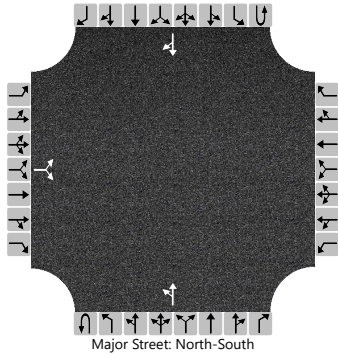


DRIVEWAYS

HCS Two-Way Stop-Control Report

General Information		Site Information	
Analyst	MF	Intersection	Michigan Avenue & Driveway
Agency/Co.	LANGAN	Jurisdiction	Miami Beach
Date Performed	5/14/2025	East/West Street	Driveway
Analysis Year	2028	North/South Street	Michigan Avenue
Time Analyzed	AM Peak Hour - Dwy	Peak Hour Factor	0.92
Intersection Orientation	North-South	Analysis Time Period (hrs)	0.25
Project Description	1440 Michigan Avenue		

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Movement																
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	1	0		0	0	0		0	1	0		0	1	0
Configuration			LR							LT						TR
Volume (veh/h)		14		9						3	80				37	9
Percent Heavy Vehicles (%)		3		3						3						
Proportion Time Blocked																
Percent Grade (%)	0															
Right Turn Channelized																
Median Type Storage					Left Only								1			

Critical and Follow-up Headways

Base Critical Headway (sec)		7.1		6.2						4.1						
Critical Headway (sec)		6.43		6.23						4.13						
Base Follow-Up Headway (sec)		3.5		3.3						2.2						
Follow-Up Headway (sec)		3.53		3.33						2.23						

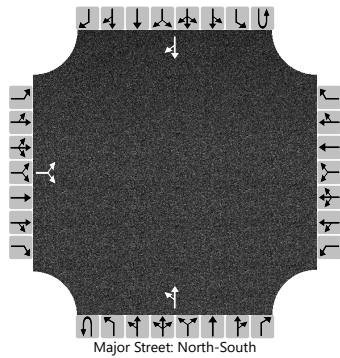
Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)			25							3						
Capacity, c (veh/h)			888							1550						
v/c Ratio			0.03							0.00						
95% Queue Length, Q ₉₅ (veh)			0.1							0.0						
95% Queue Length, Q ₉₅ (ft)			2.6							0.0						
Control Delay (s/veh)			9.2							7.3	0.0					
Level of Service (LOS)			A							A	A					
Approach Delay (s/veh)	9.2								0.3							
Approach LOS	A								A							

HCS Two-Way Stop-Control Report

General Information				Site Information			
Analyst	MF	Intersection	Michigan Avenue & Driveway				
Agency/Co.	LANGAN	Jurisdiction	Miami Beach				
Date Performed	5/14/2025	East/West Street	Driveway				
Analysis Year	2028	North/South Street	Michigan Avenue				
Time Analyzed	PM Peak Hour - Dwy	Peak Hour Factor	0.92				
Intersection Orientation	North-South	Analysis Time Period (hrs)	0.25				
Project Description	1440 Michigan Avenue						

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound				
	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R	
Movement																	
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6	
Number of Lanes		0	1	0		0	0	0		0	1	0		0	1	0	
Configuration			LR							LT						TR	
Volume (veh/h)		7		4						7	174				82	12	
Percent Heavy Vehicles (%)		3		3						3							
Proportion Time Blocked																	
Percent Grade (%)		0															
Right Turn Channelized																	
Median Type Storage					Left Only								1				

Critical and Follow-up Headways

Base Critical Headway (sec)		7.1		6.2						4.1						
Critical Headway (sec)		6.43		6.23						4.13						
Base Follow-Up Headway (sec)		3.5		3.3						2.2						
Follow-Up Headway (sec)		3.53		3.33						2.23						

