TRAFFIC IMPACT ANALYSIS

FOR

SIMPLY SOCIAL COFFEE SHOP

TOWN OF VIENNA, VIRGINIA

Prepared For

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Table of Contents

List of Exhibits

Appendices

1. INTRODUCTION

1.1 Purpose

This traffic impact analysis documents the traffic analysis and findings for the proposed Special Exception for a coffee shop with a drive-through facility at 260 Cedar Lane in the town of Vienna, Virginia. The facility will be located in the Cedar Park Shopping Center in southwest Vienna. The site plan is as shown in **Exhibit 1**. The proposed 1,890 square foot (SF) development will be situated in a property that previously housed a drive-through financial institution of approximately the same size. Access to the site is provided by two existing driveways along Cedar Ln, just south of the intersection of Cedar Lane and Amanda Pl. The general site plan of the proposed development is shown in **Exhibit 2**.

The study scope, methodologies, and parameters were established with the representatives of the development team and the town of Vienna. The traffic study scope is included in **Appendix A**. The site is expected to be operational in 2020.

1.2 Study Objectives/Methodologies

The report describes the area transportation system, existing traffic volumes and analysis, estimation of non-covid-19 traffic (post pandemic traffic) on Cedar Lane, trip generation by the existing shopping center and the proposed coffee shop, and on-site circulation, queuing patterns and traffic impacts on neighboring streets in terms of Level of Service (LOS), Vehicle Delay (seconds) and Queuing (number of vehicles in queue).

Turning movement counts were collected at the two driveways intersecting Cedar Lane during the weekday AM and PM peak periods, as agreed to in the scoping meeting. The data was analyzed to develop the weekday AM and PM peak hour levels of service using Synchro Model (Version 9.2). A scaling factor was developed and applied to the existing traffic on Cedar Lane to reflect real traffic (non-COVID-19) conditions. At the time of opening, traffic accessing the shopping center and the proposed coffee shop from Cedar Lane will be from the north driveway as the south driveway will be closed. The existing shopping center and the proposed coffee shop trips were estimated and distributed to the roadway based on the existing traffic distribution observed at the driveways. The total 2020 traffic conditions were estimated combining the site trips and scaled-up traffic on Cedar Ln.

1.3 Site Location and Study Area

The proposed coffee shop with drive-through will be located at 260 Cedar Lane in town of Vienna, Virginia. The property is currently occupied by BB&T bank of the same size that is no longer operational. Access to the site is provided by two existing driveways along Cedar Lane (Rte 698). The two driveways will be consolidated in to one driveway in the future site plan. Drive-through traffic is expected to follow the existing site circulation pattern, as the drive-through will remain a single one-way adjoining lane. The parking lot would provide space for 9 vehicles in front of the proposed facility. In addition to the planned parking, ample parking spaces are available right next to the proposed development within the shopping center. The facility will have primary operation during the morning and evening peak hours.

For the purpose of the study, the coffee shop is assumed to be built-out and occupied by the end of 2020.

The intersections studied for detailed analysis are:

1. Cedar Lane (Rte 698) and South Driveway (Unsignalized)
2. Cedar Lane (Rte 698) and North Driveway (Unsignalized)

2. BACKGROUND INFORMATION

2.1 Roadway Network

2.1.1 Existing Roadway Conditions

Cedar Lane (Rte 698) is a minor arterial with a posted speed limit of 35 mph and carries approximately 13,000 vehicles per day. Cedar Lane is a two-way undivided roadway, two lanes wide, with left and occasional right turn lanes at the vicinity of the site and runs in the northeast-southwest direction.

2.1.2 Existing Bicycle and Pedestrian Facilities

There are no designated bicycle lanes in the study area. There are sidewalks on the east and west side of Cedar Lane.

2.1.3 Existing Transit Stops

There are bus stops along Cedar Lane serviced by Fairfax Connector.

3. ANALYSIS OF EXISTING CONDITIONS

3.1 Traffic Counts

Vehicle turning movement counts were conducted on Wednesday, June 10th, 2020 at the study intersections from 6:00 AM to 9:00 AM and 4:00 PM to 7:00 PM. The data was analyzed to develop AM and PM peak hours. The existing peak hour traffic counts, lane configuration and traffic control are shown in **Exhibit 3**.

The peak hours of the study site intersections occurred between 8:00 AM to 9:00 AM and between 4:15 PM to 5:15 PM during the weekday AM and PM conditions respectively. Traffic count data are included in **Appendix B**. No pedestrian activity was noted at the study site intersection. The intersection was observed to operate at acceptable levels of service with no residual queue and/or excessive delays for left-turning vehicles to/from Cedar Lane and also for left turning vehicles exiting the two driveways.

3.2 Capacity and Queue Analysis

Capacity analyses were conducted at the study intersections based on the existing lane use and traffic controls shown in Exhibit 3 on Synchro network model.

Synchro software (version 9.2, build 914, revision 6) was used to evaluate levels of service at the study intersections during the weekday AM and PM peak hours. The levels of service reported for the signalized intersection was taken from the Highway Capacity Manual 2010 (HCM) reports generated by Synchro. The existing operational analysis results (levels of service, delay and 95th percentile queues) are presented in **Appendix C**. The levels of service, delay and queue information are summarized in **Exhibit 4**. The study intersections currently operate at an overall LOS “A” during both the weekday AM and PM peak hours.

<u>Cedar Lane (Rte 698) and South Driveway:</u> All approaches operate at LOS A for both AM and PM peak hours with minimal delay. Vehicle queue lengths were calculated by movement for all approaches using the Synchro model. The 95th percentile queue is typically defined as the maximum back of queue with 95th percentile traffic volumes and is summarized as shown in Exhibit 4. No queues were reported.

<u>Cedar Lane (Rte 698) and North Driveway:</u> All approaches operate at LOS A for both AM and PM peak hours with minimal delay. Vehicle queue lengths were calculated by movement for all approaches using the Synchro model. No queues were reported.

4. NON-COVID-19 TRAFFIC ESTIMATION FOR CEDAR LANE

The travel demand has significantly reduced on account of the Coronavirus (COVID-19) pandemic. The reduction in traffic volumes is the result of factors such as school closures, restrictions on business operations, stay-at-home order, and an increase in telecommuting. The existing turning movement count conducted during this time, therefore under-represents the actual conditions and is not a true representation of the real traffic. In order to model the impact from the proposed development accurately, the traffic data on Cedar Lane had to be converted to reasonable estimates of traffic under non-COVID-19 conditions.

The existing traffic data on Cedar Lane was converted to a reasonable estimate by using a scaling factor that was derived from 12-hour turning movement counts conducted at a similar intersection nearby, for a period of three years (2018-2020). The intersection of Old Courthouse Rd and Woodford Rd was selected as the roadways are of similar functional class, and the ADT on Old Courthouse Rd was similar to that of Cedar Lane. The scaling factor, thus derived was applied to the peak-hour volumes. To match the travel patterns, directional distribution from the existing counts was then applied to the scaled-up volumes. The estimation procedure tabulated is as shown in **Exhibit 5**.

5. TRIP GENERATION, DISTRIBUTION AND ASSIGNMENT

5.1 Trip Generation

Peak hour volumes generated by the proposed development and the existing shopping center were calculated using the Institute of Transportation Engineers ITE's Trip Generation Handbook (10^{th} Edition, 2017). The shopping center trips were estimated to replicate the actual traffic accessing the driveway on Cedar Lane. Trip generation for the proposed coffee shop was calculated using the average rates for land use code 937 (coffee/donut shop with drive-through window). Trip generation for the existing shopping center was calculated using the equations for land use code 820 (shopping center).

For land use code 937(coffee/donut shop with drive-through window), the ITE Trip Generation Handbook, 3^{rd} Edition recommends a pass-by trip reduction of 49% and 50% during the AM peak hour and PM peak hour, respectively. The pass-by trip reduction of 34% during the AM peak hour is recommended for land use code 820 (shopping center). The same percentage reduction was assumed for the PM peak hour pass-by trips as well.

It was assumed that 97% of trips generated by the proposed coffee shop and 50% of the trips generated by the shopping center would access the site using a single consolidated, north driveway on Cedar Lane. **Exhibit 6** shows the trip generation comparison for the two land use codes and estimated trips accessing the site driveway.

5.2 Site Trip Distribution and Assignment

The site generated trips shown in Exhibit 6 were assigned to the road network based on the existing traffic patterns at the two driveways during the AM and PM peak hours. The traffic distribution was determined by consolidating traffic at the two driveways into a single driveway. This traffic distribution reflects traffic patterns for the shopping center and was assumed to be the same for the proposed coffee shop as well. The trip distribution for the shopping center and the proposed coffee shop is shown in **Exhibit 7**. The trips generated by the proposed coffee shop and the existing shopping center are shown in **Exhibit 8**. The total site trips are shown in **Exhibit 9**.

6. ANALYSIS FOR NON-COVID-19 CONDITIONS

6.1 Traffic Volumes

Exhibit 10 shows the non-COVID-19 traffic generated by the addition of estimated trips from the proposed coffee shop and shopping center to the scaled-up traffic volume on Cedar Lane.

6.2 Capacity and Queue Analysis

Capacity analyses were conducted at the consolidated intersection based on the existing lane use and traffic controls shown in Exhibit 9 on Synchro network model.

Synchro software (version 9.2, build 914, revision 6) was used to evaluate levels of service at the study intersections during the weekday AM and PM peak hours for the non-COVID-19 conditions. The levels of service reported for the signalized intersection was taken from the Highway Capacity Manual 2010 (HCM) reports generated by Synchro. The existing operational analysis results (levels of service, delay and 95th percentile queues) are presented in **Appendix D**. The levels of service, delay and queue information are summarized in **Exhibit 11**. The study intersection currently operate at an overall LOS “A” during both the weekday AM and PM peak hours

Cedar Lane (Rte 698) and Driveway: The northbound and southbound approaches operate at LOS A for both the AM and PM peak hours with minimal delay. The eastbound approach is projected to operate at LOS B during the AM peak hour while it is projected to operate at LOS C during the PM peak hour. Vehicle queue lengths were calculated by movement for all approaches using the Synchro model. The 95th percentile queue for the eastbound approach during the AM peak hour and PM peak hour is estimated to be about 0.9 vehicle and 2 vehicles respectively. The 95th percentile queue for the northbound left turn movement during the AM peak hour and PM peak hour is estimated to be about 0.2 vehicle and 0.3 vehicle respectively. The existing northbound left turn lane at the upstream intersection extends beyond the consolidated driveway for about 85 feet and this storage length is adequate to accommodate the minimal queue.

The queuing analysis results show that the queuing at the site egress point is expected to be minimal and not exceed 2 vehicles at any given time during the peak hour and will not impact site circulation.

7. QUEUEING ANALYSIS (ON-SITE)

Queuing analysis was performed to evaluate potential on-site queuing in the drive-through lane. The proposed drive-through has a capacity of fifteen (15) vehicles, which includes ten (10) vehicle queuing positions for the ordering/pick-up window and five (5) vehicle queuing positions in the parking lot aisle. **Exhibit 12** shows the vehicle queuing capacity available on-site.

The queuing expected at the drive-through window can be defined as a single server, single phase queuing system. In this system, the patrons will drive up to the order/service window, place their order, pay for the service and wait till the order has been fulfilled before they leave. The arrival rate of the patrons at the drive-through window and the service rate for the service rendered are both random in nature and therefore a stochastic model may be used to simulate the queuing system to determine the probabilities associated with queuing.

Based on the study conducted by John C. La Sala et.al, drive-through data collected at coffee shops of similar size indicate drive-through trips to be in the range of 28%-26%. The percentage of drive-through trips for this study was assumed to be 27%. The paper is shown in **Appendix E.**

When the queues approach the drive-through capacity, it was assumed that patrons would walk-in rather than join the queue, thereby controlling the queues formed. An arrival rate of 22 customers per hour was estimated to arrive at the drive-through facility during the AM peak hour. An arrival rate of 11 customers per hour was estimated to arrive at the drive-through facility during the PM peak hour.

The service rate at the order/pick-up window was based off data collected for a starbucks study (Kimley-Horn: Traffic Impact Study for Starbucks at 362 Maple Avenue East). The service rate from the study is shown in **Exhibit 13**. The service rate of 142 seconds (25 vehicles/hr) was used for the queuing analysis.

The statistical analysis uses the average service time and the arrival rate as the basis for all calculations and accounts for the likely variability in operating conditions. The analysis results in probabilities of vehicles waiting to be serviced by the drive-through being equal or less than n, a variable reflecting the number of vehicles in the system. The system is defined as the service position, plus vehicle(s) in queue. **Exhibit 14** shows the probabilities of vehicles waiting to be serviced at the service station based on average service time and arrival rate. The queue calculation worksheets are presented in **Appendix F**.

8. CONCLUSION

As a result of this study, it is concluded that the on-site circulation and area roadway network will accommodate the proposed development.

Under the existing conditions and non-COVID-19 conditions, the two driveways operate at levels of service A for both AM and PM peak hour. Minor delays are expected for the eastbound approach at both driveways during non-COVID-19 conditions. Queuing on Cedar Lane is expected to be minimal. Queuing at the egress points is not expected to exceed 2 vehicles at any given time during the peak hours during the non-COVID-19 conditions.

Based on stochastic queuing models, assuming an arrival rate of 22 vehicles per hour and service rate of 25 vehicles per hour, the probability that the queue is greater than 10 vehicles is 21%. Therefore, the anticipated vehicle demand will be accommodated over 79% of the time during the AM peak hour of arrivals. In the event longer queues are formed, stacking space to accommodate vehicles is available in the driving aisle before any spillback occurs onto Cedar Lane. It is assumed that the patrons to the site are expected to park and walk-in to the store rather than join the queue under such a scenario. No queuing issues at the drive-through lane are anticipated during the PM peak hour. Directional arrows and signage will help mitigate any confusion and further help orderly on-site circulation in a safe and efficient manner for vehicles as well as pedestrians.

