Local Trip Generation Adjustments for Transit Oriented Development

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DELAWARE VALLEY
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REGIONAL
PLANNING COMMISSION

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DVRPC's mission is to achieve this vision by convening the widest array of partners to inform and facilitate data-driven decision-making. We are engaged across the region, and strive to be leaders and innovators, exploring new ideas and creating best practices.

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Executive Summary

The main purpose of this study is to answer the following two questions:

- Is vehicle trip (and parking) generation at suburban residential Transit Oriented Development (TOD) lower than at comparable non-TOD sites?
- and if it is lower, how much lower?

To answer these questions, data was collected at 13 study sites throughout the Philadelphia urban area. The study sites are residential apartment buildings between three and seven stories tall. Ten of the sites are located within a short walk of a rail station, and three sites have no rail access.

The following data was collected:

- Number of vehicle trips entering and exiting each site during the AM peak hour of a weekday
- Number of vehicle trips entering and exiting each site over an entire week day
- Total number of parking spaces, and the number of spaces that were occupied on a weekday morning before most residents left for work

The number of vehicle trips generated by the suburban TOD sites was compared to vehicle trips generated by the non-TOD sites. The total number of parking spaces, and the number of occupied spaces was also compared.

In addition to the three Philadelphia non-TOD sites, Institute of Transportation Engineers (ITE) data was also used for comparison. ITE collects data at similar mid-level apartment buildings in numerous states and urban areas across the United States. Most of their data is collected in low density, auto oriented, suburban neighborhoods. Therefore, ITE data serves as another example of non-TOD suburban development.

The data show a clear vehicle trip reduction benefit to suburban TOD development during the AM peak hour. However, there is less of a benefit over the course of an entire day. This suggests that while suburban households located near a rail station may use the train to commute back and forth to work, they probably are still making many trips each day by car. For example, trips to the grocery store or ferrying the kids to soccer practice.

While this survey has provided a lot of useful information, there are still many unanswered questions. To gain a more complete understanding of travel behavior requires additional information, such as the origin, destination, purpose, and mode of travel for every trip made by every member of the household over the entire day. The next household travel survey that will be conducted by the Delaware Valley Regional Planning Commission (DVRPC) represents an excellent opportunity to collect this more detailed information.

Introduction

Since the end of the Great Recession in 2009, between 60 to 70 percent of new residential development in the Philadelphia urban area has been multi-family apartments.[1] Approximately 15 percent of these new multi-family developments are located within a half-mile of a rail station. This is in contrast to the prevailing development pattern in the 30 years preceding the recession, when single-family detached housing in the suburbs was by far the most prevalent type of residential development. This change reflects some long-standing shifts in socio-demographics, as the traditional household of a married couple with children has been replaced by married with no children, and single-member households. It also reflects a change in where people are choosing to live—for the first time since 1950, people are moving back to cities and the population and number of households in the City of Philadelphia is increasing once again.[2]

From a transportation planning perspective, there is a general sense that these changes are a good thing: that more people living within walking distance of rail should translate into fewer vehicle trips and less congestion. But there is very little data to support this fact. There is certainly little if any data in the Philadelphia urban area to back up the notion that residential TOD generates fewer vehicle trips. So, the purpose of this study is to determine if there really is a vehicle trip reduction benefit, and a parking reduction benefit to TOD development, and to quantify this benefit.

To do this, we compared daily and AM peak hour vehicle trip rates for mid-level apartments located next to train stations to similar mid-level apartments *not* located near train stations. And we also compared locally observed data to ITE trip generation rates for mid-level apartments—with the understanding that ITE's data is collected nationally and usually represents more suburban, auto-oriented sites. Data was collected at 13 sites throughout the Philadelphia region. Most of the data was collected in 2018.

This report consists of three sections. The first section provides information on each study site, such as its location, the number of units in the development, the number of parking spaces, and the distance to the nearest rail station. The second section compares the observed vehicle trip generation and parking utilization at the TOD sites to similar data for non-TOD sites. This section includes analysis to determine if the differences in trip generation rates are statistically significant. The third and final section discusses caveats, conclusions, and next steps.

Finally, while the focus of this report is on the traffic and parking impacts of TOD, there is a companion document to this study that more broadly evaluates a variety of potential impacts related to multifamily housing. *Development Matters: Understanding the Opportunities and Implications of Multifamily Development* (Publication 18033) documents multifamily development trends and presents research on

[1] U.S. Census Bureau, *Residential Construction Statistics Division*, May 2017.

[2] Michaelle Bond and John Duchneskie, "Slow, But Steady: For the Last 12 Years, Philly Has Continued to Grow—Even Faster Than Its Suburban Neighbors—According to Census Numbers Revealed Today for Pa. and N.J.," *The Philadelphia Inquirer*, April 18, 2019, https://www.inquirer.com/news/a/philadelphia-population-growth-census-south-jersey-20190418.html.

the economic, transportation, and community implications of multifamily development. Other recent DVRPC reports related to TOD include the forthcoming *SEPTA Transit-Oriented Development (TOD) Policy Research* (Publication 18031) and the 2017 study, *Building on our Strengths: Evaluating TOD Opportunities in Greater Philadelphia* (Publication 16036).

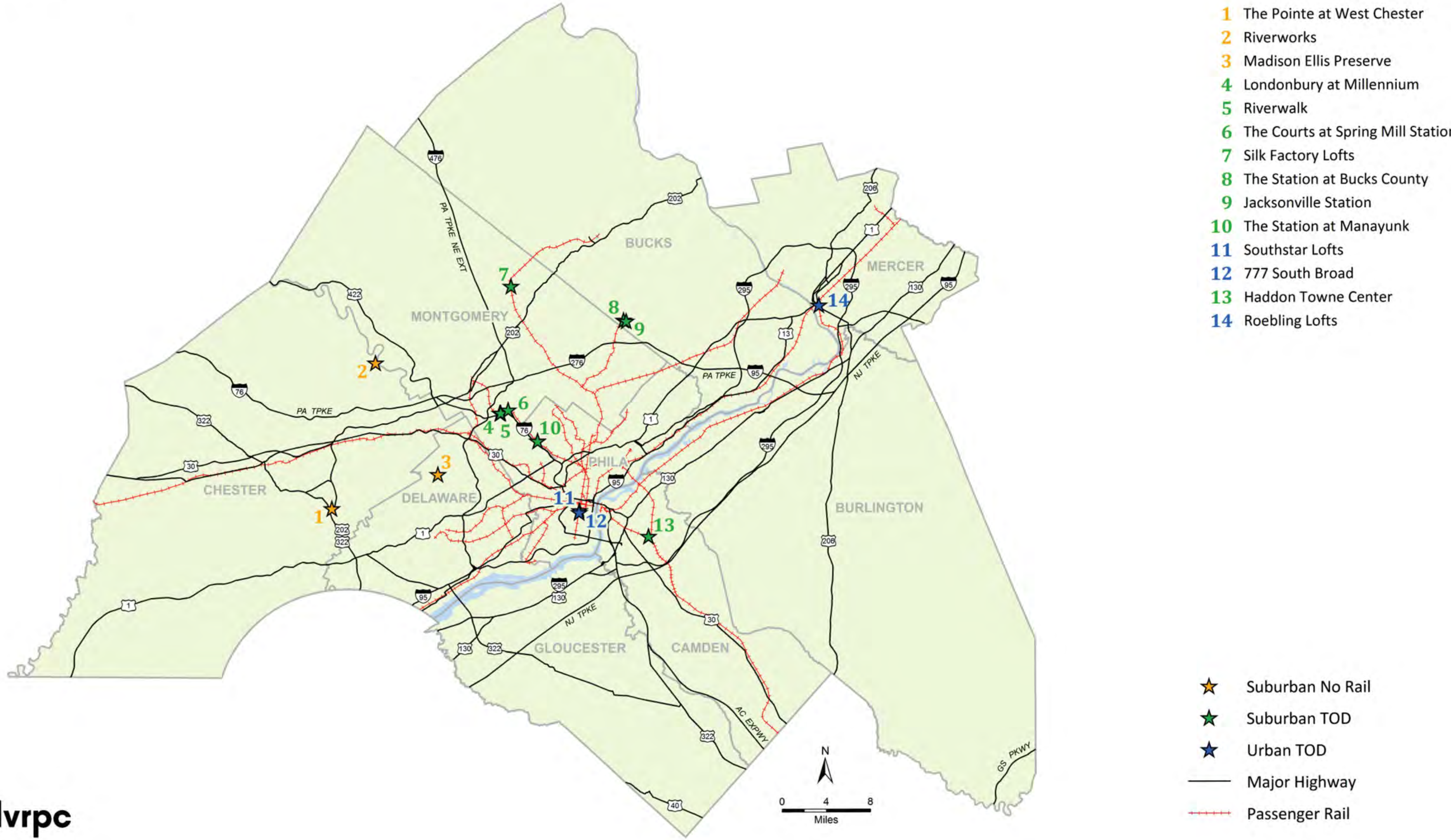
Study Sites

A total of 13 study sites were analyzed for this project. The locations of study sites are shown in Figure 1. All of the sites are multi-family residential apartment buildings between three and seven stories tall and built after the end of the Great Recession, which lasted from December 2007 to June 2009. Ten of the sites are within a short walk of rail transit. Of these, three sites are located in urban areas (City of Philadelphia and City of Trenton), and seven are located in suburban areas along regional rail lines.

The remaining three sites are suburban but not located near rail transit and are included as "controls." The assumption is that the vehicle trip generation rates of the non-rail sites will be higher than vehicle trip generation rates at the rail sites. The main purpose of this study is to gather data to support (or disprove) this theory.

This section provides brief background information on each site. There are two summary tables that provide data on each site. Table 1 lists the number of units, the number that were occupied at the time the trip generation data was collected, the year the site was built, the distance to the nearest rail station, and the number of parking spaces. Table 2 lists the journey-to-work (JTW) walk and transit shares, the average number of vehicles per household, and the median household income for the surrounding census tract. There are also location maps for each site in Appendix A, and photos of each site in Appendix B.

Figure 1: Study Site Locations



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The Pointe at West Chester (#1)

This is one of the suburban sites without rail access. The Pointe is located at the interchange of US 202 and South Matlack Street in West Chester, approximately 1.6 miles south of downtown West Chester.

Riverworks (#2)

Another suburban site with no rail access, Riverworks is a short five-minute walk from downtown Phoenixville, across French Creek.

Madison Ellis Preserve (#3)

Madison Ellis Preserve is the third suburban site without rail access. It is a new residential development built in 2018 and a short walk (0.7 mile) from the center of Newtown Square.

Millennium (#4 and #5)

Millennium is a large apartment complex located along the Manayunk/Norristown rail line in Conshohocken, 13 miles north of downtown Philadelphia. The complex includes two apartment buildings, Riverwalk and Londonbury, adjacent to each other. Because they are accessed via shared driveways, we were unable to separate out the vehicle trips generated by each individual building. Instead, we counted the total number of trips going to and from both buildings. The two buildings are located a half-mile from the Conshohocken Station, and 0.8 mile from the Spring Mill Station.

The Courts at Spring Mill Station (#6)

The Courts at Spring Mill Station is located in Conshohocken, 12 miles north of downtown Philadelphia. The building is located immediately adjacent to the Spring Mill rail station on the Manayunk/Norristown rail line.

Silk Factory Lofts (#7)

This building was constructed in 1922 as the Interstate Hosiery Mill. It was renovated in 2008 and converted to loft-style apartments.[3] It is located 0.6 mile from the Lansdale rail station and 0.7 mile from the Pennbrook rail station.

The Station at Bucks County (#8)

The Station at Bucks is County located 18 miles north of the City of Philadelphia in Warminster, and right next to the Warminster regional rail station.

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[3] Crissa Shoemaker DeBree, "Lansdale's Silk Factory Lofts Sold to Real Estate Company," *The Intelligencer*, December 6, 2012, https://www.theintell.com/790af91f-4542-5a71-8b99-012e63035143.html.

Jacksonville Station (#9)

This is a new apartment complex in Warminster, located near the intersection of Street Road (PA 132) and Jacksonville Road, and a short walk (a half-mile) to the Warminster train station.

The Station at Manayunk (#10)

The Station at Manayunk is located eight miles north of downtown Philadelphia, right along the Manayunk/Norristown rail line. Residents of the apartment building have a short walk (300 feet) across their parking lot to the Ivy Ridge Station.

Southstar Lofts (#11)

Southstar Lofts is one of the urban TOD sites. It is located in downtown Philadelphia approximately a half-mile south of Center City and directly above the Lombard South subway station. Southstar Lofts is a seven-story apartment building that was built in 2014. It is a mixed-use site, with two restaurants and an ice cream shop on the first floor.

777 South Broad (#12)

777 South Broad is another urban TOD site. It is located in downtown Philadelphia, 0.7 mile south of Center City and 0.2 mile from the Lombard South subway station. It is a five-story apartment building that was built in 2010.

Haddon Towne Center (#13)

Haddon Towne Center is located in the center of Haddon Township, New Jersey, on Haddon Avenue and a short walk (0.3 mile) to the Westmont Port Authority Transit Corporation (PATCO) rail station.

Roebling Lofts (#14)

Roebling Lofts is the third urban TOD site. It is located in Trenton, New Jersey, approximately 1.1 miles south of the downtown, 0.1 mile east of the Hamilton Avenue Light Rail station, and a half-mile south of the Trenton Transit Center. It is a four-story apartment building that was originally constructed in 1917 and used to manufacture wire rope.[4] The building was renovated and converted to residential apartments in 2018.

[4] Roebling Lofts, https://roeblinglofts.com/history/.

Table 1: Study Site Data

Study Site	Category	Number of Units	Occupied Units[1]	Year Built	Distance to Rail (miles)	Number of Parking Spaces
Southstar Lofts	Urban TOD	85	78	2014	0.0	85
777 South Broad	Urban TOD	146	137	2010	0.2	170
Roebling Lofts	Urban TOD	138	110	2017	0.1	158
The Courts at Spring Mill Station	Suburban TOD	385	370	2014	0.0	690
The Station at Manayunk	Suburban TOD	149	142	2014	0.0	129[2]
Silk Factory Lofts	Suburban TOD	116	107	2008	0.6	189
Jacksonville Station	Suburban TOD	151	141	2017	0.3	333[2]
Haddon Towne Center	Suburban TOD	252	239	2017	0.2	441
The Station at Bucks County	Suburban TOD	256	251	2012	0.0	434[2]
Millennium [Riverwalk and Londonbury]	Suburban TOD	375 + 309 = 684	651	Riverwalk in 2005, Londonbury in 2010	0.5	561 + 392 = 953
Riverworks	Suburban No Rail	349	335	2017	NA	515
The Pointe at West Chester	Suburban No Rail	230	214	2012	NA	350
Madison Ellis Preserve	Suburban No Rail	252	202	2018	NA	500

Source: Delaware Valley Regional Planning Commission (DVRPC), 2019

NOTES:

1. Occupied units at the time the data was collected, which in most cases was during calendar year 2018 or early 2019.
2. These sites had additional covered parking (garages) that we could not gain access to.

