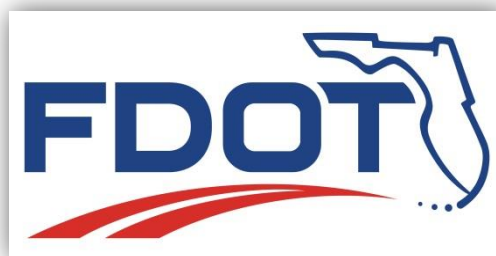


# Trip Generation Recommendations Report



October 2014

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Transportation, Systems Planning Office*

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## Introduction

### *Purpose and Need*

FDOT has the responsibility of maintaining the State's roadway system. As a result, it is FDOT's responsibility to monitor the traffic impacts of new development along the State Highway System. In response to the ever changing economic climate following the downturn of the economy, FDOT saw the need to assess the validity and applicability of trip generation and internal capture practices in Florida. Historically, actual trip generation rates for many land uses in Florida have had the tendency to be slightly higher than the national averages reported in the ITE trip generation reports, the most recent of which is the *Trip Generation Manual, 9<sup>th</sup> Ed.* If traffic impact studies utilize data that results in trip estimates being too high or too low, appropriate development and associated infrastructure modifications will not be appropriately identified.

In an effort to better understand current practices and improve the accuracy of trip generation estimates in Florida, FDOT conducted two research studies on new and emerging land uses in 2011 and 2012, the results of which are summarized in this report. Additionally, a literature review was conducted to gather and assess current trip generation and internal capture research to better understand practices throughout the nation. The review also included various trip generation and internal capture estimation software and tools were analyzed based on their accuracy, capabilities, and ease-of-use. The purpose of this document is to summarize and provide recommendations on trip generation/internal capture research and software/estimation tools in an effort to improve the accuracy of traffic studies in Florida.

## Gather and Review Additional Available Trip Generation Studies

### *Need for Additional Land Use Data*

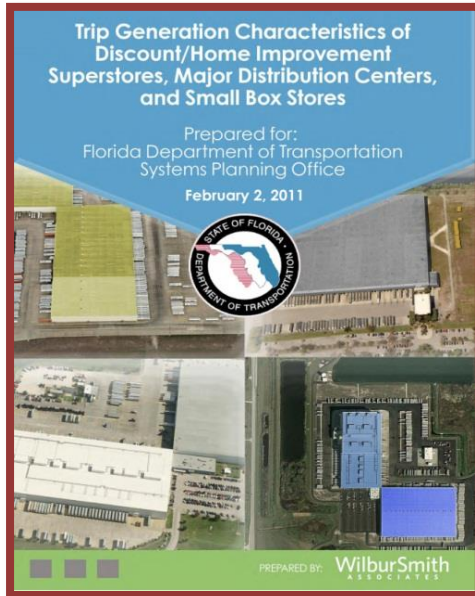
Many land uses included in modern developments have small data sample sizes or are not included at all in the ITE *Trip Generation Manual, 9<sup>th</sup> Ed.* As a result, it is often necessary to either use rates from similar land uses, limited local empirical data, or some combination of both. In an effort to more accurately estimate trip generation characteristics, additional research is needed to study new and emerging land uses. The following section describes several land uses that are becoming increasingly popular in Florida for which ITE currently has limited or no data.

### *Review of FDOT Trip Generation Studies*

#### Background

The Florida Department of Transportation (FDOT) has the responsibility of analyzing the traffic impacts of development along the State Highway System. With changes in the present economy, FDOT saw the need to assess the validity and applicability of trip generation rates for several land use types in Florida. Historically, it has been reported that trip generation rates for many land uses in Florida have had the tendency to be slightly higher than the national averages specified in the Institute of Transportation Engineers' (ITE) *Trip Generation Manual.* If traffic studies use trip generation rates that are too high or

too low, appropriate development and associated infrastructure and/or mitigated will not be recommended. In an effort to better understand the accuracy of trip generation estimates in Florida, FDOT conducted two research studies on new and emerging land uses, the reports for both of which are described below. This document summarizes and provides recommendations on their findings. Brief descriptions for each of the two reports are provided below.



### TRIP GENERATION CHARACTERISTICS OF DISCOUNT/HOME IMPROVEMENT SUPERSTORES, MAJOR DISTRIBUTION CENTERS, AND SMALL BOX STORES, FEBRUARY 2011

This document includes the study methodology analysis and findings for trip generation rates for the following land uses in Florida:

- *Free-Standing Discount Superstores, such as Wal-Mart, etc.*
- *Home Improvement Superstores, such as Home Depot, etc.*
- *“Small Box” Stores, such as Dollar General, etc.*
- *Single Retailer Distribution Centers*

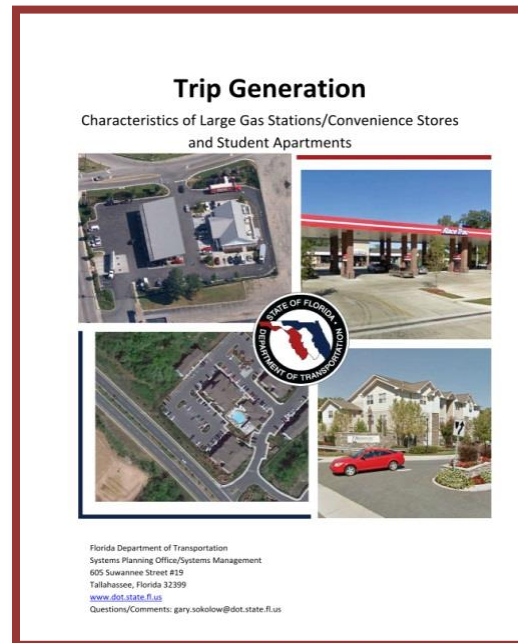
At the time of the study, not all of these land uses were specifically covered in the ITE *Trip Generation Manual*; therefore, study results were compared to existing land use data from similar ITE land uses and other research.

### TRIP GENERATION CHARACTERISTICS OF LARGE GAS STATIONS/CONVENIENCE STORES AND STUDENT APARTMENTS, DECEMBER 2012

This document includes the study methodology analysis and findings for trip generation rates for the following land uses in Florida:

- *Convenience Markets with Gas Pumps*
- *Suite Style Student Apartments*

The two land uses described in this study are emerging land use types, which may vary from those currently included in the ITE *Trip Generation Manual*; therefore, study data is compared to data from similar ITE land uses and findings from other research studies.



## Convenience Markets with Gas Pumps

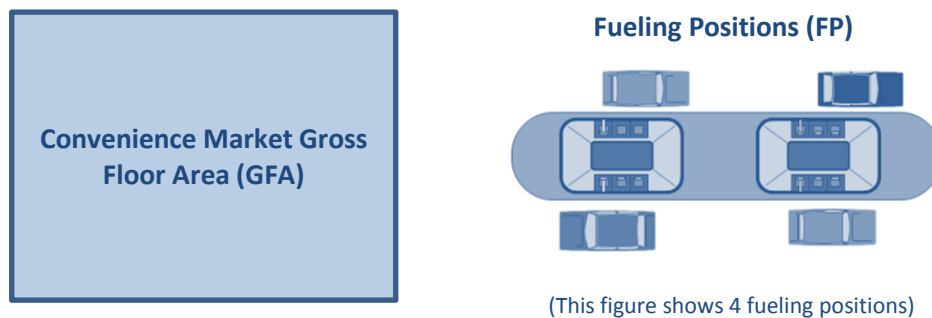
### Introduction

Over the last ten years, convenience markets with large numbers of fueling positions have become an emerging trend. Previous studies on convenience markets with gas pumps indicated that newer Florida developments may have trip generation characteristics different from those already included in ITE reports, specifically **ITE Land Use (LU) 853: Convenience Market with Gas Pumps**. To assess these differences, FDOT studied 12 modern convenience market with gas pumps sites throughout Florida in 2012.

### Average Trip Generation Rates

Similar to ITE, this study determined that both gross floor area (GFA) and the number of fueling positions (FP) were significant variables in estimating trip generation for convenience markets with gas pumps. A graphic depicting the gross floor area and fueling position variables is included below in **Figure 1**.

**Figure 1: Example of Gross Floor Area and Fueling Positions**



Average trip generation rates were calculated for both 1,000 square feet of GFA and FP during the weekday daily and PM peak hour of the adjacent street periods. The rates per 1,000 square feet of GFA were compared to **ITE LU 853 - Convenience Market with Gas Pumps**, which represents sites where the convenience market has more impact than the fueling positions. Similarly, the rates per FP were compared to **ITE LU 945 - Gasoline/Service Station with Convenience Market**, which represents sites where emphasis is placed on fueling over the convenience market. For comparative purposes, findings from similar research were obtained and a brief description of each study is provided below.

The 1992 *Trip Generation of Convenience Stores with Gas Pumps* study prepared for FDOT was the first which considered the possibility of using multi-variable equations. All of the current ITE equations have only one independent variable, such as number of fueling positions *or* square footage of the convenience market. The 1992 analysis suggested an equation that uses both gross floor area and gas pumps to find the number of trips during the PM peak. The convenience stores were slightly smaller ranging from 700 – 3,600 square feet. However, the sites in their study did include up to 12 gas pumps (24 vehicle fueling positions), which is similar to the sites included in the FDOT 2012 study. Research findings indicated that the model had an adjusted  $R^2$  value of 0.904, which indicates a high level of correlation.  $R^2$  is described as a measure of correlation between two variables, expressed on a scale of 0

to +1. The closer to +1 that the  $R^2$  value is, the better the correlation is between variables (e.g. the more reliable that an estimation of trips will be using FP, 1000 square feet of GFA, or both).

In 2001, the ITE Journal published an article titled *Trip Generation Characteristics for Convenience Stores* that suggested the consideration of a new land use code due to different trip generation characteristics of modern stores. The authors began by noting the historical changes in the size of convenience stores and number of fueling positions. They claimed contemporary stores to be two or three times larger than traditional stores, as well as averaging about twice as many fueling positions. Their trip generation rates for ITE LU 853 Convenience Market with Gas Pumps were higher during the AM peak hour, significantly lower in the PM peak hour, and had higher pass-by rates than seen in *Trip Generation 6<sup>th</sup> Edition*. Their sites were located in the northeast, but otherwise had characteristics similar to the 2012 FDOT study with an average of 15 fueling positions and 5,070 square feet of gross floor area.

The research described in the 2011 ITE Journal article and 2008 report *Traffic Operational Impacts of Contemporary Multi-Pump Island Fueling Centers* studied sites located in North Carolina and also indicated that new gas stations had different characteristics than traditional sites. However, instead of recommending new rates, they chose to focus on multi-variable regression analysis. They suggested that because modern facilities have so many more potential services to offer, traditional analyses can no longer estimate traffic impacts with only one variable. The ability to pay at the pump, presence of more fueling stations, car wash facilities, larger convenience markets, and fast-food restaurants are some examples of relatively new services. The study included 30 sites with a variety of characteristics, including four called “**hybrid**” which most closely resemble those FDOT chose to study in 2012. Due to a small sample size, their hybrid specific equation had a very low  $R^2$  value. The researchers recommended equations that incorporate average daily traffic (ADT), characteristics (hybrid, yes or no), and presence of a drive-through. The  $R^2$  values for the AM and PM peak equations were 0.591 and 0.558 respectively.

A comparison of the results from this study to those found in previous research is provided in **Table 1**.



**Table1: Trip Generation Rate Comparisons for Convenience Markets with Gasoline Pumps**

Trip Generation Rate Source	Rate per 1,000 ft <sup>2</sup> Gross Floor Area			
	Weekday Daily		PM Peak Hour of Adjacent Street	
	Rate	% Difference from ITE LU 853	Rate	% Difference from ITE LU 853
ITE LU 853 - Convenience Market with Gas Pumps <sup>1</sup>	845.6		50.92	
<b>2012 FDOT Statewide Study</b>	<b>1141.59</b>	<b>+35%</b>	<b>85.66</b>	<b>+68%</b>
2011 ITE Journal Article <sup>2</sup>	-	-	60.50	+19%
2001 ITE Journal Article <sup>3</sup>	-	-	48.03	-6%
1992 UF Study <sup>4</sup>	-	-	56.40	+11%
Trip Generation Rate Source	Rate per # of Fueling Positions			
	Weekday Daily		PM Peak Hour of Adjacent Street	
	Rate	% Difference from ITE LU 945	Rate	% Difference from ITE LU 945
ITE LU 945 - Gasoline/Service Station With Convenience Market <sup>1</sup>	162.78		13.51	
<b>2012 FDOT Statewide Study</b>	<b>233.7</b>	<b>+44%</b>	<b>17.09</b>	<b>+26%</b>
2011 ITE Journal Article <sup>2</sup>	-	-	23.23	+72%
2001 ITE Journal Article <sup>3</sup>	-	-	16.58	+23%
1992 UF Study <sup>4</sup>	-	-	9.45	-30%
<b>Sources:</b>				
<sup>1</sup> 9 <sup>th</sup> Edition Trip Generation Manual, ITE				
<sup>2</sup> Traffic Operational Impacts of Contemporary Multi-Pump Island Fueling Centers, ITE Journal June 2011				
<sup>3</sup> Trip Generation Characteristics for Convenience Stores, ITE Journal August 2001				
<sup>4</sup> Trip Generation of Convenience Stores with Gas Pumps, Transportation Research Center UF February 1992				

*Findings*

The following observations were made from the above table:

A comparison of the FDOT study results with **ITE LU 853 - Convenience Market with Gas Pumps** using square footage as the independent variable shows weekday daily and PM peak rates significantly higher than the 9<sup>th</sup> Edition published ITE rates.

A comparison of the FDOT study with **ITE LU 945 - Gasoline/Service Station with Convenience Market** using Fueling Positions as the independent variable shows weekday daily and PM peak rates higher than the published 9<sup>th</sup> Edition ITE rates.

It should be noted that much of the data included in **ITE LU 853 - Convenience Market with Gas Pumps** and **ITE LU 945 - Gasoline/Service Station with Convenience Market** was collected prior to 1995, and may not accurately represent the larger modern convenience markets with gas pumps included in this study. Since both GFA and FP were found to be significant independent variables in the study, and both have higher rates than those specified in ITE, it is reasonable to assume that a multi-variable equation could be formed from the study data to provide more accurate trip generation estimates than using either variable individually.

*Multi-Variable Equation*

The multi-variable equation, which includes both GFA and FP, was found to estimate trips more accurately than using the variables independently. ITE currently only allows the use of single-variable equations; however, due to the increasing types of uses present at these new developments (fast food, prepared food, other services), a more detailed, multi-variable analysis may be preferable in estimating



trip generation. **Table 2** shows the multi-variable equations for the weekday daily and PM peak hour periods. It should be noted that the R<sup>2</sup> values for both equations are 0.88 or greater.

**Table 2: Multi-Variable Trip Generation Rate Comparisons for Convenience Markets with Gasoline Pumps**

Analysis Period:	Multi-Variable Equation:
Weekday Daily	Rate = 256.7 x (FP) - 144.5 x (kft <sup>2</sup> )
Weekday PM Peak Hour of the Adjacent Street	Rate = 12.3 x (FP) + 15.5 x (kft <sup>2</sup> )
Where:	
FP = # of Fueling Positions	
kft <sup>2</sup> = Gross Floor Area (in thousands of square feet)	
R <sup>2</sup> = Measure of correlation between two variables, expressed on a scale of 0 to +1. The closer to +1 the R <sup>2</sup> is, the better the correlation between the variables. (e.g. the better the reliability that an estimation of trips is better using FP, GFA, or both)	

*Pass-By Trips*

Data related to pass-by trips were also collected during the study. Pass-by trips are described as trips made with intermediate stops on the way from an origin to a primary trip destination without a route diversion. Pass-by trips are attracted from traffic passing the site on an adjacent street or roadway that offers direct access to the generator. It was determined that pass-by trips for the sites for this land use ranged from 65% to 84%, with an average rate of 78%. This rate is significantly higher than the average of 66% found in the ITE *Trip Generation Handbook, 2<sup>nd</sup> Edition* for **LU 853: Convenience Market with Gas Pumps**. However, the average rate for Florida sites included in the 2001 ITE *Trip Generation Handbook* is 76%. The consistency of this data suggests that future developments of this type could reasonably assume an average pass-by rate of 77% (devised from the average of 76% and 78% referenced above). **Table 3** includes a comparison of pass-by trip percentages between the study and ITE.

