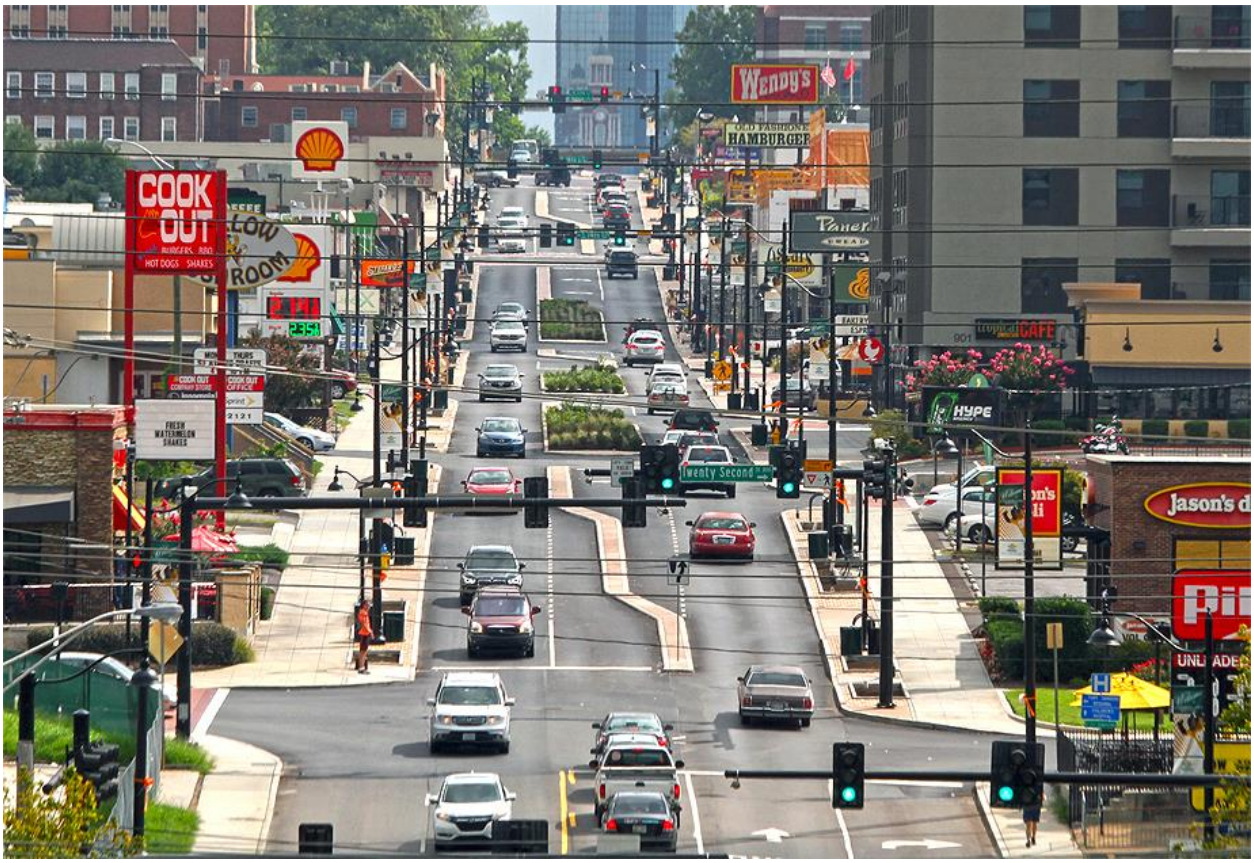
Cumberland Avenue Corridor Project:
Traffic Analysis Results and Impacts



CITY OF KNOXVILLE

Department of Engineering – Traffic Engineering Division
and Office of Redevelopment

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Executive Summary

The goal of the Cumberland Avenue Corridor Project was to chart the course for a "more attractive, economically successful, vibrant and safe Cumberland Avenue." This report aims to assess how successful the City and its partners were in achieving those goals after investing $25 million in public funds.

Engaging extensively with stakeholders, the public, the University of Tennessee community and media, three key litmus tests emerged:

- Is Cumberland Avenue safer?
- Does traffic flow well?
- Has the public investment in infrastructure leveraged significant private reinvestment in hotels, retail, entertainment and residential housing along the corridor?

For each of these measuring sticks of whether the project was successful, the data clearly indicates that the City has hit its milestone goals and that the public investment has reaped handsome rewards.

Consider:

- In the six-month period since the project was completed, Police Department traffic crash data shows an approximate 40 percent reduction in vehicle crashes along the corridor. In addition, no pedestrian or bicycle crashes with vehicles have been reported, in the same time period – a direct result of inherent conflicts having been dramatically reduced.
- As predicted, traffic volumes are down by 5 to 21 percent at different points throughout the corridor. This reflects the desired effect of Cumberland Avenue being transformed from a cut-through route to a destination. Delays in average commute times have been minimal overall. And at different peak travel times, signal system optimization has improved travel times for both eastbound and westbound commuters by 7.5 to more than 20 percent.

- The $25 million project has leveraged more than $190 million in private investment and brought more than 1,400 new residents to the half-mile corridor from 17th Street to University Commons Way.

Based on these findings, the City is confident in stating that it has met the goals of the Cumberland Avenue Corridor Plan and that the implementation of the project has been successful.

Additional Context

Cumberland Avenue was a four-lane undivided street that was often congested; vehicles would turn unexpectedly, in the middle of blocks and with no regulation, and delivery trucks would frequently park in traffic lanes. The result was unpredictability – sometimes, a reasonably free-flowing commute, and at other times, complete gridlock.

The reconstructed Cumberland Avenue reduced it to a three-lane street with a median to direct left-turn movements. Traffic signals were better synchronized, and a new right-turn lane from westbound Cumberland Avenue onto northbound Alcoa Highway was added.

The original vision plan assumed a 70-foot right-of-way, a continuous left-turn lane and the closure of all the driveway curb cuts on Cumberland Avenue. The use of Federal Highway Administration (FHWA) funds to construct the project meant that the closure of driveway curb cuts would fall under the Uniform Act for land acquisition and was determined to be infeasible due to costs. Since the driveways would not be closed, the two-way left turn lane created the potential for "head-on" conflicts and did not meet the City's goal of improved safety. Finally, the right-of-way was determined to be only 65 feet on average and therefore less room was available than originally anticipated. These issues were studied by a second, independent consultant at the City's request and the proposed configuration was recommended to accomplish the increase in safety for pedestrians, bicyclist, transit users, deliveries and motorists along Cumberland Avenue. Construction began on the project in April 2015, and it reached substantial completion in August 2017.

To determine whether or not the City met the goal as stated above - a "more attractive, economically successful, vibrant and safe Cumberland Avenue" – the City's Traffic Engineering Division and the Office of Redevelopment have compiled data regarding traffic counts, travel times, improved safety and economic success.

This includes assessing the Annual Average Daily Trips for vehicles along Cumberland Avenue from 2008 through 2018 (before, during and after construction). The studies indicated that the City would see up to 20 percent diversion with the construction of the project. The trends show at different intersections of the corridor a decrease in traffic volumes from 5 percent to 21 percent from 2008 to 2018.

Another indicator that was studied was travel times and delay through the corridor for the various peak travel times, including morning, midday and afternoon peaks.

Travel time was not assessed for the four-lane cross section prior to the start of construction; however, the model of the three-lane cross section and level of service of intersections was modeled and has been compared with actual post-construction traffic counts. In general, these models show that the expected delay is very close to the real-time experience and that in general the level of service has been maintained or improved by the project, obtaining the expectation of "settling at an acceptable level."

Travel times were also observed pre- and post-signal system optimization, and that information shows an improvement in travel times for both eastbound and westbound commuters by 7.5 percent to more than 20 percent at different peak times.

For a six-month period following the project's completion, KPD has provided traffic crash data, and that data shows an approximate 40 percent reduction in vehicle crashes along the corridor. (Most road diets see approximately 20 to 45 percent improvements in crash rates.)

The demand for pedestrian use along this corridor is extremely high, given the proximity to the University of Tennessee flagship campus, adjacency of the Fort Sanders neighborhood, the redevelopment of several

parcels into mixed use (retail and housing), and the presence of two regional hospitals. The project has reduced pedestrian crossing distances along Cumberland and highlighted crossing locations through stamped asphalt crosswalks. These changes along with directed-turn movements from the median have improved pedestrian safety. There were no reported collisions between vehicles and pedestrians or bicycles in the seven months after project completion.

Additionally, the $25 million project has leveraged more than $190 million in private investment. Major new or upgraded private redevelopments include: Hilton Garden Inn - $17 Million, Evolve Mixed Use Building - $20 Million, University Commons retail center - $65Million, The Standard student housing and parking - $39Million, The TENN student housing and retail center - $45Million. East Tennessee Children's Hospital also recently completed a $70 Million expansion in this district which is not included in the leveraged investment, as it was planned long range growth.

Finally, one of the goals of the project was to make Cumberland Avenue more inviting and aesthetically pleasing – both as a quality-of-life upgrade to better serve the dense population and UT community surrounding the corridor, but also as a means of spurring more immediate economic redevelopment.

So along the new Cumberland Avenue, sidewalks are wider, featuring decorative brick detail. Ugly overhead utility lines have been relocated to the alleys a block off Cumberland. Street furniture including - benches, kiosks and waste receptacles, energy-efficient streetlights and ADA-accessible transit stops have been installed. Landscaping has been planted in the medians, and 93 canopy trees – everything from round-lobed sweetgums, to lacebark elms, to sweetbay magnolias, to greenspire little leaf linden – were planted up and down Cumberland, between 16th and 22nd streets. The 3 to 4-inch caliper trees were 15 to 20 feet tall when planted and now provide shade to pedestrians.

Introduction

This study compares traffic conditions on Cumberland Avenue before and after the Cumberland Avenue Streetscapes Project that was completed in August 2017. The Cumberland Avenue Corridor Project was originally envisioned in a planning document "Cumberland Avenue: A History of Connection", by Glatting Jackson and adopted by the Metropolitan Planning Commission and City Council in 2007 (available at www.knoxvilletn.gov/cumberland). The City's goal was to "chart the course for a more attractive, economically successful, vibrant and safe Cumberland Avenue". There were two recommended outcomes of the plan – 1) a streetscape plan for Cumberland Avenue that included a road diet; and 2) a new form based zoning code for private property adjacent to the street. The pre-project expectation was that the amount of through traffic would decrease as a result of the road reconfiguration, resulting in a net decrease of traffic volume. It was also expected that delay would increase after the project by a small amount and settle at an acceptable level of service (Appendix E).

Traffic Engineering evaluated historic and current traffic volumes and compared delay and simulated travel times between models generated by Gresham Smith & Partners before the project and City of Knoxville after the project. A travel time comparison for the Cumberland Avenue corridor for the signal re-timing efforts completed by the City of Knoxville is also included. Several intersections along the corridor, between Alcoa Highway and 11th Street, required specific intersection timing adjustments in order to optimize the system. The 13 signalized intersections involved in this analysis are listed below in Table 1.

Table 1: Signalized Intersections

List of Signalized Intersections		
Intersection Number	Major Street	Minor Street
1	Cumberland Avenue	Alcoa Highway Southbound Ramp
2	Cumberland Avenue	Alcoa Highway Northbound Ramp
3	Cumberland Avenue	University Commons Way/ Metron Center Way
4	Cumberland Avenue	Volunteer Boulevard
5	Cumberland Avenue	22nd Street
6	Cumberland Avenue	19th Street
7	Cumberland Avenue	18th Street
8	Cumberland Avenue	S. 17th Street/Melrose Place
9	Cumberland Avenue	16th Street/Volunteer Boulevard
10	Cumberland Avenue	James Agee Street/Phillip Fulmer Way
11	Cumberland Avenue	Circle Drive
12	Cumberland Avenue	13th Street
13	Cumberland Avenue	11th Street/Estabrook Road

Map 1: Cumberland Avenue Signalized Intersections

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Traffic Counts and Speed

Station Location

Traffic Engineering placed radar counters at the following locations below from September 24, 2018 to October 1, 2018. These locations were chosen to coincide with TDOT stations for which there is a data history. The counters track number of vehicles in each direction, and record speed data for any vehicle that has passed by the counter. There were no major events that affected traffic, such as a University of Tennessee football home game, during this time period. Traffic Engineering conducted additional manual counts at Location 1 and Location 2 for verification of the automated radar counts.

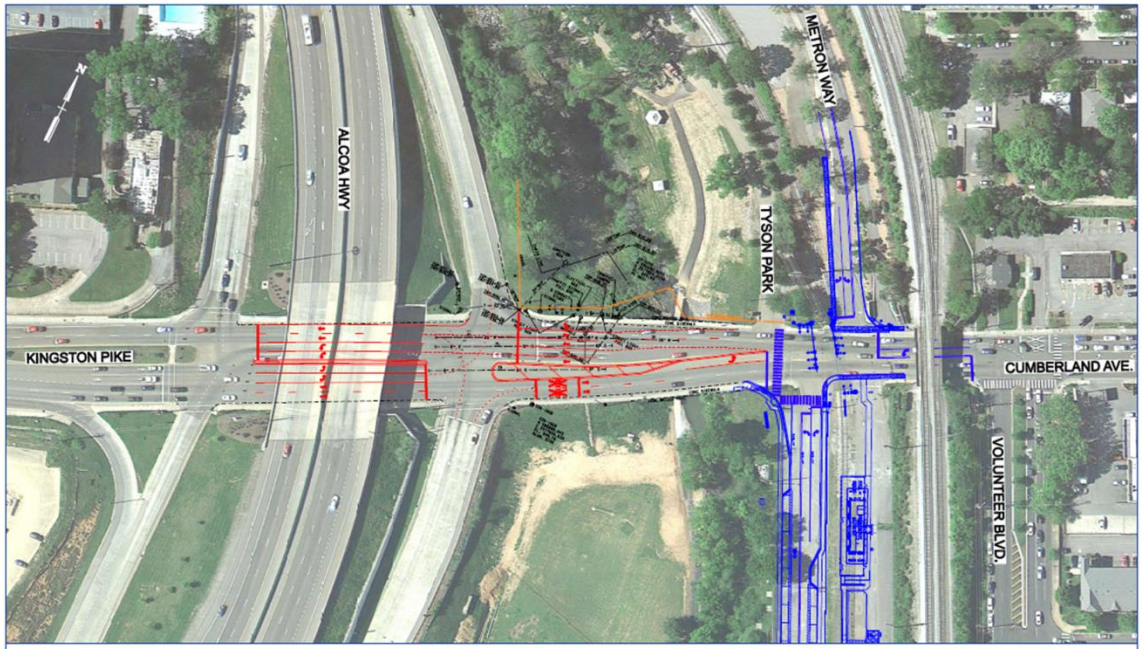
Table 2. Traffic Count Stations

Identification	**Location**	**TDOT Station**
Location 1	Cumberland Avenue between Alcoa Highway and University Commons Way	157
Location 2	Cumberland Avenue between 18th Street and 17th Street	404
Location 3	Cumberland Avenue between 13th Street and 11th Street	155

Figures 1 through 3 and Tables 3 through 5 show TDOT vehicle count data and trends from 2008 through 2017, along with City of Knoxville counts for 2018. It should be noted that some of the TDOT counts were estimated, including most of the data points for Location 1 (Alcoa Hwy. to University Commons Way) and the data for the years during project construction for Location 2 (18th Street to 17th Street).

The Alcoa Highway/University Commons Way count station is on the western edge of the project and was not part of the road diet. There was a westbound right turn lane added near this station for access to northbound Alcoa Highway. The addition of a turn lane at this location addressed a long standing congestion issue where if one westbound vehicle was stopped in the right lane vehicles that would otherwise leave the system were stuck until a green signal was given for through movement.

Map 2: Proposed striping for additional turn lane onto Alcoa Highway, 2012, Wilber Smith & Assoc.



This segment is also affected by recent development of University Commons. University Commons is a former brownfield site that sat vacant for a decade after Fulton Bellows closed their industrial site. Over the course of several years, CHM LLC redeveloped the property into the first vertical retail in Knoxville providing more than 240,000 square feet of commercial space and both surface and covered parking. The University Commons project started construction in 2012 and opened to tenants in 2014. Some of the traffic counts for this section were estimated by TDOT and that was partially due to the construction and construction vehicles accessing this site. The last measured count at this station was in 2011 (Table 3). The AADT at this location has decreased 5% between 2011 and 2018.

