Metro Orange Line Speed Evaluation Study

Final Report

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1 EXECUTIVE SUMMARY

Iteris, Inc. (Iteris) was selected by the Los Angeles County Metropolitan Transportation Authority (Metro) to complete the Orange Line Speed Improvement Study. The purpose of the study is to determine the criteria appropriate for designation of safe intersection crossing speeds for Metro buses that will reduce signal delay encountered by buses along the Orange Line busway. The bus speeds identified in the study will be used to determine how best to make changes in the current signal timing program used by the City of Los Angeles.

This study consists of six (6) primary components:

1. Line rides to observe existing bus operations, and a review of existing operator instructions
2. Collection and review of traffic data (speeds, volumes, queuing, dwell times and travel times) for buses and vehicles
3. Review of collision records along the busway
4. Field review of existing traffic control devices and geometric conditions at all busway crossings
5. Review and simulation of traffic signal operations
6. Development of recommendations of optimal crossing speed for each busway crossing intersection, as well as any additional mitigation measures and timing adjustments that may be required to support the recommended optimal crossing speeds

The study findings can be summarized as follows:

- The Orange Line is currently the only bus transit service operating on an exclusive right-of-way in Los Angeles County, and the operations of the traffic signal controlled crossings are similar to other street running light rail operations throughout the County.
- Since a series of high-profile bus-involved collisions occurred in the months following the opening of the line in 2005, bus-involved collision rates along the line have subsequently reduced and are consistent with collision rates experienced on other roadways in Los Angeles County where buses operate.
- There are a combination of factors resulting in a general sense of uncertainty for bus operators of cross-traffic activity at the intersections along the alignment. By addressing and reducing the factors creating this sense of uncertainty, bus speeds can be increased.
- There are some immediate minor modifications that can be made to improve stopping sight distance and signage visibility at selected crossings along the Orange Line; in general, there are no unique or major geometric or operational concerns at any crossing.
- There are ten crossing locations along the corridor where adjacent sound walls and/or structures limit sight distances for buses approaching the crossing, which therefore requires bus operators to approach the crossing at reduced speeds.
- Current operator instructions restrict bus speeds at all crossings to 10 miles per hour (mph), and should be immediately modified to allow for increased bus speeds at signalized crossings.
- At increased travel speeds, the benefits of the existing traffic signal timing parameters should be realized, and travel time savings of 10 minutes or more could be achieved along the entire alignment.

  - Based on signal timing plans provided by the Los Angeles Department of Transportation (LADOT), it appears that the buses should be able to progress along the route at roughly 35 mph.
  - Due to the current slow order, it cannot be determined if the current signal timing is optimized for the progression of buses; therefore, immediate travel time reductions from increased bus speeds may be reduced.
- There is no data – in terms of collision records, observed field conditions, or documented bus operator concerns – to indicate that increasing bus speeds at crossings would increase the frequency of collisions along the busway. With higher bus speeds, it is likely that the severity of any bus-involved collision would be greater.

The key recommendations of the study are summarized below:

- Immediate modifications to landscaping to address sight distance constraints.
- Various improvements to signage, traffic control, and/or geometric features to reduce the uncertainties of traffic – vehicular, pedestrian, and bicycle - entering or crossing the busway at crossing intersections.
- Rescinding of the existing "Slow Order," thereby allowing bus operators the ability to improve travel times by traveling at faster speeds through intersections.
  - There are ten crossings where sight distance and visibility constraints cannot be mitigated; therefore, crossing speed increases over the existing speeds as stipulated by the "Slow Order" will be minimal.
- Adjustment of bus operating procedures to account for both bus operating characteristics and operator orders.
- Traffic signal timing improvements may be necessary to reduce delay experienced by buses at signalized crossing locations and improve progression through signalized crossings between stations along the busway.
  - Once the slow order is rescinded, then it will be beneficial to reevaluate signal operations to determine the extent of any traffic signal timing improvements necessary.
  - Any signal adjustments have to account for required changes in pedestrian and bicycle timing per new State requirements, and will therefore require close coordination with LADOT staff.
- Improve the current system to register and monitor the functionality of bus transponders, or discontinue the practice of "registering" transponders, instead allowing any transponders to activate the transit signal priority (TSP) functions along the busway.
- The collision history indicates that approximately 80% of bus-involved collisions were due to vehicles running red lights and/or disregarding posted signs. At locations along the Orange Line where red light photo enforcement cameras have been implemented, the rate of violations has declined since the cameras were installed, and violations still occur. This evidence suggests that in order to reduce the potential of collisions due to such violations, Metro should consider installing red light photo enforcement cameras at all intersections along the alignment.
- During line rides and interviews with senior Metro bus operators, it was noted that the presence of in-roadway warning light systems reduced operator uncertainty regarding vehicle activities at crossings. Metro should consider expanding this feature to other intersections which may provide

an added level of assurance and confidence to operators as bus speeds are increased through the intersections.

- Consider a pilot program to implement an in-vehicle signal timing notification system to provide real-time signal information to bus operators, notifying them of the status of the green or red signals at an approaching signalized crossing. Such a system could provide bus operators with a recommended speed to approach a crossing to ensure they would not stop abruptly at a red light.

2 INTRODUCTION

The Metro Orange Line (MOL) opened in October 2005 from North Hollywood to Warner Center along the former Southern Pacific Railroad right-of-way, followed by an extension to Chatsworth in 2012. The Metro Orange Line totals nearly 18 miles in length from North Hollywood to Chatsworth, and includes 38 signalized crossings, with an additional five pedestrian only crossings. The line diverges in Canoga Park near the intersection of Canoga Avenue and Victory Boulevard, with the dedicated busway continuing north to Chatsworth and the line to Warner Center running on the street in mixed-flow traffic. **Figure 1** shows the extents of the line as well as the station locations.

The North Hollywood Station provides a connection with the Metro Red Line to Hollywood and Downtown Los Angeles as well as other local services and the Los Angeles DOT 549 Commuter Express. The Chatsworth Station provides a connection with the Metrolink Ventura County Line and Amtrak Pacific Surfliner. Connections are provided to Metro Rapid service at the Van Nuys, Sepulveda, Reseda, and Warner Center Stations.

2.1.1 Purpose

Immediately following the opening of the first segment of the Orange Line, in November and December 2005, there were a series of high-profile bus-involved collisions along the line at crossing intersections. It became apparent that some motorists did not react to the new traffic signals that controlled the busway and the street crossings, and there were 11 collisions in the first two months of initial operation. The cause of the collisions were attributed to driver inattentiveness and/or disregard of traffic signals.

The traffic signals were originally programmed for allow for bus operators to drive through signalized crossings at speeds similar to those of vehicles on adjacent surface streets. Because of the number and severity of the collisions immediately following the opening of the line, Metro, in consultation with the Los Angeles Police Department (LAPD), Los Angeles Sheriff’s Department (LASD), and the Los Angeles City Council, determined that a “slow order” would be issued for all crossings along the Orange Line. The slow order requires operators to slow to 10 mph approaching and crossing all intersections, and then to accelerate to cruising speed after ascertaining that the intersection was safe to enter. The ultimate result of this action was to slow the operation of Orange Line buses across the Valley such that the average speed fell to 21 mph or less.

The MOL serves as the backbone of the San Fernando Valley’s transit service. In order to improve service, the Metro Board of Directors approved a motion directing staff to work with the Los Angeles Department of Transportation (LADOT) to adjust traffic signal timing to advantage the buses, improve travel times and speeds, and provide smoother and more reliable service for Metro’s customers. Metro then initiated a competitive procurement process using their approved bench of on-call contractors, and initiated the Orange Line Speed Evaluation study in July 2015.

There is a desire on the part of many stakeholders – from the Metro Board, Metro staff, Metro operators, riders, and members of the Los Angeles City Council - to see improvements in MOL travel times from North Hollywood to Warner Center and Chatsworth. The MOL service is the premier bus rapid transit (BRT) experience in Los Angeles County, and riders continue to express frustration with the seemingly purposeless stops that are experienced on the buses at signalized crossings. The purpose of the study is to determine the criteria appropriate for designation of safe intersection crossing speeds for Metro buses that will reduce signal delay encountered by buses along the Orange Line busway. The bus speeds identified in the study will be used to determine changes necessary, if any, to the current signal timing program used by the City of Los Angeles.

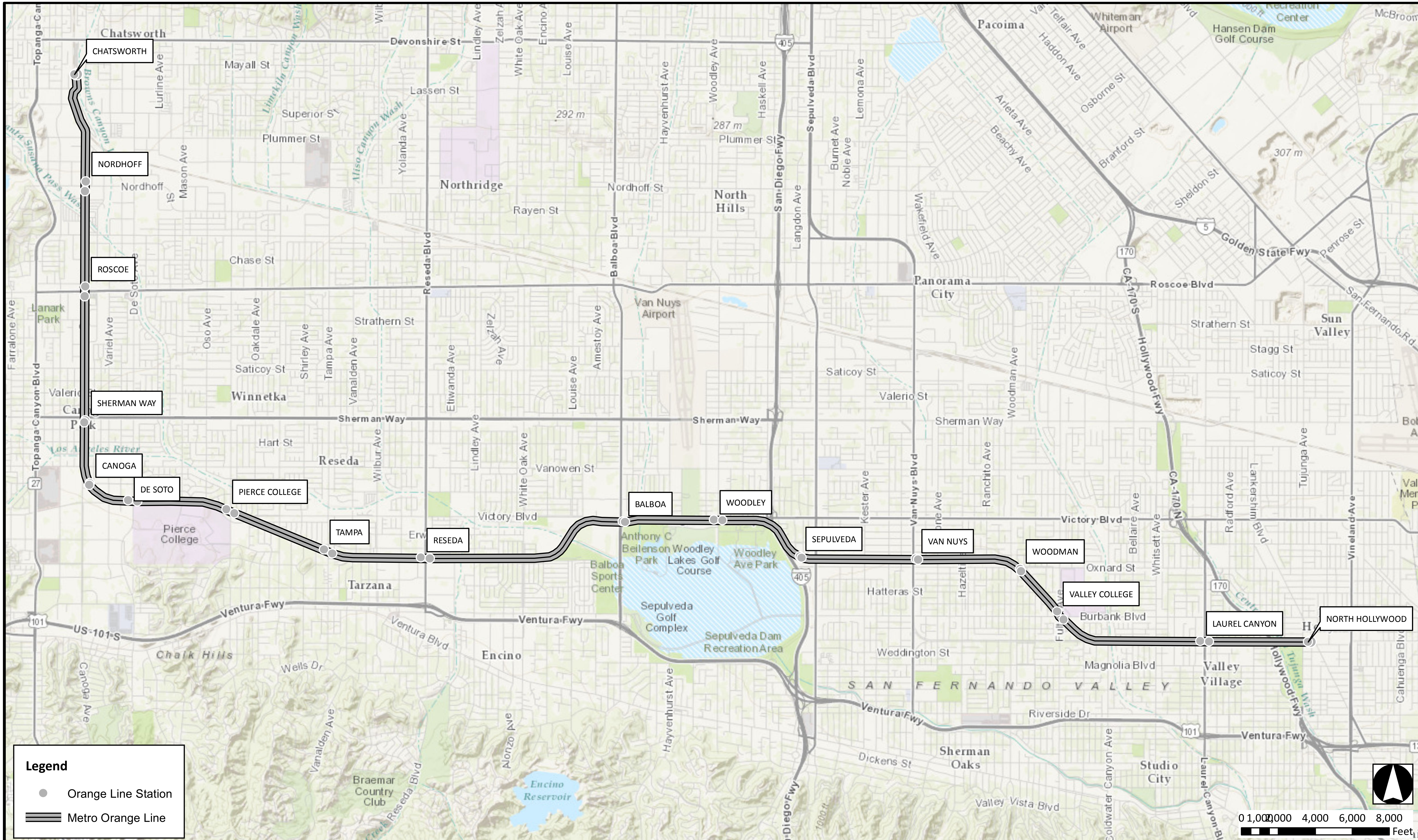

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Figure 1
Metro Orange Line

3 EXISTING OPERATING CHARACTERISTICS

This section provides the results of the consultant team's review of the existing MOL operating characteristics. This review included several line rides by the consultant team, interviews with current bus operators, review of current bus operating instructions, field visits to intersection crossings, evaluation of traffic data, and an assessment of collision history in the vicinity of the route.

