ARIZONA
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May 5, 2016

Mr. Anthony Beach, P.E.
BSP Engineers
4800 Lakewood Drive, Suite 4
Waco, Texas 76710

Re: Intersection and Access Analysis along Business 190 in Copperas Cove

Dear Mr. Beach:

Lee Engineering has performed a traffic analysis to assess access management improvements along Business 190 in Copperas Cove, Texas. The study corridor is Business 190 between Avenue D (FM 1113) and Robert Griffin III Drive, and includes the signalized intersections at Avenue D, at Martin Luther King Jr. Drive, at Constitution Drive, and at Robert Griffin III Drive. The study section of Business 190 is approximately 1.4 miles in length. An aerial view of the study area is shown in **Figure 1**.

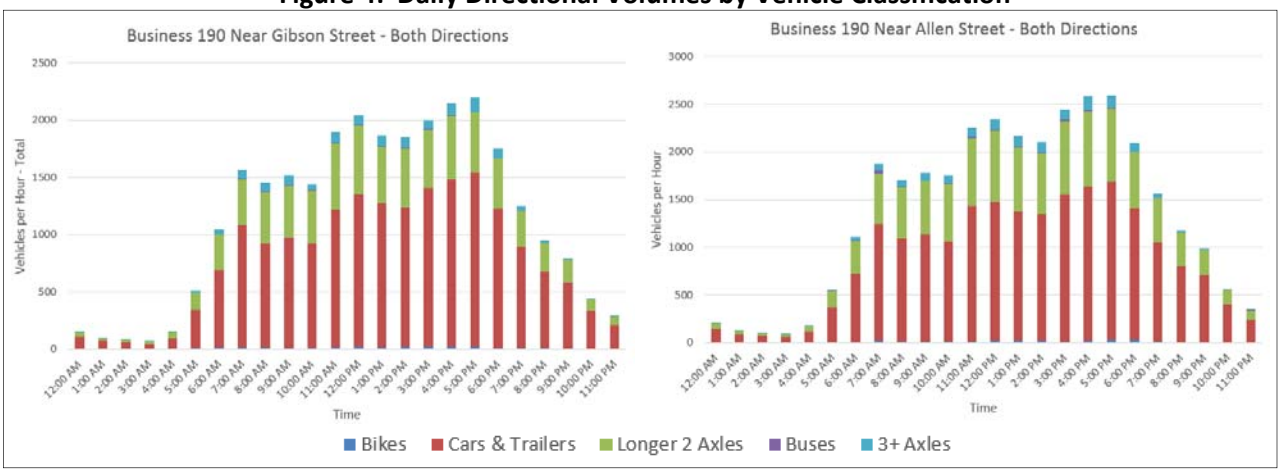
Figure 1: Vicinity Map of the Study Area

Business 190 is currently a seven-lane roadway with a two-way center left turn lane. Existing intersection lane configurations are shown in **Figure 2** (attached). The purpose of this study is to determine the recommended signalized intersection turn lane lengths and potential median opening locations.

Traffic Volumes

Turning movement traffic volumes were collected for 12 hours at the four study area signalized intersections on Thursday, December 10, 2015. 24-hour directional volumes were also collected at two locations, along with vehicle classifications. **Figure 3** summarizes the peak hour turning movement volumes and daily directional volumes. **Figure 4** shows the volumes throughout the day by vehicle classification at the two locations studied.

Figure 4: Daily Directional Volumes by Vehicle Classification



Based on available historical and available projected traffic volumes in the area, an annual growth rate of 1% was applied to the existing traffic volumes to obtain projected volumes for the year 2036, as shown in **Figure 5**. In addition, it was assumed that a northbound leg would be added to the signalized intersection of Business 190 and Avenue D to provide access to the existing gas station and McDonalds. The assumed directional distribution and estimated site generated trips for this new driveway approach are shown in **Figure 6**.

Finally, left turn movements at the intersections of Business 190 with Avenue D, Martin Luther King Jr. Drive, and Constitution Drive were increased to account for additional left turn and U-turn movements. With construction of a raised median, left turn opportunities would be reduced and more vehicles would have to perform a left turn or U-turn movement at these signalized intersections to access many of the developments along Business 190. The eastbound approach at Constitution Drive does not currently have a left turn as there is no southbound leg at this intersection, but a future U-turn movement was assumed. U-turn volumes at the intersection of Business 190 and Robert Griffin III Drive were not increased due to limited existing development in the vicinity of this intersection. The final 2036 peak hour traffic volumes used for analysis are shown in **Figure 7**.

Capacity Analysis

Intersection capacity analysis was performed using the macroscopic traffic analysis software package *Synchro 9.0* to determine if the Business 190 corridor would operate acceptably as a four-lane divided roadway rather than a six-lane divided roadway. Existing signal timing sheets were provided by the TxDOT Waco District. Based on field observations and a review of the existing timings it was evident that the signal timings along the corridor require adjustment. The cycle lengths were updated to be the same throughout the study corridor. This results in shorter cycle lengths than the existing cycle lengths at the two eastern intersections (at Constitution Drive and at Robert Griffin III Drive), along with longer cycle lengths at the two western intersections during the PM peak hour.

The Level of Service (LOS) of an intersection is a qualitative measure of capacity and operating conditions and is directly related to vehicle delay. The LOS criteria for a signalized intersection are shown in **Table 1**. LOS is given a letter designation from A to F, with LOS A representing very short delays (less than 10 seconds of average control delay per vehicle) and LOS F representing very long delays (more than 80 seconds of average

control delay per vehicle). LOS D, ranging from 35.1 to 55 seconds of average control delay per vehicle, is typically considered the minimum acceptable condition in an urban environment.

