Trip and Parking Generation Study of Orenco Station TOD, Portland Region

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ABSTRACT

Guidelines for trip and parking generation in the United States come mainly from the Institute of Transportation Engineers (ITE). However, their trip and parking manuals focus on suburban locations with limited transit and pedestrian access. This study aims to determine how many fewer vehicle trips are generated at transit-oriented developments (TODs), and how much less parking is required at TODs, than ITE guidelines would suggest. This study follows a trip and parking generation study by the authors at five exemplary TODs across the U.S. The subject of this case study is Orenco Station, on the west side of the Portland metropolitan area in the suburban city of Hillsboro. Orenco Station may be the most famous and lauded freestanding TOD (as opposed to infill TOD) in the nation.

Like the first five case studies, Orenco Station is more or less exemplary of the D variables featured in the built environment-travel literature. The Orenco Station TOD creates significantly less demand for parking and driving than do conventional suburban developments. Peak parking demand is less than one half the parking supply guideline in the ITE *Parking Generation* manual. Also, vehicle trip generation rates are about half what is predicted in the ITE *Trip Generation Manual*. The automobile mode share is 31 percent of all trips, with the remainder being mostly transit and walk trips.

Keywords: Transit-oriented development, trip generation, parking generation, mode share

INTRODUCTION

This study follows a trip and parking generation study by the authors at five exemplary TODs across the U.S.: Redmond TOD in Seattle; Rhode Island Row in Washington D.C.; Fruitvale Village in San Francisco-Oakland; Englewood TOD in Denver; and Wilshire/Vermont in Los Angeles (*1*). The subject of this case study is Orenco Station, on the west side of the Portland metropolitan area in the suburban city of Hillsboro. Orenco Station may be the most famous and lauded freestanding TOD (as opposed to infill TOD) in the nation.

Like the first five case studies, Orenco Station is more or less exemplary of the D variables featured in the built environment-travel literature. It contains a **diverse land use mix**, with residential, commercial, and public uses. It has public spaces, ample sidewalks, street trees, curbside parking, small building setbacks, and other features that make it **well designed** from a pedestrian standpoint. It **minimizes distance to transit**, literally abutting a light rail transit (LRT) station. It is served by one of the best transit systems in the nation, giving it exemplary **destination accessibility via transit**. It provides affordable housing, and thus attracts the **demographics** most likely to use transit and walk. It has **high residential density** relative to the region in which it is located. And some of its buildings have parking management policies that can be considered progressive, these falling under the heading of **demand management**.

What distinguishes Orenco Station from the first five TODs is its scale (see Table 1). All but one of the first five TODs are less than 10 acres in size. The entirety of Orenco Station is 237 acres, and even the portion featured in this study is about 60 acres. The scale suggests that a much high proportion of trips will be internal to the development, a good thing from a transportation and physical activity standpoint. However, it also suggests that part of the development will be at a considerable distance from the transit station, which means that the average transit mode share may be lower since transit use falls off with distance from a station. It may also suggest a decline in transit use because, unlike the first five TODs studied, not all of the housing will be multifamily on a large site like Orenco Station. A large site ordinarily requires a mix housing types for rapid land absorption and, in fact, our study area includes single-family attached product.

TABLE 1 Net and Gross Residential Densities, and Floor Area Ratios for Commercial Uses, for the First Five TODs Studied and Orenco Station

TOD	Region	Gross Area (acres)	Gross Residential Density (units per gross acre)	Net Residential Area (acres)	Net Residential Density (units per net acre)	Gross Commercial FAR (for retail and office uses)
Redmond TOD	Seattle	2.5	129	2.5	129	0.11
Rhode Island Row	Washington, D.C.	6	46	6	46	0.27
Fruitvale Village	San Francisco	3.4	14	3.4	14	0.94
Englewood	Denver	30	15	10.7	41	0.25
Wilshire/Vermont	Los Angeles	3.2	140	3.2	140	0.27
Orenco Station (study area)	Portland	60	32.4	60	32.4	0.10

LITERATURE REVIEW

The question of how much vehicle trip and parking demand reduction occurs with TOD is still largely unanswered in the literature. Everyone agrees that there should be some reduction, but is it 10 percent or 20 percent or 30 percent or more?

First we review the literature on vehicle trip generation at TODs. The ITE *Trip Generation Manual* itself states that its "[d]ata were primarily collected at suburban locations having little or no transit service, nearby pedestrian amenities, or travel demand management (TDM) programs" (*2*, pp.1). It goes on to say: "At specific sites, the user may wish to modify trip-generation rates presented in this document to reflect the presence of public transportation service, ridesharing, or other TDM measures; enhanced pedestrian and bicycle trip-making opportunities; or other special characteristics of the site or surrounding area" (*2*, pp.1). This kind of modification is seldom done in practice.

Surveying 17 housing projects near transit in five U.S. metropolitan areas, Cervero and Arrington (*3*) found that vehicle trips per dwelling unit were substantially below the ITE's estimates. Over a typical weekday period, the surveyed housing projects averaged 44 percent fewer vehicle trips than that estimated by using the ITE manual (3.8 versus 6.7). Another study in San Francisco Bay Area found that residents living near transit generated half as many vehicle miles traveled (VMT) as their suburban and rural counterparts (*4*). Nasri & Zhang (*5*) found people living in TOD areas reduced their VMT by around 38% in Washington, D.C. and 21% in Baltimore, compared to their non-TOD counterparts. At the same time, residents living in developments near transit are reported to have higher rates of transit trips than residents living at greater distances (*4,6,7,8*), especially for commuting trips (*6,9,10,11,12*). However, another study found that new residents in seven TODs in North American adopted more active and transit trips only for amenities and leisure after they relocated to a TOD but that they were less likely to do so for work and shopping (*13*). These results are specific to multifamily housing developments near transit. To our knowledge, there are only two studies of vehicle trip generation at TODs (defined as mixed-use developments –*1,14*).