**Table 3: Weekday PM Peak Hour Average Pass-By Percentage Comparisons**

Data Source	Number of Sites	Average % Pass-By Trips	% Difference from FDOT Study
2012 FDOT Statewide Study	12	78%	
ITE LU 853, <i>ITE Trip Generation Handbook</i> , 2nd Ed.	15	66%	-15%
ITE LU 853, <i>ITE Trip Generation Handbook</i> , 2nd Ed. (Florida only)	6	76%	-3%

*Recommendations*

The significant number of studies of travel characteristics for the new convenience markets with gas pumps and the wide geographical spread of these studies in Florida likely represent the majority of new facilities that will be built in the future. **With this in mind, the multi-variable equation and average pass-by trip percentage of 77% from the 2012 study may be the best to use in Florida for studying similar new proposed convenience markets with gas pumps.**

## “Small Box”/Variety Stores








### Introduction

Since the economic downturn of 2008 and on, there has been an increase in the popularity of small box stores in Florida. A small box store (or variety store) is a discount retail store that provides health and beauty aids, cleaning supplies, snack food, household items, and some apparel. Since small box stores did not have their own ITE LU category at the time of the study, other related ITE land uses were often used to estimate trip ends for small box stores, including **ITE LU 826 - Specialty Retail Center**, **ITE LU 820 - Shopping Center**, and **ITE LU 815 - Free-Standing Discount Superstore**. However, it is believed that this land use type may generate more trips than these other similar land use categories. Fifteen small box study sites ranging in size from roughly 8,000 square feet to 17,000 square feet GFA were selected throughout the state to be studied. Since this study was performed, the *ITE Trip Generation Manual, 9<sup>th</sup> Edition* has added **ITE LU 814 - Variety Store**, which includes the data from this study and is the appropriate land use category for estimating small box store trip generation.

### Analysis of Results

The small box stores included in the study were found to generate 64.01 trips per 1,000 square feet of GFA during the weekday daily period and 6.82 trips per 1,000 square feet of GFA during the PM peak hour of the adjacent street. **Table 4** below compares the study rates to other ITE LU categories typically used to represent small box stores, as well as a 2009 study performed in Polk County which analyzed three small box store sites.

**Table 4: Trip Generation Rate Comparisons for Small Box Stores**

Trip Generation Rate Source	Rate per 1,000 ft <sup>2</sup> Gross Floor Area			
	Weekday Daily		PM Peak Hour of Adjacent Street	
	Rate	% Difference from FDOT Study	Rate	% Difference from FDOT Study
<b>2010 FDOT Statewide Study (ITE 814 in 9th Ed.)</b>	<b>64.01</b>		<b>6.82</b>	
ITE LU 826 -Specialty Retail Center <sup>1</sup>	44.32	-31% 	2.71	-60% 
ITE LU 820 - Shopping Center <sup>1</sup>	42.7	-33% 	3.71	-46% 
ITE LU 815 - Free-Standing Discount Superstore <sup>1</sup>	57.24	-11% 	4.98	-27% 
2009 Polk County Study	81.08	+27% 	-	-
<b>Sources:</b>				
<sup>1</sup> 9 <sup>th</sup> Edition Trip Generation Manual, ITE				

### Summary

As seen in **Table 4**, the study rate is significantly higher than the **ITE LU 826 - Specialty Retail Center**, **ITE LU 820 - Shopping Center**, and **ITE LU 815 - Free-Standing Discount Superstore** rates for both the weekday daily and PM peak hour periods. Additionally, the 2009 Polk County Study daily rate is higher than all of the other daily rates.

### Pass-By Trips

Pass-by trip interviews were conducted at five of the study sites. It was determined that the sites had an average of 34% pass-by trips. This percentage is considerably higher than the 17% average for **ITE LU 815 - Free-Standing Discount Superstore**, but is consistent with the pass by rate for **ITE LU 820 -**

**Shopping Center.** Table 5 includes a comparison of the pass-by trip percentages between the study and ITE land uses.

**Table 5: Weekday PM Peak Hour Average Pass-By Percentage Comparisons**

Data Source	Number of Sites	Average % Pass-By Trips	% Difference from FDOT Study
2010 FDOT Statewide Study	5	34%	
ITE LU 815, <i>ITE Trip Generation Handbook</i> , 2nd Ed.	22	17%	-50%
ITE LU 820, <i>ITE Trip Generation Handbook</i> , 2nd Ed.	100	34%	0%

*Recommendations*

The rates from this study are roughly 30% to 60% higher than the rates for the commonly cited ITE retail land use categories during both the weekday daily and PM peak hour periods, which suggests that small box stores are a distinct land use category that have been underestimated in the past. **Since this study was originally released in 2011, the collected data has been included in the *ITE Trip Generation Manual*, 9<sup>th</sup> Edition, as Land Use 814: Variety Store. Therefore, it is recommended that these rates be used to estimate trip generation for small box stores in Florida. Additionally, it is recommended that a PM peak hour pass-by rate of 34% be used for small box store land uses in Florida.**

**Free-Standing Discount Superstores**

*Introduction*

Several studies, including a 2007 FDOT District 7 study and several ITE Journal Articles, have shown higher trip generation rates for **ITE LU 813 - Free-Standing Discount Superstores** than published in the 9<sup>th</sup> Edition of ITE’s *Trip Generation Manual*. In an effort to more accurately predict trips for this land use, FDOT collected data at 20 sites ranging in size from 125,000 square feet to 200,000 square feet GFA throughout the state of Florida in 2010.

*Average Rates and Related Studies*

Using the collected data, the average rate was determined to be 45.41 trips per 1,000 square feet GFA in the weekday daily period and 3.56 trips per 1,000 square feet GFA in the PM peak hour of the adjacent street traffic. Table 3.6 shows the rate from this study and how it compares to ITE and previous related studies. It is apparent that the rate determined from this study is significantly lower than those determined in previous studies. The 2009 ITE Journal Article included research of 32 Wal-Mart Supercenters nationwide and found that trip generation was slightly higher than ITE rates. The 2006 ITE Journal Article included a study of five sites in the south central United States and found the trip generation rates to be substantially higher than ITE rates. The 2007 FDOT District 7 study analyzed twelve discount superstore sites in Florida and found higher average trip generation rates than those specified in ITE’s data. Three of the sites in the FDOT 2011 study were common to the FDOT District 7 study, and it was determined that there was an average of 31% decline in PM peak-hour trips from year 2007 to year 2010 for those sites. **Table 6** shows a comparison of the study rates to **ITE LU 813 – Free-Standing Discount Superstore** and rates from previous related research.

**Table 6: Trip Generation Rate Comparisons for Free-Standing Discount Superstores**

Trip Generation Rate Source	Rate per 1,000 ft <sup>2</sup> Gross Floor Area			
	Weekday Daily		PM Peak Hour of Adjacent Street	
	Rate	% Difference from ITE LU 813	Rate	% Difference from ITE LU 813
ITE LU 813 - Free-Standing Discount Superstore <sup>1</sup>	50.75		4.35	
<b>2010 FDOT Statewide Study</b>	<b>45.41</b>	<b>-11%</b>	<b>3.56</b>	<b>-18%</b>
2007 FDOT District 7 Study	76.7	<b>+51%</b>	5.70	<b>+31%</b>
2009 ITE Journal Article <sup>2</sup>	53.04	<b>+5%</b>	4.50	<b>+3%</b>
2006 ITE Journal Article <sup>3</sup>	-	-	5.50	<b>+26%</b>
<b>Sources:</b>				
<sup>1</sup> 9 <sup>th</sup> Edition Trip Generation Manual, ITE				
<sup>2</sup> Discount Superstore Trip Generation				
<sup>3</sup> Trip Generation Characteristics of Free-Standing Discount Superstores				

*Pass-By Trips*

In addition to traffic counts, interviews were conducted with a sample of customers at the study site in Pensacola to determine travel patterns and percentage of pass-by trips. It was determined that the site had an average pass-by trip rate of 29%, which is consistent with the 28% pass-by trip average according to ITE for Land Use 813. **Table 7** shows a comparison of the pass-by trip percentage between the FDOT study and the percentage for **ITE LU 813 – Free-Standing Discount Superstore**.

**Table 7: Weekday PM Peak Hour Average Pass-By Percentage Comparisons**

Data Source	Number of Sites	Average % Pass-By Trips	% Difference from FDOT Study
2010 FDOT Statewide Study	1	29%	
ITE LU 813, ITE Trip Generation Handbook, 2nd Ed.	8	28%	-3%

*Recommendations*

Due to the decline in trips shown in the FDOT 2011 study, the calculated rates from the statewide study may not be representative of actual trips generated in the future. **Since the studies were completed entering the downturn in the economy, it is recommended to continue to use the ITE LU 813 - Free-Standing Discount Superstore trip generation rates. Additionally, the ITE PM peak-hour pass-by rate of 28% is recommended for this land use.**

**Distribution Centers**

*Introduction*

At the time of the study, large single-retailer distribution centers of approximately one million square feet GFA were not specifically addressed in ITE’s *Trip Generation*, 8<sup>th</sup> Edition. These large distribution centers are of particular importance to FDOT due to their typical proximity to freeway interchanges. At the time of the study, the ITE Land Use Categories 152: High Cube Warehouse, and 150: Warehouse were used to estimate trips generated at distribution centers. High cube warehouses tend to be about the same size as the large single-retailer distribution centers, but have a higher storage function which results in different trip-making characteristics. Warehouses tend to be much smaller than the large distribution centers, thus having different characteristics and a wider range of rates. A 2007 study performed by Putnam County/FDOT Districts 2 & 5 analyzed three large distribution center sites and found an average daily trip generation rate of 1.98 trips/1000 sf, which is 18% higher than the rate

specified in ITE’s data. In an effort to assess the trip generation characteristics of large single-retailer distribution centers, data was collected at nine sites throughout the state that varied in size from just under 500,000 square feet to just under 1.5 million square feet GFA.

*Analysis of Results*

The weighted average rate for the weekday daily period was determined to be 1.86 trips per 1,000 square feet GFA and the PM peak hour of the adjacent street was determined to be 0.14 trips per 1,000 square feet GFA. Since the study, the ITE *Trip Generation Manual*, 9<sup>th</sup> Edition, has revised Land Use 152 to include Distribution Center in both the title and definition of the land use. The revised land use includes the data from the FDOT study, as well as other distribution center data collected by the Texas Transportation Institute (TTI). **Table 8** below shows the rate from this study and how it compares to the ITE High Cube Warehouse/Distribution Center rate, as well as rates determined in a 2006 study performed by Putnam County and FDOT Districts 2 and 5 and a 2009 Polk County study.

**Table 8: Trip Generation Rate Comparisons for Distribution Centers**

Trip Generation Rate Source	Rate per 1,000 ft <sup>2</sup> Gross Floor Area			
	Weekday Daily		PM Peak Hour of Adjacent Street	
	Rate	% Difference from ITE LU 152 (9th Edition)	Rate	% Difference from ITE LU 152 (9th Edition)
ITE LU 152 -High Cube Warehouse <sup>1</sup>	1.68	-	0.10	-
<b>2010 FDOT Statewide Study</b>	<b>1.86</b>	<b>+11%</b>	<b>0.14</b>	<b>+40%</b>
Putnam County/FDOT District 2 & 5 Study <sup>2</sup>	1.98	+18%	0.12	+18%
Polk County Study	1.95	+16%	-	-
<b>Sources:</b>				
<sup>1</sup> 9 <sup>th</sup> Edition Trip Generation Manual, ITE				
<sup>2</sup> Trip Generation for the South Putnam Distribution Warehouse Special Planning Area (SPA) Transportation Analysis				

*Recommendations*

As seen in the table above, the weekday daily and PM peak hour of adjacent street rates from the study are higher than the average ITE rates for High Cube Warehouse/Distribution Center. This shows that the average rates in Florida are generally higher than the average rates for all of the data included by ITE. The data collected in this study has since been included in **ITE LU 152 – High Cube Warehouse** in the ITE *Trip Generation Manual*, 9<sup>th</sup> Edition. **However, since the rates determined in this study were found to be higher than those for ITE LU 152 – High Cube Warehouse, it is recommended that the FDOT 2011 study rates be used for Large Single-Retailer Distribution Centers in Florida.**

**Home Improvement Superstores**

*Introduction*

In an effort to estimate the trip generation of home improvement superstores in Florida, ten sites ranging from 100,000 square feet to 138,000 square feet GFA studied were chosen from around the state. The data collected most closely relates to **ITE LU 862 - Home Improvement Superstore** in ITE’s *Trip Generation Manual*, 9<sup>th</sup> Edition.

*Analysis of Results*

From the collected data, it was determined that the average trip generation rate during the weekday daily period was 30.74 trips per 1,000 square feet and the PM peak hour of the adjacent street was 2.31 trips per 1,000 square feet GFA. The table below shows the average rates from this study and how they compare to the rates from ITE and a 2007 FDOT District 7 study that analyzed four home improvement superstore sites in the Tampa, Florida area. As shown in the table, the PM trip rate from the 2010 study was significantly lower than the rate determined in the 2007 FDOT District 7 study. There was one site that was common to the two studies and it was found to have a 47% decrease in PM peak-hour trips since 2007. The decline at this site closely reflects the average trend between the two studies. **Table 9** shows a comparison of rates between the FDOT study and **ITE LU 862 – Home Improvement Superstore**, as well as the 2007 District 7 Study.

**Table 9: Trip Generation Rate Comparisons for Home Improvement Superstores**

Trip Generation Rate Source	Rate per 1,000 ft <sup>2</sup> Gross Floor Area			
	Weekday Daily		PM Peak Hour of Adjacent	
	Rate	% Difference from ITE LU 862	Rate	% Difference from ITE LU 862
ITE LU 862 -Home Improvement Superstore <sup>1</sup>	30.74	-	2.33	-
<b>2010 FDOT Statewide Study</b>	<b>31.51</b>	<b>+3%</b>	<b>2.31</b>	<b>-1%</b>
2007 FDOT District 7 Study	49.5	<b>+61%</b>	3.90	<b>+67%</b>
<b>Sources:</b>				
<sup>1</sup> 9 <sup>th</sup> Edition Trip Generation Manual, ITE				

*Pass-By Trips*

Interviews were conducted at one of the sites to estimate the percentage of pass-by trips. It was determined that 25% of PM peak hour trips were pass-by trips, which were considerably lower than the 48% average from the ITE *Trip Generation Handbook* for **ITE LU 862 – Home Improvement Superstore**. **Table 10** includes a comparison of the pass-by rate estimated in this study and the rate from **ITE LU 862 – Home Improvement Superstore**.

**Table 10: Weekday PM Peak Hour Average Pass-By Percentage Comparisons**

Data Source	Number of Sites	Average % Pass-By Trips	% Difference from FDOT Study
2010 FDOT Statewide Study	1	25%	
ITE LU 862, <i>ITE Trip Generation Handbook</i> , 2nd Ed.	3	48%	+92%

*Recommendations*

Due to the significant decline in trips seen between the 2007 FDOT District 7 and 2010 FDOT Statewide studies, the study calculated rates may not be representative of future trips generated for this land use. **Because the study rates were found to be similar to the ITE rates, it is recommended to continue to use the ITE LU 862 - Home Improvement Superstore trip generation rates. Additionally, the ITE PM peak-hour pass-by percentage of 48% should be used for this land use. It is also recommended that additional research be performed for this land use in the future as economic conditions change.**

## Suite Style Student Apartments

### *Introduction*

Development trends indicate that there will be continued growth in the number of student apartment developments in the coming years. There is little existing data available for this land use, much of which relies on rough estimates and assumptions. It was determined that current Florida trip generation data for suite style student apartments were needed. Suite style student apartments differ from traditional apartments in that they offer leases by the bedroom instead of by whole apartment unit. In an effort to better understand trip generation characteristics at suite style student apartments, 18 sites were carefully selected throughout Florida for data collection.

