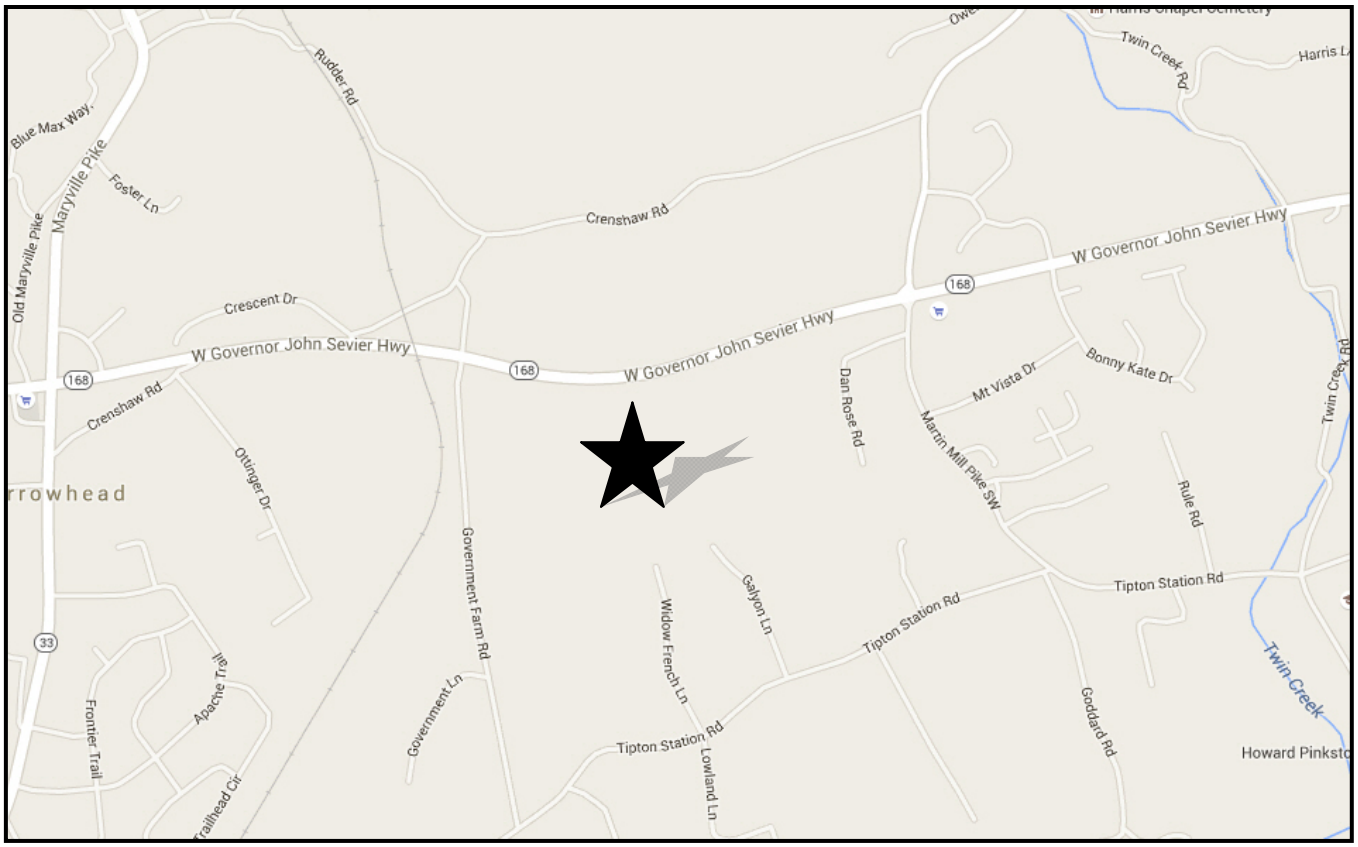
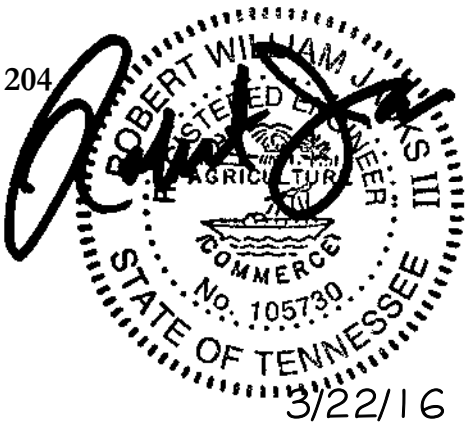


TRAFFIC IMPACT STUDY
GREENBRIER SENIOR CENTER
KNOX COUNTY, TENNESSEE

-Prepared For-

DSH & Associates, LLC
2099 Thunderhead Road, Suite 204
Knoxville, TN 37922

-Prepared By-



AJAX ENGINEERING

Revised March 2016

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INTRODUCTION

The purpose of this traffic study is to analyze the traffic impacts of a new proposed senior living and assisted living development in Knox County, Tennessee. At this point in the concept stage, this development is identified as Greenbrier Senior Center. This development is being proposed adjacent to John Sevier Highway in south Knox County in between Maryville Pike and Martin Mill Pike. This traffic impact study follows the procedures and standards as outlined for a Level 1 study developed 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 increased school enrollment
- Evaluation of the road system locations to determine the potential traffic impacts of the proposed senior center
- 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 will be located off of John Sevier Highway on a property that is almost 49 acres in size. The site currently consists of undeveloped land that is comprised mainly of woodland. The northwest corner of the property is crossed by a large transmission electric line. Immediate access to the proposed development will be provided solely by John Sevier Highway. In the adjacent vicinity of this study area, there are a couple of other residential subdivisions, individual residences and undeveloped properties. The property is relatively sloped. The site slopes from John Sevier Highway downward in elevation towards the rear of the property.

The proposed plan layout designed by DSH & Associates, LLC is shown in Figure 2. One main driveway entrance on John Sevier Highway is being proposed for the new development.

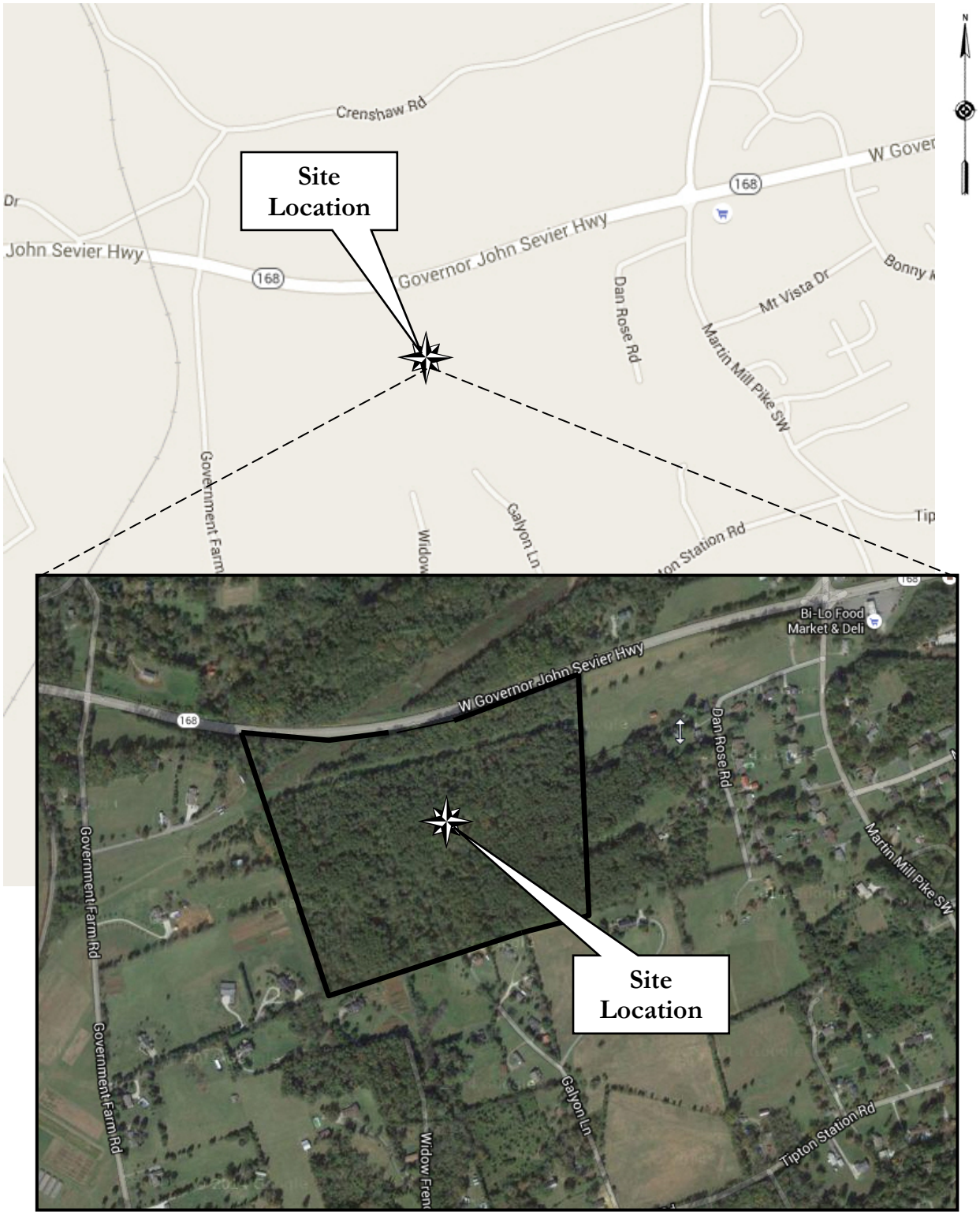


Figure 1
Location Map
Greenbrier Senior Center

The proposed senior community is expected to be comprised of several new internal roadways and parking lot areas on the property. At this stage of design, it is proposed that the development will include the following:

- 72 units of assisted living in one building structure (one bedroom, bathroom, and living area per each unit)
- 78 residential lots with single detached homes for retired and senior persons
- 88 units of independent living in one building structure (one bedroom, bathroom, kitchen, eating area, and living area per each unit)
- Several internal private drives that total nearly 4,500 feet in length
- Greenways and park areas

Two parcels are shown on the concept plan at the front of the property at John Sevier highway and are labeled as for "Future Use". These two parcels are being reserved for future activities that will be related to supporting the detached homes, assisted, and independent living structures. The future activities on these lots will only be related to the senior center and will not be accessed by the surrounding community.

The actual schedule for completion of this senior living development is dependent on economic factors. This project is also contingent on permitting, design, and other issues. The implementation schedule is currently for the independent living facility to be operational by mid-year 2018 and the assisted living unit by mid-year 2019. The individual home sites are expected to start construction of homes by the end of 2017. For the purposes of this study, it was assumed that the total construction build-out and full capacity of the development will occur by the year 2020.

