

# Light Rail Collision Investigation Phoenix, Arizona

April 2010

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**Prepared for:**

CITY OF PHOENIX AND VALLEY METRO RAIL, INC.



**M-M Project Number:** 8131.017

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## **EXECUTIVE SUMMARY**

Phoenix selected Morrison-Maierle to provide an independent assessment of the education program, enforcement programs, collision history, and traffic control for the Valley Metro Rail Light Rail system within the city limits of Phoenix. The scope of services for the project consisted of fifteen separate, related tasks scheduled for completion during the six-month study.

Valley Metro Rail provided an extensive public awareness program prior to the initiation of test service in September of 2008, which intensified prior to operation initiation on 28 December 2008. A separate police unit is assigned to the Light Rail Transit system with the responsibility of ensuring safety and law awareness and compliance for passengers, motor vehicle operators, bicyclists, and pedestrians.

The following thirty-one (31) systems were reviewed to select four (4) systems with characteristics similar to the Valley Metro Rail system in Phoenix.

1. Baltimore, Baltimore Light Rail
2. Boston, MBTA Green Line Ashmont–Mattapan High Speed Line
3. Buffalo, Buffalo Metro Rail
4. Charlotte, LYNX Rapid Transit Services
5. Cleveland, The Rapid Blue and Green Lines
6. Dallas, DART: Red and Blue Lines, MATA Streetcar
7. Denver, Denver RTD, The Ride Light Rail
8. Houston, MetroRail
9. Jersey City, Hudson-Bergen Light Rail
10. Little Rock, River Rail Streetcar
11. Los Angeles, Los Angeles County Metro Rail Blue, Green and Gold Lines
12. Memphis, Memphis RTA Trolley
13. Minneapolis, Hiawatha Line
14. New Orleans, RTA Streetcar
15. Newark, Newark City Subway and Newark Light Rail
16. Oceanside, Sprinter
17. Philadelphia, SEPTA Subway-Surface Lines, Suburban Trolley Lines and Girard Avenue Trolley
18. Pittsburgh, The T
19. Portland, MAX Light Rail (not including Portland Streetcar)
20. Sacramento, Sacramento Regional Transit District Light Rail
21. Salt Lake City, UTA TRAX
22. San Diego, San Diego Trolley
23. San Francisco, Muni Metro and F/Market Line Muni Cable Cars
24. San Jose, Santa Clara VTA Light Rail
25. Seattle, South Lake Union Streetcar
26. St. Louis, St. Louis MetroLink
27. Tacoma, Tacoma Link
28. TECO Line Streetcar System, Tampa
29. Trenton/Camden, River Line

30. Kenosha Transit, Kenosha

31. Galveston Island Trolley, Galveston

The primary City of Phoenix Valley Metro Rail system characteristics that were compared to other United States systems were: urban, at-grade, in-street, and same-direction flow. The following four (4) Light Rail systems were selected for the historic collision analyses:

- Los Angeles County Metro Rail – Los Angeles, California
- Portland Tri-Met Light Rail – Portland, Oregon
- Santa Clara VTA Light Rail – San Jose, California
- Sacramento Regional Transit District Light Rail – Sacramento, California

Data on historic collisions for these four (4) systems and for all systems in the United States was examined. The Federal Highway Administration provides data for all collisions with an estimated minimum cost of \$5,000 for the years prior to 2008; and for all collisions with an estimated minimum cost of \$25,000 for 2008. Phoenix data for collisions involving Light Rail Vehicles does not include the estimated injury and damage costs. Therefore, direct comparisons are not possible between collision data for other United States Light Rail systems and Phoenix.

The following list summarizes the results of the collision rate investigation. The collision rate is the number of collisions per directional-route-mile.

<u>SYSTEM</u>	<u>ANNUAL COLLISION RATE CHANGE FROM 2002 TO 2007</u>
Los Angeles	Decrease of 10%
Portland	Decrease of 11%
Santa Clara	No change
Sacramento	Decrease of 11%
All United States Systems	Decrease of 4%

Thirty-nine collisions involving Valley Metro Rail Light Rail Vehicles occurred within the city limits of Phoenix in the initial 13 months of system testing and operation. A substantial majority of the collisions occurred with motor vehicles traveling in the same direction as Light Rail Vehicles, with drivers improperly entering the intersection, and with drivers turning right or left. Also, a substantial majority of the collisions did not result in injuries to Light Rail Vehicle passengers or motor vehicle occupants. None of the collisions involved pedestrians or bicyclists.

The following list provides a generalized summary of the characteristics for the 39 collisions.

- 87.2% of the private vehicles were travelling in the same direction as the Light Rail vehicle.
- 86.2% of the private vehicle drivers improperly entered the intersection.
- 85.2% of the collisions did not involve injuries to passengers or drivers
- 76.9% of the private vehicle drivers were turning right or left.
- 68.4% of the collisions occurred during day-time hours.
- 66.7% of the private vehicle drivers are metropolitan Phoenix residents.
- 59.0% of the collisions occurred between 1<sup>st</sup> Avenue, 7<sup>th</sup> Street, Van Buren, and Jefferson.
- 33.3% of the private vehicle drivers are between 31 and 40 years old.
- 21.0% of the collisions occurred with the vehicle driver facing the sun.
- Nine (23.1%) collisions occurred on Wednesday.
- Five (12.8%) collisions occurred in each of February, April, June, and July 2009.
- Zero (0) collisions involved pedestrians or bicyclists.

One intersection was specifically investigated early in the analysis – the interchange of I-10 and Jefferson Street and Washington Street. The concern that initiated the investigation was vehicles on either Jefferson Street or Washington Street crossing the Light Rail Transit tracks from the primary motor vehicle travel lanes to the frontage road motor vehicle travel lane when traffic control indicated Light Rail Vehicle right-of-way. While no collisions occurred at this interchange, there existed a greater than reasonable possibility of collisions occurring at this location. The specific investigation recommended traffic signal timing changes, which were implemented in November 2009.

Conversations with representatives of the Phoenix Street Transportation Department, the Phoenix Police Department, and Valley Metro Rail resulted in a list of twenty-five specific locations for detailed analysis for potential traffic control modification. All four (4) of the intersections with more than one collision, and two (2) additional intersections with similar characteristics to the four (4) with more than one collision were analyzed. Six (6) locations where the Light Rail Transit crossed the motor vehicle lanes were specifically analyzed. Five (5) locations with frequent driver disobedience of traffic control were studied. Four (4) locations with concerns regarding pedestrian activity and four (4) locations with concerns regarding bicyclist pavement marking were analyzed.

The general recommendations subsequent to the detailed analyses included:

Removal of light-rail “blank-out” signs.

Removal of symbolic “DO NOT DRIVE ON TRACKS” signs.

Removal of “LEFT (RIGHT) TURN ON GREEN ARROW ONLY” signs and replacement with “NO TURN ON RED” signs.

Inclusion of track symbol on overhead and groundmount median and lane control signs.

Modification of signal timing to allow left and right turns during the absence of Light Rail Vehicles.

Increase public awareness of traffic control devices in the vicinity of Light Rail Transit / street intersections.

Dedicated police education and enforcement campaign at downtown Light Rail Transit / street intersections.

Monitor right-turn-on-red violations at the four (4) intersections with more than one collision.

Consider installation of red light cameras at the four (4) intersections with more than one collision.

Of the twenty-five locations of specific analysis, there were no recommended changes for four (4) locations. At thirteen (13) locations, there were no additional recommendations beyond the general recommendations. At four (4) locations, there were recommendations for additional bicycle lane striping or pavement markings. At one location, an additional pedestrian signal was recommended, while at another location, an increase in the pedestrian walk time was recommended. At two locations, one-way signs and traffic signal relocations were recommended.

## **INTRODUCTION**

Testing for the Valley Metro Rail Light Rail Transit system began in September 2008. Operation began on 28 December 2008. This was the first fixed rail transit system in the metropolitan Phoenix area since the trolley system. Approximately 13 miles of the total approximately 20-mile Valley Metro Rail system are located within Phoenix. The Valley Metro Rail system operates at-grade in the same right-of-way as traditional motor vehicle travel lanes. However, there are no Light Rail Transit tracks coincident with motor vehicle travel lanes.

The Light Rail Transit tracks intersect streets at numerous locations – most of which are also intersections of two streets. At these intersections, the Light Rail Transit tracks are parallel to one street and perpendicular to the other street.

At some locations, the Light Rail Transit tracks intersect with only one street. Some of these intersections are essentially perpendicular. At other locations, the Light Rail Transit tracks have a skewed intersection.

There are a wide variety of possible traffic control devices for these different intersection types and specific circumstances – particularly because of at-grade operation within the same right-of-way. The primary purpose for traffic control devices is to maximize safety, with a secondary purpose of maximizing efficiency. An unfortunate, inherent circumstance of transportation is collisions. Collisions have occurred between Light Rail Vehicles and motor vehicles. An analysis of past collisions can provide assistance in determining optimal traffic control devices to minimize future collisions, beneficial education campaigns, and effective enforcement programs.

Therefore, Phoenix Street Transportation Department and Valley Metro Rail desired to examine the traffic control for the Light Rail Transit system. They elected to utilize an independent consulting traffic engineer to assist this examination. Furthermore, they preferred a private consultant who previously had long-term responsibility for traffic control devices for a relatively large municipal agency in metropolitan Phoenix. Finally Phoenix Street Transportation Department preferred a consultant that had not been previously involved in any aspect of the Light Rail Transit project to ensure an independent review and assessment.

## **SCOPE OF SERVICES**

### **Scope of Services for Light Rail Transit (LRT) Traffic Safety Evaluation Street Transportation Department Phoenix, Arizona Page 1 of 4**

- 1) The Consultant shall meet with City of Phoenix officials and Valley Metro Rail Rail, inc. (METRO) officials to initiate the project.
- 2) The Consultant shall accomplish a literature search of historic LRV / vehicle collision experiences for systems in other cities.
- 3) The Consultant shall accomplish a review of available data for historic LRV / vehicle collisions experience for three (3) cities with similar LRT systems and street network to those of Phoenix.
- 4) The City will provide Police collision reports and LRV video and a summary of the vehicle collisions.
- 5) The Consultant shall review the police reports prepared for all collisions to date that have occurred in Phoenix involving Light Rail Vehicles (LRV). As of June 24, 2009, twenty (20) LRV / vehicle collisions have been reported in Phoenix. If additional LRV collisions occur during the study, prior to submittal of the initial draft report, the Consultant shall include a review of those collisions as part of the study. The Consultant shall also review all available Department Reports for these collisions and any pertinent video retrieved from the LRV cameras.
- 6) The Consultant shall conduct field observations of and photograph a maximum of 120 signal-controlled light rail intersections in Phoenix from 19<sup>th</sup> Avenue at Montebello Avenue to Washington Street at 54<sup>th</sup> Place. The purpose of the review is to observe and photographically document the current conditions; specifically the presence, clarity, and visibility of the following:
  - Traffic sign design and placement.
  - Pavement marking design and placement.
  - Traffic signal design and signal head placement, including the placement of the electronic TRAIN COMING symbol blank-out warning signs.

This review will not result in any measurements or diagrams. The review will not include comparison with the intended or designed devices. This review shall not include traffic signal timing, cycle length, and phase sequencing along the Light Rail Transit (LRT) guideway. The purpose of these observations is to determine the situations and circumstances that might require detailed analysis or measurement. The photographs will be catalogued in an appendix to the final report.

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The City will provide a copy of the LRT sign, paint and traffic signal equipment plans developed by the Valley Metro Rail Rail, Inc. (METRO) Consultants, however, there have been several changes made to these plans so they may not reflect actual or current field conditions.

Prior to the Consultant entering the METRO guideway during the study (except in a signal-controlled crosswalk during a WALK interval), the Consultant shall complete the one-hour track access course given by METRO, obtain a track access permit, be escorted onto the guideway by a METRO representative, and wear a safety vest.

- 7) The Consultant shall interview key Police Department, Street Transportation Department, and METRO Safety officials to obtain their perspectives on police enforcement, other safety efforts and strategies, and perceived challenges to improving LRT safety.

The City and METRO will provide a summary of Police Department enforcement activities deployed along the LRT guideway and enforcement results.

- 8) The Consultant shall interview METRO officials to review public safety education campaigns and messages with respect to LRV / vehicle and LRV / pedestrian safety.

METRO will provide a summary of traffic safety education campaigns (TV, radio, billboard, brochures, etc.) as well as a summary of campaign objectives and results.

- 9) Based upon the discoveries of Tasks 5, 6, 7, and 8; the Consultant shall identify a maximum of twenty (20) LRT / vehicle intersection locations for detailed review. These locations shall include those locations with the highest collision frequency, other locations with similar characteristics to the “high collision frequency” locations, and other locations identified by METRO or City of Phoenix officials.