### *Related Studies*

Previous research has suggested that student apartments tend to have higher trip generation rates than existing apartment ITE land uses. The differences in trip-making habits for student apartments can likely be attributed to a higher number of individual drivers in the household, varying school schedules, and proximity to campus that may encourage more pedestrian, bicycle, and transit activity.

### *Analysis and Findings*

Data were collected for multiple independent variables including number of dwelling units, number of occupied dwelling units, number of persons, and number of vehicles, all of which are used by ITE for apartment land uses. In addition, the FDOT study included information on the number of bedrooms (where possible) as a predictor for trip generation. For comparative purposes, results from the following similar studies were obtained: *Trip Generation Rates for Off-Campus Student Apartments* (City of Auburn, Alabama, 2010), *Traffic Impact Analysis for Welsh Hill Commons* (Lenhart Traffic Consulting, Inc., 2008), and *Traffic Impact Analysis for Baltimore Avenue* (Lenhart Traffic Consulting, Inc., 2008). The City of Auburn research included several studies to determine trip generation rates for off-campus student apartments in the city, which were found to be similar to ITE rates per person for locations near transit. The study performed for the Welsh Hill Commons development in Maryland conducted counts on three buildings in order to estimate trip generation for an expansion effort. Similarly, the study done for the Baltimore Avenue development was part of an expansion project. However, the characteristics varied considerably as the Baltimore Avenue site was located across a pedestrian bridge from the University of Maryland and also had nearby transit connections. **Table 11** shows the average trip generation rates from the study, as well as comparisons to previous research during the weekday daily and PM peak hour of adjacent street traffic periods.



**Table 11: Trip Generation Rate Comparisons for Student Apartments**

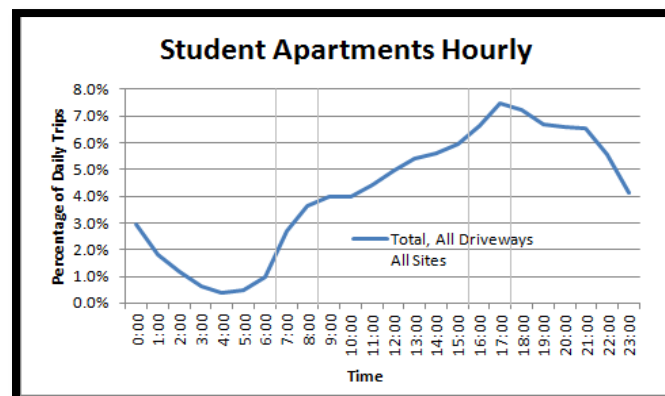
Independent Variable Unit	Trip Generation Rate Source	Weekday Daily		PM Peak Hour of Adjacent Street	
		Rate	% Difference from FDOT Study	Rate	% Difference from FDOT Study
# of Dwelling Units (DU)	2012 FDOT Statewide Study	12.57		1.00	
	ITE LU 220 - Apartment (9th Ed.)	6.65	-47%	0.62	-38%
	ITE LU 223 - Mid-Rise Apartment (9th Ed.)	-	-	0.39	-61%
	2008 TIA - Welsh Hill Commons (Maryland)	-	-	0.83	-17%
	2008 TIA - 8204 Baltimore Avenue (Maryland, near transit and ped. Facilities)	-	-	0.35	-65%
# of Occupied Dwelling Units	2012 FDOT Statewide Study	13.06		1.04	
	ITE LU 221 - Low-Rise Apartment (9th Ed.)	6.59	-50%	0.58	-44%
# of Persons (Renters)	2012 FDOT Statewide Study <sup>1</sup>	4.11		0.32	
	ITE LU 220 - Apartment (9th Ed.)	-	-	0.40	+25%
	ITE LU 221 - Low-Rise Apartment (9th Ed.)	3.31	-19%	0.38	+19%
	2007 Auburn Study (Alabama, near transit)	-	-	0.40	+25%
	2007 Auburn Study (Alabama, no transit)	-	-	0.49	+53%
# of Bedrooms	2012 FDOT Statewide Study <sup>2</sup>	3.98		0.31	
	2008 TIA - Welsh Hill Commons (Maryland)	-	-	0.52	+68%
	2008 TIA - 8204 Baltimore Avenue (Maryland, near transit and ped. Facilities)	-	-	0.12	-61%
# of Vehicles	2012 FDOT Statewide Study <sup>3</sup>	4.47		0.35	
	ITE LU 220 - Apartment (9th Ed.)	5.1	+14%	0.60	+71%

Notes:  
<sup>1</sup> Based on values from 17 of 18 sites  
<sup>2</sup> Based on best estimates from 16 of 18 sites  
<sup>3</sup> Based on best estimates from 15 of 18 sites

*Hourly Variation of Traffic*

The figure below shows the hourly distribution of traffic for the study collected data. The PM peak of the generator was found to be the same as the adjacent street peak; however, far more trips occur during the midday and late evening periods than during the AM peak of the generator. This appears logical, as varying student schedules and afternoon classes would result in the slow climb of traffic as the day progresses. As the majority of tenants in student apartments do not yet have families, the unusually high quantity of trips generated after the evening peak is also expected. **Figure 2** shows the hourly variation of trips throughout the day for suite-style student apartments.

**Figure 2: Hourly Variation of Daily Trips for Student Apartments**



### *Recommendations*

It is expected that future student apartment developments will generate the greatest amount of trips during the PM peak hour, but may also generate a significant number of trips during the afternoon and evening periods. Additionally, there has been a lot of variation in studies for this land use due to factors such as proximity to school, specialized transit, etc. According to the FDOT 2012 study, the best independent variable for estimating trip generation for suite-style student apartments is number of bedrooms. **However, due to the variation in peak trip periods and the variable nature of students' trip-making habits, it is recommended that additional research be conducted for this land use type and that the rates determined in this study be used with caution.**

### *Additional Land Uses Recommended for Study*

This section provides a list of land uses recommended for study to improve the accuracy of trip generation in Florida. Land use types that have been identified as good candidates for study include power centers, charter schools, beach resorts, retirement communities, casinos, IKEA stores, and Bass Pro Shops stores. The following sections provide a brief description of each land use, as well as the status of any existing data from Florida sites.

#### **Power Centers**

As previously mentioned in the literature review section, power centers are an emerging trend amongst new developments. A power center is generally defined as a large-scale shopping center development, which usually contains one or more anchor stores, as well as smaller in-line retail stores and free-standing outparcel stores. There has been concern that ITE's *Trip Generation Manual, 9<sup>th</sup> Ed.* may not accurately predict the traffic impacts of these facilities due to the wide variety of shopping center types and sizes, the age of the data, and potential inconsistencies with determining trip generation. An article included in ITE's *Journal of Transportation* reviewed data from 10 power center sites in North Carolina and made recommendations on which existing ITE land use data most closely match the collected data set. There are currently no data on power center site trip generation in FL; it may be beneficial to conduct a similar study on these developments to supplement the NC data and more accurately estimate trip generation at these sites in Florida.

#### **Charter Schools**

Charter schools have increased in popularity and are one of the fastest growing school options in Florida. According to *floridaschoolchoice.org*, the number of charter schools, which are generally described as "public schools of choice," in Florida has grown to over 570 in 2013, and charter school enrollment now tops 200,000 students. There is currently no specific land use category for charter schools in ITE's *Trip Generation Manual, 9<sup>th</sup> Ed.* As a result, analysts typically use ITE LU 520 Elementary School or ITE LU 534 Private School data to estimate trip generation. In an effort to improve the accuracy of charter school trip generation estimates, several studies have been conducted at sites in Florida as part of traffic impact studies. To provide an example of the trip generation differences, studies were found for three Florida sites varying in size from 650 to 1,256 students (with an average of 986 students). The sites were located in Broward and Miami-Dade Counties and had AM peak-hour trip generation rates ranging from 0.95 trips/student to 1.03 trips/student. The average AM-peak hour rate

found for the study sites was determined to be 0.99 trips/student, which is higher than both the ITE LU 534 Private School AM peak-hour rate of 0.9 trips/student and the ITE LU 520 Elementary School AM peak-hour rate of 0.45 trips/student. As the popularity of charter schools continues to grow in Florida, it would be beneficial for additional studies to be conducted to build the trip generation database to more accurately estimate charter school trips.

### **Beach Resort Communities**

Beach resort communities are especially popular in FL, however, there are currently no distinct data or rates in the *ITE Trip Generation Manual, 9<sup>th</sup> Ed.* for this particular land use. In the past, analysis methodology agreements have been made to create “hybrid” trip generation rates for analyzing beach resort community traffic impacts. These hybrid rates are typically created through combining rate data from vacation home and single-family residential land uses. The hybrid rates were created due to the lack of data for vacation homes and because the single-family residential land use would likely overestimate trip generation for the beach resort communities. In an effort to develop more accurate rates for estimating trip generation for this land use, it would be beneficial to perform trip generation studies at various sites throughout Florida. In the coming years, it is anticipated that Florida will see an increase in beach resort communities, thus making the need for accurate trip generation estimates more important.

### **Retirement Communities**

Retirement communities are an increasingly common land use type in Florida. Many of these developments are age restricted communities via deed restriction, in which at least one owner in each residence must be aged 55 or older and no permanent residents younger than 19 years of age are allowed. Because of this, travel characteristics for these communities are different than those of single family developments, due to the limited amount of commuter traffic throughout the week. In addition, retirement communities typically have fewer automobiles per household than single-family residential subdivisions, resulting in fewer transportation impacts. Using data from several Florida retirement community trip generation studies, a comparison of the vehicle miles of travel (VMT) reported for the two single-family residential and retirement community land use types in Marion County, Florida yielded an average of 15.5 daily VMT per dwelling unit for a retirement community and 46.4 daily VMT per dwelling unit for a single-family community. Therefore, the retirement communities studied have about one-third of the roadway impacts per dwelling unit of the single-family subdivisions studied. *ITE’s Trip Generation Manual, 9<sup>th</sup> Ed.* contains two land use descriptions that are potentially applicable to retirement communities in Florida: LU 251 Senior Adult Housing Detached, and LU 252 Senior Adult Housing Attached. The description for LU 251 states that the sites were surveyed in the 1980s, 1990s, and 2000s in California, Florida, New Jersey, and Canada. Based on the information provided, the specific dates and locations of the ITE data used to calculate the weekday daily trip generation rates were not provided.

In an effort to improve the accuracy of trip generation estimates for retirement communities in FL, study data has been collected at numerous development sites in Florida since the year 2000. It is reasonable to assume that the Florida-collected data would provide a more representative trip generation rate for

retirement communities in Florida than the ITE rates. For this report, data was gathered from nine studies performed in Marion and St. Johns Counties between years 2002 and 2011. Using this data, it was estimated that on average, a Florida retirement community site generates 2.81 trips/dwelling unit/day, which is lower than both ITE LU 251 Senior Adult Housing – Detached, and ITE LU 252 Senior Adult Housing Attached, which have daily average rates of 3.68 and 3.44 trips/dwelling unit, respectively. However, it would be beneficial to conduct additional trip generation studies at retirement communities throughout Florida in an effort to create a more robust dataset for the daily rate, as well as to potentially develop rates for the AM and PM peak hour periods.

## Casinos

The number of study sites available for estimating trip generation at casino sites is currently lacking in the *ITE Trip Generation Manual, 9<sup>th</sup> Ed.* Casino trip generation is often estimated based on trips per gaming position or trips per slot for slot machine casinos. Additionally, previous studies show that the generator peak hour for casinos is often different than the peak hour of the adjacent street.

Currently, the only ITE land use representing casinos is ITE LU 473—Casino/Video Lottery Establishment. The average trip generation rate for ITE LU 473 estimates that a casino will generate 13.43 trips per 1,000 sf in the PM peak hour. Several trip generation studies have been performed to assess the impacts of casino developments in Pennsylvania. One study determined average trip rates from three casinos:

- Casino St. Charles (St. Louis, MO)
- SugarHouse Casino (Philadelphia, PA)
- Parx Casino (Bensalem, PA)

The average casino trip generation rates (trips per gaming position) were determined to be 0.29 for the Friday PM peak hour of the adjacent street, 0.43 for the Friday casino peak hour, and 0.50 for the Saturday casino peak hour.

Additional casino trip generation rates based on gaming positions and visitors were determined for several analysis periods and are shown in **Table 12**.

**Table 12: Pennsylvania Casino Trip/Visitor Generation Rates**

Location	Independent Variable	Description	Rate per Gaming Position	Directional Split	
				Entering	Exiting
<b>Friday P.M. (4:00-6:00 P.M.) Peak Hour</b>					
City of Philadelphia (North Delaware)	2,007	Trips	T = 0.623*(X)	55%	45%
		Visitors	T = 0.925*(X)		
City of Chester	3,732	Trips	T = 0.275*(X)	55%	45%
		Visitors	T = 0.464*(X)		
City of Bethlehem	4,164	Trips	T = 0.341*(X)	55%	45%
		Visitors	T = 0.526*(X)		
<b>Friday Evening (7:00-10:00 P.M.) Peak Hour</b>					
City of Philadelphia (North Delaware)	2,007	Trips	T = 0.538*(X)	53%	47%
		Visitors	T = 0.895*(X)		
City of Chester	3,732	Trips	T = 0.412*(X)	52%	48%
		Visitors	T = 0.689*(X)		
City of Bethlehem	4,164	Trips	T = 0.442*(X)	64%	36%
		Visitors	T = 0.661*(X)		
<b>Saturday Evening (6:00-9:00 P.M.) Peak Hour</b>					
City of Philadelphia (North Delaware)	2,007	Trips	T = 0.608*(X)	48%	52%
		Visitors	T = 0.982*(X)		
City of Chester	3,732	Trips	T = 0.378*(X)	48%	52%
		Visitors	T = 0.624*(X)		
City of Bethlehem	4,164	Trips	T = 0.382*(X)	58%	42%
		Visitors	T = 0.612*(X)		

T = Total trips generated

X = Gaming Positions (includes slot machines and table games)

Source: Tower Entertainment, LLC Transportation Impact Study, Appendix D

Casino developments are also unique because they are often part of mixed-use developments with land uses marketed toward casino patrons (restaurants, specialty retail, hotels, events centers, etc.). These ancillary land uses can often result in high internal capture percentages within casino developments.

While there are currently very few casino developments in Florida, future legislation could result in an increase in casino sites. In preparation for this potential development, it may be beneficial to research trip generation for casinos with similar characteristics to those anticipated in Florida.

**IKEA Stores**

IKEA stores are large, typically multi-level stores that offer furniture, appliances and home accessories. Additionally, many locations also include restaurants, food markets, and child-care services for shoppers. Due to their size and variety of services, IKEA stores likely generate trips differently than typical furniture stores represented by ITE LU 890 Furniture Store. There is currently very little research related to IKEA trip generation, however, one study was performed at the Portland, Oregon IKEA store by the Portland State University ITE student chapter. The study analyzed the Saturday peak period and determined that the store generated 4.47 trips per 1,000 square feet GFA during the peak hour. For comparison, ITE LU 890 Furniture Store has a rate of 0.95 trips per 1,000 square feet GFA during the same analysis period. From these findings, it is apparent that the IKEA store generates significantly more trips than typical furniture stores. Because of this, it may be beneficial to perform additional trip generation research at IKEA stores. There are currently three IKEA locations in Florida, and many more

throughout the US. Studying these locations would help improve the trip generation database for studies of IKEA and similar stores in Florida and throughout the US.

### **Bass Pro Shops**

Bass Pro Shops are specialty outdoor stores that have increased in popularity and number of locations over the years. These stores offer outdoor related sporting goods, but many stores also include large indoor water features, demonstrations, workshops, and restaurants. The large size of the store and additional features suggest that Bass Pro Shops may generate trips differently than the more common sporting goods stores represented in ITE's data. Based on data provided by Bass Pro Shops in a 2006 traffic study, the daily traffic estimated for a 300,000 square foot store is 10,000 and 20,000 vehicles per day on a weekday and Saturday, respectively. For comparison purposes, it should be noted that the weekday trip generation for ITE LU 820 Shopping Center estimates a 300,000 square foot shopping center to estimate almost 14,000 trips daily. As there are currently nine Bass Pro Shops locations in Florida and four more planned to open soon, it may be beneficial to conduct trip generation research on Bass Pro Shops.

