McMAHON ASSOCIATES, INC.
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West Palm Beach, FL 33409
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November 8, 2019

VIA E-MAIL

Ivan Busto III
BUSLAM
960 Arthur Godfrey Road #206
Miami Beach, FL 33140

RE: Aqua Hotel Miami Beach Traffic Analysis
McMahon Project No. K19301.01

Dear Mr. Busto:

McMahon Associates, Inc. (McMahon) has completed a traffic analysis for the proposed redevelopment of the Aqua Hotel Miami Beach (project site), located at 1530 Collins Avenue, Miami Beach, Florida. The site has a current approval for 49 hotel rooms. The proposed development, with an anticipated buildout year of 2022, will include 100 hotel rooms and an approximately 1,700-square foot restaurant. The project site location is graphically shown on **Figure 1**.

Figure 1 Project Site Location

Trip Generation Analysis

Using trip generation information obtained from the Institute of Transportation Engineers (ITE), *Trip Generation Manual*, 10th Edition, trip generation estimates were developed for the existing and proposed land uses for weekday PM peak hour conditions, Saturday peak hour conditions and Sunday peak hour conditions. Internal capture of trips between the restaurant and the hotel land uses was also based on ITE. For analysis purpose, it was assumed that 20 percent of all external trips would be multimodal trips. This includes pedestrians and/or bicyclists to and from the project site. Given the location of the hotel, no pass-by traffic was assumed for the analysis.

The trip generation and internal capture spreadsheets, as well as excerpts from ITE, are attached in **Appendix A**. Table A-1 and Table A-2 summarize the PM peak hour trip generation and internal capture analysis; Table A-3 and Table A-4 summarize the Saturday peak hour trip generation and internal capture analysis; Table A-5 and Table A-6 summarize the Sunday peak hour trip generation and internal capture analysis. Results of the analyses indicate that the proposed redevelopment is expected to generate an increase of 35 PM peak hour trips, 42 Saturday peak hour trips, and 39 Sunday peak hour trips.

Project Distribution and Assignment

The project distribution was developed using the Miami-Dade County TAZ data, attached in **Appendix B**. The project site is located in Origin Zone 644. The cardinal distribution for Zone 644 was obtained from the *Miami-Dade 2040 Long Range Transportation Plan Directional Trip Distribution Report*, dated October 23, 2014. Year 2010 and 2040 distribution information was available and included in Appendix B. For this project, the distribution was linearly interpolated to obtain a Year 2022 distribution. The distribution worksheet is included in Appendix B. The cardinal distribution for the project is as follows: NNE – 13 percent; ENE – 0 percent; ESE – 0 percent; SSE – 0 percent; SSW – 11 percent; WSW – 30 percent; WNW – 25 percent; NNW – 21 percent.

For vehicular traffic destined to the project site, vehicles could use several roadways to access Miami Beach. The main east-west roadways near the project site include I-395, Venetian Causeway, and I-195. The main north-south roadways include Collins Avenue and Washington Avenue. The project site can be accessed via one (1) inbound and one (1) outbound driveway, intended for guest drop-off/pick-up only, located along Collins Avenue. Long-term parking is not intended at the driveway. Parking for guests destined to the project site is available via on-street parking or within parking structures within the Miami Beach area. On-street parking is available along Washington Avenue, 16th Street, 15th Street and Espanola Way, in the vicinity of the project site. The nearest parking garage structures are located at 230 16th Street (1/2 block north of the project site) and at 1501 Collins Avenue (directly across from the project site).

The general distribution for vehicular traffic is graphically depicted on **Figure 2**. The general assignment of vehicular trips is graphically shown of **Figure 3**.

Figure 2 Project Distribution of Vehicular Traffic

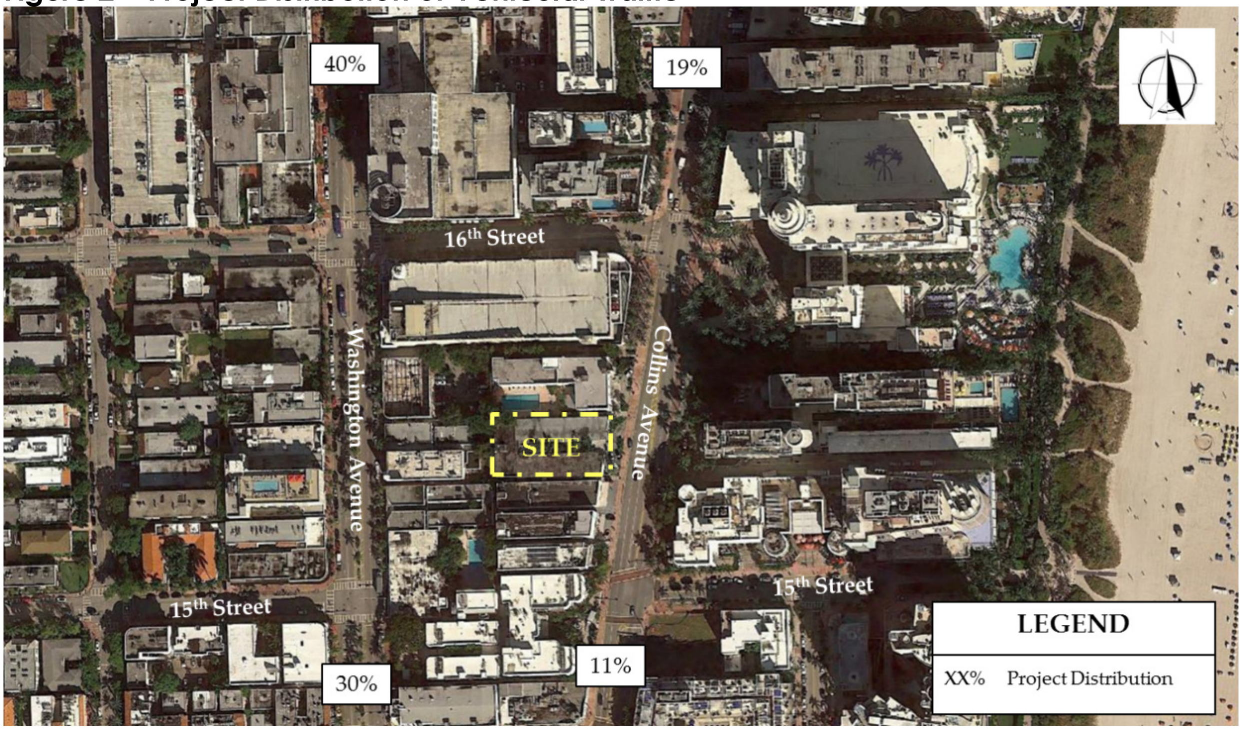
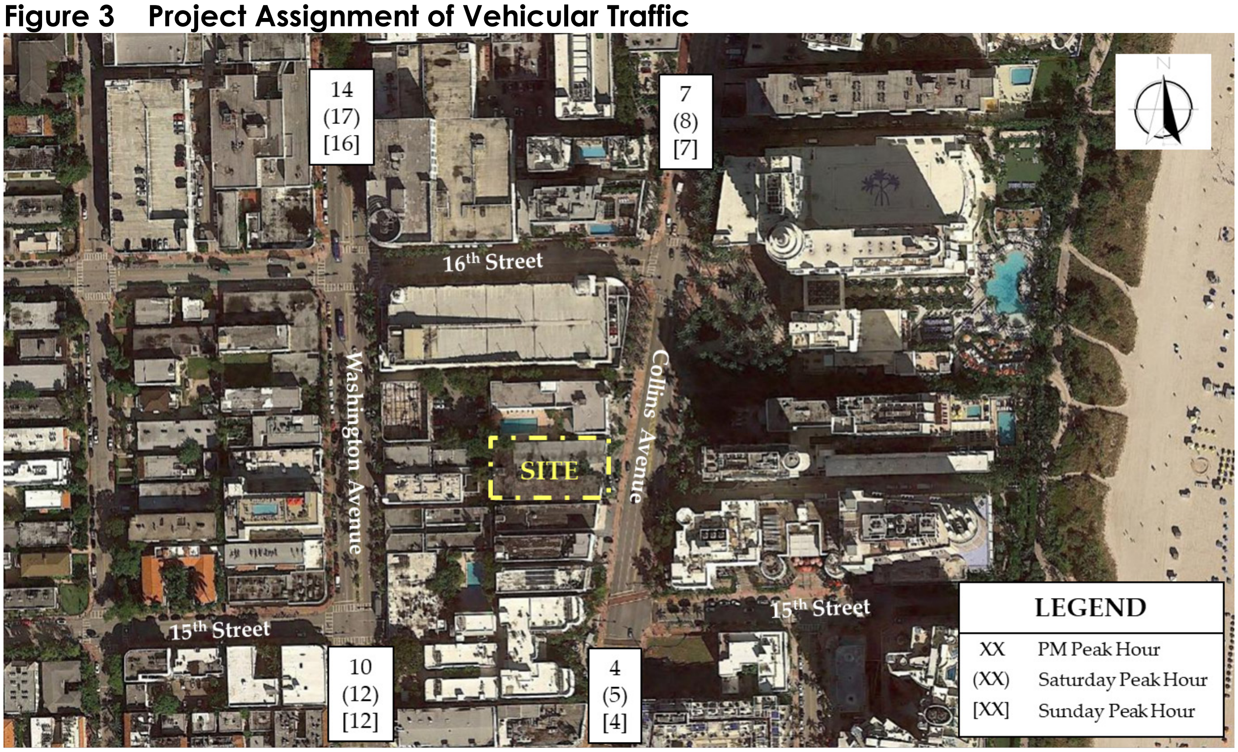


Figure 3 Project Assignment of Vehicular Traffic



Valet Operations

Valet Location - An analysis was performed for the future valet operations to determine the number of valet attendants that will be needed during the worst-case scenario at the project site so that vehicular queues do not spill back onto Collins Avenue. The driveway to the hotel is located at the front of the hotel along Collins Avenue and is proposed to be reconfigured from existing conditions. This will be the proposed pick-up/drop-off area for valet and rideshare operations. The proposed driveway will accommodate approximately three (3) to four (4) vehicles.

Valet Demand - Based on the trip generation analysis, the worst-case traffic scenario was determined to be during the Saturday peak hour. Therefore, the valet operations analysis was performed for Saturday conditions. The vehicular trips for Saturday conditions include 42 inbound vehicles and 30 outbound vehicles, for a total of 72 vehicles for the proposed development. Based on coordination with City of Miami Beach staff, 20 percent of the proposed trips were assumed to self park in the vicinity of the project site. Forty-two (42) percent of the remainder of the trips were assumed to arrive/leave the hotel through rideshare vehicles (Uber, Lyft, Taxi, etc..). Based on these reductions, the trips expected to use the valet operations were determined to be 20 inbound vehicles and 14 outbound vehicles, as summarized in **Table 1**.

