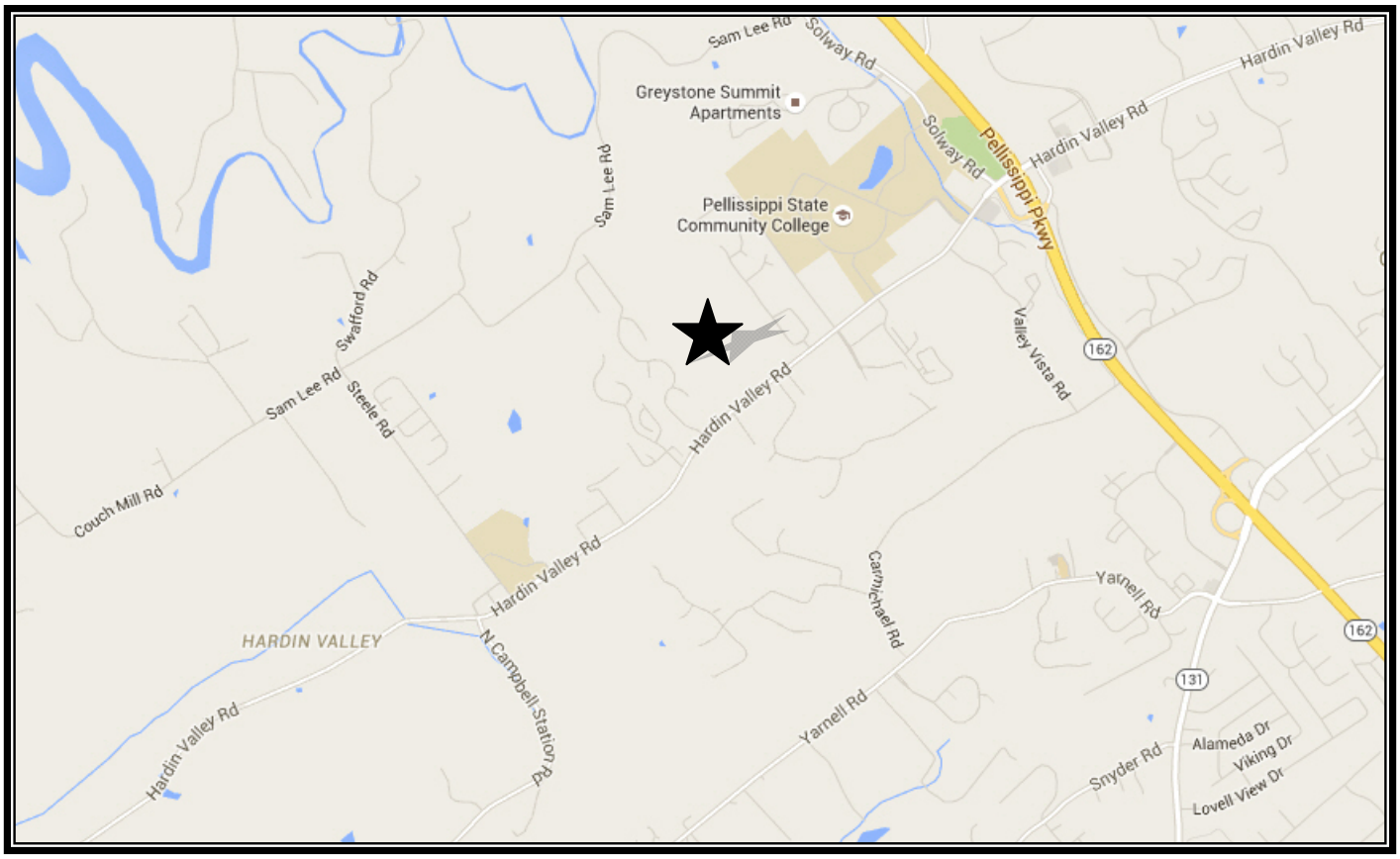

TRAFFIC IMPACT STUDY

LAUREL RIDGE

KNOX COUNTY, TENNESSEE

-Prepared For-

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Revised March 30, 2016

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INTRODUCTION

The purpose of this traffic study is to analyze the traffic impacts of a new proposed residential subdivision in Knox County, Tennessee. At this point in the concept stage, this development is named Laurel Ridge. This development is being proposed to the north of Hardin Valley Road and to the south of Sam Lee Road in west Knox County. This traffic impact study follows the procedures and standards as outlined for a Level 1 study in accordance with the standards set forth by the Knoxville/Knox County Metropolitan Planning Commission.

In this study the following analyses/methodologies were conducted:

- A review of the operating characteristics of the existing adjacent roadway system that will provide access to the proposed site
- Determination and application of the trips to the existing adjacent road system that are expected to be generated by the proposed development
- Evaluation of the road system locations to determine the potential traffic impacts of the proposed development
- Identification of recommendations for road improvements that would mitigate the expected increase in traffic volume from the projected future traffic volumes

PROJECT DESCRIPTION

The proposed location of this new development is shown on a map in Figure 1. The development is to be located adjacent to Hardin Valley Road approximately one mile to the southwest of the intersection of Hardin Valley Road and Pellissippi Parkway. Immediate access to the development will be provided by Hardin Valley Road to the south. In the adjacent vicinity of this study area, there are a several other residential subdivisions, individual residences, undeveloped properties, businesses, and schools. The existing site primarily consists of undeveloped woods and pasture land. Conner Creek bisects the property on the southern end and the property has several large sinkholes.

The proposed subdivision is expected to be comprised of several new internal drives on approximately 73 acres. At this stage, the subdivision design contains a maximum of 225 single family residential lots.

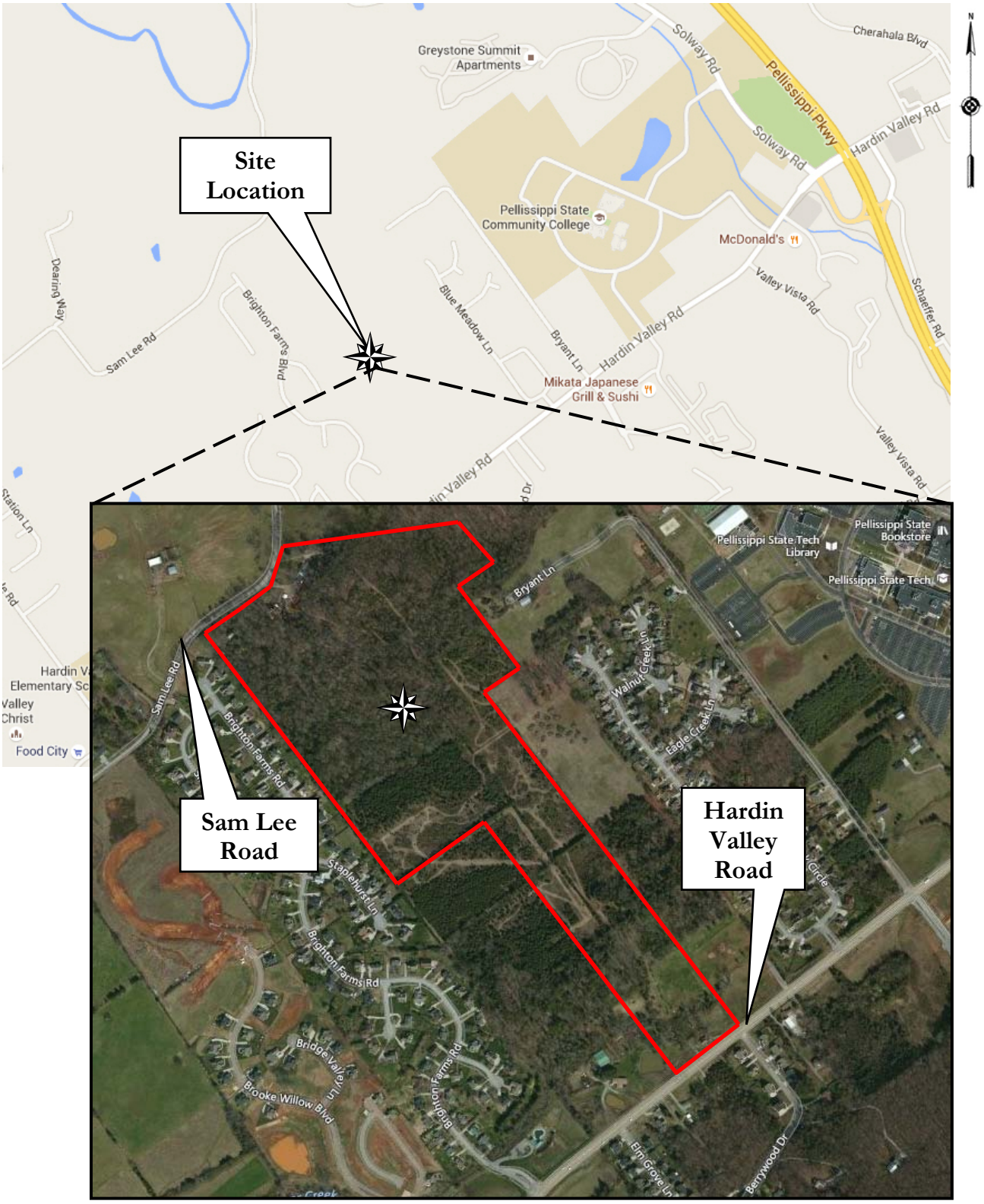


Figure 1
Location Map

The proposed plan layout given by David Campbell, PE is shown in Figure 2a. As can be seen in the figure, one main entrance will tie onto Hardin Valley Road. Figure 2b shows the typical road cross sections for the development.

The actual schedule for completion of this new residential development is dependent on economic factors. However, the current market in this area of Knox County is experiencing renewed rapid growth. This project is also contingent on permitting, design, and other issues. However, for the purposes of this study, it was assumed that the total construction build-out of the development will occur by the year 2021 (in 5 years).

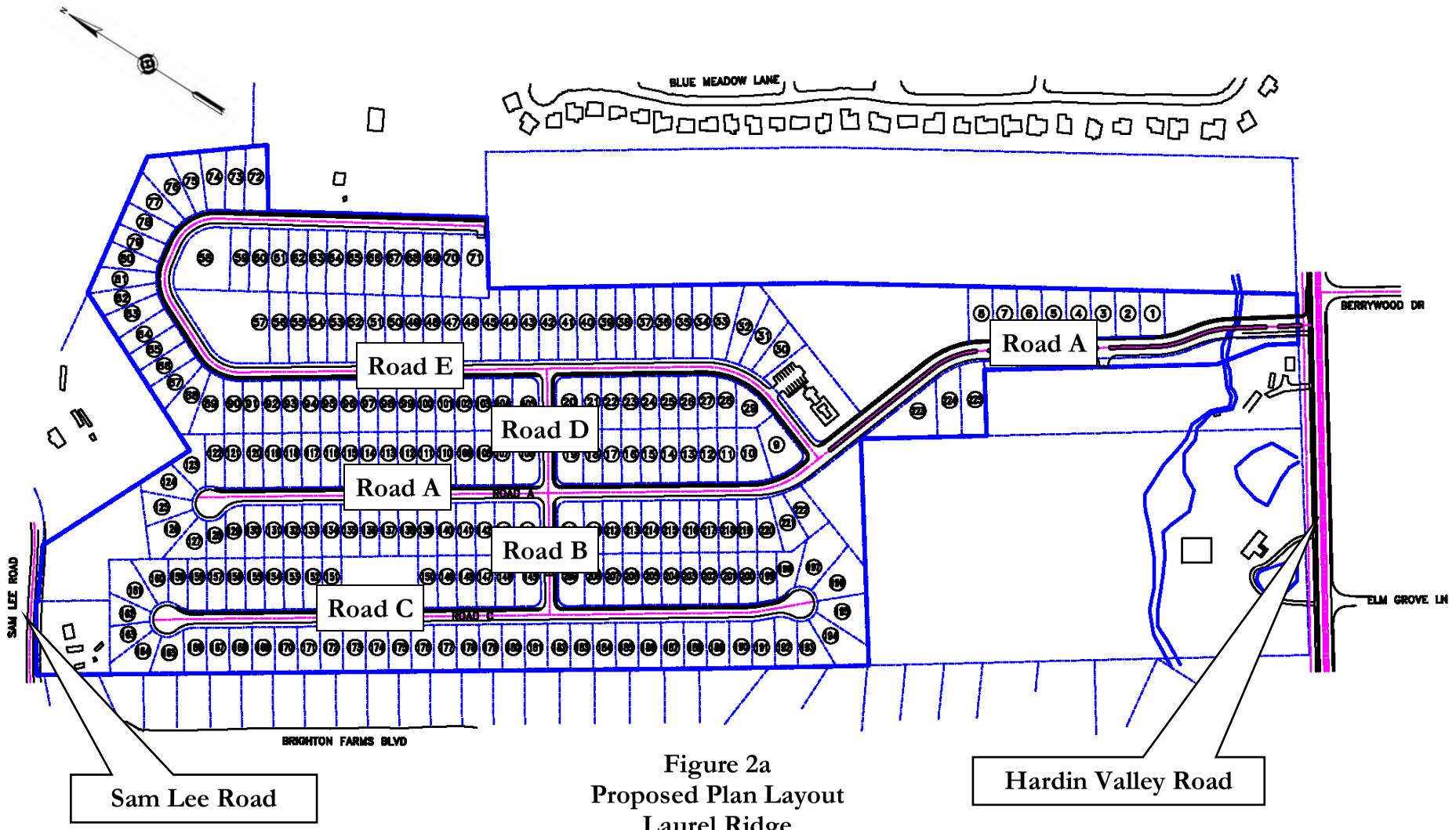
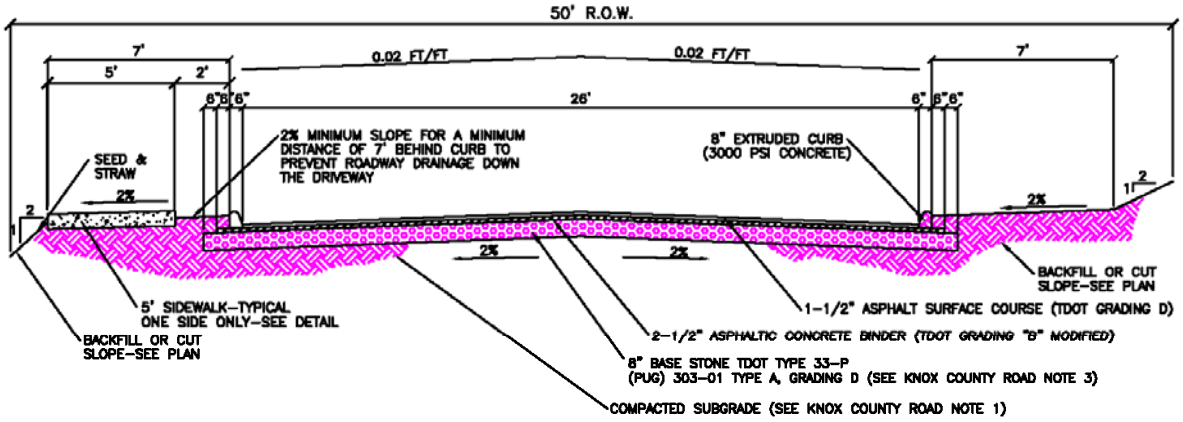
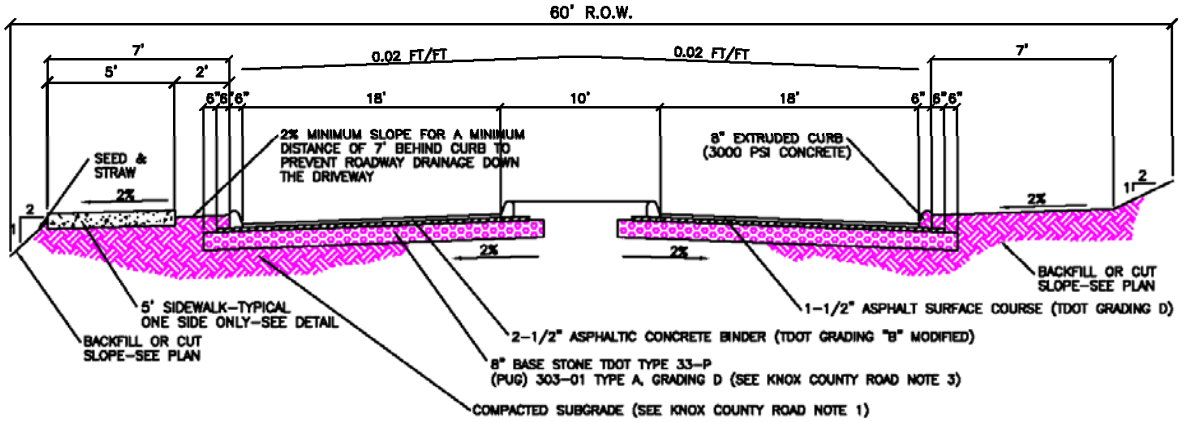


Figure 2a
Proposed Plan Layout
Laurel Ridge



TYPICAL KNOX COUNTY ROAD CROSS SECTION
NOT TO SCALE

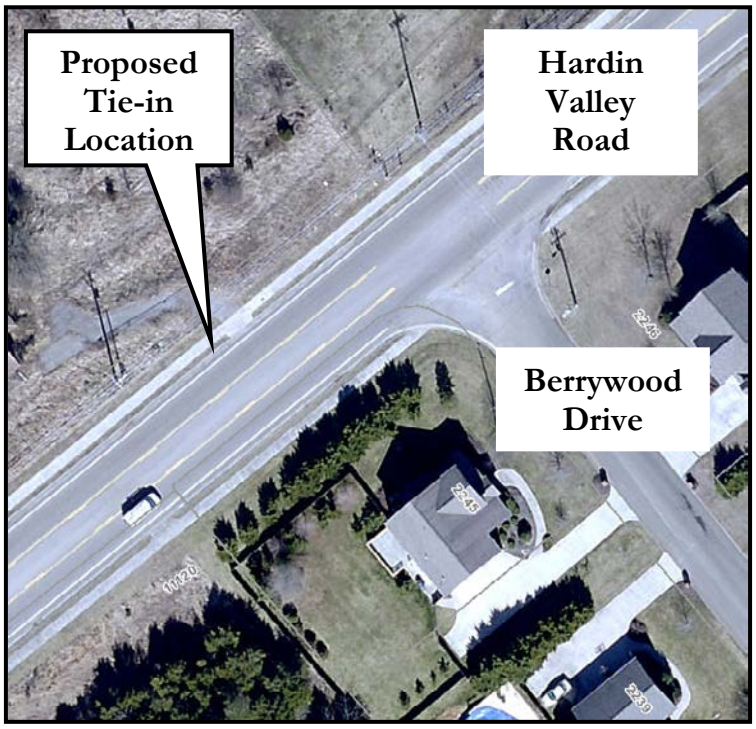


TYPICAL BOULEVARD ROAD CROSS SECTION STA 0+00 - 5+22
NOT TO SCALE

Figure 2b
Proposed Typical Road Cross Sections
Laurel Ridge

EXISTING CONDITIONS IN STUDY AREA

Hardin Valley Road is classified as a Minor Arterial and traverses in a general northeast-southwest direction. Hardin Valley Road intersects Pellissippi Parkway at a bridge underpass to the northeast. The speed limit on Hardin Valley Road is posted at 40 mph in the project area. Hardin Valley Road at the proposed road connection for the subdivision consists of a 3-lane section that includes a center two way turn lane that separates the opposing traffic and there are concrete sidewalks on both sides. Hardin Valley Road in the study area has a fairly level vertical alignment. In the Major Road Plan published by the MPC, Hardin Valley is listed as having 88 feet of right-of-way at this project location.