Next we review the literature on parking generation at transit-served sites. The ITE *Parking Generation* manual notes that study sites upon which the manual is based are "primarily isolated, suburban sites" (*15*). Studies show that the vehicle ownership is lower in transit-served areas than those that are not transit-served (*6,8*). By comparing parking-generation rates for housing projects near rail stops with parking supplies and with ITE's parking-generation rates, Cervero et al. (*16*) found there is an oversupply of parking near transit, sometimes by as much as 25-30 percent. Oversupply of parking spaces may result in an increase in vehicle ownership (*3*). This is supported by the strong positive correlation between parking supply and vehicle ownership (*17,18*) and auto use (*17,19,20*). Again, these studies mostly relate to residential developments. Although Loo et al. (*21*) studied rail-based TOD and the connection with variables such as parking and car ownership, they did not examine parking demand. To our knowledge, there is only one study of parking demand at TODs (again, defined as mixed-use developments – *1*), the others being for residential developments near transit.

Simply put, Ewing et al.'s (*1*) case study TODs (even the most auto-oriented) were found to create significantly less demand for parking and driving than do conventional suburban developments. With one exception, peak parking demand in these TODs was less than one half the parking supply guideline in the

ITE *Parking Generation* manual. Also, with one exception, vehicle trip generation rates were about half or less of what is predicted in the ITE *Trip Generation Manual*. Automobile mode shares were as low as one quarter of all trips, with the remainder being mostly transit and walk trips.

STUDY AREA AND DATA COLLECTION

Study area

Orenco Station is served by TriMet's light rail and a standard bus route. The station is the 14th stop westbound on the Blue Line from Downtown Portland. The Blue Line generally runs every ten minutes between 5 am and 1 am. The Blue Line is part of an ever expanding network of LRT lines.

For the purposes of this trip and parking generation study, the TOD study area is the approximately 60 acres south of the original Orenco Station neighborhood (Figure 1). This is the portion of the Orenco Station community within about a quarter mile of the LRT station. The rough boundaries are Cornell Road on the north, the LRT station on the south, the Nexus Apartments on the west, and Northwest 67th and Northeast Century Boulevard on the east (see Figure 1). Orenco Station Parkway runs north-south down the center of the study site. We did counts and intercepts in the 8-acre Town Center ("main street") just north of Cornell Road, and will be referring to mode shares for visitors to this area. But the rest of the analysis focuses on the section of Orenco Station south of Cornell Road. See Table 2 for the summary of the developments within this area.