Table 2: Data for Surrounding Census Tracts

Study Site	JTW Transit	JTW Walk	Vehicles per HH[1]	Median HH Income	Census Tract
Southstar Lofts	24.7%	37.2%	0.58	$72,869	11.01, Philadelphia County
777 South Broad	13.5%	28.3%	0.89	$87,222	18, Philadelphia County
Roebling Lofts	12.2%	6.8%	0.99	$30,033	8, Mercer County
The Courts at Spring Mill Station	5.3%	2.6%	1.75	$98,654	2031.06, Montgomery County
The Station at Manayunk	25.3%	1.8%	1.54	$71,280	216, Philadelphia County
Silk Factory Lofts	4.2%	3.5%	1.61	$60,476	2009.03, Montgomery County
Jacksonville Station	0.5%	2.8%	1.45	$35,863	1016.05, Bucks County
Haddon Towne Center	11.9%	1.9%	1.90	$105,096	6038, Camden County
The Station at Bucks County	0.5%	2.8%	1.45	$35,863	1016.05, Bucks County
Millennium	7.3%	3.9%	1.58	$81,601	2041.02, Montgomery County
Riverworks	2.8%	2.0%	1.71	$89,360	3006, Chester County
The Pointe at West Chester	2.4%	1.4%	1.93	$76,250	3027.06, Chester County
Madison Ellis Preserve	2.0%	0.2%	2.13	$153,393	4099.04, Delaware County

Source: U.S. Census Bureau, *American FactFinder*, https://factfinder.census.gov/, 2018

NOTES:

1. HH = Household.

Vehicle Trip and Parking Generation

As mentioned previously, the major purpose of this study is to estimate the vehicle trip reduction benefit of TOD development. By locating a mid-level apartment complex within walking distance of a rail station, how many fewer vehicle trips will that development generate over the course of an entire weekday or during the AM peak hour?

To estimate this, there are a couple of comparisons we can make. First, we can compare trip generation among the local sites here in the Delaware Valley region. Data was collected at 10 suburban multi-family developments. Seven of these are located within a short walk of rail, and the other three have no rail access. We can compare the daily and AM peak hour trip generation at these sites to get some sense as to how much of a difference proximity to rail makes, in terms of the number of vehicle trips that are generated.

Second, we can also compare our local data to ITE's national trip generation data. ITE collected trip generation data at multi-family developments located in suburban, low-density, auto-oriented settings. Comparing our multi-family development that is located next to a suburban rail station to ITE's multi-family development in an auto-oriented suburb will give us another indication of how much of a vehicle trip reduction benefit is due to proximity to rail.

Methodology

This section describes how the local and ITE data was collected.

Local Data

The study sites are recently constructed mid-level apartment buildings in the Philadelphia region. We counted the number of vehicles entering and exiting each of these sites over an entire weekday. The data was collected in 2018 and 2019. The three methods used by DVRPC to collect data are pneumatic tube, video camera, and direct field observation by staff.

Pneumatic tubes as shown in Figure 2 were used at several sites. These are the same tubes that are laid across roadways to count cars. In this case, they were laid across the driveway entrances to the apartment buildings. The advantages with tubes are that the equipment can be easily installed and left in place for an entire day, and it automatically produces a ready-to-use database file: a count of every vehicle that drove over the tube, in 15-minute intervals. However, there are also a couple of disadvantages to using tubes. They usually need to be placed several feet back from where the property's driveway meets the main road (public right-of-way). This means asking permission from the property owner to set the tube up on the property—which owners are not always willing to allow. Also, tubes do not provide any visual record of what happened. This is important if you notice something does not look right with the data, and you have questions about what the drivers of the vehicles were actually doing.

Figure 2: Pneumatic tubes

Source: Delaware Valley Regional Planning Commission, 2019

Video cameras are an alternative way to collect traffic data. They are usually attached to a telephone pole or streetlight high enough from the ground so that the camera is beyond the reach of humans and is safe from being stolen or tampered with. The advantage of video cameras is that you get to actually see what is going on within the area where the camera is focused (Figure 3), and therefore they give some insight into the behavior of the drivers. Unfortunately, they do not produce the easy to use database that pneumatic tubes do, and that we need for analysis. An engineer or planner needs to download the video and watch it back at the office and manually record vehicles entering and exiting the site into a database. Watching the videos can be time consuming.

Figure 3: Image from video camera

Source: Delaware Valley Regional Planning Commission, 2019

In a few circumstances, we also send people out to the field to observe and manually record vehicles entering and exiting a study site. This is probably the most expensive approach in terms of staff time. The downside to this method is that people can only sit or stand at a study site for a limited amount of time; usually four hours is the maximum. But no other method gives us as complete a picture or understanding of what is really happening. Usually we only resort to this method when we are struggling to explain something that does not look right with the data. For example, we first used a pneumatic tube to collect data at one of our TOD study sites. After getting the data back, we noticed that this site seemed to be generating an excessive amount of vehicle trips during the AM peak hour. The apartment building is set back from the main road by about 400 feet and is somewhat secluded. The site is also located right next to a rail stop, and the people who live in the apartment building have a short walk across their small parking lot to the rail stop. Unbeknownst to us (until we actually went out to the site to observe) the rail stop is also used by the neighboring residential area as a kiss-and-ride. Hence, the driveway leading to/from the apartment complex had many more trips than would be expected for an apartment building of this size. In addition to the vehicle trips that were being generated by the apartment complex, there were also a lot of kiss-and-ride vehicle trips from the neighboring community.

All of the parking data was collected by site visit. Most of the study sites featured a mixture of surface parking and covered garages. It was relatively easy to count the number of parked cars at the surface lots. But entry to most of the garages was restricted by barrier gates (a mechanical arm that can be raised and lowered). Additionally, in some cases the garages also had parking lot attendants or video surveillance cameras. We tried to get prior approval from property managers to access the restricted garages, and in a few instances we were able to get permission. But there were several sites where we were unable to get permission; therefore, our parking data is somewhat limited.

For the sites that we were able to gain access to, we counted the total number of parking spaces and the number of spaces that were occupied. In most cases, the parking data was gathered early in the morning (between 5:00 and 6:00 AM) on a weekday, before most people had left for work.

ITE Data

ITE collects trip and parking generation data from a wide variety of land uses all across the country: everything from office buildings to retail stores to various types of residential buildings. Their sites tend to be located in more suburban and auto-oriented areas: e.g., not close to rail stations. They publish their data in two manuals,[5,6] which are widely used by transportation engineers and planners to estimate the parking needs and vehicle traffic generated by various types of development.

For the purposes of this study, we wanted to do an "apples to apples" comparison: comparing our data collected at mid-rise apartments throughout the Philadelphia region to ITE data collected at similar types of apartment complexes. ITE does have something very similar: a mid-rise apartment category (Land Use 221). They define *mid-rise apartments* as rental buildings that have between three and 10 levels or floors, which matches the local apartment buildings at which we collected data.

For residential land uses such as mid-level apartment buildings, ITE selects a sample of several apartment buildings from across the country. ITE's sample includes buildings in California; Delaware; Florida; Georgia; Illinois; Maryland; Massachusetts; Minnesota; New Hampshire; New Jersey; Oregon; Pennsylvania; South Carolina; South Dakota; Tennessee; Utah; Virginia; Washington, DC; and Wisconsin. ITE's trip generation data for mid-rise apartments is shown in Appendix C, and their parking generation data for mid-rise apartments is shown in Appendix D.

ITE provides two trip generation numbers for most of their land uses. They provide a weighted average trip generation rate (referred to as the "average trip rate") and a fitted curve linear regression equation. It should also be noted that sometimes ITE provides their trip generation rates per the total number of units in the apartment building, and/or the number of occupied units.[7] An engineer or planner using their data may get slightly different results depending on which method or independent variable is used.

ITE's average trip rate is calculated by counting the number of vehicle trips generated by every site in their sample over the course of an entire weekday. They then calculate the daily trip generation rate for each site by dividing the number of trips by the number of dwelling units (and/or the number of

[5] ITE, *Trip Generation Manual*, Volume 2: Land Use Data Plots, 10th ed. (Washington, DC: ITE, 2017).
[6] ITE, *Parking Generation Manual*, 4th ed. (Washington, DC: ITE, 2018).
[7] In most cases, the occupancy rate of the apartment buildings is above 90 percent, and there is not too much of a difference between an average trip rate calculated using occupied units versus an average trip rate calculated using total units. However, if the occupancy rate is low, then an average trip rate that is calculated using the number of occupied units as the independent variable could lead to different (higher) results.

occupied units). Then they calculate a weighted average trip rate for all of the apartment buildings in their sample based on the size (number of units) of each apartment building: e.g., a larger apartment building carries more weight than a smaller apartment building. Weighted average trip rates are produced for different days of the week (weekday, weekend), time periods (daily, AM peak hour, PM peak hour), and per different independent variable (total dwelling units, occupied dwelling units).

If ITE has four or more data points (study sites) in their sample, they also estimate a linear regression equation. In the case of mid-level apartments, the independent variable is usually either the total number of units or the number of occupied units, and the dependent variable is the number of vehicle trips generated by the site. The coefficient of determination (R^2) is also calculated and is an indication of how well the curve fits the data.

Up until the 10th edition of their trip generation manual, most of ITE's sites were located in relatively low-density, auto-oriented suburban sites. For the first time, the 10th edition also includes data for more urban settings. ITE defines their suburban and urban settings as follows:

- General Urban/Suburban: An area associated with almost homogeneous vehicle-centered access. Nearly all person trips that enter or exit a development site are by personal passenger or commercial vehicle. The area can be fully developed (or nearly so) at low to medium density with a mix of residential and commercial uses. The commercial land uses are typically concentrated at intersections or spread along commercial corridors, often surrounded by low-density, almost entirely residential development. Most commercial buildings are located behind the parking area or surrounded by parking. The mixing of land uses is only in terms of their proximity, not in terms of function. A retail land use may focus on serving a regional clientele, whereas a service land use may target motorists or pass-by vehicle trips for its customers. Even if the land uses are complementary, a lack of pedestrian, bicycling, and transit facilities or services limit non-auto travel.
- Dense Multi-Use Urban: A fully developed area (or nearly so) with diverse and interacting complementary land uses, good pedestrian connectivity, and convenient and frequent transit service. This area type can be a well-developed urban area outside a major metropolitan downtown or a moderate-sized urban area downtown. The land use mix typically includes office; retail; residential; and often entertainment, hotel, and other commercial uses. The residential uses are typically multi family or single family on lots no larger than one-quarter of an acre. The commercial uses often have little or no setback from the sidewalk. Because the motor vehicle still represents the primary mode of travel to and from the area, there typically is on-street parking and often off-street public parking. The complementary land uses provide the opportunity for short trips within the Dense Multi-Use Urban area, made convenient by walking, biking, or transit. The area is served by significant transit (either rail or bus) that enables a high level of transit usage to and from area development.

There are several limitations to using ITE's trip generation data. First, ITE has very small samples for some of their land use settings. For example, there is only one data point; i.e., they only surveyed one site, for their estimate of daily weekday trip generation per dwelling unit for mid-level apartments in an urban setting. Per ITE's own guidance, in this situation they recommend either trying another one of their closely related land uses that may have more data points or collecting your own local data.

Another limitation on the use of ITE's data has to do with the size of the study sites that they included in their sample. For example, they surveyed three sites for their estimate of daily weekday trip generation per occupied dwelling unit for mid-level apartments in an urban setting. The size of these three sites ranged between 35 and 50 occupied units. Our comparable local Philadelphia mid-level apartments in an urban setting ranged between 78 and 137 occupied units: about twice as many units as ITE's sites. Trip-making behavior may be slightly different at a bigger apartment building. We do not really know, based on ITE's limited sample size. To be safe, ITE advises not to use their data when the value of the independent variable (in this case, the number of occupied units in an apartment complex) for the local site falls outside of the range in ITE's sample. ITE established these guidelines or precautions regarding how their data should and should not be used to guard against the misapplication of their data and to ensure that any analysis conducted using their data is statistically valid. We tried to adhere as closely as possible to ITE's guidelines for the analysis conducted for this study.

Results and Analysis

This section presents the locally derived vehicle trip and parking generation rates and compares them to ITE's rates.

Trip Generation

AM peak hour trip generation data is shown in Table 3, and daily trip generation data is shown in Table 4. The local study sites were categorized as urban or suburban based on ITE's definitions. If ITE's Dense Multi-Use Urban description more accurately applies to the neighborhood where the site is located, then the study site was classified as urban. If ITE's General Urban/Suburban description was a better fit, then the study site was classified as suburban. The data for each local study site includes the total number of units, the number of occupied units, and the total number of daily vehicle trips counted at the site. Two trip rates were calculated using local data: the average number of vehicle trips generated per the total number of units and the average number of vehicle trips generated per the number of occupied units. This gave us the ability to compare our locally observed data to ITE's data, no matter which independent variable was used by ITE. The average (mean) trip rate and standard deviation is also calculated for each category.

For comparison purposes, Tables 3 and 4 also include vehicle trip generation at each local site using ITE trip rates. These are the rates an engineer or planner would use to estimate vehicle trip generation at each site if they did not have local data and were following ITE's guidelines regarding the use of their data: e.g., when to use their regression equation versus their average trip rate, or when to use the total number of units in the apartment complex as the independent variable versus the number of occupied units.

Looking at the locally observed AM peak hour data shown in Figure 4, the seven suburban TOD sites have an average rate of 0.32 vehicle trips per occupied unit, whereas the three suburban sites that are not located near rail have an average trip generation rate of 0.43. This tends to support the idea that there is a vehicle trip reduction benefit to TOD, especially during the morning rush hour when people are going to work.

Comparing the locally observed suburban TOD data to ITE data yields almost identical results. As mentioned previously, ITE's suburban sites are relatively low density, auto oriented, without access to rail. ITE's AM peak hour trip rate for suburban sites that are not located near rail is 0.42 trips per occupied unit, just a little bit lower than what was observed for comparable local sites (0.43).