Figure 1. Traffic Counts on Cumberland Avenue between Alcoa Highway and University Commons Way, Location 1.

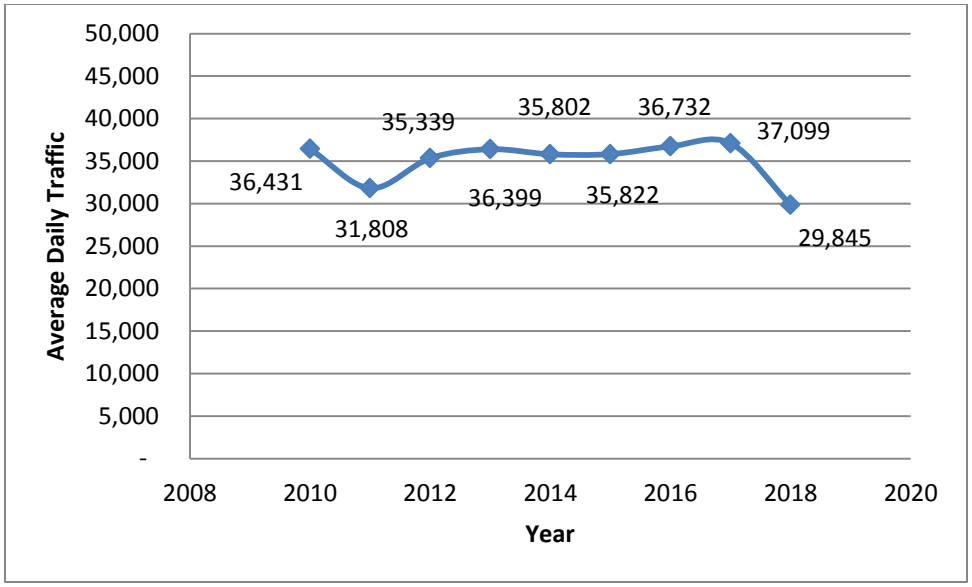


Table 3. Traffic Counts on Cumberland Avenue between Alcoa Highway and University Commons Way, Location 1.

Year	Average Daily Traffic
2010**	36,431
2011*	31,808
2012**	35,339
2013**	36,399
2014**	35,802
2015**	35,822
2016**	36,732
2017**	37,099
2018†	29,845

*TDOT count.
* * TDOT estimate.
†City of Knoxville count.

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The 18th Street/17th Street count station is within the project limits. The last measured AADT was in 2015 (Figure 2). The AADT at this location has decreased 21% between 2015 and 2018 and show a downward trend since 2010.

Figure 2. Traffic Counts on Cumberland Avenue between 17th Street and 18th Street, Location 2.

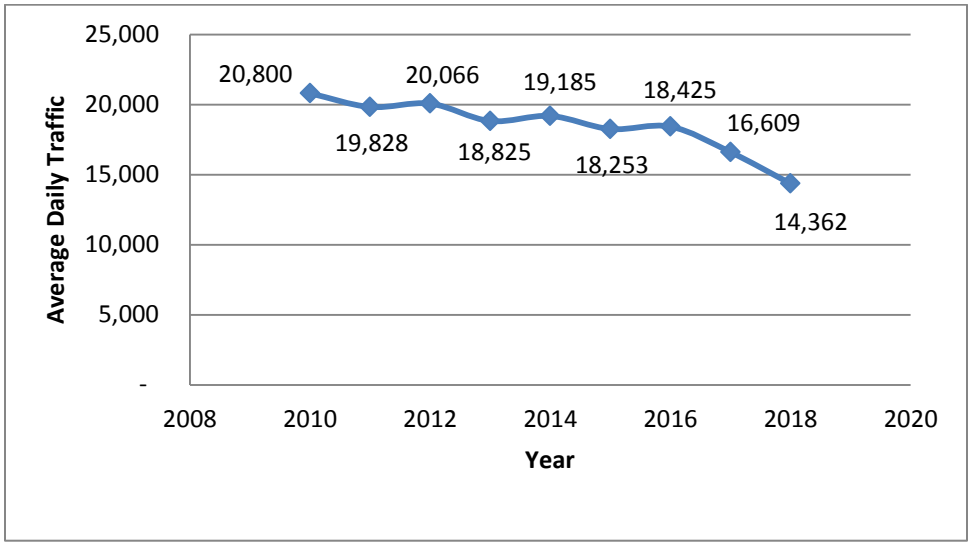

Table 4. Traffic Counts on Cumberland Avenue between 17th Street and 18th Street, Location 2.

Year	Average Daily Traffic
2010*	20,800
2011*	19,828
2012**	20,066
2013*	18,825
2014*	19,185
2015*	18,253
2016**	18,425
2017**	18,609
2018†	14,362

*TDOT count.
* * TDOT estimate.
†City of Knoxville count.

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The 13th Street/11th Street count station is located on Cumberland Avenue east of the project limits. The most recent count was in 2017 (Figure 3). The AADT at this location has increased 10% between 2017 and 2018, but the 2017 count is lower than for other years in the record, likely due to construction of the Ken and Blaire Mossman Building by the University of Tennessee along Cumberland Avenue between 11th and 13th Streets during this time period. It is known that the radar counters did not count slow moving vehicles due to congestion. The radar data appears to show that slow moving or stopped vehicles were not counted when comparing 2017 turning movement counts to the 2018 AADT data. Consequently, manual counts were performed during the peak hours to confirm measured counts. Estimated percentage increases were given to non-peak hours throughout the day to account for any non-counted vehicles.

Figure 3. Traffic Counts on Cumberland Avenue between 11th Street and 13th Street, Location 3.

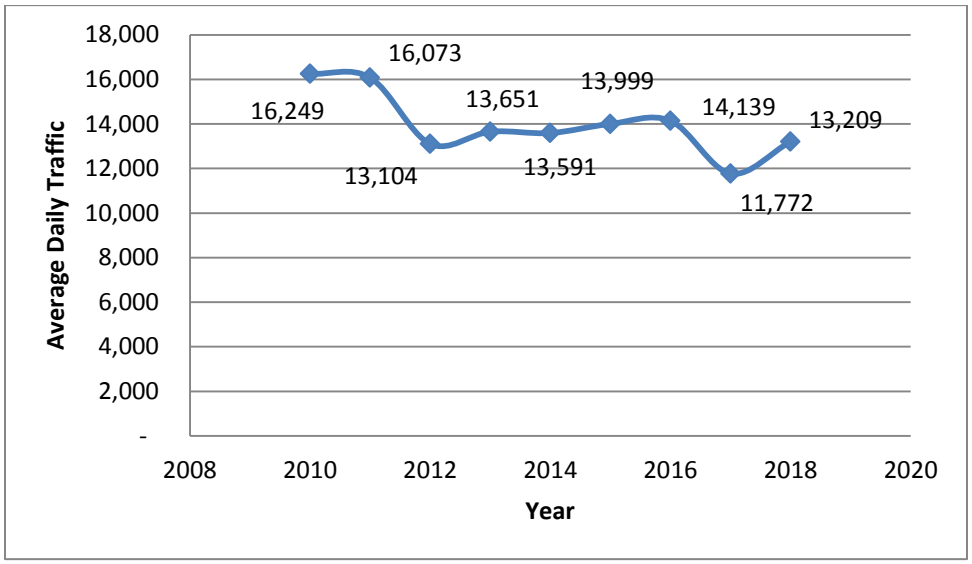

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Table 5. Traffic Counts on Cumberland Avenue between 11th Street and 13th Street, Location 3.

Year	Average Daily Traffic
2010*	16,249
2011*	16,073
2012*	13,104
2013*	13,651
2014*	13,591
2015*	13,999
2016*	14,139
2017*	11,772
2018†	13,209

*TDOT count
†City of Knoxville count

The design speed for the signal optimization timing for the three-lane section and four-lane sections were 25 MPH and 35 MPH, respectively. The 85th percentile speed in the three-lane section was 26 MPH, and the four-lane section was 35 MPH, verifying compliance with the original design speed assumptions.

Travel Times and Delay

The purpose of a travel time study is to compare before and after travel times to reveal any improvements to cycle lengths and signal timing/coordination. Cumulative travel time and delay through the corridor was modeled for each direction along Cumberland Avenue. Traffic Engineering's model results were compared to the results reported in the Gresham Smith and Partners report, "Cumberland Avenue Streetscape Traffic Study Technical Memorandum #1" completed in April 2009. This report details the expected traffic conditions of Cumberland Avenue following the completion of the Cumberland Avenue Streetscape Project.

One of the final steps of the Streetscape Project was signal timing. Travel times post signal timing changes were observed on September 25 and 26, 2018. Throughout the report, the AM peak hours are 7:00 a.m. to 9:00 am, the midday peak hours are 11:00 a.m. and 1:00 p.m., and the PM peak hours are 4:00 p.m. to 6:00 p.m.

Simulation Travel Times and Delay

The 2009 Gresham Smith and Partners "Cumberland Avenue Streetscape Traffic Study Technical Memorandum #1" traffic model results and the 2018 City of Knoxville traffic model were compared for simulated travel times and delay to show if the anticipated results exist today. The Gresham Smith and Partner study shows expected traffic conditions of Cumberland Avenue following the completion of the Cumberland Avenue Streetscape Project. Table 6 and Table 7 below show comparisons of cumulative expected delay and level of service between the Gresham Smith model and the City of Knoxville model.

These analyses relating to delay and level of service (LOS) are measures outlined in the Highway Capacity Manual and using Synchro Traffic Software. LOS is a measurement in engineering detailing how well an intersection or roadway performs. Similar to a grading scale, LOS A indicates an intersection or roadway operating at free flow conditions which from a motorist's perspective is the optimum. LOS F is the worst and indicates congested conditions showing saturation of the intersection. Cycle length is the

amount of time (seconds) required to serve all movements at an intersection based off of vehicle demand at each approach. The difference between the Gresham Smith 120 second cycle and the 130 or 140 second is that COK's cycle length provides more Cumberland Avenue green time to maximize main street vehicle progression. The 130 or 140 second cycle was used in the analysis because that is what is currently implemented. Table 6 details the midday peak cumulative delay, and Table 7 details the PM peak cumulative delay.

Table 6: Mid-day Peak Comparison of Traffic Performance

	Gresham Smith Model Results (120 sec cycle)			City of Knoxville Model Results (130 sec cycle)		
Intersection	Cumberland Avenue Seconds of Delay		Intersection LOS	Cumberland Avenue Seconds of Delay		Intersection LOS
	Eastbound	Westbound		Eastbound	Westbound	
W. Volunteer Blvd	5.6	4.8	B	2.5	5.6	B
22nd St.	12.6	13.0	B	6.4	15.7	B
19th St.	8.4	7.6	B	6.8	5.6	A
18th St.	6.0	15.4	C	7.8	6.6	B
17th St.	13.2	14.9	C	8.7	13.9	C
16th St./Volunteer Blvd	19.6	22.8	C	13.3	7.7	B
15th St./James Agee	3.7	12.8	A	12.6	12.0	B
TOTAL	**69.1**	**91.3**		**58.1**	**67.1**	

Table 7: PM Peak Comparison of Traffic Performance

	Gresham Smith Revised Results (120 sec cycle)			City of Knoxville Model Results (140 sec cycle)		
Intersection	Cumberland Avenue Seconds of Delay		Intersection LOS	Cumberland Avenue Seconds of Delay		Intersection LOS
	Eastbound	Westbound		Eastbound	Westbound	
W. Volunteer Blvd	7.4	10.8	B	27.1	7.2	C
22nd St.	10.7	14.7	C	25.0	37.5	C
19th St.	8.7	9.5	B	3.7	5.5	B
18th St.	7.5	13.3	C	5.9	4.2	B
17th St.	56.1	61.4	E	29.4	23.8	D
16th St./Volunteer Blvd	22.2	25.7	C	20.3	9.0	C
15th St./James Agee	4.2	5.9	A	10.0	11.4	B
TOTAL	**116.8**	**141.3**		**121.4**	**98.6**	

The Gresham Smith study did not include traffic projections relating to the University Commons development started in 2012, as it was prior to the conceptualization of the project. The increased eastbound delay at West Volunteer Boulevard and 22nd Street can be attributed to the signals being optimized for westbound traffic at this location and the additional traffic as a part of the development.

Synchro travel time simulations were completed using the City of Knoxville signal timing model. An average of these observed City of Knoxville simulations compared to Gresham Smith and Partners projected travel times can be seen in Table 8 below. The Synchro travel time simulations show comparable travel times between the two models for both the midday and PM peaks.

Table 8: Synchro Simulation Travel Time Comparison

		Midday Peak Travel Time (minutes : seconds)		PM Peak Travel Time (minutes : seconds)	
Model	**Cycle Length (seconds)**	**Eastbound**	**Westbound**	**Eastbound**	**Westbound**
Gresham Smith	120	3:19	3:47	4:05	4:41
City of Knoxville	130/140	3:10	3:42	3:55	4:09

Travel Time Study

Traffic Engineering conducted a travel time study for eastbound and westbound Cumberland Avenue from Alcoa Highway to 11th Street. Travel times were observed on April 3, 2018 prior to the signal timing project. Travel times post signal timing project were observed on September 25 and 26, 2018. A summary for each peak hour prior and post to the signal timing project can be seen in Table 9, Table 10, and Table 11.

Table 9: AM Peak Hour Travel Time Comparison

Pre Travel Times - AM Peak Hour April 3, 2018		
Direction	Time of Day	Travel Time
Eastbound	7:53 AM	5:37
	8:07 AM	4:53
	8:20 AM	4:35
Westbound	7:45 AM	5:16
	8:00 AM	4:32
	8:13 AM	4:19

Average Eastbound	5:01
Average Westbound	4:42

Post Travel Times - AM Peak Hour September 25, 2018		
Direction	Time of Day	Travel Time
Eastbound	8:03 AM	4:51
	8:17 AM	4:29
	8:29 AM	4:15
Westbound	7:57 AM	4:21
	8:11 AM	3:52
	8:23 AM	2:42

Average Eastbound	4:31
Average Westbound	3:38

Decrease Eastbound	9.9%
Decrease Westbound	22.7%

Table 10: Midday Peak Hour Travel Time Comparison

Pre Travel Times - Midday Peak Hour April 3, 2018		
Direction	Time of Day	Travel Time
Eastbound	11:48 AM	6:15
	12:08 PM	8:34
	12:30 PM	5:26
Westbound	11:40 AM	5:46
	11:57 AM	7:39
	12:20 PM	5:57

Average Eastbound	6:45
Average Westbound	6:27

Post Travel Times - Midday Peak Hour September 25, 2018		
Direction	Time of Day	Travel Time
Eastbound	11:42 AM	3:46
	12:00 PM	8:30
	12:21 PM	7:21
	12:45 PM	4:55
Westbound	11:35 AM	5:32
	11:51 AM	3:35
	12:10 PM	5:10
	12:31 PM	8:51

Average Eastbound	6:08
Average Westbound	5:47

Decrease Eastbound	9.1%
Decrease Westbound	10.4%

Table 11: PM Peak Hour Travel Time Comparison

Pre Travel Times - PM Peak Hour April 3, 2018		
Direction	Time of Day	Travel Time
Eastbound	4:39 PM	6:02
	5:00 PM	9:17
	5:25 PM	10:27
Westbound	4:31 PM	4:29
	4:48 PM	8:45
	5:14 PM	9:47

Average Eastbound	8:35
Average Westbound	7:40

Post Travel Times - PM Peak Hour September 26, 2018		
Direction	Time of Day	Travel Time
Eastbound	4:34 PM	5:23
	4:55 PM	9:33
	5:25 PM	8:53
Westbound	4:28 PM	3:20
	4:42 PM	8:24
	5:08 PM	8:51

Average Eastbound	7:56
Average Westbound	6:51

Decrease Eastbound	7.6%
Decrease Westbound	10.6%

Overall, the City of Knoxville signal optimization timing efforts have shown a decrease in travel times during the peak hours of the day. The travel times during the non-peak hours show minimal delay and proper 85th percentile speeds of 35 MPH in four lane sections, and 26 MPH in the two lane section. The speed study is in the Appendix.