Table 1 Trip Summary for Proposed Development

CONDITION	NEW TRIPS		
	IN	OUT	TOTAL
Total Proposed Use Trips	42	30	72
20% Self Park Reduction	8	6	14
Non Self Parking Trips	34	24	58
42% Ride Share Reduction	14	10	24
Remaining Valet Trips	20	14	34

Valet Processing Time - The project site currently has valet operations. However, given the low demand for the service, valet services are requested through the front desk of the hotel and computer system. There is currently no valet attendant that is dedicated to the hotel at a valet stand. The Iberostar Berkeley Shore Hotel, located at 1610 Collins Avenue, does provide actual valet attendant services on a Saturday, consistent with the valet company that will be used for the Aqua Hotel Miami Beach. One (1) valet attendant is stationed onsite and other attendants are called, as necessary. Coordination with the Berkeley Hotel management staff revealed that a Saturday between 10am and 4pm was generally the peak period for valet operations. Valet attendants from the Berkeley Shore Hotel park the vehicles at the garages located along 16th Street between Collins Avenue and Washington Avenue, consistent with the proposed valet location for the Aqua Hotel. The existing valet parking and retrieval routes for the Berkeley Hotel and the Aqua Hotel were measured to determine if they were similar so that actual processing times could be collected at the Berkeley hotel to simulate future processing times for the Aqua Hotel. The expected valet parking and retrieval routes for the Berkeley Hotel and the Aqua Hotel, graphically depicted on **Figure 4,** were determined to be similar.

Figure 4 Valet Routes

Actual valet processing times were collected at the Berkeley Shore Hotel on Saturday, November 2, 2019 from 10am to 4pm. The collected data, attached in **Appendix C**, indicates that there were three (3) instances where a vehicle arrived at the hotel for valet drop-off and five (5) instances where vehicles were retrieved from the garage for valet pick up. The processing times generally ranged between nine (9) minutes and 11 minutes; however, there were two instances when the processing times were 19 and 22 minutes. The valet attendant was questioned as to the nature of the increased processing times. This revealed an organizational issue with the key placement for the vehicles. Therefore, these two processing times were excluded from any further analysis. The average processing time was, therefore, calculated to be approximately 11 minutes.

Rideshare vehicles were also observed to drop off and pick up hotel guests from the valet area, as well as along Collins Avenue. Based on our observations, these events occurred quickly and were less than 30 seconds processing time.

The collected processing times were used to determine the service rate for the valet queueing analysis for the proposed Aqua Hotel land uses.

Valet Queuing Analysis - The valet operations analysis was performed based on the methodology outlined in *Transportation and Land Development*, 1988, published by ITE, excerpts of which are attached in Appendix C. The required storage (M) in vehicles is determined by the following equation:

$$M = \frac{[\ln P(x > M) - \ln Q_M]}{\ln \varrho} - 1$$

- $\varrho = q/NQ$. ϱ is the coefficient of utilization, which is the ratio of the demand rate to the service rate.
- q is the demand rate and is the peak vehicles per hour based on the trip generation analysis. Therefore, $q_{valet} = 34$ vehicles per hour and $q_{rideshare} = 14$ vehicles per hour.
- N is the number of attendants. An iterative process revealed that $N_{valet} = 10$ attendants and $N_{rideshare} = 1$ attendant will be required to ensure traffic does not spill back onto Collins Avenue.
- Q is the service rate per hour for each attendant. Therefore $Q_{valet} = 5.5$ services/hour and $Q_{rideshare} = 120$ services/hour.

Valet Queuing

The operations analysis worksheet is attached in Appendix C. Based on the analysis, when 10 attendants are available for valet services, the expected queue, with 95 percent confidence, is expected to be one (1) vehicle, in addition to the vehicle being serviced. As previously mentioned, the site can accommodate approximately four (4) vehicles without spilling onto Collins Avenue. With less attendants, the vehicles would queue onto Collins Avenue. However, it appears that there are organizational and operational issues that occur today that are conducive to higher processing times. If necessary, in the future for the Aqua Hotel, these issues could be resolved and streamlined to allow for quicker processing times, and therefore require less valet attendants.

Rideshare Queuing

The operations analysis worksheet is attached in Appendix C. Based on the analysis with one (1) attendant to simulate the rideshare vehicle, no queues are expected using a 95 percent confidence level.

Loading/Delivery Operations

Loading and delivery operations currently occur along 16^{th} street within the designated loading areas and during the designated loading times. The proposed loading/delivery operations will continue to occur along 16^{th} Street.

Trash Operations

Trash operations currently occur along Collins Avenue. Vehicles collecting trash stop momentarily along Collins Avenue to collect the trash, then continue travelling along Collins Avenue. The proposed trash operations will continue to occur from Collins Avenue.

Transportation Demand Strategies

The developer for the subject project recognizes the need to minimize the single occupant Auto-Trip Based mode of transportation. As such, every effort will be made to promote the use of various modes available to this site. Such strategies as carpooling and ridesharing will be considered in keeping with the City's effort to alleviate traffic congestion. The proposed Transportation Demand Management Plan is listed below.

- Designate EDEL LIMA as the Employee Transportation Coordinator, under which responsibility he will provide all Staff with available information on ridesharing and biking alternative to commute to/from the workplace. Additionally, he will coordinate the implementation of a car-pooling program between employees.
- Bike Racks: the company will provide a 16 unit bike rack for the use of the Managers and/or Employees that decide to use this alternative transportation.
- Employees Lockers & Bathroom facility will be provided for this same objective.
- Bicycles: The company will provide non-interest-bearing loans to all Employees towards the purchase of a bicycle, with an individual cap of $100.
- Carpooling: The company will provide a 50% discount for those Employees that Carpool on their commute to/from the workplace (2+ employees per car).
- Communication: The Aqua Hotel will showcase all "ridesharing" services, such as Uber, Lyft, Car2Go in its corporate communication, including its web page, social media, brochures, and Front Desk banners.
- Telecommuting: 1530 Collins LLC will allow Management to work from home one or more days a week when operations allow to do so.

The Aqua Hotel will employ around 15 to 20 fulltime and part time Employees on a 5 daily shifts basis.

Should you have any questions or comments regarding these findings, please do not hesitate to call me.

NATALIA THAIS LERCARI
LICENSE
No. 68205
STATE OF
FLORIDA
PROFESSIONAL ENGINEER

Sincerely,

11/8/19

Natalia Thais Lercari, P.E.
Professional Engineer
License No. 68205
State of Florida, Board of Professional Engineers
Certificate of Authorization No. 4908

NTL/cc
Attachment

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APPENDIX A

TRIP GENERATION INFORMATION

TABLE A-1
PM TRIP GENERATION ANALYSIS
AQUA HOTEL MIAMI BEACH TRAFFIC ANALYSIS

LAND USE	ITE CODE	INTENSITY	TRIP GENERATION RATE [1]	IN	OUT	TOTAL TRIPS			INTERNAL TRIPS[1]				EXTERNAL TRIPS			MULTI MODAL REDUCTION[2]				NEW TRIPS		
						IN	OUT	TOTAL	IN	OUT	TOTAL	%	IN	OUT	TOTAL	IN	OUT	TOTAL	%	IN	OUT	TOTAL
EXISTING USES																						
Hotel	310	49 Rooms	Ln(T) = 0.93 Ln(X) - 0.14	58%	42%	19	13	32	0	0	0	0.0%	19	13	32	3	3	6	20%	16	10	26
SUBTOTAL						**19**	**13**	**32**	**0**	**0**	**0**	**0.0%**	**19**	**13**	**32**	**3**	**3**	**6**		**16**	**10**	**26**
PROPOSED USES																						
Hotel	310	100 Rooms	Ln(T) = 0.93 Ln(X) - 0.14	58%	42%	37	26	63	0	0	0	0.0%	37	26	63	7	6	13	20%	30	20	50
Quality Restaurant	931	1,700 SF	T = 8.28 (X)	61%	39%	9	5	14	0	0	0	0.0%	9	5	14	2	1	3	20%	7	4	11
SUBTOTAL						**46**	**31**	**77**	**0**	**0**	**0**	**0.0%**	**46**	**31**	**77**	**9**	**7**	**16**		**37**	**24**	**61**
TOTAL						**27**	**18**	**45**	**0**	**0**	**0**		**27**	**18**	**45**	**6**	**4**	**10**		**21**	**14**	**35**

(1) Source: ITE Trip Generation Manual, 10th Edition.

(2) Based on coordination with the City of Miami Beach

McMAHON TRANSPORTATION ENGINEERS & PLANNERS

TABLE A-2

PM TRIP INTERNAL CAPTURE
AQUA HOTEL MIAMI BEACH TRAFFIC ANALYSIS

Land Use B Quality Restaurant

ITE Land Use Code	931		
Size	1,700 SF		
	Total	Internal	External
Enter	9	0	9
Exit	5	0	5
Total	14	0	14
%	100%	0.0%	100.0%

Enter from External: 9

Exit to External: 5

Demand 0

Demand 0

Balanced 0

Balanced 0

Demand 0

Demand 0

Demand 7% 0

5% 0

Balanced 0

Balanced 0

Demand 71% 26

Demand 68% 18

Land Use C Shopping Center

ITE Land Use Code	0		
Size	0	0	
	Total	Internal	External
Enter	0	0	0
Exit	0	0	0
Total	0	0	0
%	#DIV/0!	#DIV/0!	#DIV/0!

Enter from External: 0

Exit to External: 0

Demand 0 | Balanced 0 | Demand 0

Demand 0 | Balanced 0 | Demand 0

Land Use A Hotel

ITE Land Use Code	310		
Size	100 Rooms		
	Total	Internal	External
Enter	37	0	37
Exit	26	0	26
Total	63	0	63
%	100%	0.0%	100.0%

Enter from External: 37

Exit to External: 26

Net External Trips for Multi-Use Development

	Land Use B		Land Use C		Land Use A		Total	
Enter	9		0		37		46	
Exit	5		0		26		31	Internal
Total	14		0		63		77	Capture
Single-Use Trip Gen Estimate	14		0		63		77	0.0%

Source: McMahon Associates, Inc. based on Templates from the ITE Trip Generation Manual, 10th Edition.

