MEMORANDUM

To:	Stephen S. Rolle, P.E., Commissioner Department of Transportation & Mobility City of Worcester
From:	Bill Scully, PE, RSP1 Lisa Juan, PE Peyton Graham Kimley-Horn and Associates, Inc.
Date:	February 25, 2025
Subject:	4 Brandt Lane ZB-2024-098

Kimley-Horn received the City of Worcester's Department of Transportation & Mobility (DTM) comments dated January 23, 2025, regarding the review of the *Traffic Impact, Access, and Parking* Study (TIAPS) for Grafton *Woods, 4 Brandt Lane, Updated October 2024.* This proposed development will include five (5) residential buildings totaling 491 dwelling units and 4,500 square feet of ground floor commercial space in one (1) building, Building 5. Building 5, with the ground floor commercial space, would be located adjacent to Grafton Street (Route 122). The primary Site Driveway is along Brandt Lane, and a secondary Site Driveway is along Pine Hill Road. Kimley-Horn prepared an initial response to DTM Comments to ZBA dated February 6, 2025, and the City of Worcester DTM provided a response letter dated February 10, 2025. These letters are included in **Attachment A** for reference.

The following summarizes the outstanding items, specifically the updated forecasts and analyses, identified in the letters from the City of Worcester's DTM dated January 23, 2025, and February 10, 2025. Additionally, this memo provides an update on the Roosevelt School Site Improvements, an updated parking analysis to reflect the change in land use assumption setting/location from dense multi-use urban to general urban/suburban, and also some clarifications displaying potential Grafton Woods (Route 122) corridor improvements.

As is demonstrated herein, the updated analysis showed the following key items:

- While the project will result in a measurable amount of vehicle trips added to the abutting network compared to the original analysis, the impact of this additional traffic is relatively small as it is anticipated site traffic will be dispersed almost evenly north and south of the site.
- Although the site drive exiting movement may experience some long delays on the single lane approach to Grafton Street, the delays are incurred by residents of the project with little effect on Grafton Street traffic movement.
- The traffic signal warrant criteria is **NOT** satisfied for the site drive intersection with Grafton Street.

- It is concluded that a southbound left turn lane **NOT** be installed at the site drive based on the analysis of MassDOT criterion, the level of service analysis, and the physical conditions of Grafton Street where a wide shoulder exists in the area of the site drive and is capable of accommodating bypass traffic.
- Even with updated assumptions and analysis as requested by the DTM, the proposed parking supply is more than sufficient to meet the anticipated parking needs of the development with surplus of parking resulting. This updated analysis again supports providing **less** parking supply than current zoning would require.
- The updated analysis has not altered the currently proposed mitigation plan for the street sections in the immediate project area as well as the proposed Transportation Demand Management (TDM) plan, which encourages alternative modes of travel and reduces the amount of vehicle trip generation.

TRIP GENERATION

Trip generation calculations for the proposed development were performed using the Institute of Transportation Engineers' (ITE) Trip Generation Manual, 11th Edition. The trip generation for the proposed development was determined using ITE Land Use Code (LUC) 221 (Multifamily Housing (Mid-Rise)) and LUC 822 (Strip Retail Plaza (<40k)). In the TIAPS dated October 2024, the setting/location for the residential land use used dense multi-use urban that is described as *a developed area with a mix of residential, commercial, and office uses situated closely together, promoting walking and transit use with good pedestrian access and diverse land uses within a compact space*. However, the City's DTM requested that the setting/location assumption be changed to general urban/suburban, which is referred to as *a typical urban or suburban area with mostly single land uses, primarily car-dependent access, and less pedestrian connectivity*.

The following table updates the trip generation estimates and also compares the updated forecasts with those used in the original traffic analysis. The change in setting/location resulted in an increase of 44 vehicle trips (22 entering and 22 exiting) during the AM peak hour and 63 vehicle trips (23 entering and 40 exiting) during the PM peak hour. The trip generation worksheets are found in **Attachment B**.

The updated trips were used to develop updated Build peak hour volume networks using the same trip distribution assumptions from the original report. While there is a primary drive, there are two Site Driveways for the proposed development and trips can utilize both driveways. For the purposes of this analysis, it is assumed that Buildings 1 to 4 use the Brandt Lane Site Driveway and Building 5 uses both the Brandt Lane Site Driveway and the Site Driveway off Pine Hill Road. The updated network diagram is included in the appendix to this response.

It should be noted that although an updated analysis was completed using more conservative trip models to estimate site generated trips, it is believed that the project will generate traffic more in line with the original estimate for several reasons. First, since the pandemic, the **"work from home"** (WFH) practice has remained fairly strong. Some of the latest studies indicate that in Massachusetts, the WFH group is at the 25% to 30% level. It is common for many businesses in the current environment to allow staff to work 1-2 days at home, some businesses allow for more. With that backdrop, the project is

being designed with amenities to encourage and accommodate the WFH residents with co-workspace and office equipment.

AM Peak Hour (PM Peak Hour)						
Future Land Use (ITE Code)	**Scale**	**Setting/Location**	**Daily[1]**	**Total Peak Hour Trips**	**Entering Trips**	**Exiting Trips**
Multifamily Housing (Mid-Rise) (221)	491 dwelling units	Dense Multi-Use Urban	2,230	138 (128)	20 (94)	118 (34)
		General Urban/Suburban		182 (191)	42 (117)	140 (74)
Strip Retail Plaza (<40k) (822)	4,500 square feet	General Urban/Suburban	420	11 (30)	6 (15)	5 (15)
Net Change in Total Vehicle Trips		**Dense Multi-Use Urban**	**2,650**	**149 (158)**	**26 (109)**	**123 (49)**
		General Urban/Suburban		**193 (221)**	**48 (132)**	**145 (89)**
Change in Vehicle Trips				**+44 (+63)**	**+22 (+23)**	**+22 (+40)**

[1] Setting/Location: General Urban/Suburban

Additionally, the site is situated within close proximity of commercial land uses, including banks, coffee shops, grocery stores, and other uses. By incorporating safe and pleasant sidewalk connections and other proposed mitigation, the project will encourage walking, biking and transit use that is anticipated to encourage other modes for certain types of trips and result in lower vehicle trip generation. Consequently, based on these reasons, we are confident that peak hour site trip generation to be lower than estimated in this update – again, more similar to the original estimates.

LEVEL OF SERVICE/CAPACITY ANALYSIS

With updated forecasts, the original level of service/capacity analyses was also updated for the Build conditions. Similar to the original analysis, the new analyses were performed using the Synchro Software Package (Version 12), which utilizes methodologies contained in the *Highway Capacity Manual (6th Edition)* for signalized and unsignalized intersections. The same methods were used in the original analyses. For intersections with timing configurations that are incompatible with *HCM 6th Edition*, the built-in Synchro analysis methodology is used. According to the *HCM 6th Edition*, capacity is defined as the maximum number of vehicles that can pass over a particular road segment or through a particular intersection within a fixed time duration. The analyses results are described qualitatively by Level of Service (LOS) to indicate the operating characteristics of a road segment or intersection. LOS is defined as a qualitative measure that describes operational conditions and motorist perceptions within a traffic stream and relates to the level of delay experienced. The *HCM 6th Edition* defines six levels of service, LOS A through LOS F, with 'A' being the best and 'F' being the worst. Typically, a LOS D or better at signalized and unsignalized intersections is preferred, although lower levels are

increasingly tolerated during peak travel hours, particularly in urban settings. The updated Build capacity analyses results were compared with the for Existing and 2030 Future No-Build, for the study area intersections.

Overall, the traffic operations remain fairly similar to the original analysis that used the setting/location of dense multi-use urban. Listed below are key findings:

- The two (2) signalized intersections, Grafton Street (Route 122) & Dalton Street/S&S Driveway and Grafton Street (Route 122) & Sunderland Road, operate at an overall LOS D or better during both the AM and PM peak hour. The proposed development resulted in small increases in vehicle delay at the two intersections.
- For the main Site Driveway, Brandt Lane, exiting movements are anticipated to operate at LOS F during the AM and PM peak hours, but with relatively short vehicle queues. Note that the delay in the exit movement impacts the proposed development and is not anticipated to substantially increase delays along Grafton Street (Route 122). This condition could be alleviated by converting the single-lane exit approach to a two lane approach. However, it is our preference to minimize the pedestrian crossing distance at this location for safety reasons and have the project's residents incur delays.
- Entering the site, the southbound left turn movement can do so with minimal delays and will operate at LOS A and LOS B during those same two peak hours.
- The Site Driveway off Pine Hill Road, while expected to be a low volume driveway, is anticipated to operate at LOS A at all approaches for the eastbound left-turn entering movement and southbound exiting movement.
- The revised Build conditions with the higher trip generation forecasts will result in higher delays to motorists exiting the unsignalized driveways or minor street approaches, including Jennings Street, Jolma Road, and AutoParts Drive. For example, exiting the AutoParts Drive during the PM peak hour, average vehicle delays will increase from 30.8 seconds to 36.4 seconds. Another example is during the morning peak hour at Jennings Street, the exiting movement will experience an increase in average vehicle delay from 23.7 seconds to 28.6 seconds. These changes in delay will tend to not be noticeable to the average motorist. In some cases, the LOS is reduced by one level but with no or minimal change in the 95th percentile vehicle queue estimate.

While the updated projected volumes result in some additional vehicle delays at the study intersections compared to the original analysis, particularly the Brandt Lane site exit drive, the updated analysis has **NOT** altered the proposed initial mitigation plan for the proposed development at this time. Again, we expect the actual site trip generation to be more focused on the original study results.

The table below summarizes the intersection capacity analysis for the weekday AM and PM peak hours for the 2030 Future Build Conditions. The intersection analysis worksheets are in **Attachment C**.

	Intersection	Traffic Control	Movement	2023 Existing						2030 No-Build						2030 Build					
				AM Peak Hour			PM Peak Hour			AM Peak Hour			PM Peak Hour			AM Peak Hour			PM Peak Hour		
				Delay (s)	LOS	95th % Queue Length (ft)	Delay (s)	LOS	95th % Queue Length (ft)	Delay (s)	LOS	95th % Queue Length (ft)	Delay (s)	LOS	95th % Queue Length (ft)	Delay (s)	LOS	95th % Queue Length (ft)	Delay (s)	LOS	95th % Queue Length (ft)
1	Grafton Street (Route 122) & Jennings Street	One-Way Stop Control	WB	23.2	C	42.5	33.5	D	60	23.7	C	45	36.3	E	60	28.6	D	50	50.5	F	90
			SBL	8.6	A	25	9.4	A	25	8.7	A	25	9.7	A	25	8.9	A	25	9.9	A	25
2	Grafton Street (Route 122) & Dalton Street/S&S Driveway	Signalized	NBL	6.5	A	25	7.0	A	30	6.4	A	25	6.8	A	30	6.6	A	23	7.3	A	33
			NBT	7.7	A	167	8.9	A	245	7.8	A	173	9.2	A	261	8.5	A	212	9.9	A	290
			Approach	7.6	A	-	8.8	A	-	7.7	A	-	9.0	A	-	8.4	A	-	9.7	A	-
			EB	23.6	C	82	19.1	B	61	17.3	B	88	17.3	B	64	17.9	B	91	17.3	B	67
			Approach	23.6	C	-	19.1	B	-	17.3	B	-	17.3	B	-	17.9	B	-	17.3	B	-
			WBT	26.5	C	49	28.9	C	#84	24.6	C	48	27.4	C	83	24.8	C	49	27.8	C	84
			WBR	0.2	A	-	0.6	A	-	0.2	A	0	0.6	A	-	0.2	A	0	0.6	A	25
			Approach	21.6	C	-	21.7	C	-	20.2	C	-	20.5	C	-	20.4	C	-	20.8	C	-
			SBL	2.8	A	25	2.9	A	25	2.7	A	25	2.9	A	25	2.8	A	25	2.9	A	25
			SBT	7	A	115	6.8	A	113	6.6	A	121	6.4	A	121	6.8	A	131	7.1	A	146
			Approach	6.9	A	-	6.6	A	-	6.4	A	-	6.2	A	-	6.7	A	-	6.9	A	-
			Intersection	**11**	**B**	**-**	**10.3**	**B**	**-**	**9.5**	**A**	**-**	**9.9**	**A**	**-**	**9.8**	**A**	**-**	**10.2**	**B**	**-**
3	Grafton Street (Route 122) & Starbucks Entrance/Jolma Road	Two-Way Stop Control	NBL	9.2	A	25	8.6	A	0	9.2	A	25	8.8	A	0	9.3	A	25	9.1	A	0
			WB	33.6	D	25	34.3	D	30	30.9	D	25	40.8	E	30	37.4	E	25	52.3	F	35
			SBL	8.6	A	0	9.9	A	0	8.6	A	0	10.2	B	0	8.9	A	0	10.5	B	0
4	Grafton Street (Route 122) & Auto Parts Driveway	One-Way Stop Control	WB	19.3	C	25	27.5	D	25	19.1	C	25	30.8	D	25	21.6	C	25	36.4	E	25
			SBL	8.8	A	0	9.3	A	0	8.8	A	0	9.6	A	0	9.1	A	0	9.8	A	0
5	Grafton Street (Route 122) & Roosevelt Elementary Driveway/Brandt Lane	Two-Way Stop Control	NBL	8.9	A	0	8.8	A	0	9.0	A	0	9.0	A	0	9.0	A	0	9.0	A	0
			EB	19.9	C	25	24.6	C	25	19.8	C	0	27.4	D	25	24.7	C	0	44.8	E	25
			WB	22.8	C	25	37.5	E	0	23.3	C	25	45.5	E	25	70.1	F	140	98.2	F	110
			SBL	8.8	A	0	0.0	A	0	8.8	A	0	0.0	A	0	8.9	A	25	10.4	B	25

	Intersection	Traffic Control	Movement	2023 Existing						2030 No-Build						2030 Build					
				AM Peak Hour			PM Peak Hour			AM Peak Hour			PM Peak Hour			AM Peak Hour			PM Peak Hour		
				Delay (s)	LOS	95th % Queue Length (ft)	Delay (s)	LOS	95th % Queue Length (ft)	Delay (s)	LOS	95th % Queue Length (ft)	Delay (s)	LOS	95th % Queue Length (ft)	Delay (s)	LOS	95th % Queue Length (ft)	Delay (s)	LOS	95th % Queue Length (ft)
6	Grafton Street (Route 122) & Roosevelt Elementary Driveway/Pine Hill Road	Two-Way Stop Control	NBL	9.1	A	25	8.7	A	0	9.3	A	25	8.9	A	0	9.5	A	25	9.0	A	0
			WB	27.5	D	37.5	29.5	D	25	26.2	D	25	32.8	D	25	34.3	D	40	47.9	E	35
			SBL	8.9	A	25	9.4	A	25	8.9	A	25	9.7	A	25	9.0	A	25	10.0	A	25
7	Grafton Street (Route 122) & Sunderland Road	Signalized	NBT	39.5	D	#312	39.9	D	#319	45.1	D	#335	48.6	D	#319	51.0	D	#352	72.3	E	#406
			NBR	40.4	D	#287	20.3	C	98	45.1	D	#304	20.6	C	98	45.1	D	#304	20.6	C	102
			Approach	**39.9**	**D**	**-**	**34.7**	**C**	**-**	**45.1**	**D**	**-**	**41.2**	**D**	**-**	**48.3**	**D**	**-**	**59.8**	**E**	**-**
			EB	58	E	#229	41.0	D	#141	56.2	E	#230	41.3	D	#141	56.5	E	#230	44.3	D	#150
			Approach	**58**	**E**	**-**	**41.0**	**D**	**-**	**56.2**	**E**	**-**	**41.3**	**D**	**-**	**56.5**	**E**	**-**	**44.3**	**D**	**-**
			WBL	16.6	B	78	32.0	C	#205	16.6	B	79	36.8	D	#205	16.6	B	79	36.8	D	#225
			WBT	11.3	B	106	37.2	D	#364	11.2	B	115	44.9	D	#364	11.2	B	108	48.0	D	#405
			Approach	**13.1**	**B**	**-**	**35.1**	**D**	**-**	**13.0**	**B**	**-**	**41.6**	**D**	**-**	**13.0**	**B**	**-**	**43.4**	**D**	**-**
			SBL	11	B	62	11.7	B	67	11.3	B	62	12.3	B	67	12.3	B	65	12.8	B	71
			SBT	13.1	B	155	13.4	B	164	13.1	B	160	13.3	B	164	14.3	B	192	14.1	B	194
			Approach	**12.4**	**B**	**-**	**12.8**	**B**	**-**	**12.5**	**B**	**-**	**13.0**	**B**	**-**	**13.4**	**B**	**-**	**13.7**	**B**	**-**
			Intersection	**28.8**	**C**	**-**	**29.5**	**C**	**-**	**30.9**	**C**	**-**	**34.2**	**C**	**-**	**32.0**	**C**	**-**	**40.3**	**D**	**-**
8	Pine Hill Road and Site Driveway	One-Way Stop Control	SBL	[1]						[1]						8.6	A	0	8.5	A	0
			EBL													7.3	A	0	7.3	A	0

[1] Intersection does not exist

SIGNAL WARRANT ANALYSIS

The primary site driveway for the proposed development is Brandt Lane. The one-way STOP controlled intersection of Grafton Street (Route 122) at Brandt Lane was evaluated to determine whether this intersection warranted a traffic signal based on the traffic signal warrants per the *Manual on Uniform Traffic Control Devices* (MUTCD). There are nine (9) warrants, but for the purposes of this analysis, only Warrant 1 (Eight-Hour Vehicular Volume) and Warrant 2 (Four-Hour Vehicle Volume) were evaluated. However, this intersection does not meet the warrants, therefore a traffic signal is **NOT** recommended. The signal warrant analysis can be found in **Attachment D**.

Intersection	Warrant	Warrant Satisfied?
Grafton Street (Route 122) at Brandt Lane	Warrant 1: Eight-Hour Vehicle Volume	No
	Warrant 2: Four-Hour Vehicle Volume	No

LEFT-TURN LANE CRITERIA

The question of providing a dedicated southbound left turn lane at the development's site drive. This was evaluated using the left-turn lane criterion and method presented in the MassDOT *Project Development and Design Guide*. **Figure 1** depicts the Criteria for Left Turn Lanes for unsignalized intersections, two-lane roads, and streets from the MassDOT *Project Development and Design Guide*. The posted speed limit along Grafton Street (Route 122) is currently 35 miles per hour (mph) and was used as the design speed. It is noted that the City has recently adopted a citywide 25 mph speed limit but it is not clear yet if and when that would be imposed on the section of Grafton Street in our study area.

During the AM peak hour, the opposing volume in the northbound direction is 601 vehicles per hour, the advancing motor vehicle volume in the southbound direction is 667 vehicles per hour, and less than 5% is turning left. As a result, a left-turn lane is not warranted in the AM peak hour. Analyzing the PM peak hour, the opposing volume in the northbound direction is 851 vehicles per hour, and the advancing motor vehicle volume in the southbound direction is 713 vehicles per hour, and approximately 8.5% of that volume is estimated to be turning left. Based on that finding, the left-turn lane criterion is satisfied for the PM peak hour.

In reviewing the existing pavement section on Grafton Street, a southbound left-turn lane is potentially feasible within the existing pavement if the shoulders are restriped and reduced in width substantially. This action will reduce the shoulders to a minimal curb offset width (i.e., 1 foot off the curb). Currently, the shoulder along the west side of Grafton Street is used by parents during arrival and departure school periods. As discussed later in this memorandum, the site improvements in process will alleviate the condition the waiting parents create on this section of Grafton Street. Once the school project is completed, there will be no further situations where parents are queued and waiting on the street for the 20-minute period in the afternoon at the end of the school day. With the existing shoulder cleared, there would be room to maneuver past any vehicles waiting to turn left into Brandt Lane. This would obviate the need to mark a designated left turn lane. Furthermore, the level of service analysis showed

that this left turn-entering movement could be accomplished with minimal vehicle delays and an LOS A during peak hours.

The analysis showed that with the MassDOT left turn lane criteria satisfied only during the PM peak hour, the conservatively estimated left turn entering volume is relatively low (i.e. about one vehicle per minute), and the full shoulder on Grafton Street at this location would allow southbound through motorists to pass by waiting vehicles, it is not proposed to alter pavement markings to define a southbound left turn lane at the Brandt Lane site drive.