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)			12							8							
Capacity, c (veh/h)			780							1484							
v/c Ratio			0.02							0.01							
95% Queue Length, Q ₉₅ (veh)			0.0							0.0							
95% Queue Length, Q ₉₅ (ft)			0.0							0.0							
Control Delay (s/veh)			9.7							7.4	0.0						
Level of Service (LOS)			A							A	A						
Approach Delay (s/veh)		9.7								0.3							
Approach LOS		A								A							

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

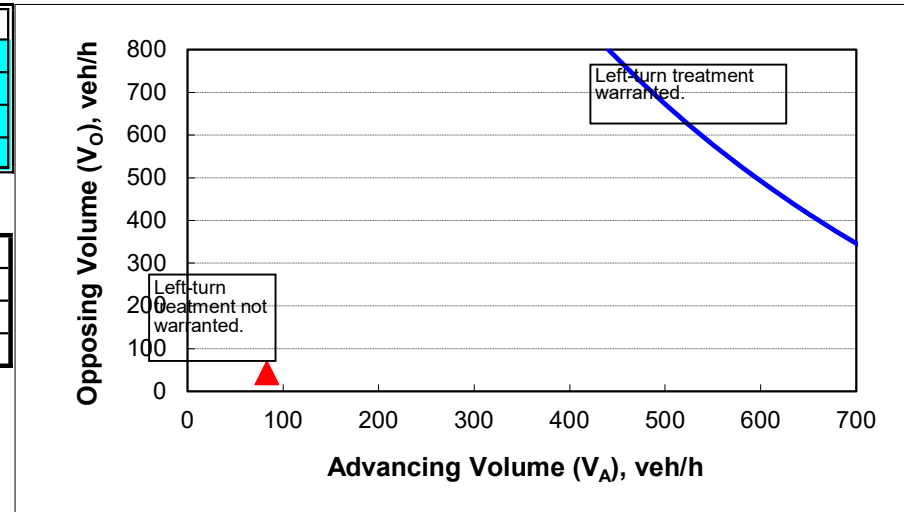
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	30
Percent of left-turns in advancing volume (V_A), %:	4%
Advancing volume (V_A), veh/h:	83
Opposing volume (V_O), veh/h:	44

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	988
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

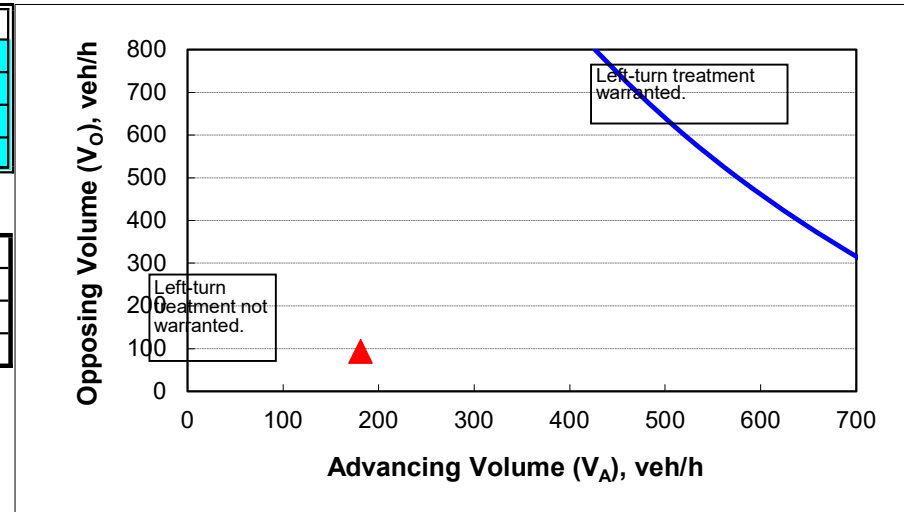
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	30
Percent of left-turns in advancing volume (V_A), %:	4%
Advancing volume (V_A), veh/h:	181
Opposing volume (V_O), veh/h:	94