- 10) The City will obtain LRV, vehicle, and pedestrian traffic count data at the intersections observed in Task 9. The counts will include 24-hour approach counts and peak four-hour pedestrian and bicycle counts.

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- 11) The Consultant shall conduct field observations at the locations determined in Task 9. The Consultant shall document general indications of the existing lane configurations, signs, pavement markings, and traffic signal devices. The observations shall also consist of two (2) to four (4) hours per intersection during the peak travel times, and shall include observations of LRV operator, motorist, and pedestrian behavior.

If video camera locations in or on adjacent buildings are available, overhead videotaping of these intersections shall be accomplished. If these locations are not available, ground level videotaping of these intersections shall be accomplished. Ground level digital still camera photographs of these intersections shall also be obtained.

- 12) The Consultant shall review the proposed Federal Highway Administration (FHWA) rulings to provide audible pedestrian signals at light rail traffic signals intended for inclusion in the next version of the Manual on Uniform Traffic Control Devices (MUTCD). The Consultant shall also identify and recommend the most cost-effective accessible pedestrian push button treatments that will be in compliance with the proposed ruling based on the most current information available from the FHWA.

- 13) The Consultant shall examine and photograph the bicycle lane signing and pavement markings and the bicycle traffic signal detection needs and devices on the Washington Street and Jefferson Street bicycle lanes from the intersection of 5<sup>th</sup> Street and Jefferson Street to the east City limits. The examination shall include the three bicycle box locations (7<sup>th</sup> Street and Jefferson Street, 24<sup>th</sup> Street and Jefferson Street, and 24<sup>th</sup> Street and Washington Street), eastbound Jefferson Street at 9<sup>th</sup> Street, and the location where the bicycle lanes cross from the north curb of Jefferson Street (main line) to the right side of the frontage road. The photographs will be cataloged in an appendix to the final report. If, in the opinion of the Consultant, modifications to these devices are necessary, the Consultant shall include recommendations for modifications of the existing signing, pavement markings, and traffic signal detection.

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14)Based on the police collision reports, field observations, METRO Safety, Street Transportation and Police interviews, the Consultant shall provide cost-effective recommendations for improvements to the following practices along the LRT guideway:

- Vehicle, bicycle and pedestrian traffic signing (sign design and placement).
- Pavement marking (pavement marking design and placement).
- Traffic signal design (driver signal head placement and design), and accessible pushbutton design and push button placement.
- Signing and pavement marking design and placement for the bicycle facilities along Washington Street and Jefferson Street.
- Police enforcement to minimize the risk of an LRV / vehicle or LRV / pedestrian collision.
- Public safety education efforts to minimize the risk of a LRV / vehicle or LRV / pedestrian collision.
- Recommendations to discourage or prevent pedestrians or bicyclists from illegally crossing, walking, or riding on or near the guideway.
- Innovative treatments to minimize the risk of a LRV / vehicle or LRV / pedestrian collision along the LRT guideway and at the signalized intersections.

15)The Consultant shall summarize the results, conclusions, and recommendations in a report including cost estimates for each recommendation. The report shall include an Executive Summary. The Consultant shall present the project findings and recommendations at a maximum of two (2) meetings with Street Transportation and METRO staff. If requested by Phoenix Street Transportation Department, the Consultant shall present the findings to the City Council or the City Council Transportation and Infrastructure Subcommittee. The meetings described in these tasks are in addition to the meetings in Tasks 1, 8 and 9.

## **INITIALLY PREPARED DOCUMENTS**

The initial resulting document for the Light Rail Transit Collisions Investigation for Phoenix and Valley Metro was a summary of the collisions that occurred since operation began in December 2008. **Appendix A** provides the complete results of these summaries.

Four statistics from this summarization are important to reducing collisions involving Light Rail Vehicles and motor vehicles. Motor vehicles traveling in the same direction as Light Rail Vehicles comprised approximately 87% of the total collisions. These are circumstances where the Light Rail Vehicle is approaching the driver from behind. Approximately 85% of the collisions involved motor vehicles entering the intersection improperly. Motor vehicles turning right or left against red signal indications comprised approximately 75% of the total collisions. Approximately 60% of the collisions occurred in downtown Phoenix.

The second task was to accomplish a literature review of collision investigations of other Light Rail Transit systems in the United States. The results of this task are provided in **Appendix B**. Thirty-two separate systems were identified and considered, with eleven (11) systems examined in greater detail. Four (4) systems were deemed to be most similar to Phoenix system – Los Angeles, Portland, San Jose, and Sacramento.

The third task was to investigate collision trends for Light Rail Transit systems similar to the system in Phoenix. These results are provided in **Appendix C**. Three (3) of the four (4) similar systems experienced a 10% to 11% annual decrease in collisions in the first five (5) years of operation.

**Appendix D** provides the results of an investigation into a particular location – the four (4) signalized intersections comprising the I-10 interchange with Jefferson Street and Washington Street. While no collisions had occurred at this location, there was concern that motor vehicle driver behavior at this interchange might result in collisions involving serious injuries. This investigation resulted in a modification to the interchange traffic signal timing for eastbound and westbound traffic. The modification prevented potential collisions between Light Rail Vehicles and motor vehicles changing lanes from the mainline street to the frontage road. The change improved the efficiency of the interchange for motor vehicles and did not diminish the Light Rail Transit efficiency or capacity.

The conclusion from these four (4) documents was that collisions involving Light Rail Vehicles in Phoenix will likely decrease in subsequent years. Furthermore, specific examination of traffic control and operation at selected intersections might result in modifications that would result in greater decreases in motor vehicle collisions with Light Rail Vehicles.

## **MEETINGS**

The project initiation meeting occurred on 11 August 2009, and was facilitated by Mike Cynecki of Phoenix Streets Transportation Department. Nine representatives of the Phoenix Street Transportation Department, three representatives of the City Manager's Office, three representatives of Valley Metro Rail, and two representatives of Phoenix Police Department were in attendance. The purpose of the meeting was to discuss the project scope of services and to begin discussions of specific locations for detailed investigation.

The second project meeting occurred on 12 August 2009, and was facilitated by Adrian Ruiz of the Phoenix Police Department. This meeting was for the police officers who would be involved in the dedicated enforcement and education campaign in the Central Business District of Phoenix from 17 August to 21 August.

A meeting occurred on 14 September with Ron Doubek and Joel Havris of Phoenix Street Transportation Department. In this meeting, the signal operation and changes to increase safety at the I-10 / Jefferson Street / Washington Street interchange was discussed.

On 13 November 2009, Lieutenant Adrian Ruiz was interviewed regarding the police enforcement of traffic control in the vicinity of Light Rail Transit and her observations of the traffic control for the Light Rail Transit system. Also discussed were her opinions regarding the causes of the traffic collisions that had occurred and possible mitigation measures.

On 16 November 2009, Larry Engelman with Valley Metro Rail was interviewed to determine his general impressions of the public education campaigns and of the traffic control for the Light Rail Transit system. Also discussed were his opinions regarding the relationship of the traffic control to the traffic collisions.

On 18 November 2009, a meeting occurred with seven members of the Phoenix Street Transportation Department. The purpose of this meeting was to discuss the Light Rail Transit system and particularly the relationship between traffic control and traffic collisions. Also discussed were the locations for specific investigation to determine if traffic control modifications should be implemented.

## **FIELD REVIEWS**

The Light Rail Transit system in Phoenix was observed and photographed by the consultant on approximately twenty-five (25) separate occasions from August 2009 to February 2010. Each of the more than 125 signalized and major intersections of the Light Rail Transit system was specifically and carefully reviewed. The traffic control devices were thoroughly examined at numerous locations. Driver behavior – particularly response to traffic control devices – was observed. Several hundred photographs were taken and analyzed. Locations with complex lane configurations and sophisticated traffic control devices received greater attention, observation, and investigation.

## **PRELIMINARY OBSERVATIONS**

Thirty-four of the total thirty-nine collisions involved Light Rail Vehicles approaching motor vehicles from behind. Drivers may be tempted to ignore turn prohibitions if they do not recognize or understand the inherent danger from disobeying sign or signals.

Recognizing that 85% of the collisions involved motor vehicles entering intersections improperly, it appears that drivers were unaware or negligent of the proper procedure for entering intersections with Light Rail Transit. Of the twenty-nine collisions where the driver violation is known, twenty-five motor vehicle drivers involved in collisions with Light Rail Vehicles were cited for violations of “disregard traffic signal”, “failure to stop for red light”, “improper turn”, or “failure to yield right-of-way”.

Approximately 60% of the collisions occurred in the Central Business District of downtown Phoenix. Fourteen of the thirty-nine collisions occurred at four (4) downtown intersections. These are the locations with the greatest density of activity, intersections, and traffic control.

Motor vehicle drivers may be either confused or impatient as they approach intersections with Light Rail Transit. It therefore appears that engineering, enforcement, or education measures could be utilized to reduce collisions. An opportunity exists for beneficial traffic control modifications. Recognizing the numerous traffic control devices present at the downtown Phoenix intersections, it may be beneficial to reduce the number and complexity of devices.

One candidate for consideration is the activated Light Rail Vehicle sign, termed a “blank-out” sign. This sign is typically blank, and becomes lit as Light Rail Vehicles approach the intersection. This is a warning sign with no regulatory or enforcement function. It does not direct a particular driver action. Turn prohibition signs and protected turn arrows must supplement the “blank-out” signs for regulatory or enforcement purposes. The blank-out signs are relatively cryptic and ambiguous. Additionally, problems have been identified with the signs not activating as intended – typically the signs are illuminated when a Light Rail Vehicle is not present. Subsequent to an intense rainstorm, eleven signs mal-functioned for two (2) days. The “blank-out” signs currently automatically de-activate 90 seconds after activation to minimize the time the signs appear without a Light Rail Vehicle in the vicinity. Therefore the “blank-out” sign is perhaps unnecessary and may detract from driver attention to more specific signs and signals.

The blank-out signs should remain on streets perpendicular to the Light Rail Transit tracks. These signs inform drivers of the presence of Light Rail Transit tracks that would be obvious to drivers. There are very few of these signs on the system – typically located at driveways that access frontage roads near crossover locations.

The newly-released (2009 Edition) of the Manual of Traffic Control Devices has not yet been adopted by the State of Arizona. In Section 8B.19, this document states the Light Rail Transit Approaching-Activated Blank-Out Warning Sign “... supplements the traffic control devices to warn road users ... “ and “may be used at signalized intersections ... “ Therefore, the “blank-out” signs are not required.

Another candidate for consideration is the word sign, “DO NOT DRIVE ON TRACKS” and the symbol sign with the same message. The signs are redundant intending to ensure that all drivers recognize the danger of utilizing the Light Rail Transit tracks as a roadway. However, the symbol sign – consisting of a motor vehicle on tracks with the international prohibition symbol – is not readily understandable. The sign represents the Light Rail Transit tracks from an overhead perspective (plan view) and a motor vehicle from a front or rear perspective (cross-section view) . This symbol sign may present unfamiliar drivers with excessive and confusing information.

Removing both the “blank-out” sign and the symbol track prohibition sign might enhance driver awareness and obedience to the other traffic control devices.

Additionally, two separate signs pertinent to turning movements are present throughout the Light Rail Transit system. One sign states, “LEFT (RIGHT) TURN ON GREEN ARROW ONLY”. The other sign states, “NO TURN ON RED”. The first sign requires more time to read and comprehend. More importantly, the larger number of words requires smaller letters on the sign, thereby requiring drivers to be closer to the sign to read. It may be appropriate to consistently utilize only the “NO TURN ON RED” sign.

The placement of these turning movement signs should also be considered. At some intersections, the signs are located above the travel lanes on the signal mast arms. At other intersections, the signs are located on the roadside signal poles. Also, at some intersections the lane control signs (symbol turn arrow signs) are located above the travel lanes on the signal mast arms, while at other locations these lane control signs are located on the roadside signal poles. To ensure driver awareness, familiarity, and compliance; both sign types should be consistently located. Drivers must observe lane control signs in advance of the intersection to allow drivers to position themselves properly prior to arriving at the intersection. Overhead signs are more visible for greater distances, and therefore, the lane control signs should be posted overhead on the signal mast arms. The turn prohibition signs must be recognized and obeyed only after a driver has stopped their vehicle for a red signal indication. Therefore, the turn prohibition signs can be located on the roadside signal poles.