A. Unsignalized Intersections, Two-Lane Roads and Streets:

Design Speed	Opposing Volume (motor vehicles per hour)	Advancing Motor Vehicle Volume (vehicles per hour) 5% Left Turns	10% Left Turns	20% Left Turns	30% Left Turns
30 mph or less	800	370	265	195	185
	600	460	345	250	225
	400	570	430	305	275
	200	720	530	390	335
40 mph	800	330	240	180	160
	600	410	305	225	200
	400	510	380	275	245
	200	640	470	350	305
50 mph	800	280	210	165	135
	600	350	260	195	170
	400	430	320	240	210
	200	550	400	300	270
60 mph	800	230	170	125	115
	600	290	210	160	140
	400	365	270	200	175
	200	450	330	250	215

Figure 1. Left-Turn Lane Criteria (Source: *Project Development and Design Guide)*

ROOSEVELT SCHOOL SITE IMPROVEMENTS

From the outset of analysis for the proposed development, city staff input as well as public officials indicated that there was an issue along Grafton Street due to the location of the Roosevelt Elementary School, located at 1006 Grafton Street. More specifically, parents who are picking children up in the afternoon when school ends, are required to wait on Grafton Street for approximately 20 minutes before being allowed to enter the school site for child pick up so as not to interfere with school bus movement. The waiting vehicles use the Grafton Street shoulder and this queue extends from the school driveway to the north for more than 1,000 feet. The traffic study took the school activity into account and also collected traffic data during the critical school period. While it is recognized that the school parent pick-

up during the afternoon departure period creates some challenges, the effect on the proposed Grafton Woods project would be minimal given the short duration (i.e. 20 minutes) and the school departure time occurs several hours before the peak commuter hour occurs on Grafton Street. The Worcester Public Schools Department along with other city departments have developed site improvements to build a new/modified parking lot adjacent to the school as shown in **Figure 2**. The new parking lot would include room for parent pick-up and drop-off queuing and circulation to take place on site rather than having to wait on Grafton Street. The site improvements will include and the new parking area, resurfacing the existing parking area and reconstructing a portion of the sidewalk on the west side of Sunderland Road near Sunderland Woods and implement a traffic plan that would eliminate any conflicts between school bus traffic and parents picking up or dropping off students. The project is designed to move traffic away from the Roosevelt School entrance along Grafton Street, which is frequently congested during mornings and afternoons when drivers are parked along the shoulders of Grafton Street (Route 122) as well as using Pine Hill Road and AP Fish Seafood Market parking lot to wait for students.

The school project is fully designed and has been advertised for construction. It is expected to be completed within the next two years, potentially before the 2025 fall school year begins. Consequently, the school project should be completed prior to occupancy beginning in Grafton Woods.

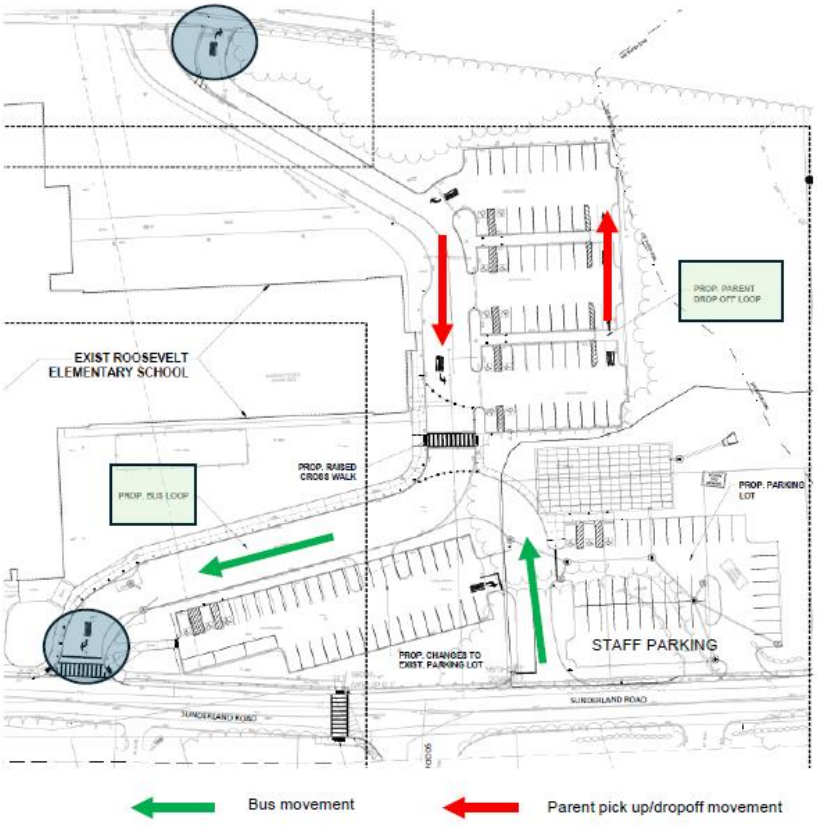


Figure 2. Roosevelt School Site Improvements Site Plan

PARKING ANALYSIS

With the DTM comments pertaining to the Institute of Transportation Engineers (ITE) Land Use Code setting related to trip generation estimates, the parking demand analysis was also updated with the assumed setting to be general urban/suburban rather than urban high density. The proposed development will be providing on-site parking either in a combination of open parking lots adjacent to the buildings or in the proposed two level parking deck located between Buildings 2 and 3. Building 5 will have some below grade parking as well. In total, there are 793 parking spaces proposed. Building 5 is set apart from Buildings 1 thru 4 and has 81 parking spaces on its immediate site.

In support of demonstrating less parking is needed for the proposed project, an analysis of parking demand for the proposed development was completed. Per the City of Worcester Zoning Ordinance, Section 7 – Off-Street Parking and Loading, for a multi-family dwelling residential, two (2) parking spaces per dwelling unit and commercial spaces (either retail sales or services), one (1) parking space per 300 square feet of gross floor area is required. Based on these requirements, a total of 997 parking spaces would be required per the zoning code. In general, providing two (2) parking spaces per unit for multifamily residential projects has been found to be excessive throughout the State and country for that matter. Providing the proposed 793 parking spaces results in a ratio of approximately 1.6 spaces per unit. In support of this proposed reduction, an updated analysis was completed estimating peak parking demands for the project as well as estimating parking demands per hour of the typical weekday to confirm that 793 spaces would be sufficient for this project.

In estimating the peaking demands, the estimating models published by the Institute of Transportation Engineers were used. Land uses have been grouped as accurately as possible into land use categories created by the ITE *Parking Generation Manual, 5th Edition.* The estimating models, including the ITE reference, are based on actual demand observations conducted at similar uses. The observed parking demands at existing multifamily developments would include resident, staff and visitor demands. The peak parking demand for the uses was determined based on the ITE models and rates, as applicable, to calculate parking demand using the 85th percentile rate because it provides an added safety factor by ensuring your parking supply can accommodate the higher demand experienced by a majority of sites, rather than just the average demand.

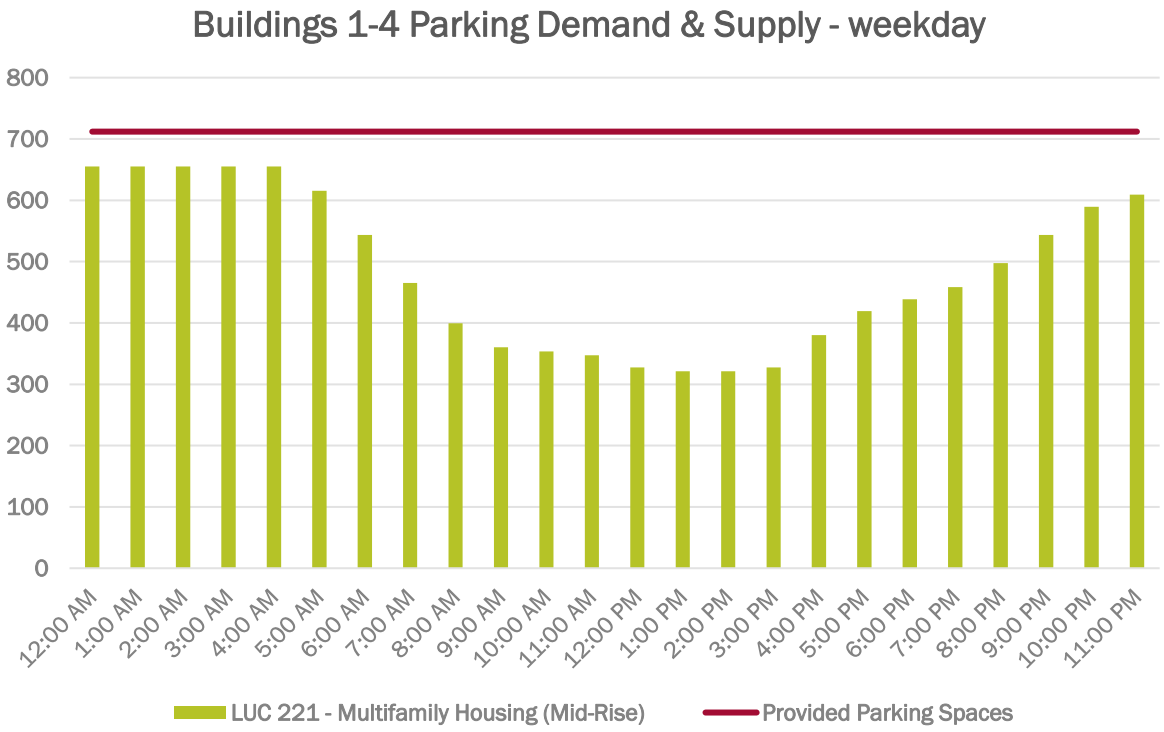
Building Group	ITE Land Use	ITE Code	Intensity	Weekday
Buildings 1-4	Multifamily Housing (Mid-Rise)	221	452 DU	655[1]
Building 5	Multifamily Housing (Mid-Rise)	221	39 DU	57[1]
	Shopping Center (Non-December)	820	4,500 GSF	10[2]
			Total	**732**

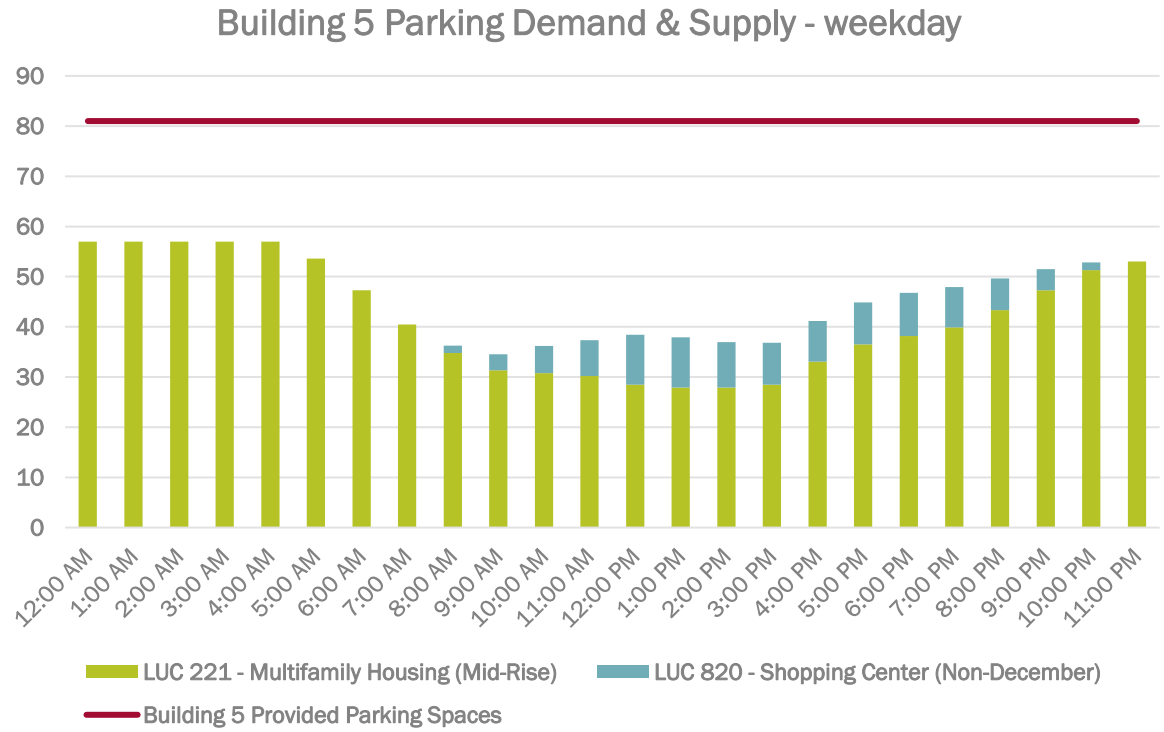
[1] Weekday includes Monday to Friday
[2] Weekday includes Monday to Thursday.

It was noted that the ITE *Parking Generation Manual, 5th Edition* does not provide data for LUC 822 (Strip Retail Plaza (<40k)), therefore, LUC 820 (Shopping Center) was used where time of day pattern data was available. The setting/location for the parking demands uses general urban/suburban, similar to the site generated trips is shown below. The detailed parking demand can be found in **Attachment E**.

The proposed development is predominantly residential with most of the spaces for Buildings 1 to 4 and served by the spaces close by. Not including Building 5, there are 712 parking spaces serving Buildings 1-4. Separate estimates were made for Buildings 1-4 and for Building 5 given their location on the overall site. The updated analysis using the more conservative assumption of land use setting and 85th percentile base demand estimate has shown that the peak demand for these four buildings in total is estimated to be 655 parked vehicles, resulting in a surplus of 57 spaces. Building 5 includes the ground floor commercial space and residential units on the upper floors. In relation to Building 5, there would be some level of shared parking as residential parking tends to peak overnight when there is no demand for commercial land use. Specifically for Building 5, the estimated peak parking demand for Building 5 also peaks overnight with an estimated demand of 57 parked vehicles. With 81 parking spaces provided, the peak demand for Building 5 would be well below the supply leaving a surplus of 24 spaces. The table below depicts the parking supply for each building group compared with the estimated peak parking demand. The charts below illustrate the estimated parking demands by hour of the day and compare them to the proposed parking supply. The first chart is for Buildings 1-4 and the second chart is for Building 5.

Building Group	Proposed Parking Supply Spaces	Estimated Peak Parking Demands	Surplus(+)/ Deficit (-)
Buildings 1-4	712	655	+57
Building 5	81	57	+24


Buildings 1-4 Parking Demand & Supply - weekday
800
700
600
500
400
300
200
100
0
12:00 AM
1:00 AM
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
7:00 AM
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
6:00 PM
7:00 PM
8:00 PM
9:00 PM
10:00 PM
11:00 PM
LUC 221 - Multifamily Housing (Mid-Rise)
Provided Parking Spaces


Building 5 Parking Demand & Supply - weekday
90
80
70
60
50
40
30
20
10
0
12:00 AM
1:00 AM
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
7:00 AM
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
6:00 PM
7:00 PM
8:00 PM
9:00 PM
10:00 PM
11:00 PM
LUC 221 - Multifamily Housing (Mid-Rise)
LUC 820 - Shopping Center (Non-December)
Building 5 Provided Parking Spaces

Based on this analysis, the estimated peak demands for the project for the 85th percentile rate, in total, as well as examined by the two main building groups remains well below the proposed parking supply. Consequently, it is concluded that more than sufficient parking supply is being provided by the project and there is full justification for providing less parking supply than zoning would require.

GRAFTON STREET (ROUTE 122) CORRIDOR

In response to questions and comments that occurred in discussions with City staff and at the initial ZBA hearing, there is a need for further discussion of Grafton Street in the area of the project and to clarify what actions could be taken along this section of the corridor. Grafton Street (Route 122) is a north-south, two-lane undivided roadway with a posted speed limit of 35 miles per hour (MPH). It is classified by the Massachusetts Department of Transportation (MassDOT) as an Urban Principal Arterial and is under the jurisdiction of the City of Worcester. In general, Grafton Street (Route 122) is an urban environment with sidewalks on both sides with multiple marked pedestrian crosswalks provided either at the fully signalized intersections or separately identified enhanced crossing with Rapid Rectangular Flashing Beacons (RRFBs). Shoulders are provided on both sides. While staff and the public have raised concerns about Grafton Street, it was not identified as part of the City's High Injury Network (HIN) as part of the recent Vision Zero plan development. During the course of the traffic analysis for the proposed Grafton Woods development, coordination was conducted with the DTM staff and as a result of those discussions and the analysis, a priority program evolved as part of the project's transportation mitigation plan. Actions included the following:

- Ensure ADA compliant and safe pedestrian connections to Grafton Street from the site,
- Enhance pedestrian and bicycle movement along Grafton Street in the area of the project that includes:
    - A proposed shared use reconstruction of the sidewalk into a shared use path between Pine Tree Road and approximately Jolma Road along the east side of the street.
    - Enhanced pedestrian crossings on Grafton Street near Jolma Road and Starbucks including an RRFB with potential curb extensions.
    - Work with WRTA and improve a bus stop with shelter, bench, sign with posted schedule.
- A Transportation Demand Management (TDM) Plan be adopted for the project that will include providing on-site bike parking, transit information and promotion information in the lobby of each building and information provided to residents of commercial uses nearby within walking and biking distances

The illustration (**Figure 3**) below depicts the current cross-section of Grafton Street. Within its approximately 60 foot wide right of way, there are two travel lanes, two shoulders that vary in width between 4 and 8 feet, and sidewalks along each side of which portions are in below or poor conditions.

There appears to be sufficient right of way to improve the accommodation of multimodal transportation along the corridor. Discussions with city staff indicate that a goal consistent with the recent City master plans is to create an improved multimodal corridor along Grafton Street into the Downtown area of the City. It is possible to create a shared use path along one side of the corridor in the area of the proposed development. The width of the corridor also suggests that it may be possible to provide buffered or protected bike lanes in the area of the proposed development and heading into the downtown area.

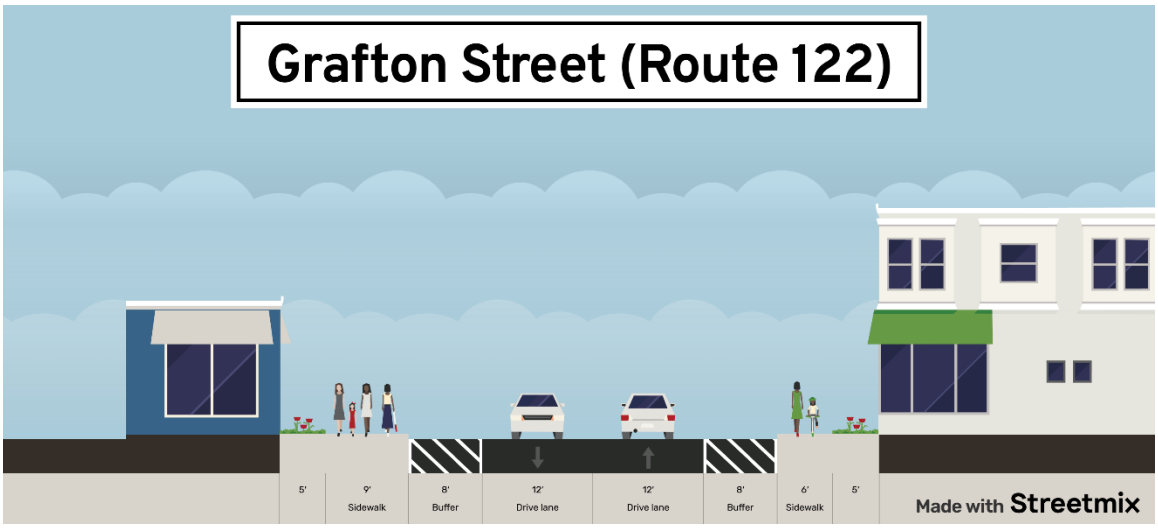


Figure 3. Grafton Street (Route 122) Typical Section Existing Conditions

Figure 4 illustrates a conceptual cross-section of an option to enhance Grafton Street. To enhance Grafton Street (Route 122) with multimodal features, there should be consideration of narrowing the travel lanes to 11 feet, converting the shoulders to buffered bicycle facilities, and installing a shared-use path on the east side abutting the proposed development with a landscape buffering zone.