## Literature Review

### *Trip Generation Practices at the Regional and State Levels*

The ITE *Trip Generation Manual, 9<sup>th</sup> Ed.* contains a variety of nationally collected trip generation data. While it is useful to have these national averages, the data may not accurately represent all geographic areas and land use trip generation may vary. In response to this, some states and municipalities have performed trip generation studies to obtain local and regional data, which may more accurately estimate trip generation in their areas.

### Vermont Trip Generation Manual

While ITE has collected trip generation data for decades, most of their data were collected in suburban and medium-sized areas, which are not representative of rural areas that make up much of Vermont. The study states that the use of ITE rates produce rather conservative estimates and provide a worst-case analysis, but are unrealistic. In an effort to obtain more accurate local trip generation data, the Vermont Agency of Transportation (VTrans) conducted a study from 2008-2010 to measure trip generation for the most widely proposed types of development in Vermont. The result of the research was the *Vermont Trip Generation Manual*, which could be used to provide more accurate estimates for traffic impact studies within the state. The research consisted of conducting manual counts at sites throughout the state and estimating trip generation, standard deviation, determining differences in rates were statistically significant when compared to ITE rates, and if the rates for urban and suburban locations differed statistically significantly from rural and small urban areas in the state. In 2008 and 2009, more than 1,000 individual trip generation counts for 17 land uses were conducted as part of the research. The land uses included in the research were:

- Park-and-Ride Lot
- Manufacturing
- Hotel
- Golf Course
- Shopping Center
- New Car Sales
- Supermarket
- Convenience Market with Gas Pumps
- Home Improvement
- Pharmacy without Drive-Thru
- Pharmacy with Drive-Thru
- Drive-In Bank
- High-Turnover (Sit-Down) Restaurant
- Fast-Food Restaurant without Drive-Thru
- Fast-Food Restaurant with Drive-Thru
- Coffee/Donut Shop without Drive-Thru
- Coffee/Donut Shop with Drive-Thru

The study states that, in general, the ITE data overestimates trip generation for these land uses in rural and small urban areas. Based on the results of the study, VTrans plans to use its normal funds to continue to conduct trip generation studies to estimate trip generation rates for unstudied land uses and to extend the trip generation studies already undertaken. The study also recommends that further trip generation studies be undertaken in other rural and small urban areas of the United States to confirm or modify the conclusions of the study.



The 2010 *Vermont Trip Generation Manual* can be accessed online via the following link:

[http://vtransengineering.vermont.gov/sites/aot\\_program\\_development/files/documents/materialsandresearch/completedprojects/VermontTripGenerationReportforweb.pdf](http://vtransengineering.vermont.gov/sites/aot_program_development/files/documents/materialsandresearch/completedprojects/VermontTripGenerationReportforweb.pdf)

### **Southern New Hampshire Planning Commission Trip Generation Study**

In 2009-2010, the Southern New Hampshire Planning Commission (SNHPC) began a regional trip generation study in an effort to develop local trip generation rates for land use types in which ITE lacks data. A secondary purpose of the study was to compare locally gathered data with ITE national average data. The SNHPC selected 66 land use types to be researched, seven of which did not exist in ITE *Trip Generation, 8<sup>th</sup> Ed.* at the time of the study. Since the study was proposed to be a multi-year effort, the first study report only included the following 12 land uses:

- Elderly Housing (Attached)
- Adult Housing (Detached)
- Day Care Center
- Drive-Thru Only Coffee Shop
- U.S. Post Office
- Pharmacy/Drugstore with Drive-Thru Window
- Large Book Store
- Clinic
- Nursing Home
- General Office Building
- Church
- Park-and-Ride Lot with Bus Service

The report states that local trip rates may vary from these nationally averaged rates based on factors such as location (CBD, outer limits of city, suburb, rural area, etc.) and the presence of any other major trip generators. The differences between study and ITE rates tended to vary for each land use as to whether they are higher or lower than ITE rates. Since the study was designed as a multi-year effort, the SNHPC stated that the reliability of the data and observations drawn from it will increase with the number of sites studied. The SNHPC report states that periodically, an updated version of the report is to be prepared as additional data is collected.

The SNHPC 2010 Trip Generation Study report can be accessed online via the following link:

<http://www.snhpc.org/index.php?page=reports>

### **FDOT District 7 Research on Discount and Home Improvement Superstores**

Due to an increase in the number of discount and home improvement superstores in Florida, there has been concern about the impact of such stores on the local roadways, as many of the new stores are larger in size and offer more services than those represented in ITE's data. In an effort to assess the differences in trip generation, FDOT District 7 collected local trip generation data for discount and home improvement superstores in order to develop and compare local trip generation rates with those published by ITE.

For the discount superstore research, nine Wal-Mart Super Centers and three Super Targets in Florida were studied. All sites operated seven days a week with long business hours, had dedicated off-street parking, and offered general merchandise, groceries, and several other services. The building square footages for discount superstores ranged in size from 108,000 square feet to 228,000 square feet of gross floor area (GFA), with an average size of 193,840 square feet.

The average daily trip generation rate for discount superstores was determined to be 76.7 trips per 1,000 square feet of GFA. The average PM peak hour of the adjacent street trip generation rate was determined to be 5.7 trips per 1,000 square feet of GFA; the AM peak hour of the adjacent street the rate was 2.4 trips per 1,000 square feet of GFA. The study found that field-measured trip rates for discount superstores were higher than the ITE published rates for all three of the commonly used land use types for discount superstores (ITE LU 813 Free-Standing Discount Superstore, ITE LU 815 Free-Standing Discount Store, ITE LU 820 Shopping Center).

For the home improvement superstore research, two Home Depots and two Lowes' stores within the greater Tampa Bay area were studied. All of the sites had dedicated off-street parking and offered a variety of customer services, centralized cashiering, and operated seven days a week with long business hours. The building sizes ranged from 105,000 square feet to 138,000 square feet, with an average size of 124,000 square feet.

The average daily trip generation rate for the home improvement superstores was determined to be 49.5 trips per 1,000 square feet GFA, the PM peak hour of the adjacent street rate was 3.9 trips per 1,000 square feet GFA, and the AM peak hour of the adjacent street rate was 2.6 trips per 1,000 square feet GFA. All of the study rates were found to be higher than the home improvement superstore rates included in ITE's data for ITE LU 862 Home Improvement Super Store.

Overall, the trip generation rates determined in the FDOT District 7 study showed that trip generation rates for discount and home improvement superstores are greater in Florida than the national average rates included in ITE's data.

### ***Research on Land Uses Not Currently Included by ITE***

Many new and emerging land uses are not currently included in ITE's *Trip Generation Manual*. As a result, it is often difficult for an analyst to estimate trip generation for these sites because related data is either difficult to find or non-existent. It would be beneficial for the research community to study these land uses in an effort to supplement, or eventually include in ITE's data.

### **ITE Journal Article on Power Centers**

Over the years, there has been an emerging trend with regards to the construction of large-scale shopping center developments, commonly referred to as "power centers." The *ITE Journal of Transportation*, November 2012, included an article titled "Predicting Trip Generation Characteristics of Power Centers." There has been concern that ITE's *Trip Generation Manual*, 9<sup>th</sup> Ed. may not accurately predict the traffic impacts of these facilities because of the wide variety of shopping center types and sizes, the age of the data, and potential inconsistencies in estimating trip generation. Additionally, the internal capture of trips within these developments complicates the task of estimating the impact of the development on adjacent public roads. The International Council of Shopping Centers (ICSC) defines six categories of open-air shopping centers, with the power center most closely aligned with the type of sites included in the research (category-dominant anchors with a total size of 250,000 to 600,000 square feet). To evaluate the validity of these concerns, data were collected at 10 sites by a task force formed by the Traffic Engineering Council of the North Carolina Section of ITE (NCSITE) to investigate the trip generation characteristics and the most appropriate method to predict trips at a power center. The

power centers included in the study were composed of at least one national chain store that anchors the development, as well as connected smaller in-line retail stores and free-standing outparcel stores. The study included ten power center sites located throughout North Carolina.

As part of their study, a literature review of related research was performed, which included a survey of state transportation agencies to determine the state of the practice in estimating trip generation for power centers. The survey was sent to 52 transportation agencies including all 50 states, the District of Columbia, and Puerto Rico. Of the 21 respondents, 20 agencies reported using typical ITE trip generation rates or equations to determine the trip generation of such sites. Only the Florida Department of Transportation stated that each power center project is handled on a site-specific basis.

According to the report, there are various opinions on how to estimate trip generation for power center developments which use different land use codes, combinations of land use codes, and internal capture rates. The two types of land use codes typically used in North Carolina and considered for the analysis were the individual land use of each business type and the shopping center land use (ITE LU 820). To test these trip generation options, the NCSITE task force used the following different combinations of land uses:

**Scenario 1:** Analyze all square footage as the shopping center land use type.

**Scenario 2:** Analyze the anchor store and in-line retail stores as the shopping center land use type and the outparcel stores as their individual land use types.

**Scenario 3:** Analyze the anchor store as its individual land use type, the in-line retail stores as the shopping center land use type, and the outparcel stores as their individual land use types.

Using the above three scenarios, trip generation estimates were developed and compared to traffic counts conducted for each analysis period at the sites. From the comparisons, it was determined that there was no statistically significant difference from the actual counts for Scenario 1 during the PM peak hour, Saturday peak hour, and daily total; Scenario 2 during the AM peak hour and daily total; and Scenario 3 with the daily total. Scenario 1 underestimated the actual trips observed by the research team in the AM peak hour by an average of 51 percent, while Scenario 2 was the closest estimator, with an average difference of 9 percent. For the remaining time periods, Scenario 1 resulted in the lowest average differences with 6 percent difference in the weekday PM peak hour, 6 percent difference in the Saturday peak hour, and a -11 percent difference for the daily total.

The study resulted in a recommendation that ITE LU 820 Shopping Center be used for estimating trips for the weekday daily, PM peak hour, and Saturday peak hour at power centers. Analyzing the anchor store and in-line retail stores as ITE LU 820 Shopping Center and the outparcel stores as their individual land use types was recommended for the AM peak hour.

### ***Trip Generation Research for Urban Infill Developments***

Over the years, urban infill developments have become more common in larger cities. As these developments are typically located in close vicinity to other existing land uses, it is often difficult to accurately estimate their trip generation characteristics due to a high number of internally captured trips.

## CalTrans Urban Infill Development Study

Infill development is defined as new development and redevelopment located on vacant or underutilized land within existing developed areas. Infill development is one strategy for revitalizing declining city and suburban cores and town centers. It promotes efficient and cost-effective use of existing infrastructure and services (such as streets, transit, and utilities), and expands opportunities for housing, recreation, and economic growth.

Some of the benefits of infill development are:

- 1.0 Provides housing opportunities closer to jobs
- 2.0 Encourages community revitalization
- 3.0 Reduces suburban sprawl
- 4.0 Makes better use of existing infrastructure
- 5.0 Encourages walking and the use of transit
- 6.0 Reduces the need for automobile ownership

For traffic impact analyses, ITE published trip generation rates are most commonly used for infill developments due to a lack of more appropriate data. However, ITE data typically reflects isolated suburban development lacking availability of and proximity to transit service, as well as the existence of pedestrian and bicycle facilities. As a result, the use of ITE trip generation rates for proposed urban infill development projects served by transit and having good pedestrian access could significantly over-predict vehicular traffic impacts. Despite the vast amount of data collected by ITE over the past decades, these trip generation rates may not be sufficient to guide the approval of proposed developments in urban infill areas because the sources of the rates do not reflect variations in density, diversity (land use mix), site design, and the multimodal transportation systems of our larger metropolitan areas, which are critical factors in travel demand. In metropolitan areas, the amount of vehicle trip generation is affected by multiple factors including:

- 1.1 Proximity to transit
- 1.2 Density of development
- 1.3 Development compactness
- 1.4 The pedestrian environment
- 1.5 Cost of parking
- 1.6 Traveler demographics such as income and auto ownership

In an effort to more accurately estimate trip generation in urban infill areas, research was undertaken by the California Department of Transportation (CalTrans) to address the need for more accurate data regarding travel characteristics of infill development in California's metropolitan areas. Specifically, the primary objectives of the study were to:

- Develop a methodology for identifying and describing urban infill locations suitable for collecting infill trip rate data
- Define and test a methodology for collecting trip generation rate data in urban infill areas of California
- Develop trip generation rates for common infill land use categories in urban areas of California
- Establish a California urban infill land use trip generation database
- Supplement ITE trip generation data

The study report states that the most applicable outcome from the research was the production of quantitative information on travel demand characteristics of urban infill land uses that can be used in traffic impact studies in California. Additionally, a goal of the study was to collaborate closely with ITE so that the resulting methodology and data, combined with the addition of national empirical data, eventually could be integrated into a future edition of ITE's *Trip Generation Manual*.

The research was conducted and published as two phases. Phase 1 was completed in 2008, the purpose of which was to develop methodology for identifying and describing urban infill areas, as well as collecting trip generation rate data in urban infill areas. Additionally, the first phase involved a Pilot Study to establish a preliminary trip generation rate database. The purpose of Phase 2, which was completed in 2009, was to collect and report additional trip generation data for an expanded set of land uses. Data for the study was collected in all metropolitan areas of California, including the Los Angeles, San Francisco Bay, Sacramento, and San Diego areas. Sites included in the study were selected based on the following specific criteria:

- Transit Criteria
  - Proximity (<1/3 mile to rail transit/<1,200 ft to BRT corridor)
  - Headways (<15 minutes for at least 5 hrs/day)
- Density Criteria
  - Residential (10.0 units/acre)
  - Non-Residential (floor area ratio>1.0 & employment >35.0/acre)
- Additional Criteria:
  - Site maturity
  - Destination retail excluded
  - Practicality of collecting data
  - Ability to gain permission
  - Located within a walkable district
  - Below market rate housing excluded

Additionally, specific land uses were included in the study. The land uses selected for the study were based on the following criteria:

1. Common urban land uses consistent with ITE categories
2. Land uses with frequent applications for development review demand for empirical data
3. Propensity for shifting drivers to other modes
4. Beneficial to the revitalization of urban areas, lack of accurate data may create barriers

The study sites surveyed were divided into residential and non-residential land use categories. The residential land use categories included high-rise apartments, mid-rise apartments, mid-rise residential condominiums/townhouses, and high-rise residential condominium/townhouses. The non-residential land use categories included general office building, specialty retail/shopping center, fast-food restaurant (without drive-through window), quality restaurant, and drinking place.

For residential land use categories, the observed vehicle trip generation rates were lower than ITE trip rates at all locations surveyed during the AM and PM peak hours, with the exception of one mid-rise apartment site. The study's preliminary findings for residential land uses are included in **Table 13**.

**Table 13: Urban Infill Development Trip Generation Results – Residential Land Uses**

Land Use	Location	AM Peak Hour			PM Peak Hour		
		Observed Trip Rate	Avg. ITE Trip Rate (ITE Code)	% Diff.	Observed Trip Rate	Avg. ITE Trip Rate (ITE Code)	% Diff.
<b>Residential Land Use</b>							
Mid-Rise Apartments	Berkeley	0.04	0.30 (223)		0.28	0.39 (223)	
Mid-Rise Apartments	Santa Monica	0.25			0.25		
Mid-Rise Apartments	Pasadena	0.34			0.32		
Weighted Average of Mid-Rise Apartment Sites		<b>0.22</b>			<b>-27%</b>		
High-Rise Apartments	San Francisco	0.05	0.30 (222)	-83%	0.07	0.35 (222)	-0.80
Mid-Rise Residential Condominiums/ Townhouses	San Diego	0.46	0.44 (230)	5%	0.41	0.52 (230)	-21%
High-Rise Condominiums/ Townhouses	San Diego	0.10	0.34 (232)	-71%	0.17	0.38 (232)	-55%
Weighted Average of All Residential Sites		<b>0.17</b>			<b>0.32</b>		
Notes: Average ITE trip rates from Trip Generation, 8th Edition, 2008. ITE average trip rate for 'Peak Hour of Adjacent Street Traffic' was used for comparison, except where noted. Weighted average is computed by dividing the total number of auto trips from all sites by the total number of units in all sites.							