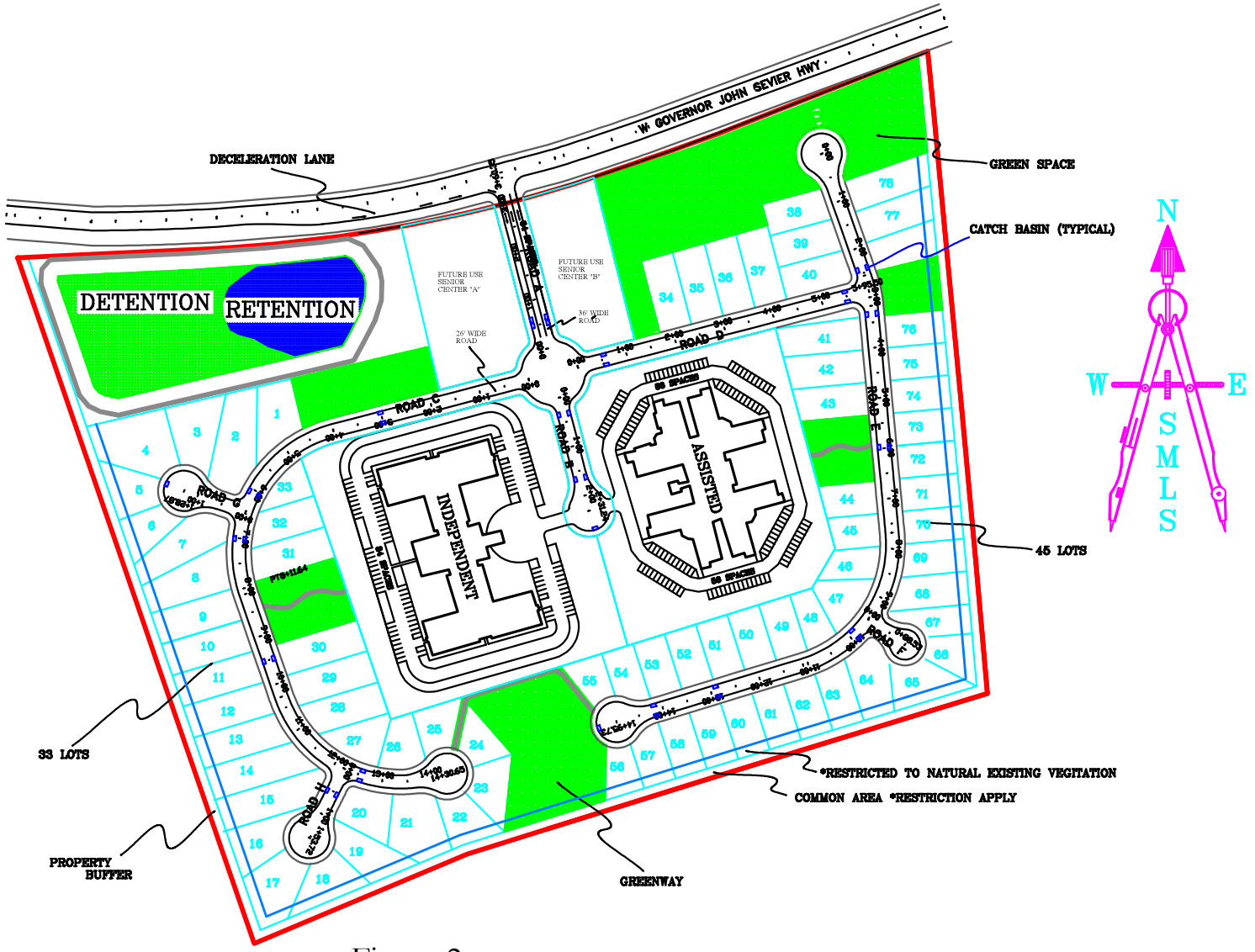


Figure 2
Proposed Plan Layout

EXISTING CONDITIONS IN STUDY AREA

John Sevier Highway (State Route 168) is a Tennessee State Highway and is classified as a Major Arterial. The highway traverses in a general east-west direction near the proposed site and the highway has a total length of 18.1 miles. John Sevier Highway intersects Alcoa Highway at its beginning on its west side and terminates at Highway 11E (Asheville Highway) on the eastern side of its length.

In front of the proposed development, John Sevier Highway currently consists of a 3-lane pavement section with a center two way left turn lane and one thru lane in each direction. The highway lanes are 12 feet in width with a 5 foot paved surface outside the white edge line. The roadway speed limit is posted at 50 mph. There are not any developments located on either side of John Sevier Highway at the proposed location. This section of John Sevier Highway has a significant upward grade in the eastbound direction. There are not any streetlights on this section of the highway currently.

Average Daily Traffic (ADT) on John Sevier Highway in the vicinity of this development was reported by the Tennessee Department of Transportation (TDOT) at 14,440 vehicles per day in 2014 (Station #000290). Refer to Appendix A for this historical traffic count data.

PHOTO REFERENCES

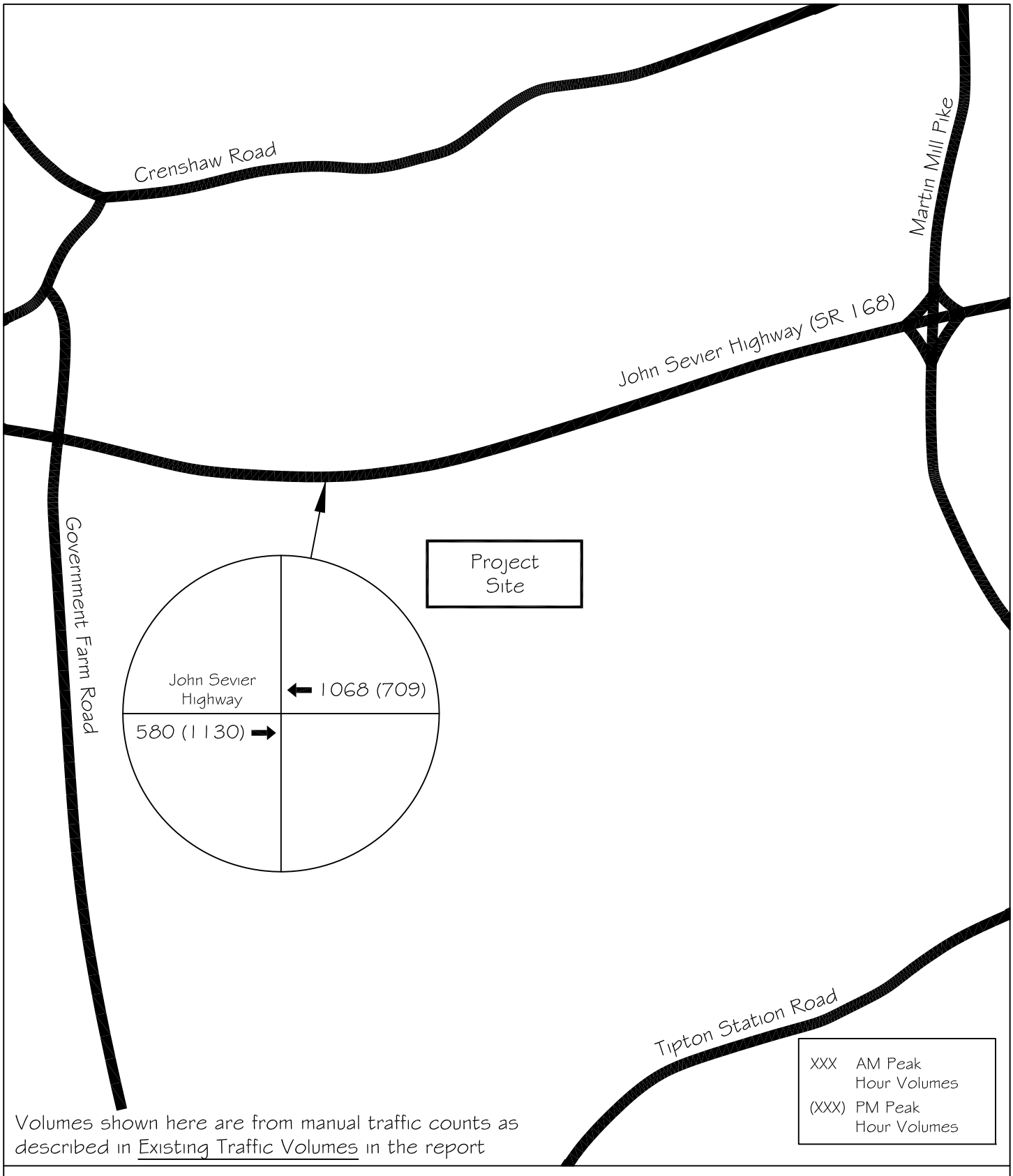
View of John Sevier Highway at the Proposed Site
(Looking East)

View of John Sevier Highway at the Proposed Site
(Looking West)

EXISTING TRAFFIC VOLUMES

In order to analyze the traffic impacts associated with the proposed future development, traffic counts were obtained on John Sevier Highway adjacent to the proposed site. The traffic count was obtained on Tuesday, October 27th, 2015, a day when local schools were in session, during the morning and afternoon peak periods. The AM peak hour was observed from 7:15 - 8:15 and the PM peak hour was observed from 4:45 – 5:45 on the highway. The manual traffic counts can be reviewed in Appendix B and the existing peak hour volumes on John Sevier Highway are shown in Figure 3.

It should be noted that during the manual traffic counts on John Sevier Highway, traffic queues formed during the PM peak periods. These queues were observed for a brief period around 5 pm and were formed from the eastbound approach at the signalized intersection of John Sevier Highway and Martin Mill Pike. The brief queue spillback from the signalized intersection to the east was of significant length to be observed at the traffic count location 2,000 feet away. The speed and flow of traffic heading eastbound was noticeably slowed during this period.



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

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FIGURE 3

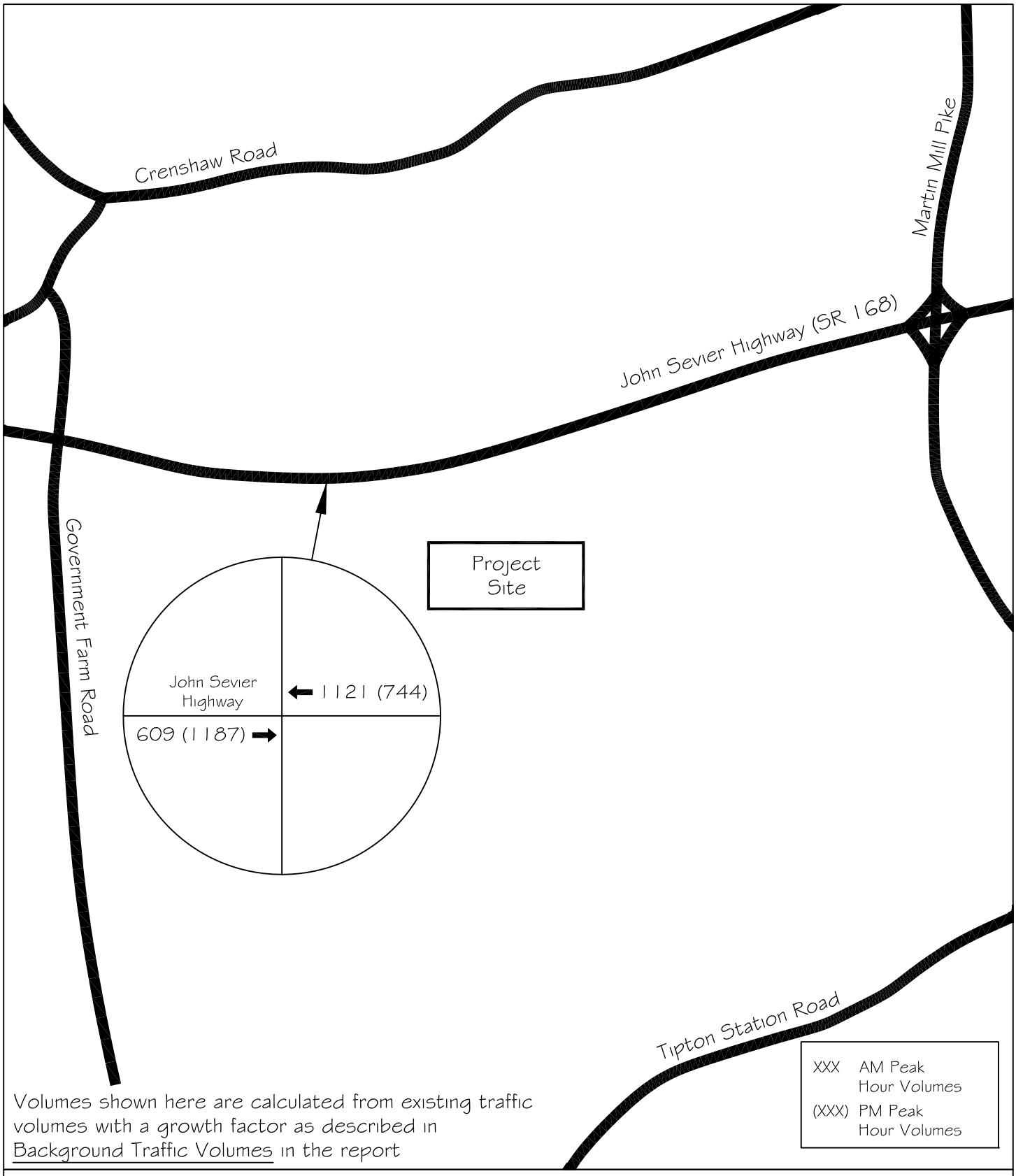
GREENBRIER SENIOR CENTER

2015 Peak Hour Traffic Volumes - EXISTING

BACKGROUND TRAFFIC VOLUMES

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

As previously stated, the build-out year for the proposed new senior community has assumed to be fully operational and at capacity in 2020. Background traffic volumes for this project were calculated by applying an annual growth rate to the existing traffic volumes obtained during the manual traffic count shown in Figure 3. This growth rate was determined by obtaining and analyzing a nearby traffic count in the area located on John Sevier Highway provided by TDOT. This data is located in Appendix A. The traffic data at this count station indicates that the average daily traffic has fluctuated with positive and negative growth over the past few years. Overall, the traffic counts recently have shown a growth of 0.1%. To insure a conservative estimate for this study, a 1% growth was used to take into account any future development in the area and possible rising travel volumes. The results of this growth rate application to the existing traffic volumes can be seen in Figure 4 for the year 2020.