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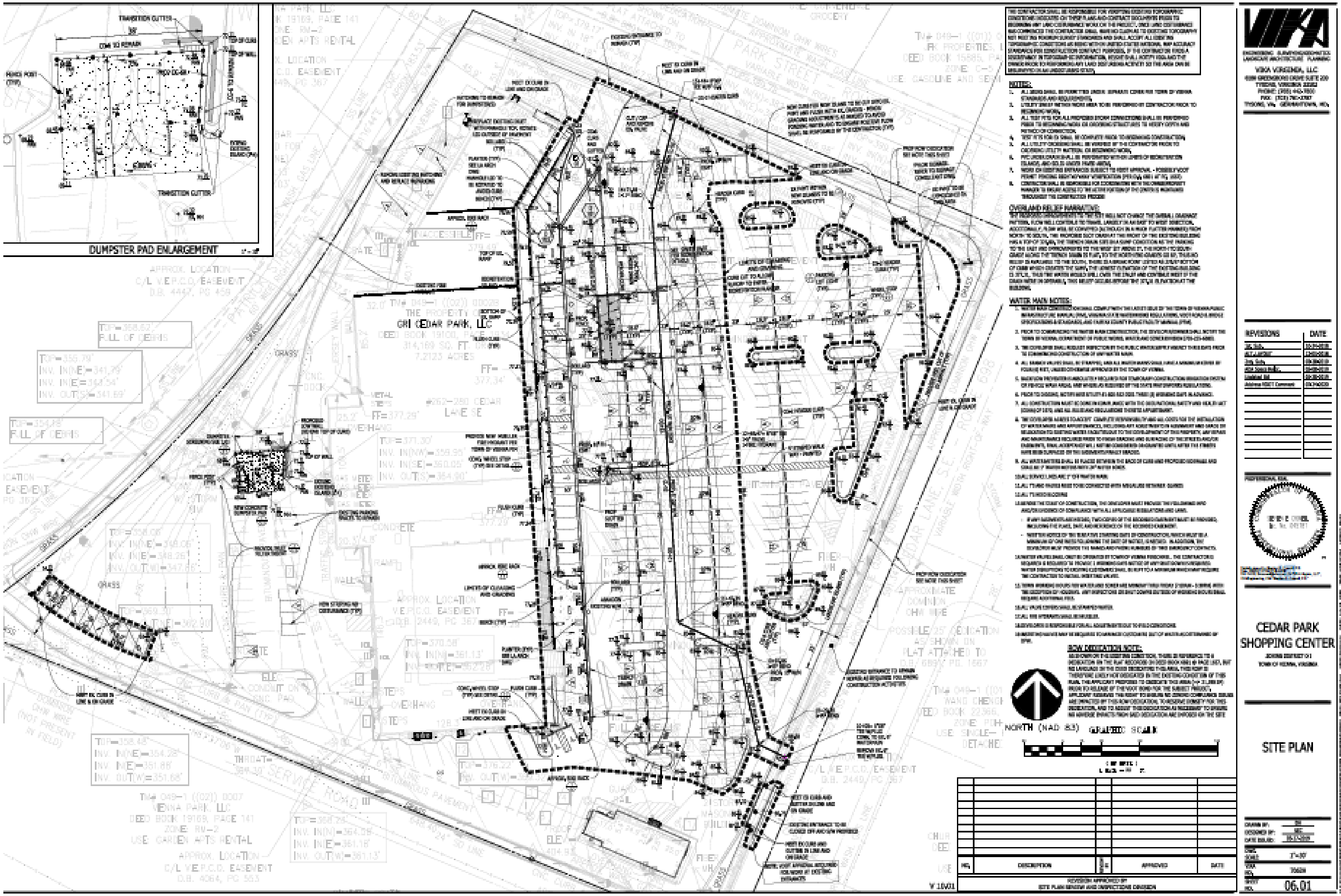
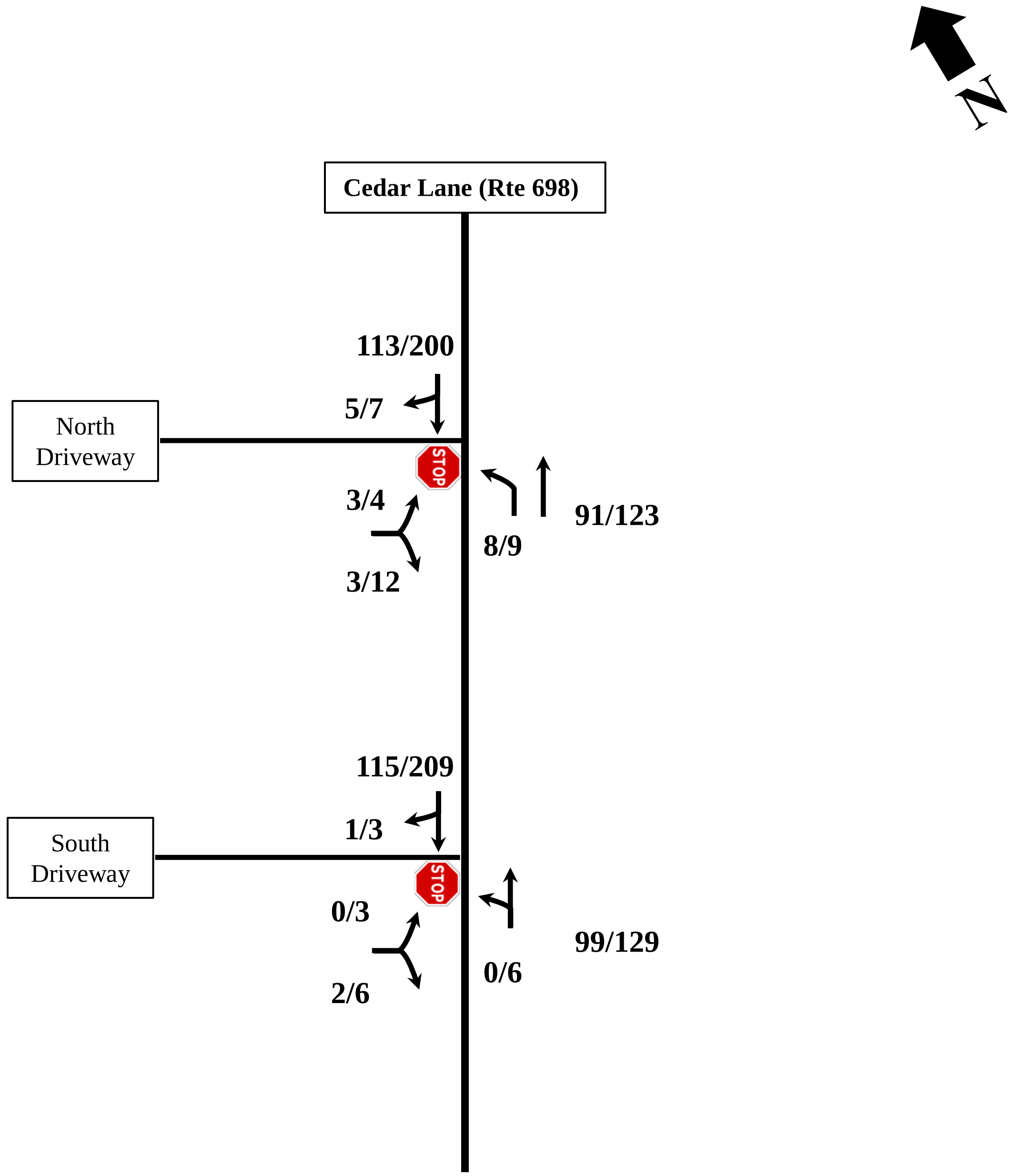
Site Location

Exhibit 1



MCV ASSOCIATES, INC Planning . Engineering . Information Technology	Site Plan	Exhibit 2



XXX/XXX – Weekday AM/PM Peak Hour

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Weekday AM & PM Peak Hour Volumes and Lane Configuration –

Existing Conditions

Exhibit 3

AM PEAK HOUR					
Intersection Information			Existing Conditions (COVID-19 traffic)		
Traffic Control	Approach	Movement	LOS	95% Queue (Veh)	Delay (sec)
1. Cedar Ln @ South Driveway					
Unsignalized	Northbound (Cedar Ln)	NBLT	A	0.0	0.0
		NB Approach			**0.0**
	Eastbound (South Driveway)	EBLR	A	0.0	8.9
		EB Approach	**A**		**8.9**
	Southbound (Cedar Ln)	SBTR			
		SB Approach			**0.0**
	Intersection Delay (LOS)	**0.1 (A)**			
2. Cedar Ln @ North Driveway					
Unsignalized	Northbound (Cedar Ln)	NBL	A	0.0	7.5
		NBT			
		NB Approach			**0.6**
	Eastbound (North Driveway)	EBLR	A	0.0	9.4
		EB Approach	**A**		**9.4**
	Southbound (Cedar Ln)	SBTR			
		SB Approach			**0.0**
	Intersection Delay (LOS)	**0.5 (A)**			

PM PEAK HOUR					
Intersection Information			Existing Conditions (COVID-19 traffic)		
Traffic Control	Approach	Movement	LOS	95% Queue (Veh)	Delay (sec)
1. Cedar Ln @ South Driveway					
Unsignalized	Northbound (Cedar Ln)	NBLT	A	0.0	7.7
		NB Approach			**0.3**
	Eastbound (South Driveway)	EBLR	A	0.0	9.9
		EB Approach	**A**		**9.9**
	Southbound (Cedar Ln)	SBTR			
		SB Approach			**0.0**
	Intersection Delay (LOS)	**0.4 (A)**			
2. Cedar Ln @ North Driveway					
Unsignalized	Northbound (Cedar Ln)	NBL	A	0.0	7.7
		NBT			
		NB Approach			**0.5**
	Eastbound (North Driveway)	EBLR	A	0.1	9.8
		EB Approach	**A**		**9.8**
	Southbound (Cedar Ln)	SBTR			
		SB Approach			**0.0**
	Intersection Delay (LOS)	**0.6 (A)**			

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Weekday AM & PM Peak Hour
Levels of Service, Delays & Queue Lengths
Existing Conditions

Exhibit 4

Location	12-hr Two-way Total (TMC)			Percent Change		Growth	Non-COVID-	Scaling
Old Courthouse Rd @ Woodford Rd	2018	2019	2020	18-'19	19-'20	Rate	19 Estimate	Factor
North of Woodford	14428	14738	5909	2.149%	-59.906%	1.02	15055	2.55
South of Woodford	12157	12288	5047	1.078%	-58.927%	1.01	12420	**2.46**
Woodford	5428	6065	1871	12%	-69%	1.12	6777	3.62

Time	Cedar Ln (Existing Directional Distribution)		
Period	Peak Hr Total	NB	SB
AM	204	45%	55%
PM	323	38%	62%

Time	Cedar Ln (Non-COVID-19 Estimate)		
Period	Peak Hr Total	NB	SB
AM	502	224	278
PM	795	303	492

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Weekday AM & PM Peak Hour Volume Estimates for Cedar Lane –

Non-COVID-19 Conditions

Exhibit 5

ITE Code	Land Use	Size (SF)	Average Rate	AM Peak Hour IN (%)	AM Peak Hour OUT (%)	AM Peak Hour IN (Trips)	AM Peak Hour OUT (Trips)	AM Peak Hour TOTAL (Trips)	Average Rate	PM Peak Hour IN (%)	PM Peak Hour OUT (%)	PM Peak Hour IN (Trips)	PM Peak Hour OUT (Trips)	PM Peak Hour TOTAL (Trips)	Daily
Site Trip Generation (Weekday)															
Trips based on 1000 Sq.Ft of Gross Floor Area															
937	Coffee/Donut Shop with Drive-Through Window	1,890	88.99	51%	49%				43.38	50%	50%				820.38
		*Pass-by Trips (AM= -49%)**							*Pass-by Trips (PM= -50%)*						
		Net New Trips							***Net New Trips***						
Total Trips									***Total Trips***						
820	Shopping Center	75,472		62%	38%	T = 0.5x(x)+151.78				48%	52%	Ln(T)=0.74Ln(X)+2.89			Ln(T)=0.68Ln(X)+5.57
		*Pass-by Trips (AM= -34%)**							*Pass-by Trips (PM= -34%)*						
		Net New Trips							***Net New Trips***						

ITE Code	Land Use	Size (SF)	Average Rate	AM Peak Hour IN (%)	AM Peak Hour OUT (%)	AM Peak Hour IN (Trips)	AM Peak Hour OUT (Trips)	AM Peak Hour TOTAL (Trips)	Average Rate	PM Peak Hour IN (%)	PM Peak Hour OUT (%)	PM Peak Hour IN (Trips)	PM Peak Hour OUT (Trips)	PM Peak Hour TOTAL (Trips)	Daily
Site Trip Generation (Weekday)															
Trips based on 1000 Sq.Ft of Gross Floor Area															
937	Coffee/Donut Shop with Drive-Through Window	1,890	88.99	51%	49%	86	82	168	43.38	50%	50%	41	41	82	1551
		*Pass-by Trips (AM= -49%)**				-42	-40	-82	*Pass-by Trips (PM= -50%)*			-21	-21	-42	-760
		Net New Trips				**44**	**42**	**86**	***Net New Trips***			**20**	**20**	**40**	**791**
Total Trips						***44***	***42***	***86***	***Total Trips***			***20***	***20***	***40***	***791***
820	Shopping Center	75,472		62%	38%	118	72	190		48%	52%	212	229	441	4965
		*Pass-by Trips (AM= -34%)**				-40	-24	-64	*Pass-by Trips (PM= -34%)*			-72	-78	-150	-1688
		Net New Trips				**78**	**48**	**126**	***Net New Trips***			**140**	**151**	**291**	**3277**
Total Trips						***78***	***48***	***126***	***Total Trips***			***140***	***151***	***291***	***3277***

Trips Accessing the Driveway			AM IN	AM OUT	AM Total	PM IN	PM OUT	PM Total
LUC 937	Coffee/Donut Shop with Drive-Through Window (97%)	Trips	83	80	163	40	40	80
		Pass-by Trips	-41	-39	-80	-20	-20	-41
		Primary Trips	**43**	**41**	**83**	**19**	**19**	**39**
LUC 820	Shopping Center (50%)	Trips	59	36	95	106	115	221
		Pass-by Trips	-20	-12	-32	-36	-39	-75
		Primary Trips	**39**	**24**	**63**	**70**	**76**	**146**