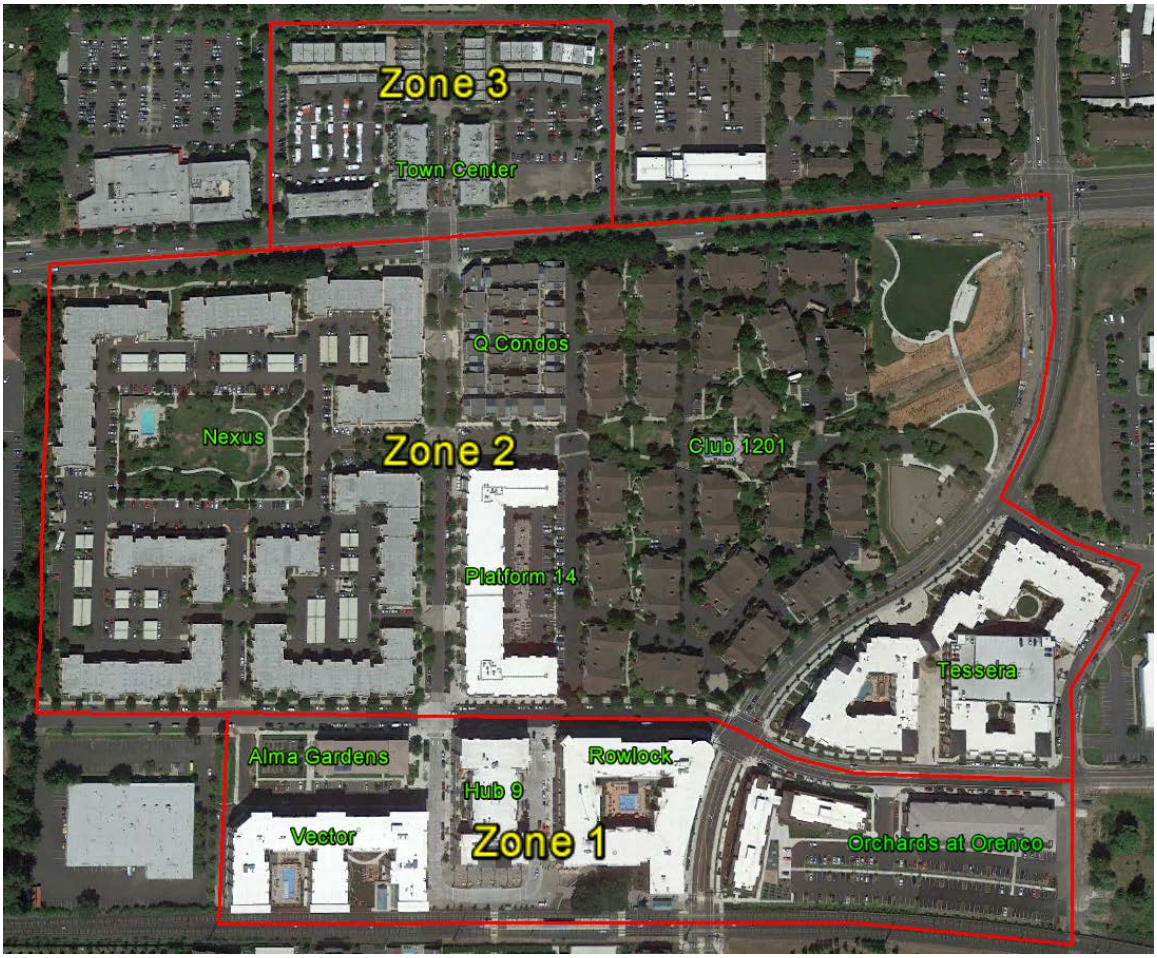

FIGURE 1 Study Area and Major Developments

142 **TABLE 2 Development summary of Orenco Station TOD (60 acres)**

Land uses	***Description***	***Unit***	***Occupancy*** [1]
Commercial			
Platform District			
Hub 9	Ground floor	9,118 sq.ft.	97.8%
Rowlock	Ground floor	9,692 sq.ft.	85.1%
Vector	Ground floor	6,505 sq.ft.	100%
Platform 14	Ground floor	17,523 sq.ft.	79.1%
Tessera	Ground floor	6,792 sq. ft.	75.4%
Nexus	Ground floor	7,100 sq. ft.	79%
Residential			
Platform District			
Hub 9	6-story apartments above commercial and 2-story parking structure	124 units	92.7%
Rowlock	6-story apartments above commercial and 2-story parking structure	255 units	93.7%
Vector	6-story apartments above commercial and 2-story parking structure	230 units	83.9%
Platform 14	4-story apartments above commercial	177 units (166 apartments, 11 live/work units)	94.4%
Tessera	4-story apartments above commercial	304 units	93.4%
Club 1201	2-story condominiums	210 units	N/A (no rental unit)
Q Condos	3-story condominiums	62 units	N/A (no rental unit)
Nexus	3-story apartments	422 units	98%
Orchards at Orenco I	3-story affordable apartments	57 units	96.6%
Orchards at Orenco II	3-story affordable apartments	58 units	100%
Alma Gardens	4-story affordable apartments for seniors	45 units	100%
Parking	***Description***	***Unit***	***Peak Occupancy*** [2]
Transit Park-and-Ride			
Vector	2-level parking structure	125 stalls (level 1)	53.5%[3]
Residents-only parking			
Platform District			
Hub 9	2-level parking structure	121 stalls	63.6%
Rowlock	2-level parking structure (105 stalls at level 1 are public)	184 stalls (at level 2)	66.3%
Vector	2-level parking structure	155 stalls (level 2)	49.7%
Platform 14		107 stalls	76.4%
Tessera	6-level parking structure	381 stalls	54.3%
Club 1201	Parking lot and garage	543 stalls [4]	30.4%
Q Condos	Parking garage	118 stalls	Not available
Nexus	Parking garage with	535 stalls (300 open spots,	Not available

	shared parking	125 carports and 110 garages)	
Orchards at Orenco I &II	Surface parking & on-street parking	134 stalls on surface parking lot and 17 on-street parking	50.7%
Alma Gardens	on- and off-street parking	55 stalls	89.1%
Public Parking (on-street or garage)			
Platform District			
Hub 9	on-street parking	22 stalls	81.8%
Rowlock	105 stalls at level 1 of parking structure and 12 stalls on-street parking	117 stalls	91.5%
Vector	2-level parking structure	100 stalls (level 1)	53.5% [5]
Platform 14	on-street parking	48 stalls	89.6%
Tessera	on-street parking	45 stalls	100%
Nexus	on-street parking	45 stalls	71.1%
Orchards at Orenco I & II	on-street parking	28 stalls	40.0% [4]
Orenco Station Pwky	on-street parking	35 stalls	88.6%
NE Cornell Orenco	on-street parking	64 stalls	84.4%

Note: [1] *by May 23, 2017*

[2] *The peak occupancy at May 23, 2017*

[3] *The parking occupancy was measured for the whole first floor in Vector (225 stalls) including public parking lots (100 stalls) and park-and-ride lots (125 stalls).*

[4] *Club 1201 (East Village) has 21 buildings, 10 condos in each of those buildings. Of the 10 condos, 8 have 1 car garages and 2 have 2 car garages. That equals 252 spaces in the garage. In addition to these, there is adequate space for one additional parking space in the driveway in front of each parking garage. Most units utilize the driveway as an additional (or primary) parking space for their unit and use the garage for storage. This equals an additional 252 spaces. Finally, there are 39 extra visitor/overflow spaces, which brings our grand total to 543 parking spaces.*

[5] *The parking occupancy was measured for the whole on-street parking (45 stalls) including some residents-only (17 stalls).*

Data collection

The data were collected between 7:30 am and 9:00 pm on Tuesday, May 23, 2017. Actually, parking occupancy counts were conducted even later than that to capture peak residential parking demand. Given Portland's reputation for rain, we waited for a month known to have less rain than earlier in the year, and waited for a week and day forecasted a week out to have clear weather. The weather forecasts were right, May 23th was a beautiful day. We also scheduled data collection for a time when Portland State University (PSU) was still in session and before final exams, as we made a decision early on to use urban planning students for the counts and surveys.

That was a wise decision. Not only were students less expensive than random part-time employees hired through a temporary employment agency (which charges a fee of service on top of hourly wages), but the students were more conscientious in their data collection because, as urban planning students, they understood the importance of the study. Students were recruited through an emailed announcement by Professor Jennifer Dill of PSU. Given the size of the study area, the number of buildings, and the number of entrances, we were prepared to hire all takers. Ultimately, 65 students were employed for up to 14 hours on that one day, at a total one-day cost of more than $13,000.