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

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2020 Peak Hour Traffic Volumes - BACKGROUND

TRIP GENERATION

The estimated amount of traffic that will be generated by the proposed development 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 uses below is shown in Appendix C. A summary of this information is presented in the following:

TABLE 1
TRIP GENERATION FOR GREENBRIER SENIOR CENTER

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
				35%	**65%**		**61%**	**39%**	
#251	Senior Adult Housing - Detached	80 dwellings	388	15	29	44	23	15	38
				65%	**35%**		**40%**	**60%**	
#255	Continuing Care Retirement Community	163 occupied units	554	27	15	42	32	48	80
Total New Volume Site Trips			942	42	44	86	55	63	118

Based on these calculations, it is expected that 42 vehicles will enter the development during the AM Peak Hour, 44 will exit, for a total of 86 new generated trips during the AM Peak Hour (7:15 AM – 8:15 AM) in the year 2020 at full development. Similarly, it is expected that 55 vehicles will enter the development during the PM Peak Hour, 63 will exit, for a total of 118 new generated trips during the PM Peak Hour (4:45 PM – 5:45 PM) at full development. Additionally, the calculated trips generated for an average day are expected to be approximately 927 vehicles for the entire development. No trip rate reductions were made for pass-by trips or for multi-development reductions since they would not be appropriate for this type of development.

As can be expected, trip generation rates provided by ITE indicate a much lower incidence of trips for retired and senior individuals for the senior adult housing land use. Traditionally, senior individuals are less likely to be employed, less likely to have children residing in the household, and have fewer vehicles which all would result in lower trips generated. The single detached residences that are proposed for this development will also yield lower trips since the residences are smaller than average with less upkeep and maintenance and will be handled by on-site staff.

TRIP DISTRIBUTION & ASSIGNMENT

The potential directional distribution of trips that will be generated by the proposed development are shown in Figure 5. Figure 5 shows the projected distribution for traffic entering/exiting the new development during the future peak hours at the proposed intersection on John Sevier Highway for the proposed development. The percentages shown only pertain to the new trips generated by the new development. The new internal roundabout intersection is also shown in Figure 5 and illustrates the distribution of traffic within the development at the roundabout and is based on the separate land uses.

The projected trip distributions shown are based on the existing traffic movements at the examined roadway and were also surmised from surrounding concentrations of development and population. Figure 7 shows the Traffic Assignment of the computed trips that will be generated by the development (as shown in Table 1) which is then applied to the various intersection movements based on the assumed distribution of trips shown in Figure 5.

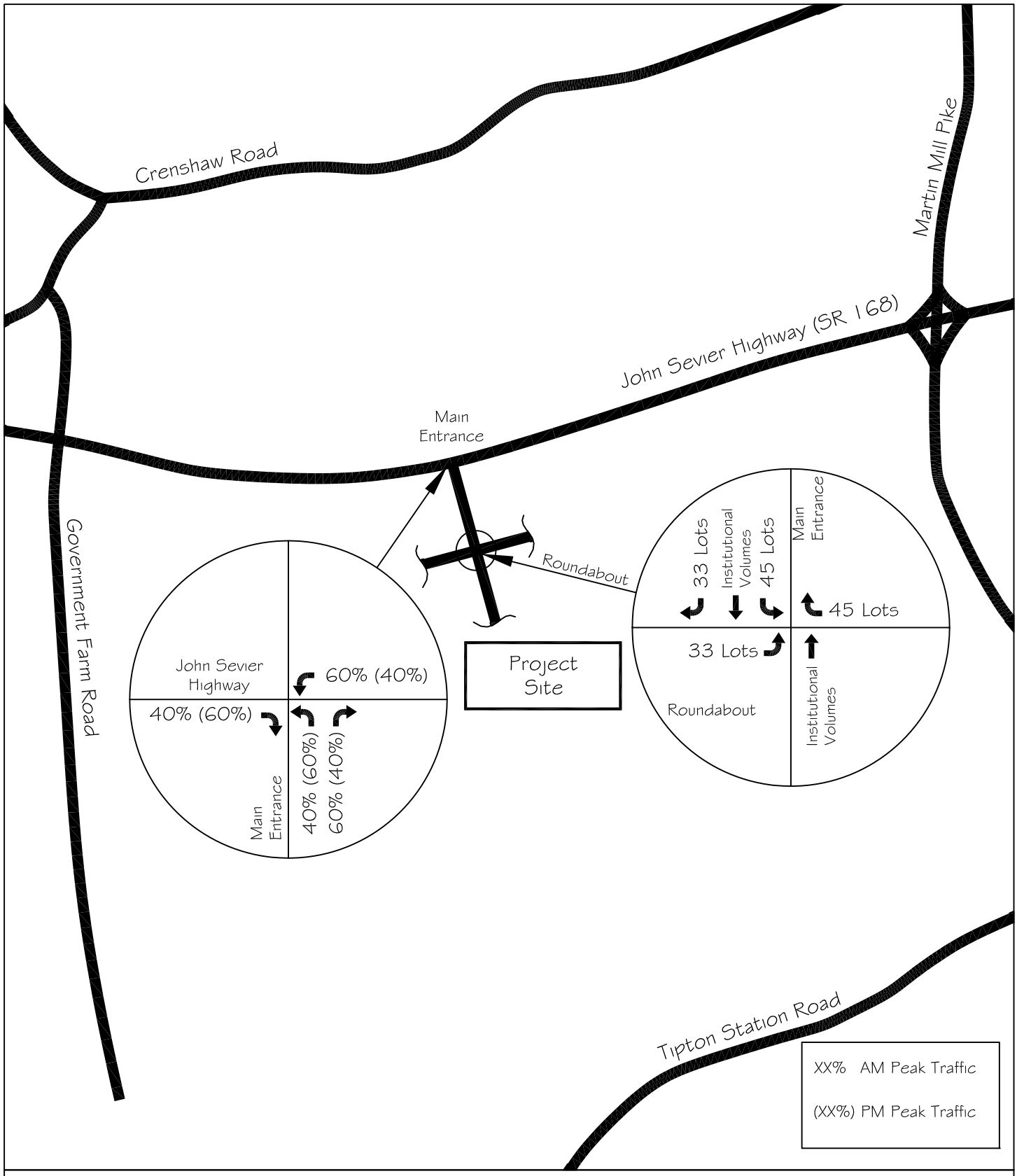

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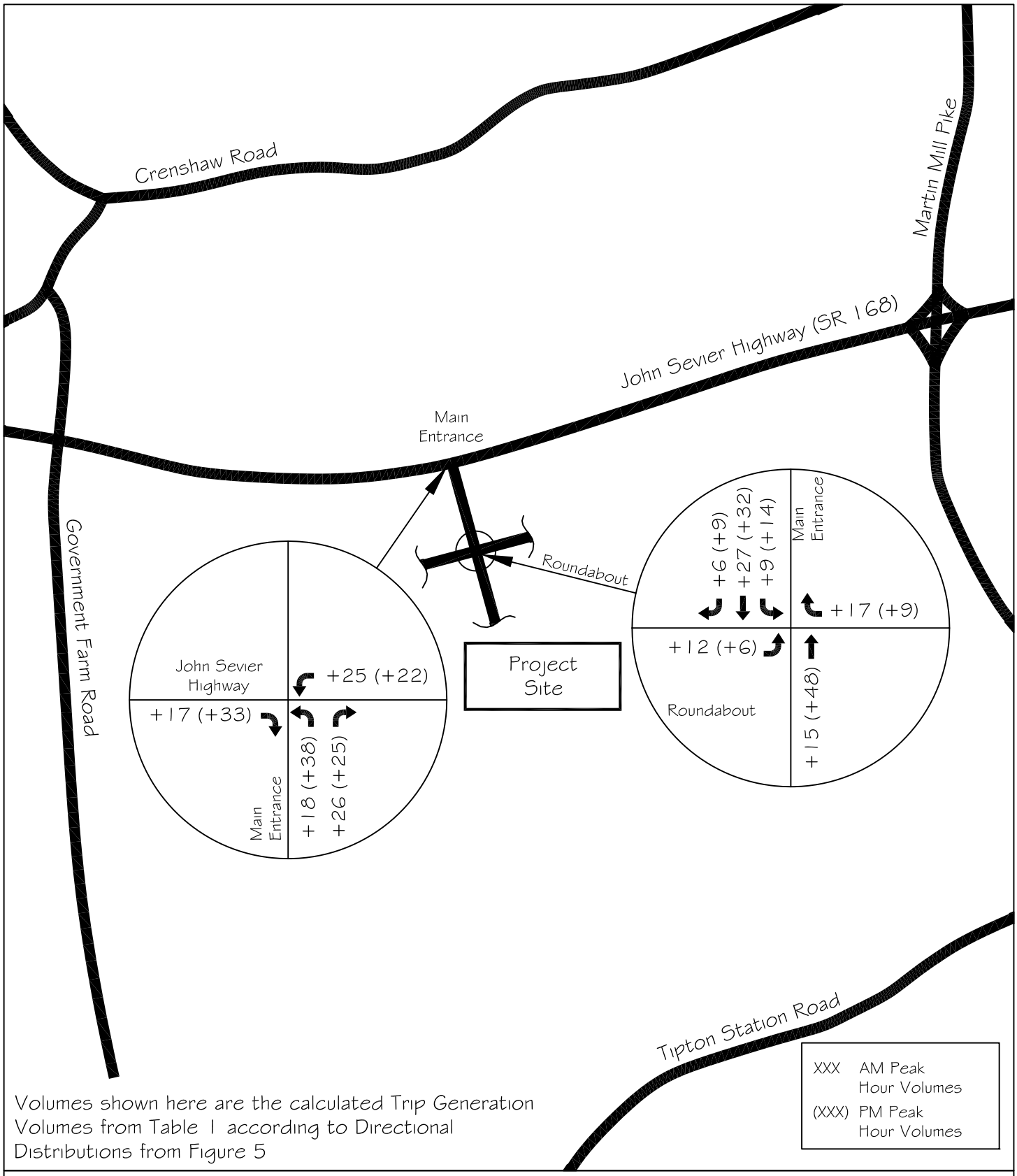
FIGURE 5

GREENBRIER SENIOR CENTER

Directional Distribution of Generated Traffic for Greenbrier Senior Center



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

GREENBRIER SENIOR CENTER

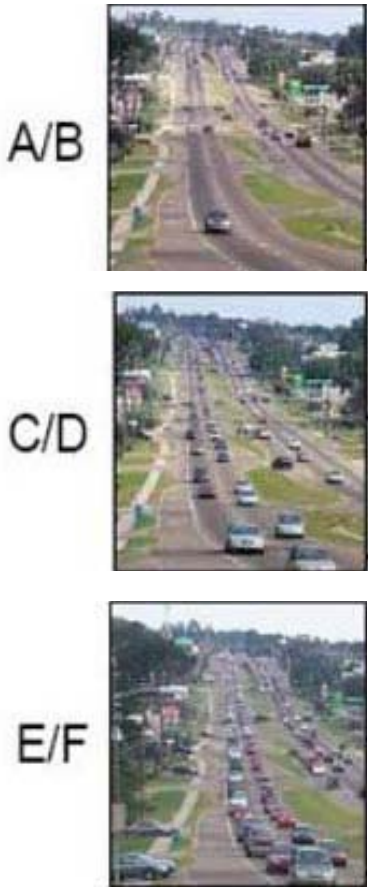
Traffic Assignment of Generated Traffic

PROJECTED TRAFFIC VOLUMES

To calculate the total future projected traffic volumes, application of the calculated peak hour traffic (from Table 1) generated by the new proposed Greenbrier Senior Center were added to the 2020 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 operational and at full capacity by the year 2020.