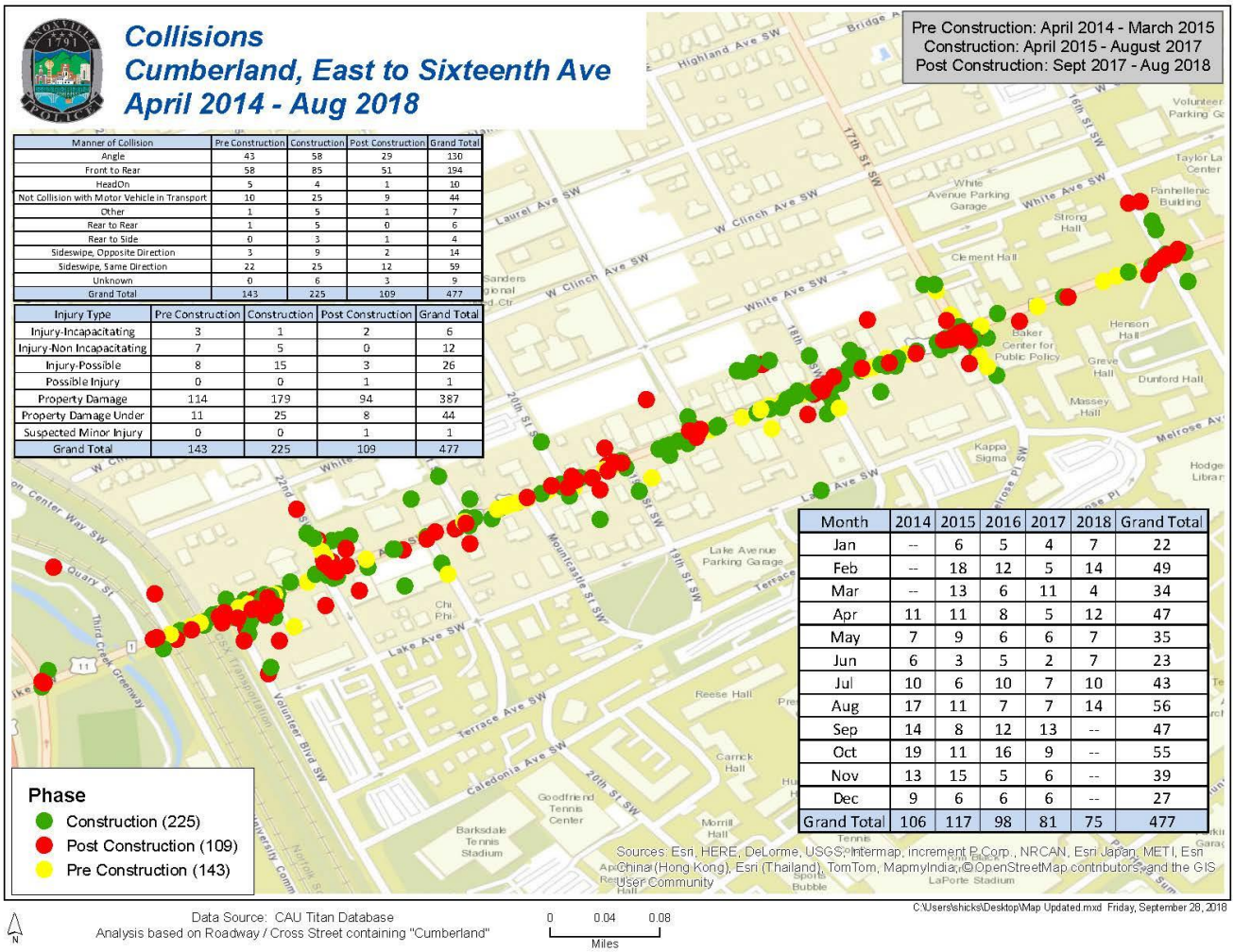
Observations during Travel Time Study

The weather conditions during travel times before signal optimization were cloudy during the AM peak hour and sunny for the midday and PM peak hours. Weather conditions for travel times after signal optimization were light rain for AM and PM peak hours, and heavy rain for the midday peak hour. Rain during observed travel times could have contributed to masking greater improvements by the signal timing project. Minimal congestion was observed during the AM peak hour. The heavy vehicular and pedestrian volumes during the mid-day peak hour creates congestion along the corridor. Around 12:00 p.m., University of Tennessee classes release, pedestrian and vehicular volumes increase. The PM peak hour signal timing plan is optimized for westbound traffic for the heavy vehicular volumes exiting the Fort Sanders area towards Alcoa Highway and the suburbs of west Knoxville.

Safety and Traffic Accidents

The Knoxville Police Department has collected traffic collision data along Cumberland between 17th Street and Alcoa Highway. Construction started in April 2015, an analysis of the 6 months prior and post project saw an almost 40% reduction in vehicle crashes. The map and data below show a full year's worth of data prior to the project from April 2014 through March 2015 there were 143 accidents in the project area. The project reached substantial completion in August 2017. The number of vehicle accidents for the 12 months after the project were 109. The reduction in crashes between 2014-15 and 2017-18 was 23 percent. These numbers fall in line with the U.S. Department of Transportation Federal Highway Administration which states road diet benefits include an overall crash reduction of 19-47 percent (see Appendix "October 18, 2017 FHWA Proven Safety Countermeasures).

Map 3: KPD Collisions - Cumberland Avenue, April 2014 to August 2018



Manner of Collision	Pre Construction	Construction	Post Construction	Grand Total
Angle	43	58	29	130
Front to Rear	58	85	51	194
HeadOn	5	4	1	10
Not Collision with Motor Vehicle in Transport	10	25	9	44
Other	1	5	1	7
Rear to Rear	1	5	0	6
Rear to Side	0	3	1	4
Sideswipe, Opposite Direction	3	9	2	14
Sideswipe, Same Direction	22	25	12	59
Unknown	0	6	3	9
Grand Total	143	225	109	477

Injury Type	Pre Construction	Construction	Post Construction	Grand Total
Injury-Incapacitating	3	1	2	6
Injury-Non Incapacitating	7	5	0	12
Injury-Possible	8	15	3	26
Possible Injury	0	0	1	1
Property Damage	114	179	94	387
Property Damage Under	11	25	8	44
Suspected Minor Injury	0	0	1	1
Grand Total	143	225	109	477

Month	2014	2015	2016	2017	2018	Grand Total
Jan	--	6	5	4	7	22
Feb	--	18	12	5	14	49
Mar	--	13	6	11	4	34
Apr	11	11	8	5	12	47
May	7	9	6	6	7	35
Jun	6	3	5	2	7	23
Jul	10	6	10	7	10	43
Aug	17	11	7	7	14	56
Sep	14	8	12	13	--	47
Oct	19	11	16	9	--	55
Nov	13	15	5	6	--	39
Dec	9	6	6	6	--	27
Grand Total	106	117	98	81	75	477

CITY OF KNOXVILLE

Intersection Observations

All intersections along the Cumberland Avenue corridor except University Commons Way/Metron Center Way feature side street signal times to match the pedestrian crossing clearance time. This feature allows the corridor to remain coordinated and not force the system to become uncoordinated when pedestrian phases are activated. The follow sections below will identify intersections along the corridor that require specific signal timing measures and detail these specific issues faced during the signal timing project.

Cumberland Avenue & University Commons Way/Metron Center Way

The intersection of Cumberland Avenue and University Commons Way/Metron Center Way is approximately 200 feet west from the signalized intersection of Cumberland Avenue and Volunteer Boulevard. The heavy left turn volumes off of Volunteer Boulevard require this intersection to be optimized to flush these left turns and westbound Cumberland Avenue traffic during the allocated westbound green time. This measure lowers the efficiency of eastbound movement and will increase delay.

Cumberland Avenue & 17th Street/Melrose Place

The intersection of Cumberland Avenue and 17th Street/Melrose Place is the center piece of the corridor for both pedestrians and vehicles. The signal is split phased to reduce left turn vehicle and pedestrian conflicts. This decision resulted in decreased capacity for westbound and eastbound vehicular movements through the intersection by taking time away from main street green to increased side street green times. This intersection requires a larger cycle length to accommodate both side street pedestrian clearance times and to maximize main street green time. These accommodations reduce the eastbound and westbound capacity for the corridor.

Pedestrian and Bicyclist Counts

As discussed above, the LOS for intersections has been typically associated with motorist satisfaction; however, LOS shouldn't be just for motorist, but also pedestrians and bicyclists that use the corridor. The Cumberland Avenue Corridor Project emphasized the importance of improving pedestrian and bicyclist safety. The Transportation Planning Organization (TPO) conducted bi-annual bike and pedestrian counts at the intersection of Cumberland Avenue and 16th Street over the last 10 years and it shows a trend of increasing pedestrian use of this intersection from around 2,500 to around 4,500 over this period. A decreasing trend was observed for cyclists), although the trend fluctuates from about 150 to 200 bicyclist daily (source: http://www.ibikeknx.com/What-We-Do/Traffic-Counts). Some possible reasons for the reduction in bicyclist using this corridor are congestion of pedestrians, weather conditions on the day and time the counts were taken, and the ease of using different intersections to access campus or Fort Sanders' neighborhood. The Student Union, Strong Hall and East Volunteer Boulevard have been under construction at the intersection of 16th Street and Cumberland since 2014 and included lane closures and traffic changes, making navigation on a bike more difficult.

Table 12: Pedestrian and Bicyclist counts at Cumberland Avenue and 16th Street

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2017
Pedestrians	2,956	2,627	2,978	2,989	2,425	4,583	3,060	5,101	3,939	4,278	4,278
Bicyclists	238	165	182	194	120	212	222	147	175	134	134

Figure 4. Pedestrian Counts on Cumberland Avenue at 16th Street

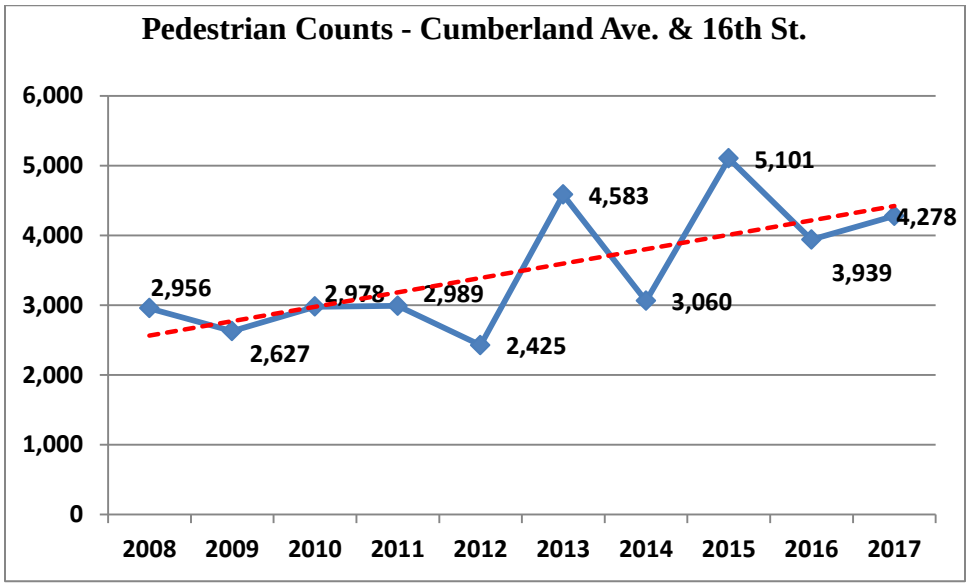
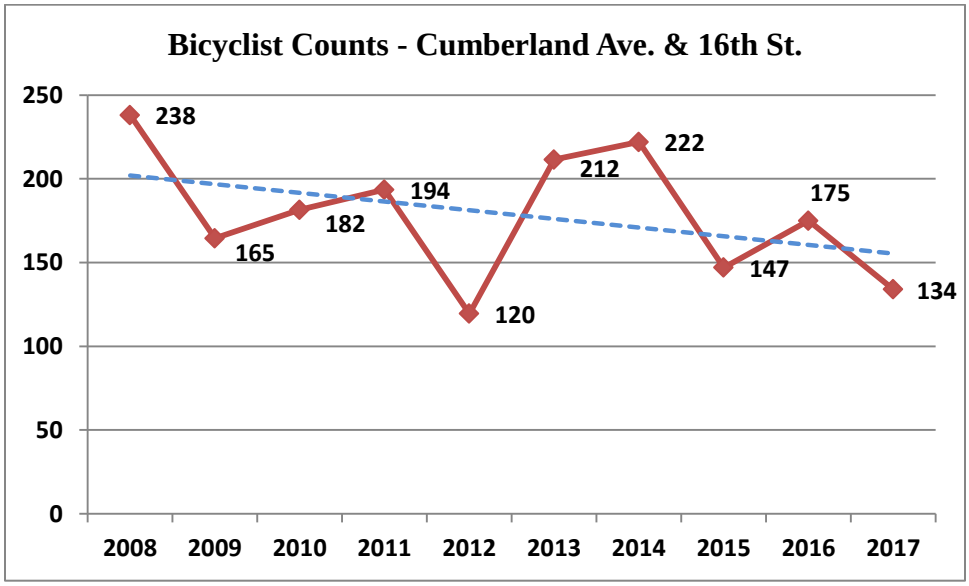


Figure 5. Bicycle Counts on Cumberland Avenue at 16th Street



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Factors Affecting Operation

The lane configuration changes from four lanes to three lanes with a median along Cumberland Avenue have resulted in lowered vehicle capacity while increasing safety for pedestrians and vehicles. Distracted driving and unexpected events, detailed below, can increase delay along the corridor. These behaviors were observed previously before the Cumberland Avenue Corridor Project. These observed events increased delay and reduce efficiency along the corridor and include:

- Pedestrians crossing street midblock or against pedestrian signal time
- Frequent bus stops effectively blocking lanes for vehicle progression
- Queued vehicles on Cumberland allowing exiting access point vehicles out and creating large gaps during green time
- Approximately 7% eastbound uphill grade west of 17th Street creating gaps between vehicles
- Passenger cars stopping for passenger loading/unloading
- Distracted driving causing late start ups at signals
- Large volume of pedestrians crossing Cumberland during class change time

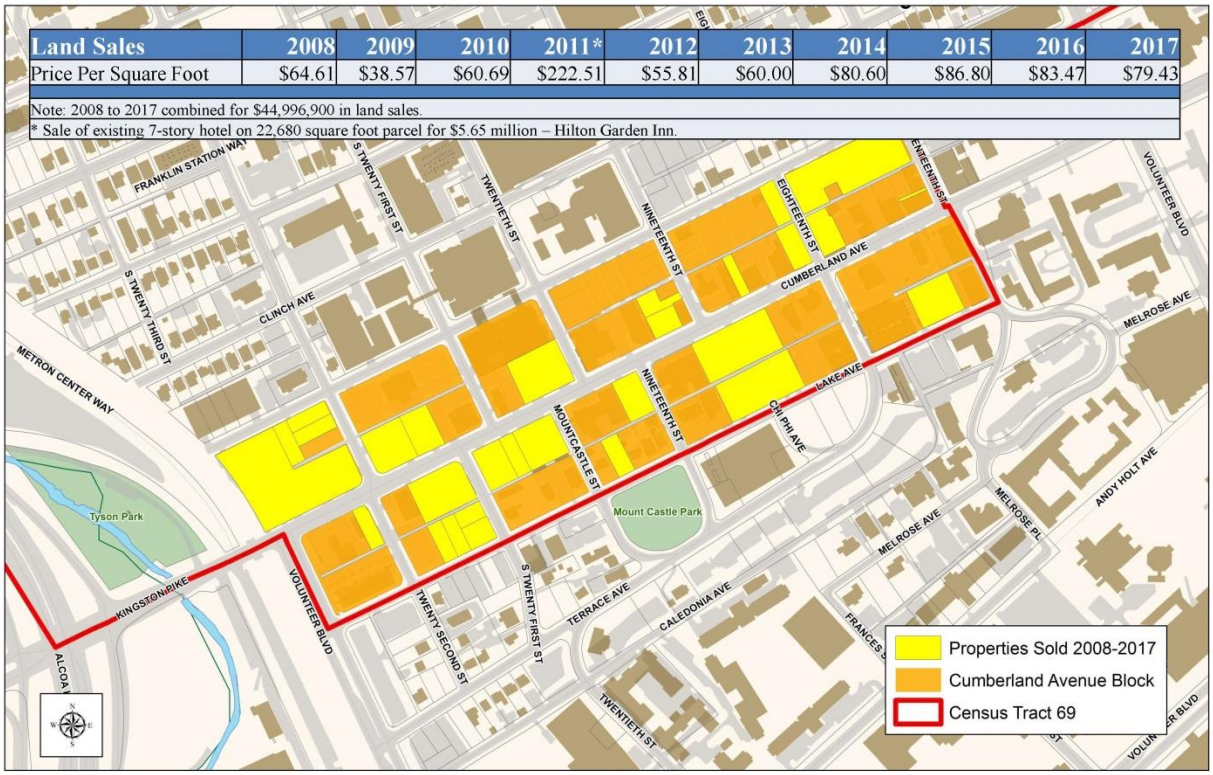
Economic Impact

To date the project has leveraged approximately $190M in private investment with the following projects: Hilton Garden Inn - $17 Million, Evolve Mixed Use Building - $20 Million, University Commons retail center - $65Million, The Standard student housing and parking - $39Million, The TENN student housing and retail center - $45Million. East Tennessee Children's Hospital also recently completed a $70 Million expansion in this district which is not included in the leveraged investment, as it was planned long range growth. Four metrics were selected to gauge the economic impact of the project in relation to the original goal.