The multimodal transportation planning firm of Fehr & Peers developed a data collection plan and protocols (see Figure 2). The firm also managed data collection in the field and subsequent data entry for three types of travel data: (1) full counts of all persons entering and exiting the buildings that make up the TOD, (2) brief intercept surveys of samples of individuals entering and exiting the buildings that make up the TOD, and (3) parking inventory and occupancy surveys of all off-street parking accessory to the commercial and residential uses of the TOD.

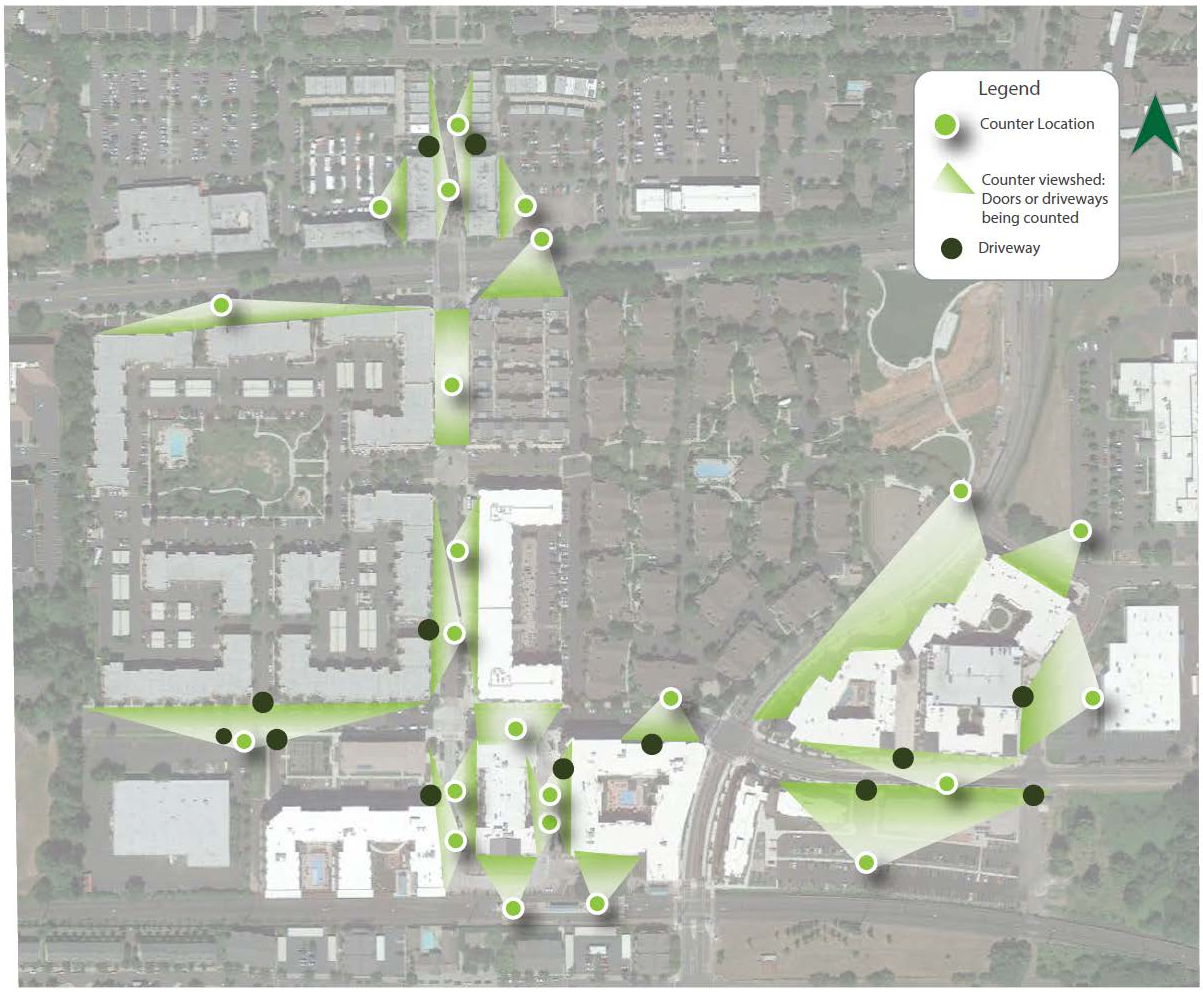

FIGURE 2 Count Locations (Intercept Surveyors Circulated Around These Locations)

The intent of this approach was to develop an accurate measure of total trip generation associated with the commercial and residential uses at the site, as well as complementary travel survey and parking utilization data that provide a picture of the mode of travel, origin/destination, parking location – if applicable – and purpose for all trips to and from the building throughout the course of the day.

As a first step, surveyors noted whether the subject was observed "coming" or "going" to/from the buildings and the type and location of entrance/exit used, and recorded the time of intercept by checking a box on the data collection form associated with one of four 15-minute periods per hour.

People leaving the building were asked: (1) "How do you plan to get to your next destination?" (e.g., by what mode of travel?), (2) What is the purpose of your trip? (e.g., "Going home," "Going to work," "Shopping," or "other"), and (3) How many destinations are you visiting while in Orenco Station.

People arriving at the building were asked: (1) "How did you get here?" (e.g., by what mode of travel?), (2) What is the purpose of your trip? (e.g., "I live here/coming home," "coming to work," "shopping," or "other"), and (3) How many destinations are you visiting while in Orenco Station.

Individuals who indicated that they had arrived by or would be leaving by automobile were also asked where they parked their vehicle (e.g., "on-street," "in the [Vector Building] garage" or at an "other" location/facility).

Surveyors counted and attempted to intercept only individuals observed walking to or from an entrance to the TOD buildings (or, in observation of the garage entrance, only drivers and passengers in vehicles entering/exiting the garage driveway to/from the public street). Individuals waiting for the bus or train, or walking between the transit stops park-and-ride garages, were not counted or surveyed unless they entered or exited one of the respective TOD buildings.