Capacity analyses were undertaken to determine the existing Level of Service (LOS) for the proposed driveway intersection at John Sevier Highway and the internal roundabout within the development. The capacity analyses were calculated by following the methods outlined in the Highway Capacity Manual and using Synchro Traffic Software (Version 8). Figure 7 shows the projected AM and PM peak hour volumes at the studied intersection for the year 2020. Appendix D includes the worksheets for these capacity analyses.

LOS is a qualitative measurement developed by the transportation profession of how well an intersection or roadway performs based on a driver's perception. 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 (HCM) lists level of service criteria for unsignalized intersections and is presented in this report as Table 2.



(Source: FDOT)

For unsignalized intersections, Level of Service is measured in terms of delay (in seconds). This measure is an attempt to quantify delay that includes 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 operational performance and level of service of the intersections. Generally, for most instances, LOS D or E is considered the upper limit of acceptable delay.

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

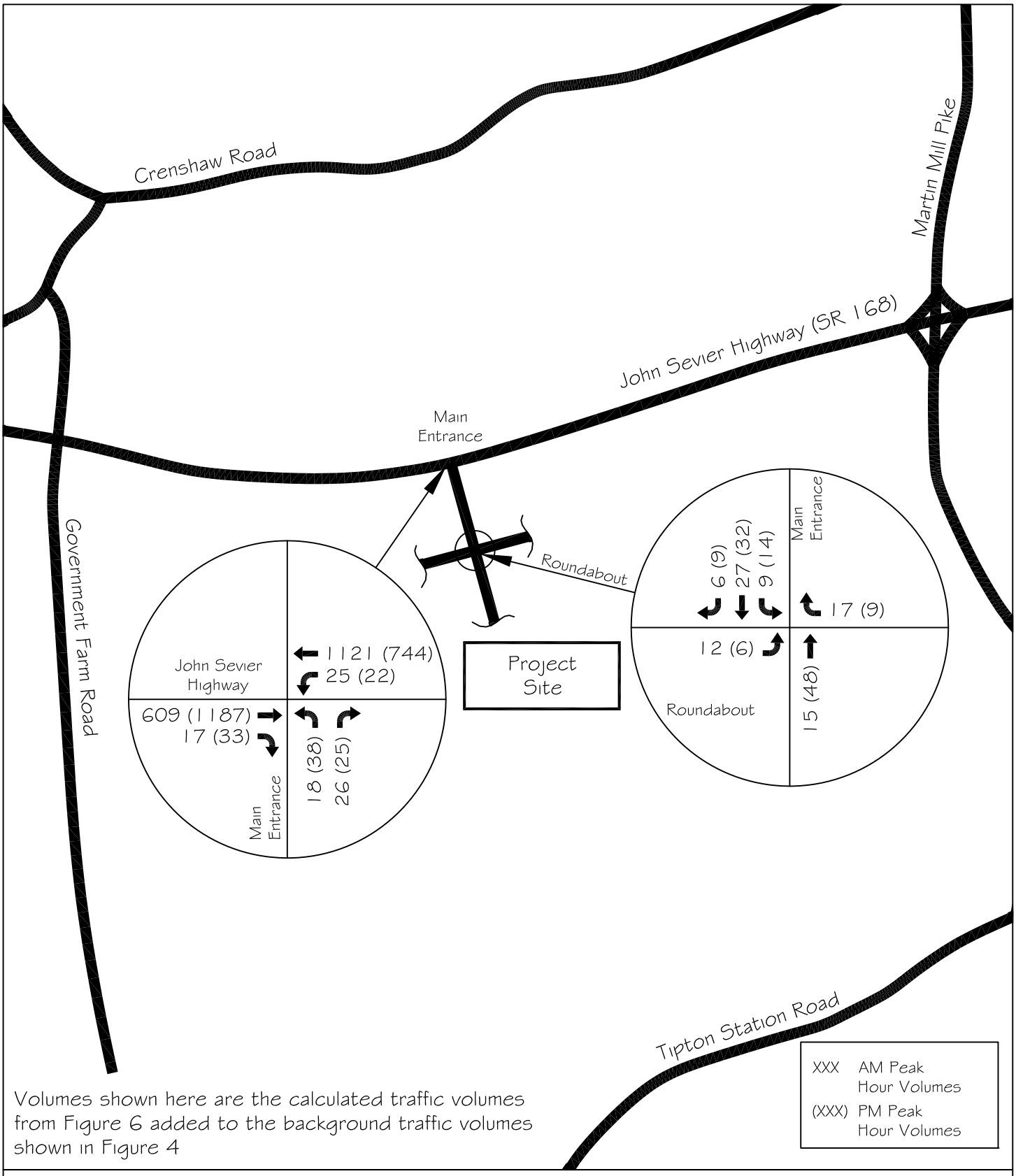
Source: Highway Capacity Manual

The results of the capacity calculations of the projected peak hour traffic can be seen in Table 3 for the intersections. The unsignalized internal roundabout intersection volumes were obtained from the calculated entering and exiting volumes from the main intersection at John Sevier Highway and determined from the calculated individual land uses. For the intersections, the peak hour levels of service are shown to operate at very good levels during both the AM and PM peak hours. The only exception to these results is for the left turns on the northbound approach (exiting out of the development). Motorists attempting to exit by turning left onto John Sevier Highway could potentially experience LOS D during the peak periods. It should be noted that for the project analysis, it was assumed that separate northbound (exiting) left and right turn lanes would be constructed at the main entrance.

TABLE 3
2020 PEAK HOUR LEVEL OF SERVICE & DELAY - PROJECTED

INTERSECTION	TRAFFIC CONTROL	APPROACH	LEVEL OF SERVICE		DELAY (seconds)	
			AM PEAK	PM PEAK	AM PEAK	PM PEAK
Main Entrance Driveway at John Sevier Highway	 Unsignalized	Northbound Left Turn	D	D	28.6	32.0
		Northbound Right Turn	B	C	13.8	24.0
		Westbound Left Turn	A	B	9.1	11.6
Main Driveway Entrance at Internal Driveway	 Roundabout	Easbound Approach	A	A	3.4	3.4
		Westbound Approach	A	A	3.5	3.5
		Northbound Approach	A	A	3.4	3.7
		Southbound Approach	A	A	3.5	3.6

Note: All analyses were calculated in Synchro 8 software and reported with HCM 2010 methodology



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

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FIGURE 7

GREENBRIER SENIOR CENTER

2020 Peak Hour Traffic Volumes - PROJECTED

SPOT SPEED STUDY

As a part of the traffic count observations, a spot speed study was also conducted. The spot speed study was conducted on John Sevier Highway 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 John Sevier Highway travels at a greater speed than the posted speed limit. The posted speed limit for John Sevier Highway is 50 mph. The results of the spot speed study indicate that the observed 85th percentile speed was just at 55 mph near the proposed development location on John Sevier Highway. The spot speed field observations are provided in Appendix E.

EVALUATION OF TURN LANE THRESHOLDS

The proposed intersection to be located at John Sevier Highway for the development was also evaluated for the need for a separate right turn lane into the development on John Sevier Highway based on the projected traffic volumes. Based on the projected traffic volumes at the main entrance, it does appear that a separate eastbound right turn lane into the development will be warranted. This was determined by utilizing "Knox County's Access Control and Driveway Design Policy" for turn lane requirements. The projected volumes for right turns into the development at the main entrance are just slightly over the requirement threshold. The Knox County turn lane policy worksheet is located in Appendix F.

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 approximately 55 mph. Therefore, this study evaluation used the Knox County classification for speeds of 46 to 55 mph and the calculated projected volumes.

CONCLUSIONS AND RECOMMENDATIONS

The analyses presented in this study of the proposed new Greenbrier Senior Center indicate that the calculated traffic generated by this development in tandem with projected future traffic volumes should operate fairly well at the proposed unsignalized driveway intersection at John Sevier Highway. 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 cost.

1) **John Sevier Highway at the Main Entrance Driveway:** From the capacity calculations, it has been shown (Table 3) that the westbound left turns into the development at the main entrance should operate very well during the AM and PM peak periods once the development becomes fully developed. This is due to the projected sufficient amount of gaps in traffic that should be available for vehicles turning left into the development. The level of service for exiting vehicles will operate at a reduced level. For the AM and PM peak periods, northbound exiting left turn vehicles will operate at LOS D. For northbound exiting right turn vehicles, the level of service was calculated to be at B in the morning peak and C in the afternoon peak. These lower levels of service are directly related to the large amount of thru vehicles on John Sevier Highway in the peak periods that conflict with these future exiting turning movements.

   It is expected that these projected lower levels of service might be partially offset with the knowledge that the seniors and retired residents at this development may very well be able to avoid peak periods of traffic due to their flexibility in travel schedules as compared to average aged home communities. Furthermore, this study did not include modeling the signalized intersection of John Sevier Highway at Martin Mill Pike. It is not known if this traffic signal has been updated recently to reflect the current traffic demands in the afternoon peak hour to reduce the amount of queue formation that was observed backing up on John Sevier Highway during the manual traffic counts.

   1a) **From the capacity calculations, it does appear that separate northbound left and right turn lanes are required at the main driveway intersection for exiting vehicles out of the development at John Sevier Highway.** This would allow 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.

1b) An analysis was undertaken to examine the potential queue length for northbound left turn/right turn vehicles based on the projected volumes. To estimate this length, SimTraffic (Version 8) software was utilized which performs micro-simulation and animation of vehicular traffic and also calculates various vehicle parameters such as intersection queue lengths. Based on the software results according to the projected volumes, the 95th percentile queue distance was calculated to be 232 feet during the PM peak for northbound (exiting) left turns. (The 95th percentile queue is a traditional measurement used when reviewing queue distances. A 95th percentile queue means that there is a 95% certainty the queue will not extend beyond that point. The queue results were based on averaging the outcome obtained during 10 separate traffic simulations.) **It is recommended that the left turn lane exiting at the main entrance be designed and constructed with at least 240 feet of left turn storage.** The queue results from the SimTraffic software are located in Appendix G. This storage length should be available in between the intersection of John Sevier Highway and the internal roundabout intersection. The designed roadway distance of this section is just over 360 feet from centerline to centerline.

1c) Based on an observed speed limit of 55 mph on John Sevier Highway; the recommended intersection sight distance requirement is 650 feet. While not surveyed in the field, it appears from visual observation that this distance is more than available for vehicles entering John Sevier Highway 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. This additional distance should be provided with the knowledge that the driveway will be used by seniors and retired persons who on average have longer perception and reaction times than the average motoring public.

1d) **Based on the traffic volumes and operating speeds on John Sevier Highway, it is recommended that a separate eastbound right turn lane be designed and constructed at the main entrance. Based on operating speeds of 55 mph, this turn lane should be at least 495 feet in length (which could include taper lengths).** This length is based on the stopping sight distance for an observed operating speed of 55 mph and will be advantageous

since it will help remove slowing turn vehicles from the thru lane. For this eastbound approach at the new intersection, the new right turn lane should be marked with the appropriate right turn pavement marking symbols to insure that the eastbound traffic does not confuse the new right turn lane as a potential thru lane. Refer to TDOT Roadway Design Guidelines for appropriate taper lengths.

1e) **It is recommended that the main entrance approach at the intersection with John Sevier Highway be designed and constructed with a 24" white stop bar and with a Stop Sign (R1-1). The center of John Sevier Highway should be re-striped to accommodate the new intersection with the new turning movements. This would involve installing breaks in the striping in the existing two-way left turn lane.**

1f) **Intersection sight distance at the new proposed main entrance at John Sevier Highway must not be impacted by new signage, future landscaping or existing vegetation.** The existing site is heavily forested and will need site clearing along the highway to insure sight distances are adequate.

1g) The road and/or site designer for the new driveway intersections at John Sevier Highway should apply for the proper TDOT driveway permits prior to construction.

1h) **Due to the number of dwelling units in the development, the roadway in between John Sevier Highway and the roundabout should be designed and constructed as a boulevard section.**

2) **Internal Drives**: The current layout plans show new private roadways being constructed within the development as shown in Figure 2.