Land Sales

The first was land sales and price per square foot. Since 2008, approximately half of the parcels in the Cumberland Avenue district from 17th Street to Volunteer Boulevard sold. It is important to note the vision plan was adopted in 2007 and set the stage for many of these transactions. The price per square foot of land sales fluctuated early on due to the Great Recession from a high of $64 in 2008, to a low of $38 in 2009. In 2011, an anomaly occurred comparatively with the sale of a eight story building on a 22,680 square foot parcel at a price of $222.51 per square foot. This was the former Days Inn and is now the Hilton Garden Inn. However, in 2014 the year before construction started land sales jumped to $80 a square foot and remained at or above this in subsequent years.

Figure 6. Land Sale Values, 2008-2017



Land Sales	2008	2009	2010	2011*	2012	2013	2014	2015	2016	2017
Price Per Square Foot	$64.61	$38.57	$60.69	$222.51	$55.81	$60.00	$80.60	$86.80	$83.47	$79.43

Note: 2008 to 2017 combined for $44,996,900 in land sales.
* Sale of existing 7-story hotel on 22,680 square foot parcel for $5.65 million – Hilton Garden Inn.

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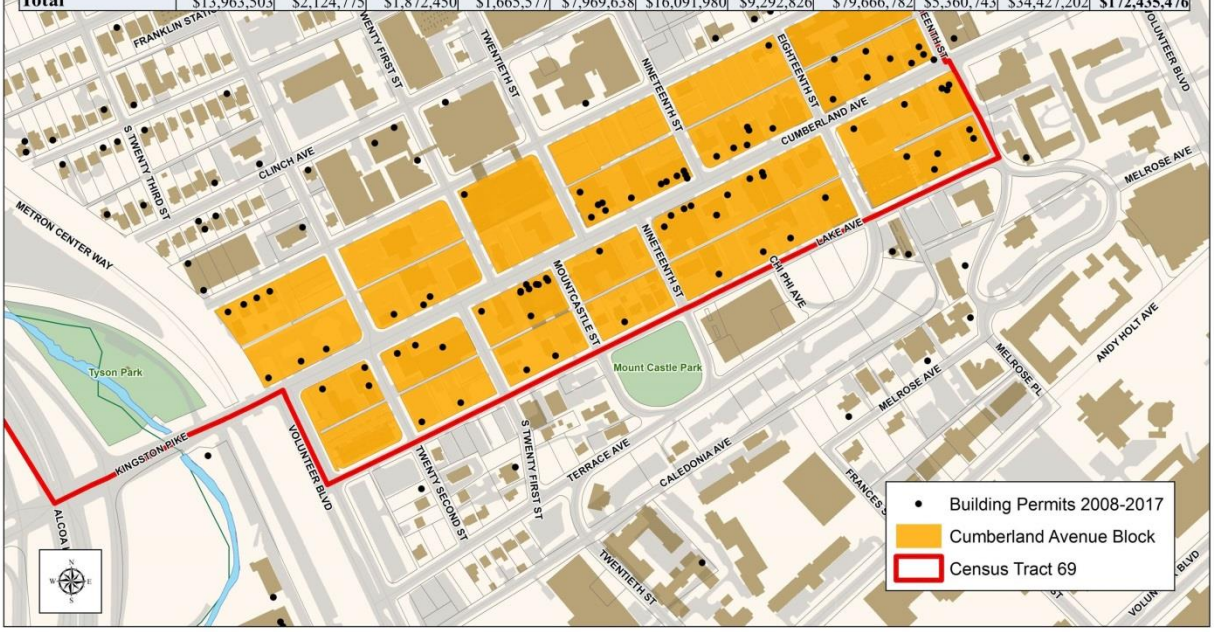
Building Permits

Another indicator of economic success is building permit activity. In the last ten years over $172 million in both new construction and renovations has been added to Cumberland Avenue district with 66 percent of the total coming in the last three years. Some of the highlights are in 2015 the Neonatal Intensive Care Unit at Children's Hospital ($46 million) and The Standard Apartment Complex ($29 million) and in 2017 the TENN Apartment Complex ($28 million).

Figure 7. Building Permit Value, 2008 - 2017

Building Permits	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
New	$10,566,500	$0	$0	$400,000	$160,000	$12,900,000	$8,000,000	$76,571,020	$0	$28,390,000	**$136,987,520**
Renovation	$3,397,003	$2,124,775	$1,872,450	$1,265,577	$7,809,638	$3,191,980	$1,292,826	$3,095,762	$5,360,743	$6,037,202	**$35,447,956**
Total	$13,963,503	$2,124,775	$1,872,450	$1,665,577	$7,969,638	$16,091,980	$9,292,826	$79,666,782	$5,360,743	$34,427,202	**$172,435,476**



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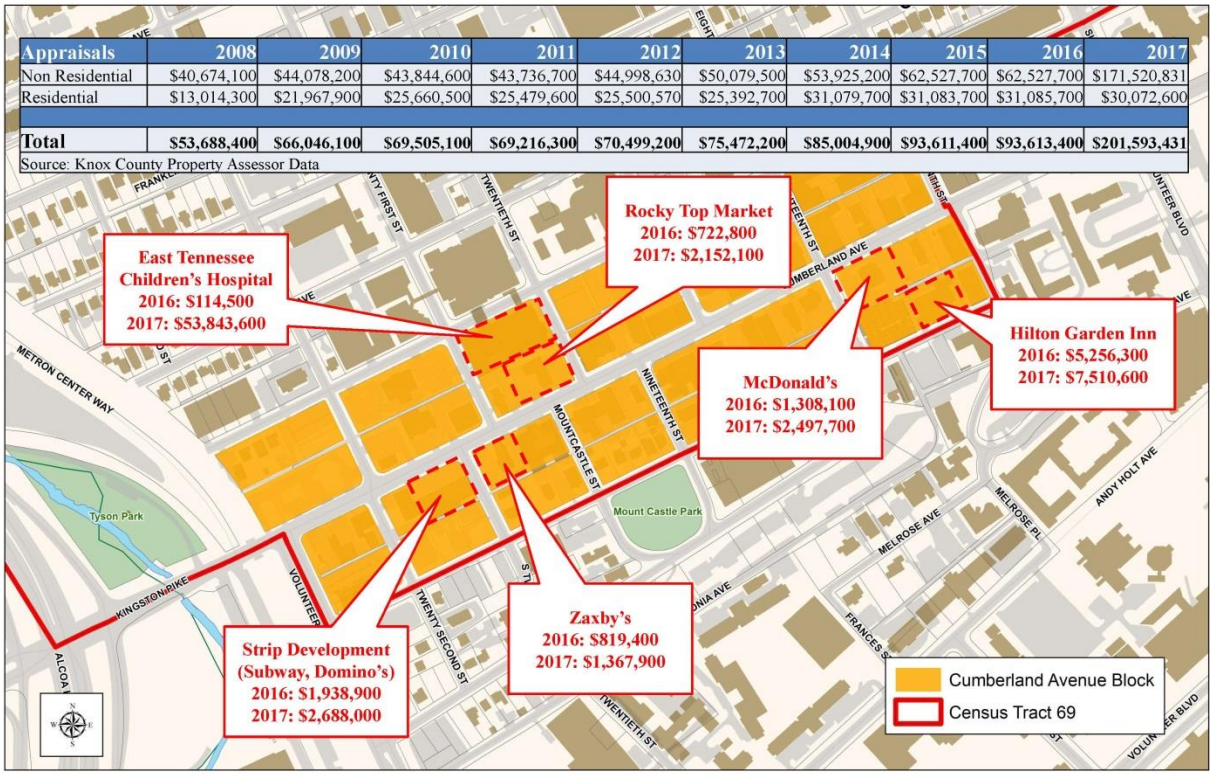
Appraisals

Appraised property values showed significant increases as well. Reappraisals occurred in the years 2009, 2013, and 2017. The 2017 appraisal totaled over $201 million, an increase of 115% over the previous year. Again the addition at East Tennessee Children's Hospital played a large part in the market growth, but existing properties showed across the board increases as well.

Figure 8. Appraised Property Values, 2008 - 2017



Appraisals	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Non Residential	$40,674,100	$44,078,200	$43,844,600	$43,736,700	$44,998,630	$50,079,500	$53,925,200	$62,527,700	$62,527,700	$171,520,831
Residential	$13,014,300	$21,967,900	$25,660,500	$25,479,600	$25,500,570	$25,392,700	$31,079,700	$31,083,700	$31,085,700	$30,072,600
Total	**$53,688,400**	**$66,046,100**	**$69,505,100**	**$69,216,300**	**$70,499,200**	**$75,472,200**	**$85,004,900**	**$93,611,400**	**$93,613,400**	**$201,593,431**

Source: Knox County Property Assessor Data

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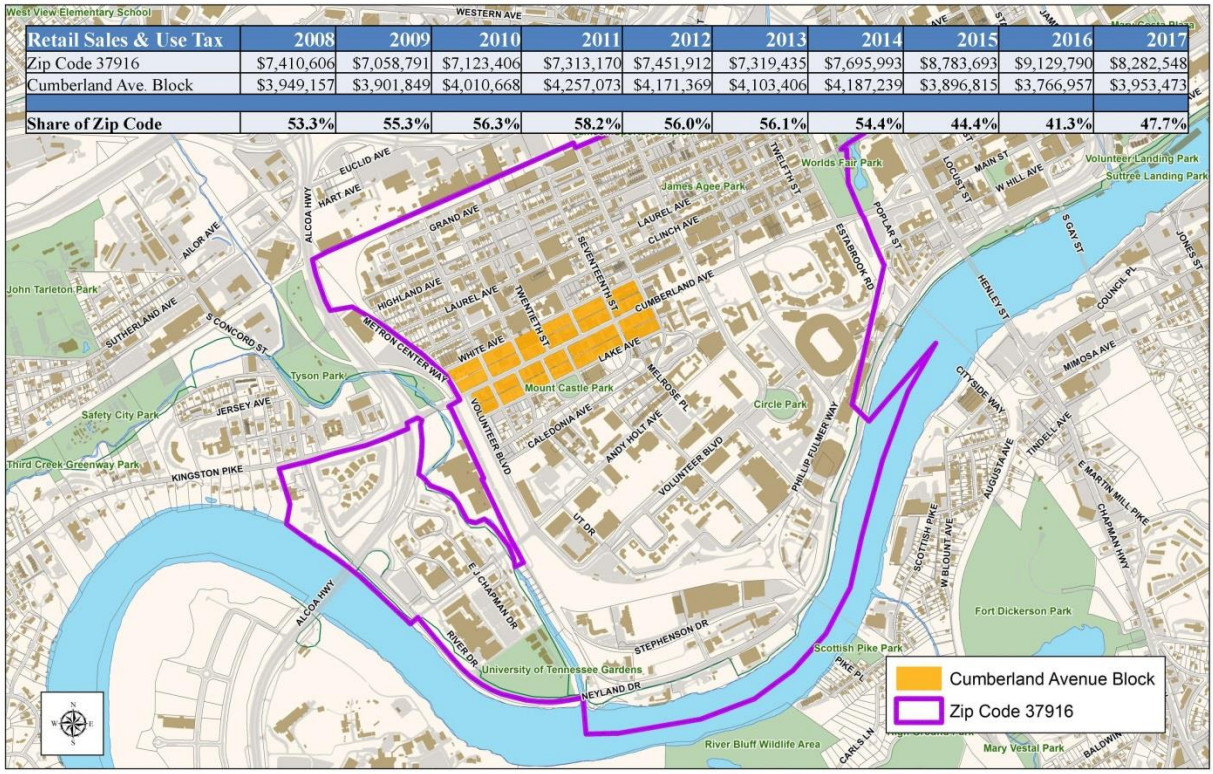
Retail Sales and Use Tax

From 2008 to 2014, the study area comprised over 50% of the total retail sales in the 37916 zip code. This share dropped to a low of 41% during construction, but since rebounded to a 48% share in 2017 with continued growth expected. It is also important to note the 37916 zip code does not include the University Commons development which would have a significant impact on retail sales tax given the size of the development and presence of large retailers (Walmart and Publix Grocery).

Figure 9. Retail Sales & Use Tax, 2008 - 2017

Retail Sales & Use Tax	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Zip Code 37916	$7,410,606	$7,058,791	$7,123,406	$7,313,170	$7,451,912	$7,319,435	$7,695,993	$8,783,693	$9,129,790	$8,282,548
Cumberland Ave. Block	$3,949,157	$3,901,849	$4,010,668	$4,257,073	$4,171,369	$4,103,406	$4,187,239	$3,896,815	$3,766,957	$3,953,473
Share of Zip Code	**53.3%**	**55.3%**	**56.3%**	**58.2%**	**56.0%**	**56.1%**	**54.4%**	**44.4%**	**41.3%**	**47.7%**



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Other Goal Factors

Attractiveness

The project installed more than 90 street trees, hundreds of shrubs and grasses, benches, trash and recycling cans and ADA accessible bus shelters. Also the inclusion of decorative LED lighting, not only makes the corridor safer for drivers and pedestrians, but also reduces the energy consumption of lighting this key corridor between the University and the historic Fort Sanders neighborhood.

Vibrancy

Not only has the project set the stage for improved safety, leveraged investment and an attractive environment, it has also become home to more than 1,400 new residents through the development of the Evolve Building, the Standard at White & 17th Street, and the TENN mixed use development at 1830 Cumberland Avenue. These developments have reduced pressure and demand for land/historic homes in the Fort Sanders area.

These students and residents are living in a cleaner and greener environment with storm water being captured and filtered by permeable pavers along the sidewalks. These pavers direct the water to the new street trees that have been planted with Silva Cell technology under the sidewalks giving the trees more access to soil, water and air and will also prevent sidewalk heaving long term. The new storm water lines are now large enough to capture the water from the significant grade off Fort Sanders to Cumberland Avenue with an almost four foot diameter storm water line. This line is connected to a storm water treatment device that filters both large floatables and suspended solids from the water before discharging into Third Creek and ultimately the Tennessee River. Additionally, the new trash and recycling cans along the corridor are collecting more than 4,000 pounds of waste each week.

Conclusion

Early metrics reveal that in the last three years from the start of construction to completion, the goal at the outset of the project is being achieved with the following:

- Decline in the number of annual pedestrian and bicycle crashes with vehicles
- Decline in the number of annual vehicle crashes
- Increase in the price per square foot of land sales
- Increase in the dollar value of development activity
- Increase in property appraisal values
- Increasing retail sales and use tax

A comparative look at pre- and post- project completion data on annual average daily traffic along the Cumberland Avenue corridor revealed a decrease in traffic volumes between Alcoa Highway and University Commons Way, and between 18th Street and 17th Street as anticipated. Cumulative delay and travel time simulation comparisons also showed the latest City of Knoxville data in 2018 is closely matching the delay and travel times anticipated pre-construction by Gresham Smith & Partners in 2009.

The Cumberland Avenue Streetscape Project has created a safe atmosphere for pedestrians, bicyclists, and motorists by decreasing speeds to an 85th percentile speed of 26 MPH in the project area. While the corridor does experience congestion during the mid-day and evening peak hours, the corridor has achieved an acceptable level of service. Drivers could continue to divert to alternative routes in the coming years to lower the AADT and overall delay. Ultimately, based on the factors presented in this report, the City is able to demonstrate measureable success in each of the stated project goals. Cumberland Avenue is more attractive, economically successful, vibrant and safer.

