7’s Reverse Lane Study
7th Street and 7th Avenue
from McDowell Road to Dunlap Avenue

Technical Memorandum

Project No. ST89340552-1

Prepared for:

City of Phoenix

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December 2021

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1.0 Executive Summary

A planning and traffic operations study was initiated to examine the existing traffic operations, safety and ITS infrastructure along the 7th Avenue and 7th Street corridors, where the reversible lanes are present, north of downtown Phoenix. Currently, the reversible lanes are operational during the AM and PM peak hours (6-9 AM and 4-6 PM). This planning and operations study identifies strategies and associated costs to improve the traffic operations and safety on both the 7th Avenue and 7th Street reversible lane corridors. Strategies to improve operations and safety have been developed based on field review, operational analysis, crash data analysis, review of existing infrastructure on the study corridors and published documentation on reversible lane operations in similar cities.

The study was completed in two phases:

1. Phase 1 considered the removal of the reversible lane between McDowell Road and Osborn Road on 7th Street. Phase 1 was expedited to support traffic impact studies for developments along 7th Street. Phase 1 concluded that the reversible lane on 7th Street between McDowell Road and Osborn Road is essential to maintain acceptable traffic operations and serve the expected travel demand to and from downtown Phoenix. Phase 1 also concluded that the lane utilization of the reversible lane is less than the utilization of the normal through lanes and that it can be increased by improving reversible lane sign visibility and enforcement.

2. Phase 2 evaluated the traffic operations along the entire stretch of the reversible lane corridors on both 7th Avenue and 7th Street. 7th Avenue and 7th Street were evaluated separately to better convey the existing operations as well as quantify corridor improvements. Phase 2 developed high-level cost estimates for improvement strategies which ranged from improving communication and detection to an overhaul of existing sign control in lieu of advanced dynamic lane control strategies. In addition to sign control, signal control and ITS infrastructure improvement costs, Phase 2 also estimated costs to restripe the reversible lane corridors for uniform lane widths and to add pull-out bus bays at Valley Metro bus stop locations.

Field reviews were conducted to observe traffic operations during peak hours and document existing intersection infrastructure and reversible lane signs. Field observations indicated that most of the drivers on the reversible lanes are generally familiar with using the reversible lanes. However, there were numerous instances where drivers performed unsafe maneuvers as they exit or enter the reversible lane. These include turning left where prohibited, turning into the reversible lanes from side streets when the reversible lane is operational as an opposing through lane, bypassing a vehicle waiting to turn into a side street from the reversible lane by making sudden and unexpected lane changes at slow speeds conflicting with fast moving vehicles on a regular through lane. Field review also indicated that vehicles bypass stopped Valley Metro buses at bus stops often causing slowdown of traffic and resulting in unsafe headways in vehicular stream on congested portions of the two corridors.

Operational analysis of the two corridors indicates that the reversible lanes are required to accommodate the directionally heavy traffic in the peak hours. The ADT on 7th Avenue varies between 35,000 and 62,000 and on 7th Street between 46,000 and 65,000. Traffic counts provided by the City indicated that a few vehicles make prohibited left turning maneuvers at signalized intersections during the peak hours when the reversible lanes are operational. Operational analysis using the intersection volumes as provided indicated that the prohibited left turn maneuvers reduce the through lane capacity substantially. Travel demand analysis of the two corridors using a dynamic traffic assignment process in microsimulation platform indicated that the reversible lanes are essential to accommodate the vehicular demand in the peak hours. Operations along parallel north-south arterials including Central Avenue, 15th Avenue and 12th Street will deteriorate if the reversible lanes on 7th Street and 7th Avenue are eliminated. Moreover, the traffic using the reversible lanes is generally on the shortest path to get to their eventual destinations; vehicular travel times will not improve if reversible lanes are eliminated.

Corridor crash analyses were performed to assess the safety of both corridors. Crash distributions and severities were compared to the statewide averages for 2018 (expected fatal crash distribution of 0.51%, an expected possible injury crash distribution of 26.8%, and an expected no injury crash distribution of 70.8%). These values were used as a baseline for all crash analyses and it was determined that both corridors experience crash rates that exceed the statewide averages. Findings indicate that along 7th Avenue 41.1% of crashes occurred when the reversible lane was operational and 58.9% occurred during other times. Further, along 7th Street 44.1% of crashes occurred when the reversible lane was operational and 55.9% occurred during other times. Within the Study Area, five of the top 100 high-risk crash intersections exist per Maricopa Association of Governments (MAG) "Top 100 Intersections Ranked by Crash Risk – 2014 to 2018 Crash Data". These intersections are as follows:

1. 7th Avenue and Indian School Road
2. 7th Street and McDowell Road
3. 7th Street and Indian School Road
4. 7th Street and Bethany Home Road
5. 7th Street and Camelback Road

Improvement strategy categories, as defined in this report, can be used as a baseline for future corridor improvements to improve traffic operations and corridor safety along 7th Avenue and 7th Street. Seven improvement strategies were selected from a decision matrix based on corridor need and were categorized by:

1. No-build improvements,
2. Communication improvements, and
3. Operations improvements.

Field visits indicated that at a minimum the existing reversible lane static signs should be removed and replaced to remove inconsistencies in signage and to eliminate sign structures with poor structural integrity of the mast arms. Beyond the minimum requirements for improvement, alternatives including intersection improvements, fiber trunk line additions, dynamic lane control signs, corridor restriping, and pull-out bus bay constructions were considered.

High-level cost estimates have been compiled for each improvement strategy and are broken down by individual corridor. Corridor Improvement Levels have been defined to identify different paths to improve the operations and safety along the reversible lanes on 7th Avenue and 7th Street along with the cost of each improvement level, in million USD as shown in ***Figure 1*** and ***Figure 2***, respectively.

Figure 1 – Improvement Levels Summary 7th Avenue

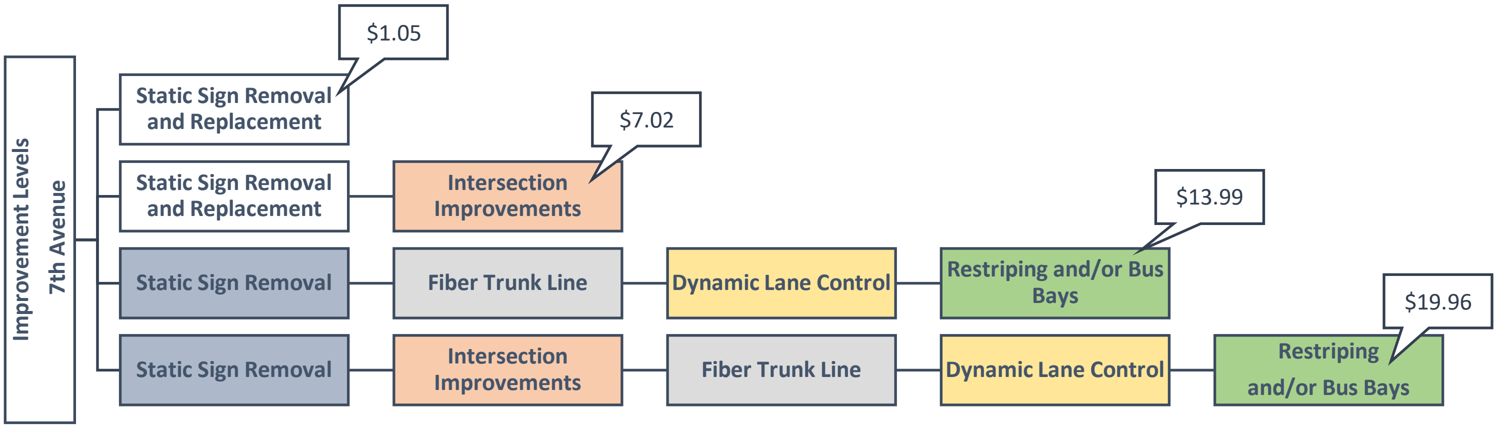
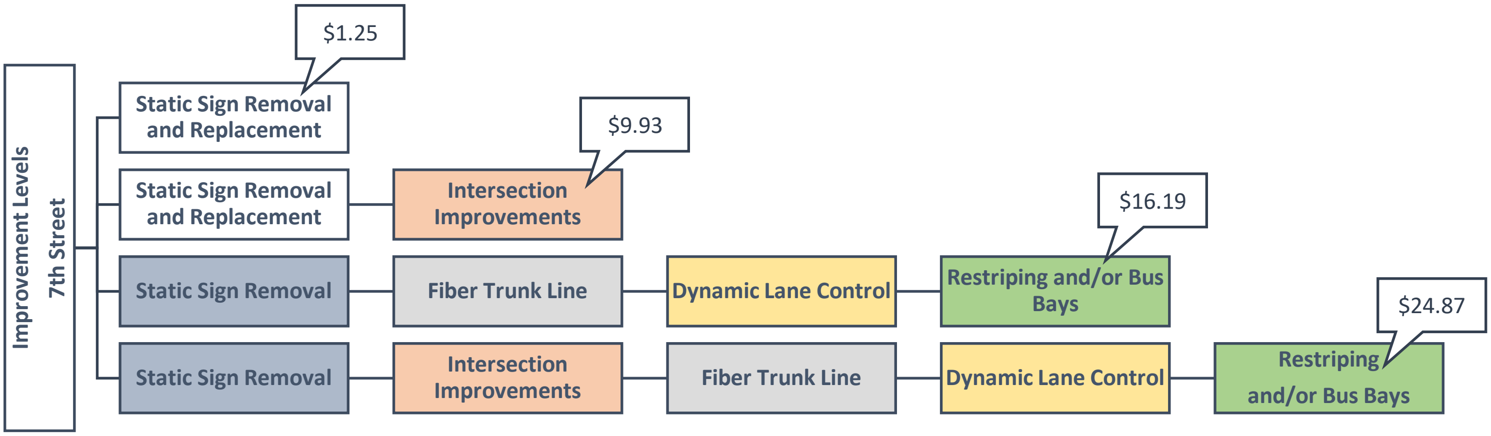


Figure 2 – Imporvement Levels Summary 7th Street



Proposed costs associated with each improvement strategy based on corridor are as follows:

- Static Sign Removal and Replacement
    - 7th Avenue: $1.05 million
    - 7th Street: $1.25 million
- Static Sign Removal
    - 7th Avenue: $150,000
    - 7th Street: $190,000
- Intersection Improvements
    - 7th Avenue: $5.97 million
    - 7th Street: $8.68 million
- Fiber Trunk Line
    - 7th Avenue: $4.78 million
    - 7th Street: $5.55 million
- Dynamic Lane Control
    - 7th Avenue: $8 13 million
    - 7th Street: $9.03 million
- Corridor Restriping
    - 7th Avenue: $340,000
    - 7th Street: $410,000
- Bus Bays
    - 7th Avenue: $4.80 million
    - 7th Street: $5.56 million

The City can pursue any combination of the above identified strategies to improve both traffic operations and safety along the two corridors. **At a minimum, it is recommended that the City remove and replace the existing static reversible lane signs along the two corridors.**

2.0 Introduction

A planning and traffic operations study was initiated to examine the existing traffic operations, safety and ITS infrastructure along the 7th Avenue and 7th Street corridors, where the reversible lanes are present, north of downtown Phoenix. Currently, the reversible lanes are operational during the AM and PM peak hours (6-9 AM and 4-6 PM).

The reversible lane corridor along 7th Avenue extends from McDowell Road to Northern Avenue; the corridor along 7th Street extends from McDowell Road to Dunlap Road. The corridors are considered as two separate entities for analysis purposes. In doing so, traffic operations, safety analysis and cost estimates are able to be quantified. Analysis will be conducted using travel demand and microsimulation models to classify the current operations of the reversible lanes for the City. Travel demand modeling will enable the identification of origin-destination traffic patterns during reversible lane hours. Microsimulation modeling will quantify operational effects of the reversible lane. Improvements strategies will be recommended in order to ease traffic operations during reversible lane operations along both corridors, as well as provide upgrades to the existing infrastructure of the corridor intersections.

The initial phase of the study evaluated the reversible lane operations on 7th Street between McDowell Road and Osborn Road in the City of Phoenix (City) and determined that the reversible lanes shall remain within the corridors. Findings proposed that sign visibility and enforcement improvements would improve the through volume capacity and vehicular safety of the Study Area. This report was submitted to the City on June 15, 2020 and revised for submittal on July 10, 2020. The full report can be found in ***Appendix M***.

This report will analyze the second phase of the study which addresses the entire Study Area. The scope of the second phase is to identify opportunities to improve traffic operations of reversible lanes on 7th Avenue and 7th Street in the City of Phoenix. In the existing conditions, the reversible lanes are operational during peak hours and are implemented via static overhead lane control signs. Several sign structures and foundations need repair and upkeep. A few static overhead signs were recently removed and not replaced while the City identifies a comprehensive solution to address and improve the reversible lane operations. The study team identified several improvement strategies to upgrade the corridors and improve operations. This project report describes these improvement strategies, benefits and associated costs as well as identifies the summary costs associated with each of the improvement strategies.

The static overhead sign structures need replacement and are included in the cost estimation process. Therefore, the cost associated with the static sign structure removal and replacement will serve as a benchmark (no-build) cost for comparison purposes. In addition to the static sign improvements, the signalized intersections along the corridor can benefit from improved detection and communications. Therefore, an additional benchmark for cost considerations will be intersection control upgrades which may include, upgrades to detection, communication, cabinets and other related infrastructure.

This report will review the existing reversible lane infrastructure and identify potential improvement strategies as mentioned to enhance the functionality of the reversible lanes. The study will identify opportunities for efficient operations, ITS infrastructure integration, and other traffic management measures in the corridors to optimize their operational performance. Strategies to improve traffic flows and throughput on 7th Avenue and 7th Street include dynamic lane control sign installation, upgrading striping to create travel lanes with uniform width and to replace in-lane bus stops with pull-out bus bays. Project costs, inclusive of design, construction, right-of-way and utility costs were calculated for each improvement category as outlined in this report as well.

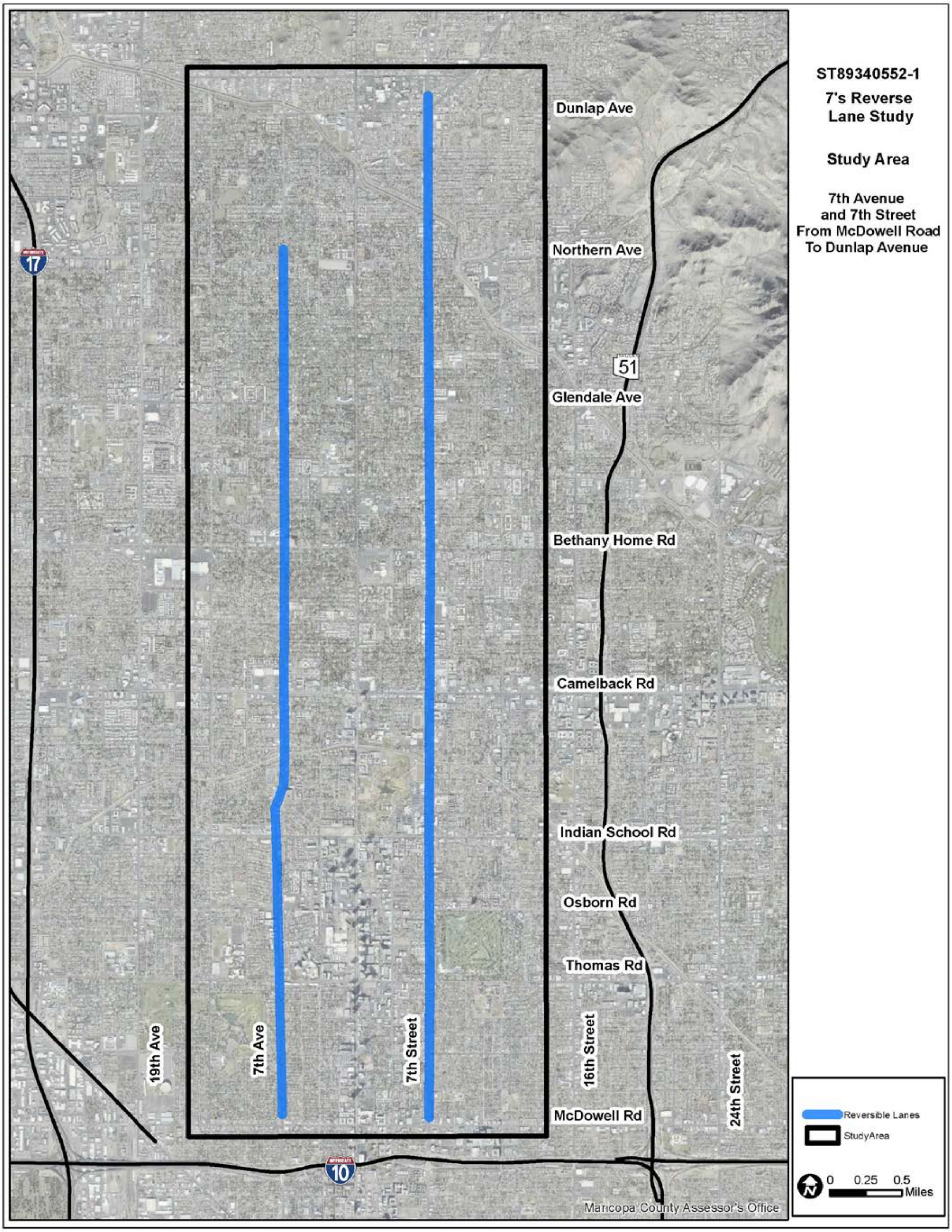
3.0 Study Area

The reversible lane corridors on 7th Avenue and 7th Street are from East McDowell Road to Northern Avenue and from East McDowell Road to East Dunlap Road, respectively. The vicinity map is shown in ***Figure 3***.

Interstate 10 (I-10), located south of the Study Area, is a major interstate facility in the region and provides connections to the greater Phoenix region. All the roadways that provide a direct connection to I-10 include:

- 16th Street a mile Street to the east;
- 3rd Street a quarter-mile to the west;
- 7th Avenue a mile to the west; and
- 19th Avenue two miles to the west.

Figure 3 – Vicinity Area



3.1. 7th Avenue Study Area

7th Avenue is classified as a major arterial in the Study Area. It intersects with 6 major arterials streets and 5 collector streets. There are 13 signalized intersections and 65 unsignalized intersections as listed in ***Table 3-1***. A detailed list of the corresponding roadways and intersections can be found in ***Appendix A***. Unsignalized intersections account for the local side streets that are along the corridor. Potential conflict areas are likely caused by prohibited turning movements at signalized and unsignalized intersections.

Major/minor/local arterials in the north-south direction parallel to 7th Avenue include:

- 15th Avenue a half mile to the west;
- Central Avenue a half mile to the east; and
- 7th Street a mile to the east.

Table 3-1 – 7th Avenue: Street Classification Summary

Major Arterials	Collector Streets	Signalized Intersections	Unsignalized Intersections
6	5	13	65

Along 7th Avenue, within the study area, there are three locations of pedestrian High-intensity Activated crossWalK (HAWK) signals. The pedestrian HAWK signals are located along 7th Avenue at Flower Street, Glenrosa Avenue, and Highland Avenue. In the future, a pedestrian HAWK signal is planned for 7th Avenue and Turney Avenue. The pedestrian HAWK signal gets activated when pedestrians push the ped actuation button associated with the HAWK signal. When the HAWK is activated, the traffic in the north-south directions on 7th Avenue is stopped.

3.2. 7th Street Study Area

7th Avenue is classified as a major arterial in the Study Area. It intersects with 7 major arterials streets and 16 collector streets. There are 20 signalized intersections and 63 unsignalized intersections as listed in ***Table 3-2***. A detailed list of the corresponding roadways and intersections can be found in ***Appendix B***. Unsignalized intersections account for the local side streets that are along the corridor. Potential conflict areas are likely caused by prohibited turning movements at signalized and unsignalized intersections.

Major/minor/local arterials in the north-south direction parallel to 7th Street include:

- 12th Street a half mile to the east;
- 16th Street a-mile to the east;
- Central Avenue a half mile to the west; and
- 7th Avenue a mile to the west.

Table 3-2 – 7th Street: Street Classification Summary

Major Arterials	Collector Streets	Signalized Intersections	Unsignalized Intersections
7	16	20	63

In addition to the signalized intersections identified above, the intersection of 7th Street and Oak Street has a pedestrian HAWK signal. Operations of the HAWK signal are the same as those on 7th Avenue. This HAWK will be upgraded to a full signal in the future with the Oak Street Project between 3rd Street and State Route (SR) 51. Evaluation of this signal was not included in the scope of this project.

3.3. Regional Significance of Reversible Lanes

In close proximity to the Study Area are Interstate 17 (I-17) to the west and SR 51 to the east. Both freeways run parallel to the 7th Avenue and 7th Street reversible lane corridors. The initial implementation of the reversible lanes began in 1979; the City converted the center two-way left turn lane into a reversible lane between McDowell Road and Northern Avenue along 7th Avenue. Shortly after, the City converted the center two-way left turn lane on 7th Street to a reversible lane in 1982. The reversible lanes added through traffic capacity while reducing cut through traffic in the surrounding neighborhoods resulting from the congestion during peak hours. Currently, both I-17 and SR 51 experience high volumes of traffic during peak periods which causes traffic congestion. Due to this, drivers will seek alternative routes to travel to and from downtown Phoenix. Existing footprints of both I-17 and SR 51 prevent the expansion which provides a rationale to improve the reversible lane corridors. Improvements to the reversible lane corridors will help mitigate traffic congestion along the existing highway network and provide drivers with alternative, yet time efficient routes.

4.0 Relevant Studies

Reversible lanes have been utilized by transportation and traffic engineers for the past 80 years to redirect heavy flows of traffic at certain times of day or during certain occasions. In the late 1970s, Phoenix, Arizona, became one of the first cities to implement reversible lanes to mitigate unbalanced traffic volumes during peak hours. These corridors are typically accompanied by complex roadway signage and multiple traffic lights throughout the corridor. At times, they can provide flexibility in the segment location because the hours of reverse lane operation can be adjusted to better suit the demand of traffic volume.

Reversible lanes have been used to target high directional congestion, mitigate event traffic at stadiums, or in case of emergencies (flood cases for hurricanes). The overall outcomes of reversible lanes should be to, at its maximum efficiency, reduce congestion by borrowing lanes during peak hours, postpone the need to construct additional lanes to meet volume demand, and hasten evacuation during unexpected weather conditions.

Reversible lanes have been most successful on existing roadways with at least two lanes in each direction where the traffic volumes are split, at a minimum of 65 percent in one direction at a given time frame. Reversible lanes are incorporated into existing roadway networks where the initial design of the road previously did not meet the capacity requirements.

In 2007, the Phoenix City Council asked the Street Transportation Department to evaluate the operations of the reversible lanes and analyze project traffic conditions. Concerns arose from business owners along the corridors who expressed that business was negatively impacted due to limited left turn access points during peak hours. For the scope of the study, four alternatives were considered:

1. Maintain reverse lane operation;
2. Remove reverse lanes;
3. Keep reverse lanes and modify to add overhead flashing beacons or lane control devices; and
4. Test the removal of the reverse lane on 7th Avenue for one year.

As a result of the 2007 study, in 2010, the City published a Reverse Lane Study for 7th Avenue and 7th Street. The analysis examined traffic crash history, capacity, and other operational characteristics. Study findings indicated that operations along 7th Avenue and 7th Street were safe compared to similar arterial streets in the central Phoenix area. There was no supporting evidence that crash data differed significantly from surrounding streets. Travel times are relatively the same surrounding alternative northbound and southbound traffic routes. In addition, the reverse lane during peak hour operations carries a substantial amount of traffic on both 7th Avenue and 7th Street. Future growth (from 2007 to present day and future cases) will likely result in increased congestion and travel delays; removal of the reverse lanes could intensify the traffic congestion during peak hours.

The following sections document implementation of reversible lane strategies and implementation methods across other major Cities in the United States.

4.1. Washington D.C.

In Washington D.C., the reversible lane system operates with reliable signal barriers to address safety concerns in the highly populated area. The combination of high-level functional architecture, monitoring and controlling components, and evaluation criteria create an effective system of reversible lanes.

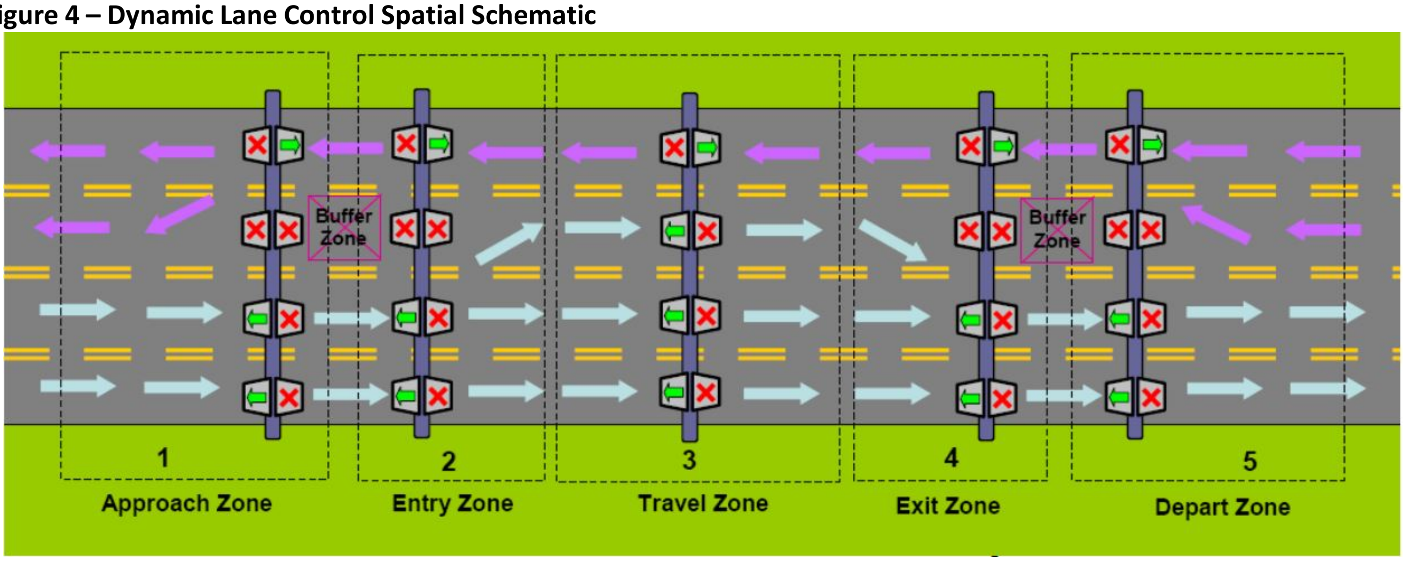
High-Level Functional Architecture utilizes traffic control centers to monitor traffic performance, check timing, and regularly updates data along the corridor. By doing so, it supports continuous monitoring of vehicles utilizing the reversible lane. The unique roadway detectors can detect wrong way vehicles or misuse of the reversible lane during operation hours. At the control centers, roadway signs are monitored and can be changed instantaneously to caution drivers about changes in reverse lane operations. Within the roadway itself, monitoring and controlling components such as inductive loop detectors (roadway sensors and video cameras) and in-pavement LED lights are used to enhance visibility of the direction of the reversible lane. In using the design elements, the city has an effective method of informing drivers of the presence and direction of reversible lane.

4.2. State Route 173, Utah

Along this Utah corridor, there is an imbalance of traffic during the AM and PM travel directions. Utah Department of Transportation (UDOT) identified that flex lanes would ease congestion in the corridor. Flex lanes are synonymous to reversible lanes. During the AM peak hour, there are four lanes traveling eastbound and two lanes traveling in westbound. In the PM peak hour, the roadway configuration is the opposite; four lanes traveling westbound, two lanes traveling eastbound. It also provides a two-way left turn lane. During different peak hour cases, the seven-lane corridor transitioned between different reverse lane and two-way left turn lane configurations. The left most lane in either direction served as a two-way left turn (i.e. during the AM peak hour, there were two westbound lanes, then a two-way left turn lane, next to four eastbound lanes.

Schematic design of spatial transition zones was identified during the design phases of this corridor. ***Figure 4*** depicts a sample progression of dynamic lane control signs during reversible lane operations. The timing plans associated with the displays were engineered based on reversible lane operation time frames. The State Route 173 corridor accounts for a buffer zone during transition periods to allow drivers to adjust to the changes in lane control when necessary.

Figure 4 – Dynamic Lane Control Spatial Schematic



Source: Reversible Lanes in Utah – Adding Efficiency Safely (Proceedings of 2010 Transportation Association of Canada Annual Conference)

4.3. Charlotte, North Carolina on Tyvola Road

The reversible lanes system was implemented prior to the Charlotte Coliseum opening in 1987 but was rebuilt in 1998 and is used to accommodate the traffic demand associated with special events. A five-lane road was constructed with three reversible lanes so that four lanes could be used before and after events. It uses overhead signals in order to direct traffic at the coliseum for traffic to flow more smoothly. It is considered one of the most technologically sophisticated systems in the United States. Obtained from the 2000 NCHRP Synthesis 340: Convertible Roadways and Lanes, ***Figure 5*** displays the dynamic lane control signs placed on overhead mast arms within the corridor.

Figure 5 – Reversible Lane on Tyvola Road, Charlotte, NC

4.4. Louisville, Kentucky on Bardstown Road

Bardstown Road is a major arterial feeding Downtown Louisville that has reversible lanes for 2½ miles. Southbound traffic leaving Downtown Louisville is restricted to one lane during the morning rush hour with northbound traffic having the same restriction during the evening rush hour. Electronic signs over the roadway alert motorists to the traffic flow dedication of each lane.