Table 1: Level of Service Criteria for Signalized Intersections

Level-of-Service (LOS)	Average Control Delay (seconds/vehicle)	Description
A	≤ 10.0	Very low vehicle delays, free flow, signal progression extremely favorable, most vehicles arrive during given signal phase.
B	10.1 to 20.0	Good signal progression, more vehicles stop and experience higher delays than for LOS A.
C	20.1 to 35.0	Stable flow, fair signal progression, significant number of vehicles stop at signals.
D	35.1 to 55.0	Congestion noticeable, longer delays and unfavorable signal progression, many vehicles stop at signals.
E	55.1 to 80.0	Limit of acceptable delay, unstable flow, poor signal progression, traffic near roadway capacity, frequent cycle failures.
F	> 80.0	Unacceptable delays, extremely unstable flow and congestion, traffic exceeds roadway capacity, stop-and-go conditions.

SOURCE: *Highway Capacity Manual, HCM 2010*, Transportation Research Board, 2010.

To evaluate whether Business 190 could be narrowed to a four lane roadway, the study intersections were analyzed using the Projected 2036 peak hour traffic volumes (Figure 7). **Table 2** presents the results of this analysis for the signalized intersections.

Table 2: Intersection Capacity Analysis Results – Projected 2036 Volumes

Business 190 at Robert Griffin III Drive (Signalized)						
Peak Hour:	AM Peak		Midday Peak		PM Peak	
Lanes:	6	4	6	4	6	4
Intersection LOS:	7.1 (A) [1]	8.6 (A)	25.5 (C)	28.3 (C)	14.6 (B)	16.4 (B)
Business 190 at Constitution Drive (Signalized)						
Peak Hour:	AM Peak		Midday Peak		PM Peak	
Lanes:	6	4	6	4	6	4
Intersection LOS:	12.0 (B)	12.3 (B)	18.0 (B)	21.3 (C)	17.0 (B)	17.5 (B)
Business 190 at Martin Luther King Jr Drive (Signalized)						
Peak Hour:	AM Peak		Midday Peak		PM Peak	
Lanes:	6	4	6	4	6	4
Intersection LOS:	18.9 (B)	20.8 (C)	21.6 (C)	27.0 (C)	23.7 (C)	42.6 (D)
Business 190 at E Avenue D (FM 1113) (Signalized)						
Peak Hour:	AM Peak		Midday Peak		PM Peak	
Lanes:	6	4	6	4	6	4
Intersection LOS:	44.5 (D)	47.0 (D)	40.9 (D)	43.6 (D)	54.3 (D)	52.0 (D)

[1] Delay in seconds/vehicle (Level of Service)

As shown in Table 2, the study intersections operate at acceptable levels of service for a six-lane corridor and for a four-lane corridor, and the delay is similar between the six-lane roadway and the four-lane roadway. Thus, reduction of Business 190 to a four-lane divided roadway could be considered.

Queuing Analysis and Left Turn Lane Configuration

Intersection capacity analysis was performed using the macroscopic traffic analysis software package *Synchro 9.0*. Queuing analysis was also performed using *SimTraffic*, a microscopic traffic analysis software package. Existing signal timing sheets were provided by the TxDOT Waco District. Based on field observations and a review of the existing timings it was evident that the signal timings along the corridor require adjustment. The cycle lengths were updated to be the same throughout the study corridor. This results in significantly shorter cycle lengths than the existing cycle lengths at the two eastern intersections (at Constitution Drive and at Robert Griffin III Drive).

The maximum 95th percentile queue lengths throughout the day for each left turn movement were utilized to determine the required left turn storage length. Based on TxDOT's *Roadway Design Manual*, the minimum required storage length is 100 feet. The required deceleration length and taper length were based on TxDOT requirements for a 35 mph roadway and a 45 mph roadway, with an assumed 20 mph in-lane deceleration. The resulting 95th percentile queue lengths and the recommended left turn lane dimensions are shown in **Table 3**. The City of Copperas Cove desires a corridor with an operational speed between 30 mph and 40 mph. Narrower lane widths and turn lanes that do not facilitate high speed travel are desired throughout the corridor.