MODE SHARES

In the intercept survey, we had surveyors at building entrances to ask people the three questions. We received 649 valid responses out of 655 respondents. One question in the survey was what transportation mode was used to get to/from this development. The mode shares from the intercept survey are presented in Table 3. We then applied these mode shares to the total trip generation counts by entrance to compute the final weighted mode shares.

The final mode shares for Orenco Station TOD are 45.8 percent walk, 2.5 percent bike, 3.9 percent bus, 16.0 percent rail, and 31.4 percent auto (see Table 3). According to the 2011 Oregon Household Activity Survey, the regional mode shares for Portland metropolitan area are 17.6 percent walk, 2.8 percent bike, 5.6 percent transit, and 70.9 percent auto. Compared to the regional mode shares, Orenco Station TOD shows a significant mode shift, a shift from auto to walk and transit. Orenco Station TOD has 2.6 times higher percentage of walk trips than the regional average, and 3.6 times higher percentage of transit (bus and rail) trips than the regional average.

As one would expect, the mode shares vary across the study area (see Figure 1 for reference). In Zone 1, closest to the LRT station, the transit mode shares are highest (21.1 percent for rail, and 5.3 percent for bus). In Zone 3, farthest from the LRT station and sitting right on Cornell Road, the auto mode share is highest (61 percent). In Zone 2, in the center of the study area, the walk share is highest (56.7 percent).

Interestingly, in Zone 3, the bike mode share is significant at 4.9 percent. This is not too surprising since the neighborhood to the north and east is very bicycle-friendly, and distances are great enough to make bicycling to the Town Center an attractive option. The bike mode share for this portion of Orenco Station is higher than the shares recorded at the original five TODs studied (*1*).

TABLE 3 Mode Shares in Orenco Station TOD

Intercept survey							
Entrance	***Count***	***Mode share (%)***					
		Walk	***Bike***	***Bus***	***Rail***	***Auto***	***Other***
Zone 1	361	43.5	1.7	5.3	21.1	28.0	0.6
Zone 2	247	56.7	2.4	1.6	14.6	24.3	0.4
Zone 3	41	19.5	4.9	7.3	7.3	61.0	0.0
Trip generation counts							

Entrance	***Count***	***Count for modes***					
		Walk	***Bike***	***Bus***	***Rail***	***Auto***	***Other***
Zone 1	5,998	2,609	100	316	1,263	1,678	33
Zone 2	7,096	4022	172	115	1034	1724	29
Zone 3	2,401	468	117	176	176	1,464	0
Final mode shares	15,495	45.8%	2.5%	3.9%	16.0%	31.4%	0.4%

TRIP GENERATION

Our actual trip generation counts from the survey did not distinguish residential trips and commercial trips. It is not possible to distinguish between them when land uses are as mixed, both vertically and horizontally, as they are at Orenco Station. To compare the observed trip generation with ITE's benchmarks, we will combine all estimated trips for different uses into a total that can be compared to ITE. We have not yet acquired the development information for the Zone 3 in our study area (see Figure 1). Hence, for this trip generation analysis, we focus on developments within Zones 1 and 2.

There were 13,094 person trips and 6,358 vehicle trips observed in Zones 1 and 2 for the day of the survey (7:30 am til 9:00 pm). Those trips were generated by the occupied residential units, 1,841 units, and 48,261 sq. ft. leased commercial space. The occupied residential units were computed by multiplying occupancy rates, provided by the property managers, times the total number of units.

The residential buildings at Orenco Station TOD include eight three- to six-level apartments, one two-level condominium, and one three-level condominium. For the eight three- to six-level apartments, we used the value for "223 Mid-Rise Apartment" in the *Trip Generation Manual*, which is defined as "apartments (rental dwelling units) in rental buildings that have between three and 10 levels (floors)." The ITE manual reports a trip generation rate for the peak hour but does not report a daily trip generation rate for mid-rise apartments. However, the ITE manual reports both the peak hour and the daily trip generation rate for all apartments ("220 Apartments"). We used this the ratio of daily to peak hour rates for all apartments to compute the daily trip generation rate for mid-rise apartments.

For the two-level condominium, we used the value for "231 Low-Rise Residential Condominium/Townhouse" in the *Trip Generation Manual*, which is defined as "residential condominiums/townhouses are units located in buildings that have one or two levels (floors)." The ITE manual reports a trip generation rate for the peak hour but does not report a daily trip generation rate for low-rise condominiums. However, the ITE manual reports the daily trip generation rate for all condominiums ("230 Residential Condominium/Townhouse"). We used the same process as for mid-rise apartments to get daily vehicle trip generation rate.

For the three-level condominium, we used the ITE *Trip Generation Manual*'s value for "232 High-Rise Residential Condominium/Townhouse," which is defined as "residential condominiums/townhouses are units located in buildings that have three or more levels (floors)". The average daily vehicle trip-generation rate is 4.18 per dwelling units on a weekday.

For trip generation rates of the many commercial uses in our study area, we used the most appropriate ITE land use categories. For example, by reviewing the ITE land use definitions, and perusing restaurant

menus on-line, we placed the many restaurants on-site in one of three categories—"931 Quality Restaurant" or "932 High-Turnover (Sit-Down) Restaurant" or "933 Fast-Food Restaurant without Drive-Through Window"—and then assigned them the corresponding daily trip generation rate from ITE's *Trip Generation Manual*.

The matches were not always perfect or even close, so in those cases, we assigned the Orenco Station commercial use the most analogous (in our judgment) ITE land use category. A difficult match, for example, was the Kumon Math and Reading Center at Orenco Station. We assumed its trip generation pattern across the day, hours of operation, and daily trip totals would be very different from the ITE school categories such as "530 High School." The best match we could find in this case, and it is approximate at best, is the trip generation associated with the category "590 Library."