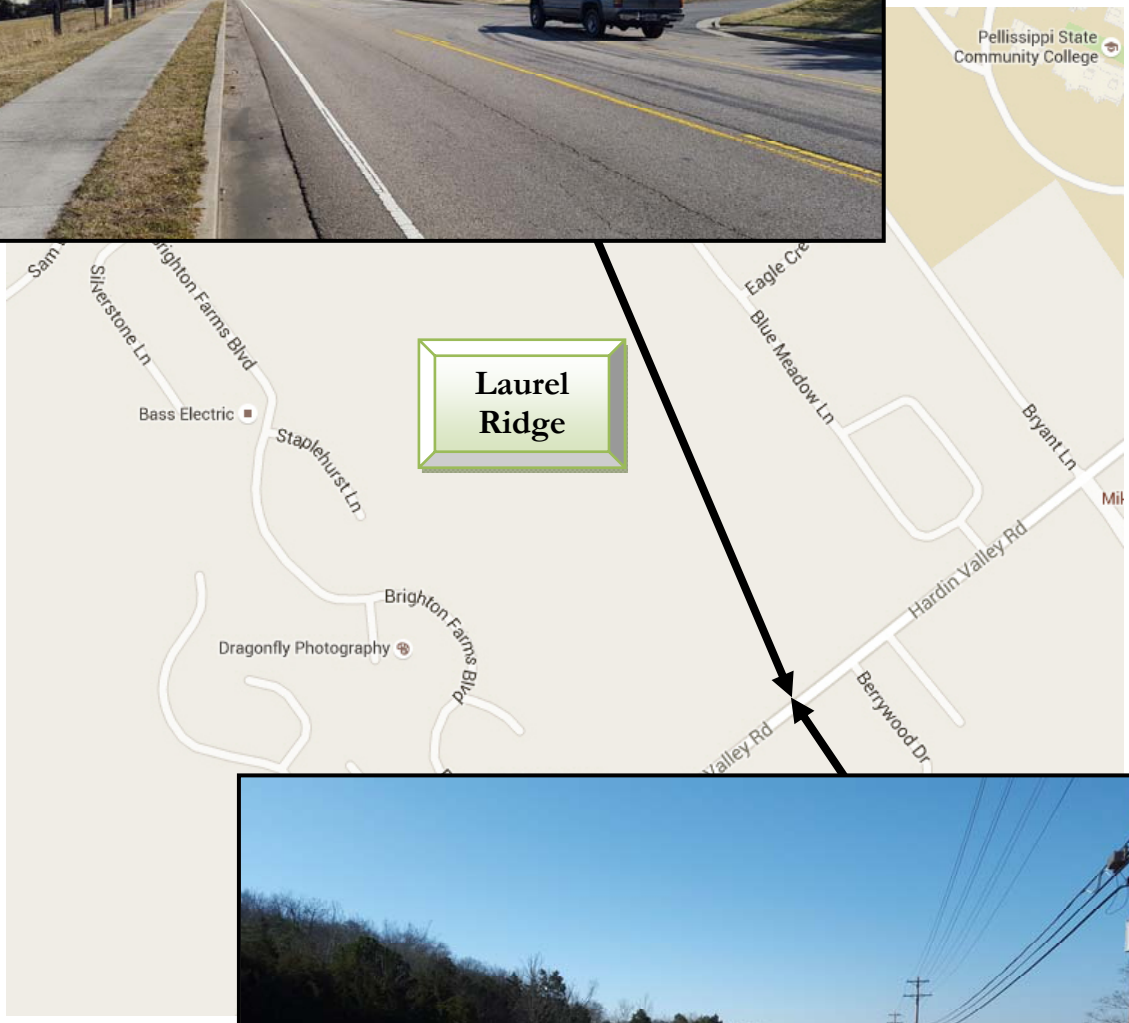
Hardin Valley Road at Berrywood Drive

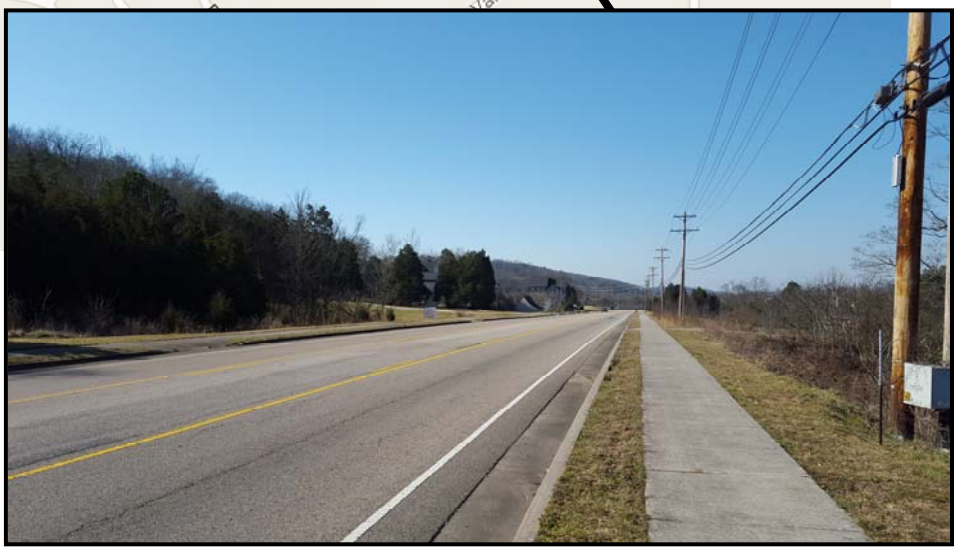
Hardin Valley Road provides road access to several schools in the surrounding area. Pellissippi State Community College is located about 2,100 feet to the northeast of the site and Hardin Valley Academy (high school) and Hardin Valley Elementary are located approximately 4,800 feet to the southwest of the project site. Hardin Valley schools have flashing school beacons for northeast-bound and southwest-bound traffic. During the periods of operation, the flashing school beacon indicates a speed limit of 20 mph.

Berrywood Drive is a residential local street that intersects Hardin Valley Road just to the south and east of the property. Average Daily Traffic (ADT) on Hardin Valley Road northeast of the project site near Pellissippi Parkway was reported by the Tennessee Department of Transportation (TDOT) at 17,441 vehicles per day in 2014 (Station #000084). Historical TDOT traffic count data can be viewed in Appendix A.

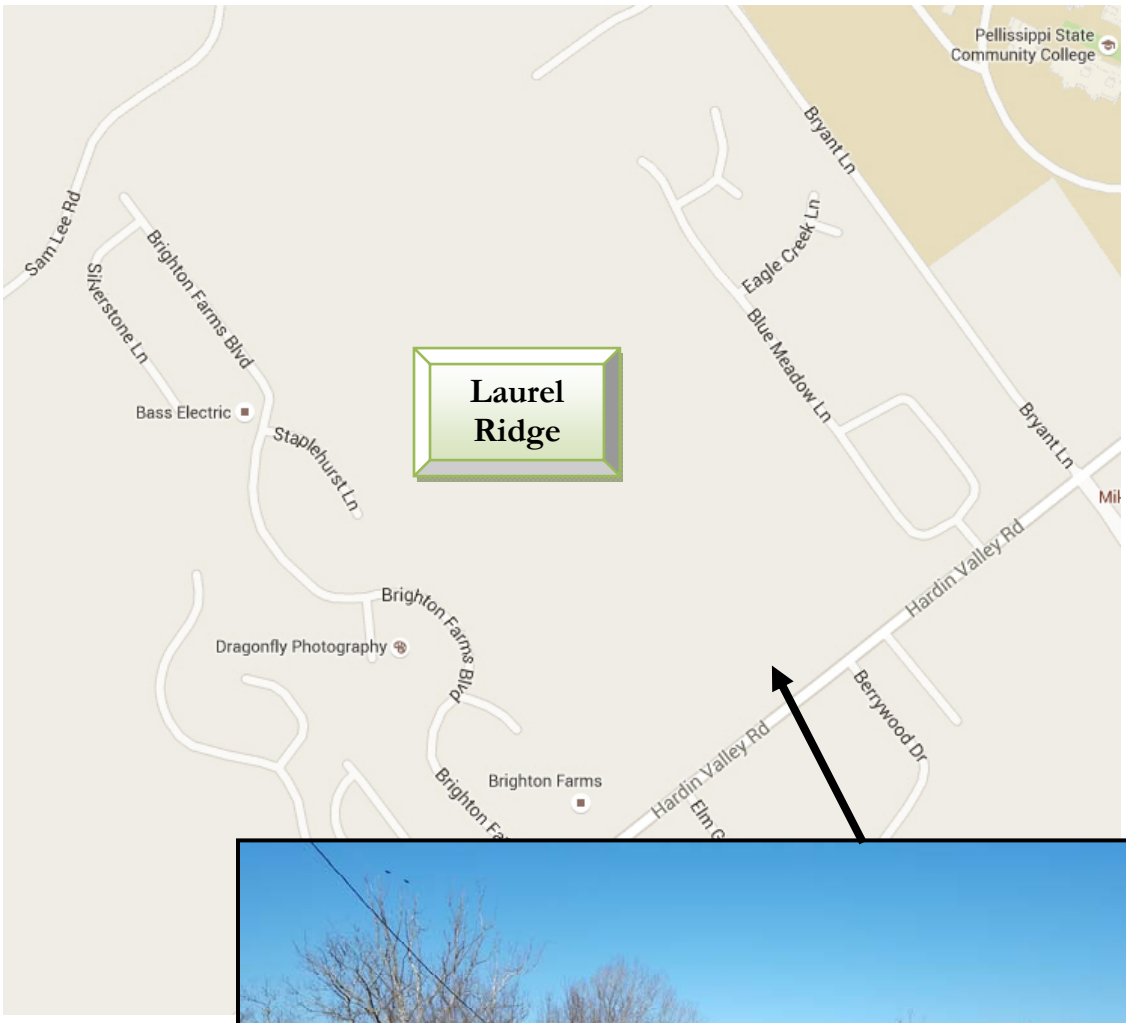
PHOTO EXHIBITS

View of Hardin Valley Road at Proposed Tie-In Location
(Looking Northeast)





View of Hardin Valley Road at Proposed Tie-In Location
(Looking Southwest)

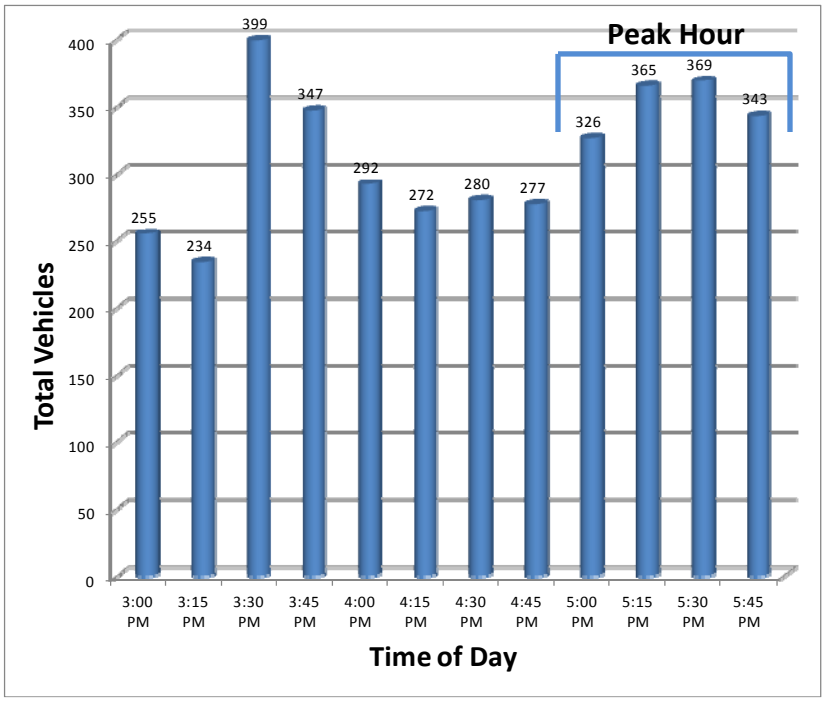


View of Hardin Valley Road at Proposed Tie-In Location
(Looking Northwest)

EXISTING TRAFFIC VOLUMES

In order to analyze the traffic impacts associated with the proposed future development, traffic counts were obtained at Hardin Valley Road near the proposed tie-in point for the subdivision. The counts included the intersection of Hardin Valley Road at Berrywood Drive. Turning movement counts were counted at this intersection on Hardin Valley Road due to its close proximity to the proposed entrance for Laurel Ridge. Also, the turning movements were counted and observed to help extrapolate future directional travel movements for the new proposed intersection.

The traffic count on Hardin Valley Road was obtained on Thursday, February 18th, 2016 for a total of 8 hours. The counts were conducted during the morning, mid-day and afternoon peak periods. The local schools were in session when the traffic counts were conducted. Based on the traffic volumes counted, the AM peak hour of traffic was observed at 7:30 - 8:30 at the intersection of Hardin Valley Road and Berrywood Drive. The PM peak hour was from 5:00 - 6:00 at the intersection with a significant secondary 15 minute peak at 3:30 PM during the local school dismissal. The manual tabulated traffic counts can be reviewed in Appendix B and the existing peak hour volumes are shown in Figure 3. The individual 15 minute periods during the PM traffic count are also shown here for informational purposes.



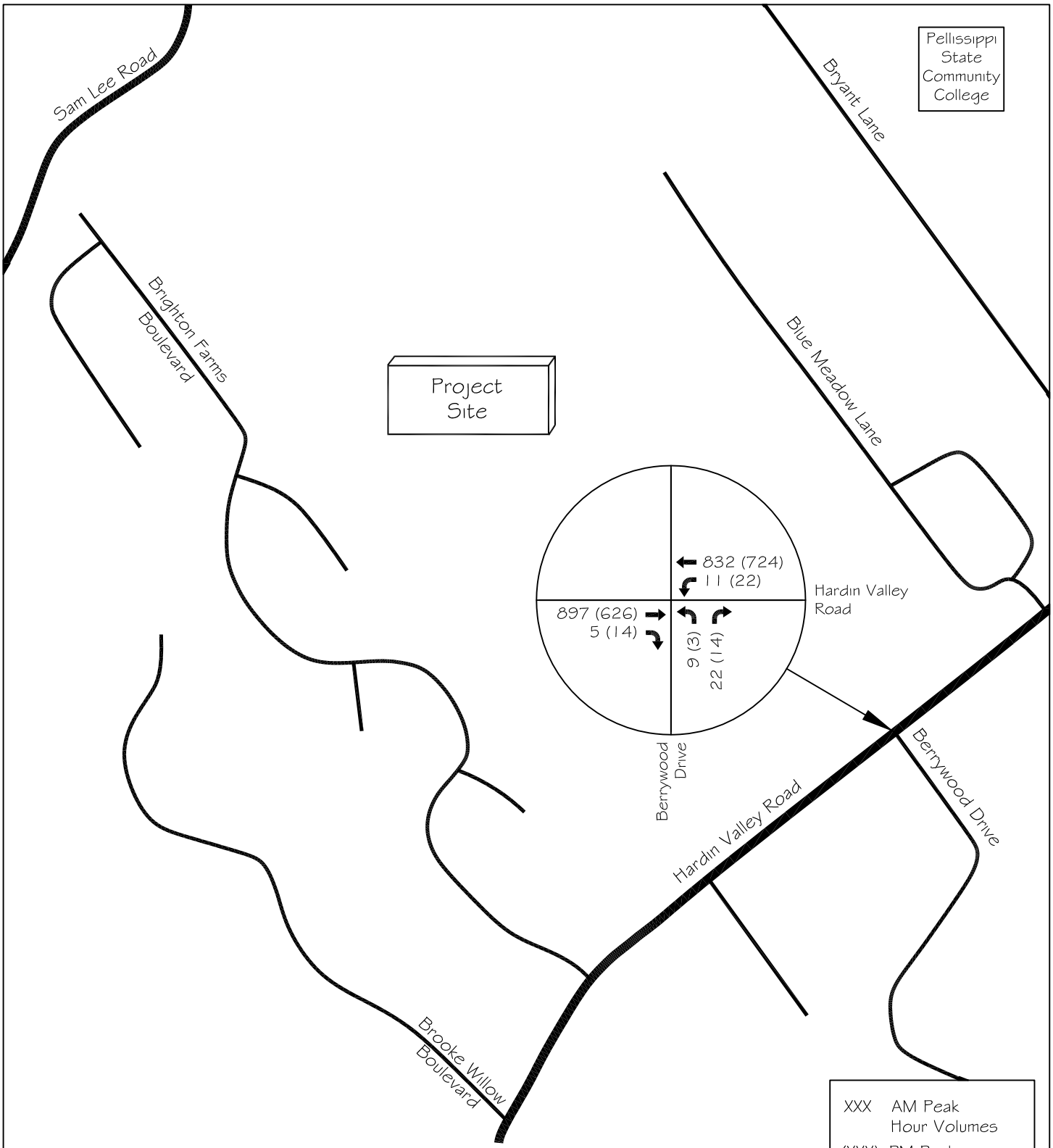
Existing PM Traffic Count Results

During the traffic counts on Hardin Valley Road, it was observed that significant northeast-bound traffic queues formed from approximately 3:40 to 3:50 pm. These queues extended back from the existing signalized intersection at the driveway to Pellissippi State Community College. This signalized intersection is approximately 2,100 feet to the east of

Berrywood Drive. This observed queue extended to a maximum just partially past Berrywood Drive in the northeast direction. This queue was the result of large amount of traffic leaving the Hardin Valley schools for the afternoon dismissal.