3.1.1 Summary of Line Rides

The Iteris consultant team conducted a total of 35 line rides on the MOL in August 2015. The majority of line rides were conducted during the afternoon peak periods, when surface street congestion levels are at their highest. **Table 1** presents a summary of the average travel times recorded during line rides conducted during the weekday morning, mid-day, and afternoon periods. **Figure 2** displays a more detailed view of the travel times by presenting average ranges between stations. **Figure 3** shows the average dwell/loading times at each station per direction. As shown, loading times are highest at the Van Nuys, Sepulveda, Balboa, Reseda, and Nordhoff stations, with average loading times exceeding 30 seconds. An inventory of the travel time data from each line ride is provided in **Appendix A**.

The following exhibits highlight observations from the line rides.

Exhibit 1: High ridership during peak hours, including bicycles and wheelchairs

Exhibit 2: Sight distance constraints due to landscaping, buildings, and walls

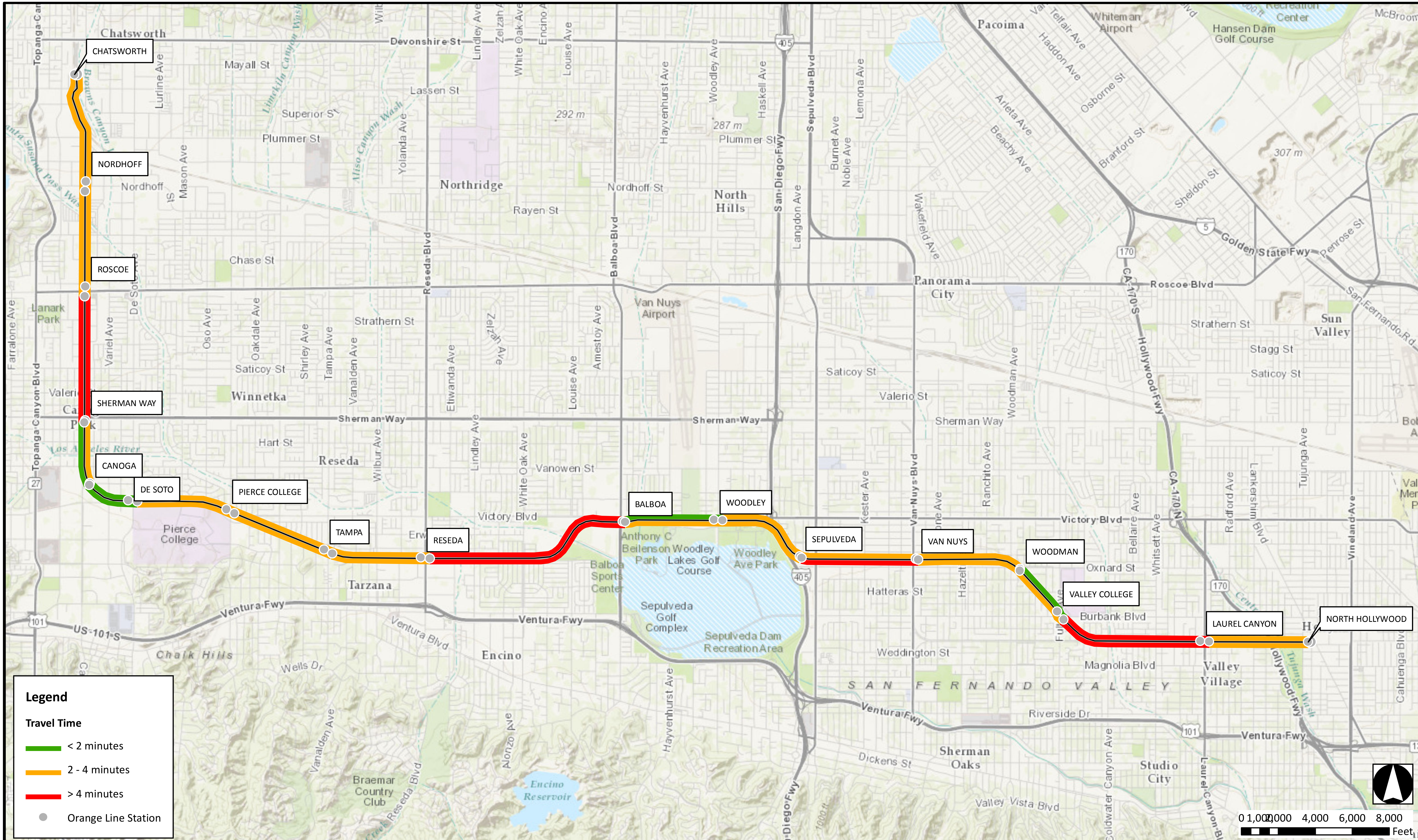

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Figure 2
Average Travel Time

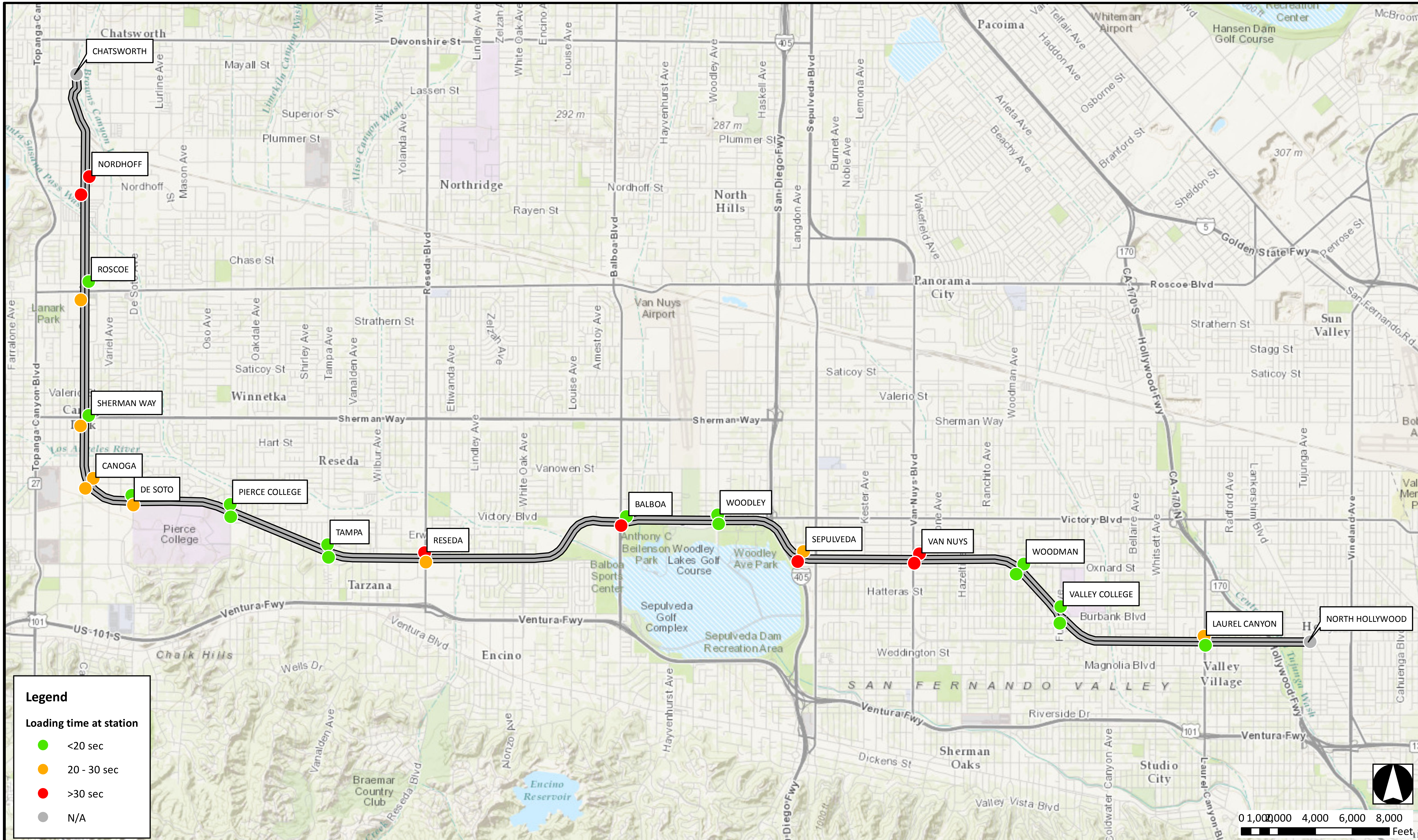

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Figure 3
Average Loading Time

Table 1 – Metro Orange Line Average Travel Times

SEGMENT	WESTBOUND/NORTHBOUND TRAVEL TIME (MIN)				EASTBOUND/SOUTHBOUND TRAVEL TIME (MIN)			
	AM[1]	MID-DAY[1]	PM[1]	DAY[1]	AM[1]	MID-DAY[1]	PM[1]	DAY[1]
North Hollywood to Canoga Time between stations[2] (min)	39	40	42	40	38	42	39	39
Canoga to Chatsworth Time between stations[3] (min)	14	16	14	15	15	12	14	14
North Hollywood to Chatsworth Total travel time (min)[4]	53	56	56	55	53	54	53	53

Source: Iteris Travel Time Runs, August 2015
Notes:
[1] The travel times shown represent the average travel times of all line rides conducted during this time period. AM time period occurred from 7:00-10:00 AM, Mid-day occurred from 10:00 AM -3:00 PM, PM period occurred from 3:00-7:00 PM; DAY is the average for all three time periods.
[2] The distance between the North Hollywood station and the Canoga station is approximately 13.5 miles.
[3] The distance between the Canoga station and the Chatsworth station is approximately 4.5 miles.
[4] Total travel time results include dwell times for boarding/alighting at stations.

As shown in **Table 1**, the average travel time in the eastbound direction is generally a few minutes shorter than the westbound direction for the mid-day and PM time periods, whereas the average travel time during AM time period was approximately the same for each direction.

Note that these travel times include dwell time at stations for passenger boardings/alightings. Dwell times can vary significantly, particularly with high demand for bicycles and/or wheelchairs. During field observations, bicycle and wheelchair loadings were minimal – approximately one or two instances per route. With more bicycle and/or wheelchair loading, or increased numbers attempting to board the buses, dwell times may increase.

It is also important to note the number of times buses stop at traffic signals along the route. **Table 2** shows two type of stops at the signalized intersections: buses slowing down to approach the red light and buses making a full stop at the red light.

