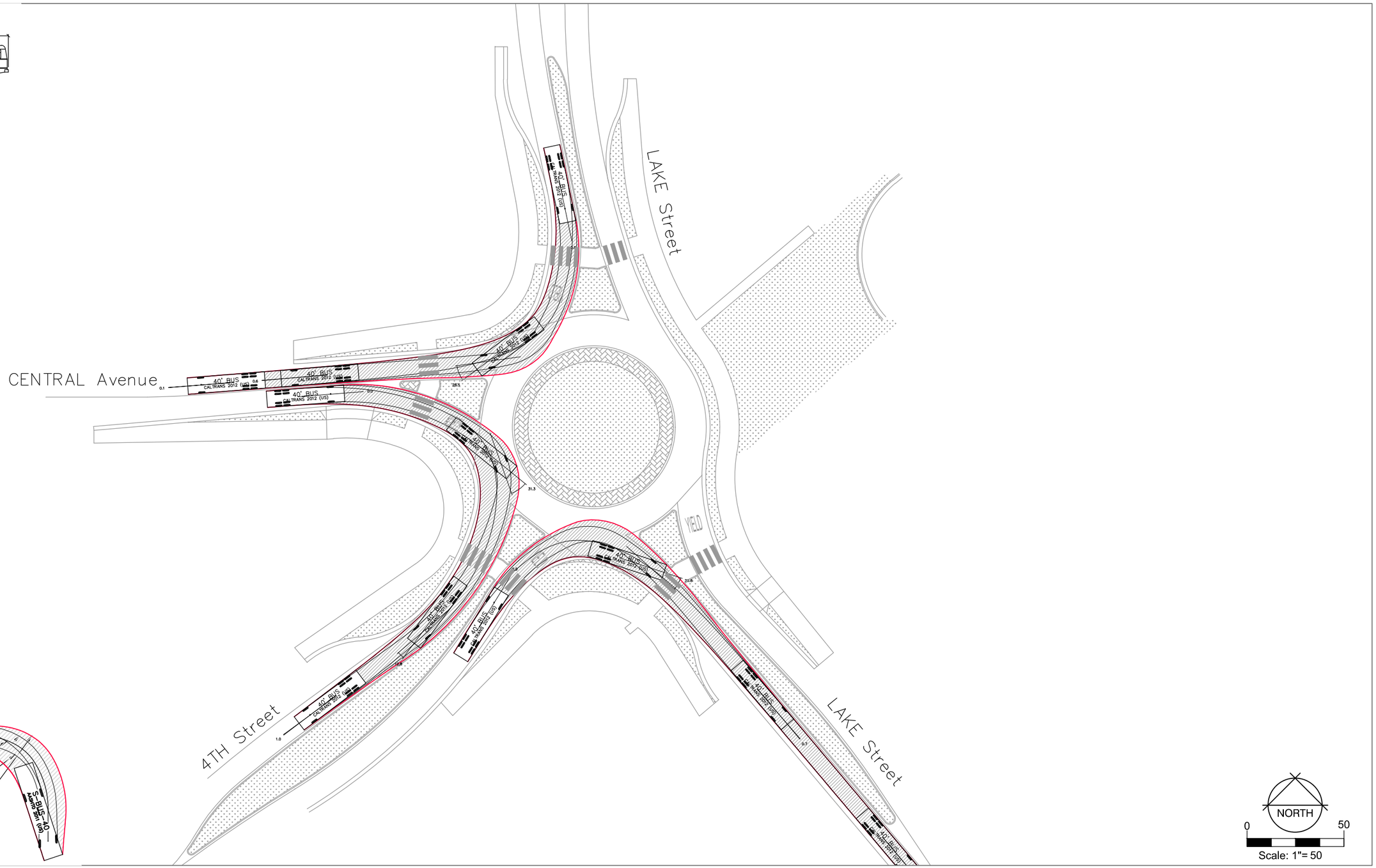
Bus 40 VehicleTurn (Right-Turn Movement Only)

VEHICLE PROFILE

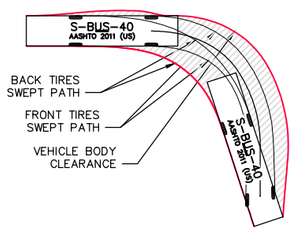


S-BUS-40
feet

Width	: 8.00
Track	: 8.00
Lock to Lock Time	: 6.0
Steering Angle	: 34.4



LEGEND



NORTH

0 50

Scale: 1"= 50

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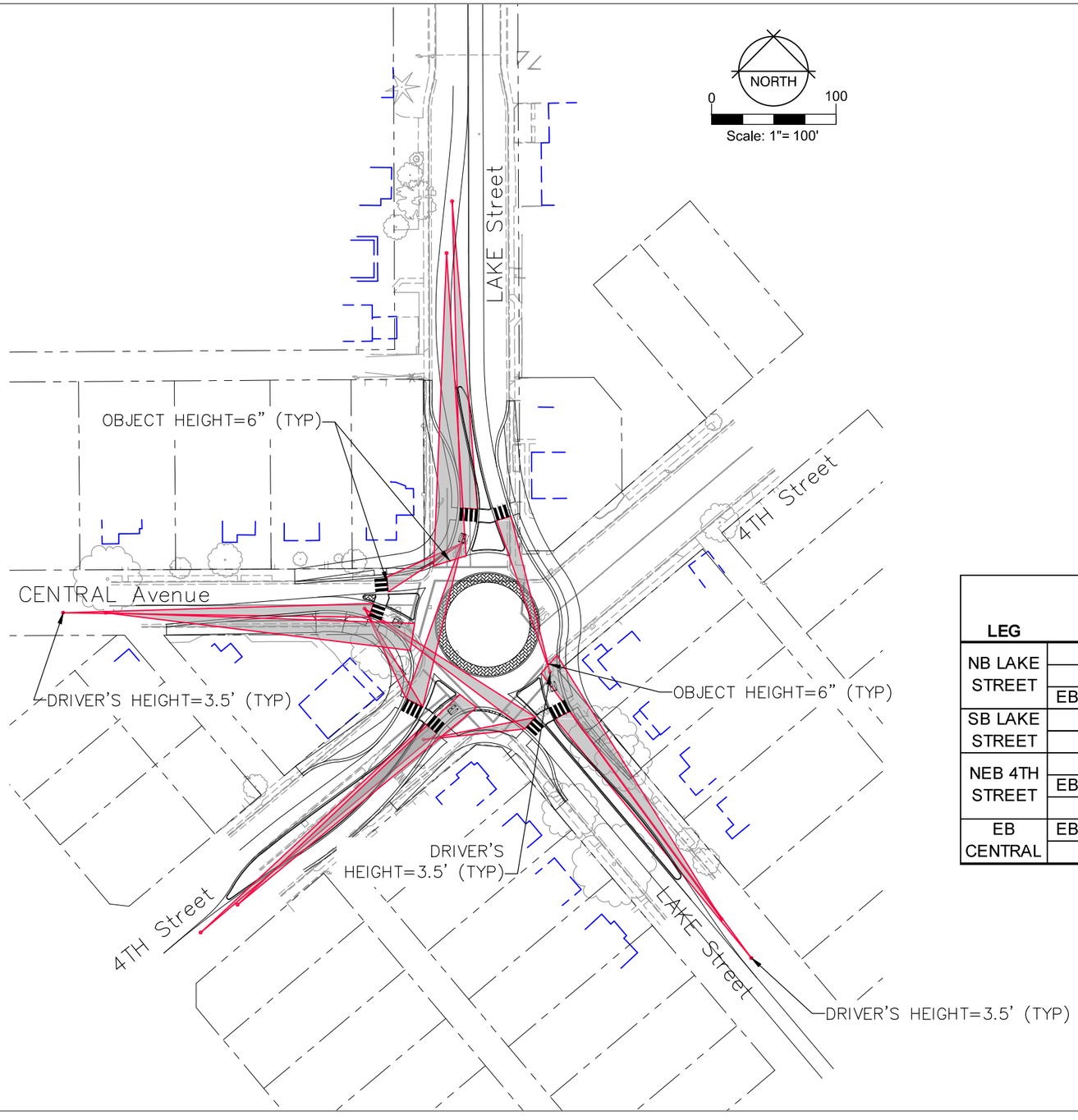
LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure C8

Madera, California

2264EX007.dwg

Stopping Sight Distance



NOTES:

1. STOPPING SIGHT DISTANCE CRITERIA OBTAINED FROM NCHRP REPORT 672
2. STOPPING SIGHT DISTANCE IS MEASURED USING AN ASSUMED DRIVER'S EYE HEIGHT OF 3.5 FT AND AN ASSUMED OBJECT HEIGHT OF 6 INCHES.