TABLE A-3
SATURDAY TRIP GENERATION ANALYSIS
AQUA HOTEL MIAMI BEACH TRAFFIC ANALYSIS

LAND USE	ITE CODE	INTENSITY		TRIP GENERATION RATE [(1)]	IN	OUT	TOTAL TRIPS			INTERNAL TRIPS[(1)]				EXTERNAL TRIPS			MULTI MODAL REDUCTION[(2)]				NEW TRIPS		
							IN	OUT	TOTAL	IN	OUT	TOTAL	%	IN	OUT	TOTAL	IN	OUT	TOTAL	%	IN	OUT	TOTAL
EXISTING USES																							
Hotel	310	49	Rooms	T = 0.69 (X) + 4.32	56%	44%	21	17	38	0	0	0	0.0%	21	17	38	4	4	8	20%	17	13	30
SUBTOTAL							**21**	**17**	**38**	**0**	**0**	**0**	**0.0%**	**21**	**17**	**38**	**4**	**4**	**8**		**17**	**13**	**30**
PROPOSED USES																							
Hotel	310	100	Rooms	T = 0.69 (X) + 4.32	56%	44%	41	32	73	0	1	1	1.4%	41	31	72	7	7	14	20%	34	24	58
Quality Restaurant	931	1,700	SF	T = 10.68 (X)	59%	41%	11	7	18	1	0	1	5.6%	10	7	17	2	1	3	20%	8	6	14
SUBTOTAL							**52**	**39**	**91**	**1**	**1**	**2**	**2.2%**	**51**	**38**	**89**	**9**	**8**	**17**		**42**	**30**	**72**
TOTAL							**31**	**22**	**53**	**1**	**1**	**2**		**30**	**21**	**51**	**5**	**4**	**9**		**25**	**17**	**42**

(1) Source: ITE Trip Generation Manual, 10th Edition.

(2) Based on coordination with the City of Miami Beach

McMAHON TRANSPORTATION ENGINEERS & PLANNERS

TABLE A-4

SATURDAY TRIP INTERNAL CAPTURE
AQUA HOTEL MIAMI BEACH TRAFFIC ANALYSIS

Land Use B Quality Restaurant

ITE Land Use Code		931	
Size		1,700 SF	
	Total	Internal	External
Enter	11	1	10
Exit	7	0	7
Total	18	1	17
%	100%	5.6%	94.4%

Enter from External: 10

Exit to External: 7

Demand | 0

Demand | 0

Balanced: 0

Balanced: 0

Demand | 0

Demand | 0

Demand 7% | 0

5% | 1

Balanced: 0

Balanced: 1

Demand 71% | 29

Demand 68% | 22

Land Use C Shopping Center

ITE Land Use Code		0	
Size		0	0
	Total	Internal	External
Enter	0	0	0
Exit	0	0	0
Total	0	0	0
%	#DIV/0!	#DIV/0!	#DIV/0!

Enter from External: 0

Exit to External: 0

Demand | 0 — Balanced: 0 — Demand | 0

Demand | 0 — Balanced: 0 — Demand | 0

Land Use A Hotel

ITE Land Use Code		310	
Size		100 Rooms	
	Total	Internal	External
Enter	41	0	41
Exit	32	1	31
Total	73	1	72
%	100%	1.4%	98.6%

Enter from External: 41

Exit to External: 31

Net External Trips for Multi-Use Development

	Land Use B		Land Use C		Land Use A		Total	
Enter	10		0		41		51	
Exit	7		0		31		38	Internal
Total	17		0		72		89	Capture
Single-Use Trip Gen Estimate	18		0		73		91	2.2%

Source: McMahon Associates, Inc. based on Templates from the ITE Trip Generation Manual, 10th Edition.

Internal Capture Rates based on PM peak hour

TABLE A-5
SUNDAY TRIP GENERATION ANALYSIS
AQUA HOTEL MIAMI BEACH TRAFFIC ANALYSIS

LAND USE	ITE CODE	INTENSITY	TRIP GENERATION RATE (1)	IN	OUT	TOTAL TRIPS			INTERNAL TRIPS(1)				EXTERNAL TRIPS			MULTI MODAL REDUCTION(2)				NEW TRIPS		
						IN	OUT	TOTAL	IN	OUT	TOTAL	%	IN	OUT	TOTAL	IN	OUT	TOTAL	%	IN	OUT	TOTAL
EXISTING USES																						
Hotel	310	49 Rooms	T = 0.7 (X) - 29.89	46%	54%	2	2	4	0	0	0	0.0%	2	2	4	1	0	1	20%	1	2	3
SUBTOTAL						**2**	**2**	**4**	**0**	**0**	**0**	**0.0%**	**2**	**2**	**4**	**1**	**0**	**1**		**1**	**2**	**3**
PROPOSED USES																						
Hotel	310	100 Rooms	T = 0.7 (X) - 29.89	46%	54%	18	22	40	0	0	0	0.0%	18	22	40	4	4	8	20%	14	18	32
Quality Restaurant	931	1,700 SF	T = 7.8 (X)	63%	37%	8	5	13	0	0	0	0.0%	8	5	13	2	1	3	20%	6	4	10
SUBTOTAL						**26**	**27**	**53**	**0**	**0**	**0**	**0.0%**	**26**	**27**	**53**	**6**	**5**	**11**		**20**	**22**	**42**
TOTAL						**24**	**25**	**49**	**0**	**0**	**0**		**24**	**25**	**49**	**5**	**5**	**10**		**19**	**20**	**39**

(1) Source: ITE Trip Generation Manual, 10th Edition.

(2) Based on coordination with the City of Miami Beach

TABLE A-6

SUNDAY TRIP INTERNAL CAPTURE
AQUA HOTEL MIAMI BEACH TRAFFIC ANALYSIS

Land Use B Quality Restaurant

ITE Land Use Code	931	
Size	1,700 SF	

	Total	Internal	External
Enter	8	0	8
Exit	5	0	5
Total	13	0	13
%	100%	0.0%	100.0%

Enter from External: 8

Exit to External: 5

Demand | 0

Demand | 0

Balanced: 0

Balanced: 0

Demand | 0

Demand | 0

Demand: 7% | 0

5% | 0

Balanced: 0

Balanced: 0

Demand: 71% | 13

Demand: 68% | 15

Land Use C Shopping Center

ITE Land Use Code	0	
Size	0	0

	Total	Internal	External
Enter	0	0	0
Exit	0	0	0
Total	0	0	0
%	#DIV/0!	#DIV/0!	#DIV/0!

Enter from External: 0

Exit to External: 0

Demand | 0 — Balanced: 0 — Demand | 0

Demand | 0 — Balanced: 0 — Demand | 0

Land Use A Hotel

ITE Land Use Code	310	
Size	100 Rooms	

	Total	Internal	External
Enter	18	0	18
Exit	22	0	22
Total	40	0	40
%	100%	0.0%	100.0%

Enter from External: 18

Exit to External: 22

Net External Trips for Multi-Use Development

	Land Use B		Land Use C		Land Use A		Total	
Enter	8		0		18		26	
Exit	5		0		22		27	Internal
Total	13		0		40		53	Capture
Single-Use Trip Gen Estimate	13		0		40		53	0.0%

Source: McMahon Associates, Inc. based on Templates from the ITE Trip Generation Manual, 10th Edition.
Internal Capture Rates based on PM peak hour

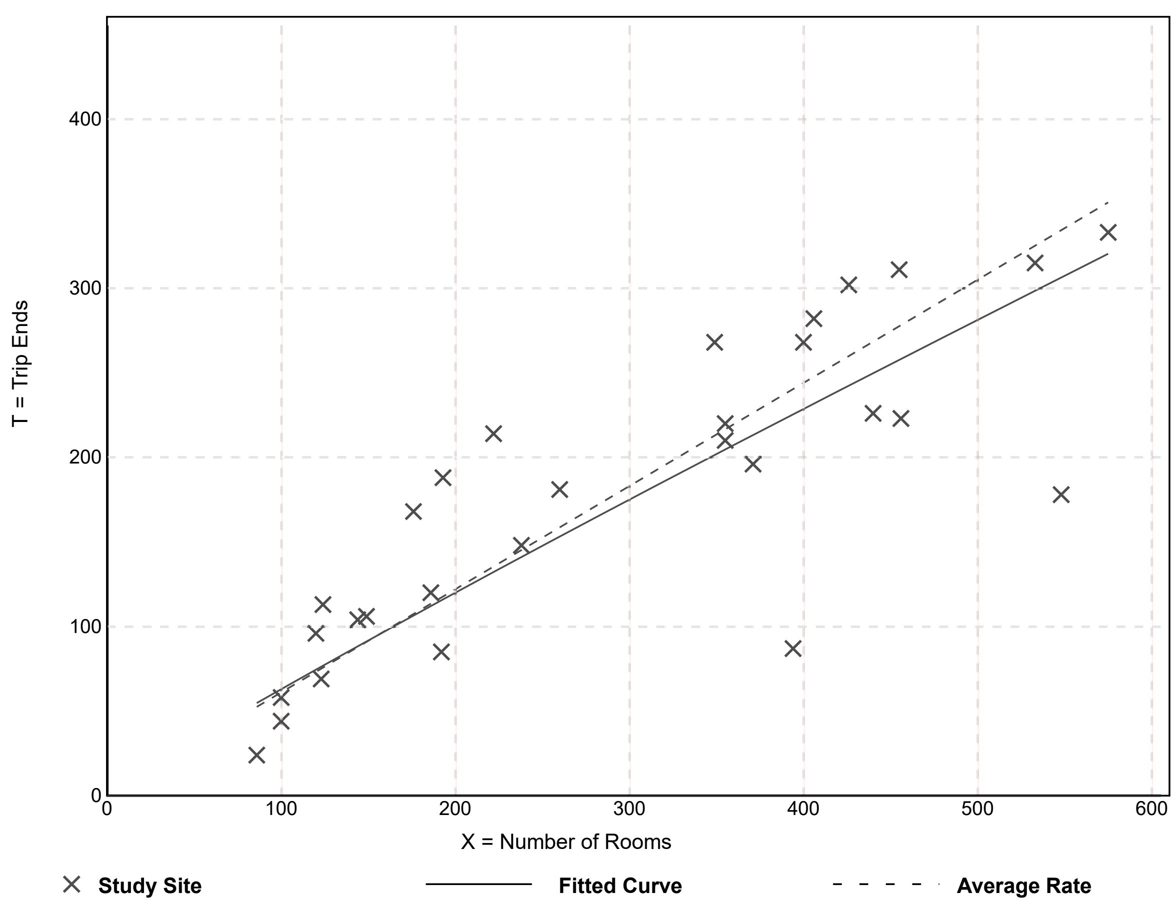
Hotel
(310)

Vehicle Trip Ends vs:	**Rooms**
On a:	**Weekday,** **PM Peak Hour of Generator**
Setting/Location:	**General Urban/Suburban**
Number of Studies:	29
Avg. Num. of Rooms:	292
Directional Distribution:	58% entering, 42% exiting

Vehicle Trip Generation per Room

Average Rate	Range of Rates	Standard Deviation
0.61	0.22 - 0.97	0.18

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.93 Ln(X) - 0.14 **R^2= 0.71**

Hotel
(310)