Table 2 – Number of Red Lights Encountered Along Bus Route

SEGMENT	AM PEAK[1]			MID-DAY[1]			PM PEAK[1]		
	App. Red Light[2]	Stop Red Light	Total	App. Red Light[2]	Stop Red Light	Total	App. Red Light[2]	Stop Red Light	Total
North Hollywood to Chatsworth (Westbound/Northbound)	10	5	**15**	9	4	**13**	8	5	**13**
Chatsworth to North Hollywood (Eastbound/Southbound)	9	4	**13**	5	5	**10**	5	2	**7**

Source: TransLink Consulting, LLC, August 2015
Notes: [1] AM time period occurred from 7:00-10:00 AM, Mid-day occurred from 10:00 AM -3:00 PM, PM period occurred from 3:00-7:00 PM.
[2] Approached Red Light – Driver slowed bus approximately 100 feet prior to intersection to avoid a full stop at the signal.

Table 2 shows that during the AM peak period, buses slow down or come to a full stop at 13-15 signalized crossings. During the midday peak period, buses slow down or come to a full stop at 10-13 signalized crossings. During the PM peak period, buses slow down or come to a full stop at 7-13 signalized crossings. Based on the field observations, bus travel times can increase by up to five (5) minutes due to traffic signal delays at crossings.

3.1.2 Automobile Travel Times on Parallel Surface Streets

In November 2015, travel time data was collected for automobiles travelling on roadways parallel to the MOL, as shown in **Table 3**. The automobile travel time data was then compared to the MOL travel times. **Table 3** shows that the MOL travel times are very similar, and sometimes even lower than driving automobiles. For instance, in the eastbound direction, it was observed that the average driving travel time during the AM peak hours is 62 minutes, while the MOL buses take an average of 53 minutes. In the westbound, it was observed that the average driving travel time during the PM peak hours is 63 minutes, while the MOL buses take an average of 56 minutes. It should be noted that during the mid-day peak hours, in both directions, the MOL travel times are between 5-8 minutes higher than automobile travel times. Overall, it appears that during morning and afternoon peak weekday commute periods, buses on the MOL traverse the corridor faster than automobile drivers on surface streets.

Table 3 – Automobile Travel Times on Parallel Surface Streets

SEGMENT	WESTBOUND/NORTHBOUND TRAVEL TIME (MIN)			EASTBOUND/SOUTHBOUND TRAVEL TIME (MIN)		
	AM[1]	MID-DAY[1]	PM[1]	AM[1]	MID-DAY[1]	PM[1]
North Hollywood to Canoga Time between stations (min)	42	36	51	45	34	33
Canoga to Chatsworth Time between stations (min)	12	15	12	17	12	12
North Hollywood to Chatsworth Total travel time (min)	54	51	63	62	46	45

Source: Translink Consulting Travel Time Runs, November 2015
Notes:
[1] The travel times shown represent the average travel times of all line rides conducted during this time period. AM time period occurred from 7:00-10:00 AM, Mid-day occurred from 10:00 AM -3:00 PM, PM period occurred from 3:00-7:00 PM; DAY is the average for all three time periods.

In addition to the drive alone travel time surveys, automobile travel time estimates were collected the week of November 16th from Google Maps and Waze, which are navigation tools that collect current traffic data and provide real-time travel time estimates based on this data. **Table 4** shows the peak hour estimated travel times on a regular weekday for automobiles traveling along the corridor on parallel surface streets. It was observed that the estimated travel times are comparable to the automobile travel time survey, within 0 – 5 minute range, validating the observations that the MOL buses currently run faster than automobiles on surface streets during peak weekday commute periods.

Table 4 – Google Maps/Waze Estimated Travel Times on Parallel Surface Streets

SEGMENT	WESTBOUND/NORTHBOUND TRAVEL TIME (MIN)			EASTBOUND/SOUTHBOUND TRAVEL TIME (MIN)		
	AM	MID-DAY	PM	AM	MID-DAY	PM
North Hollywood to Canoga Time between stations (min)	40	40	44	50	37	37
Canoga to Chatsworth Time between stations (min)	14	15	15	16	14	13
North Hollywood to Chatsworth Total travel time (min)	54	55	59	66	51	50

Source: Iteris, Inc., 2015 via Google Maps (https://www.google.com/maps/) and Waze (https://www.waze.com/livemap)

3.1.3 Traffic Data

Existing available traffic data was compiled from sources provided by Metro and the City of Los Angeles. New traffic counts were collected, during AM and PM peak periods, for each signalized intersection in the vicinity of MOL crossings where existing count data was not available. **Figure 4** summarizes the locations and sources of peak period intersection counts through the study area. In addition to traffic counts, travel time runs were performed along corridors parallel to the MOL in order to validate the computer simulation model (discussed in Section 5). All traffic count data sheets are provided in **Appendix B**.

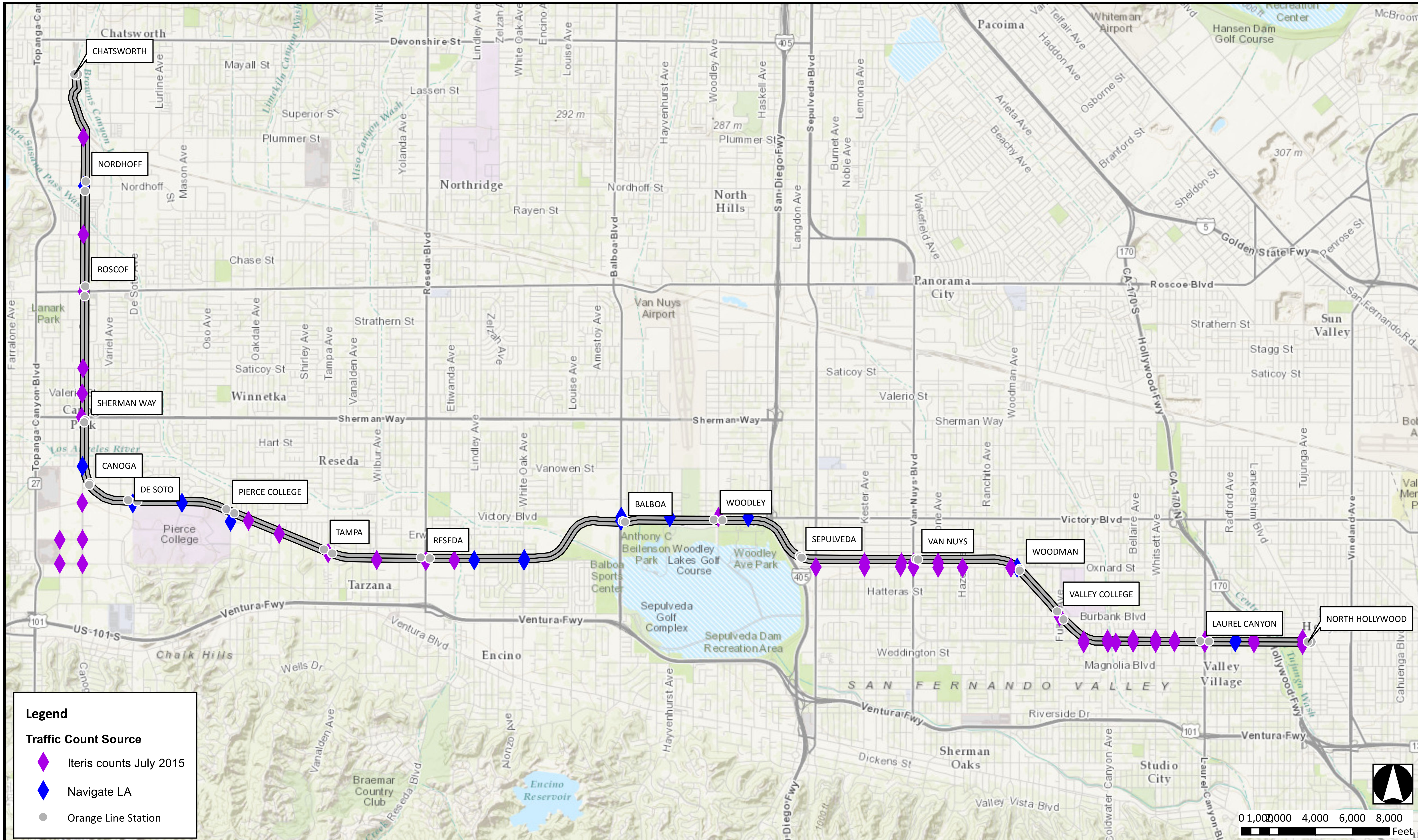

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Figure 4
Traffic Count Location

3.1.4 Collision History

This section summarizes the findings from the collision data provided by Metro and obtained from the Statewide Integrated Traffic Records System (SWITRS). Metro-provided data listed all bus-involved collisions along the Orange Line since its opening in 2005. In addition, Metro provided data for bus-involved collisions along the 750 and 910 Lines. Line 750 runs along Ventura Boulevard and represents a bus route traveling on local streets in a similar geographic vicinity. Line 910 is the Silver Line that predominantly runs on I-110 and I-10 in the ExpressLanes, a limited access facility.

3.1.4.1 MOL

MOL Collision data at busway crossing locations was provided by Metro, from 2005 when the MOL first opened, to April 2015. This collision data focused on collisions along the busway and involving Metro buses with vehicles and pedestrians. A summary of the total collisions at signalized crossings and the identified cause of each collision is provided in **Table 5a**.

Table 5a – Bus-Involved Collision History (Metro, 2005 – 2015)

CROSSING	TOTAL COLLISIONS	CAUSE OF COLLISION			
		RAN RED LIGHT (THRU MOVEMENT)	PROHIBITED LEFT/RIGHT TURN	HIT & RUN	OTHER*
Tujunga Ave	1	1			
Colfax Ave	2				2
Laurel Cyn Blvd	1				1
Whitsett Ave	3	3			
Bellaire Ave	1	1			
Coldwater Cyn Ave	4		4		
Ethel Ave	1	1			
Burbank Blvd-Fulton Ave	1				1
Oxnard St	1				1
Woodman Ave	10	9			1
Hazeltine Ave	5	4			1
Tyrone Ave	2	2			
Van Nuys Blvd	6	3			3
Vesper Ave	3	3			
Kester Ave	9	9			
Sepulveda Blvd	9	4			5
Densmore Ave	2	2			
Woodley Ave	5	5			
Balboa Blvd	6	5			1
White Oak Ave	3			1	2
Lindley Ave	1		1		
Reseda Blvd	3	3			
Wilbur Ave	3		2		1
Tampa Ave	2	1	1		
Corbin Ave	10	1	9		

Table 5a – Bus-Involved Collision History (Metro, 2005 – 2015)

CROSSING	TOTAL COLLISIONS	CAUSE OF COLLISION			
		RAN RED LIGHT (THRU MOVEMENT)	PROHIBITED LEFT/RIGHT TURN	HIT & RUN	OTHER*
Victory Blvd	4	1			3
Winnetka Ave	2	2			
Mason Ave	11	7	4		
De Soto Ave	5	2	2		1
Vanowen St	N/A				
Sherman Wy	N/A				
Valerio St	N/A				
Saticoy St	1				1
Roscoe Blvd	N/A				
Parthenia St	N/A				
Nordhoff St	N/A				
TOTAL	**117**	**69**	**23**	**1**	**24**
		59%	**20%**	**>1%**	**21%**

Source: Metro, 2015
* Cause of collision not provided
N/A – No record of collisions in Metro database

As shown in **Table 5a**, the majority of collisions were caused by motorists running a red light at a through movement crossing the busway. In other cases, illegal left turns or right turns on red were made resulting in a collision. The signalized crossings at Mason Avenue, Corbin Avenue, Woodman Avenue, Kester Avenue, and Sepulveda Boulevard show the highest frequency of collisions over the ten year period.