A handful of bicyclists were observed during the counts. Fourteen pedestrians were observed crossing Berrywood Drive on the southern side of Hardin Valley Road and twenty-three pedestrians were observed on the north side of the Hardin Valley Road sidewalk. Two school busses heading northeast-bound on Hardin Valley Road were observed stopping at Berrywood Drive to unload children during the traffic counts in the afternoon.

Capacity analyses utilizing the 2016 existing volumes were not conducted for the proposed site access since the intersection does not currently exist with development traffic.



Volumes shown here are from manual traffic counts as described in Existing Traffic Volumes in the report

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FIGURE 3

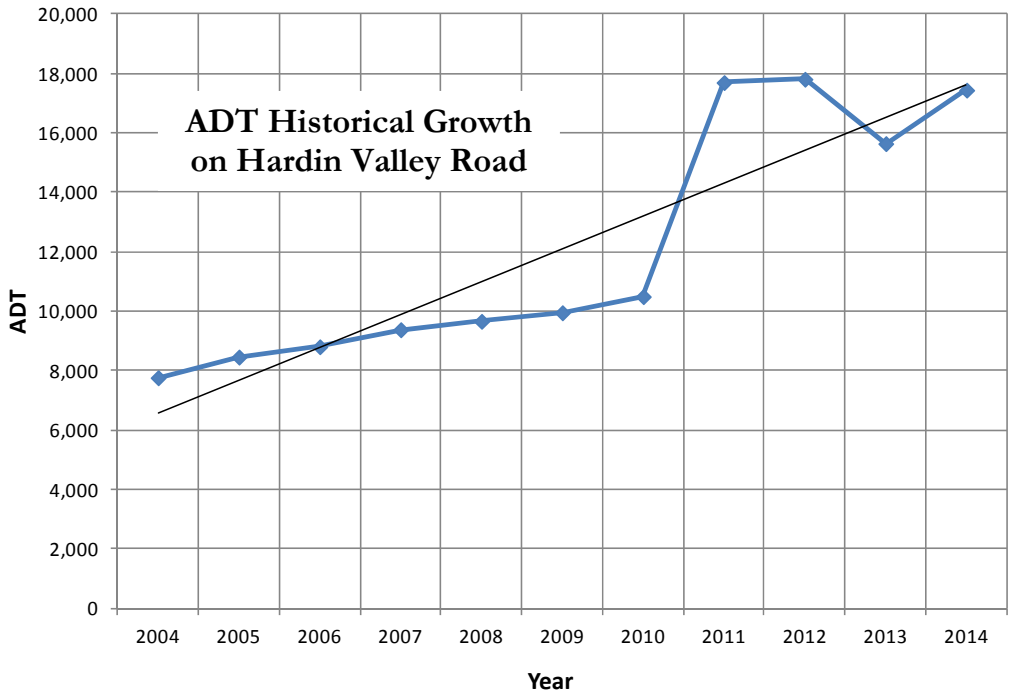
Laurel Ridge Subdivision

2016 Peak Hour Traffic Volumes - EXISTING

BACKGROUND TRAFFIC VOLUMES

Background traffic volumes are estimates of non-development related traffic for a particular horizon or design year. These background traffic volume estimates represent the future base condition for which the proposed study area is potentially subject to without the project being developed.

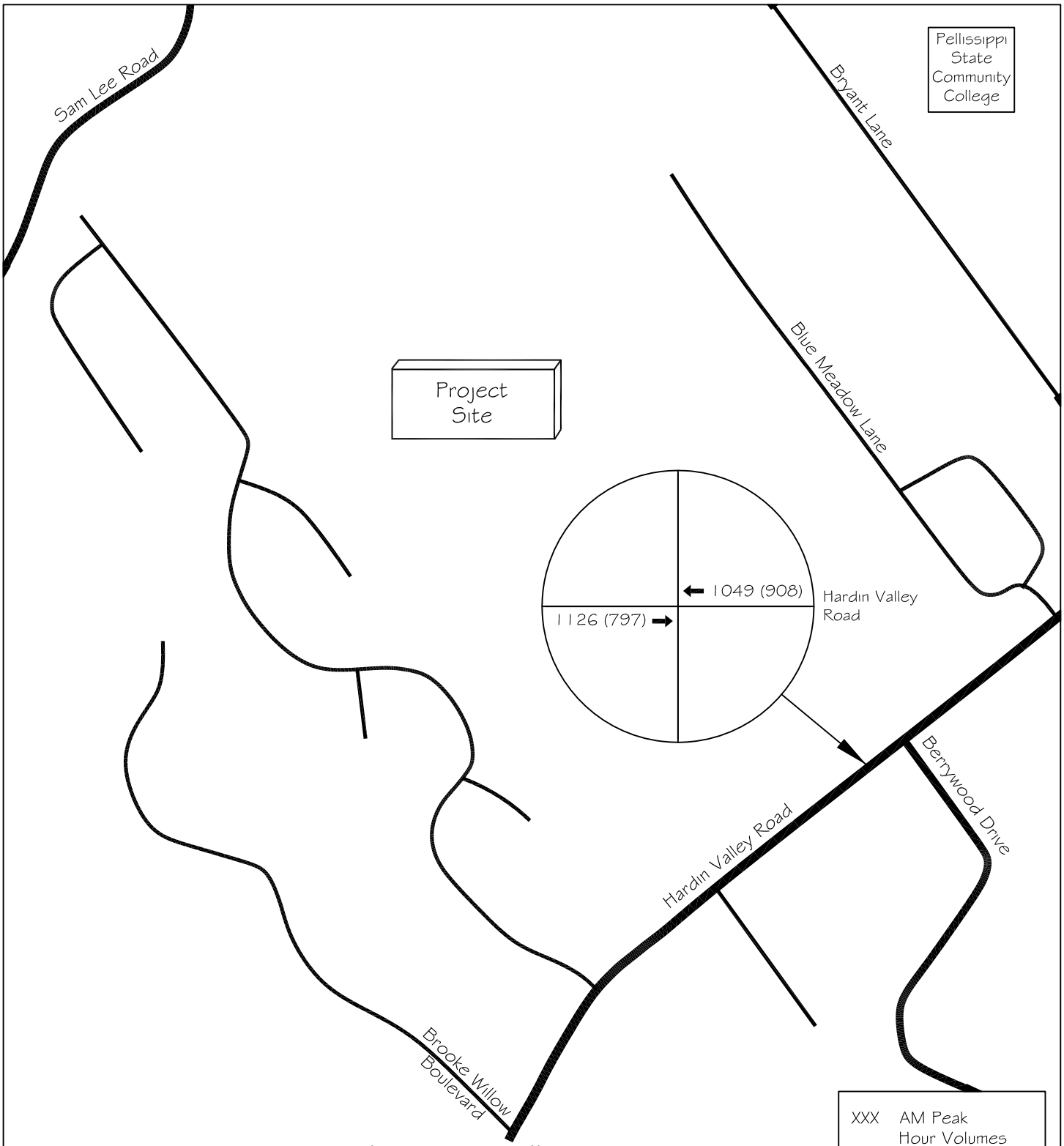
As previously stated, the build-out year for the proposed new residential subdivision was assumed to occur in 2021. Traffic growth on Hardin Valley Road has exploded over the last 10 years due to the construction of the Hardin Valley schools and the expansion of residential development in the area. However, the past 4 years of traffic counts on Hardin Valley Road have shown the traffic volumes leveling out. This historical TDOT traffic count data can be viewed in Appendix A.



Groundbreaking has just occurred for a new middle school that will be built adjacent to the Hardin Valley high school and elementary schools. The middle school is expected to be open by the year 2018. Currently all middle school students in the study area attend Karns Middle School on Oak Ridge Highway which is located several miles away to the north and east of the proposed subdivision. It is not known at this time what level of growth on Hardin Valley

Road will occur due to the addition of the new middle school. Some growth will be expected on Hardin Valley Road due to the new school but some of this growth will be offset with the sharing of the three school bus routes, carpooling, and trips that would be occurring otherwise for attendance to the other schools.

Nevertheless, it was assumed that with the residential growth in the area and the new middle school, traffic volumes will begin to increase at a fairly rapid rate. Therefore, background traffic volumes for this project were calculated by applying a 5% annual growth rate to the calculated existing traffic volumes shown in Figure 3. This 5% growth is used to take into account the future development in the area and rising travel volumes from the current time frame to the year 2021. The results of this growth rate application to the existing traffic volumes can be seen in Figure 4 for the year 2021.



Volumes shown here are calculated from existing traffic volumes with a growth factor as described in Background Traffic Volumes in the report

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FIGURE 4

Laurel Ridge Subdivision

2021 Peak Hour Traffic Volumes - BACKGROUND

TRIP GENERATION

The estimated amount of traffic that will be generated by the proposed residential subdivision was calculated based upon rates and equations for peak hour trips provided by Trip Generation Manual, 9th Edition, a publication of the Institute of Transportation Engineers (ITE). A generated trip is a single or one-direction vehicle movement that is either entering or exiting the study site. The Trip Generation Manual is the traditional and most-sourced resource for determining trip generation rates when traffic impact studies are produced. The Manual lists and includes data for a variety of land uses. The data from ITE for the land use below is shown in Appendix C. A summary of this information is presented in the following table:

TABLE 1
TRIP GENERATION FOR LAUREL RIDGE

ITE LAND USE CODE	LAND USE DESCRIPTION	UNITS	GENERATED DAILY TRAFFIC	GENERATED TRAFFIC AM PEAK HOUR			GENERATED TRAFFIC PM PEAK HOUR		
				ENTER	EXIT	TOTAL	ENTER	EXIT	TOTAL
				25%	75%		63%	37%	
#210	Single-Family Detached Housing	225 Lots	2,215	42	126	168	137	81	218
Total New Volume Site Trips			2,215	42	126	168	137	81	218

ITE Trip Generation Manual, 9th Edition

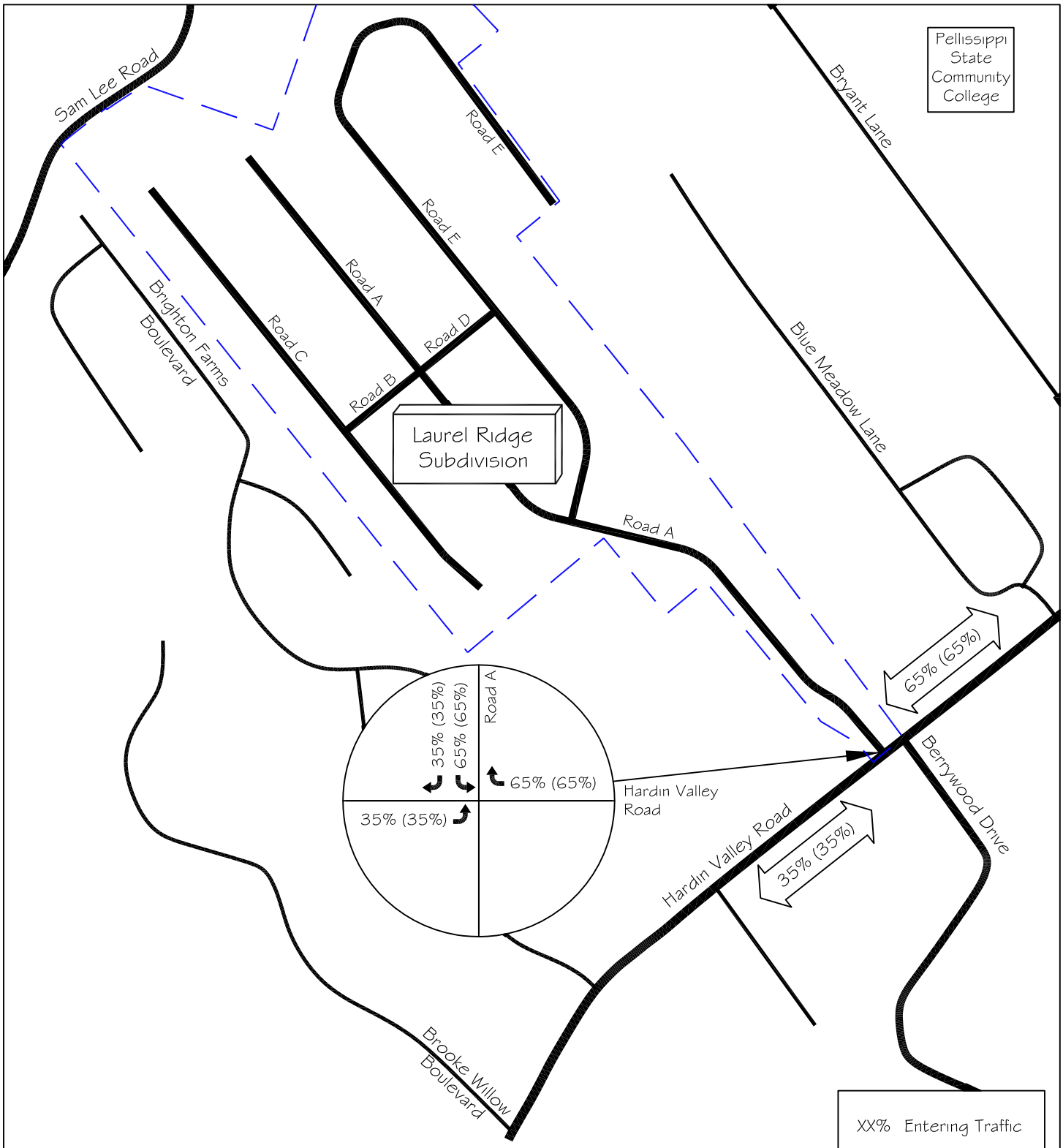
Based on these calculations, it is expected that 42 vehicles will enter the development, 126 will exit, for a total of 168 new generated trips during the AM Peak Hour (7:30 AM – 8:30 AM) in the year 2021. Similarly, it is expected that 137 vehicles will enter the development, 81 will exit, for a total of 218 new generated trips during the PM Peak Hour (5:00 PM – 6:00 PM) in the year 2021. The calculated trips generated for an average day are expected to be approximately 2,215 vehicles for the entire 225 lot development.

TRIP DISTRIBUTION & ASSIGNMENT

Figure 5 shows the projected distribution for traffic entering/exiting the new residential subdivision during the future peak hours at the new proposed road entrance/exit on Hardin Valley Road. The percentages shown only pertain to the new trips generated by the new residential dwellings in the subdivision.

There are a variety of nearby developments that will potentially "attract" the projected generated traffic to and from the new subdivision, the largest being the Hardin Valley Academy (high school), Hardin Valley Elementary School, Pellissippi State Community College, and the soon to be built Hardin Valley Middle School. Pellissippi Parkway will be the major adjacent access for further destinations in the surrounding Knoxville area.

The projected trip distributions are based on the existing traffic movements at the examined roadway and also surmised from the aforementioned surrounding concentrations of development and population. The turning movements that were counted at the intersection of Hardin Valley Road at Berrywood Drive were also used to help assume projected trip distributions. Currently 74 residential lots access Berrywood Drive as the only means of access. Figure 6 shows the Traffic Assignment of the computed trips that will be generated by the development (as shown in Table 1) that is applied to the various intersection movements based on the assumed distribution of trips shown in Figure 5.