Finally, the duration of the turn prohibition signals appears to be excessive to some drivers. Their impatience may result in inappropriate, illegal, and unsafe disobedience. Delays are necessary at locations where two-directional Light Rail Transit tracks are present. Light Rail Vehicles might approach from either direction and in close time proximity. Thereby, Light Rail Vehicles may approach intersections numerous times within short periods of time. However, at locations with only one direction of Light Rail Vehicle travel, the Light Rail Vehicles enter each intersection six (6) times per hour. This circumstance implies that motor vehicles could travel across the Light Rail Vehicle tracks a large percentage of each hour. Separate signal control of Light Rail Vehicles may therefore be acceptable.

Currently, through motor vehicles on streets that parallel Light Rail Transit tracks and Light Rail Vehicles have relatively long green indications. Turning traffic from these streets and intersecting street motor vehicles and pedestrians have relatively long red indications. These long red indications result from the potential that Light Rail Vehicles might appear. However, Light Rail Vehicles appear only every ten minutes. Therefore, the turning traffic from streets that parallel Light Rail Transit tracks should receive red indications only when Light Rail Vehicles are approaching or when through motor vehicle traffic receives red indications. At other times, the turning traffic should receive green indications.

This modification would reduce delay for turning traffic from streets that parallel the Light Rail Transit tracks. It would also result in shorter delays for pedestrian and motor vehicle traffic that crosses Light Rail Transit tracks. It might increase delay for Light Rail Vehicles. The decrease in delay for turning traffic should result in less disobedience of red turn arrows, which should then result in fewer collisions involving turning motor vehicles and Light Rail Vehicles.

**DEDICATED POLICE ENFORCEMENT AND POLICE EDUCATION**

The Phoenix Police Department includes the Police Transit Bureau within its Homeland Security Division within the Public Transit Department. This bureau specifically patrols the immediate vicinity of the Light Rail Transit route – emphasizing the downtown Phoenix area. The following arrests and citations were issued by month in calendar year 2009.

<u>ACTIVITY</u>	<u>JANUARY</u>	<u>FEBRUARY</u>	<u>MARCH</u>	<u>APRIL</u>	<u>MAY</u>	<u>JUNE</u>
Arrests.....	3	25	24	20	22	27
Citations.....	0	15	84	49	62	62

<u>ACTIVITY</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>	<u>OCTOBER</u>	<u>NOVEMBER</u>	<u>DECEMBER</u>
Arrests.....	3	25	24	20	22	27
Citations.....	0	15	84	49	62	62

As an example of typical police education and enforcement activity, on 4 March 2010, seven (7) officers in the vicinity of Light Rail Transit issued the following citations:

Speeding.....	1
Red-light Disobedience.....	2
Failure to Obey Traffic Control Device.....	11
Stop Sign Disobedience.....	6
Other Hazardous Citations.....	4
Other Non-Hazardous Citations.....	13

In addition, there were two (2) educational contacts. Also, on this particular day, in conversation with the drivers, the officers discovered that more than 80% of the drivers were not employed in Downtown Phoenix, and were visiting the vicinity for a different reason.

The Phoenix Police Department conducted an intensive enforcement and education campaign in central downtown Phoenix from 17 August 2009 to 21 August 2009. The primary purpose of the dedicated program was to inform and remind drivers of the need to obey red-turn-arrows. It was hoped that the campaign and ensuing publicity would encourage compliance with traffic control devices. While there is inadequate data to provide statistical evaluation, the collision experience before and after the dedicated education and enforcement campaign can be reported.

Prior to the dedicated enforcement, fourteen (14) right-turn collisions occurred in 29 weeks. Subsequent to the dedicated enforcement, three (3) right-turn collisions occurred in 15 weeks. Therefore, 0.48 right-turn collisions occurred per week before the dedicated enforcement and 0.20 right-turn collisions occurred per week after the dedicated enforcement, implying an approximate 60% decrease in collisions involving right-turn vehicles.

Prior to the dedicated enforcement, nine (9) left-turn collisions occurred in 29 weeks. Subsequent to the dedicated enforcement, four (4) left-turn collisions occurred in 15 weeks. Therefore, 0.31 left-turn collisions occurred per week before the dedicated enforcement and 0.27 left-turn collisions occurred per week after the dedicated enforcement.

There were fewer right-turn collisions subsequent to the dedicated education and enforcement campaign. However, all three (3) of the right-turn collisions that occurred subsequent to the dedicated enforcement campaign occurred in downtown Phoenix.

These data indicate that the dedicated education and enforcement campaign may have been of benefit in reducing right-turn collisions. This campaign should be continued at six-month intervals.

## **PHOTOGRAPHIC ENFORCEMENT**

Photographic enforcement of red-light violations has become common throughout metropolitan Phoenix in the past twenty years. This automated mechanism for encouraging obedience to red traffic signals has numerous advantages. It is always present; provides photographic evidence of violations; provides relative certainty of citation; is intended to recover its expense; and most importantly, appears to be an effective deterrent to illegal and unsafe driving behavior.

This technique may have application at intersections of Light Rail Transit tracks and streets – particularly for turn-lanes with exclusive turn arrow operation. Four (4) intersections have experienced a total of fourteen (14) collisions. Thirteen (13) of these collisions involved right-turning motor vehicles colliding with parallel Light Rail Vehicles approaching from behind the motor vehicle drivers. The four (4) intersections are:

1 <sup>st</sup> Avenue and Washington Street	5 collisions
1 <sup>st</sup> Street and Jefferson Street	4 collisions
3 <sup>rd</sup> Street and Washington Street	3 collisions
5 <sup>th</sup> Street and Washington Street	2 collisions

Photographic enforcement of right-turn, red-light violations should be considered at these four (4) intersections. If the recommendation to adjust signal timing to minimize red-turn-arrow duration cannot be implemented, then it is recommended that photographic enforcement be implemented on a trial basis. If the signal timing modifications are implemented, and red-turn-arrow violations continue, then photographic enforcement should be implemented.

Prior to installing photographic enforcement devices, the right-turn movements at each of these four (4) intersections should be discreetly monitored. Individuals should record the number of red-turn-arrow violations and the number of right-turning vehicles during both peak and off-peak periods. Approximately four to six months subsequent to photographic enforcement implementation, the recording of red-turn-arrow violations and right-turn volume should be repeated. The data should be collected for each of the four (4) intersections for sufficient time periods to ensure statistical significance. If the four-month to six-month trial period indicates that red-turn-arrow violations decrease, then photographic enforcement should be expanded to other similar intersections and movements.

## **GENERAL EDUCATION AND COMMUNITY AWARENESS**

In the past two (2) years, Valley Metro Rail has provided more than 2.7 million safety messages to a diverse audience of community groups and the general public. Communication efforts included the distribution of printed, e-mail, and website materials; participation at public events; and specific presentations by Valley Metro personnel. Directed communication has occurred with specific groups including youth; Arizona State University students, faculty, and staff; employees and residents of businesses and homes in proximity to Light Rail Transit or with specific interest; visitors, seniors, bicyclists, and disabled.

In addition, Valley Metro has produced and distributed an award-winning driver safety video to 100 private and governmental fleet managers throughout Arizona; professional drivers including taxi and trucking companies; schools and school districts; student driver education providers; the Maricopa County Court system; and the AAA Arizona website.

Light Rail Transit characteristics have been incorporated into the Arizona Department of Motor Vehicles driver licensing examinations.

These education and awareness programs have been extensive and effective.

The transit system operators and traffic engineering jurisdictions responsible for the transportation systems in the communities of Los Angeles, Portland, and Sacramento should be contacted. These agencies may have education and community awareness program attributes that should be considered to supplement the past and current Valley Metro Rail efforts.

Additionally, education campaigns including brochures, billboard advertisements, professional sports and music venue posters and advertisements, bus shelter and vehicle posters, and city cable television advertisements and announcements should focus on “red light means stop” and “red arrow means stop” in general without emphasis on intersections with Light Rail Transit tracks. Red turn arrows adjacent to Light Rail Transit tracks should be portrayed in the advertisements and announcements in addition to red signals at other locations. The more general the announcements, the more frequently they can be used and the greater the distribution and public awareness.

## **AUDIBLE PEDESTRIAN WARNING INDICATION**

The Light Rail Vehicles in Phoenix activate their horns as they approach intersections with streets. The 2009 edition of the Manual on Uniform Traffic Control Devices discusses the use of audible warning devices. Section 8C.07 states that train horns are intended to “provide audible warning of approaching rail traffic to road users on the highway or pathway approaches to a grade crossing”.

Section 4E.06 of the 2009 edition of the Manual on Uniform Traffic Control Devices states,

“The primary technique that pedestrians who have visual disabilities use to cross streets at signalized locations is to initiate their crossing when they hear the traffic in front of them stop and the traffic alongside them begin to move, corresponding to the onset of the green interval. This technique is effective at many signalized locations. The existing environment is often sufficient to provide the information that pedestrians who have visual disabilities need to operate reasonably safely at a signalized location. Therefore many signalized locations will not require any accessible pedestrian signals.”

“If a particular signalized location presents difficulties for pedestrians who have visual disabilities to cross reasonably safely and effectively, an engineering study should be conducted that considers the safety and effectiveness for pedestrians in general, as well as the information needs of pedestrians with visual disabilities.”

“The factors that might make crossing at a signalized location difficult for pedestrians who have visual disabilities include: increasingly quiet cars, right turn on red (which masks the beginning of the through phase), continuous right-turn lane movements, complex signal operations, traffic circles, and wide streets. Further low traffic volumes might make it difficult for pedestrians who have visual disabilities to discern signal phase changes.”

An audible pedestrian device utilizes a sound to indicate to a visually-impaired pedestrian that it is safe to cross a street. However, the train horn indicates to a visually-impaired pedestrian that it is unsafe to cross the tracks.

Section 8C.10 of the 2009 edition of the Manual on Uniform Traffic Control Devices states,

“The provisions of Part 4 and Section 8C.09 relating to traffic control signal design, installation, and operation, including interconnection with nearby automatic gates or flashing-light signals shall be applicable as appropriate where traffic control signals are used at highway-LRT grade crossings.”

“If traffic control signals in operation at a crossing that is used by pedestrians, bicyclists, and/or other non-motorized road users, an audible device such as a bell shall also be provided and shall be operated in conjunction with the traffic control signals.”

Phoenix Street Transportation has received confirmation from the Federal Highway Administration that Accessible Pedestrian Push-buttons are required by the 2009 Manual on Uniform Traffic Control Devices. Vibra-tactile buttons that emit two different sounds satisfy these requirements. One sound informs a visually-impaired pedestrian of the button location. A different sound informs a visually-impaired pedestrian of the WALK and flashing DON'T WALK signal indicating that it is safe to cross the Light Rail Transit tracks. One of these devices has been installed near Phoenix City Hall on Washington Street at Marvin Andrews Way.

### **VEGETATION TRIMMING OR REMOVAL:**

The Entire Light Rail Transit route – both mainline and frontage roads – within the city limits of Phoenix was driven specifically to examine locations where vegetation was potentially obstructing traffic control devices from driver view. There was only one mainline location where vegetation potentially obstructed driver view of traffic control devices for the Light Rail Transit system. This location was westbound Washington Street approaching the traffic signal at 2550 East Washington. As indicated in **Figure 1** and **Figure 2** the traffic control devices are visible beyond the tree. Recognizing that this location was the only location where vegetation potentially obstructed driver view of Light Rail Transit traffic control, there are no locations where vegetation should be trimmed or removed to provide visibility.



**Figure 1: 2550 East Washington Street – Westbound Approach – Distant**



**Figure 2: 2550 East Washington Street – Westbound Approach – Near**

There were several frontage road locations where the side-mounted pole signal heads were obstructed by vegetation – as indicated in the representative photographs of **Figure 3** through **Figure 6**. All photographs were taken from the travel lane in the approximate location of a driver eye. In each of the circumstances throughout the Light Rail system within Phoenix, the overhead mast arm signal head was clearly visible several hundred feet prior to the signal. Also, at each location, the side-mounted pole signal head was clearly visible from a vehicle at the stop bar.



**Figure 3: 2550 East Washington Street – Left-side Frontage Road Approach**



**Figure 4: 1850 East Washington Street – Left-side Frontage Road Approach**



**Figure 5: 700 East Washington Street – Right-side Frontage Road Turn-lane Approach**



**Figure 6: 1325 East Jefferson Street – Left-side Frontage Road Approach**

### **SIGNAL TIMING CHANGE AT I-10 / JEFFERSON / WASHINGTON:**

The I-10 / Jefferson / Washington Interchange includes Light Rail Transit tracks. As provided in **Appendix D**, the four traffic signals comprising this interchange were thoroughly examined. The concern that initiated the investigation was vehicles crossing the Light Rail Transit tracks from the primary motor vehicle travel lanes to the frontage road motor vehicle travel lane when traffic control indicated Light Rail Vehicle right-of-way. This motor vehicle movement is desired by drivers as it enables a more expeditious left-turn at the subsequent traffic signal within the interchange.