Table 3: AM Peak Hour Trip Generation

					Observed Trip Gen Rate		ITE Trip Gen Rate[1]			
Study Site	Category/Setting	Total Units	Occupied Units	AM Peak Hour Vehicle Trips	Per Total Units	Per Occupied Units	ITE Setting[2]	Fitted Curve	Average Rate	Observed rate as % of ITE rate
Southstar Lofts	Urban TOD	85	78	8	0.09	0.10	1	0.38[3]		26.32%
777 South Broad	Urban TOD	146	137	26	0.18	0.19	1	0.33		57.58%
Roebling Lofts	Urban TOD	138	110	24	0.17	0.22	1	0.35		62.86%
Mean					0.15	0.17		0.35		48.11%
Std. Dev.					0.05	0.06				
The Courts at Spring Mill Station	Suburban TOD	385	370	136	0.35	0.37	2		0.42[4]	88.10%
The Station at Manayunk	Suburban TOD	149	142	44	0.30	0.31	2		0.42	73.81%
Silk Factory Lofts	Suburban TOD	116	107	28	0.24	0.26	2		0.42	61.90%
Jacksonville Station	Suburban TOD	151	141	39	0.26	0.28	2		0.42	66.67%
Haddon Towne Center	Suburban TOD	252	239	83	0.33	0.35	2		0.42	83.33%
The Station at Bucks County	Suburban TOD	256	251	84	0.33	0.33	2		0.42	78.57%
Millennium	Suburban TOD	684	651	222	0.32	0.34	2		0.42	80.95%
Mean					0.30	0.32			0.42	76.19%
Std. Dev.					0.04	0.04				
Riverworks	Suburban No Rail	349	335	151	0.43	0.45	2		0.42	107.14%
The Pointe at West Chester	Suburban No Rail	230	214	78	0.34	0.36	2		0.42	85.71%
Madison Ellis Preserve	Suburban No Rail	252	202	94	0.37	0.47	2		0.42	111.90%
Mean					0.38	0.43			0.42	101.59%
Std. Dev.					0.05	0.05				

Source: DVRPC, 2019

NOTES:

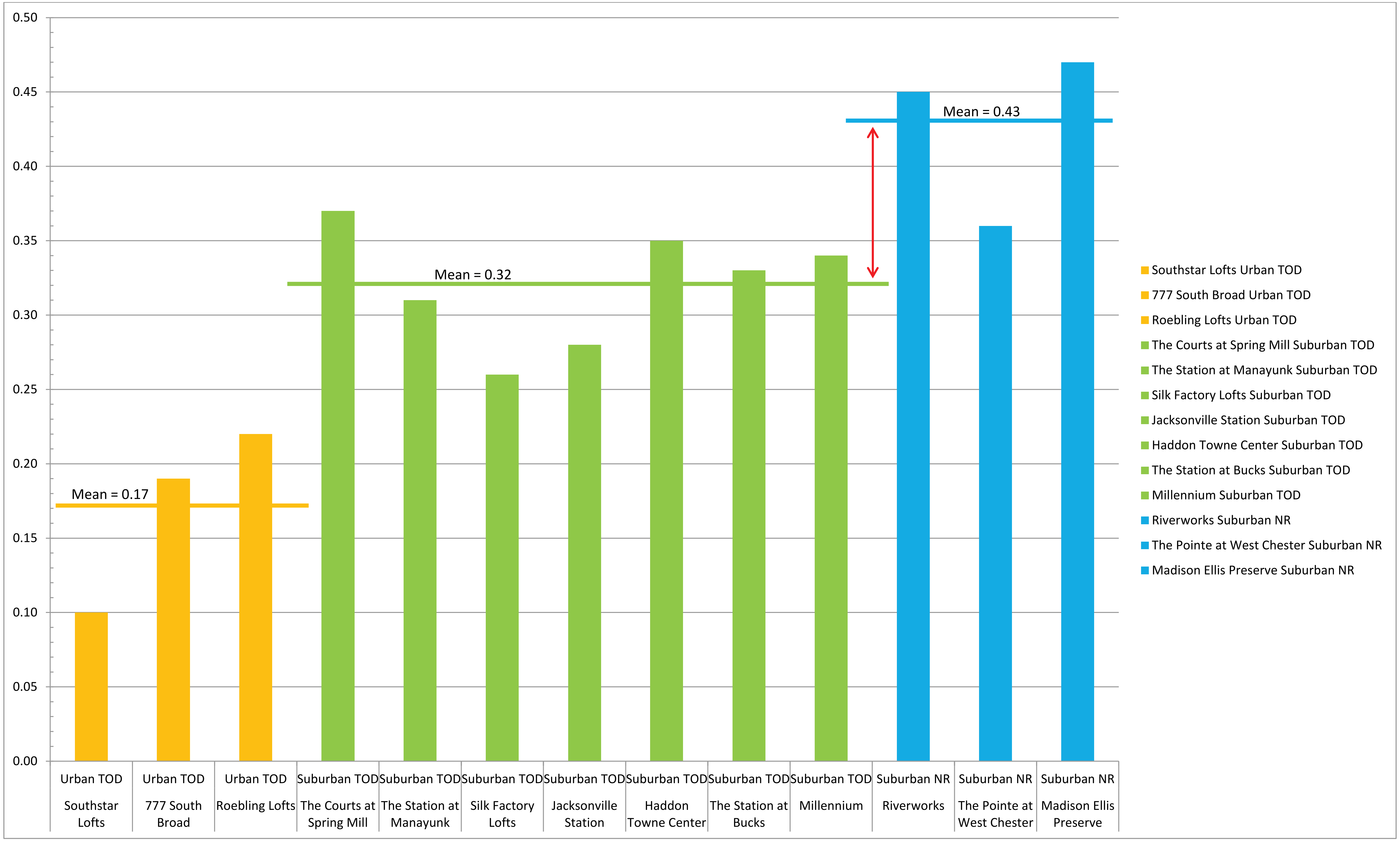
1. Decision as to whether to use ITE's average rate or fitted curve, or whether to use per total number of rental units in the apartment complex versus per occupied units, was based on ITE guidance (ITE, *Trip Generation Handbook*, 3rd ed. [Washington, DC: ITE, September 2017], 27–30).

2. ITE Setting 1 = Dense Multi-Use Urban, ITE Setting 2 = General Urban/Suburban.

3. Used fitted curve for ITE's Dense Multi-Use Urban category, AM Peak Hour of Generator, vehicle trips per *occupied* dwelling units.

4. ITE's General Urban/Suburban, AM Peak Hour of Generator, vehicle trip ends per *occupied* dwelling units was used instead of General Urban/Suburban, AM Peak Hour of Generator, vehicle trips per *total* dwelling units based on lower standard deviation for average trip rate and higher R^2 statistic for fitted curve. ITE's data set consists of six study sites. There is virtually no difference between using the average trip rate or the fitted curve.

Figure 4: Observed Data, Vehicle Trips per AM Peak Hour



NOTES:

1. AM Peak Hour average trip rate = vehicle trips generated /number of occupied units

Looking at the locally observed daily trip generation data shown in Figure 5, there does not appear to be much difference between the suburban TOD sites and the suburban sites that are not located near rail (3.81 versus 4.06). However, a *t*-test of two independent means at the 0.05 significance level[8] indicates that the difference is statistically significant. It also makes sense that the daily vehicle trip reduction benefit would be smaller than during the AM peak hour when most people are traveling to work (or school). For a suburban household, even one within walking distance of a rail station, there are many more trips made over the course of an entire day, such as trips to the grocery store or trips ferrying children to soccer practice that are still going to be made by car.

Another striking observation from looking at the local data is the sharp drop in the number of vehicle trips between the suburban TOD and urban TOD sites, both for the AM peak hour (0.17 urban TOD versus 0.32 suburban TOD) and daily (1.25 urban TOD versus 3.81 suburban TOD). In many respects, travel behavior is fundamentally different in the city. With higher density, many destinations are within walking distance, and the cost of owning a car is much higher in the city. All of this is borne out by the data for the surrounding census tracts shown in Table 2. The urban sites tend to have much lower levels of auto ownership and much higher transit and walk JTW shares.

For any engineer or planner engaged in the traffic analysis of a TOD site in the Philadelphia region, the recommendation would be to use the locally observed rates rather than ITE's rates. The last column (furthest right) in both Tables 3 and 4 shows the local rates as a percentage of ITE's rates. In all but a few cases, using ITE's rates would result in an overestimation of vehicle trip generation.

[8] Where Ho: $\mu 1 = \mu 2$, Ha: $\mu 1 < \mu 2$. Sample 1 (Suburban TOD) Size = 6, Mean = 3.81, Standard Deviation = 0.31. Sample 2 (Suburban No Rail) Size = 3, Mean = 4.06, Standard Deviation = 0.17.

Table 4: Daily Trip Generation

						Observed Trip Gen Rate			ITE Trip Gen Rate[1]				
Study Site	Category/Setting	Total Units	Occupied Units	Daily Vehicle Trips		Per Total Units	Per Occupied Units		ITE Setting[2]	Fitted Curve	Average Rate		Observed rate as % of ITE rate
Southstar Lofts	Urban TOD	85	78	54		0.64	0.69		1		3.83[3]		18.02%
777 South Broad	Urban TOD	146	137	200		1.37	1.46		1		3.83		38.12%
Roebling Lofts	Urban TOD	138	110	240		1.74	2.18		1		3.83		56.92%
Mean						1.25	1.44				3.83		37.60%
Std. Dev.						0.56	0.74				------		
The Courts at Spring Mill Station	Suburban TOD	385	370	1,292		3.36	3.49		2	5.45[4]			61.65%
The Station at Manayunk	Suburban TOD	149	142	555		3.72	3.91		2	5.44			68.38%
Silk Factory Lofts	Suburban TOD	116	107	427		3.68	3.99		2	5.43			67.77%
Jacksonville Station	Suburban TOD	151	141	573		3.79	4.06		2	5.44			69.67%
Haddon Towne Center	Suburban TOD	252	239	1,010		4.01	4.23		2	5.44			73.71%
The Station at Bucks County	Suburban TOD	256	251	1,093		4.27	4.35		2	5.44			78.49%
Millennium	Suburban TOD	684	651	NA[5]		-------				-------			
Mean						3.81	4.01			5.44			70.04%
Std. Dev.						0.31	0.30						
Riverworks	Suburban No Rail	349	335	1,348		3.86	4.02		2	5.44			70.96%
The Pointe at West Chester	Suburban No Rail	230	214	959		4.17	4.48		2	5.44			76.65%
Madison Ellis Preserve	Suburban No Rail	252	202	1,045		4.15	5.17		2	5.44			76.29%
Mean						4.06	4.56			5.44			74.63%
Std. Dev.						0.17	0.58						

Source: DVRPC, 2019

NOTES:

1. Decision as to whether to use ITE's average rate or fitted curve, or whether to use per total number of rental units in the apartment complex versus per occupied units, was based on ITE guidance (ITE, *Trip Generation Handbook*, 3rd ed. [Washington, DC: ITE, September 2017], 27–30).

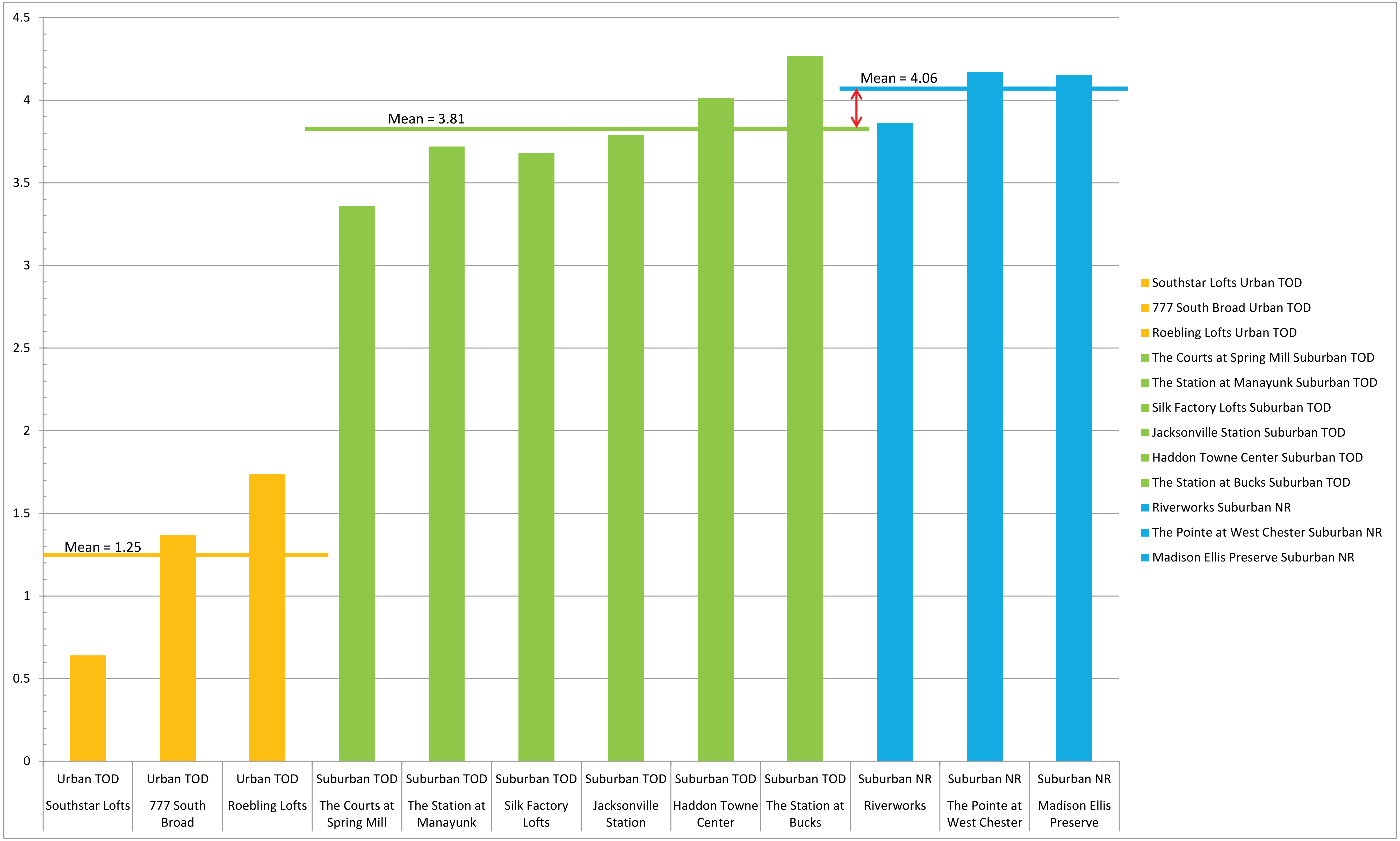
2. ITE Setting 1 = Dense Multi-Use Urban, ITE Setting 2 = General Urban/Suburban.

3. For Multi-Family Housing (Mid-Rise) (221), for vehicle trip ends versus *occupied* dwelling units, for a weekday, for Dense Multi-Use Urban setting. Per ITE's guidance, some caution should be used in using their rate if the sample size is less than 6 (in this case, ITE sample size = 3). Also, the size of the local Philadelphia study sites in terms of the unit of measurement of the independent variable is outside of the range of the data shown in the ITE data plot (in this case, the largest ITE site only has 50 occupied dwelling units).

4. For Multi-Family Housing (Mid-Rise) (221), for vehicle trip ends versus *total* dwelling units, for a weekday, for General Urban/Suburban setting. ITE sample size is 27. ITE's guidance is to use the fitted curve in this instance.

5. Only AM peak hour vehicle trips are available for the Millennium site.

Figure 5: Observed Data, Vehicle Trips per Day (vpd)



NOTES:

1. Daily average trip rate = vehicle trips generated/total number of units.

Parking Generation

One of the major challenges with collecting the parking data was the lack of accessibility to the garages. A good example is the Station at Manayunk. Most of the parking at this apartment complex is surface spaces. But, for an additional $125 per month,[9] some of the units have their own covered parking space (as shown in Figure 6).

Figure 6: Parking Garages at The Station at Manayunk

Source: Delaware Valley Regional Planning Commission, 2019

At the time of the site visit, a few of the garage doors were open, and we could see inside. Some had cars inside. But there were several that were being used as extra rooms, with furniture, workbenches, exercise equipment—anything but a car. And because of the way the parking lot was configured, those units that had paid for a covered space could also park a car in front of their garage. Do the people who paid for a garage actually have two spaces? It was not clear what this apartment complex's true parking capacity or utilization was. Rather than guess, our approach was to count the spaces we could see: i.e., the surface spaces. It is a little inexact, but it is the best we can do given the circumstances.

[9] Station at Manayunk, https://www.stationatmanayunk.com/.

The parking data is shown in Table 5. For each apartment complex, the table shows the number of units, the number of parking spaces, the number of spaces that were occupied in the early morning before most people left for work, and the number of spaces that were empty. We also calculated the number of spaces per unit and the utilization rate (the number of occupied spaces divided by the total number of spaces). As best as we can tell, the "real" number of spaces per unit ranges from a low of 1.00 at the Southstar Lofts in downtown Philadelphia to a high of 2.21 at Jacksonville Station in suburban Warminster. ITE's data for a similar type of mid-rise apartment buildings has an average of 1.40 spaces per unit.

Figure 7 shows the observed empty spaces at the local study sites. The six sites with appreciable numbers of empty spaces (Riverworks, Riverwalk, Silk Factory Lofts, The Station at Bucks County, The Courts at Spring Mill, and Jacksonville Station) all have a spaces-per-unit ratio greater than ITE's 1.40, which tends to suggest that to avoid providing too much parking for a mid-level apartment complex in the Philadelphia region, a safe bet or recommended approach might be to not exceed 1.40 spaces per unit.