Percentages shown here are assumed as described in Trip Distribution & Assignment in the report

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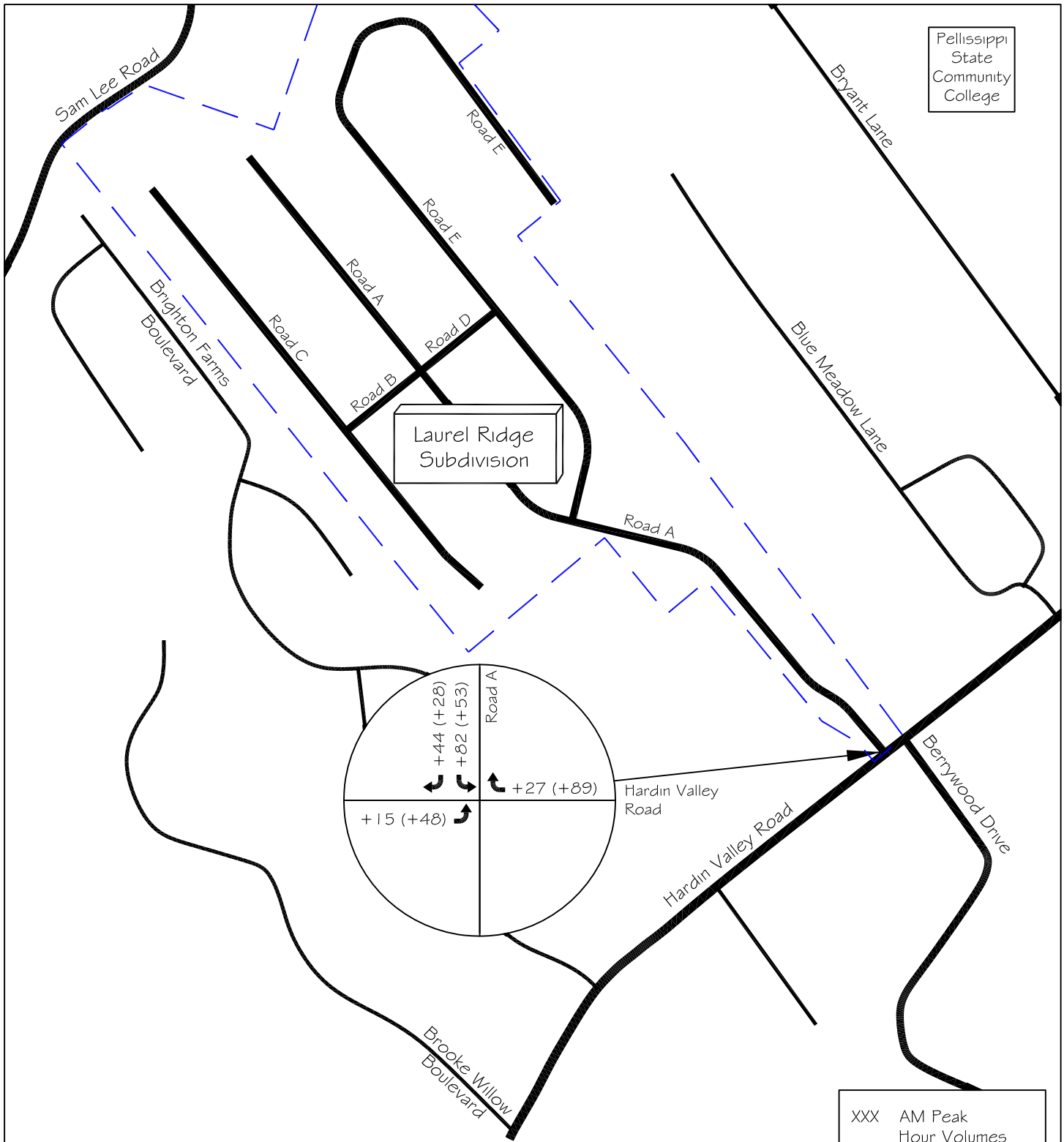
FIGURE 5

Laurel Ridge Subdivision

Directional Distribution of Generated Traffic for Laurel Ridge



Volumes shown here are the calculated Trip Generation Volumes from Table 1 according to Directional Distributions from Figure 5

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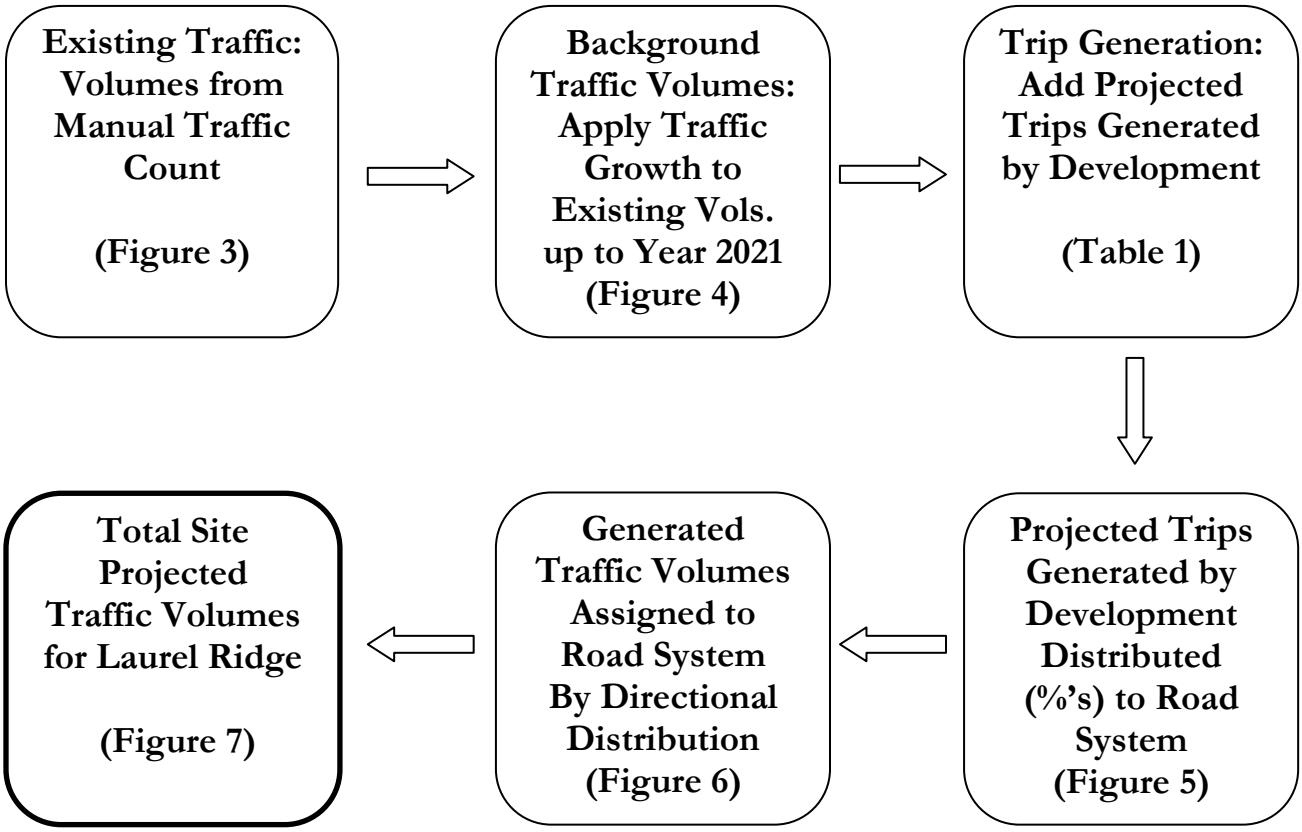
FIGURE 6

Laurel Ridge Subdivision

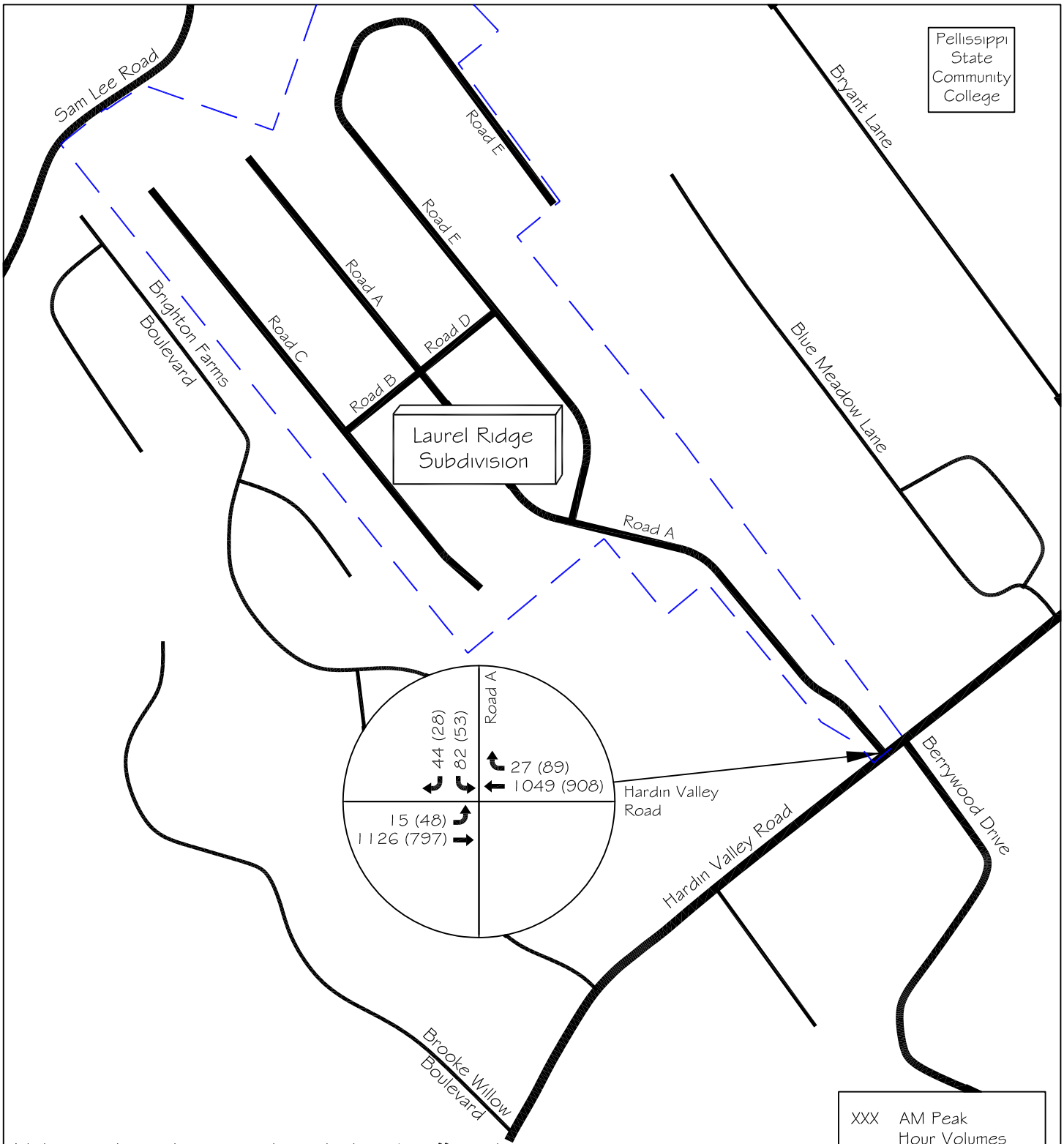
Traffic Assignment of Generated Traffic for Laurel Ridge

PROJECTED TRAFFIC VOLUMES

Overall, several additive steps were taken to calculate the total future projected traffic volumes at the studied unsignalized intersections when the residential subdivision is fully constructed and built-out (by 2021). The steps as described previously are illustrated below for clarity:



To calculate the total future projected traffic volumes at the proposed intersection on Hardin Valley Road, application of the calculated peak hour traffic (from Table 1) generated by the new proposed Laurel Ridge were added to the 2021 background traffic volumes (shown in Figure 4) in accordance to the predicted directional distributions and assignments (shown in Figure 5 and 6). This procedure was necessary to obtain the total projected traffic volumes at the time the development is fully built-out by the year 2021. Figure 7 shows the projected AM and PM peak hour volumes at the studied intersection for the year 2021. (Note: In Figures 6 & 7, the subdivision tie-in street is labeled as Road "A" in accordance to the concept plan.)



Volumes shown here are the calculated traffic volumes from Figures 5 & 6 added to the background traffic volumes shown in Figure 4

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FIGURE 7

Laurel Ridge Subdivision

2021 Peak Hour Traffic Volumes - PROJECTED

Capacity analyses were undertaken to determine the existing Level of Service (LOS) for the proposed intersection. The capacity analyses were calculated by following the methods outlined in the Highway Capacity Manual and using Synchro Traffic Software (Version 8). Appendix D includes the worksheets for these capacity analyses.

LOS is an indication of how well an intersection or roadway performs, and LOS designations include LOS A through LOS F. The designation of LOS A signifies a roadway or intersection operating at best, while LOS F signifies road operations at the worst. The Highway Capacity Manual lists level of service criteria for unsignalized intersections and is presented in this report as Table 2.

(Source: FDOT)

For unsignalized intersections, LOS is measured in terms of delay (in seconds). This measure is an attempt to quantify delay that includes lost travel time, driver discomfort, and fuel consumption. LOS for unsignalized intersections are only calculated for turning movements associated with stop or yield control and also for left turns on "un-controlled" major streets. In other words, the delays of vehicles making left and right turns out of side streets and left turns off of the main street are the main factors for determining the

TABLE 2

LEVEL OF SERVICE AND DELAY FOR UNSIGNALIZED INTERSECTIONS

LEVEL OF SERVICE	DESCRIPTION	DELAY RANGE (seconds/vehicle)
A	Little or no delay	≤ 10
B	Short Traffic Delays	>10 and ≤15
C	Average Traffic Delays	>15 and ≤25
D	Long Traffic Delays	>25 and ≤35
E	Very Long Traffic Delays	>35 and ≤50
F	Extreme Traffic Delays	>50

Source: Highway Capacity Manual

operational performance and level of service of the intersections. Generally, for most instances, LOS D is considered the lowest limit of acceptable delay.

From the capacity calculations, the results from the existing peak hour traffic can be seen in Table 3 for the intersection. The intersection is shown with a LOS designation for the AM and PM peak hours in the table and delay (in seconds). For the proposed new intersection on Hardin Valley Road at Road "A", the peak hour levels of service are shown to operate at fairly respectable condition for entering vehicles during both the AM and PM peak hours but somewhat poor conditions for exiting vehicles during the AM peak. (Note: For the proposed intersection, the exiting approach out of the development is labeled as southbound and the left turns into the development are labeled as eastbound. Also, the southbound exit for the subdivision was modeled with separate left and right turns.)

TABLE 3
2021 PEAK HOUR LEVEL OF SERVICE & DELAY - PROJECTED

INTERSECTION	TRAFFIC CONTROL	APPROACH	LEVEL OF SERVICE		DELAY (seconds)	
			AM PEAK	PM PEAK	AM PEAK	PM PEAK
Hardin Valley Road at Laurel Ridge (Road A)	 Unsignalized	Southbound Left	E	C	40.2	24.4
		Southbound Right	D	C	26.7	17.8
		Eastbound Left	B	B	11.7	10.9

Note: All analyses were calculated in Synchro 8 software and reported with HCM 2000 methodology

TRAFFIC SIGNALIZATION WARRANTS

To determine whether the future traffic conditions might warrant a traffic signal, this study included examining traffic signal warrants. The Manual on Uniform Traffic Control Devices – 2009 Edition (MUTCD) presents 9 different warrants that have been developed by the traffic engineering profession as a means to determine whether or not a traffic signal is warranted. These warrants cover a broad range of minimum elements required to indicate whether a traffic signal is justified for any particular location. These elements exist of traffic volumes, pedestrian volumes, accident history, and other factors. The MUTCD explicitly states that a traffic control signal should not be installed unless one or more of the signal warrants in the manual are met. However, the satisfaction of a warrant does not entirely in itself justify the need for a traffic signal. Sometimes further engineering studies and judgments also need to be applied before justifying the need for a traffic signal to be installed.

Although the MUTCD provides 9 different warrants, only three of these are potentially applicable in this case for the intersection of Laurel Ridge Road "A" and Hardin Valley Road. These three warrants are as follows:

Warrant 1, Eight-Hour Vehicular Volume

Warrant 1 is comprised of 2 conditions – A and B. The Minimum Vehicular Volume, Condition A, is intended for application where the volume of intersecting traffic is the principal reason for consideration of signal installation. The Interruption of Continuous Traffic, Condition B, is intended for application at locations where Condition A is not satisfied and where the traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict in entering or crossing the major street. A total of 8 unique hours must be met to satisfy this warrant.

Warrant 2, Four-Hour Vehicular Volume

The Four-Hour Vehicular Volume signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal. A total of 4 unique hours must be met to satisfy this warrant.

Warrant 3, Peak Hour

The Peak Hour signal warrant is intended for use at a location where traffic conditions are such that for a minimum of 1 hour of an average day, the minor-street traffic suffers undue

delay when entering or crossing the major street. A total of 1 unique hour must be met to satisfy this warrant.

The proposed intersection of Laurel Ridge Road "A" and Hardin Valley Road was evaluated for possible justification for a traffic signal based on the MUTCD Warrants listed above. Laurel Ridge Road "A" was used as the minor side street for the warrant analysis and Hardin Valley Road was the major street. Right turn volumes were excluded in the evaluation. This evaluation was based on the projected traffic volumes (Figure 7) at the intersection in the year 2021. The volumes from the peak hour trip generation for the subdivision were used as the side street volumes. The intersection did not satisfy Warrant 1, 2, or 3 in this analysis during the two peak hours in the morning and afternoon. The intersection volumes only met Warrant 1 and Warrant 2 for one unique hour for the two peak hours.

It is not anticipated that the site entrance would meet the warrants if additional hours were analyzed. The volumes required that would trigger satisfying any of the warrants would need to materialize from the side street volumes (from the development). However, it is not expected that the projected volumes calculated to be generated by the development will be exceeded in the future. Generally, it is expected that the number of calculated trips generated by this development will be an overestimation. The results of the traffic signal warrant assessments are located in Appendix E.