Based on ITE's trip generation rates, the Orenco Station TOD (60-acre study area) would be expected to generate 10,859 daily vehicle trips if it were a typical suburban development without transit (see Table 4). The actual vehicle trips we observed on the survey day totaled 6,358, which is 58.5 percent of the ITE expected value.

TABLE 4 The Comparison of Daily Vehicle Trip Generation between ITE Guideline and Orenco Station TOD

		Trip generation rate	***Units / sq. ft.***	***Total daily trips***
ITE guideline		-	-	**10,859**
Hub 9	223 Mid-Rise Apartment	4.31	115	495
Rowlock	223 Mid-Rise Apartment	4.31	239	1030
Vector	223 Mid-Rise Apartment	4.31	193	832
Platform 14	223 Mid-Rise Apartment	4.31	167	720
Tessera	223 Mid-Rise Apartment	4.31	284	1224
Nexus	223 Mid-Rise Apartment	4.31	414	1782
Orchards at Orenco	223 Mid-Rise Apartment	4.31	113	487
Alma Gardens	223 Mid-Rise Apartment	4.31	45	194
Club 1201	231 Low-Rise Residential Condominium	7.14	62	443
Q Condos	232 High-Rise Residential Condominium	4.18	210	878
Schmizza Public House	931 Quality Restaurant	89.95	1,909	172
Ava Roasteria	932 High-Turnover (Sit-Down) Restaurant	127.15	3,000	381
Little Big Burger	932 High-Turnover (Sit-Down) Restaurant	127.15	1,142	145
9 Dang Fine Thai	931 Quality Restaurant	89.95	2,867	258
Master Yoo's TKD	492 Health/Fitness Club	32.93	2,060	68
iSpark Toys	864 Toy/Children's Superstore	49.9*	1,367	68
Aloto Gellato	933 Fast-Food Restaurant without Drive-Through Window	186	985	183
La Provence	931 Quality Restaurant	89.95	3,838	345
Orange Theory	492 Health/Fitness Club	32.93	6,495	214

Fitness				
Orenco Tap House	925 Drinking Place	124**	1719	213
Cloud Break Yoga	492 Health/Fitness Club	32.93	733	24
Salon 14	918 Hair Salon	19.3	733	14
American Pacific Mortgage	715 Single Tenant Office Building	11.65	733	9
Orenco Station Cyclery	861 Sporting Goods Superstore	18.4*	1,466	27
The Ridge	630 Clinic	31.45	1,466	46
Leasing office	715 Single Tenant Office Building	11.65	1,466	17
Salam Restaurant	932 High-Turnover (Sit-Down) Restaurant	127.15	2,415	307
Insured by Gallegos	715 Single Tenant Office Building	11.65	733	9
Paperboy	879 Arts and Crafts Store	68.5*	733	50
Platform Real Estate	715 Single Tenant Office Building	11.65	733	9
Holland Construction	715 Single Tenant Office Building	11.65	928	11
Vivid eye care	630 Clinic	31.45	2,145	67
Orenco Barber Beauty	918 Hair Salon	19.3	834	16
Kumon®	590 Library	56.24	2,145	121
Orenco Station TOD		-	-	**6,358**

*Where only peak hour trip generation rates are available from ITE, and no close analogous land use is available, we assumed a default ratio of daily to peak hour trips of 10.
**Absent guidance from ITE, and assuming that drinking establishments have a lower daily to peak hour ratio that restaurants, we assumed a ratio of 8.0.

PARKING GENERATION

Residential parking supply and demand recorded for the Orenco Station TOD project were compared to the number of parking stalls as well as occupancy rates from the 2010 ITE *Parking Generation* manual. There are 10 apartment complexes and condominiums at Orenco Station TOD. Each of them has its own parking garage, parking lot, or designated on-street parking (see Table 2 for details).

For the residential component in the ITE *Parking Generation* manual, "221 Low/Mid-Rise Apartment" (rental dwelling units) are defined as units located in rental buildings that are up to four stories (floors) in height. This is the best match for five apartment buildings (Platform 14, Tessera, Orchards I & II, Nexus, Alma Gardens) in the Orenco Station TOD. The average parking supply ratio reported by ITE is 1.4 parking spaces per dwelling unit at both urban and suburban sites (68 study sites).

For the ITE land use category 221: Low/Mid-Rise Apartment (urban location), the average peak period parking demand from 40 study sites is 1.20 vehicles per dwelling unit with standard deviation of 0.42, a range of 0.66–2.50, an 85th percentile value of 1.61, and a 33rd percentile value of 0.93. Besides the average rate, the ITE manual also provides the best-fitting regression line for estimating total parked vehicles as a function of the total number of dwelling units:

$$P = 0.92x + 4$$

Where P = parked vehicles and x = dwelling units

For the residential component in the ITE *Parking Generation* manual, "222 High-Rise Apartment" (rental dwelling units) are defined as units located in rental buildings that have five or more levels (floors). This is the best match for three apartment buildings (Hub 9, Rowlock, Vector). The average parking supply ratio reported by ITE is 2.0 parking spaces per dwelling unit at central city, not downtown (CND) and urban central business district (CBD) sites.

For the ITE land use category 222: High-Rise Apartment (Central City, Not Downtown), the average peak period parking demand from 7 study sites is 1.37 vehicles per dwelling unit with standard deviation of 0.15, a range of 1.15–1.52, an 85th percentile value of 1.52, and a 33rd percentile value of 0.38. Besides the average rate, the ITE manual also provides the best-fitting regression line for estimating total parked vehicles as a function of the total number of dwelling units:

$$P = 1.04x + 130$$

Where P = parked vehicles and x = dwelling units

For the residential component in the ITE *Parking Generation* manual, "230 Residential Condominium/Townhouse" is defined as ownership units that have at least one other owned unit within the same building structure. This is the best match for the two condo projects (Club 1201 and Q Condos). The average parking supply ratio reported by ITE is 1.4 parking spaces per dwelling unit.