4.5. Covington, Kentucky on the Clay Wade Bailey Bridge

The Clay Wade Bailey Bridge is a cantilever bridge that carries US Route 42 and 127 across the Ohio River which connects Cincinnati, Ohio to Covington, Kentucky. It is 675 feet wide and has three lanes which use the center lane as a reversible lane to be used during heavy traffic flow in the appropriate direction of flow.

5.0 7th Avenue Overview

5.1. Roadway Characteristics and Infrastructure

7th Avenue is a six-lane arterial road with posted speeds of 35 mph between McDowell Road and Missouri Avenue and 40 mph between Missouri Avenue and Northern Avenue. The roadway consists of two southbound lanes, three northbound lanes, and a reversible lane. The reversible lane operates from McDowell Road to Northern Avenue. When the reversible lane is not in operation, the lane is used as a two-way left turn lane. The light rail crosses at the intersection of Camelback Avenue and 7th Avenue.

The reversible lane operates as an additional southbound lane from 6 to 9 AM. Between 4 and 6 PM, the reversible lane operates as an additional northbound lane. At most signalized intersections, northbound and southbound left turns are prohibited during reversible lane operations. During certain hours of operations, northbound and southbound left turns are permitted at signalized intersections. At McDowell Road, left turns are permitted on all approaches. At Encanto Boulevard, northbound left turns are permitted during the PM peak period (4-6 PM). At Earll Drive, southbound left turns are permitted during the AM peak period (6-9 AM). At Campbell Avenue, northbound left turns are permitted during the PM peak hour and southbound left turns are permitted during the AM peak hour. At Camelback Road, northbound left turns are permitted during the PM peak hour and southbound left turns are permitted during the AM peak hour. At Northern Avenue, northbound and southbound left turns are permitted during the PM peak hour. Note that east and west lane configurations do not change during peak or off-peak hours. Left turns in the southbound and northbound directions are generally allowed at unsignalized intersections and to businesses adjacent to the corridor.

The Study Area is entirely in the jurisdictions of the City. The City operates and maintains all signalized intersections along this corridor. Along 7th Avenue between McDowell Road and Indian School Road, the existing land use is primarily residential with some open space and educational to the west and some commercial and medical to the east. Between Indian School Road and Camelback Road, the existing land use is primarily commercial and residential. North of Camelback Road, the existing land use is predominantly residential.

In the future, some land use along Camelback Road and east of 7th Avenue from McDowell Road to Camelback Road shifts to mixed use. This shift might reduce auto dependency for travel as the area is served by light rail and transit. The existing and future land use of the Study Area is shown in ***Figure 6*** and ***Figure 7***.

Figure 6 – 7th Avenue Existing Land Use

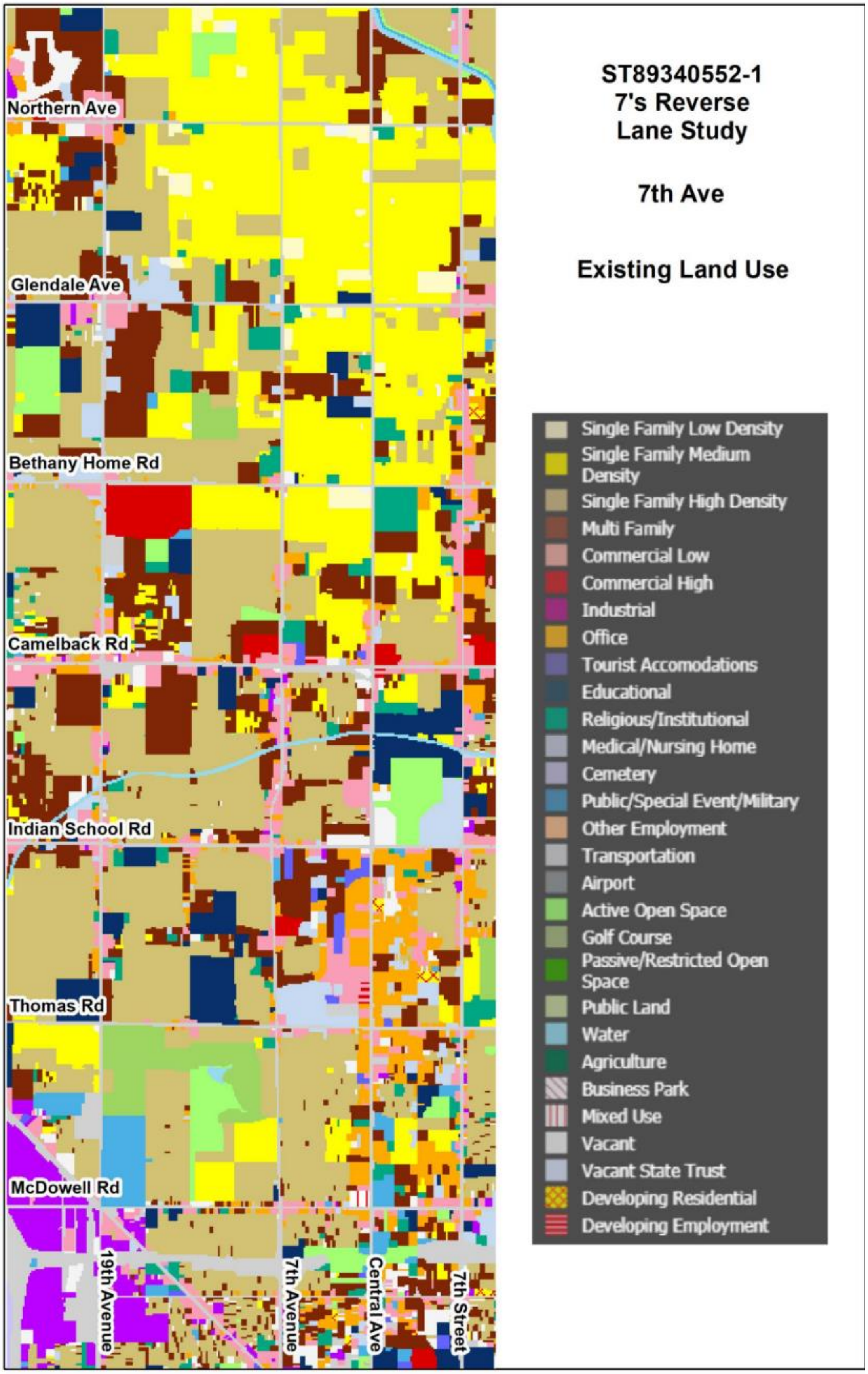
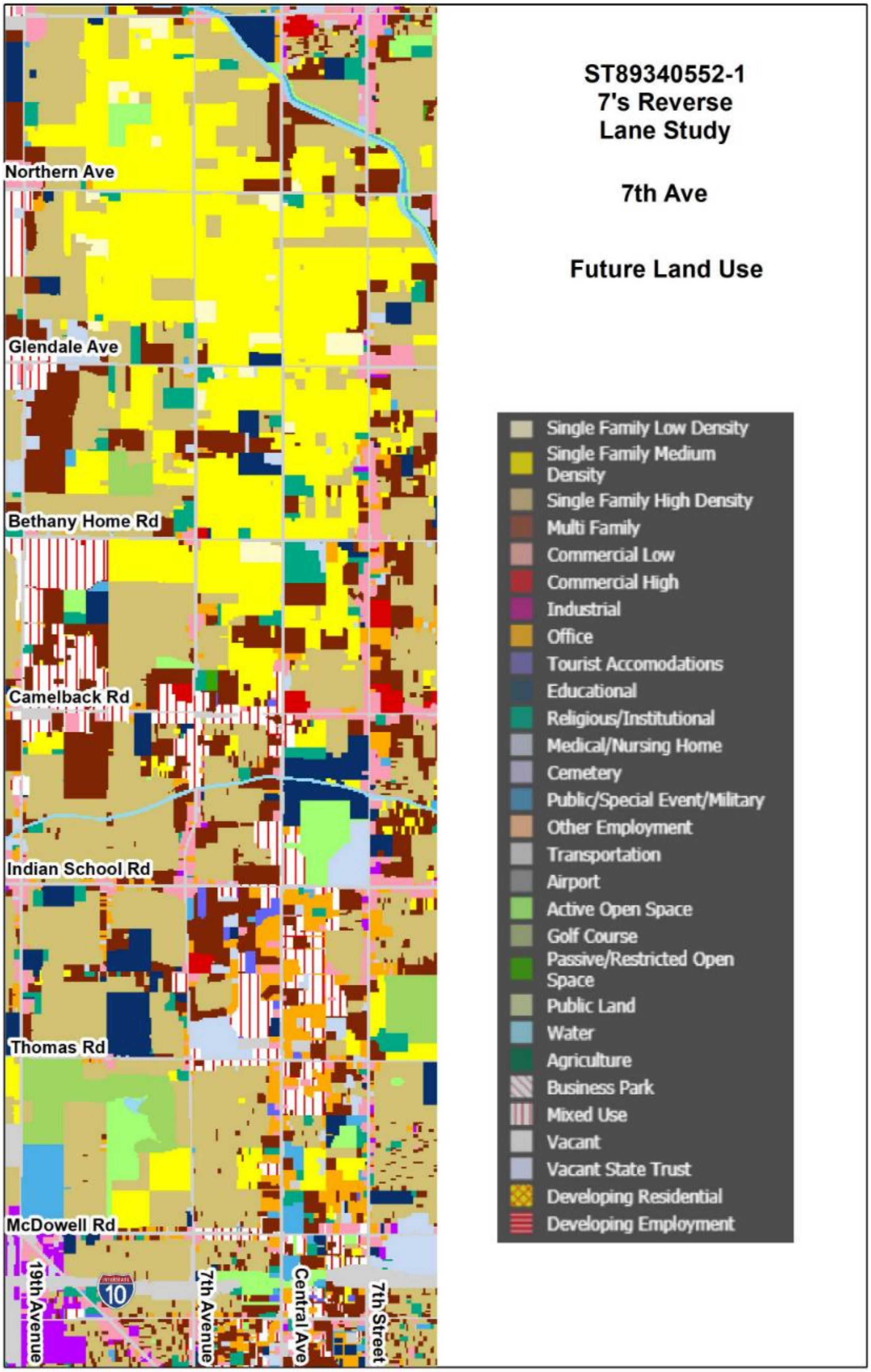


Figure 7 – 7th Avenue Future Land Use



5.2. Traffic Signal Timing Plans

Traffic signal timing plans were provided by the City for signalized intersections within the Study Area. The traffic signal timing plans can be found in ***Appendix C.*** The plans were used to perform the existing conditions analysis.

5.3. Existing Traffic Volumes

Existing turning movement count data were collected at 13 Study Area locations on November 27, 2018, with count data for Camelback Road collected on November 29, 2018. Count locations are shown in ***Figure 8***. Counts were collected for 6 hours: from 6:30 AM to 8:30 AM, from 11 AM to 1 PM and from 4 PM to 6 PM. The northbound through movements in the PM peak hour are greater than the southbound through movements in the AM peak hour. The 2018 peak hour turning movement counts collected for the Study Area are shown on ***Figure 9.*** As mentioned in **Section 5.1**, left turns are prohibited at signalized intersections during the peak periods. However, left turn movements were observed at these locations. These left turn maneuvers reduce the intersection capacity in the peak hours. More detailed traffic count data is included in ***Appendix E***.

The turning movement counts were used to derive 24-hour traffic volumes along the corridor. ***Figure 10*** shows the existing annual average daily traffic (AADT) for the Study Area corridor.

Existing daily traffic volumes along 7th Avenue within Study Area extents along the corridor; AADT ranges between approximately 35,000 and 62,000 vehicles per day. The highest AADT is near the middle of the corridor at Indian School Road. The AADT increases south to north between McDowell Road and Indian School Road, then the AADT decreases from south to north between Indian School Road and Northern Avenue. The AADT is directionally skewed towards northbound.

Figure 8 – 7th Avenue Turning Movement Count Locations

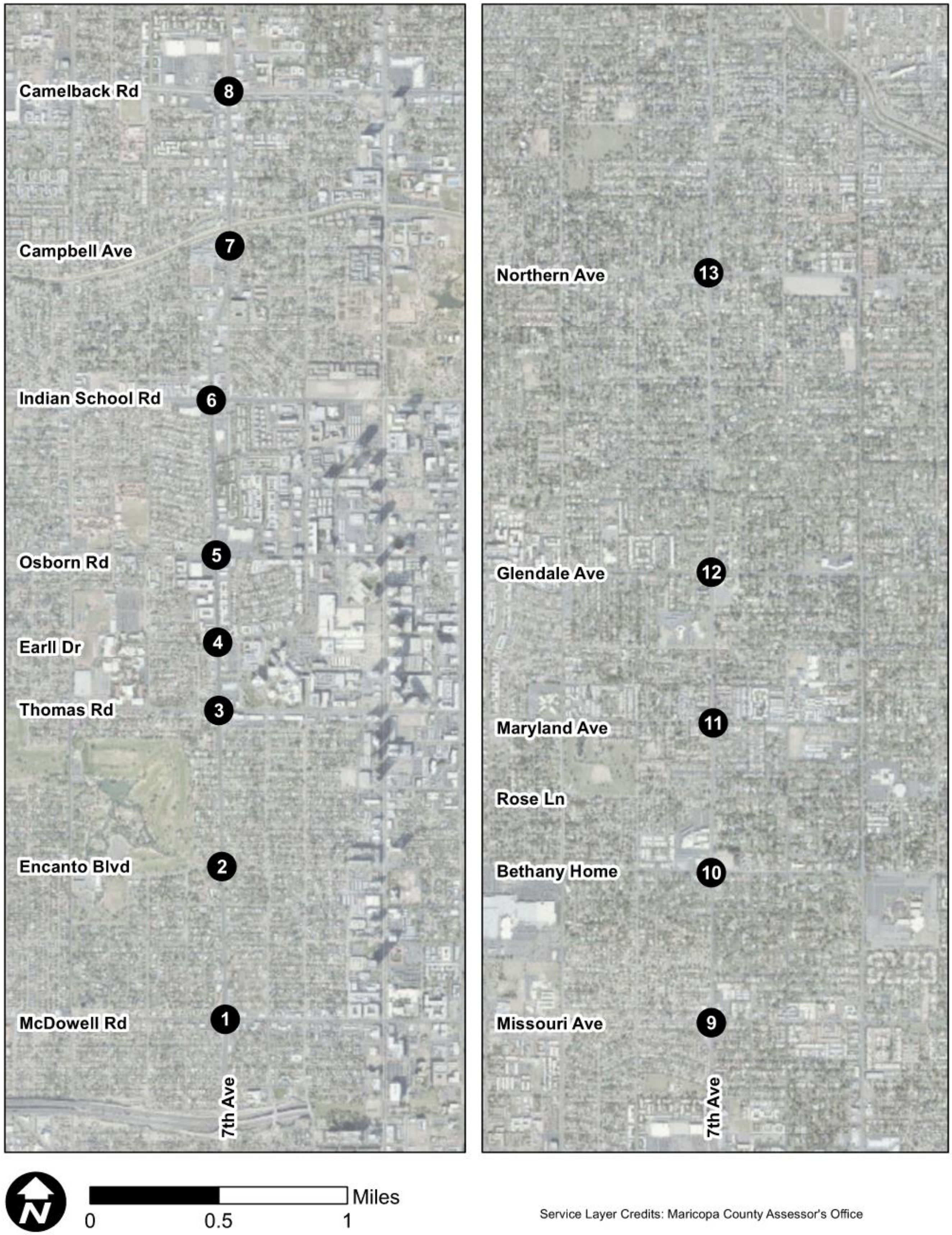
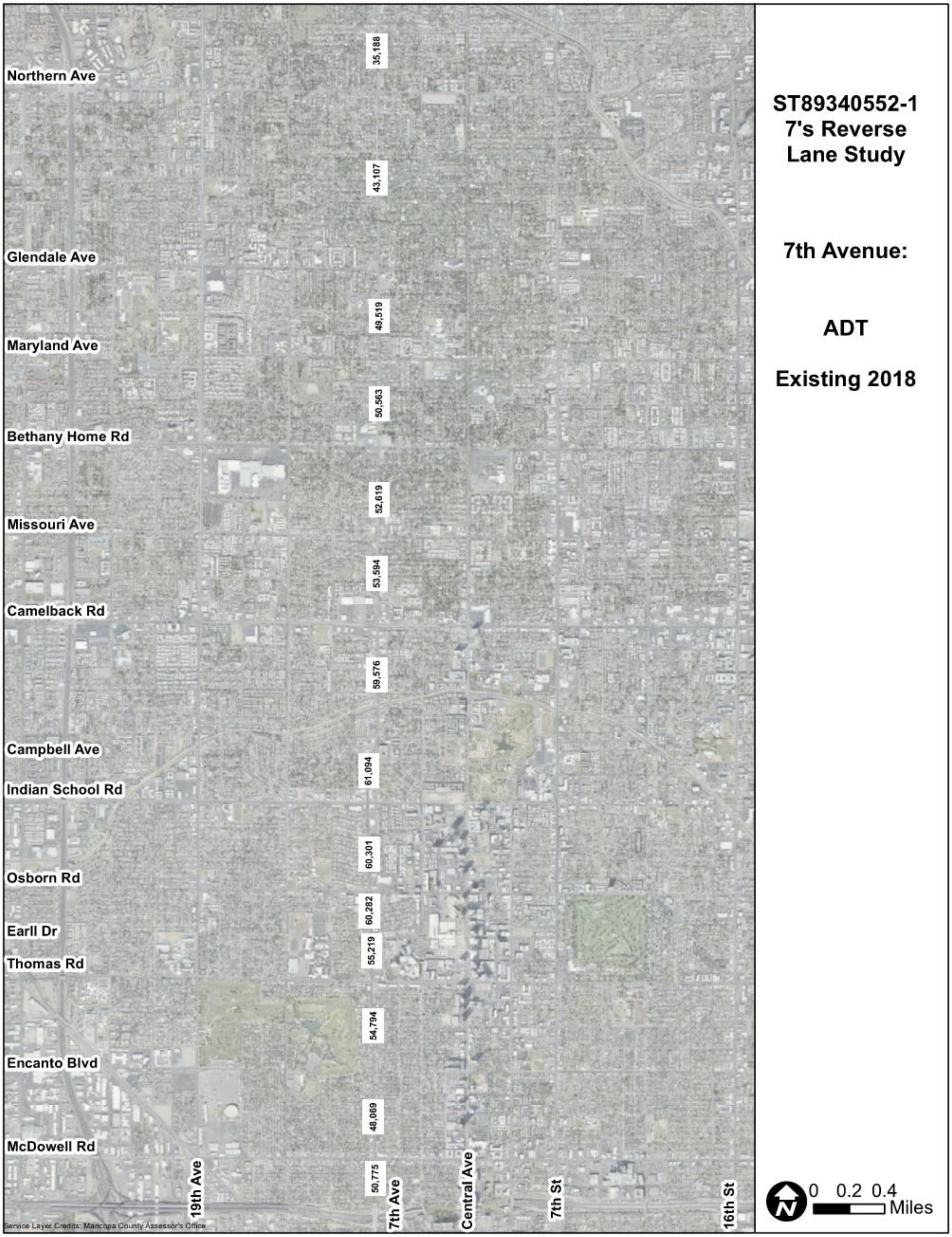


Figure 9 – 7th Avenue Existing Turning Movement Counts

Figure 10 – 7th Avenue Existing Traffic Volumes



5.3.1. INRIX Data Analysis

The corridor experiences two traditional peaks representing commuter traffic and a mid-day peak representing commercial traffic. Historic data, prior to the shelter-in home orders, was examined from the INRIX database for 7th Avenue. The posted speed limited along 7th Avenue is 35 mph from McDowell Road to Missouri Avenue and 40 mph from Missouri Avenue to Northern Avenue. The travel speeds by time and direction of travel are shown in ***Figure 11***. The graphs depict the average speed during a 24-hour typical weekday case. As shown, the speeds are generally less than that of the posted speed even during off-peak hours possibly due to narrow lanes and side street friction. In both the northbound and southbound directions, there is a notable travel speed reduction in both peak periods. The travel time by time and direction of travel are shown in ***Figure 12*** and the planning time by time and direction of travel are shown in ***Figure 13***. The decrease in travel speeds along 7th Avenue causes an increase in travel time and planning time. In the northbound direction, there is an increase in travel and planning time during both peak periods. In the southbound direction, there is also a notable increase in travel and planning time in both peak periods.

Figure 11 – 7th Avenue Travel Speeds by Direction of Travel

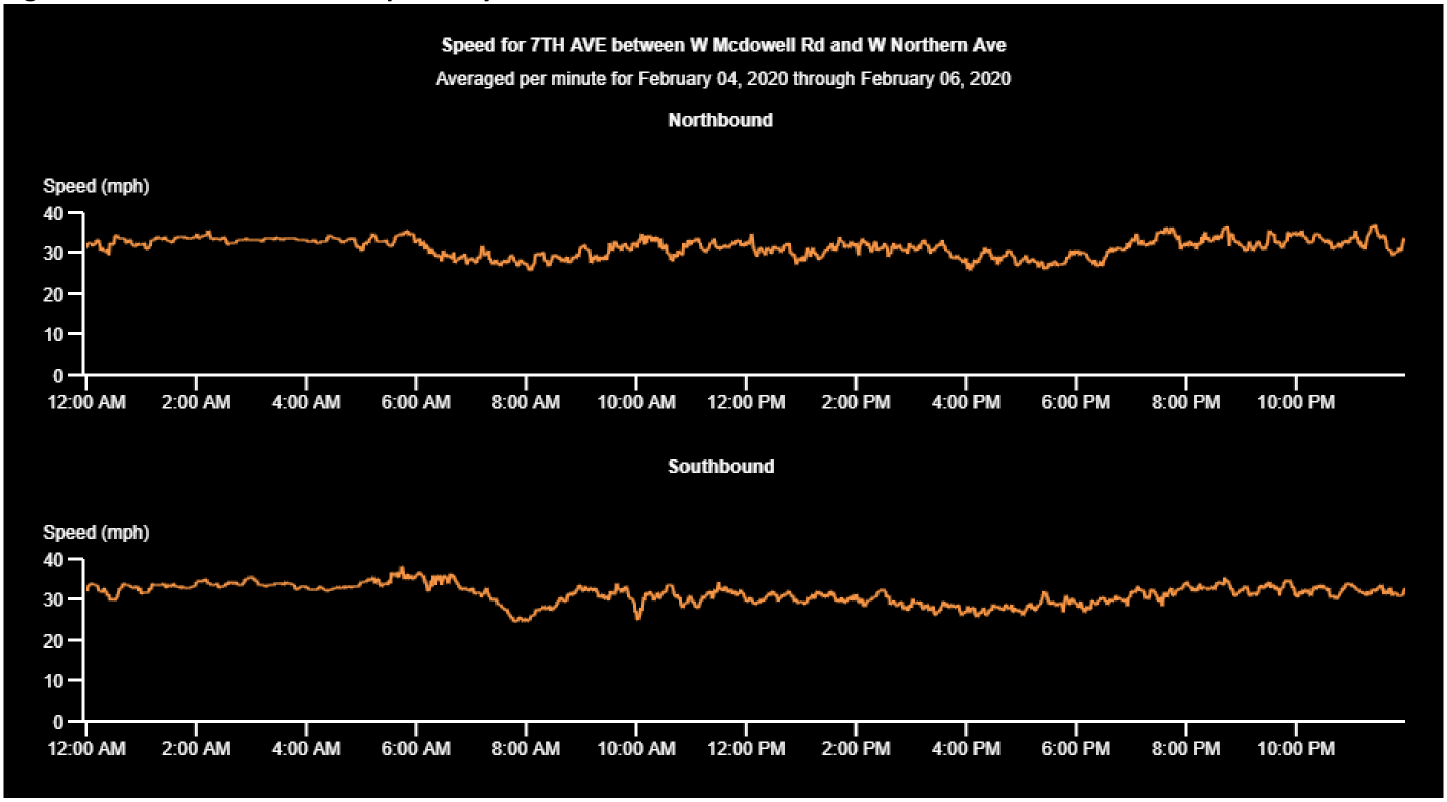


Figure 12 – 7th Avenue Travel Time by Direction of Travel

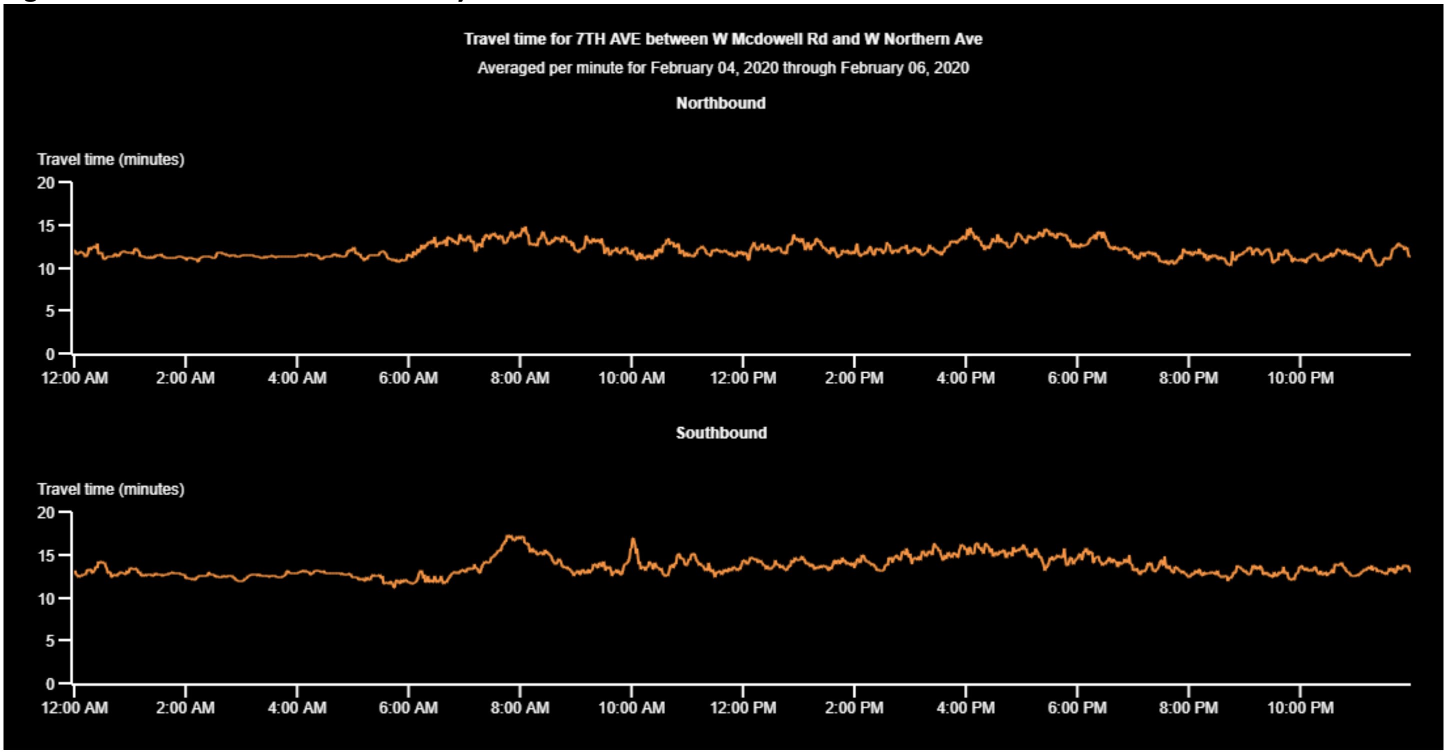
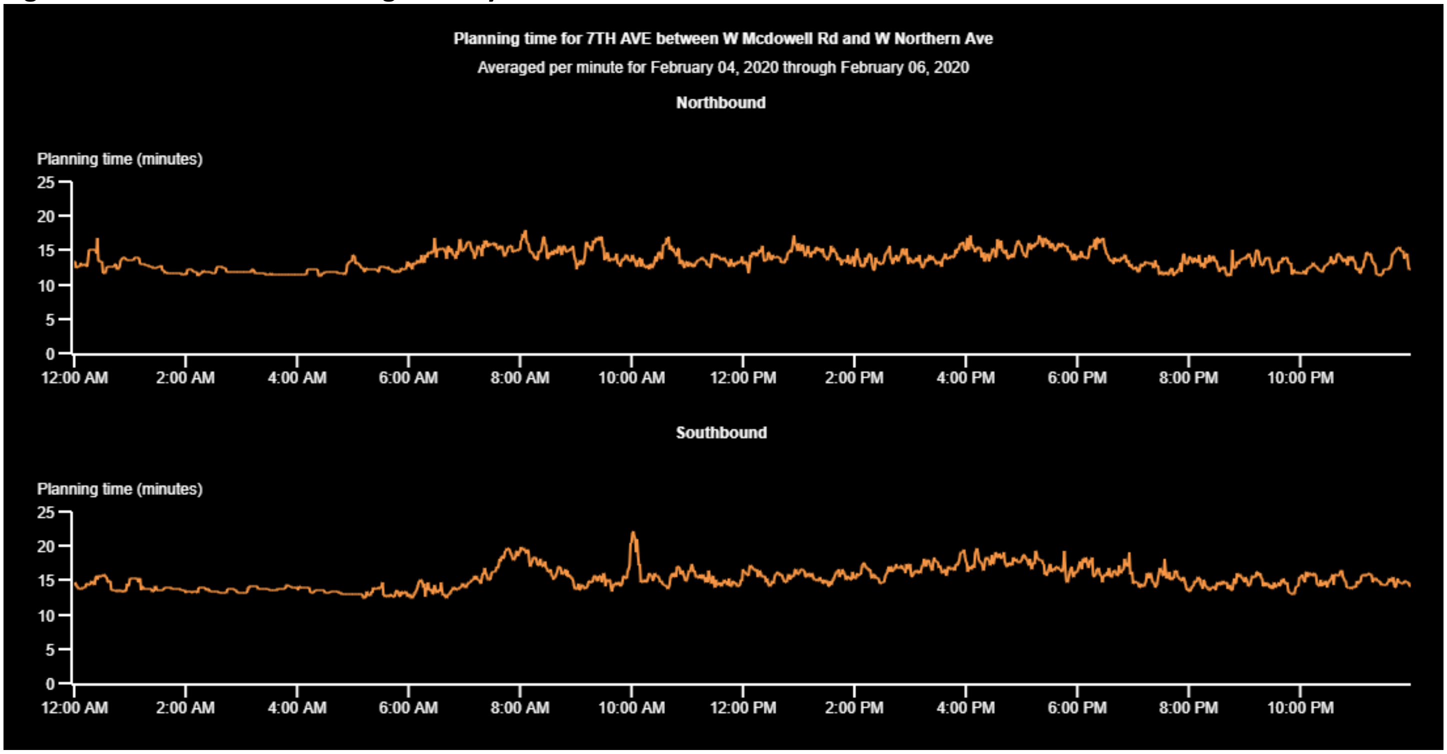