Table 3: Estimated Queue Lengths and Recommended Turn Lane Lengths

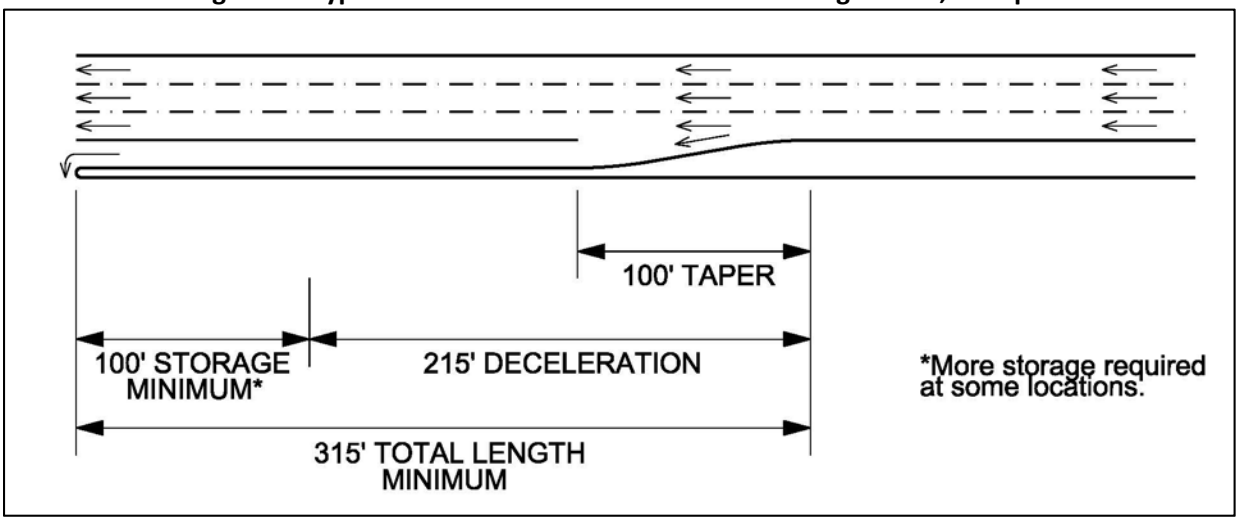
Intersection	Left Turn Approach	Estimated 95th Percentile Queue (2036)	Required Storage Length	Required Deceleration Length		Total Left Turn Length (Storage + Deceleration)	
				45 mph[2]	35 mph[3]	45 mph[4]	35 mph[5]
Business 190 at Robert Griffin III Dr	WB	500'	500'	215'	110'	715'	610'
Business 190 at Constitution Dr	EB	99'	100' [1]	215'	110'	315'	210'
	WB	260'	260'	215'	110'	475'	370'
Business 190 at Martin Luther King Jr Dr	EB	74'	100' [1]	215'	110'	315'	210'
	WB	67'	100' [1]	215'	110'	315'	210'
Business 190 at Avenue D	EB	92'	100' [1]	215'	110'	315'	210'
	WB	181'	185'	215'	110'	400'	295'

[1] Minimum required storage length for a 35 mph or 45 mph speed limit, based on TxDOT's *Roadway Design Manual*
[2] Required deceleration length for a 45 speed limit and a 20 mph speed differential, based on TxDOT's *Roadway Design Manual*
[3] Required deceleration length for a 35 speed limit and a 20 mph speed differential, based on TxDOT's *Roadway Design Manual*
[4] Total length includes required minimum taper length of 100 feet for a 45 mph roadway
[5] Total length includes required minimum taper length of 50 feet for a 35 mph roadway

It should be noted that Business 190 is already divided east of Constitution Drive. The existing westbound left turn lane at Constitution Drive is approximately 750 feet in total length and the existing westbound left turn lane at Robert Griffin III Drive is approximately 830 feet in total length. Existing queues are long due to protected-only phasing and overly long cycle lengths.

The total left turn lane length is 315 feet minimum for a 45 mph roadway and 210 feet minimum for a 35 mph roadway. **Figure 8** shows the recommended typical configuration and dimensions for a left turn lane on Business 190.

Figure 8: Typical Recommended Left Turn Lane Configuration, 45 mph



Access Management

Based on the above intersection analysis, a knowledge of the study corridor, and the developed design criteria of left turn lanes, Lee Engineering developed a preliminary concept drawing of the study corridor, as shown in **Figure 9**. The schematic includes outside curb lines, major intersecting roadways and driveways, potential new, relocated, or shared driveway locations, potential sidewalk locations, and preliminary median design. It was also assumed that Business 190 would be reduced to a four-lane divided roadway in the study area. The MicroStation concept file will be provided to BSP.

An attempt was made to reduce the number of driveways along the Business 190 Corridor while attempting to provide similar levels of access for existing properties. As properties redevelop, driveway spacing should be increased and cross access should be provided.

Figure 9: Preliminary Concept of Median Design on Business 190 Corridor

As the 100-foot tapers may overlap, the minimum spacing between full median openings should be 530 feet. Shorter spacing to partial, or hooded, openings may be possible. Based on TxDOT's *Access Management Manual*, driveway spacing should be 360 feet for a 45 mph roadway and 250 feet for a 35 mph roadway.

Considerations for Future Design

The schematic drawing assumed that Business 190 was reduced to a four-lane divided roadway. This design results in a wide median throughout the corridor. Based on information provided in the AASHTO manual *A Policy on Geometric Design of Highways and Streets* (Green Book), offset left turn lanes are desirable for medians wider than 18 feet. Rather than placing the left turn lane next to the adjacent through lane, the left turn lane is located further to the left and closer to the opposing through lanes. By maximizing the positive offset between opposing left turn lanes, sight distance for left turning vehicles is improved. Final design of the corridor should consider offset left turn design to improve visibility.

On the other hand, U-turns would likely be more difficult for passenger cars with offset left turns and a four-lane divided roadway configuration. U-turns are desirable within the study corridor to increase property access. An additional benefit of the wide median design is that the City has the option to expand Business 190 back to a six-lane divided roadway in the future if necessary. Landscaping opportunities are also greater with the wide median, though care will be necessary to preserve minor street and driveway sight triangles.

It should also be noted that the MicroStation file includes dual-left turn lanes on the westbound approach of Business 190 at Robert Griffin III Drive and at Constitution Drive. Use of dual left turns would allow additional vehicles to turn left during each cycle and should reduce the queue lengths. However, left turn phasing should remain as protected-only with the use of dual left turns. In addition, pavement markings may be necessary at the intersection to guide left turning vehicles, particularly through the wide median opening at Robert Griffin III Drive. Coordination with TxDOT will be necessary to transition from three through lanes westbound to two through lanes upstream of Robert Griffin III Drive.