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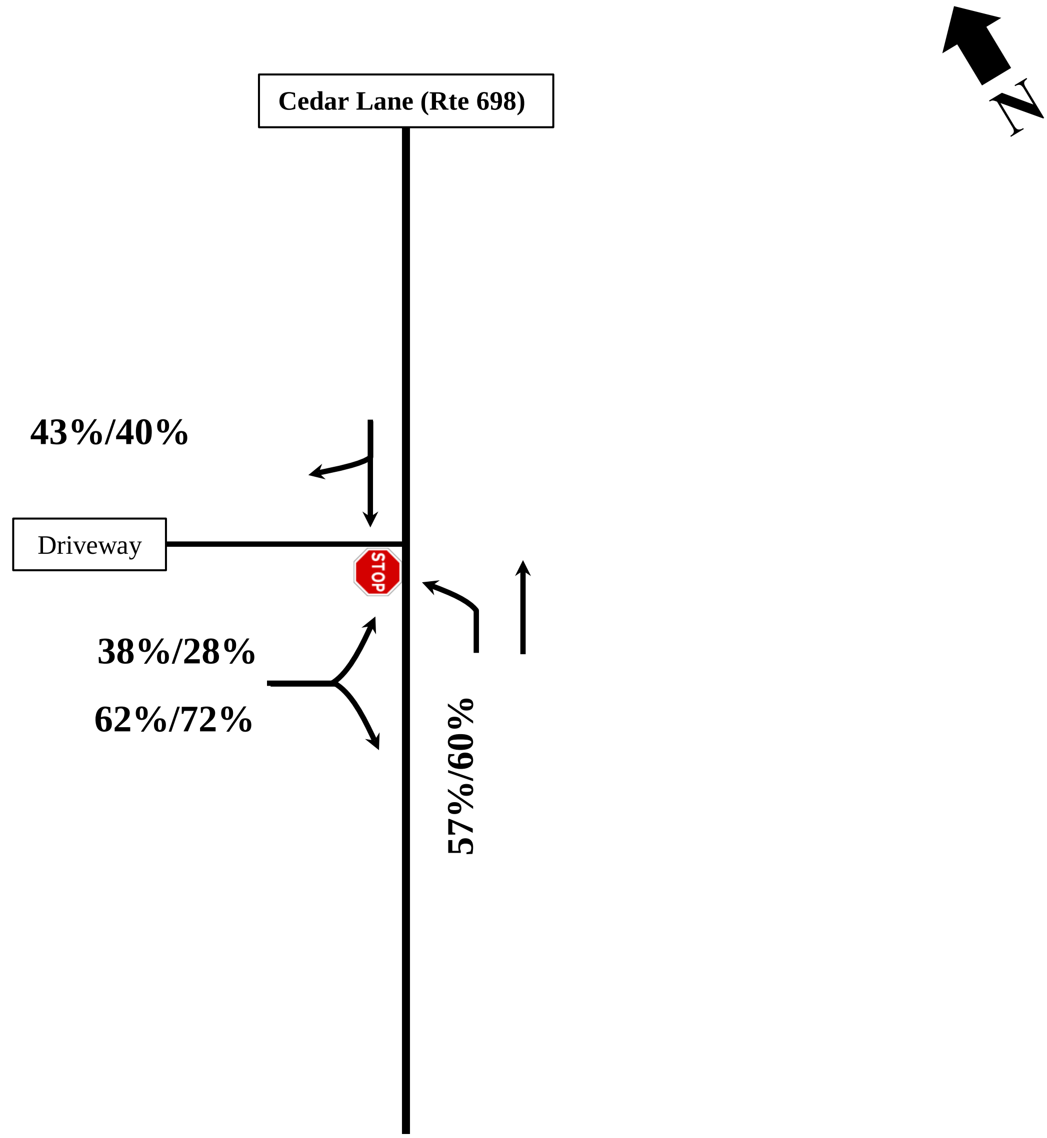
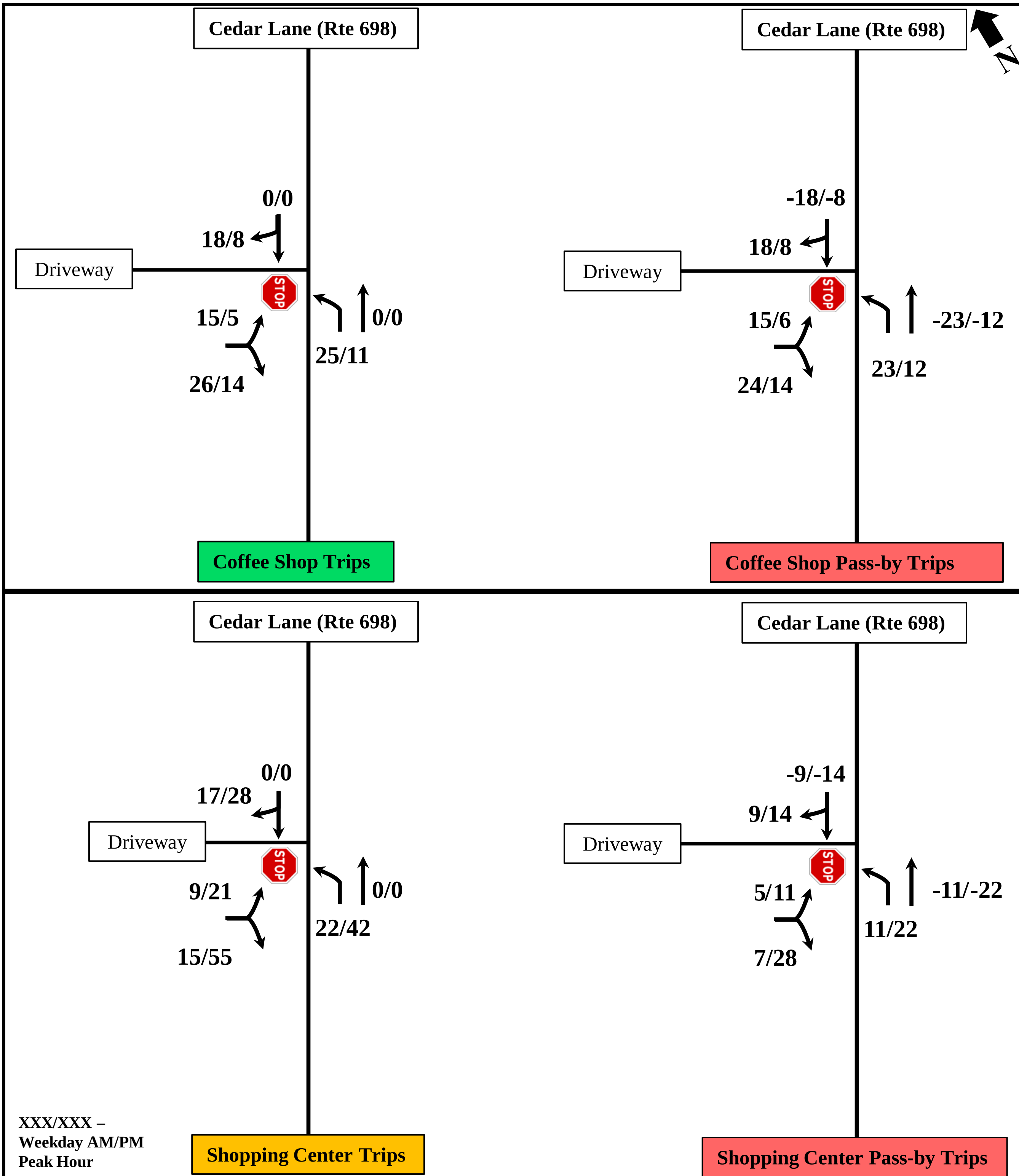
Trip Generation

Exhibit 6

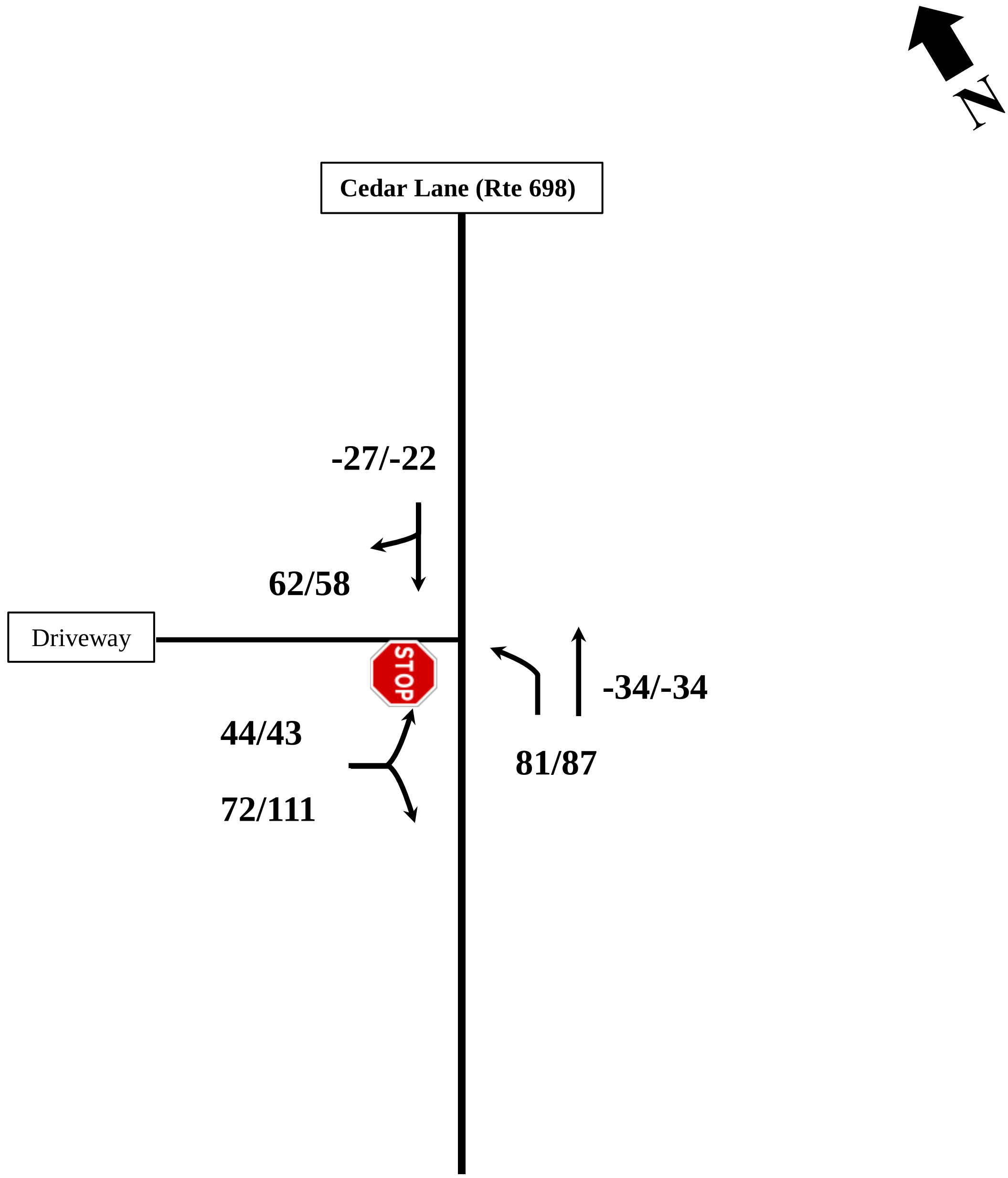


XXX/XXX – Weekday AM/PM Peak Hour

MCV ASSOCIATES, INC — Planning . Engineering . Information Technology	Weekday AM & PM Peak Hour Trip Distribution – Coffee Shop & Shopping Center	Exhibit 7

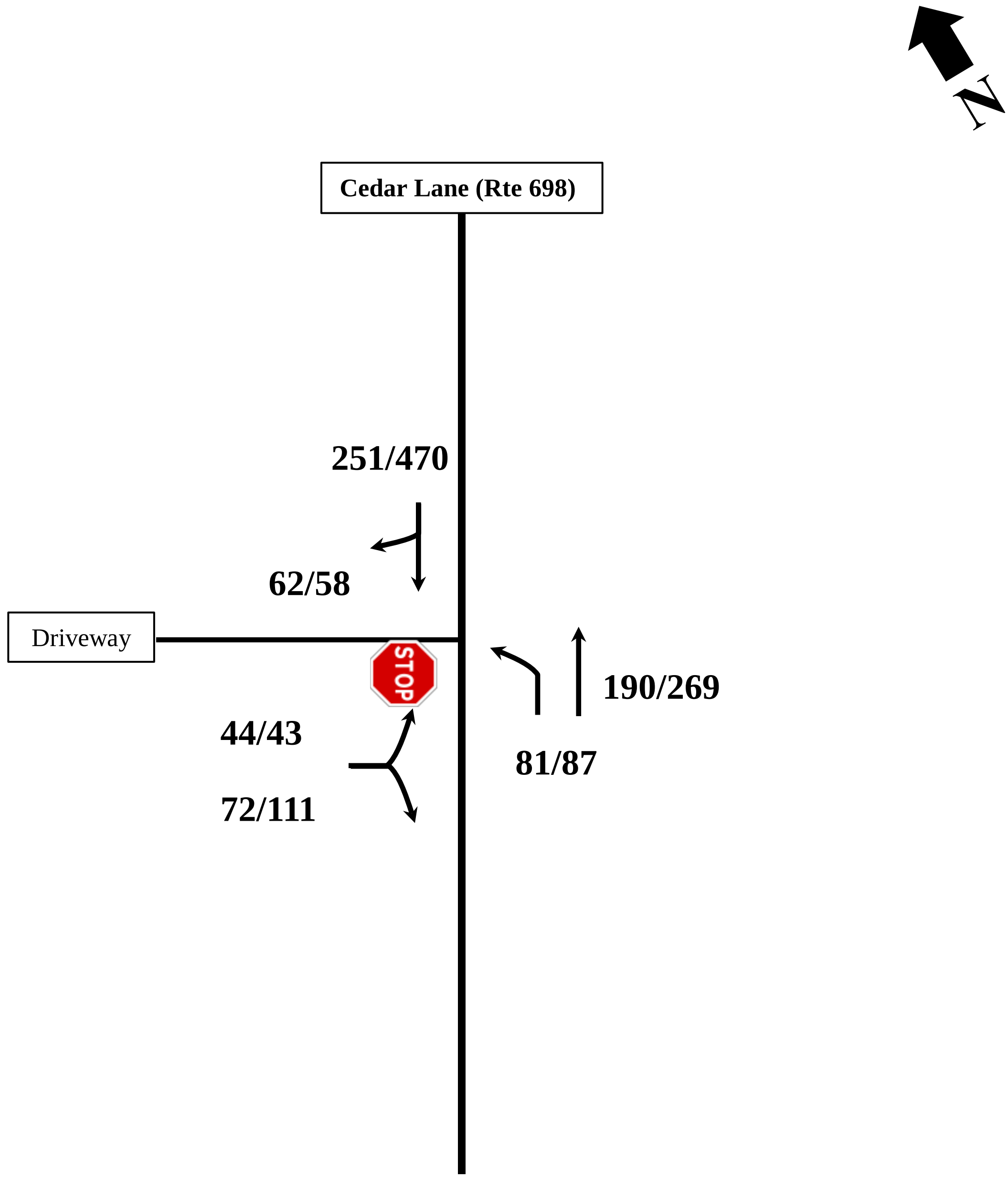


MCV ASSOCIATES, INC Planning . Engineering . Information Technology	Weekday AM & PM Peak Hour - Site Trips	Exhibit 8