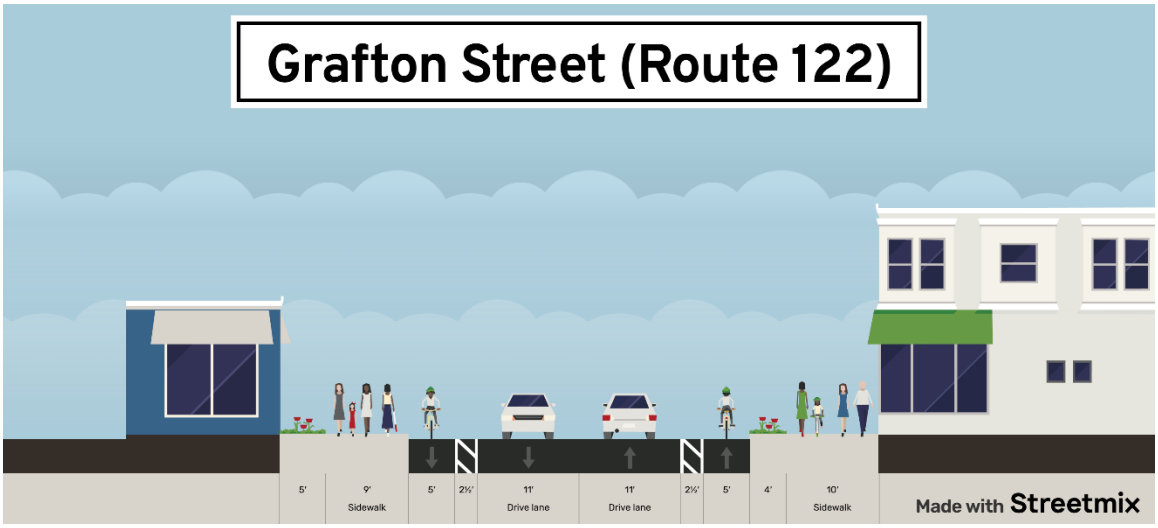


Figure 4. Grafton Street (Route 122) Typical Section Proposed Conditions

CONCLUSIONS AND MITIGATIONS

- The change in setting/location from dense multi-use urban to general urban/suburban resulted in an increase of 44 vehicle trips (22 entering and 22 exiting) during the AM peak hour and 63 vehicle trips (23 entering and 40 exiting) during the PM peak hour.
- The main Site Driveway, at Brandt Lane, exiting movements are anticipated to operate at LOS F during the AM and PM peak hours with relatively short vehicle queues. Note that the delay impacts the proposed development and is not anticipated to increase delays along Grafton Street (Route 122). It is the Applicant's preference that a single-lane exit approach be provided rather than widening the approach to reduce the average vehicle delay. The single lane is safer for pedestrians.
- The Site Driveway off Pine Hill Road is anticipated to operate at LOS A at all approaches for the westbound left-turn movement and southbound left-turn movement.
- The primary site driveway, Brandt Lane at Grafton Street (Route 122) does **NOT** warrant a traffic signal based on Warrant 1 and Warrant 2.
- While a southbound left-turn lane is feasible within the existing pavement if the shoulders are restriped, it is not recommended at this time. Guideline warrants for a dedicated southbound left-turn lane are only satisfied in the PM peak hour. The level of service analysis shows minimal delays in entering traffic, and a full shoulder is preferred.
- The Roosevelt Elementary School is constructing a new parking lot on the School site along Sunderland Road designed to accommodate parent pick up/drop off, move this waiting traffic off of Grafton Street, and avoid conflicts with school bus traffic.
- The updated parking analysis showed the estimated peak demands to continue to remain well below the proposed parking supply. It is concluded that more than sufficient parking supply is being provided by the project and there is full justification for providing less parking supply than zoning would require.
- The originally proposed transportation mitigation program, including the TDM Plan, remains valid for the proposed project.

LIST OF ATTACHMENTS

Attachment A. Correspondence

Attachment B. ITE Trip Generation

Attachment C. Capacity Analysis

Attachment D. Signal Warrant Analysis

Attachment E. Parking Demand

Attachment F. Figures

ATTACHMENT A

Correspondence

The City of WORCESTER

Department of Transportation & Mobility
Stephen S. Rolle, P.E., Commissioner
76 East Worcester Street, Worcester, MA 01604
P | 508-799-1300 x49500
mobility@worcesterma.gov

January 23, 2025

Russell Karlstad, Chair
Worcester Zoning Board of Appeals
City Hall
Worcester, MA 01608

RE: 4 Brandt Lane
ZB-2024-098

Dear Chair Karlstad,

The staff of the Department of Transportation & Mobility (DTM) has reviewed the plan set and other supporting materials for the above referenced project and offer the following:

1. With respect to the Traffic Impact, Access, and Parking Study
    a. We request an updated report be provided as the the peak hour trip generation calculations are based on rates for "Dense Multi-Use Urban" settings, which is not appropriate for the project setting and therefore underestimates anticipated peak period traffic levels. The trip generation and traffic analysis should be updated for a "General Urban/Suburban" setting.
    b. We request that after updating the traffic analysis, please confirm whether projected traffic volumes are sufficient to meet warrants for traffic signal control at the site driveway.
    c. Given the volume of traffic turning left from eastbound Grafton Street, we request that the consultant evaluate the need for and feasibility of providing a left turn lane from eastbound Grafton Street at the site driveway.

2. We concur with the consultant that the amount of parking proposed is adequate and we support the requested relief.

3. We support the inclusion of all Proposed Mitigation Measures on pages 4 and 5 of the Traffic Impact, Access, and Parking Study report dated October 2024 and ask they be conditions of approval.

4. We support the proposed Transportation Demand Management (TDM) measures outlined in the memo dated Thursday, January 23, 2025, from Bill Scully et. All to Victor Panak and ask they be conditions of approval.

5. To promote walkability, bikability, safety, and access for pedestrians and cyclists as required in the City's adopted Complete Streets Policy and the draft recommendations of the ongoing Now/Next and Worcester Mobility Action Plan master planning processes, we request:
    a. that the driveway across Pine Hill Rd be construction at sidewalk level for a minimum of 4 feet and then slope down to street level per City specifications as

determined by the Commissioner of Public Works & Parks and the Commissioner of Transportation & Mobility. Said driveway crossing shall be ADA compliant.

b. that the project reconstructs the sidewalk along its frontage on Grafton Street and down Pine Hill Rd to just beyond the driveway using cement concrete and granite curbing to City specifications as determined by the Commissioner of Public Works & Parks and the Commissioner of Transportation & Mobility.
c. the project reconstructs the curb ramps on both sides of Brandt Lane and Pine Hill Road to be ADA compliant path of travel to improve pedestrian safety and access to City specifications as determined by the Commissioner of Public Works & Parks and the Commissioner of Transportation & Mobility.
d. that that the internal bike storage has an access door leading into the building. The current design is external only.
e. that the project includes external bike racks near the front entrance of all buildings and recreational areas for short term resident and visitor use and that the racks comply with the Association of Pedestrian and Bicycle Professionals Guidelines.
f. that internal walkway, parking lots, etc. be ADA and MAAB compliant.

6. Request a condition that 20% of all spaces have Level 2 EV Chargers installed and the remaining spaces for employes and customers be made EV Ready with installation of empty conduit to be used for future buildout as demand increases.

7. Request a condition that all signs, pavement markings, and other materials used on the public way meet City specifications as determined by the Commissioner of Public Works & Parks and the Commissioner of Transportation & Mobility.

8. Request that if any construction activity damages the public sidewalk or other public infrastructure, the applicant is required to replace the damaged infrastructure at their own cost to City Specifications as approved by the Commissioner of Public Works & Parks and the Commissioner of Transportation & Mobility including making all sidewalks ADA compliant.

9. Requests that, prior to the issuance of a building permit, a formal Construction Management Plan be submitted for review and approval by the Department of Public Works & Parks and Department of Transportation & Mobility to ensure the negative impact to the right of way is minimized and mitigated appropriately.

If you have any questions or need additional information regarding this review, please do not hesitate to contact the Department at (508) 929-1300 x 49500.

Warmest Regards,

Todd M. Kirrane
Assistant Director of Transportation & Mobility

Kimley»Horn

February 8, 2025

Stephen S. Rolle, P.E., Commissioner
Department of Transportation & Mobility
76 East Worcester Street
Worcester, MA 01604

Re: Proposed Development 4 Brandt Lane (Prop. Grafton Woods)
Response to DTM Comments to ZBA (1/23/25)

Dear Commissioner Rolle,

We are in receipt of DTM comments made in regard to the traffic study and site design for the proposed Grafton Woods development off Brandt Lane at Grafton Street. On behalf of the applicant, we have reviewed these comments and prepared responses as presented below. We have attached copies of the DTM comment letter and thus have only repeated the essence of the comment below.

January 23, 2025, Letter to Russell Karistad, Chair, Zoning Board of Appeals

Comment 1: With respect to the Traffic Impact, Access and Parking Study:

a. We request an updated report be provided using the ITE trip generation rates based on land use with a General urban/Suburban setting.
b. We request that after updating the traffic analysis, confirm whether the (updated) projected traffic volumes are sufficient to meet warrants for traffic signal control at the site driveway.
c. Given the volume of (estimated) left turning left turn from eastbound Grafton Street, we request that the consultant evaluate the need for and feasibility of providing a left turn lane from eastbound Grafton Street at the site drive.

Response: This requested updated trip forecast and analysis is underway and will be transmitted to DTM as soon as completed. We anticipate that using the new land use code assumption will result in a higher amount of trip generation than originally estimated, however, given the project's location and encouraging walking, biking and transit with the proposed mitigation and project design, it is believed that the actual site traffic generation will likely be between the original and updated estimates.

Comment 2: We concur with the consultant that the amount of parking proposed is adequate and we support the requested relief.

Response: No response required.

Comment 3: We support the inclusion of all Proposed Mitigation measures on pages 4 and 5 of the Traffic Impact, Access, and Parking Study report dated October 2024 and ask they be conditions of approval.

Response: No response required.

Comment 4: We support the proposed Transportation Demand management (TDM) measures outlined in the memo date Thursday, January 23, 2025, from Bill Scully et. All to Victor Panak and ask that they be conditions of approval.

Response: No response required.

Comment 5: To promote walkability, bikability, safety and access for pedestrians and cyclists as required in the City's adopted Complete Streets Policy and draft recommendations of the ongoing Now/Next and Worcester Mobility Action Plan…, we request:

a. That the driveway across Pine Hill Road be constructed at sidewalk level of a minimum of 4 feet and then slope down to street level per City specifications with crossing being ADA compliant.
b. That project reconstruct sidewalk along frontage on Grafton Street and Pine Hill Road using cement concrete and granite curbing to City specifications.
c. The project reconstructs the curb ramps on both Brandt Lane and Pine Hill Road to be ADA compliant … and meet City specifications …
d. That the internal bike storage has an access door leading into the building. The current design is external only.
e. That the project include external bike racks near the front entrance of all buildings and recreation areas for short term resident and visitor use and that the racks comply with APBP guidelines.
f. That internal walkways, parking lots, etc. be ADA and MAAB compliant.

Response: The above items are generally acceptable and will be incorporated into the plans if not already included.

Comment 6: Request a condition that 20% of all spaces have Level 2 EV charges installed and the remaining spaces … be made EV ready with installation of empty conduit for future buildout.

Response: This project will provide a total of just under 800 parking spaces. The applicant is proposing to install conduit and cabling at 20% of the total. The applicant is not prepared to immediately have 20% operational with Level 2 EV charging stations as it is economically infeasible (est. costs range between $1.5M and $2.5M). However, it is proposed to install EV operational spaces at each building and parking garage at the project outset. It is proposed that each building would have 6 spaces that are EV operational (3 dual charging stations) providing for a total up to 30 parking spaces in relation to the five buildings. The owner will then monitor market conditions in the future and work with a goal of increasing the number of EV spaces by approximately 6-10 spaces per year for five years after opening.

Comment 7: Request a condition that all signs, pavement marking and other materials used on the public way meet City specifications …

Response: Applicant concurs with this request.

Comment 8: Request that if any construction related activity damages the public sidewalk or public infrastructure, the applicant is required to replace the damaged infrastructure at the (developer's) cost and meet City specifications.

Response: It is agreed that if project construction damages public infrastructure will be appropriately repaired.

Comment 9: … prior to the issuance of a building permit, a formal construction management plan be submitted for review and approval by DPW and DTM.

Response: This will be done.

If you have any questions, please do not hesitate to contact me on behalf of the applicant.

Sincerely,
KIMLEY-HORN AND ASSOCIATES, INC.

William J. Scully, P.E., RSP_1
Sr. Project Manager

Attachments: City Correspondence

cc. V. Panak, Department of Planning
T. Kirrane, DTM
S. Galbraith, DTM
S. Madeus
P. Healy
J. Baldwin
W. Morris
J. Maroney

The City of WORCESTER

Department of Transportation & Mobility
Stephen S. Rolle, P.E., Commissioner
76 East Worcester Street, Worcester, MA 01604
P | 508-799-1300 x49500
mobility@worcesterma.gov

February 10, 2025

Worcester Zoning Board of Appeals
City Hall
Worcester, MA 01608

RE: 4 Brandt Lane
ZB-2024-098
Response to Kimley Horn Letter dated February 8, 2025

Dear Chair Karlstad,

The staff of the Department of Transportation & Mobility (DTM) has reviewed the response letter from the petitioner's consultant and offer the following:

1. Given the need to update the trip forecast and analysis based on the new land use code, and the consultant's expectation that "using the new land use code assumption will result in a higher amount of trip generation than originally estimated" we request that the ZBA delay any decision on this project until the updated report is provided to staff and we are given sufficient time to analyze the data.

2. With respect to EV Charging infrastructure, we understand that our Department's request exceeds the requirements of local ordinances, however we feel as though including a certain number of chargers in the beginning of the project for resident use is in line with the City's goals relative to the Green Worcester Plan and Mobility Action Plan. Provided that the developer commits to including operational chargers at each building, as provided for in their response, we withdraw our previous request and substitute if for:

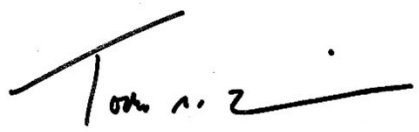
    a. Request a condition that the project include 3 Level 2 Dual port chargers operational upon certificate of occupancy for all 5 residential buildings and they meet the stretch code requirements for EV Ready conduit in other spaces.

3. To clarify our request for a sidewalk along Pine Hill Road, we request a condition that the sidewalk run from Grafton Street to their proposed driveway. If the Board requires the sidewalk along their entire property line, we would not be opposed to this buildout of our sidewalk network.

4. With respect to the question posed by Planning & Regulatory Services Division staff, it is our expectation that all mitigation and transportation demand management measures provided for in the Traffic Impact, Access, and Parking Study be fully funded by the project and not by the City.

All other comments and requests for conditions from previous letters stand. If you have any questions or need additional information regarding this review, please do not hesitate to contact the Department at (508) 929-1300 x 49500.

Warmest Regards,



Todd M. Kirrane
Assistant Director of Transportation & Mobility

ATTACHMENT B

ITE Trip Generation

Multifamily Housing (Mid-Rise)
Not Close to Rail Transit (221)

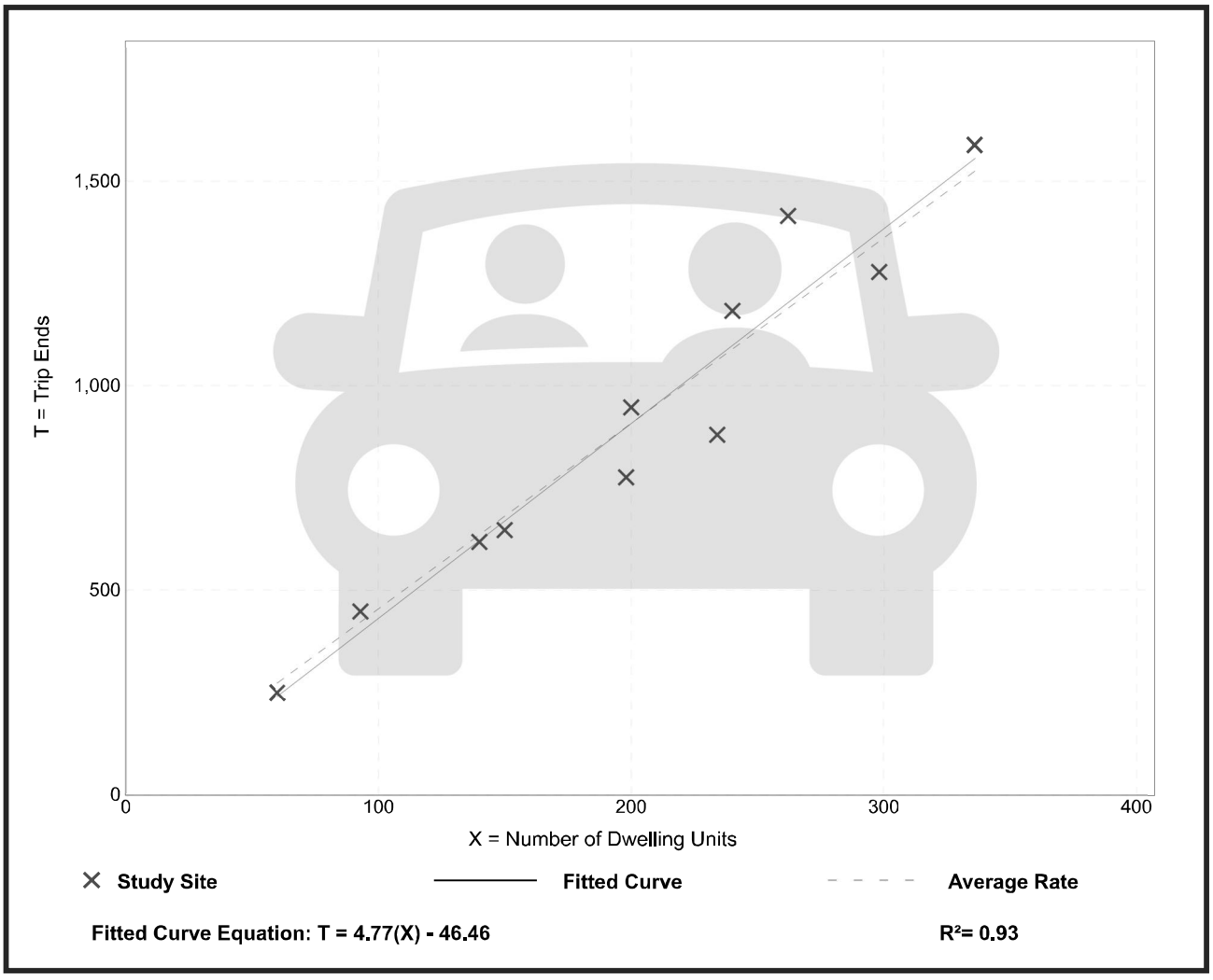
Vehicle Trip Ends vs: **Dwelling Units**
On a: **Weekday**

Setting/Location: **General Urban/Suburban**
Number of Studies: 11
Avg. Num. of Dwelling Units: 201
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
4.54	3.76 - 5.40	0.51

Data Plot and Equation



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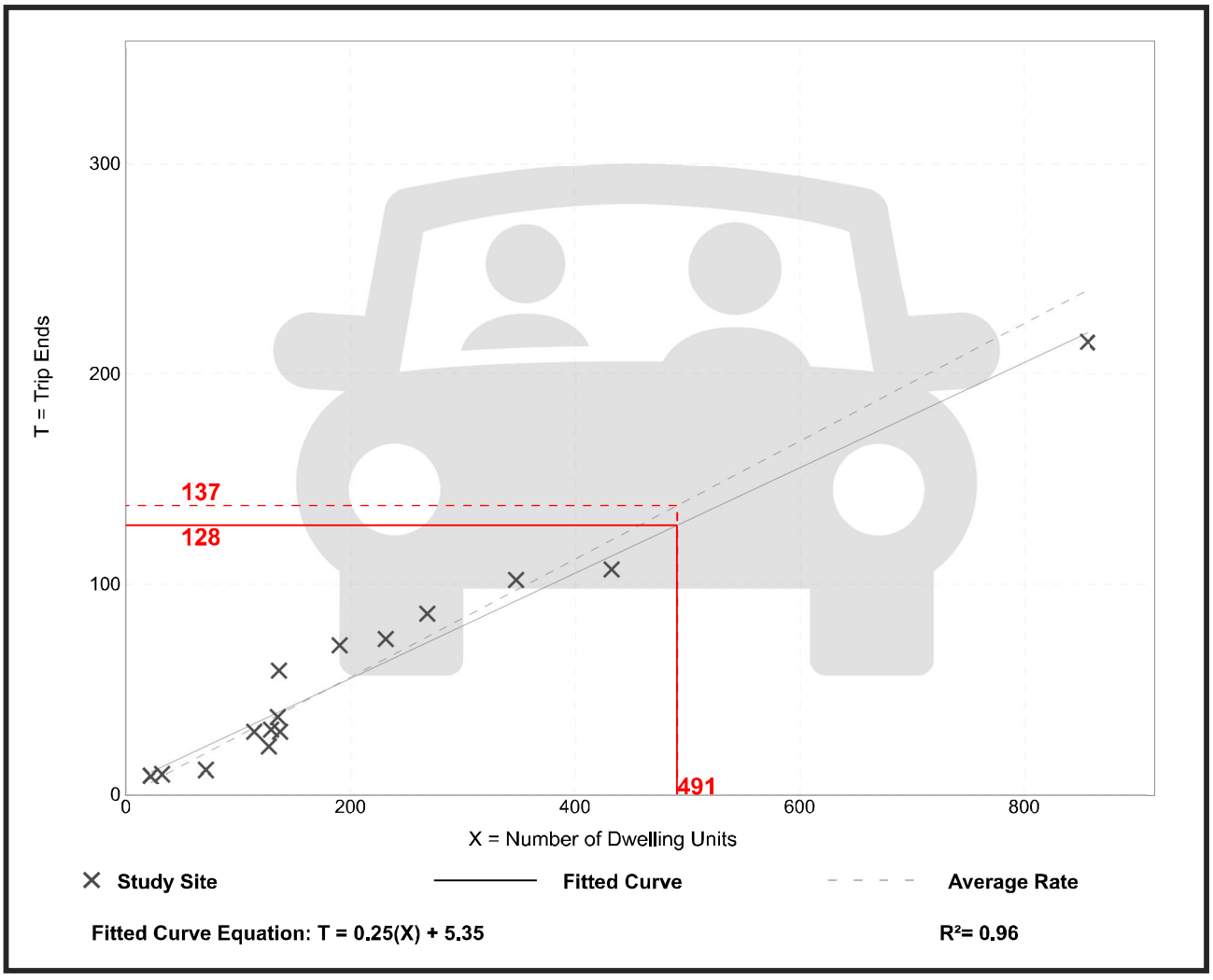
Multifamily Housing (Mid-Rise)
Not Close to Rail Transit (221)