Drivers attempting this “cross-over” movement may not be cognizant of the inherent danger of a Light Rail Vehicle approaching from the rear. The circumstance of motor vehicles and Light Rail Vehicles traveling in the same direction occurred in thirty-four of the thirty-nine collisions. While none of these collisions occurred at this interchange, there existed a greater than reasonable possibility of collisions occurring at this location.

A specific investigation at the I-10 / Jefferson / Washington interchange recommended that the traffic signal timing be changed to provide motor vehicle right-of-way when Light Rail Vehicles were not approaching. This signal timing was implemented in November 2009. The modified traffic signal timing permits traffic from the mainline to cross-over the Light Rail Transit tracks to the frontage road. The Light Rail Vehicle receives a stop indication during the green indication for this motor vehicle movement. It required video detection for the frontage roads, and no-turn-on-red signs for northbound and southbound traffic.

**Figure 7** through **Figure 11** provide a sequence of photographs of the signal operation. This signal operation has been frequently observed since its implementation, and has increased both safety and efficiency.



**Figure 7: I-10 / Jefferson West Signal – LRT Stop, Mainline Red, Frontage Green**



**Figure 8: I-10 / Jefferson West Signal – LRT Go, Mainline Red, Frontage Green**



**Figure 9: I-10 / Jefferson West Signal – LRT Go, Mainline Red, Frontage Green (with LRV)**



Figure 10: I-10 / Jefferson West Signal – LRT Stop, Mainline Green, Frontage Red (Truck 1)



Figure 11: I-10 / Jefferson West Signal – LRT Stop, Mainline Green, Frontage Red (Truck 2)

**GENERAL RECOMMENDATIONS:**

1. The signs and signals at the signalized Light Rail Transit intersections should be as consistent as possible.
2. At median locations, the symbol signs depicting the median and arrows should be replaced with symbol signs that depict Light Rail Tracks and arrows.



NOT RECOMMENDED



RECOMMENDED



NOT RECOMMENDED



RECOMMENDED (WITH LIGHT RAIL TRACKS)

3. The symbol signs indicating that vehicles should not drive on tracks should be removed.
4. At driveway exits to frontage roads parallel to Light Rail Vehicle tracks, “ONE WAY” and no left (right) turn symbol signs should be provided.
5. At locations where bicycle lanes must change from mainline travel lanes to frontage road travel lanes or the reverse, bent arrows should be provided at the intersections of bike lanes and bike-boxes.
6. The existing “LEFT (RIGHT) TURN ON GREEN ARROW” signs should be replaced with “NO TURN ON RED” signs.
7. The lane control signs should be posted overhead on the signal mast arms, with the turn prohibition signs posted on the roadside signal poles.



OVERHEAD



ROADSIDE

8. The blank-out signs for motor vehicle traffic parallel to the Light Rail Transit tracks should be removed. For system maintenance purposes, another device would be necessary to inform signal and system personnel of approaching Light Rail Vehicles. The blank-out signs on driveways perpendicular to the Light Rail Transit tracks that access frontage roads near track crossover locations should remain.
9. The signal timing for all intersections with one-way Light Rail Transit operation should be modified to be similar to the recently implemented operation at I-10 / Jefferson / Washington, particularly at locations with red turn arrows.



Figure 12: Recommendations

## **DETERMINATION OF LOCATIONS FOR DETAILED ANALYSIS:**

The locations selected for specific and detailed analysis included all locations with more than one (1) collision in the first thirteen (13) months of operation. Additional locations were determined through discussions with representatives of Phoenix Street Transportation Department, Phoenix Police Department, and Valley Metro Rail.

As part of the contract to investigate the collisions that have occurred between light rail vehicles and motor vehicles, twenty-five (25) locations have been selected for detailed analysis. The following locations have been analyzed for the indicated primary reasons.

1. 1<sup>st</sup> Avenue and Washington Street – Five (5) collisions.
2. 1<sup>st</sup> Street and Jefferson Street – Four (4) collisions.
3. 3<sup>rd</sup> Street and Washington Street – Three (3) collisions.
4. 5<sup>th</sup> Street and Washington – Two (2) collisions.
5. 7<sup>th</sup> Street and Washington – Similar configuration to 3<sup>rd</sup> Street and Washington Street, and 5<sup>th</sup> Street and Washington Street.
6. 1<sup>st</sup> Avenue and Adams Street – Similar configuration to 1<sup>st</sup> Avenue and Washington Street and Crossover.
7. 9<sup>th</sup> Street and Jefferson Street – Crossover.
8. 9<sup>th</sup> Street and Washington Street – Crossover.
9. 1<sup>st</sup> Avenue, South of Van Buren Street – Crossover.
10. Jefferson Street, near 5<sup>th</sup> Street – Crossover.
11. Central Avenue and Camelback Road – Crossover.
12. Central Avenue and Washington Street – Curve.
13. Central Avenue and Campbell Street – Pedestrian activity from nearby high school.
14. Central Avenue and Glenrosa Avenue – Pedestrian activity from nearby high school.
15. 19<sup>th</sup> Avenue and Montebello Avenue – Pedestrian activity from Light Rail termination.
16. 19<sup>th</sup> Avenue and Camelback Road – Pedestrian activity and southbound-to-northbound U-turns.
17. 22<sup>nd</sup> Street and Jefferson Street – Vehicles turning left against prohibition.
18. 22<sup>nd</sup> Street and Washington Street – Vehicles turning left against prohibition.
19. 12<sup>th</sup> Street and Washington Street – Wrong way frontage road travel.
20. 12<sup>th</sup> Street and Jefferson Street – Wrong way frontage road travel.
21. Central Avenue and McKinley Street – Wrong way frontage road travel.
22. Jefferson Street, east of 9<sup>th</sup> Street – Bicycle lane cross-over
23. 7<sup>th</sup> Street and Jefferson Street – Bike box.
24. 24<sup>th</sup> Street and Washington Street – Bike box.
25. 24<sup>th</sup> Street and Jefferson Street – Bike box.

1. **1<sup>ST</sup> AVENUE AND WASHINGTON STREET:**

**Table 1: 1<sup>st</sup> Avenue and Washington Street – Collision Summary**

Report #	Date	Movement	Vehicle	LRT	Sun Location	Violation
961H-090638017	4/20/2009	Right-turn	SB	SB	No Influence	Unknown
962-090896973	6/4/2009	Right-turn	SB	SB	No Influence	Disregarded Signal
961-091089998	7/8/2009	Right-turn	SB	SB	No Influence	Failed to Stop
Unknown	11/11/2009	Through	EB	SB	Into Sun	Unknown
961-091804550	11/13/2009	Right-turn	SB	SB	No Influence	Unknown

Day	Time	Injury Number	Injury Severity	Age	Gender
Monday	4:29 PM	Unknown	Unknown	Unknown	Unknown
Thursday	6:38 AM	9	3 @ "4" and 6 @ "1"	48	Male
Wednesday	1:18 PM	0	0	60	Male
Wednesday	10:27 AM	Unknown	Unknown	Unknown	Unknown
Friday	10:27 AM	Unknown	Unknown	Unknown	Unknown

Note: An injury severity of “4” indicates an incapacitating injury, while an injury severity of “1” indicates no injury.



**Figure 13: 1<sup>st</sup> Avenue and Washington Street – Southbound Approach**

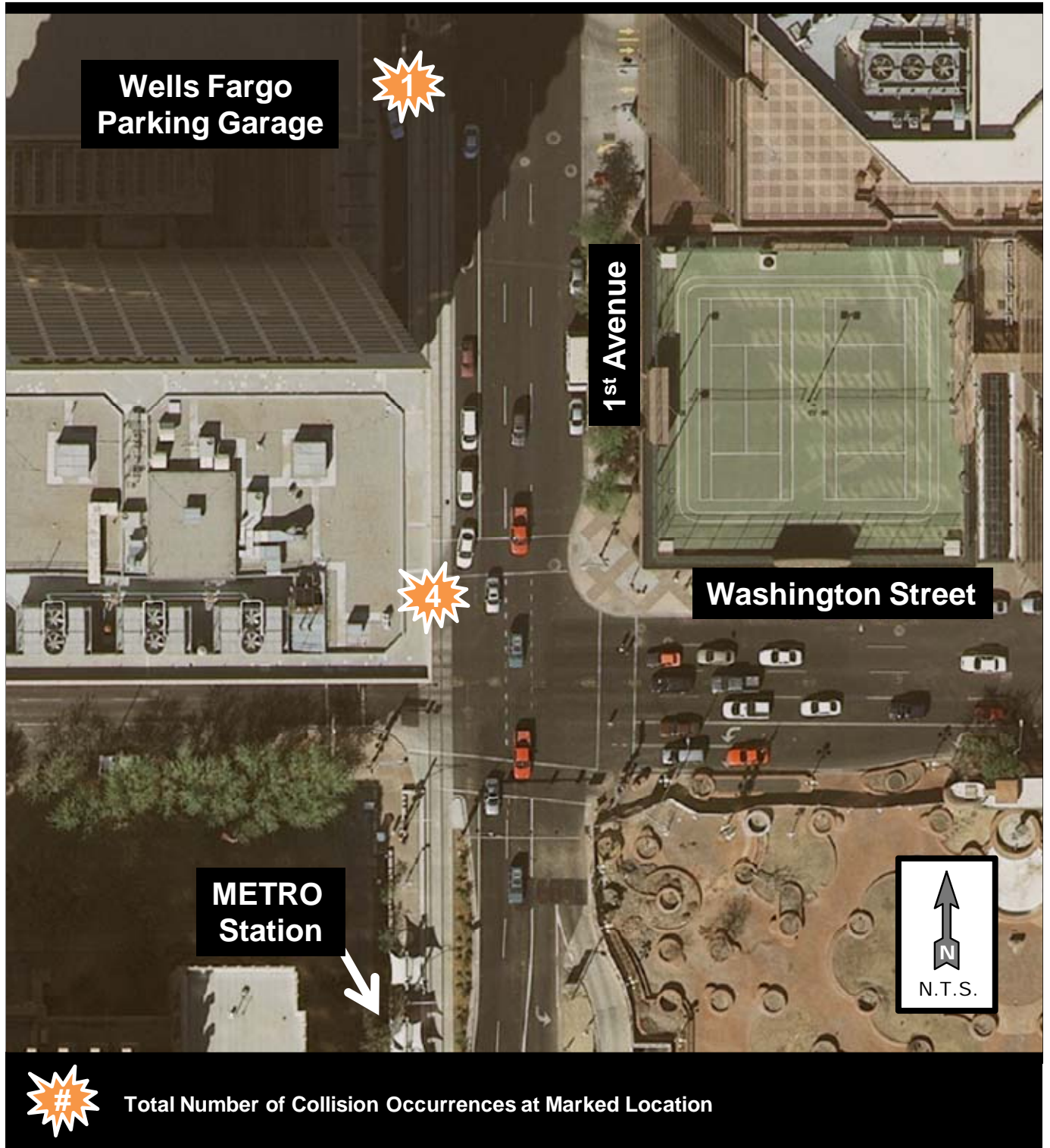


Figure 14: 1<sup>st</sup> Avenue and Washington Street – Collision Location



Figure 15: 1<sup>st</sup> Avenue and Washington Street – Existing Traffic Control



Figure 16: 1<sup>st</sup> Avenue and Washington Street – Recommended Traffic Control

**2. 1<sup>ST</sup> STREET AND JEFFERSON STREET:**

**Table 2: 1<sup>st</sup> Street and Jefferson Street – Collision Summary**

Report #	Date	Movement	Vehicle	LRT	Sun Location	Violation
None	12/30/2008	Right-turn	EB	EB	Night	Unknown
962-090899754	6/4/2009	Right-turn	EB	EB	Sun Behind	Improper Turn
961-090973875	6/17/2009	Right-turn	EB	EB	Night	Failed to Stop
961-091527085	9/24/2009	Right-turn	EB	EB	Into Sun	Unknown

Day	Time	Injury Number	Injury Severity	Age	Gender
Tuesday	Unknown	Unknown	Unknown	Unknown	Unknown
Thursday	4:28 PM	0	0	45	Male
Wednesday	7:16 PM	0	0	35	Female
Thursday	10:27 AM	Unknown	Unknown	Unknown	Unknown