3a) **The internal roadway approaches must be constructed with a Stop Sign (R1-1) and a 24" white stop bar where they intersect other internal drives including the cul-de-sac intersections.**

3b) The proposed roundabout in the development was shown in the capacity calculations to operate very well with respect to level of service. The site designer should follow the details and guidelines set forth by TDOT and the Federal Highway Administration (FHWA). TDOT standard drawings for roundabouts, RD01-TS-9 and RP-R-2, should be followed where appropriate. Also, FHWA's design document, Roundabouts: An Informational Guide should be followed and reviewed for design principles.

3c) **Intersection sight distance at the new internal intersections must not be impacted by new signage, future landscaping or existing vegetation.**

3d) **Due to the inherent nature of the aging process, it is recommended that the overall site design take into account slower walking speeds, decreased sight abilities and reaction times.** If the site includes sidewalks, it should take into account design principles that incorporate seniors and handicapped persons. The site should be signed internally with appropriate directional signage with large lettering if at all possible. **The internal site roads should be posted with speed limit signs of 15 mph or less.**

3e) **All road grade and intersection elements internally should be designed to AASHTO, TDOT, and Knox County Engineering specifications and guidelines to insure proper operation.**

SUMMARY OF MAJOR RECOMMENDATIONS

The following is a summary of the major recommendations presented in this Traffic Impact Study for the proposed Greenbrier Senior Center in Knox County, TN:

- As shown in the proposed plan layout, design and construct a single main entrance on John Sevier Highway according to TDOT guidelines and regulations. The roadway in between John Sevier Highway and the internal roundabout should be designed and constructed as a boulevard section.
- At the main entrance on John Sevier Highway, construct a 3 lane northbound approach with one entering lane and two exiting lanes. The exiting lanes should include a separate left and right turn lane. The left turn lane should also include a minimum of 240 feet of storage length. The eastbound approach at this intersection should include a separate right turn lane for entering vehicles off of John Sevier Highway. The length of this new right turn lane should be approximately 495 feet in length (including taper length).

APPENDIX A

HISTORICAL TRAFFIC COUNT DATA

Historical Traffic Counts

Organization: TDOT

Station ID #: 000290

Location: John Sevier Highway (SR 168) - approximately 2,700 feet to the east of Martin Mill Pike

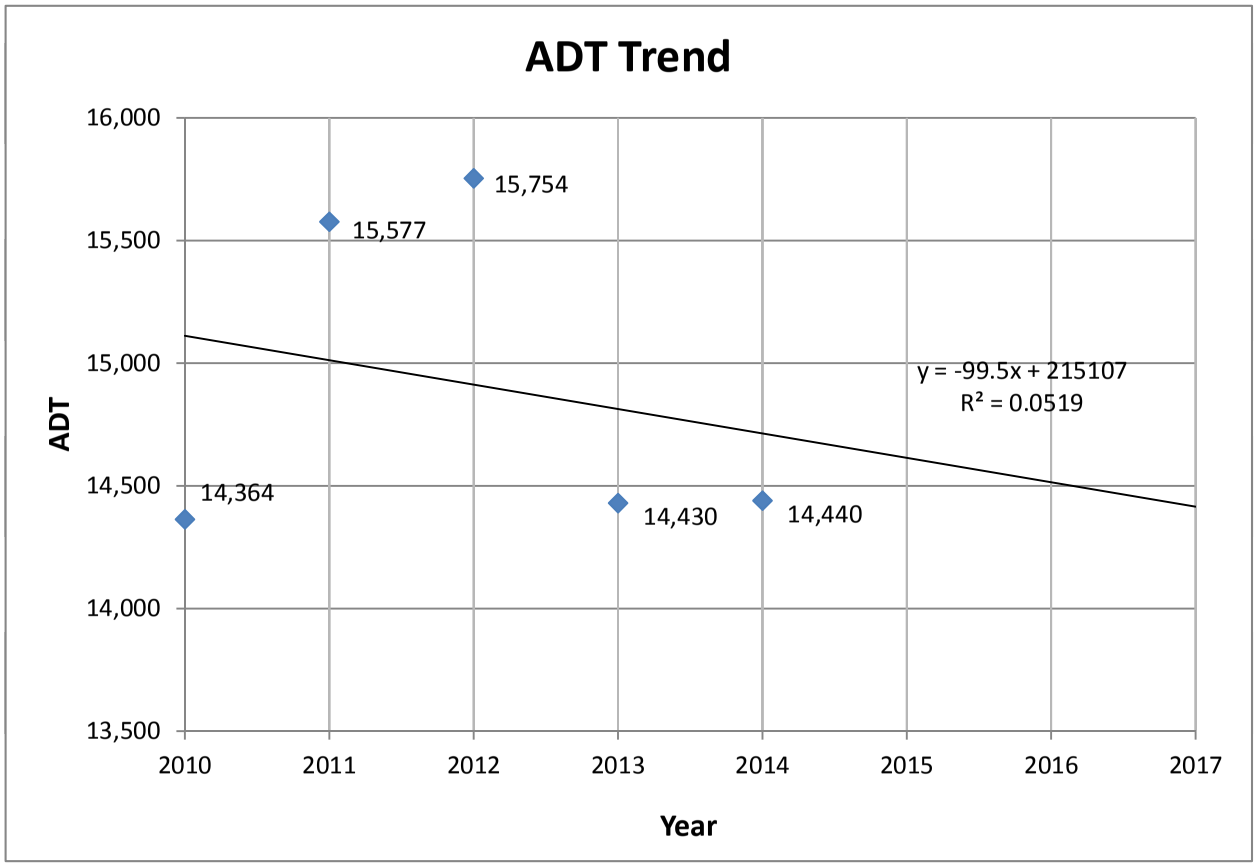
YEAR	ADT
2010	14,364
2011	15,577
2012	15,754
2013	14,430
2014	14,440

Recent Trend Line Growth

2013	14,430
2014	14,440

Annual % Growth = 0.1%

Trendline

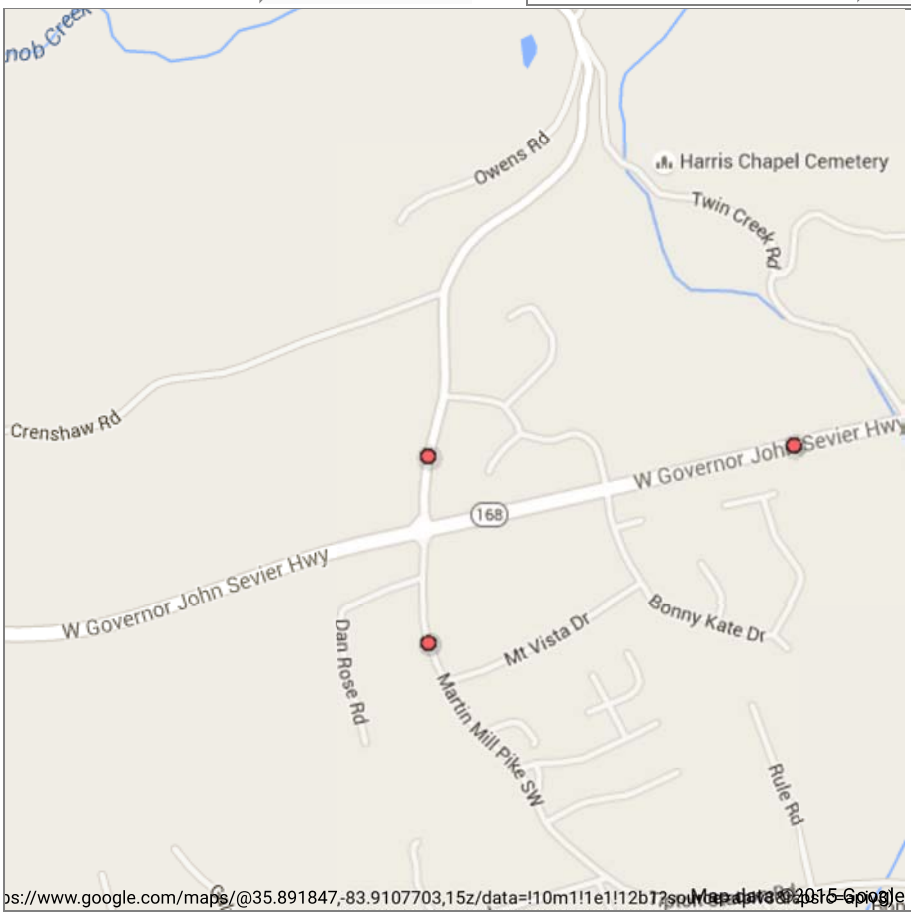


Traffic History

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: Anderson Station Number: Search



Station Information

Station	000290
Route	SR168
Location	SOUTH KNOXVILLE
County	Knox
2014	14440
2013	14430
2012	15754
2011	15577
2010	14364
2009	15064
2008	15433
2007	15068
2006	15281
2005	14987
2004	15338
2003	14495
2002	13604
2001	13901
2000	14941
1999	13110
1998	11635
1997	11701
1996	11185

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

APPENDIX B

MANUAL TRAFFIC COUNT DATA

TRAFFIC COUNT DATA

Major Street: John Sevier Highway — 10/27/2015 (Tuesday)
Minor Street: n/a — Cloudy/Rain

Primary Movement: Vehicles

TIME BEGIN	WESTBOUND THRU	EASTBOUND THRU	VEHICLE TOTAL	PEAK HOUR
7:00 AM	224	115	339	
7:15 AM	***278***	***120***	***398***	**7:15 AM - 8:15 AM**
7:30 AM	***302***	***143***	***445***	
7:45 AM	***259***	***168***	***427***	
8:00 AM	***229***	***149***	***378***	
8:15 AM	238	134	372	
8:30 AM	224	126	350	
8:45 AM	164	104	268	
TOTAL	**1918**	**1059**	**2977**	
3:00 PM	123	157	280	
3:15 PM	120	153	273	
3:30 PM	153	177	330	
3:45 PM	172	212	384	
4:00 PM	142	240	382	
4:15 PM	146	227	373	
4:30 PM	171	232	403	
4:45 PM	***168***	***282***	***450***	**4:45 PM - 5:45 PM**
5:00 PM	***193***	***283***	***476***	
5:15 PM	***185***	***270***	***455***	
5:30 PM	***163***	***295***	***458***	
5:45 PM	145	263	408	
TOTAL	**1881**	**2791**	**4672**	

Peak Hour AM

TIME BEGIN	WESTBOUND THRU	EASTBOUND THRU
7:15 AM	***278***	***120***
7:30 AM	***302***	***143***
7:45 AM	***259***	***168***
8:00 AM	***229***	***149***
TOTAL	1068	580
PHF	0.88	0.86

Peak Hour PM

TIME BEGIN	WESTBOUND THRU	EASTBOUND THRU
4:45 PM	***168***	***282***
5:00 PM	***193***	***283***
5:15 PM	***185***	***270***
5:30 PM	***163***	***295***
TOTAL	709	1130
PHF	0.92	0.96

APPENDIX C

ITE TRIP GENERATION RATES

Land Use: 251
Senior Adult Housing—Detached

Description

Senior adult housing consists of detached independent living developments, including retirement communities, age-restricted housing and active adult communities. These developments may include amenities such as golf courses, swimming pools, 24-hour security, transportation and common recreational facilities. However, they generally lack centralized dining and on-site health facilities. Detached senior adult housing communities may or may not be gated. Residents in these communities are typically active (requiring little to no medical supervision). The percentage of retired residents varies by development. Senior adult housing—attached (Land Use 252), congregate care facility (Land Use 253) and continuing care retirement community (Land Use 255) are related land uses.

Additional Data

Caution should be used when applying trip rates for this land use as it may contain a wide variety of studies ranging from communities with very active, working residents to communities with older, retired residents. As more data becomes available, consideration will be given to future stratification of this land use.

Many factors affected the trip rates for detached senior adult housing. Factors such as the average age of residents, development location and size, affluence of residents, employment status and vehicular access should be taken into consideration when conducting an analysis. Some developments were located within close proximity to medical facilities, restaurants, shopping centers, banks and recreational activities.

The peak hour of the generator typically did not coincide with the peak hour of the adjacent street traffic. The A.M. peak hour of the generator typically ranged from 7:00 a.m. to 12:00 p.m. and the P.M. peak hour of the generator typically ranged from 1:00 p.m. to 6:00 p.m.

The sites were surveyed in the 1980s, the 1990s and the 2000s in California, Florida, New Hampshire, New Jersey, Pennsylvania and Canada.