XXX/XXX – Weekday AM/PM Peak Hour

MCV ASSOCIATES, INC Planning . Engineering . Information Technology	Weekday AM & PM Peak Hour Volumes – Total Site Trips	Exhibit 9



XXX/XXX – Weekday AM/PM Peak Hour

MCV ASSOCIATES, INC Planning . Engineering . Information Technology	Weekday AM & PM Peak Hour Volumes – Non-COVID-19 Conditions	Exhibit 10

AM PEAK HOUR					
Intersection Information			Existing Conditions		
Traffic Control	Approach	Movement	LOS	95% Queue (Veh)	Delay (sec)
Cedar Ln @ Driveway					
Unsignalized	Northbound (Cedar Ln)	NBL	A	0.2	8.2
		NBT			
		NB Approach			**2.4**
	Eastbound (North Driveway)	EBLR	B	0.9	13.5
		EB Approach	**B**		**13.5**
	Souththbound (Cedar Ln)	SBTR			
		SB Approach			**0.0**
	Intersection Delay (LOS)	**3.2 (A)**			

PM PEAK HOUR					
Intersection Information			Existing Conditions		
Traffic Control	Approach	Movement	LOS	95% Queue (Veh)	Delay (sec)
Cedar Ln @ Driveway					
Unsignalized	Northbound (Cedar Ln)	NBL	A	0.3	8.9
		NBT			
		NB Approach			**2.2**
	Eastbound (North Driveway)	EBLR	C	2	20.3
		EB Approach	**C**		**20.3**
	Souththbound (Cedar Ln)	SBTR			
		SB Approach			**0.0**
	Intersection Delay (LOS)	**3.8 (A)**			

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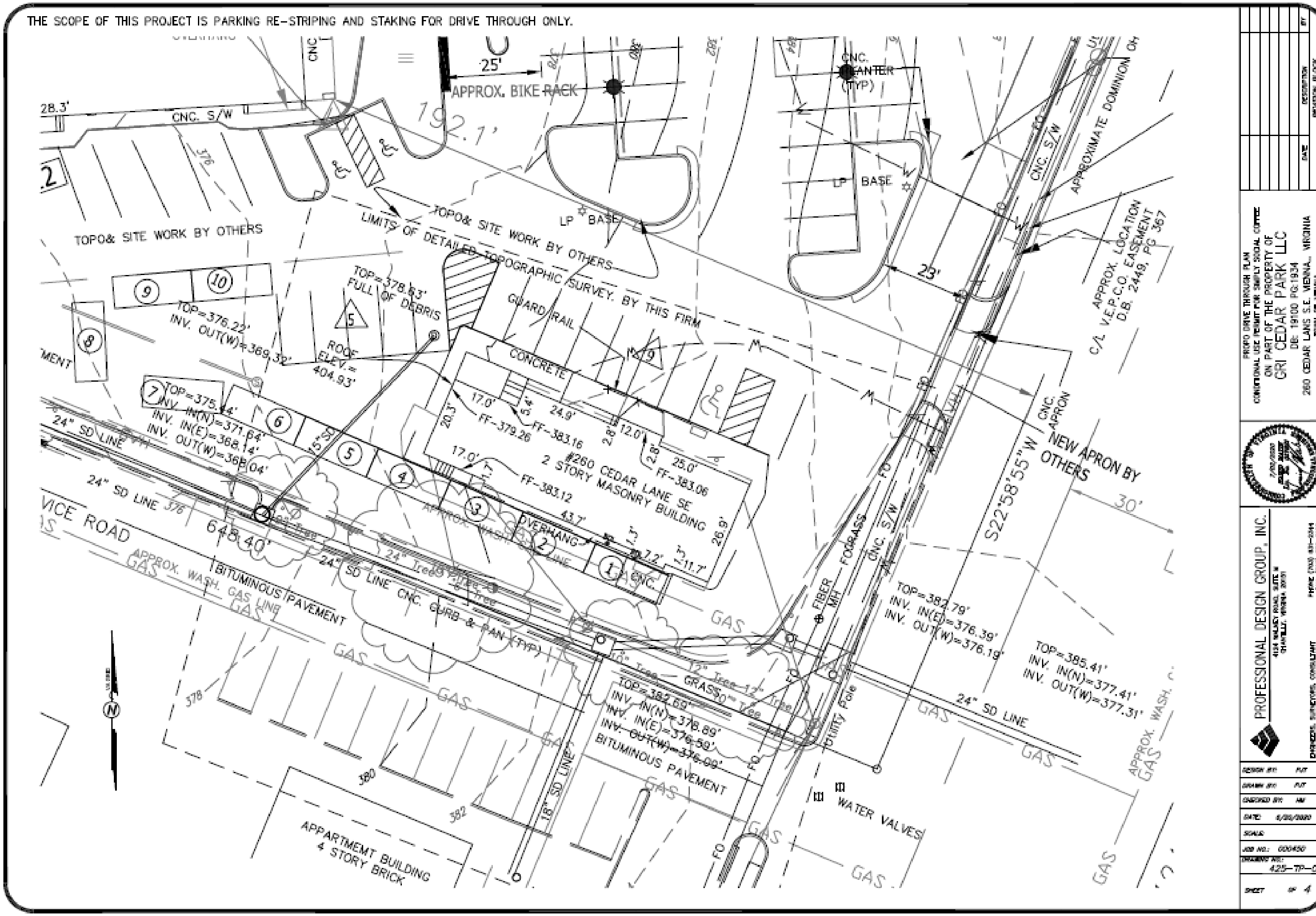
Weekday AM & PM Peak Hour
Levels of Service, Delays & Queue Lengths
Non-COVID-19 Conditions

Exhibit 11



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Stacking Distance for the Drive-through Aisle

Exhibit 12

Time	Arrivals	Q (veh)	Service Time (sec)
7:30	8	9	127
7:35	7	7	126
7:40	8	6	115
7:45	11	5	157
7:50	13	8	129
7:55	11	10	206
8:00	6	7	153
8:05	11	5	203
8:10	9	5	164
8:15	12	11	142
8:20	9	11	123
8:25	8	7	134
8:30	13	10	146
8:35	9	10	208
8:40	9	13	125
8:45	14	15	117
8:50	10	12	123
8:55	13	14	145
9:00	10	11	168
9:05	7	6	121
9:10	7	3	131
9:15	11	8	133
9:20	9	7	110
9:25	7	5	93
9:30	9	5	151
Average Service Rate			**142**

Source: Kimley-Horn (Traffic Impact Study for Starbucks at 362 Maple Avenue East)

MCV ASSOCIATES, INC Planning . Engineering . Information Technology	Service Rate for Drive-through Queue	Exhibit 13

Drive-through Queue Probability Summary during the AM Peak Hour		
Vehicles Waiting (n)	Probability of exactly ***n*** vehciles waiting	Probability of ***n*** or fewer vehciles waiting
0	13%	13%
1	11%	25%
2	10%	35%
3	9%	43%
4	7%	51%
5	7%	57%
6	6%	63%
7	5%	68%
8	4%	72%
9	4%	76%
10	3%	79%
11	3%	82%
12	2%	84%
13	2%	86%
14	2%	88%

Drive-through Queue Probability Summary during the PM Peak Hour		
Vehicles Waiting (n)	Probability of exactly ***n*** vehciles waiting	Probability of ***n*** or fewer vehciles waiting
0	57%	57%
1	25%	81%
2	11%	92%
3	5%	96%
4	2%	98%
5	1%	99%
6	0%	100%

Source for Drive-Through %: http://www.cowyite.org/technical/CoffeePaper.pdf

MCV ASSOCIATES, INC Planning . Engineering . Information Technology	Drive-through Queue Probability Summary - AM & PM Peak Hour	Exhibit 14

APPENDIX A: SCOPE OF WORK

Good Morning Joe,

Thanks for the call yesterday to provide me more details on your questions. The two site driveways will be enough for your analysis from the shopping center entrance perspective (for the proposed facility/drive-thru). If traffic counts are done now then please apply an appropriate rate increase that would match "normal" conditions. This must be done due to the decrease in traffic due to the virus situation. Attached is something that might help. Please feel free to reach out to me if you have any questions.

Thanks!

Andrew Jinks, PE
Transportation Engineer

<image001.jpg>

andrew.jinks@viennava.gov
703-255-6381

From: jmehra@mcvainc.com <jmehra@mcvainc.com>
Sent: Wednesday, May 20, 2020 11:55 AM
To: Jinks, Andrew <Andrew.Jinks@viennava.gov>
Subject: RE: 260 Cedar Lane

Good Morning Andrew:

Thanks for sending the Starbucks Report as an example. We will follow that in our preparation of the traffic study. Just want to confirm that the analysis of the two site driveways in to and out of the shopping center on Cedar Lane during AM and Pm peak hours along with the queue analysis at the drive-through would meet the requirements. The other question I have is can we do a traffic count now and use it for the analysis?

Again Thanks for your assistance.

Joe Mehra, PE, PTOE
MCV Associates, Inc.
4605-C Pinecrest Office Park Drive
Alexandria, Virginia 22312
(703) 914-4850
Fax: (703) 914-4865
Cell: (571) 437-1032
www.mcvainc.com

-------- Original Message --------
Subject: RE: 260 Cedar Lane
From: "Jinks, Andrew" <Andrew.Jinks@viennava.gov>
Date: Wed, May 20, 2020 12:20 am
To: "jmehra@mcvainc.com" <jmehra@mcvainc.com>

Good Morning Joe,

Attached is the Starbucks example traffic study for you to use as an example to develop your scope. Please also use the information that Kelly provided below. I apologize to the lengthy delay on us connecting, it was good to talk to you yesterday.

Thanks!

Andrew Jinks, PE
Transportation Engineer

<image001.jpg>

andrew.jinks@viennava.gov
703-255-6381

From: jmehra@mcvainc.com <jmehra@mcvainc.com>
Sent: Wednesday, May 6, 2020 10:20 AM
To: Jinks, Andrew <Andrew.Jinks@viennava.gov>
Subject: RE: 260 Cedar Lane

Good Morning Andrew:

I am going to be doing the traffic study needed for the drive-thru. Can you provide me with what do I need to do for the study. Appreciate it.

I know you maybe busy with the family matters and please respond when you can.

Thanks
Joe Mehra, PE, PTOE
MCV Associates, Inc.
4605-C Pinecrest Office Park Drive
Alexandria, Virginia 22312
(703) 914-4850
Fax: (703) 914-4865
Cell: (571) 437-1032
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APPENDIX B: TRAFFIC COUNT DATA

Your Company Name Here

This is your address
Your City, State, Zip Code
Your Tagline Here

File Name : Cedar Ln @ South Driveway
Site Code : 001
Start Date : 6/10/2020
Page No : 1