The Metro collision records highlight some important points:

- The entire line has averaged slightly over 10 bus-involved collisions per year since opening.
- Almost 80% of all bus-involved collisions were caused by vehicles either running red lights or disobeying signs prohibiting turns.
- The locations with the highest numbers of collisions average approximately one collision per year since the opening of the line.
- Bus-involved collisions on the Orange Line are not any more frequent than bus-involved collisions on any other roadway in Los Angeles County.

While **Table 5a** summarizes the data set provided by Metro, Iteris also obtained additional collision information from the SWITRS database. This data identifies all bus-involved collisions along the busway from 2011 to 2014. A summary of the SWITRS collision records is provided in **Table 5b.**

Table 5b – Bus-Involved Collision History (SWITRS, 2011 – 2014)

CROSSING	TOTAL COLLISIONS	CAUSE OF COLLISION				
		DUI	UNSAFE SPEEDS	DRIVER ERRORS	RIGHT-OF-WAY/SIGNAGE	OTHER*
Vanowen St	4	1	2	1		
Sherman Wy	2			1	1	
Valerio St	1				1	
Saticoy St	2			1		1
Roscoe Blvd	5	1	1	1	2	
Parthenia St	3	1		1	1	
Nordhoff St	1		1			
TOTAL	**18**	**3**	**4**	**5**	**5**	**1**
		17%	**22%**	**28%**	**28%**	**6%**

Source: SWITRS 2011 – 2014
Driver error collisions include: vehicles following too closely, improper passing, and unsafe lane change;
Right-of-way/signage collisions include: improper turning, automobile right of way, and traffic signals and signs.
* Cause of collision not provided
N/A – No record of collisions in Metro database

The SWITRS collision records also highlight some important points:

- The line has averaged approximately four bus-involved collisions per year.
    - Note that the Metro data indicates an average of 10 collisions per year; therefore, this study considers the higher average rate which is inclusive of collisions solely within Metro's right-of-way.
- Almost 95% of all bus-involved collisions were caused by motorists.
- The locations with the highest numbers of collisions average approximately one collision per year.
- Bus-involved collisions on the Orange Line are not any more frequent than bus-involved collisions along any other roadway in Los Angeles County.

Based on the collision records collected from both Metro and SWITRS, it should be noted that pedestrian-involved collisions are not common on the MOL. Only one pedestrian-involved collision was identified in February 2011 at the De Soto Avenue crossing (*Source: SWITRS – Case ID 5066099*), and this collision did not involve a bus. Therefore, pedestrian-involved collisions with buses do not appear to be a concern; likely due to the fact that the highest levels of pedestrian activity occur at stations, where the buses are already slowing to a stop.

Detailed collision history, identifying the collisions per year, is provided in **Appendix C**. The total number of collisions at each crossing is also shown in **Figure 5**.

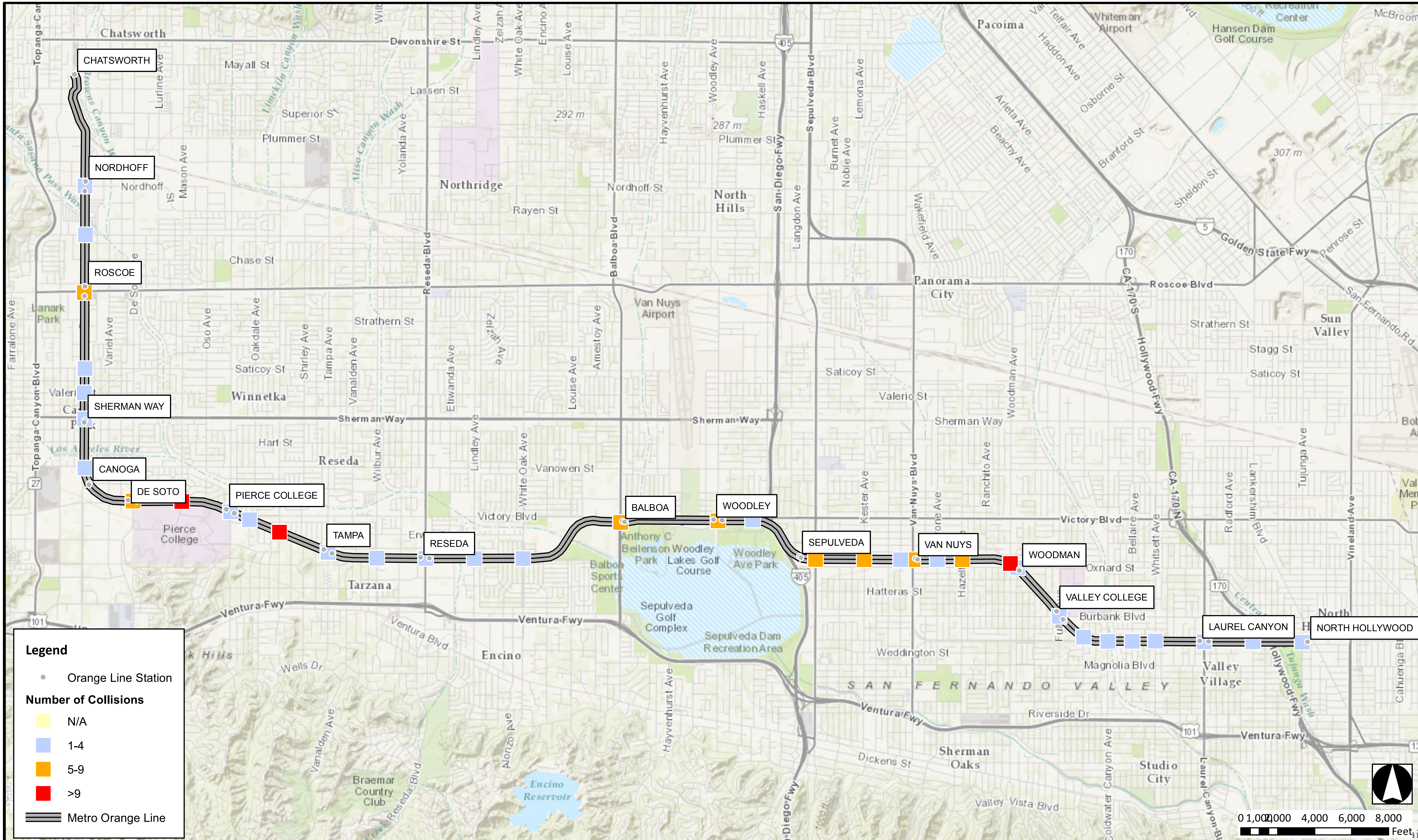


Figure 5
Collision History

3.1.4.2 Metro Line 750 and Line 910

MOL collision data was compared to the data of Metro Lines 750 and 910. A brief description and corresponding characteristics, including routes and frequencies of Metro Lines 750 and 910 are provided below:

- Metro Line 750 operates between Universal City and Warner Center. This line travels along Ventura Boulevard and Topanga Canyon Boulevard. This route operates from 5:30 a.m. to 10:00 p.m. with 15 minute headways during the weekday peak periods. No service is provided on weekends.

- Metro Line 910 operates between the Harbor Gateway Transit Center in Gardena, Union Station in Downtown Los Angeles, and El Monte Transit Station. This lines uses High Occupancy Vehicle (HOV) lanes/High Occupancy Toll (HOT) lanes outside of Downtown Los Angeles. Within Downtown, the line shares the road with other vehicles. This route operates from 3:30 a.m. to 1:00 a.m. with 4-10 minute headways during the weekday peak periods. Service is also provided on weekends with 20 minute headways.

Collision data for Metro Lines 750 and 910 was provided by Metro from 2011 to 2015. A summary of the total collisions at signalized crossings and whether the collision was considered avoidable or not is provided in **Table 5c**.

Table 5c – Bus-Involved Collision History (Metro, 2011 – 2015)

LINE	TOTAL COLLISIONS	COLLISION WAS		
		AVOIDABLE	UNAVOIDABLE	OTHER*
Line 750 – Ventura Boulevard Line	69	23	44	2
		33%	*64%*	*3%*
Line 910 – Silver Line	163	70	90	3
		43%	*55%*	*2%*
TOTAL	**232**	**93**	**134**	**5**
		40%	**58%**	**2%**

Source: Metro 2011 – 2015
Avoidable collisions do not involve other vehicles (i.e. bus hitting a tree/branch)
Unavoidable collisions involve other vehicles.
* Cause of collision not provided.

Table 5c shows that Line 750, running along Ventura Blvd, averages more than 10 bus-involved collisions per year, with more than 60% of the collisions identified as “unavoidable.” On Line 910 there were more than 30 bus-involved collisions per year, with 55% of the collisions identified as “unavoidable.” Metro determines collisions are “unavoidable” if the cause of the collisions was determined to be outside of the control of the bus operator or the bus operator would not have been able to avoid the collision through evasive maneuvers. In nearly every case, an “unavoidable” collision is directly attributed to another motor vehicle colliding with a Metro bus or in some other way causing the Metro bus to collide.

Comparing the MOL and Lines 750 and 910, it is clear that the collision rates are independent of the facility – the highest annual frequency of bus-involved collisions appears to occur on Line 910, which operates on the semi-exclusive rights-of-way along the HOV /HOT lanes outside of Downtown Los Angeles. With an average of approximately 10 bus-involved collisions per year, the MOL is very similar to Line 750. Furthermore, on the MOL alignment, a greater percentage of collisions (80% or more) are caused by drivers disobeying traffic signals and signs.

3.1.5 Field Review

Iteris staff completed detailed field evaluations of each crossing. The field evaluations included a review and inventory of all existing traffic control devices (signage, markings, and traffic signals), measurement of stopping-sight distance for buses traveling on the busway, and the documentation of other conditions that would not be readily apparent to bus operators. Detailed observations from the field reviews include:

- All signage and traffic control devices were documented to be installed per the approved design plans. However, some enhancements of existing signage and traffic control devices could be implemented at certain locations, including:
  - Vanowen intersection
  - Canoga station
  - Mason intersection
  - Pierce College station
  - Van Nuys station
  - Woodman station
  - Van Nuys intersection
  - Tyrone intersection
  - Valley College station

  Enhancements include replacing faded signage or relocating signage to increase visibility.

- Along the corridor, the stopping sight distance for a bus to observe crossing activities is constrained due to landscaping (e.g., trees, bushes, and/or other landscaping features) at the following locations:
  - Ethel Avenue (all sides)
  - Hazeltine Avenue (southeast and southwest corner)
  - Vesper Avenue (southeast and southwest corner)
  - Kester (southeast and southwest corner)
  - Sepulveda Boulevard
  - Woodley Avenue (southwest corner)
  - Hayvenhurst Avenue (northeast side of crossing)
  - White Oak Avenue
  - Lindley Avenue (northwest corner)
  - Reseda Boulevard
  - Wilbur Avenue
  - Tampa Avenue

- Mason Avenue/Victory Boulevard
- Valerio Street
- Saticoy Street
- Roscoe Boulevard
- Parthenia Street
- Nordhoff Street

- Along the corridor, the stopping sight distance for a bus to observe crossing activities is constrained due to the proximity of a sound wall/structure/fence at the following locations:

    - Tujunga Avenue
    - Tyrone Avenue
    - Kester Avenue
    - Sepulveda Boulevard
    - Tampa Avenue
    - Corbin Avenue
    - Victory Boulevard/Topham Street
    - Sherman Way
    - Valerio Street
    - Saticoy Street

Further details on each specific crossing are provided in Section 3.6.