Source Numbers

221, 289, 398, 421, 500, 550, 598, 601, 629, 734

Senior Adult Housing - Detached
(251)

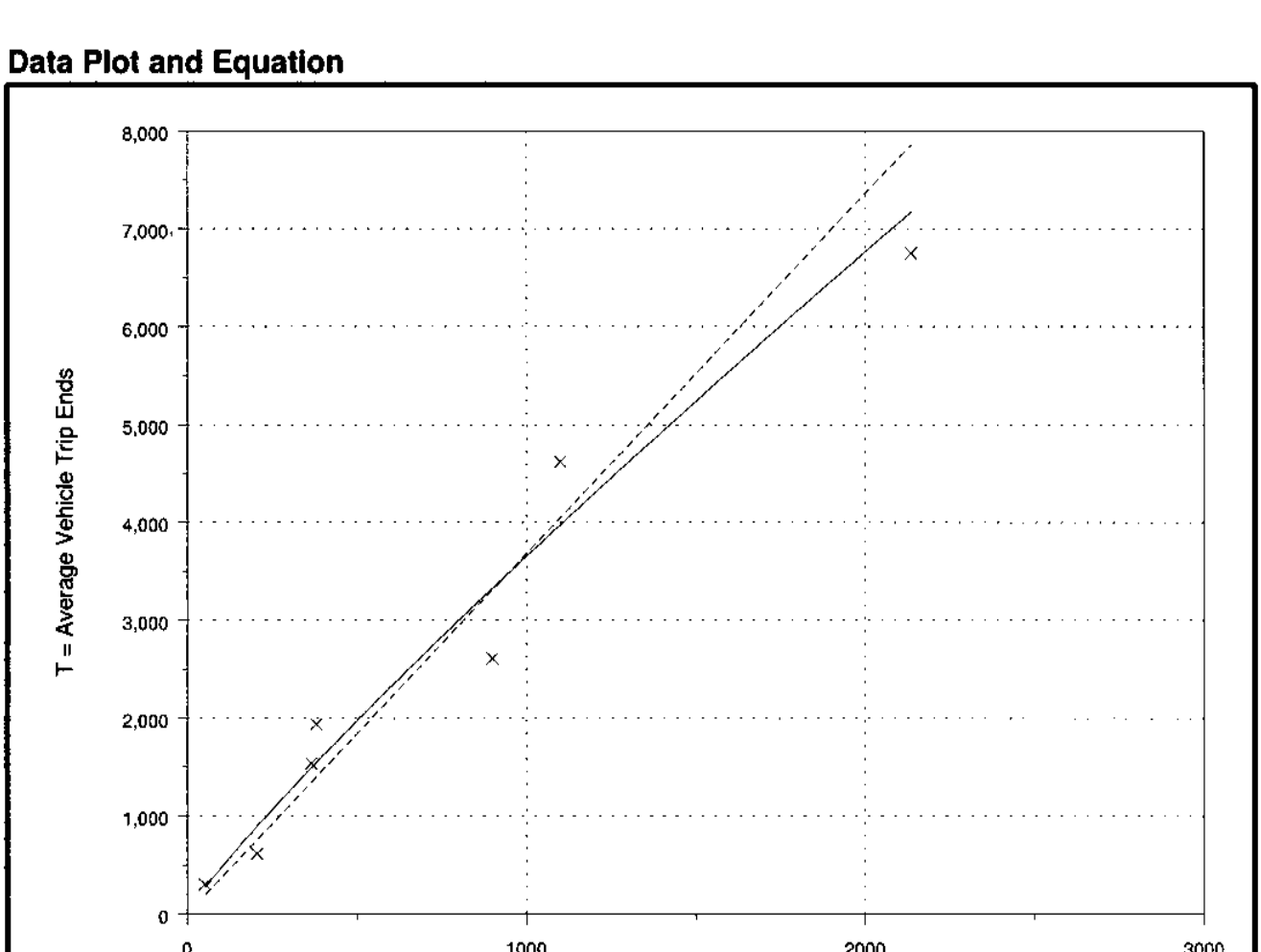
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Number of Studies: 8
Avg. Number of Dwelling Units: 780
Directional Distribution: 50% entering, 50% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
3.68	2.90 - 5.70	2.04

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.89 Ln(X) + 2.06

R^2 = 0.96

Senior Adult Housing - Detached
(251)

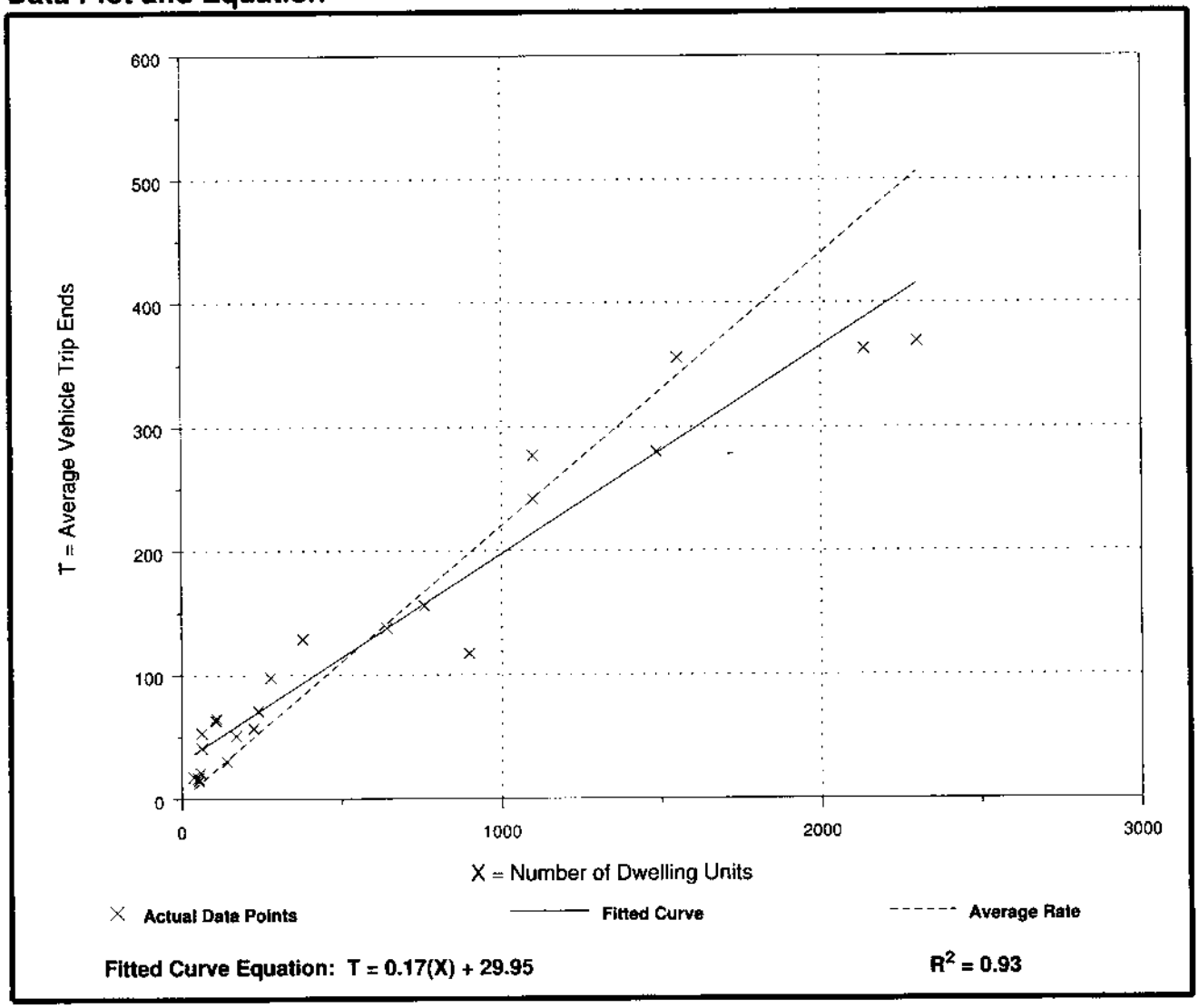
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.

Number of Studies: 23
Avg. Number of Dwelling Units: 607
Directional Distribution: 35% entering, 65% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.22	0.13 - 0.84	0.47

Data Plot and Equation



Fitted Curve Equation: T = 0.17(X) + 29.95

R^2 = 0.93

Senior Adult Housing - Detached
(251)

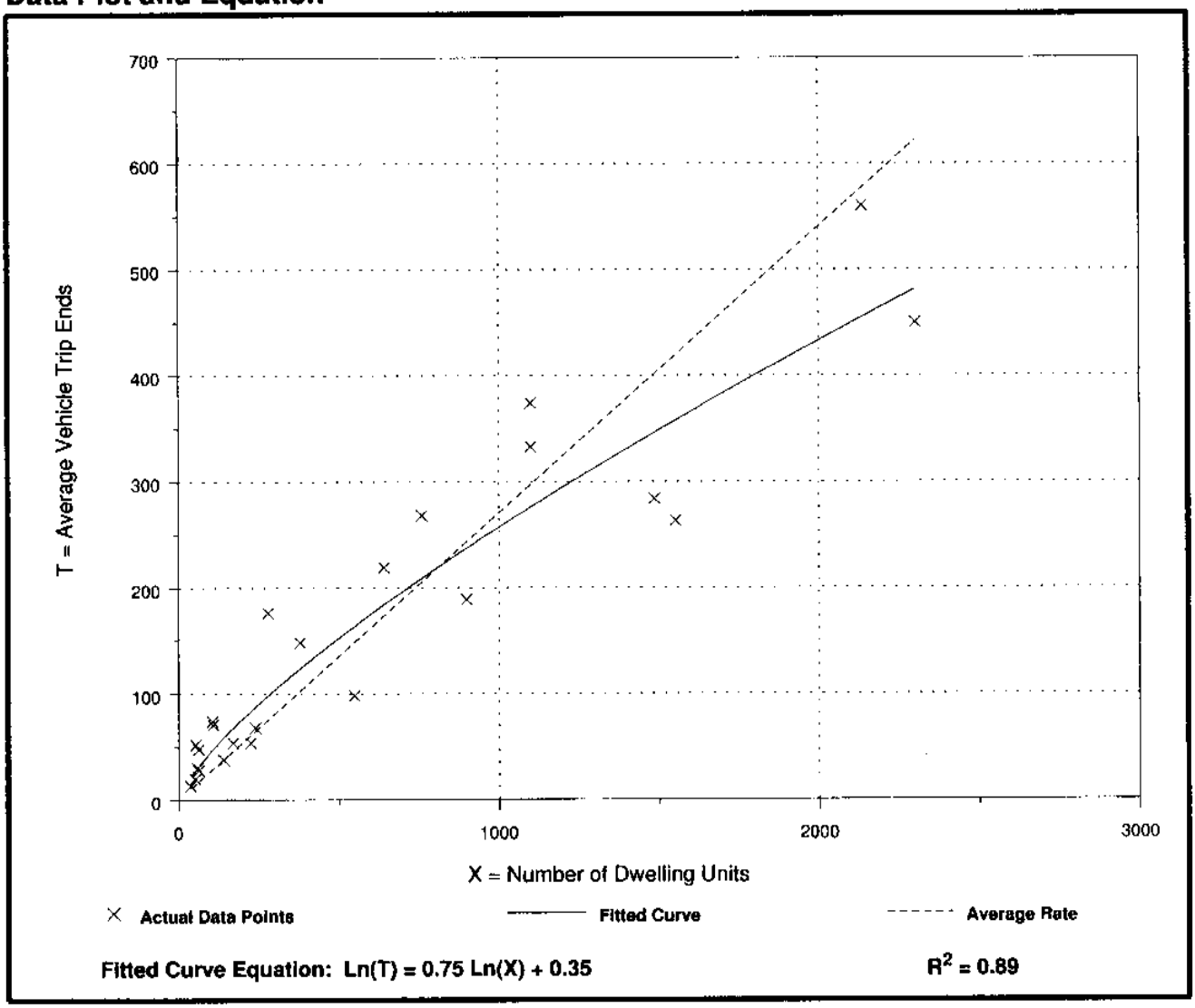
Average Vehicle Trip Ends vs: **Dwelling Units**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.