Transit Median Access

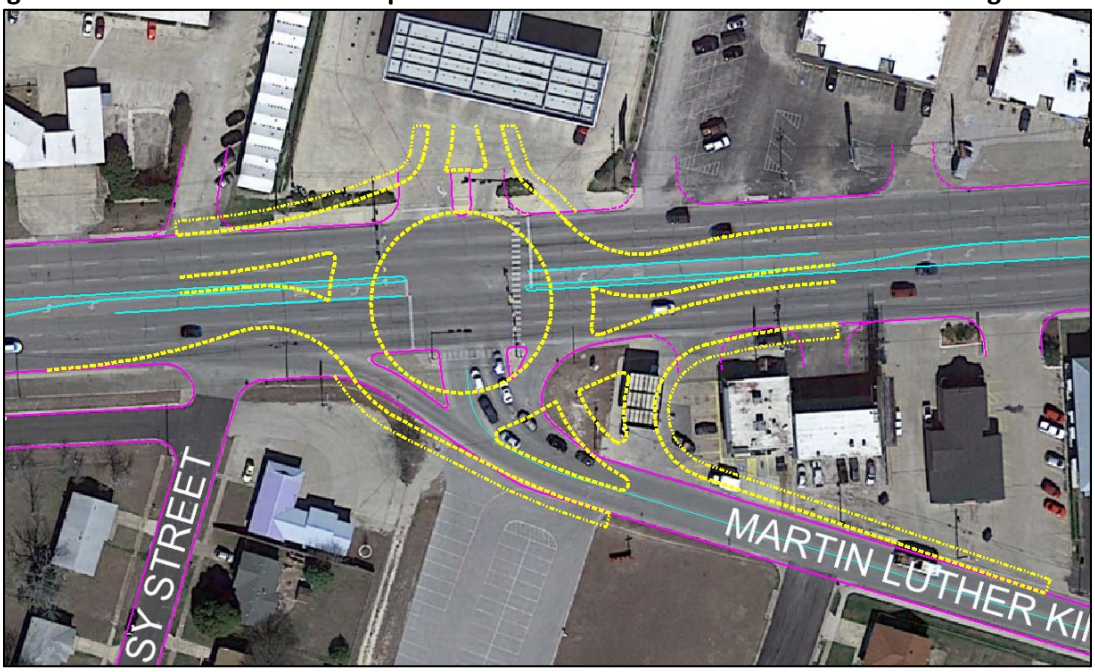
Based on the City of Copperas Cove "Business 190 Master Plan", HOP bus stops are planned on the median. The HOP is a public transit system operated by Hill Country Transit District (HCTD). However, use of median bus stops is not recommended at this time. Because passengers would step out of the bus into a moving lane of traffic, new buses would have to be purchased with doors on each side of the bus to allow for median stops and for typical stops. Transit users would have to also have to cross the roadway to get to and from the transit stops, which may be difficult. In addition, discussion with the HOP representatives indicates that they are not in support of any design that requires new buses.

Roundabout Concept

The "Business 190 Master Plan" also shown a potential roundabout at the intersection of Business 190 and Martin Luther King Jr. Drive. A concept sketch was created by Lee Engineering to illustrate the ROW requirements for a potential roundabout at this location, as shown in **Figure 10**. The yellow line indicates curb lines for the roundabout sketch and the green lines represent potential ROW that would have to be acquired. It should be noted that the concept sketch is for a roundabout with two circulation lanes and two entry/exit lanes on Business 190. ROW requirements would be greater for three circulation lanes.

The roundabout shown is highly conceptual in nature and no formal design efforts should be based off of the sketch. No capacity analysis has been performed to verify the suitability of a roundabout for the projected 2036 volumes.

Figure 10: Roundabout ROW Requirements at Business 190 and Martin Luther King Jr. Drive



As shown, several properties and a public street in the vicinity of the intersection would be impacted by the ROW requirements associated with a roundabout, especially with the angled approach of Martin Luther King Jr. Drive. In addition, existing driveways and the intersection of Easy Street at Business 190 may have to be closed. Installation of a roundabout is not recommended at this location.

Conclusions

Based on the results of this analysis, the following observations and recommendations are made with installation of a raised median along Business 190:

- Reduction of Business 190 to a four-lane divided roadway could be considered.
    - With the resulting wide median, the City may consider offset left turn lanes to improve visibility. However, consideration should be given to U-turning traffic as well.
- Traffic signal cycle length, splits, and offsets should be coordinated and optimized.
- A combined driveway for the existing gas station and McDonalds is recommended to be installed as the northbound approach at the intersection of Business 190 and Avenue D.
- Construction of median openings is recommended at city streets where possible (i.e. Nauert Street, Dewald Street, and Gibson Street).
    - City streets located too close to signalized intersections should not be provided with a median opening (i.e. Allen Street and Easy Street).
- Existing westbound left turn lanes on Business 190 at Constitution Drive and at Robert Griffin III Drive may remain with the existing configuration or could become dual left turn lanes if Business 190 becomes a four-lane roadway. Protected-only phasing and pavement markings should be considered with dual left turn lanes.
    - Coordination with TxDOT will be required to transition from three westbound lanes to two upstream of Robert Griffin III Drive.
- An eastbound left turn lane should be constructed at Business 190 and Constitution Drive to allow U-turn movements, although there is currently no southbound leg at this intersection.