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	900
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT

Roadway geometry:	2-lane roadway	
Variable	Value	
Major-road speed, mph:	30	
Major-road volume (one direction), veh/h:	44	
Right-turn volume, veh/h:	4	

OUTPUT

Variable	Value
Limiting right-turn volume, veh/h:	67317817
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

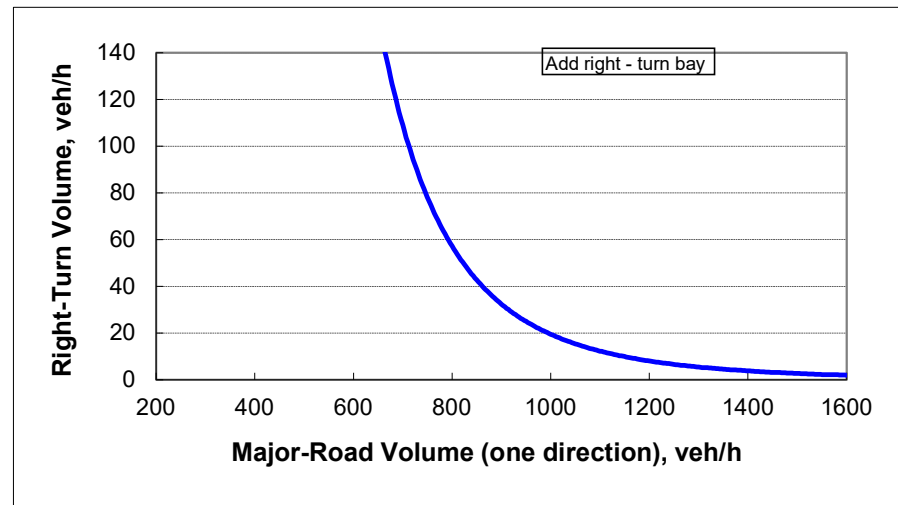


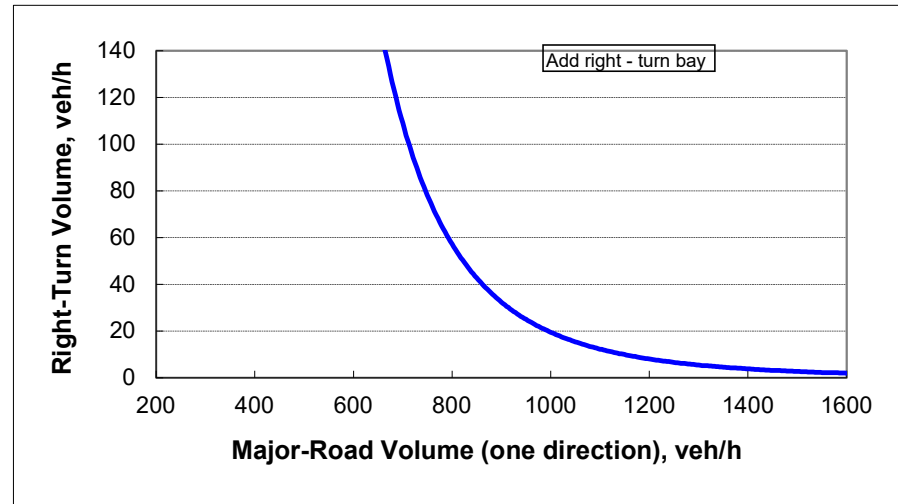
Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT

Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	30
Major-road volume (one direction), veh/h:	94
Right-turn volume, veh/h:	12

OUTPUT

Variable	Value
Limiting right-turn volume, veh/h:	1735464
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	



APPENDIX G
TRIP GENERATION DATA

**TRIP GENERATION ANALYSIS
1440 MICHIGAN AVENUE**

DAILY

Land Use	ITE Code	Size	Trip Generation Rate	In	Out	Total Trips		
						In	Out	Total
<u>Proposed Uses</u> Multifamily Housing (Low-Rise)	220	23 DU	T = 6.41 (X) + 75.31	50%	50%	111	112	223