SPOT SPEED STUDY

As a further investigation of the study area, a spot speed study was also conducted. The spot speed study was conducted on Hardin Valley Road to sample and tabulate the existing motoring speeds along the road in the vicinity of the proposed development. The equipment used for the speed study was a Bushnell Speedster III Radar Speed Gun. The results of the study indicate that the majority of the traffic along Hardin Valley Road travels at a greater speed than the posted speed limit. The posted speed limit for Hardin Valley Road is 40 mph. The results of the spot speed study indicate that the observed 85th percentile speed was just at 51 mph near the proposed intersection at Hardin Valley Road. The spot speed field observations are provided in Appendix F.

EVALUATION OF TURN LANE THRESHOLDS

The proposed intersection to be located at Hardin Valley Road for the development was also evaluated for the need for a separate right turn lane into the development on Hardin Valley Road. Hardin Valley Road currently has a continuous center left turn lane at the site and therefore a separate left turn lane into the site is already provided. Based on the projected traffic volumes at the subdivision entrance, it does appear that a separate southwest-bound right turn lane into the development will be warranted. This was determined by using "Knox County's Access Control and Driveway Design Policy" for turn lane requirements. The projected volumes for right turns into the development at the entrance are just slightly over the requirement threshold. The Knox County turn lane policy worksheet is located in Appendix G.

The design policy for turn lane warrants relate volume thresholds based on prevailing speeds for two-lane roadways. The speed classification that was chosen for this evaluation was based on the spot speed study that showed the 85th percentile speed was 51 mph. Therefore, this study evaluation used the Knox County classification for speeds of 46 to 55 mph and the calculated projected volumes. However, the separate right turn lane is also warranted for the actual posted speed limit of Hardin Valley Road with a lower threshold of speed between 36 to 45 mph.

CONCLUSIONS AND RECOMMENDATIONS

The following is an overview of recommendations to minimize the traffic impacts of the development with the surrounding road system while achieving an acceptable level of traffic flow, safety, and construction cost.

1) **Hardin Valley Road at Laurel Ridge Road "A":** From the capacity calculations, it has been shown (Table 3) that the northeast-bound left turns into the development at the entrance should operate very well during the AM and PM peak periods once the development is complete. The level of service for exiting vehicles out of the development will operate at a reduced level especially in the AM peak hour. For the AM peak period, southbound left-turning exiting vehicles are shown to operate at LOS E and southbound right-turning vehicles are projected to operate at LOS D. These lower levels of service are directly related to the large amount of thru vehicles on Hardin Valley Road in the peak periods that conflict with these exiting turning movements. During peak periods, queues should be expected to form at this southbound exiting approach and drivers will experience large delays.

   It is expected that these projected lower levels of service for exiting vehicles out of the subdivision could potentially operate at a greater level of service than reflected in this analysis. As stated previously, the existence and influence of the traffic signal on Hardin Valley Road to the northeast of the proposed site currently allows gaps in traffic and this should continue into the future conditions. This traffic signal influence is reflected in the creation of vehicle platoons with gaps in between due to the signal phase changes at the upstream traffic signal.

   1a) **From the capacity calculations, separate southbound left and right turn lanes are required at the main driveway intersection for exiting vehicles out of the development at Hardin Valley Road.** The LOS E that was reported for exiting left turns during the AM peak hour is based on separate left and right lanes. This allows separation of left turning vehicles and right turning vehicles for greater efficiencies and reduced queues. It should be noted, however, that even with separate turn lanes, the development will still potentially experience fairly large delays and queues during peak periods for left turning exiting vehicles

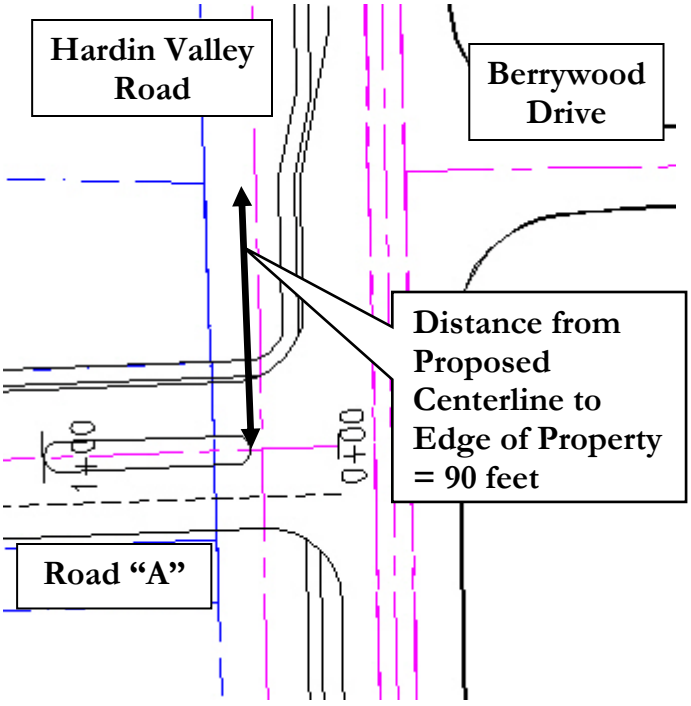
especially in the AM peak periods. Separating these two movements into separate lanes will allow an increase in the level of service for southbound exiting right turn movements.

1b) An analysis was undertaken to examine the potential queue length for southbound left turn vehicles based on the projected volumes. The computer software Synchro includes SimTraffic. Synchro performs the macroscopic calculations for intersections and SimTraffic performs micro-simulation and animation of vehicular traffic. Both software programs estimate 95th percentile queue lengths. The 95th percentile queue is a traditional measurement used when estimating queue distances. For this proposed intersection, the queue results were derived from Synchro since SimTraffic is not able to accurately model intersections with center two-way left turn lanes and their effects on gap acceptance.

Based on the software results in Synchro with the projected volumes, the 95th percentile queue distance was calculated to be 57 feet during the AM peak and 22 feet during the PM peak. However, to account for the variability of the traffic growth in the area, **it is recommended that the left turn lane exiting at the entrance be designed and constructed with at least 200 feet of left turn storage.** This would allow for approximately 10 vehicles to queue during peak times.

1c) Based on a speed of 50 mph on Hardin Valley Road (average observed speed was 51 mph), the recommended intersection sight distance requirement is 590 feet. While not surveyed in the field, from visual observation this distance is more than available for vehicles exiting Hardin Valley Road from the new proposed main driveway. The site designer should insure that these sight distance lengths are met and they should be labeled on the plans. The overall required sight distance should be measured at the intersection at a minimum of 14.5 feet off of the edge of the traveled way as shown in TDOT Standard Drawing RD01-SD-1.

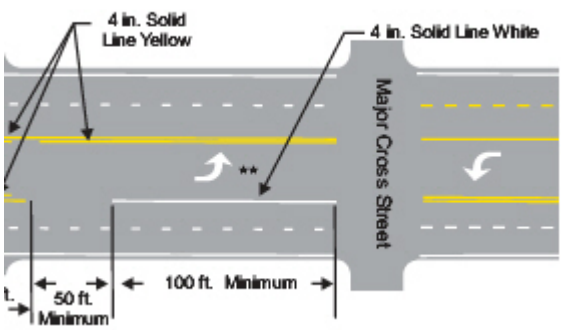
1d) **As described previously in <u>Evaluation of Turn Lane Thresholds</u> based on the traffic volumes and operating speeds on Hardin Valley Road, it is recommended that a separate southwest-bound right turn lane be designed and constructed at the entrance.** Typically the length of a right turn lane would be determined by calculating the stopping sight distance based on the observed operating speed. For an observed speed of 50 mph, this turn lane would need to be at least 425 feet in length. However, as seen in the figure on this page, the amount of available roadway frontage property for this development is nowhere near approaching this distance without encroaching on the adjacent property to the north and east. A right turn lane should be constructed with a maximum appropriate length as appropriate within the right-of-way that the property lines can allow. The current revised plan shows a right turn lane entering the development with a distance of 120 feet (including taper). While this design distance is not close to 425 feet (based on the observed speed), due to the site constraints, this distance will at least be somewhat beneficial for removing right turning vehicles from the thru traffic. For this westbound approach at the new intersection, the new right turn lane should be marked with the appropriate right turn pavement marking symbols. Refer to TDOT Roadway Design Guidelines for appropriate taper lengths and pavement markings.



1e) **It is recommended that the main entrance approach at the intersection with Hardin Valley Road be designed and constructed with a 24" white top bar and with a Stop Sign (R1-1). To accommodate pedestrians on the north side of Hardin Valley Road, the entrance should be designed**

appropriately with curb cuts and crosswalks markings.

1f) **The center of Hardin Valley Road should be re-striped to accommodate the new intersection with the new left turning movements into the development. The existing pavement marking for the continuous center turn lane should be converted into a pavement marking scheme that delineates an exclusive left turn lane into the subdivision. To accommodate the future left turns into the development from Hardin Valley Road, the exclusive left turn should be marked to delineate a storage length of 100 feet minimum. The gap opening in the pavement marking for the left turns should be 50 feet minimum.**



1g) **Intersection sight distance at the new proposed main entrance at Hardin Valley Road must not be impacted by new signage, future landscaping or existing vegetation.**

1h) The centerline of the proposed left turn of Road "A" exiting from the Laurel Ridge subdivision has been re-designed (as shown in Figure 2a) to intersect Hardin Valley Road approximately 110 feet from the centerline of the exiting lane out of Berrywood Drive. The narrowness of the project's property does confine the locations available for intersecting Road "A" into Hardin Valley Road. Additionally, the sale of the property is contingent on saving the existing home at Hardin Valley Road which would preclude shifting the entrance further away that as currently designed. The proximity of Road "A" and Berrywood Drive does provide the possibility for exiting left turning vehicles from each intersecting street to potentially interfere with each others' movements. This is particularly possible if the drivers utilize the existing continuous two-way center turn lane as a refuge in completing their turns onto Hardin Valley Road. However, the revised

design distance in between the exiting lane of Road "A" and the exiting lane of Berrywood Drive should be adequate for maintaining enough separation to avoid these conflicting turning movements. For a driver utilizing the center turn lane as a temporary refuge for completing their left turn, nearly 60 feet of two-way center turn lane storage would be left available if a turning radius of 25 feet for left turning exiting vehicles is assumed.

2) **Laurel Ridge Internal Drives and Sight Distance**: The current layout plans show 5 new roadways being constructed within the development labeled Road "A" thru Road "E" as shown on Figure 2a. Road "A" will be the connecting road to Hardin Valley Road.

2a) A Stop Sign (R1-1) should be installed at the Road "B' approach at the intersection of Road "C". A Stop Sign should also be installed at the Road "D" approach at the intersection of Road "E". Stop Signs (R1-1) should be installed at all of the approaches at the 4-way intersection of Road "A" at Road "B" and "D". Finally, a Stop Sign (R1-1) should be installed at the Road "E" approach at the intersection of Road "A".

2b) **Sight distance at all of the new internal "T" and four-way intersections must not be impacted by new signage, or future landscaping.** For an assumed posted 25 mph speed for the internal development streets, the recommended stopping sight distance is approximately 155 feet for level conditions and the intersection sight distance requirement is 275 feet. The road layout designer should insure that these sight distance lengths are met, maximized, and they should be labeled on the plans.

2d) **All road grade and intersection elements internally and externally should be designed to AASHTO, TDOT, and Knox County Engineering specifications and guidelines to ensure proper operation.**

2e) P**ossible traffic calming measures might be needed for this development.** The current road alignments within the development are straight and have been designed to maximize the lots on the property within a fairly narrow land parcel.

The narrowness of the land parcel hinders the potential to design curvature in the horizontal road alignment that could discourage excessive vehicular speeds. If excessive speeds and conflicts are observed once the new subdivision is developed, the developer should work with the Knox County Engineering Department to investigate traffic calming/speed reduction strategies. As currently exists within the adjacent existing subdivision on Hardin Valley Road, Brighton Farms, speed humps could be employed to lower speeds through the subdivision.

Ultimately, the traffic calming measures inside the project for the proposed roads will need to be coordinated with the Knox County Engineering and Public Works during the detailed design phase.

SUMMARY OF MAJOR RECOMMENDATIONS

The following is a summary of the major recommendations presented in this Traffic Impact Study for Laurel Ridge in Knox County, TN:

- Construct separate left and right turn lanes on Laurel Ridge Road "A" at the intersection at Hardin Valley Road with a recommended left turn lane with at least 200 feet of left turn storage. Stripe the two exiting lanes on Road "A" as a separate left turn and a separate right turn.

- Construct a separate southwest-bound right turn lane on Hardin Valley Road at the proposed entrance as shown on the revised design plan in Figure 2a with a minimum of 120 feet (including the taper length).

- Re-stripe the continuous center two-way left turn lane of Hardin Valley Road to accommodate the new intersection with the new left turning movements into the development.

- Recommended pursuing traffic calming measures for roads inside development due to lack of horizontal curvature and potential for excessive speeds. Alternatives could include speed humps. Traffic calming measures inside the project for the proposed roads will need to be coordinated with the Knox County Engineering and Public Works during the detailed design phase.

APPENDIX A

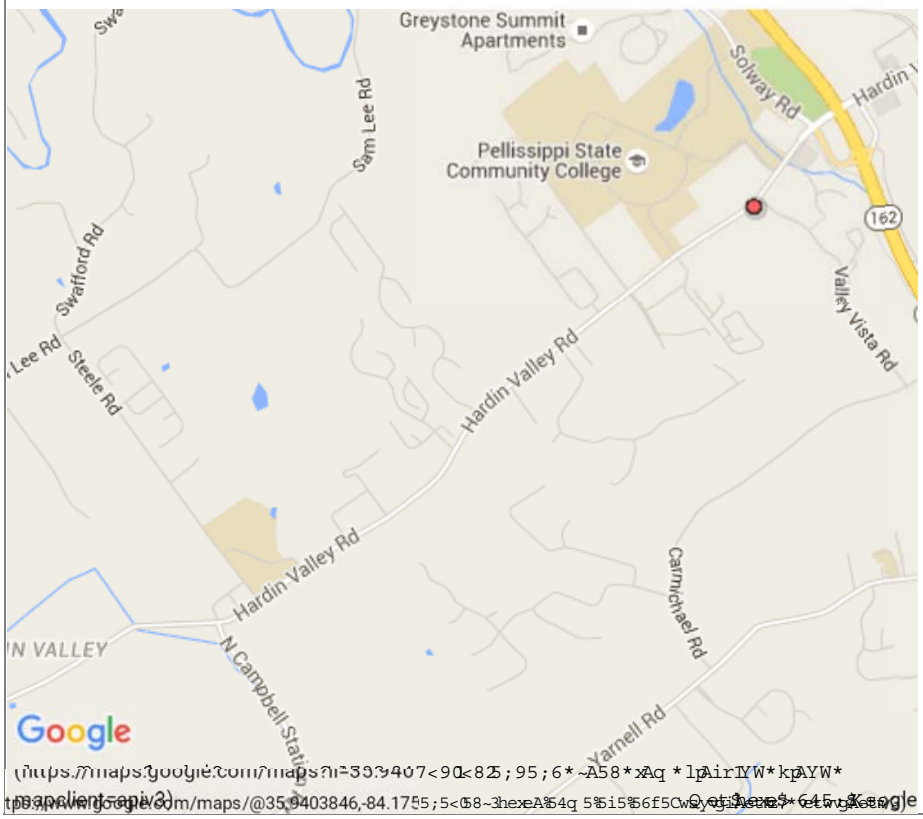
HISTORICAL TRAFFIC COUNT DATA

Traffic History

Traffic History reflects the Annual Average Daily Traffic (AADT) count along specific locations on Tennessee's road network

View stations on map: Select a county...