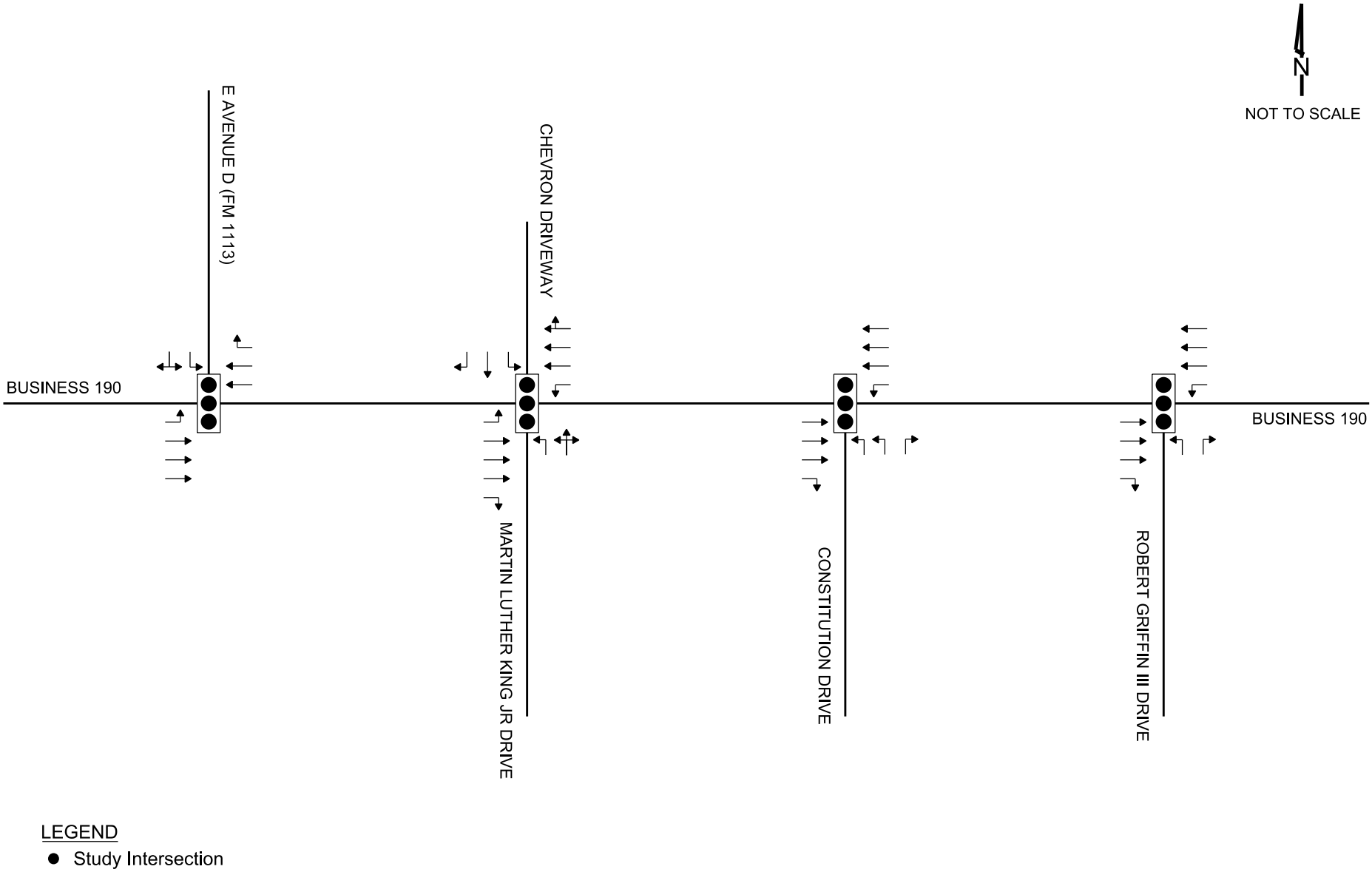
- Hooded left turns may be utilized where left turn lanes are provided in only one direction. This would restrict left turns in the opposing direction and minor street left turns onto Business 190.
- With construction of a raised median, access would be limited to many of the existing sites along Business 190. It is recommended to construct shared driveways and cross-access between existing developments where possible.
    - Shared access easements should be required of all future development and redevelopment along the corridor.
    - Based on TxDOT requirements, driveway spacing should be 360 feet for a 45 mph roadway or 250 feet for a 35 mph roadway.
- It is recommended to realign opposing offset driveways at median openings.
- Consider the potential for cut-through traffic between Business 190 and Martin Luther King Jr. Drive if a median opening is placed at the Federal Credit Union driveway located 940 feet west of Dewald Street.
- Bus stops on the median are not recommended.
- Construction of a roundabout at the intersection of Business 190 and Martin Luther King Jr. Drive is not recommended.

We appreciated the opportunity to provide these services to you. If you have any questions, please contact me at (972) 248-3006.