SSD - ENTRY

APPROACH	INITIAL SPEED (MPH)	STOPPING SIGHT DISTANCE (FT)
NB LAKE STREET	35.0	247.3
SB LAKE STREET	35.0	247.3
NEB 4TH STREET	35.0	247.3
EB CENTRAL AVENUE	35.0	247.3

SSD - PEDESTRIAN CROSSING

LEG	APPROACH	CONFLICTING SPEED (MPH)	SIGHT TRIANGLE LENGTH (FT)
NB LAKE STREET	NB LAKE STREET INITIAL SPEED	35.0	247.3
	NEB 4TH STREET RIGHT TURN (V5)	15.7	81.8
	EB CENTRAL AVENUE CIRCULATING SPEED (V2)	26.0	161.0
SB LAKE STREET	SB LAKE STREET INITIAL SPEED	35.0	247.3
	NB LAKE STREET CIRCULATING SPEED (V2)	22.2	129.2
NEB 4TH STREET	NEB 4TH STREET INITIAL SPEED	35.0	247.3
	EB CENTRAL AVENUE RIGHT TURN (V5)	15.4	79.6
	SB LAKE STREET CIRCULATING SPEED (V2)	23.4	139.0
EB CENTRAL	EB CENTRAL AVENUE INITIAL SPEED	35.0	247.3
	SB LAKE STREET RIGHT TURN (V5)	13.4	66.3

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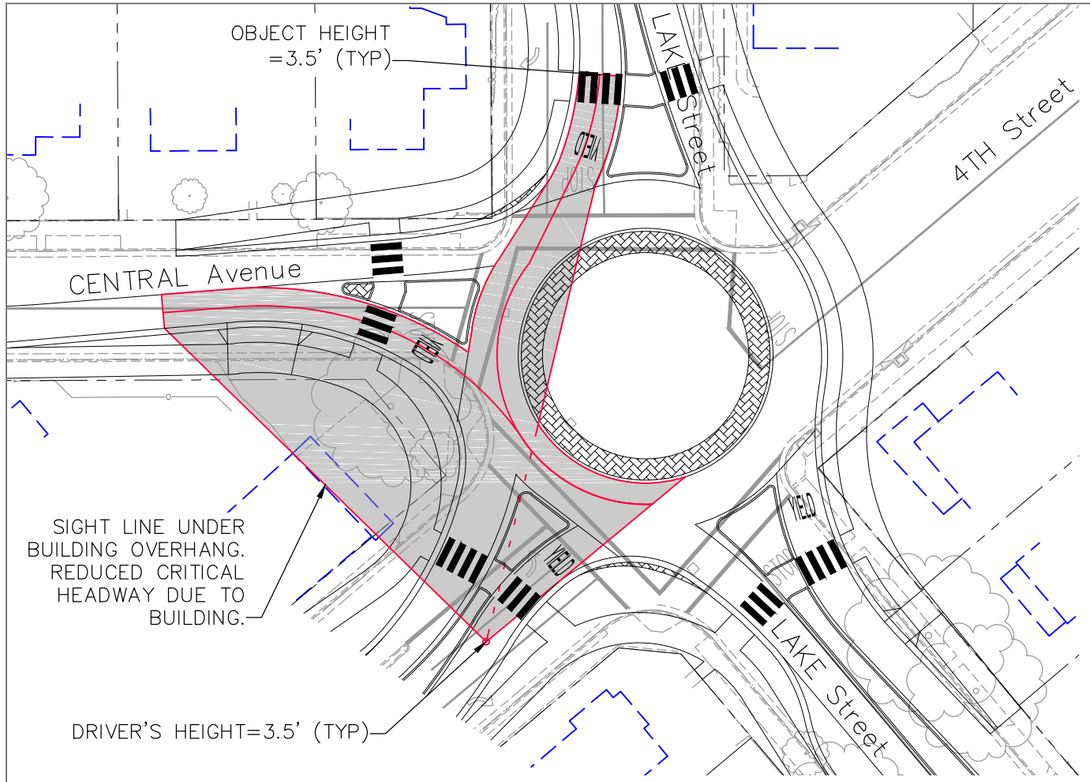
LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

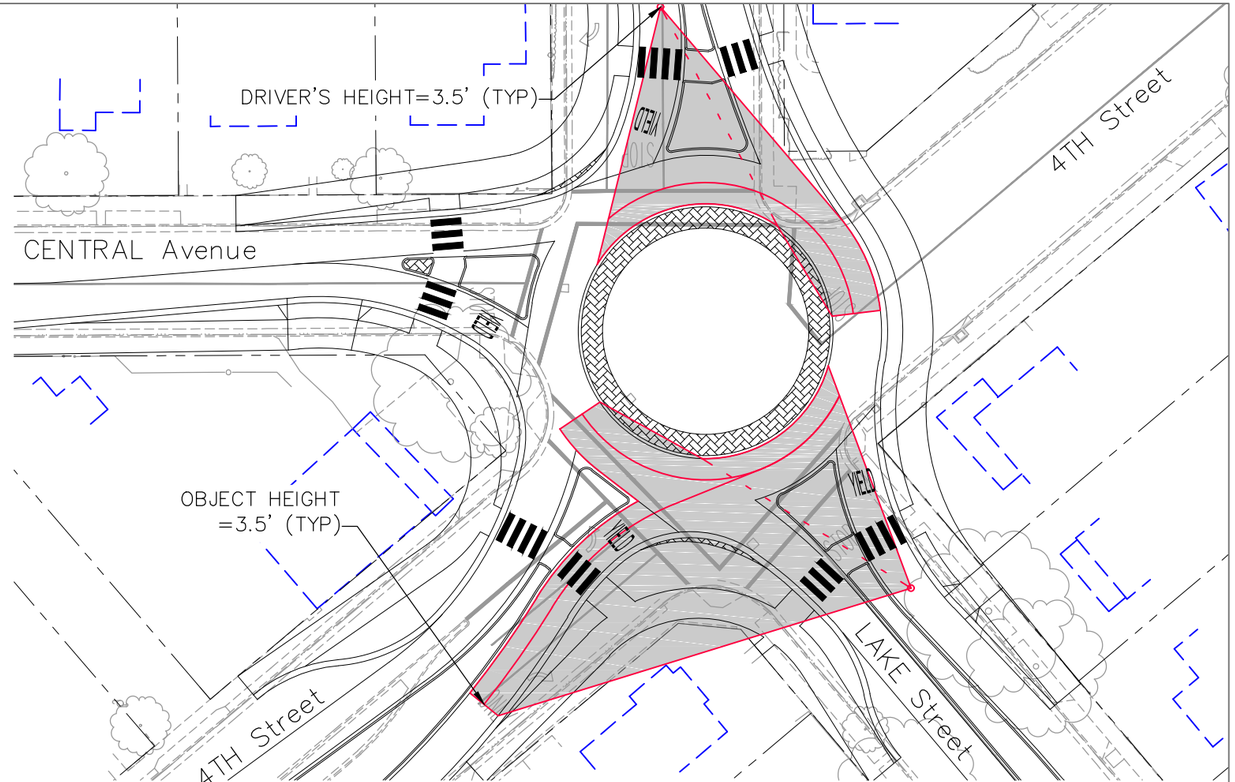
Figure C9

Madera, California

2264EX007.dwg

Intersection Sight Distance

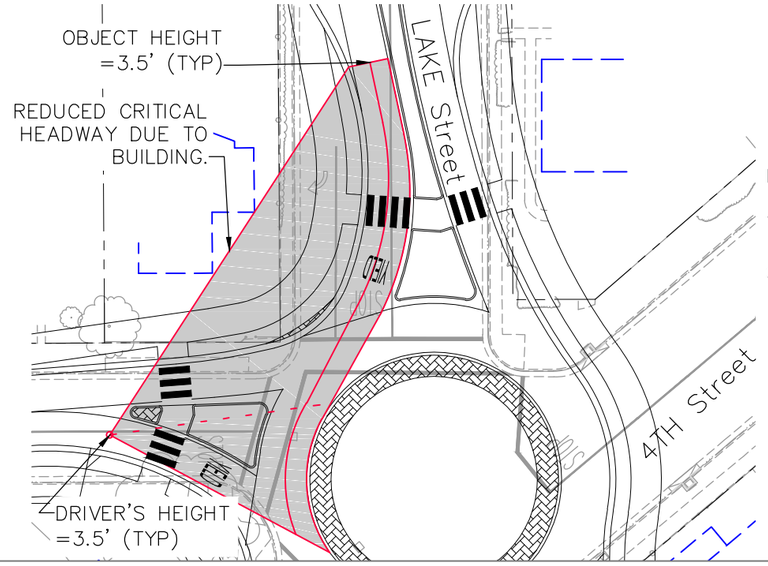




INTERSECTION SIGHT DISTANCE

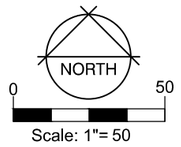
LEG	APPROACH		CONFLICTING SPEED (MPH)	SIGHT TRIANGLE LENGTH (FT)
NB LAKE STREET	NEB 4TH STREET	ENTERING LEG (D1)	21.8	159.9
	EB CENTRAL AVENUE	CIRCULATING LEG (D2)	14.0	103.0
SB LAKE STREET	NB LAKE STREET	CIRCULATING LEG (D2)	14.6	107.1
NEB 4TH STREET	EB CENTRAL AVENUE	ENTERING LEG (D1)	26.0	183.2*
	SB LAKE STREET	CIRCULATING LEG (D2)	24.4	178.8
EB CENTRAL AVENUE	SB LAKE STREET	ENTERING LEG (D1)	23.4	163.8**

* CRITICAL HEADWAY=4.8 SECONDS
** CRITICAL HEADWAY=4.77 SECONDS



NOTES:

1. INTERSECTION SIGHT DISTANCE IS MEASURED USING AN ASSUMED DRIVER'S EYE HEIGHT OF 3.5 FT AND AN ASSUMED OBJECT HEIGHT OF 3.5 FT.
2. INTERSECTION SIGHT DISTANCE CRITERIA OBTAINED FROM NCHRP REPORT 672 WITH 5 SECOND CRITICAL HEADWAY (tc), UNLESS NOTED OTHERWISE.