Source: Trip –Generation Rates for Urban Infill Land Uses in California, Phase 2: Data Collection, CalTrans, June 15, 2009

For the non-residential land use categories surveyed, the derived urban infill trip rates were lower than published ITE trip rates at all the locations surveyed during the AM and PM peak-hours, with the exception of one Quality Restaurant and one Specialty Retail Center. The preliminary findings for the non-residential land uses are included in **Table 14**.

**Table 14: Urban Infill Development Trip Generation Results – Non-Residential Land Uses**

Land Use	Location	AM Peak Hour			PM Peak Hour		
		Observed Trip Rate	ITE Trip Rate	% Diff.	Observed Trip Rate	ITE Trip Rate	% Diff.
<b>Non-Residential Land Use</b>							
General Office Building	San Francisco	1.21	1.55 (ITE 710)		0.92	1.49 (ITE 710)	
General Office Building	Los Angeles	0.81			0.62		
General Office Building	Los Angeles	0.28			0.50		
General Office Building	Los Angeles	0.60			0.95		
Weighted Average of Office Sites		<b>0.78</b>			<b>-50%</b>		
Retail Clothing Store <sup>1,4</sup>	Oakland	12.03	N/A <sup>2</sup>	N/A	4.01	3.73 (ITE 820)	8%
Florist <sup>4</sup>	Berkeley	0.83	1.00 (ITE 820)	-17%	2.92	3.73 (ITE 820)	-22%
Bakery & Cafe <sup>5</sup>	Berkeley	5.21	70.22 (ITE 939)	-93%	8.46	28.00 (ITE 939)	-70%
Coffee Shop <sup>6</sup>	San Diego	50.80	117.23 (ITE 936)	-57%	8.77	40.57 (ITE 936)	-78%
Quality Restaurant	San Francisco	4.56	5.57 <sup>3</sup> (ITE 931)		4.20	7.49 (ITE 931)	
Quality Restaurant	San Francisco	1.75			8.29		
Weighted Average of Quality Restaurant Sites		<b>3.62</b>			<b>-35%</b>		
Notes: ITE trip rates from <i>Trip Generation</i> manual, 8 <sup>th</sup> Edition, 2008. ITE average trip rate for 'Peak Hour of Adjacent Street Traffic' was used for comparison, except where noted. <sup>1</sup> The clothing store was not open during the AM peak hour. This rate is the midday rate representing the PM peak hour of the generator as defined by ITE. <sup>2</sup> ITE Trip Generation does not provide a weekday rate for "peak hour of the generator" for shopping centers. However, the trip generation manual provides rates for "apparel store" (Code 870). The ITE average PM peak hour rate for this land use is 3.83 trips per 1,000 SF, and 4.20 trips for the PM peak hour of the generator. Therefore, the observed rates for the clothing store, when compared to ITE's apparel store category, provides a close match with the PM peak hour and a significantly higher rate when compared to ITE's peak hour of the generator. <sup>3</sup> The quality restaurants were closed during the AM peak hour. Therefore, the restaurants were surveyed during the midday period (11:30AM-2:00PM). For comparative purposes, the ITE 931 rate for the AM peak hour of the generator is shown above. <sup>4</sup> ITE Trip Generation does not provide specific trip generation rates for each of the different types of retail land uses included in this study; therefore, the TAC chose to compare all forms of retail to ITE Trip Generation's Shopping Center land use category (Code 820). <sup>5</sup> Compared to ITE's bread/donut/bagel shop category under land use code 939 (Bread/Donut/Bagel Shop without Drive-Through Window). <sup>6</sup> Compared to ITE's coffee/donut shop category under land use code 936 (Coffee/Donut Shop without Drive-Through Window).							

Source: *Trip –Generation Rates for Urban Infill Land Uses in California, Phase 2: Data Collection, CalTrans, June 15, 2009*

Despite the fact that the research project failed to meet its overall data collection goals in terms of quantity of data, the data that was obtained provides some insight into the differences in travel patterns between urban infill and conventional suburban sites and establishes the beginning of an urban infill trip generation database. The study was successful in identifying and testing data collection methods and determining ways to address challenges. The data collected and evaluated at the 27 sites indicate that the observed trip generation rates are generally lower (in some cases significantly) when compared to



ITE trip generation rates, although some individual sites show trip rates equal to or higher than ITE rates. More data points are required for the full set of selected land uses to substantiate this preliminary conclusion and to establish statistical correlations between urban contexts and trip generation characteristics. Since the publication of this study, additional research has been conducted and is anticipated to be published in a future NCHRP report.

The reports published for the CalTrans urban infill study can be accessed online via the following link:

<http://www.dot.ca.gov/hq/tpp/offices/ocp/projects.html>

### **NCHRP 758 – Trip Generation Rates for Transportation Impact Analyses of Infill Developments**

Most ITE trip generation rates and equations are based on data collected at primarily single-use suburban developments that lack transit service and are in areas where walking or bicycling modes are not extensively used. As a result, the ITE trip generation rates often over predict vehicular traffic impacts for infill development projects in urban areas served by transit with good pedestrian and bicycle access. Suburban and urban sites commonly have important differences in trip generation that result from their localized circumstances, such as zoning ordinances that segregate uses, the diversity and mix of land use types, site design, density, and the availability of multimodal transportation options. Given that many agencies and jurisdictions are prioritizing the development of infill, mixed-use, and transit oriented development (TOD), the refinement of trip generation methods and data for urban contexts is of increasing interest.

The objective of the research was to develop a methodology to estimate automobile trip generation and mode shares of non-vehicular trips for transportation impact analyses of infill development areas. An assessment of the current state of the practice for infill trip generation was performed which found that there is no standardized and nationally accepted methodology for infill trip generation estimation. The study recommends adjusting trip generation estimates based on data in the ITE trip Generation Manual using mode share and vehicle occupancy as adjustment factors based on two methods:

- *Proxy site method*—adjustment factors are derived from data collected from a site or sites that serve as a proxy for the proposed project’s land use in the context of urban infill development
- *Travel survey method*—extracts mode share and vehicle occupancy adjustment factors for a particular land use and context from regional household travel survey data for the metropolitan regions within which the study is being conducted

The recommended approach uses person trips as the common denominator between conventional and infill land uses. This concept—that a particular land use generates an equal number of person trips whether it is located in a suburban or urban context—is supported by common practice for infill trip generation. Based on this relationship, the proposed approach is a simple exercise in conversion from conventional automobile trips to person trips, and from person trips to infill vehicle trips. The approach can be applied to any of the land use categories in the ITE Trip Generation Manual, making it compatible with current practice in preparing impact analyses.

The approach developed from the research has five primary steps:

1. Baseline ITE trip generation data are used to estimate the vehicular trip generation of the proposed infill development
2. Baseline mode share and vehicle occupancy adjustment factors are used to convert baseline vehicle-trip estimates to baseline person trips
3. An infill mode-share adjustment factor representing the appropriate context is used to convert baseline person trips to infill person trips where the person travels by automobile
4. An infill vehicle occupancy adjustment factor representing the appropriate context is used to convert infill person trips where the person travels by automobile to infill vehicle trips
5. Infill vehicle trips are used in the evaluation of site traffic impacts

The use of person trips as the common denominator supports the idea that land uses in single-use suburban environments (baseline sites) generate approximately the same quantity of person trips as land uses in dense urban environments (infill sites). The proxy site method uses empirical data collected from a site or sites that serve as a proxy for the proposed project to obtain mode share and vehicle occupancy to adjust the baseline ITE trip generation data. The steps and their associated equations include:

1. Determine the study area context and identify the infill proxy site
2. Convert baseline ITE vehicle-trip generation to baseline ITE person-trip generation

$$\text{Person-Trips}_{\text{BASELINE}} = \frac{\text{VehTrips}_{\text{BASELINE}} \times \text{VehOcc}_{\text{BASELINE}}}{\left[ 100\% - \left( \begin{array}{l} \% \text{Transit}_{\text{BASELINE}} \\ + \% \text{WalkBicycle}_{\text{BASELINE}} \end{array} \right) \right]}$$

Where:

- $\text{Person-Trips}_{\text{Baseline}}$  = baseline ITE vehicle-trip estimates converted to baseline ITE person trips by all modes of travel;
- $\text{VehTrips}_{\text{Baseline}}$  = Vehicle-trip generation estimate from the ITE Trip Generation Manual for the subject site;
- $\text{VehOcc}_{\text{Baseline}}$  = Average baseline ITE vehicle occupancy in the baseline ITE trip generation estimate, as input by the user;
- $\% \text{Transit}_{\text{Baseline}}$  = Average transit mode share assumed in ITE trip generation rates; and
- $\% \text{WalkBicycle}_{\text{Baseline}}$  = Average walk and bicycle mode share assumed in ITE trip generation rates

3. Convert baseline ITE person-trip generation to infill person-vehicle-trip generation

$$\begin{aligned} \text{Person-Vehicle-Trips}_{\text{INFILL}} &= \text{Person-Trips}_{\text{BASELINE}} \\ &\times [100\% - (\% \text{Transit}_{\text{INFILL}} \\ &+ \% \text{WalkBicycle}_{\text{INFILL}})] \end{aligned}$$

Where:

- Person-Vehicle-Trips<sub>Infill</sub> = Infill person trips using vehicular mode of travel;
  - Person-Trips<sub>Baseline</sub> = Baseline ITE vehicle trips converted to baseline ITE person-trips<sub>Baseline</sub> from Step 2;
  - %Transit<sub>Infill</sub> = Average transit mode share applicable for specific infill area based on data collected in the proposed methodology (see section on developing adjustment factors); and
  - %WalkBicycle<sub>Infill</sub> = Average walk and bicycle mode share for specific infill area based on data collected in the proposed methodology
4. Convert infill person-vehicle trips to infill vehicle trips

$$\text{Vehicle-Trips}_{\text{INFILL}} = \frac{\text{Person-Vehicle-Trips}_{\text{INFILL}}}{\text{VehOcc}_{\text{INFILL}}}$$

Where:

- Vehicle-Trips<sub>Infill</sub> = Vehicular trip generation adjusted for urban infill conditions;
- Person-Vehicle-Trips<sub>Infill</sub> = Infill person trips using vehicle mode of travel resulting from Step 3; and
- VehOcc<sub>Infill</sub> = Persons per vehicle based on local data collection

There are two variants of data collection: the minimum data collection variant and the comprehensive data collection variant. The minimum variant is the default methodology for collecting data from proxy sites to derive adjustment factors. Unless additional data are desired or there are challenges in collecting the necessary data, the minimum variant is sufficient for most applications.

Infill adjustment factors may be derived for sites proposed within metropolitan areas that have current Household Travel Survey (HTS) data. This method of deriving mode share and auto occupancy is limited to the land use categories that can be deduced from HTS linked-trip data. The data normally available to use from the HTS method can be divided into four categories: household, person, vehicle, and travel and activity data.

The research team identified two types of confirmation as evidence of the approach's ability to predict urban infill trip generation and to demonstrate its validity to the transportation profession:

1. Verification—focuses on ensuring that the proposed methodology was correctly developed and that there are no gross errors or oversights in the theory, translation of the theory into a procedure, or the implementation of the procedure.
2. Validation—the act of demonstrating, at a reasonable level of confidence, that the methodologies' predictions are able to repeatedly match empirical data—in this case, vehicle traffic generation of infill development.

The predicted results of the household travel survey method were compared to the Metropolitan Washington, DC actual data and ITE estimates as described below.

- Residential LUC—the method resulted in substantially higher (2 to 3.5 times) peak hour trip generation at the 3 residential infill case study sites when compared to actual trips. When compared to ITE trip generation, the method predicts about 1/3 to 1/2 fewer trips at all 3 study sites.

- Office LUC—the method resulted in a minimum of 60% over prediction over actual trips during both peak hours. The method predicts peak hour trip generation at about 1/2 of the trips estimated using ITE rates. The research concludes that the difference between actual and predicted trips varies enough to find the results inconclusive without data sites would result in overestimation if analyzed using ITE rates.
- Retail LUC—the expected pattern for predicted versus actual did not occur, and instead the results were quite variable. The comparison of predicted to ITE trips shows that the method produces consistently lower trip estimates, ranging from 2/3 to 3/4 less than the ITE estimates.
- Restaurant LUC—Only one restaurant site was included in the data collection site, and this fact alone makes any findings inconclusive, however, the research team wanted to see if the method resulted in the same pattern of over predicting surveys and estimating substantially lower trips than ITE data produces. It was found that the same pattern is followed as residential and office, and that the method over predicts trips compared to surveys, and has substantially lower estimates compared to ITE trips.

The predicted results of the household travel survey method were also compared to the San Francisco Bay Area actual data and ITE estimates.

- Unlike the Washington, D.C. analysis, there was no discernible pattern of predicted trips overestimated when compared to actual trips and underestimated when compared to ITE estimates.
- The method consistently results in a lower number of trips, by 1/3 to 1/2 of trips estimated using ITE rates, similar to the findings of the Washington, D.C. analysis for residential and office land uses.

The research team concluded that adjusting baseline ITE trip generation data with factors derived from empirical data, or with factors extracted from HTSs, is logical and intuitive to users and can be a useful tool for estimating trip generation in traffic impact analyses of urban infill development. This conclusion is despite the fact that there were insufficient study sites to validate the proposed methodology or draw definitive conclusions on the accuracy of the method's estimates of infill trip generation.

Basing the approach on the collection of empirical data, as well as an alternative method to extract data from travel surveys, the proposed methodology meets the research objective

The research team believes this objective has been met based on the following four reasons:

1. The method has compatibility with existing traffic impact analysis methods (i.e., ability to estimate peak hour, directional-dependent variables)
2. The method applies to the land uses in the ITE trip generation manual and has few, if any, restrictions on land use categories and geography.
3. Input data needed to apply the method are readily available, or the ease and cost of collecting and applying the data are reasonable
4. The method would likely be accepted by members of the transportation planning and traffic engineering profession who prepare and review site traffic analyses

Additional conclusions include:

- The sample of case studies is too small to be conclusive (14 sites were studied for four LUCs)
- The analysis of case study sites lacked sufficient empirical vehicle occupancy data
- Small sample size cannot show the distribution of data or meaningful calculation of statistical measures

- Determining consistency in context and land use characteristics for selected case study sites is a critical task in validating the method

The full report for NCHRP 758 – Trip Generation Rates for Transportation Impact Analyses of Infill Developments can be accessed online via the following link:

[http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp\\_rpt\\_758.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_758.pdf)

### *Methodologies for Estimating Internal Capture*

Internally captured trips can be very important to analyzing the traffic impacts of developments with more than one land use. The current ITE internal capture methodology is based on a limited number of sites and may not accurately represent all mixed-use developments. In an effort to improve the accuracy of site internal capture estimations, several internal capture research studies have been conducted and are described in this section.

#### **NCHRP 684 – Enhancing Internal Trip Capture Estimation for Mixed-Use Developments**

The current methodology most widely used for estimating site internal capture is specified in ITE's *Trip Generation Handbook, 2<sup>nd</sup> Ed.*, last updated in 2004. The percentages included in the current ITE methodology are based on studies from only three locations in south Florida and cover trips only between the three most frequent land use categories present in mixed-use developments: residential, retail, and office land uses. Data are available for the weekday PM and midday peak hours, as well as what is called "daily," which is drawn from data collected between noon and 6:30 PM. The AM analysis period is not currently included in ITE's methodology. There has been concern that using only the three land use categories as specified by ITE may not provide an accurate representation of sites with a large variety of land uses, resulting in an underestimation in internal capture percentages. In an effort to enhance the accuracy of internal capture estimation, a research team lead by the Texas Transportation Institute (TTI) developed a methodology to provide an improved estimate of internal trips generated in mixed-use developments. This methodology was developed under NCHRP Project 08-51 and published as NCHRP 684 – Enhancing Internal Trip Capture Estimation for Mixed-Use Developments. The study was performed using analyses from existing data from previous studies, as well as through conducting and analyzing traffic counts and interviews at sites in Dallas, TX; Atlanta, GA; and Plano, TX. The team developed a classification system for mixed-use developments, an improved methodology for estimating internal trip capture, a data-collection framework and methodology, and a spreadsheet estimation tool to facilitate application of the internal trip capture methodology. At the time of publication of the report, the approach developed in the research had not yet been advanced through the ITE process for development of recommended practices.