Sincerely,

John Denholm, P.E., PTOE
Project Manager
Lee Engineering, LLC
TBPE Firm F-450

Attachments



3030 LBJ FREEWAY
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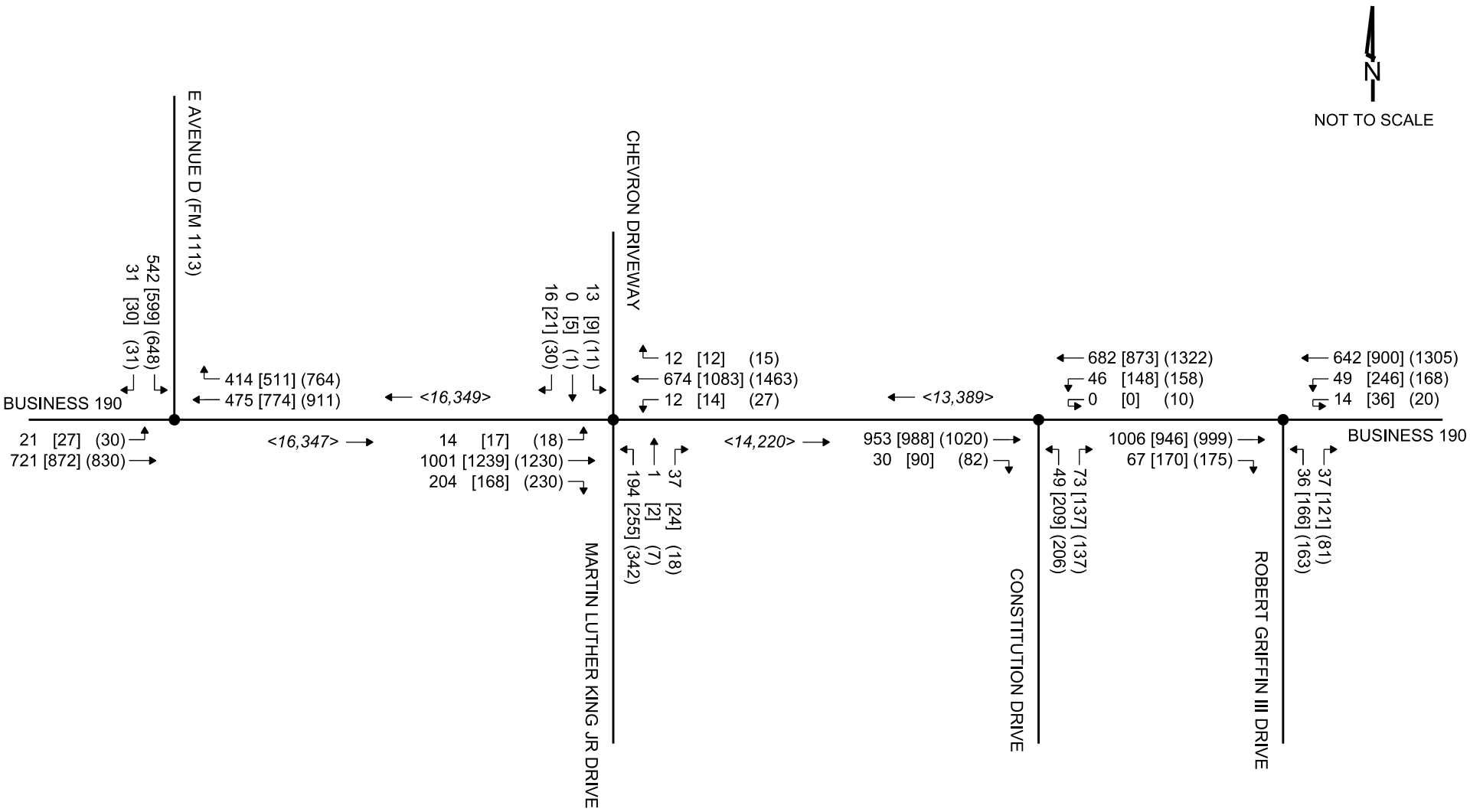
Existing Intersection Lane Configurations

Figure 2



LEGEND

● Study Intersection

← AM Peak Hour [Midday Peak Hour] (PM Peak Hour) - Turning movement volumes collected on Thursday, December 10, 2015.

← *<24-Hour Volume>*

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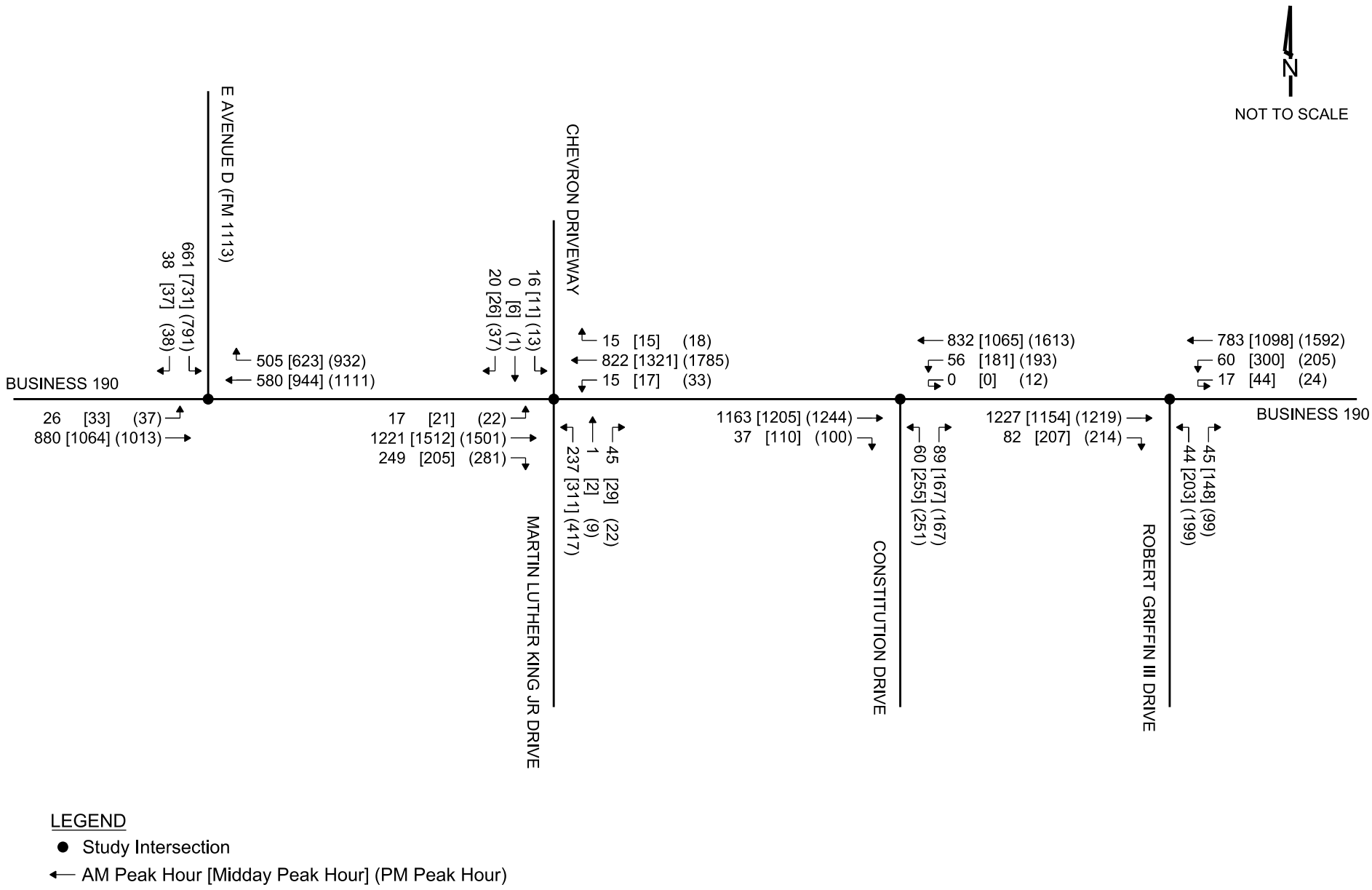
Existing (2016) Peak Hour Traffic Volumes