Non-Map Record Search: Knox Station Number: Search



Station Information

Station	000084
Route	01277
Location	VALLEY RD-NEAR ANDERSON CO LINE
County	Knox
2014	17441
2013	15642
2012	17809
2011	17696
2010	10492
2009	9950
2008	9660
2007	9379
2006	8804
2005	8457
2004	7761
2003	7533
2002	7179
2001	7019
2000	7520
1999	5587
1998	5137
1997	5820

Download File:	KML (/Applications/Files/TrfcHist.kmz)	ESRI Geodatabase (/Applications/Files/TrfcHistFGDB.zip)	ESRI Shapefile (/Applications/Files/TrfcHistSHP.zip)	Database Table (/Applications/File/TrfcHistDBF.zip)
Open With:	Google Earth (https://earth.google.com/)	ArcGIS Explorer (http://www.esri.com/software/arcgis/explorer/index.html)		MS Access or Exce

Traffic History

Station #	County	Location	Route #
000084	Knox	VALLEY RD-NEAR ANDERSON CO LINE	01277

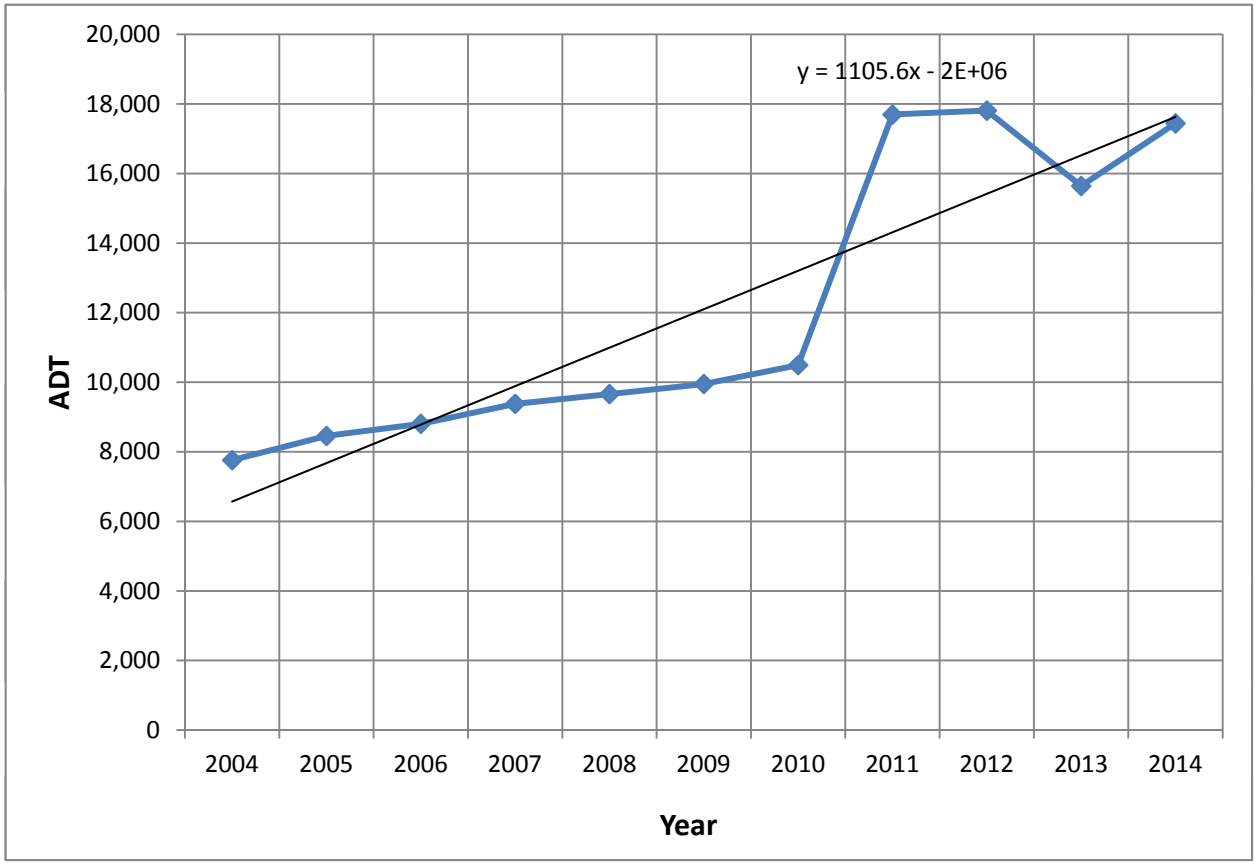
Record	Year	AADT
1	2014	17441
2	2013	15642
3	2012	17809
4	2011	17696
5	2010	10492
6	2009	9950
7	2008	9660
8	2007	9379
9	2006	8804
10	2005	8457
11	2004	7761
12	2003	7533
13	2002	7179
14	2001	7019
15	2000	7520
16	1999	5587
17	1998	5137
18	1997	5820
19	1996	5589
20	1995	5037
21	1994	6800
22	1993	6929
23	1992	6651
24	1991	5473
25	1990	5568
26	1989	2989
27	1988	3436

Record	Year	AADT
28	1987	4427
29	1986	3372
30	1985	2171

Historical Traffic Counts

Organization: TDOT
Station ID #: 000084
Location: Hardin Valley Road - West of Pellissippi Parkway

YEAR	ADT	
2004	7,761	
2005	8,457	
2006	8,804	
2007	9,379	
2008	9,660	
2009	9,950	
2010	10,492	Trendline
2011	17,696	
2012	17,809	
2013	15,642	
2014	17,441	



Recent Annual Growth (5 Year)
2010-2014
Annual % Growth = 66.2%

APPENDIX B

MANUAL TRAFFIC COUNT DATA

TRAFFIC COUNT DATA

Major Street: Hardin Valley Road (EB-WB) 2/18/2015 (Thursday)
Minor Street: Berrywood Drive (NB) Mild/Sunny
Traffic Control: Stop Control on Minor Street

Primary Movement: Vehicles

TIME	WESTBOUND		NORTHBOUND		EASTBOUND		VEHICLE	PEAK
BEGIN	LT	THRU	LT	RT	THRU	RT	TOTAL	HOUR
7:00 AM	1	108	0	3	142	2	256	
7:15 AM	1	213	5	12	213	0	444	
7:30 AM	***2***	***180***	***4***	***9***	***237***	***2***	***434***	7:30 AM - 8:30 AM
7:45 AM	***1***	***188***	***0***	***2***	***230***	***2***	***423***	
8:00 AM	***5***	***248***	***3***	***8***	***193***	***1***	***458***	
8:15 AM	***3***	***216***	***2***	***3***	***237***	***0***	***461***	
8:30 AM	4	86	1	4	150	0	245	
8:45 AM	3	77	0	4	154	1	239	
TOTAL	20	1316	15	45	1556	8	2960	
11:00 AM	5	64	0	5	67	0	141	
11:15 AM	4	70	0	2	81	1	158	
11:30 AM	***8***	***65***	***1***	***7***	***84***	***0***	***165***	11:30 AM - 12:30 PM
11:45 AM	***4***	***88***	***4***	***3***	***67***	***0***	***166***	
12:00 PM	***2***	***112***	***1***	***0***	***92***	***4***	***211***	
12:15 PM	***4***	***76***	***1***	***3***	***90***	***0***	***174***	
12:30 PM	4	68	0	5	79	2	158	
12:45 PM	5	88	1	4	64	0	162	
TOTAL	36	631	8	29	624	7	1335	
2:00 PM	4	110	1	0	146	2	263	
2:15 PM	5	134	2	3	99	3	246	
2:30 PM	3	132	1	3	102	1	242	
2:45 PM	4	129	1	5	148	4	291	
3:00 PM	8	125	1	5	114	2	255	
3:15 PM	3	143	2	1	85	0	234	
3:30 PM	2	161	2	5	229	0	399	
3:45 PM	5	152	1	3	183	3	347	
4:00 PM	5	138	2	4	139	4	292	
4:15 PM	8	120	0	5	136	3	272	
4:30 PM	2	143	0	4	130	1	280	
4:45 PM	6	146	1	6	118	0	277	
5:00 PM	***4***	***175***	***1***	***5***	***137***	***4***	***326***	5:00 PM - 6:00 PM
5:15 PM	***6***	***174***	***2***	***0***	***182***	***1***	***365***	
5:30 PM	***5***	***183***	***0***	***2***	***173***	***6***	***369***	
5:45 PM	***7***	***192***	***0***	***7***	***134***	***3***	***343***	
TOTAL	77	2357	17	58	2255	37	4801	

Peak Hour 7:30 AM - 8:30 AM

TIME	WESTBOUND		NORTHBOUND		EASTBOUND	
BEGIN	LT	THRU	LT	RT	THRU	RT
7:30 AM	***2***	***180***	***4***	***9***	***237***	***2***
7:45 AM	***1***	***188***	***0***	***2***	***230***	***2***
8:00 AM	***5***	***248***	***3***	***8***	***193***	***1***
8:15 AM	***3***	***216***	***2***	***3***	***237***	***0***
TOTAL	11	832	9	22	897	5
PHF	0.55	0.84	0.56	0.61	0.95	0.63

Peak Hour 5:00 PM - 6:00 PM

TIME	WESTBOUND		NORTHBOUND		EASTBOUND	
BEGIN	LT	THRU	LT	RT	THRU	RT
7:30 AM	***4***	***175***	***1***	***5***	***137***	***4***
7:45 AM	***6***	***174***	***2***	***0***	***182***	***1***
8:00 AM	***5***	***183***	***0***	***2***	***173***	***6***
8:15 AM	***7***	***192***	***0***	***7***	***134***	***3***
TOTAL	22	724	3	14	626	14
PHF	0.79	0.94	0.38	0.50	0.86	0.58

APPENDIX C

ITE TRIP GENERATION

Land Use: 210
Single-Family Detached Housing

Description

Single-family detached housing includes all single-family detached homes on individual lots. A typical site surveyed is a suburban subdivision.

Additional Data

The number of vehicles and residents had a high correlation with average weekday vehicle trip ends. The use of these variables was limited, however, because the number of vehicles and residents was often difficult to obtain or predict. The number of dwelling units was generally used as the independent variable of choice because it was usually readily available, easy to project and had a high correlation with average weekday vehicle trip ends.

This land use included data from a wide variety of units with different sizes, price ranges, locations and ages. Consequently, there was a wide variation in trips generated within this category. Other factors, such as geographic location and type of adjacent and nearby development, may also have had an effect on the site trip generation.

Single-family detached units had the highest trip generation rate per dwelling unit of all residential uses because they were the largest units in size and had more residents and more vehicles per unit than other residential land uses; they were generally located farther away from shopping centers, employment areas and other trip attractors than other residential land uses; and they generally had fewer alternative modes of transportation available because they were typically not as concentrated as other residential land uses.

The peak hour of the generator typically coincided with the peak hour of the adjacent street traffic.

The sites were surveyed between the late 1960s and the 2000s throughout the United States and Canada.

Source Numbers

1, 4, 5, 6, 7, 8, 11, 12, 13, 14, 16, 19, 20, 21, 26, 34, 35, 36, 38, 40, 71, 72, 84, 91, 98, 100, 105, 108, 110, 114, 117, 119, 157, 167, 177, 187, 192, 207, 211, 246, 275, 283, 293, 300, 319, 320, 357, 384, 435, 550, 552, 579, 598, 601, 603, 611, 614, 637, 711, 735

Single-Family Detached Housing
(210)

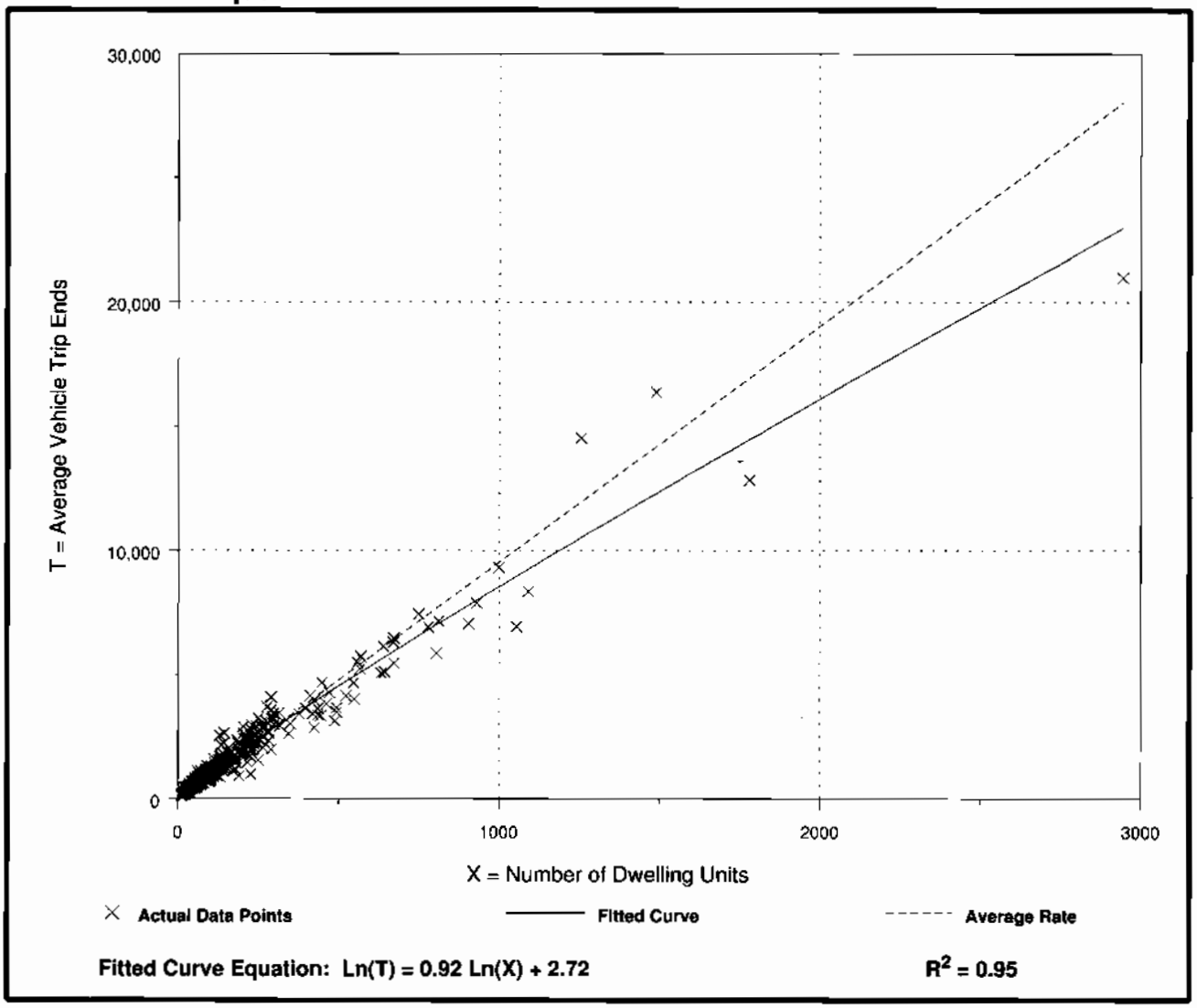
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Number of Studies: 355
Avg. Number of Dwelling Units: 198
Directional Distribution: 50% entering, 50% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
9.52	4.31 - 21.85	3.70

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.92 Ln(X) + 2.72

R^2 = 0.95

Single-Family Detached Housing
(210)

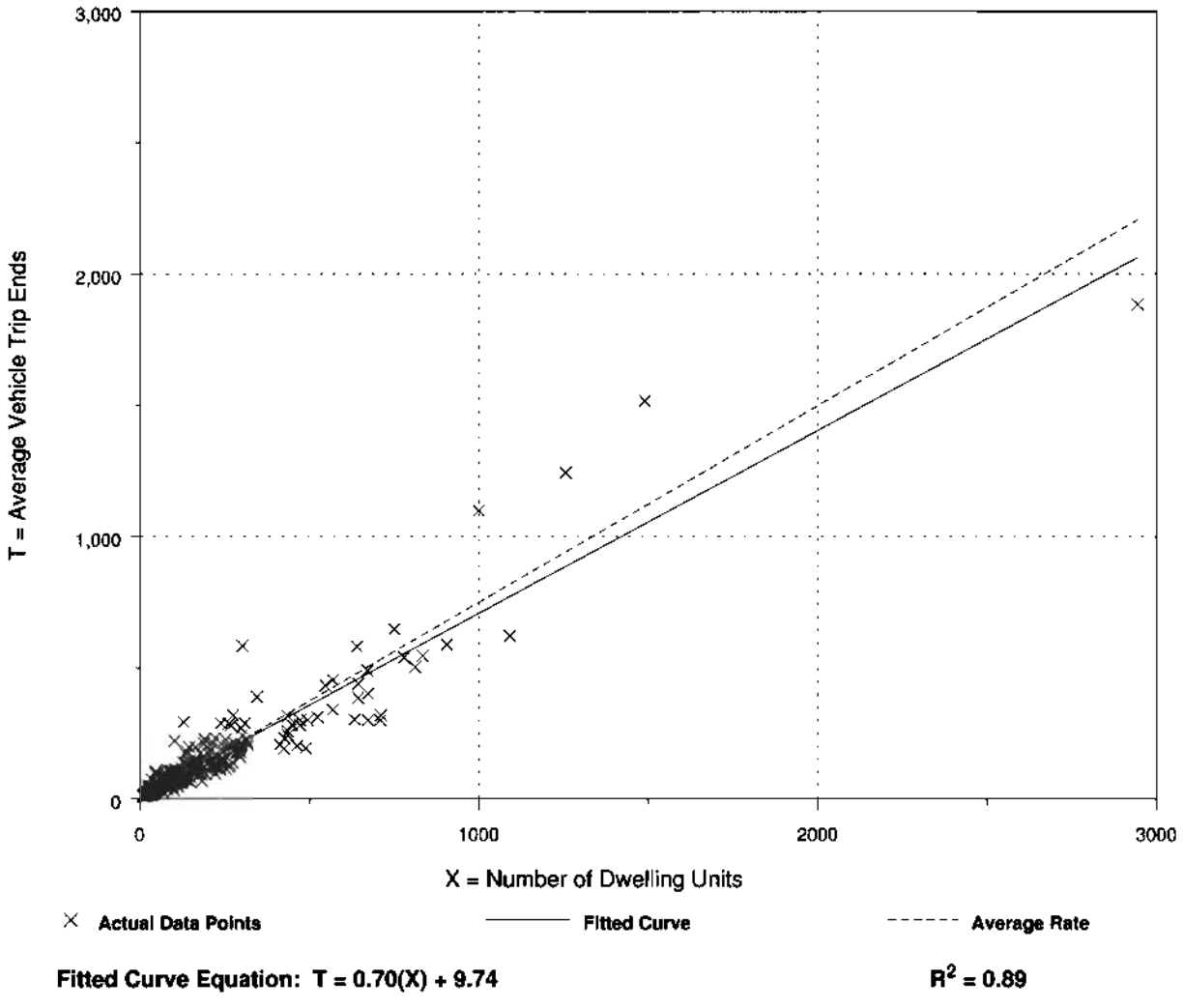
Average Vehicle Trip Ends vs: **Dwelling Units**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.