Vehicle Trip Ends vs: **Dwelling Units**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: **Dense Multi-Use Urban**
Number of Studies: 15
Avg. Num. of Dwelling Units: 215
Directional Distribution: 14% entering, 86% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.28	0.17 - 0.43	0.06

Data Plot and Equation



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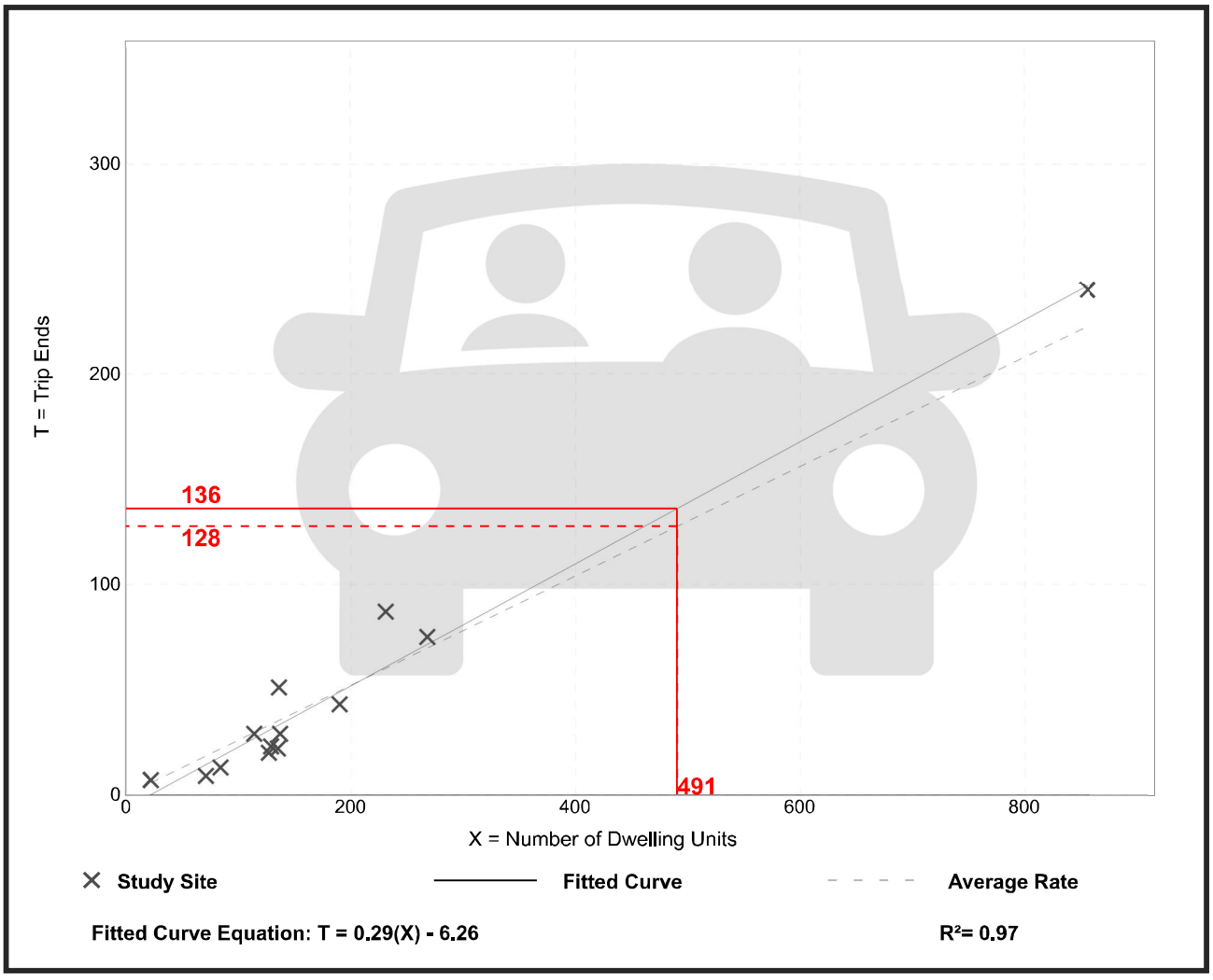
Multifamily Housing (Mid-Rise)
Not Close to Rail Transit (221)

Vehicle Trip Ends vs: **Dwelling Units**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.
Setting/Location: **Dense Multi-Use Urban**
Number of Studies: 13
Avg. Num. of Dwelling Units: 192
Directional Distribution: 74% entering, 26% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.26	0.13 - 0.38	0.07

Data Plot and Equation



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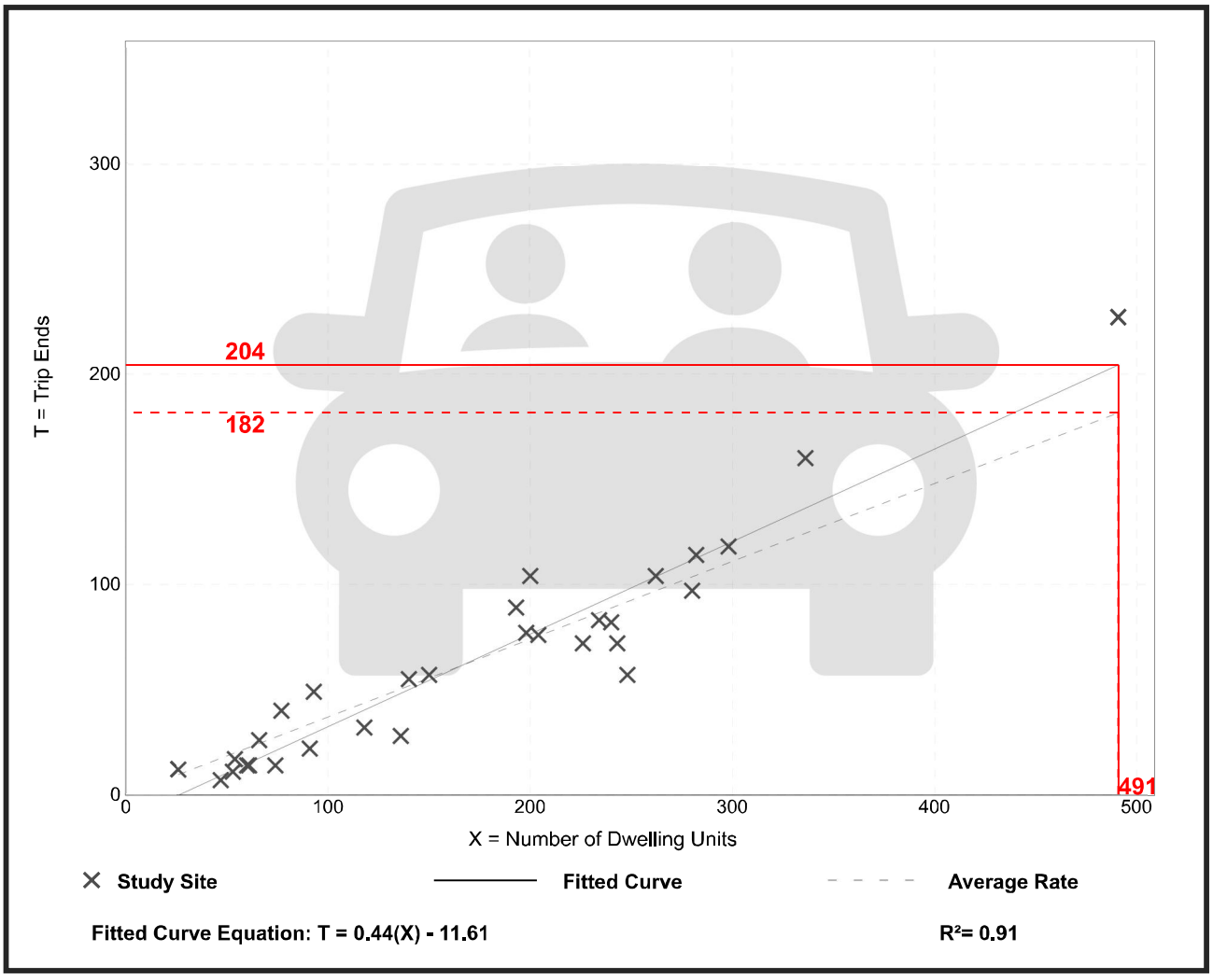
Multifamily Housing (Mid-Rise)
Not Close to Rail Transit (221)

Vehicle Trip Ends vs: **Dwelling Units**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 30
Avg. Num. of Dwelling Units: 173
Directional Distribution: 23% entering, 77% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.37	0.15 - 0.53	0.09

Data Plot and Equation



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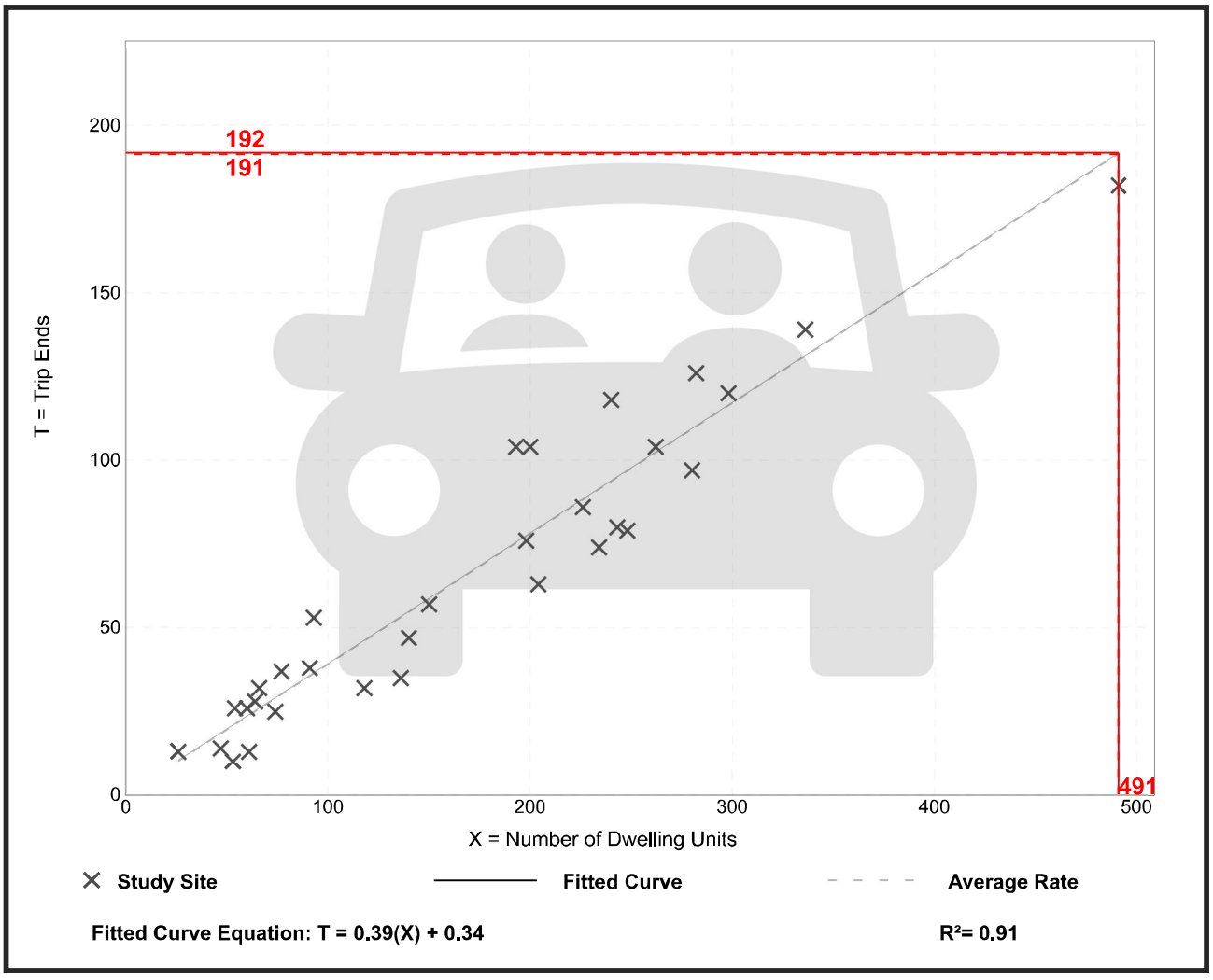
Multifamily Housing (Mid-Rise)
Not Close to Rail Transit (221)

Vehicle Trip Ends vs: **Dwelling Units**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 31
Avg. Num. of Dwelling Units: 169
Directional Distribution: 61% entering, 39% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.39	0.19 - 0.57	0.08

Data Plot and Equation



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Multifamily Housing (Mid-Rise)
Not Close to Rail Transit (221)

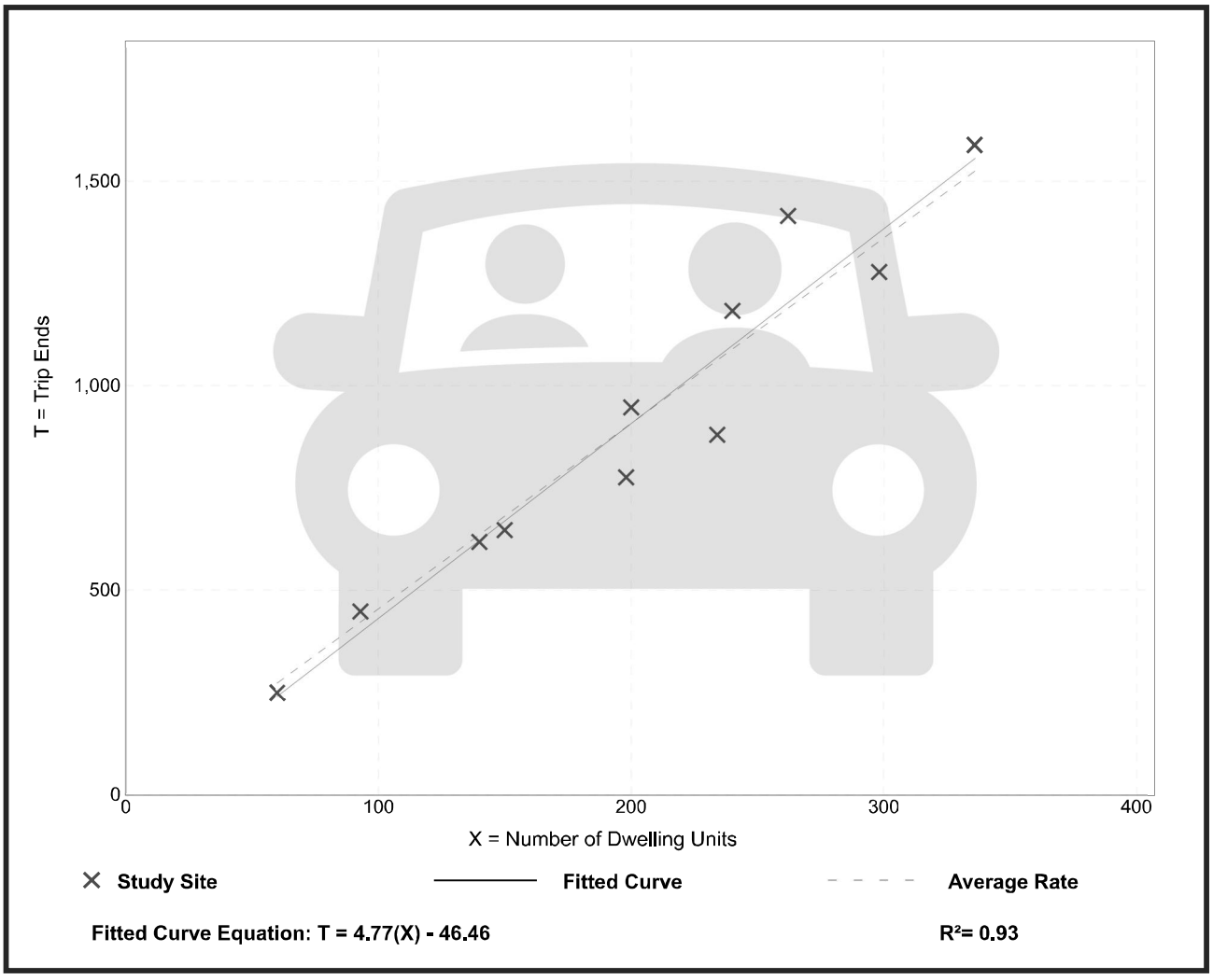
Vehicle Trip Ends vs: **Dwelling Units**
On a: **Weekday**

Setting/Location: **General Urban/Suburban**
Number of Studies: 11
Avg. Num. of Dwelling Units: 201
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
4.54	3.76 - 5.40	0.51

Data Plot and Equation



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Strip Retail Plaza (<40k)
(822)

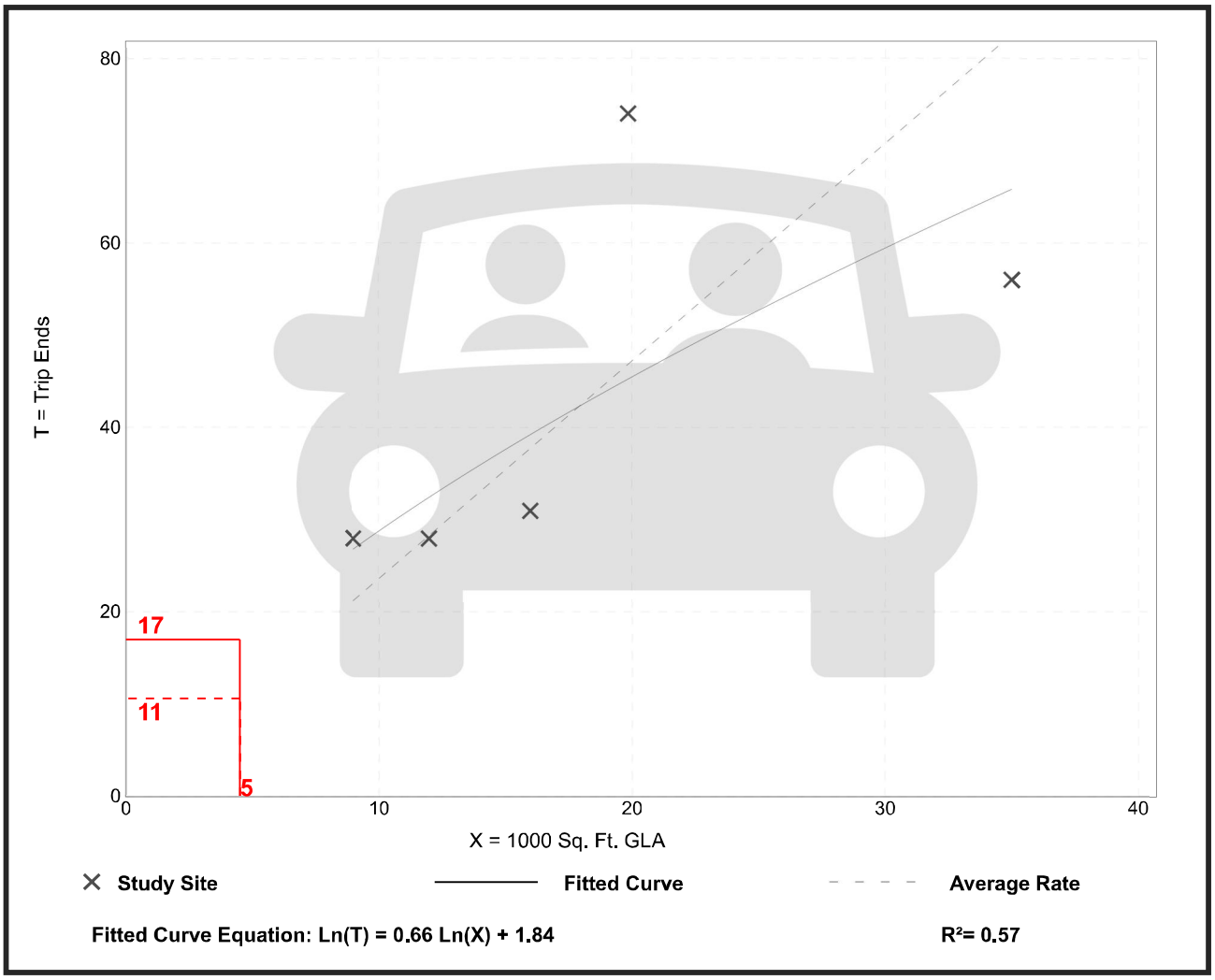
Vehicle Trip Ends vs: **1000 Sq. Ft. GLA**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 5
Avg. 1000 Sq. Ft. GLA: 18
Directional Distribution: 60% entering, 40% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GLA