MORNING PEAK HOUR

Land Use	ITE Code	Size	Trip Generation Rate	In	Out	Total Trips		
						In	Out	Total
<u>Proposed Uses</u> Multifamily Housing (Low-Rise)	220	23 DU	T = 0.31 (X) + 22.85	24%	76%	7	23	30

AFTERNOON PEAK HOUR

Land Use	ITE Code	Size	Trip Generation Rate	In	Out	Total Trips		
						In	Out	Total
<u>Proposed Uses</u> Multifamily Housing (Low-Rise)	220	23 DU	T = 0.43 (X) + 20.55	63%	37%	19	11	30

Multifamily Housing (Low-Rise) Not Close to Rail Transit (220)

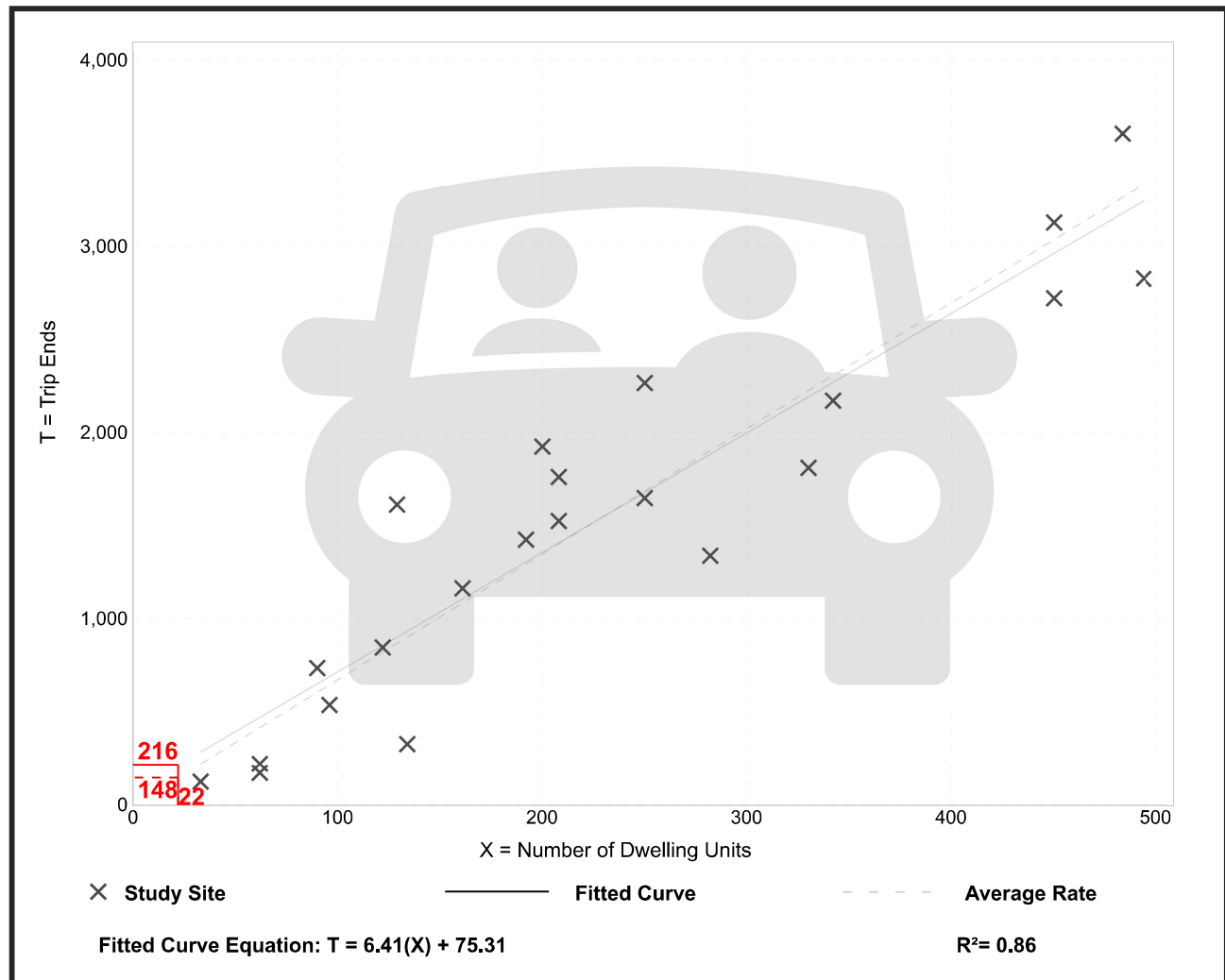
Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 22
Avg. Num. of Dwelling Units: 229
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
6.74	2.46 - 12.50	1.79