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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure C10

omni·means A GHD Company

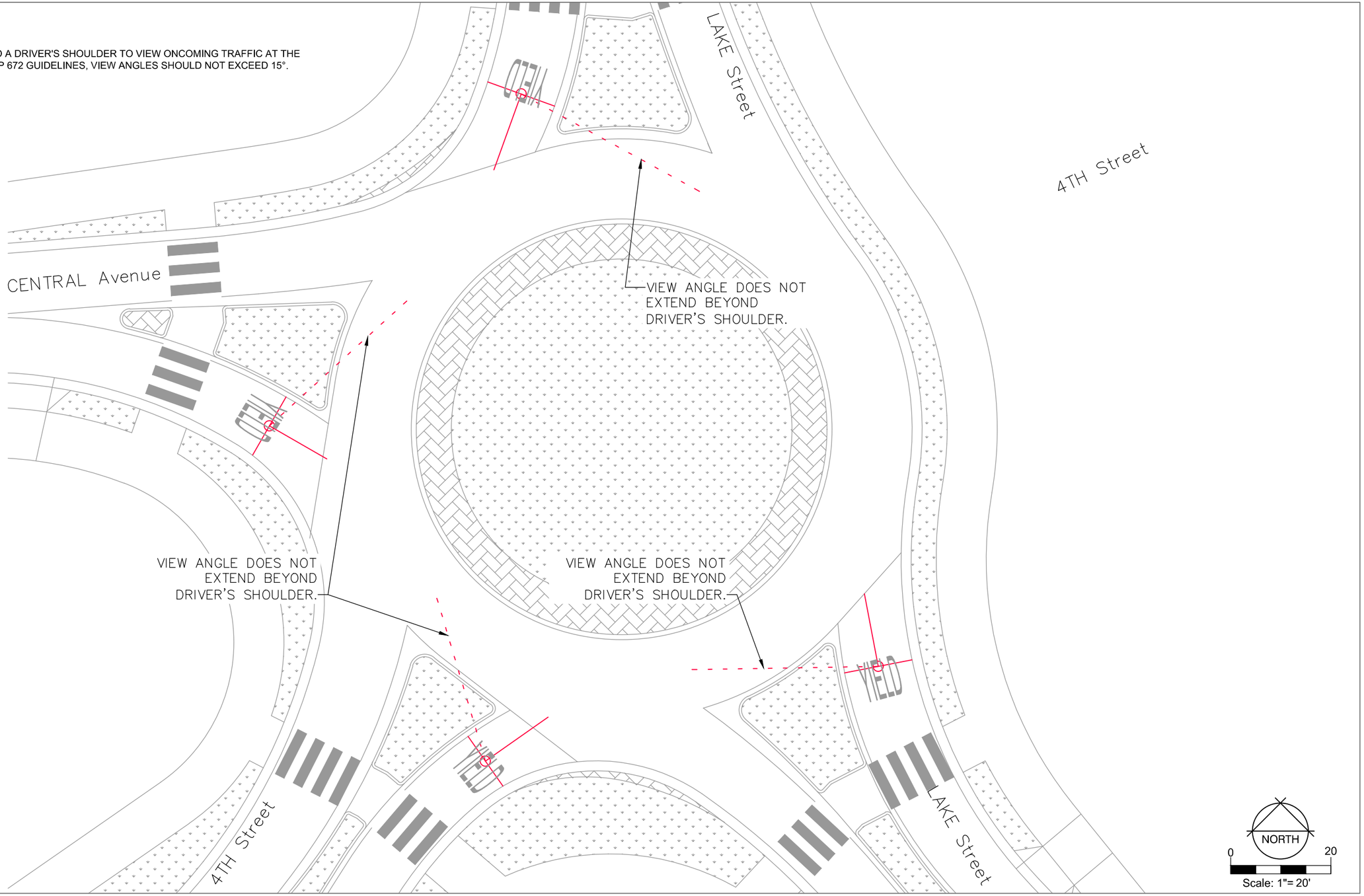
GHD

Madera, California

2264EX007.dwg

View Angles

NOTE
VALUE SHOWN IS THE ANGLE BEYOND A DRIVER'S SHOULDER TO VIEW ONCOMING TRAFFIC AT THE ROUNDABOUT ENTRANCE. PER NCHRP 672 GUIDELINES, VIEW ANGLES SHOULD NOT EXCEED 15°.



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LAKE St/4TH St/CENTRAL Ave INTX IMPROVEMENTS

Figure C11

Madera, California

omni·means A GHD Company

2264EX007.dwg

LANE SUMMARY

Site: 1 [2017 AM Peak Hour]

4th Street/Lake Street/Central Avenue
2017 AM Peak Hour
Roundabout

Lane Use and Performance													
	Demand Flows		Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue		Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	Total veh/h	HV %	veh/h	v/c	%	sec		Veh	Dist ft		ft	%	%
SouthEast: North Lake Street													
Lane 1[d]	249	4.0	1098	0.227	100	5.4	LOS A	1.4	35.5	Full	360	0.0	0.0
Approach	249	4.0		0.227		5.4	LOS A	1.4	35.5				
North: North Lake Street													
Lane 1[d]	520	4.0	1064	0.488	100	9.0	LOS A	3.8	98.6	Full	730	0.0	0.0
Approach	520	4.0		0.488		9.0	LOS A	3.8	98.6				
West: East Central Avenue													
Lane 1[d]	99	4.0	777	0.127	100	5.9	LOS A	0.8	20.1	Full	450	0.0	0.0
Approach	99	4.0		0.127		5.9	LOS A	0.8	20.1				
SouthWest: 4th Street													
Lane 1[d]	296	4.0	992	0.299	100	6.7	LOS A	1.9	48.3	Full	320	0.0	0.0
Approach	296	4.0		0.299		6.7	LOS A	1.9	48.3				
Intersection	1164	4.0		0.488		7.4	LOS A	3.8	98.6				

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

LANE SUMMARY

Site: 1 [2017 PM Peak Hour]

4th Street/Lake Street/Central Avenue
2017 PM Peak Hour
Roundabout

Lane Use and Performance													
	Demand Flows		Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue		Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	Total veh/h	HV %	veh/h	v/c	%	sec		Veh	Dist ft		ft	%	%
SouthEast: North Lake Street													
Lane 1[d]	380	1.0	1071	0.354	100	7.0	LOS A	2.4	60.1	Full	360	0.0	0.0
Approach	380	1.0		0.354		7.0	LOS A	2.4	60.1				
North: North Lake Street													
Lane 1[d]	435	1.0	1010	0.431	100	8.4	LOS A	3.1	79.3	Full	730	0.0	0.0
Approach	435	1.0		0.431		8.4	LOS A	3.1	79.3				
West: East Central Avenue													
Lane 1[d]	99	1.0	897	0.110	100	5.1	LOS A	0.7	16.7	Full	450	0.0	0.0
Approach	99	1.0		0.110		5.1	LOS A	0.7	16.7				
SouthWest: 4th Street													
Lane 1[d]	342	1.0	1028	0.333	100	6.9	LOS A	2.2	54.6	Full	320	0.0	0.0
Approach	342	1.0		0.333		6.9	LOS A	2.2	54.6				
Intersection	1256	1.0		0.431		7.3	LOS A	3.1	79.3				

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

LANE SUMMARY

Site: 1 [2040 AM Peak Hour]

4th Street/Lake Street/Central Avenue
2040 AM Peak Hour
Roundabout

Lane Use and Performance													
	Demand Flows		Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue		Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	Total veh/h	HV %	veh/h	v/c	%	sec		Veh	Dist ft		ft	%	%
SouthEast: North Lake Street													
Lane 1[d]	314	4.0	1040	0.301	100	6.5	LOS A	2.0	50.8	Full	360	0.0	0.0
Approach	314	4.0		0.301		6.5	LOS A	2.0	50.8				
North: North Lake Street													
Lane 1[d]	654	4.0	994	0.658	100	13.6	LOS B	7.3	188.0	Full	730	0.0	0.0
Approach	654	4.0		0.658		13.6	LOS B	7.3	188.0				
West: East Central Avenue													
Lane 1[d]	125	4.0	638	0.196	100	8.0	LOS A	1.3	34.0	Full	450	0.0	0.0
Approach	125	4.0		0.196		8.0	LOS A	1.3	34.0				
SouthWest: 4th Street													
Lane 1[d]	372	4.0	909	0.409	100	8.7	LOS A	2.8	73.2	Full	320	0.0	0.0
Approach	372	4.0		0.409		8.7	LOS A	2.8	73.2				
Intersection	1464	4.0		0.658		10.3	LOS B	7.3	188.0				