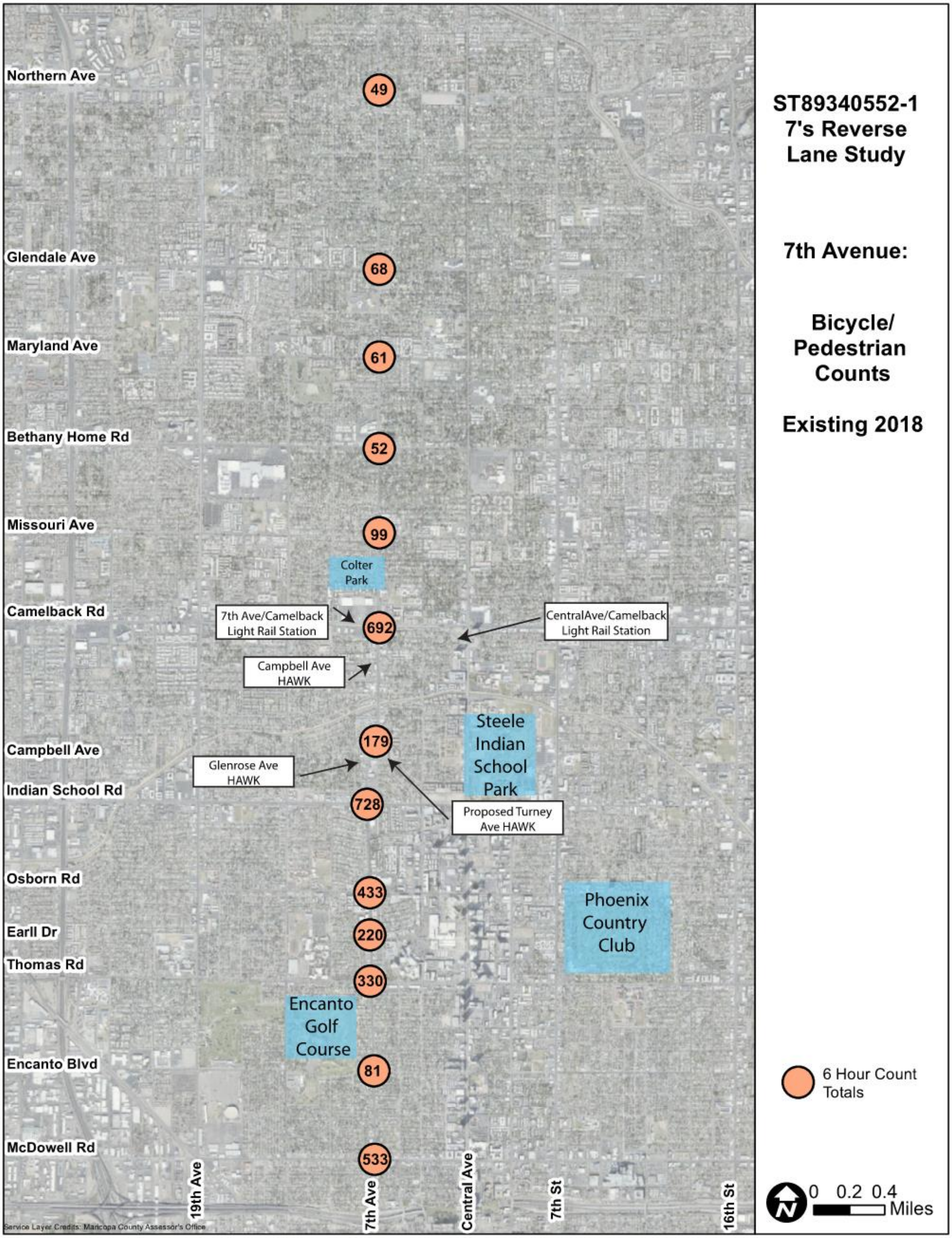
Figure 13 – 7th Avenue Planning Time by Direction of Travel



5.4. Bicycle and Pedestrian Counts

Existing bicycle and pedestrian count data were collected at 15 Study Area locations on November 27, 2018, with count data for Camelback Road collected on November 29, 2018. Counts were collected for 6 hours: from 6:30 AM to 8:30 AM, from 11 AM to 1 PM and from 4 PM to 6 PM. The Study Area experiences a high bicycle and pedestrian volume. Frequent pedestrian actuations at signalized intersections can reduce vehicular throughput and reduce capacity of the overall intersections. In the study corridor, pedestrian push buttons are available at minor collector streets. Therefore, the high pedestrian demand will not result in reduced capacity due to actuations. Higher peak hour travel demand combined with pedestrian activity increases the potential for pedestrian related crashes in the Study Area. The 6-hour bicycle and pedestrian counts collected for the Study Area are shown on ***Figure 14***.

Figure 14 – 7th Avenue Bicycle and Pedestrian Counts at Crosswalks



5.5. Transit Service

The Study Area is serviced by the Valley Metro Rail and Local Bus systems. Metro Valley Local Bus Route 8 runs directly along 7th Avenue as far south as Baseline Road and as far north as Dunlap Avenue and operates seven days a week. During weekdays, it operates with approximately a half-hour frequency from 4:00 AM to 1:00 AM. Hours of operation extend later on Friday evenings. Passengers may board the bus routes at designated bus stops. Bus Route 8 along the study corridor primarily has "in lane" bus stops, with a few "pull out" bus stops, as shown in ***Table 5-1***. When a bus stops at an "in lane" bus stop, a lane of traffic is not operational for a few minutes. In that time, the vehicular throughputs are reduced significantly.

Table 5-1 – 7th Avenue Route 8 Bus Stop Locations

Transit Stop Location	NB Stop Location	SB Stop Location
7th Avenue and McDowell Road	In Lane	Pull Out
7th Avenue and Palm Lane	In Lane	In Lane
7th Avenue and Encanto Boulevard	In Lane	In Lane
7th Avenue and Virginia Avenue	In Lane	In Lane
7th Avenue and Thomas Road	Pull Out	In Lane
7th Avenue and Earll Drive	In Lane	In Lane
7th Avenue and Osborn Road	In Lane	Pull Out
7th Avenue and Indianola Avenue/Clarendon Avenue	In Lane	In Lane
7th Avenue and Indian School Road	In Lane	In Lane
7th Avenue and Glenrosa Avenue	In Lane	Pull Out
7th Avenue and Campbell Avenue	In Lane	In Lane
7th Avenue and Highland Avenue/Elm Street	In Lane	In Lane
7th Avenue and Camelback Road	In Lane	In Lane
7th Avenue and Colter Road	In Lane	In Lane
7th Avenue and Missouri Avenue	In Lane	In Lane
7th Avenue and Luke Avenue	In Lane	-
7th Avenue and Montebello Avenue/Solano Drive	In Lane	In Lane
7th Avenue and Bethany Home Road	In Lane	In Lane
7th Avenue and Rose Lane	In Lane	In Lane
7th Avenue and Maryland Avenue	In Lane	In Lane
7th Avenue and Ocotillo Road	In Lane	In Lane
7th Avenue and Glendale Avenue	In Lane	In Lane
7th Avenue and Myrtle Avenue	In Lane	In Lane
7th Avenue and Orangewood Avenue/Vista Avenue	In Lane	In Lane
7th Avenue and Frier Drive	In Lane	In Lane
7th Avenue and Northern Avenue	In Lane	In Lane

Within the Study Area, the noted transit Route 8 overlaps with Valley Metro Local Bus Routes 17, 29, 41, 50, 60, 70, 80, and 90. Bus Route 0 runs parallel to Bus Route 8 along Central Avenue as far south as Dobbins Road and as far north as Dunlap Avenue. Bus Route 0 operates with approximately a half-hour frequency from 4:00 AM to 1:30 AM. During peak travel periods, the bus route frequency increases. Hours of operation extend later on Friday evenings. Passengers may board the bus routes at designated bus stops.

The Valley Metro Rail extends from the intersection of 19th Avenue and Dunlap Avenue to the intersection of Gilbert Road and Main Street. The Valley Metro Rail travels eastbound and westbound along Camelback Road west of Central Avenue then travels along Central Avenue within the Study Area. The Valley Metro Rail operates during weekdays with approximately a 15-minute frequency from 3:30 AM to 1:20 AM. Hours of operation extend later on Friday evenings. Passengers may board the Valley Metro Rail at designated rail stations.

The Central Avenue and Camelback Road Park and Ride (PNR) is within the Study Area. In the current condition, the Central Avenue and Camelback Road PNR can be accessed via two driveways. The driveway connecting to 3rd Avenue is a full access drive while the driveway connecting to Camelback Road allows right in/right out access. The 7th Avenue and Camelback Road PNR is also within the Study Area. This PNR can be accessed by two right in/right out driveways connecting to Camelback Road.

Sunnyslope Multi Access Residential Transit (SMART), a free neighborhood circulator service provided by Phoenix Public Transit, operates within the Study Area towards the north. SMART intersects with 7th Avenue at Hatcher Road, runs parallel to Central Avenue between Hatcher Road and Mountain View Road, and intersects 7th Street at Alice Avenue, Hatcher Road, and Mountain View Road. SMART operates during weekdays with a 35-minute frequency from 6:00 AM to 6:45 PM. Passengers may board SMART at designated bus stops and in “Flag Stop” zones.

6.0 7th Street Overview

6.1. Roadway Characteristics and Infrastructure

7th Street is a six-lane arterial road with posted speeds of 35 mph between McDowell Road and Missouri Avenue, 40 mph between Missouri Avenue and Butler Drive, and 35 mph between Butler Drive and Dunlap Avenue. The roadway consists of two southbound lanes, three northbound lanes, and a reversible lane. The reversible lane operates from McDowell Road to Dunlap Avenue. When the reversible lane is not in operation, the lane is used as a two-way left turn lane.

The reversible lane operates as an additional southbound lane from 6 to 9 AM. Between 4 and 6 PM, the reversible lane operates as an additional northbound lane. At most signalized intersections, northbound and southbound left turns are prohibited during reversible lane operations. During certain hours of operations, northbound and southbound left turns are permitted at signalized intersections. At McDowell Road, left turns are permitted on all approaches. Note that east and west lane configurations do not change during peak or off-peak hours. Left turns in the southbound and northbound directions are generally allowed at unsignalized intersections and to businesses adjacent to the corridor.

The Study Area is entirely in the jurisdictions of the City. The City operates and maintains all signalized intersections along this corridor. Between McDowell Road and Indian School Road, the existing land use is primarily commercial/office to the west and residential to the east. Between Indian School Road and Bethany Home Road, the land use consists of commercial, educational, and some residential. From Bethany Home Road to Northern Avenue, the land use is predominantly residential with some commercial. Between Northern Avenue and Dunlap Avenue, the land usage is commercial and residential. In the future, the land use west of 7th Street shifts to mixed use. This shift might reduce auto dependency for travel as the area is served by light rail and transit. The existing and future land use of the Study Area is shown in ***Figure 15*** and ***Figure 16***.

Figure 15 – 7th Street Existing Land Use

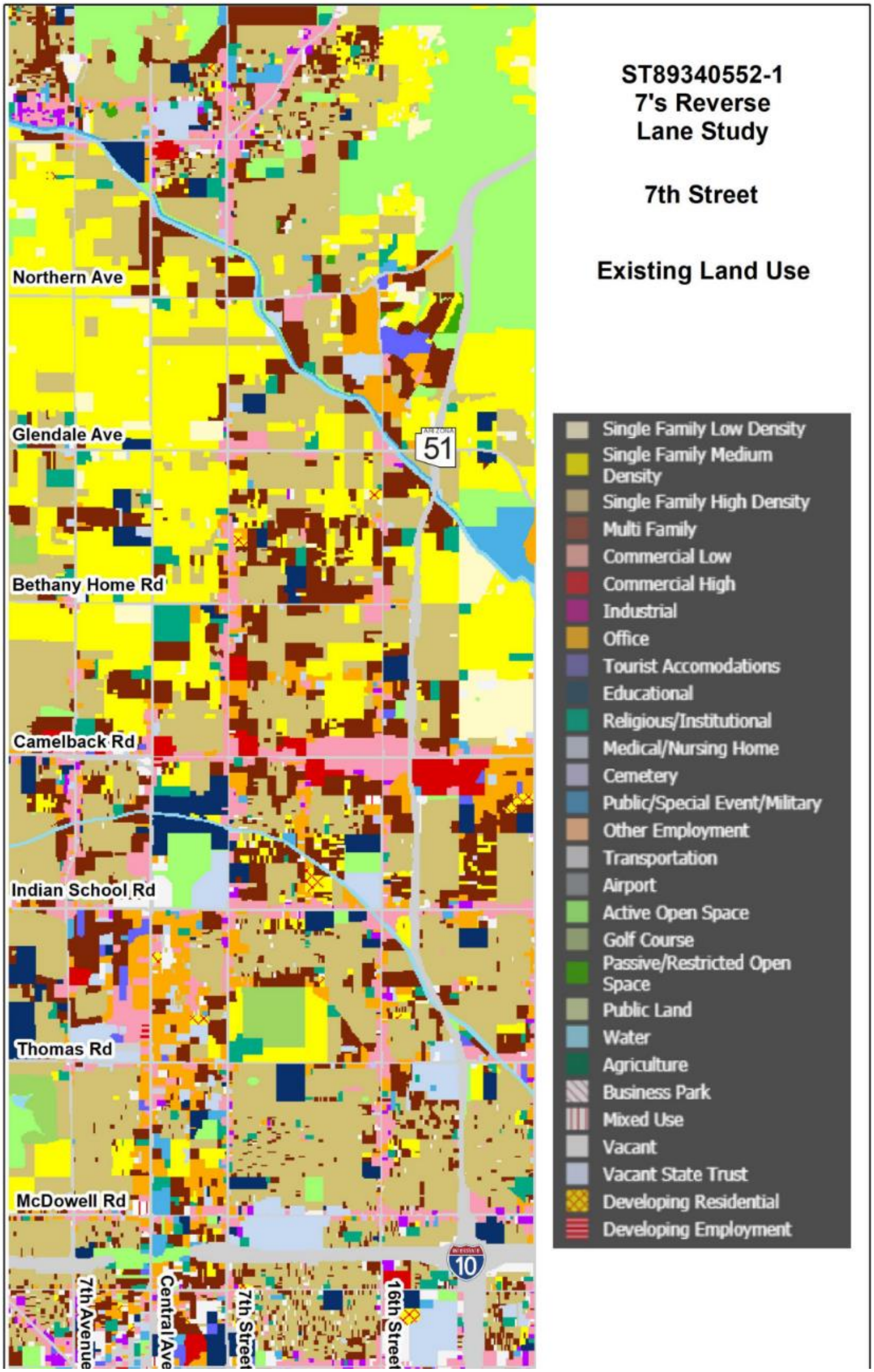
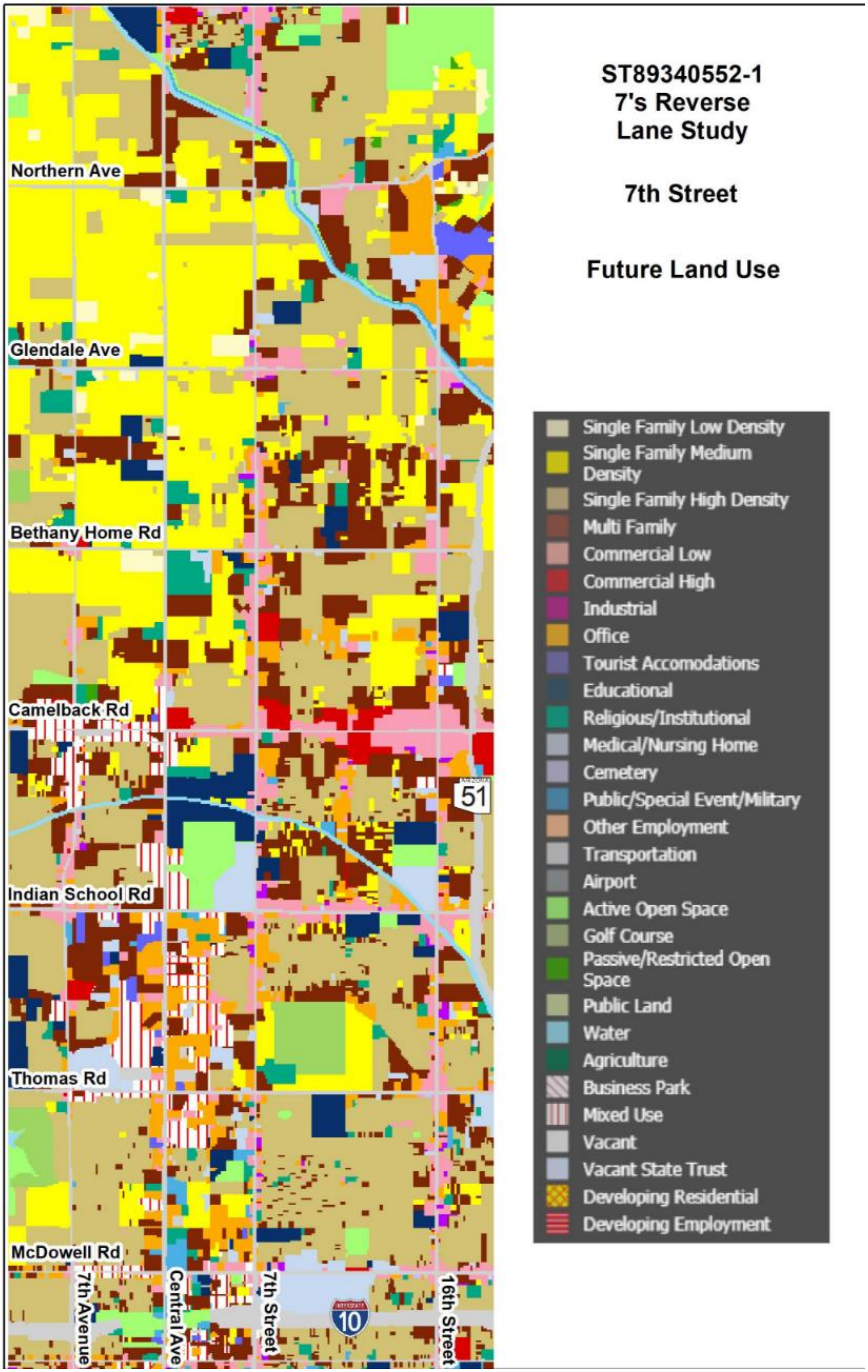


Figure 16 – 7th Street Future Land Use



6.2. Traffic Signal Timing Plans

Traffic signal timing plans were provided by the City for signalized intersections within the Study Area. The traffic signal timing plans can be found in ***Appendix D.*** The plans were used to perform the existing conditions analysis.

6.3. Existing Traffic Volumes

Existing turning movement count data were collected at 18 Study Area locations on November 29, 2018, with count data for Bethany Home Road and Rose Lane collected on November 27, 2018. Count locations are shown in ***Figure 17.*** Counts were collected for 6 hours: from 6:30 AM to 8:30 AM, from 11 AM to 1 PM and from 4 PM to 6 PM. The northbound through movements in the PM peak hour are greater than the southbound through movements in the AM peak hour. The 2018 peak hour turning movement counts collected for the Study Area are shown on ***Figure 18.*** As mentioned in **Section 6.1**, left turns are prohibited at signalized intersections during the peak periods. However, left turn movements were observed at these locations. These left turn maneuvers reduce the intersection capacity in the peak hours. More detailed traffic count data is included in ***Appendix F***.

The turning movement counts were used to derive 24-hour traffic volumes along the corridor. ***Figure 19*** shows the existing AADT for the Study Area corridor.

Existing daily traffic volumes along 7th Street within Study Area extents along the corridor; AADT ranges between approximately 46,000 and 65,000 vehicles per day. The highest AADT is near Highland Avenue, in the middle of the corridor. The AADT increases south to north between McDowell Road and Highland Avenue, then decrease from Highland Avenue to Dunlap Road. Road. A K-factor of 8.0% was used. The AADT is directionally skewed towards northbound.

Figure 17 – 7th Street Turning Movement Count Locations

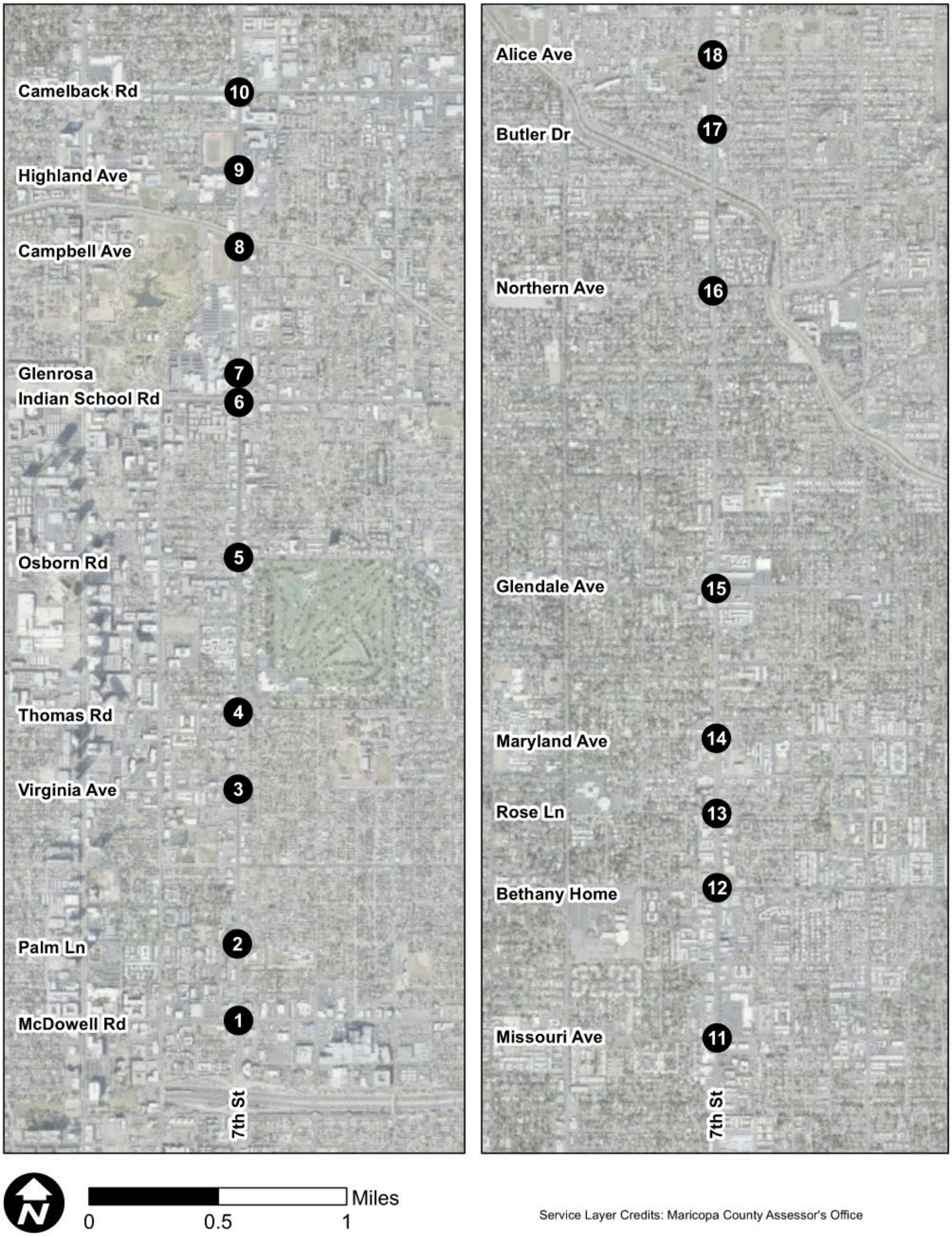
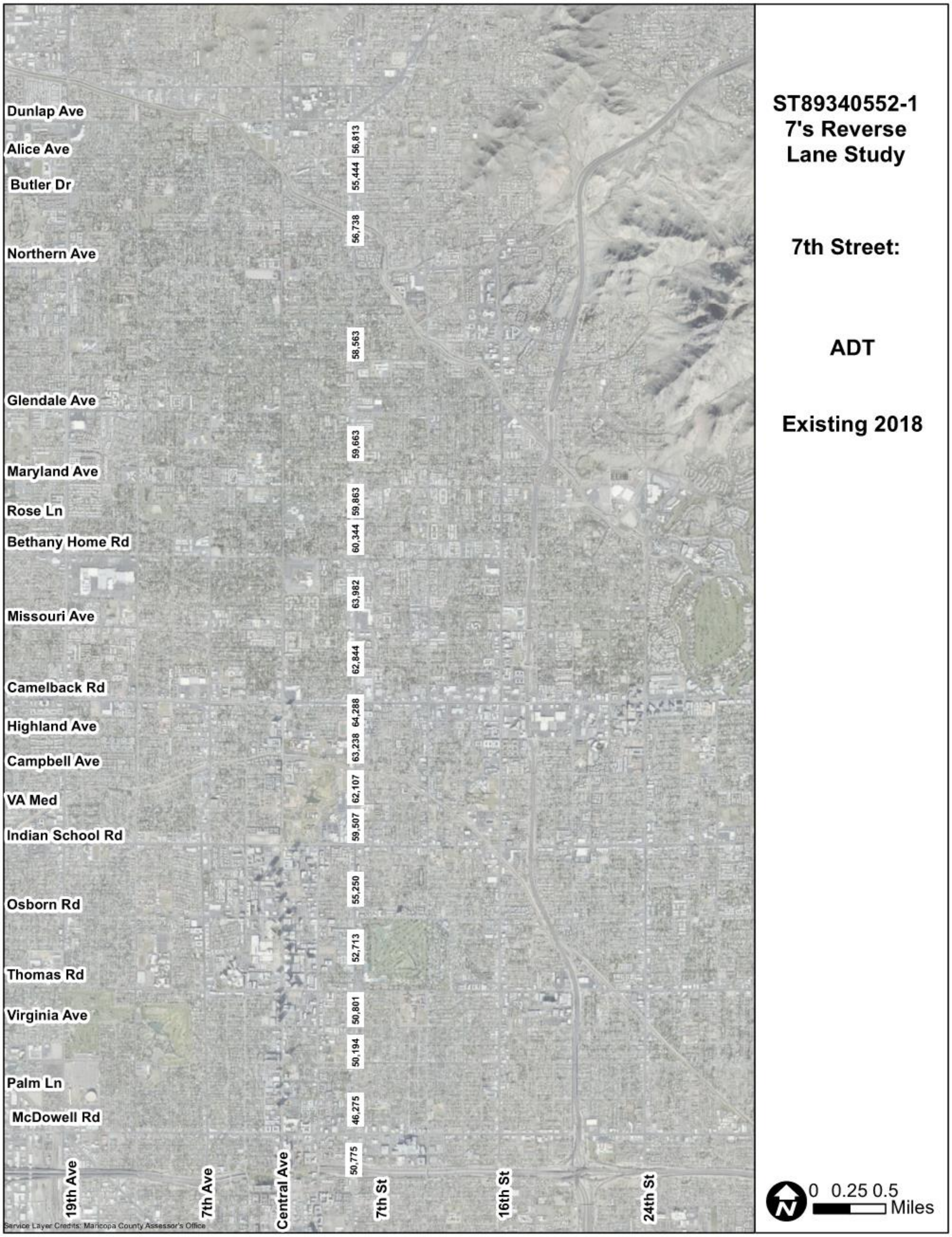


Figure 18 – 7th Street Existing Turning Movement Counts

Figure 19 – 7th Street Existing Traffic Volumes



6.3.1. INRIX Data Analysis

The corridor experiences two traditional peaks representing commuter traffic and a mid-day peak representing commercial traffic. Historic data, prior to the shelter-in home orders, was examined from the INRIX database for 7th Street. The posted speed limited along 7th Street rages from 35 to 40 mph. The travel speeds by time and direction of travel are shown in

Figure 20. The graphs depict the average speed during a 24-hour typical weekday case. As shown, the speeds are generally less than that of the posted speed even during off-peak hours possibly due to narrow lanes and side street friction. In the northbound direction, there is a notable travel speed reduction in the PM peak period. In the southbound direction, there is also a notable travel speed reduction in both peak periods. The travel time by time and direction of travel are shown in ***Figure 21*** and the planning time by time and direction of travel are shown in ***Figure 22***. A decrease in travel speeds along 7th Street causes an increase in corridor travel time and planning time. For vehicles traveling northbound, there is an increase in travel time and planning time during both peak periods due to reduced speeds. Similarly, during southbound traffic, increased travel time and planning time is experienced by vehicle drivers during both peak periods.