Appendix

Appendix A: 2018 City of Knoxville AADT

Appendix B: Cumberland and Metron Speed Study

Appendix C: Cumberland and 17th Speed Study

Appendix D: Cumberland and 13th Speed Study

Appendix E: Gresham Smith & Partners Technical Memo #1

Appendix F: KPD Traffic Crash Data Comparison – 12 months

Appendix G: KPD Traffic Crash Data Comparison – 6 months

Appendix H: FHWA Proven Safety Countermeasures – October 16, 2017

Appendix A

2018 City of Knoxville AADT

Cumberland Ave between Alcoa Hwy & University Commons			
Time of Day	**Eastbound**	**Westbound**	**Total**
12:00 AM	135	237	372
1:00 AM	83	155	238
2:00 AM	47	91	138
3:00 AM	42	66	108
4:00 AM	62	48	110
5:00 AM	238	95	332
6:00 AM	638	259	898
7:00 AM	1,110	481	1,591
8:00 AM	1,241	463	1,704
9:00 AM	835	702	1,537
10:00 AM	667	703	1,370
11:00 AM	782	904	1,686
12:00 PM	953	1,099	2,052
1:00 PM	700	1,085	1,785
2:00 PM	652	1,033	1,685
3:00 PM	644	1,236	1,880
4:00 PM	946	1,431	2,377
5:00 PM	883	1,466	2,349
6:00 PM	640	1,313	1,953
7:00 PM	541	926	1,468
8:00 PM	616	856	1,471
9:00 PM	572	679	1,251
10:00 PM	391	520	911
11:00 PM	219	361	580
	Eastbound	***Westbound***	***Combined***
Totals	13,636	16,209	29,845

Cumberland Ave between 17th and 18th			
Time of Day	**Eastbound**	**Westbound**	**Total**
12:00 AM	141	134	275
1:00 AM	88	87	175
2:00 AM	46	51	97
3:00 AM	30	35	65
4:00 AM	25	24	49
5:00 AM	69	41	110
6:00 AM	150	132	282
7:00 AM	358	252	610
8:00 AM	377	319	696
9:00 AM	333	261	594
10:00 AM	459	344	804
11:00 AM	409	495	904
12:00 PM	494	504	998
1:00 PM	483	464	947
2:00 PM	447	350	797
3:00 PM	506	373	879
4:00 PM	551	464	1,015
5:00 PM	543	521	1,064
6:00 PM	552	367	919
7:00 PM	422	298	720
8:00 PM	413	320	733
9:00 PM	373	294	667
10:00 PM	295	275	570
11:00 PM	203	190	393
	Eastbound	***Westbound***	***Combined***
Totals	7,767	6,595	14,362

Cumberland Ave between 17th and 18th			
Time of Day	**Eastbound**	**Westbound**	**Total**
12:00 AM	87	81	168
1:00 AM	74	53	127
2:00 AM	33	23	56
3:00 AM	22	23	45
4:00 AM	12	26	38
5:00 AM	23	71	94
6:00 AM	82	173	255
7:00 AM	210	473	683
8:00 AM	304	538	842
9:00 AM	242	408	650
10:00 AM	323	428	751
11:00 AM	389	414	803
12:00 PM	402	437	839
1:00 PM	385	436	821
2:00 PM	433	422	855
3:00 PM	407	381	788
4:00 PM	439	416	855
5:00 PM	491	481	972
6:00 PM	430	412	842
7:00 PM	383	380	763
8:00 PM	350	342	692
9:00 PM	309	262	571
10:00 PM	251	203	454
11:00 PM	118	127	245
	Eastbound	***Westbound***	***Combined***
Totals	6,199	7,010	13,209

EB Weekly Speeds
Cumberland at Metron EB from Mon-Sep-24-2018-10-00-AM to Mon-Oct-01-2018-10-59-AM

	2018-09-24	to	2018-09-30							
	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday	Week	Weekend	Week Day 85%
Hour	2018-09-24	2018-09-25	2018-09-26	2018-09-27	2018-09-28	2018-09-29	2018-09-30	Day Avg	Avg	Avg Speed
0 - 1	*	31.22	31.56	30.14	29.63	30.68	32.04	30.64	31.36	35.98
1 - 2	*	31.54	30.6	30.43	31.4	31.14	31.99	30.99	31.57	35.8
2 - 3	*	30.39	31.48	31.86	30.81	32.81	31.14	31.14	31.97	36.38
3 - 4	*	30.8	28.83	30.81	31.16	31.8	32.1	30.4	31.95	35.25
4 - 5	*	31.44	31.94	31.56	31.58	31.2	30.92	31.63	31.06	36.2
5 - 6	*	31.34	31.59	30.61	31.89	31.52	33.81	31.36	32.66	36.12
6 - 7	*	31.22	31.09	31.56	32.63	31.86	32.31	31.62	32.08	36.65
7 - 8	*	29.28	28.1	28.78	31.28	31.64	33.05	29.36	32.34	34.85
8 - 9	*	29.66	28.69	27.99	31.06	31.35	31.63	29.35	31.49	34.6
9 - 10	*	28.86	30.04	27.75	30.45	31.08	31.79	29.28	31.43	35.05
10 - 11	29.99	28.92	28.7	29.23	30.3	30.29	30.78	29.43	30.54	35.64
11 - 12	28.08	28.88	27.65	28.94	29.7	30.28	29.75	28.65	30.01	34.5
12 - 13	25.09	26.2	24.97	26.44	25.49	29.26	28.02	25.64	28.64	31.06
13 - 14	26.48	28.3	26.6	26.9	27.69	29.6	28.26	27.2	28.93	33.26
14 - 15	27.52	30	27.16	28.62	29.34	29.34	29.07	28.53	29.21	34.8
15 - 16	25.9	28.79	27.75	26.63	29.66	29.29	29.27	27.74	29.28	33.26
16 - 17	25.38	27.94	26.75	27.08	27.87	30.15	29.08	27	29.62	33.2
17 - 18	23.15	26.77	25.43	25.1	28.54	29.43	28.1	25.8	28.76	31.58
18 - 19	22.87	24.85	19.76	23.71	28.41	29.2	27.46	23.92	28.33	29.06
19 - 20	26.4	26.7	20.92	25.33	29.5	29.47	27.98	25.77	28.72	30.76
20 - 21	28.38	28.28	24.97	28.45	28.91	29.13	28.66	27.8	28.89	33.84
21 - 22	30.11	29.83	30.76	29.75	30.15	29.87	28.75	30.12	29.31	35.64
22 - 23	30.94	32.96	31.79	31.56	30.5	29.87	30.58	31.55	30.23	37.44
23 - 24	29.37	31.12	30.74	30.35	29.43	30.93	31.89	30.2	31.41	35.54

EB Weekly EightyFifthSpeeds
Cumberland at Metron EB from Mon-Sep-24-2018-10-00-AM to Mon-Oct-01-2018-10-59-AM

	2018-09-24	to	2018-09-30							
	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday	Week	Weekend	Week Day 85%
Hour	2018-09-24	2018-09-25	2018-09-26	2018-09-27	2018-09-28	2018-09-29	2018-09-30	Day Avg	Avg	Avg Speed
0 - 1	*	35.9	37.2	35.2	35.6	35.6	37.3	35.98	36.45	35.98
1 - 2	*	36.2	35.5	35.5	36	35.6	37.4	35.8	36.5	35.8
2 - 3	*	35.5	36	38	36	37.5	36.3	36.38	36.9	36.38
3 - 4	*	35	34	35	37	36.7	37	35.25	36.85	35.25
4 - 5	*	36	37	36	35.8	36.5	35	36.2	35.75	36.2
5 - 6	*	35.9	36.2	35.4	37	35.5	38	36.12	36.75	36.12
6 - 7	*	36.1	36.2	36.3	38	37	37.7	36.65	37.35	36.65
7 - 8	*	34.4	34.4	34.2	36.4	37.5	39.1	34.85	38.3	34.85
8 - 9	*	34.6	34.1	33.1	36.6	36	36.8	34.6	36.4	34.6
9 - 10	*	34.6	35.6	33.4	36.6	37	37.9	35.05	37.45	35.05
10 - 11	36.6	35	34.7	34.9	37	35.5	36	35.64	35.75	35.64
11 - 12	33.7	34.4	33.4	35	36	35.3	35.1	34.5	35.2	34.5
12 - 13	30.9	31.4	29.9	32.2	30.9	34.4	33.3	31.06	33.85	31.06
13 - 14	32.1	34.2	32.8	33.3	33.9	35	33.8	33.26	34.4	33.26
14 - 15	33.3	35.9	32.9	35.6	36.3	34.6	34.4	34.8	34.5	34.8
15 - 16	31.9	34.3	33	31.2	35.9	34.9	34.4	33.26	34.65	33.26
16 - 17	31.5	33.8	33.1	33.6	34	35.3	34.8	33.2	35.05	33.2
17 - 18	27.9	33.4	31.2	30.8	34.6	34.6	33.8	31.58	34.2	31.58
18 - 19	26.7	31.4	24.4	28.5	34.3	35	33.8	29.06	34.4	29.06
19 - 20	31.4	31.7	25.6	29.7	35.4	34.9	33.5	30.76	34.2	30.76
20 - 21	33.9	33.6	33.7	33.6	34.4	34.2	34.5	33.84	34.35	33.84
21 - 22	36	35.2	36.5	34.9	35.6	35.2	34.2	35.64	34.7	35.64
22 - 23	36.5	39.1	37.6	37.6	36.4	35.4	36.4	37.44	35.9	37.44
23 - 24	35.4	37.2	36.2	35	33.9	35.8	36.5	35.54	36.15	35.54

WB Weekly Speeds

Cumberland at Metron WB from Mon-Sep-24-2018-10-00-AM to Sun-Sep-30-2018-11-59-PM

	2018-09-24	to	2018-09-30							
	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday	Week	Weekend	Week Day 85%
Hour	2018-09-24	2018-09-25	2018-09-26	2018-09-27	2018-09-28	2018-09-29	2018-09-30	Day Avg	Avg	Avg Speed
0 - 1	*	29.48	30.91	29.49	29.78	30.75	30.05	29.91	30.4	34.2
1 - 2	*	29.89	30.19	29.97	30.26	30.42	30.52	30.08	30.47	34.47
2 - 3	*	30.3	29.73	31.29	31.06	31.2	30.36	30.59	30.78	34.9
3 - 4	*	28.98	28.21	30.76	31.39	30.91	31.07	29.83	30.99	34.62
4 - 5	*	30	29.31	31.22	32.54	30.67	31	30.77	30.84	36.28
5 - 6	*	30.85	31.35	30	32.23	31.23	31.55	31.11	31.39	35.42
6 - 7	*	29.55	30.47	29.88	30.29	31.69	30.98	30.05	31.34	34.55
7 - 8	*	29.35	29.43	29.07	30.03	30.67	31.47	29.47	31.07	33.78
8 - 9	*	28.93	29.3	29.21	30.52	30.74	31.13	29.49	30.93	33.75
9 - 10	*	29.53	28.93	28.78	29.28	30.35	31.18	29.13	30.76	33.35
10 - 11	28.85	28.32	27.9	29.11	29.3	30.01	30.63	28.7	30.32	32.78
11 - 12	28.19	28.63	27.13	28.81	28.68	29.66	30.15	28.29	29.91	32.2
12 - 13	27.67	28.08	26.33	28.13	27.56	29.49	29.96	27.55	29.72	31.28
13 - 14	27.35	28.81	26.92	28.39	28.47	29.19	30.13	27.99	29.66	31.76
14 - 15	27.17	28.57	27.08	28.23	28.72	29.39	29.98	27.96	29.68	31.8
15 - 16	27.44	28.68	27.85	27.83	28.76	29.58	30.44	28.11	30.01	32.18
16 - 17	27.13	28.54	27.93	28.74	28.42	29.9	30.06	28.15	29.98	32.16
17 - 18	27.87	28.02	28.03	27.81	28.75	29.39	30.15	28.1	29.77	32.2
18 - 19	27.45	28.2	28.23	28.47	28.55	29.88	29.68	28.18	29.78	31.96
19 - 20	28.03	28.43	27.61	26.69	28.74	29.39	29.84	27.9	29.62	31.4
20 - 21	28.13	27.83	28.42	28.1	28.5	29.22	29.49	28.2	29.36	31.82
21 - 22	29.33	29.17	29.65	29.4	29.17	29.16	30.56	29.34	29.86	33.14
22 - 23	30.2	30.55	29.78	30.12	28.85	30.05	31.32	29.9	30.69	33.98
23 - 24	29.39	30.18	30.11	29.81	29.6	30.16	30.74	29.82	30.45	34.14

WB Weekly EightyFifthSpeeds
Cumberland at Metron WB from Mon-Sep-24-2018-10-00-AM to Sun-Sep-30-2018-11-59-PM

	2018-09-24	to	2018-09-30							
	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday	Week	Weekend	Week Day 85%
Hour	2018-09-24	2018-09-25	2018-09-26	2018-09-27	2018-09-28	2018-09-29	2018-09-30	Day Avg	Avg	Avg Speed
0 - 1	*	33.7	35.2	33.7	34.2	35.3	34.1	34.2	34.7	34.2
1 - 2	*	34.6	34.5	34.1	34.7	34.8	34.4	34.47	34.6	34.47
2 - 3	*	35.6	33.3	35.8	34.9	36	34.4	34.9	35.2	34.9
3 - 4	*	33.5	32.5	36	36.5	35.5	35.1	34.62	35.3	34.62
4 - 5	*	36.5	35	37.3	36.3	35.7	37	36.28	36.35	36.28
5 - 6	*	34.5	36	34.2	37	36.5	36	35.42	36.25	35.42
6 - 7	*	34.8	34.5	33.7	35.2	37	35.7	34.55	36.35	34.55
7 - 8	*	33.4	34	33.2	34.5	34.9	36.3	33.78	35.6	33.78
8 - 9	*	33.5	33.6	33	34.9	35.7	36.5	33.75	36.1	33.75
9 - 10	*	33.8	33.1	32.7	33.8	35.2	35.6	33.35	35.4	33.35
10 - 11	33	32.2	31.9	33.3	33.5	34.9	35.2	32.78	35.05	32.78
11 - 12	32.2	32.5	30.9	32.9	32.5	34.3	34.5	32.2	34.4	32.2
12 - 13	31.4	31.9	29.6	31.9	31.6	34.5	34.4	31.28	34.45	31.28
13 - 14	31.1	32.9	30.9	31.9	32	33.5	35	31.76	34.25	31.76
14 - 15	30.6	32.6	31.3	32	32.5	34.3	34.5	31.8	34.4	31.8
15 - 16	31.4	32.8	31.9	32	32.8	34.3	34.8	32.18	34.55	32.18
16 - 17	31	32.7	31.7	32.8	32.6	34.3	34.7	32.16	34.5	32.16
17 - 18	31.9	32	32.1	32	33	34.1	34.6	32.2	34.35	32.2
18 - 19	31.3	31.9	32.1	32.1	32.4	34.6	34.1	31.96	34.35	31.96
19 - 20	31.1	32.2	31	30	32.7	34	33.6	31.4	33.8	31.4
20 - 21	31.8	31.4	32	31.8	32.1	33.9	33.6	31.82	33.75	31.82
21 - 22	32.5	32.9	33.7	33.2	33.4	33.4	34.6	33.14	34	33.14
22 - 23	34	35.1	34.1	33.9	32.8	34.4	35.9	33.98	35.15	33.98
23 - 24	33.6	34.8	34.3	34.2	33.8	34.9	34.8	34.14	34.85	34.14

Merged Weekly Speeds
Cumberland @ 17th EB and WB Merged from Mon-Sep-24-2018-09-00-AM to Sun-Sep-30-2018-11-59-PM