**Figure 17: 1<sup>st</sup> Street and Jefferson Street – Eastbound Approach**

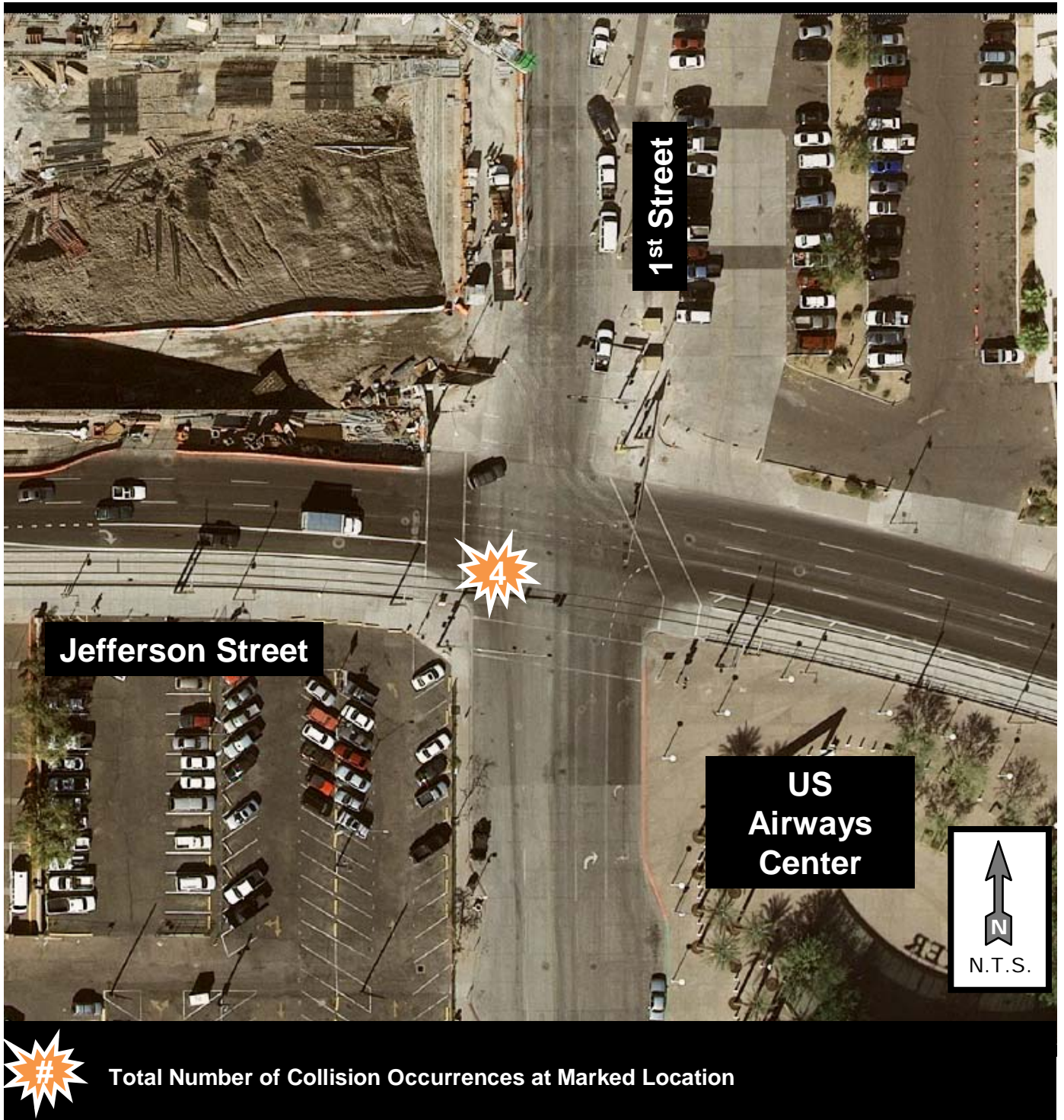


Figure 18: 1<sup>st</sup> Street and Jefferson Street – Collision Location



Figure 19: 1<sup>st</sup> Street and Jefferson Street – Existing Traffic Control



Figure 20: 1<sup>st</sup> Street and Jefferson Street – Recommended Traffic Control

**3. 3<sup>RD</sup> STREET AND WASHINGTON STREET:**

**Table 3: 3<sup>rd</sup> Street and Washington Street – Collision Summary**

Report #	Date	Movement	Vehicle	LRT	Sun Location	Violation
961-090047737	1/9/2009	Right-turn	WB	WB	Into Sun	Disregarded Signal
961-090219819	2/6/2009	Right-turn	WB	WB	Night	Failed to Stop
961-091122709	7/14/2009	Right-turn	WB	WB	Sun Behind	Disregarded Signal

Day	Time	Injury Number	Injury Severity	Age	Gender
Friday	5:58 PM	0	0	37	Male
Friday	7:15 PM	0	0	19	Female
Tuesday	10:44 AM	0	0	39	Female



**Figure 21: 3<sup>rd</sup> Street and Washington Street – Westbound Approach**

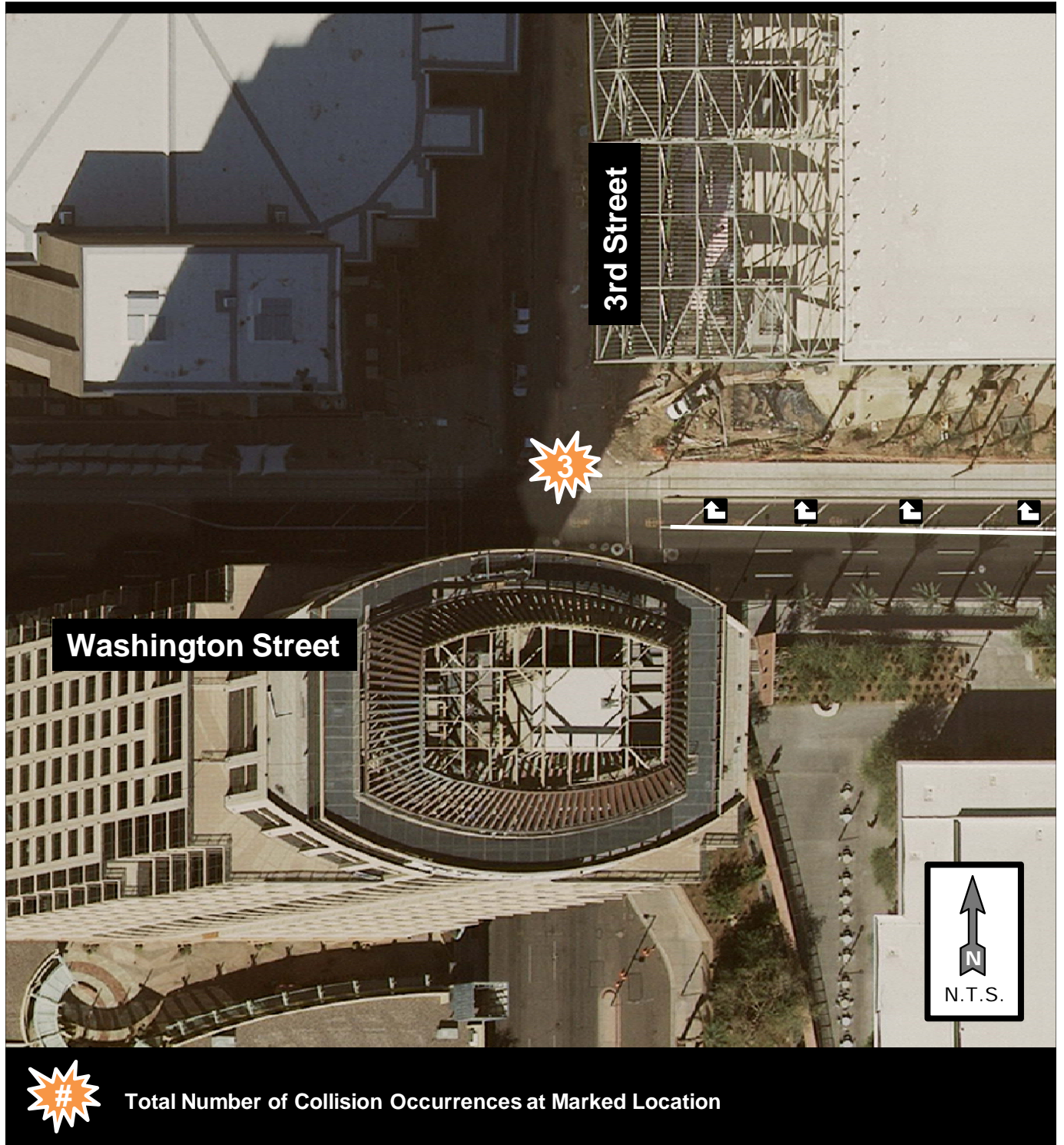


Figure 22: 3<sup>rd</sup> Street and Washington Street – Collision Location



Figure 23: 3<sup>rd</sup> Street and Washington Street – Existing Traffic Control



Figure 24: 3<sup>rd</sup> Street and Washington Street – Recommended Traffic Control

**4. 5<sup>TH</sup> STREET AND WASHINGTON STREET:**

**Table 4: 5th Street and Washington Street – Collision Summary**

Report #	Date	Movement	Vehicle	LRT	Sun Location	Violation
961H-090600740	4/14/2009	Right-turn	WB	WB	No Influence	Disregarded Signal
961-090646579	4/22/2009	Right-turn	WB	WB	Sun Behind	Disregarded Signal

Day	Time	Injury Number	Injury Severity	Age	Gender
Tuesday	11:36 AM	0	0	27	Male
Wednesday	7:23 AM	0	0	60	Male



**Figure 25: 5<sup>th</sup> Street and Washington Street – Westbound Approach**



Figure 26: 5<sup>th</sup> Street and Washington Street – Collision Location



Figure 27: 5<sup>th</sup> Street and Washington Street – Existing Traffic Control



Figure 28: 5<sup>th</sup> Street and Washington Street – Recommended Traffic Control

**5. 7<sup>TH</sup> STREET AND WASHINGTON STREET:**

**Table 5: 7<sup>th</sup> Street and Washington Street – Collision Summary**

Report #	Date	Movement	Vehicle	LRT	Sun Location	Violation
961-091011167	6/24/2009	Right-turn	WB	WB	No Influence	Disregarded Signal

Day	Time	Injury Number	Injury Severity	Age	Gender
Wednesday	11:25 AM	0	0	43	Male



**Figure 29: 7<sup>th</sup> Street and Washington Street – Westbound Approach**



Figure 30: 7<sup>th</sup> Street and Washington Street – Collision Location



Figure 31: 7<sup>th</sup> Street and Washington Street – Existing Traffic Control



Figure 32: 7<sup>th</sup> Street and Washington Street – Recommended Traffic Control

6. 1<sup>ST</sup> AVENUE AND ADAMS STREET:

1<sup>st</sup> Avenue and Adams Street – No Collisions



Figure 33: 1<sup>st</sup> Avenue and Adams Street – Southbound Approach



Figure 34: 1<sup>st</sup> Avenue and Adams Street – Southbound, South of Intersection



Figure 35: 1<sup>st</sup> Avenue and Adams Street – Existing Traffic Control



Figure 36: 1<sup>st</sup> Avenue and Adams Street – Recommended Traffic Control

**7. JEFFERSON STREET, EAST OF 9<sup>TH</sup> STREET:**

**Crossover on Jefferson Street, East of 9<sup>th</sup> Street – No Collisions**



**Figure 37: Crossover on Jefferson Street, East of 9<sup>th</sup> Street – Eastbound Approach**



**Figure 38: Crossover on Jefferson Street, East of 9<sup>th</sup> Street – Existing Traffic Control**



**Figure 39: Crossover on Jefferson Street, East of 9<sup>th</sup> Street – Recommendation**

**8. WASHINGTON STREET, WEST OF 9<sup>TH</sup> STREET:**

**Crossover on Washington Street, West of 9<sup>th</sup> Street – No Collisions**



**Figure 40: Crossover on Washington Street, West of 9<sup>th</sup> Street**



**Figure 41: Crossover on Washington Street, West of 9<sup>th</sup> Street – Existing Traffic Control**

**NO CHANGE**

**Figure 42: Crossover on Washington Street, West of 9<sup>th</sup> Street – Recommendation**

9. 1<sup>ST</sup> AVENUE, SOUTH OF VAN BUREN STREET:

1<sup>st</sup> Avenue, South of Van Buren Street – No Collisions



Figure 43: 1<sup>st</sup> Avenue, South of Van Buren Street – Existing Traffic Control