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

LANE SUMMARY

Site: 1 [2040 PM Peak Hour]

4th Street/Lake Street/Central Avenue
2040 PM Peak Hour
Roundabout

Lane Use and Performance													
	Demand Flows		Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue		Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	Total veh/h	HV %	veh/h	v/c	%	sec		Veh	Dist ft		ft	%	%
SouthEast: North Lake Street													
Lane 1[d]	476	1.0	998	0.477	100	9.2	LOS A	3.6	90.9	Full	360	0.0	0.0
Approach	476	1.0		0.477		9.2	LOS A	3.6	90.9				
North: North Lake Street													
Lane 1[d]	548	1.0	926	0.592	100	12.3	LOS B	5.8	145.2	Full	730	0.0	0.0
Approach	548	1.0		0.592		12.3	LOS B	5.8	145.2				
West: East Central Avenue													
Lane 1[d]	125	1.0	782	0.160	100	6.3	LOS A	1.0	26.1	Full	450	0.0	0.0
Approach	125	1.0		0.160		6.3	LOS A	1.0	26.1				
SouthWest: 4th Street													
Lane 1[d]	430	1.0	946	0.455	100	9.2	LOS A	3.3	83.5	Full	320	0.0	0.0
Approach	430	1.0		0.455		9.2	LOS A	3.3	83.5				
Intersection	1580	1.0		0.592		10.1	LOS B	5.8	145.2				

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

Preliminary Opinion of Costs (Construction Costs Only)

4th Street/Lake Street/Central Avenue Intersection Improvements - **Roundabout Alternative**

City of Madera

1/2/2018

55-4549-03/2264

No.	*Item Description*	*Units*	*Quantity*	*Unit Cost*	*Total*
1	Traffic Control System	LS	1	$90,000.00	$90,000.00
2	Remove Tree	EA	5	$800.00	$4,000.00
3	Remove Fence	LF	220	$20.00	$4,400.00
4	Remove Thermoplastic Traffic Stripe	LF	570	$4.25	$2,422.50
5	Remove Thermoplastic Pavement Marking	SQFT	50	$12.50	$625.00
6	Remove Roadside Sign	EA	20	$155.00	$3,100.00
7	Remove Concrete Curb	LF	500	$19.50	$9,750.00
8	Remove Concrete Sidewalk	SQYD	560	$31.50	$17,640.00
9	Remove Concrete (Curb & Gutter)	LF	1900	$12.50	$23,750.00
10	Roadway Excavation	CY	2400	$32.00	$76,800.00
11	Class 2 Aggregate Base	CY	770	$53.00	$40,810.00
12	Hot Mix Asphalt (Type B)	TON	720	$90.00	$64,800.00
13	Minor Concrete (Stamped Concrete -Truck Apron)	CY	40	$690.00	$27,600.00
14	Minor Concrete (Median Curb)	CY	40	$770.00	$30,800.00
15	Minor Concrete(Curb-Truck Apron)	CY	10	$780.00	$7,800.00
16	Minor Concrete (Curb and Gutter)	CY	80	$355.00	$28,400.00
17	Minor Concrete (Sidewalk)	CY	140	$405.00	$56,700.00
18	Thermoplastic Traffic Stripe	LF	3800	$2.00	$7,600.00
19	Thermoplastic Pavement Marking	SQFT	640	$7.00	$4,480.00
20	Landscape	SQFT	20000	$5.00	$100,000.00
21	Signs	EA	30	$380.00	$11,400.00
22	Lighting and Sign Illumination	LS	1	$250,000.00	$250,000.00
23	Storm Drain System	LS	1	$50,000.00	$50,000.00
24	Mobilization	LS	1	$82,300.00	$82,300.00
	Subtotal (Construction Costs)				$ 995,177.50
	Minor/ Supplemental Items			30%	$ 299,000.00
	Construction Contingency			25%	$ 324,000.00
	Total Construction Costs				**$ 1,618,177.50**
	Rounded				**$ 1,620,000.00**

APPENDIX D – BENEFIT/COST RATIO BACK-UP

Intersection Control Evaluation
Collision Cost Analysis and B/C

-- Fill in tan boxes along with 'Area' --

County	Rte	Postmile	Location Description
Madera	N/A	N/A	4th/Lake/Central

Area
- ○ Rural
- ◉ Suburban
- ◉ Urban

Intersection Types:
- F - Four-Legged
- M - Multi-Legged
- S - Offsett -Tee
- Y - "Y" Wye
- Z - Others

Existing Condition	# of Years for Analysis	Rate Group
All Way Stop, Type F, M or S	23	I8

Existing ADT (x1000)		Future ADT (x1000)			
Mainline	Cross St	Mainline	Cross St	Average ADT	VCF
8.3	6.4	10.5	8.0	16.6	1.13

Est. Capital Cost (x1000) for Desired Improvement			
Desired Improvement	Const	R/W	Total
Yield Control (Roundabout 1-Lane)	$ 1,620	$ 755	$ 2,375
Yield Control (Roundabout 2-Lane)		$ -	$ -
Traffic Signal, Type F, M or S	$ 1,050	$ 2	$ 1,052

Existing Collision Data			
Number of Years	5	Total Collisions	10
Injury	1	PDO	9
Fatal		Fat + Inj	1

	Collision Cost (x1000)					B/C
	Existing Condition		Desired Improvement		Projected Savings	
1	All Way Stop, Type F, M or S	$6,973	Yield Control (Roundabout 1-Lane)	$2,330	$4,644	1.95
2	All Way Stop, Type F, M or S	$6,973	Yield Control (Roundabout 2-Lane)	$3,450	$3,524	0.00
3	All Way Stop, Type F, M or S	$6,973	Traffic Signal, Type F, M or S	$7,872	($898)	-0.85

v1.00

NOTE: Only average collision costs are used for calculation purposes.

NOTE: Collision costs reported are costs for anticipated collisions over the number of years of analysis (20 years)

Fill in Orange Cells.

Delay Entry

Enter average vehicle occupancy. This is used to convert vehicle delay to person delay.

Vehicle Occupancy	1.15	From Caltrans Life-Cycle Benefit-Cost Analysis - Economic Parameters 2016

Enter the duration in hours of each time period of the day. If delay data is not available for a time period, enter a duration of

	Weekday		Weekend	
AM	1			
PM	1			
Midday				
Off-Peak1				This could be us
Off-Peak2				This could be us
Total	2		0	

Total for weekday and weekend should equal 24 for analysis of all hours of the week, or should equal less than 24 for analysis of certain time periods only. Full day analysis for weekdays and weekends is recommended if sufficient data is available.

Enter the hourly volume (total entering vehicles) for each time period of the day. This is used to convert average delay per v
If analysis of certain time periods is not desired, leave cells for that time period blank

	Weekday		Weekend	
	Existing Year	Design Year	Opening Year	Design Year
AM	955	1203		
PM	1188	1495		
Midday				
Off-Peak1				
Off-Peak2				
ADT	**Requires 24**	**hour data**	**Requires 24**	**hour data**

Orange cells in tables below can be left blank if consideration of time period is not desired.
For example, if it is desired to only analyze peak hours, delay entries for midday and off-peak may be left blank.
Enter the delay from SIDRA outputs.

Weekday

Roundabout Alternative

	AM	PM	Midday	Off-Peak1	Off-Peak2
	Delay	**Delay**	**Delay**	**Delay**	**Delay**
	sec/veh	sec/veh	sec/veh	sec/veh	sec/veh
2017	**7.4**	**7.3**			
2040	**10.3**	**10.1**			

Enter the delay from Synchro/SimTraffic outputs.

Signal Alternative

	AM	PM	Midday	Off-Peak1	Off-Peak2
	Delay	**Delay**	**Delay**	**Delay**	**Delay**
	sec/veh	sec/veh	sec/veh	sec/veh	sec/veh
2017	**23.8**	**24.3**			
2040	**28.2**	**38.3**			

These cells calculate average weekday peak hour totals. No data entry here.