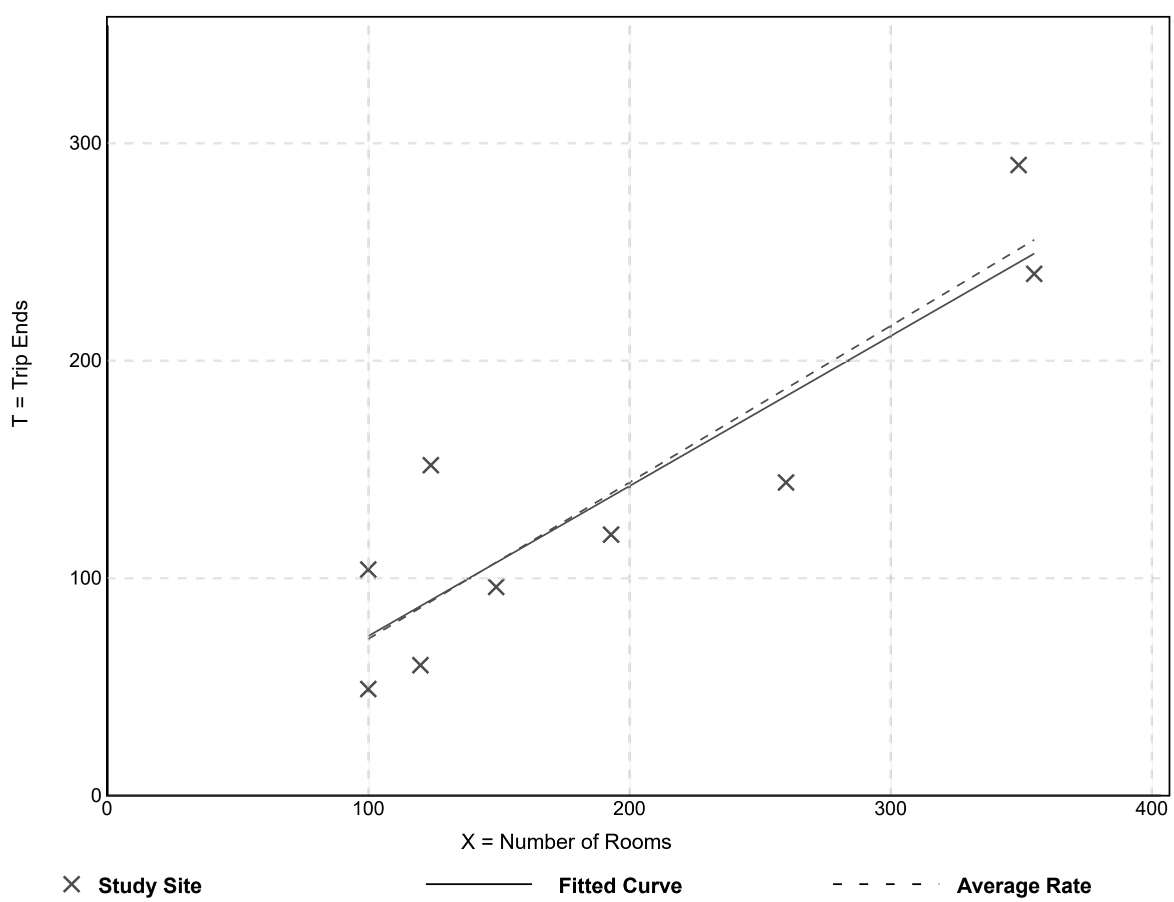
Vehicle Trip Ends vs: Rooms
On a: Saturday, Peak Hour of Generator

Setting/Location: General Urban/Suburban
Number of Studies: 9
Avg. Num. of Rooms: 194
Directional Distribution: 56% entering, 44% exiting

Vehicle Trip Generation per Room

Average Rate	Range of Rates	Standard Deviation
0.72	0.49 - 1.23	0.21

Data Plot and Equation



Fitted Curve Equation: $T = 0.69(X) + 4.32$

$R^2 = 0.80$

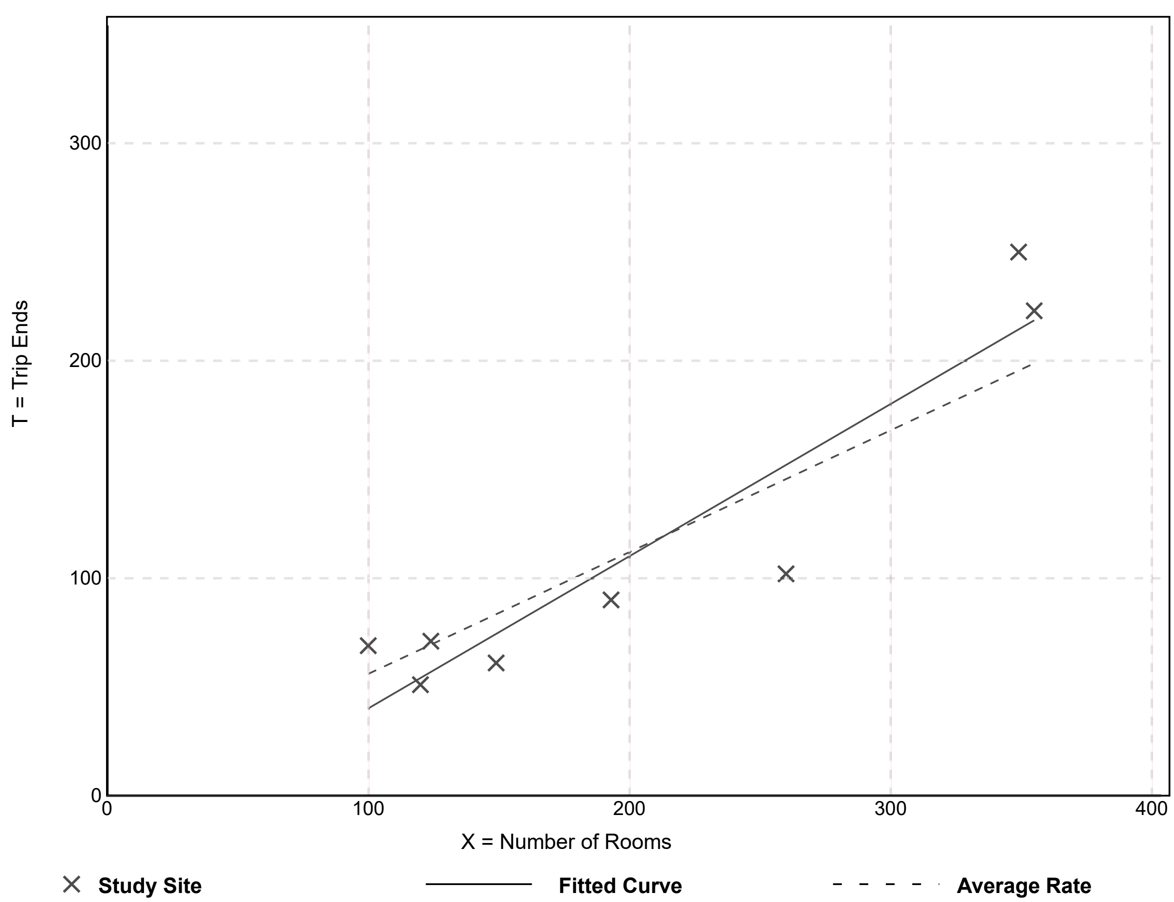
Hotel
(310)

Vehicle Trip Ends vs:	**Rooms**
On a:	**Sunday, Peak Hour of Generator**
Setting/Location:	**General Urban/Suburban**
Number of Studies:	8
Avg. Num. of Rooms:	206
Directional Distribution:	46% entering, 54% exiting

Vehicle Trip Generation per Room

Average Rate	Range of Rates	Standard Deviation
0.56	0.39 - 0.72	0.14

Data Plot and Equation



Fitted Curve Equation: $T = 0.70(X) - 29.89$ **$R^2 = 0.87$**

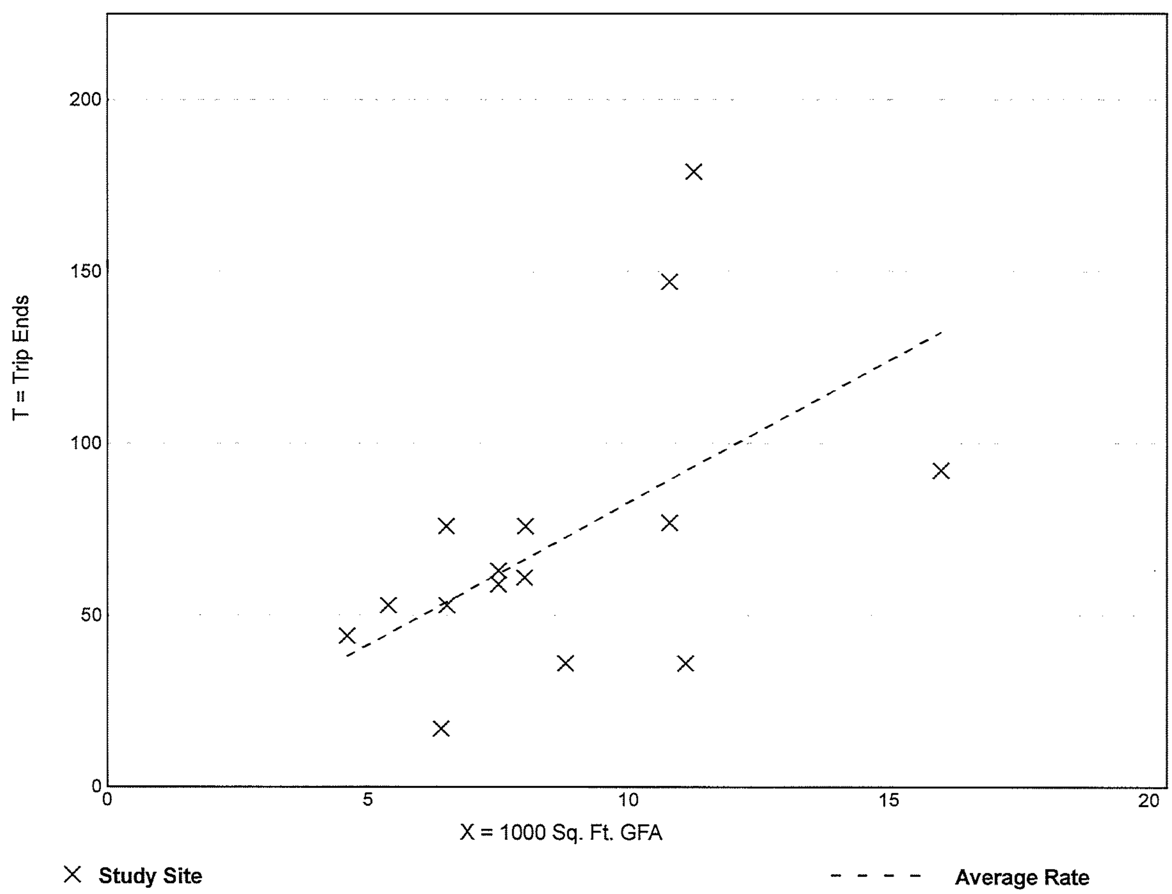
Quality Restaurant
(931)