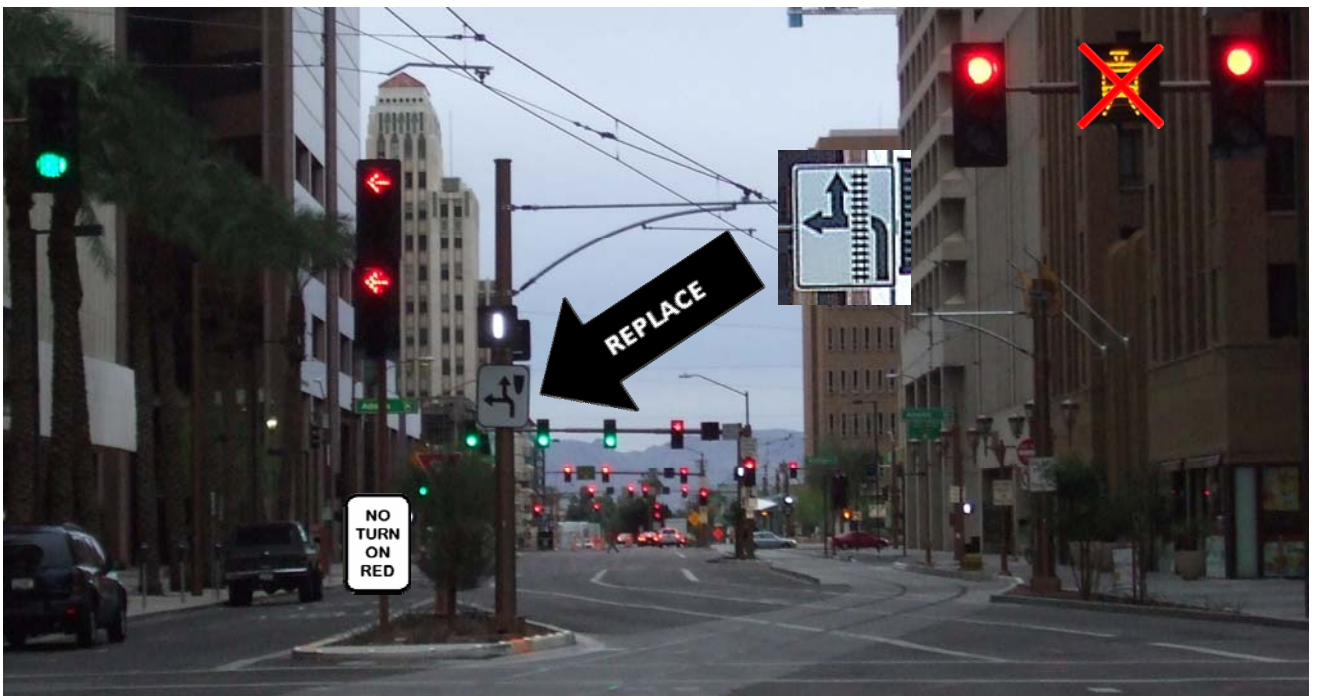


Figure 44: 1<sup>st</sup> Avenue, South of Van Buren Street – Recommended Traffic Control

**10. JEFFERSON STREET, EAST OF 5<sup>TH</sup> STREET:**

**Crossover on Jefferson Street, East of 5<sup>th</sup> Street – No Collisions**



**Figure 45: Crossover on Jefferson Street, East of 5<sup>th</sup> Street – Existing Traffic Control**



**Figure 46: Crossover on Jefferson Street, East of 5<sup>th</sup> Street – Recommendation**

**11. CENTRAL AVENUE, SOUTH OF CAMELBACK ROAD:**

**Central Avenue, South of Camelback Road – No Collisions**



**Figure 47: Central Avenue, South of Camelback Road – Existing Traffic Control**



**Figure 48: Central Avenue, South of Camelback Road – Recommendation**

**12. CENTRAL AVENUE AND WASHINGTON STREET:**

**Central Avenue and Washington Street – No Collisions**



**Figure 49: Central Avenue and Washington Street – Westbound Approach**



**Figure 50: Central Avenue and Washington Street – Existing Traffic Control**

**NO CHANGE**

**Figure 51: Central Avenue and Washington Street – Recommendation**

### 13. CENTRAL AVENUE AND CAMPBELL AVENUE:

#### Central Avenue and Campbell Avenue – No Collisions



Figure 52: Central Avenue and Campbell Avenue – Pedestrian Demand on DON'T WALK



Figure 53: Central Avenue and Campbell Avenue – Pedestrian Demand on WALK



Figure 54: Central Avenue and Campbell Avenue – Pedestrian Demand on DON'T WALK

**INCREASE PEDESTRIAN WALK TIME  
DURING PEAK 20-MINUTE PERIODS OF  
SCHOOL ARRIVAL AND DEPARTURE**

Figure 55: Central Avenue and Campbell Avenue – Recommendation

**14. CENTRAL AVENUE AND GLENROSA AVENUE:**

**Central Avenue and Glenrosa Avenue – No Collisions**



**Figure 56: Central Avenue and Glenrosa Avenue – Southbound Approach**



Figure 57: Central Avenue and Glenrosa Avenue – Existing Traffic Control



Figure 58: Central Avenue and Glenrosa Avenue – Recommendation

**15. 19<sup>TH</sup> AVENUE AND MONTEBELLO AVENUE:**

**19<sup>th</sup> Avenue and Montebello Avenue – No Collisions**



**Figure 59: 19<sup>th</sup> Avenue and Montebello Avenue – Northbound Approach**



**Figure 60: 19<sup>th</sup> Avenue and Montebello Avenue – Southbound Approach**



**Figure 61: 19<sup>th</sup> Avenue and Montebello Avenue – Existing Crosswalk**

**NO CHANGE**

**Figure 62: 19<sup>th</sup> Avenue and Montebello Avenue – Recommendation**

**16. 19<sup>TH</sup> AVENUE AND CAMELBACK ROAD:**

**Table 6: 19<sup>th</sup> Avenue and Camelback Road – Collision Summary**

Report #	Date	Movement	Vehicle	LRT	Sun Location	Violation
None	9/5/2009	Through	WB	WB	Into Sun	Unknown
Day	Time	Injury Number	Injury Severity		Age	Gender
Saturday	4:45 PM	Unknown	Unknown		Unknown	Unknown



**Figure 63: 19<sup>th</sup> Avenue and Camelback Road – Westbound Approach**



**Figure 64: 19<sup>th</sup> Avenue and Camelback Road – Southbound Approach**

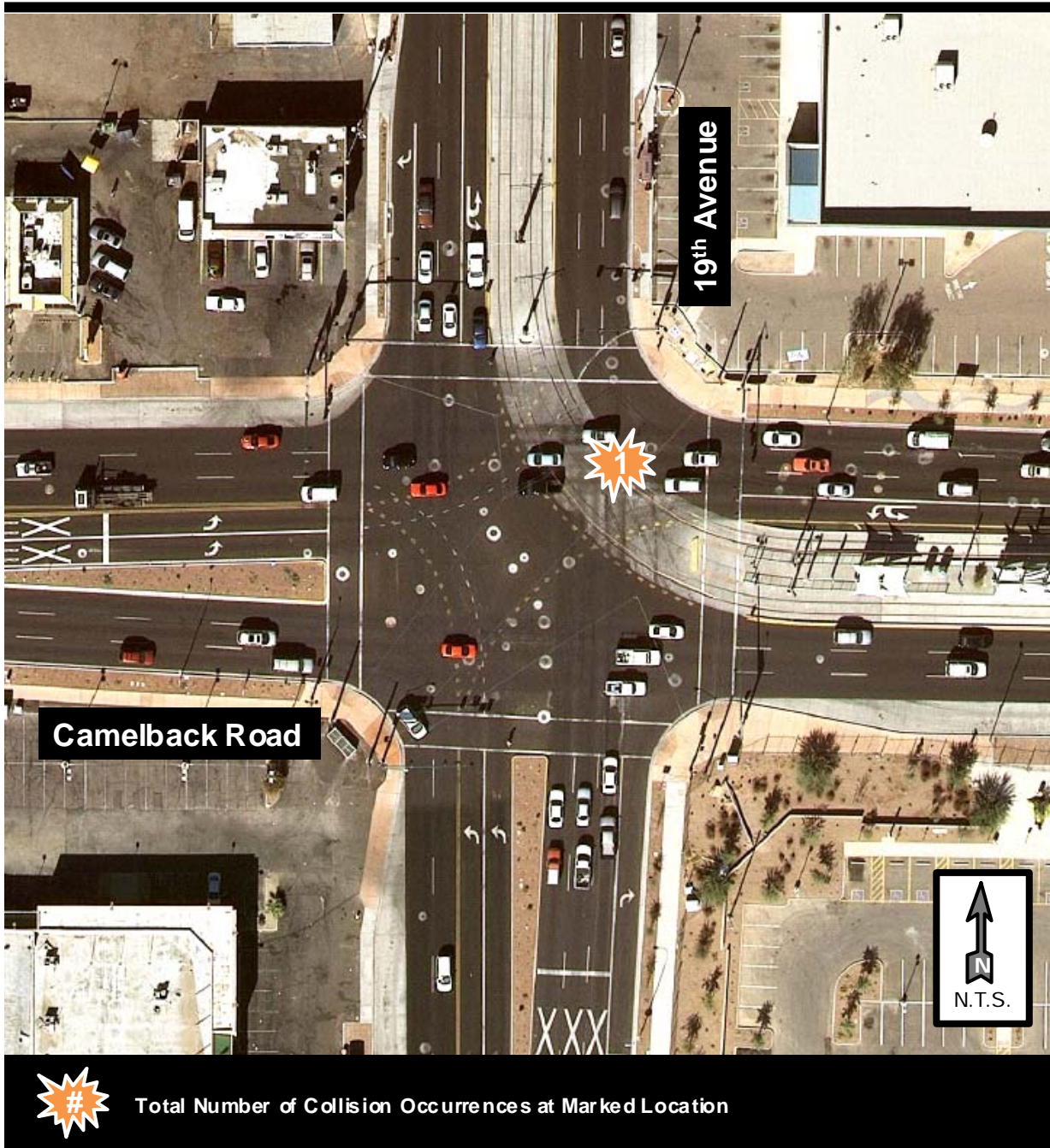


Figure 65: 19<sup>th</sup> Avenue and Camelback Road – Collision Location



Figure 66: 19<sup>th</sup> Avenue and Camelback Road – Westbound Approach Existing Traffic Control



Figure 67: 19<sup>th</sup> Avenue and Camelback Road – Westbound Approach Recommendation



Figure 68: 19<sup>th</sup> Avenue and Camelback Road – Southbound Approach Existing Traffic Control



Figure 69: 19<sup>th</sup> Avenue and Camelback Road – Southbound Approach Recommendation



**Figure 70: 19<sup>th</sup> Avenue and Camelback Road – East Crosswalk – Northbound**



Figure 71: 19<sup>th</sup> Avenue and Camelback Road – East Crosswalk Existing Traffic Control



Figure 72: 19<sup>th</sup> Avenue and Camelback Road – East Crosswalk Recommendation



**18. 22<sup>ND</sup> STREET AND JEFFERSON STREET:**

**22<sup>nd</sup> Street and Jefferson Street – No Collisions**



**Figure 75: 22<sup>nd</sup> Street and Jefferson Street – Eastbound Approach**



Figure 76: 22<sup>nd</sup> Street and Jefferson Street – Existing Traffic Control