Number of Studies: 292
Avg. Number of Dwelling Units: 194
Directional Distribution: 25% entering, 75% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.75	0.33 - 2.27	0.90

Data Plot and Equation



Fitted Curve Equation: T = 0.70(X) + 9.74

R^2 = 0.89

Single-Family Detached Housing
(210)

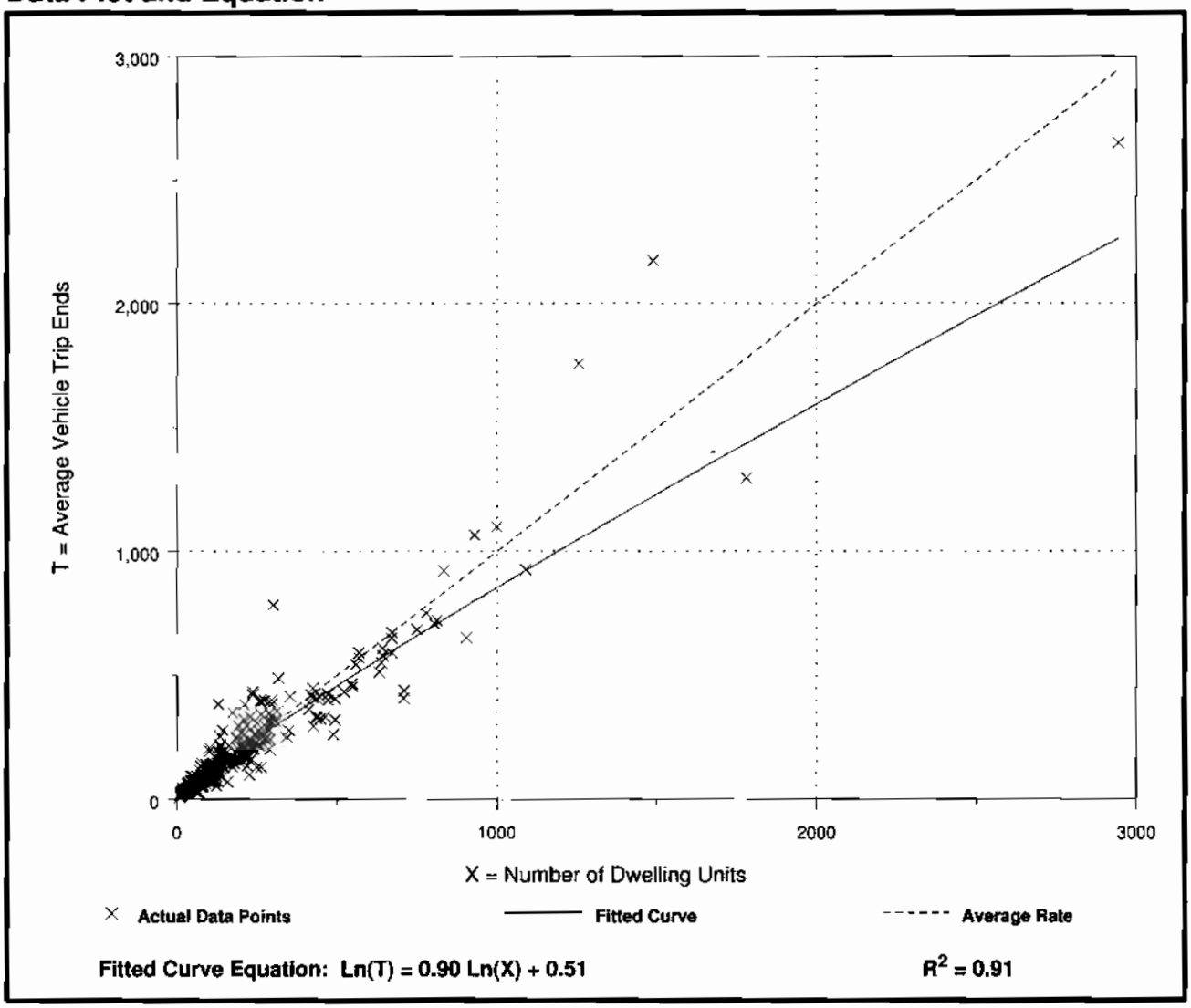
Average Vehicle Trip Ends vs: **Dwelling Units**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.

Number of Studies: 321
Avg. Number of Dwelling Units: 207
Directional Distribution: 63% entering, 37% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
1.00	0.42 - 2.98	1.05

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.90 Ln(X) + 0.51

R^2 = 0.91

APPENDIX D

CAPACITY ANALYSES - HCM WORKSHEETS (SYNCHRO 8)

Movement	SEL	SER	NEL	NET	SWT	SWR
Lane Configurations						
Volume (veh/h)	82	44	15	1126	1049	27
Sign Control	Stop			Free	Free	
Grade	2%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.95	0.84	0.92
Hourly flow rate (vph)	89	48	16	1185	1249	29
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				TWLTL	TWLTL	
Median storage veh)				2	2	
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	2467	1249	1278			
vC1, stage 1 conf vol	1249					
vC2, stage 2 conf vol	1218					
vCu, unblocked vol	2467	1249	1278			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)	5.4					
tF (s)	3.5	3.3	2.2			
p0 queue free %	53	78	97			
cM capacity (veh/h)	188	213	550			

Direction, Lane #	SE 1	SE 2	NE 1	NE 2	SW 1	SW 2
Volume Total	89	48	16	1185	1249	29
Volume Left	89	0	16	0	0	0
Volume Right	0	48	0	0	0	29
cSH	188	213	550	1700	1700	1700
Volume to Capacity	0.47	0.22	0.03	0.70	0.73	0.02
Queue Length 95th (ft)	57	21	2	0	0	0
Control Delay (s)	40.2	26.7	11.7	0.0	0.0	0.0
Lane LOS	E	D	B			
Approach Delay (s)	35.5		0.2		0.0	
Approach LOS	E					

Intersection Summary			
Average Delay	1.9		
Intersection Capacity Utilization	70.5%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	SEL	SER	NEL	NET	SWT	SWR
Lane Configurations						
Volume (veh/h)	53	28	48	797	908	89
Sign Control	Stop			Free	Free	
Grade	2%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.86	0.94	0.92
Hourly flow rate (vph)	58	30	52	927	966	97
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				TWLTL	TWLTL	
Median storage veh)				2	2	
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1997	966	1063			
vC1, stage 1 conf vol	966					
vC2, stage 2 conf vol	1031					
vCu, unblocked vol	1997	966	1063			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)	5.4					
tF (s)	3.5	3.3	2.2			
p0 queue free %	76	90	92			
cM capacity (veh/h)	243	311	663			

Direction, Lane #	SE 1	SE 2	NE 1	NE 2	SW 1	SW 2
Volume Total	58	30	52	927	966	97
Volume Left	58	0	52	0	0	0
Volume Right	0	30	0	0	0	97
cSH	243	311	663	1700	1700	1700
Volume to Capacity	0.24	0.10	0.08	0.55	0.57	0.06
Queue Length 95th (ft)	22	8	6	0	0	0
Control Delay (s)	24.4	17.8	10.9	0.0	0.0	0.0
Lane LOS	C	C	B			
Approach Delay (s)	22.1		0.6		0.0	
Approach LOS	C					

Intersection Summary			
Average Delay	1.2		
Intersection Capacity Utilization	57.8%	ICU Level of Service	B
Analysis Period (min)	15		

APPENDIX E

TRAFFIC SIGNAL WARRANTS

Traffic Signal Warrant Analysis Workbook

STUDY AND ANALYSIS INFORMATION

Municipality:		**Analysis Date:**	2/23/2016
County:		**Conducted By:**	RWJ
PennDOT Engineering District:		**Agency/Company Name:**	AJAX

Analysis Information

Data Collection Date:	2/18/2016
Day of the Week:	Thursday

Is the intersection in a built-up area of an isolated community of <10,000 population? No

Major Street Information

Major Street Name and Route Number:	Hardin Valley Road
Major Street Approach #1 Direction:	E-Bound
Major Street Approach #2 Direction:	W-Bound

Number of Lanes for Moving Traffic on Each Major Street Approach:	1	**LANE(S)**
Speed Limit or 85th Percentile Speed on the Major Street:	50	**MPH**

Minor Street Information

Minor Street Name and Route Number:	Laurel Ridge (Road A)
Minor Street Approach #1 Direction:	S-Bound
Minor Street Approach #2 Direction:	N/A

Number of Lanes for Moving Traffic on Each Minor Street Approach:	1	**LANE(S)**

TRAFFIC SIGNAL WARRANT ANALYSIS FINDINGS

	Applicable?	Warrant Met?
Warrant 1, Eight-Hour Vehicular Volume	**Yes**	**No**
Warrant 2, Four-Hour Vehicular Volume	**Yes**	**No**
Warrant 3, Peak Hour	**Yes**	**No**
Warrant 4, Pedestrian Volume	**No**	**N/A**
Warrant 5, School Crossing	**No**	**N/A**
Warrant 6, Coordinated Signal System	**No**	**N/A**
Warrant 7, Crash Experience	**No**	**N/A**
Warrant 8, Roadway Network	**No**	**N/A**
Warrant 9, Intersection Near a Grade Crossing	**No**	**N/A**
Warrant PA-1, ADT Volume Warrant	**No**	**N/A**
Warrant PA-2, Midblock and Trail Crossings	**No**	**N/A**

ENTER VOLUME DATA PER 15 MINUTE INTERVAL, PER APPROACH

Time Interval		Major Street Approach #1 (E-Bound)	Major Street Approach #2 (W-Bound)	Major Street Combined	Minor Street Approach #1 (S-Bound)	Minor Street Approach #2 (N/A)
Begin At	End Of	Volume	Volume	Total Volume	Volume	Volume
12:00 AM	12:14 AM			0		
12:15 AM	12:29 AM			0		
12:30 AM	12:44 AM			0		
12:45 AM	12:59 AM			0		
1:00 AM	1:14 AM			0		
1:15 AM	1:29 AM			0		
1:30 AM	1:44 AM			0		
1:45 AM	1:59 AM			0		
2:00 AM	2:14 AM			0		
2:15 AM	2:29 AM			0		
2:30 AM	2:44 AM			0		
2:45 AM	2:59 AM			0		
3:00 AM	3:14 AM			0		
3:15 AM	3:29 AM			0		
3:30 AM	3:44 AM			0		
3:45 AM	3:59 AM			0		
4:00 AM	4:14 AM			0		
4:15 AM	4:29 AM			0		
4:30 AM	4:44 AM			0		
4:45 AM	4:59 AM			0		
5:00 AM	5:14 AM			0		
5:15 AM	5:29 AM			0		
5:30 AM	5:44 AM			0		
5:45 AM	5:59 AM			0		
6:00 AM	6:14 AM			0		
6:15 AM	6:29 AM			0		
6:30 AM	6:44 AM			0		
6:45 AM	6:59 AM			0		
7:00 AM	7:14 AM			0		
7:15 AM	7:29 AM			0		
7:30 AM	7:44 AM	1126	1049	2175	82	
7:45 AM	7:59 AM			0		
8:00 AM	8:14 AM			0		
8:15 AM	8:29 AM			0		
8:30 AM	8:44 AM			0		
8:45 AM	8:59 AM			0		
9:00 AM	9:14 AM			0		
9:15 AM	9:29 AM			0		
9:30 AM	9:44 AM			0		
9:45 AM	9:59 AM			0		
10:00 AM	10:14 AM			0		
10:15 AM	10:29 AM			0		
10:30 AM	10:44 AM			0		
10:45 AM	10:59 AM			0		
11:00 AM	11:14 AM			0		
11:15 AM	11:29 AM			0		
11:30 AM	11:44 AM			0		
11:45 AM	11:59 AM			0		

ENTER VOLUME DATA PER 15 MINUTE INTERVAL, PER APPROACH

Time Interval		Major Street Approach #1 (E-Bound)	Major Street Approach #2 (W-Bound)	Major Street Combined	Minor Street Approach #1 (S-Bound)	Minor Street Approach #2 (N/A)
Begin At	End Of	Volume	Volume	Total Volume	Volume	Volume
12:00 PM	12:14 PM			0		
12:15 PM	12:29 PM			0		
12:30 PM	12:44 PM			0		
12:45 PM	12:59 PM			0		
1:00 PM	1:14 PM			0		
1:15 PM	1:29 PM			0		
1:30 PM	1:44 PM			0		
1:45 PM	1:59 PM			0		
2:00 PM	2:14 PM			0		
2:15 PM	2:29 PM			0		
2:30 PM	2:44 PM			0		
2:45 PM	2:59 PM			0		
3:00 PM	3:14 PM			0		
3:15 PM	3:29 PM			0		
3:30 PM	3:44 PM			0		
3:45 PM	3:59 PM			0		
4:00 PM	4:14 PM			0		
4:15 PM	4:29 PM			0		
4:30 PM	4:44 PM			0		
4:45 PM	4:59 PM			0		
5:00 PM	5:14 PM	797	908	1705	53	
5:15 PM	5:29 PM			0		
5:30 PM	5:44 PM			0		
5:45 PM	5:59 PM			0		
6:00 PM	6:14 PM			0		
6:15 PM	6:29 PM			0		
6:30 PM	6:44 PM			0		
6:45 PM	6:59 PM			0		
7:00 PM	7:14 PM			0		
7:15 PM	7:29 PM			0		
7:30 PM	7:44 PM			0		
7:45 PM	7:59 PM			0		
8:00 PM	8:14 PM			0		
8:15 PM	8:29 PM			0		
8:30 PM	8:44 PM			0		
8:45 PM	8:59 PM			0		
9:00 PM	9:14 PM			0		
9:15 PM	9:29 PM			0		
9:30 PM	9:44 PM			0		
9:45 PM	9:59 PM			0		
10:00 PM	10:14 PM			0		
10:15 PM	10:29 PM			0		
10:30 PM	10:44 PM			0		
10:45 PM	10:59 PM			0		
11:00 PM	11:14 PM			0		
11:15 PM	11:29 PM			0		
11:30 PM	11:44 PM			0		
11:45 PM	11:59 PM			0		
	Approach Totals:	1923	1957	3880	135	0

MUTCD WARRANT 1, EIGHT-HOUR VEHICULAR VOLUME

Number of Lanes for Moving Traffic on Each Approach	
Major Street:	1 Lane
Minor Street:	1 Lane

Built-up Isolated Community With Less Than 10,000 Population or Above 40 MPH on Major Street?	Yes

Combination of Conditions A and B Necessary?*: No

**Only applicable for Warrant 1 if after an adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems. See Section 4C.02 of the 2009 MUTCD for application.*

Condition A - Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor street approach (one direction only)			
Major Street	Minor Street	100%	80%	70%	56%	100%	80%	70%	56%
1	1	500	400	350	280	150	120	105	84
2 or More	1	600	480	420	336	150	120	105	84
2 or More	2 or More	600	480	420	336	200	160	140	112
1	2 or More	500	400	350	280	200	160	140	112

Condition B - Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor street approach (one direction only)			
Major Street	Minor Street	100%	80%	70%	56%	100%	80%	70%	56%
1	1	750	600	525	420	75	60	53	42
2 or More	1	900	720	630	504	75	60	53	42
2 or More	2 or More	900	720	630	504	100	80	70	56
1	2 or More	750	600	525	420	100	80	70	56

Condition A Evaluation

Number of Unique Hours Met: 0 **Condition A Satisfied?** No

Condition B Evaluation

Number of Unique Hours Met: 2 **Condition B Satisfied?** No

Combination of Condition A and Condition B Evaluation

Number of Unique Hours Met for Condition A: N/A

Number of Unique Hours Met for Condition B: N/A

Combination of Condition A and Condition B Satisfied? N/A

MUTCD WARRANT 2, FOUR-HOUR VEHICULAR VOLUME

Number of Lanes for Moving Traffic on Each Approach	
Major Street:	1 Lane
Minor Street:	1 Lane

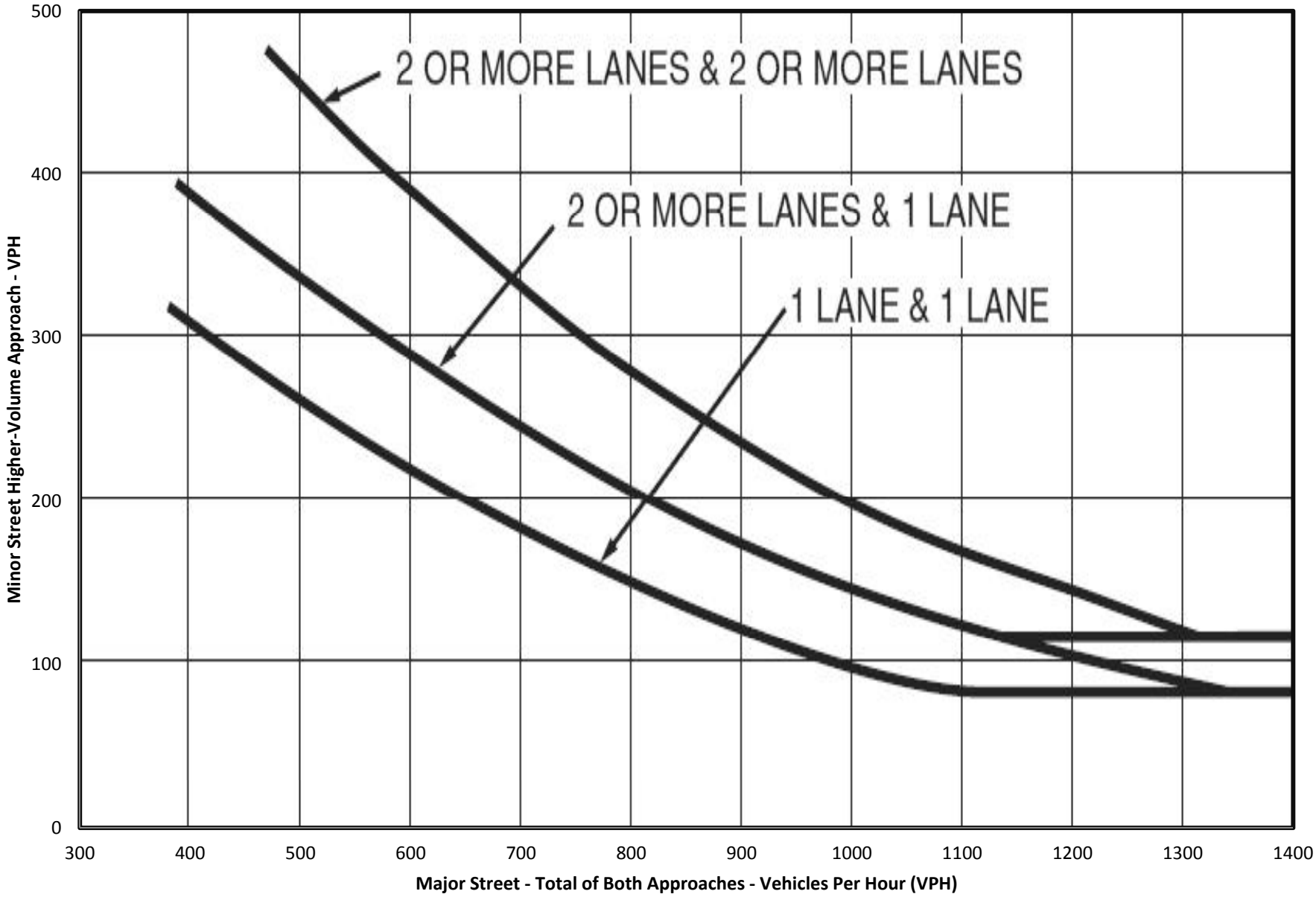
Total Number of Unique Hours Met On Figure 4C-2
1