Vehicle Trip Ends vs:	**1000 Sq. Ft. GFA**
On a:	**Weekday, PM Peak Hour of Generator**
Setting/Location:	**General Urban/Suburban**
Number of Studies:	15
1000 Sq. Ft. GFA:	9
Directional Distribution:	61% entering, 39% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
8.28	2.66 - 15.90	3.89

Data Plot and Equation



Fitted Curve Equation: Not Given

R^2= ****

Quality Restaurant
(931)

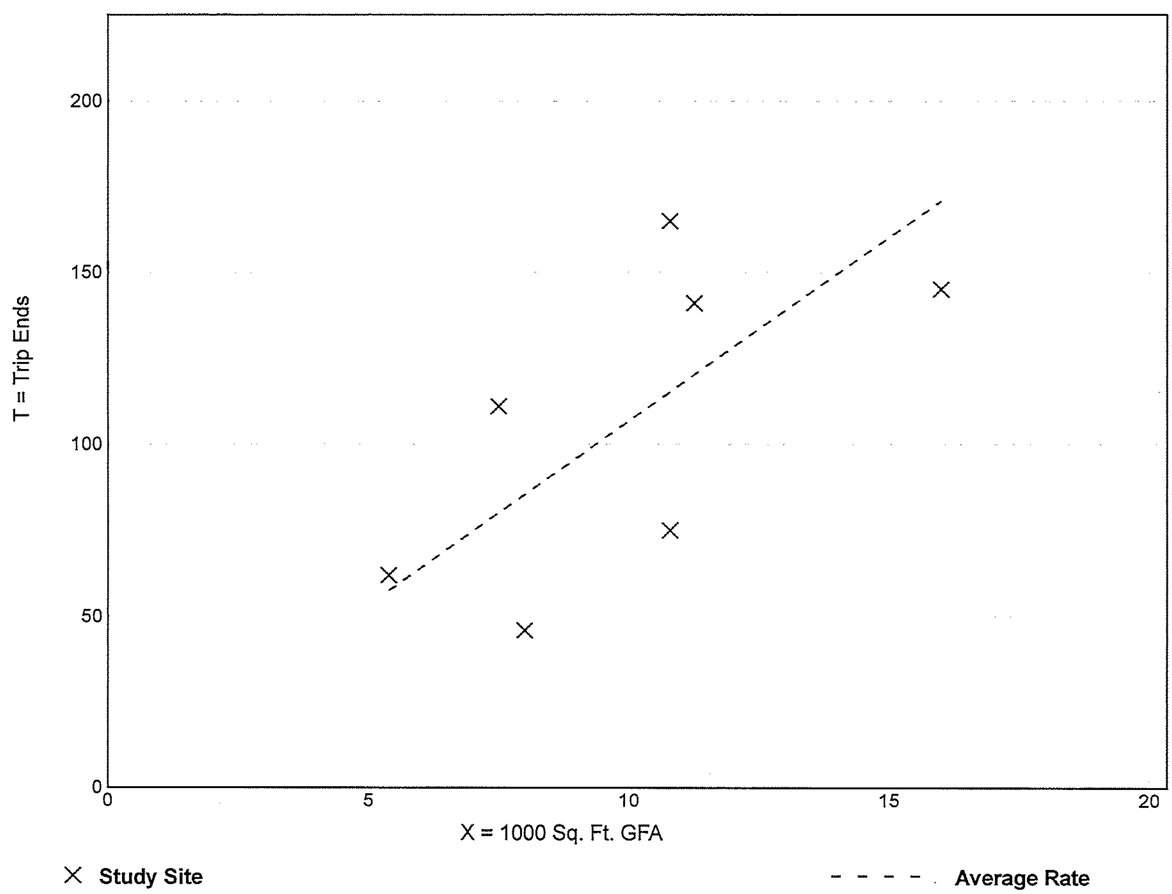
Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Saturday, Peak Hour of Generator**

Setting/Location: **General Urban/Suburban**
Number of Studies: 7
1000 Sq. Ft. GFA: 10
Directional Distribution: 59% entering, 41% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
10.68	5.75 - 15.29	3.62

Data Plot and Equation



Fitted Curve Equation: Not Given

R^2= ****

Quality Restaurant
(931)

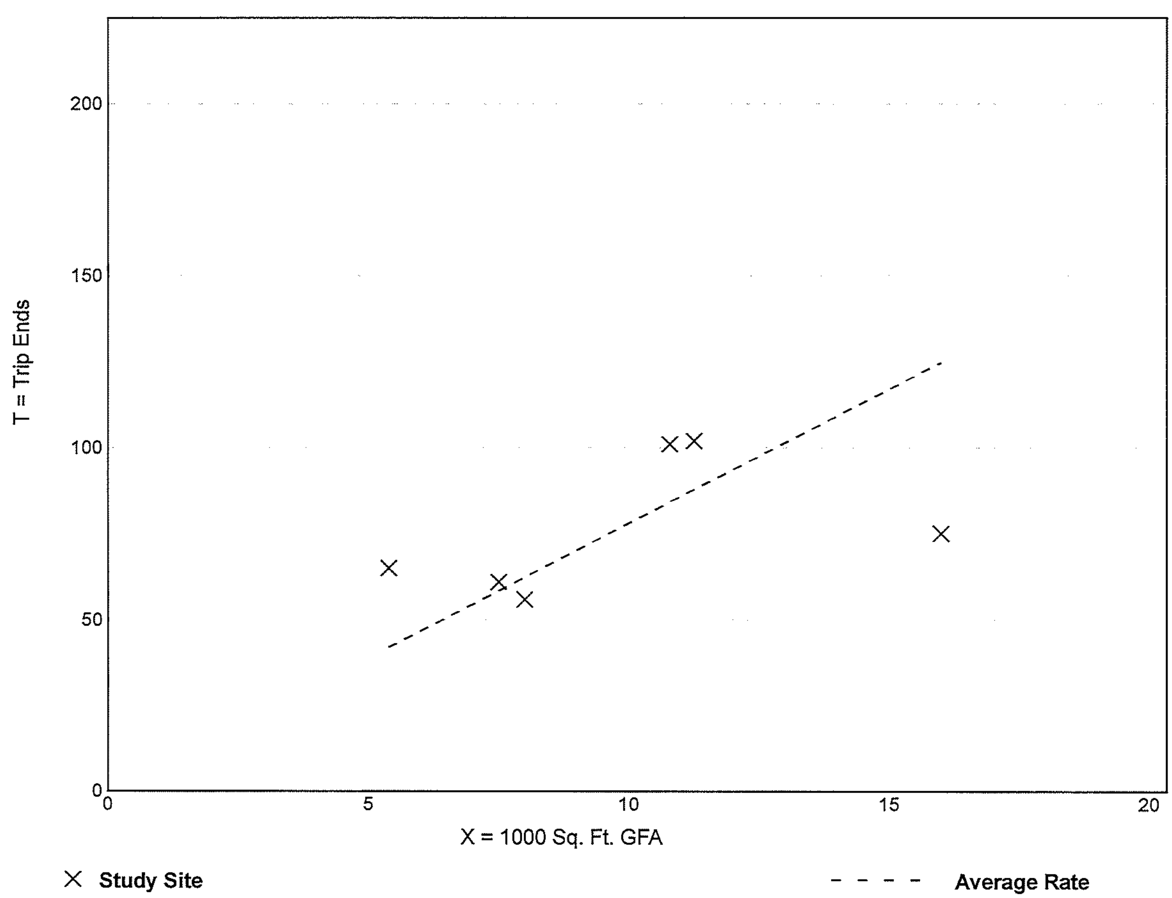
Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Sunday, Peak Hour of Generator**

Setting/Location: **General Urban/Suburban**
Number of Studies: 6
1000 Sq. Ft. GFA: 10
Directional Distribution: 63% entering, 37% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
7.80	4.69 - 12.06	2.48

Data Plot and Equation



Fitted Curve Equation: Not Given

R^2= ****

APPENDIX B

CARDINAL DISTRIBUTION INFORMATION

Project Name: Aqua Hotel Miami Beach Traffic Analysis
Location: 1530 Collins Avenue
Client: BUSLAM
McM Project No.: K19301.01
Date Prepared: 10/2/2019
Prepared by: Natalia T. Lercari, P.E.
Municipality: Miami Beach, Florida

TAZ # 644

2010 Percent Distribution	
NNE	11.20%
ENE	0.00%
ESE	0.00%
SSE	0.00%
SSW	9.60%
WSW	29.70%
WNW	27.30%
NNW	22.10%
Total	**99.90%**

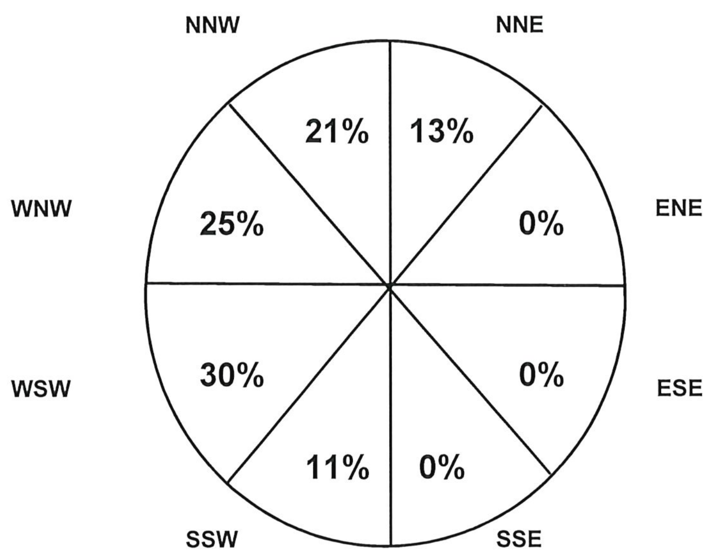
2040 Percent Distribution	
NNE	16.10%
ENE	0.00%
ESE	0.00%
SSE	0.00%
SSW	12.40%
WSW	30.00%
WNW	22.20%
NNW	19.40%
Total	**100.10%**