Roundabout Alternative

	Average Week Day Peak Hour Totals	
	Vehicle Delay	**Person Delay**
	(in sec)	(in sec)
2017	7,870	9,050
2040	13,745	15,807

Signal Alternative

	Average Week Day Peak Hour Totals	
	Vehicle Delay	**Person Delay**
	(in sec)	(in sec)
2017	25,799	29,669
2040	45,592	52,430

Annual Costs	Roundabout Alternative		Traffic Signal Alternative	
Safety	**Predicted Annual Crashes**	**Safety Cost**	**Predicted Annual Crashes**	**Safety Cost**
Predicted Fatal/Injury Crashes	Safety Data Omitted	0	Safety Data Omitted	0
Predicted PDO Crashes	Safety Data Omitted	0	Safety Data Omitted	0
	Annual Costs of Predicted Crashes	**$ 135,695**	***Annual Costs of Predicted Crashes***	**$ 202,062**
Delay	**Annual Intersection Delay (person-hrs)**	**Delay Cost**	**Annual Intersection Delay (person-hrs)**	**Delay Cost**
Average Annual Person (in Vehicle) Delay	898	**$ 11,000**	2965	**$ 36,000**
Operation and Maintenance	**Operation and Maintenance**	**O&M Cost**	**Operation and Maintenance**	**O&M Cost**
Annualized Cost of Signal Retiming		$ -	Signal Retiming Every 3 Years	$ 1,000
Annual Cost of Power for Signal		$ -	Power for Signal	$ 750
Annual Cost of Illumination	Intersection Illumination	$ 750	Intersection Illumination	$ 750
Annual Cost of Maintenance	Landscaping Costs	$ 1,500	Signal Maintenance Costs (power outage, detection, etc.)	$ 1,500
	Total Annual Operation and Maintenance Costs	**$ 2,250**	***Total Annual Operation and Maintenance Costs***	**$ 4,000**
Initial Capital Costs	**Total Capital Costs**	**Cost**	**Total Capital Costs**	**Cost**
Preliminary Engineering		$ 234,392		$ 120,699
Right-of-way and Utilities		**$ 755,410**		**$ 1,600**
Construction		**$ 1,620,000**		**$ 1,050,000**

***Delay cost is based upon an average of the AM and PM peak hours.**

Total Discounted Life Cycle Costs (2017 - 2040)	Roundabout Alternative		Traffic Signal Alternative	
Safety	**Total Predicted Crashes**	**Safety Cost**	**Total Predicted Crashes**	**Safety Cost**
Predicted Fatal/Injury Crashes	Safety Data Omitted	$ -	Safety Data Omitted	$ -
Predicted PDO Crashes	Safety Data Omitted	$ -	Safety Data Omitted	$ -
	Total Costs of Predicted Crashes	**$ 2,016,000**	***Total Costs of Predicted Crashes***	**$ 3,002,000**
Delay	**Total Intersection Delay (person-hrs)**	**Delay Cost**	**Total Intersection Delay (person-hrs)**	**Delay Cost**
Total Person (in Vehicle) Delay	21543	**$ 260,000**	71152	**$ 860,000**
Fuel and GHG Cost	**Fuel and Green House Gas Cost**		**Fuel and Green House Gas Cost**	
		$ 505,120		**$ 536,123**
Operation and Maintenance	**Operation and Maintenance**	**O&M Cost**	**Operation and Maintenance**	**O&M Cost**
Annualized Cost of Signal Retiming		$ -	Signal Retiming Every 3 Years	$ 14,857
Annual Cost of Power for Signal		$ -	Power for Signal	$ 11,143
Annual Cost of Illumination	Intersection Illumination	$ 11,143	Intersection Illumination	$ 11,143
Annual Cost of Maintenance	Landscaping Costs	$ 22,285	Signal Maintenance Costs (power outage, detection, etc.)	$ 22,285
	Total Annual Operation and Maintenance Costs	**$ 33,428**	***Total Annual Operation and Maintenance Costs***	**$ 59,427**
Initial Capital Costs	**Total Capital Costs**	**Cost**	**Total Capital Costs**	**Cost**
Preliminary Engineering		$ 234,392		$ 120,699
Right-of-way and Utilities		$ 755,410		$ 1,600
Construction		$ 1,620,000		$ 1,050,000
	Total Initial Capital Costs	**$ 2,609,802**	***Total Initial Capital Costs***	**$ 1,172,299**
Total Life Cycle Costs (Opening Year $)	**Net Present Value**	**$ 4,919,230**	**Net Present Value**	**$ 5,093,726**

***Delay cost is based upon an average of the AM and PM peak hours.**

Roundabout Alternative

Traffic Signal Alternative

Life Cycle Benefit/Cost Ratio

Roundabout Alt vs. Signal Alt	
Safety Benefit	$ 986,000
Delay Reduction Benefit	$ 600,000
Fuel and GHG Benefit	$ 31,004
Total Benefits	**$ 1,617,004**
Added Operations&Maintenance Costs	$ (25,999)
Added Capital Costs	$ 1,437,503
Total Costs	**$ 1,411,504**
Life Cycle Benefit/Cost Ratio	**1.1**

Roundabout Preferred

QUANTITIES

		Travel Time (pers-hr)		Intersection Performance-Annual Values (From SIDRA Intersection Summary Reports)					
				Fuel (gal/yr)		Carbon Monoxide (kg/yr)		Nitrogen Oxide (kg/yr)	
		Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative
		2,143	654	**7,741**	**7,319**	**66.5**	**63.5**	**93.0**	**86.5**
		3,787	1,142	**12,611**	**11,883**	**118.5**	**116.0**	**132.0**	**131.5**
	2017					0.07	0.07	0.10	0.10
	2040				Convert to tons/yr	0.13	0.13	0.15	0.14

		Travel Time (pers-hr)		Fuel (gal/yr)		Carbon Monoxide (ton/yr)		Nitrogen Oxide (kg/yr)	
		Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative
Year 0	2017	2143	654	7741.00	7319.00	0.07	0.07	0.10	0.10
Year 1	2018	2214	675	7952.74	7517.43	0.08	0.07	0.10	0.10
Year 2	2019	2286	696	8164.48	7715.87	0.08	0.08	0.11	0.10
Year 3	2020	2357	717	8376.22	7914.30	0.08	0.08	0.11	0.10
Year 4	2021	2429	738	8587.96	8112.74	0.08	0.08	0.11	0.10
Year 5	2022	2500	760	8799.70	8311.17	0.09	0.08	0.11	0.11
Year 6	2023	2572	781	9011.43	8509.61	0.09	0.09	0.11	0.11
Year 7	2024	2643	802	9223.17	8708.04	0.09	0.09	0.12	0.11
Year 8	2025	2715	823	9434.91	8906.48	0.09	0.09	0.12	0.11
Year 9	2026	2786	845	9646.65	9104.91	0.10	0.09	0.12	0.11
Year 10	2027	2857	866	9858.39	9303.35	0.10	0.10	0.12	0.12
Year 11	2028	2929	887	10070.13	9501.78	0.10	0.10	0.12	0.12
Year 12	2029	3000	908	10281.87	9700.22	0.10	0.10	0.12	0.12
Year 13	2030	3072	929	10493.61	9898.65	0.11	0.10	0.13	0.12
Year 14	2031	3143	951	10705.35	10097.09	0.11	0.11	0.13	0.13
Year 15	2032	3215	972	10917.09	10295.52	0.11	0.11	0.13	0.13
Year 16	2033	3286	993	11128.83	10493.96	0.11	0.11	0.13	0.13
Year 17	2034	3358	1014	11340.57	10692.39	0.12	0.11	0.13	0.13
Year 18	2035	3429	1036	11552.30	10890.83	0.12	0.12	0.14	0.13
Year 19	2036	3501	1057	11764.04	11089.26	0.12	0.12	0.14	0.14
Year 20	2037	3572	1078	11975.78	11287.70	0.12	0.12	0.14	0.14
Year 21	2038	3644	1099	12187.52	11486.13	0.13	0.12	0.14	0.14
Year 22	2039	3715	1120	12399.26	11684.57	0.13	0.13	0.14	0.14
Year 23	2040	3787	1142	12611.00	11883.00	0.13	0.13	0.15	0.14
Total		**71152**	**21543**	**244224.00**	**230424.00**	**2.45**	**2.37**	**2.98**	**2.88**
Average		**2965**	**898**	**10176.00**	**9601.00**	**0.10**	**0.10**	**0.12**	**0.12**

COSTS

Life-Cycle Benefit-Cost Analysis

Travel Time Parameter	Fuel (gal/yr)	Carbon Monoxide (kg/yr)	Nitrogen Oxide (kg/yr)
Auto/Truck Composite (Weighted Average)	Average Fuel Price for Regular Unleaded (Auto)	CA Urban Area	CA Urban Area
($/per-hr)	($/Gal)	($/Ton)	($/Ton)
$18.95	**$3.18**	**$80.00**	**$18,700.00**