3.1.6 Current Operator Instructions

Bus operators are provided "Paddles" which refer to the schedule of work for each bus operator showing all routes they will operate for the day, including the times to depart and return to the bus garage, and arrival and departure times at key timepoints for the specific directions of travel. Operating schedules are developed by the Metro Scheduling Department and provided to each bus operating garage for the bus routes operated from that garage for distribution to bus operators. Operating schedules are constantly reviewed based on feedback from bus operators, scheduling staff and passengers to ensure their accuracy based on the current operating environment. Metro makes adjustments to bus schedules approximately every six months as needed.

Metro provides paddles for each bus operator assignment on the MOL for weekday, Saturday, and Sunday service. A review of the MOL paddles with an effective date of June 28, 2015 provides the following information regarding the scheduled performance of the MOL:

- MOL service is based out of Metro's Division 8 Chatsworth bus garage. The current bus schedule requires a maximum total of 33 buses in service during peak periods on weekdays, and 13 buses on Saturday and Sunday. At the start of the day, buses are scheduled to leave the Division 8 Chatsworth garage and begin service at either the Chatsworth MOL Station or at the Warner Center Transit Terminal. Bus operators are provided nine minutes to operate between Division 8 and the Chatsworth MOL Station, and 15 minutes to operate between Division 8 and Warner Center.
- During the work day, when a bus operator has completed their work assignment before reaching the end of the route, they are relieved from service along the route by a new bus operator. This

action is done in-route to keep the bus in service and not have the operator take the bus out of service and return to the garage to end their work day. For the MOL, the paddles indicate that bus operator relief is made at the Nordhoff Metro Orange Line Station, which is adjacent to the Division 8 bus garage.

- For weekday service during the greater part of the day, MOL bus operators are scheduled to “interline” buses for operation from the North Hollywood MOL Station to both Warner Center and Chatsworth Stations on alternate trips. Interlining is done to provide more efficient scheduling and resource utilization by minimizing the number of buses required for service, and efficiently balancing the amount of layover time between the two branches of the MOL. Weekend service is not interlined, and bus operator assignments are scheduled to operate to either Chatsworth or Warner Center throughout their assignment. On all service days, after approximately 7:00 PM, MOL buses are scheduled to operate one routing between North Hollywood and Chatsworth with a link to Warner Center. The MOL schedule also provides for a separate shuttle schedule that operates exclusively between Chatsworth and Warner Center during weekday peak hours.

In addition, shortly after the MOL opened in 2005, Metro issued a “Slow Order” instructing bus operators to cover the brakes and not exceed 10 mph while entering and continuing through all intersections on the busway. It is generally understood that the decision was made in response to the frequency of initial vehicular collisions. The observed results are that the MOL does not reach the intended operating speeds for which the dedicated busway service was designed. It is also understood that the Slow Order was not meant to be a permanent measure to fix any perceived safety issues, but rather a short term fix. Nevertheless, the order has continued to be in effect to this day.

3.1.7 Compilation of Findings by Crossing

Based on the observations and data collected, a compilation of the findings related to the busway physical characteristics at each crossing has been prepared. **Table 6** summarizes detailed findings at each MOL crossing, and includes documentation of additional traffic control devices present at selected crossings. Additional traffic control devices include red light cameras and in-road warning lights. Red light cameras are used as a traffic enforcement mechanism capturing images of vehicles entering an intersection during a red phase. In-road warning lights (IRWL) are flashing warning light systems installed in the roadway surface to provide additional warning to motorists to adhere to traffic control devices (e.g., warning signs and/or signals).

Table 6 – Factors Affecting Bus Operating Speeds

CROSSING STREET	CROSSING TRAFFIC VOLUME (ADT)	COLLISIONS[4]	TRAFFIC CONTROL[1]	STOPPING SIGHT DISTANCE[2]	EXISTING SPEED LIMIT[3]
Tujunga Ave	8,350	1	Red light cameras	Constrained due to adjacent property and fencing	35 mph
Colfax Ave	9,280	2	-	-	
Laurel Cyn Blvd	24,930	1	-	-	
Corteen Pl	1,280	-	-	-	
Whitsett Ave	12,270	3	-	-	
Bellaire Ave	1,640	1	-	-	

Table 6 – Factors Affecting Bus Operating Speeds

CROSSING STREET	CROSSING TRAFFIC VOLUME (ADT)	COLLISIONS[4]	TRAFFIC CONTROL[1]	STOPPING SIGHT DISTANCE[2]	EXISTING SPEED LIMIT[3]
Coldwater Cyn Ave	18,090	4	-	-	
Chandler Blvd	5,910	-	-	-	
Ethel Ave	980	1	-	Constrained due to landscaping and fencing	35 mph
Burbank Blvd-Fulton Ave	Burbank: 13,430 Fulton: 13,335	1	-	-	
Oxnard St	26,160	1	Red light cameras	-	
Woodman Ave	24,850	10	Red light cameras	Constrained due to adjacent property	
Hazeltine Ave	16,770	5	-	Constrained due to landscaping	
Tyrone Ave	2,690	2	-	Constrained due to fencing	
Van Nuys Blvd	31,150	6	-	-	45 mph
Vesper Ave	3,090	3	-	-	
Kester Ave	23,340	9	Right light cameras	Constrained due to adjacent property and landscaping	
City of Los Angeles, Bureau of Street Maintenance, Van Nuys District Yard Private Dwy	N/A	-	-	Buses cannot see vehicles at private driveway	
Sepulveda Blvd	43,090	9	Red light cameras	Constrained due to landscaping, fencing, wall, adjacent property	35 mph 25 mph
Woodley Ave	19,130	5	Red light cameras	-	35 mph EB 55 mph WB
Balboa Blvd	28,340	6	Red light cameras	Constrained due to fencing, landscaping, wall, adjacent property	
White Oak Ave	33,570	3	Red light cameras	-	55 mph EB
Lindley Ave	24,420	1	Red light cameras	Constrained due to landscaping and fencing	
Reseda Blvd	22,010	3	Red light cameras	Constrained due to adjacent property and landscaping	
Wilbur Ave	15,400	3	-	-	
Tampa Ave	24,770	2	-	Constrained due to wall and landscaping	
Corbin Ave	14,220	10	-	Constrained due to wall	
Victory Blvd	28,890	4	-	-	
Winnetka Ave	25,920	2	-	-	45 mph
Mason Ave	14,050	11	Red light cameras	Constrained due to landscaping	

Table 6 – Factors Affecting Bus Operating Speeds

CROSSING STREET	CROSSING TRAFFIC VOLUME (ADT)	COLLISIONS[4]	TRAFFIC CONTROL[1]	STOPPING SIGHT DISTANCE[2]	EXISTING SPEED LIMIT[3]
De Soto Ave	33,990	5	Red light cameras	-	45 mph
Vanowen St	23,520	-	Red light cameras In-road warning lights	-	
Sherman Wy	22,100	-	Red light cameras In-road warning lights	Constrained due to adjacent property, fencing	
Valerio St	4,920	-	Red light cameras In-road warning lights	Constrained due to fencing	
Saticoy St	25,400	1	Red light cameras In-road warning lights	Constrained due to wall and fencing	
Roscoe Blvd	30,250	-	Red light cameras In-road warning lights	Constrained due to fencing, landscaping	45 mph
Parthenia St	18,940	-	Red light cameras In-road warning lights	-	
Nordhoff St	21,420	-	Red light cameras In-road warning lights	Constrained due to landscaping	45 mph

Source: Metro, City of Los Angeles, and Iteris; August 2015
ADT – Average Daily Traffic
[1] Traffic Control refers to devices installed to improve driver adherence to traffic signals and signs.
[2] Stopping Sight Distance refers to a minimum distance required for a bus operator to observe a potential obstacle (crossing vehicle, bike, or pedestrian) and bring the bus to a complete stop. A detailed plan-view is provided in Appendix D.
[3] This is the posted speed limit on the busway approaching the crossing street
[4] Collisions involving Metro buses on the busway (2005-2015)

For each crossing, a detailed plan-view figure is provided in **Appendix D** to show the location of existing signage as well as the locations where stopping sight distance was observed to be constrained by the physical environment adjacent to the busway.

4 CONSULTANT TEAM FINDINGS

Based on the existing operating characteristics discussed in Section 3, the following section presents a summary of findings related to bus speeds, operations, collisions, and other factors.

4.1.1 Criteria Affecting Bus Speeds

In general, bus speeds appear to be most impacted by three criteria:

1) Uncertainty of cross-traffic activity when approaching a crossing, as shown in **Exhibit 4**:

- A history of collisions, as well as observed intrusions into the busway by vehicles, bicycles, and pedestrians, creates a general sense of uncertainty for bus operators as to whether the intersection will be clear. It is important to note that this uncertainty is certainly not unique to the Orange Line busway when looking at all Metro bus routes in the greater Los Angeles area.
- Sight distance constraints, limited by landscaping, adjacent soundwalls, or structures, can further exacerbate the sense of uncertainty at certain crossings.

Exhibit 4: Sight distance constraints at intersection crossing

2) Signal timing at crossings:

- Traffic signal timing operations also create a sense of uncertainty for bus operators. The more seasoned operators are familiar with existing signal timing and phasing, and can modulate bus approach speeds to maintain forward motion without having to come to a complete stop at red lights. For more junior operators, it is clear that the signal operations are not apparent. During many line rides, consultant team staff observed signals changing from green to red as the buses approached, as shown in **Exhibit 5**.

Exhibit 5: Traffic signal changes from green to red as bus approaches intersection

3) Bus operational characteristics:

   - The bus vehicles themselves have some limitations in terms of acceleration and deceleration rates. These limitations make it difficult for a bus vehicle to accelerate to posted speed limits between crossings, and also require deceleration well in advance of stations and/or crossings.
   - In order to "trigger" traffic signals and exclusive bus timing features, only those buses that have been "registered" with LADOT will be recognized by LADOT's traffic signal system. Each bus is outfitted with a transponder to communicate with the traffic signal system. Due to regular maintenance and scheduling demands, Metro regularly substitutes different buses along the Orange Line. These buses are not "registered" with LADOT, and therefore their transponders are not recognized by the signal system. This results in the buses not communicating with the traffic signal system, stopping for more red lights, and generally proceeding at a much slower rate.

The slowest segments of the Orange Line, in terms of relative bus speeds, are the following segments:

- **Westbound/Northbound:**
  - Between North Hollywood and Valley College
  - Between Sepulveda Boulevard and Woodley Avenue
  - Between Tampa Avenue and Pierce College
  - Between Roscoe Boulevard and Chatsworth
- **Eastbound/Southbound:**
  - Between Sherman Way and Canoga
  - Between Woodley Avenue and Van Nuys Boulevard
  - Between Valley College and Laurel Canyon Boulevard

Figure 6 shows the maximum bus speeds through the corridor.