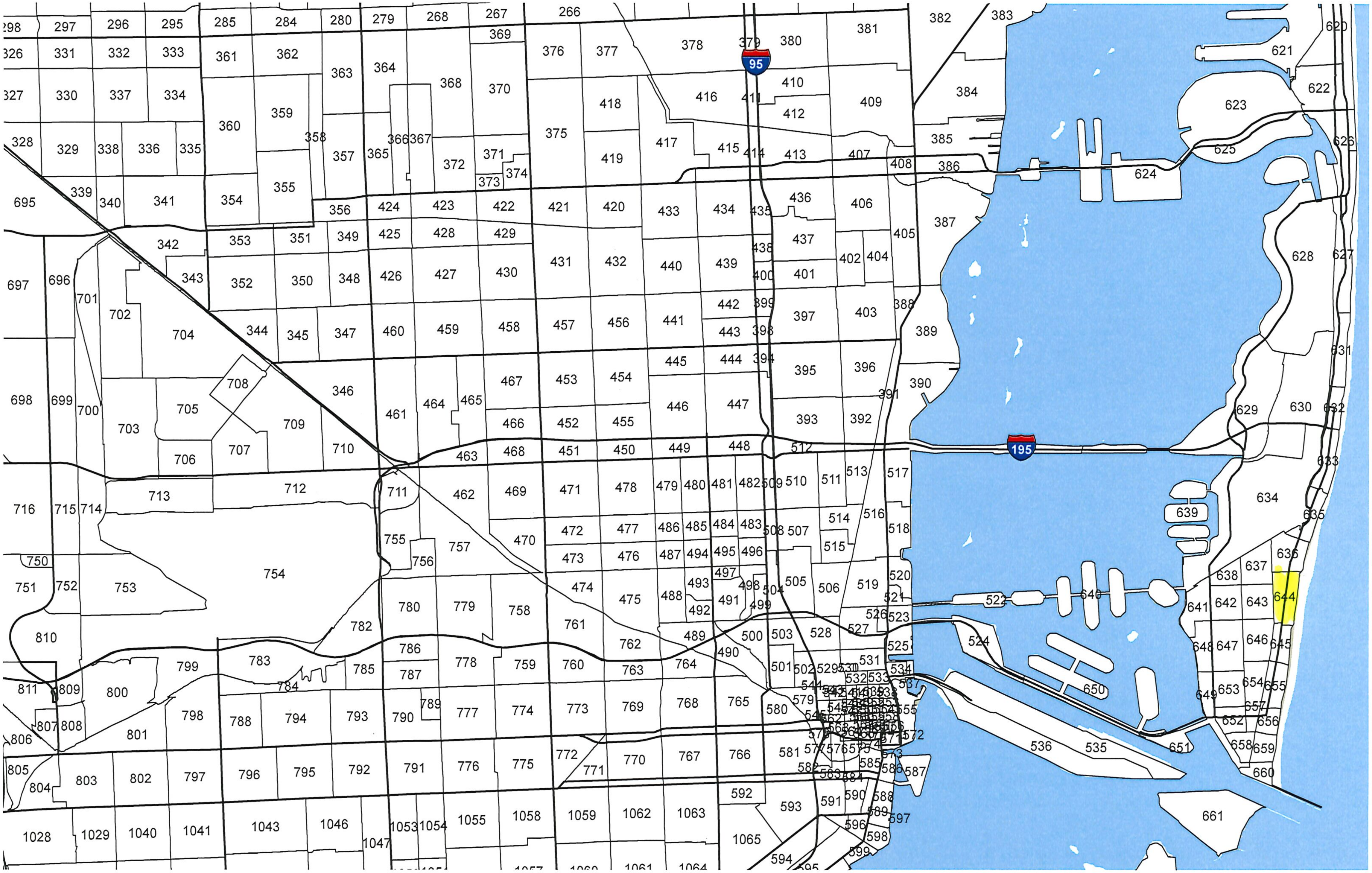
Linear Interpolation: **2022**

Percent Distribution	
NNE	13.16%
ENE	0.00%
ESE	0.00%
SSE	0.00%
SSW	10.72%
WSW	29.82%
WNW	25.26%
NNW	21.02%
Total	**99.98%**

2022

CARDINAL DISTRIBUTION

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750 755 757 756 470 472 477 486 485 484 483 508 507 514 516 518
751 752 753 754 473 476 487 494 495 496 497 515 636 637 638
474 475 488 493 498 504 505 506 519 520 521 522 640 641 642 643 644
810 782 780 779 758 761 492 491 499 526 523 527
786 762 489 490 500 503 528 525 524 648 647 646 645
811 809 800 799 783 784 785 787 778 759 760 763 764 501 502 529 530 531 532 533 534 537 650 649 653 654 655
807 808 806 801 798 788 794 793 790 789 777 774 773 769 768 765 580 579 544 545 555 657 652 656
805 804 803 802 797 796 795 792 791 776 775 772 771 770 767 766 581 577 575 576 573 572 536 535 651 658 659
582 583 584 585 586 587 660
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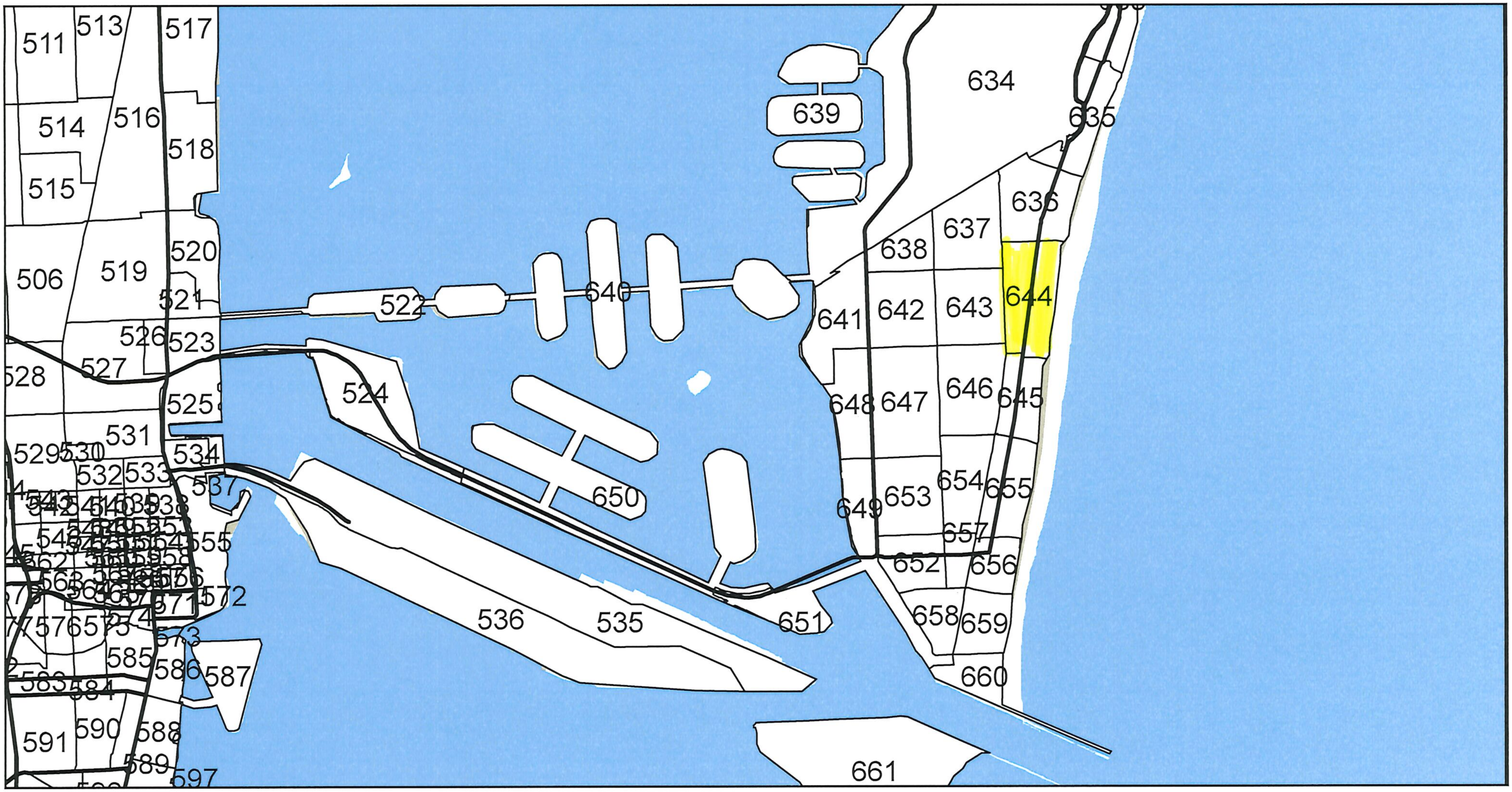
1028 1029 1040 1041 1043 1046 1047 1053 1054 1055 1058 1059 1062 1063 1065 593 591 589 597 596 598 594 595 599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Miami-Dade 2010 Directional Distribution Summary

Origin TAZ			Cardinal Directions								Total
County TAZ	Regional TAZ		NNE	ENE	ESE	SSE	SSW	WSW	WNW	NNW	
636	3536	PERCENT	10.7	0.0	0.0	4.4	10.0	34.0	20.8	20.1	
637	3537	TRIPS	437	39	52	212	109	449	313	207	1,818
637	3537	PERCENT	24.0	2.2	2.9	11.7	6.0	24.7	17.2	11.4	
638	3538	TRIPS	148	25	57	108	66	231	258	107	1,000
638	3538	PERCENT	14.8	2.5	5.7	10.8	6.6	23.1	25.8	10.7	
639	3539	TRIPS	694	286	232	913	139	1,445	989	693	5,391
639	3539	PERCENT	12.9	5.3	4.3	16.9	2.6	26.8	18.4	12.9	
640	3540	TRIPS	436	242	845	100	107	663	503	303	3,199
640	3540	PERCENT	13.6	7.6	26.4	3.1	3.3	20.7	15.7	9.5	
641	3541	TRIPS	1,374	1,440	228	555	352	2,014	2,014	1,124	9,101
641	3541	PERCENT	15.1	15.8	2.5	6.1	3.9	22.1	22.1	12.4	
642	3542	TRIPS	2,054	891	109	1,000	541	3,435	3,075	2,196	13,301
642	3542	PERCENT	15.4	6.7	0.8	7.5	4.1	25.8	23.1	16.5	
643	3543	TRIPS	1,551	277	0	514	462	2,180	2,043	1,648	8,675
643	3543	PERCENT	17.9	3.2	0.0	5.9	5.3	25.1	23.6	19.0	
644	3544	TRIPS	1,376	0	0	0	1,181	3,638	3,350	2,709	12,254
644	3544	PERCENT	11.2	0.0	0.0	0.0	9.6	29.7	27.3	22.1	
645	3545	TRIPS	547	0	0	0	341	1,032	1,603	1,258	4,781
645	3545	PERCENT	11.4	0.0	0.0	0.0	7.1	21.6	33.5	26.3	
646	3546	TRIPS	862	0	61	243	184	1,226	1,566	1,133	5,275
646	3546	PERCENT	16.3	0.0	1.2	4.6	3.5	23.2	29.7	21.5	
647	3547	TRIPS	454	68	83	148	89	427	406	402	2,077
647	3547	PERCENT	21.9	3.3	4.0	7.1	4.3	20.6	19.6	19.4	
648	3548	TRIPS	1,234	415	131	265	56	788	950	546	4,385
648	3548	PERCENT	28.1	9.5	3.0	6.0	1.3	18.0	21.7	12.5	
649	3549	TRIPS	846	215	84	123	15	631	680	403	2,997
649	3549	PERCENT	28.2	7.2	2.8	4.1	0.5	21.1	22.7	13.5	
650	3550	TRIPS	124	133	83	0	20	325	229	66	980
650	3550	PERCENT	12.7	13.6	8.5	0.0	2.0	33.2	23.4	6.7	
651	3551	TRIPS	612	46	55	0	11	438	656	555	2,373
651	3551	PERCENT	25.8	1.9	2.3	0.0	0.5	18.5	27.6	23.4	
652	3552	TRIPS	743	68	63	25	87	625	873	981	3,465
652	3552	PERCENT	21.4	2.0	1.8	0.7	2.5	18.0	25.2	28.3	
653	3553	TRIPS	708	34	64	143	67	703	835	753	3,307
653	3553	PERCENT	21.4	1.0	1.9	4.3	2.0	21.3	25.3	22.8	
654	3554	TRIPS	490	0	203	74	114	628	1,068	1,058	3,635
654	3554	PERCENT	13.5	0.0	5.6	2.0	3.1	17.3	29.4	29.1	
655	3555	TRIPS	1,475	0	0	0	368	1,892	2,676	2,034	8,445
655	3555	PERCENT	17.5	0.0	0.0	0.0	4.4	22.4	31.7	24.1	
656	3556	TRIPS	372	0	0	0	96	740	997	698	2,903
656	3556	PERCENT	12.8	0.0	0.0	0.0	3.3	25.5	34.3	24.0	