Travel Time (pers-hr)		Fuel (gal/yr)		Carbon Monoxide (ton/yr)		Nitrogen Oxide (kg/yr)			
Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative		
$40,605	$12,386	$24,616	$23,274	$6	$6	$1,917	$1,783	0	1.00000
$41,959	$12,788	$25,290	$23,905	$6	$6	$1,952	$1,823	1	0.96154
$43,314	$13,190	$25,963	$24,536	$6	$6	$1,987	$1,864	2	0.92456
$44,668	$13,592	$26,636	$25,167	$6	$6	$2,022	$1,904	3	0.88900
$46,022	$13,994	$27,310	$25,799	$7	$6	$2,057	$1,944	4	0.85480
$47,377	$14,396	$27,983	$26,430	$7	$7	$2,092	$1,985	5	0.82193
$48,731	$14,799	$28,656	$27,061	$7	$7	$2,127	$2,025	6	0.79031
$50,086	$15,201	$29,330	$27,692	$7	$7	$2,162	$2,065	7	0.75992
$51,440	$15,603	$30,003	$28,323	$7	$7	$2,197	$2,106	8	0.73069
$52,795	$16,005	$30,676	$28,954	$8	$7	$2,232	$2,146	9	0.70259
$54,149	$16,407	$31,350	$29,585	$8	$8	$2,267	$2,186	10	0.67556
$55,503	$16,809	$32,023	$30,216	$8	$8	$2,302	$2,227	11	0.64958
$56,858	$17,211	$32,696	$30,847	$8	$8	$2,336	$2,267	12	0.62460
$58,212	$17,613	$33,370	$31,478	$8	$8	$2,371	$2,307	13	0.60057
$59,567	$18,015	$34,043	$32,109	$9	$8	$2,406	$2,348	14	0.57748
$60,921	$18,417	$34,716	$32,740	$9	$9	$2,441	$2,388	15	0.55526
$62,276	$18,819	$35,390	$33,371	$9	$9	$2,476	$2,428	16	0.53391
$63,630	$19,221	$36,063	$34,002	$9	$9	$2,511	$2,469	17	0.51337
$64,984	$19,623	$36,736	$34,633	$9	$9	$2,546	$2,509	18	0.49363
$66,339	$20,025	$37,410	$35,264	$10	$9	$2,581	$2,549	19	0.47464
$67,693	$20,427	$38,083	$35,895	$10	$10	$2,616	$2,590	20	0.45639
$69,048	$20,829	$38,756	$36,526	$10	$10	$2,651	$2,630	21	0.43883
$70,402	$21,232	$39,430	$37,157	$10	$10	$2,686	$2,670	22	0.42196
$71,757	$21,634	$40,103	$37,788	$10	$10	$2,721	$2,711	23	0.40573
$1,348,336	$408,237	$ 776,632	$ 732,748	$ 196	$ 190	$ 55,656	$ 53,924		
$56,181	$17,010	$32,360	$30,531	$8	$8	$2,319	$2,247		

ADJUSTED COSTS

Average Yearly Costs							
Travel Time (pers-hr)		Fuel (gal/yr)		Carbon Monoxide (ton/yr)		Nitrogen Oxide (kg/yr)	
Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative
$36,000	$11,000	$21,000	$20,000	$5	$5	$1,500	$1,500

Environmental Costs

Signal Alternative	$1,505
Roundabout Alternative	$1,505

Travel Time (pers-hr)		Fuel (gal/yr)		Carbon Monoxide (ton/yr)		Nitrogen Oxide (kg/yr)	
Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative	Signal Alternative	Roundabout Alternative
$40,605	$12,386	$24,616	$23,274	$6	$6	$1,917	$1,783
$40,345	$12,296	$24,317	$22,986	$6	$6	$1,877	$1,753
$40,046	$12,195	$24,004	$22,685	$6	$6	$1,837	$1,723
$39,710	$12,084	$23,680	$22,374	$6	$6	$1,797	$1,693
$39,340	$11,962	$23,344	$22,053	$6	$5	$1,758	$1,662
$38,940	$11,833	$23,000	$21,723	$6	$5	$1,719	$1,631
$38,513	$11,695	$22,648	$21,386	$6	$5	$1,681	$1,600
$38,061	$11,551	$22,288	$21,043	$6	$5	$1,643	$1,569
$37,587	$11,401	$21,923	$20,695	$5	$5	$1,605	$1,539
$37,093	$11,245	$21,553	$20,342	$5	$5	$1,568	$1,508
$36,581	$11,084	$21,179	$19,986	$5	$5	$1,531	$1,477
$36,054	$10,919	$20,802	$19,628	$5	$5	$1,495	$1,446
$35,513	$10,750	$20,422	$19,267	$5	$5	$1,459	$1,416
$34,961	$10,578	$20,041	$18,905	$5	$5	$1,424	$1,386
$34,398	$10,403	$19,659	$18,542	$5	$5	$1,390	$1,356
$33,827	$10,226	$19,277	$18,179	$5	$5	$1,356	$1,326
$33,249	$10,048	$18,895	$17,817	$5	$5	$1,322	$1,297
$32,666	$9,868	$18,514	$17,456	$5	$5	$1,289	$1,267
$32,078	$9,687	$18,134	$17,096	$5	$5	$1,257	$1,239
$31,487	$9,505	$17,756	$16,738	$5	$4	$1,225	$1,210
$30,894	$9,323	$17,381	$16,382	$4	$4	$1,194	$1,182
$30,300	$9,141	$17,008	$16,029	$4	$4	$1,163	$1,154
$29,707	$8,959	$16,638	$15,679	$4	$4	$1,133	$1,127
$29,114	$8,777	$16,271	$15,332	$4	$4	$1,104	$1,100
$860,000	$260,000	$ 500,000	$ 470,000	$ 123	$ 120	$ 36,000	$ 35,000
$36,000	$11,000	$21,000	$20,000	$5	$5	$1,500	$1,500

Roundabout Alternative to Signal Alternative

Life Cycle Costs (20 year design)	Traffic Signal Alternative	Roundabout Alternative
Collision and Mobility Costs		
Collision Costs of predicted crashes	$3,002,000	$2,016,000
Delay Costs	$860,000	$260,000
Fuel and GHG Costs	$537,000	$506,000
Project Costs including design, construction and maintenance		
Operations and Maintenance Costs	$60,000	$34,000
Project Costs (including R/W)	$1,172,299	$2,609,802
Total Life Cycle Costs (Opening Year $ - Net Present Value)	**$5,631,299**	**$5,425,802**

INTERSECTION SUMMARY

Site: 1v [2017 AM Peak Hour - Conversion]

4th Street/Lake Street/Central Avenue
2017 AM Peak Hour
Signals - Pretimed Isolated Cycle Time = 50 seconds (User-Given Cycle Time)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	15.0	mph	15.0	mph
Travel Distance (Total)	229.3	veh-mi/h	275.1	pers-mi/h
Travel Time (Total)	15.3	veh-h/h	18.3	pers-h/h
Demand Flows (Total)	1165	veh/h	1399	pers/h
Percent Heavy Vehicles (Demand)	4.0	%		
Degree of Saturation	0.682			
Practical Spare Capacity	31.9	%		
Effective Intersection Capacity	1708	veh/h		
Control Delay (Total)	6.82	veh-h/h	8.19	pers-h/h
Control Delay (Average)	21.1	sec	21.1	sec
Control Delay (Worst Lane)	27.2	sec		
Control Delay (Worst Movement)	27.2	sec	27.2	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	21.1	sec		
Idling Time (Average)	16.8	sec		
Intersection Level of Service (LOS)	LOS C			
95% Back of Queue - Vehicles (Worst Lane)	7.5	veh		
95% Back of Queue - Distance (Worst Lane)	192.8	ft		
Queue Storage Ratio (Worst Lane)	0.23			
Total Effective Stops	930	veh/h	1116	pers/h
Effective Stop Rate	0.80	per veh	0.80	per pers
Proportion Queued	0.95		0.95	
Performance Index	76.8		76.8	
Cost (Total)	280.89	$/h	280.89	$/h
Fuel Consumption (Total)	17.0	gal/h		
Carbon Dioxide (Total)	152.3	kg/h		
Hydrocarbons (Total)	0.015	kg/h		
Carbon Monoxide (Total)	0.147	kg/h		
NOx (Total)	0.280	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	559,407	veh/y	671,289	pers/y
Delay	3,274	veh-h/y	3,929	pers-h/y
Effective Stops	446,557	veh/y	535,868	pers/y
Travel Distance	110,045	veh-mi/y	132,054	pers-mi/y
Travel Time	7,327	veh-h/y	8,793	pers-h/y
Cost	134,828	$/y	134,828	$/y
Fuel Consumption	8,153	gal/y		
Carbon Dioxide	73,080	kg/y		
Hydrocarbons	7	kg/y		
Carbon Monoxide	70	kg/y		
NOx	134	kg/y		

INTERSECTION SUMMARY

Site: 1v [2017 PM Peak Hour - Conversion]

4th Street/Lake Street/Central Avenue
2017 PM Peak Hour
Signals - Pretimed Isolated Cycle Time = 55 seconds (User-Given Cycle Time)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	14.8	mph	14.8	mph
Travel Distance (Total)	230.1	veh-mi/h	276.1	pers-mi/h
Travel Time (Total)	15.5	veh-h/h	18.6	pers-h/h
Demand Flows (Total)	1156	veh/h	1387	pers/h
Percent Heavy Vehicles (Demand)	1.0	%		
Degree of Saturation	0.658			
Practical Spare Capacity	36.9	%		
Effective Intersection Capacity	1758	veh/h		
Control Delay (Total)	7.18	veh-h/h	8.62	pers-h/h
Control Delay (Average)	22.4	sec	22.4	sec
Control Delay (Worst Lane)	24.4	sec		
Control Delay (Worst Movement)	24.4	sec	24.4	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	22.4	sec		
Idling Time (Average)	18.2	sec		
Intersection Level of Service (LOS)	LOS C			
95% Back of Queue - Vehicles (Worst Lane)	7.4	veh		
95% Back of Queue - Distance (Worst Lane)	185.9	ft		
Queue Storage Ratio (Worst Lane)	0.32			
Total Effective Stops	910	veh/h	1092	pers/h
Effective Stop Rate	0.79	per veh	0.79	per pers
Proportion Queued	0.95		0.95	
Performance Index	79.7		79.7	
Cost (Total)	267.60	$/h	267.60	$/h
Fuel Consumption (Total)	15.3	gal/h		
Carbon Dioxide (Total)	136.1	kg/h		
Hydrocarbons (Total)	0.013	kg/h		
Carbon Monoxide (Total)	0.130	kg/h		
NOx (Total)	0.108	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	554,939	veh/y	665,927	pers/y
Delay	3,448	veh-h/y	4,138	pers-h/y
Effective Stops	436,731	veh/y	524,078	pers/y
Travel Distance	110,447	veh-mi/y	132,536	pers-mi/y
Travel Time	7,457	veh-h/y	8,949	pers-h/y
Cost	128,447	$/y	128,447	$/y
Fuel Consumption	7,328	gal/y		
Carbon Dioxide	65,329	kg/y		
Hydrocarbons	6	kg/y		
Carbon Monoxide	63	kg/y		
NOx	52	kg/y		