4.1.2 Operators

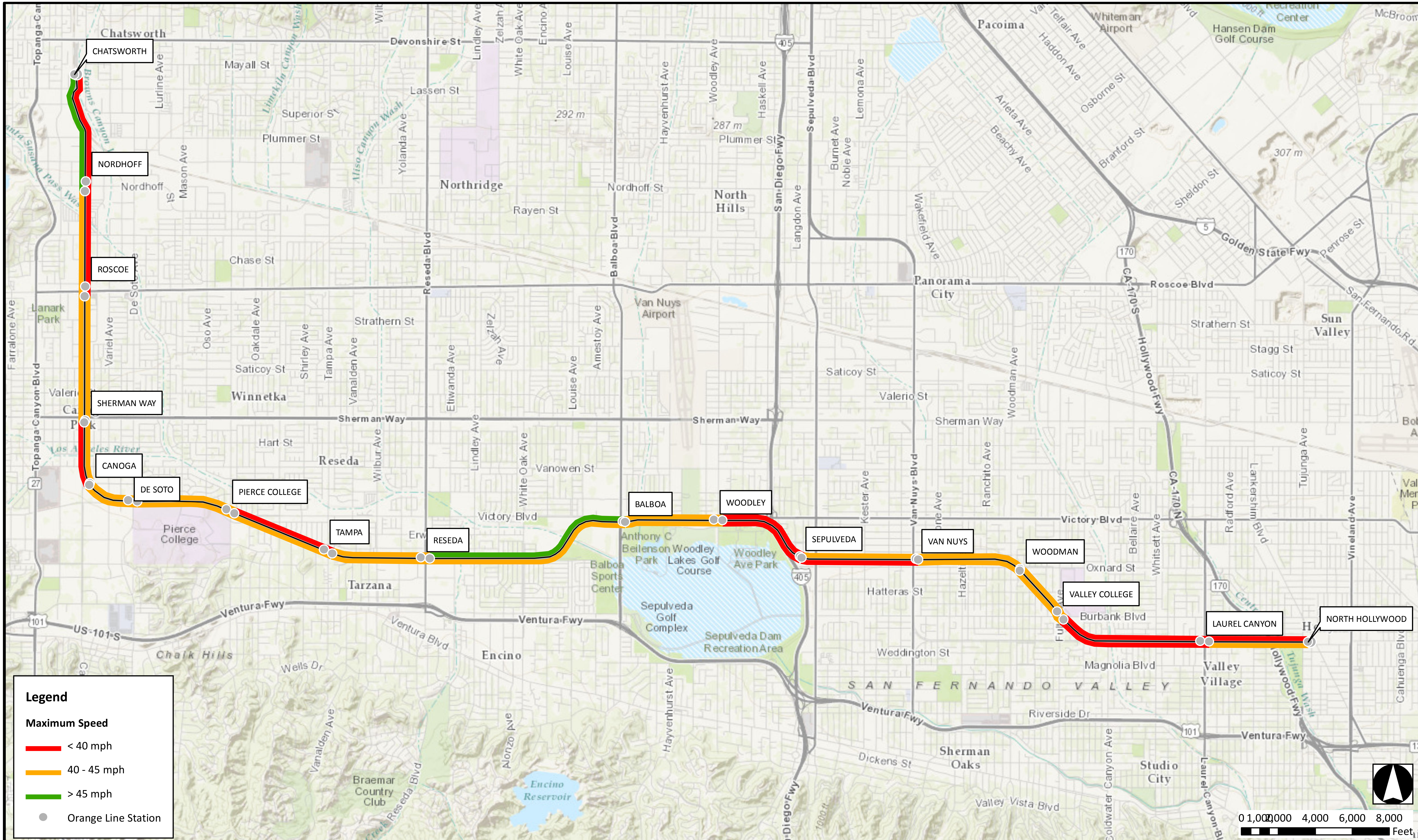
During interviews with Metro bus operators, Iteris staff identified specific operating procedures or considerations that directly affect bus speeds. These items are summarized below:

- Operators, in the course of their assigned duties providing a customer service to passengers, strive to operate the buses smoothly. This means that rapid acceleration and deceleration is avoided. This can affect the ability of a bus to achieve the posted speed limit between crossings and stations.
- Following a series of bus-involved collisions in the early years of operation, a “slow order” was issued requiring all bus operators to adhere to a maximum speed of 10 mph at all crossings.

4.1.3 Collisions

Although initial collisions spurred some immediate changes in operations, the data does not indicate collisions as a specific criteria impacting bus speeds, and collisions on the Orange Line are consistent with collision rates of other Metro bus lines.

More than half of all collisions that have occurred in the past 10 years have been attributed to red light violations. Almost 20% of the collisions are attributed to vehicles disobeying left- or right- turn prohibitions. Between these two types of collisions, almost **80% of all collisions along the Orange Line busway are attributable to vehicles disobeying traffic signals and signs**. Furthermore, there has been only one pedestrian-involved collision (*Source: SWITRS February 2011 – Case ID 5066099*) along the MOL, but the collision did not involve a bus.


CHATSWORTH
NORDHOFF
ROSCOE
SHERMAN WAY
CANOGA
DE SOTO
PIERCE COLLEGE
TAMPA
RESEDA
BALBOA
WOODLEY
SEPULVEDA
VAN NUYS
WOODMAN
VALLEY COLLEGE
LAUREL CANYON
NORTH HOLLYWOOD
Legend
Maximum Speed
< 40 mph
40 - 45 mph
> 45 mph
Orange Line Station
0 1,000 2,000 4,000 6,000 8,000
Feet

5 MICROSIMULATION

Utilizing the data and findings collected in the previous tasks, Iteris prepared a computer simulation, using VISSIM, of the operation of the MOL. This section describes the steps taken to develop the VISSIM model, the results of an existing conditions simulation, and the results of potential operational scenarios simulations.

5.1 Model Development, Calibration, and Validation

5.1.1 Model Development

The microsimulation platform VISSIM was used to develop the model. The VISSIM model was developed using VISSIM build 6.00-21, and was calibrated for existing year 2015 conditions. The VISSIM model developed for this project includes roadway geometrics, traffic signal parameters, and driver behavior characteristics. Unlike static analyses conducted according to the Highway Capacity Manual (HCM), a simulation model includes "virtual drivers" that travel through the model network, from entry nodes to exit nodes, along network paths that are assigned by the analyst. The model uses random seeds and probability distributions for a number of traffic flow characteristics, such that each model run will produce slightly different outputs. Each seed contains random variables to account for variations in driver behavior and departure time. This model is therefore stochastic; it allows simulating the random fluctuations that are typically observed in real-time traffic networks. This feature makes the results more robust, given that they are based on the average of multiple observations or model runs, rather than a single calculation.

<u>Network Coding</u>
The existing network includes the Metro Orange Line busway between the North Hollywood Station and Chatsworth Station. An aerial image of the existing network was used as a background and scaled in VISSIM. Links and connectors were coded to match the geometric design and configuration. There are approximately 50 signalized intersections coded in the VISSIM network along the busway and parallel streets. Signal timing plans were provided by LADOT. The following parallel streets were included in the network:

- Chandler Boulevard between North Hollywood Station and Ethel Avenue
- Oxnard Street between Woodman Avenue and Sepulveda Boulevard
- Victory Boulevard between Densmore Avenue and Balboa Boulevard
- Oxnard Street between White Oaks Avenue and Corbin Avenue
- Victory Boulevard between Topham Avenue and De Soto Avenue
- Canoga Avenue between Vanowen Street and Prairie Avenue

<u>Data Inputs</u>
To develop data to be used as inputs as well as calibration targets, multiple data resources were used:

- Traffic Volumes – Intersection counts conducted in August 2015
- Travel Time – Travel time runs using floating car method conducted in August 2015
- Lane Configuration – Field Survey
- Signal Timing Plan – Provided by LADOT

Error Checking

The error correction process involved software error checking, input coding, and animation review. Input coding included geometry, demand, signal timing, traffic volumes, and route choices. The animation review was to determine if it is showing unrealistic vehicle behavior and if there were coding errors causing the simulation model to represent travel behaviors. Also during this step, the error file produced by VISSIM was checked and errors were eliminated based on minor coding adjustments. Error checking was completed for this project before calibration began.

5.1.2 Calibration

The objective of model calibration is to obtain the best match possible between model performance estimates and the field measurements of performance. However, there are diminishing returns where large investments in effort yield small improvements in accuracy at a certain point in the calibration process. The Federal Highway Administration (FHWA) has set calibration procedures and standards for microsimulation models and these were used in the calibration process. FHWA calibration targets were applied as follows:

Hourly Flows, Model Versus Observed

- Individual Link Flows
  - Within 100 vehicles/hour (v/h), for Flows < 700 v/h
  - Within 15%, for 700 v/h < Flow < 2,700 v/h
  - Within 400 v/h, for Flow > 2,700 v/h
- Sum of All Link Flows
  - Within 5% of the sum of all link counts
- GEH Statistic* < 5 for Individual Link Flows > 85% of cases
- GEH Statistic* for Sum of All Link Flows GEH < 4 for sum of all link

*The use of the GEH statistic (named after its developer, Geoffrey E. Havers) "stems from the inability of either the absolute difference or relative difference statistics to cope with flows over a wide range" of values (Scottish Transport Appraisal Guidance, 2002). The GEH statistic is a modified Chi-squared statistic that incorporates both relative and absolute differences to compare modeled and observed characteristics. The form of the GEH statistic allows for greater absolute differences for low volumes while requiring lower relative differences for large volumes. The expression for the GEH statistic is GEH = [square root of 2[(E - V).sup.2] / (E + V)] (2) Where E = model estimated characteristic; V = observed characteristic.

Travel Times, Model Versus Observed

- Travel Times, Network within 15%

Visual Audits

Bottlenecks

- Visually Acceptable Queues – To analyst's satisfaction

5.1.3 Calibration Results

VISSIM Model Run Procedure

The model is set to run for 5,400 simulation seconds (1 hour and 30 minutes). This allows for a 30-minute "warm-up" period (0 to 1,800 seconds) where congestion can develop, and then a 60-minute period

(1,800 to 5,400 seconds) when the analysis statistics are collected. The simulation resolution is set at 10 time steps per simulation second. In order to increase the confidence level of the data obtained from the simulation runs, a total of 10 simulation runs, each with a different random seed, were performed for the p.m. peak hour, and the average of these runs was used in the calibration.

Results

A comparison of the input demand volumes and corresponding simulated VISSIM volume output is included in **Appendix E**. The comparison in **Appendix E** indicates the magnitude of vehicles that VISSIM has processed in the simulation versus the actual number of vehicles that were entered as inputs. **Table 7** summarizes the results for calibration criteria of traffic flow. **Table 7** shows that all calibration targets based on volumes were achieved.

Table 7 – Calibration Criteria – Volume

CRITERIA - VOLUME	TARGET	RESULTS	ACHIEVED?
Individual Vehicle Flow			
Within 100 veh/h, for flow < 700 veh/h	> 85% of cases	100%	Yes
Within 15 % for 700 veh/h < flow < 2700 veh/h	> 85% of cases	100%	Yes
Within 400 veh/h, for flow> 2700/h	> 85% of cases	-	-
Sum of all Links	Within 5%	-0.4%	Yes
GEH Statistic < 5 for Individual Link Flows	> 85% of cases	100%	Yes
GEH Statistics for sum of all link flows	Less than 4	1.41	Yes

Travel time data was collected along busway and parallel streets, in both directions. In total, 10 travel time runs were compared. A comparison of travel time data from the VISSIM model and the actual field observations is presented in **Appendix E**. **Table 8** summarizes the results for calibration criteria of travel time. **Table 8** shows that 100% of the travel time corridors met the calibration criteria.