Table 5: Parking Utilization

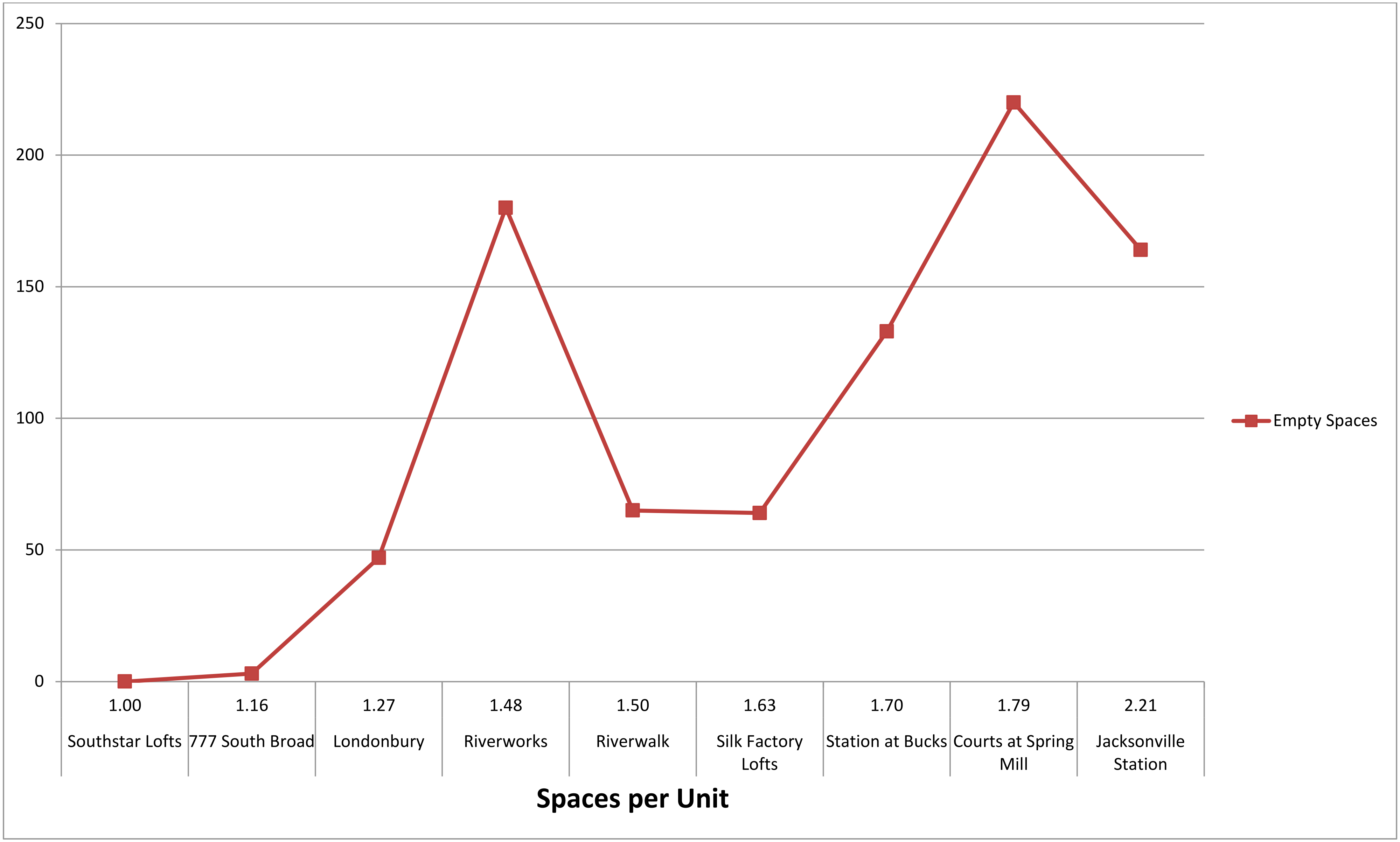
			Observed						ITE			
Study Site	**Category**	**Units**	**Spaces**	**Spaces/Unit**	**Occupied**	**Empty**	**Utilization**		**Spaces / Unit**[4]	**Spaces**		**Observed rate as % of ITE rate**
Southstar Lofts	Urban TOD	85	85	1.00	85	0	100%		1.40	119		71.43%
777 South Broad	Urban TOD	146	170	1.16	167	3	98%		1.40	204		83.17%
The Courts at Spring Mill Station	Suburban TOD	385	690	1.79	470	220	68%		1.40	539		128.01%
The Station at Manayunk	Suburban TOD	149	129[3]	0.87	119	10	92%		1.40	209		61.84%
Silk Factory Lofts	Suburban TOD	116	189	1.63	125	64	66%		1.40	162		116.38%
Jacksonville Station	Suburban TOD	151	333[3]	2.21	169	164	51%		1.40	211		157.52%
The Station at Bucks County	Suburban TOD	256	434[3]	1.70	301	133	69%		1.40	358		121.09%
Londonbury	Suburban TOD	309	392	1.27	345	47	88%		1.40	433		90.61%
Riverwalk	Suburban TOD	375	561	1.50	496	65	88%		1.40	525		106.86%
Millennium Total	Suburban TOD	684	953	1.39	841	112	88%		1.40	958		99.52%
Riverworks	Suburban No Rail	349	515	1.48	335	180	65%		1.40	489		105.40%

Source: DVRPC, 2019

NOTES:

1. Observed between 5:00 AM and 6:00 AM on a weekday.
2. Some sites would not give us permission to enter garages.
3. Only counting the surface spaces we could see.
4. ITE, "Land Use 221, Low/Mid-Rise Apartment," in *Parking Generation Manual*, 4th ed., vol. 2, *Data Residential (Land Uses 200–299)* (Washington, DC: ITE, 2018), 50–55.

Figure 7: Observed Number of Empty Parking Spaces



Caveats / Disclaimers

As with any data collection effort, in the interest of full disclosure there are a few things that the reader should be made aware of:

- In a few instances, data was collected before the sites were fully occupied, or while construction was still underway. In particular, this was the case at the Madison Ellis Preserve site in Newtown Square. The data was collected in January 2019. On the one hand, there were some construction-related vehicles still entering and exiting the site, and despite our best efforts to subtract these vehicle trips out, they may have increased the trip total a little bit. And on the flip side, because the apartment complex was so new, the number of occupied units was probably a little lower than normal. But the two errors may have cancelled each other out.

- Despite our best efforts to collect parking data, not every study site was willing to grant us access to enter their parking garage. A certain amount of parking was hidden from our view, and it is hard to know what the real parking occupancy rate is for several of the sites.

- For the urban TOD sites like Southstar Lofts, we suspect that some of the tenants may be using on-street parking or using other neighborhood parking lots within a short walk of the apartment building (and with cheaper monthly rates). This was another factor that was very hard for us to gauge. It may be that we slightly underestimated auto ownership, vehicle trip generation, and number of parked vehicles at these urban sites.

- In a few instances, there were study sites that we wanted to analyze, but they were too complicated for us to collect the needed data. An example of this is the Camelot at Cinnaminson apartment complex located right on the River LINE light rail transit in New Jersey. This site is a mixture of several different land uses. In addition to the apartment complex, there is also a section of the community that is townhouses (Cinnaminson Harbour). The whole combined community is accessed via two driveways, but we did not have the ability to count the different land uses separately; we had a combined total number of trips entering/exiting via the two driveways but no clean way to attribute trips to their respective land use.

- Most of the sites included in this study are new high-end “luxury” apartments. Although we do not have any data on the tenants, we suspect that they probably do not represent the average Philadelphia resident in terms of income, education level, and auto ownership. The residents in these buildings may be making fewer vehicles trips because they want to, whereas a lower-income household may be making fewer vehicle trips because they have to: e.g., they have no other choice but to take the bus, walk, or carpool (or not make the trip).

Recommendations / Next Steps

The primary recommendation would be to use these locally observed vehicle trip and parking generation rates instead of ITE's trip rates. Using ITE's rates could lead to overestimation of the number of vehicle trips generated at a suburban TOD site by hundreds of vehicle trips per day (vpd).

Another recommendation would be to collect more local data; 13 study sites is a relatively small sample size. Following ITE's guidelines,[10] a reasonable goal seems to be to aim for at least six sites per each of the different land use categories (Urban TOD, Suburban TOD, and Suburban No Rail)—and also, in the interest of completeness, to find and include urban sites that are not within a short walk of a rail station (Urban No Rail). This would enable us to see if the vehicle trip reduction benefit that was observed at the suburban sites also applies to urban sites.

Finally, DVRPC should update the region-wide household travel survey in the next decade, coinciding with the 2030 Census. The last household travel survey conducted in 2012 included few if any TOD residences. The next survey will be a great opportunity to collect detailed information on the trip-making behavior of TOD households. As this study demonstrates, proximity to a train station does not fully explain whether someone will, or will not, ride the train. There are many more factors that contribute to someone's travel behavior: for example, whether they are employed, and if they are, where their job is located. Other factors that play a big role in travel behavior include whether they own a car, and the number of people in the household. Also, household travel surveys can gather detailed information on every trip made by the household over the course of an entire day, such as the origin, destination, time of trip, and mode of travel. This type of information would be extremely valuable in our effort to develop a more complete understanding of the travel behavior of suburban households that are located close to rail stations.

[10] ITE, Chapter 4, in *Trip Generation Handbook*, 3rd ed (Washington, DC: ITE, September 2017), 23.