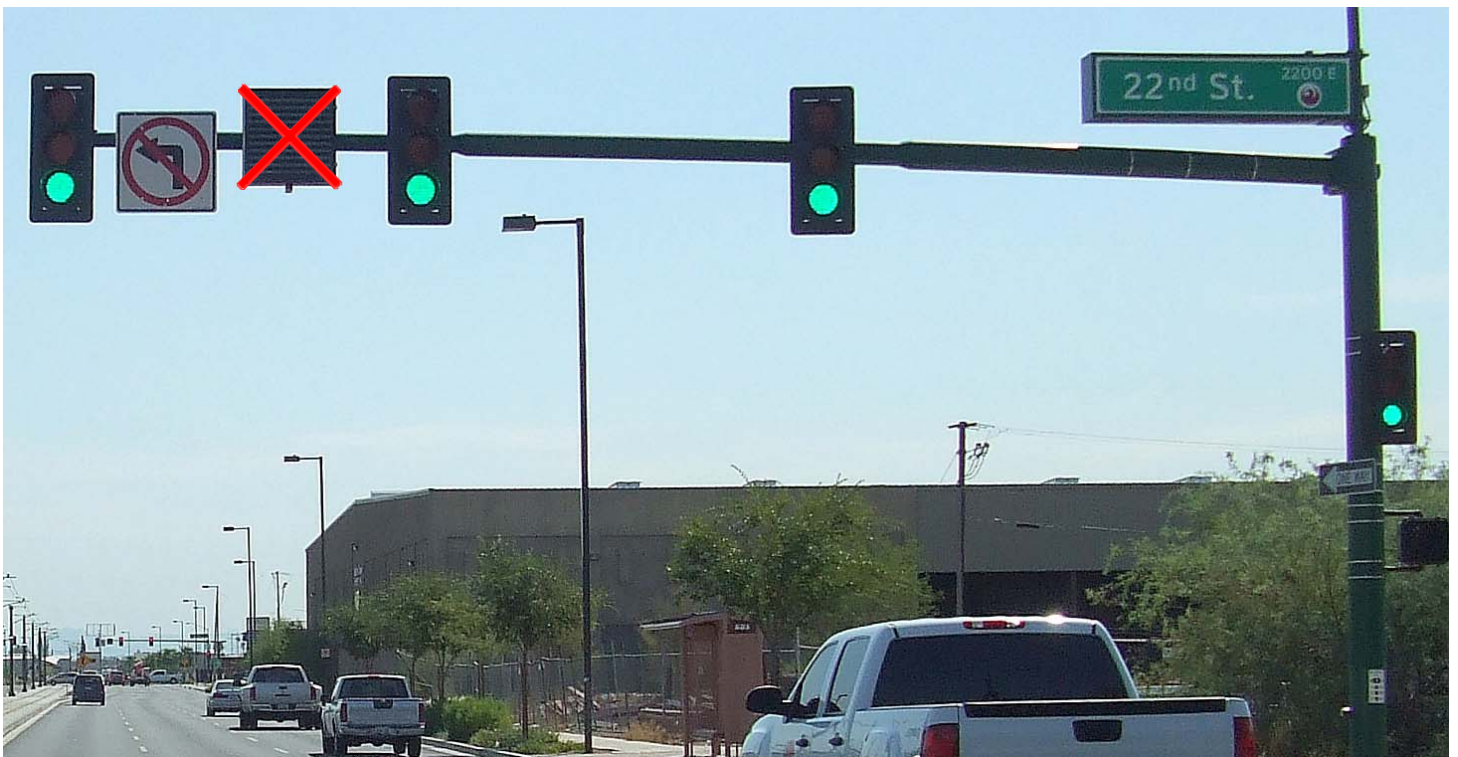


Figure 77: 22<sup>nd</sup> Street and Jefferson Street – Recommendation

**19. 12<sup>TH</sup> STREET AND WASHINGTON STREET:**

**12<sup>th</sup> Street and Washington Street – No Collisions**



**Figure 78: 12<sup>th</sup> Street and Washington Street – Existing Traffic Control**



**Figure 79: 12<sup>th</sup> Street and Washington Street – Recommended Traffic Control**



Figure 80: Washington, West of 12<sup>th</sup> Street – Existing Traffic Control



Figure 81: Washington Street, West of 12<sup>th</sup> Street – Recommended Traffic Control

**20.12<sup>TH</sup> STREET AND JEFFERSON STREET:**

**Table 7: 12<sup>th</sup> Street and Jefferson Street – Collision Summary**

Report #	Date	Movement	Vehicle	LRT	Sun Location	Violation
961-091303334	8/15/2009	Left-turn	EB	EB	Sun Behind	Failed to Yield

Day	Time	Injury Number	Injury Severity	Age	Gender
Saturday	2:03 PM	0	0	30	Female



**Figure 82: 12<sup>th</sup> Street and Jefferson Street – Exiting Traffic Control**



**Figure 83: 12<sup>th</sup> Street and Jefferson Street – Recommended Traffic Control**



Figure 84: Jefferson Street, East of 12<sup>th</sup> Street – Existing Traffic Control



Figure 85: Jefferson Street, East of 12<sup>th</sup> Street – Recommended Traffic Control

**21. CENTRAL AVENUE AND MCKINLEY STREET:**

**Central Avenue and McKinley Street – No Collisions**



**Figure 86: Central Avenue, North of McKinley Street – Access**



**Figure 87: Central Avenue and McKinley Street – Existing Traffic Control**

**NO CHANGE**

**Figure 88: Central Avenue and McKinley Street – Recommendation**

**22. JEFFERSON STREET, EAST OF 9<sup>TH</sup> STREET:**

**Jefferson Street, East of 9<sup>th</sup> Street – No Collisions**



**Figure 89: Jefferson Street, East of 9<sup>th</sup> Street – Street Level Photograph**



**Figure 90: Jefferson Street, East of 9<sup>th</sup> Street – Aerial Photograph**



**Figure 91: Jefferson, East of 9<sup>th</sup> Street – Existing Traffic Control**



**Figure 92: Jefferson Street, East of 9<sup>th</sup> Street – Recommended Traffic Control**

This recommendation requires one of two (2) modifications. At the crosswalk, east of 9<sup>th</sup> Street, the distance from the curb to the concrete track base is approximately 32 feet. The distance from the curb to the rail is approximately 36 feet. Reconstruction of the curb and sidewalk in the northeast corner of the intersection would provide additional width for the recommended bicycle lane. Alternatively, the crossover could begin at the crosswalk.

An alternative recommendation is to retain the bicycle lane on the north side of the frontage road, and transition the bicycle lane across the motor vehicle travel lanes further east – separated from the intersection with 9<sup>th</sup> Street.

**23.7<sup>TH</sup> STREET AND JEFFERSON STREET:**

**Table 8: 7<sup>th</sup> Street and Jefferson Street – Collision Summary**

Report #	Date	Movement	Vehicle	LRT	Sun Location	Violation
961-090207066	2/6/2009	Right-turn	EB	EB	Into Sun	Improper Turn

Day	Time	Injury Number	Injury Severity	Age	Gender
Friday	9:51 AM	0	0	73	Female



**Figure 93: 7<sup>th</sup> Street and Jefferson Street – Eastbound Approach**

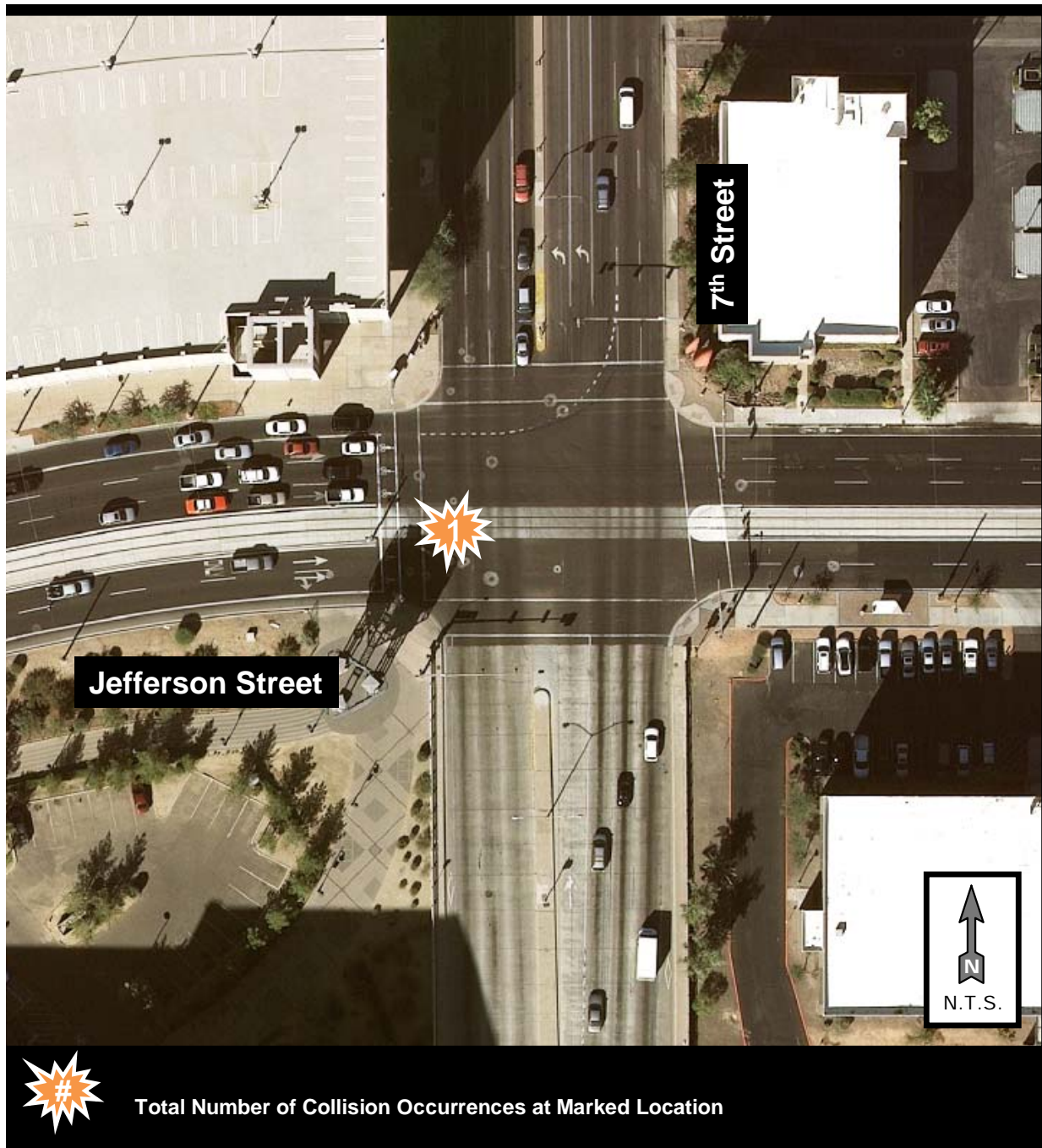


Figure 94: 7<sup>th</sup> Street and Jefferson Street – Collision Location



Figure 95: 7<sup>th</sup> Street and Jefferson Street – Existing Traffic Control

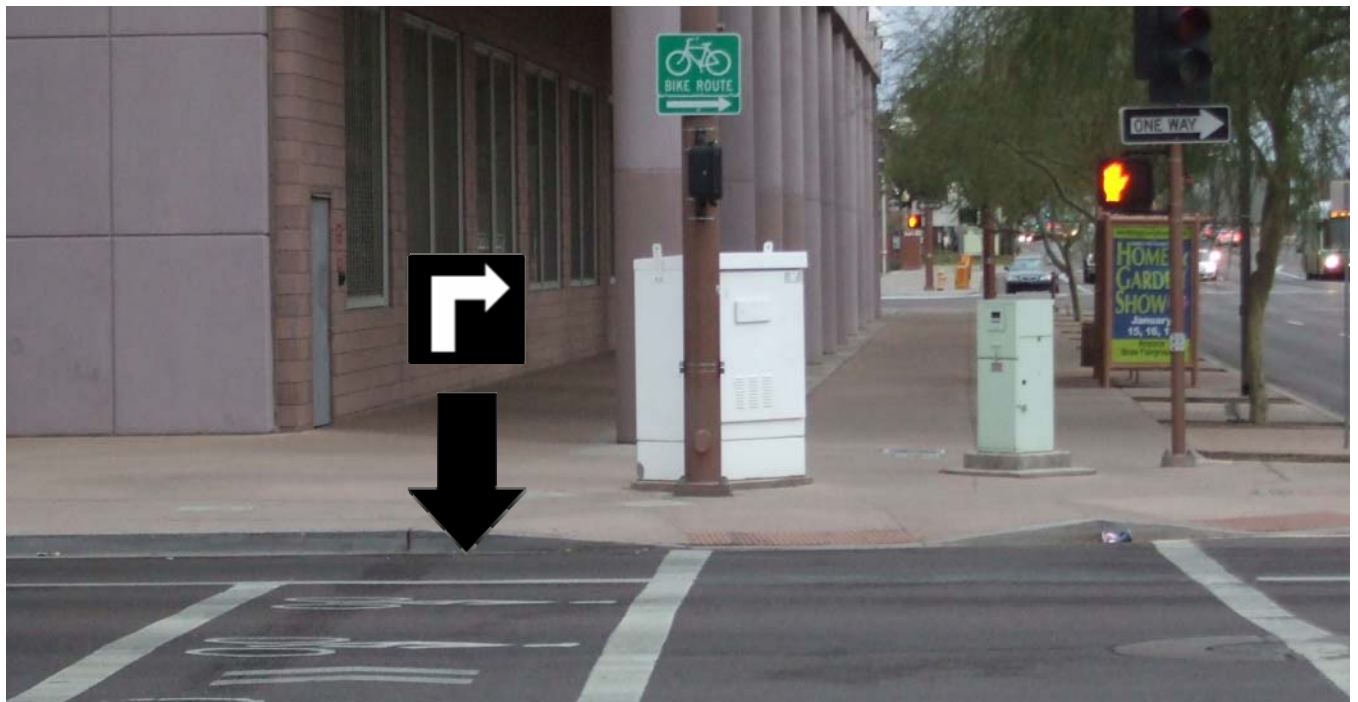


Figure 96: 7<sup>th</sup> Street and Jefferson Street – Recommended Traffic Control