Table 8 – Calibration Criteria – Travel Time

CRITERIA – TRAVEL TIME	TARGET	
	(FHWA CRITERIA)	ACHIEVED
Within 155 (or 1 min, if higher)	85%	100%

5.1.4 Existing Operational Simulation

The existing conditions VISSIM model is shown to be well calibrated and within applicable thresholds of the FHWA. For the volume calibration criteria, the model meets FHWA criteria for: individual vehicle flows, sum of all links, and both GEH statistics. The model also meets FHWA criteria for travel time. Overall, the VISSIM model is well suited to analyze future conditions with the proposed improvements.

Existing conditions were simulated in the VISSIM model to establish baseline conditions. Video recordings of the existing simulation are provided separately.

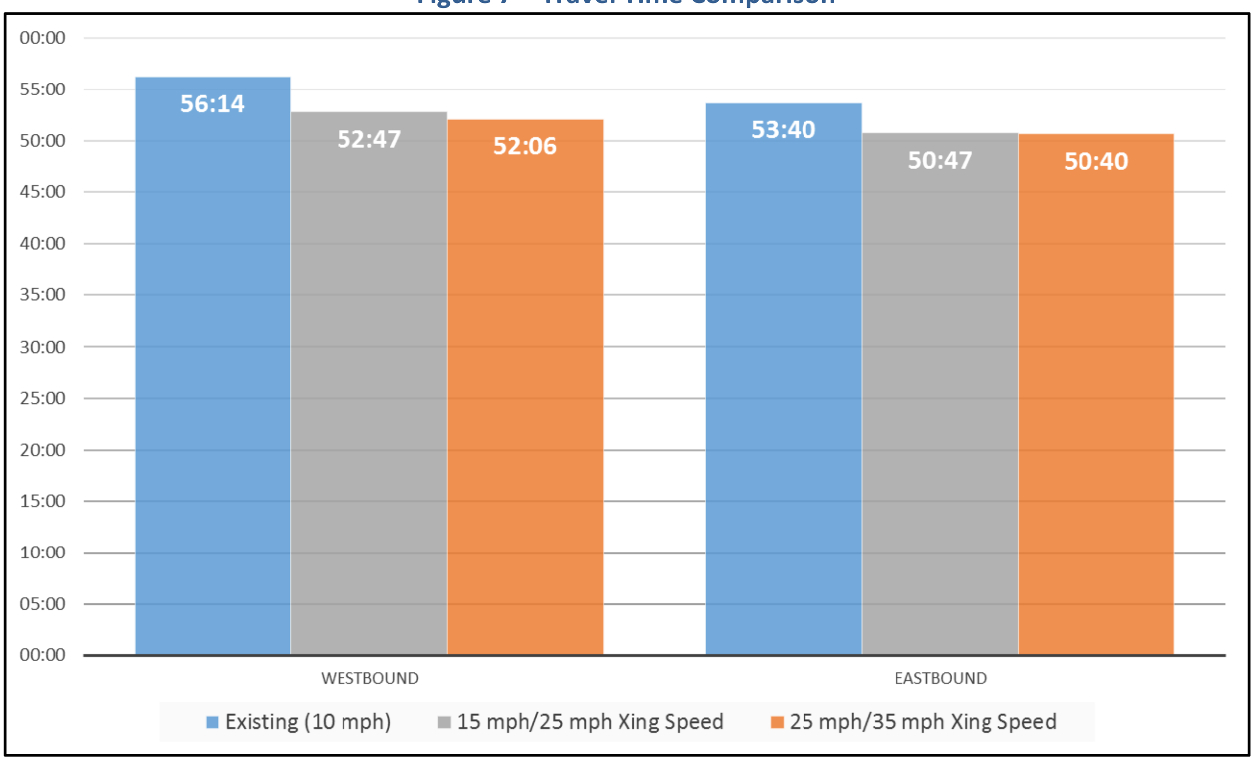
5.1.5 Potential Operational Scenarios Simulation

Potential operating scenarios, reflecting changes in bus operating speeds and/or traffic signal timing parameters, were simulated in a VISSIM model. The operating scenarios are used to develop recommendations presented in Section 6.0. The following different operating scenarios have been simulated:

1. Existing operations (calibrated to reflect operating conditions observed during field investigations).
2. Buses driving at increased speeds between stations. The intersection crossing speeds are 15 mph (at station crossings) and 25 mph (at all other crossings). This scenario includes LADOT traffic signal priority, and delays at stops and signalized crossings.
3. Buses driving at the posted speed limit between stations. The intersection crossing speeds are 25 mph (at station crossings) and 35 mph (at all other crossings). This scenario includes LADOT traffic signal priority, and delays at stops and signalized crossings.

Figure 7 below presents a summary of the modeled travel time along the entire alignment, under the three scenarios described above.

Figure 7 – Travel Time Comparison



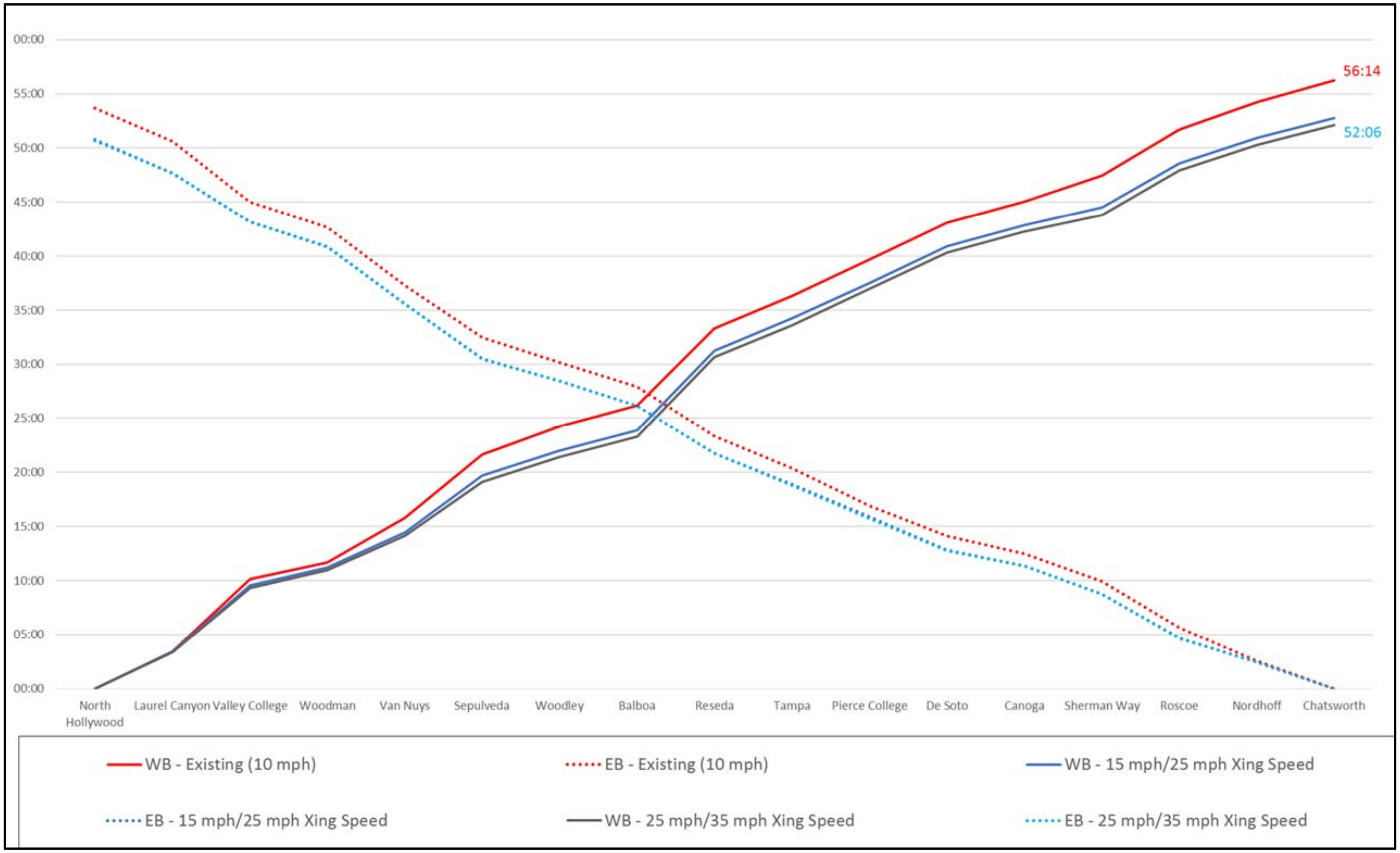
As shown in **Figure 7**, the "Immediate" scenario shows a maximum travel time savings of approximately three and a half minutes, while the "Recommended" scenario provides travel time savings of over four (4) minutes.

The consultant team recognizes that these travel time savings are identified via a simulation model; therefore, the likely reduction in travel time would be somewhat less.

Figure 8 below plots the eastbound and westbound travel times along the entire alignment, by stop, under the three simulated operational scenarios.

As mentioned before in Section 3.1.2, the existing MOL travel times are very similar to the drive-alone travel times. During the PM peak hours, the westbound travel time for vehicles is 63 minutes, compared to the MOL buses at 56 minutes. Similarly, the eastbound travel time for vehicles is 45 minutes, compared to the MOL buses at 53 minutes. The field observations show the existing MOL already as a more convenient mode of transportation versus driving an automobile on surface streets. Furthermore, once the bus speeds are increased, it is expected that the MOL buses would traverse the corridor up to approximately 10 minutes faster, or more, than driving an automobile on surface streets.

Figure 8 – Eastbound and Westbound Travel Time Plots



As shown in **Figure 8**, travel times between North Hollywood and Canoga currently take approximately 45 minutes. The travel time could be reduced to approximately 30 minutes or less by eliminating stop delays at signalized crossings between stations, and increasing bus speeds to the existing posted speed limits.

6 CONCLUSIONS AND RECOMMENDATIONS

Based on the observations and data collected, as well as the findings described in Section 4 and simulation results documented in Section 5, Iteris has developed a set of recommendations to improve bus speeds and travel times:

- **Recommendations for Immediate Implementation:** These recommendations should be implemented as quickly as possible. Many of these recommendations may appear to have no direct effect on bus speeds; however, these actions will position the line for speed improvement following the subsequent recommendations. These recommendation are described below:

    - It is recommended that Metro rescind the "Slow Order", which went into effect shortly after the MOL opened in 2005, allowing bus operators the ability to improve travel times by traveling at faster speeds through intersections. The order was considered a short-term measure to alleviate safety concerns resulting from drivers not being familiar with traffic control at crossings. However, ten years later, the order remains despite collision data showing that drivers are much more familiar with the MOL.
        - Recommended intersection crossing speeds are shown on **Table 9.**
    - It is recommended that Metro improve its current system to monitor the functionality of bus transponders. One option is that Metro should consider providing a list of transponders to LADOT to verify if the transponders are communicating with the traffic signal system. Another option is for Metro to review all current transponders in buses operating on the MOL and verify that the transponders are operational. A third option would be for LADOT to discontinue the practice of “registering” transponders, and instead allowing any transponders to activate the transit signal priority (TSP) functions along the busway.
    - There are certain locations, noted in Section 3.4 (and shown in **Appendix D**), where existing landscaping is overgrown and reduces stopping sight distance for buses approaching crossings. The landscaping should be trimmed, and a regular program for monitoring landscaping growth and regular trimming should be implemented by Metro. As this suggestion would likely prove difficult to implement, an alternate consideration should be for the removal and replacement of existing landscaping in the locations identified. Any new landscaping or design features should require little to no maintenance, to ensure that the improvement to sight distance is permanent. Any landscaping or design improvements should provide stopping sight distance clearance in compliance with Highway Design Manual (HDM) standards.
    - Signage at the busway crossings should be identifiable and legible. It is recommended that signage improvements be implemented at the locations identified in Section 3.4 to better guide motorists and pedestrians.