Average Rate	Range of Rates	Standard Deviation
2.36	1.60 - 3.73	0.94

Data Plot and Equation

Caution – Small Sample Size



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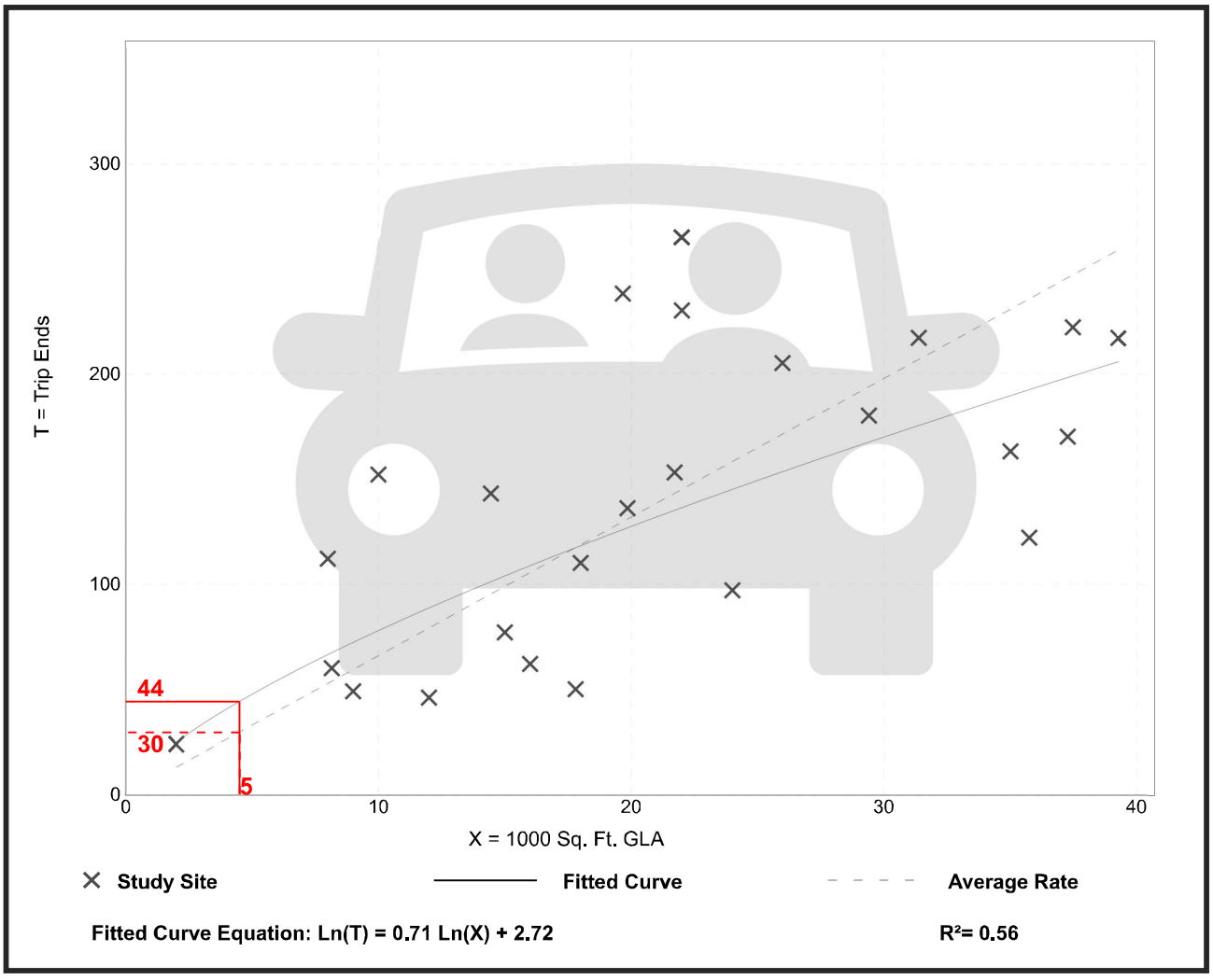
Strip Retail Plaza (<40k)
(822)

Vehicle Trip Ends vs: **1000 Sq. Ft. GLA**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 25
Avg. 1000 Sq. Ft. GLA: 21
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GLA

Average Rate	Range of Rates	Standard Deviation
6.59	2.81 - 15.20	2.94

Data Plot and Equation



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ATTACHMENT C

Capacity Analysis

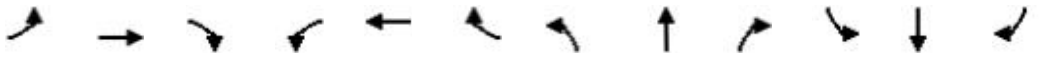
Intersection	
Int Delay, s/veh	3.1

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Vol, veh/h	78	37	502	73	30	440
Future Vol, veh/h	78	37	502	73	30	440
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	10	-	2	-	-	-2
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	4	3	6	8	4	7
Mvmt Flow	85	40	546	79	33	478

Major/Minor	Minor1		Major1		Major2	
Conflicting Flow All	1130	586	0	0	625	0
Stage 1	586	-	-	-	-	-
Stage 2	544	-	-	-	-	-
Critical Hdwy	8.44	7.23	-	-	4.14	-
Critical Hdwy Stg 1	7.44	-	-	-	-	-
Critical Hdwy Stg 2	7.44	-	-	-	-	-
Follow-up Hdwy	3.536	3.327	-	-	2.236	-
Pot Cap-1 Maneuver	119	432	-	-	947	-
Stage 1	399	-	-	-	-	-
Stage 2	427	-	-	-	-	-
Platoon blocked, %			-	-		-
Mov Cap-1 Maneuver	113	432	-	-	947	-
Mov Cap-2 Maneuver	235	-	-	-	-	-
Stage 1	399	-	-	-	-	-
Stage 2	407	-	-	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s/v	28.6	0	0.6
HCM LOS	D		

Minor Lane/Major Mvmt	NBT	NBR	WBLn1	SBL	SBT
Capacity (veh/h)	-	-	275	947	-
HCM Lane V/C Ratio	-	-	0.455	0.034	-
HCM Control Delay (s/veh)	-	-	28.6	8.9	0
HCM Lane LOS	-	-	D	A	A
HCM 95th %tile Q (veh)	-	-	2.2	0.1	-



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	49	21	138	43	17	13	42	503	24	16	490	16
Future Volume (vph)	49	21	138	43	17	13	42	503	24	16	490	16
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	15	12	12	12	12	11	16	12	12	12	12
Grade (%)		-6%			2%			2%			-2%	
Storage Length (ft)	0		0	0		130	65		0	150		0
Storage Lanes	0		0	0		1	1		0	1		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	0	1814	0	0	1815	1480	1677	2020	0	1823	1827	0
Flt Permitted		0.900			0.582		0.453			0.348		
Satd. Flow (perm)	0	1653	0	0	1095	1480	800	2020	0	668	1827	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		109				116		3			3	
Link Speed (mph)		25			25			35			35	
Link Distance (ft)		493			255			152			1165	
Travel Time (s)		13.4			7.0			3.0			22.7	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles (%)	15%	5%	4%	0%	0%	8%	3%	5%	0%	0%	4%	20%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	226	0	0	65	14	46	573	0	17	550	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane											Yes	
Headway Factor	0.96	0.85	0.96	1.01	1.01	1.01	1.06	0.86	1.01	0.99	0.99	0.99
Turning Speed (mph)	15		9	15		9	15		9	15		9
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		pm+pt	NA	
Protected Phases		4			8			2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	2	2		1	6	
Switch Phase												
Minimum Initial (s)	10.0	10.0		10.0	10.0	10.0	20.0	20.0		7.0	35.0	
Minimum Split (s)	15.0	15.0		15.0	15.0	15.0	25.0	25.0		9.0	40.0	
Total Split (s)	15.0	15.0		15.0	15.0	15.0	30.0	30.0		10.0	40.0	
Total Split (%)	20.0%	20.0%		20.0%	20.0%	20.0%	40.0%	40.0%		13.3%	53.3%	
Yellow Time (s)	4.0	4.0		4.0	4.0	4.0	4.0	4.0		2.0	4.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		0.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		5.0			5.0	5.0	5.0	5.0		2.0	5.0	
Lead/Lag							Lag	Lag		Lead		
Lead-Lag Optimize?							Yes	Yes		Yes		
Recall Mode	None	None		None	None	None	Max	Max		None	Max	
Act Effct Green (s)		10.0			10.0	10.0	33.2	33.2		38.0	35.0	
Actuated g/C Ratio		0.18			0.18	0.18	0.60	0.60		0.69	0.64	
v/c Ratio		0.58			0.33	0.04	0.10	0.47		0.03	0.47	
Control Delay (s/veh)		17.9			24.8	0.2	6.6	8.5		2.8	6.8	

Lane Group	Ø9
Lane Configurations	
Traffic Volume (vph)	
Future Volume (vph)	
Ideal Flow (vphpl)	
Lane Width (ft)	
Grade (%)	
Storage Length (ft)	
Storage Lanes	
Taper Length (ft)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Right Turn on Red	
Satd. Flow (RTOR)	
Link Speed (mph)	
Link Distance (ft)	
Travel Time (s)	
Peak Hour Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Enter Blocked Intersection	
Lane Alignment	
Median Width(ft)	
Link Offset(ft)	
Crosswalk Width(ft)	
Two way Left Turn Lane	
Headway Factor	
Turning Speed (mph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	11.0
Total Split (s)	20.0
Total Split (%)	27%
Yellow Time (s)	4.0
All-Red Time (s)	0.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay (s/veh)	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Queue Delay		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay (s/veh)		17.9			24.8	0.2	6.6	8.5		2.8	6.8	
LOS		B			C	A	A	A		A	A	
Approach Delay (s/veh)		17.9			20.4			8.4			6.7	
Approach LOS		B			C			A			A	
Queue Length 50th (ft)		34			19	0	5	77		1	76	
Queue Length 95th (ft)		91			49	0	23	212		5	131	
Internal Link Dist (ft)		413			175			72			1085	
Turn Bay Length (ft)						130	65			150		
Base Capacity (vph)		389			199	364	483	1220		629	1163	
Starvation Cap Reductn		0			0	0	0	0		0	0	
Spillback Cap Reductn		0			0	0	0	0		0	0	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		0.58			0.33	0.04	0.10	0.47		0.03	0.47	

Intersection Summary			
Area Type:	Other		
Cycle Length: 75			
Actuated Cycle Length: 55			
Natural Cycle: 70			
Control Type: Actuated-Uncoordinated			
Maximum v/c Ratio: 0.58			
Intersection Signal Delay (s/veh): 9.8		Intersection LOS: A	
Intersection Capacity Utilization 62.2%		ICU Level of Service B	
Analysis Period (min) 15			

Splits and Phases: 2: Grafton Street (Route 122) & Dalton Street/S&S Driveway

Lane Group	Ø9
Queue Delay	
Total Delay (s/veh)	
LOS	
Approach Delay (s/veh)	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Intersection	
Int Delay, s/veh	1.1

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	0	14	1	9	47	559	61	5	602	63
Future Vol, veh/h	0	0	0	14	1	9	47	559	61	5	602	63
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	2	-	-	2	-	-	-2	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	29	0	56	0	4	7	0	4	0
Mvmt Flow	0	0	0	15	1	10	51	608	66	5	654	68

Major/Minor	Minor1			Major1			Major2		
Conflicting Flow All	1441	1475	641	722	0	0	674	0	0
Stage 1	743	743	-	-	-	-	-	-	-
Stage 2	698	732	-	-	-	-	-	-	-
Critical Hdwy	7.09	6.9	6.96	4.1	-	-	4.1	-	-
Critical Hdwy Stg 1	6.09	5.9	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.09	5.9	-	-	-	-	-	-	-
Follow-up Hdwy	3.761	4	3.804	2.2	-	-	2.2	-	-
Pot Cap-1 Maneuver	108	108	377	889	-	-	927	-	-
Stage 1	392	391	-	-	-	-	-	-	-
Stage 2	414	396	-	-	-	-	-	-	-
Platoon blocked, %					-	-		-	-
Mov Cap-1 Maneuver	97	0	377	889	-	-	927	-	-
Mov Cap-2 Maneuver	97	0	-	-	-	-	-	-	-
Stage 1	356	0	-	-	-	-	-	-	-
Stage 2	410	0	-	-	-	-	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s/v	37.4	0.7	0.1
HCM LOS	E		

Minor Lane/Major Mvmt	NBL	NBT	NBR	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	889	-	-	137	927	-	-
HCM Lane V/C Ratio	0.057	-	-	0.19	0.006	-	-
HCM Control Delay (s/veh)	9.3	0	-	37.4	8.9	0	-
HCM Lane LOS	A	A	-	E	A	A	-
HCM 95th %tile Q (veh)	0.2	-	-	0.7	0	-	-

Intersection	
Int Delay, s/veh	0.3

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Vol, veh/h	5	10	658	3	5	662
Future Vol, veh/h	5	10	658	3	5	662
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	2	-	1	-	-	-1
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	0	0	5	0	0	6
Mvmt Flow	5	11	715	3	5	720

Major/Minor	Minor1		Major1		Major2	
Conflicting Flow All	1447	717	0	0	718	0
Stage 1	717	-	-	-	-	-
Stage 2	730	-	-	-	-	-
Critical Hdwy	6.8	6.4	-	-	4.1	-
Critical Hdwy Stg 1	5.8	-	-	-	-	-
Critical Hdwy Stg 2	5.8	-	-	-	-	-
Follow-up Hdwy	3.5	3.3	-	-	2.2	-
Pot Cap-1 Maneuver	125	416	-	-	892	-
Stage 1	450	-	-	-	-	-
Stage 2	443	-	-	-	-	-
Platoon blocked, %			-	-		-
Mov Cap-1 Maneuver	124	416	-	-	892	-
Mov Cap-2 Maneuver	124	-	-	-	-	-
Stage 1	450	-	-	-	-	-
Stage 2	439	-	-	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s/v	21.6	0	0.1
HCM LOS	C		

Minor Lane/Major Mvmt	NBT	NBR	WBLn1	SBL	SBT
Capacity (veh/h)	-	-	233	892	-
HCM Lane V/C Ratio	-	-	0.07	0.006	-
HCM Control Delay (s/veh)	-	-	21.6	9.1	0
HCM Lane LOS	-	-	C	A	A
HCM 95th %tile Q (veh)	-	-	0.2	0	-

Intersection	
Int Delay, s/veh	7.5

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	1	0	2	64	0	83	4	576	24	27	632	7
Future Vol, veh/h	1	0	2	64	0	83	4	576	24	27	632	7
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	1	-	-	1	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	0	0	0	0	5	0	0	6	0
Mvmt Flow	1	0	2	70	0	90	4	626	26	29	687	8

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1441	1409	691	1397	1400	639	695	0	0	652	0	0
Stage 1	749	749	-	647	647	-	-	-	-	-	-	-
Stage 2	692	660	-	750	753	-	-	-	-	-	-	-
Critical Hdwy	7.1	6.5	6.2	7.1	6.5	6.2	4.1	-	-	4.1	-	-
Critical Hdwy Stg 1	6.1	5.5	-	6.1	5.5	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.1	5.5	-	6.1	5.5	-	-	-	-	-	-	-
Follow-up Hdwy	3.5	4	3.3	3.5	4	3.3	2.2	-	-	2.2	-	-
Pot Cap-1 Maneuver	111	140	448	120	142	480	910	-	-	944	-	-
Stage 1	407	422	-	463	470	-	-	-	-	-	-	-
Stage 2	437	463	-	407	420	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	86	132	448	114	134	480	910	-	-	944	-	-
Mov Cap-2 Maneuver	86	132	-	114	134	-	-	-	-	-	-	-
Stage 1	404	401	-	460	467	-	-	-	-	-	-	-
Stage 2	352	460	-	385	399	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s/v	24.7	70.1	0.1	0.4
HCM LOS	C	F		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	910	-	-	186	200	944	-	-
HCM Lane V/C Ratio	0.005	-	-	0.018	0.799	0.031	-	-
HCM Control Delay (s/veh)	9	0	-	24.7	70.1	8.9	0	-
HCM Lane LOS	A	A	-	C	F	A	A	-
HCM 95th %tile Q (veh)	0	-	-	0.1	5.6	0.1	-	-

Intersection	
Int Delay, s/veh	2.1

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	0	23	5	36	64	569	29	18	556	120
Future Vol, veh/h	0	0	0	23	5	36	64	569	29	18	556	120
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	2	-	-	1	-	-	1	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	0	20	0	3	5	4	6	5	10
Mvmt Flow	0	0	0	25	5	39	70	618	32	20	604	130

Major/Minor	Minor1		Major1				Major2		
Conflicting Flow All	1483	1548	634	734	0	0	650	0	0
Stage 1	774	774	-	-	-	-	-	-	-
Stage 2	709	774	-	-	-	-	-	-	-
Critical Hdwy	6.8	7.1	6.4	4.13	-	-	4.16	-	-
Critical Hdwy Stg 1	5.8	6.1	-	-	-	-	-	-	-
Critical Hdwy Stg 2	5.8	6.1	-	-	-	-	-	-	-
Follow-up Hdwy	3.5	4.18	3.3	2.227	-	-	2.254	-	-
Pot Cap-1 Maneuver	118	88	466	866	-	-	917	-	-
Stage 1	421	352	-	-	-	-	-	-	-
Stage 2	454	352	-	-	-	-	-	-	-
Platoon blocked, %					-	-		-	-
Mov Cap-1 Maneuver	99	0	466	866	-	-	917	-	-
Mov Cap-2 Maneuver	99	0	-	-	-	-	-	-	-
Stage 1	368	0	-	-	-	-	-	-	-
Stage 2	437	0	-	-	-	-	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s/v	34.3	0.9	0.2
HCM LOS	D		

Minor Lane/Major Mvmt	NBL	NBT	NBR	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	866	-	-	191	917	-	-
HCM Lane V/C Ratio	0.08	-	-	0.364	0.021	-	-
HCM Control Delay (s/veh)	9.5	0	-	34.3	9	0	-
HCM Lane LOS	A	A	-	D	A	A	-
HCM 95th %tile Q (veh)	0.3	-	-	1.6	0.1	-	-

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	13	161	57	147	79	206	1	442	376	174	413	3
Future Volume (vph)	13	161	57	147	79	206	1	442	376	174	413	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	12	12	11	11	11	10	10	11	11	10	12
Grade (%)		-5%			3%			1%			-2%	
Storage Length (ft)	0		0	250		0	0		220	175		0
Storage Lanes	0		0	1		0	0		1	1		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	0	1815	0	1606	1564	0	0	1681	1508	1695	1721	0
Flt Permitted		0.962		0.323				0.999		0.191		
Satd. Flow (perm)	0	1752	0	546	1564	0	0	1679	1508	341	1721	0
Right Turn on Red			Yes			Yes			No			Yes
Satd. Flow (RTOR)		15			147							
Link Speed (mph)		25			25			35			35	
Link Distance (ft)		559			391			698			1056	
Travel Time (s)		15.2			10.7			13.6			20.6	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles (%)	15%	3%	2%	7%	1%	4%	0%	5%	3%	4%	4%	0%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	251	0	160	310	0	0	481	409	189	452	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			11			0			11	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	0.97	0.97	0.97	1.07	1.07	1.07	1.10	1.10	1.05	1.03	1.08	0.99
Turning Speed (mph)	15		9	15		9	15		9	15		9
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	Perm	pm+pt	NA	
Protected Phases		4		3	8			2		1	6	
Permitted Phases	4			8			2		2	6		
Detector Phase	4	4		3	8		2	2	2	1	6	
Switch Phase												
Minimum Initial (s)	9.0	9.0		10.0	23.0		16.0	16.0	16.0	10.0	32.0	
Minimum Split (s)	14.0	14.0		12.0	28.0		21.0	21.0	21.0	12.0	37.0	
Total Split (s)	14.0	14.0		14.0	28.0		25.0	25.0	25.0	12.0	37.0	
Total Split (%)	16.1%	16.1%		16.1%	32.2%		28.7%	28.7%	28.7%	13.8%	42.5%	
Yellow Time (s)	3.0	3.0		2.0	3.0		3.0	3.0	3.0	2.0	3.0	
All-Red Time (s)	2.0	2.0		0.0	2.0		2.0	2.0	2.0	0.0	2.0	
Lost Time Adjust (s)		0.0		0.0	0.0			0.0	0.0	0.0	0.0	
Total Lost Time (s)		5.0		2.0	5.0			5.0	5.0	2.0	5.0	
Lead/Lag	Lag	Lag		Lead			Lag	Lag	Lag	Lead		
Lead-Lag Optimize?	Yes	Yes		Yes			Yes	Yes	Yes	Yes		
Recall Mode	None	None		None	None		Max	Max	Max	None	Max	
Act Effct Green (s)		10.4		26.0	23.0			20.0	20.0	35.0	32.0	
Actuated g/C Ratio		0.16		0.40	0.35			0.31	0.31	0.54	0.49	
v/c Ratio		0.86		0.41	0.48			0.93	0.88	0.48	0.53	
Control Delay (s/veh)		56.5		16.6	11.2			51.0	45.1	12.3	14.3	