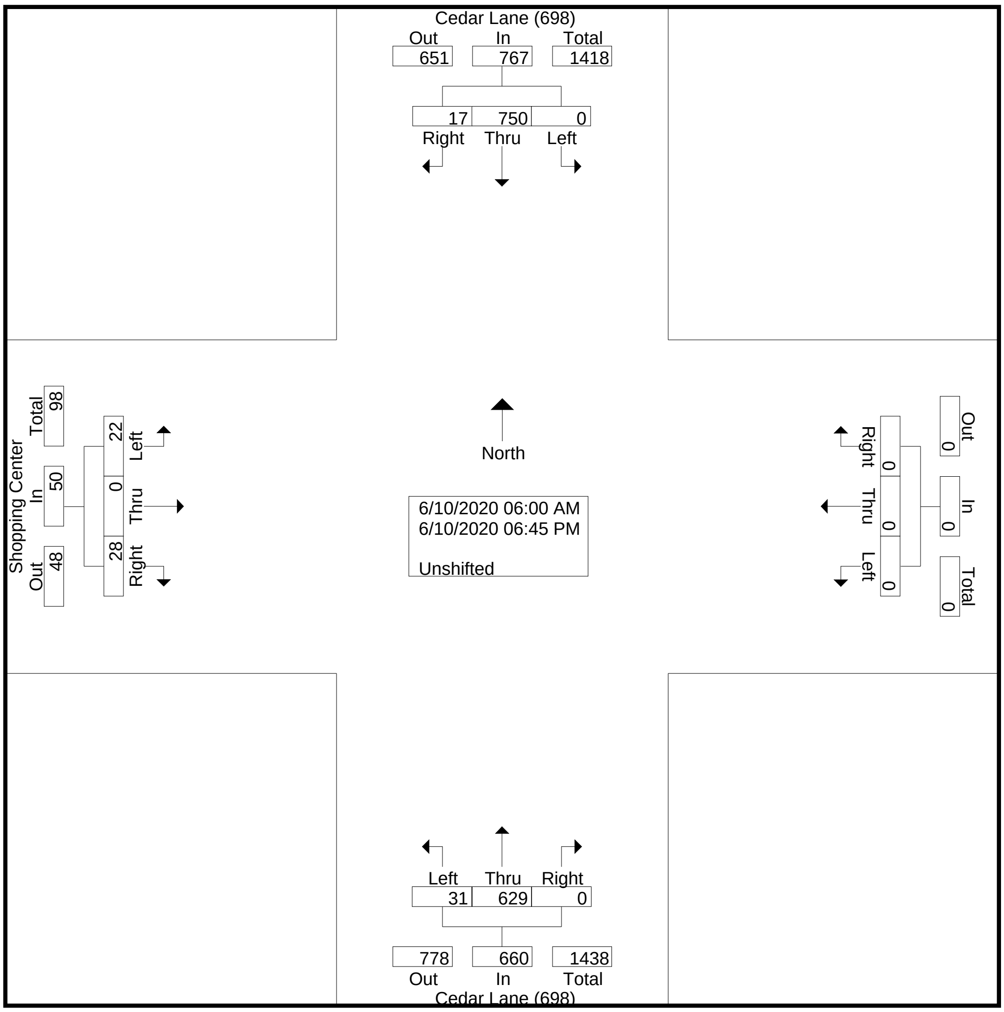
Groups Printed- Unshifted

	Cedar Lane (698) From North				From East				Cedar Lane (698) From South				Shopping Center From West				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	0	12	0	12	0	0	0	0	2	19	0	21	1	0	0	1	34
06:15 AM	0	8	0	8	0	0	0	0	1	8	0	9	1	0	0	1	18
06:30 AM	0	15	1	16	0	0	0	0	3	26	0	29	2	0	0	2	47
06:45 AM	0	21	1	22	0	0	0	0	3	21	0	24	1	0	1	2	48
Total	0	56	2	58	0	0	0	0	9	74	0	83	5	0	1	6	147
07:00 AM	0	22	0	22	0	0	0	0	0	28	0	28	3	0	1	4	54
07:15 AM	0	11	0	11	0	0	0	0	0	17	0	17	1	0	1	2	30
07:30 AM	0	22	0	22	0	0	0	0	1	21	0	22	1	0	0	1	45
07:45 AM	0	18	0	18	0	0	0	0	2	22	0	24	0	0	1	1	43
Total	0	73	0	73	0	0	0	0	3	88	0	91	5	0	3	8	172
08:00 AM	0	22	0	22	0	0	0	0	0	30	0	30	0	0	0	0	52
08:15 AM	0	31	0	31	0	0	0	0	0	18	0	18	0	0	0	0	49
08:30 AM	0	28	1	29	0	0	0	0	0	23	0	23	0	0	1	1	53
08:45 AM	0	34	0	34	0	0	0	0	0	28	0	28	0	0	1	1	63
Total	0	115	1	116	0	0	0	0	0	99	0	99	0	0	2	2	217
04:00 PM	0	31	0	31	0	0	0	0	2	24	0	26	1	0	2	3	60
04:15 PM	0	60	0	60	0	0	0	0	0	27	0	27	1	0	1	2	89
04:30 PM	0	55	1	56	0	0	0	0	4	43	0	47	1	0	3	4	107
04:45 PM	0	44	1	45	0	0	0	0	1	32	0	33	1	0	1	2	80
Total	0	190	2	192	0	0	0	0	7	126	0	133	4	0	7	11	336
05:00 PM	0	50	1	51	0	0	0	0	1	27	0	28	0	0	1	1	80
05:15 PM	0	52	2	54	0	0	0	0	0	29	0	29	2	0	3	5	88
05:30 PM	0	32	2	34	0	0	0	0	2	30	0	32	0	0	2	2	68
05:45 PM	0	37	1	38	0	0	0	0	1	38	0	39	1	0	2	3	80
Total	0	171	6	177	0	0	0	0	4	124	0	128	3	0	8	11	316
06:00 PM	0	35	0	35	0	0	0	0	2	28	0	30	2	0	1	3	68
06:15 PM	0	43	3	46	0	0	0	0	0	26	0	26	1	0	1	2	74
06:30 PM	0	24	2	26	0	0	0	0	3	34	0	37	1	0	4	5	68
06:45 PM	0	43	1	44	0	0	0	0	3	30	0	33	1	0	1	2	79
Total	0	145	6	151	0	0	0	0	8	118	0	126	5	0	7	12	289
Grand Total	0	750	17	767	0	0	0	0	31	629	0	660	22	0	28	50	1477
Apprch %	0	97.8	2.2		0	0	0		4.7	95.3	0		44	0	56		
Total %	0	50.8	1.2	51.9	0	0	0	0	2.1	42.6	0	44.7	1.5	0	1.9	3.4	

Your Company Name Here

This is your address
Your City, State, Zip Code
Your Tagline Here

File Name : Cedar Ln @ South Driveway
Site Code : 001
Start Date : 6/10/2020
Page No : 2

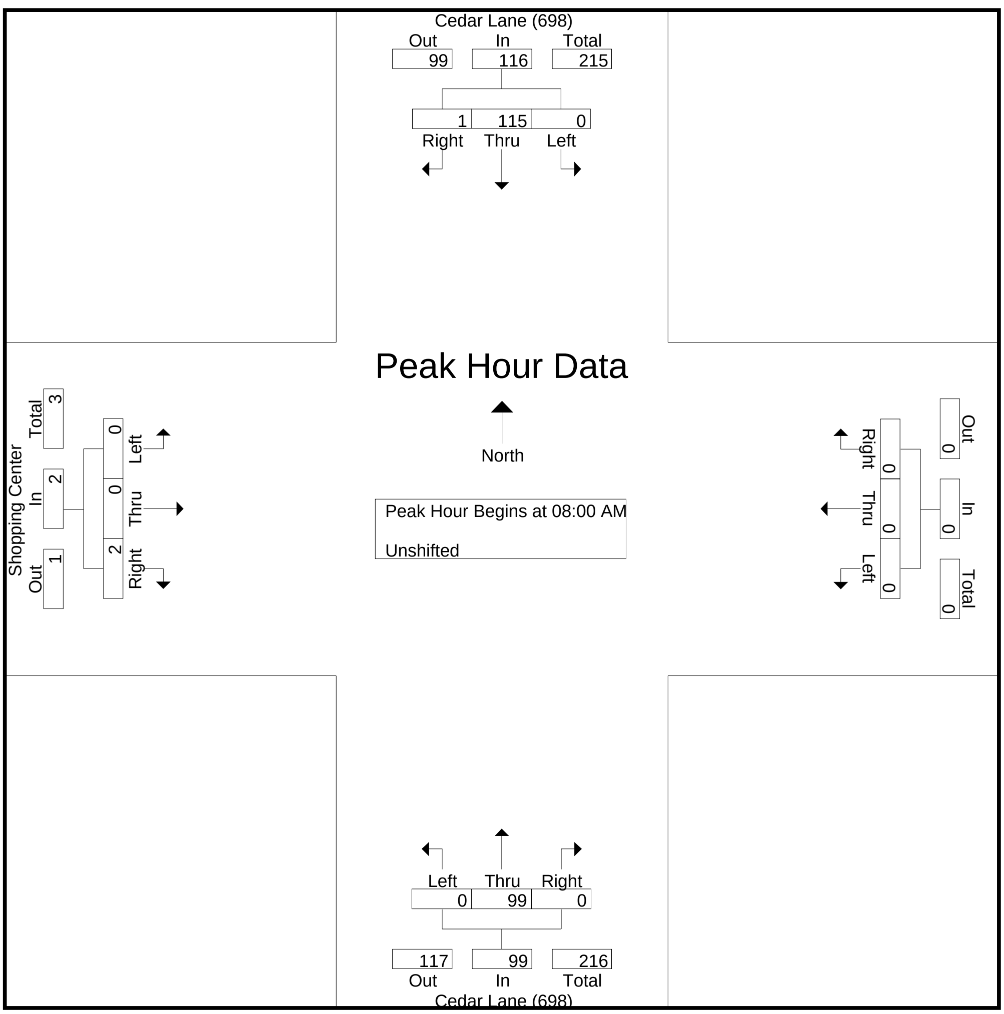


Your Company Name Here

This is your address
Your City, State, Zip Code
Your Tagline Here

File Name : Cedar Ln @ South Driveway
Site Code : 001
Start Date : 6/10/2020
Page No : 3

	Cedar Lane (698) From North				From East				Cedar Lane (698) From South				Shopping Center From West				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 08:00 AM																	
08:00 AM	0	22	0	22	0	0	0	0	0	**30**	0	**30**	0	0	0	0	52
08:15 AM	0	31	0	31	0	0	0	0	0	18	0	18	0	0	0	0	49
08:30 AM	0	28	**1**	29	0	0	0	0	0	23	0	23	0	0	**1**	**1**	53
08:45 AM	0	**34**	0	**34**	0	0	0	0	0	28	0	28	0	0	1	1	**63**
Total Volume	0	115	1	116	0	0	0	0	0	99	0	99	0	0	2	2	217
% App. Total	0	99.1	0.9		0	0	0		0	100	0		0	0	100		
PHF	.000	.846	.250	.853	.000	.000	.000	.000	.000	.825	.000	.825	.000	.000	.500	.500	.861



Your Company Name Here

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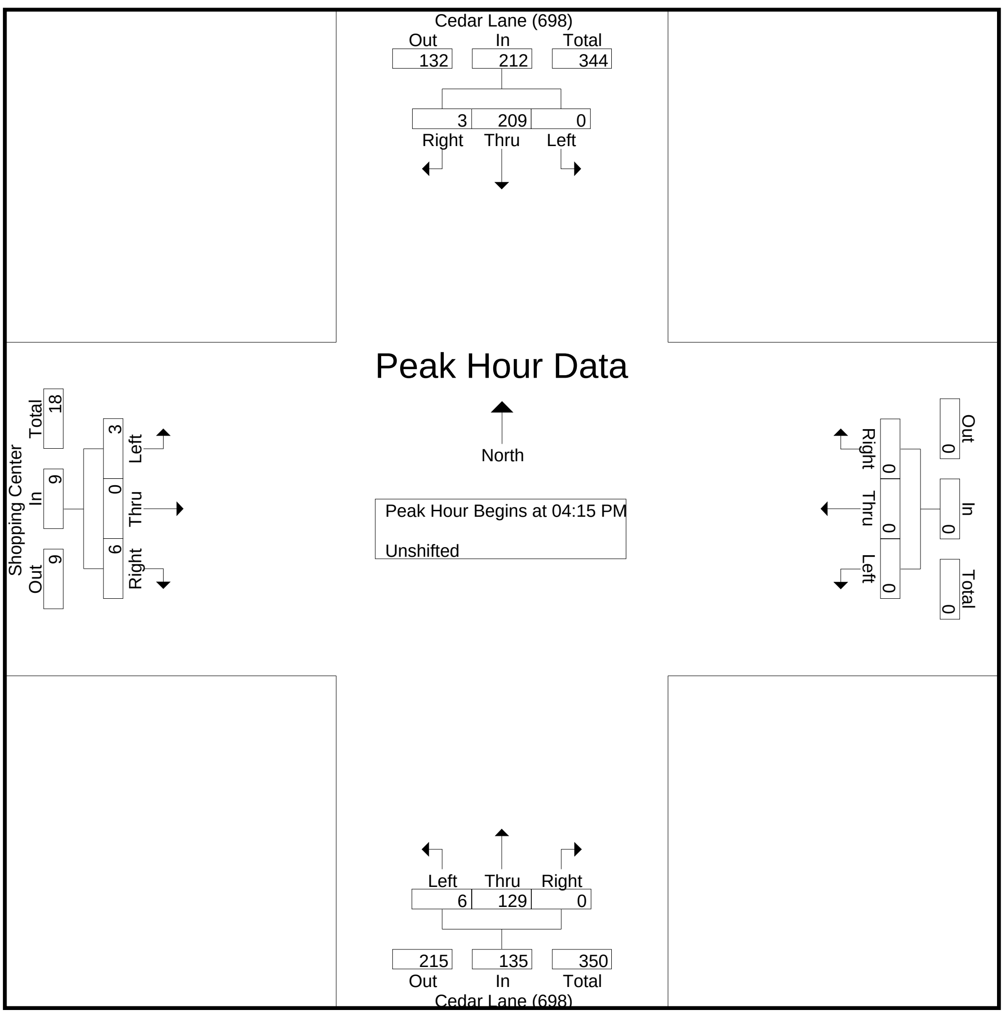
Your City, State, Zip Code
Your Tagline Here

File Name : Cedar Ln @ South Driveway
Site Code : 001
Start Date : 6/10/2020
Page No : 4

	Cedar Lane (698) From North				From East				Cedar Lane (698) From South				Shopping Center From West				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 04:00 PM to 06:45 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 04:15 PM																	
04:15 PM	0	**60**	0	**60**	0	0	0	0	0	27	0	27	**1**	0	1	2	89
04:30 PM	0	55	**1**	56	0	0	0	0	**4**	**43**	0	**47**	1	0	**3**	**4**	**107**
04:45 PM	0	44	1	45	0	0	0	0	1	32	0	33	1	0	1	2	80
05:00 PM	0	50	1	51	0	0	0	0	1	27	0	28	0	0	1	1	80
Total Volume	0	209	3	212	0	0	0	0	6	129	0	135	3	0	6	9	356
% App. Total	0	98.6	1.4		0	0	0		4.4	95.6	0		33.3	0	66.7		
PHF	.000	.871	.750	.883	.000	.000	.000	.000	.375	.750	.000	.718	.750	.000	.500	.563	.832



Your Company Name Here

This is your address
Your City, State, Zip Code
Your Tagline Here

File Name : Cedar Ln @ North Driveway
Site Code : 002
Start Date : 6/10/2020
Page No : 1

Groups Printed- Unshifted

	Cedar Lane (698) From North				From East				Cedar Lane (698) From South				Shopping Center From West				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	0	10	1	11	0	0	0	0	6	14	0	20	0	0	2	2	33
06:15 AM	0	8	0	8	0	0	0	0	2	7	0	9	0	0	0	0	17
06:30 AM	0	16	3	19	0	0	0	0	0	28	0	28	1	0	0	1	48
06:45 AM	1	22	0	23	0	0	0	0	3	18	1	22	0	0	0	0	45
Total	1	56	4	61	0	0	0	0	11	67	1	79	1	0	2	3	143
07:00 AM	0	19	0	19	0	0	0	0	2	29	0	31	0	0	3	3	53
07:15 AM	0	11	1	12	0	0	0	0	1	17	0	18	0	0	0	0	30
07:30 AM	0	20	1	21	0	0	0	0	1	21	0	22	0	0	2	2	45
07:45 AM	0	18	0	18	0	0	0	0	2	20	0	22	0	0	0	0	40
Total	0	68	2	70	0	0	0	0	6	87	0	93	0	0	5	5	168
08:00 AM	0	21	0	21	0	0	0	0	4	26	0	30	0	0	1	1	52
08:15 AM	0	30	2	32	0	0	0	0	0	18	0	18	2	0	1	3	53
08:30 AM	0	29	2	31	0	0	0	0	3	20	0	23	0	0	0	0	54
08:45 AM	0	33	1	34	0	0	0	0	1	27	0	28	1	0	1	2	64
Total	0	113	5	118	0	0	0	0	8	91	0	99	3	0	3	6	223
04:00 PM	0	30	2	32	0	0	0	0	0	25	0	25	0	0	1	1	58
04:15 PM	0	57	2	59	0	0	0	0	2	26	0	28	3	0	3	6	93
04:30 PM	0	55	1	56	0	0	0	0	3	41	0	44	0	0	1	1	101
04:45 PM	0	42	2	44	0	0	0	0	1	32	0	33	0	0	3	3	80
Total	0	184	7	191	0	0	0	0	6	124	0	130	3	0	8	11	332
05:00 PM	0	46	2	48	0	0	0	0	3	24	0	27	1	0	5	6	81
05:15 PM	0	52	1	53	0	0	0	0	1	30	0	31	0	0	2	2	86
05:30 PM	0	34	1	35	0	0	0	0	3	27	0	30	0	0	0	0	65
05:45 PM	0	34	1	35	0	0	0	0	7	32	0	39	0	0	4	4	78
Total	0	166	5	171	0	0	0	0	14	113	0	127	1	0	11	12	310
06:00 PM	0	34	2	36	0	0	0	0	2	28	0	30	1	0	1	2	68
06:15 PM	0	41	0	41	0	0	0	0	3	24	0	27	1	0	5	6	74
06:30 PM	0	22	3	25	0	0	0	0	5	30	0	35	1	0	4	5	65
06:45 PM	0	40	1	41	0	0	0	0	3	28	0	31	1	0	4	5	77
Total	0	137	6	143	0	0	0	0	13	110	0	123	4	0	14	18	284
Grand Total	1	724	29	754	0	0	0	0	58	592	1	651	12	0	43	55	1460
Apprch %	0.1	96	3.8		0	0	0		8.9	90.9	0.2		21.8	0	78.2		
Total %	0.1	49.6	2	51.6	0	0	0	0	4	40.5	0.1	44.6	0.8	0	2.9	3.8	