Data Plot and Equation



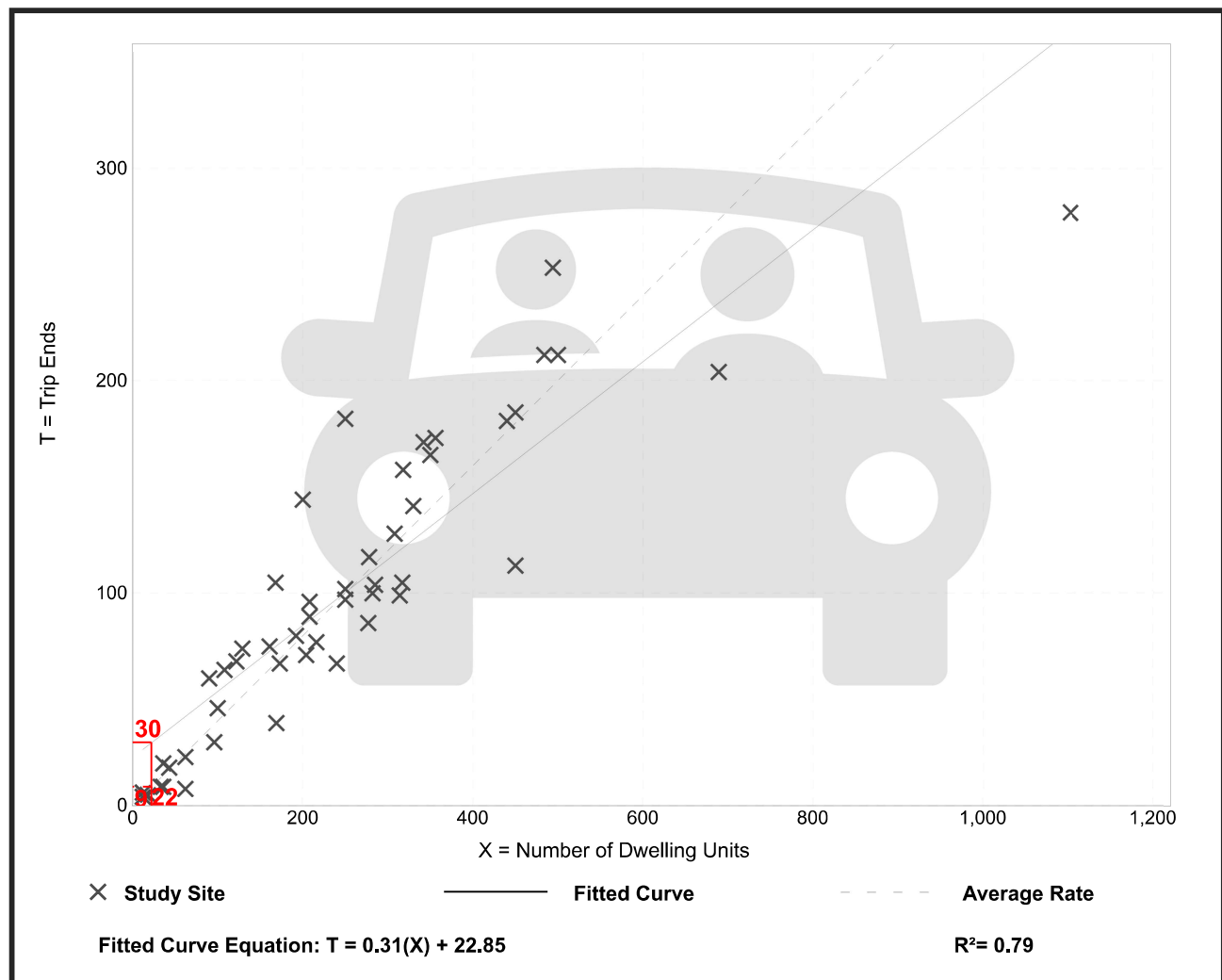
Multifamily Housing (Low-Rise) Not Close to Rail Transit (220)