INTERSECTION SUMMARY

Site: 1 [2017 AM Peak Hour]

4th Street/Lake Street/Central Avenue
2017 AM Peak Hour
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	23.1	mph	23.1	mph
Travel Distance (Total)	243.6	veh-mi/h	292.3	pers-mi/h
Travel Time (Total)	10.5	veh-h/h	12.7	pers-h/h
Demand Flows (Total)	1164	veh/h	1397	pers/h
Percent Heavy Vehicles (Demand)	4.0	%		
Degree of Saturation	0.385			
Practical Spare Capacity	120.8	%		
Effective Intersection Capacity	3023	veh/h		
Control Delay (Total)	1.96	veh-h/h	2.36	pers-h/h
Control Delay (Average)	6.1	sec	6.1	sec
Control Delay (Worst Lane)	6.5	sec		
Control Delay (Worst Movement)	6.5	sec	6.5	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	6.1	sec		
Idling Time (Average)	4.1	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	3.0	veh		
95% Back of Queue - Distance (Worst Lane)	77.4	ft		
Queue Storage Ratio (Worst Lane)	0.06			
Total Effective Stops	327	veh/h	392	pers/h
Effective Stop Rate	0.28	per veh	0.28	per pers
Proportion Queued	0.44		0.44	
Performance Index	27.2		27.2	
Cost (Total)	218.18	$/h	218.18	$/h
Fuel Consumption (Total)	15.6	gal/h		
Carbon Dioxide (Total)	140.1	kg/h		
Hydrocarbons (Total)	0.013	kg/h		
Carbon Monoxide (Total)	0.135	kg/h		
NOx (Total)	0.255	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	558,815	veh/y	670,578	pers/y
Delay	943	veh-h/y	1,132	pers-h/y
Effective Stops	156,735	veh/y	188,082	pers/y
Travel Distance	116,907	veh-mi/y	140,288	pers-mi/y
Travel Time	5,062	veh-h/y	6,074	pers-h/y
Cost	104,727	$/y	104,727	$/y
Fuel Consumption	7,499	gal/y		
Carbon Dioxide	67,232	kg/y		
Hydrocarbons	6	kg/y		
Carbon Monoxide	65	kg/y		

NOx	122	kg/y

INTERSECTION SUMMARY

Site: 1 [2017 PM Peak Hour]

4th Street/Lake Street/Central Avenue
2017 PM Peak Hour
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	23.2	mph	23.2	mph
Travel Distance (Total)	258.1	veh-mi/h	309.7	pers-mi/h
Travel Time (Total)	11.1	veh-h/h	13.3	pers-h/h
Demand Flows (Total)	1218	veh/h	1462	pers/h
Percent Heavy Vehicles (Demand)	1.0	%		
Degree of Saturation	0.353			
Practical Spare Capacity	140.7	%		
Effective Intersection Capacity	3450	veh/h		
Control Delay (Total)	2.07	veh-h/h	2.48	pers-h/h
Control Delay (Average)	6.1	sec	6.1	sec
Control Delay (Worst Lane)	6.9	sec		
Control Delay (Worst Movement)	6.9	sec	6.9	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	6.1	sec		
Idling Time (Average)	4.0	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	2.4	veh		
95% Back of Queue - Distance (Worst Lane)	59.3	ft		
Queue Storage Ratio (Worst Lane)	0.07			
Total Effective Stops	390	veh/h	468	pers/h
Effective Stop Rate	0.32	per veh	0.32	per pers
Proportion Queued	0.48		0.48	
Performance Index	28.6		28.6	
Cost (Total)	216.00	$/h	216.00	$/h
Fuel Consumption (Total)	14.9	gal/h		
Carbon Dioxide (Total)	132.6	kg/h		
Hydrocarbons (Total)	0.012	kg/h		
Carbon Monoxide (Total)	0.130	kg/h		
NOx (Total)	0.107	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	584,774	veh/y	701,729	pers/y
Delay	992	veh-h/y	1,191	pers-h/y
Effective Stops	187,234	veh/y	224,681	pers/y
Travel Distance	123,875	veh-mi/y	148,650	pers-mi/y
Travel Time	5,335	veh-h/y	6,402	pers-h/y
Cost	103,682	$/y	103,682	$/y
Fuel Consumption	7,139	gal/y		
Carbon Dioxide	63,648	kg/y		
Hydrocarbons	6	kg/y		
Carbon Monoxide	62	kg/y		

NOx	51	kg/y

INTERSECTION SUMMARY

Site: 1v [2040 AM Peak Hour - Conversion]

4th Street/Lake Street/Central Avenue
2040 AM Peak Hour
Signals - Pretimed Isolated Cycle Time = 50 seconds (User-Given Cycle Time)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	11.9	mph	11.9	mph
Travel Distance (Total)	276.3	veh-mi/h	331.6	pers-mi/h
Travel Time (Total)	23.2	veh-h/h	27.8	pers-h/h
Demand Flows (Total)	1464	veh/h	1757	pers/h
Percent Heavy Vehicles (Demand)	4.0	%		
Degree of Saturation	0.891			
Practical Spare Capacity	1.0	%		
Effective Intersection Capacity	1643	veh/h		
Control Delay (Total)	12.84	veh-h/h	15.41	pers-h/h
Control Delay (Average)	31.6	sec	31.6	sec
Control Delay (Worst Lane)	50.2	sec		
Control Delay (Worst Movement)	50.2	sec	50.2	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	31.6	sec		
Idling Time (Average)	26.0	sec		
Intersection Level of Service (LOS)	LOS C			
95% Back of Queue - Vehicles (Worst Lane)	11.3	veh		
95% Back of Queue - Distance (Worst Lane)	291.1	ft		
Queue Storage Ratio (Worst Lane)	0.38			
Total Effective Stops	1332	veh/h	1598	pers/h
Effective Stop Rate	0.91	per veh	0.91	per pers
Proportion Queued	0.98		0.98	
Performance Index	112.3		112.3	
Cost (Total)	445.08	$/h	445.08	$/h
Fuel Consumption (Total)	25.5	gal/h		
Carbon Dioxide (Total)	228.4	kg/h		
Hydrocarbons (Total)	0.024	kg/h		
Carbon Monoxide (Total)	0.242	kg/h		
NOx (Total)	0.378	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	702,815	veh/y	843,378	pers/y
Delay	6,165	veh-h/y	7,398	pers-h/y
Effective Stops	639,207	veh/y	767,049	pers/y
Travel Distance	132,642	veh-mi/y	159,170	pers-mi/y
Travel Time	11,115	veh-h/y	13,338	pers-h/y
Cost	213,639	$/y	213,639	$/y
Fuel Consumption	12,239	gal/y		
Carbon Dioxide	109,625	kg/y		
Hydrocarbons	12	kg/y		
Carbon Monoxide	116	kg/y		
NOx	181	kg/y		

INTERSECTION SUMMARY

Site: 1v [2040 PM Peak Hour - Conversion]

4th Street/Lake Street/Central Avenue
2040 PM Peak Hour
Signals - Actuated Isolated Cycle Time = 75 seconds (User-Given Phase Times)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	9.8	mph	9.8	mph
Travel Distance (Total)	302.7	veh-mi/h	363.3	pers-mi/h
Travel Time (Total)	30.8	veh-h/h	37.0	pers-h/h
Demand Flows (Total)	1597	veh/h	1916	pers/h
Percent Heavy Vehicles (Demand)	1.0	%		
Degree of Saturation	0.813			
Practical Spare Capacity	10.7	%		
Effective Intersection Capacity	1964	veh/h		
Control Delay (Total)	19.71	veh-h/h	23.65	pers-h/h
Control Delay (Average)	44.4	sec	44.4	sec
Control Delay (Worst Lane)	55.1	sec		
Control Delay (Worst Movement)	55.1	sec	55.1	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	44.4	sec		
Idling Time (Average)	40.6	sec		
Intersection Level of Service (LOS)	LOS D			
95% Back of Queue - Vehicles (Worst Lane)	14.9	veh		
95% Back of Queue - Distance (Worst Lane)	376.0	ft		
Queue Storage Ratio (Worst Lane)	0.64			
Total Effective Stops	1270	veh/h	1524	pers/h
Effective Stop Rate	0.80	per veh	0.80	per pers
Proportion Queued	0.95		0.95	
Performance Index	160.7		160.7	
Cost (Total)	540.71	$/h	540.71	$/h
Fuel Consumption (Total)	27.0	gal/h		
Carbon Dioxide (Total)	241.0	kg/h		
Hydrocarbons (Total)	0.026	kg/h		
Carbon Monoxide (Total)	0.251	kg/h		
NOx (Total)	0.172	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	766,435	veh/y	919,722	pers/y
Delay	9,460	veh-h/y	11,352	pers-h/y
Effective Stops	609,616	veh/y	731,539	pers/y
Travel Distance	145,314	veh-mi/y	174,377	pers-mi/y
Travel Time	14,795	veh-h/y	17,754	pers-h/y
Cost	259,540	$/y	259,540	$/y
Fuel Consumption	12,982	gal/y		
Carbon Dioxide	115,694	kg/y		
Hydrocarbons	12	kg/y		
Carbon Monoxide	121	kg/y		
NOx	83	kg/y		