Number of Studies: 24
Avg. Number of Dwelling Units: 605
Directional Distribution: 61% entering, 39% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.27	0.17 - 0.95	0.53

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.75 Ln(X) + 0.35

R^2 = 0.89

Land Use: 255
Continuing Care Retirement Community

Description

Continuing care retirement communities (CCRCs) are land uses that provide multiple elements of senior adult living. CCRCs combine aspects of independent living with increased care, as lifestyle needs change with time. Housing options may include various combinations of senior adult (detached), senior adult (attached), congregate care, assisted living and skilled nursing care—aimed at allowing the residents to live in one community as their medical needs change. The communities may also contain special services such as medical, dining, recreational and some limited, supporting retail facilities. CCRCs are usually self-contained villages. Senior adult housing—detached (Land Use 251), senior adult housing—attached (Land Use 252), congregate care facility (Land Use 253), assisted living (Land Use 254) and nursing home (Land Use 620) are related uses.

Additional Data

Caution should be used when applying these data. CCRCs are relatively new and unique land uses. These developments consist of various housing components (dwelling units, rooms and beds[1]) that often exist in varying proportions. Therefore, the use of a single housing component does not fully describe the trip generation characteristics of these communities. Based upon the limited data submitted for this land use, it was determined that a comprehensive independent variable, units, was the most appropriate descriptor of the characteristics. This variable is defined as an aggregate of all living accommodations common to these communities. The independent variable, occupied units, provides data on the number of units that were occupied at the study sites at the time of the survey.

To illustrate the varying proportions of housing options that exist, the following table is provided for nine of the CCRCs included in this land use as an example. Users are strongly cautioned to exercise proper engineering judgment in applying these data.

[1] Dwelling units, rooms and beds are the independent variables typically used to represent independent housing (detached/attached/congregate care), assisted living facilities and nursing homes, respectively. Occupied dwelling units/rooms may be private or shared accommodations.

Continuing Care Retirement Community
(255)

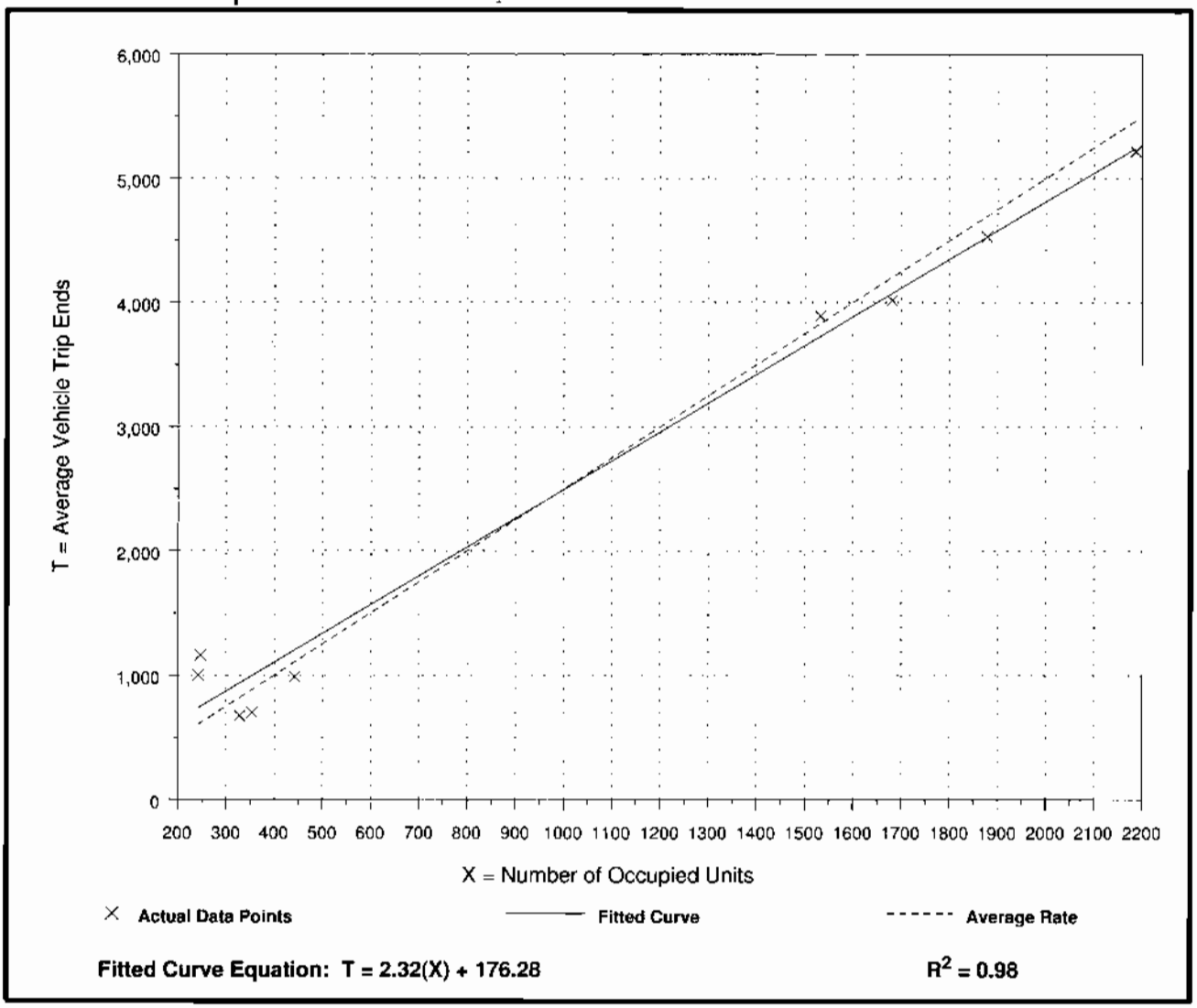
Average Vehicle Trip Ends vs: Occupied Units
On a: Weekday

Number of Studies: 9
Average Number of Occupied Units: 988
Directional Distribution: 50% entering, 50% exiting

Trip Generation per Occupied Unit

Average Rate	Range of Rates	Standard Deviation
2.50	1.98 - 4.71	1.65

Data Plot and Equation



Fitted Curve Equation: T = 2.32(X) + 176.28

R^2 = 0.98

Continuing Care Retirement Community
(255)

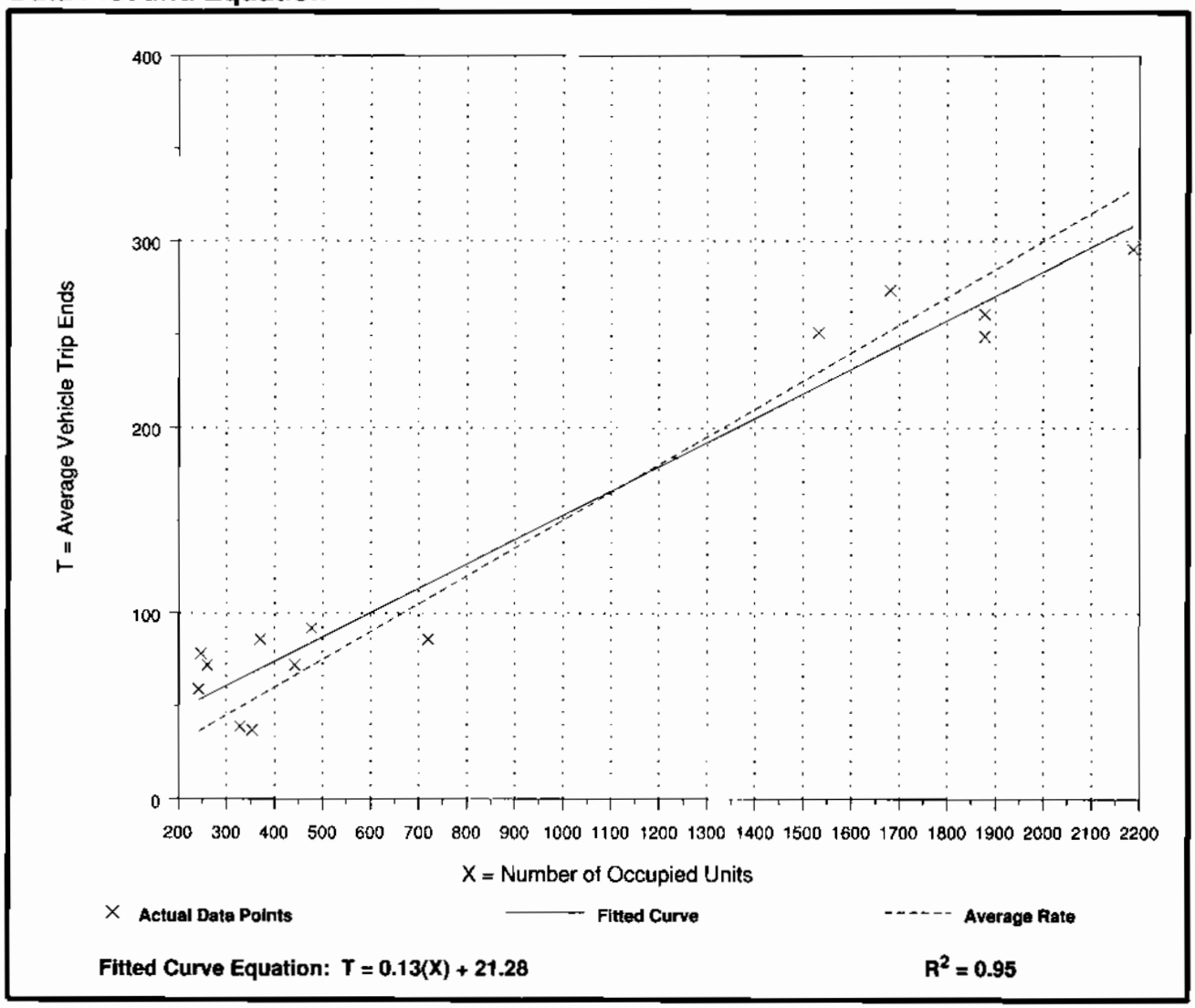
Average Vehicle Trip Ends vs: **Occupied Units**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.

Number of Studies: 14
Average Number of Occupied Units: 900
Directional Distribution: 65% entering, 35% exiting

Trip Generation per Occupied Unit

Average Rate	Range of Rates	Standard Deviation
0.15	0.10 - 0.32	0.40

Data Plot and Equation



Fitted Curve Equation: T = 0.13(X) + 21.28

R^2 = 0.95

Continuing Care Retirement Community
(255)