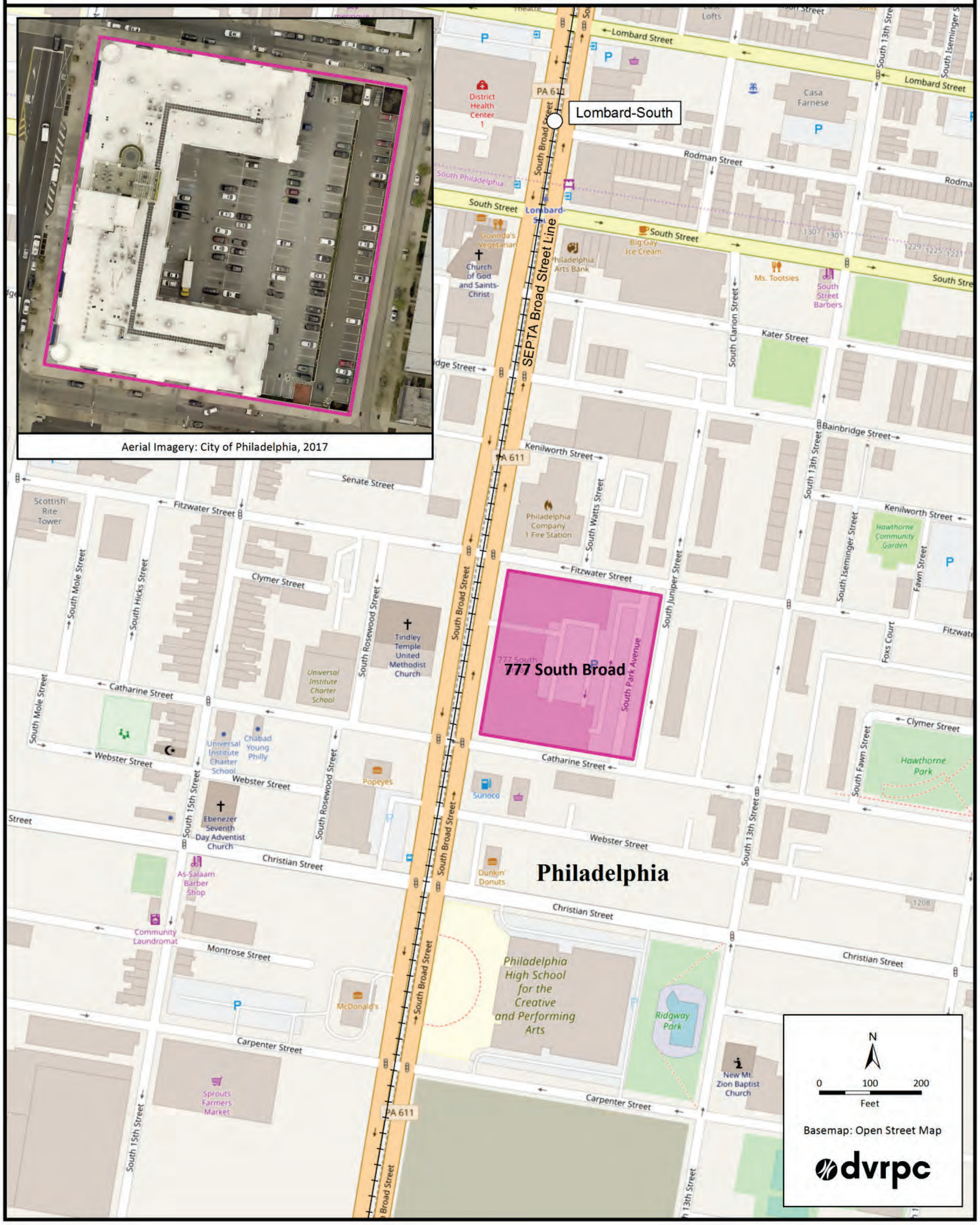
Appendix A: Study Site Location Maps

Southstar Lofts

Philadelphia, PA

777 South Broad

Philadelphia, PA

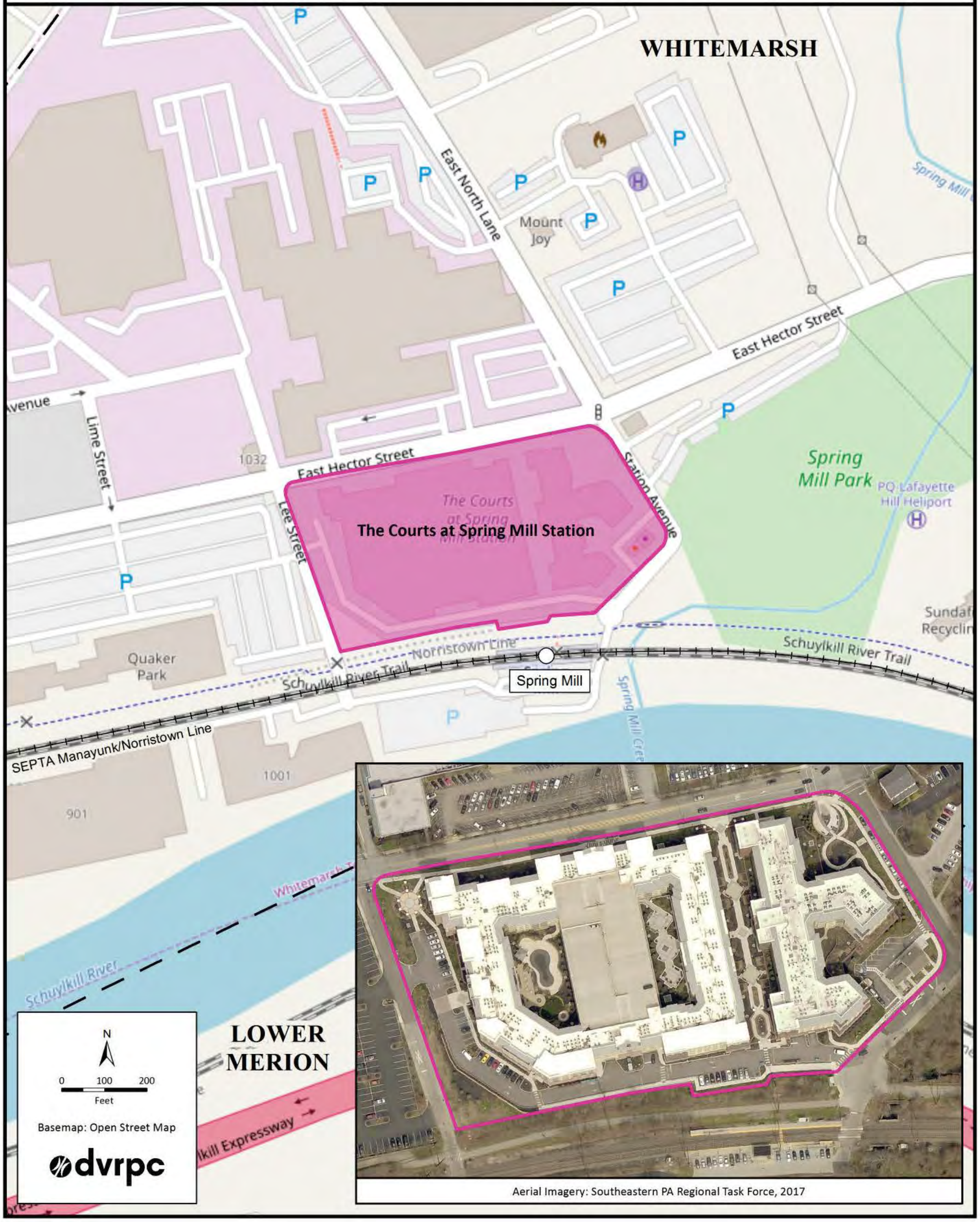


Roebling Lofts

Trenton, NJ

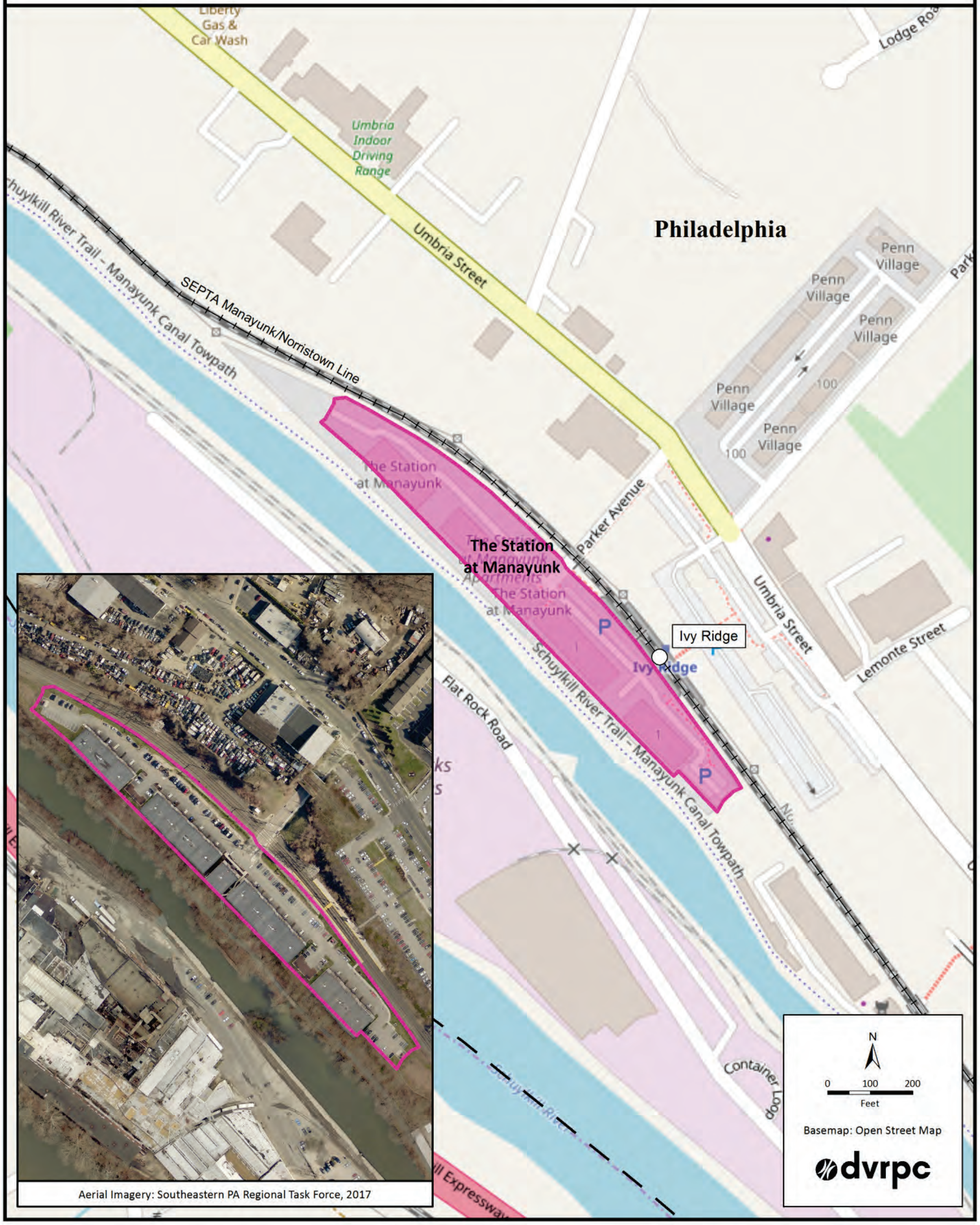
The Courts at Spring Mill Station

Whitemarsh Township, Montgomery County, PA



The Station at Manayunk

Philadelphia, PA



Silk Factory Lofts

Lansdale Borough, Montgomery County, PA

Jacksonville Station

Warminster Township, Bucks County, PA

Haddon Towne Center

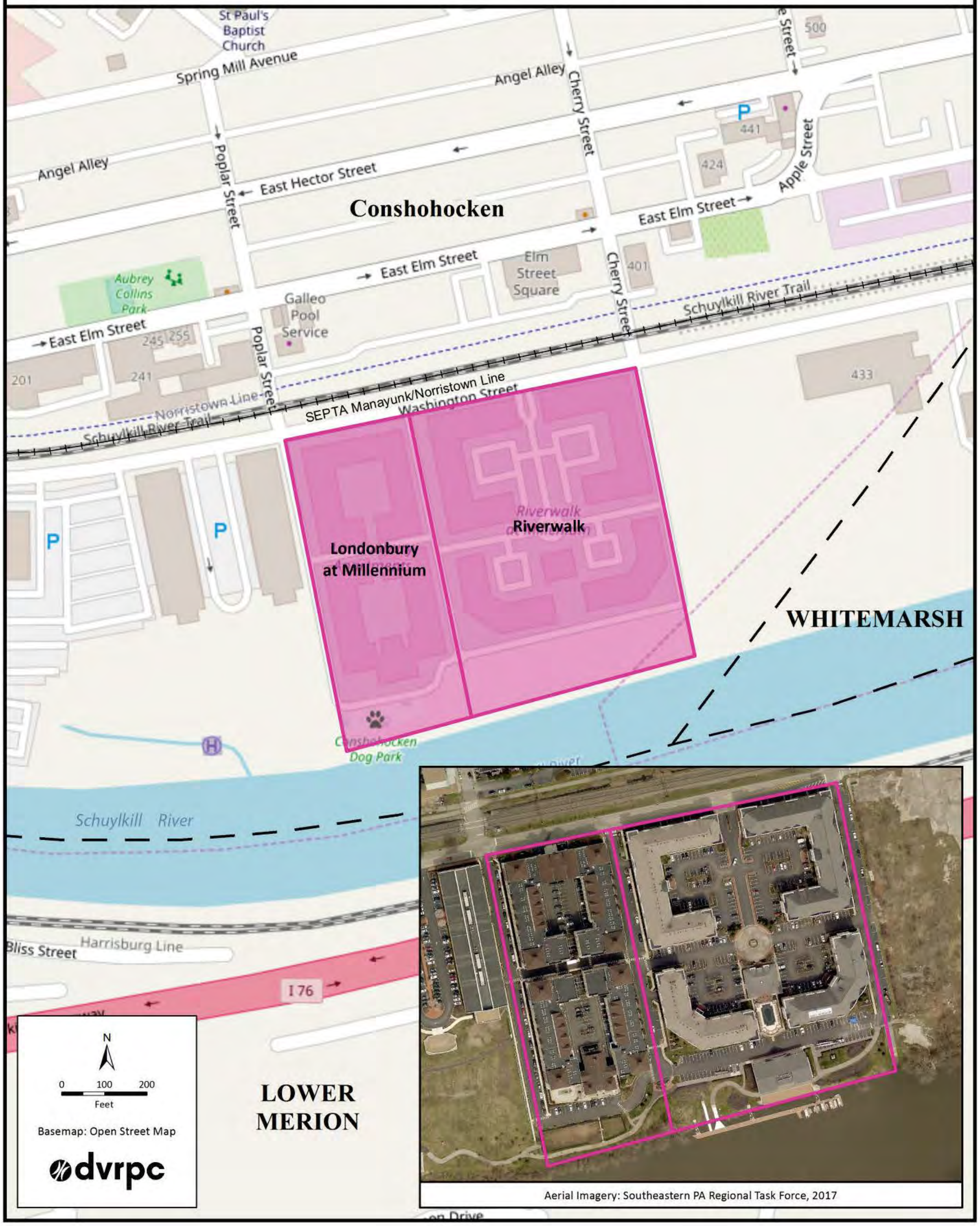
Haddon Township, Camden County, NJ

The Station at Bucks County

Warminster Township, Bucks County, PA

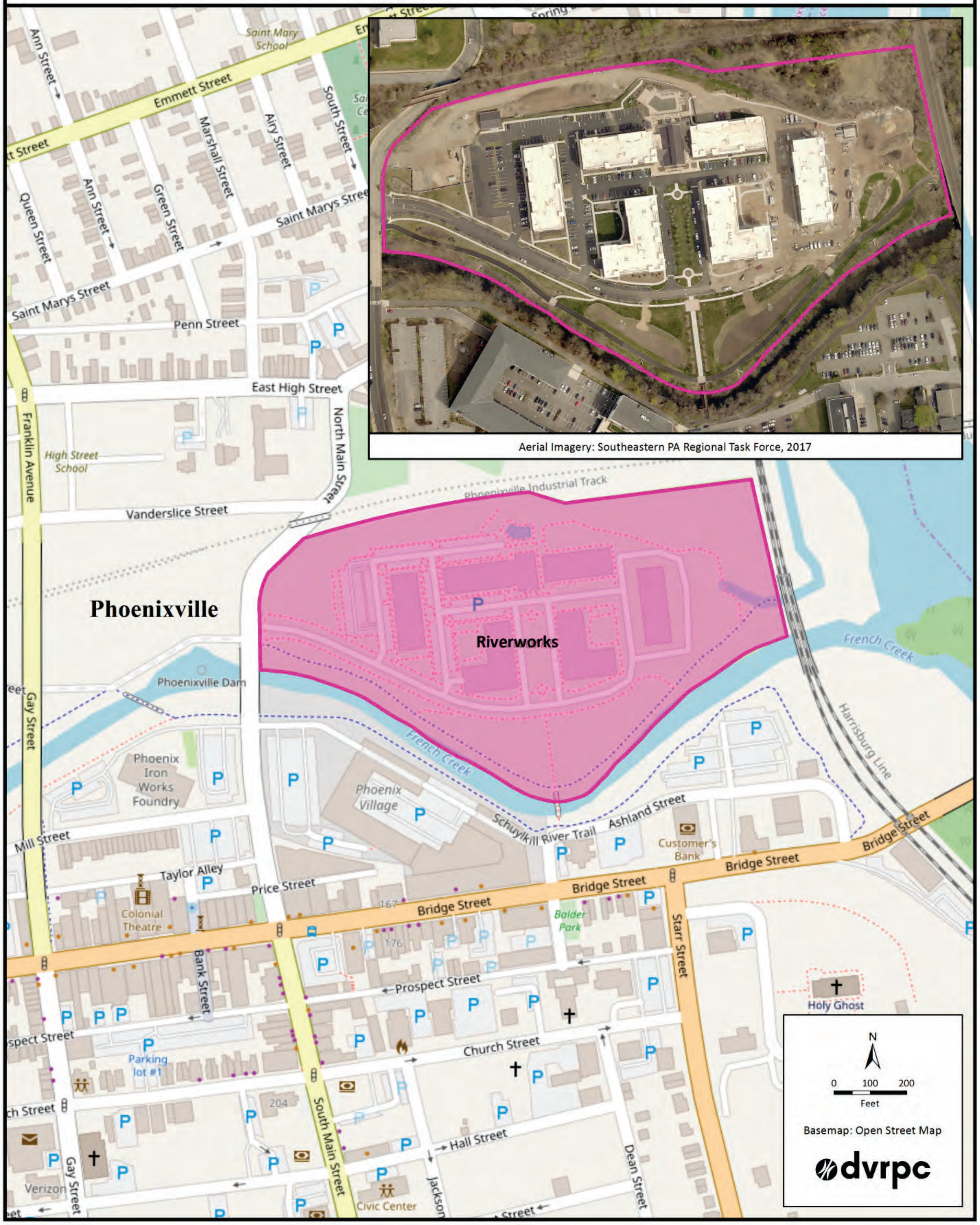
Londonbury at Millennium/Riverwalk

Conshohocken Borough, Montgomery County, PA



Riverworks

Phoenixville Borough, Chester County, PA

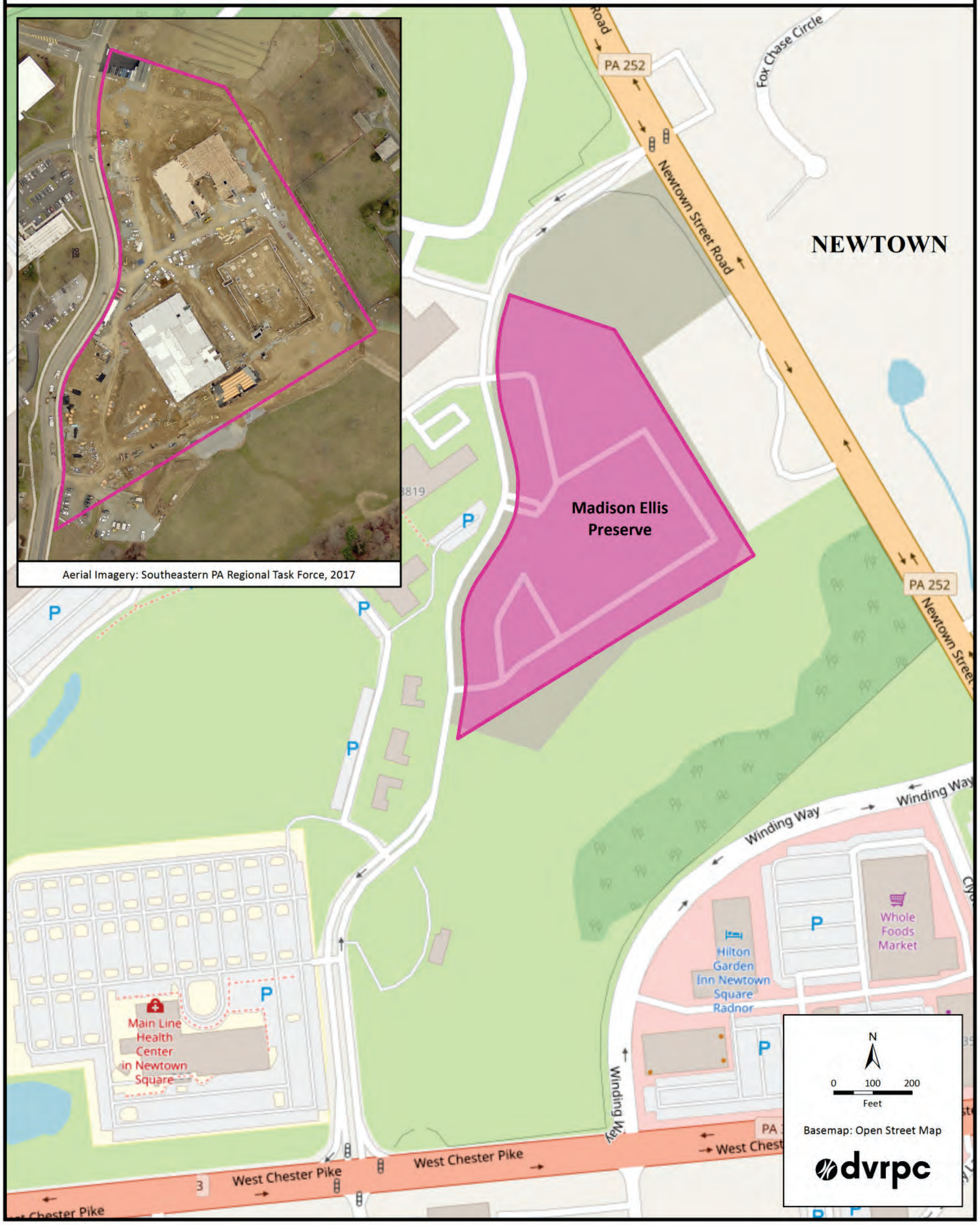


The Pointe at West Chester

West Goshen Township, Chester County, PA

Madison Ellis Preserve

Newtown Township, Delaware County, PA



Appendix B: Study Site Photos

Southstar Lofts

777 South Broad

Roebling Lofts

The Courts at Spring Mill

The Station at Manayunk

Silk Factory Lofts

Jacksonville Station

Haddon Towne Center

The Station at Bucks County

Warminster Station, at the Station at Bucks County

Riverwalk

Londonbury at Millennium

Riverworks

The Pointe at West Chester

Madison Ellis Preserve

Appendix C: ITE Trip Generation Data

Land Use: 221
Multifamily Housing (Mid-Rise)