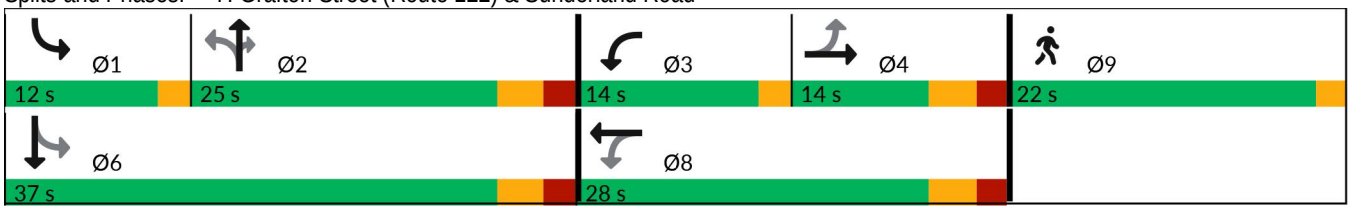
Lane Group	Ø9
Lane Configurations	
Traffic Volume (vph)	
Future Volume (vph)	
Ideal Flow (vphpl)	
Lane Width (ft)	
Grade (%)	
Storage Length (ft)	
Storage Lanes	
Taper Length (ft)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Right Turn on Red	
Satd. Flow (RTOR)	
Link Speed (mph)	
Link Distance (ft)	
Travel Time (s)	
Peak Hour Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Enter Blocked Intersection	
Lane Alignment	
Median Width(ft)	
Link Offset(ft)	
Crosswalk Width(ft)	
Two way Left Turn Lane	
Headway Factor	
Turning Speed (mph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	6.0
Minimum Split (s)	8.0
Total Split (s)	22.0
Total Split (%)	25%
Yellow Time (s)	2.0
All-Red Time (s)	0.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay (s/veh)	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Queue Delay		0.0		0.0	0.0			0.0	0.0	0.0	0.0	
Total Delay (s/veh)		56.5		16.6	11.2			51.0	45.1	12.3	14.3	
LOS		E		B	B			D	D	B	B	
Approach Delay (s/veh)		56.5			13.0			48.3			13.7	
Approach LOS		E			B			D			B	
Queue Length 50th (ft)		91		41	46			183	152	36	115	
Queue Length 95th (ft)		#230		79	108			#352	#304	66	192	
Internal Link Dist (ft)		479			311			618			976	
Turn Bay Length (ft)				250					220	175		
Base Capacity (vph)		292		414	648			516	464	391	847	
Starvation Cap Reductn		0		0	0			0	0	0	0	
Spillback Cap Reductn		0		0	0			0	0	0	0	
Storage Cap Reductn		0		0	0			0	0	0	0	
Reduced v/c Ratio		0.86		0.39	0.48			0.93	0.88	0.48	0.53	

Intersection Summary			
Area Type:	Other		
Cycle Length: 87			
Actuated Cycle Length: 65			
Natural Cycle: 80			
Control Type: Actuated-Uncoordinated			
Maximum v/c Ratio: 0.93			
Intersection Signal Delay (s/veh): 32.0		Intersection LOS: C	
Intersection Capacity Utilization 98.5%		ICU Level of Service F	
Analysis Period (min) 15			

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 7: Grafton Street (Route 122) & Sunderland Road



Lane Group	Ø9
Queue Delay	
Total Delay (s/veh)	
LOS	
Approach Delay (s/veh)	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Intersection	
Int Delay, s/veh	0.8

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	4	43	57	0	0	7
Future Vol, veh/h	4	43	57	0	0	7
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	2	-	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	4	47	62	0	0	8

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	62	0	-	0	117	62
Stage 1	-	-	-	-	62	-
Stage 2	-	-	-	-	55	-
Critical Hdwy	4.12	-	-	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	2.218	-	-	-	3.518	3.318
Pot Cap-1 Maneuver	1541	-	-	-	879	1003
Stage 1	-	-	-	-	961	-
Stage 2	-	-	-	-	968	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	1541	-	-	-	876	1003
Mov Cap-2 Maneuver	-	-	-	-	876	-
Stage 1	-	-	-	-	958	-
Stage 2	-	-	-	-	968	-

Approach	EB	WB	SB
HCM Control Delay, s/v	0.6	0	8.6
HCM LOS			A

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	1541	-	-	-	1003
HCM Lane V/C Ratio	0.003	-	-	-	0.008
HCM Control Delay (s/veh)	7.3	0	-	-	8.6
HCM Lane LOS	A	A	-	-	A
HCM 95th %tile Q (veh)	0	-	-	-	0

Intersection	
Int Delay, s/veh	4

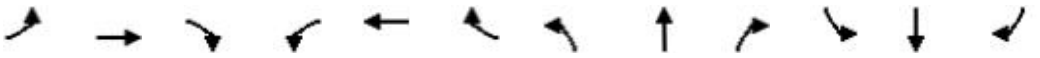
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Vol, veh/h	63	45	719	66	55	556
Future Vol, veh/h	63	45	719	66	55	556
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	10	-	2	-	-	-2
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	0	2	0	1	0	1
Mvmt Flow	68	49	782	72	60	604

Major/Minor	Minor1		Major1		Major2	
Conflicting Flow All	1542	818	0	0	854	0
Stage 1	818	-	-	-	-	-
Stage 2	724	-	-	-	-	-
Critical Hdwy	8.4	7.22	-	-	4.1	-
Critical Hdwy Stg 1	7.4	-	-	-	-	-
Critical Hdwy Stg 2	7.4	-	-	-	-	-
Follow-up Hdwy	3.5	3.318	-	-	2.2	-
Pot Cap-1 Maneuver	~ 54	300	-	-	794	-
Stage 1	278	-	-	-	-	-
Stage 2	323	-	-	-	-	-
Platoon blocked, %			-	-		-
Mov Cap-1 Maneuver	~ 48	300	-	-	794	-
Mov Cap-2 Maneuver	151	-	-	-	-	-
Stage 1	278	-	-	-	-	-
Stage 2	286	-	-	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s/v	50.5	0	0.9
HCM LOS	F		

Minor Lane/Major Mvmt	NBT	NBR	WBLn1	SBL	SBT
Capacity (veh/h)	-	-	190	794	-
HCM Lane V/C Ratio	-	-	0.618	0.075	-
HCM Control Delay (s/veh)	-	-	50.5	9.9	0
HCM Lane LOS	-	-	F	A	A
HCM 95th %tile Q (veh)	-	-	3.5	0.2	-

Notes			
~: Volume exceeds capacity	$: Delay exceeds 300s	+: Computation Not Defined	*: All major volume in platoon



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	24	46	55	80	40	41	63	620	46	25	527	28
Future Volume (vph)	24	46	55	80	40	41	63	620	46	25	527	28
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	15	12	12	12	12	11	16	12	12	12	12
Grade (%)		-6%			2%			2%			-2%	
Storage Length (ft)	0		0	0		130	65		0	150		0
Storage Lanes	0		0	0		1	1		0	1		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	0	2005	0	0	1809	1599	1661	2091	0	1753	1888	0
Flt Permitted		0.912			0.768		0.415			0.249		
Satd. Flow (perm)	0	1845	0	0	1435	1599	726	2091	0	459	1888	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		44				116		5			5	
Link Speed (mph)		25			25			35			35	
Link Distance (ft)		493			255			152			1165	
Travel Time (s)		13.4			7.0			3.0			22.7	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles (%)	0%	0%	0%	1%	0%	0%	4%	1%	0%	4%	1%	0%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	136	0	0	130	45	68	724	0	27	603	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane											Yes	
Headway Factor	0.96	0.85	0.96	1.01	1.01	1.01	1.06	0.86	1.01	0.99	0.99	0.99
Turning Speed (mph)	15		9	15		9	15		9	15		9
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		pm+pt	NA	
Protected Phases		4			8			2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	2	2		1	6	
Switch Phase												
Minimum Initial (s)	10.0	10.0		10.0	10.0	10.0	20.0	20.0		7.0	35.0	
Minimum Split (s)	15.0	15.0		15.0	15.0	15.0	25.0	25.0		9.0	40.0	
Total Split (s)	15.0	15.0		15.0	15.0	15.0	30.0	30.0		10.0	40.0	
Total Split (%)	20.0%	20.0%		20.0%	20.0%	20.0%	40.0%	40.0%		13.3%	53.3%	
Yellow Time (s)	4.0	4.0		4.0	4.0	4.0	4.0	4.0		2.0	4.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		0.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		5.0			5.0	5.0	5.0	5.0		2.0	5.0	
Lead/Lag							Lag	Lag		Lead		
Lead-Lag Optimize?							Yes	Yes		Yes		
Recall Mode	None	None		None	None	None	Max	Max		None	Max	
Act Effct Green (s)		10.0			10.0	10.0	33.2	33.2		38.0	35.0	
Actuated g/C Ratio		0.18			0.18	0.18	0.60	0.60		0.69	0.64	
v/c Ratio		0.37			0.50	0.12	0.16	0.57		0.06	0.50	
Control Delay (s/veh)		17.3			27.8	0.6	7.3	9.9		2.9	7.1	

Lane Group	Ø9
Lane Configurations	
Traffic Volume (vph)	
Future Volume (vph)	
Ideal Flow (vphpl)	
Lane Width (ft)	
Grade (%)	
Storage Length (ft)	
Storage Lanes	
Taper Length (ft)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Right Turn on Red	
Satd. Flow (RTOR)	
Link Speed (mph)	
Link Distance (ft)	
Travel Time (s)	
Peak Hour Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Enter Blocked Intersection	
Lane Alignment	
Median Width(ft)	
Link Offset(ft)	
Crosswalk Width(ft)	
Two way Left Turn Lane	
Headway Factor	
Turning Speed (mph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	11.0
Total Split (s)	20.0
Total Split (%)	27%
Yellow Time (s)	4.0
All-Red Time (s)	0.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay (s/veh)	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Queue Delay		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay (s/veh)		17.3			27.8	0.6	7.3	9.9		2.9	7.1	
LOS		B			C	A	A	A		A	A	
Approach Delay (s/veh)		17.3			20.8			9.7			6.9	
Approach LOS		B			C			A			A	
Queue Length 50th (ft)		26			39	0	7	107		2	85	
Queue Length 95th (ft)		67			84	1	33	290		7	146	
Internal Link Dist (ft)		413			175			72			1085	
Turn Bay Length (ft)						130	65			150		
Base Capacity (vph)		371			260	385	438	1264		505	1203	
Starvation Cap Reductn		0			0	0	0	0		0	0	
Spillback Cap Reductn		0			0	0	0	0		0	0	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		0.37			0.50	0.12	0.16	0.57		0.05	0.50	

Intersection Summary			
Area Type:	Other		
Cycle Length: 75			
Actuated Cycle Length: 55			
Natural Cycle: 70			
Control Type: Actuated-Uncoordinated			
Maximum v/c Ratio: 0.57			
Intersection Signal Delay (s/veh): 10.4		Intersection LOS: B	
Intersection Capacity Utilization 72.4%		ICU Level of Service C	
Analysis Period (min) 15			

Splits and Phases: 2: Grafton Street (Route 122) & Dalton Street/S&S Driveway

Lane Group	Ø9
Queue Delay	
Total Delay (s/veh)	
LOS	
Approach Delay (s/veh)	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Intersection	
Int Delay, s/veh	1.5

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	0	31	0	10	9	711	86	3	654	9
Future Vol, veh/h	0	0	0	31	0	10	9	711	86	3	654	9
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	2	-	-	2	-	-	-2	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	7	0	0	0	1	7	33	1	0
Mvmt Flow	0	0	0	34	0	11	10	773	93	3	711	10

Major/Minor	Minor1			Major1			Major2		
Conflicting Flow All	1562	1567	820	721	0	0	866	0	0
Stage 1	840	840	-	-	-	-	-	-	-
Stage 2	722	727	-	-	-	-	-	-	-
Critical Hdwy	6.87	6.9	6.4	4.1	-	-	4.43	-	-
Critical Hdwy Stg 1	5.87	5.9	-	-	-	-	-	-	-
Critical Hdwy Stg 2	5.87	5.9	-	-	-	-	-	-	-
Follow-up Hdwy	3.563	4	3.3	2.2	-	-	2.497	-	-
Pot Cap-1 Maneuver	101	94	361	890	-	-	661	-	-
Stage 1	378	349	-	-	-	-	-	-	-
Stage 2	436	399	-	-	-	-	-	-	-
Platoon blocked, %					-	-		-	-
Mov Cap-1 Maneuver	98	0	361	890	-	-	661	-	-
Mov Cap-2 Maneuver	98	0	-	-	-	-	-	-	-
Stage 1	370	0	-	-	-	-	-	-	-
Stage 2	433	0	-	-	-	-	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s/v	52.3	0.1	0
HCM LOS	F		

Minor Lane/Major Mvmt	NBL	NBT	NBR	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	890	-	-	119	661	-	-
HCM Lane V/C Ratio	0.011	-	-	0.374	0.005	-	-
HCM Control Delay (s/veh)	9.1	0	-	52.3	10.5	0	-
HCM Lane LOS	A	A	-	F	B	A	-
HCM 95th %tile Q (veh)	0	-	-	1.5	0	-	-

Intersection	
Int Delay, s/veh	0.4

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Vol, veh/h	8	9	832	11	4	704
Future Vol, veh/h	8	9	832	11	4	704
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	2	-	1	-	-	-1
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	13	0	1	0	0	1
Mvmt Flow	9	10	904	12	4	765

Major/Minor	Minor1		Major1		Major2	
Conflicting Flow All	1683	910	0	0	916	0
Stage 1	910	-	-	-	-	-
Stage 2	773	-	-	-	-	-
Critical Hdwy	6.93	6.4	-	-	4.1	-
Critical Hdwy Stg 1	5.93	-	-	-	-	-
Critical Hdwy Stg 2	5.93	-	-	-	-	-
Follow-up Hdwy	3.617	3.3	-	-	2.2	-
Pot Cap-1 Maneuver	81	319	-	-	753	-
Stage 1	339	-	-	-	-	-
Stage 2	401	-	-	-	-	-
Platoon blocked, %			-	-		-
Mov Cap-1 Maneuver	80	319	-	-	753	-
Mov Cap-2 Maneuver	80	-	-	-	-	-
Stage 1	339	-	-	-	-	-
Stage 2	397	-	-	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s/v	36.4	0	0.1
HCM LOS	E		

Minor Lane/Major Mvmt	NBT	NBR	WBLn1	SBL	SBT
Capacity (veh/h)	-	-	133	753	-
HCM Lane V/C Ratio	-	-	0.139	0.006	-
HCM Control Delay (s/veh)	-	-	36.4	9.8	0
HCM Lane LOS	-	-	E	A	A
HCM 95th %tile Q (veh)	-	-	0.5	0	-

Intersection	
Int Delay, s/veh	5.4

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	3	0	4	33	0	48	1	793	58	71	641	1
Future Vol, veh/h	3	0	4	33	0	48	1	793	58	71	641	1
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	1	-	-	1	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	0	0	0	0	1	25	0	1	0
Mvmt Flow	3	0	4	36	0	52	1	862	63	77	697	1

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1774	1779	698	1750	1748	894	698	0	0	925	0	0
Stage 1	852	852	-	896	896	-	-	-	-	-	-	-
Stage 2	922	927	-	854	852	-	-	-	-	-	-	-
Critical Hdwy	7.1	6.5	6.2	7.1	6.5	6.2	4.1	-	-	4.1	-	-
Critical Hdwy Stg 1	6.1	5.5	-	6.1	5.5	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.1	5.5	-	6.1	5.5	-	-	-	-	-	-	-
Follow-up Hdwy	3.5	4	3.3	3.5	4	3.3	2.2	-	-	2.2	-	-
Pot Cap-1 Maneuver	65	83	444	68	87	343	908	-	-	747	-	-
Stage 1	357	379	-	338	362	-	-	-	-	-	-	-
Stage 2	327	350	-	356	379	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	48	69	444	59	72	343	908	-	-	747	-	-
Mov Cap-2 Maneuver	48	69	-	59	72	-	-	-	-	-	-	-
Stage 1	356	315	-	337	361	-	-	-	-	-	-	-
Stage 2	277	349	-	293	315	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s/v	44.8	98.2	0	1
HCM LOS	E	F		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	908	-	-	98	116	747	-	-
HCM Lane V/C Ratio	0.001	-	-	0.078	0.759	0.103	-	-
HCM Control Delay (s/veh)	9	0	-	44.8	98.2	10.4	0	-
HCM Lane LOS	A	A	-	E	F	B	A	-
HCM 95th %tile Q (veh)	0	-	-	0.2	4.3	0.3	-	-

Intersection	
Int Delay, s/veh	1.4

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	2	21	1	18	7	831	36	15	641	11
Future Vol, veh/h	0	0	2	21	1	18	7	831	36	15	641	11
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	2	-	-	1	-	-	1	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	0	0	0	0	1	4	0	2	0
Mvmt Flow	0	0	2	23	1	20	8	903	39	16	697	12

Major/Minor	Minor1		Major1				Major2		
Conflicting Flow All	1674	1680	923	709	0	0	942	0	0
Stage 1	939	939	-	-	-	-	-	-	-
Stage 2	735	741	-	-	-	-	-	-	-
Critical Hdwy	6.8	6.9	6.4	4.1	-	-	4.1	-	-
Critical Hdwy Stg 1	5.8	5.9	-	-	-	-	-	-	-
Critical Hdwy Stg 2	5.8	5.9	-	-	-	-	-	-	-
Follow-up Hdwy	3.5	4	3.3	2.2	-	-	2.2	-	-
Pot Cap-1 Maneuver	88	79	313	899	-	-	736	-	-
Stage 1	346	311	-	-	-	-	-	-	-
Stage 2	440	392	-	-	-	-	-	-	-
Platoon blocked, %					-	-		-	-
Mov Cap-1 Maneuver	83	0	313	899	-	-	736	-	-
Mov Cap-2 Maneuver	83	0	-	-	-	-	-	-	-
Stage 1	339	0	-	-	-	-	-	-	-
Stage 2	424	0	-	-	-	-	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s/v	47.9	0.1	0.2
HCM LOS	E		

Minor Lane/Major Mvmt	NBL	NBT	NBR	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	899	-	-	126	736	-	-
HCM Lane V/C Ratio	0.008	-	-	0.345	0.022	-	-
HCM Control Delay (s/veh)	9	0	-	47.9	10	0	-
HCM Lane LOS	A	A	-	E	B	A	-
HCM 95th %tile Q (veh)	0	-	-	1.4	0.1	-	-

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	10	118	30	376	240	312	4	492	159	187	413	11
Future Volume (vph)	10	118	30	376	240	312	4	492	159	187	413	11
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	12	12	11	11	11	10	10	11	11	10	12
Grade (%)		-5%			3%			1%			-2%	
Storage Length (ft)	0		0	250		0	0		220	175		0
Storage Lanes	0		0	1		0	0		1	1		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	0	1880	0	1685	1639	0	0	1713	1494	1745	1767	0
Flt Permitted		0.885		0.432				0.996		0.182		
Satd. Flow (perm)	0	1669	0	766	1639	0	0	1707	1494	334	1767	0
Right Turn on Red			Yes			Yes			No			Yes
Satd. Flow (RTOR)		11			73						2	
Link Speed (mph)		25			25			35			35	
Link Distance (ft)		559			391			698			1056	
Travel Time (s)		15.2			10.7			13.6			20.6	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles (%)	0%	0%	3%	2%	1%	1%	0%	3%	4%	1%	1%	0%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	172	0	409	600	0	0	539	173	203	461	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			11			0			11	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	0.97	0.97	0.97	1.07	1.07	1.07	1.10	1.10	1.05	1.03	1.08	0.99
Turning Speed (mph)	15		9	15		9	15		9	15		9
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	Perm	pm+pt	NA	
Protected Phases		4		3	8			2		1	6	
Permitted Phases	4			8			2		2	6		
Detector Phase	4	4		3	8		2	2	2	1	6	
Switch Phase												
Minimum Initial (s)	9.0	9.0		10.0	23.0		16.0	16.0	16.0	10.0	32.0	
Minimum Split (s)	14.0	14.0		12.0	28.0		21.0	21.0	21.0	12.0	37.0	
Total Split (s)	14.0	14.0		14.0	28.0		25.0	25.0	25.0	12.0	37.0	
Total Split (%)	16.1%	16.1%		16.1%	32.2%		28.7%	28.7%	28.7%	13.8%	42.5%	
Yellow Time (s)	3.0	3.0		2.0	3.0		3.0	3.0	3.0	2.0	3.0	
All-Red Time (s)	2.0	2.0		0.0	2.0		2.0	2.0	2.0	0.0	2.0	
Lost Time Adjust (s)		0.0		0.0	0.0			0.0	0.0	0.0	0.0	
Total Lost Time (s)		5.0		2.0	5.0			5.0	5.0	2.0	5.0	
Lead/Lag	Lag	Lag		Lead			Lag	Lag	Lag	Lead		
Lead-Lag Optimize?	Yes	Yes		Yes			Yes	Yes	Yes	Yes		
Recall Mode	None	None		None	None		Max	Max	Max	None	Max	
Act Effct Green (s)		9.0		26.0	23.0			20.0	20.0	35.0	32.0	
Actuated g/C Ratio		0.14		0.40	0.35			0.31	0.31	0.54	0.49	
v/c Ratio		0.72		0.86	0.96			1.03	0.38	0.51	0.53	
Control Delay (s/veh)		44.3		36.8	48.0			72.3	20.6	12.8	14.1	