Built-up Isolated Community With Less Than 10,000 Population or Above 40 MPH on Major Street?	Yes

Hourly Vehicular Volume			
Hour Interval Beginning At	Major Street Combined Vehicles Per Hour (VPH)	Highest Minor Street Approach Vehicles Per Hour (VPH)	Hour Met?
12:00 AM	0	0	
12:15 AM	0	0	
12:30 AM	0	0	
12:45 AM	0	0	
1:00 AM	0	0	
1:15 AM	0	0	
1:30 AM	0	0	
1:45 AM	0	0	
2:00 AM	0	0	
2:15 AM	0	0	
2:30 AM	0	0	
2:45 AM	0	0	
3:00 AM	0	0	
3:15 AM	0	0	
3:30 AM	0	0	
3:45 AM	0	0	
4:00 AM	0	0	
4:15 AM	0	0	
4:30 AM	0	0	
4:45 AM	0	0	
5:00 AM	0	0	
5:15 AM	0	0	
5:30 AM	0	0	
5:45 AM	0	0	
6:00 AM	0	0	
6:15 AM	0	0	
6:30 AM	0	0	
6:45 AM	2175	82	Met
7:00 AM	2175	82	Met
7:15 AM	2175	82	Met
7:30 AM	2175	82	Met
7:45 AM	0	0	
8:00 AM	0	0	
8:15 AM	0	0	
8:30 AM	0	0	
8:45 AM	0	0	
9:00 AM	0	0	
9:15 AM	0	0	
9:30 AM	0	0	
9:45 AM	0	0	
10:00 AM	0	0	
10:15 AM	0	0	
10:30 AM	0	0	
10:45 AM	0	0	
11:00 AM	0	0	
11:15 AM	0	0	
11:30 AM	0	0	
11:45 AM	0	0	

Hourly Vehicular Volume			
Hour Interval Beginning At	Major Street Combined Vehicles Per Hour (VPH)	Highest Minor Street Approach Vehicles Per Hour (VPH)	Hour Met?
12:00 PM	0	0	
12:15 PM	0	0	
12:30 PM	0	0	
12:45 PM	0	0	
1:00 PM	0	0	
1:15 PM	0	0	
1:30 PM	0	0	
1:45 PM	0	0	
2:00 PM	0	0	
2:15 PM	0	0	
2:30 PM	0	0	
2:45 PM	0	0	
3:00 PM	0	0	
3:15 PM	0	0	
3:30 PM	0	0	
3:45 PM	0	0	
4:00 PM	0	0	
4:15 PM	1705	53	
4:30 PM	1705	53	
4:45 PM	1705	53	
5:00 PM	1705	53	
5:15 PM	0	0	
5:30 PM	0	0	
5:45 PM	0	0	
6:00 PM	0	0	
6:15 PM	0	0	
6:30 PM	0	0	
6:45 PM	0	0	
7:00 PM	0	0	
7:15 PM	0	0	
7:30 PM	0	0	
7:45 PM	0	0	
8:00 PM	0	0	
8:15 PM	0	0	
8:30 PM	0	0	
8:45 PM	0	0	
9:00 PM	0	0	
9:15 PM	0	0	
9:30 PM	0	0	
9:45 PM	0	0	
10:00 PM	0	0	
10:15 PM	0	0	
10:30 PM	0	0	
10:45 PM	0	0	
11:00 PM	0	0	

MUTCD Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume



MUTCD WARRANT 3, PEAK HOUR

Number of Lanes for Moving Traffic on Each Approach	
Major Street:	1 Lane
Minor Street:	1 Lane

Built-up Isolated Community With Less Than 10,000 Population or Above 40 MPH on Major Street?	Yes
Is this signal warrant being applied for an unusual case, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time?	No

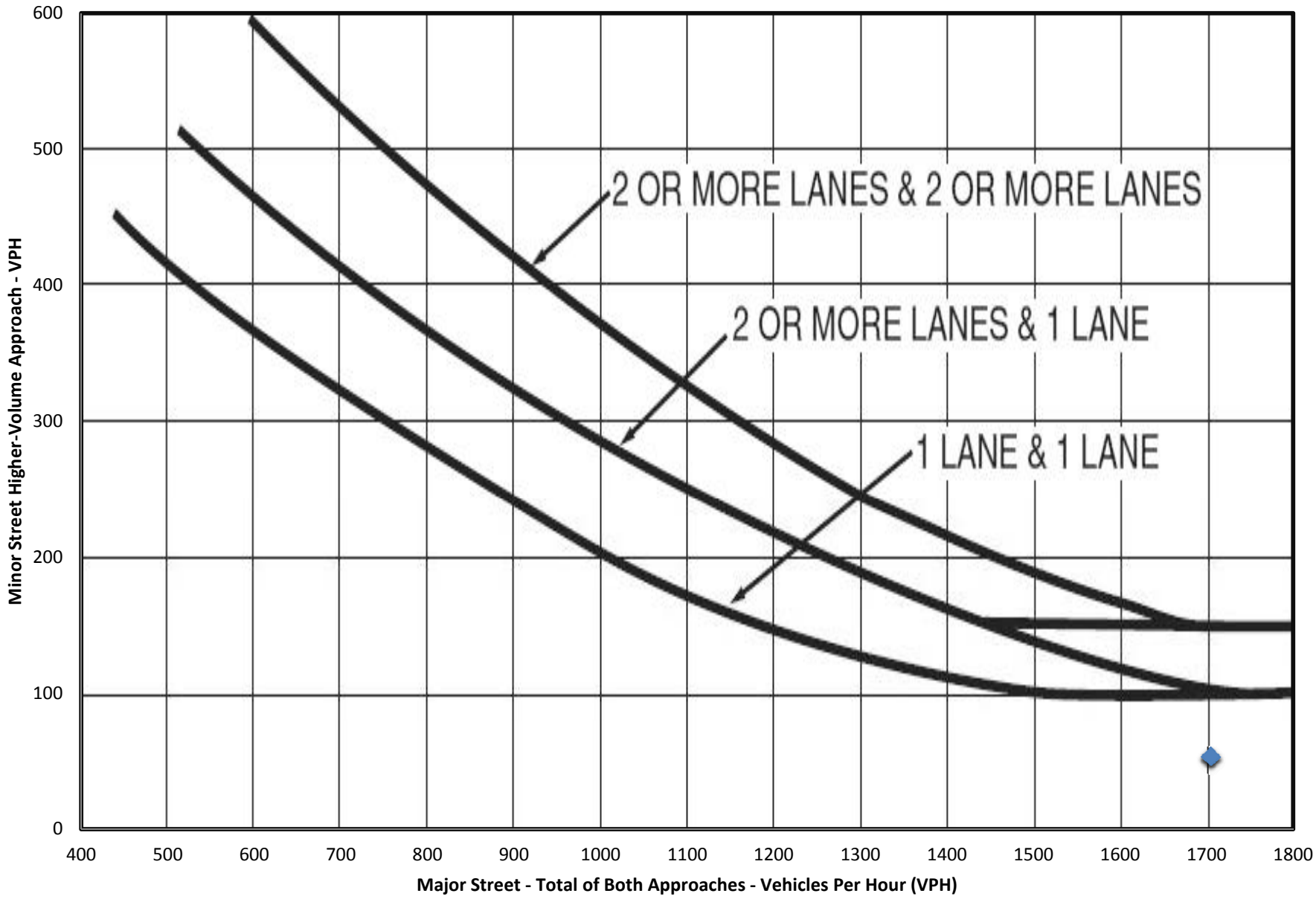
Indicate whether all three of the following conditions for the same 1 hour (any four consecutive 15-minute periods) of an average day are present*	
Does the total stopped time delay experienced by the traffic on one minor-street approach (one direction only) controlled by a STOP sign equal or exceed 4 vehicle-hours for a one-lane approach or 5 vehicle-hours for a two-lane approach?	Yes
Does the volume on the same minor-street approach (one direction only) equal or exceed 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour for two moving lanes?	N/A
Does the total entering volume serviced during the hour equal or exceed 650 vehicles per hour for intersection with three approaches or 800 vehicles per hour for intersections with four or more approaches?	Yes
**If applicable, attach all supporting calculations and documentation.*	

Total Number of Unique Hours Met On Figure 4C-4
1

Hourly Vehicular Volume			
Hour Interval Beginning At	Major Street Combined Vehicles Per Hour (VPH)	Highest Minor Street Approach Vehicles Per Hour (VPH)	Hour Met?
12:00 AM	0	0	
12:15 AM	0	0	
12:30 AM	0	0	
12:45 AM	0	0	
1:00 AM	0	0	
1:15 AM	0	0	
1:30 AM	0	0	
1:45 AM	0	0	
2:00 AM	0	0	
2:15 AM	0	0	
2:30 AM	0	0	
2:45 AM	0	0	
3:00 AM	0	0	
3:15 AM	0	0	
3:30 AM	0	0	
3:45 AM	0	0	
4:00 AM	0	0	
4:15 AM	0	0	
4:30 AM	0	0	
4:45 AM	0	0	
5:00 AM	0	0	
5:15 AM	0	0	
5:30 AM	0	0	
5:45 AM	0	0	
6:00 AM	0	0	
6:15 AM	0	0	
6:30 AM	0	0	
6:45 AM	2175	82	Met
7:00 AM	2175	82	Met
7:15 AM	2175	82	Met
7:30 AM	2175	82	Met
7:45 AM	0	0	
8:00 AM	0	0	
8:15 AM	0	0	

Hourly Vehicular Volume			
Hour Interval Beginning At	Major Street Combined Vehicles Per Hour (VPH)	Highest Minor Street Approach Vehicles Per Hour (VPH)	Hour Met?
8:30 AM	0	0	
8:45 AM	0	0	
9:00 AM	0	0	
9:15 AM	0	0	
9:30 AM	0	0	
9:45 AM	0	0	
10:00 AM	0	0	
10:15 AM	0	0	
10:30 AM	0	0	
10:45 AM	0	0	
11:00 AM	0	0	
11:15 AM	0	0	
11:30 AM	0	0	
11:45 AM	0	0	
12:00 PM	0	0	
12:15 PM	0	0	
12:30 PM	0	0	
12:45 PM	0	0	
1:00 PM	0	0	
1:15 PM	0	0	
1:30 PM	0	0	
1:45 PM	0	0	
2:00 PM	0	0	
2:15 PM	0	0	
2:30 PM	0	0	
2:45 PM	0	0	
3:00 PM	0	0	
3:15 PM	0	0	
3:30 PM	0	0	
3:45 PM	0	0	
4:00 PM	0	0	
4:15 PM	1705	53	
4:30 PM	1705	53	
4:45 PM	1705	53	
5:00 PM	1705	53	
5:15 PM	0	0	
5:30 PM	0	0	
5:45 PM	0	0	
6:00 PM	0	0	
6:15 PM	0	0	
6:30 PM	0	0	
6:45 PM	0	0	
7:00 PM	0	0	
7:15 PM	0	0	
7:30 PM	0	0	
7:45 PM	0	0	
8:00 PM	0	0	
8:15 PM	0	0	
8:30 PM	0	0	
8:45 PM	0	0	
9:00 PM	0	0	
9:15 PM	0	0	
9:30 PM	0	0	
9:45 PM	0	0	
10:00 PM	0	0	
10:15 PM	0	0	
10:30 PM	0	0	
10:45 PM	0	0	
11:00 PM	0	0	

MUTCD Figure 4C-3. Warrant 3, Peak Hour



APPENDIX F

SPOT SPEED STUDY

SPOT SPEED STUDY

Location:	Hardin Valley Road	(adjacent to proposed property)		Date:	2/19/2016
Posted Speed Limit:	40 mph			Weather:	Sunny
Equipment:	Bushnell Speedster III Radar Speed Gun			Time:	11:00 AM

Vehicle	Speed (mph)
1	45
2	50
3	50
4	36
5	38
6	46
7	48
8	51
9	45
10	51
11	50
12	40
13	47
14	56
15	40
16	42
17	45
18	49
19	49
20	45
21	47
22	45

Sample Size Requirements (from *ITE Manual of Transportation Engineering Studies*)

$N = (S * K/E)^2$

where:
- N = minimum number of measured speeds
- S = estimated sample standard deviation (mph)
- K = constant corresponding to the desired confidence level
- E = permitted error in the average speed estimate (mph)

- S = 5 mph (Table 3-2, page 38)
- K = 2.58 (Confidence level of 99% - Table 3-3, page 38)
- E = 2 mph assumed error range

Therefore, N = 42

SPOT SPEED STUDY

Location:	Hardin Valley Road (adjacent to proposed property)	Date:	2/19/2016
Posted Speed Limit:	40 mph	Weather:	Sunny
Equipment:	Bushnell Speedster III Radar Speed Gun	Time:	11:00 AM

23	44
24	43
25	40
26	56
27	41
28	47
29	44
30	50
31	51
32	48
33	51
34	44
35	52
36	49
37	55
38	42
39	45
40	50
41	42
42	52
43	48
44	49
45	43
46	46
47	46

SPOT SPEED STUDY

Location:	Hardin Valley Road	(adjacent to proposed property)	Date:	2/19/2016
Posted Speed Limit:	40 mph		Weather:	Sunny
Equipment:	Bushnell Speedster III Radar Speed Gun		Time:	11:00 AM

48	51
49	53
50	49
51	50
52	46
53	51
54	57
55	42
56	47
57	49
58	43
59	43
60	47

85th percentile speed = 51.0 mph

APPENDIX G

KNOX COUNTY TURN LANE THRESHOLD WORKSHEET

TABLE 6A

LEFT-TURN LANE VOLUME THRESHOLDS FOR TWO-LANE ROADWAYS WITH A PREVAILING SPEED OF 46 TO 55 MPH

(If the left-turn volume exceeds the table value a left -turn lane is needed)

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	100 - 149	150 - 199	200 - 249	250 - 299	300 - 349	350 - 399
100 - 149	200	140	100	75	60	50
150 - 199	175	120	85	65	55	45
200 - 249	150	100	75	60	50	40
250 - 299	130	85	65	55	45	35
300 - 349	110	75	60	50	40	30
350 - 399	95	65	55	45	35	25
400 - 449	80	60	50	40	30	25
450 - 499	70	55	45	35	25	20
500 - 549	60	50	40	30	25	20
550 - 599	50	45	35	25	20	20
600 - 649	45	40	30	25	20	20
650 - 699	40	35	30	20	20	20
700 - 749	35	35	25	20	20	15
750 or More	35	35	25	20	15	15

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	=/ > 600
100 - 149	50	45	40	35	30	25
150 - 199	45	40	35	30	30	25
200 - 249	40	35	30	25	25	20
250 - 299	35	35	30	25	25	20
300 - 349	30	30	25	25	20	20
350 - 399	25	25	25	20	20	20
400 - 449	25	25	20	20	20	15
450 - 499	20	20	20	20	20	15
500 - 549	20	20	20	20	15	15
550 - 599	20	20	20	15	15	15
600 - 649	20	20	15	15	15	15
650 - 699	20	15	15	15	15	15
700 - 749	15	15	15	15	15	15
750 or More	15	15	15	15	15	15

* Or through volume only if a right-turn lane exists.

TABLE 6B

RIGHT-TURN LANE VOLUME THRESHOLDS FOR TWO-LANE ROADWAYS WITH A PREVAILING SPEED OF 46 TO 55 MPH

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME *					
	< 100	100 - 199	200 - 249	250 - 299	300 - 349	350 - 399
Fewer Than 25 25 - 49 50 - 99						
100 - 149 150 - 199						Yes
200 - 249 250 - 299				Yes	Yes Yes	Yes Yes
300 - 349 350 - 399			Yes Yes	Yes Yes	Yes Yes	Yes Yes
400 - 449 450 - 499		Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
500 - 549 550 - 599	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME *					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 600	+ / > 600
Fewer Than 25 25 - 49 50 - 99 (89)				Yes Yes	Yes Yes	(908) Yes Yes
100 - 149 150 - 199	Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
200 - 249 250 - 299	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
300 - 349 350 - 399	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
400 - 449 450 - 499	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
500 - 549 550 - 599	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

* Or through volume only if a left-turn lane exists.