Figure 20 – 7th Street Travel Speeds by Direction of Travel

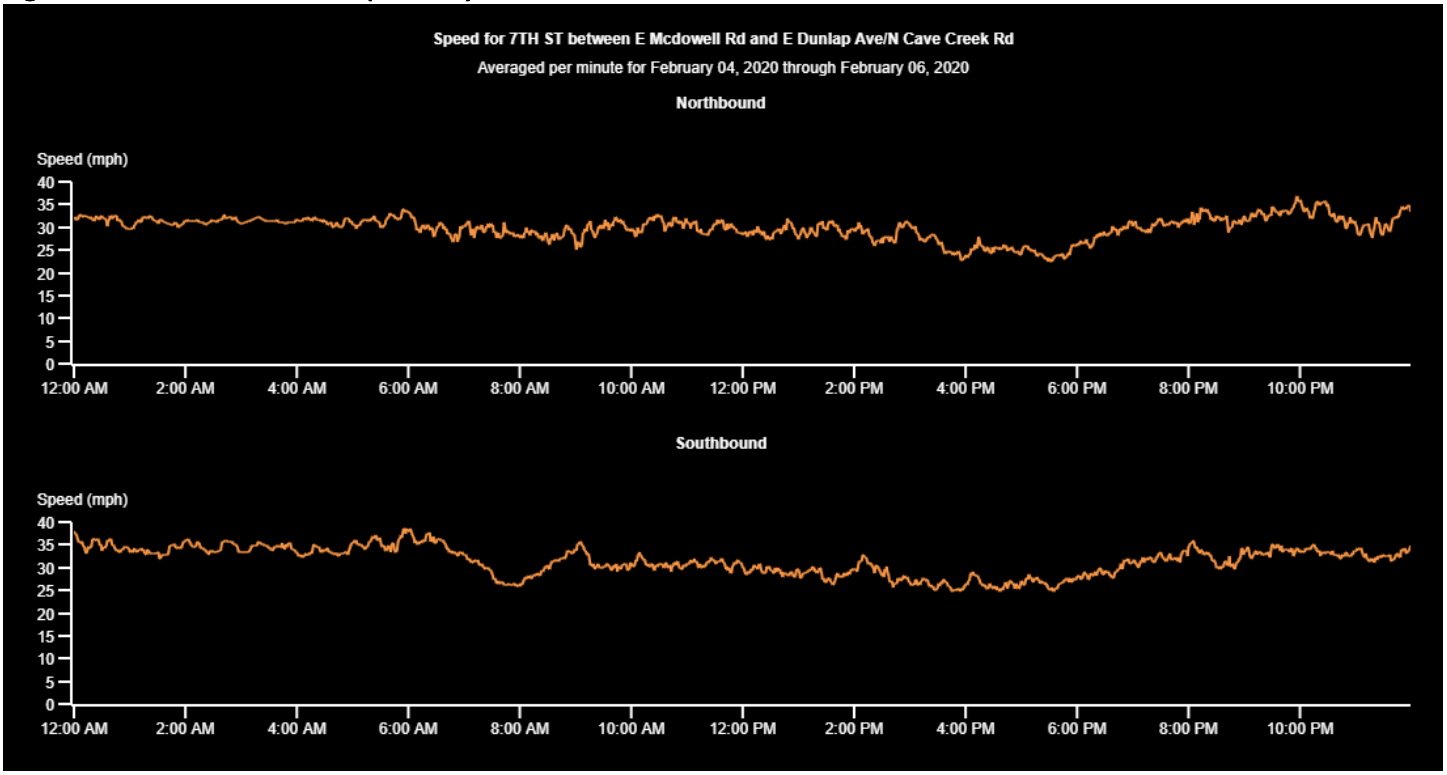


Figure 21 – 7th Street Time of Day Distribution by Direction of Travel

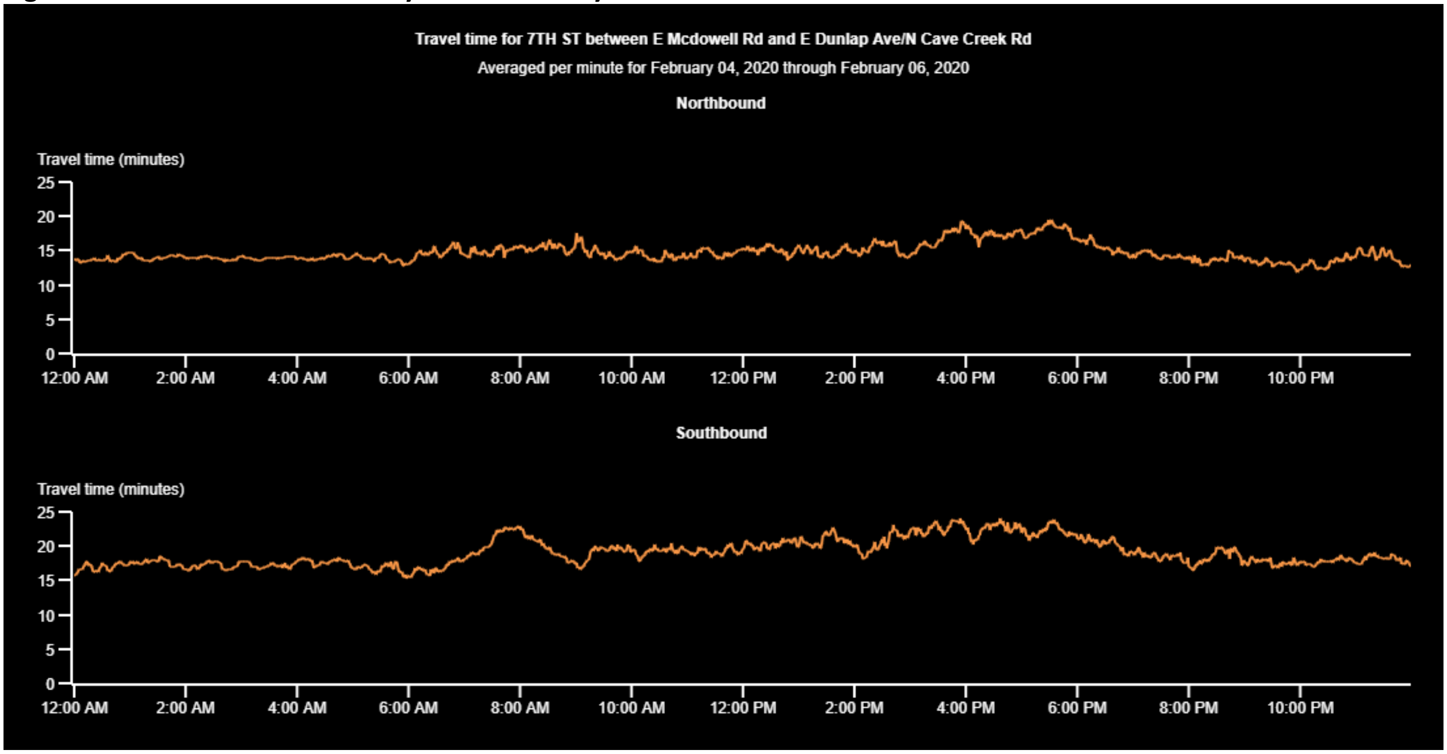
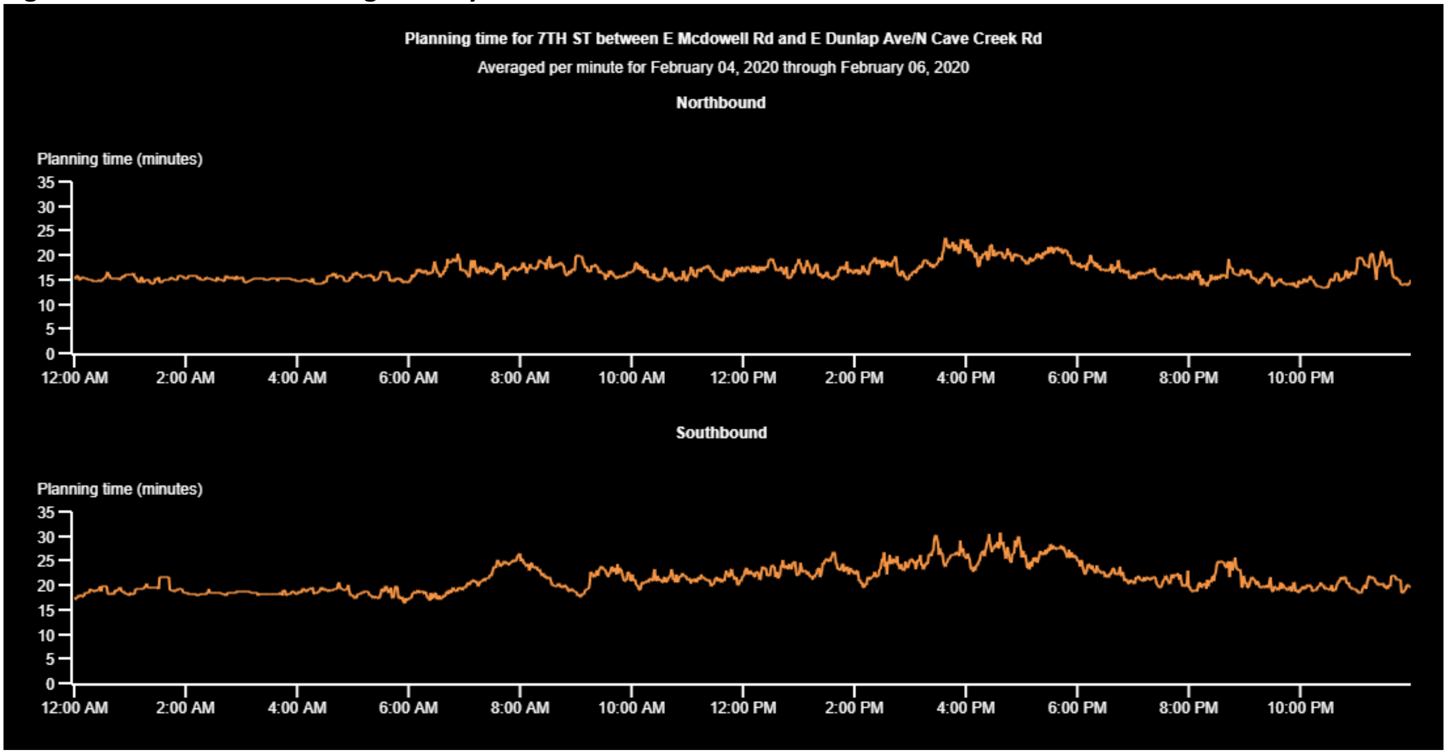


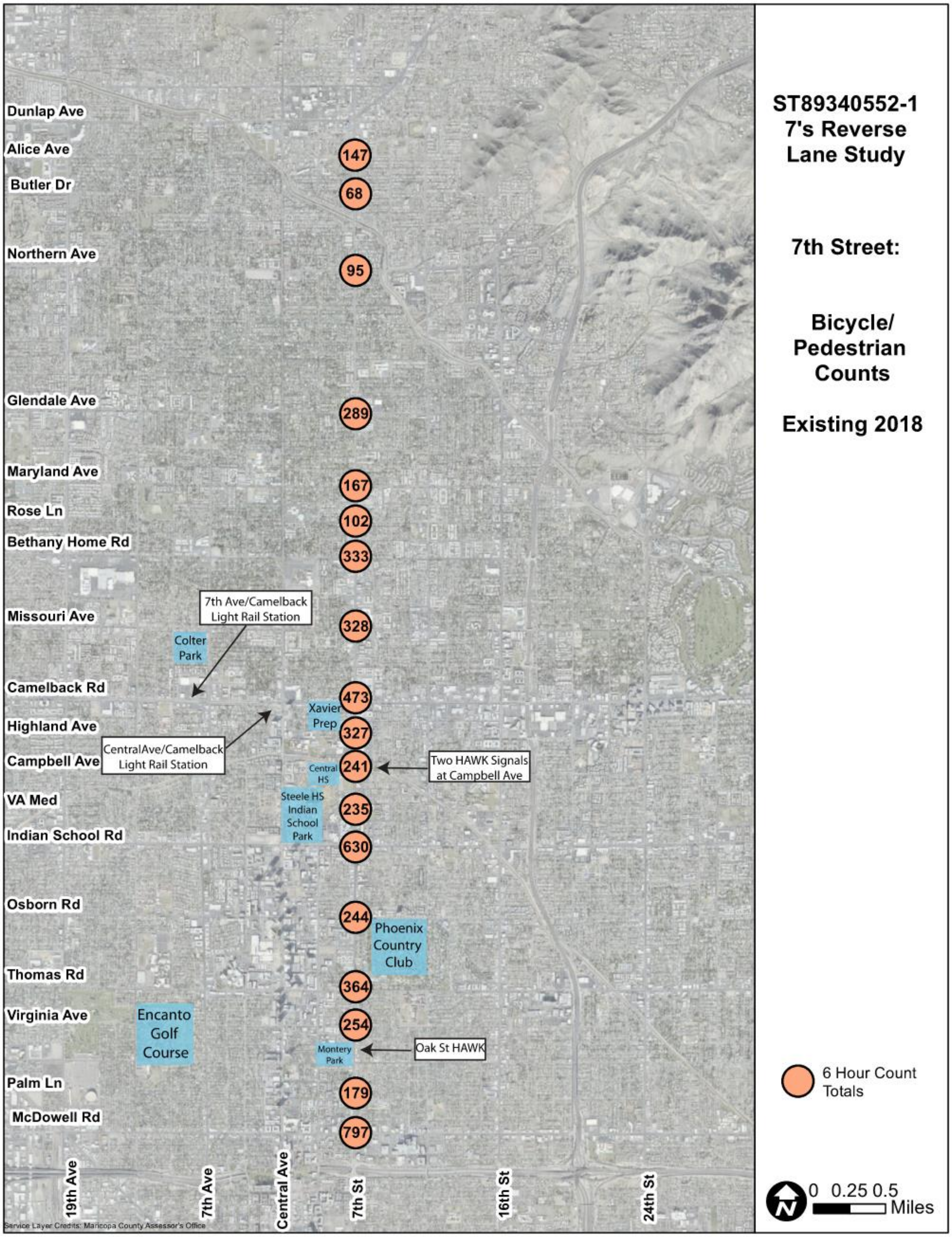
Figure 22 – 7th Street Planning Time by Direction of Travel



6.4. Bicycle and Pedestrian Counts

Existing bicycle and pedestrian count data were collected at 18 Study Area locations on November 29, 2018, with count data for Bethany Home Road and Rose Lane collected on November 27, 2018. Counts were collected for 6 hours: from 6:30 AM to 8:30 AM, from 11 AM to 1 PM and from 4 PM to 6 PM. The Study Area experiences a high bicycle and pedestrian volume. Frequent pedestrian actuations at signalized intersections reduce vehicular throughput and reduce capacity of the overall intersections. In the study corridor, pedestrian push buttons are available at minor collector streets. Therefore, the high pedestrian demand will not result in reduced capacity due to actuations. Higher peak hour travel demand combined with pedestrian activity increases the potential for pedestrian related crashes in the study area. The 6-hour bicycle and pedestrian counts collected for the Study Area are shown on ***Figure 23***. Note that the mid-block HAWK at Oak Street will become a fully signalized intersection in the future.

Figure 23 – 7th Street Bicycle and Pedestrian Counts



6.5. Transit Service

Metro Valley Bus Route 7 runs directly along 7th Street as far south as Dobbins Road and as far north as Deer Valley Road and operates seven days a week. During weekdays, it operates with approximately a half-hour frequency from 4:00 AM to 2:00 AM. During peak travel periods, the bus route frequency increases. Hours of operation extend later on Friday evenings. Passengers may board the bus routes at designated bus stops. Bus Route 7 along the study corridor primarily has "in lane" bus stops, with a few "pull out" bus stops, as shown in ***Table 6-1***. When a bus stops at an "in lane" bus stop, a lane of traffic is not operational for a few minutes. In that time, the vehicular throughputs are reduced significantly.

Table 6-1 – 7th Street Route 7 Bus Stop Locations

Transit Stop Location	NB Stop Location	SB Stop Location
7th Street and McDowell Road	In Lane	Pull Out
7th Street and Granada Road/Palm Lane	In Lane	In Lane
7th Street and Oak Street	In Lane	In Lane
7th Street and Virginia Avenue	In Lane	In Lane
7th Street and Thomas Road	Pull Out	Pull Out
7th Street and Earll Drive	In Lane	In Lane
7th Street and Osborn Road	In Lane	In Lane
7th Street and Weldon Avenue	In Lane	In Lane
7th Street and Indian School Road	Pull Out	In Lane
7th Street and Montecito Avenue/ Devonshire Avenue	In Lane	In Lane
7th Street and Grand Canal/Roma Avenue	In Lane	In Lane
7th Street and Highland Avenue	In Lane	In Lane
7th Street and Camelback Road	In Lane	In Lane
7th Street and Colter Street	In Lane	In Lane
7th Street and Missouri Avenue	In Lane	Pull Out
7th Street and Montebello Avenue	In Lane	In Lane
7th Street and Bethany Home Road	Pull Out	In Lane
7th Street and Rose Lane	In Lane	In Lane
7th Street and Maryland Avenue	In Lane	In Lane
7th Street and Ocotillo Road	In Lane	In Lane
7th Street and Glendale Avenue	In Lane	In Lane
7th Street and Nicolet Avenue	In Lane	In Lane
7th Street and Orangewood Avenue	In Lane	In Lane
7th Street and Belmont Avenue	In Lane	In Lane
7th Street and Northern Avenue	Pull Out	In Lane
7th Street and Corte Oro/ Griswold Road	In Lane	In Lane
7th Street and Butler Drive	In Lane	In Lane
7th Street and Alice Avenue	In Lane	In Lane
7th Street and Townley Avenue	In Lane	-
7th Street and Dunlap Avenue	Pull Out	Pull Out

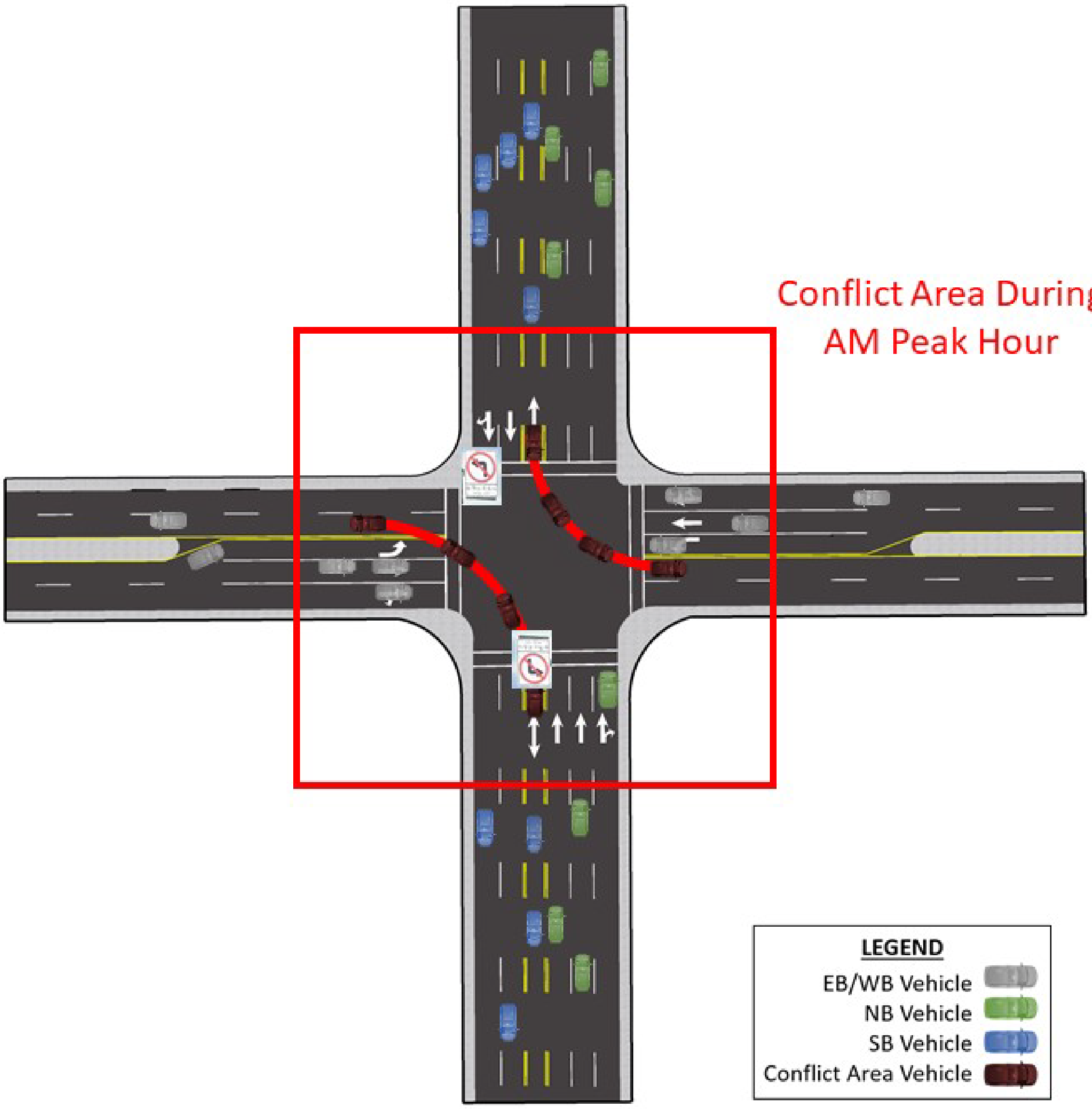
Within the Study Area, the noted transit Route 7 overlaps with Valley Metro Local Bus Routes 17, 29, 41, 50, 60, 70, 80, and 90. The Study Area is also serviced by the Valley Metro Rail and other local bus systems.

7.0 Reversible Lane Conflict Areas

Conflict areas exist when vehicles make prohibited turning movements during reversible lane operations. Conflict areas stem from vehicles turning left at signalized intersections or turning left at any other point along the corridor. ***Figure 24*** through ***Figure 29*** depict movements of vehicles at the mentioned potential conflict areas during the AM peak hour along 7th Avenue and 7th Street. All conflict areas for the corridors can be found in ***Appendix G***. Reversible lane operations are in effect during weekday peak periods, the remaining time periods and weekends the reversible lane acts as a center two-way left turn lane.

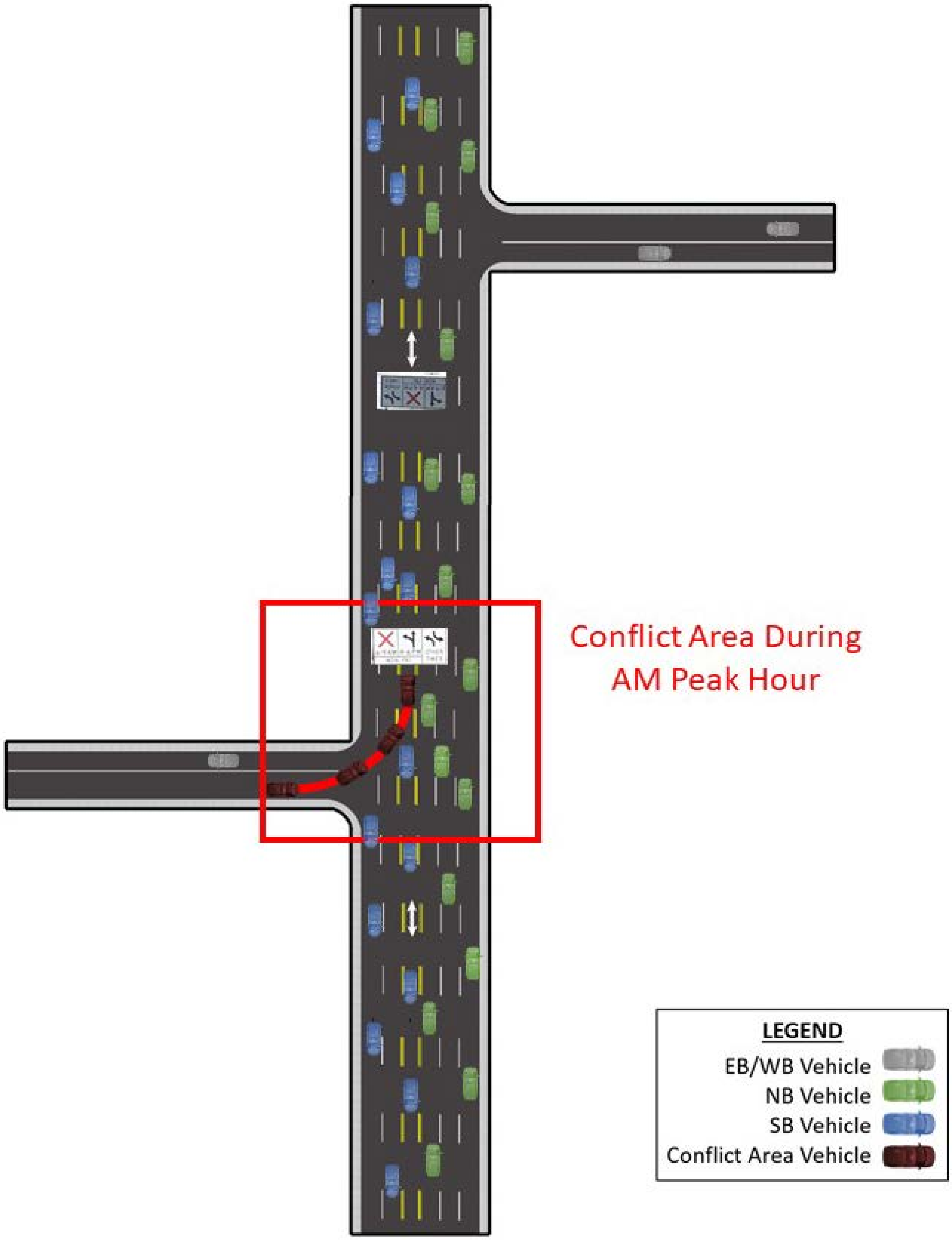
Conflict Area Type 1 exists at signalized intersections along the 7th Avenue and 7th Street corridors. Posted regulatory signs at intersection signal mast arms, with the exception of 7th Avenue and Camelback Road prohibit vehicles turning left from northbound and southbound approaches during reversible lane operations. This conflict area is displayed in ***Figure 24.***

Figure 24 – Conflict Area Type 1



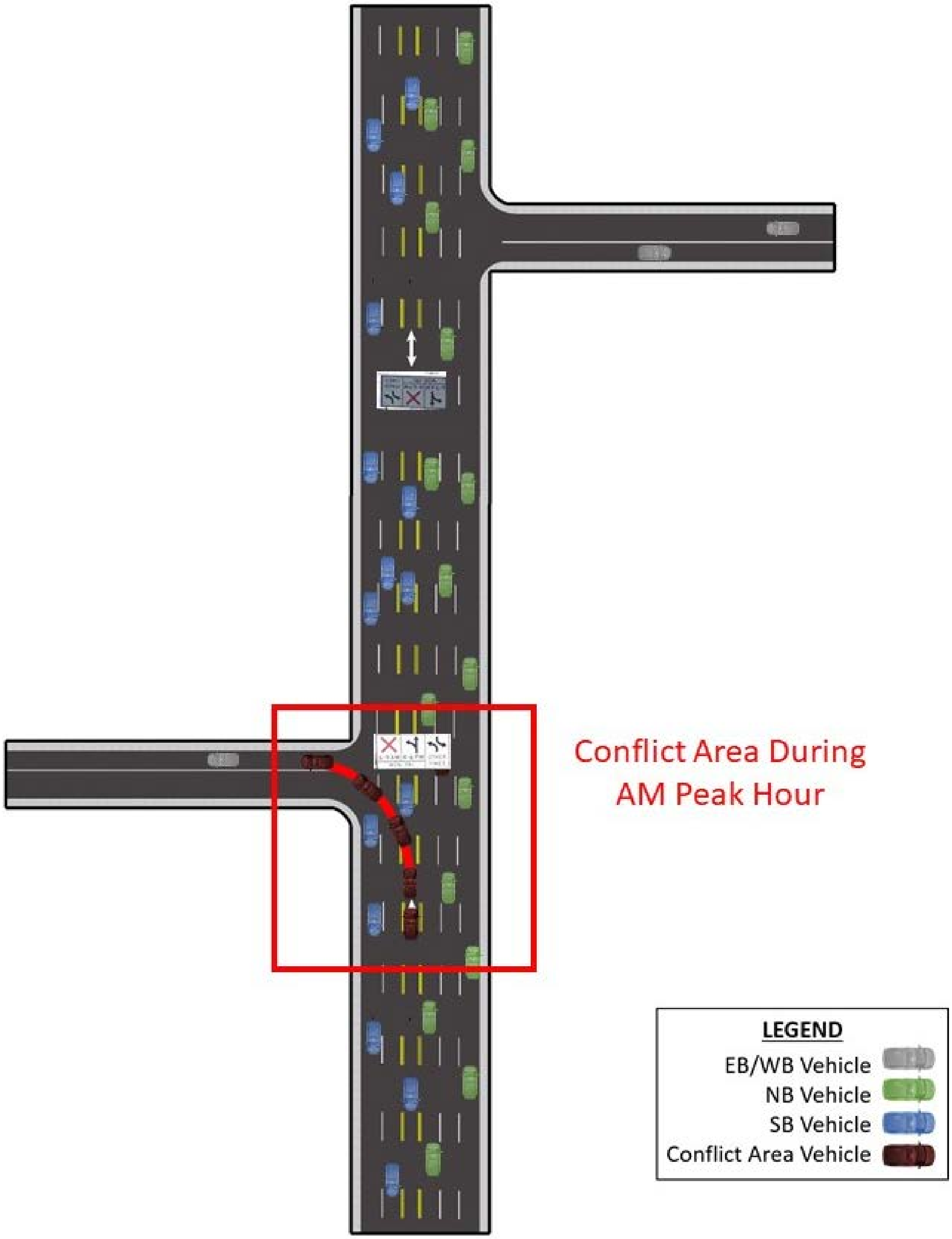
Conflict Area Type 2 exists along the corridor at any access point, in particular local roads or business driveways. Conflict areas shall be considered when vehicles turn left across lanes of traffic during reversible lane operations and use the reversible lane as a stopping point before merging into the flow of travel. As such, this creates the potential for a head-on collision for drivers obeying reversible lane regulations. This conflict area is displayed in ***Figure 25***.