Lane Group	Ø9
Lane Configurations	
Traffic Volume (vph)	
Future Volume (vph)	
Ideal Flow (vphpl)	
Lane Width (ft)	
Grade (%)	
Storage Length (ft)	
Storage Lanes	
Taper Length (ft)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Right Turn on Red	
Satd. Flow (RTOR)	
Link Speed (mph)	
Link Distance (ft)	
Travel Time (s)	
Peak Hour Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Enter Blocked Intersection	
Lane Alignment	
Median Width(ft)	
Link Offset(ft)	
Crosswalk Width(ft)	
Two way Left Turn Lane	
Headway Factor	
Turning Speed (mph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	6.0
Minimum Split (s)	8.0
Total Split (s)	22.0
Total Split (%)	25%
Yellow Time (s)	2.0
All-Red Time (s)	0.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay (s/veh)	

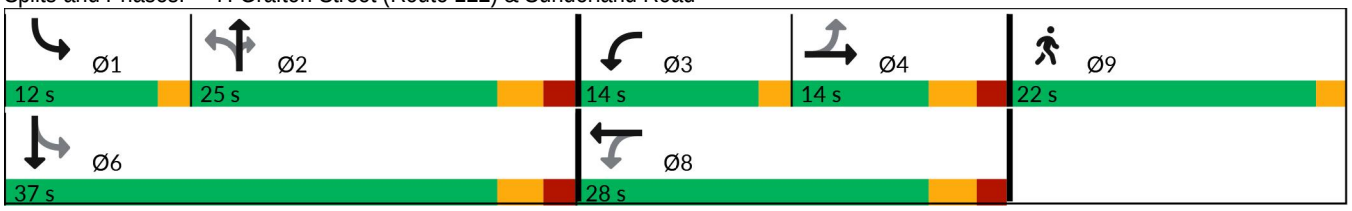
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Queue Delay		0.0		0.0	0.0			0.0	0.0	0.0	0.0	
Total Delay (s/veh)		44.3		36.8	48.0			72.3	20.6	12.8	14.1	
LOS		D		D	D			E	C	B	B	
Approach Delay (s/veh)		44.3			43.4			59.8			13.7	
Approach LOS		D			D			E			B	
Queue Length 50th (ft)		62		124	204			~222	53	38	116	
Queue Length 95th (ft)		#150		#225	#405			#406	102	71	194	
Internal Link Dist (ft)		479			311			618			976	
Turn Bay Length (ft)				250					220	175		
Base Capacity (vph)		240		476	627			525	459	396	870	
Starvation Cap Reductn		0		0	0			0	0	0	0	
Spillback Cap Reductn		0		0	0			0	0	0	0	
Storage Cap Reductn		0		0	0			0	0	0	0	
Reduced v/c Ratio		0.72		0.86	0.96			1.03	0.38	0.51	0.53	

Intersection Summary			
Area Type:	Other		
Cycle Length: 87			
Actuated Cycle Length: 65			
Natural Cycle: 90			
Control Type: Actuated-Uncoordinated			
Maximum v/c Ratio: 1.03			
Intersection Signal Delay (s/veh): 40.3		Intersection LOS: D	
Intersection Capacity Utilization 109.8%		ICU Level of Service H	
Analysis Period (min) 15			

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 7: Grafton Street (Route 122) & Sunderland Road



Lane Group	Ø9
Queue Delay	
Total Delay (s/veh)	
LOS	
Approach Delay (s/veh)	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Intersection	
Int Delay, s/veh	1.7

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	11	40	32	0	0	9
Future Vol, veh/h	11	40	32	0	0	9
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	2	-	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	12	43	35	0	0	10

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	35	0	-	0	102	35
Stage 1	-	-	-	-	35	-
Stage 2	-	-	-	-	67	-
Critical Hdwy	4.12	-	-	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	2.218	-	-	-	3.518	3.318
Pot Cap-1 Maneuver	1576	-	-	-	896	1038
Stage 1	-	-	-	-	987	-
Stage 2	-	-	-	-	956	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	1576	-	-	-	889	1038
Mov Cap-2 Maneuver	-	-	-	-	889	-
Stage 1	-	-	-	-	979	-
Stage 2	-	-	-	-	956	-

Approach	EB	WB	SB
HCM Control Delay, s/v	1.6	0	8.5
HCM LOS			A

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	1576	-	-	-	1038
HCM Lane V/C Ratio	0.008	-	-	-	0.009
HCM Control Delay (s/veh)	7.3	0	-	-	8.5
HCM Lane LOS	A	A	-	-	A
HCM 95th %tile Q (veh)	0	-	-	-	0

ATTACHMENT D

Signal Warrant Analysis

TRAFFIC SIGNAL WARRANT ANALYSIS FINDINGS

Scenario: Build 2030 (2030)

	Included?	Warrant Satisfied?	Notes and Comments:
Warrant 1, Eight-Hour Vehicular Volume	Yes	**No**	
Warrant 2, Four-Hour Vehicular Volume	Yes	**No**	
Warrant 3, Peak Hour	No		Warrant Not Applicable
Warrant 4, Pedestrian Volume	No		
Warrant 5, School Crossing	No		
Warrant 6, Coordinated Signal System	No		
Warrant 7, Crash Experience	No		
Warrant 8, Roadway Network	No		
Warrant 9, Intersection Near a Grade Crossing	No		

Conclusion: Enter Conclusion

Notes:

Results by Scenario

Scenario	W1	W2	W3	W4	W5	W6	W7	W8	W9
Build 2030 (2030)	No	No							

WARRANT 1, EIGHT-HOUR VEHICULAR VOLUME

Intersection Name: Grafton Street at Brandt Lane
Jurisdiction: City of Worcester
Scenario: Build 2030 (2030)

Warrant Met: No

Number of Lanes for Moving Traffic on Each Approach	
Major Street (NB/SB)	1 Lane
Minor Street 1 (EB)	1 Lane
Minor Street 2 (WB)	1 Lane

Apply 70% Reduction to Warrant Thresholds? No

Notes:

Lanes	Adjusted Volumes		Condition A								Condition B								Combination A/B											
																			Cond. A				Cond. B				Cond. A			
Major/Minor	Major Street (NB/SB)	Minor Street 2 (WB)	100%				70%				100%				70%				80%				80%				56%			
			Maj.	Min. 1	Min. 2						Maj.	Min. 1	Min. 2						Maj.	Min. 1	Min. 2		Maj.	Min. 1	Min. 2					
1 / 1	X	X	500	150	150						750	75	75						400	120	120		600	60	60					
2+ / 1			600	150	150						900	75	75						480	120	120		720	60	60					
2+ / 2+			600	200	200						900	100	100						480	160	160		720	80	80					
1 / 2+	X		500	200	200						750	100	100						400	160	160		600	80	80					
HOURS MET			**19**	**1**							**17**	**3**							**19**	**2**			**18**	**6**						
WARRANT SATISFIED (8+ Hours)?			**NO**								**NO**								**NO**											
12:00 AM	289	4																												
12:15 AM	195	4																												
12:30 AM	177	4																												
12:45 AM	163	4																												
1:00 AM	153	4																												
1:15 AM	116	3																												
1:30 AM	108	2																												
1:45 AM	98	1																												
2:00 AM	96	1																												
2:15 AM	100	2																												
2:30 AM	98	3																												
2:45 AM	97	4																												
3:00 AM	97	4																												
3:15 AM	182	4																												
3:30 AM	199	5																												
3:45 AM	227	7																												
4:00 AM	255	10																												
4:15 AM	508	14	X																X											
4:30 AM	552	19																												
4:45 AM	614	26																					X							
5:00 AM	692	36																												
5:15 AM	1082	52	X								X								X											
5:30 AM	1164	70																												
5:45 AM	1252	91																					X		X	X				
6:00 AM	1314	114																												
6:15 AM	1625	132	X								X		X	X					X		X	X								
6:30 AM	1726	148																												
6:45 AM	1779	157																					X		X	X				
7:00 AM	1843	156																												
7:15 AM	1983	150	X		X	X					X		X	X					X		X	X								
7:30 AM	1984	139																												
7:45 AM	1995	124																					X		X	X				
8:00 AM	1998	109																												
8:15 AM	1976	94	X								X		X	X					X											
8:30 AM	1966	79																												
8:45 AM	1954	68																					X		X	X				
9:00 AM	1956	61																												
9:15 AM	1949	55	X								X								X											
9:30 AM	1955	51																												
9:45 AM	1971	48																					X							
10:00 AM	1970	44																												
10:15 AM	1979	43	X								X								X											
10:30 AM	1991	44																												
10:45 AM	1969	45																					X							
11:00 AM	1957	47																												
11:15 AM	1991	49	X								X								X											
11:30 AM	2011	49																												
11:45 AM	2037	49																					X							

WARRANT 1, EIGHT-HOUR VEHICULAR VOLUME

Intersection Name: Grafton Street at Brandt Lane
Jurisdiction: City of Worcester
Scenario: Build 2030 (2030)

Warrant Met: No

Number of Lanes for Moving Traffic on Each Approach	
Major Street (NB/SB)	1 Lane
Minor Street 1 (EB)	1 Lane
Minor Street 2 (WB)	1 Lane

Apply 70% Reduction to Warrant Thresholds? No

Notes:

Lanes	Adjusted Volumes		Condition A								Condition B								Combination A/B											
																			Cond. A				Cond. B				Cond. A			
Major/Minor	Major Street (NB/SB)	Minor Street 2 (WB)	100%				70%				100%				70%				80%				80%				56%			
			Maj.	Min. 1	Min. 2						Maj.	Min. 1	Min. 2						Maj.	Min. 1	Min. 2		Maj.	Min. 1	Min. 2					
1 / 1	X	X	500	150	150						750	75	75						400	120	120		600	60	60					
2+ / 1			600	150	150						900	75	75						480	120	120		720	60	60					
2+ / 2+			600	200	200						900	100	100						480	160	160		720	80	80					
1 / 2+	X		500	200	200						750	100	100						400	160	160		600	80	80					
HOURS MET			**19**	**1**							**17**	**3**							**19**	**2**			**18**	**6**						
WARRANT SATISFIED (8+ Hours)?			**NO**								**NO**								**NO**											
12:00 PM	2063	50																												
12:15 PM	2144	49	X								X								X											
12:30 PM	2150	48																												
12:45 PM	2184	46																					X							
1:00 PM	2203	42																												
1:15 PM	2281	40	X								X								X											
1:30 PM	2300	39																												
1:45 PM	2315	39																					X							
2:00 PM	2345	40																												
2:15 PM	2408	40	X								X								X											
2:30 PM	2414	41																												
2:45 PM	2423	42																					X							
3:00 PM	2401	45																												
3:15 PM	2453	49	X								X								X											
3:30 PM	2442	53																												
3:45 PM	2460	58																					X							
4:00 PM	2522	61																												
4:15 PM	2733	62	X								X								X											
4:30 PM	2797	62																												
4:45 PM	2841	62																					X		X	X				
5:00 PM	2832	61																												
5:15 PM	2538	62	X								X								X											
5:30 PM	2491	64																												
5:45 PM	2402	63																					X		X	X				
6:00 PM	2350	63																												
6:15 PM	2144	61	X								X								X											
6:30 PM	2093	56																												
6:45 PM	2071	52																					X							
7:00 PM	2034	47																												
7:15 PM	1746	41	X								X								X											
7:30 PM	1695	36																												
7:45 PM	1617	31																					X							
8:00 PM	1542	26																												
8:15 PM	1317	22	X								X								X											
8:30 PM	1262	19																												
8:45 PM	1228	18																					X							
9:00 PM	1176	17																												
9:15 PM	934	17	X								X								X											
9:30 PM	880	17																												
9:45 PM	816	15																					X							
10:00 PM	772	14																												
10:15 PM	632	12	X																X											
10:30 PM	594	9																												
10:45 PM	570	7																												
11:00 PM	527	5																												
11:15 PM	182	3																												
11:30 PM	110	2																												
11:45 PM	44	1																												

ATTACHMENT E

Parking Demand

ITEParkGen Web App

Graph Look-Up

How to Use ITEParkGen

PGM Desk Reference

Support Documents

Add Users

Comments

Graph Look Up

Query | Filter

DATA SOURCE: Parking Generation Manual, 6th Ed

SEARCH BY LAND USE CODE: 221

LAND USE GROUP: (200-299) Residential

LAND USE: 221 - Multifamily Housing - 2+ BR (Mid-Rise)

LAND USE SUBCATEGORY: Not Close to Rail Transit

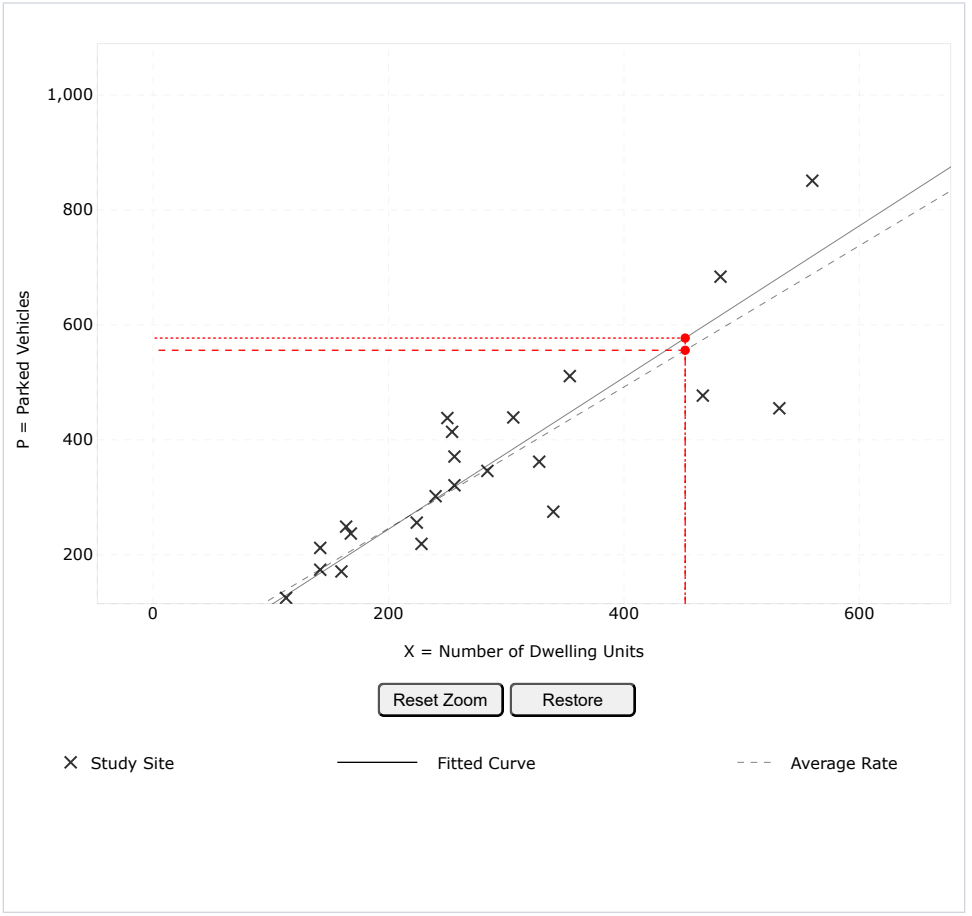
SETTING/LOCATION: General Urban/Suburban

INDEPENDENT VARIABLE (IV): Dwelling Units

TIME PERIOD: Weekday (Monday - Friday)

ENTER IV VALUE TO CALCULATE PARKING DEMAND: 452 Calculate

Data Plot and Equation



Use the mouse wheel to Zoom Out or Zoom In.
Hover the mouse pointer on data points to view X and P values.

DATA STATISTIC

Land Use:
Multifamily Housing - 2+ BR (Mid-R
to Rail Transit (221) Click for Desc
Plots

Independent Variable:
Dwelling Units

Time Period:
Weekday (Monday - Friday)

Setting/Location:
General Urban/Suburban

Number of Studies:
44

Avg. Num. of Dwelling Units:
231

Average Rate:
1.23

Range of Rates:
0.39 - 1.75

33rd / 85th Percentile:
0.98 / 1.45

95% Confidence Interval:
1.15 - 1.31

Standard Deviation:
0.27

Coefficient of Variation:
22%

Fitted Curve Equation:
P = 1.32(X) - 19.46

R^2:
0.96

Calculated Parking Demand:
Weighted Average: 556
Fitted Curve: 577
85th Percentile: 655

Graph Look Up

Graph Look-Up

How to Use ITEParkGen

PGM Desk Reference

Support Documents

Add Users

Comments

Query | Filter

DATA SOURCE:
Parking Generation Manual, 6th Ed

SEARCH BY LAND USE CODE:
221

LAND USE GROUP:
(200-299) Residential

LAND USE:
221 - Multifamily Housing - 2+ BR (Mid-Rise)

LAND USE SUBCATEGORY:
Not Close to Rail Transit

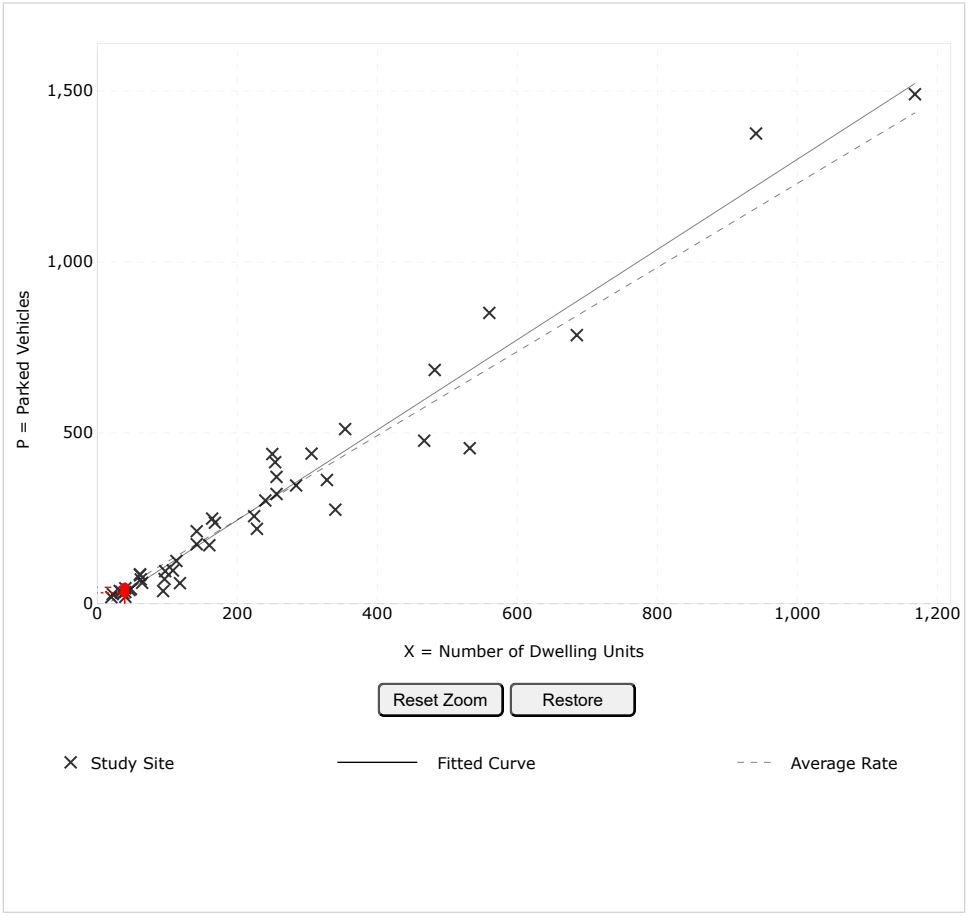
SETTING/LOCATION:
General Urban/Suburban

INDEPENDENT VARIABLE (IV):
Dwelling Units

TIME PERIOD:
Weekday (Monday - Friday)

ENTER IV VALUE TO CALCULATE PARKING DEMAND:
39 Calculate

Data Plot and Equation



Use the mouse wheel to Zoom Out or Zoom In.
Hover the mouse pointer on data points to view X and P values.