INTERSECTION SUMMARY

Site: 1 [2040 AM Peak Hour]

4th Street/Lake Street/Central Avenue
2040 AM Peak Hour
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	19.3	mph	19.3	mph
Travel Distance (Total)	297.7	veh-mi/h	357.2	pers-mi/h
Travel Time (Total)	15.4	veh-h/h	18.5	pers-h/h
Demand Flows (Total)	1464	veh/h	1757	pers/h
Percent Heavy Vehicles (Demand)	4.0	%		
Degree of Saturation	0.658			
Practical Spare Capacity	29.2	%		
Effective Intersection Capacity	2225	veh/h		
Control Delay (Total)	4.21	veh-h/h	5.05	pers-h/h
Control Delay (Average)	10.3	sec	10.3	sec
Control Delay (Worst Lane)	13.6	sec		
Control Delay (Worst Movement)	13.6	sec	13.6	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	10.3	sec		
Idling Time (Average)	6.2	sec		
Intersection Level of Service (LOS)	LOS B			
95% Back of Queue - Vehicles (Worst Lane)	9.1	veh		
95% Back of Queue - Distance (Worst Lane)	235.6	ft		
Queue Storage Ratio (Worst Lane)	0.13			
Total Effective Stops	950	veh/h	1141	pers/h
Effective Stop Rate	0.65	per veh	0.65	per pers
Proportion Queued	0.73		0.73	
Performance Index	53.8		53.8	
Cost (Total)	347.98	$/h	347.98	$/h
Fuel Consumption (Total)	24.6	gal/h		
Carbon Dioxide (Total)	219.9	kg/h		
Hydrocarbons (Total)	0.022	kg/h		
Carbon Monoxide (Total)	0.237	kg/h		
NOx (Total)	0.372	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	702,815	veh/y	843,378	pers/y
Delay	2,019	veh-h/y	2,423	pers-h/y
Effective Stops	456,215	veh/y	547,458	pers/y
Travel Distance	142,897	veh-mi/y	171,476	pers-mi/y
Travel Time	7,404	veh-h/y	8,885	pers-h/y
Cost	167,029	$/y	167,029	$/y
Fuel Consumption	11,785	gal/y		
Carbon Dioxide	105,567	kg/y		
Hydrocarbons	11	kg/y		
Carbon Monoxide	114	kg/y		

NOx	179	kg/y

INTERSECTION SUMMARY

Site: 1 [2040 PM Peak Hour]

4th Street/Lake Street/Central Avenue
2040 PM Peak Hour
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	19.3	mph	19.3	mph
Travel Distance (Total)	327.6	veh-mi/h	393.2	pers-mi/h
Travel Time (Total)	16.9	veh-h/h	20.3	pers-h/h
Demand Flows (Total)	1597	veh/h	1916	pers/h
Percent Heavy Vehicles (Demand)	1.0	%		
Degree of Saturation	0.602			
Practical Spare Capacity	41.3	%		
Effective Intersection Capacity	2654	veh/h		
Control Delay (Total)	4.56	veh-h/h	5.47	pers-h/h
Control Delay (Average)	10.3	sec	10.3	sec
Control Delay (Worst Lane)	12.6	sec		
Control Delay (Worst Movement)	12.6	sec	12.6	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	10.3	sec		
Idling Time (Average)	6.4	sec		
Intersection Level of Service (LOS)	LOS B			
95% Back of Queue - Vehicles (Worst Lane)	6.9	veh		
95% Back of Queue - Distance (Worst Lane)	175.1	ft		
Queue Storage Ratio (Worst Lane)	0.11			
Total Effective Stops	1065	veh/h	1278	pers/h
Effective Stop Rate	0.67	per veh	0.67	per pers
Proportion Queued	0.75		0.75	
Performance Index	55.1		55.1	
Cost (Total)	368.43	$/h	368.43	$/h
Fuel Consumption (Total)	25.0	gal/h		
Carbon Dioxide (Total)	222.5	kg/h		
Hydrocarbons (Total)	0.023	kg/h		
Carbon Monoxide (Total)	0.245	kg/h		
NOx (Total)	0.176	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	766,435	veh/y	919,722	pers/y
Delay	2,187	veh-h/y	2,624	pers-h/y
Effective Stops	511,127	veh/y	613,352	pers/y
Travel Distance	157,271	veh-mi/y	188,725	pers-mi/y
Travel Time	8,133	veh-h/y	9,760	pers-h/y
Cost	176,849	$/y	176,849	$/y
Fuel Consumption	11,981	gal/y		
Carbon Dioxide	106,781	kg/y		
Hydrocarbons	11	kg/y		
Carbon Monoxide	118	kg/y		

NOx	84	kg/y

APPENDIX E – ALTERNATIVES COMPARISON BACK-UP

Alternatives Performance Comparison

Performance Measure	Traffic Signal Alternative	Roundabout Alternative
Cumulative Condition		
Delay - All approaches LOS "D" or better LOS A rated at 5 and E rated at 1.	2.4 ✓	**4.8** ✓✓
95th % Queue - Adequate queue storage	✓	✓✓
Future Investment Needs		
Service Life – function past the design year	D ✓	**B** ✓✓
Costs		
Operations & Maintenance - Annualized	$3,000	**$1,700** ✓
Collision Costs - Annualized	$150,100	**$100,800** ✓
Delay Costs - Annualized	$36,000	**$11,000** ✓
Fuel Costs - Annualized	$21,000	**$20,000** ✓
Environmental Costs - Annualized	$1,505	$1,505
Capital Costs - Annualized	**$48,000** ✓	$119,000
Truck Accommodations		
Serves design vehicle for all movements	✓	✓
Safety		
Predictive Measures - Greatest crash reduction potential for expected fatal and injury crashes	17%	**56%** ✓
Vehicle Conflicts - The number of potential conflict points that may occur at the intersection based on layout geometry	32	**8** ✓
Pedestrian Safety - Exposure to traffic in terms of number of lanes, conflict points, crossing times, and expected vehicular speeds.	4 35-45 mph	**1** **15-25mph** ✓✓
Bicycle Safety - Exposure to traffic in terms of number of lanes, conflict points, and speed differential		✓
Property Impacts		
Property Impacts	✓✓	
Local Access		
Maintains local access and circulation	✓	✓
Total Performance Measures Met	**8**	**17**

Performance Measures Procedures/Definitions

Except where noted, a check mark will be placed in each category for the alternative that performs the best. In instances where both alternatives meet the criteria, each will receive a check mark.

Delay: Level of Service (LOS) A will be rated at 5.0 and E will be rated at 1.0. The average score is shown as a composite of each approach's AM and PM LOS score. A check mark is given to the alternative that has all approaches scoring a LOS of D or higher in both peak hours. Another check mark is given to the alternative with the highest score.

95th Percentile Queue: Adequate queue storage provided to prevent blocking of turning movements by approach will get a check mark.

Service Life: Will the alternative function acceptably beyond the design year.

Operations and Maintenance: Total annualized cost for landscape maintenance, electrical service, signal maintenance, and pavement rehabilitation.

Crash Costs: Derived from applying crash reduction factors (CRF) per FHWA "Desktop Reference for Crash Reduction Factors".

Delay Costs: Cumulative vehicle delay derived from SIDRA multiplied by $18.95/hr; per Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2016.

Fuel Costs: Derived from SIDRA: fuel consumption * $3.18/gal per Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2016.

Environmental Costs: Emissions derived from SIDRA: CO * $80/ton, and NOx * $18,700/ton; per Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2016.

Capital Cost (Annualized): Total Construction + ROW Cost divided by Service Life (20 yr).

Serves Design Vehicle for All Movements: Check mark if all movements are served for the design vehicle

Safety Predictive Measures: Greatest crash reduction potential based on fatal and injury crashes between the alternatives.

Vehicle Conflicts: Number of conflict points.

Pedestrian Safety: Most # of lanes crossed at a time, expected vehicle speeds

Bicycle Safety: Access, exposure to traffic, and speed differential (# conflict points * (vehicle speed - 15 mph average bicycle speed)).

Maintains existing access and circulation: Percentage of existing access/turning movements maintained.