Figure 25 – Conflict Area Type 2



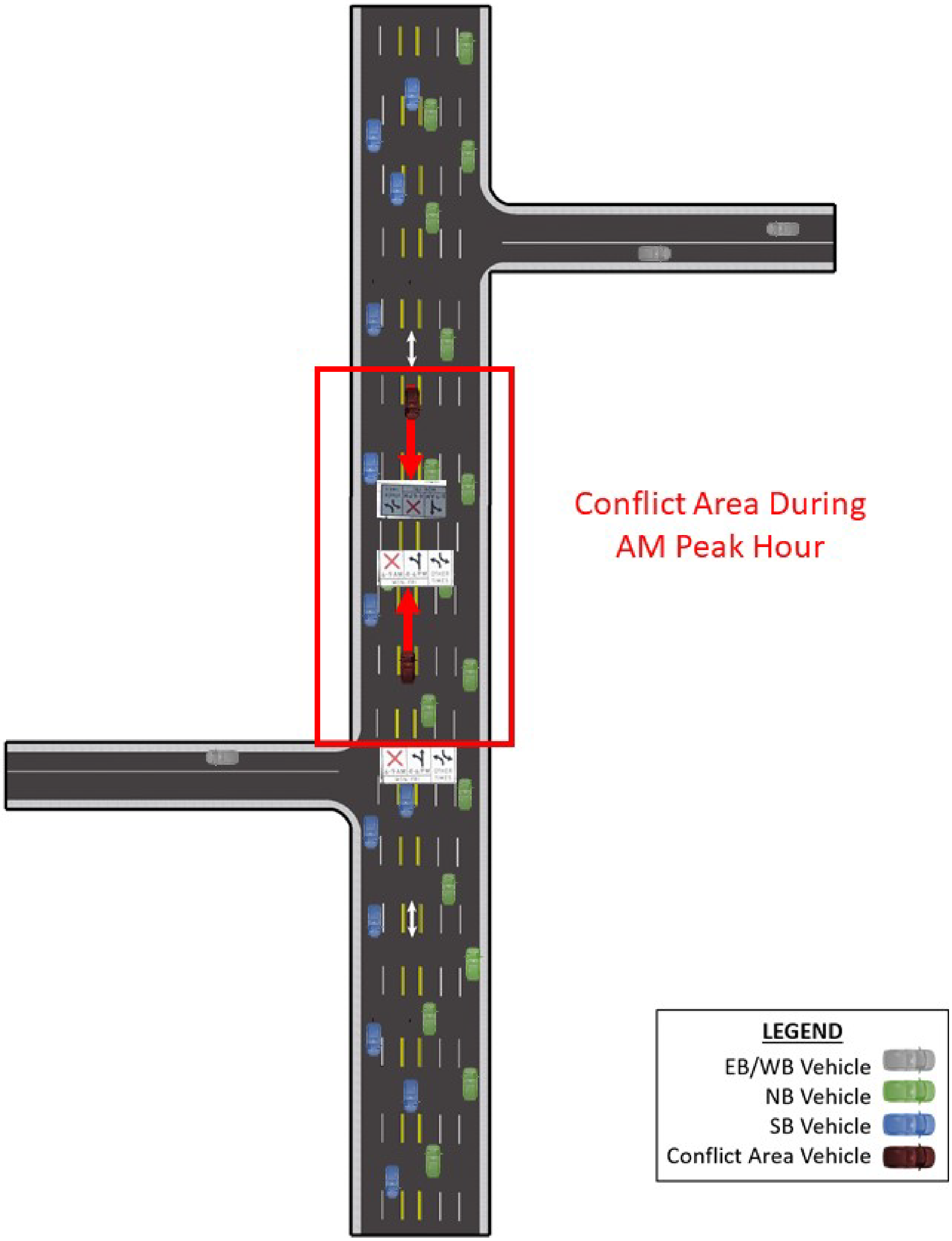
Conflict Area Type 3 considers vehicle drivers treating the reversible lane as only a turn lane to access side street or driveway access points. This conflict area is displayed in ***Figure 26.***

Figure 26 – Conflict Area Type 3



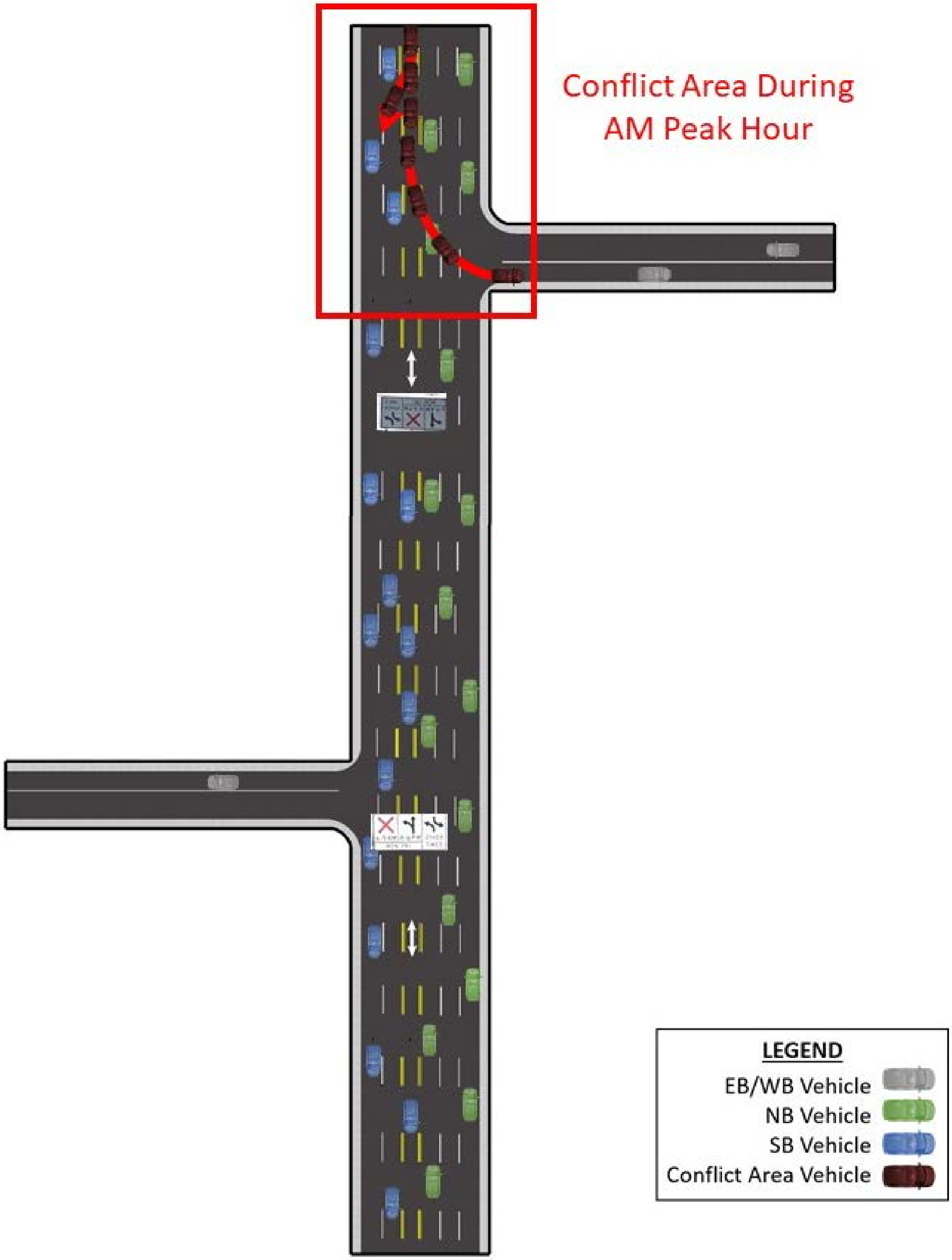
Conflict Area Type 4 combines Conflict Area Types 2 and 3 to account for drivers who are unaware that the reversible lane is in operation. This conflict area was commonly seen during field visits during transition periods (fifteen minutes before and after the posted reversible lane operation time frame). This conflict area is displayed in ***Figure 27***.

Figure 27 – Conflict Area Type 4



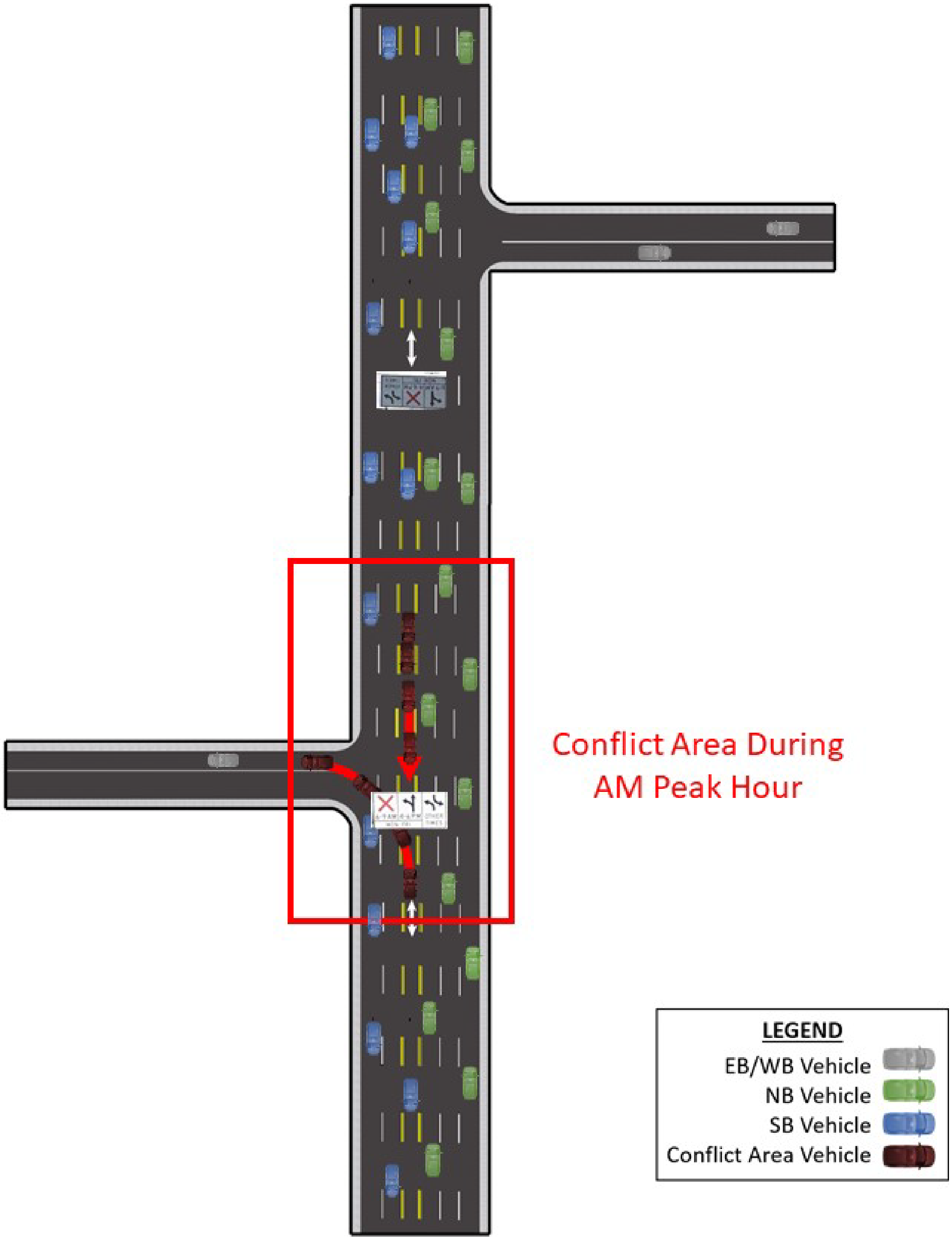
Conflict Area Type 5 is a result of vehicles disobeying reversible lane operations per Conflict Area Type 3. When vehicles use the reversible lane as a center two-way left turn lane, vehicles behind the driver turning left are queued. As a result, queues drivers may signal to change lanes which results in creating unsafe driving conditions on through lanes adjacent to the reversible lanes. This conflict area is displayed in ***Figure 28*.**

Figure 28 – Conflict Area Type 5



Conflict Area Type 6 is a result of driver confusion of reversible lane operations. A conflict area arises when vehicles are traveling in the reversible lane and a vehicle traveling in the opposite direction desires to make a prohibited left turn. This causes a queue of vehicles in the reversible lane, which some may choose to merge to the right. This conflict area is displayed in ***Figure 29.***

Figure 29 – Conflict Area Type 6



8.0 7th Avenue Crash Analysis

Crash data for the five-year period from January 1, 2014, to December 31, 2018, was obtained from the City database. Within this period, a total of 2,262 crashes occurred along 7th Avenue in the Study Area. Crash distribution by year and severity is summarized in ***Table 8-1***. Comparisons to statewide averages for urban areas are offered to provide context to Study Area performance. Statewide crash information was collected from the 2018 Arizona Motor Vehicle Crash Facts (Crash Facts) published by ADOT and was found to have an expected fatal crash distribution of 0.51%, an expected possible injury crash distribution of 26.8%, and an expected no injury crash distribution of 70.8%. These values are used as a baseline for all crash analyses.

Table 8-1 – 7th Avenue Crash Distribution by Year and Severity

Year	Fatal	Incapacitating Injury	Non-incapacitating Injury	Possible Injury	No Injury	Total
2014	1	9	30	69	282	391
2015	0	6	38	90	297	431
2016	1	10	64	78	355	508
2017	1	6	44	74	334	459
2018	2	13	37	75	346	473
Total	5	44	213	386	1,614	2,262
% 7th Avenue	0.22%	1.9%	9.4%	17.1%	***71.4%***	100%
% Statewide Urban Areas	0.51%	28.6%			70.8%	100%

Note: Bold, red, italicized text denotes values exceeding the % statewide urban areas.

Table 8-1 indicates the Study Area experiences a higher proportion of property damage only (PDO) crashes than experienced in urban areas statewide. Crash analysis was performed for both standard operation and reversible lane operation. As previously noted, the reversible lane operates during the peak period for five hours a day. It should be noted this period likely accounts for approximately 32% of average daily trips. Of the 2,262 crashes, 930 (41.1%) occurred while the reversible lane was operational and 1,332 (58.9%) occurred during standard operation. Crash distribution during reversible lane operation by year and severity is summarized in ***Table 8-2;*** standard operation is summarized in ***Table 8-3*** Comparisons are offered to the five-year crash history for 7th Avenue.

Table 8-2 – 7th Avenue Reversible Lane Crash Distribution by Year and Severity

Year	Fatal	Incapacitating Injury	Non-incapacitating Injury	Possible Injury	No Injury	Total
2014	1	2	8	25	104	140
2015	0	1	16	29	143	189
2016	0	1	28	30	154	213
2017	1	2	15	30	144	192

2018	0	3	10	42	141	196
Total	2	9	77	156	686	930
% 7th Avenue RL	0.2%	1.0%	8.3%	16.8%	***73.8%***	100%
% 7th Avenue	0.2%	1.9%	9.4%	17.1%	71.4%	100%
Note: Bold, red, italicized text denotes values exceeding the % of overall crashes on 7th Avenue.						

Table 8-3 – 7th Avenue Standard Operation Crash Distribution by Year and Severity						
Year	**Fatal**	**Incapacitating Injury**	**Non-incapacitating Injury**	**Possible Injury**	**No Injury**	**Total**
2014	0	7	22	44	178	251
2015	0	5	22	61	154	242
2016	1	9	36	48	201	295
2017	0	4	29	44	190	267
2018	2	10	27	33	205	277
Total	3	35	136	230	928	1,332
% 7th Avenue SO	0.2%	***2.6%***	***10.2%***	***17.3%***	69.7%	100%
% 7th Avenue	0.2%	1.9%	9.4%	17.1%	71.4%	100%
Note: Bold, red, italicized text denotes values exceeding the % of crashes on 7th Avenue.						

Table 8-1 through ***Table 8-3*** indicate that overall, 7th Avenue experiences a lower proportion of injury crashes than urban areas statewide. The percentage of fatal crashes is equivalent during reversible and standard lane operation. A slightly higher proportion of injury crashes occur during standard operation. Congested corridors sometimes experience fewer severe crashes due to lower speeds, which may be a contributing factor to this distribution.

The first harmful event was assessed for the Study Area as well as both operations. The results follow in ***Table 8-4*** through ***Table 8-6***.

Table 8-4 – 7th Avenue First Harmful Event						
First Harmful Event Type	**Total**	**% 7th Avenue**	**% Statewide Urban Areas**	**Fatal**	**% Fatal 7th Avenue**	**% Fatal Statewide Urban Areas**
Collision with Motor Vehicle in Transport	2,063	***91.2%***	80.5%	1	20.0%	38.4%
Overturning	0	0.0%	0.8%	0	0.0%	3.7%
Collision with Pedestrian	58	***2.6%***	1.4%	4	***80.0%***	34.0%

Collision with Pedalcyclist	30	***1.3%***	1.1%	0	0.0%	3.4%
Collision with Animal	0	0.0%	0.3%	0	0.0%	0.0%
Collision with Fixed Object	44	1.9%	7.7%	0	0.0%	18.8%
Collision with Non-fixed Object*	36	1.6%	4.3%	0	0.0%	0.2%
Vehicle Fire or Explosion	0	0.0%	0.1%	0	0.0%	0.0%
Other Non-collision**	1	0.0%	0.2%	0	0.0%	1.1%
Unknown/Not Reported/Other	30	1.3%	3.7%		0.0%	0.4%
Total	2,263	100%	100%	5	100.0%	100.0%

Note: Bold, red, italicized text denotes values exceeding the % statewide urban areas.

Table 8-5 – 7th Avenue Reversible Lane First Harmful Event

First Harmful Event Type	Total	% 7th Avenue Reversible Lane	% 7th Avenue	Fatal	% Fatal	% Fatal 7th Avenue
Collision with Motor Vehicle in Transport	898	***95.4%***	91.2%	0	0.0%	20.0%
Overturning	0	0.0%	0.0%	0	0.0%	0.0%
Collision with Pedestrian	13	1.4%	2.6%	2	***100.0%***	80.0%
Collision with Pedalcyclist	8	0.9%	1.3%	0	0.0%	0.0%
Collision with Animal	0	0.0%	0.0%	0	0.0%	0.0%
Collision with Fixed Object	13	1.4%	1.9%	0	0.0%	0.0%
Collision with Non-fixed Object*	6	0.6%	1.6%	0	0.0%	0.0%
Vehicle Fire or Explosion	0	0.0%	0.0%	0	0.0%	0.0%
Other Non-collision**	1	0.1%	0.0%	0	0.0%	0.0%
Unknown/Not Reported/Other	2	0.2%	1.3%	0	0.0%	0.0%
Total	941	100%	100%	2	100.0%	100.0%

Note: Bold, red, italicized text denotes values exceeding the % of crashes on 7th Avenue.

Table 8-6 – 7th Avenue Standard Operation First Harmful Event

First Harmful Event Type	Total	% 7th Avenue Standard Operation	% 7th Avenue	Fatal	% Fatal	% Fatal 7th Avenue
Collision with Motor Vehicle in	1,175	88.2%	91.2%	1	***33.3%***	20.0%

Transport						
Overturning	0	0.0%	0.0%	0	0.0%	0.0%
Collision with Pedestrian	46	***3.5%***	2.6%	2	66.6%	80.0%
Collision with Pedal cyclist	22	***1.7%***	1.3%	0	0.0%	0.0%
Collision with Animal	0	0.0%	0.0%	0	0.0%	0.0%
Collision with Fixed Object	31	***2.3%***	1.9%	0	0.0%	0.0%
Collision with Non-fixed Object*	30	***2.3%***	1.6%	0	0.0%	0.0%
Vehicle Fire or Explosion	0	0.0%	0.0%	0	0.0%	0.0%
Other Non-collision**	0	0.0%	0.0%	0	0.0%	0.0%
Unknown/Not Reported/Other	28	***2.1%***	1.3%	0	0.0%	0.0%
Total	1,332	100%	100%	3	100.0%	100.0%
Note: Bold, red, italicized text denotes values exceeding the % of crashes on 7th Avenue.						

Considering the corridor characteristics (straight, very urban setting, etc.), a higher proportion of multivehicle crashes and fewer fixed object and animal crashes seems appropriate. However, there is a higher percentage of pedestrian and bicycle crashes. Pedestrian crashes account for 4 fatalities (80.0%) and 16 incapacitating injuries (36.3%); bicycle crashes account for 2 of the incapacitating crashes (4.5%). If possible, mitigating measures for bicycle and pedestrian crashes, especially the latter, should be identified as part of potential solutions. Crash analysis indicated:

- 4 out of the 5 fatal crashes involved a pedestrian.
- Most of the pedestrian crashes occurred between 3 PM and 7 PM.
- Fault was assigned to the driver in 28 crashes and the pedestrian in 30 crashes.

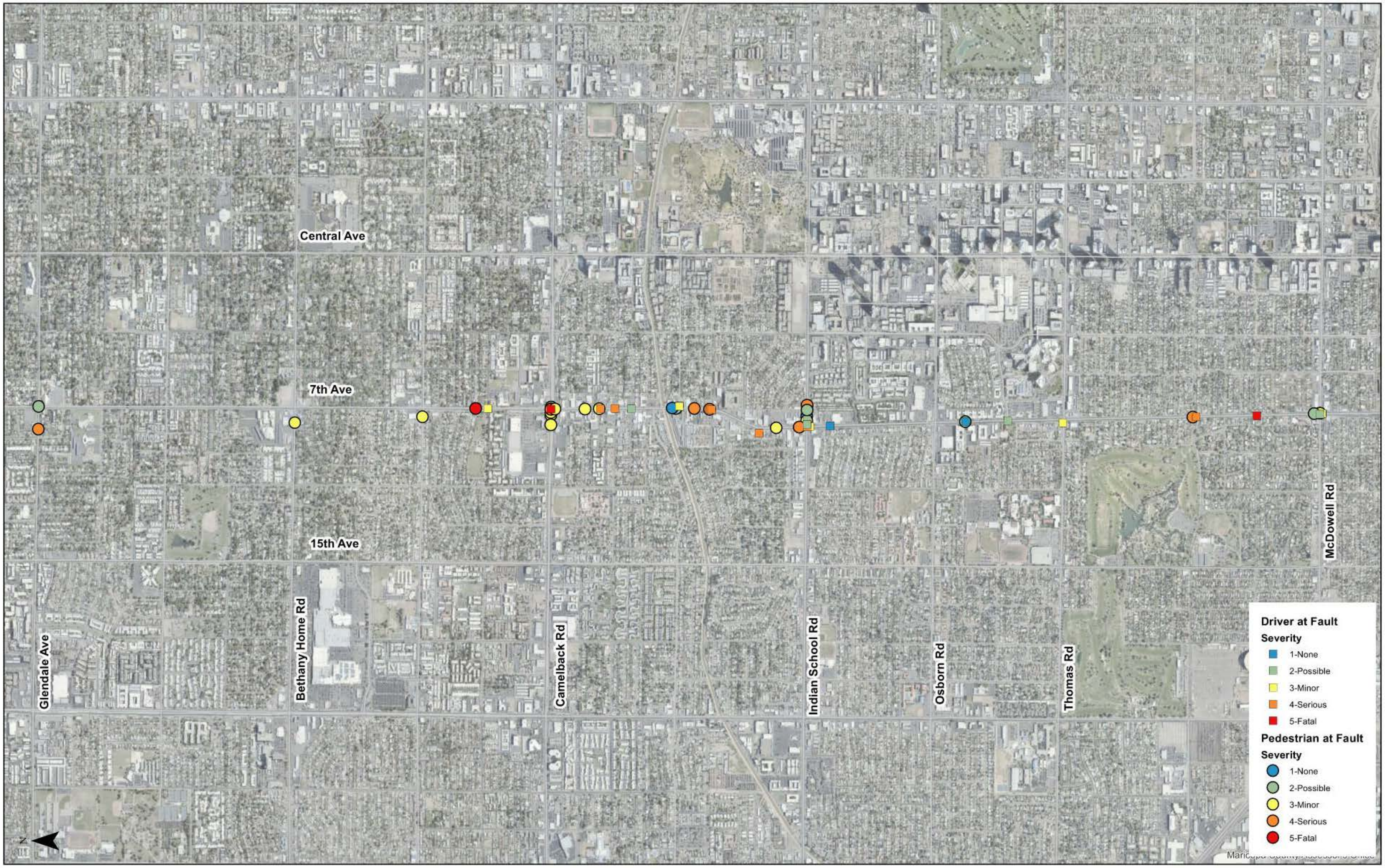
Table 8-7 – 7th Avenue Violations Cited in Pedestrian Crashes

Violation	Count	Percent	Driver Cited	Pedestrian Cited
Did Not Use Xwalk	13	22.4%	0	13
Disregarded Pavement Markings	2	3.4%	1	1
Disregarded Signal	5	8.6%		5
Failed to Yield	19	32.8%	15	4
Inattention	1	1.7%	1	0
Speed Too Fast	2	5.2%	2	0
Traveling in Opposing Lane	1	8.6%	0	1
Unknown	7	3.4%	5	2
Other	5	1.7%	1	4

None	3	12.1%	3	0
Total	58		28	30

As shown, the most prevalent driver violation was failure to yield; the most common pedestrian violation was not using a crosswalk. Though street lighting is present, the majority of pedestrian crashes (53.4%) occur during dark/dusk/dawn conditions; statewide, the majority of crashes occur during daylight conditions (70.9%). Pedestrian level lighting could be considered to mitigate nighttime pedestrian crashes, whether at key intersections or through the corridor. The most nighttime pedestrian crashes occurred at Indian School Road (7 crashes). A map showing the location and severity of pedestrian crashes is included as ***Figure 30***.

Figure 30 – 7th Avenue Pedestrian Crashes



There are pedestrian crashes clustered at Indian School Road, Camelback Road, and at the Grand Canal Trail multiuse path crossing. Notes and observations from each of these locations follow.

Indian School Road

There are bus stops on all four legs of the intersection of Indian School Road and 7th Avenue. During the field review on March 6, 2020 (pre-COVID-19 traffic shift), a large number of pedestrians were observed at this intersection.

Grand Canal Trail Multiuse Path Crossing

Based on aerial imagery, some type of overhead signing was installed on the north leg of the multiuse path intersection just south of the intersection at Campbell Avenue and 7th Avenue sometime between February 2018 and August 2018; it was converted to a HAWK between August 2018 and May 2019.

Camelback Road

There is a light rail station as well as bus stops on all four legs of the intersection at Camelback Road.