DATA STATISTIC

Land Use:
Multifamily Housing - 2+ BR (Mid-R
to Rail Transit (221) Click for Desc
Plots

Independent Variable:
Dwelling Units

Time Period:
Weekday (Monday - Friday)

Setting/Location:
General Urban/Suburban

Number of Studies:
44

Avg. Num. of Dwelling Units:
231

Average Rate:
1.23

Range of Rates:
0.39 - 1.75

33rd / 85th Percentile:
0.98 / 1.45

95% Confidence Interval:
1.15 - 1.31

Standard Deviation:
0.27

Coefficient of Variation:
22%

Fitted Curve Equation:
P = 1.32(X) - 19.46

R^2:
0.96

Calculated Parking Demand:
Weighted Average: 48
Fitted Curve: 32
85th Percentile: 57

Graph Look Up

Graph Look-Up

How to Use ITEParkGen

PGM Desk Reference

Support Documents

Add Users

Comments

Query | Filter

DATA SOURCE: Parking Generation Manual, 6th Ed

SEARCH BY LAND USE CODE: 820

LAND USE GROUP: (800-899) Retail

LAND USE: 820 - Shopping Center (>150k)

LAND USE SUBCATEGORY: All Sites

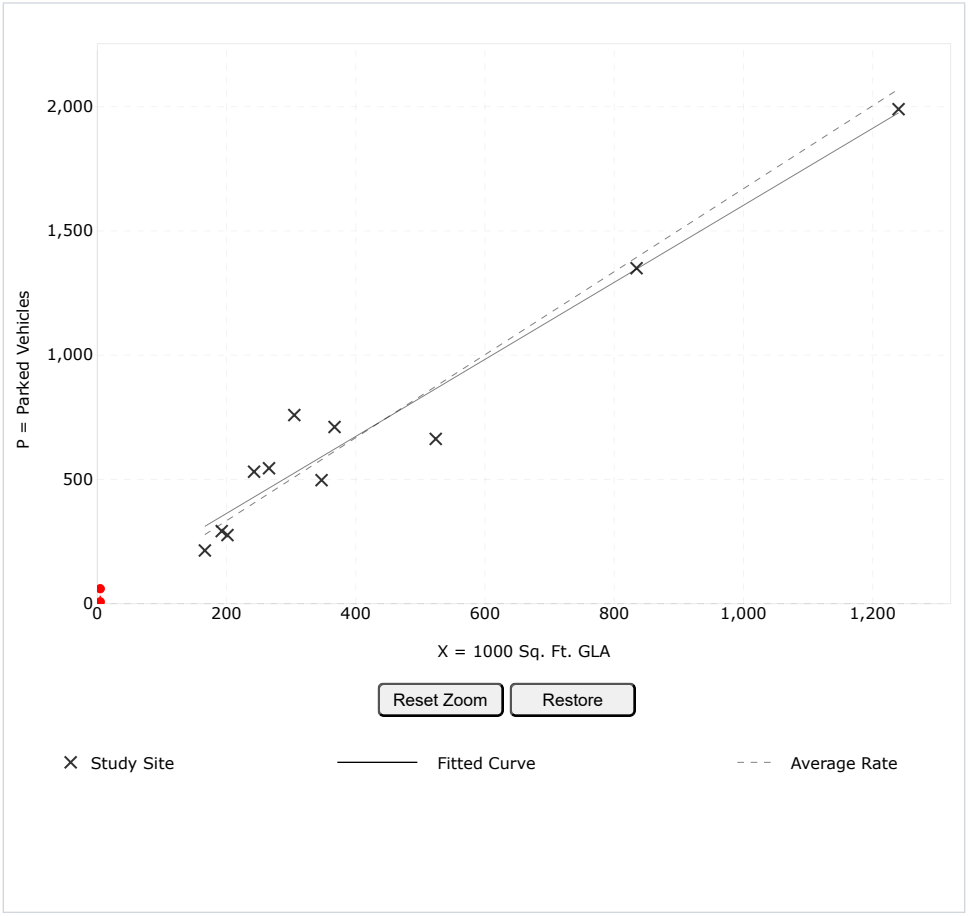
SETTING/LOCATION: General Urban/Suburban

INDEPENDENT VARIABLE (IV): 1000 Sq. Ft. GLA

TIME PERIOD: Weekday (Monday - Thursday)

ENTER IV VALUE TO CALCULATE PARKING DEMAND: 4.5 Calculate

Data Plot and Equation



Use the mouse wheel to Zoom Out or Zoom In.
Hover the mouse pointer on data points to view X and P values.

DATA STATISTIC

Land Use:
Shopping Center (>150k) (820) Cli
and Data Plots

Independent Variable:
1000 Sq. Ft. GLA

Time Period:
Weekday (Monday - Thursday)

Setting/Location:
General Urban/Suburban

Number of Studies:
11

Avg. 1000 Sq. Ft. GLA:
426

Average Rate:
1.67

Range of Rates:
1.27 - 2.49

33rd / 85th Percentile:
1.43 / 2.25

95% Confidence Interval:
***

Standard Deviation:
0.34

Coefficient of Variation:
20%

Fitted Curve Equation:
P = 1.55(X) + 53.20

R^2:
0.95

Calculated Parking Demand:
Weighted Average: 8
Fitted Curve: 60
85th Percentile: 10

ATTACHMENT F

Figures

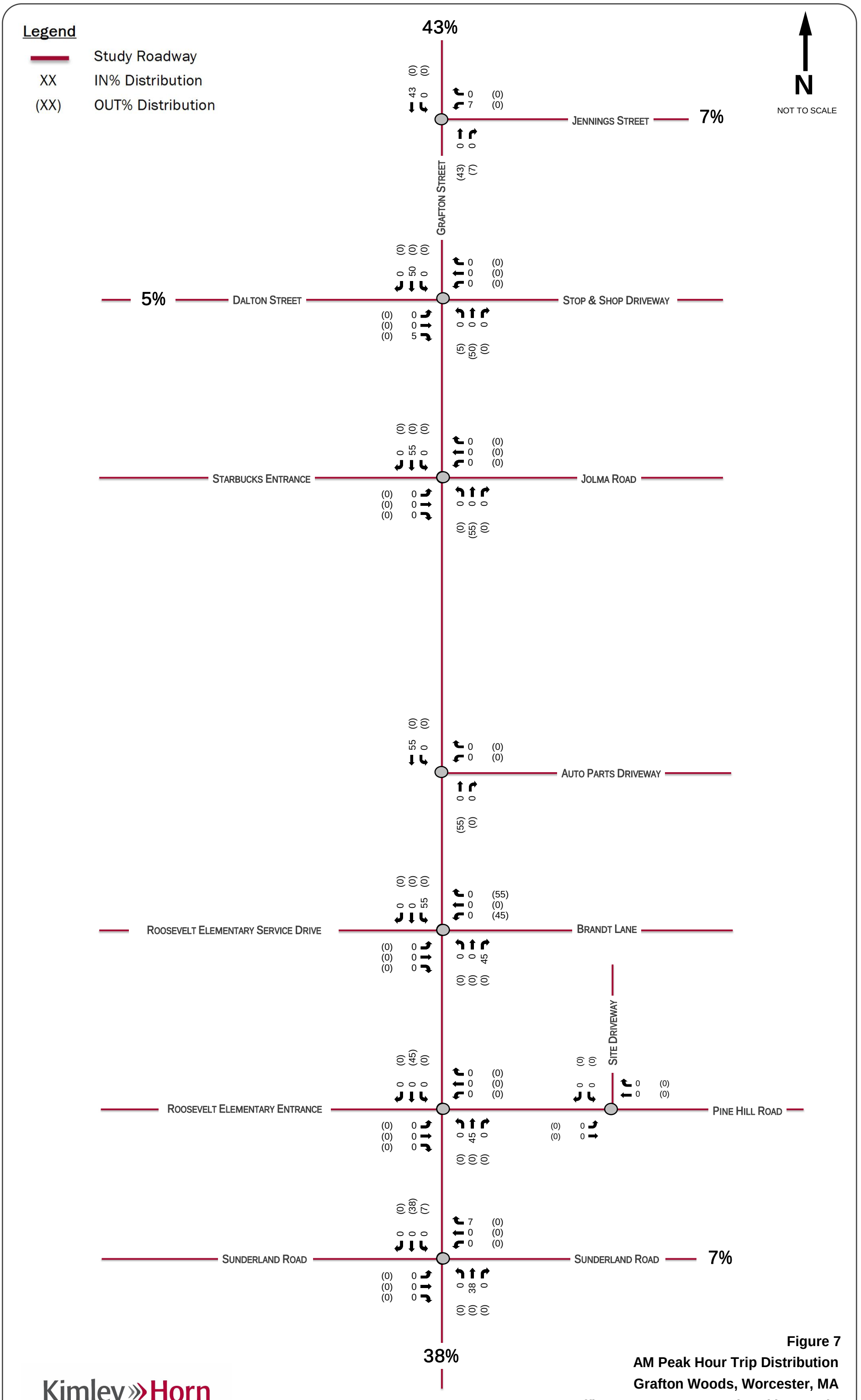


Figure 7
AM Peak Hour Trip Distribution
Grafton Woods, Worcester, MA
Traffic Impact, Access, and Parking Study

Kimley»Horn

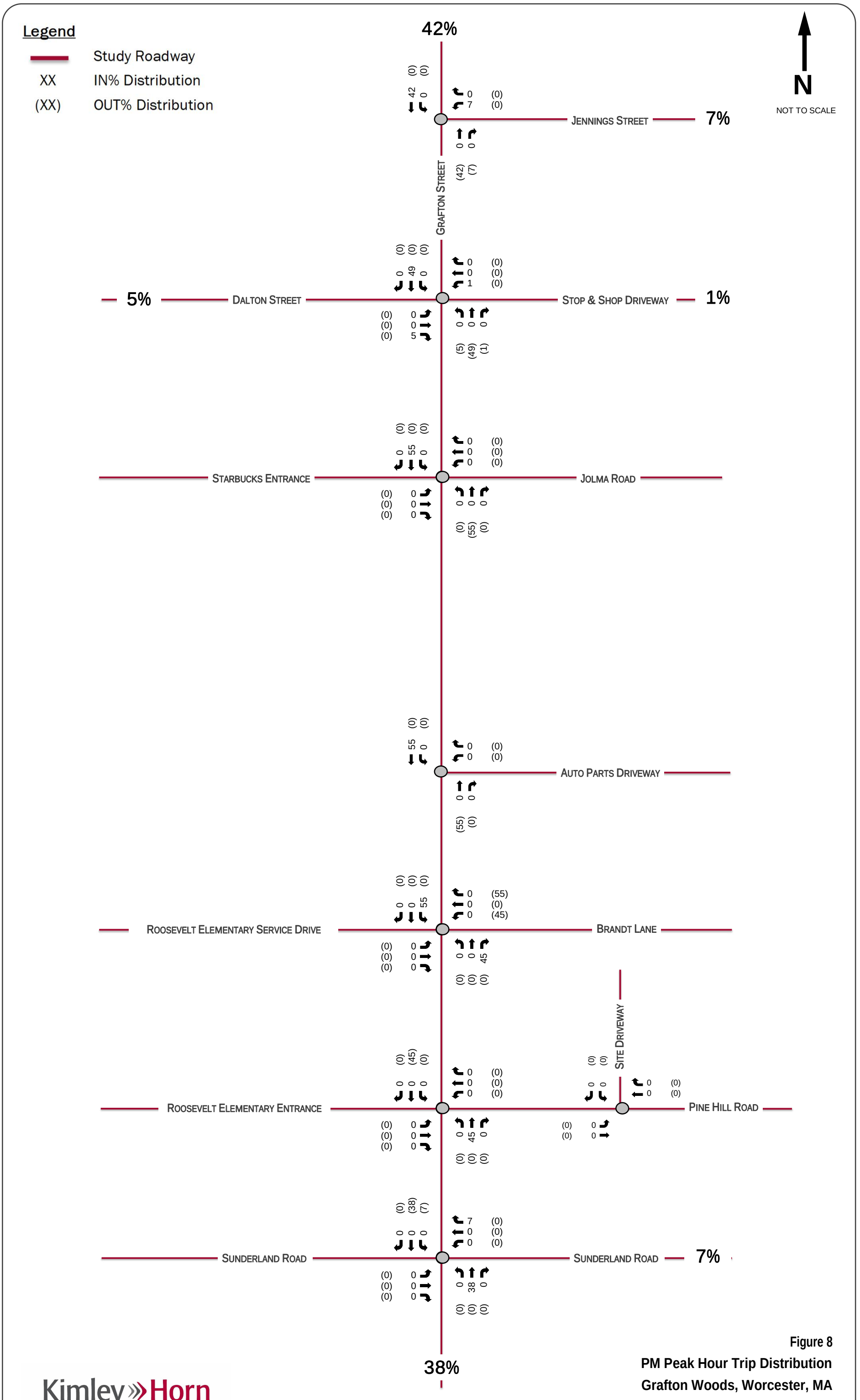


Figure 8

PM Peak Hour Trip Distribution

Grafton Woods, Worcester, MA

Traffic Impact, Access, and Parking Study

Kimley»Horn

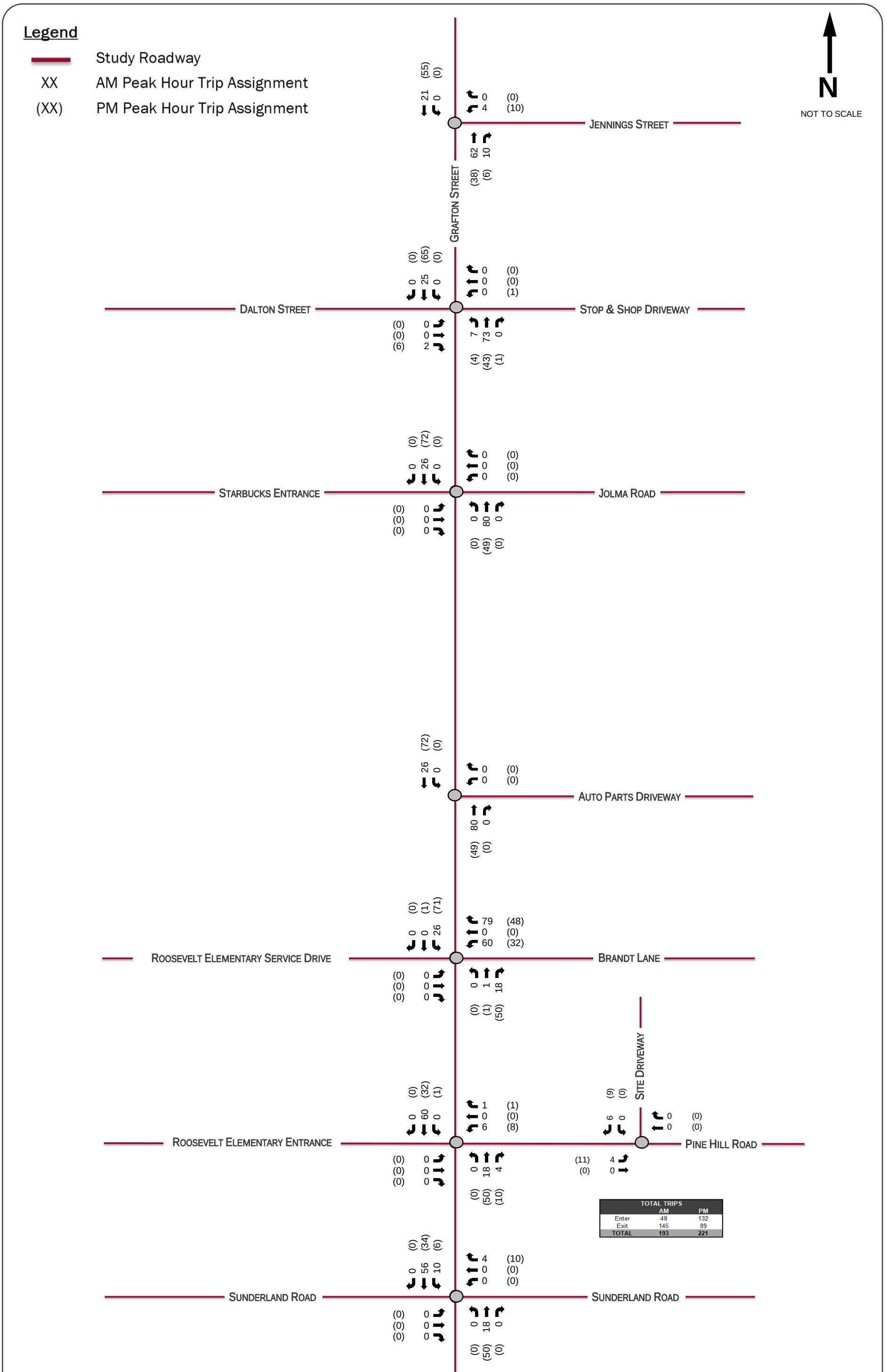


Figure 9

Peak Hour Trip Assignments

Grafton Woods, Worcester, MA

Traffic Impact, Access, and Parking Study

Kimley»Horn

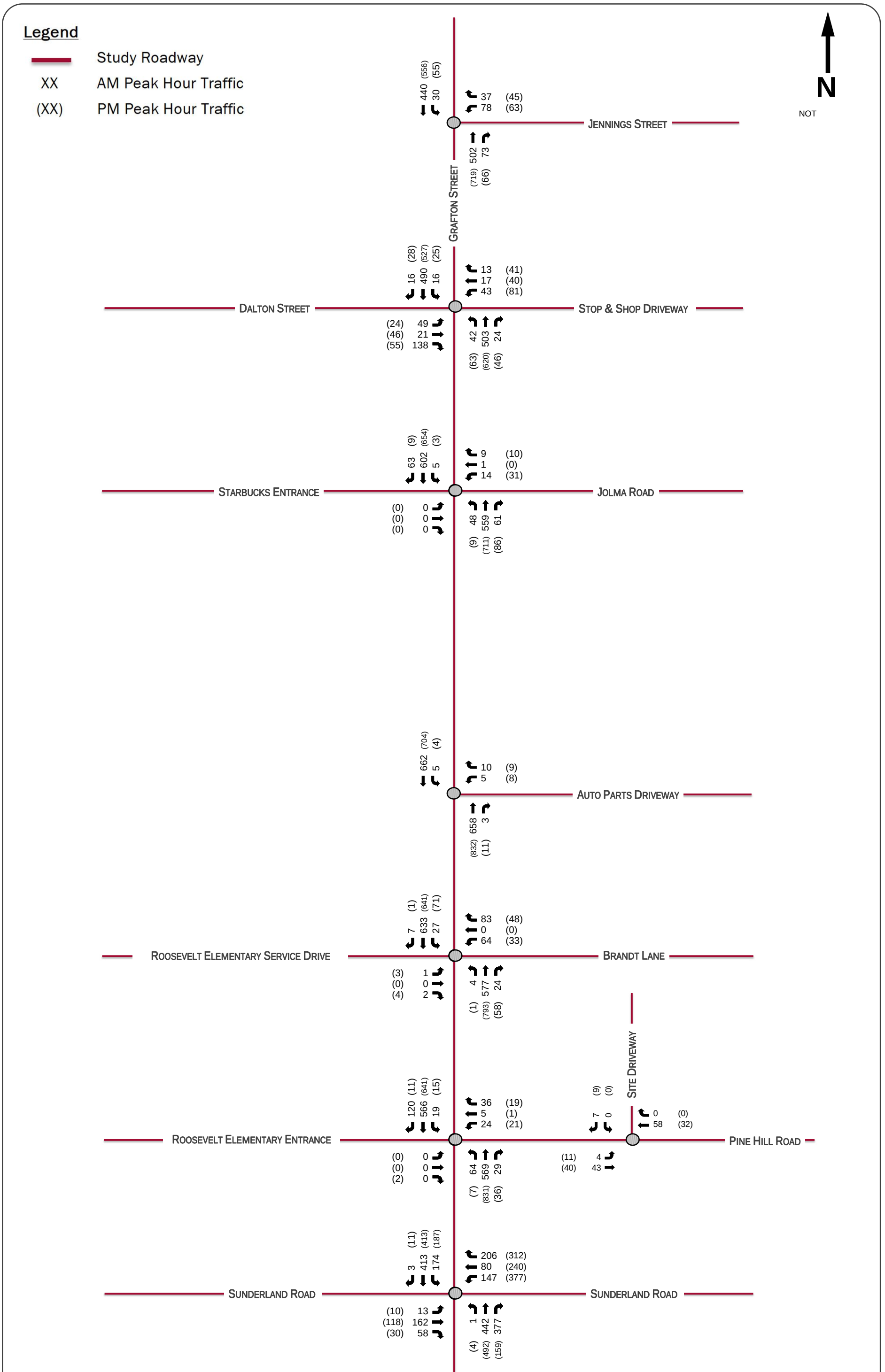


Figure 10
2030 Build Condition Volumes
Grafton Woods, Worcester, MA
Traffic Impact, Access, and Parking Study

Kimley»Horn