Your Company Name Here

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File Name : Cedar Ln @ North Driveway
Site Code : 002
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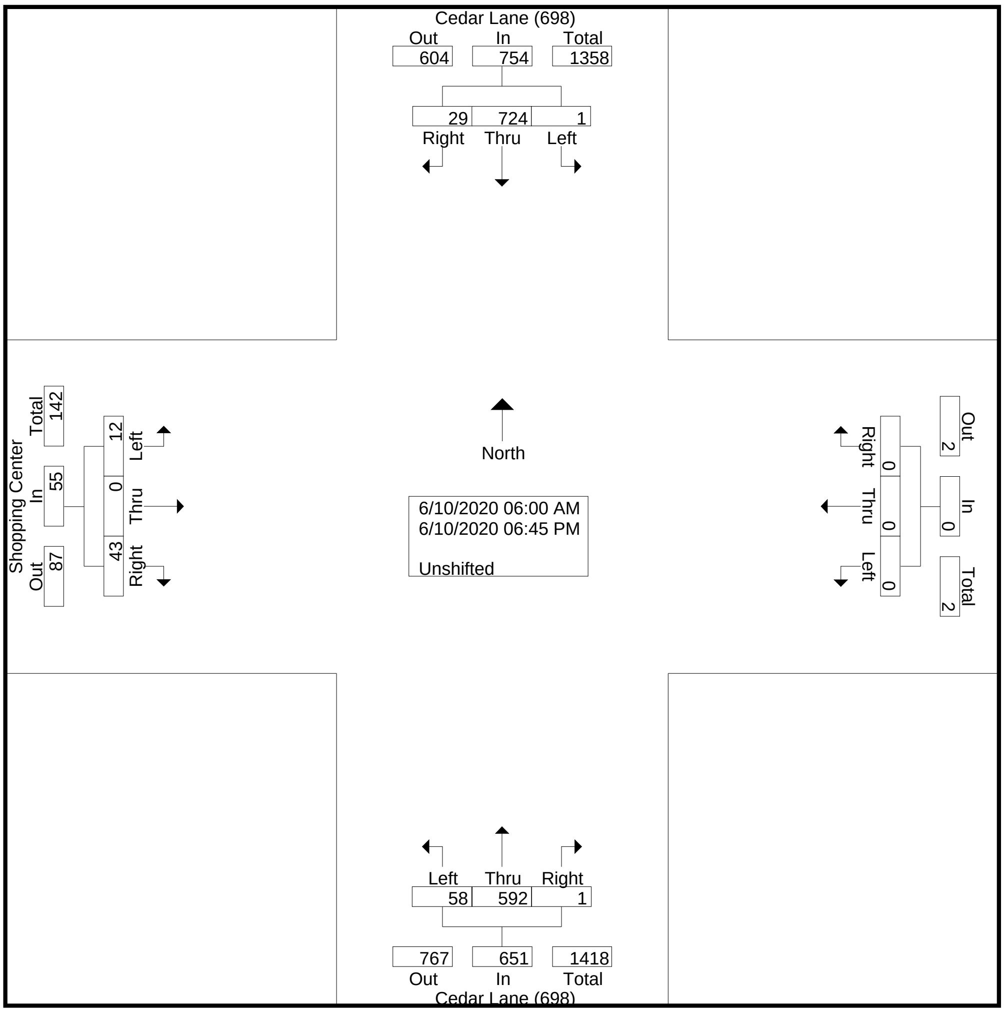
Page No : 2



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File Name : Cedar Ln @ North Driveway
Site Code : 002
Start Date : 6/10/2020
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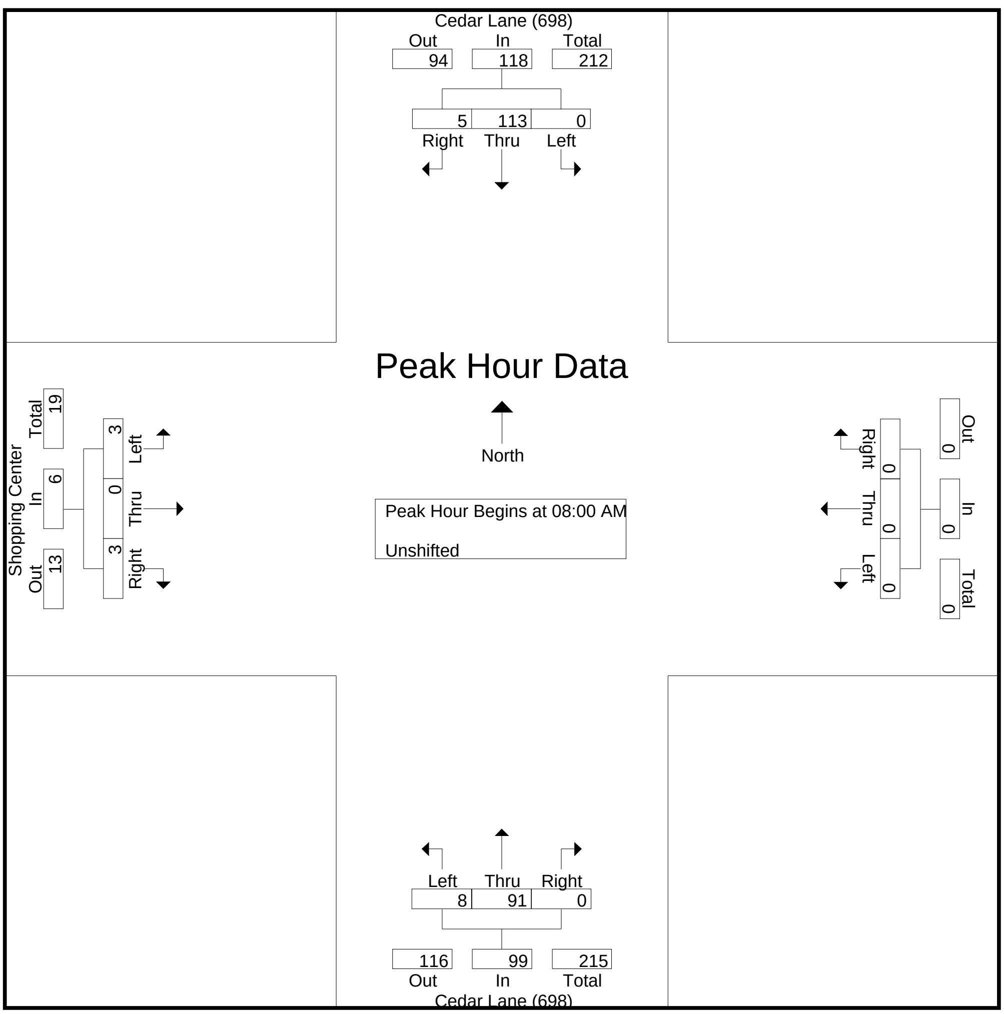
	Cedar Lane (698) From North				From East				Cedar Lane (698) From South				Shopping Center From West				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 08:00 AM																	
08:00 AM	0	21	0	21	0	0	0	0	**4**	26	0	**30**	0	0	**1**	1	52
08:15 AM	0	30	**2**	32	0	0	0	0	0	18	0	18	**2**	0	1	**3**	53
08:30 AM	0	29	2	31	0	0	0	0	3	20	0	23	0	0	0	0	54
08:45 AM	0	**33**	1	**34**	0	0	0	0	1	**27**	0	28	1	0	1	2	**64**
Total Volume	0	113	5	118	0	0	0	0	8	91	0	99	3	0	3	6	223
% App. Total	0	95.8	4.2		0	0	0		8.1	91.9	0		50	0	50		
PHF	.000	.856	.625	.868	.000	.000	.000	.000	.500	.843	.000	.825	.375	.000	.750	.500	.871



Your Company Name Here

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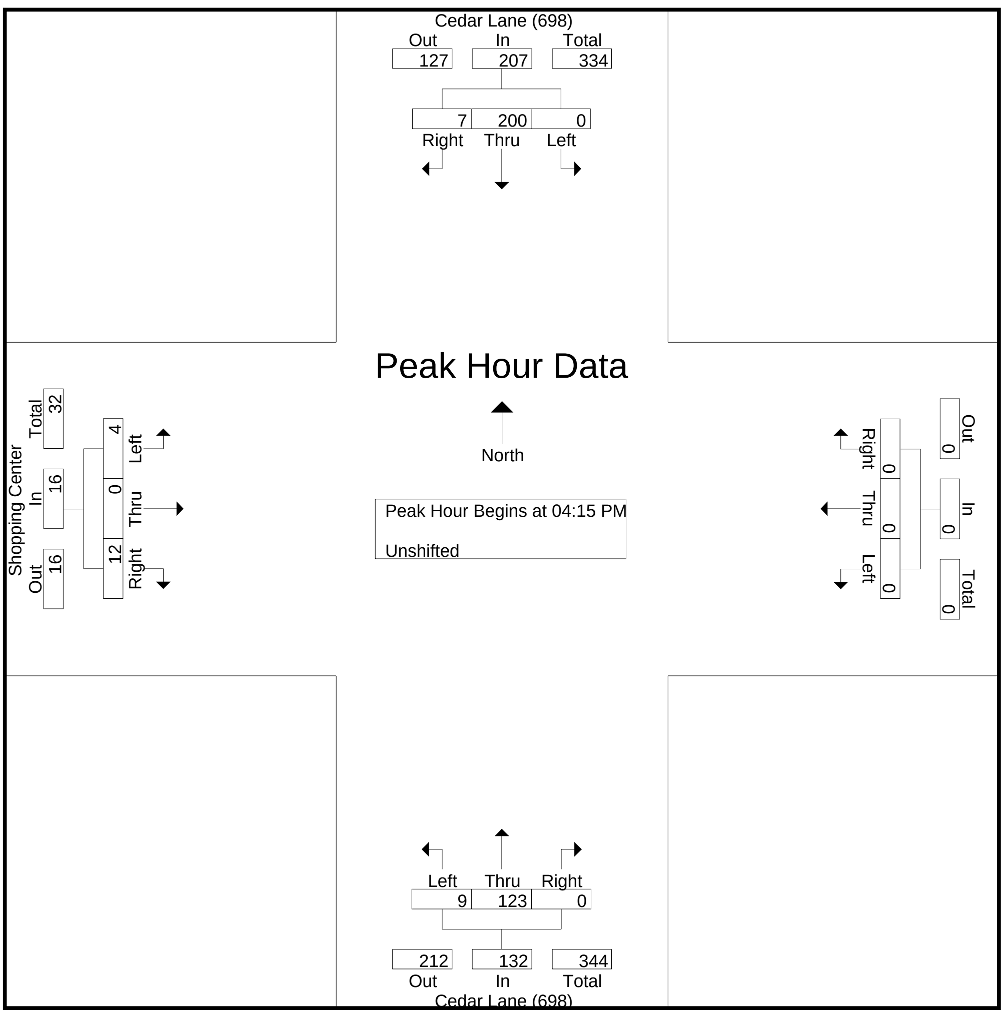
Your Tagline Here

File Name : Cedar Ln @ North Driveway
Site Code : 002
Start Date : 6/10/2020
Page No : 4

	Cedar Lane (698) From North				From East				Cedar Lane (698) From South				Shopping Center From West				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 04:00 PM to 06:45 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 04:15 PM																	
04:15 PM	0	**57**	**2**	**59**	0	0	0	0	2	26	0	28	**3**	0	3	**6**	93
04:30 PM	0	55	1	56	0	0	0	0	**3**	**41**	0	**44**	0	0	1	1	**101**
04:45 PM	0	42	2	44	0	0	0	0	1	32	0	33	0	0	3	3	80
05:00 PM	0	46	2	48	0	0	0	0	3	24	0	27	1	0	**5**	6	81
Total Volume	0	200	7	207	0	0	0	0	9	123	0	132	4	0	12	16	355
% App. Total	0	96.6	3.4		0	0	0		6.8	93.2	0		25	0	75		
PHF	.000	.877	.875	.877	.000	.000	.000	.000	.750	.750	.000	.750	.333	.000	.600	.667	.879



APPENDIX C: EXISTING CONDITIONS (SYNCHRO OUTPUT SHEETS)

Intersection	
Int Delay, s/veh	0.1

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	0	2	0	99	115	1
Future Vol, veh/h	0	2	0	99	115	1
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	2	2	0
Mvmt Flow	0	2	0	108	125	1

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	234	126	126	0	-	0
Stage 1	126	-	-	-	-	-
Stage 2	108	-	-	-	-	-
Critical Hdwy	6.4	6.2	4.1	-	-	-
Critical Hdwy Stg 1	5.4	-	-	-	-	-
Critical Hdwy Stg 2	5.4	-	-	-	-	-
Follow-up Hdwy	3.5	3.3	2.2	-	-	-
Pot Cap-1 Maneuver	759	930	1473	-	-	-
Stage 1	905	-	-	-	-	-
Stage 2	921	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	759	930	1473	-	-	-
Mov Cap-2 Maneuver	759	-	-	-	-	-
Stage 1	905	-	-	-	-	-
Stage 2	921	-	-	-	-	-

Approach	EB		NB		SB	
HCM Control Delay, s	8.9		0		0	
HCM LOS	A					

Minor Lane/Major Mvmt		NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)		1473	-	930	-	-
HCM Lane V/C Ratio		-	-	0.002	-	-
HCM Control Delay (s)		0	-	8.9	-	-
HCM Lane LOS		A	-	A	-	-
HCM 95th %tile Q(veh)		0	-	0	-	-