	2018-09-24	to	2018-09-30							
	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday	Week	Weekend	Week Day 85%
Hour	2018-09-24	2018-09-25	2018-09-26	2018-09-27	2018-09-28	2018-09-29	2018-09-30	Day Avg	Avg	Avg Speed
0 - 1	*	23.6	23.09	22.17	22.55	20.77	21.44	22.85	21.1	26.85
1 - 2	*	24.33	23.83	23.25	22.71	21.8	22.18	23.53	21.99	27.75
2 - 3	*	24.29	24.12	23.79	24.94	22.59	22.19	24.29	22.39	29.12
3 - 4	*	23.93	23.49	24.99	24.22	24.66	23.06	24.16	23.86	28.7
4 - 5	*	25.02	26.44	24.24	22.96	24.36	23.94	24.67	24.15	29.7
5 - 6	*	25.88	24.93	24.99	26.04	25.13	24.23	25.46	24.68	30.15
6 - 7	*	25.02	24.25	24.04	25.18	25.76	25.04	24.62	25.4	29.68
7 - 8	*	22.55	22.53	22.42	23.42	23.25	25.37	22.73	24.31	27.35
8 - 9	*	22.19	21.73	21.43	22.41	23	23.77	21.94	23.39	26.35
9 - 10	21.6	21.87	21.88	21.47	22.5	24.25	24.72	21.86	24.49	25.86
10 - 11	21.58	21.86	21.21	21.59	22.3	23.87	24.09	21.71	23.98	25.8
11 - 12	19.42	20.67	20.57	20.53	20.34	21.94	22.45	20.31	22.2	24.14
12 - 13	18.92	19.71	19.14	19.88	19.49	21.03	21.57	19.43	21.3	23.02
13 - 14	19.71	20.68	20.11	20.39	19.64	21.18	21.59	20.11	21.38	23.94
14 - 15	19.91	20.88	20.31	20.61	19.17	21.15	21.57	20.18	21.36	23.76
15 - 16	20.55	21.04	19.91	19.88	19.96	21.78	21.4	20.27	21.59	24.1
16 - 17	20.41	19.98	20.25	20.59	20.13	21.17	22.31	20.27	21.74	24
17 - 18	19.34	20.56	19.81	19.14	20.15	21.91	21.19	19.8	21.55	23.32
18 - 19	19.83	19.52	20.25	19.77	20.72	21.43	20.72	20.02	21.07	23.62
19 - 20	20.28	19.31	20.69	19.46	21.28	20.11	20.23	20.2	20.17	23.76
20 - 21	21.05	19.5	21.31	20.87	20.66	20.76	20.6	20.68	20.68	24.48
21 - 22	21.79	21	21.43	20.96	20.85	20.4	22.35	21.21	21.38	24.94
22 - 23	22.6	22.17	22.48	22.36	20.85	21	22.96	22.09	21.98	26.2
23 - 24	22.75	22.61	22.56	21.92	21.24	20.72	23.15	22.21	21.93	26

Appendix C

Merged Weekly EightyFifthSpeeds
Cumberland @ 17th EB and WB Merged from Mon-Sep-24-2018-09-00-AM to Sun-Sep-30-2018-11-59-PM

	2018-09-24	to	2018-09-30							
	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday	Week	Weekend	Week Day 85%
Hour	2018-09-24	2018-09-25	2018-09-26	2018-09-27	2018-09-28	2018-09-29	2018-09-30	Day Avg	Avg	Avg Speed
0 - 1	*	27.6	26.9	26.1	26.8	24.9	25.2	26.85	25.05	26.85
1 - 2	*	28.9	28	27.5	26.6	25.7	26.2	27.75	25.95	27.75
2 - 3	*	27.7	29.5	29.2	30.1	26.6	26.7	29.12	26.65	29.12
3 - 4	*	29	26.8	30.2	28.8	29.4	26.9	28.7	28.15	28.7
4 - 5	*	30.3	31.2	30	27.3	29	29	29.7	29	29.7
5 - 6	*	31	29.6	29	31	29.8	28.5	30.15	29.15	30.15
6 - 7	*	30	29.6	28.8	30.3	30.3	30.3	29.68	30.3	29.68
7 - 8	*	27	27.4	26.8	28.2	27.6	30.5	27.35	29.05	27.35
8 - 9	*	26.7	26.1	25.7	26.9	27.9	28.6	26.35	28.25	26.35
9 - 10	25	25.8	26.4	25.3	26.8	29.1	29.4	25.86	29.25	25.86
10 - 11	25.6	26.4	25.2	25.9	25.9	28.1	28.4	25.8	28.25	25.8
11 - 12	23.2	24.4	24.8	24.3	24	25.7	26.7	24.14	26.2	24.14
12 - 13	22.6	23.4	22.3	23.5	23.3	24.9	25.3	23.02	25.1	23.02
13 - 14	23.5	24.6	24	23.9	23.7	24.7	25.5	23.94	25.1	23.94
14 - 15	23.3	24.8	23.9	24.2	22.6	24.8	25.3	23.76	25.05	23.76
15 - 16	24.6	24.8	23.8	23.7	23.6	26.2	25.2	24.1	25.7	24.1
16 - 17	23.9	23.6	24.1	24.4	24	25	26.4	24	25.7	24
17 - 18	22.9	23.8	23.3	22.6	24	26.1	25.2	23.32	25.65	23.32
18 - 19	23.6	23.2	24	23	24.3	24.9	24.4	23.62	24.65	23.62
19 - 20	23.8	23	24.6	22.5	24.9	23.8	23.4	23.76	23.6	23.76
20 - 21	24.7	23.1	25.6	24.4	24.6	24.7	23.8	24.48	24.25	24.48
21 - 22	25.3	24.4	25.3	24.5	25.2	24.4	26.1	24.94	25.25	24.94
22 - 23	26.8	26.3	26.8	26.2	24.9	24.8	26.7	26.2	25.75	26.2
23 - 24	26.4	26.4	26.5	25.6	25.1	24.4	26.7	26	25.55	26

EB Weekly Speeds
13th St EB from Mon-Sep-24-2018-09-00-AM to Sun-Sep-30-2018-11-59-PM

	2018-09-24	to	2018-09-30							
	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday	Week	Weekend	Week Day 85%
Hour	2018-09-24	2018-09-25	2018-09-26	2018-09-27	2018-09-28	2018-09-29	2018-09-30	Day Avg	Avg	Avg Speed
0 - 1	*	27.49	30.67	27.07	30.02	29.16	28.27	28.81	28.71	34.52
1 - 2	*	27.13	26.35	27.48	28.46	29.75	29.75	27.36	29.75	32.55
2 - 3	*	28.35	29.85	28.52	27.05	29.37	28.55	28.44	28.96	33.4
3 - 4	*	26.36	28.1	28.96	28.38	29.31	28.02	27.95	28.66	33.25
4 - 5	*	27.62	28.5	30.4	26	34.06	28.34	28.13	31.2	32.38
5 - 6	*	26.41	26.14	28.57	28.58	30.19	27.35	27.42	28.77	33.05
6 - 7	*	32.14	32.39	32.34	33.75	30.33	29.03	32.66	29.68	36.72
7 - 8	*	30.74	30.57	30.7	31.7	28.37	29.73	30.93	29.05	35.58
8 - 9	*	30.33	31.02	30.53	30.81	28.01	26.88	30.67	27.45	35.45
9 - 10	28.5	30.06	29.79	29.6	30.42	31.67	31.57	29.67	31.62	34.5
10 - 11	29.85	29.66	28.54	30.47	29.67	32.02	31.7	29.64	31.86	34.3
11 - 12	29.11	30.12	29.49	30.35	30.31	31.86	32.65	29.87	32.25	34.6
12 - 13	29.73	29.65	28.53	29.24	30.31	31.07	32.44	29.49	31.75	34.04
13 - 14	28.5	29.99	28.89	29.96	30.88	31.18	32.91	29.64	32.04	34.46
14 - 15	29.22	30.88	29.78	30.11	30.38	31	32.02	30.07	31.51	34.78
15 - 16	28.3	28.5	28.79	28.7	29.81	31.5	32.26	28.82	31.88	34.52
16 - 17	28.71	29.29	28.83	29.03	30.07	30.86	31.81	29.18	31.33	34.68
17 - 18	28.31	29.95	29.11	28.85	30.86	32.88	31.88	29.42	32.38	34.8
18 - 19	30.92	30.97	31.63	30.63	32.13	31.83	31.48	31.26	31.66	35.56
19 - 20	30.85	30.66	31.9	29.95	32.4	32.09	32.34	31.15	32.21	35.46
20 - 21	31.15	31.47	32.04	31.27	32.18	31.52	32.03	31.62	31.78	36
21 - 22	32.68	32.72	32.12	31.13	32.37	31.46	32.52	32.2	31.99	36.74
22 - 23	32.81	33.6	33.18	33.08	33.28	32.21	32.74	33.19	32.48	37.74
23 - 24	27.62	27.98	27.59	28.74	28.91	28.22	28.87	28.17	28.55	32.46

Appendix D

EB Weekly EightyFifthSpeeds
13th St EB from Mon-Sep-24-2018-09-00-AM to Sun-Sep-30-2018-11-59-PM

	2018-09-24	to	2018-09-30							
	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday	Week	Weekend	Week Day 85%
Hour	2018-09-24	2018-09-25	2018-09-26	2018-09-27	2018-09-28	2018-09-29	2018-09-30	Day Avg	Avg	Avg Speed
0 - 1	*	32	38	32.1	36	34.2	33.5	34.52	33.85	34.52
1 - 2	*	31.8	30.7	33	34.7	34.7	34.8	32.55	34.75	32.55
2 - 3	*	33	33	34.3	33.3	35	35	33.4	35	33.4
3 - 4	*	32	32	33	36	32.8	31.3	33.25	32.05	33.25
4 - 5	*	31.5	32	34	32	44	34.2	32.38	39.1	32.38
5 - 6	*	32	29.5	32.7	38	36	33	33.05	34.5	33.05
6 - 7	*	36.8	37	36	37.1	34.8	33	36.72	33.9	36.72
7 - 8	*	35.5	35.5	35.4	35.9	33.3	34.8	35.58	34.05	35.58
8 - 9	*	35.2	35.7	35.1	35.8	31.8	31.7	35.45	31.75	35.45
9 - 10	32.3	35	35.1	34.2	35.9	37.4	37	34.5	37.2	34.5
10 - 11	34.6	34	33.2	35.6	34.1	38.1	36.8	34.3	37.45	34.3
11 - 12	33.9	34.8	33.6	35.4	35.3	36.9	37.6	34.6	37.25	34.6
12 - 13	34.2	34.7	32.7	33.6	35	36.6	38	34.04	37.3	34.04
13 - 14	33.5	34.8	33.5	34.5	36	36.4	37.3	34.46	36.85	34.46
14 - 15	34	35.5	34.5	35	34.9	36.7	37.2	34.78	36.95	34.78
15 - 16	33.6	34.4	34.5	34.3	35.8	36.9	37	34.52	36.95	34.52
16 - 17	34.3	35.2	34.7	33.9	35.3	36	36.8	34.68	36.4	34.68
17 - 18	33.7	35.4	34.5	34.3	36.1	38.5	37.4	34.8	37.95	34.8
18 - 19	35.2	35.3	35.9	34.8	36.6	37.1	36.5	35.56	36.8	35.56
19 - 20	34.9	35.1	36.2	34.4	36.7	36.8	36.8	35.46	36.8	35.46
20 - 21	35.4	35.6	36.5	35.5	37	35.9	37.8	36	36.85	36
21 - 22	36.9	37.8	36.7	35.5	36.8	36.3	38.1	36.74	37.2	36.74
22 - 23	37.1	37.8	38.1	37.6	38.1	37.9	38.6	37.74	38.25	37.74
23 - 24	31.4	33	31.4	32.8	33.7	32.7	34.7	32.46	33.7	32.46

WB Weekly Speeds
13th St WB from Mon-Sep-24-2018-09-00-AM to Mon-Oct-01-2018-10-59-AM

	2018-09-24	to	2018-09-30							
	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday	Week	Weekend	Week Day 85%
Hour	2018-09-24	2018-09-25	2018-09-26	2018-09-27	2018-09-28	2018-09-29	2018-09-30	Day Avg	Avg	Avg Speed
0 - 1	*	27.23	28.73	27.67	27.69	27.6	27.05	27.83	27.32	33.28
1 - 2	*	26.74	26.18	27.93	27.81	28.59	28.75	27.17	28.67	33.2
2 - 3	*	30.96	29.18	28.78	30.39	29.52	30.38	29.83	29.95	35.75
3 - 4	*	27.5	27.81	26.12	27.22	31.27	27.3	27.16	29.29	33.12
4 - 5	*	29.1	28.27	30.87	28.79	27.78	28.72	29.26	28.25	38
5 - 6	*	27.81	28.04	27	27.42	28.87	27.15	27.57	28.01	34.7
6 - 7	*	31.3	31.02	31.18	31.17	29.71	28.26	31.17	28.99	36.1
7 - 8	*	30.28	29.91	29.69	30.7	28.59	29.05	30.15	28.82	34.4
8 - 9	*	30.12	29.39	29.33	30.59	28	28.51	29.86	28.26	34.55
9 - 10	27.81	28.5	28.2	28.18	29.7	30.3	31.86	28.48	31.08	32.94
10 - 11	29.56	28.92	28.98	28.93	29.44	30.11	30.6	29.17	30.36	33.98
11 - 12	28.53	28.27	28.01	28.7	29.22	30.04	30.01	28.55	30.03	33.5
12 - 13	28.57	28.66	26.91	28.15	29.26	29.68	29.21	28.31	29.44	33.06
13 - 14	28.43	28.87	27.84	28.84	29.33	30.04	29.9	28.66	29.97	33.66
14 - 15	28.18	29.76	28.85	28.84	29.72	29.05	30.98	29.07	30.02	33.9
15 - 16	27.1	27.61	27.82	27.26	28.33	29.96	29.97	27.62	29.96	32.38
16 - 17	27.98	28.32	28.53	28.05	29.31	29.56	30.15	28.44	29.85	33.5
17 - 18	27.81	28.52	28.63	27.9	28.75	29.7	30.04	28.32	29.87	33.58
18 - 19	28.89	29.38	30.12	28.97	30.92	29.21	29.78	29.65	29.5	34.58
19 - 20	28.06	29.18	29.35	26.87	30.52	29.74	29.32	28.8	29.53	33.66
20 - 21	29.52	29.81	29.68	29.46	29.8	28.28	29.59	29.65	28.93	34.18
21 - 22	30.36	30.01	30.58	30.31	30.51	27.96	29.97	30.35	28.96	34.8
22 - 23	30.58	29.72	30.6	30.89	30.44	28.9	30.58	30.45	29.74	35.44
23 - 24	28.27	27.69	26.69	25.93	28.4	27.56	29.13	27.4	28.35	32.7

WB Weekly EightyFifthSpeeds
13th St WB from Mon-Sep-24-2018-09-00-AM to Mon-Oct-01-2018-10-59-AM

	2018-09-24	to	2018-09-30							
	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday	Week	Weekend	Week Day 85%
Hour	2018-09-24	2018-09-25	2018-09-26	2018-09-27	2018-09-28	2018-09-29	2018-09-30	Day Avg	Avg	Avg Speed
0 - 1	*	33.5	33.4	33.2	33	33	32	33.28	32.5	33.28
1 - 2	*	33.3	31.7	33.4	34.4	34.8	33.4	33.2	34.1	33.2
2 - 3	*	39	33	33	38	35.8	35.4	35.75	35.6	35.75
3 - 4	*	33	35	31	33.5	39	35.5	33.12	37.25	33.12
4 - 5	*	37	39	38	38	32	33	38	32.5	38
5 - 6	*	37	33.5	34	34.3	34.2	33	34.7	33.6	34.7
6 - 7	*	35.3	35.7	35.6	37.8	36.5	34.3	36.1	35.4	36.1
7 - 8	*	34.7	34.1	33.9	34.9	35.9	34.7	34.4	35.3	34.4
8 - 9	*	34.4	34.3	33.9	35.6	33.1	35.8	34.55	34.45	34.55
9 - 10	32.7	33.1	32.5	32.3	34.1	35.6	37.6	32.94	36.6	32.94
10 - 11	34.5	34	33.4	33.6	34.4	34.7	35.7	33.98	35.2	33.98
11 - 12	33.7	33.5	32.5	33.7	34.1	34.9	34.8	33.5	34.85	33.5
12 - 13	33	33.9	31.4	33.1	33.9	34.2	34.4	33.06	34.3	33.06
13 - 14	33.9	34.2	32.2	33.6	34.4	35.9	35.2	33.66	35.55	33.66
14 - 15	32.9	35.2	33.1	33.6	34.7	34.5	36.1	33.9	35.3	33.9
15 - 16	31.9	32.4	32.3	32	33.3	34.9	35	32.38	34.95	32.38
16 - 17	32.8	33.5	34.1	32.8	34.3	35.2	35	33.5	35.1	33.5
17 - 18	32.5	33.8	33.9	33.4	34.3	35	35.5	33.58	35.25	33.58
18 - 19	34.1	34	35.1	33.8	35.9	33.8	35.3	34.58	34.55	34.58
19 - 20	33.2	33.5	34.8	31.6	35.2	34.8	34.5	33.66	34.65	33.66
20 - 21	34.3	34.4	34.3	34	33.9	33.3	35.4	34.18	34.35	34.18
21 - 22	33.9	34.7	34.8	34.8	35.8	32.6	34.5	34.8	33.55	34.8
22 - 23	35.3	35.2	35.8	35.5	35.4	34.7	36	35.44	35.35	35.44
23 - 24	34	32	31.6	31.4	34.5	33	35.4	32.7	34.2	32.7

Appendix: E

Technical Memorandum #1

(REVISED DRAFT 3/18/09)

Traffic, Pedestrian, Bicycle and Transit Operations Study
for Cumberland Streetscape Project

Prepared by:

Gresham, Smith and Partners

March 3, 2009

G S & P

Purpose

The purpose of this Technical Memorandum is to document findings, conclusions and recommendations based on a review of the previous Cumberland Avenue traffic analysis (using the previously developed Synchro/SimTraffic model) performed by Glatting Jackson Kercher Anglin, Inc. and documented in a Memorandum to Jeff Welch from Walter Kulash and Ed McKinney dated April 13, 2007. The objective of the evaluation of the previously developed Synchro/SimTraffic model is to validate that the projected traffic conditions for the proposed three-lane conversion of Cumberland Avenue (overall delay, left turn queue storage deficiencies, etc.) are accurately identified, quantified and considered in the analysis.