**24.24<sup>TH</sup> STREET AND WASHINGTON STREET:**

**Table 9: 24<sup>th</sup> Street and Washington Street – Collision Summary**

Report #	Date	Movement	Vehicle	LRT	Sun Location	Violation
961-082053060	12/2/2008	Through	NB	WB	No Influence	Disregarded Signal

Day	Time	Injury Number	Injury Severity	Age	Gender
Tuesday	10:27 AM	0	0	78	Female



**Figure 97: 24<sup>th</sup> Street and Washington Street – Bike-Crosswalk**



Figure 98: 24<sup>th</sup> Street and Washington Street – Collision Location

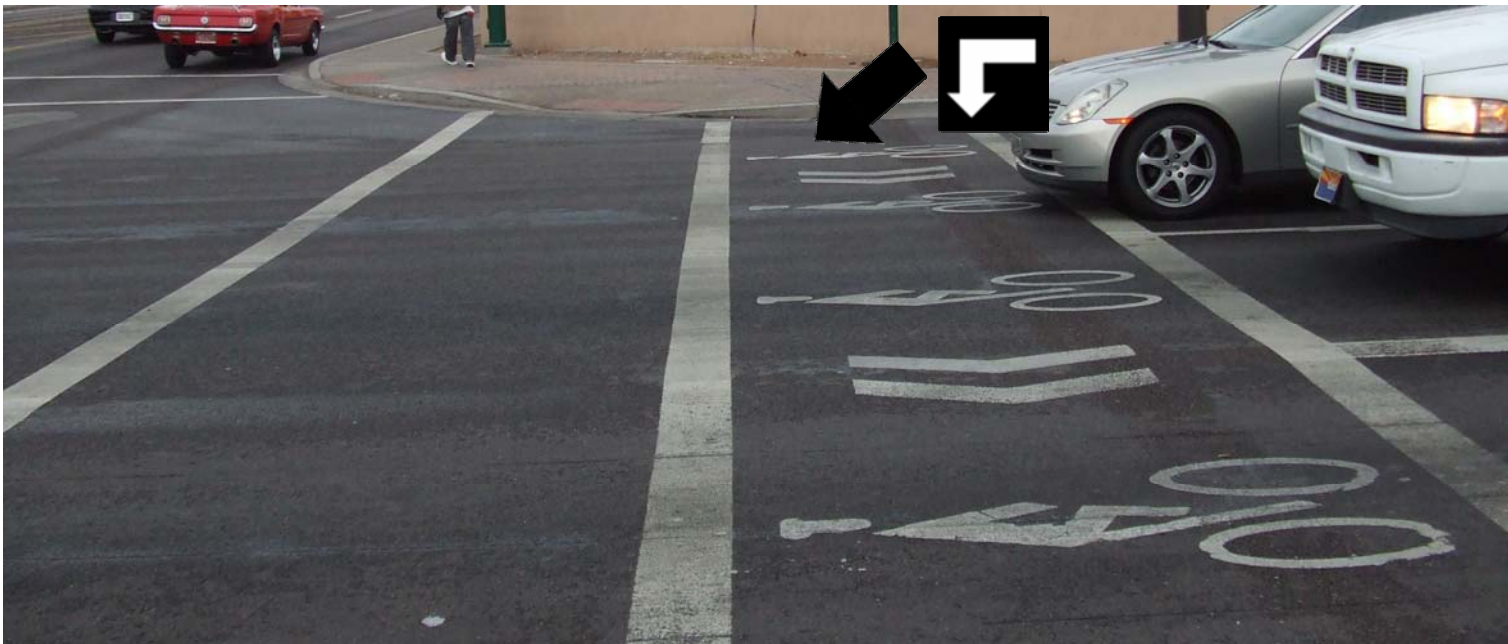


Figure 99: 24<sup>th</sup> Street and Washington Street – Recommended Traffic Control

**25.24<sup>TH</sup> STREET AND JEFFERSON STREET:**

**Table 10: 24<sup>th</sup> Street and Jefferson Street – Collision Summary**

Report #	Date	Movement	Vehicle	LRT	Sun Location	Violation
961-091212116	7/30/2009	Through	SB	EB	No Influence	Disregarded Signal

Day	Time	Injury Number	Injury Severity	Age	Gender
Thursday	5:21 AM	0	0	51	Male



**Figure 100: 24<sup>th</sup> Street and Jefferson Street – Westbound Approach**

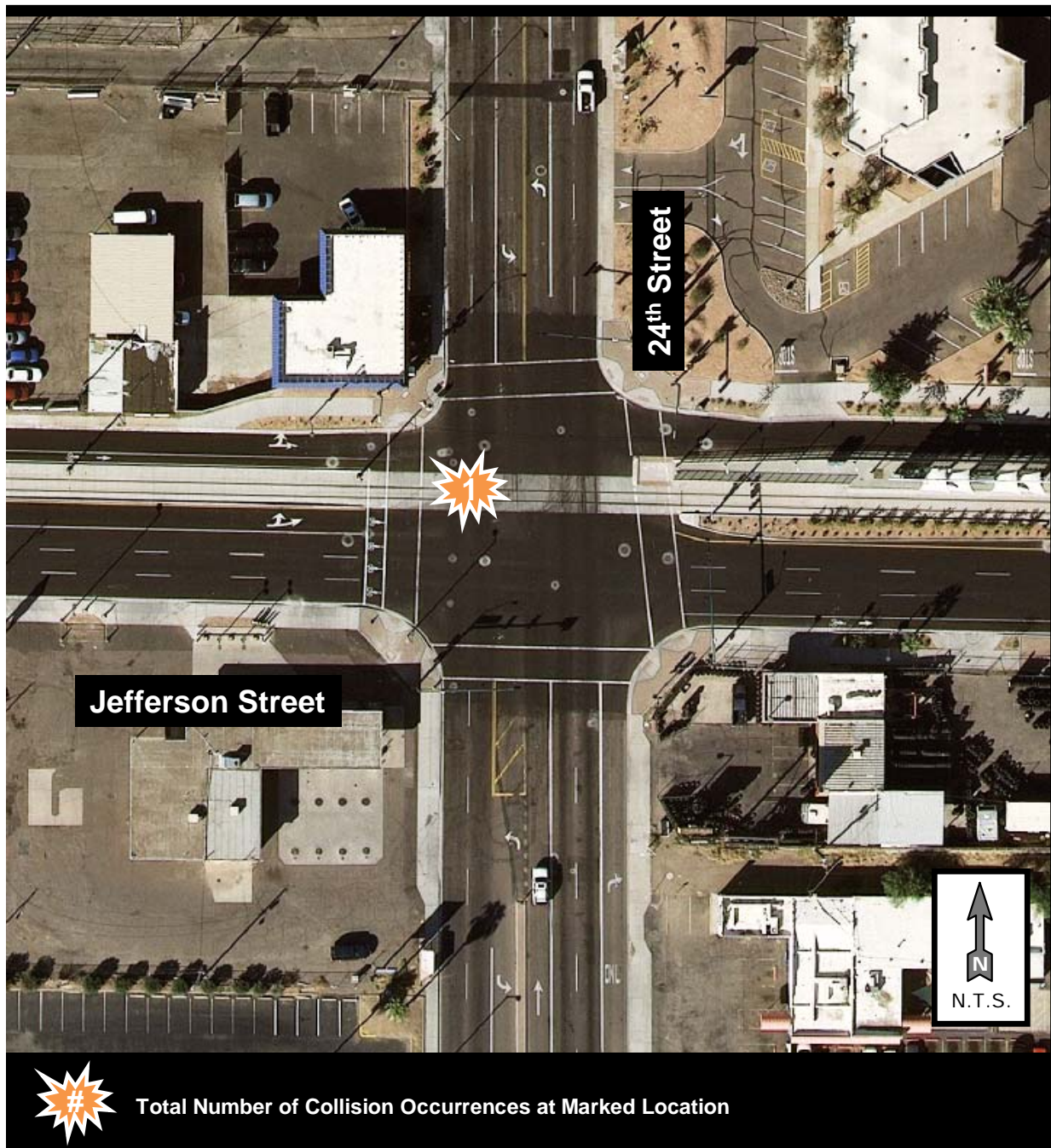


Figure 101: 24<sup>th</sup> Street and Jefferson Street – Collision Location

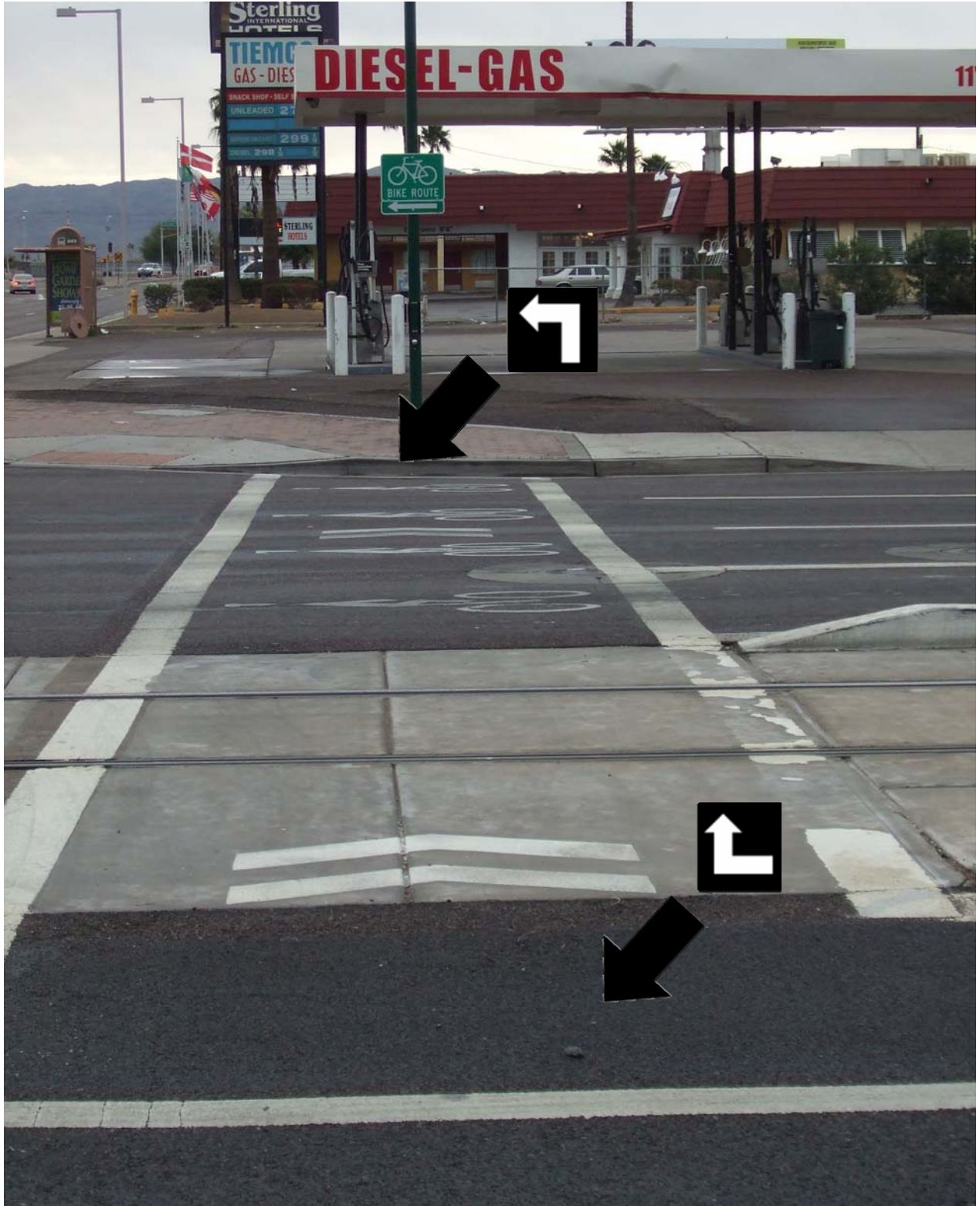


Figure 102: 24<sup>th</sup> Street and Jefferson Street – Recommended Traffic Control

**COST OF RECOMMENDATIONS:**

The cost of the recommended improvements ranges from approximately \$70,000 to approximately \$750,000. The greatest cost would be the signal timing modifications for turn arrows at approximately \$350,000. The least expensive recommendations would be the pedestrian walk time increases, pedestrian signal addition, and bicycle pavement markings for approximately \$500 to \$5,000. The sign change recommendations are the most variable costs. If these changes are included with regular maintenance, the additional costs would be approximately \$50 per intersection. If these changes are accomplished as a separate program, the total cost could be approximately \$350,000.