Figure 3



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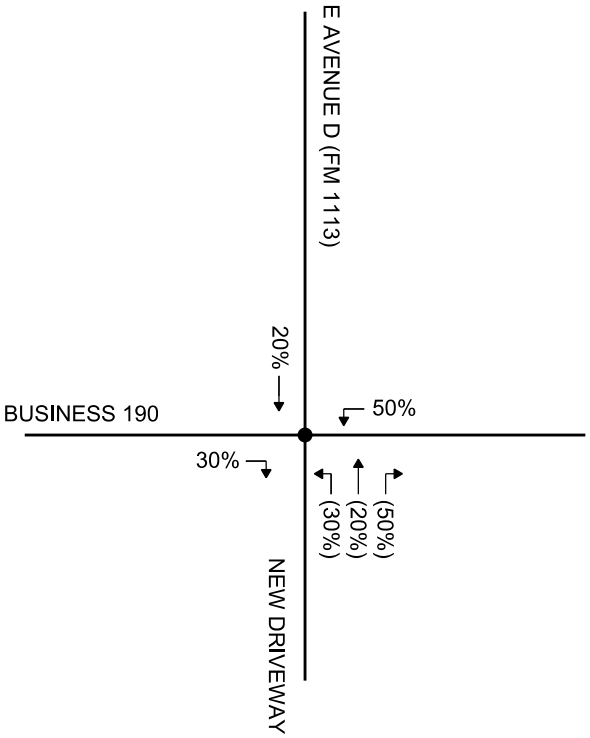
Projected 2036 Peak Hour Traffic Volumes