The manner of collision in multi-vehicle crashes was assessed and is presented in ***Table 8-8.***

Table 8-8 – 7th Avenue Manner of Collision in Multi-Vehicle Crashes

Collision Manner	7th Avenue				% Statewide
	All Times	% All Times	Reversible Lane	Standard Operation	
Angle	412	***20.0%***	***16.7%***	***20.9%***	14.5%
Backing	6	0.3%	0.0%	0.5%	-
Left Turn	341	16.5%	11.0%	***19.4%***	16.5%
Rear End	717	34.8%	31.4%	34.8%	44.4%
Head-On	13	0.6%	0.6%	0.6%	1.7%
Sideswipe (same)	513	***24.9%***	***36.0%***	14.3%	15.5%
Sideswipe (opposite)	31	***1.5%***	1.2%	***1.5%***	1.4%
U-Turn	24	***1.2%***	***1.2%***	***1.0%***	0.2%
Other	6	0.3%	2.3%	***5.9%***	5.2%
Unknown	0	0.0%	0.0%	0.0%	0.7%
Total			100%	100%	100%

Note: Bold, red, italicized text denotes values over statewide averages

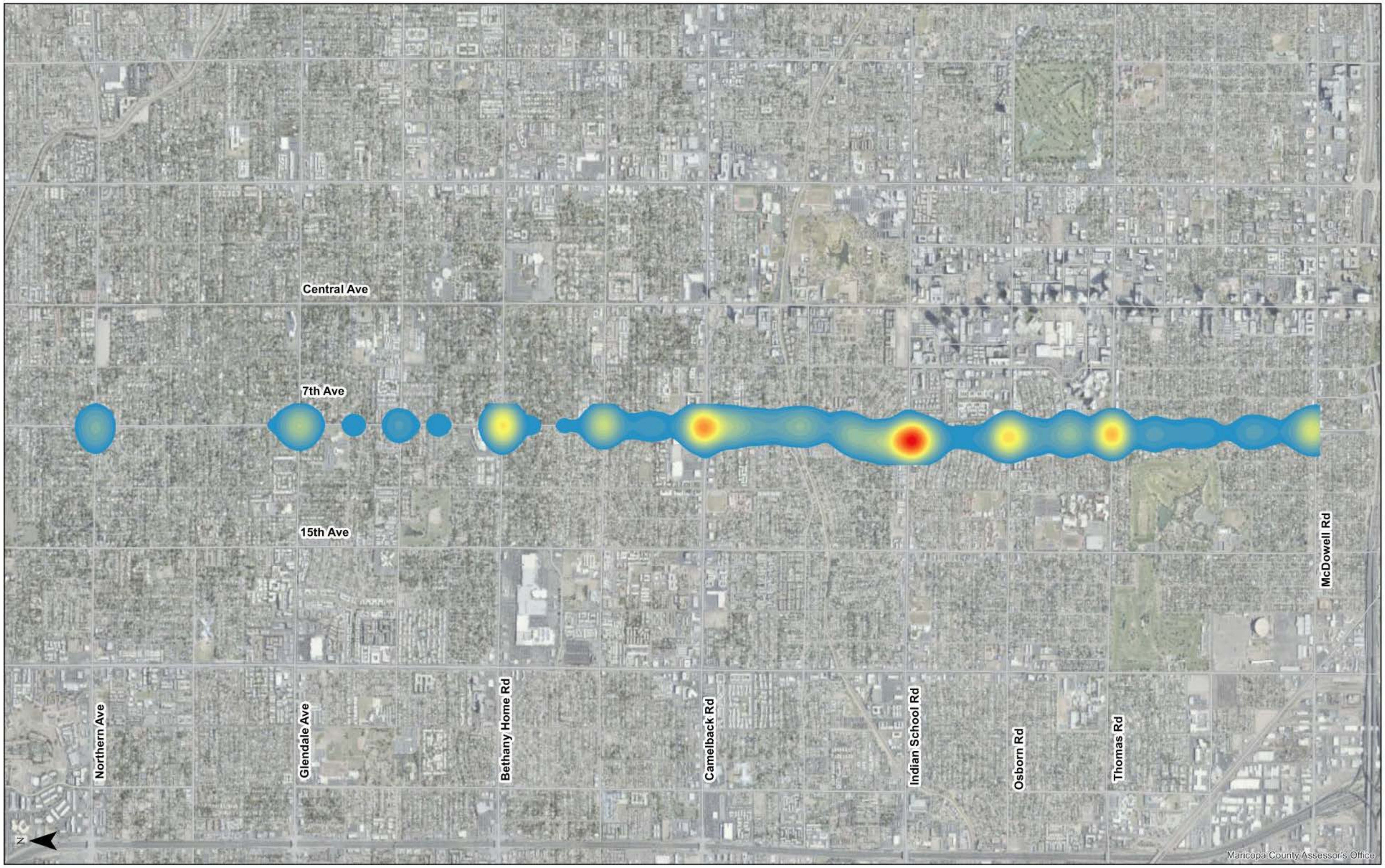
The Study Area experiences a higher percentage of sideswipe crashes (same and opposite direction), as well as angle and U-turn crashes compared to the statewide average. An analysis of the collision manner along 7th Avenue through the Study Area indicated a higher percentage of left-turn and sideswipe crashes than the statewide area averages. Sideswipe same direction crashes are exacerbated during reversible lane operation, occurring at 2.3 times the rate during standard operations and compared to the statewide average. There is a slightly higher proportion of left-turn crashes during standard operation. Solutions should seek to mitigate sideswipe same direction crashes during reversible lane operation

and left-turn crashes at other times. Angle crash mitigation should also be considered.
An examination of the crash trends within the Study Area shows:

- During the AM peak period reversible lanes, 121 sideswipe crashes occurred. 80 of the crashes were when both cars were heading south, in the direction of the reversible lane.
- During the PM peak period reversible lanes, 213 sideswipe crashes occurred. 174 of the crashes were when both cars were heading north, in the direction of the reversible lane.

A heat map depicting the location of the sideswipe crashes is included as ***Figure 31. Figure 31*** indicates hot spots at major arterial intersections, especially at Indian School and Camelback Roads.

Figure 31 – 7th Avenue Heat Map of Sideswipe Crashes



8.1. Driver Behavior – Field Observations

The following are general observations which were taken from the field review conducted on Friday, March 6, 2020 as well as on Wednesday, August 26, 2020.

- Numerous drivers traveling with and against the reversible lane make left-turns that can result in potentially unsafe conditions.
    - Drivers traveling with the reversible lane were observed using it as a left-turn lane at signalized intersections; these turning movements violate posted no-left turn signs.
    - Drivers treating the "Green-Ball" at intersections as a permissive left turn phase creating potential for rear-end collisions.
    - Drivers traveling against the reversible lane made mid-block left-turns either from the through lane (adjacent to the reversible lane) or from the reversible lane;
- Little separation between reversible through lane and opposing traffic; potential for opposing direction side-swipe crashes.

Photo 1 – Driver Turning Left at Northern Avenue During AM Peak (Static No Left-Turn Sign Visible)

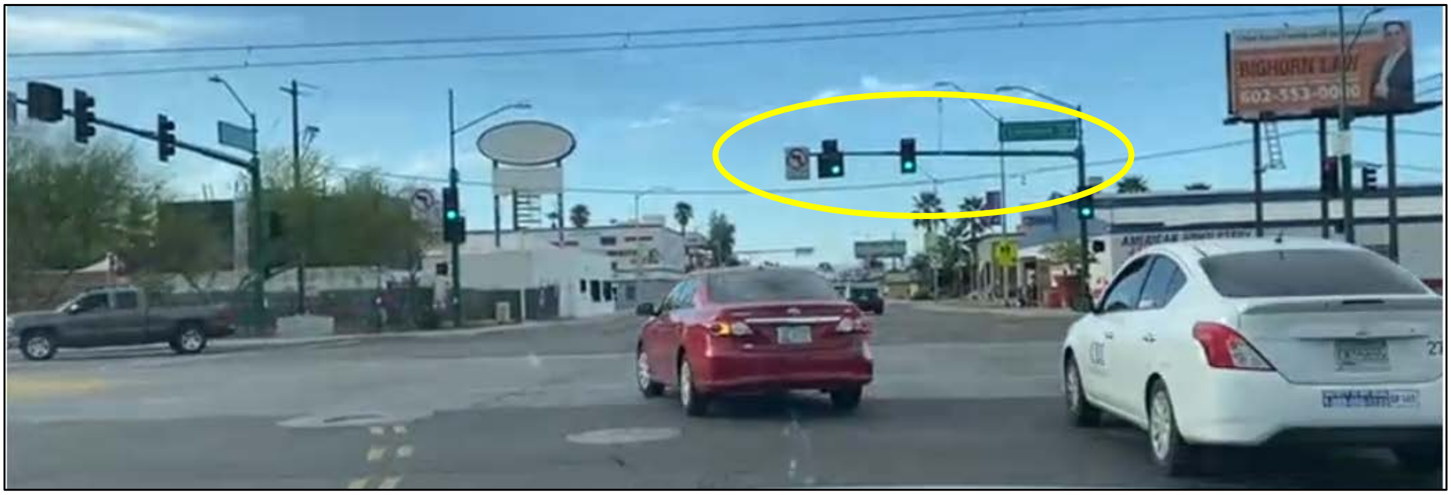


Photo 2 – Driver Turning Left at Camelback Road During PM Peak (No Left-Turn Sign Visible)

Photo 3 and Photo 4 – Driver Turning Left from Opposing Through Lane

Photo 5 – Queueing in Adjacent Through Lanes Approaching Indian School Road (Southbound)

The reversible lane is operational during peak hours and likely experiences a large proportion of the same commuter traffic day to day. It has also been operational for a number of years. Driver behavior, paired with the history and location of the corridor, suggest many drivers are aware of the reversible lane operation, but are non-compliant. Based on field observations, it appears there is poor driver compliance with no-left turn signage. Sideswipe collisions may be attributed to drivers avoiding delay or rear-end collisions by abruptly merging when another driver is waiting to turn left from the reversible lane. Crash reports may be able to provide additional insights. Potential solutions should strive to mitigate sideswipe collisions during reversible lane operation and should consider past driver compliance challenges.

8.2. Bus Stop Conflicts

The majority of bus stops that exist along 7th Avenue are in-lane bus stops. The Valley Metro Route 8 travels northbound and southbound within the corridor. In-lane bus stops require the bus to stop in the right-most travel lane in order to drop off and/or pick up passengers. Corridor free flow travel is impacted by in-lane bus stops, as vehicles traveling behind on the bus are required to stop or change lanes in order to maintain speed. Bus bay locations exist in few locations along the corridor and can be found in ***Table 5-1.*** They provide buses the opportunity to allow passengers to enter and exit the transit system without delaying the far-right travel lane. However, during congested periods bus bays may provide challenges for buses to reenter the traffic. The conversion of in-lane bus stops to pull-out bus bays will improve free flow travel and increase corridor safety by reducing the potential conflict pinch points.

9.0 7th Street Crash Analysis

Crash data for the five-year period from January 1, 2014, to December 31, 2018, was obtained from the City database. Within this period, a total of 3,989 crashes occurred along 7th Street in the Study Area. Crash distribution by year and severity is summarized in ***Table 9-1***. Comparisons to statewide averages for urban areas are offered to provide context to Study Area performance. Statewide crash information was collected from the 2018 Arizona Motor Vehicle Crash Facts (Crash Facts) published by ADOT and was found to have an expected fatal crash distribution of 0.51%, an expected possible injury crash distribution of 26.8%, and an expected no injury crash distribution of 70.8%. These values are used as a baseline for all crash analyses.

Table 9-1 – 7th Street Crash Distribution by Year and Severity

Year	Fatal	Incapacitating Injury	Non-incapacitating Injury	Possible Injury	No Injury	Total
2014	0	17	43	143	489	692
2015	2	11	72	174	497	756
2016	3	20	94	142	604	863
2017	5	16	82	141	601	845
2018	2	16	67	132	616	833
Total	12	80	358	732	2,807	3,989
% 7th Street	0.30%	***2.0%***	***9.0%***	***18.4%***	70.4%	100%
% Statewide Urban Areas	0.51%	28.6%			70.8%	100%

Note: Bold, red, italicized text denotes values exceeding the % statewide urban areas.

Table 9-1 indicates the Study Area experiences a higher proportion of property damage only (PDO) crashes than experienced in urban areas statewide. Crash analysis was performed for both standard operation and reversible lane operation. As previously noted, the reversible lane operates during the peak period for five hours a day. It should be noted this period likely accounts for approximately 29% of average daily trips. Of the 3,989 crashes, 1,759 (44.1%) occurred while the reversible lane was operational and 2,230 (55.9%) occurred during standard operation. Crash distribution during reversible lane operation by year and severity is summarized in ***Table 9-2;*** standard operation is summarized in ***Table 9-3.*** Comparisons are offered to the five-year crash history for 7th Street.

Table 9-2 – 7th Street Reversible Lane Crash Distribution by Year and Severity						
Year	**Fatal**	**Incapacitating Injury**	**Non-incapacitating Injury**	**Possible Injury**	**No Injury**	**Total**
2014	0	4	20	48	218	290
2015	0	6	25	66	236	333
2016	1	6	28	65	291	391
2017	1	3	29	67	264	364
2018	0	4	41	58	278	381
Total	2	23	143	304	1,287	1,759
% 7th Street RL	0.11%	1.3%	8.1%	17.2%	***73.2%***	100%
% 7th Street	0.30%	2.0%	9.0%	18.4%	70.4%	100%
Note: Bold, red, italicized text denotes values exceeding the % of overall crashes on 7th Street.						

Table 9-3 – 7th Street Standard Operation Crash Distribution by Year and Severity						
Year	**Fatal**	**Incapacitating Injury**	**Non-incapacitating Injury**	**Possible Injury**	**No Injury**	**Total**
2014	0	13	23	95	271	402
2015	2	5	47	108	261	423
2016	2	14	66	77	313	472
2017	4	13	53	74	337	481
2018	2	12	26	74	338	452
Total	10	57	215	428	1,520	2,230
% 7th Street SO	***0.45%***	***2.6%***	***9.6%***	***19.2%***	68.2%	100%
% 7th Street	0.30%	2.0%	9.0%	18.4%	70.4%	100%
Note: Bold, red, italicized text denotes values exceeding the % of overall crashes on 7th Street.						

Table 9-1 through ***Table 9-3*** indicate that overall, 7th Street experiences a lower proportion of fatal crashes than urban areas statewide; it experiences a higher proportion of injury crashes. A higher proportion of fatal and injury crashes occur during standard operation than reversible operation. Congested corridors sometimes experience fewer severe crashes due to lower speeds, which may be a contributing factor to this distribution.

The first harmful event was assessed for the Study Area as well as both operations. The results follow in ***Table 9-4*** through ***Table 9-6***.

Table 9-4 – 7th Street First Harmful Event

First Harmful Event Type	Total	% 7th Street	% Statewide Urban Areas	Fatal	% Fatal 7th Street	% Fatal Statewide Urban Areas
Collision with Motor Vehicle in Transport	3,753	***94.1***%	80.5%	6	***50%***	38.4%
Overturning	0	0.0%	0.8%	0	0%	3.7%
Collision with Pedestrian	55	1.4%	1.4%	6	***50%***	34.0%
Collision with Pedal cyclist	51	***1.3%***	1.1%	0	0%	3.4%
Collision with Animal	0	0.0%	0.3%	0	0%	0.0%
Collision with Fixed Object	57	1.4%	7.7%	0	0%	18.8%
Collision with Non-fixed Object*	28	0.7%	4.3%	0	0%	0.2%
Vehicle Fire or Explosion	0	0.0%	0.1%	0	0%	0.0%
Other Non-collision**	5	0.1%	0.2%	0	0%	1.1%
Unknown/Not Reported/Other	40	1.0%	3.7%	0	0%	0.4%
Total	3,989	100%	100%	12	100%	100.0%

Note: Bold, red, italicized text denotes values exceeding the % statewide urban areas.

Table 9-5 – 7th Street Reversible Lane First Harmful Event

First Harmful Event Type	Total	% 7th Street Reversible Lane	% 7th Street	Fatal	% Fatal	% Fatal 7th Street
Collision with Motor Vehicle in Transport	1,700	***96.6%***	94.1%	2	***100%***	50%
Overturning	0	0.0%	0.0%	0	0%	0%
Collision with Pedestrian	16	0.9%	1.4%	0	0%	50%
Collision with Pedal cyclist	15	0.9%	1.3%	0	0%	0%
Collision with Animal	0	0.0%	0.0%	0	0%	0%
Collision with Fixed Object	7	0.4%	1.4%	0	0%	0%

Collision with Non-fixed Object*	10	0.6%	0.7%	0	0%	0%
Vehicle Fire or Explosion	0	0.0%	0.0%	0	0%	0%
Other Non-collision**	2	0.1%	0.1%	0	0%	0%
Unknown/Not Reported/Other	9	0.5%	1.0%	0	0%	0%
Total	1,759	100%	100%	2	100%	100%
Note: Bold, red, italicized text denotes values exceeding the % of crashes on 7th Street.						

Table 9-6 – 7th Street Standard Operation First Harmful Event

First Harmful Event Type	Total	% 7th Street Standard Operation	% 7th Street	Fatal	% Fatal	% Fatal 7th Street
Collision with Motor Vehicle in Transport	2,053	92.1%	94.1%	4	40%	50%
Overturning	0	0.0%	0.0%	0	0%	0%
Collision with Pedestrian	39	***1.7%***	1.4%	6	***60%***	50%
Collision with Pedal cyclist	36	***1.6%***	1.3%	0	0%	0%
Collision with Animal	0	0.0%	0.0%	0	0%	0%
Collision with Fixed Object	50	***2.2%***	1.4%	0	0%	0%
Collision with Non-fixed Object*	18	***0.8%***	0.7%	0	0%	0%
Vehicle Fire or Explosion	0	0.0%	0.0%	0	0%	0%
Other Non-collision**	3	0.1%	0.1%	0	0%	0%
Unknown/Not Reported/Other	31	***1.4%***	1.0%	0	0%	0%
Total	2,230	100%	100%	10	100%	100%
Note: Bold, red, italicized text denotes values exceeding the % of crashes on 7th Street.						

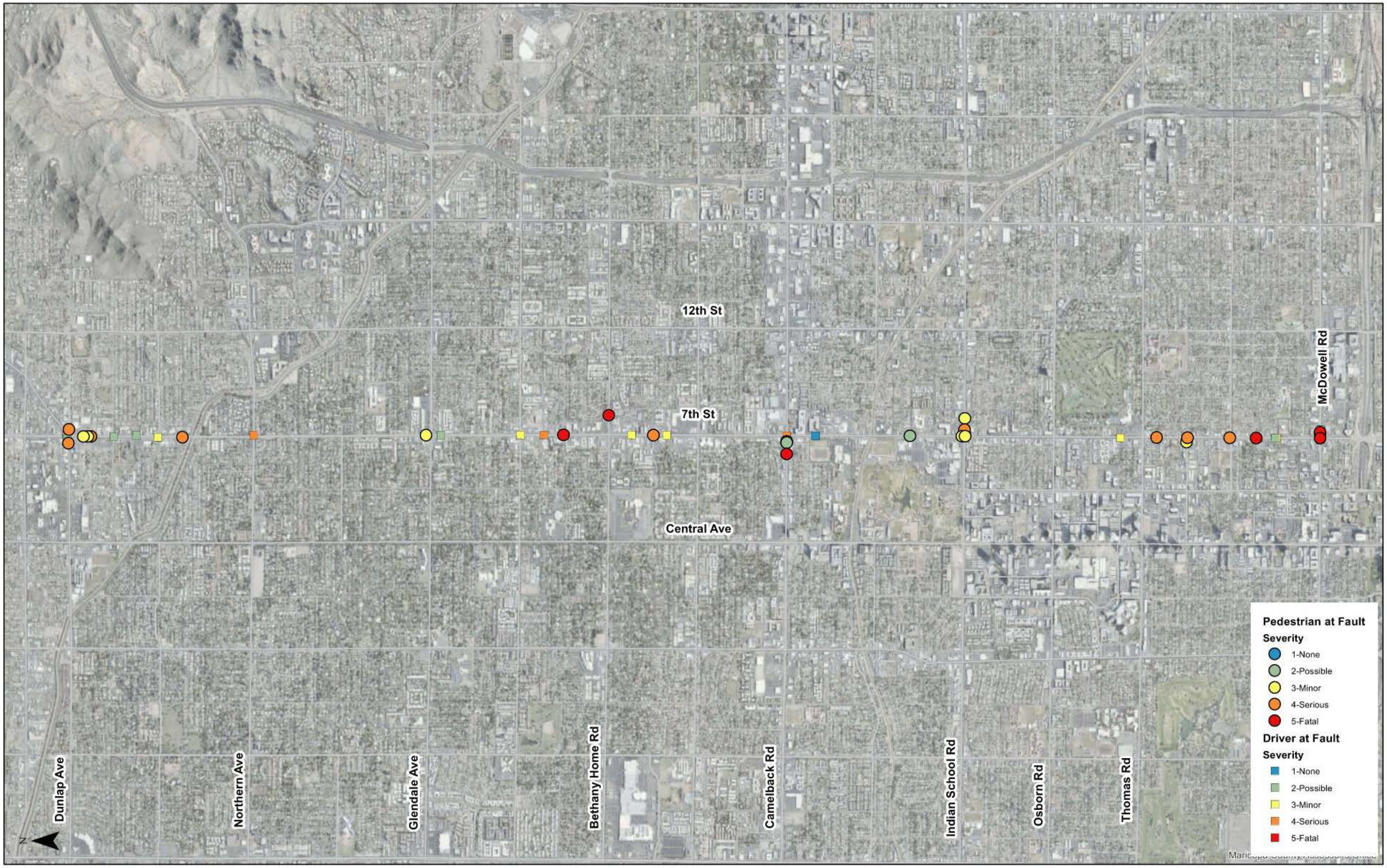
Considering the corridor characteristics (straight, very urban setting, etc.), a higher proportion of multivehicle crashes and fewer fixed object and animal crashes seems appropriate. However, there is a higher proportion of pedestrian and bicycle crashes. Pedestrian crashes account for 6 fatalities (50.0%) and 14 incapacitating injuries (17.5%); bicycle crashes account for 6 of the incapacitating crashes (7.5%). If possible, mitigating measures for bicycle and pedestrian crashes, especially the latter, should be identified as part of potential solutions. Crash analysis indicated:

- 6 out of the 12 fatal crashes involved a pedestrian. 5 of 6 fatal crashes occurred after 6 PM.
- Most of the pedestrian crashes occurred between 3 PM and 7 PM.
- Almost half (47.3%) of the pedestrian crashes occurred between 4 PM and 8 PM.
- Fault was assigned to the driver in 28 crashes and the pedestrian in 27 crashes.

Table 9-7 – 7th Street Violations Cited in Pedestrian Crashes				
	Count	**Percent**	**Driver Cited**	**Pedestrian Cited**
Did Not Use Crosswalk	13	23.6%	0	13
Disregarded Signal	7	12.7%	2	5
Failed to Yield	15	27.3%	11	4
Inattention	1	1.8%	1	0
None	6	10.9%	5	1
Other	3	5.5%	0	3
Speed Too Fast	1	1.8%	1	0
Unknown	8	14.5%	8	0
Unsafe Lane Change	1	1.8%	0	1
Total	55	100.0%	28	27

Though street lighting is present, a large proportion of pedestrian crashes (43.6%) occur during nighttime (dark/dusk/dawn) conditions. 7th Street experiences a lower proportion of nighttime crashes compared to the statewide average (19.9% compared to 29.1%). These comparisons may be indicative that 7th Street lighting is acceptable for vehicular traffic but may not be sufficient for pedestrians. Pedestrian level lighting could be considered to mitigate nighttime pedestrian crashes, whether at key intersections or through the corridor. The most nighttime pedestrian crashes occurred at Indian School Road (7 crashes). A map showing the location and severity of pedestrian crashes is included as ***Figure 32***. There is a cluster of crashes at McDowell Road, which includes two fatal crashes and one incapacitating crash (9 crashes total). There are bus stops on all four legs of this intersection. There are also clustered crashes at the northern end of the reversible lane near Dunlap Avenue, extending south to Townley Avenue.

Figure 32 – 7th Street Pedestrian Crash Location and Severity



The manner of collision in multi-vehicle crashes was assessed and is presented in percentages are presented in ***Table 9-8***.

Table 9-8 – 7th Street Manner of Collision in Multi-Vehicle Crashes

Collision Manner	7th Street				% Statewide
	All Times	% All Times	Reversible Lane	Standard	
Angle	780	***20.8%***	***17.6%***	***22.4%***	14.5%
Backing	21	0.6%	0.1%	0.9%	-
Left Turn	603	16.1%	11.0%	***19.4%***	16.5%
Rear End	1,303	34.7%	33.0%	34.4%	44.4%
Head-On	27	0.7%	0.6%	0.8%	1.7%
Sideswipe (same)	930	***24.8%***	***34.1%***	***17.1%***	15.5%
Sideswipe (opposite)	67	***1.8%***	***1.9%***	***1.7%***	1.4%
U-Turn	17	***0.5%***	***0.4%***	***0.5%***	0.2%
Other	3	0.1%	1.8%	3.6%	5.2%
Unknown	2	0.1%	0.1%	0.0%	0.7%
Total	3,753	100%	100%	100%	100%
Note: Bold, red, italicized text denotes values over statewide averages					

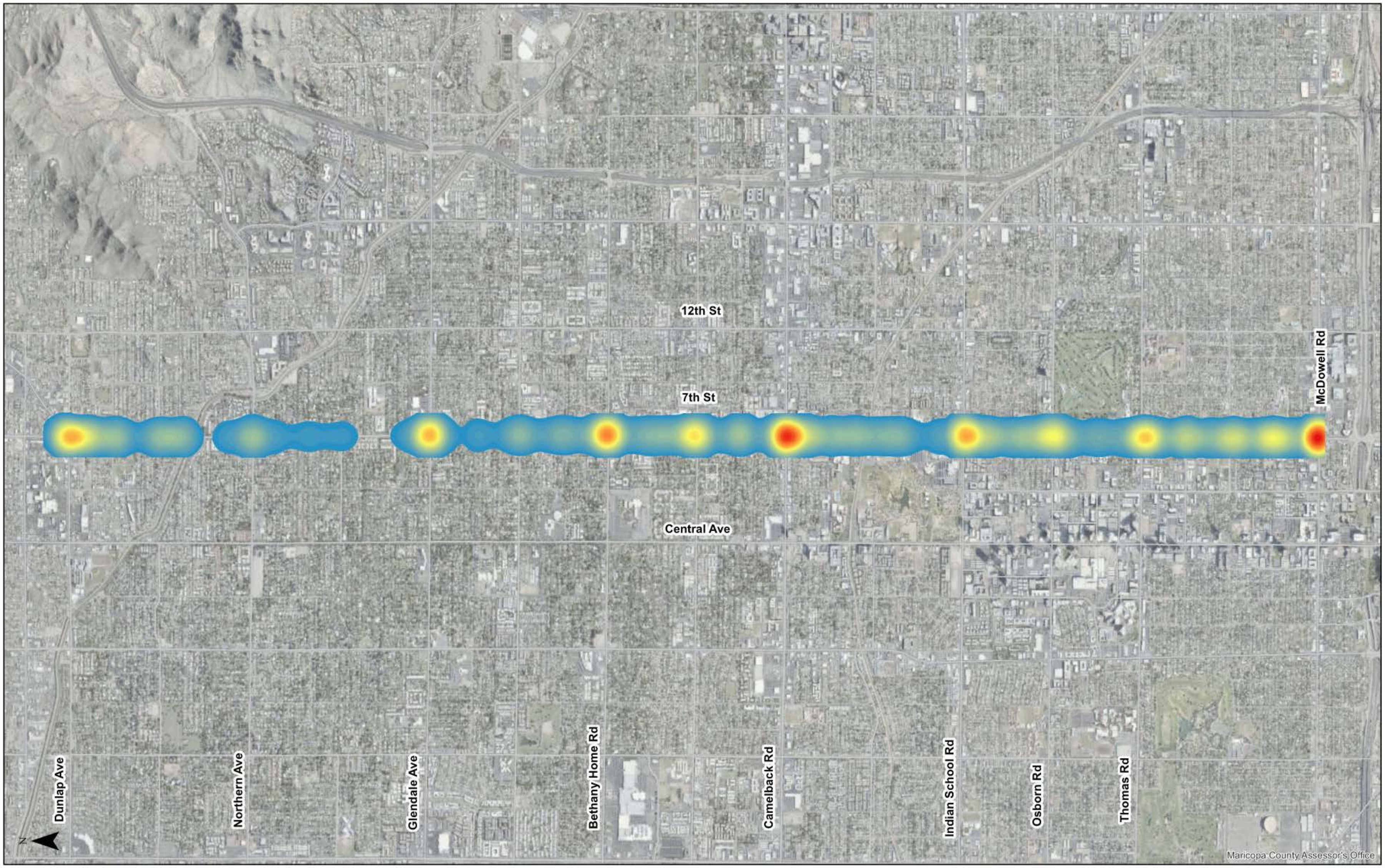
An analysis of the collision manner along 7th Street indicated a higher percentage of sideswipe (same and opposite direction), angle, and U-turn crashes compared to the statewide average for all times as well as both standard and reversible lane operation. Left-turn crashes exceed the statewide average during standard operation only. Sideswipe crashes are especially prevalent during reversible lane operation, occurring at a rate 2.2 times the statewide average.

An examination of the crash trends within the Study Area shows:

- During the AM peak period reversible lanes, 165 sideswipe crashes occurred. 101 of the crashes were when both cars were heading south, in the direction of the reversible lane.
- During the PM peak period reversible lanes, 447 sideswipe crashes occurred. 357 of the crashes were when both cars were heading north, in the direction of the reversible lane.

A heat map depicting the location of the sideswipe crashes is included as ***Figure 33***. ***Figure 33*** indicates hot spots at major arterial intersections, especially at McDowell, Camelback, and Bethany Home Roads.

Figure 33 – 7th Street Heat Map of Sideswipe Crashes



9.1. Driver Behavior – Field Observations

The following are general observations which were taken from the field review conducted on Friday, March 6, 2020 as well as on Monday, August 24, 2020.

- Numerous drivers traveling with and against the reversible lane make left-turns.
    - Drivers traveling with the reversible lane were observed using it as a left-turn lane mid-block, which is permitted during the AM peak. However, some mid-block intersections prohibit left turns, and the signage is posted near to the reversible lane signage.
    - Drivers traveling against the reversible lane made mid-block left-turns either from the through lane (adjacent to the reversible lane) or from the reversible lane. No left-turn signs were often clearly visible.
- Queued vehicles waiting behind a vehicle turning left often change lanes to continue driving. Little separation between reversible through lane and opposing traffic.

Photo 6 – Driver Turning Left from Opposing Through Lane (Northbound)

Photo 7 – Conflicting Signage at Winter Drive (Southbound)

Photo 8 – Driver Turning Left from Opposing Through Lane (Southbound)

The reversible lane is operational during peak hours and likely experiences a large proportion of the same commuter traffic day to day. It has also been operational for a number of years. Driver behavior, paired with the history and location of the corridor, suggest many drivers are aware of the reversible lane operation, but are non-compliant. Based on field observations, it appears there is poor driver compliance with no-left turn signage. Sideswipe collisions may be attributed to drivers avoiding delay or rear-end collisions by abruptly merging when another driver is waiting to turn left from the reversible lane. Crash reports may be able to provide additional insights. Potential solutions should strive to mitigate sideswipe collisions during reversible lane operation and should consider past driver compliance challenges.