Part 2 of the Glatting Jackson Memorandum documents additional analysis as a result of comments received from the City of Knoxville, the Knoxville-Knox County Metropolitan Planning Commission (MPC) and the Tennessee Department of Transportation (TDOT). As a result of these comments (specifically to include all unsignalized intersections between West Volunteer Boulevard and 13th Street as well as three driveways), the Synchro model was updated and referred to as Configuration #3. This Technical Memorandum documents the evaluation of Configuration #3 for both the Mid-day and PM peak hours.

Validation of Previous Synchro/SimTraffic Model

The Synchro models referred to as Configuration #3 (Noon) and Configuration #3 (PM) were reviewed to ensure that the model inputs accurately portray the three-lane conversion of Cumberland Avenue to a more pedestrian and bicycle-friendly corridor from 17th Street to West Volunteer Boulevard.

After reviewing the previous Synchro models, the following observations and recommended changes were identified:

Observation #1: Pedestrian volumes were not included in the model.

It is recommended that pedestrian volumes be included in the model. Pedestrian volumes were obtained from the City of Knoxville for several unsignalized intersections along Cumberland Avenue. The pedestrian volumes were estimated where no count data was available.

Observation #2: Bicycle volumes were not included in the model.

It is recommended that bicycle volumes be included in the model. In the absence of bicycle count data, bicycle volumes were estimated to be 20 conflicting bicycles per hour at each intersection. This number reflects an increase in level of bicycle activity along the corridor due to the addition of on-street bicycle lanes in the three-lane section.

Observation #3: Transit bus blockages were not included in the model.

It is recommended that transit bus blockages be included in the model. Information was obtained from Knoxville Area Transit (KAT) regarding the current transit routes that serve Cumberland Avenue and the number of buses for each route will travel along Cumberland Avenue within an hour. It was determined that five routes serve Cumberland Avenue (Routes 10, 11, 50C, and the Green and Orange Line trolleys). Based on anecdotal evidence, it was estimated that 2 bus blockages per hour will occur in each direction at the intersections along the corridor.

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<u>Observation #4</u>: The default value for saturation flow rate of 1900 passenger cars per hour per lane (pc/h/ln) was used in the model.

It is recommended that the default saturation flow rate be adjusted to 1700 pc/h/ln to account for the friction caused by the numerous driveways that exist along the corridor. A saturation flow rate of 1700 pc/h/ln is typical of a central business district (CBD), as noted in the Highway Capacity Manual (HCM).

<u>Observation #5</u>: A cycle length of 120 seconds was used in the model.

It appears that Synchro was used to optimize the cycle length, which resulted in a cycle length of 120 seconds. It is recommended that the cycle length be re-optimized with all of the recommended inputs. One goal should be a shorter cycle length which will create a more pedestrian-friendly environment (i.e., less pedestrian wait times at the signalized intersections and more frequent traffic gaps for unsignalized crossings).

<u>Observation #6</u>: Traffic signal Phases 2 and 6 (designation of main street for signal progression purposes) were not always used to serve Cumberland Avenue.

It is recommended that Phases 2 and 6 always serve Cumberland Avenue thru movements since they are the reference phases used for the signal coordination along the corridor.

<u>Observation #7</u>: Queue analysis for the thru and left-turn movements were not performed along Cumberland Avenue.

It is recommended that a queue analysis be evaluated for the signalized thru and left-turn movements along Cumberland Avenue. The extent of the thru and left turn queues may impact access to the two-way-left-turn-lane (TWLTL), unsignalized intersections and driveways.

Updating the Synchro models referred to as <u>GJ Configuration #3 (Mid-day Peak)</u> and <u>GJ Configuration #3 (PM Peak)</u> with the recommended changes listed above resulted in changes to traffic performance along the corridor. The seconds of delay and intersection and arterial levels of service (LOS) for each of the signalized intersections is compared for the Glatting Jackson and Gresham, Smith and Partners' revised Configuration #3 Synchro models in **Tables 1 and 2**. The Gresham, Smith and Partners Revised #1 model uses the same cycle length (120 seconds) that the Glatting Jackson model used. The Gresham, Smith and Partners Revised #2 model allowed Synchro to optimize the network signal cycle (for the subject segment), which resulted in a cycle length of 96 seconds for the Mid-day Peak and 86 seconds for the PM Peak. It should be noted that although the Revised #2 model results in greater delay in the PM Peak period than the Revised #1 model, the signal timings could be adjusted to provide less delay for Cumberland Avenue, which would however likely increase the delay for side street traffic. More detailed work will be needed to develop signal timings for this segment and the entire Cumberland Avenue corridor.

Table 3 provides a comparison of seconds of delay and travel time along Cumberland Avenue for both the Mid-day and PM Peak periods for the <u>GJ Existing 4-Lane</u>, <u>Configuration #3</u> and Gresham, Smith and Partners' revised Configuration #3 models.

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TABLE 1: PM PEAK COMPARISON OF TRAFFIC PERFORMANCE FOR CONFIGURATION #3

	Glatting Jackson Model Results (120 sec cycle)				Gresham Smith Revised #1 Model Results (120 sec cycle)				Gresham Smith Revised #2 Model Results (86 sec cycle)			
	Cumberland Avenue Seconds of Delay		Intersection LOS	Arterial LOS (EB / WB)	Cumberland Avenue Seconds of Delay		Intersection LOS	Arterial LOS (EB / WB)	Cumberland Avenue Seconds of Delay		Intersection LOS	Arterial LOS (EB / WB)
Intersection	EB	WB			EB	WB			EB	WB		
W. Volunteer Blvd.	6.2	8.3	B	E / D	7.4	10.8	B	E / D	14.0	6.3	B	F / D
22nd St.	2.9	6.7	B	C / B	10.7	14.7	C	D / C	14.4	13.8	B	E / C
19th St.	11.8	10.1	B	B / D	8.7	9.5	B	B / D	9.3	18.9	B	B / E
18th St.	4.4	10.4	B	C / D	7.5	13.3	C	C / D	7.1	19.1	B	D / E
17th St.	25.3	34.6	D	F / E	56.1	61.4	E	F / F	57.7	59.7	E	F / F
16th St./E. Volunteer	18.8	23.6	C	D / E	22.2	25.7	C	D / E	26.9	27.1	C	D / E
15th St. / James Agee	2.6	5.0	A	C / D	4.2	5.9	A	C / C	2.3	7.9	A	C / C
TOTAL	72.0	98.7			116.8	141.3			131.7	152.8		
				DIFFERENCE	**+44.8**	**+42.6**	**Created one "E" intersection**	**Created one "F" segment**	**+59.7**	**+54.1**	**Created one "E" intersection**	**Created two "F" segments**

TABLE 2: MID-DAY PEAK COMPARISON OF TRAFFIC PERFORMANCE FOR CONFIGURATION #3

	Glatting Jackson Model Results (120 sec cycle)				Gresham Smith Revised #1 Model Results (120 sec cycle)				Gresham Smith Revised #2 Model Results (96 sec cycle)			
	Cumberland Avenue Seconds of Delay		Intersection LOS	Arterial LOS (EB / WB)	Cumberland Avenue Seconds of Delay		Intersection LOS	Arterial LOS (EB / WB)	Cumberland Avenue Seconds of Delay		Intersection LOS	Arterial LOS (EB / WB)
Intersection	EB	WB			EB	WB			EB	WB		
W. Volunteer Blvd.	3.4	1.6	B	D / C	5.6	4.8	B	E / D	7.3	3.8	B	E / C
22nd St.	4.8	5.8	B	D / B	12.6	13.0	B	E / C	8.2	14.3	B	D / C
19th St.	12.7	9.3	B	C / D	8.4	7.6	B	B / D	8.9	7.5	B	B / D
18th St.	4.0	10.1	B	C / D	6.0	15.4	C	C / D	6.0	16.2	B	C / D
17th St.	8.1	13.4	C	D / C	13.2	14.9	C	D / D	13.3	16.5	C	D / D
16th St./E. Volunteer	14.9	16.0	C	D / D	19.6	22.8	C	D / D	17.2	13.5	C	D / D
15th St. / James Agee	2.7	5.3	A	C / D	3.7	12.8	A	C / D	3.1	13.5	A	C / D
TOTAL	50.6	61.5			69.1	91.3			64.0	85.3		
				DIFFERENCE	**+18.5**	**+29.8**		**Created two "E" segments**	**+13.4**	**+23.8**		**Created one "E" segment**

TABLE 3: SUMMARY OF TRAFFIC PERFORMANCE FOR EXISTING, PROPOSED AND REVISED SYNCHRO MODELS									
		Midday Peak Cumberland Avenue Seconds of Delay		Midday Peak Travel Time (seconds)		PM Peak Cumberland Avenue Seconds of Delay		PM Peak Travel Time (seconds)	
Model	**Cycle Length (Seconds)**	**EB**	**WB**	**EB**	**WB**	**EB**	**WB**	**EB**	**WB**
GJ Existing 4-Lane[1]	120	N/A	N/A	N/A	N/A	66.4	68.1	175.8	188.0
GJ Configuration #3[2]	120	50.6	61.5	180.4	202.0	72.0	98.7	206.9	244.7
GSP Revised #1[3]	120	69.1	91.3	198.8	226.6	116.8	141.3	245.1	281.4
GSP Revised #2[4]	96 (Midday) 86 (PM)	64.0	85.3	192.1	222.2	131.7	152.8	264.4	295.1

Notes:

1 The Glatting Jackson (GJ) Synchro model for the Existing 4-lane configuration only includes the signalized intersections.

2 The GJ Synchro model referred to as Configuration #3 (for the proposed 3-lane conversion) includes the unsignalized intersections from West Volunteer to 13th St. as well as 3 driveways (McDonald's in and out and Krystal's in).

3 The Gresham, Smith and Partners (GSP) Revised #1 model builds on the GJ Configuration #3 model by adding pedestrian and bicycle volumes, bus blockages per hour, reduces the saturation flow rate, ensures that Phases 2 and 6 always serve the Cumberland Avenue thru movement, but keeps the signal cycle length at 120 seconds.

4 The GSP Revised #2 model includes all of the changes listed in Note 3, but instead of setting the cycle length at 120 seconds, allows Synchro to optimize the cycle length.

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Queue Analysis

The Glatting Jackson traffic report analyzed left turn movements in the TWLTL and concluded that there is no reasonable chance of blockages happening since the average queue length for any given turning movement at the "worst case" unsignalized locations is no longer than 22 feet. For several reasons we are concerned that this analysis and conclusion in not an accurate representation of the likely TWLTL conditions that will exist along the corridor. One of those reasons is that the ability of traffic to use the TWLTL for unsignalized location turns will be impacted by the left turn and thru lane queues that exist at the signalized locations.

To better understand the impacts of the queue length conditions along the corridor and how they might affect TWLTL operations, an analysis was performed to evaluate the impact of the thru and left-turn queues at each of the signalized intersections between 17th Street and West Volunteer Boulevard using the GSP Revised #1 (PM) Synchro model that was updated with the aforementioned recommendations.

The results of the queue analysis indicate that the 50th percentile thru queues exceed the distance to the previous signalized intersection at 17th Street and 22nd Street in the eastbound direction, and at 17th Street in the westbound direction along Cumberland Avenue. The 50th percentile queues were analyzed because in many cases the 95th percentile queue will not be experienced due to upstream signal metering; therefore, the 50th percentile queue better represents the likely maximum queue experienced (as recommended by the Synchro developer).

It is anticipated that the extent of the thru queues in the PM peak (and to some degree the Midday peak) will greatly impact access to the TWLTL, unsignalized intersections and driveways. The results of the analysis are provided in **Table 4**.

Table 4: GSP Revised #1 - 50th Percentile Queue Lengths (ft) at Signalized Intersections

Intersection	EB Left	EB Thru	Distance to Previous Intersection	WB Left	WB Thru	Distance to Previous Intersection
Cumberland @ 22nd	20	500	300	8	287	320
Cumberland @ 19th	2	66	200*	N/A	207	250
Cumberland @ 18th	4	165	450	4	154	465
Cumberland @ 17th	N/A	~855	465	9	~895	670

Queue exceeds distance to previous signalized intersection

* to previous unsignalized intersection

~ = approach is above capacity and queue length could be much longer

It should be noted that this analysis does not account for the additional issues related to competing driveway demands and conflicts in the TWLTL, since Synchro (or any other commercially available software tool) cannot effectively model the impact of a TWLTL of numerous driveways and unsignalized intersections along a street. However, it is reasonable to conclude from the queue analysis that the thru queues along Cumberland Avenue in the PM and Midday peaks will hamper the ability of left-turners to turn across the thru movement at unsignalized intersections and driveways.

Findings

After updating the Glatting Jackson Synchro model with the recommended changes, the following conclusions have been drawn:

- Changing the saturation flow rate and adding pedestrian and bicycle hourly volumes as well as bus blockages per hour increases the vehicular delay along Cumberland Avenue but more accurately portrays the three-lane conversion of Cumberland Avenue to a more pedestrian and bicycle-friendly corridor.
- Using a shorter traffic signal cycle length may increase overall delay but provides for a more pedestrian friendly corridor.
- As a result of the degradation of the thru movement in both the Mid-day and PM peaks, it can be expected that a greater amount of traffic will divert from Cumberland Avenue than the 5-10% previously estimated.
- Since Synchro is not able to model conflicts in the TWLTL or the impact of numerous, closely spaced driveways, the traffic delay can be expected to be greater than what the Synchro model is predicting.

Conclusions

The primary purpose of this task was to assess the results of the Glatting Jackson Synchro model analysis regarding its projected traffic conditions along Cumberland Avenue with the 3-lane conversion. Based on our evaluation as described above, it is our opinion that the previous analysis has likely under-stated, to a fairly significant degree, the level of delay and congestion that would result from the cross section changes if the corridor served the level of traffic that exists on Cumberland Avenue today.

Continued analysis planned for Task 2 will provide additional insight into how corridor traffic flow conditions may also be impacted by left-turn conflicts in the TWLTL.