Figure 5

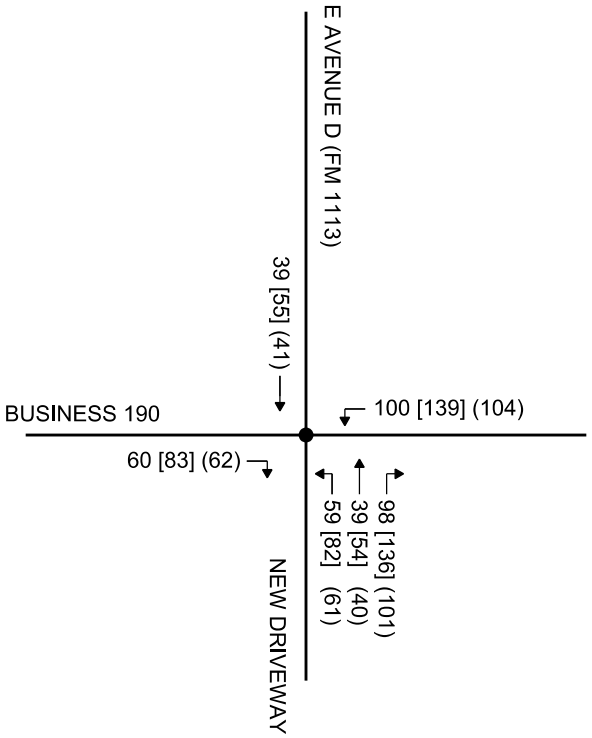
Assumed Directional Distribution



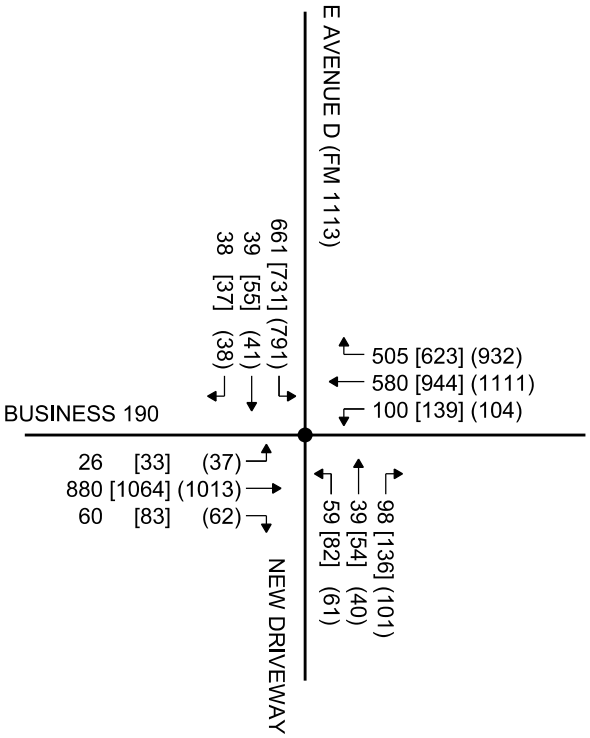
LEGEND

- ● Study Intersection
- ← Inbound % (Outbound %)

Site Generated Trips - Gas Station and McDonalds



2036 Total Traffic



LEGEND

- ● Study Intersection
- ← AM Peak Hour [Midday Peak Hour] (PM Peak Hour)

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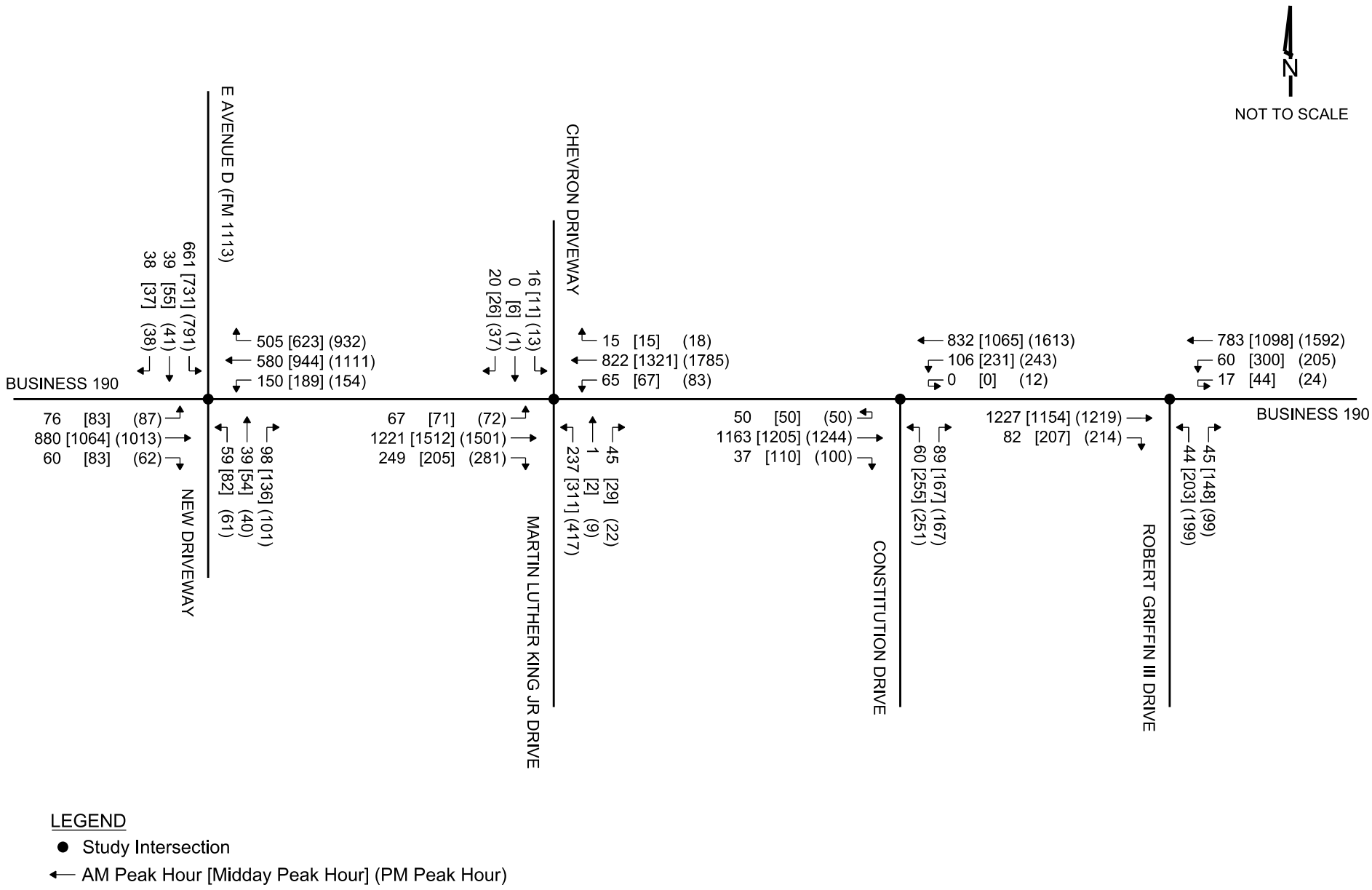
New Peak Hour Traffic Volumes at Avenue D with Driveway

Figure 6



LEGEND

● Study Intersection

← AM Peak Hour [Midday Peak Hour] (PM Peak Hour)

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Assumed 2036 Peak Hour Traffic Volumes with Median

Figure 7