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: 49
 Avg. Num. of Dwelling Units: 249
 Directional Distribution: 24% entering, 76% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.40	0.13 - 0.73	0.12

Data Plot and Equation



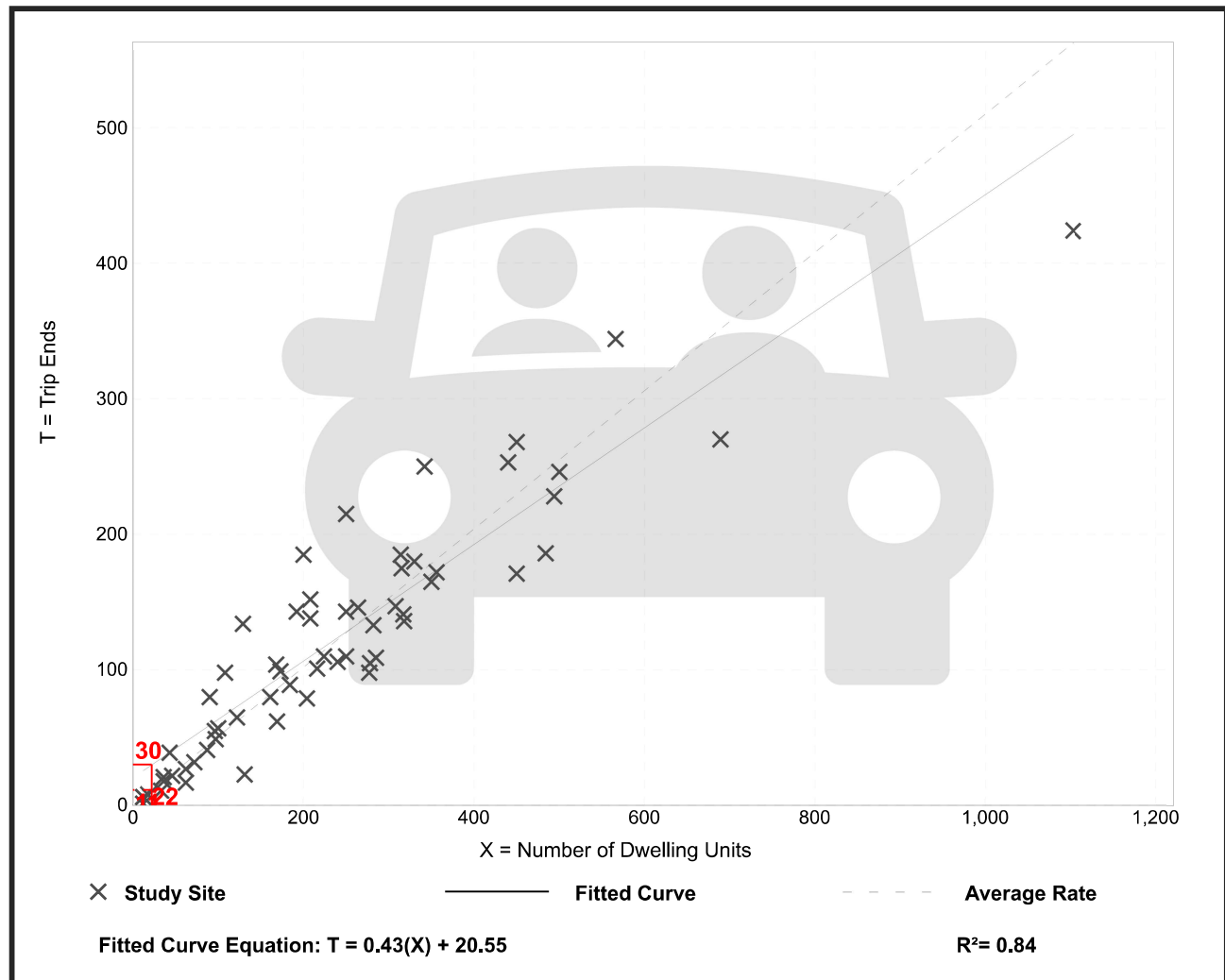
Multifamily Housing (Low-Rise) Not Close to Rail Transit (220)