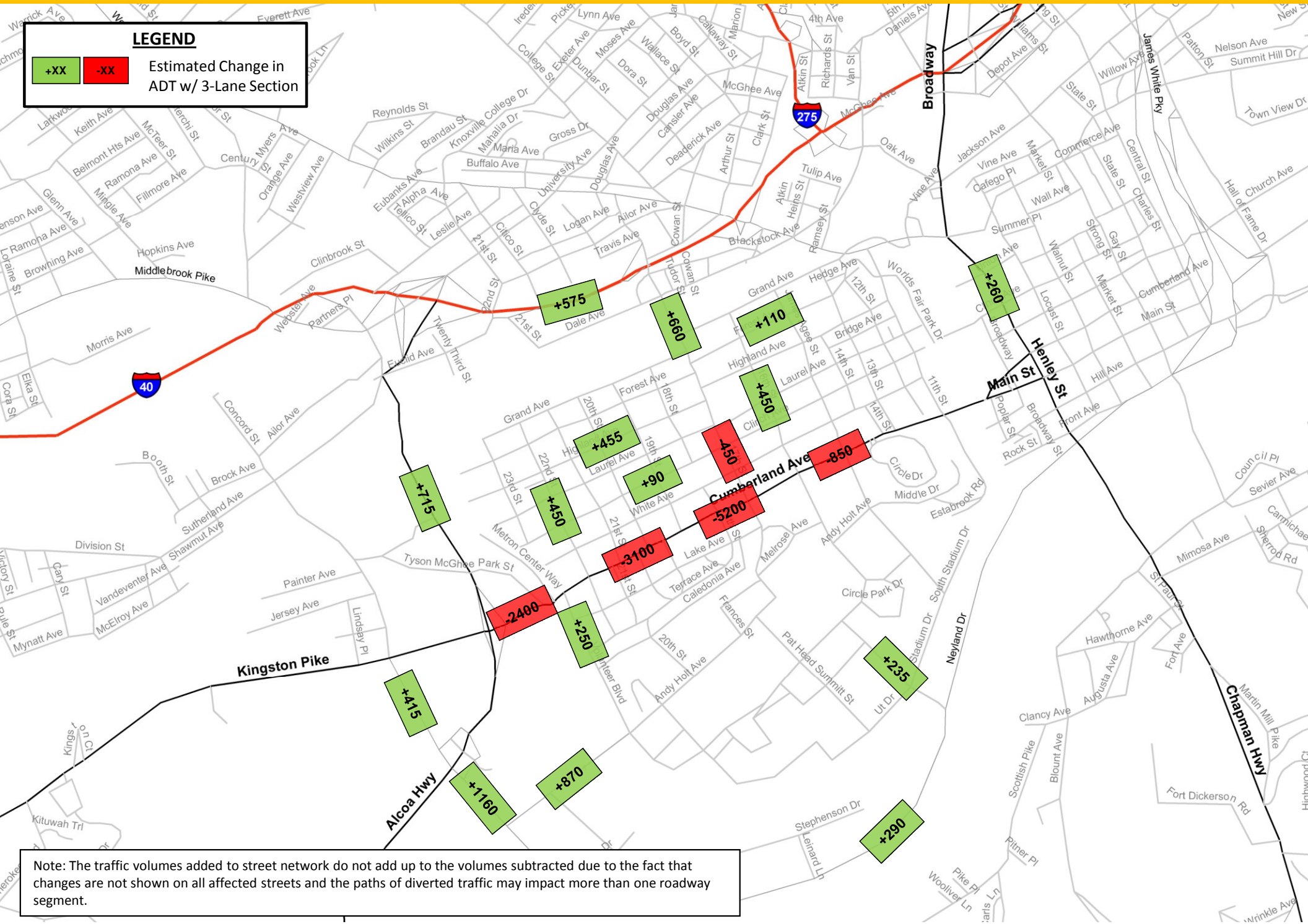
These conclusions do not necessarily imply that the corridor will reach the congestion levels shown in the Synchro model. This is because many drivers will likely divert to what they consider better alternative routes with more acceptable traffic conditions. Experience has shown that drivers will make, when possible, route changes to avoid street sections experiencing high levels of delay. The drivers most likely to make this change are those with no local destination or origin in the immediate area and use Cumberland Avenue as a through route. The end result will likely be that the typical weekday traffic along the corridor settles at a level that most users will accept. The further evaluation of diverted traffic and its impact on those diversion routes is the intent of Task 3 of this study.

Recommendation

It is recommended that this information be presented to the City in conjunction with the results of Task 2, so that all corridor traffic flow condition assessments are available for discussion at one time.

Figure 1: Cumberland Avenue Streetscape Project

Estimated Path and Volume of Diverted Traffic



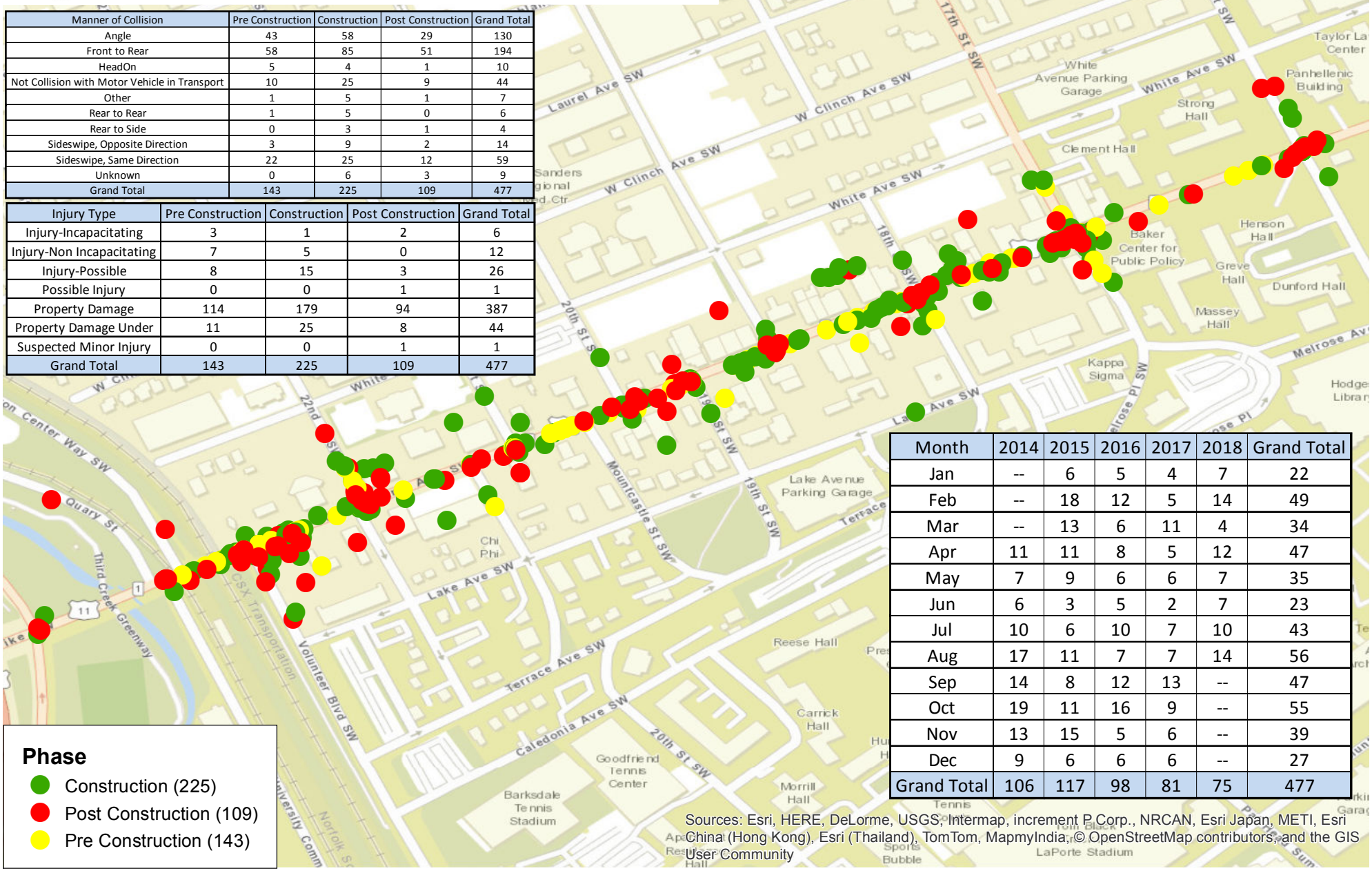
Note: The traffic volumes added to street network do not add up to the volumes subtracted due to the fact that changes are not shown on all affected streets and the paths of diverted traffic may impact more than one roadway segment.

Collisions
Cumberland, East to Sixteenth Ave
April 2014 - Aug 2018

Pre Construction: April 2014 - March 2015
Construction: April 2015 - August 2017
Post Construction: Sept 2017 - Aug 2018

Manner of Collision	Pre Construction	Construction	Post Construction	Grand Total
Angle	43	58	29	130
Front to Rear	58	85	51	194
HeadOn	5	4	1	10
Not Collision with Motor Vehicle in Transport	10	25	9	44
Other	1	5	1	7
Rear to Rear	1	5	0	6
Rear to Side	0	3	1	4
Sideswipe, Opposite Direction	3	9	2	14
Sideswipe, Same Direction	22	25	12	59
Unknown	0	6	3	9
Grand Total	143	225	109	477

Injury Type	Pre Construction	Construction	Post Construction	Grand Total
Injury-Incapacitating	3	1	2	6
Injury-Non Incapacitating	7	5	0	12
Injury-Possible	8	15	3	26
Possible Injury	0	0	1	1
Property Damage	114	179	94	387
Property Damage Under	11	25	8	44
Suspected Minor Injury	0	0	1	1
Grand Total	143	225	109	477



Month	2014	2015	2016	2017	2018	Grand Total
Jan	--	6	5	4	7	22
Feb	--	18	12	5	14	49
Mar	--	13	6	11	4	34
Apr	11	11	8	5	12	47
May	7	9	6	6	7	35
Jun	6	3	5	2	7	23
Jul	10	6	10	7	10	43
Aug	17	11	7	7	14	56
Sep	14	8	12	13	--	47
Oct	19	11	16	9	--	55
Nov	13	15	5	6	--	39
Dec	9	6	6	6	--	27
Grand Total	106	117	98	81	75	477

Phase
- Construction (225)
- Post Construction (109)
- Pre Construction (143)

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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Data Source: CAU Titan Database
Analysis based on Roadway / Cross Street containing "Cumberland"

N

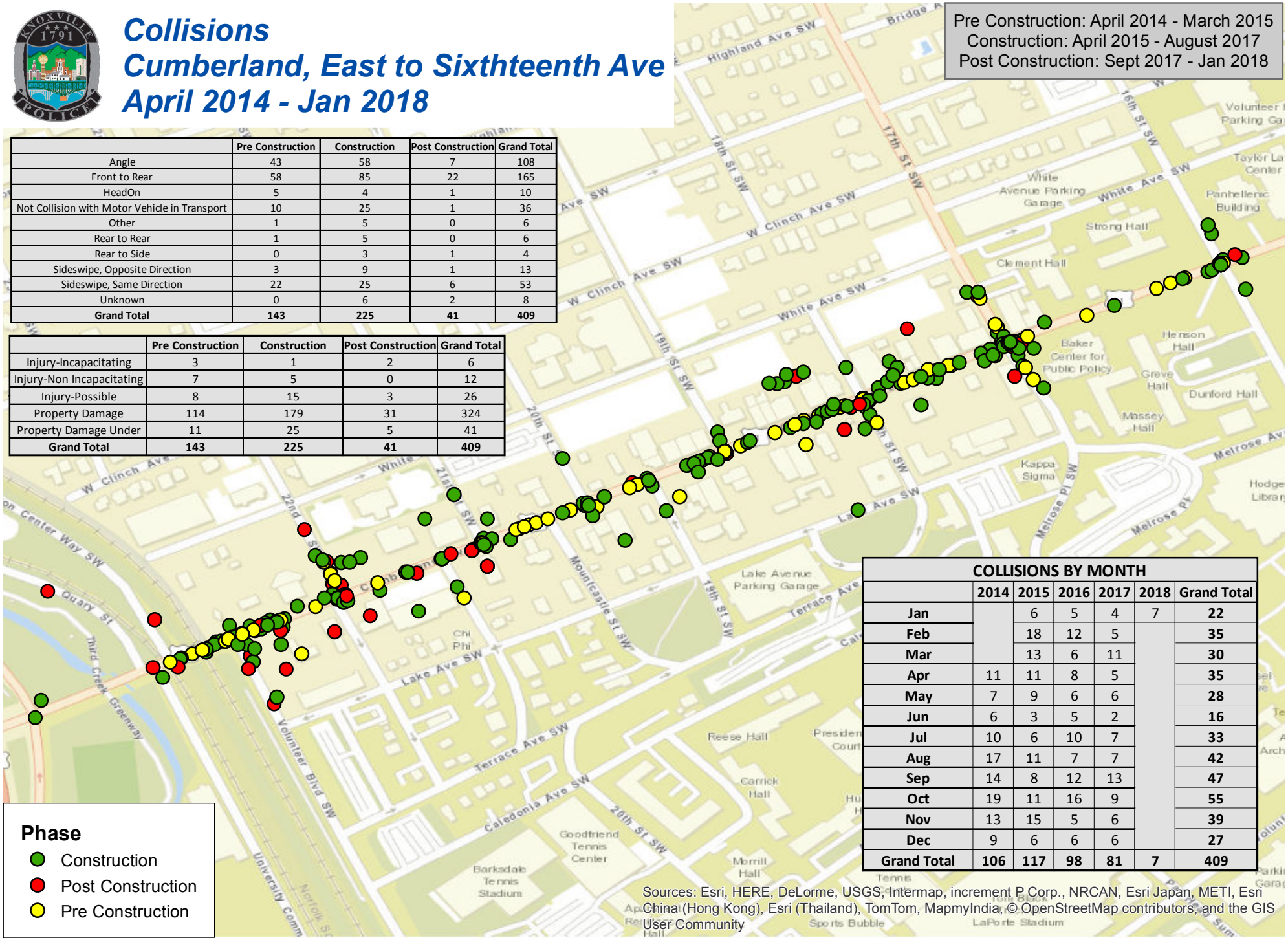
0 0.04 0.08
Miles

Collisions
Cumberland, East to Sixthteenth Ave
April 2014 - Jan 2018

Pre Construction: April 2014 - March 2015
Construction: April 2015 - August 2017
Post Construction: Sept 2017 - Jan 2018

	Pre Construction	Construction	Post Construction	Grand Total
Angle	43	58	7	108
Front to Rear	58	85	22	165
HeadOn	5	4	1	10
Not Collision with Motor Vehicle in Transport	10	25	1	36
Other	1	5	0	6
Rear to Rear	1	5	0	6
Rear to Side	0	3	1	4
Sideswipe, Opposite Direction	3	9	1	13
Sideswipe, Same Direction	22	25	6	53
Unknown	0	6	2	8
Grand Total	**143**	**225**	**41**	**409**

	Pre Construction	Construction	Post Construction	Grand Total
Injury-Incapacitating	3	1	2	6
Injury-Non Incapacitating	7	5	0	12
Injury-Possible	8	15	3	26
Property Damage	114	179	31	324
Property Damage Under	11	25	5	41
Grand Total	**143**	**225**	**41**	**409**



COLLISIONS BY MONTH						
	2014	2015	2016	2017	2018	Grand Total
Jan		6	5	4	7	22
Feb		18	12	5		35
Mar		13	6	11		30
Apr	11	11	8	5		35
May	7	9	6	6		28
Jun	6	3	5	2		16
Jul	10	6	10	7		33
Aug	17	11	7	7		42
Sep	14	8	12	13		47
Oct	19	11	16	9		55
Nov	13	15	5	6		39
Dec	9	6	6	6		27
Grand Total	**106**	**117**	**98**	**81**	**7**	**409**

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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N

Data Source: CAU Titan Database
Analysis based on Roadway / Cross Street containing "Cumberland"

0 0.04 0.08
Miles

U.S. Department of Transportation
Federal Highway Administration

PROVEN SAFETY COUNTERMEASURES

Road Diets

(Roadway Reconfiguration)

A "Road Diet," or roadway reconfiguration, can improve safety, calm traffic, provide better mobility and access for all road users, and enhance overall quality of life.

SAFETY BENEFIT:

4-LANE → 3-LANE ROAD DIET CONVERSIONS

19-47%

Reduction in total crashes

Before and after photos of a Road Diet project.

Source: City of Orlando, Florida

A Road Diet typically involves converting an existing four-lane undivided roadway to a three-lane roadway consisting of two through lanes and a center two-way left-turn lane (TWLTL).

Benefits of Road Diet installations may include:

- An overall crash reduction of 19 to 47 percent.
- Reduction of rear-end and left-turn crashes due to the dedicated left-turn lane.
- Reduced right-angle crashes as side street motorists cross three versus four travel lanes.
- Fewer lanes for pedestrians to cross.
- Opportunity to install pedestrian refuge islands, bicycle lanes, on-street parking, or transit stops.
- Traffic calming and more consistent speeds.
- A more community-focused, "Complete Streets" environment that better accommodates the needs of all road users.

A Road Diet can be a low-cost safety solution when planned in conjunction with a simple pavement overlay, and the reconfiguration can be accomplished at no additional cost.

Road Diet project in Honolulu, Hawaii.

Source: Leidos

Source: *Evaluation of Lane Reduction "Road Diet" Measures on Crashes,* FHWA-HRT-10-053.

→ For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures.

Safe Roads for a Safer Future
Investment in roadway safety saves lives

FHWA-SA-17-066

http://safety.fhwa.dot.gov