Intersection	
Int Delay, s/veh	0.4

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	3	6	6	129	209	3
Future Vol, veh/h	3	6	6	129	209	3
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	2	2	0
Mvmt Flow	3	7	7	140	227	3

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	382	229	230	0	-	0
Stage 1	229	-	-	-	-	-
Stage 2	153	-	-	-	-	-
Critical Hdwy	6.4	6.2	4.1	-	-	-
Critical Hdwy Stg 1	5.4	-	-	-	-	-
Critical Hdwy Stg 2	5.4	-	-	-	-	-
Follow-up Hdwy	3.5	3.3	2.2	-	-	-
Pot Cap-1 Maneuver	624	815	1350	-	-	-
Stage 1	814	-	-	-	-	-
Stage 2	880	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	620	815	1350	-	-	-
Mov Cap-2 Maneuver	620	-	-	-	-	-
Stage 1	814	-	-	-	-	-
Stage 2	875	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	9.9	0.3	0
HCM LOS	A		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1350	-	738	-	-
HCM Lane V/C Ratio	0.005	-	0.013	-	-
HCM Control Delay (s)	7.7	0	9.9	-	-
HCM Lane LOS	A	A	A	-	-
HCM 95th %tile Q(veh)	0	-	0	-	-

Intersection						
Int Delay, s/veh	0.5					

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	3	3	8	91	113	5
Future Vol, veh/h	3	3	8	91	113	5
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	0	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	2	2	0
Mvmt Flow	3	3	9	99	123	5

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	242	126	128	0	-	0
Stage 1	126	-	-	-	-	-
Stage 2	116	-	-	-	-	-
Critical Hdwy	6.4	6.2	4.1	-	-	-
Critical Hdwy Stg 1	5.4	-	-	-	-	-
Critical Hdwy Stg 2	5.4	-	-	-	-	-
Follow-up Hdwy	3.5	3.3	2.2	-	-	-
Pot Cap-1 Maneuver	751	930	1470	-	-	-
Stage 1	905	-	-	-	-	-
Stage 2	914	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	746	930	1470	-	-	-
Mov Cap-2 Maneuver	746	-	-	-	-	-
Stage 1	905	-	-	-	-	-
Stage 2	908	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	9.4	0.6	0
HCM LOS	A		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1470	-	828	-	-
HCM Lane V/C Ratio	0.006	-	0.008	-	-
HCM Control Delay (s)	7.5	-	9.4	-	-
HCM Lane LOS	A	-	A	-	-
HCM 95th %tile Q(veh)	0	-	0	-	-

Intersection	
Int Delay, s/veh	0.6

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	4	12	9	123	200	7
Future Vol, veh/h	4	12	9	123	200	7
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	0	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	2	2	0
Mvmt Flow	4	13	10	134	217	8

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	374	221	225	0	-	0
Stage 1	221	-	-	-	-	-
Stage 2	153	-	-	-	-	-
Critical Hdwy	6.4	6.2	4.1	-	-	-
Critical Hdwy Stg 1	5.4	-	-	-	-	-
Critical Hdwy Stg 2	5.4	-	-	-	-	-
Follow-up Hdwy	3.5	3.3	2.2	-	-	-
Pot Cap-1 Maneuver	631	824	1356	-	-	-
Stage 1	821	-	-	-	-	-
Stage 2	880	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	626	824	1356	-	-	-
Mov Cap-2 Maneuver	626	-	-	-	-	-
Stage 1	821	-	-	-	-	-
Stage 2	874	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	9.8	0.5	0
HCM LOS	A		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1356	-	764	-	-
HCM Lane V/C Ratio	0.007	-	0.023	-	-
HCM Control Delay (s)	7.7	-	9.8	-	-
HCM Lane LOS	A	-	A	-	-
HCM 95th %tile Q(veh)	0	-	0.1	-	-

APPENDIX D: NON-COVID-19 CONDITIONS (SYNCHRO OUTPUT SHEETS)

Intersection						
Int Delay, s/veh	3.2					

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	44	72	81	190	251	62
Future Vol, veh/h	44	72	81	190	251	62
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	0	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	2	2	0
Mvmt Flow	48	78	88	207	273	67

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	690	307	340	0	-	0
Stage 1	307	-	-	-	-	-
Stage 2	383	-	-	-	-	-
Critical Hdwy	6.4	6.2	4.1	-	-	-
Critical Hdwy Stg 1	5.4	-	-	-	-	-
Critical Hdwy Stg 2	5.4	-	-	-	-	-
Follow-up Hdwy	3.5	3.3	2.2	-	-	-
Pot Cap-1 Maneuver	414	738	1230	-	-	-
Stage 1	751	-	-	-	-	-
Stage 2	694	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	384	738	1230	-	-	-
Mov Cap-2 Maneuver	384	-	-	-	-	-
Stage 1	751	-	-	-	-	-
Stage 2	644	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	13.5	2.4	0
HCM LOS	B		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1230	-	547	-	-
HCM Lane V/C Ratio	0.072	-	0.231	-	-
HCM Control Delay (s)	8.2	-	13.5	-	-
HCM Lane LOS	A	-	B	-	-
HCM 95th %tile Q(veh)	0.2	-	0.9	-	-

Intersection	
Int Delay, s/veh	3.8

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	43	111	87	269	470	58
Future Vol, veh/h	43	111	87	269	470	58
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	0	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	2	2	0
Mvmt Flow	47	121	95	292	511	63

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1024	542	574	0	-	0
Stage 1	542	-	-	-	-	-
Stage 2	482	-	-	-	-	-
Critical Hdwy	6.4	6.2	4.1	-	-	-
Critical Hdwy Stg 1	5.4	-	-	-	-	-
Critical Hdwy Stg 2	5.4	-	-	-	-	-
Follow-up Hdwy	3.5	3.3	2.2	-	-	-
Pot Cap-1 Maneuver	263	544	1009	-	-	-
Stage 1	587	-	-	-	-	-
Stage 2	625	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	238	544	1009	-	-	-
Mov Cap-2 Maneuver	238	-	-	-	-	-
Stage 1	587	-	-	-	-	-
Stage 2	566	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	20.3	2.2	0
HCM LOS	C		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1009	-	400	-	-
HCM Lane V/C Ratio	0.094	-	0.418	-	-
HCM Control Delay (s)	8.9	-	20.3	-	-
HCM Lane LOS	A	-	C	-	-
HCM 95th %tile Q(veh)	0.3	-	2	-	-

APPENDIX E: DRIVE-THROUGH PAPER

TRIP GENERATION OF COFFEE SHOPS WITH COMBINATION DRIVE-THROUGH AND SIT-DOWN FACILITIES

By the Technical Committee of the Colorado-Wyoming Section of ITE[1]

Abstract. A recent trend in the development of coffee shops incorporates a drive-through facility in conjunction with the traditional sit-down coffee house. A new quandary enfolds when transportation and traffic professionals plan new stores and search for the proper category of trip generation estimates to fit this type of development. Should one use "Fast-Food Restaurant with Drive-Through Window", a category which contains a sufficient sample of data necessary for reliability? Or, should an engineer use "Coffee/Bread/Sandwich Shop", which appears as a subcategory of Fast-Food Restaurant with Drive-Through Window, and for which only one study has been performed?

Many people, ranging from engineers and planners to politicians and the general public, rely upon trip generation data and their resulting traffic impact studies. This diverse group of personalities, each with its own unique perspective, would benefit from more reliable estimates resulting from further data collection pertaining specifically to the new breed of coffee shop with drive-through facility.

The purpose of this study entails collection of new data on the trip generation characteristics of coffee shops with a combination drive-through and sit-down facilities. Furthermore, this study ties together two recent data collection efforts. This paper will compare and analyze subtle differences in the results, differentiating between realistic trends versus mere anomalies. The measured trip generation rates for coffee houses with drive-through facilities are presented for use by the Transportation Professional. In conjunction with this study, data was recently submitted to ITE for inclusion in a future edition of *Trip Generation*[2].

BACKGROUND

In March of 2006, Krager and Associates[3] completed a study of six Starbucks coffee houses located along the Front Range urban areas of Colorado. All six sites included a combination of drive-through and sit-down facilities. At that time, the Technical Committee of the Colorado/Wyoming Section of ITE (CO/WY ITE) received multiple inquiries concerning a need for trip generation data of coffee shops with drive-through facilities. Evidencing the broad need for data, requests originated from professionals in both the private and public sectors. Following completion of their study, Krager and Associates

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[2] *Trip Generation*, 7th Edition. Institute of Transportation Engineers, 2003.

[3] Krager and Associates, Inc., Starbucks Coffee House, Study of Trip Generation Rates, Colorado Stores with both Walk-in and Drive-Through Facilities. March 2006.

generously shared their study with the Technical Committee of CO/WY ITE, who built upon the data collection efforts by Krager.

In addition to the study by Krager, the Fall 2005 edition of INCITER, the newsletter of the North Central Section of ITE, contains an article by Mike Spack and Brian Bergquist[4] which summarizes trip generation rates for eight coffee shops in metropolitan Minneapolis-St. Paul, Minnesota. The study by the North Central Section counted four sites each of shops with and without drive-through windows. All eight sites contained sit-down facilities. As shown below in Table 1, for shops with drive-through windows, the trip generation rates per 1,000 square feet of gross floor area correlated well between the two studies.

Study	AM Peak Hour			PM Peak Hour		
	In	Out	Total	In	Out	Total
INCITE, Minnesota, 2005	65	66	131	18	17	35
Krager, Colorado, 2006	59	59	118	18	20	38

Table 1: From Previous Studies, Peak Hour Trip Generation Rates per 1,000 SF GFA for Coffee Shops with Combination Drive-Through and Sit-Down Facilities. Peak hours reference peak hour of adjacent street traffic.

TRIP GENERATION MANUAL

Updates to the ITE *Trip Generation*[5] manual occur on a cycle of approximately every five years, with the most recent revision (7th edition) in 2003. When faced with a need for data on coffee shops, a transportation professional would currently find limited information. Within the category of Fast-Food Restaurant without Drive-Through Window (Land Use # 933), one specialized land use contains two studies for Coffee Shop. Under the category of Fast-Food Restaurant with Drive-Through Window (Land Use # 934), one specialized and very broad category of Coffee/Bread/Sandwich Shop is based upon only one study. Under land use category # 935 (Fast Food Restaurant with Drive-Through Window and No Indoor Seating), there exists a specialized listing of Coffee/Espresso Stand which also contains only one study.

When attempting to analyze a combination drive-through/sit-down coffee shop, one could possibly choose between the following categories from *Trip Generation*: Coffee/Bread/Sandwich Shop or Fast-Food Restaurant with Drive-Through Window. The first category contains only one study, presumably conducted at a combination coffee/bread/sandwich shop. Therefore, utilization of this specialized land use for a drive-through/sit-down coffee shop would be conducted with caution. Perhaps, the closest land-use category would be Fast-Food Restaurant with Drive-Through Window (Land Use # 934). However, since coffee shops typically generate more morning trips than fast food restaurants, the selection of Land Use # 934 could produce skewed results in a traffic study. Krager[6] notes that inaccurate estimates have contributed to operational or circulation problems when a site is built. Also, questionable data has occasionally caused

[4] Spack, Mike and Bergquist, Brian, Coffee Shop Trip Generation Study. INCITER, Volume 22, Number 4, Fall 2005.
[5] Ibid, *Trip Generation*, 7th Edition.
[6] Ibid, Krager and Associates, Inc.

delays in access permitting where jurisdictions require more refined data. Table 2 summarizes the data available from *Trip Generation* for similar land uses.

ITE Land Use	Daily Trips (# Studies)	AM Peak Trips	PM Peak Trips
Fast-Food Restaurant without Drive-Through Window	716 (1)	44 (2)	26 (4)
Coffee Shop	No data	73 (2)	29 (2)
Fast-Food Restaurant with Drive-Through Window	496 (21)	53 (59)	35 (110)
Coffee/Bread/Sandwich Shop	No data	183 (1)	39 (1)

Table 2: Similar land uses from ITE *Trip Generation* manual, 7th edition, showing total trips generated per 1,000 SF GFA. Number of studies are shown in parentheses.

METHODOLOGY

Because of the rapidly growing trend of combination drive-through/sit-down coffee shops, it was decided to specifically focus our study on this land use. Also, since both the Krager and INCITE studies counted land uses of this type, a more suitable frame of reference was available. Since the Technical Committee was given access to the data from the Krager study and since both parties were interested in expanding upon this study, it was agreed to use similar methodology. Measurement of additional sites would provide a validity test of the privately performed study.

All traffic entering and exiting the sites were measured during weekdays (Tuesday, Wednesday or Thursday). At a minimum, all sites were counted during the morning peak period between 7:00 and 9:00 am. Evening peak counts were collected between the hours of 4:00 and 6:00 pm. Since the peak hour of adjacent street traffic typically occurs during those hours, unless a 24-hour count of the access driveways was conducted, it was assumed that the one hour peak obtained corresponded with the peak hour of adjacent street traffic. If a 24-hour count of the site accesses was obtained, then morning and evening peak hours of the generator could be determined. The Krager study obtained counts through video taping all accesses and drive-through lanes. With the exception of one site at which a 24-hour tube count was conducted, the Technical Committee manually counted all vehicles entering and exiting the site, also differentiating between sit-down and drive-through trips. As a result, both studies reported percentage of drive-through trips in addition to entering and exiting trips.

Since the Krager study restricted their analysis to only the Starbucks brand of coffee shop, the Technical Committee hoped to diversify the array of brands. However, within the category of combination drive-through/sit-down facilities, no other brand was found along the Front Range of Colorado. Perhaps, more diverse branding exists in other regions, but other than one count taken in Chicago, Illinois, we did not have the resources readily available to scout for shops outside of our region.

DISCUSSION OF DATA AND FUTURE NEEDS

Tables 3 and 4 summarize the trip generation data for the twelve shops included in this study. Table 3 shows the location and characteristics for each site, while Table 4 summarizes the trip generation data. In Table 3, the final column differentiates between stores located in-line with other facilities such as a strip-mall configuration, versus free-standing (stand-alone) coffee shops. It should be noted that traffic was properly differentiated in all cases with counts consisting solely of trips to and from the subject site. As seen from Table 3, only site # 9 is located outside of Colorado. All counts were conducted in either urban areas outside the central business district (non-CBD), or in suburban areas. For this study, no counts were taken at stores located in rural areas. Counts from six sites were taken from the Krager study while six more sites were counted by the CO/WY ITE Technical Committee.