9.2. Bus Stop Conflicts

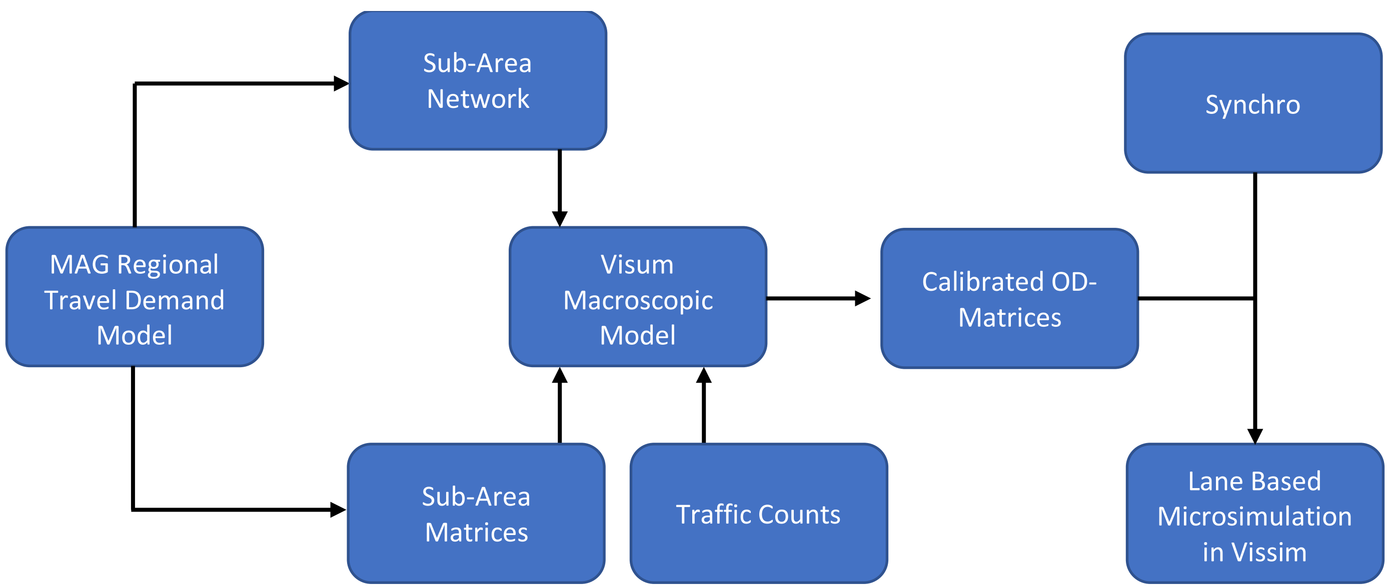
The majority of bus stops that exist along 7th Street are in-lane bus stops. The Valley Metro Route 7 travels northbound and southbound within the corridor. In-lane bus stops require the bus to stop in the right-most travel lane in order to drop off and/or pick up passengers. Corridor free flow travel is impacted by in-lane bus stops, as vehicles traveling behind on the bus are required to stop or change lanes in order to maintain speed. Bus bay locations exist in few locations along the corridor and can be found in ***Table 6-1.*** They provide buses the opportunity to allow passengers to enter and exit the transit system without delaying the far-right travel lane. However, during congested periods bus bays may provide challenges for buses to reenter the traffic. The conversion of in-lane bus stops to pull-out bus bays will improve free flow travel and increase corridor safety by reducing the potential conflict pinch points.

10.0 Traffic Operations Analysis

Existing traffic patterns for the Study Area and several subareas were assessed using a combination of methodologies and software. A Synchro (Version 10.0) model, a microsimulation model (Vissim), and a macrosimulation model (TransCAD and Visum) were developed for the Study Area to provide a complete description of traffic patterns within the Study Area for the existing and alternate conditions. The analysis methodology, models, and results of the traffic analyses are described in this section.

The general modeling methodology is illustrated in ***Figure 34***. MAG travel demand model information was obtained for the Study Area for the existing conditions. The data provided the Origin-Destination (OD) data needed to model the Study Area microscopically and macroscopically. OD data, contained in a matrix format, has the number of trips for a specified time period expected between each possible origin zone and destination zone in the Study Area network. The macroscopic model was calibrated with existing traffic counts and the Study Area network was modeled for existing and alternate conditions to identify circulation and intersection turning movement volumes.

Figure 34 – Lane-Based Microsimulation Model Development Methodology



10.1.1. MAG Regional Travel Demand Model

A Travel Demand Model (TDM) is often referred to as a "regional" model because the roadway network it represents typically spans multiple jurisdictions. TDMs are extensively calibrated and rooted in survey-informed population, employment, and socioeconomic data which influence trip generation and mode choice. Calibration is the process by which the model is fine-tuned against actual count data to improve accuracy.

The Study Area lies completely within the MAG TDM. MAG TDM data representing the model network within the Study Area and OD matrices with travel data for 24-hour, AM, PM, and mid-day peaks for existing year conditions were used in this study. Travel data in the OD matrices reflects how many vehicles are entering and exiting the network, where they are entering and exiting, and their origin or destination within the network, if applicable.

10.1.2. Origin Destination Analysis

Much of the mobility-related information necessary to support the analysis of the 7th Street and 7th Avenue reversible lanes comes from the regional travel demand model developed and maintained by MAG. Travel demand models assign regionally generated household trips to transportation network using a variety of assignment procedures. Link capacities, travel times and model measured congested travel times are used to find the best path between each origin destination pair. The total travel demand for an Origin-Destination pair can be assigned to multiple paths connecting them. The final converged assignment in the model usually aims to arrive at user equilibrium where the perceived travel times between the different paths are in equilibrium and no user (driver) can improve their travel time by shifting to a different path.

The MAG regional model does not specifically model the reversible lanes on 7th Street and 7th Avenue. Therefore, the directional capacities and turning movement restrictions in the peak periods are not exclusively modeled. While this approach is imperfect at a local level, at a regional level it allows the identification of travel demand on 7th Street and 7th Avenue.

Origin-destination analysis indicated that the travel times for traffic on reversible lanes will not improve, by choosing an alternate path. Congested travel times along parallel north-south facilities are higher than those on 7th Street and 7th Avenue. Furthermore, much of the demand on 7th Street and 7th Avenue serves local traffic and therefore the traffic intends to use the two reversible lane corridors.

10.1.3. Microsimulation Model Development in Vissim

A microsimulation model was developed for the project Study Area using PTV Vissim (Vissim) software to provide a detailed assessment of traffic circulation patterns and to evaluate the operations on reversible lanes. The microsimulation model was developed to supplement the result from travel demand model and origin destination analysis. The Vissim model accounts for lane restrictions and for reversible lane operations.

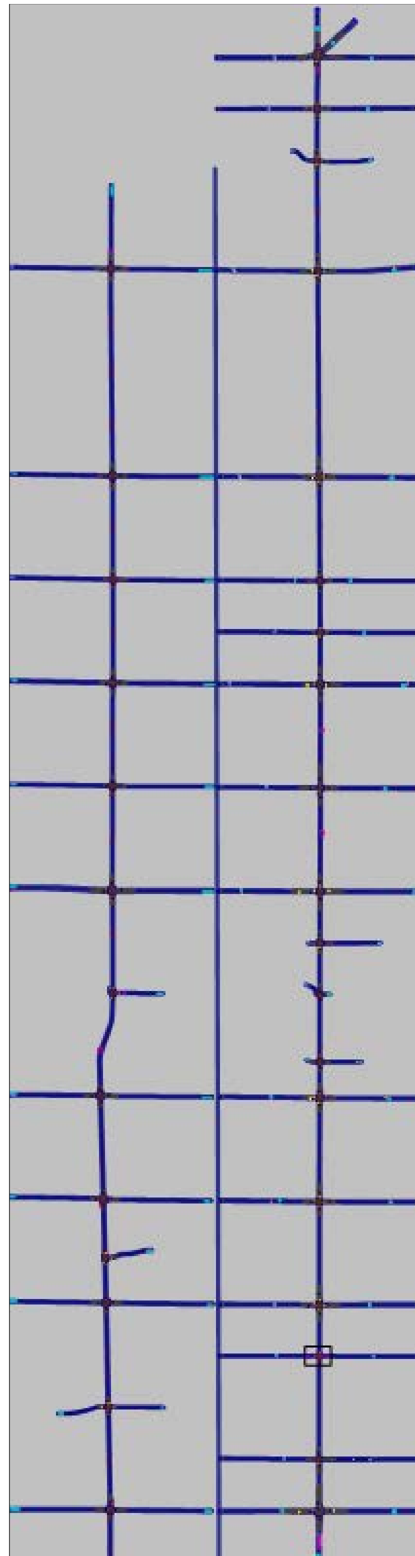
Signal timing plans currently implemented in the field were emulated in the Vissim software and travel demand was specified as OD matrices. Prior to developing the Vissim models, travel demand information along with OD-matrices was imported into Visum, a macroscopic model. The Visum model was used along with turning movement counts and OD-matrices from the regional model to develop synthetic OD-matrices that better represent traffic counts observed along the two corridors. The calibrated OD-matrix was used in Vissim to evaluate scenarios where reversible lane is eliminated, partially or completely.

This Vissim model network is illustrated in ***Figure 35***. The Vissim model was used to evaluate alternatives where the reversible lanes are eliminated. The sub-area OD matrices were assigned in the Vissim models to identify impacts to travel times when reversible lanes are eliminated. ***Table 10-1*** below provides a comparison of travel times along the two corridors when the reversible lanes are eliminated:

Table 10-1 – Travel Time Comparison

Corridor	Travel Time with Reversible Lanes	Travel Time without Reversible Lanes
7th Street NB AM Peak	18 min	24 min
7th Street SB AM Peak	20 min	32 min
7th Street NB PM Peak	22 min	36 min
7th Street SB PM Peak	20 min	28 min
7th Avenue NB AM Peak	15 min	17 min
7th Avenue SB AM Peak	17 min	26 min
7th Avenue NB PM Peak	19 min	29 min
7th Avenue SB PM Peak	16 min	22 min

Figure 35 – Vissim Model for the Reversible Lane Corridors



The table above indicates the travel times along the corridors worsens significantly when the reversible lanes are eliminated. Model simulations also indicated that the major signalized intersections experience severe congestion when the reversible lanes are eliminated.

10.1.4. Synchro Model

A Synchro (Version 10.0) model was developed to provide a LOS analysis of Study Area intersections. The following sections discuss the LOS analysis process and the factors that determine LOS.

10.1.4.1. Level of Service Analysis

LOS is a qualitative measure of how well an intersection or roadway segment operates on a graded scale of A (best) to F (worst). LOS considers a variety of factors, including stability of traffic flow, opportunity for passing, and driver comfort. Operations of LOS D and better are typically considered good and acceptable in urban settings. Operations of LOS E or F typically need attention.

For the purpose of intersection analysis, LOS is determined using the total delay, in seconds, of vehicles which approach the intersection over the course of one traffic signal cycle. Intersections within the Study Area were analyzed using the LOS thresholds shown in ***Table 10-2*** and ***Table 10-3*** for signalized and unsignalized intersections, respectively.

Table 10-2 – LOS Thresholds for Signalized Intersections

Control Delay (s)	Level of Service
<= 10 seconds	A
10-20 seconds	B
20 – 35 seconds	C
35-55 seconds	D
55- 80 seconds	E
> 80 sec seconds	F

Table 10-3 – LOS Thresholds for Unsignalized Intersections

Control Delay (s)	Level of Service
<= 10 seconds	A
10-15 seconds	B
15 – 25 seconds	C
25-35 seconds	D
35- 50 seconds	E
> 50 seconds	F

The LOS analysis was conducted using Synchro's built-in methodology. While Highway Capacity Manual (HCM) 6th edition methodology is most commonly used to assess intersection LOS, it cannot assess intersections with unique signal timing and geometric configurations. To allow for similar comparison between intersections and because multiple intersections within the Study Area have unique signal timing and/or geometric configurations, the built-in Synchro methodology was used.

11.0 7th Avenue Existing Conditions: Impact of Turn Violations

The intent of this study was to identify the impacts of prohibited left turns along 7th Avenue. Specifically, the delay at each signalized intersection was compared for three cases. The provided turning movement counts from the City of Phoenix provided insight into vehicle operations along both corridors. The impact of prohibited left turns is in question, thus three conditions of traffic analyses were examined. It Is hypothesized that violations, even on a small scale, worsen reversible lane operations during peak hours.

Case 1 considers the provided turning movement counts with the removal of any provided left turn movements in the northbound and southbound approaches. There were not many vehicles throughout both corridors that were counted turning left, but they were removed. This case is considered the "No Left Turn" case. Any traffic counts that were of left turning movements were added as through movement counts.

Case 2 considers the turning movements as provided by the City of Phoenix. Turning movement counts were provided at intersections where left turns are prohibited. These were at the following intersections:

7th Avenue AM Peak Hour

- Encanto Boulevard southbound only;
- Thomas Road southbound only;
- Earll Drive southbound only;
- Osborn Road southbound only;
- Indian School Road northbound and southbound;
- Campbell Avenue southbound only;
- Camelback Road southbound only;
- Missouri Avenue southbound only;
- Bethany Home Road southbound only;
- Maryland Avenue northbound and southbound; and
- Glendale Avenue northbound and southbound.

7th Avenue PM Peak Hour

- Encanto Boulevard northbound only;
- Thomas Road northbound and southbound;
- Earll Drive southbound only;
- Osborn Road southbound only;
- Indian School Road northbound only;
- Campbell Avenue northbound only;
- Camelback Road northbound only (turns are allowed during PM Peak operations);
- Missouri Avenue northbound only;
- Bethany Home Road northbound only;
- Maryland Avenue northbound only; and
- Glendale Avenue northbound only.

Case 3 considers the addition of turning movements at intersections that did not display any left turning vehicles. Vehicles were added to the Synchro models to analyze the delay impacts of the added vehicles. Any intersection within the corridor that did not have left turn counts in either the northbound or southbound approaches were manually given an additional 10 vehicles. Operations under these conditions were then examined.

The calculated delay (in seconds) for the three described cases for 7th Avenue can be found in ***Table 11-1*** and ***Table 11-2***. Highlighted rows indicate where the delay increased from Case 1 to Case 2 or from Case 1 to Case 3.

Table 11-1 – 7th Avenue Overall Intersection Delay AM Peak Hour

Intersection	Case 1: No Left Turn Delay (s)	Case 2: Accounted Lefts Delay (s)	Case 3: Added Lefts Delay (s)
McDowell Road	42.4	43.3	43.3
Encanto Boulevard	15.7	17.0	21.6
Thomas Road	25.5	25.7	65.6
Earll Drive	41.3	38.8	37.7
Osborn Road	43.2	41.2	42.9
Indian School Road	99.8	112.0	111.2
Campbell Avenue	24.3	24.3	25.5
Camelback Road	70.4	69.0	69.6
Missouri Avenue	48.2	48.3	49.0
Bethany Home Road	60.2	67.3	68.6
Maryland Avenue	31.2	30.2	29.9
Glendale Avenue	49.1	54.8	54.9
Northern Avenue	35.5	35.6	35.6

Table 11-2 – 7th Avenue Overall Intersection Delay PM Peak Hour

Intersection	Case 1: No Left Turn Delay (s)	Case 2: Accounted Lefts Delay (s)	Case 3: Added Lefts Delay (s)
McDowell Road	41.7	41.8	44.8
Encanto Boulevard	16.8	16.3	97.8
Thomas Road	28.8	29.4	29.4
Earll Drive	39.5	36.4	34.9
Osborn Road	31.3	31.3	68.2
Indian School Road	46.9	50.2	103.4
Campbell Avenue	23.0	24.1	29.2
Camelback Road	40.5	39.0	64.1
Missouri Avenue	42.2	43.0	57.1
Bethany Home Road	46.5	43.6	46.8
Maryland Avenue	27.3	26.2	29.5
Glendale Avenue	41.4	42.0	44.7
Northern Avenue	36.3	36.6	36.6

From ***Table 11-1*** and ***Table 11-2***, it can be concluded that during the AM Peak Hour and PM Peak Hour on 7th Avenue, reversible lane operations worsened as left turns were added at most of the signalized intersections. This does not include the prohibited left turns made to access businesses or private driveways along the corridor. Mitigation measures to reduce the number of left turns made at prohibited intersections as well as to access points would improve overall corridor operations.

General observations show that when more vehicles are added at prohibited left turns, the northbound and southbound directions are compromised. When the reversible lane is in effect, the opposite direction of travel experiences increased travel delays and worsening level of service. Detailed capacity analysis results can be found in ***Appendix H***.

12.0 7th Street Existing Conditions: Impact of Turn Violations

The intent of this study was to identify the impacts of prohibited left turns along 7th Street. Specifically, the delay at each signalized intersection was compared for three cases. The provided turning movement counts from the City of Phoenix provided insight into vehicle operations throughout the 7th Street corridor. The impact of prohibited left turns is in question, thus three conditions of traffic analyses were examined. It Is hypothesized that violations, even on a small scale, worsen reversible lane operations during peak hours.

Case 1 considers the provided turning movement counts with the removal of any provided left turn movements in the northbound and southbound approaches. There were not many vehicles throughout both corridors that were counted turning left, but they were removed. This case is considered the “No Left Turn” case. Any traffic counts that were of left turning movements were added as through movement counts.

Case 2 considers the turning movements as provided by the City of Phoenix. Turning movement counts were provided at intersections where left turns are prohibited. These were at the following intersections:

7th Street AM Peak Hour

- Palm Lane northbound and southbound;
- Virginia Avenue northbound and southbound;
- Thomas Road southbound only;
- Osborn Road southbound only
- Indian School Road southbound only;
- VA Med Center northbound only;
- Campbell Avenue northbound and southbound;
- Highland Avenue southbound only;
- Campbell Avenue southbound only;
- Camelback Road southbound only;
- Missouri Avenue northbound and southbound;
- Bethany Home Road northbound and southbound;
- Rose Lane northbound and southbound;
- Maryland Avenue southbound only;
- Glendale Avenue southbound only;
- Northern Avenue northbound and southbound;
- Butler Drive northbound and southbound; and
- Alice Avenue northbound and southbound.

7th Street PM Peak Hour

- Palm Lane northbound and southbound only;
- Virginia Avenue northbound and southbound;
- Thomas Road northbound only;
- Osborn Road northbound only;
- Indian School Road northbound only;
- VA Med Center northbound only;
- Campbell Avenue northbound only;
- Highland Avenue northbound and southbound;
- Camelback Road northbound only;
- Missouri Avenue northbound only;
- Bethany Home Road northbound only;
- Rose Lane northbound and southbound;
- Maryland Avenue northbound and southbound;
- Glendale Avenue northbound only;
- Northern Avenue northbound and southbound;
- Butler Avenue northbound and southbound; and
- Alice Avenue northbound and southbound.

Case 3 considers the addition of turning movements at intersections that did not display any left turning vehicles. Vehicles were added to the Synchro models to analyze the delay impacts of the added vehicles. Any intersection within the corridor that did not have left turn counts in either the northbound or southbound approaches were manually given an additional 10 vehicles. Operations under these conditions were then examined.

The calculated delay (in seconds) for the three described cases for 7th Avenue can be found in ***Table 12-1*** and ***Table 12-2***. Highlighted rows indicate where the delay increased from Case 1 to Case 2 or from Case 1 to Case 3. Intersection Delay was not accounted for at 7th Street and Dunlap Road as no counts were obtained.

Table 12-1 – 7th Street Overall Intersection Delay AM Peak Hour

Intersection	Case 1: No Left Turn Delay (s)	Case 2: Accounted Lefts Delay (s)	Case 3: Added Lefts Delay (s)
McDowell Road	67.3	67.5	67.5
Palm Lane	11.7	12.5	12.5
Virginia Avenue	14.8	13.6	13.6
Thomas Road	44.4	47.5	49.7
Osborn Road	52.2	52.3	54.4
Indian School Road	39.6	38.6	39.4
VA Med Center	19.2	19.8	226.3
Campbell Ave	11.3	10.0	11.6
Highland Avenue	17.9	18.9	17.9
Camelback Road	50.0	58.9	59.1
Missouri Avenue	48.6	55.0	55.8
Bethany Home Road	56.8	61.4	64.0
Rose Lane	15.7	14.2	14.4

Table 12-1 – 7th Street Overall Intersection Delay AM Peak Hour			
Intersection	Case 1: No Left Turn Delay (s)	Case 2: Accounted Lefts Delay (s)	Case 3: Added Lefts Delay (s)
Maryland Avenue	26.4	27.4	27.6
Glendale Avenue	46.2	56.3	56.7
Northern Avenue	70.9	75.7	75.4
Butler Avenue	8.4	8.3	8.3
Alice Avenue	15.0	14.6	14.5

Table 12-2 – 7th Street Overall Intersection Delay PM Peak Hour			
Intersection	Case 1: No Left Turn Delay (s)	Case 2: Accounted Lefts Delay (s)	Case 3: Added Lefts Delay (s)
McDowell Road	45.1	44.8	44.7
Palm Lane	18.3	18.6	16.4
Virginia Avenue	16.5	16.5	18.1
Thomas Road	34.8	35.7	108.5
Osborn Road	51.5	52.6	115.0
Indian School Road	40.2	43.6	68.3
VA Med Center	12.5	5.9	11.7
Campbell Ave	59.4	12.8	24.5
Highland Avenue	6.6	21.4	22.5
Camelback Road	41.8	39.0	80.5
Missouri Avenue	53.2	55.4	103.6
Bethany Home Road	52.2	64.2	66.2
Rose Lane	7.8	8.6	7.0
Maryland Avenue	27.2	26.1	29.0
Glendale Avenue	41.0	42.1	68.8
Northern Avenue	39.4	40.9	40.9
Butler Avenue	30.4	26.2	26.2
Alice Avenue	7.9	8.9	8.9

Similarly, operations on 7th Street worsen when left turns movements are added, violating reversible lane operations. Recognition that many intersections worsen per ***Table 12-1*** and ***Table 12-2*** indicate that operations with left turn violations increase intersection delay. In addition, intersection delay at minor street signalized intersections was drastically impacted by the addition of prohibited left turns. This can be contributed to delay at the major intersections causing congestion throughout the corridor and/or the desire for vehicles to turn left at these intersections due to available access to neighborhoods and businesses.

General observations show that when more vehicles are added at prohibited left turns, the northbound and southbound directions are compromised. When the reversible lane is in effect, the opposite direction of travel experiences increased travel delays and worsening level of service. Detailed capacity analysis results can be found in ***Appendix I***.

13.0 Field Review Findings

The purpose of the field review was to document and evaluate the location of signs, pedestrian push buttons, controller cabinets at each signalized intersection, in-pavement detection loops, and any CCTV or pre-emption technologies.

13.1. ADA Compliance

Per City of Phoenix Street Planning and Design Guidelines, Section 8.5 Sidewalks, "sidewalks shall be a minimum of 4 feet in width on local streets and 5 feet on arterials, collector and on local street with setback sidewalks. As per the Americans with Disabilities Act (ADA), a 5 foot by 5 foot passing area must be provided every 200 feet to allow wheelchairs to pass on all sidewalks less than 5 feet wide."

From visual observations and field visit documentation, the sidewalks in both corridors meet the requirements per the City code, however, there are ample locations within both corridors where sections are not ADA compliant. A few locations have been identified in ***Photos 9*** through ***12***. Two trends of non-compliance for sidewalks prevail throughout the corridors:

- Reversible lane sign poles locations that constrict the sidewalk width to less than 4 feet.
- Light poles, overhead utility poles, and reversible lane sign poles located within the sidewalk panels.

The ADA (Americans with Disability Act) compliant regulations for arterial streets are defined as such:

- Minimum clear width of pedestrian access route (sidewalk) shall be 60 inches (5 feet), exclusive of the width of the curb
- *Exceptions:*
    - *Driveways/alleyways where public sidewalks intersect driveways, the width may be reduced to 48 inches*
    - Accessible building entrances:" Where construction is permitted in the sidewalk to provide an accessible entrance to an existing adjoining property, and site constraints do not allow full compliance with the requirements of this section, the width of the pedestrian access route may be reduced to 48 inches (1220 mm)."
    - Street Fixtures: "Where insufficient *public right-of-way* is available to locate street fixtures outside the 60 inch (1525mm) minimum clear width, the pedestrian access route may be reduced to 48 inches (1220mm) for a length of 24 inches (610mm) maximum, provided that reduced width segments are separated by segments of the pedestrian access route that are 60 inches (1525mm) minimum in length and 60 inches (1525mm) minimum in width."

Photo 9 – Southbound on 7th Avenue between Encanto Boulevard and Thomas Road:
Overhead Power Pole in Sidewalk

Photo 10 – Northbound on 7th Street between Palm Lane to Virginia Avenue: Pole in Sidewalk

Photo 11 – Southbound on 7th Street between Virginia Avenue to Thomas Road: Pole in Sidewalk

Photo 12 – Southbound on 7th Street between Indian School Road and the VA Med Center: Pole in Sidewalk

13.3. 7th Avenue

13.3.1. Infrastructure

Generally, the infrastructure at each intersection along 7th Avenue varied in terms of available technology, cabinet controller placement, and mast-arm technology. Within the 13 signalized intersection corridors, not all intersections had CCTV/pre-emption or intersection camera technologies. In addition, each signalized intersection was not equipped with a pedestrian push button or loop detectors; it was rare to find an intersection that had both. Minor signalized intersections tended to have pedestrian push buttons, whereas the major intersections did not. Loop detectors existed on the minor intersection streets, and typically only in the left turn lane if there was one present, or the leftmost lane of the approach. Mast arms placed on sidewalks provided a narrow walking path.

13.3.2. Sign Placement and Sign Type

- Driving through the corridor proved there was ample signs, conveying both information to drivers about reversible lane operations and other traffic operations.
- Throughout the Melrose District (Indian School Road to Camelback Road) the sides of the corridor were cluttered; traffic operation signs, billboards, and reversible lane operation signs took over the visibility of that stretch of the corridor.
- There was no equal spacing between the location of the mast arms.
- At some points along the corridor, there were clusters of signs which could make it challenging for drivers to quickly process the information.
- In the surrounding residential area, the reversible lane signs present were hidden by private property trees and shrubbery.

Photo 13 – Northbound on 7th Avenue between Glendale Avenue and Northern Avenue: Several Left Turn Prohibited Signs

Photo 14 – Southbound on 7th Avenue between Glendale Avenue and Maryland Avenue: Landscape Obstructing Reversible Lane Static Sign

13.3.3. Driver Maneuvers

In the northern portion of the corridor (residential neighborhood area) drivers were more likely to turn left and cross the reversible lane during the AM peak hour when no left turns are permitted for northbound traffic.

Photo 15 – Northbound on 7th Avenue between Missouri Avenue and Bethany Home Road:
Vehicle Turning Left from Leftmost Non-Reverse Lane during AM Peak Hour to Enter Side Street

13.4. 7th Street

13.4.1. Infrastructure

Generally, the infrastructure at each intersection along 7th Street varied in terms of available technology, cabinet controller placement, and mast-arm technology. Within the 18 signalized intersection corridors, not all intersections had CCTV/pre-emption or intersection camera technologies. In addition, each signalized intersection was not equipped with a pedestrian push button or loop detectors; it was rate to find an intersection that had both. Minor signalized intersections tended to have pedestrian push buttons, whereas the major intersections did not. Loop detectors existed on the minor intersection streets, and typically only in the left turn lane if there was one present, or the leftmost lane of the approach. Mast arms placed on sidewalks provided a narrow walking path. Some pedestrian push buttons were also placed on sidewalks leaving minimized space for pedestrians.

13.4.2. Sign Placement and Sign Type

Driving through the corridor proved there was ample signs, conveying both information to drivers about reversible lane operations and other traffic operations. Spacing between overhead mast arm signs was inconsistent. There was no equal spacing between the location of the mast arms. At some points along the corridor, there were clusters of signs which could make it challenging for drivers to quickly process the information. At the mast arm located on the southbound side of 7th Street, across from The Carlyle, there was a vacant mast arm. It should be the location of a sign displayed in ***Photo 18***, but the sign was not present. At the Bethany Home and 7th Street intersection, the westbound approach mast arm did not have the street sign labeled.

Photo 16 – Southbound on 7th Street: Warning Sign for End of Reversible Lane

Photo 17 – Southbound on 7th Street: End Reverse Lane Static Sign

Photo 18 – Southbound at Highland Avenue and Camelback Road:
Missing Overhead Mast Arm Sign with No Construction

Photo 19 – Northbound on 7th Street Between Alice Avenue and Dunlap Road:
Change in Signage on Overhead Mast Arms

13.4.3. Driver Maneuvers

Driver confusion was exhibited during the initial time-frame of the reversible lane operation, as drivers traveling northbound were not aware that the double yellow dashed lane was a true southbound travel lane. Drivers aware of the reversible lane made prohibited left turns from the reversible lane and left-most northbound lane during AM reversible lane operations. These select vehicles were turning into businesses or driveways.

Photo 20 – Southbound on 7th Street Between Thomas Road and Osborn Road:
Vehicle Turning Left During AM Peak Reversible Lane Operations

14.0 Improvement Strategies

Evaluation of existing conditions and field visits lend themselves towards multiple corridor improvement strategies. Proposed strategies are mutually exclusive or combined efforts, varying with the strategy selected. The strategies are listed in ***Table 14-1***.