For this project, the database of land use categories for mixed-use developments were expanded from three to six and made the following modifications to the existing ITE method to:

- Add the weekday AM peak hour
- Add restaurant, cinema, and hotel land uses
- Create a land use classification structure that would permit disaggregation of the six land uses to more detailed categories should enough data become available

- Include the effects of proximity (convenient walking distance) between interacting land uses to represent both compactness and design
- Provide a method that could easily be put in spreadsheet form

The study collected traffic count and interview data at the previously mentioned sites, from which origin-destination internal capture percentages were developed. The report provides step-by-step guidance for the procedure in the order in which it would be performed by the analyst, consisting of the following six steps:

- Step 1: Determine whether the methodology is appropriate for the analysis
- Step 2: Define the pertinent site characteristics
- Step 3: Calculate single-use trip generation for the site components
- Step 4: Estimate the unconstrained internal capture rates for all land use pairs at the site and add adjustments for proximity
- Step 5: Calculate the balanced internal trips between all land use pairs
- Step 6: Calculate the overall internal capture rate for the site

The method developed was tested for its ability to estimate external vehicle trip generation by comparing calculated estimates against actual data collected from several mixed-use developments. It was determined that the NCHRP 684 method produces roughly one-fourth as much estimation error as raw trip generation rates. Compared with peak-period cordon counts, the recommended method overestimates external trips by an average of about 1%. More telling is an absolute average of about 13% and a standard deviation of about 15%. All of the data and procedures from the study were input into a spreadsheet estimator, which uses user-input site characteristics to calculate internal capture percentages for the site. Information on the use of the spreadsheet estimator is included in *Section 4* of this report.

The report states that it is intended that the findings from NCHRP 684 be used to modify the existing ITE procedures. Incorporation of the project's recommendations could be accomplished by expanding Tables 7.1 and 7.2 of the *Trip Generation Handbook, 2<sup>nd</sup> Ed.* to include the origin-destination internal capture percentages for all six land uses in the report, as well as by adding the proximity adjustment. The adjusted internal trip capture rates for mixed use developments based on the research findings are shown in **Table 15**.

The NCHRP-684 report and its associated spreadsheet estimator can be accessed online via the following link:

<http://www.trb.org/Main/Blurbs/165014.aspx>

**Table 15: NCHRP 684 Adjusted Internal Capture Rates for Origins and Destinations within a Multi-Use Development**

Table 7.1a Adjusted Internal Trip Capture Rates for Trip Origins within a Multi-Use Development				Table 7.2a Adjusted Internal Trip Capture Rates for Trip Destinations within a Multi-Use Development			
Land Use Pairs		Weekday		Land Use Pairs		Weekday	
		AM Peak Hour	PM Peak Hour			AM Peak Hour	PM Peak Hour
From OFFICE	To Office	0.0%	0.0%	To OFFICE	From Office	0.0%	0.0%
	To Retail	28.0%	20.0%		From Retail	4.0%	31.0%
	To Restaurant	63.0%	4.0%		From Restaurant	14.0%	30.0%
	To Cinema/Entertainment	0.0%	0.0%		From Cinema/Entertainment	0.0%	6.0%
	To Residential	1.0%	2.0%		From Residential	3.0%	57.0%
To Hotel	0.0%	0.0%	From Hotel		3.0%	0.0%	
From RETAIL	To Office	29.0%	2.0%	To RETAIL	From Office	32.0%	8.0%
	To Retail	0.0%	0.0%		From Retail	0.0%	0.0%
	To Restaurant	13.0%	29.0%		From Restaurant	8.0%	50.0%
	To Cinema/Entertainment	0.0%	4.0%		From Cinema/Entertainment	0.0%	4.0%
	To Residential	14.0%	26.0%		From Residential	17.0%	10.0%
To Hotel	0.0%	5.0%	From Hotel		4.0%	2.0%	
From RESTAURANT	To Office	31.0%	3.0%	To RESTAURANT	From Office	23.0%	2.0%
	To Retail	14.0%	41.0%		From Retail	50.0%	29.0%
	To Restaurant	0.0%	0.0%		From Restaurant	0.0%	0.0%
	To Cinema/Entertainment	0.0%	8.0%		From Cinema/Entertainment	0.0%	3.0%
	To Residential	4.0%	18.0%		From Residential	20.0%	14.0%
To Hotel	3.0%	7.0%	From Hotel		6.0%	5.0%	
From CINEMA/ ENTERTAINMENT	To Office	0.0%	2.0%	To CINEMA/ ENTERTAINMENT	From Office	0.0%	1.0%
	To Retail	0.0%	21.0%		From Retail	0.0%	26.0%
	To Restaurant	0.0%	31.0%		From Restaurant	0.0%	32.0%
	To Cinema/Entertainment	0.0%	0.0%		From Cinema/Entertainment	0.0%	0.0%
	To Residential	0.0%	8.0%		From Residential	0.0%	0.0%
To Hotel	0.0%	2.0%	From Hotel		0.0%	0.0%	
From RESIDENTIAL	To Office	2.0%	4.0%	To RESIDENTIAL	From Office	0.0%	4.0%
	To Retail	1.0%	42.0%		From Retail	2.0%	46.0%
	To Restaurant	20.0%	21.0%		From Restaurant	5.0%	16.0%
	To Cinema/Entertainment	0.0%	0.0%		From Cinema/Entertainment	0.0%	4.0%
	To Residential	0.0%	0.0%		From Residential	0.0%	0.0%
To Hotel	0.0%	3.0%	From Hotel		0.0%	0.0%	
From HOTEL	To Office	75.0%	0.0%	To HOTEL	From Office	0.0%	0.0%
	To Retail	14.0%	16.0%		From Retail	0.0%	17.0%
	To Restaurant	9.0%	68.0%		From Restaurant	4.0%	71.0%
	To Cinema/Entertainment	0.0%	0.0%		From Cinema/Entertainment	0.0%	1.0%
	To Residential	0.0%	2.0%		From Residential	0.0%	12.0%
To Hotel	0.0%	0.0%	From Hotel		0.0%	0.0%	

Source: NCHRP Report 684 – Enhancing Internal Trip Capture Estimation for Mixed Use Developments, Transportation Research Board 2011

### FDOT District 2 Internal Capture Study

In many locations in Florida there has been a shift toward multi-use developments as opposed to single land use type developments. These multi-use sites typically include complementary land uses such as residential, retail, and office uses. The interaction between these land uses often results in trip internalization, which can potentially lead to overestimation of traffic impacts if not properly accounted for. In an effort to simplify the estimation of site internal capture in Florida, FDOT District 2, which is comprised of 18 counties in northeast Florida, conducted an internal capture study in 2009-2010 to develop a general percentage estimate for use within the District.

The internal capture methodology included in ITE’s *Trip Generation Handbook, 2<sup>nd</sup> Ed.* is currently the most commonly used method. However, the ITE methodology does not account for location specific variables such as the proximity of the dissimilar land uses and the demographics of jobs income to residential cost. Additionally, ITE does not currently account for community capture, a term which



describes the internal capture rate for a large, multi-use site that is typically isolated enough from surrounding communities to capture a large amount of traffic on-site. The report states that there have been previous internal capture studies performed in Florida, however, the characteristics between the studies are vastly different. While the previous studies focused only on internal capture rates, the District 2 study investigated either internal or community capture rates, whichever was appropriate. Initially, 24 sites were selected as potential study sites. Upon further investigation, most of the sites were not acceptable because they lacked a true multi-use environment due to low occupancy or lack of connectivity between commercial and residential land uses. As a result, four sites were selected for data collection and trip surveys: the Palencia development in St. Augustine, and the Haile Plantation, Magnolia Parke, and Tioga Town Center developments in Gainesville. The sites were selected based on several criteria, including the mixed-use land development pattern, site maturity and occupation rates, and the application of good design principles that promote access via all modes of transportation between the dissimilar land uses. **Table 16** below provides summary information related to the four study sites.

**Table 16: FDOT District 2 Internal Capture Study Sites**

Site Name	Address	City	Comments
Haile Plantation	North of Archer Road	Gainesville	A good example of mixed use in the "New Town" concept. Very compact town center, lots of commercial, office space, and medical. Many housing mixes.
Magnolia Parke	North of NW 39th Avenue/ S.R. 222	Gainesville	Site has promoted access via trails/8-ft sidewalks from apartment complex to commercial area. Located next to residential "Lake Crossing"
Palencia	U.S. 1 & International Golf Parkway	St. Augustine	Good commercial component (grocery, pub, bank, etc.) Gated residential with internal access road. Lots of driveways on U.S. 1.
Tioga Town Center	Newberry Road & 131st Street	Gainesville	Good access from residential to commercial. Good mix of retail. Living space above retail/office. Only problem may be amount of finished construction not yet rented.

*Source: Internal Capture Study FDOT District 2, May 2010*

Data was collected for the study via hose counts and on-site survey interviews collected at each site. The report states that summary analyses were performed on both ITE trip generation rates and survey results for all site locations. The difference between the calculated ITE rate and the observed traffic counts can be explained two ways; one way is that the difference between the ITE calculated rate and the counted traffic could be assumed as internally captured trips. The other interpretation is that the land uses in ITE are general in nature and may not exactly match the existing land uses. Essentially, the study assumed that the difference between ITE estimated trip generation and field collected count data is considered to be internally captured trips. Therefore, the percent difference between ITE estimates and field collected count data is the site internal capture rate. The results of the study shown in **Table 17** concluded that the mixed-use sites included had daily internal capture rates between 24 and 38 percent.

**Table 17: FDOT District 2 Site Internal Capture Results**

Mixed-Use Development	Internal Capture %		
	Daily	AM	PM
Haile Plantation	37.91	60.00	38.89
Magnolia Parke	31.32	2.44	37.50
Palencia	23.74	25.71	13.33
Tioga Town Center	33.58	15.69	38.46

Based on these findings, the study further indicates that future mixed-use developments in District 2 should expect an average daily internal capture rate of approximately 32 percent. Surveys collected for the AM and PM peak hours show average internal capture rates of 20 percent in the AM peak hour and 30 percent in the PM peak hour.

Therefore, the average site internal capture rates found in the study may be used as a guideline to estimate site internal capture in District 2 for developments with characteristics similar to those included in the study. However, it would be beneficial to collect additional data on mixed use development sites to supplement the existing database. It is recommended that the use of the rates from this study be discussed at a methodology meeting for their applicability before being used in an analysis.

### CUTR FDOT 2014 Trip Internalization for Multi-Use Developments Research

As stated previously, the internal capture methodology included in ITE's *Trip Generation Handbook, 2<sup>nd</sup> Ed., 2004* is based on data collected in 1993 from three sites in South Florida and may not accurately estimate trip internalization at modern mixed-use developments.

In an effort to expand on the existing database of internal capture study data, the Center for Urban Transportation Research (CUTR) identified and began collecting survey data on behalf of FDOT at mixed-use development sites in Florida in November of 2010. The research was finalized and published in April 2014 and will be referred to as the FDOT 2014 study. The objective of the research was to expand the existing database of trip internalization studies. To ensure that the data collected were useful and representative of common mixed-use development sites, the following steps were identified for the study:

- Select candidate mixed-use developments to be studied
- Evaluate each mixed-use development to see how well the individual development would add to the research
- Select final sites to include in full analysis
- Work with a technical team of experts to plan and conduct data collection and analysis
- Document the results in a useful format that will be acceptable for submission to ITE

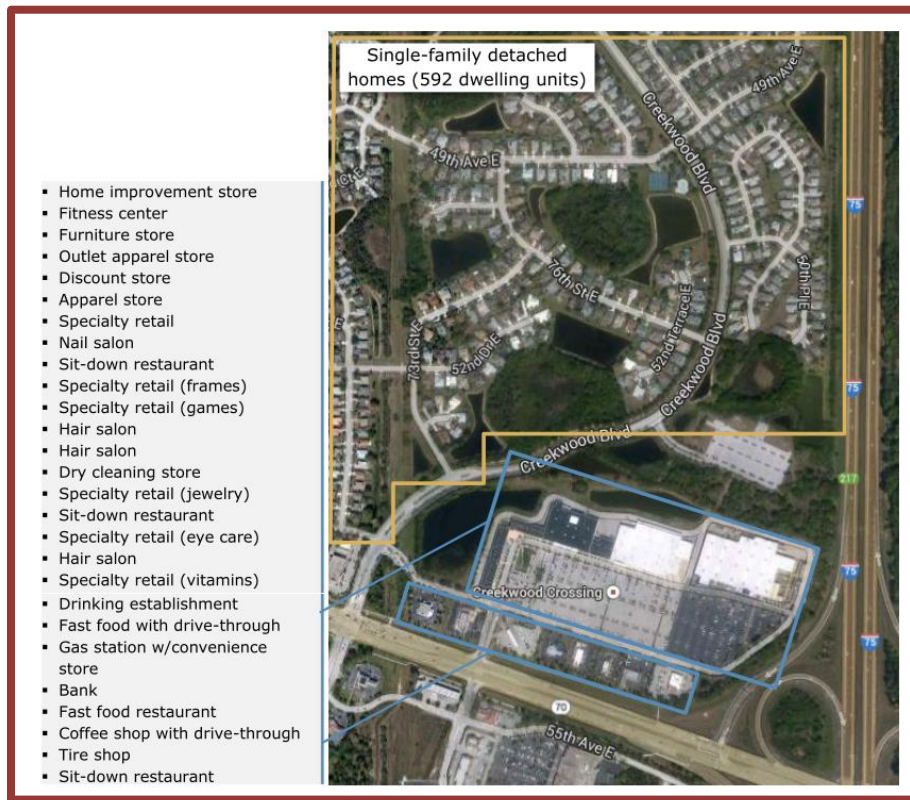
Similar to NCHRP 684, the FDOT 2014 internal capture research analyzes six land use categories: office, retail, restaurant, residential, cinema, and hotel.

During the site identification process, candidate mixed-use development sites were selected around the state using the following criteria:

- Total site area up to 200 acres
- Site can be easily isolated for cordon counts, as well as easily subdivided to obtain internal cordon counts if necessary
- Internal roads are the shortest path between internal land uses
- Type of mixed use developments include either:
  - Isolated land uses (backend residential, frontend mixed)
  - Strongly mixed land uses (high-rise residential with retail or office on lower floors)
- 80%+ occupancy for site property
- Ability to secure permission to perform site survey

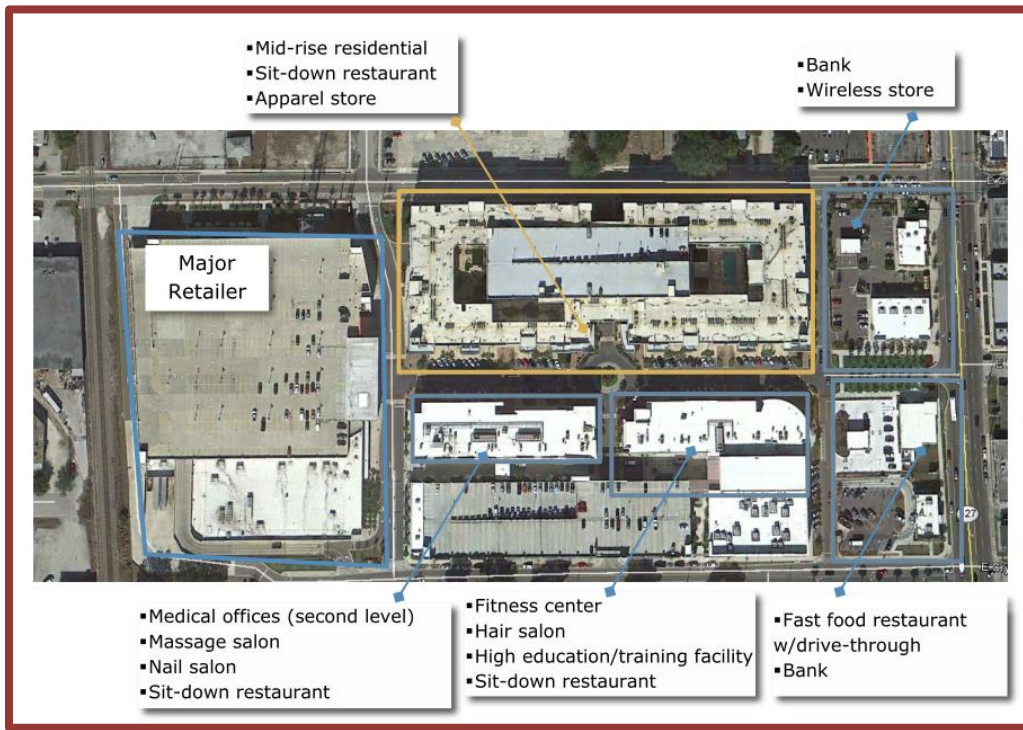
The final study included the following sites: Creekwood Crossings – Manatee Co., South of Downtown Orlando (SODO) – Orlando, Lakeside Village – Lakeland, and Uptown Altamonte – Altamonte Springs. **Figure 3** through **Figure 6** show the site layouts and land uses present for each development.