Description

Mid-rise multifamily housing includes apartments, townhouses, and condominiums located within the same building with at least three other dwelling units and that have between three and 10 levels (floors). Multifamily housing (low-rise) (Land Use 220), multifamily housing (high-rise) (Land Use 222), off-campus student apartment (Land Use 225), and mid-rise residential with 1st-floor commercial (Land Use 231) are related land uses.

Additional Data

In prior editions of *Trip Generation Manual*, the mid-rise multifamily housing sites were further divided into rental and condominium categories. An investigation of vehicle trip data found no clear differences in trip making patterns between the rental and condominium sites within the ITE database. As more data are compiled for future editions, this land use classification can be reinvestigated.

For the six sites for which both the number of residents and the number of occupied dwelling units were available, there were an average of 2.46 residents per occupied dwelling unit.

For the five sites for which the numbers of both total dwelling units and occupied dwelling units were available, an average of 95.7 percent of the total dwelling units were occupied.

Time-of-day distribution data for this land use are presented in Appendix A. For the eight general urban/suburban sites with data, the overall highest vehicle volumes during the AM and PM on a weekday were counted between 7:00 and 8:00 a.m. and 4:45 and 5:45 p.m., respectively.

For the four dense multi-use urban sites with 24-hour count data, the overall highest vehicle volumes during the AM and PM on a weekday were counted between 7:15 and 8:15 a.m. and 4:15 and 5:15 p.m., respectively. For the three center city core sites with 24-hour count data, the overall highest vehicle volumes during the AM and PM on a weekday were counted between 6:45 and 7:45 a.m. and 5:00 and 6:00 p.m., respectively.

For the six sites for which data were provided for both occupied dwelling units and residents, there was an average of 2.46 residents per occupied dwelling unit.

For the five sites for which data were provided for both occupied dwelling units and total dwelling units, an average of 95.7 percent of the units were occupied.

The average numbers of person trips per vehicle trip at the five center city core sites at which both person trip and vehicle trip data were collected were as follows:

- 1.84 during Weekday, Peak Hour of Adjacent Street Traffic, one hour between 7 and 9 a.m.
- 1.94 during Weekday, AM Peak Hour of Generator
- 2.07 during Weekday, Peak Hour of Adjacent Street Traffic, one hour between 4 and 6 p.m.
- 2.59 during Weekday, PM Peak Hour of Generator

The average numbers of person trips per vehicle trip at the 32 dense multi-use urban sites at which both person trip and vehicle trip data were collected were as follows:

- 1.90 during Weekday, Peak Hour of Adjacent Street Traffic, one hour between 7 and 9 a.m.
- 1.90 during Weekday, AM Peak Hour of Generator
- 2.00 during Weekday, Peak Hour of Adjacent Street Traffic, one hour between 4 and 6 p.m.
- 2.08 during Weekday, PM Peak Hour of Generator

The average numbers of person trips per vehicle trip at the 13 general urban/suburban sites at which both person trip and vehicle trip data were collected were as follows:

- 1.56 during Weekday, Peak Hour of Adjacent Street Traffic, one hour between 7 and 9 a.m.
- 1.88 during Weekday, AM Peak Hour of Generator
- 1.70 during Weekday, Peak Hour of Adjacent Street Traffic, one hour between 4 and 6 p.m.
- 2.07 during Weekday, PM Peak Hour of Generator

The sites were surveyed in the 1980s, the 1990s, the 2000s, and the 2010s in Alberta (CAN), British Columbia (CAN), California, Delaware, District of Columbia, Florida, Georgia, Illinois, Maryland, Massachusetts, Minnesota, New Hampshire, New Jersey, Ontario, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Utah, Virginia, and Wisconsin.

Source Numbers

168, 188, 204, 305, 306, 321, 357, 390, 436, 525, 530, 579, 638, 818, 857, 866, 901, 904, 910, 912, 918, 934, 936, 939, 944, 947, 948, 949, 959, 963, 964, 966, 967, 969, 970

Multifamily Housing (Mid-Rise)
(221)

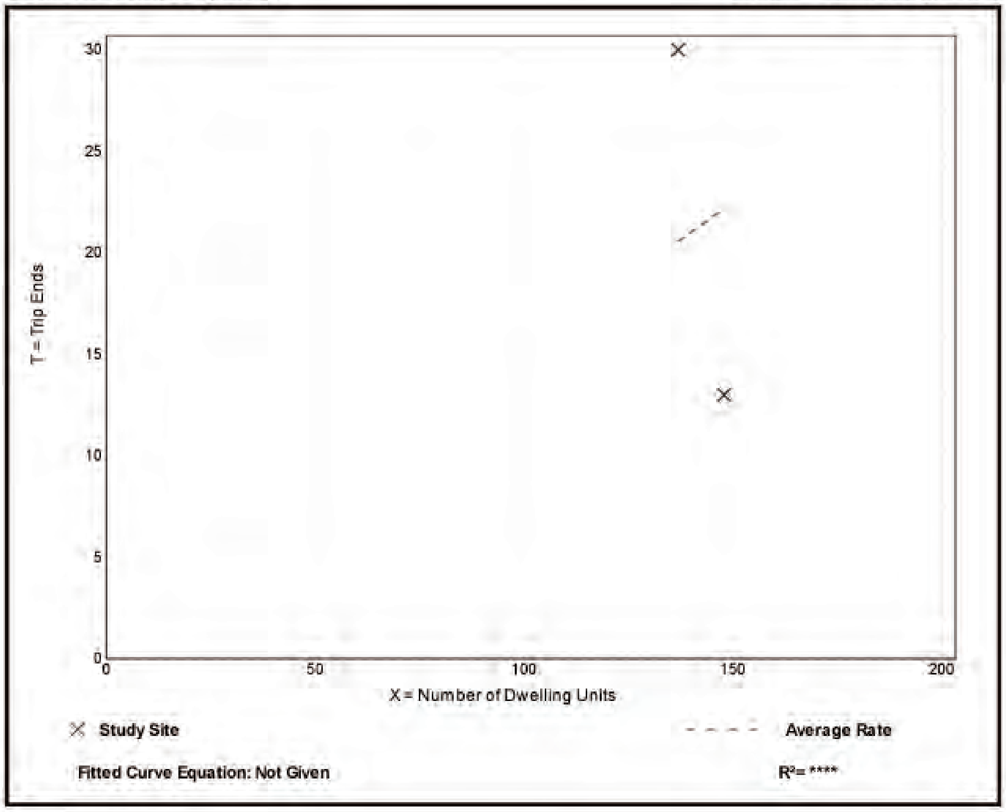
Vehicle Trip Ends vs:	**Dwelling Units**
On a:	**Weekday, AM Peak Hour of Generator**
Setting/Location:	**Dense Multi-Use Urban**
Number of Studies:	2
Avg. Num. of Dwelling Units:	143
Directional Distribution:	21% entering, 79% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.15	0.09 - 0.22	*

Data Plot and Equation

Caution – Small Sample Size



Multifamily Housing (Mid-Rise)
(221)

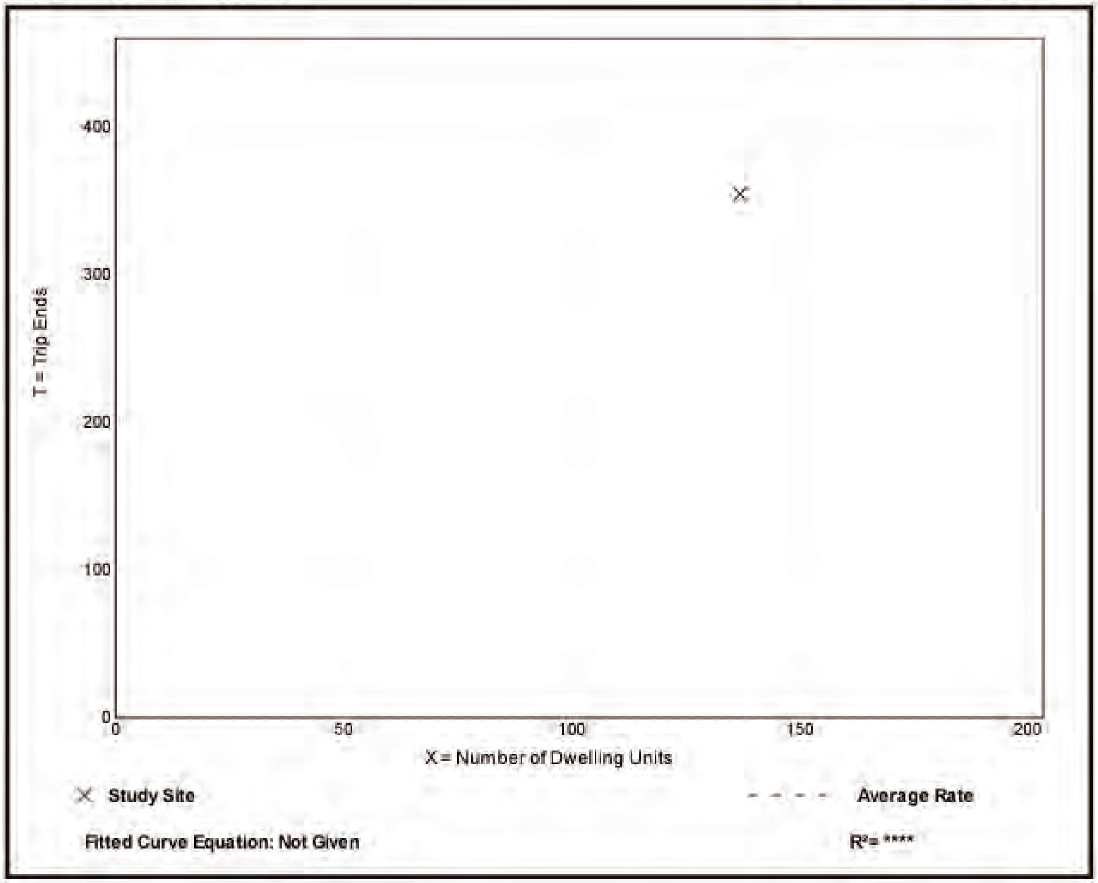
Vehicle Trip Ends vs:	**Dwelling Units**
On a:	**Weekday**
Setting/Location:	**Dense Multi-Use Urban**
Number of Studies:	1
Avg. Num. of Dwelling Units:	137
Directional Distribution:	50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
2.59	2.59 - 2.59	*

Data Plot and Equation

Caution – Small Sample Size



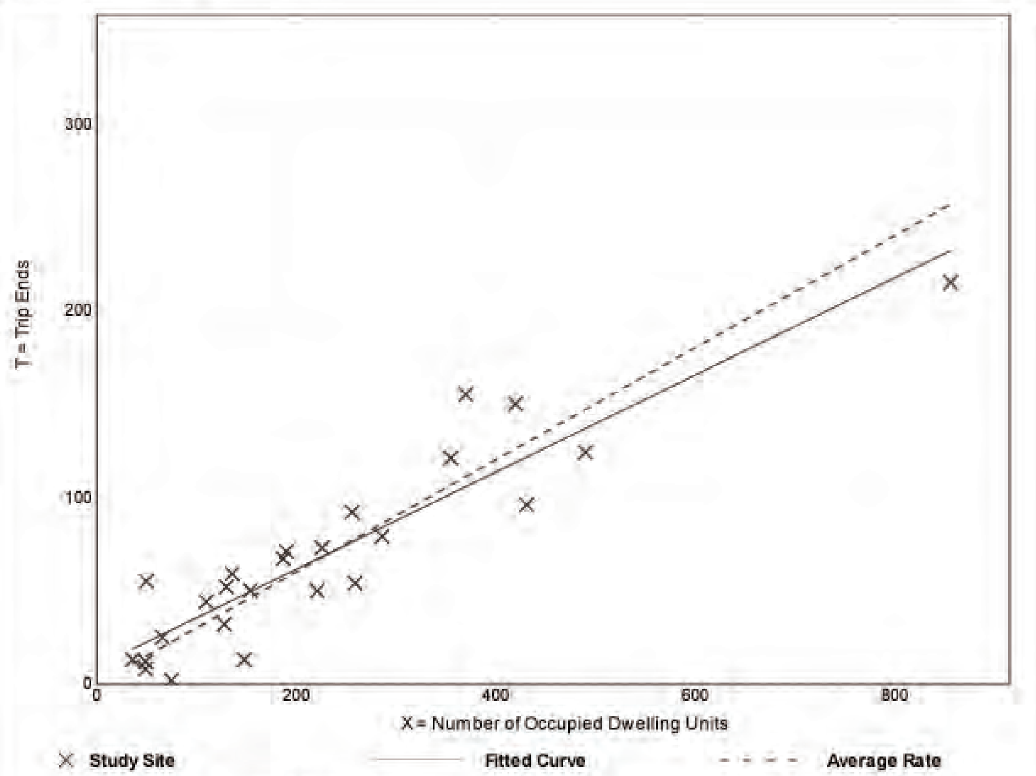
Multifamily Housing (Mid-Rise)
(221)

Vehicle Trip Ends vs:	**Occupied Dwelling Units**
On a:	**Weekday, AM Peak Hour of Generator**
Setting/Location:	**Dense Multi-Use Urban**
Number of Studies:	25
Avg. Num. of Occupied Dwelling Units:	227
Directional Distribution:	29% entering, 71% exiting