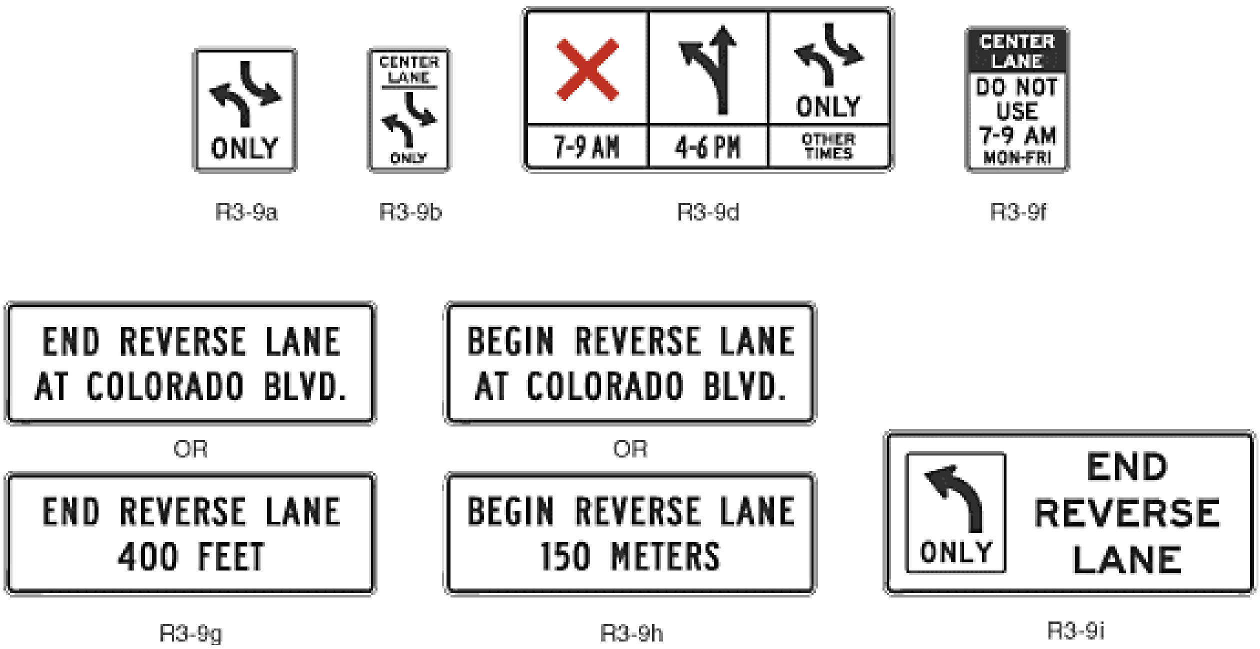
Table 14-1 – Improvement Strategy Considerations			
Improvement Strategy	**Explanation**	**Benefits**	**Challenges**
Intersection Improvements as *no-build* improvements	Upgrade intersections along both corridors for structural integrity, technology updates.	Improves structural integrity of mast arms, replace signal heads, upgrade technology to support any proposed solutions for reversible lanes.	Closures of multiple intersections along both corridors would need to be closed, timely construction project.
Dynamic Lane Control Signs as *operations* improvements	Dynamic Lane Control Signs are overhead signs that indicate the direction of travel on reversible lanes and turn lane restrictions at intersections.	Provides flexibility compared to static signs. Improved visibility of lane control signs. Increases compliance. Less information for drivers to decipher compared to existing infrastructure.	Requires redesign of corridor mast arms, and corridor monitoring and implementation by TMC. Visibility may be unappealing for residents Requires road closures for installation.
Restriping to Widen Reversible Lane as *operations* improvements	Restripe the corridor for uniform lane widths.	Wider reversible lane. Improves safety and reduces opposing side swipe crashes and same side swipe crashes. Improves operating speeds along 7th Street and 7th Avenue corridors.	Limited curb space and reduced lane widths along the corridor in the current configuration make it difficult to provide traditional lane widths. Reducing lane width of other lanes corridor shutdown to restripe.
Intelligent RPMs (Raised Pavement Markers) as *operations* improvements	Pavement markers, reflective devices on the roadway to provide delineation at night, during inclement weather, and in places where alignment variations require guidance. Have three colors (red, yellow, green) and six different pattern displays to provide information about lane operations/directional flow.	Technology controlled system (changed quickly). Lane Management flexibility and control. Ability to make buffer zones through ITS (utilize during transition periods).	System is sensitive to pavement temperature. Additional pavement treatments like Cool Pavement techniques must be used. Reversible lane operations in daylight may make RPMs difficult to see. Operations/maintenance cost increase as batteries need to be changed occasionally; drivers would need to be educated on the meaning of the different pattern displays
Install Fiber Trunk Lines along both corridors as *communications* improvements	Add fiber along the reversible lane corridors.	Improved video detection and communication.	Some property impacts.
Modify Bus Pull-Outs as *operations* improvements	Bus pull outs are designated roadway sections that allow a bus to exit the right lane and release passengers	Bus no longer has to stop in right lane, contributing to traffic	Some ROW impacts. There is the possibility that the bus will have to wait to access the

Table 14-1 – Improvement Strategy Considerations			
Improvement Strategy	**Explanation**	**Benefits**	**Challenges**
	from the bus without causing vehicles in the right lane to stop due to bus operations. Improves travel speeds, reduces rear end collisions.	congestion. Increase in right lane free flow.	through lanes, which might impact the bus schedule. Will require coordination with Valley Metro.
Access Consolidation Improvements as *operations* improvements	Consolidate access and reduce curb cuts along the corridor to decrease left turns from/to reversible lanes.	Improves safety and fewer conflict points.	Coordinate buy-in from parcel owners' businesses. Very challenging given the prevalence of commercial properties in the corridors.
Computer Vision for Turn Violation as *communications* improvements	Emerging technology to monitor turn restriction violation (similar to red light cameras and ticketing).	Improves operations, safety of intersections during reversible lane operation duration. Improves compliance and reduces driver confusion.	Integration with TMC operations. Additional maintenance cost and ongoing agreements with service providers. Additional warning signs for drivers about monitoring. Need mechanism for monitoring and triggering system.
Entire Corridor Width Dynamic Lane Control as *operations* improvements	Information of reversible lane and non-reversible lane operations can be displayed at all hours. The same display would be shown on solely northbound and southbound lanes at all times. Reversible lane display would change based on peak and off-peak hours.	Alleviates driver confusion. Eliminates the reason for drivers to look at the clock to determine operation hours and directions. Lane visibility improves during night travel. Transition period awareness improves.	Rather bulky sign structure throughout entire corridor. Could have resident push-back. Requires corridor closure for installation.
Optimize and Coordinate Signal Timings as *operations* improvements	Optimize and coordinate signal timings to give the northbound and southbound directional priority. In addition, offsets can be implemented that allow for coordination between traffic signals, optimizing the green time.	Provide as many available greens based on speed limits and vehicle capacity to keep traffic flowing during peak hours.	East-west streets may experience higher congestion if north-south streets have longer green time.

Given the decision matrix in ***Table 14-1***, the improvement strategies have been narrowed down to three feasible categories for consideration: no-build, communications, and operations.

It is understood that, at a minimum, the existing static signs will be removed and replaced with regulatory signs. The existing signs in the corridor are to Manual of Uniform Traffic Control Devices (MUTCD) standard, however, they need to be replaced. ***Figure 36*** conveys the to-standard signs that can be used to replace the existing reversible lane infrastructure, if the improvement strategy is chosen. Exiting corridor signs are slight variations of MUTCD Standard Signs R3-9d, 53-9f, R39g and R3-9h.

Figure 36 – Standard Reversible Lane Control Signs per MUTCD



14.1. Considered Improvement Strategies

After evaluation of the needs of the corridors, seven proposed improvement categories have been identified as implementable:

1. Static Sign Removal
2. Static Sign Replacement
3. Intersection Upgrades
4. Fiber Trunk Line
5. Dynamic Lane Control (DLC) Sign System
    a. DCL only for reversible lane on cantilever mast arm
    b. DCL across all lanes on staple sign structure (preferred)
6. Upgrade striping (restripe for uniform lane width)
7. Replacing in-lane bus stops with bus bays where feasible

Improvement Categories 1, 2 and 3 should be considered as baseline costs that would be included in the no-build. Further, some improvements are mutually exclusive, meaning only one for each pair can be selected.

Improvements 1 (Static Sign Removal) and 5 (Dynamic Lane Control Sign System) can be modified as desired, but both are required to meet reversible lane regulations per MUTCD. Design costs associated with Categories 4 and 5 are generally inflated to account for variation in material and labor costs, depending on the vendor.

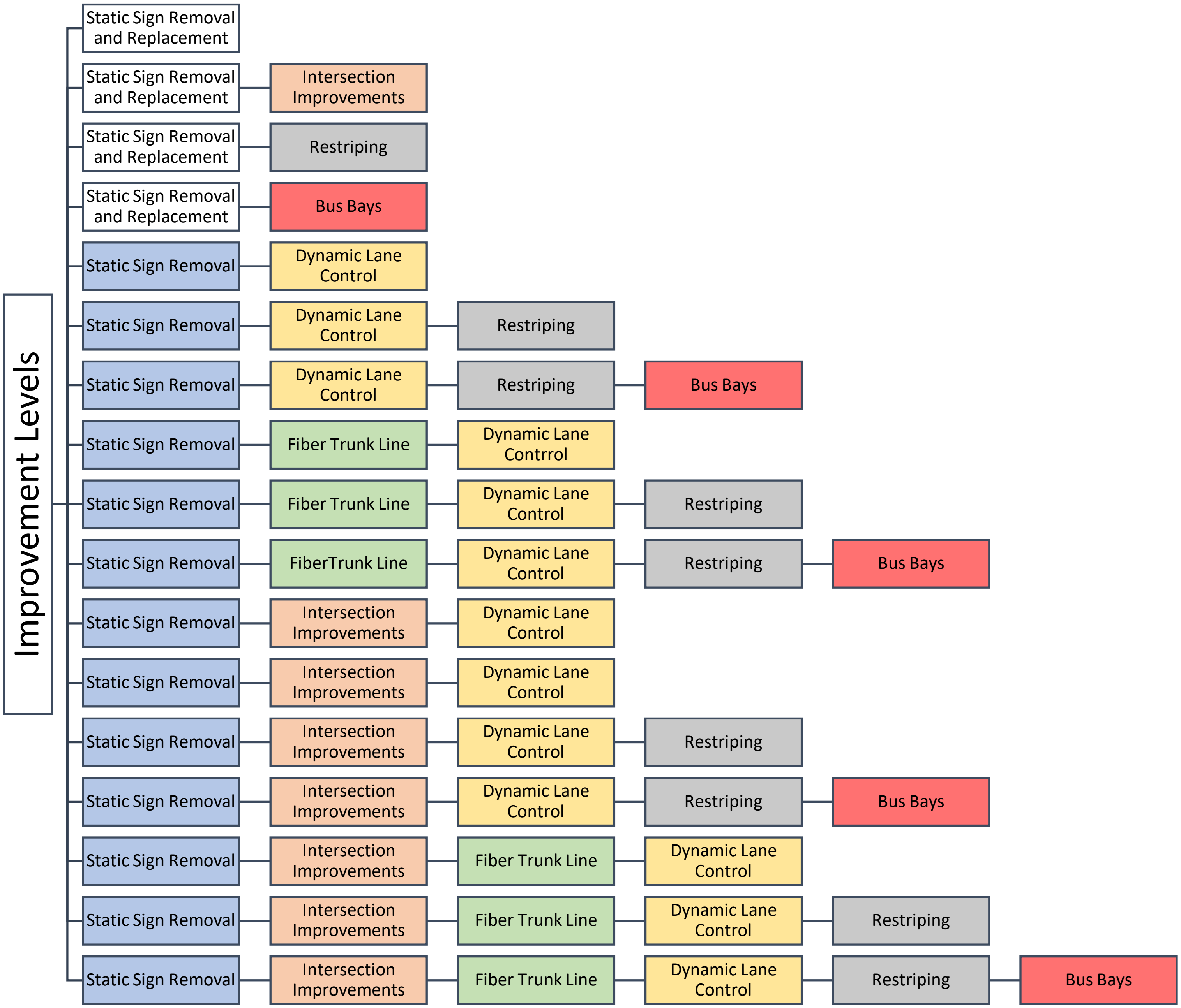
It was assumed that nearly all the existing sign structures and most of the intersection technologies will be replaced due to their age and maintenance needs. The proposed cost associated with the existing infrastructure removal is listed in Improvement Category 1.

The costs and assumptions associated with these proposed improvement strategies are found in ***Section 15.0***. Proposed improvements can be viewed in the 7th Avenue and 7th Street Corridor Map books, found in ***Appendix J*** and ***Appendix K*** respectively.

15.0 Preliminary Cost Estimates of Improvement Strategies

The proposed cost estimate is driven from the indicated improvement strategies in ***Section 14.0***. The considered improvement strategies were optimized and divided into seven categories. Improvement strategy levels can be found in ***Figure 37***. While not all improvements need to occur simultaneously and along both 7th Avenue and 7th Street at the same time, proposed improvement levels can be defined in order to consider associated costs of improvements. This section includes cost estimates for construction and markup totals for the proposed improvements as individual entities. Detailed Cost Estimates can be found in ***Appendix L***.

Figure 37 – Reversible Lane Corridor Improvement Levels



15.1. Static Sign Removal Cost Estimate

This proposed cost includes the cost of removing all static overhead lane control signs based on the understanding that existing infrastructure and signs will be replaced. The proposed preliminary cost estimate for both corridors can be found in ***Table 15-1***.

Table 15-1 – Proposed Cost Estimate for Static Sign Removal Improvements		
Item Description	***7th Avenue***	***7th Street***
	Total Cost	
Construction Subtotal	**$92,000.00**	**$121,000.00**
Unidentified Item Allowance (20%)	$18,400.00	$24,200.00
Construction Total	**$110,400.00**	**$145,200**
Traffic Control (5%)	$5,520.00	$7,260.00
Construction Engineering (14%)	$15,456.00	$20,328.00
Consultant Services (2%)	$2,208.00	$2,904.00
Construction Contingencies (3%)	$3,312.00	$4,356.00
Construction Project Total	$136,896.00	$180,048.60
Design (10%)	$13,690.00	$18,005.00
Design and Construction Project Total	**$150,586.00**	**$190,053.60**

15.2. Static Sign Replacement Cost Estimate

Per MUTCD guidelines for displaying information about reversible lanes, static signs should be used to supplement other displayed information of reversible lane operations. MUTCD Regulatory signs are shown in ***Figure 36.*** The existing signs at corridor extremes (7th Avenue and McDowell Road, 7th Avenue and Northern Avenue, 7th Street and McDowell Road and 7th Street and Dunlap Road) are similar to the proposed signs. Corridor improvements can include newly installed signs of the same nature and R3-9d sign structures at overhead lane control mast arms. The information displayed will serve the same purpose: alert drivers that the reversible lane will begin in a variable X amount of feet, depending on the placement of the sign. The proposed preliminary cost estimate for both corridors can be found in ***Table 15-2***.

This cost estimate includes the cost assumed for the reconstruction of all mast arm and pole foundations with new static signs (i.e. upgrade the existing reversible lane infrastructure).

If combined with the Improvement Category 5 (Dynamic Lane Control Sign System), a preliminary design calls for total of six static signs at corridor extremes in addition to the dynamic lane control signs.

Table 15-2 – Proposed Cost Estimate for Static Sign Replacement Improvements		
Item Description	***7th Avenue***	***7th Street***
	Total Cost	
Construction Subtotal	**$708,000.00**	**$838,000.00**
Unidentified Item Allowance (20%)	$141,600.00	$167,600.00
Construction Total	**$849,600.00**	**$1,005,600.00**
Traffic Control (5%)	$42,480.00	$50,280.00
Construction Engineering (14%)	$118,944.00	$140,784.00
Consultant Services (2%)	$16,992.00	$20,112.00
Construction Contingencies (3%)	$25,488.00	$30,168.00
Construction Project Total	**$1,053,504.00**	**$1,246,944.00**
Design (10%)	$105,350.00	$124,694.00

Table 15-2 – Proposed Cost Estimate for Static Sign Replacement Improvements		
Item Description	***7th Avenue***	***7th Street***
	Total Cost	
Design and Construction Project Total	**$1,158,854.00**	**$1,371,638.00**

15.3. Intersection Improvements Cost Estimate

The following assumptions were made:

- Intersection improvements are on a case-by-case basis. The proposed estimate includes an all-encompassing cost to reconstruct all aspects.
- Intersection improvements do not include the cost for dynamic sign integration.
- Intersection improvements include:
    - New mast arms and pole foundations
    - New traffic signals (at least two per approach)
    - New controller cabinets
    - New pull boxes to support updated technology
    - New pedestrian push buttons, or the addition of pedestrian push buttons at intersections that do not have any existing
    - Detection on all approaches
    - CCTV cameras and pre-emption technology

The proposed preliminary cost estimate for both corridors can be found in ***Table 15-3***.

Table 15-3 – Proposed Cost Estimate for Intersection Improvements		
Item Description	***7th Avenue***	***7th Street***
	Total Cost	
Construction Subtotal	**$3,650,000.00**	**$5,300,000.00**
Unidentified Item Allowance (20%)	$730,000.00	$1,060,000.00
Construction Total	**$4,380,000.00**	**$6,360,000.00**
Traffic Control (5%)	$219,000.00	$318,000.00
Construction Engineering (14%)	$613,200.00	$890,400.00
Consultant Services (2%)	$87,600.00	$127,200.00
Construction Contingencies (3%)	$131,400.00	$190,800.00
Construction Project Total	**$5,431,200.00**	**$7,886,400.00**
Design (10%)	$543,120.00	$788,640.00
Design and Construction Project Total	**$5,974,320.00**	**$8,675,040.00**

15.4. Fiber Trunk Line Cost Estimate

The cost of installing a fiber trunk line along 7th Avenue from McDowell Road to Northern Avenue and along 7th Street from McDowell Road to Dunlap Avenue was based on a typical mile of fiber trunk line installation and assumes the following:

- The trunk line consists of 3-4" PVC/HDPE conduit. One of these conduits is an empty spare.
- Laterals are installed at all dynamic sign pole locations.
- Laterals consist of 2-3" PVC/HDPE conduit. One of these conduits is an empty spare.
- When crossing paved streets, directional drilling of HDPE conduit is required.
- When installing conduit in all other areas, PVC conduit will be installed by open trench.
- Trunk line fiber will be single mode fiber-optic cable with 144 strands.
- Lateral fiber will be single mode fiber-optic cable with 12 strands and is spliced to the trunk line fiber.
- Number 9 pull boxes are installed at every lateral junction.
- Number 9 pull boxes are installed at every signalized intersection on the same corner as the signal cabinet.
- Number 7 pull boxes are installed at a minimum spacing distance of 1 per every 500 feet.
- Dynamic sign pole cabinets are not quantified in this estimate as they are a part of Lane Control System estimate.
- The estimate includes a 20% unidentified item allowance.

The proposed preliminary cost estimate for both corridors can be found in ***Table 15-4***.

Table 15-4 – Proposed Cost Estimate for Fiber Trunk Line Network

Item Description	***7th Avenue***	***7th Street***
	Total Cost	
Construction Subtotal	**$2,852,930.10**	**$3,310,258.60**
Unidentified Item Allowance (20%)	$570,586.00	$662,052.00
Construction Total	**$3,423,516.10**	**$3,972,310.00**
Traffic Control (5%)	$273,881.00	$317,785.00
Construction Engineering (14%)	$479,292.00	$556,123.00
Consultant Services (2%)	$64,470.00	$79,446.00
Construction Contingencies (3%)	$102,705.00	$119,169.00
Construction Project Total	**$4,347,864.10**	**$5,044,833.60**
Design (10%)	$434,786.00	$504,483.00
Design and Construction Project Total	**$4,782,650.10**	**$5,549,316.60**

15.5. Dynamic Lane Control Sign System Cost Estimate

The following assumptions were made:

- All lanes will display lane management information.
- Signs will display either a green arrow or a red 'X' and will be doubly sided.
- For locations proposed (see ***Appendix J*** and ***Appendix K***), sign locations with shared static and dynamic sings will only have dynamic lane control signs on the opposite direction of traffic. The static sign will be displayed on the correct side of traffic, informing drivers of beginning and ending reversible lane distances.
- All other proposed mast arm locations will include a dynamic lane control sign above each lane and only one sign per lane.

Figure 38 – Sample Mast Arm Dynamic Sign Display

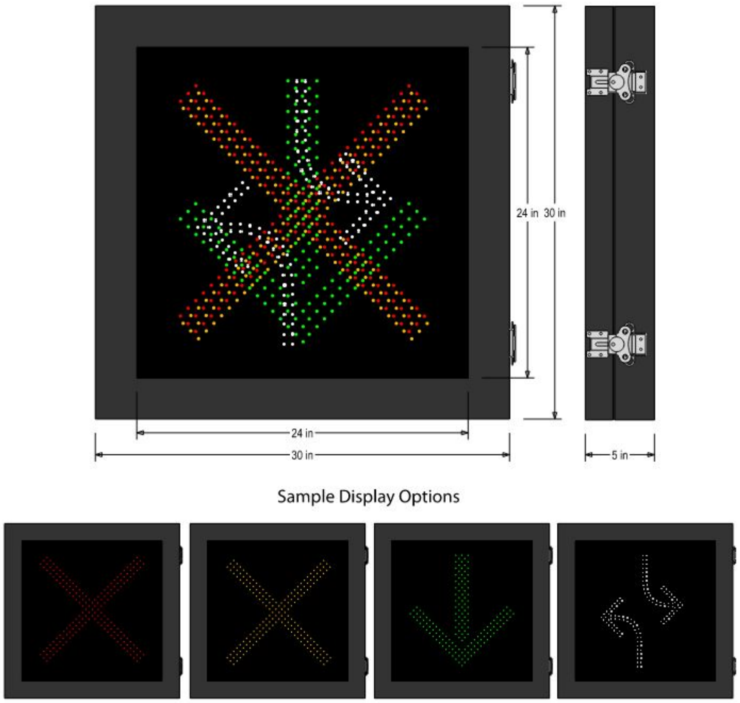
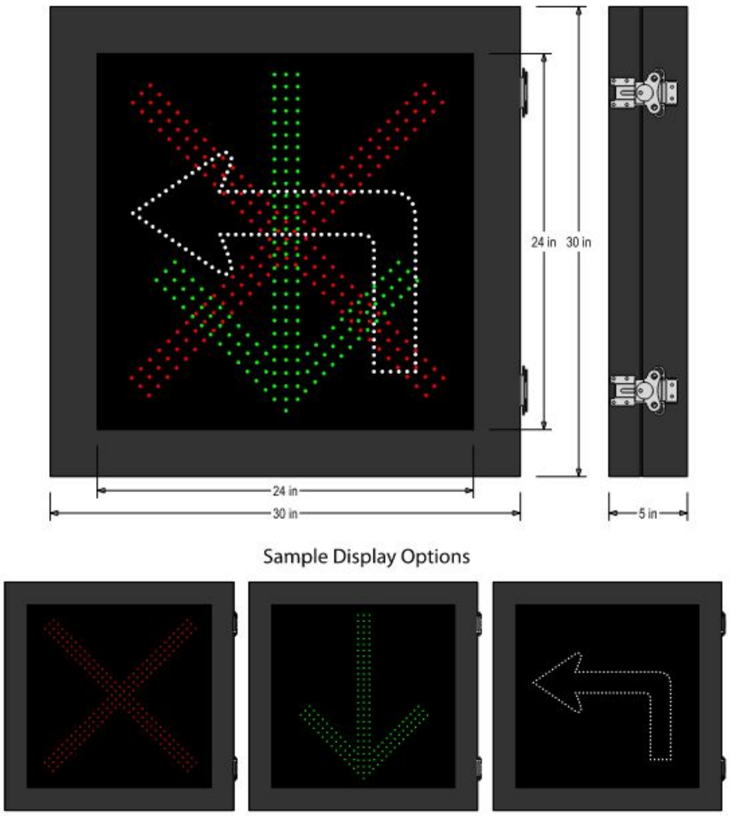


Figure 39 – Sample Intersection Dynamic Sign Display



The proposed preliminary cost estimate for both corridors can be found in ***Table 15-5.***

Table 15-5 – Proposed Cost Estimate for Dynamic Lane Control Sign Improvements (Staple Sign Structure)		
Item Description	***7th Avenue***	***7th Street***
	Total Cost	
Construction Subtotal	**$4,970,000.00**	**$5,518,600.00**
Unidentified Item Allowance (20%)	$994,000.00	$1,103.720.00
Construction Total	**$5,964,000.00**	**$6,622,320.00**
Traffic Control (5%)	$298,200.00	$331,116.00
Construction Engineering (14%)	$834,960.00	$927,125.00
Consultant Services (2%)	$119,280.00	$132,446.00
Construction Contingencies (3%)	$178,920.00	$198,670.00
Construction Project Total	**$7,395,360.00**	**$8,211,677.00**
Design (10%)	$739,536.00	$821,168.00
Design and Construction Project Total	**$8,134,896.00**	**$9,032,845.00**

15.6. Restriping Cost Estimate

The restriping is assumed to take place during other maintenance activities. This being the case, cost is not included for striping obliteration or any chip seal activities.

Striping quantities are based on lane miles, including right-turn lane pockets.

The proposed preliminary cost estimate for both corridors can be found in ***Table 15-6.***

Table 15-6 – Proposed Cost Estimate for Restriping Improvements		
Item Description	***7th Avenue***	***7th Street***
	Total Cost	
Construction Subtotal	**$180,300.00**	**$213,400.00**
Unidentified Item Allowance (20%)	$36,100.00	$42,700.00
Construction Total	**$237,000.00**	**$280,600.00**
Traffic Control (5%)	$19,000.00	$22,400.00
Construction Engineering (14%)	$19,000.00	$22,400.00
Consultant Services (2%)	$4,700.00	$5,600.00
Construction Contingencies (3%)	$11,90.00	$14,000.00
Construction Project Total	$320,600.00	$379,200.00
Design (10%)	$32,000.00	$33,800.00
Design and Construction Project Total	**$353,000.00**	**$413,000.00**

15.7. Bus Bay Cost Estimate

The proposed cost estimate for bus bay construction for 7th Avenue and 7th Street have been divided into separate corridors as well as a Study Area cost estimate. Bus bay locations that were deemed infeasible due to significant right-of-way needs or major utility reconstruction to construct were not included in the cost estimate. The following assumptions were used in creating the cost estimate for both corridors:

- Typical bus bays are assumed to be constructed per MAG Standard Detail 252.
- Typical bus bays and modified bus bays are needed, but there is no true difference in cost.
- Bus bays have been categorized based on the needs of the location. The type of category of bus bay may exist on 7th Avenue, 7th Street, or both.
- Construction needs require a combination of right-of-way acquisition, driveway reconstructions, pole relocations, and/or minor utility (pull boxes, telecom risers, water valves) relocations.
- Proposed bus bay locations with right-of-way acquisition costs do not require the reconstruction of any existing buildings (commercial or residential).
- Rights-of-way for different residential properties for both corridors were assumed to be an average of $25,000.00. This cost includes land acquisition, procurements costs, construction costs, and costs to cure for each parcel owner.
- Rights-of-way of proposed bus bays with conflict zones with commercial properties were estimated to have the same cost as residential rights-of-way.

The proposed preliminary cost estimate for both corridors can be found in ***Table 15-7.***

Table 15-7 – Proposed Cost Estimate for Bus Bay Improvements		
Item Description	***7th Avenue***	***7th Street***
	Total Cost	
Construction Subtotal	**$3,295,000.00**	**$3,815,000.00**
Unidentified Item Allowance (20%)	$659,000.00	$763,000.00
Construction Total	**$3,954,000.00**	**$4,578,000.00**
Traffic Control (5%)	$316,320.00	$366,240.00
Construction Engineering (14%)	$553,560.00	$640,920.00
Consultant Services (2%)	$79,080.00	$91,560.00
Construction Contingencies (3%)	$118,620.00	$137,340.00
Construction Project Total	**$432,580.00**	**$5,051,060.00**
Design (10%)	$432,258.00	$505,106.00
Design and Construction Project Total	**$4,798,838.00**	**$5,556,155.00**

16.0 Recommendations

The reversible lanes provide additional peak hour capacity and serve as regionally significant routes. This report concludes that eliminating the reversible lanes partially or completely will create operational delays and increase travel times by more than 40 percent. Several signalized intersections will operate at an unacceptable level of service when reversible lanes are eliminated and can increase the potential for crashes associated with traffic congestion. It is the study team's recommendation to retain the reversible lanes but consider the improvement strategies outlined in the report.

Improvement strategy categories, as defined in this report, can be used as a baseline for future corridor improvements to improve traffic operations and corridor safety along 7th Avenue and 7th Street. Seven improvement strategies were selected from a decision matrix based on corridor need and were categorized by:

1. No-build improvements,
2. Communication improvements, and
3. Operations improvements.

Field visits indicated that at a minimum the existing reversible lane static signs should be removed and replaced to remove inconsistencies in signage and to eliminate sign structures with poor structural integrity of the mast arms. Beyond the minimum requirements for improvement, alternatives including intersection improvements, fiber trunk line additions, dynamic lane control signs, corridor restriping, and pull-out bus bay constructions were considered.

We believe that the dynamic lane control signs improve the overall operations and safety along the reversible lane corridors. In addition to providing higher visibility, the dynamic lane control signs also provide the flexibility for reversible lane operations for off-peak travel conditions.

Based on the condition of existing infrastructure, traffic operational and crash analysis, we recommend that the improvements be implemented first along 7th Street and then along 7th Avenue.