Miami-Dade 2040 Directional Distribution Summary

Origin TAZ			Cardinal Directions								Total
County TAZ	Regional TAZ		NNE	ENE	ESE	SSE	SSW	WSW	WNW	NNW	
636	3536	PERCENT	19.5	0.0	0.0	8.2	14.8	29.5	14.8	13.3	
637	3537	TRIPS	374	82	83	225	55	396	261	151	1,627
637	3537	PERCENT	23.0	5.0	5.1	13.8	3.4	24.3	16.0	9.3	
638	3538	TRIPS	232	28	34	125	70	269	193	126	1,077
638	3538	PERCENT	21.5	2.6	3.2	11.6	6.5	25.0	17.9	11.7	
639	3539	TRIPS	735	283	169	948	113	1,300	821	476	4,845
639	3539	PERCENT	15.2	5.8	3.5	19.6	2.3	26.8	17.0	9.8	
640	3540	TRIPS	430	255	683	151	73	932	515	373	3,412
640	3540	PERCENT	12.6	7.5	20.0	4.4	2.1	27.3	15.1	10.9	
641	3541	TRIPS	1,419	1,154	177	632	303	1,982	1,752	1,049	8,468
641	3541	PERCENT	16.8	13.6	2.1	7.5	3.6	23.4	20.7	12.4	
642	3542	TRIPS	2,179	1,098	137	956	454	3,066	2,615	1,535	12,040
642	3542	PERCENT	18.1	9.1	1.1	7.9	3.8	25.5	21.7	12.8	
643	3543	TRIPS	2,025	464	0	785	437	2,968	1,920	1,574	10,173
643	3543	PERCENT	19.9	4.6	0.0	7.7	4.3	29.2	18.9	15.5	
644	3544	TRIPS	2,373	0	0	0	1,831	4,426	3,267	2,854	14,751
644	3544	PERCENT	16.1	0.0	0.0	0.0	12.4	30.0	22.2	19.4	
645	3545	TRIPS	1,336	0	0	0	789	1,367	1,649	1,160	6,301
645	3545	PERCENT	21.2	0.0	0.0	0.0	12.5	21.7	26.2	18.4	
646	3546	TRIPS	950	0	142	324	255	1,435	1,393	1,140	5,639
646	3546	PERCENT	16.9	0.0	2.5	5.8	4.5	25.5	24.7	20.2	
647	3547	TRIPS	400	97	99	84	58	528	545	323	2,134
647	3547	PERCENT	18.7	4.6	4.6	3.9	2.7	24.7	25.5	15.1	
648	3548	TRIPS	1,129	496	172	440	46	1,080	1,249	650	5,262
648	3548	PERCENT	21.5	9.4	3.3	8.4	0.9	20.5	23.7	12.4	
649	3549	TRIPS	917	197	118	194	38	829	1,043	478	3,814
649	3549	PERCENT	24.0	5.2	3.1	5.1	1.0	21.7	27.4	12.5	
650	3550	TRIPS	88	112	79	9	31	340	412	150	1,221
650	3550	PERCENT	7.2	9.2	6.5	0.7	2.5	27.9	33.7	12.3	
651	3551	TRIPS	833	9	103	0	52	472	1,049	629	3,147
651	3551	PERCENT	26.5	0.3	3.3	0.0	1.7	15.0	33.3	20.0	
652	3552	TRIPS	856	91	112	82	128	551	1,157	859	3,836
652	3552	PERCENT	22.3	2.4	2.9	2.1	3.3	14.4	30.2	22.4	
653	3553	TRIPS	659	74	119	117	68	718	812	627	3,194
653	3553	PERCENT	20.6	2.3	3.7	3.7	2.1	22.5	25.4	19.6	
654	3554	TRIPS	814	0	220	127	186	1,003	1,184	881	4,415
654	3554	PERCENT	18.4	0.0	5.0	2.9	4.2	22.7	26.8	20.0	
655	3555	TRIPS	2,196	0	0	0	807	1,970	3,347	2,212	10,532
655	3555	PERCENT	20.9	0.0	0.0	0.0	7.7	18.7	31.8	21.0	
656	3556	TRIPS	565	0	0	0	108	489	1,022	769	2,953
656	3556	PERCENT	19.1	0.0	0.0	0.0	3.7	16.6	34.6	26.0	

APPENDIX C

VALET AND RIDESHARE ANALYSIS

Valet Operations

Required Storage:

$$M = \frac{[\ln P(x > M) - \ln QM]}{\ln \rho} - 1$$

coefficient of utilization:

$\rho = q/NQ$

$$\rho = \frac{34}{(10)\ 5.5} = \mathbf{0.6182}$$

Required Storage with 95% confidence level [P(x >M)]:

$$M = \frac{\ln(.05) - \ln(0.1232)}{\ln(0.6182)} - 1 = \mathbf{1\ vehicles}$$

without rounding = 0.88 vehicles

q is the demand rate. For this analysis,

q = 34 veh/hr.

N is the number of attendants. For this analysis,

N = 10 attendants

Q is the processing rate per hour for each attendant. For this analysis,

Processing Time: 660 sec * 1 min/60 sec = 11 min

Total Time: **11.00 min**

$$Q = \frac{1\ \text{proccess}}{\text{process time}} * \frac{60\ \text{min}}{1\ \text{hr}} \Rightarrow \frac{1\ \text{process*60 min}}{11.00} \Rightarrow \mathbf{5.5\ proccesses/hr}$$

Q_M is a table value obtained from Table 8-11 based on ρ and N.

Table 8-11 (page 6 of pdf)

From Table:	N =	10	and	ρ =	0.6000	=> 0.1013
From Table:	N =	10	and	ρ =	0.7000	=> 0.2218

$$Q_M = 0.1013 + \frac{(0.2218 - 0.1013) * (0.6182 - 0.6000)}{(0.7000 - 0.6000)} = \mathbf{0.1232}$$

Rideshare Operations

Required Storage:

$$M = \frac{[\ln P(x > M) - \ln Q_M]}{\ln \rho} - 1$$

coefficient of utilization:

$$\rho = q/NQ$$

$$\rho = \frac{14}{(1)\ 120} = \mathbf{0.1167}$$

Required Storage with 95% confidence level [P(x >M)]:

$$M = \frac{\ln(.05) - \ln(0.1167)}{\ln(0.1167)} - 1 = \mathbf{-1 \text{ vehicles}}$$

without rounding = -0.605 vehicles

q is the demand rate. For this analysis,

q = 14 veh/hr.

N is the number of attendants. For this analysis,

N = 1 attendant

Q is the processing rate per hour for each attendant. For this analysis,

Processing Time: 30 sec * 1 min/60 sec = 0.5 min

Total Time: **0.50 min**

$$Q = \frac{1 \text{ proccess}}{\text{process time}} * \frac{60 \text{ min}}{1 \text{ hr}} \Rightarrow \frac{1 \text{ process}*60 \text{ min}}{0.50} \Rightarrow \mathbf{120 \text{ proccesses/hr}}$$

Q_M is a table value obtained from Table 8-11 based on ρ and N.

Table 8-11 (page 6 of pdf)

From Table:	N =	1	and	ρ =	0.1000	=>	0.1000
From Table:	N =	1	and	ρ =	0.2000	=>	0.2000

$$Q_M = 0.1000 + \frac{(0.2000 - 0.1000) * (0.1167 - 0.1000)}{(0.2000 - 0.1000)} = \mathbf{0.1167}$$

Berkeley Shore Hotel
November 2, 2019

Guest Vehicle Drop-off/Valet Pick-up		
Valet takes Vehicle	**Valet Returns to Stand**	**Processing Time**
1:18:00 PM	1:27:00 PM	09:00.0
2:50:00 PM	3:01:00 PM	11:00.0
4:00:00 PM	4:11:00 PM	11:00.0
Guest Vehicle Pick-up/Valet Drop-off		
Valet Leaves Stand to Pick-up Car	**Guest Leaves with Car**	**Processing Time**
10:08:00 AM	10:20:00 AM	12:00.0
10:20:00 AM	10:33:00 AM	13:00.0
10:31:00 AM	10:53:00 AM	22:00.0
10:35:00 AM	10:54:00 AM	19:00.0
10:46:00 AM	10:55:00 AM	09:00.0

Transportation and Land Development

Vergil G. Stover / Frank J. Koepke

Institute of Transportation Engineers

APPLICATIONS OF QUEUEING ANALYSIS

Providing an adequate and well-defined storage area for drive-thru traffic is particularly critical, especially at fast-food restaurants and drive-thru bank facilities where queues can, and do, become quite long. Waiting vehicles should be stored on private property clear of driveways so that traffic back-up does not interfere with movement on the arterial street. At fast-food restaurants, the menu board should be installed upstream of the service window to permit drive-thru customers to place their orders prior to their arrival at the service window. Preparation of their order can then begin before they reach the service window, thus minimizing their time at the service window. A well-defined storage area for the waiting traffic should be located so that the waiting vehicles do not block or impede the movement of driveway traffic.

Where a single service position is involved, the situation is referred to as a *single-channel problem. Multiple-channel problems* arise when two or more service positions are available. Such problems commonly arise with bank tellers (indoor as well as drive-in windows), entrances and exits at large parking lots and garages, at passenger pick-up areas at transit stations and taxi stands, truck terminals or loading/unloading areas, supermarket checkout counters, telephone calls, building entrances, and transit-station turnstiles. The assumptions of Poisson arrivals and negative exponential service time are commonly acceptable and used for both single- and multiple-channel problems. Thurgood [11] found these assumptions to be representative of drive-in facilities.