Vehicle Trip Generation per Occupied Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.30	0.03 - 1.10	0.11

Data Plot and Equation



Fitted Curve Equation: $T = 0.26(X) + 9.42$

$R^2 = 0.85$

Multifamily Housing (Mid-Rise)
(221)

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

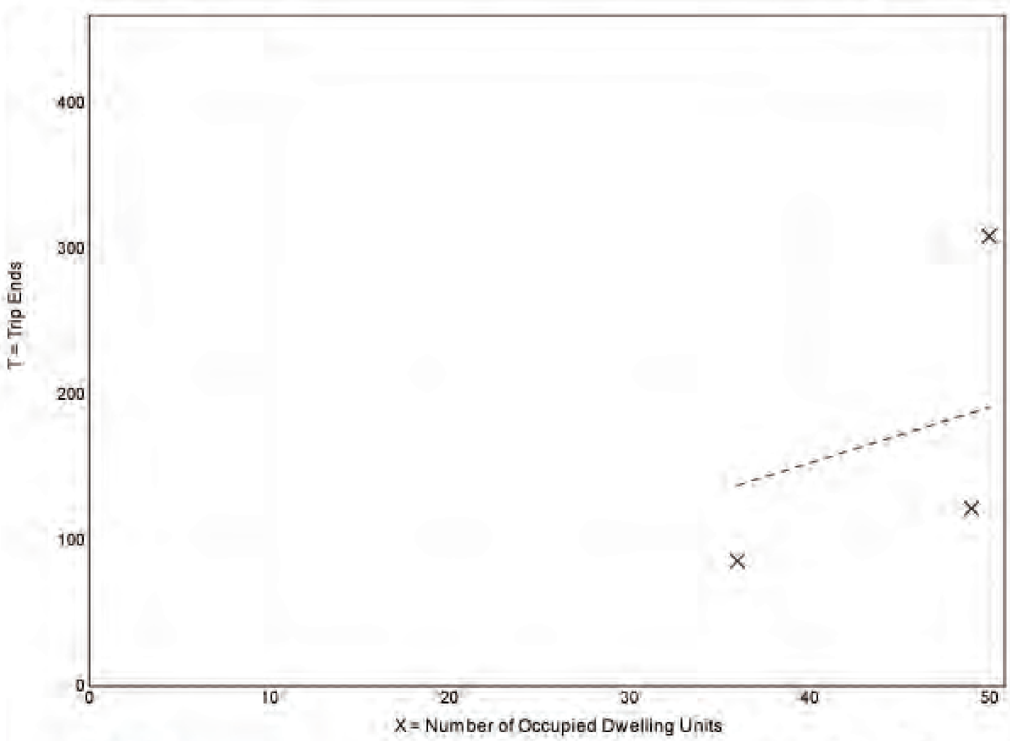
Setting/Location: Dense Multi-Use Urban
Number of Studies: 3
Avg. Num. of Occupied Dwelling Units: 45
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Occupied Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
3.83	2.39 - 6.18	5.00

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given

R^2= ****

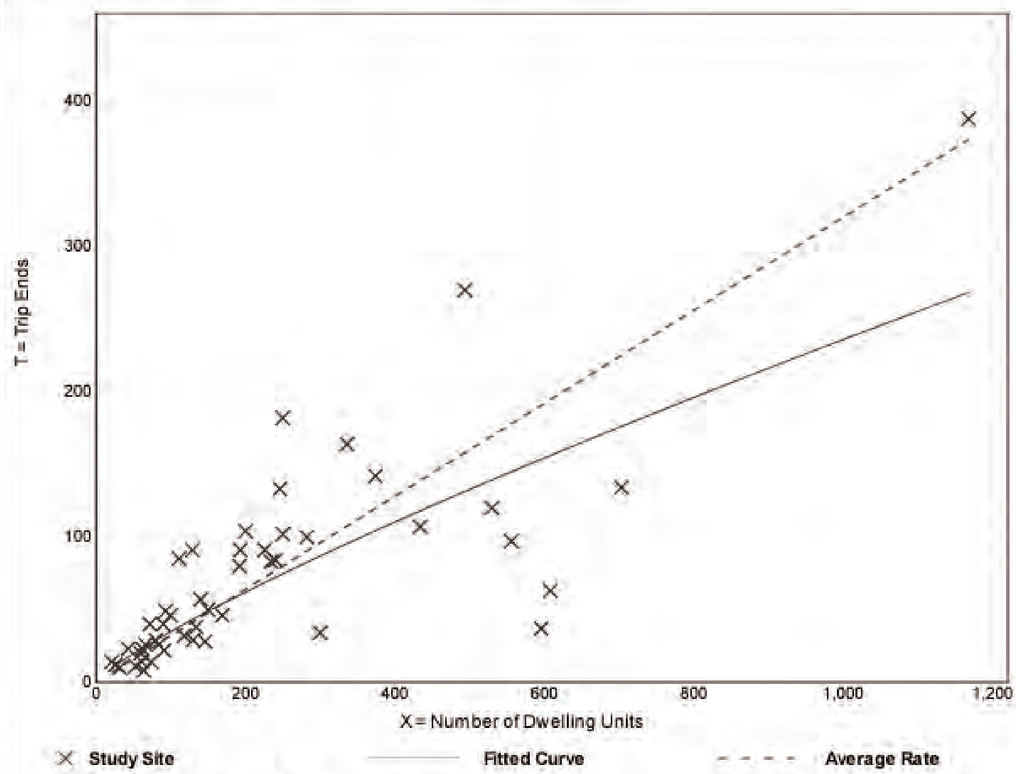
Multifamily Housing (Mid-Rise)
(221)

Vehicle Trip Ends vs:	**Dwelling Units**
On a:	**Weekday,**
	AM Peak Hour of Generator
Setting/Location:	**General Urban/Suburban**
Number of Studies:	48
Avg. Num. of Dwelling Units:	225
Directional Distribution:	27% entering, 73% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.32	0.06 - 0.77	0.17

Data Plot and Equation



Fitted Curve Equation: $Ln(T) = 0.83\ Ln(X) - 0.27$

$R^2 = 0.69$

Multifamily Housing (Mid-Rise)
(221)

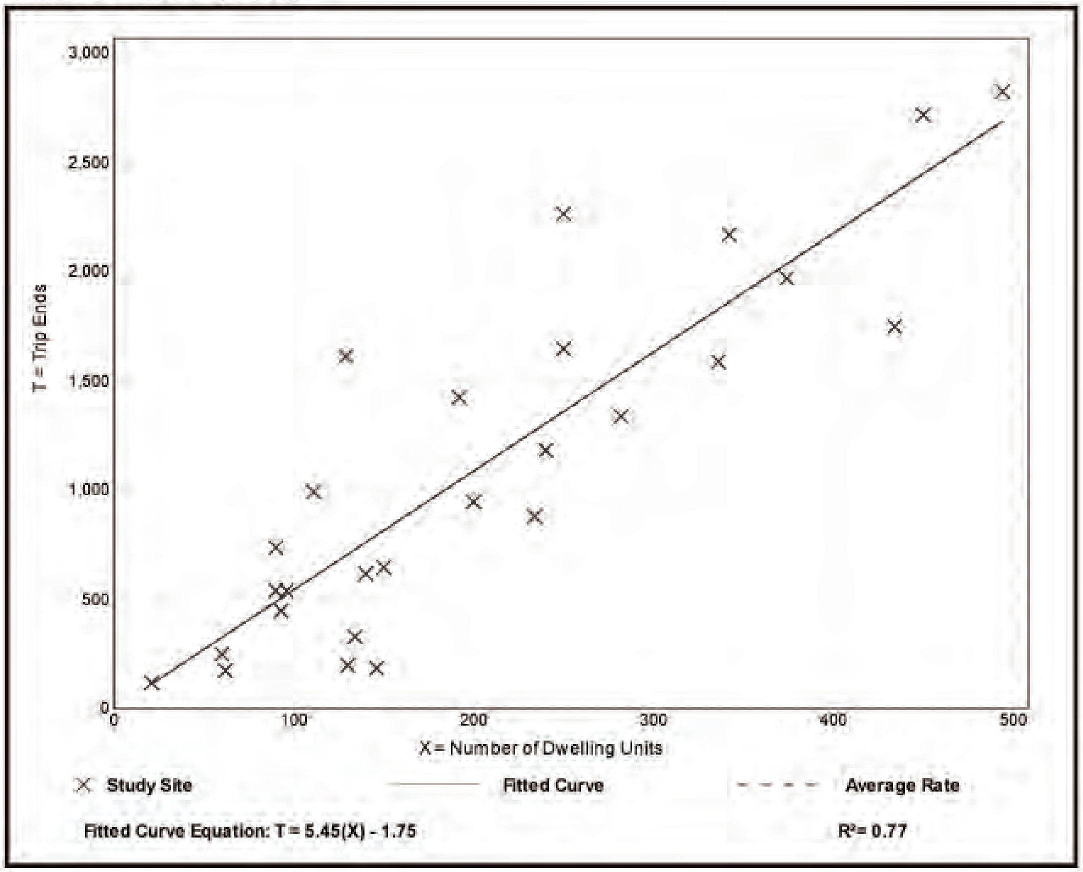
Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 27
Avg. Num. of Dwelling Units: 205
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
5.44	1.27 - 12.50	2.03

Data Plot and Equation



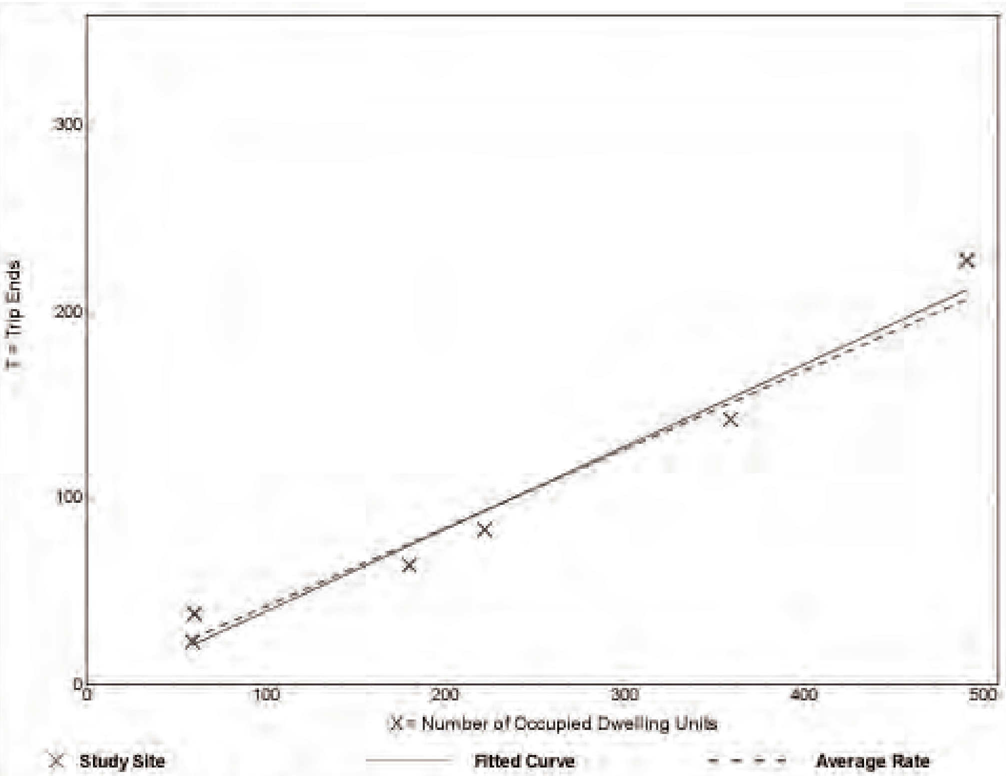
Multifamily Housing (Mid-Rise)
(221)

Vehicle Trip Ends vs:	**Occupied Dwelling Units**
On a:	**Weekday,**
	AM Peak Hour of Generator
Setting/Location:	**General Urban/Suburban**
Number of Studies:	6
Avg. Num. of Occupied Dwelling Units:	229
Directional Distribution:	28% entering, 72% exiting

Vehicle Trip Generation per Occupied Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.42	0.36 - 0.63	0.07

Data Plot and Equation



Fitted Curve Equation: $T = 0.44(X) - 4.65$ $R^2 = 0.97$

Multifamily Housing (Mid-Rise)
(221)

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

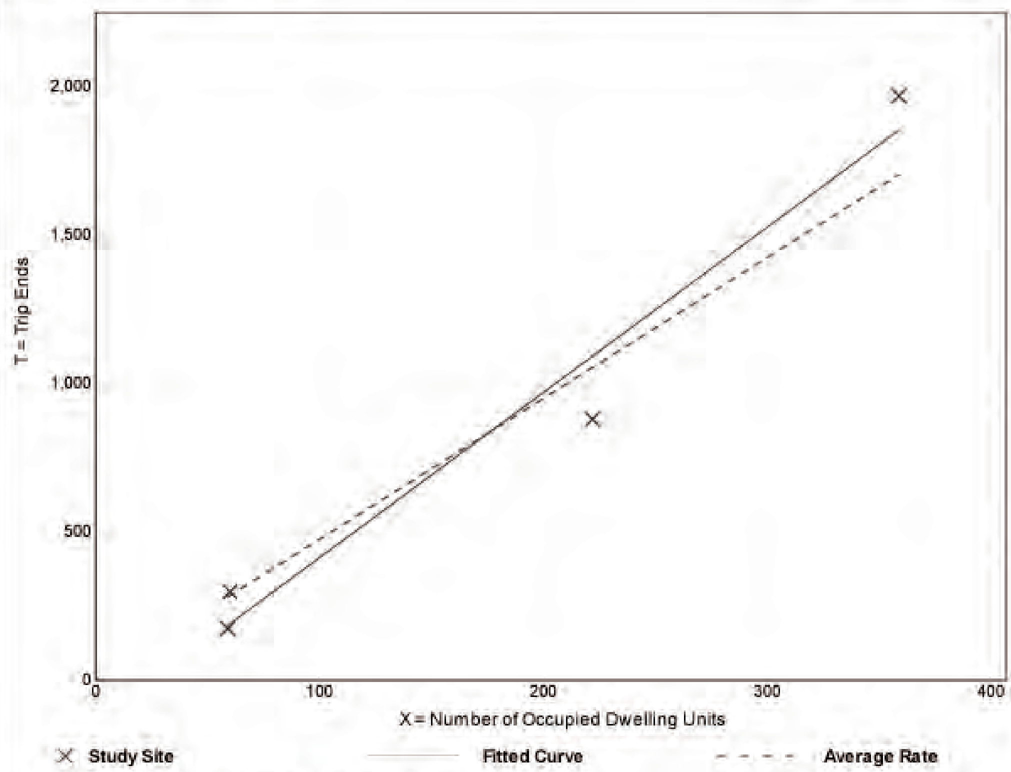
Setting/Location: General Urban/Suburban
Number of Studies: 4
Avg. Num. of Occupied Dwelling Units: 175
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Occupied Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
4.75	2.95 - 5.49	1.00

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: $T = 5.57(X) - 143.95$ **$R^2 = 0.97$**

Appendix D: ITE Parking Generation Data

Land Use: 221
Low/Mid-Rise Apartment

Description

Low/mid-rise apartments are rental dwelling units located within the same building with at least three other dwelling units: for example, quadraplexes and all types of apartment buildings. The study sites in this land use have one, two, three, or four levels. High-rise apartment (Land Use 222) is a related use.