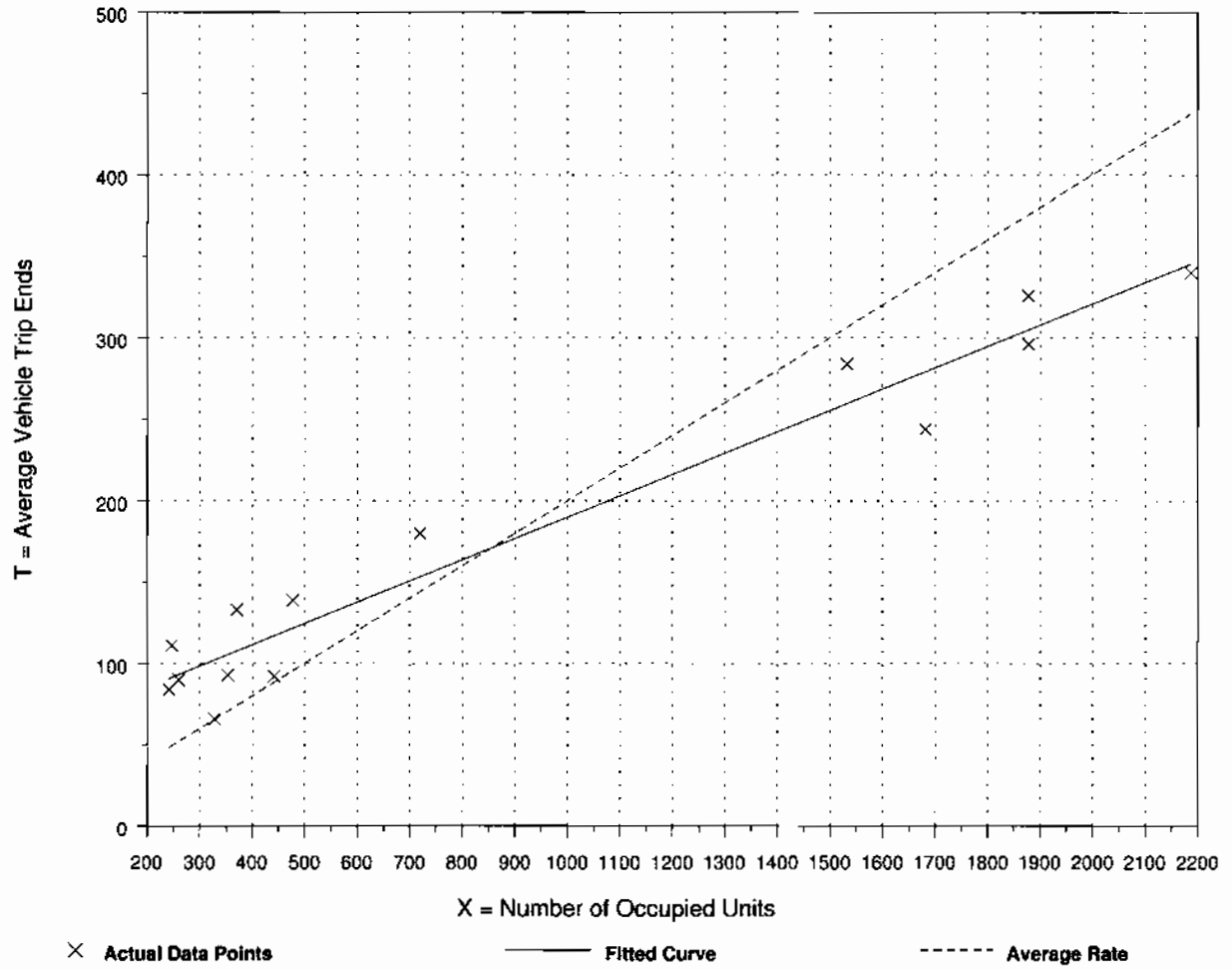
Average Vehicle Trip Ends vs: **Occupied Units**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.

Number of Studies: 14
Average Number of Occupied Units: 900
Directional Distribution: 40% entering, 60% exiting

Trip Generation per Occupied Unit

Average Rate	Range of Rates	Standard Deviation
0.20	0.15 - 0.45	0.45

Data Plot and Equation



Fitted Curve Equation: T = 0.13(X) + 59.19

R^2 = 0.95

APPENDIX D

CAPACITY ANALYSES -
HCM WORKSHEETS
(SYNCHRO 8)

Intersection	
Int Delay, s/veh	0.6

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Vol, veh/h	609	17	25	1121	18	26
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	250	500	-	422	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	5	-	-	-5	0	-
Peak Hour Factor	86	92	92	88	92	92
Heavy Vehicles, %	5	0	0	5	0	0
Mvmt Flow	708	18	27	1274	20	28

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	708	0	2036	708
Stage 1	-	-	-	-	708	-
Stage 2	-	-	-	-	1328	-
Critical Hdwy	-	-	4.1	-	6.4	6.2
Critical Hdwy Stg 1	-	-	-	-	5.4	-
Critical Hdwy Stg 2	-	-	-	-	5.4	-
Follow-up Hdwy	-	-	2.2	-	3.5	3.3
Pot Cap-1 Maneuver	-	-	900	-	63	438
Stage 1	-	-	-	-	492	-
Stage 2	-	-	-	-	250	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	900	-	61	438
Mov Cap-2 Maneuver	-	-	-	-	172	-
Stage 1	-	-	-	-	492	-
Stage 2	-	-	-	-	243	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.2	19.9
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	EBR	WBL	WBT
Capacity (veh/h)	172	438	-	-	900	-
HCM Lane V/C Ratio	0.114	0.065	-	-	0.03	-
HCM Control Delay (s)	28.6	13.8	-	-	9.1	-
HCM Lane LOS	D	B	-	-	A	-
HCM 95th %tile Q(veh)	0.4	0.2	-	-	0.1	-

Intersection	
Intersection Delay, s/veh	3.5
Intersection LOS	A

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adj Approach Flow, veh/h	13	18	16	46
Demand Flow Rate, veh/h	13	18	16	46
Vehicles Circulating, veh/h	39	29	23	0
Vehicles Exiting, veh/h	7	10	29	47
Follow-Up Headway, s	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	0	0	0	0
Ped Cap Adj	1.000	1.000	1.000	1.000
Approach Delay, s/veh	3.4	3.4	3.4	3.5
Approach LOS	A	A	A	A

Lane	Left	Left	Left	Left
Designated Moves	LT	TR	T	LTR
Assumed Moves	LT	TR	T	LTR
RT Channelized				
Lane Util	1.000	1.000	1.000	1.000
Critical Headway, s	5.193	5.193	5.193	5.193
Entry Flow, veh/h	13	18	16	46
Cap Entry Lane, veh/h	1087	1098	1104	1130
Entry HV Adj Factor	1.000	1.000	1.000	1.000
Flow Entry, veh/h	13	18	16	46
Cap Entry, veh/h	1087	1098	1104	1130
V/C Ratio	0.012	0.016	0.014	0.041
Control Delay, s/veh	3.4	3.4	3.4	3.5
LOS	A	A	A	A
95th %tile Queue, veh	0	0	0	0

Intersection	
Int Delay, s/veh	1

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Vol, veh/h	1187	33	22	744	38	25
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	250	500	-	422	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	5	-	-	-5	0	-
Peak Hour Factor	96	92	92	92	92	92
Heavy Vehicles, %	5	0	0	5	0	0
Mvmt Flow	1236	36	24	809	41	27

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	1236	0	2093	1236
Stage 1	-	-	-	-	1236	-
Stage 2	-	-	-	-	857	-
Critical Hdwy	-	-	4.1	-	6.4	6.2
Critical Hdwy Stg 1	-	-	-	-	5.4	-
Critical Hdwy Stg 2	-	-	-	-	5.4	-
Follow-up Hdwy	-	-	2.2	-	3.5	3.3
Pot Cap-1 Maneuver	-	-	571	-	58	217
Stage 1	-	-	-	-	277	-
Stage 2	-	-	-	-	419	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	571	-	56	217
Mov Cap-2 Maneuver	-	-	-	-	174	-
Stage 1	-	-	-	-	277	-
Stage 2	-	-	-	-	401	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.3	28.8
HCM LOS			D

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	EBR	WBL	WBT
Capacity (veh/h)	174	217	-	-	571	-
HCM Lane V/C Ratio	0.237	0.125	-	-	0.042	-
HCM Control Delay (s)	32	24	-	-	11.6	-
HCM Lane LOS	D	C	-	-	B	-
HCM 95th %tile Q(veh)	0.9	0.4	-	-	0.1	-

Intersection	
Intersection Delay, s/veh	3.6
Intersection LOS	A

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adj Approach Flow, veh/h	7	10	52	60
Demand Flow Rate, veh/h	7	10	52	60
Vehicles Circulating, veh/h	50	59	22	0
Vehicles Exiting, veh/h	10	15	35	69
Follow-Up Headway, s	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	0	0	0	0
Ped Cap Adj	1.000	1.000	1.000	1.000
Approach Delay, s/veh	3.4	3.5	3.7	3.6
Approach LOS	A	A	A	A

Lane	Left	Left	Left	Left
Designated Moves	LT	TR	T	LTR
Assumed Moves	LT	TR	T	LTR
RT Channelized				
Lane Util	1.000	1.000	1.000	1.000
Critical Headway, s	5.193	5.193	5.193	5.193
Entry Flow, veh/h	7	10	52	60
Cap Entry Lane, veh/h	1075	1065	1105	1130
Entry HV Adj Factor	1.000	1.000	1.000	1.000
Flow Entry, veh/h	7	10	52	60
Cap Entry, veh/h	1075	1065	1105	1130
V/C Ratio	0.007	0.009	0.047	0.053
Control Delay, s/veh	3.4	3.5	3.7	3.6
LOS	A	A	A	A
95th %tile Queue, veh	0	0	0	0

APPENDIX E

SPOT SPEED STUDY DATA

SPOT SPEED STUDY

Location: John Sevier Highway (adjacent to proposed property)
Posted Speed Limit: 50 mph
Equipment: Bushnell Speedster III Radar Speed Gun

Date: 10/27/2015
Weather: Cloudy/Rain
Time: 2:30 PM

Vehicle	Speed (mph)
1	61
2	47
3	52
4	52
5	51
6	59
7	52
8	53
9	54
10	47
11	53
12	50
13	51
14	55
15	58
16	55
17	56
18	52
19	66
20	49
21	52
22	50
23	50
24	54
25	52

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:	John Sevier Highway (adjacent to proposed property)	Date:	10/27/2015
Posted Speed Limit:	50 mph	Weather:	Cloudy/Rain
Equipment:	Bushnell Speedster III Radar Speed Gun	Time:	2:30 PM

26	52
27	56
28	52
29	55
30	57
31	57
32	57
33	53
34	49
35	47
36	49
37	53
38	51
39	54
40	55
41	51
42	50
43	51
44	52
45	55
46	52
47	53
48	50
49	52
50	58
51	50
52	55
53	54
54	55

SPOT SPEED STUDY

Location:	John Sevier Highway (adjacent to proposed property)	Date:	10/27/2015
Posted Speed Limit:	50 mph	Weather:	Cloudy/Rain
Equipment:	Bushnell Speedster III Radar Speed Gun	Time:	2:30 PM

55	53
56	54
57	54
58	55
59	52
60	52
61	51
62	50
63	49
64	52
65	50
66	49
67	50
68	49
69	51
70	53
71	54
72	54
73	55
74	51
75	54

85th percentile speed = 55.0 mph

APPENDIX F

KNOX COUNTY TURN LANE VOLUME 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					Yes	Yes
250 - 299				Yes	Yes	Yes
300 - 349			Yes	Yes	Yes	Yes
350 - 399			Yes	Yes	Yes	Yes
400 - 449		Yes	Yes	Yes	Yes	Yes
450 - 499		Yes	Yes	Yes	Yes	Yes
500 - 549	Yes	Yes	Yes	Yes	Yes	Yes
550 - 599	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						1,187
25 - 49 (33)				Yes	Yes	Yes
50 - 99			Yes	Yes	Yes	Yes
100 - 149		Yes	Yes	Yes	Yes	Yes
150 - 199	Yes	Yes	Yes	Yes	Yes	Yes
200 - 249	Yes	Yes	Yes	Yes	Yes	Yes
250 - 299	Yes	Yes	Yes	Yes	Yes	Yes
300 - 349	Yes	Yes	Yes	Yes	Yes	Yes
350 - 399	Yes	Yes	Yes	Yes	Yes	Yes
400 - 449	Yes	Yes	Yes	Yes	Yes	Yes
450 - 499	Yes	Yes	Yes	Yes	Yes	Yes
500 - 549	Yes	Yes	Yes	Yes	Yes	Yes
550 - 599	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.

APPENDIX G

SIMTRAFIC QUEUE LENGTH SUMMARY

Intersection: 3: Main Entrance & John Sevier Highway

Movement	WB	NB	NB
Directions Served	L	L	R
Maximum Queue (ft)	36	67	43
Average Queue (ft)	10	18	13
95th Queue (ft)	33	53	33
Link Distance (ft)			324
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)	500	422	
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 4: Main Entrance

Movement	EB	WB
Directions Served	LT	TR
Maximum Queue (ft)	12	6
Average Queue (ft)	0	0
95th Queue (ft)	6	4
Link Distance (ft)	220	173
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Network Summary

Network wide Queuing Penalty: 0

Intersection: 3: Main Entrance & John Sevier Highway

Movement	WB	NB	NB
Directions Served	L	L	R
Maximum Queue (ft)	54	222	112
Average Queue (ft)	14	95	19
95th Queue (ft)	41	232	82
Link Distance (ft)			324
Upstream Blk Time (%)			0
Queuing Penalty (veh)			0
Storage Bay Dist (ft)	500	422	
Storage Blk Time (%)			0
Queuing Penalty (veh)			0

Intersection: 4: Main Entrance

Movement	EB	WB	NB
Directions Served	LT	TR	T
Maximum Queue (ft)	9	6	12
Average Queue (ft)	0	0	0
95th Queue (ft)	5	4	6
Link Distance (ft)	220	173	125
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Network Summary

Network wide Queuing Penalty: 0