**Figure 3: Creekwood Crossing Site Layout and Land Use Inventory**



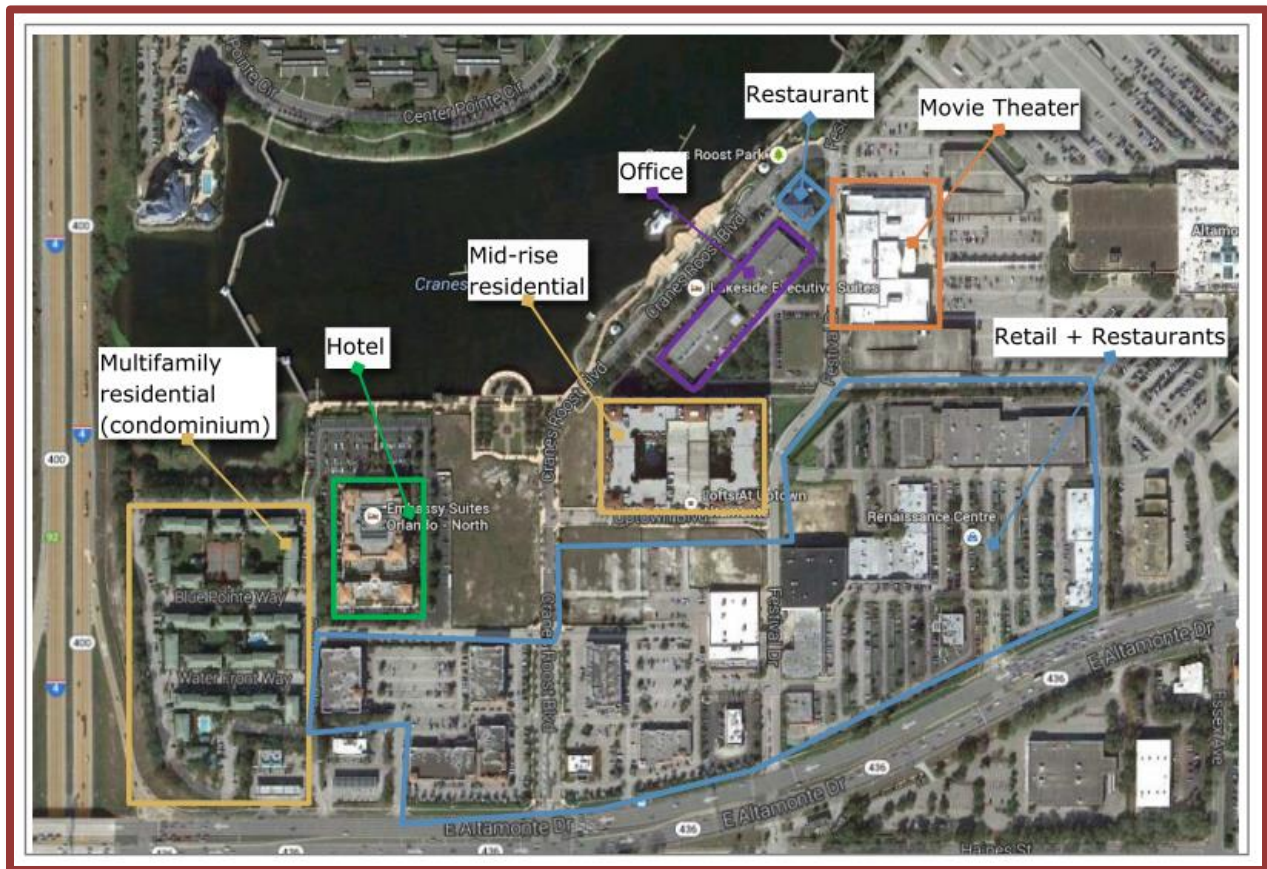


**Figure 4: SODO Layout and Land Use Inventory**



**Figure 5: Lakeside Village Site Layout and Land Use Inventory**



**Figure 6: Uptown Altamonte Site Layout and Land Use Inventory**

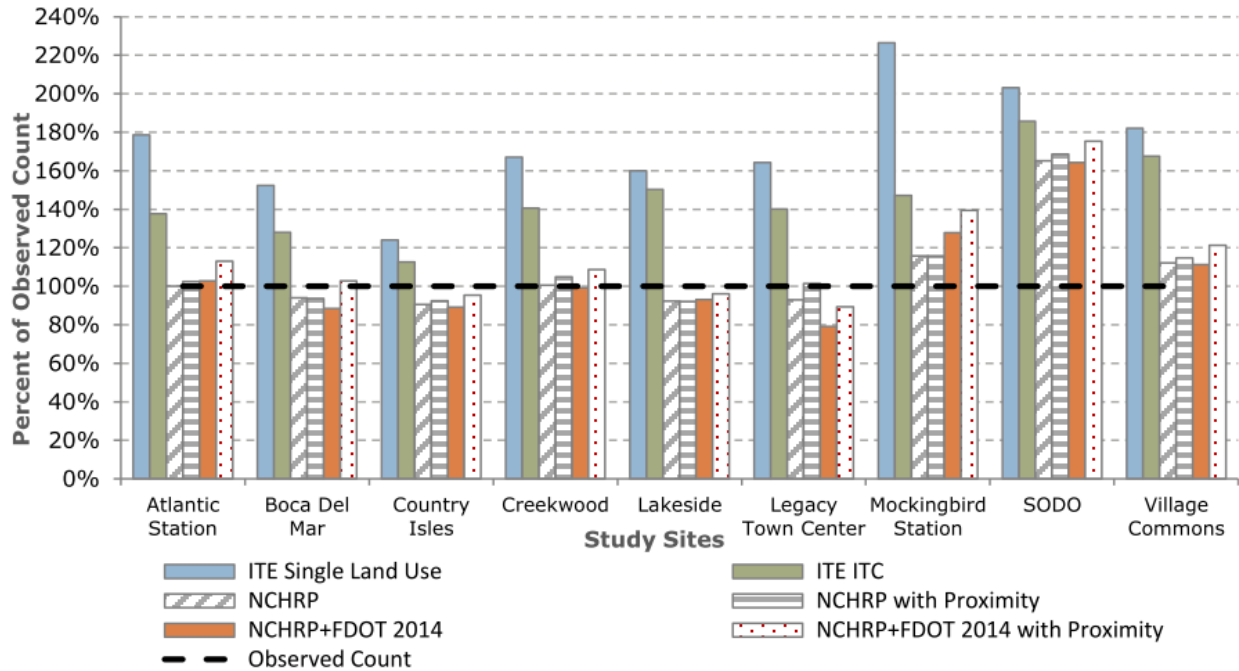
Initial descriptive data on site characteristics were collected from sources including County/City Planning Departments, Congress for the New Urbanism Florida (CNU), and commercial real estate firms. Descriptive data collected at each site included the following items:

- Site plan
- Building inventory
- Land use inventory
- Access points inventory
- Internal circulation facilities inventory
- Parking inventory
- Distance matrix

Based on the data, it was estimated that the various internal capture methodologies provide different results. It is important to note that the previous ITE internal capture rates produce significantly lower internal capture estimations for mixed-use developments. The enhanced NCHRP method with the use of the revised maximum unconstrained internal trip capture rates based on NCHRP and FDOT 2014 dataset can significantly improve the prediction capability of internal trip capture for mixed-use developments than those predicted from the previous ITE internal capture method. A series of prediction tests was developed and conducted to assess the contribution of the internal trip capture rates supplied by this research to the accuracy of trip generation estimates. It was found that the

combined data approach (NCHRP+FDOT 2014), which used updated maximum unconstrained internal capture rates based on the expanded database of NCHRP and FDOT 2014, improved the prediction capability in five out of eight test cases, with one test case tied. The results of the tests are presented in **Figure 7**.

**Figure 7: Comparison of Cordon Count Estimates (Bidirectional) Using Combinations of Internal Trip Capture Studies**



The research team reached the preliminary conclusion that for traditional multi-use developments, the average internal capture rate is estimated to be 15 percent or less. For highly integrated developments, the average internal capture rate could be as much as 40 percent. It was determined that the most appropriate approach for estimating site internal capture would be to use the maximum unconstrained internal capture rates from ITE, NCHRP 684, and the CUTR research. These maximum internal capture percentages were consolidated into tables based on land use origins and destinations, similar to the organization of the existing ITE and NCHRP 684 internal capture rates. The revised unconstrained internal trip capture rates based on the combined CUTR, NCHRP 684, and ITE data are shown in **Table 18** through **Table 21**.



**Table 18: FDOT CUTR Report 2014 Unconstrained Internal Capture Rates for Outbound Trips for PM Peak Period**

Origin Land Use From	Destination Land Use To					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	20%	4%	24%	0%	3%
Retail	2%	N/A	29%	26%	4%	5%
Restaurant	3%	41%	N/A	18%	8%	7%
Residential	4%	43%	24%	N/A	3%	4%
Cinema	2%	21%	31%	8%	N/A	4%
Hotel	0%	16%	68%	2%	14%	N/A

Source: CUTR FDOT 2014 Trip Internalization for Multi-Use Developments Research

**Table 19: FDOT CUTR Report 2014 Unconstrained Internal Capture Rates for Inbound Trips for PM Peak Period**

Destination Land Use To	Origin Land Use From					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	31%	30%	57%	6%	0%
Retail	8%	N/A	50%	10%	4%	2%
Restaurant	3%	29%	N/A	33%	3%	5%
Residential	6%	46%	16%	N/A	4%	1%
Cinema	1%	26%	36%	2%	N/A	2%
Hotel	1%	17%	71%	12%	15%	N/A

Source: CUTR FDOT 2014 Trip Internalization for Multi-Use Developments Research

**Table 20: FDOT CUTR Report 2014 Unconstrained Internal Capture Rates for Outbound Trips for AM Peak Period**

Origin Land Use From	Destination Land Use To					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	28%	63%	35%	N/A	0%
Retail	29%	N/A	14%	17%	N/A	0%
Restaurant	31%	14%	N/A	6%	N/A	8%
Residential	2%	16%	20%	N/A	N/A	0%
Cinema	N/A	N/A	N/A	N/A	N/A	N/A
Hotel	75%	14%	9%	12%	N/A	N/A

Source: CUTR FDOT 2014 Trip Internalization for Multi-Use Developments Research

**Table 21: FDOT CUTR Report 2014 Proposed Unconstrained Internal Capture Rates for Inbound Trips for AM Peak Period**

Destination Land Use To	Origin Land Use From					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	4%	14%	3%	N/A	3%
Retail	32%	N/A	8%	39%	N/A	4%
Restaurant	23%	50%	N/A	20%	N/A	7%
Residential	33%	45%	16%	N/A	N/A	9%
Cinema	N/A	N/A	N/A	N/A	N/A	N/A
Hotel	0%	0%	21%	0%	N/A	N/A

Source: CUTR FDOT 2014 Trip Internalization for Multi-Use Developments Research

Results obtained through this research verified that the enhanced NCHRP methodology produced more accurate estimates than the traditional internal trip capture procedure found in the ITE *Trip Generation Handbook*. When the internal capture data collected from this research were added to the existing data collected from the NCHRP 684 and FDOT 1993 studies, the updated maximum interaction rates for PM outbound trips comprised 64 percent NCHRP data, 33 percent FDOT 2014 data, and 3 percent FDOT 1993 data. The updated maximum interaction rates for PM inbound trips comprised 70 percent NCHRP data and 30 percent FDOT 2014 data.

In summary, the FDOT/CUTR 2014 internal capture research was found to enhance the NCHRP 684 and FDOT 1993 data. The combination of the maximum unconstrained internal capture rates from each study was found to improve the prediction capability of site internal capture at five out of eight mixed-use development test cases.

The FDOT 2014 internal capture research can be accessed online via the following link:

[http://www.dot.state.fl.us/research-center/Completed\\_Proj/Summary\\_PL/FDOT-BDK84-977-10-rpt.pdf](http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_PL/FDOT-BDK84-977-10-rpt.pdf)

### Community Capture

Current methodologies for estimating site internal capture may not be applicable in determining the number of internal trips within large, self-standing developments, such as new communities or towns. In an effort to address this, FDOT has developed a methodology for estimating community capture in Florida. The community capture methodology was accepted by the FDOT Executive Board in February 2009. FDOT, in partnership with the Florida Department of Community Affairs (now called the Department of Economic Opportunity, Division of Community Development), Regional Planning Councils (RPCs), local governments, transportation and land use professionals, and representatives of the development community, initiated the process of identifying unique trip making characteristics of large, self-standing development with a balanced mix of uses, such as a new community or town.

Community capture is defined as the reduction in the number of external vehicle trips generated by a large, mixed-use development, thus reducing the overall impact of the proposed community on the surrounding roadway network. Similarly to site internal capture, community capture occurs due to the combined land use, location, design, and multimodal characteristics of the development. The concept



of community capture extends the application of internal capture to include potential trip interactions and reductions within the boundaries of large scale, multi-use developments. In these large-scale cases, internal capture trips would be a wholly contained subset of community capture trips. It should be noted that community capture is not applicable to developments that are small or even medium to large-sized. Community capture is only relevant to very large Development of Regional Impact (DRI)-level developments with a large mix of uses and an internal roadway network.

Community capture can be applied to any large, self-standing development, such as a new community or town, with a balanced mix of uses that may fulfill a significant portion of the community's needs within the development. The Florida Statutes defines a "new town" as an urban activity center and community designated on the future land use map of sufficient size, population, and land use composition to support a variety of economic and social activities consistent with an urban area designation. New towns shall include basic economic activities, all major land use categories, with the possible exception of agricultural and industrial, and a centrally provided full-range of public facilities and services that demonstrate internal trip capture. These communities may be separated by travel-time, design, or distance from other major land use concentrations.

As each community will have unique characteristics, FDOT will not recommend minimum or maximum values for community capture. Reasonable analysis of proposed developments will be used and will be verified by substantial and ongoing monitoring programs. Ideally, over time, agreement should occur on some ranges and measurement criteria. However, because community capture is an emerging topic, many of the early estimates will be negotiated, based on best professional judgment and verified with monitoring agreements.

The justification for community capture will need to include summaries showing the numbers and percentages of trips served within the proposed development. For example, community capture for a development could state:

"X% of the entering shopping trips expected in the PM peak hour makes up Y% of the total exiting shopping trips from homes within the community."

Information must be provided in sufficient detail to clearly support and explain the process used to determine a proposed community capture value. The analysis should be done for each phase, with an agreed upon monitoring program. Expanded traffic monitoring beyond the current basic requirements of the DRI annual/biennial report will be a required provision in accepting community capture rates. While the detailed needs of the traffic monitoring program will be determined through the traffic study process, elements such as origin and destination studies, trip generation studies, and an evaluation of land use mixes in and around the community will usually also be included. If appropriate, trip characteristic assumptions and impact mitigation requirements will be revised, based on the monitoring. Traffic monitoring at a frequency greater than by phase may be required for more aggressive development programs or if significant changes are made to the planned development program.