Database Description

The database consisted of a mix of suburban and urban sites. Parking demand rates at the suburban sites differed from those at urban sites and, therefore, the data were analyzed separately.

- Average parking supply ratio: 1.4 parking spaces per dwelling unit (68 study sites). This ratio was the same at both the suburban and urban sites.
- Suburban site data: average size of the dwelling units at suburban study sites was 1.7 bedrooms, and the average parking supply ratio was 0.9 parking spaces per bedroom (three study sites).
- Urban site data: average size of the dwelling units was 1.9 bedrooms with an average parking supply ratio of 1.0 space per bedroom (11 study sites).

Saturday parking demand data were only provided at two suburban sites. One site with 1,236 dwelling units had a parking demand ratio of 1.33 vehicles per dwelling unit based on a single hourly count between 10:00 and 11:00 p.m. The other site with 55 dwelling units had a parking demand ratio of 0.92 vehicles per dwelling unit based on counts between the hours of 12:00 and 5:00 a.m.

Sunday parking demand data were only provided at two urban sites. One site with 15 dwelling units was counted during consecutive hours between 1:00 p.m. and 5:00 a.m. The peak parking demand ratio at this site was 1.00 vehicle per dwelling unit. The peak parking demand occurred between 12:00 and 5:00 a.m. The other site with 438 dwelling units had a parking demand ratio of 1.10 vehicles per dwelling unit based on a single hourly count between 11:00 p.m. and 12:00 a.m.

Four of the urban sites were identified as affordable housing.

Several of the suburban study sites provided data regarding the number of bedrooms in the apartment complex. Although these data represented only a subset of the complete database for this land use, they demonstrated a correlation between number of bedrooms and peak parking demand. Study sites with an average of less than 1.5 bedrooms per dwelling unit in the apartment complex reported peak parking demand at 92 percent of the average peak parking demand for all study sites with bedroom data. Study sites with less than 2.0 but greater than or equal to 1.5 bedrooms per dwelling unit reported peak parking demand at 98 percent of the average. Study sites with an average of 2.0 or greater bedrooms per dwelling unit reported peak parking demand at 13 percent greater than the average.

For the urban study sites, the parking demand data consisted of single or discontinuous hourly counts and therefore a time-of-day distribution was not produced. The following table presents a time-of-day distribution of parking demand at the suburban study sites.

Land Use: 221
Low/Mid-Rise Apartment

Based on Vehicles per Dwelling Unit (Suburban)	***Weekday***	
Hour Beginning	Percent of Peak Period	Number of Data Points*
12:00–4:00 a.m.	100	14
5:00 a.m.	96	14
6:00 a.m.	92	14
7:00 a.m.	74	1
8:00 a.m.	64	1
9:00 a.m.	–	0
10:00 a.m.	–	0
11:00 a.m.	–	0
12:00 p.m.	–	0
1:00 p.m.	–	0
2:00 p.m.	–	0
3:00 p.m.	–	0
4:00 p.m.	44	1
5:00 p.m.	59	1
6:00 p.m.	69	1
7:00 p.m.	66	9
8:00 p.m.	75	9
9:00 p.m.	77	10
10:00 p.m.	92	14
11:00 p.m.	94	14

* Subset of database

Parking studies of apartments should attempt to obtain information on occupancy rate and on the mix of apartment sizes (in other words, number of bedrooms per apartment and number of units in the complex). Future parking studies should also indicate the number of levels contained in the apartment building.

Additional Data

- Apartment occupancy can affect parking demand ratio. In the United States, successful apartment complexes commonly have a vacancy rate between 5 and 10 percent.[1]

Study Sites/Years

Canada:

Central City, Not Downtown:
Brooks, AB (1998)

Puerto Rico:

Central City, Not Downtown:
Mayaguez, PR (2007)

[1] Rental and Homeowner Vacancy Rates for the United States: 1960 and 1965 to 2009, U.S. Census Bureau. http://www.census.gov/hhes/www/housing/hvs/qtr309/q309tab1.html

Land Use: 221
Low/Mid-Rise Apartment

United States:

Suburban:
Skokie, IL (1964); Glendale, CA (1978); Irvine, CA (1981); Newport Beach, CA (1981); Dallas, TX (1982); Farmers Branch, TX (1982); Euless, TX (1983, 1984); Baytown, TX (1984); Syracuse, NY (1987); Devon, PA (2001); Marina del Rey, CA (2001); Milburn, NJ (2001); Parsippany, NJ (2001); Springfield, NJ (2001); Westfield, NJ (2001); Beaverton, OR (2002); Hillsboro, OR (2002); Portland, OR (2002); Vancouver, WA (2002); Goleta, CA (2008); Ventura, CA (2008); Englewood, CO (2009)

Urban:
Dallas, TX (1982, 1983); San Francisco, CA (1982); Syracuse, NY (1984, 1987); Santa Barbara, CA (1994); Long Beach, CA (2000); Santa Monica, CA (2001); San Diego, CA (2001)

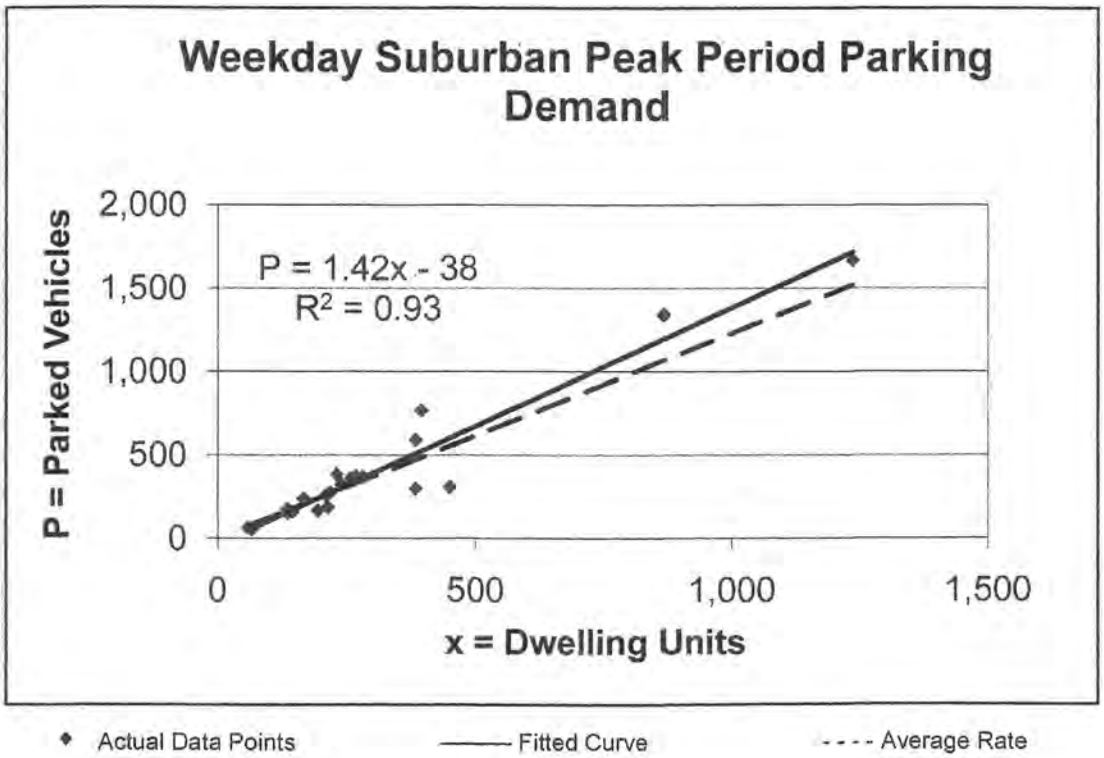
4th Edition Source Numbers

1007, 1015, 1114, 1137

Land Use: 221
Low/Mid-Rise Apartment

Average Peak Period Parking Demand vs. Dwelling Units
On a: Weekday
Location: Suburban

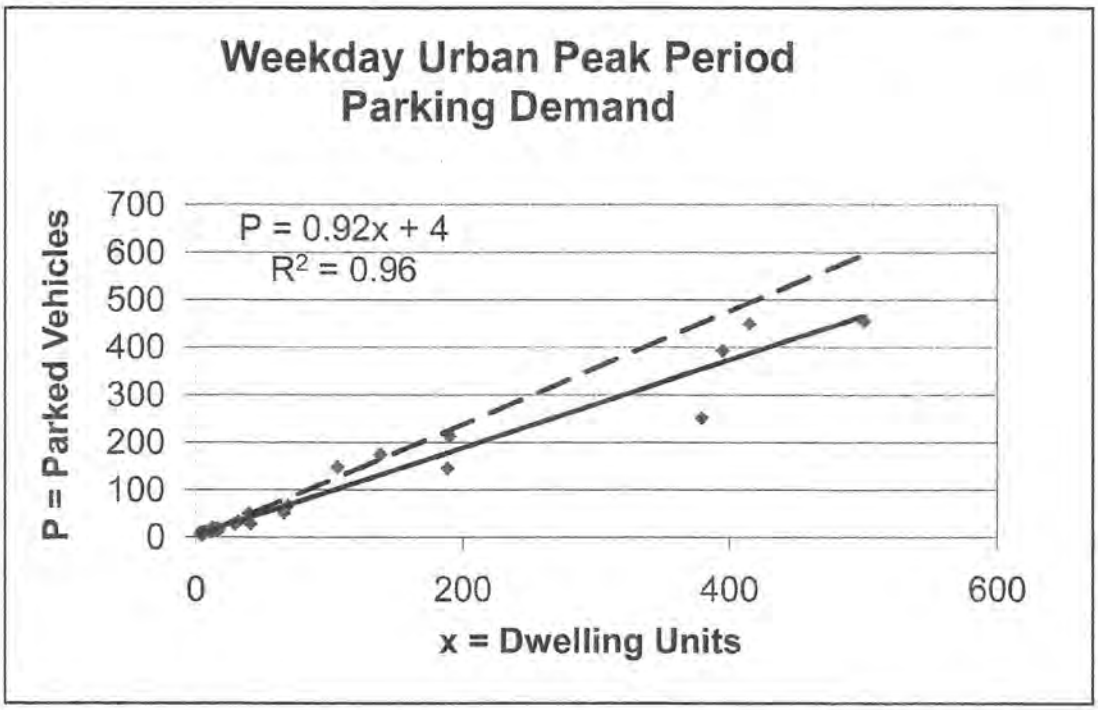
Statistic	Peak Period Demand
Peak Period	12:00–5:00 a.m.
Number of Study Sites	21
Average Size of Study Sites	311 dwelling units
Average Peak Period Parking Demand	1.23 vehicles per dwelling unit
Standard Deviation	0.32
Coefficient of Variation	21%
95% Confidence Interval	1.10–1.37 vehicles per dwelling unit
Range	0.59–1.94 vehicles per dwelling unit
85th Percentile	1.94 vehicles per dwelling unit
33rd Percentile	0.68 vehicles per dwelling unit



Land Use: 221
Low/Mid-Rise Apartment

Average Peak Period Parking Demand vs. Dwelling Units
On a: Weekday
Location: Urban

Statistic	Peak Period Demand
Peak Period	10:00 p.m.–5:00 a.m.
Number of Study Sites	40
Average Size of Study Sites	70 dwelling units
Average Peak Period Parking Demand	1.20 vehicles per dwelling unit
Standard Deviation	0.42
Coefficient of Variation	35%
95% Confidence Interval	1.07–1.33 vehicles per dwelling unit
Range	0.66–2.50 vehicles per dwelling unit
85th Percentile	1.61 vehicles per dwelling unit
33rd Percentile	0.93 vehicles per dwelling unit

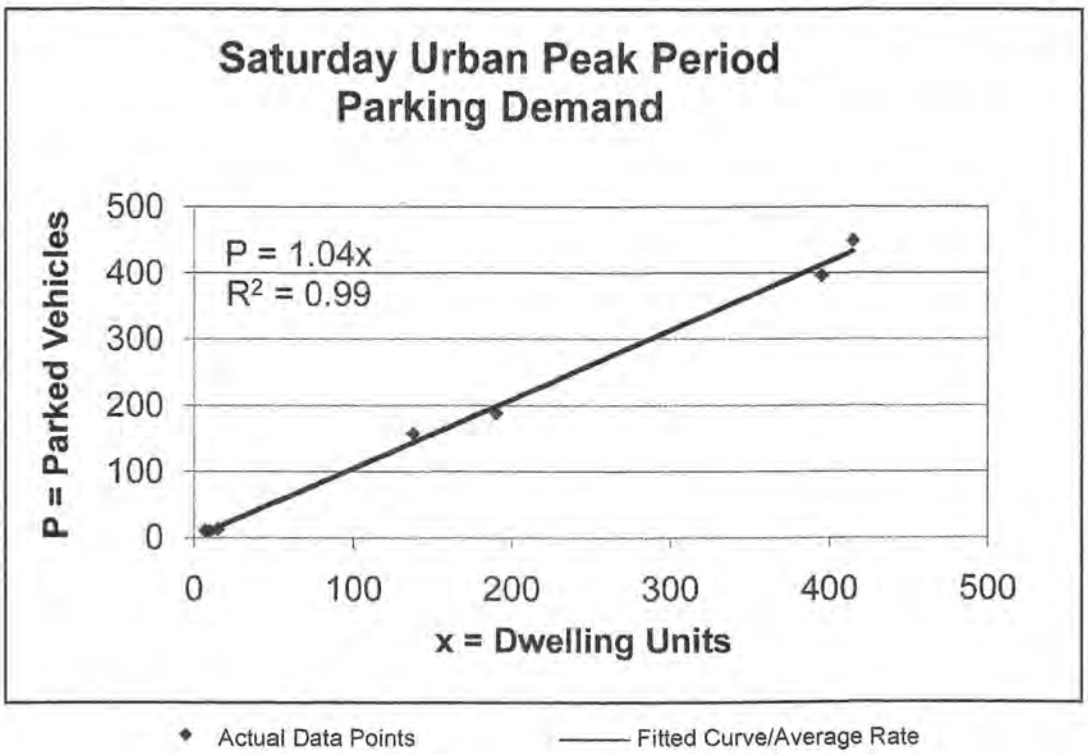


◆ Actual Data Points —— Fitted Curve - - - - Average Rate

Land Use: 221
Low/Mid-Rise Apartment

Average Peak Period Parking Demand vs. Dwelling Units
On a: Saturday
Location: Urban

Statistic	Peak Period Demand
Peak Period	No clear peak period emerged from the data; likely to fall between 10:00 p.m. and 6:00 a.m.
Number of Study Sites	8
Average Size of Study Sites	147 dwelling units
Average Peak Period Parking Demand	1.03 vehicles per dwelling unit
Standard Deviation	0.19
Coefficient of Variation	19%
Range	0.80–1.43 vehicles per dwelling unit
85th Percentile	1.14 vehicles per dwelling unit
33rd Percentile	0.93 vehicles per dwelling unit



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Local Trip Generation Adjustments for Transit-Oriented Development

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Date Published: January 9, 2020

Geographic Area Covered: Philadelphia Urban Area

Key Words:
Trip Generation, Parking Generation, Transit-Oriented Development (TOD), Mid-Rise Apartments, Institute of Transportation Engineers (ITE)

Abstract:
This study analyzes vehicle trip and parking generation rates at mid-level apartment buildings throughout the Philadelphia urban area. Data was collected at 13 sites. Ten of the sites are within a short walk of a rail station. The remaining three sites have no rail access and are auto oriented. The vehicle trip reduction benefit of Transit-Oriented Development (TOD) was estimated by comparing the vehicle trip generation rates of the rail sites to the non-rail sites.

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