For the ITE land use category 230 Residential Condominium/Townhouse, the average peak period parking demand from 12 study sites is 1.38 vehicles per dwelling unit with standard deviation of 0.24, a range of 1.04–1.96, an 85th percentile value of 1.52, and a 33rd percentile value of 1.28. Besides the average rate, the ITE manual also provides the best-fitting regression line for estimating total parked vehicles as a function of the total number of dwelling units:

$$P = 1.26x + 9$$

Where P = parked vehicles and x = dwelling units

As shown in Table 5, the average actual parking supply for all residential units in the apartments and condominiums of the Orenco Station TOD is 2,350 spaces total or 1.21 parking spaces per unit. The average parking supply for the residential uses at Orenco Station TOD is lower than the average by ITE's guideline (1.59 spaces per unit).

The peak occupancy of parking spaces in all the residential parking areas is at 10:00 pm. We were not able to acquire permission to collect parking occupancy data for Nexus Apartment and Q Condos. These two residential complexes are excluded in the parking demand analysis. For the residential component of the Orenco TOD, the peak parking demand relative to occupied units is 0.63 spaces/occupied unit. The actual demand (860 spaces) is much lower than both the ITE estimate of 1,770 (occupied units only) based on the average parking generation rate and the ITE estimate of 1,537 (occupied units only) based on the regression equation.

Computing peak parking demand for commercial uses is tricky. So much of the parking is shared with transit park-and-ride and residential uses. In the final draft of this paper, we will compare total parking supply for all uses a la ITE to total supply at the Orenco Station TOD, and total parking demand for all uses a la ITE to total demand at the Orenco Station TOD.

TABLE 5 Comparison of Residential Parking Supply and Demand between Orenco Station TOD and ITE Guidelines

Residential					
		Supply		***Peak period demand (occupied unit only)***	
		Parking spaces per unit	***Total parking spaces***	***Vehicles per unit***	***Total parked vehicles***
ITE guideline: 221 Low/Mid-Rise Apartment		1.4	1,488	1.20	731
	Platform 14	0.60	107	0.46	77
	Tessera	1.25	381	0.73	207
	Orchards I & II	1.31	151	0.76	86
	Nexus	1.27	535	-	-
	Alma Gardens	1.22	55	1.09	49
ITE guideline: 222 High-Rise Apartment		2.0	1,218	1.37	749
	Hub9	0.98	121	0.67	77
	Rowlock	0.72	184	0.51	122
	Vector	0.67	155	0.40	77
ITE guideline: 230 Condominium		1.4	381	1.38	290
	Club 1201	2.59	543	0.79	165
	Q Condos	1.90	118	-	-
ITE guideline		**1.59**	**3,087**	**1.30**	**1,770**
Orenco Station TOD		**1.21**	**2,350**	**0.63**	**860**

PARKING DEMANDS FOR DIFFERENT LAND USES

At the Orenco Station TOD, there are parking lots, parking structures, and on-street parking. We categorize parking as either residential or public, including park-and-ride and commercial users. The public parking consists of: Hub 9 – on-street parking; Rowlock – on-street parking and first-floor shared parking between retail customers and residents; Vector – first-floor park-and-ride parking open to retail customers between 2 pm to 12 am, and first-floor shared parking between retail customers and residents; and on-street parking at Platform 14, Orchards at Orenco, Nexus, Tessera, and Orenco Station Parkway.

The parking demands for the residential and public during the survey day are shown in Figure 3. The residential parking demands are low at midday and peak at night. Around 25 percent of the parking spaces are occupied from 9 am in the morning to 3 pm in the afternoon. The demand starts to increase after 3 pm in the afternoon until it hits a peak at midnight. The peak occupancy rate is about 50 percent. The public parking demands vary during the day. The demand starts about 45 percent from 9 am and increase until it hits its morning peak at 12 pm. The morning peak occupancy rate is about 60 percent. The demand drops

to about 40 percent at 2 pm and starts to increase again until it hits its afternoon peak at 6 pm. The afternoon peak occupancy rate is about 65 percent. Finally, the demand drops to about 60 percent at 10 pm.

The parking occupancy rate for public parking is higher than residential parking. This clearly shows the benefit of sharing parking among different users at TODs. However, the peak parking occupancy rates are still only 65 percent of the parking supply, meaning that even in the TOD with relatively low parking ratios, parking is oversupplied.