- **Three-Month Observation Period:** Following the immediate recommendations, Metro should monitor bus operations at the increased speeds for approximately three months.

    - As the “slow order” is currently causing buses to quickly fall out of any coordinated signal timing plans, it is impossible to effectively assess the existing TSP system along the MOL.

Therefore, once the "slow order" is rescinded, it is recommended that Metro monitor bus operations to ensure that the TSP is operating according to LADOT's existing timing plans. These plans should allow buses to operate at the recommended crossing speeds, and should minimize delays caused by stops at red traffic signals. It is important to note that buses are expected to stop at some crossings, where the traffic signals may provide a red indication to buses along the busway. However, it is anticipated that the number of stops at red traffic signals should be less than the number observed during field investigations (approximately four to five stops in each direction).

  - Metro should monitor bus operations, particularly any collisions that may be attributed to increased bus speeds.

- **Additional Considerations:** Although not directly recommended due to identified criteria impacting bus speeds, there are additional features that could be added to intersection crossings.

  - In-roadway warning lights (IRWLs) should be considered, in accordance with MUTCD guidelines. Intersections along the MOL extension from Canoga to Chatsworth already have in-road warning lights. Bus operators have expressed that they feel more comfortable when crossing at these locations. By installing IRWLs, Metro would ensure that the same features are present at all intersection crossings.
    - Metro should coordinate with LADOT for the installation, maintenance and inspection of the IRWLs.
    - All IRWL systems currently installed along the Orange Line are subject to the guidance of the California Traffic Control Devices Committee (CTCDC) and should be considered as part of the ongoing experiments titled "The Evaluation of Steady Red Stop Line Lights – Los Angeles (Official Ruling Number 4-341 (E))" and "Request to Experiment with In-Roadway Warning Lights (IRWL) System that would supplement existing traffic signals along the Metro Gold Line – (LA County Metro)" (For more information, see: http://www.dot.ca.gov/hq/traffops/engineering/ctcdc/).
  - Additional red light photo enforcement cameras should be considered at all crossings. Red light cameras are currently located at 19 crossings along the MOL. For consistency purposes, and because they have proven to be effective at reducing (though not eliminating) red light violations at MOL signalized crossings, additional red light cameras should be installed at all crossings on the MOL route.
  - It is recommended that Metro consider a pilot program to implement an in-vehicle signal timing notification system to provide real-time signal information to bus operators. New technologies exist that could provide this feature wirelessly directly to operators. Metro should consider deploying such technology on a pilot basis, working with LADOT to receive real-time traffic signal information via the City's centralized traffic signal control system. Operators would be made aware of the status of the green or red times at an approaching signalized crossing. This program could be used as a test to determine the overall benefits to bust travel times.

Table 9 summarizes the recommendations by crossing.

Table 9 – Recommendations and Additional Considerations

(A) CROSSING STREET (EAST TO WEST / SOUTH TO NORTH)	(B) IMMEDIATE RECOMMENDATION		(E) THREE-MONTH OBSERVATION PERIOD	(F) ADDITIONAL CONSIDERATIONS	
	(C) RECOMMENDATION	(D) CROSSING SPEED	TARGET CROSSING SPEED AFTER THREE MONTHS	(G) IMPROVEMENT	(H) CROSSING SPEED
Tujunga Ave[1]	• Rescind "Slow Order"	15 mph[4]	25 mph[5]	• Install in-road warning lights	25 mph[3]
Colfax Ave	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Agnes Ave-Pedestrian Crosswalk	• Rescind "Slow Order"	25 mph	35 mph		35 mph
Laurel Cyn Blvd[1]	• Rescind "Slow Order"	15 mph[2]	25 mph[3]	• Install in-road warning lights • Install red light cameras	25 mph[3]
Corteen Pl	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Whitsett Ave	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Bellaire Ave	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Goodland Ave-Pedestrian Crosswalk	• Rescind "Slow Order"	25 mph	35 mph		35 mph
Coldwater Cyn Ave	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Chandler Blvd	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Ethel Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Burbank Blvd-Fulton Ave[1]	• Rescind "Slow Order" • Improve signage: o Visibility constraint. Consider relocating "No Right on Red" sign to increase visibility.	15 mph[2]	25 mph[3]	• Install in-road warning lights • Install light cameras	25 mph[3]
Oxnard St[1]	• Rescind "Slow Order" • Install pedestrian fence • Improve signage: o Faded "No Right on Red" sign	15 mph	25 mph	• Install in-road warning lights	25 mph
Woodman Ave	• Rescind "Slow Order" • Improve signage: o Faded "No Right on Red" sign o Visibility constraint. Consider relocating "Look Both Ways" sign to increase visibility.	25 mph	35 mph	• Install in-road warning lights	35 mph
Hazeltine Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Tyrone Ave	• Rescind "Slow Order" • Improve signage: o Visibility constraint. Consider relocating "Look Both Ways" sign to increase visibility.	15 mph[4]	25 mph[5]	• Install in-road warning lights • Install red light cameras	25 mph[5]
Van Nuys Blvd[1]	• Rescind "Slow Order" • Improve signage: o Vandalized Flashing bus signal o Speed limit "45 mph" covered by trees	15 mph[2]	25 mph[3]	• Install in-road warning lights • Install light cameras	25 mph[3]
Vesper Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Kester Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints.	15 mph[4]	25 mph[5]	• Install in-road warning lights	25 mph[5]
City of Los Angeles, Bureau of Street Maintenance, Van Nuys District Yard Private Dwy	• Rescind "Slow Order"	25 mph	35 mph		35 mph
Sepulveda Blvd[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2,4]	25 mph[3,5]	• Install in-road warning lights	25 mph[3]
Densmore Ave	• Rescind "Slow Order"	25 mph	35 mph		35 mph

Table 9 – Recommendations and Additional Considerations

(A) CROSSING STREET (EAST TO WEST / SOUTH TO NORTH)	(B) IMMEDIATE RECOMMENDATION		(E) THREE-MONTH OBSERVATION PERIOD	(F) ADDITIONAL CONSIDERATIONS	
	(C) RECOMMENDATION	(D) CROSSING SPEED	TARGET CROSSING SPEED AFTER THREE MONTHS	(G) IMPROVEMENT	(H) CROSSING SPEED
Woodley Ave[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2]	25 mph[3]	• Install in-road warning lights	25 mph[3]
Hayvenhurst Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph		35 mph
Balboa Blvd[1]	• Rescind "Slow Order"	15 mph[2]	25 mph[3]	• Install in-road warning lights	25 mph[3]
White Oak Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights	35 mph
Lindley Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights	35 mph
Reseda Blvd[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2]	25 mph[3]	• Install in-road warning lights	25 mph[3]
Wilbur Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Tampa Ave[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2,4]	25 mph[3,5]	• Install in-road warning lights • Install red light cameras	25 mph[3]
Corbin Ave	• Rescind "Slow Order"	15 mph[4]	25 mph[5]	• Install in-road warning lights • Install red light cameras	25 mph[5]
Victory Blvd	• Rescind "Slow Order"	15 mph[4]	25 mph[5]	• Install in-road warning lights • Install red light cameras	25 mph[5]
Winnetka Ave[1]	• Rescind "Slow Order" • Improve signage: o Faded "Do Not Enter" sign o Faded "No Ped Xing" sign	15 mph[2]	25 mph[3]	• Install in-road warning lights • Install red light cameras	25 mph[3]
Mason Ave	• Modify landscaping to address sight distance constraints • Improve signage: o Broken Flashing bus signal o "No Right on Red" sign blocked by trees o "Stop Here on Red" sign blocked by trees	25 mph	35 mph	• Install in-road warning lights	35 mph
De Soto Ave[1]	• Rescind "Slow Order"	15 mph[2]	25 mph[3]	• Install in-road warning lights	25 mph[3]
Vanowen St	• Rescind "Slow Order" • Improve signage: o Visibility constraint. Consider relocating "No Right on Red" sign to increase visibility.	25 mph	35 mph		35 mph
Sherman Wy[1]	• Rescind "Slow Order"	15 mph[2,4]	25 mph[3,5]		25 mph[3]
Valerio St	• Rescind "Slow Order"	15 mph[4]	25 mph[5]		25 mph[5]
Saticoy St	• Rescind "Slow Order"	15 mph[4]	25 mph[5]		25 mph[5]
Roscoe Blvd[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2]	25 mph[3]		25 mph[3]
Parthenia St	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph		35 mph
Nordhoff St[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2]	25 mph[3]		25 mph[3]

Notes:
1. Station location
2. As current operating procedures require all buses to stop at all stations, busses are accelerating or decelerating at adjacent crossings. Therefore, crossing speeds are posted for guidance only.
3. If operating procedures change and buses no longer stop at all stations, Metro may consider increasing bus speeds consistent with the adjacent crossing streets.
4. At these locations, stopping sight distance is reduced due to an adjacent fence/structure/soundwall; therefore, minimal speed increases are recommended.
5. During the three-month evaluation, speed increases to 25 mph could be implemented; however, increasing speeds above 25 mph is not recommended due to the limited stopping sight distance.

How to Read this Table:
(A) At each crossing street indicated in this column, the recommended improvements listed in column (B) should be implemented. Specific improvements for each crossing are shown in column (C), with associated maximum crossings speeds listed in column (D). Once the immediate recommendations have been implemented and new maximum crossing speeds are observed, Metro should incrementally increase crossing speeds during a three-month observation period. The maximum crossing speeds during this three-month observation period should not exceed those listed in column (E). After the three-month observation period, Metro may consider additional improvements as described in column (F). Specific additional improvements for consideration are listed in column (G), and are not provided for every intersection along the alignment. Once the additional improvements are implemented, Metro may consider increasing the maximum crossing speed to those listed in column (H).

A potential recommendation that has been discussed by Metro staff and concerned citizens in the past is to design and install extinguishable "No Turn on Red" signage at all crossings, and prioritize based on those locations with the highest volumes of left- and right-turning vehicles adjacent to the busway. Based on the research of the consultant team, it is understood that LADOT and Metro have evaluated this particular improvement and concluded that it would not be feasible for the following reasons:

- Lack of available space on existing traffic signal poles,
    - Traffic signal poles and their associated foundations are rated for a certain amount of signage, based on weights and wind sheer calculations. Existing sign poles were evaluated and it was determined that no existing poles were located in acceptable locations with available space for additional signage.
- Lack of available power supply for extinguishable signs, and
- Preponderance of existing static signage.

APPENDIX A
Line Ride Data

APPENDIX B
Traffic Data

APPENDIX C

Collision History

APPENDIX D

Field Data Collected by Crossing

APPENDIX E

VISSIM Calibration Results

APPENDIX F
Cost Estimates of Recommendations