Customers arriving randomly at a drive-in facility may enter into service immediately or may have to enter the queue until they can be served. Waiting lines occur whenever the immediate demand for service exceeds the current capacity of the facility providing that service.

Basic Notation and Terminology

The following notation is employed throughout this section:

n = number of customers in the drive-in system

M = number of customers in the queue waiting to be served (number of customers in the system minus the number being served)

$P(n)$ = steady-state probability that exactly n customers are in the queueing system

$P(0)$ = probability that zero vehicles are in the queueing system

N = number of parallel service positions

q = mean average arrival rate of vehicles into the system (vehicles/hour)

Q = mean average service rate per service position (vehicles/hour/position)

Avg (t) = $60/Q$ = mean service time expressed in minutes per vehicle

$\rho = q/NQ$ = coefficient of utilization

$E(m)$ = expected (average) number of customers in the system

$E(n)$ = expected (average) number of customers waiting in the queue

$E(t)$ = expected (average) waiting time in system (includes service time)

$E(w)$ = expected (average) waiting time in queue (excludes service time)

The equations employed in the analysis of queueing problems are given in Table 8-10.

Jones, Woods, and Thurgood [4] have developed a graph (Figure 8-6) for determining the probability that there will be no customers in the system—values for $P(0)$. They also developed graphs for determining the average number of waiting customers (Figure 8-7), the average waiting time (Figure 8-8), and average queue length (Figure 8-9). These figures avoid the necessity to perform the time-consuming, although simple, queueing-analysis calculations. See pp. 228–30.

TABLE 8-10
Queueing System Equations

Equation Number	Variable	Equation
(8-1)	Coefficient of utilization	$\rho = \dfrac{q}{NQ}$
(8-2)	Probability of no customers in the system	$P(0) = \left[\sum_{n=0}^{N-1} \dfrac{\left(\frac{q}{Q}\right)^n}{n!} + \dfrac{\left(\frac{q}{Q}\right)^N}{N!(1-\rho)}\right]^{-1}$
(8-3)	Mean number in the queue	$E(m) = \left[\dfrac{\rho\left(\frac{q}{Q}\right)^N}{N!(1-\rho)^2}\right]P(0)$
(8-4)	Mean number in the system	$E(n) = E(m) + \dfrac{q}{Q}$
(8-5)	Mean wait time in queue (hours)	$E(w) = \dfrac{E(m)}{q}$
(8-6)	Mean time in the system (hours)	$E(t) = E(w) + \dfrac{1}{Q} = E(w) + \text{Avg}(t)$
(8-7)	Proportion of customers who wait	$P[E(w) > 0] = \left[\dfrac{\left(\frac{q}{Q}\right)^N}{N!(1-\rho)}\right]P(0)$
(8-8)	Probability of a queue exceeding a length M	$P(x > M) = (\rho^{N+1})P[E(w) > 0]$
(8-9a)	Queue storage required	$M = \left[\dfrac{\ln P(x > M) - \ln E(w) > 0}{\ln \rho}\right] - 1$
(8-9b)*	Queue storage required	$M = \left[\dfrac{\ln P(x > M) - \ln Q_M}{\ln \rho}\right] - 1$

*Q_M is a statistic which is a function of the utilization rate and the number of service channels (service positions); see Table 8-11. The table of Q_M values and use of Equation (8-9b) greatly simplifies the calculations compared to those using Equations (8-9a).

Use of the equations and the graphs may be illustrated by the following example of a drive-in bank.

Conditions:

Number of drive-in windows, $N = 3$
Demand on the system, $q = 70$
Service capacity per channel, $Q = 28.6$ for an average service time, Avg $(t) =$ 2.1 minutes

Solution Using Graphs:

- Coefficient of utilization $= 70/(3)(28.6) = 0.816$
- Probability that there are customers waiting in the system, Figure 8-6: $P(0) = 0.05$
- Expected average number of customers waiting in the queue, Figure 8-7: $E(m)/N = 1.0$; and the average number $E(m) = (3)(1.0) = 3$

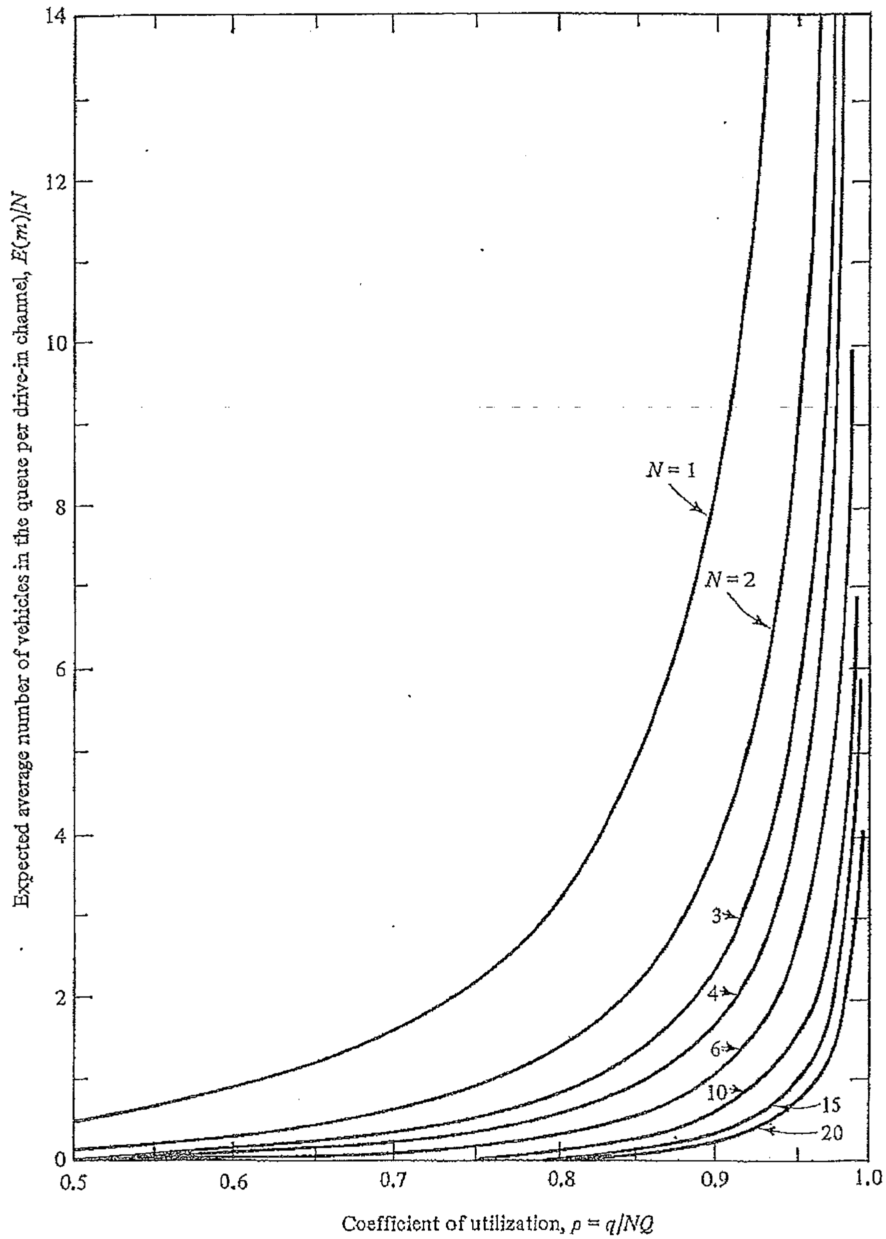

Figure 8-9 Average queue length per service position [$E(m)/N$ values]. SOURCE: Jones, Woods, and Thurgood [4].

Comparison:

Variable	Graphs	Equations
$P(0)$	0.05	0.0505
$E(m)$	3	2.97
$E(w)$	2.5	2.55

Example and Case Studies of Required Storage at a Drive-In Bank

Consider the following example of a drive-in bank facility as a demonstration of the use of queueing analysis. Review of a site plan for a proposed bank shows there are six drive-in window positions plus space to store 18 vehicles waiting to be served. In view of its location, a 5% probability of back-up onto the adjacent street is judged to be acceptable. Demand on the system for design is expected to be 110 vehicles in a 45-minute period. Average service time was expected to be 2.2 minutes. Is the queue storage adequate?

Such problems can be quickly solved using Equation (8–9b) given in Table 8-10 and repeated below for convenience.

$$M = \left[\frac{\ln P(x > M) - \ln Q_M}{\ln \rho}\right] - 1$$

where:

M = queue length which is exceeded p percent of the time
N = number of service channels (drive-in positions)
Q = service rate per channel (vehicles per hour)
$\rho = \frac{\text{demand rate}}{\text{service rate}} = \frac{q}{NQ}$ = utilization factor
q = demand rate on the system (vehicles per hour)
Q_M = tabled values of the relationship between queue length, number of channels, and utilization factor (see Table 8.11)

TABLE 8-11
Table of Q_M Values

	N = 1	2	3	4	6	8	10
0.0	0.0000	0.0000	0.0000	0.0000			
0.1	.1000	.0182	.0037	.0008	.0000	0.0000	0.0000
.2	.2000	.0666	.0247	.0096	.0015	.0002	.0000
.3	.3000	.1385	.0700	.0370	.0111	.0036	.0011
.4	.4000	.2286	.1411	.0907	.0400	.0185	.0088
.5	.5000	.3333	.2368	.1739	.0991	.0591	.0360
.6	.6000	.4501	.3548	.2870	.1965	.1395	.1013
.7	.7000	.5766	.4923	.4286	.3359	.2706	.2218
.8	.8000	.7111	.6472	.5964	.5178	.4576	.4093
.9	.9000	.8526	.8172	.7878	.7401	.7014	.6687
1.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

$\rho = \frac{q}{NQ} = \frac{\text{arrival rate, total}}{\text{(number of channels) (service rate per channel)}}$

N = number of channels (service positions)

Solution

Step 1: $Q = \frac{60 \text{ min/hr}}{2.2 \text{ min/service}} = 27.3$ services per hour

Step 2: $q = (110 \text{ veh}/45 \text{ min}) \times (60 \text{ min/hr}) = 146.7$ vehicles per hour

Step 3: $\rho = \frac{q}{NQ} = \frac{146.7}{(6)(27.3)} = 0.8956$

Step 4: $Q_M = 0.7303$ by interpolation between 0.8 and 0.9 for $N = 6$ from the table of Q_M values (see Table 8-11).

Step 5: The acceptable probability of the queue, M, being longer than the storage, 18 spaces in this example, was stated to be 5%. $P(x > M) = 0.05$, and:

$$M = \left[\frac{\ln 0.05 - \ln 0.7303}{\ln 0.8956}\right] - 1 = \left[\frac{-2.996 - (-0.314)}{-0.110}\right] - 1$$

$$= 24.38 - 1 = 23.38, \text{ say 23 vehicles.}$$