Tables 3 and 4 also represent the data which was submitted to ITE for a future edition of *Trip Generation*. The averages shown at the bottom of Table 4 are weighted average trip generation rates, calculated as specified by ITE in the *Trip Generation Handbook, 2nd Edition.*[7] The handbook states that the standard deviation should be less than or equal to 110 percent of the weighted average rate. Per 1,000 square feet of gross floor area, weighted average rates equal 113 total AM peak trips with a standard deviation of 23 percent, and 35 total PM peak trips with a standard deviation of 33 percent. Additionally, for the two sites where 24-hour counts were conducted (sites number 1 and 10), AM and PM peak hours of the generator were submitted along with the 24-hour counts. Since valid data was available for only two sites, it is probably not considered reliable for the purposes of trip generation estimates. When less than six data points exist, the *Trip Generation Handbook* recommends usage of data with caution.

#	Street(s) or Address	City (Colorado unless noted otherwise)	Square Footage	In-line (IL) or Free Standing (FS)
1	Kipling/Florida	Lakewood	2,000	FS
2	Parker/Peoria	Aurora	1,916	FS
3	Leetsdale/Holly	Denver	1,798	FS
4	4465 Centennial Blvd.	Colorado Springs	2,616	FS
5	Pearl/84th	Thornton	1,517	IL
6	Monaco/Evans	Denver	1,465	IL
7	Wildcat/Fairview	Highlands Ranch	1,750	IL
8	Sheridan/24th	Edgewater	1,520	IL
9	7101 S. Stony Island	Chicago, IL.	2,500	FS
10	Federal/44th	Denver	1,197	FS
11	1510 W. Eisenhower Blvd.	Loveland	2,646	FS
12	4320 9th St.	Greeley	1,500	IL

Table 3: Sites included in this study.

[7] *Trip Generation Handbook*, 2nd Edition. Institute of Transportation Engineers, 2004.

Site #	Square Footage	Trip Generation Rate per 1,000 SF GFA							
		AM Peak Hour of Adjacent Street				PM Peak Hour of Adjacent Street			
		Enter	Exit	Total	% DT	Enter	Exit	Total	% DT
1	2,000	60	58	118	28	23	23	46	
2	1,916	63	56	120	28				
3	1,798	73	81	154	26				
4	2,616	44	49	92	44	16	20	37	51
5	1,517	40	42	81	81	11	13	24	73
6	1,465	81	76	158	61	18	25	43	64
7	1,750	77	70	147	66	17	17	34	50
8	1,520	73	73	146	63	18	18	36	54
9	2,500	33	28	60	46	14	14	28	51
10	1,197	50	67	117		22	14	36	
11	2,646	37	36	73	73				
12	1,500	83	81	164	62				
Average	**1,869 SF**	**56.81**	**56.63**	**113.44**	**50.8%**	**17.30**	**18.13**	**35.43**	**55.5%**

Table 4: Peak Hour Trip Generation Rates per 1,000 SF. Peak hours reference peak hour of adjacent street traffic. All data rounded off to the nearest integer. Blank cells designate an uncounted value.

Table 5 pools together all referenced data in order to provide one convenient reference. It compares the data of this study with that of the previous studies of the identical land use of combination sit-down/drive-through coffee shops. It also shows the data for similar land uses from the most recent edition of *Trip Generation*.

Source of Data (Year reported)	Average Square Footage	Land Use	AM Peak Trips (# studies)	PM Peak Trips (# studies)
ITE *Trip Generation* (2003)		Fast-Food Restaurant without Drive-Through Window	44 (2)	26 (4)
ITE *Trip Generation*		Coffee Shop	73 (2)	29 (2)
ITE *Trip Generation*		Fast-Food Restaurant with Drive-Through Window	53 (59)	35 (110)
ITE *Trip Generation*		Coffee/Bread/Sandwich Shop	183 (1)	39 (1)
INCITE, Minnesota (2005)	1,675	Coffee Shop with Sit-Down and Drive-Through Facilities	131 (4)	35 (4)
Krager, Colorado (2006)	1,885		118 (6)	38 (6)
CO/WY ITE Technical Committee (2007)	1,852		109 (6)	33 (6)

Table 5: Data comparison of Peak Hour Trip Generation Rates per 1,000 SF. All values rounded off to the nearest integer.

Table 5 clearly shows the close correlation between counts conducted at the identical land use of Coffee Shop with Sit-Down and Drive-Through Facilities. It also can be clearly seen that the existing data from *Trip Generation* differs substantially from the studies conducted solely for Coffee Shop with Sit-Down and Drive-Through Facilities. Although the independent variable is identified as square footage of gross floor area (GFA), perhaps the presence of a store rather than its size more accurately determines trip generation characteristics. Table 6 shows what happens when the factor of square footage is removed from the trip generation values.

Source of Data (Year reported)	Per store, AM Peak Trips	Per store, PM Peak Trips
INCITE, Minnesota (2005)	219	57
Krager, Colorado (2006)	223	72
CO/WY ITE Technical Committee (2007)	201	57

Table 6: Data comparison of Peak Hour Trip Generation rates Per Store. All values rounded off to the nearest integer.

During the AM peak, there is little difference in variation of total trips from the average of three studies: 6.5% for trips per 1,000 square feet, versus 6.1% for trips per store. During the PM peak, the variation is clearly higher for trips per store. The statistical significance of this difference has not been analyzed. However, this bit of study shows that trip generation rates per store show no more correlation than rates per 1,000 square feet of GFA. Also, when using 1,000 square feet of GFA as the independent variable, the standard deviations of the AM and PM peak weighted average trip generation rates were well within the ITE's recommended tolerance limit of 110 percent.

If further study is conducted on an in-depth basis, perhaps the question of the most appropriate independent variable could be clearly determined. Further speculation suggested that the number of drive-through windows could have more correlation. However, at the time of this study, no sites were identified which had more than one window while also having sit-down facilities. One site was identified with two drive-up windows, but without accommodation for sit-down patrons. If a future trend leads to development of a significant quantity of sit-down shops with multiple windows, then number of drive-up windows could be analyzed as a potential independent variable.

One element not studied in this effort was the percentage of pass-by trips. As evidenced by the tables presented in this report, coffee shops tend to attract a high percentage of morning peak hour trips. Since the nature of coffee shop patrons is such that they stop for coffee en route to work, it is likely that a large number of trips could be pass-by. Table 5.26 of the *Trip Generation Handbook, 2nd Edition*[8] depicts data for only three espresso stands (drive-through window with no indoor seating) and shows an average pass-by percentage of 89%. Table 5.24 of the same publication shows pass-by percentages measured for 18 fast-food restaurants with drive-through window, with an average of 50%. Although one could speculate that the pass-by percentage for coffee shops with drive-through/sit-down facilities is likely at least as high as that of fast-food restaurants with

[8] Ibid, *Trip Generation Handbook*, 2nd Edition.

drive-through, future study of pass-by trips at coffee shops is needed in order to identify the appropriate percentage. Data needs for pass-by trips exist for all varieties of coffee shops with sit-down and/or drive-through facilities.

Another aspect of facilities with drive-through facilities which interests transportation professionals is queuing. Although queuing was not measured as a part of this study, it could be another area of future research. To a degree, queuing can tend to be self-regulating if drivers sense that spillback onto the street is occurring. In that case a driver may instead park in the lot and become a walk-in patron. Other times, the driver may visit a different facility rather than risk waiting in a long queue. However, in cases where a site is inadequately designed, spillback onto the street can occur, thus hindering traffic flow. In order to address this matter, it is suggested that the design incorporate sufficient parking in order to handle potential overflow situations.

CONCLUSIONS

- The need exists for trip generation data at all types of coffee shops, involving all combinations of drive-through and/or sit-down facilities.
- The study presented in this report focuses specifically upon coffee shops with a combination of both sit-down and drive-through facilities.
- Data was reported per 1,000 square feet of gross floor area (GFA), although further study is needed in order to determine the most suitable independent variable. At this time, square footage of GFA was determined to be the most likely candidate.
- Data from this study compares closely with that of two other studies of the same land use. Using 1,000 square feet of GFA as the independent variable, AM peak hour total trips between the three studies vary by no more than 6.5% from the average. PM peak hour trips also vary by no more than 6.5% from the average.
- Percentage of drive-through trips for both morning and evening peak periods are relatively consistent: 51% during the AM peak, with 56% during the PM peak hour.
- Further study is needed in order to determine the percentage of pass-by trips at coffee shops of all types of drive-through/sit-down combinations. Additionally, more study could be conducted in order to measure queuing at these facilities.
- **This study resulted in data submission to ITE for a future edition of Trip Generation. The data submitted to ITE is shown in Table 4. Traffic counts from twelve sites were submitted with an average square footage of 1,869. Trip generation rates were reported as an average per 1,000 square feet of GFA for both the AM and PM weekday peak hours of adjacent street traffic. Rounding off to the nearest integer, for the morning peak hour, the average trip generation rate of twelve sites is 113 total trips with 50% entering and 50% exiting trips and a standard deviation of 23 percent. For the evening peak hour, the average rate of eight sites is 35 total trips with 49% entering and 51% exiting trips and a standard deviation of 33 percent.**

APPENDIX F: QUEUING ANALYSIS WORKSHEETS

	in sec	in hour
Ordering Time:	16.76	215
Service time:	125.24	29
Total vehicles served	142	25

AM PEAK HOUR

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	0	
Probability	0.132	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.35211	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	1	
Probability	0.115	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.4	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	2	
Probability	0.100	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.3521127	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	3	
Probability	0.086	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.35211	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	4	
Probability	0.075	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.4	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	5	
Probability	0.065	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.3521127	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	6	
Probability	0.056	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.35211	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	7	
Probability	0.049	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.4	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	8	
Probability	0.043	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.3521127	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	9	
Probability	0.037	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.35211	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	10	
Probability	0.032	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.4	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	11	
Probability	0.028	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.3521127	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	12	
Probability	0.024	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.35211	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	13	
Probability	0.021	

Queueing Analysis: Single Server		
Inputs		
Time unit	hour	
Arrival Rate (lambda)	22	customers/hour
Service Rate (mu)	25.4	customers/hour
Intermediate Calculations		
Average time between arrivals	0.05	
Average service time	0.04	
Performance Measures		
Rho (average server utilization)	0.87	
P0 (probability the system is empty)	0.13	
L (average number in the system)	6.563	customers
Lq (average number waiting in the queue)	5.695	customers
W (average time in the system)	0.298	hour
Wq (average time in the queue)	0.259	hour
Probability of a specfic number of customers in the system		
Number	14	
Probability	0.018	

n	Exactly	<=
0	13%	13%
1	11%	25%
2	10%	35%
3	9%	43%
4	7%	51%
5	7%	57%
6	6%	63%
7	5%	68%
8	4%	72%
9	4%	76%
10	3%	79%
11	3%	82%
12	2%	84%
13	2%	86%
14	2%	88%

PM PEAK HOUR

Queueing Analysis: Single Server			Queueing Analysis: Single Server			Queueing Analysis: Single Server		
Inputs			Inputs			Inputs		
Time unit	hour		Time unit	hour		Time unit	hour	
Arrival Rate (lambda)	11	customers/hour	Arrival Rate (lambda)	11	customers/hour	Arrival Rate (lambda)	11	customers/hour
Service Rate (mu)	25	customers/hour	Service Rate (mu)	25.35211	customers/hour	Service Rate (mu)	25.4	customers/hour
Intermediate Calculations			Intermediate Calculations			Intermediate Calculations		
Average time between arrivals	0.09		Average time between arrivals	0.09		Average time between arrivals	0.09	
Average service time	0.04		Average service time	0.04		Average service time	0.04	
Performance Measures			Performance Measures			Performance Measures		
Rho (average server utilization)	0.43		Rho (average server utilization)	0.43		Rho (average server utilization)	0.43	
P0 (probability the system is empty)	0.57		P0 (probability the system is empty)	0.57		P0 (probability the system is empty)	0.57	
L (average number in the system)	0.766	customers	L (average number in the system)	0.766	customers	L (average number in the system)	0.766	customers
Lq (average number waiting in the queue)	0.333	customers	Lq (average number waiting in the queue)	0.333	customers	Lq (average number waiting in the queue)	0.333	customers
W (average time in the system)	0.070	hour	W (average time in the system)	0.070	hour	W (average time in the system)	0.070	hour
Wq (average time in the queue)	0.030	hour	Wq (average time in the queue)	0.030	hour	Wq (average time in the queue)	0.030	hour
Probability of a specfic number of customers in the system			Probability of a specfic number of customers in the system			Probability of a specfic number of customers in the system		
Number	0		Number	1		Number	2	
Probability	0.566		Probability	0.246		Probability	0.107	

Queueing Analysis: Single Server			Queueing Analysis: Single Server			Queueing Analysis: Single Server		
Inputs			Inputs			Inputs		
Time unit	hour		Time unit	hour		Time unit	hour	
Arrival Rate (lambda)	11	customers/hour	Arrival Rate (lambda)	11	customers/hour	Arrival Rate (lambda)	11	customers/hour
Service Rate (mu)	25.3521127	customers/hour	Service Rate (mu)	25.35211	customers/hour	Service Rate (mu)	25.4	customers/hour
Intermediate Calculations			Intermediate Calculations			Intermediate Calculations		
Average time between arrivals	0.09		Average time between arrivals	0.09		Average time between arrivals	0.09	
Average service time	0.04		Average service time	0.04		Average service time	0.04	
Performance Measures			Performance Measures			Performance Measures		
Rho (average server utilization)	0.43		Rho (average server utilization)	0.43		Rho (average server utilization)	0.43	
P0 (probability the system is empty)	0.57		P0 (probability the system is empty)	0.57		P0 (probability the system is empty)	0.57	
L (average number in the system)	0.766	customers	L (average number in the system)	0.766	customers	L (average number in the system)	0.766	customers
Lq (average number waiting in the queue)	0.333	customers	Lq (average number waiting in the queue)	0.333	customers	Lq (average number waiting in the queue)	0.333	customers
W (average time in the system)	0.070	hour	W (average time in the system)	0.070	hour	W (average time in the system)	0.070	hour
Wq (average time in the queue)	0.030	hour	Wq (average time in the queue)	0.030	hour	Wq (average time in the queue)	0.030	hour
Probability of a specfic number of customers in the system			Probability of a specfic number of customers in the system			Probability of a specfic number of customers in the system		
Number	3		Number	4		Number	5	
Probability	0.046		Probability	0.020		Probability	0.009	