No single tool for determining community capture currently exists. While refinements to existing tools are currently under development, no one procedure has demonstrated to provide a final community

capture value. Until more experience and knowledge regarding community capture exists, reasonable analysis and negotiations, supported by substantial and detailed monitoring requirements will be used.

Community capture goes beyond internal capture, accounting for the unique trip-making aspects of large, self-standing developments by focusing on:

**Land Use Characteristics:** A balance of complementary land uses which results in trip purposes (home to work, home to shopping, etc.) being satisfied within the development must exist for significant community capture to occur. Some of these characteristics are:

**Community Type:** The type of community, i.e. retirement community, recreational community, or communities with job opportunities, can have an important impact on community capture.

**Community Design:** The design features of the community can affect both the number of external vehicle trips, as well as the internal trips using major roadways. For example, a well-designed development with good internal connectivity will make it more convenient for trips to stay on site, thus reducing the number of trips needing to use a major roadway. Internal capture is facilitated by a high level of connectivity and short travel distance between complementary land uses.

**“Income Compatible” Land Uses:** Residential and employment centers should be “income compatible” to allow ample employment opportunities for residents within the community.

**Development Maturity:** The project’s fullest community capture may not occur until the complementary land uses mature, and will likely depend on the quantity and balance of land uses. However, each phase or increment must mitigate the cumulative impacts to the regional network resulting from the current and previously approved phases or increments.

**Location Context:** The location context of large, mixed-use developments may impact community capture in the following ways:

**Remote Locations:** For a remote location with a balance of complementary land uses, high trip capture may occur. For the trips not captured on site, longer external trip lengths will result because there would be few opportunities for trips to end near the site.

**Competing External Opportunities:** Discussion is ongoing regarding the trip generation characteristics of isolated communities. One assumption proposed is if a community is isolated, and a trip cannot be satisfied on site, some discretionary trips are less likely to occur. While not making a trip can be an option for some trips, such as shopping, it is not an option for work-based trips, which have the greatest impact during the peak hours.

**Multimodal Elements (Encouragement of transit, walking, and cycling):** The provisions of on-site transit circulators and integrated systems of bicycle, golf cart, and pedestrian paths may have an impact on vehicle trip generation and trip capture. Such amenities make it easier for trips to remain on site and may reduce the need for vehicle trips.

Currently, most standard large-scale travel demand models are not sufficiently detailed to predict internal capture or community capture. Unmodified models and their “raw” output alone are not appropriate tools to justify community capture values. When a model is used as part of the justification

for community capture values, clear documentation of the model process, including the submittal of all model files, must be provided, so a professional reviewer with reasonable competence in travel demand models can replicate the analysis and conclusions.

## Software and Analysis Tool Review

### *Software Reviewed*

In estimating site traffic impacts, there are numerous software tools and spreadsheet estimators which can be used to calculate trip generation, internally captured trips, and pass-by trip reductions. As part of this project, several of these estimation tools were evaluated for their advantages and potential improvements. The following sections outline each estimation tool.

### Online Traffic Impact Study Software (OTISS) – Version 3.0.0.137

In an effort to simplify the calculation process for conducting a traffic impact analysis, Transoft has developed a cloud-based software called Online Traffic Impact Study Software (OTISS). This section will describe the advantages and areas for potential improvement to the OTISS software. It should be noted that OTISS Version 3.0.0.137 was used for this review.

#### *Software Advantages*

Overall, OTISS is a useful calculation tool. There are many advantages to the software, some of which are listed below.

- **Since the software is cloud-based, the entire program is run in a web browser.** This is useful because it allows the developers to make necessary updates without the need to download new software. Additionally, the cloud-based software allows the user to access the software and their saved projects (with the appropriate license level) from any internet-connected computer.
- **ITE data may be filtered by study region and year.** The most basic feature of OTISS is the graph lookup tool. The graph lookup tool is essentially a searchable database that includes all of the information contained in volumes 2 and 3 of the 8<sup>th</sup> and 9<sup>th</sup> Editions of ITE's *Trip Generation Manual*, such as rates, equations, number of studies, land use descriptions, etc. for all land use categories. Other useful capabilities of the graph lookup tool include the ability to filter the data by source year and region, as well as simple trip-end calculations if independent variable quantities are input.
- **Private data can be input and saved in the software** (with the appropriate license level). This feature allows the user to input study data either for existing land use categories, or to create a new land use. Once private data has been input, it may be saved and used for trip generation analyses. A benefit of the private data is that the user can input local trip generation data which may be more representative of the local conditions than using an existing ITE land use. Another benefit of the private data is that once it's input, if it is included in a project analysis and then the data is updated, it will automatically update within the analysis.
- **A period analysis report provides output data for all time periods included in the analysis.** Overall, these analysis reports are useful in that they are generally easy to understand and provide all of the important outputs from a traffic analysis.

### *Opportunities for Improvement*

While OTISS has many advantages as an analysis tool, there are also aspects that could be improved upon that would benefit the software from practical and accuracy standpoints. The following list outlines potential areas for improvement.

- **Private data for existing ITE land uses can be overlaid onto ITE data, but is not included in the statistical equations.** While it is useful to see how private data relates to ITE data for a land use, it would be more beneficial if an option were provided to include private data (if reliable) in the calculation of average rates, regression equations, etc. to increase the number of studies and potentially increase the accuracy of the trip generation estimates.
- **For traffic forecasting, linear growth is not an option.** While OTISS will calculate traffic growth given the percent growth rate, number of years, and traffic volumes, the volumes can only be calculated using compound annual growth. It would be helpful to add linear growth capabilities, as many agencies prefer to use linear growth calculations.
- **Internal capture calculations are only partially automated.** To calculate internal capture in the software, OTISS gathers all of the land uses input for a particular project and creates a page with fillable fields to input the restrained internal capture percentages between the origin and destination land uses. Therefore, the user must refer to the unconstrained internal capture rates tables and input each percentage individually, which can be cumbersome depending on the number of land uses. Additionally, the user must choose whether they prefer to use ITE's *Trip Generation Handbook, 2<sup>nd</sup> Edition 2004* or NCHRP 684 methodology and then select and input which percentages are required into each field. In general, the more user input required, the longer the calculation will take and the higher the probability of user error in the calculations.
- **Multiple similar land uses cannot be aggregated for internal capture calculations.** As specified in ITE's internal capture methodology, the number of trips generated by residential land uses in a mixed use site should be aggregated before calculating site internal capture. Since OTISS calculates internal capture based on individual land use codes, the residential trips cannot be aggregated for ITE and must be calculated individually. For example, if a mixed-use development includes LU 220—Apartment, LU 233—Luxury Condominium/Townhouse, and LU 854—Discount Supermarket, the residential trips for LU 220 and 233 would be consolidated before estimating the internal capture. However, OTISS estimates the internal capture individually, so the interactions would be estimated between LU 220 and 854, 233 and 854, and 220 and 233. Estimating the internal capture using this method would typically overestimate the site internal capture. More importantly, for estimating internal capture using NCHRP 684, the trips generated by similar land uses within a development should be aggregated into the six land use categories before calculating the internal capture percentage. By calculating the internal capture based on individual land uses instead of allowing aggregation, OTISS tends to overestimate internal capture when compared to other estimation tools.
- **Period analysis output shows internal capture trips, but not percentages.** By showing the internally captured trips, the user must still calculate the percentage of internal capture, which is the most commonly used indicator of trip internalization.
- **The MS Excel output provides limited information.** OTISS has the ability to export period analysis results into Microsoft Excel, however, the output provides limited information. The output would be more beneficial if the equations and additional analysis information were summarized in the output.
- It should be noted that since OTISS is cloud-based, improvements are made frequently, and the information in this report may not reflect the most current version.

## FDOT Trip Generation, Internal Capture, and Pass-By Software (TIPS)

In 2007, FDOT released a software tool called TIPS, which stands for *Trip Generation, Internal Capture, and Pass-By Software*. The software was created to estimate the number of trips that may be generated by a specific set of land uses in a multi-use development. TIPS utilizes data from ITE's *Trip Generation Report, 7<sup>th</sup> Ed.* and the *Trip Generation Handbook, 2<sup>nd</sup> Ed.* TIPS has been a useful software as it automatically calculates most of the typical results necessary for a traffic impact analysis. The following sections list the advantages and potential improvements for the TIPS software tool. However, it should be noted that TIPS is no longer updated or supported by FDOT because it does not use the most current ITE data.

### *Software Advantages*

Overall, TIPS is a very useful tool. Some of the advantages for the software are listed below.

- **Trip generation data is already included in the software.** All trip generation rates and equations (based on ITE's *Trip Generation, 7<sup>th</sup> Ed.*) are included in the software. As a result, the user must simply select the appropriate land uses, input the number of units, and select whether to use the rate or equation (the software provides a recommendation on which to use).
- **Site trips are automatically calculated in the software.** Once relevant trip generation data is input, the software automatically calculates the number of trips for the development. Additionally, the rates and equations can be customized if necessary to reflect local conditions.
- **Internal capture and pass-by trips are automatically calculated in the software.** Based on the land uses included in the analysis, internally captured and pass-by trips are automatically calculated for the development, based on the percentages included in ITE's *Trip Generation Handbook, 2<sup>nd</sup> Edition 2004*. If needed, the rates can be modified to reflect local or unique conditions.
- **Summary and detailed reports are automatically created for the analyses.** Once all relevant calculations are completed by the software, summary and detailed results tables are created. These results can then be either exported to MS excel or printed in a report format that outlines all the analysis findings.

### *Opportunities for Improvement*

- **Update the software to include data from ITE's *Trip Generation Manual, 9<sup>th</sup> Ed.*** While TIPS is a useful calculation tool, it is no longer updated or supported by FDOT. As a result, it does not include the most up-to-date land uses and trip generation rates/equations. Because the data in TIPS is not current, it should not be used for traffic impact analyses that require the most recent ITE data to be used. Additionally, updating the software or developing alternative software could also include integration of NCHRP 684 internal capture percentages.

## *Analysis Tools Reviewed*

### **NCHRP 684: Enhancing Internal Trip Capture Estimations for Mixed-Use Development Spreadsheet**

As part of the NCHRP 684: Enhancing Internal Trip Capture Estimation for Mixed-Use Development research described in *Section 4* of this report, a spreadsheet calculator tool was developed using the site internal capture percentages found in the research. The purpose of the spreadsheet is to take mixed-use development site trip data and calculate the internal capture for the overall site, as well as between land uses. In general, the spreadsheet estimator is user-friendly and requires minimal input.

### *Software Advantages*

- **The estimator tool is available for free online.** The tool is available for download at no charge from the NCHRP 684 webpage. This allows the tool to be easily downloaded and used by anyone.
- **The estimator tool runs as a spreadsheet in MS Excel.** As the spreadsheet estimator runs in MS excel, it is easily accessible and can be used and saved in a common format.
- **The estimator tool requires minimal inputs.** To run a basic internal capture analysis using the NCHRP 684 methodology, the user need only input the number of entering and exiting trips for each of the six land use categories present in the development. Once that data is input, the tool automatically calculates the internal capture in percentages and trips for the land use categories and overall site. To perform a more detailed analysis, mode-split, vehicle occupancy, and walking distances between land uses may be input.

### *Opportunities for Improvement*

- **Provide trip generation calculation functionality in the estimator.** Currently, the spreadsheet does not currently calculate trip generation. As a result, trip generation must be estimated and aggregated into land use types before being input into the NCHRP 684 spreadsheet.
- **Provide a diagram or graphical representation of the internally captured trips.** It would be helpful if a graphic depicting internal capture origins and destinations were provided to allow the user to have a visual representation of internal trips between land use types. This would allow the user to more easily interpret the analysis results and check for errors.

## **Trip Generation Spreadsheet**

### *Software Advantages*

- **The estimator tool is available for free.** The tool is available for download at no charge from the FDOT webpages. This allows the tool to be easily downloaded and used by anyone. However, it should be noted that the spreadsheet is provided as a convenience only, and is only useful for a “first cut” analysis.
- **The estimator tool runs as a spreadsheet in MS Excel.** As the spreadsheet estimator runs in MS excel, it is easily accessible and can be used and saved in a common format.
- **The estimator tool requires minimal inputs.** To run a basic trip generation analysis using the spreadsheet, the user need only select which land uses and units are required and input the land use intensities. Once these items have been input, the spreadsheet will calculate the number of trips for each land use analyzed.

### *Opportunities for Improvement*

- **The estimator tool is based on the 8<sup>th</sup> Edition of ITE’s Trip Generation.** Since the tool is not based on ITE’s most recent edition, some of the rates and equations are not up to date, and some land uses are not included.
- **The estimator tool only includes trip generation capabilities.** As the tool only includes capabilities to estimate trip generation, it is not as functional as some of the other tools that also estimate internal capture and pass-by trips.
- **The estimator tool does not sum up the trips based on user input.** While the user may input several land uses, the tool will estimate the trip generation for each land use individually, but will not calculate a sum total. It could be beneficial to add functionality to sum up the trips for use in analyzing mixed-use development trip generation.



## Recommendations

Based on the FDOT research findings and literature review, the following recommendations can be made:

- As particular land uses become more common in Florida, it is important that trip generation estimates are reasonable. Therefore, it is recommended that trip generation research be conducted on new and emerging land uses, some examples of which are listed below:
  - Power Centers
  - Charter Schools
  - Beach Resorts
  - Retirement Communities
  - Casinos
  - IKEA Stores
  - Bass Pro Shops
- As described in the report, it is becoming more common for state and local agencies to conduct trip generation research and develop local trip generation manuals. As shown in FDOT research, there are often differences in trip generation characteristics between nationally collected ITE data and Florida data. Therefore, it is recommended that FDOT continue to research trip characteristics for land uses that are believed to generate trips differently than ITE data suggests.
- As the number of urban infill developments in Florida increases, it will be important to accurately estimate their trip generation. However, this is often difficult due to the multimodal nature that commonly exists in urban infill areas. It may be beneficial for FDOT to conduct trip generation research on urban infill developments. In the meantime, the rates specified in the CalTrans Urban Infill Development Study may be used for developments similar to those specified in the study.
- As the number of mixed-use developments in Florida continues to increase, it is important that site internal capture rates are accurately estimated. As the current ITE internal capture methodology is based on data from a limited number of sites in Florida, it will be beneficial to continue to research internal capture in Florida. The FDOT District 2 internal capture study provides general site internal capture percentages which may be used for estimating site internal capture where more detailed data is unavailable.
- The NCHRP 684 internal capture research provides an enhanced methodology for estimating internal capture. When compared to the current ITE methodology, NCHRP 684 increases the number of land use categories from three to six, allowing for more accurate internal capture estimation. However, the NCHRP 684 methodology requires land uses to be aggregated into categories instead of calculating them individually. While this aggregation allows for more accurate site internal capture estimations, it eliminates the ability to estimate the trip interaction between multiple land uses of the same category (example: trips from one retail use to another retail use). It should also be noted that the sites included in this research were heavily served by transit, therefore, this data should be used with caution.
- The CUTR FDOT 2014 internal capture research seems to have enhanced the FDOT 1993 and NCHRP 684 unconstrained internal capture percentages resulting in a more accurate predictor of internal capture at mixed-use developments. The methodology seems to work well for estimating internal capture, and may be considered as an option if appropriate and mutually agreed-to during agency methodology meetings.



- Transoft's online software OTISS is a useful reference and tool for estimating site trip generation. However, the fact that the software needs to be renewed annually as a license should be considered for its long-term costs.
- FDOT's TIPS software has been a useful tool for estimating site trip generation, internal capture, and pass-by trips for site impact analyses. However, the software is based on the 7<sup>th</sup> Ed. of ITE's *Trip Generation* and is no longer supported by FDOT. Since there have been significant changes between the 7<sup>th</sup> Ed. and the current 9<sup>th</sup> Ed., it is not recommended for anything other than a cursory first look at trip generation. It would be beneficial for FDOT to either update TIPS or develop a similar software tool for use in Florida.