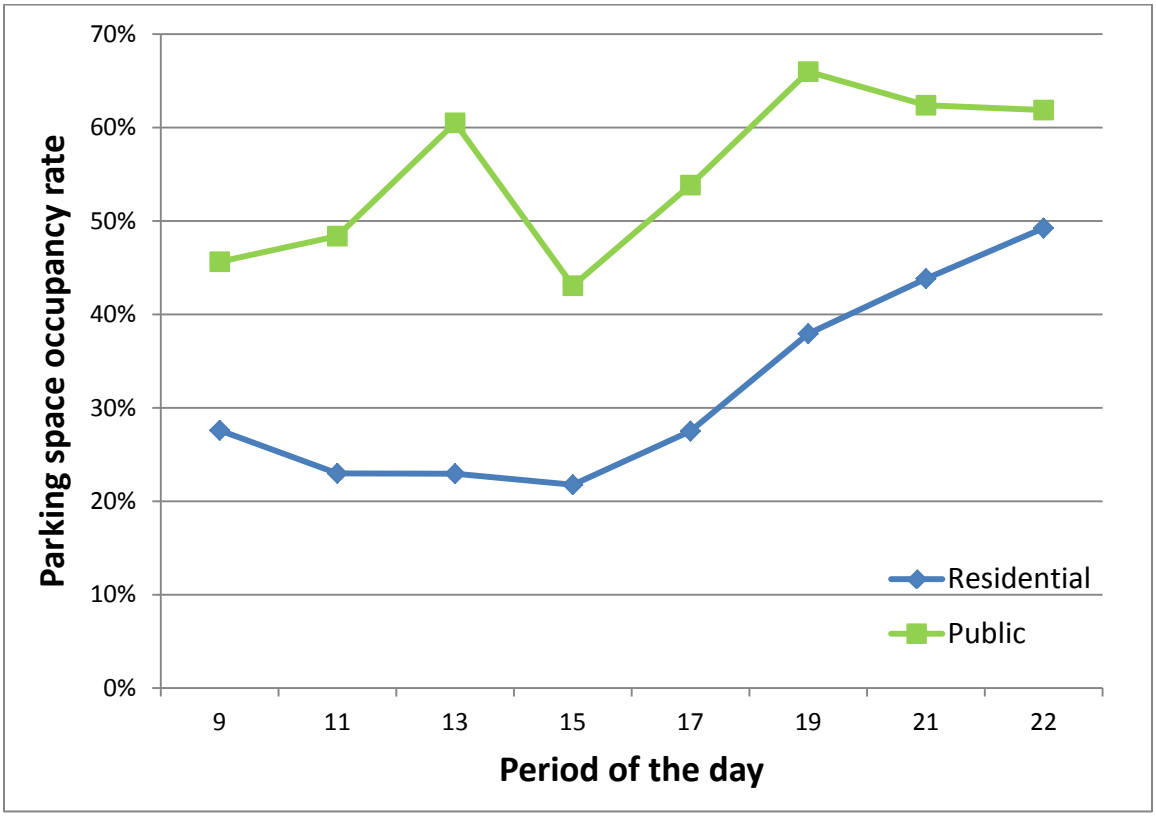

FIGURE 3 Parking Space Occupancy Rate for Different Uses at Orenco Station TOD

CONCLUSION AND DISCUSSION

Firstly, Table 6 compares the final mode shares for the Orenco Station TOD to those of our original five TOD sample. It has a higher walk mode share than the others, something we anticipate due to the size of the site and exchange of trips within the site. Its transit mode share is at the low end of the sample range, something we also anticipated. Overall, Orenco Station TOD's auto share of trips compares favorably with the others.

Secondly, Table 6 compares vehicle trip reductions for the Orenco Station TOD to those of our original five TOD sample. The actual vehicle trips we observed to/from/within the Orenco Station TOD on the survey day totaled 6,358, which is 58.5 percent of the ITE expected value. This is not as deep a discount as in some of the smaller TODs studied originally, but is deeper than the discount for Englewood, the largest and most auto-oriented TOD in our original study. As posited above, the size of the site and mix of

368 housing types may militate against a very low vehicle trip generation rate. In subsequent analyses, we will
369 attempt to isolate trips for Zone 1 and compare its vehicle trip generation rate to ITE.

370 Finally, Table 6 compares residential parking supply and demand for the Orenco Station TOD to those of
371 our original five TOD sample. The parking generation rate for Orenco Station, on a per dwelling unit
372 basis, is the lowest of all TODs studied except Rhode Island Row. It reflects the character of the
373 residential development right next to the LRT station. It is mid-rise, parking is unbundled, and
374 commercial parking in the garages is paid.

375 **TABLE 6 Comparison of Orenco Station TOD and other TODs Studied**

Average Mode Shares for TODs Studied

TOD	*Count*	*Count for modes*					
		Walk	*Bike*	*Bus*	*Rail*	*Auto*	*Other*
Redmond	1,981	18.9%	1.7%	13.0%	NA	64.9%	1.5%
Rhode Island Row	8,451	16.6%	0.3%	9.3%	27.2%	42.5%	4.0%
Fruitvale	16,558	28.3%	4.3%	15.2%	26.1%	23.0%	3.1%
Englewood	14,073	19.2%	3.8%	3.3%	13.6%	59.7%	0.2%
Wilshire/Vermont	11,043	27.4%	2.2%	21.1%	20.1%	25.9%	3.4%
Orenco Station	15,495	45.8%	2.5%	3.9%	16.0%	31.4%	0.4%

Average Vehicle Trip Reductions Relative to ITE Rates

TOD	*ITE vehicle trips*	*Actual vehicle trips*	*% of ITE trips*	*% reduction*
Redmond	1,767	661	37.4%	62.6%
Rhode Island Row	5,808	2,017	34.7%	65.3%
Fruitvale	5,899	3,056	51.8%	48.2%
Englewood	13,544	9,460	69.8%	30.2%
Wilshire/Vermont	5,180	2,228	43.0%	57.0%
Orenco Station	10,859	6,358	58.5%	41.5%

Residential Parking Supplies as a Percentage of ITE, and Residential Peak Parking Demand as a Percentage of Actual Supplies

TOD	*ITE supply (spaces per unit)*	*TOD supply (spaces per unit)*	*TOD peak demand (occupied spaces per unit)*	*TOD supply as % of ITE supply*	*TOD peak demand as % of TOD supply*
Redmond	2.0	1.19	0.86	59.5%	72.3%
Rhode Island Row	1.4	0.81	0.44	57.9%	54.3%
Fruitvale	1.4	NA	1.02	NA	NA
Englewood	1.4	1.6	1.29	114.3%	80.6%
Wilshire/Vermont	2.0	1.10	0.81	55.0%	73.6%
Orenco Station	1.6	1.2	0.63	39.4%	52.5%

376

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