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: 59
 Avg. Num. of Dwelling Units: 241
 Directional Distribution: 63% entering, 37% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.51	0.08 - 1.04	0.15

Data Plot and Equation



APPENDIX H
SERVICE TIME DATA

Langan Engineering and Environmental Services, Inc.
 110 E. Broward Boulevard, Suite 1500
 Fort Lauderdale, Florida 33301

Fiji at the Oasis (Homestead, Florida)
 Resident Entrance Gate - Remote Control
 Afternoon Peak Hour

File Name : 2019-09-18 fiji visitor data
 Site Code : 00000222
 Start Date : 9/18/2019
 Page No : 1

L n.	No.	Joined Queue	Released From Queue	Delay
1	4	3:30:52 PM	3:30:53 PM	1
1	5	3:32:26 PM	3:32:28 PM	2
1	6	3:32:38 PM	3:32:39 PM	1
1	7	3:34:09 PM	3:34:11 PM	2
1	8	3:35:11 PM	3:35:12 PM	1
1	9	3:40:46 PM	3:40:48 PM	2
1	10	3:43:04 PM	3:43:06 PM	2
1	11	3:43:42 PM	3:43:43 PM	1
1	12	3:44:30 PM	3:44:33 PM	3
1	13	3:45:17 PM	3:45:19 PM	2
1	14	3:47:18 PM	3:47:20 PM	2
1	15	3:50:58 PM	3:50:59 PM	1
1	16	3:52:00 PM	3:52:02 PM	2
1	17	3:52:40 PM	3:52:41 PM	1
1	18	3:52:59 PM	3:53:01 PM	2
1	19	3:54:52 PM	3:54:55 PM	3
1	20	3:58:18 PM	3:58:20 PM	2
1	21	3:59:03 PM	3:59:07 PM	4
1	22	3:59:22 PM	3:59:25 PM	3
1	23	3:59:56 PM	3:59:59 PM	3
1	24	4:00:38 PM	4:00:40 PM	2
1	25	4:01:15 PM	4:01:18 PM	3
1	26	4:01:29 PM	4:01:32 PM	3
1	27	4:01:51 PM	4:01:55 PM	4
1	28	4:03:34 PM	4:03:37 PM	3
1	29	4:04:47 PM	4:04:51 PM	4
1	30	4:05:38 PM	4:05:41 PM	3
1	31	4:07:59 PM	4:08:02 PM	3
1	32	4:10:42 PM	4:10:45 PM	3
1	33	4:11:48 PM	4:11:51 PM	3
1	34	4:12:04 PM	4:12:07 PM	3
1	35	4:13:02 PM	4:13:06 PM	4
1	36	4:13:23 PM	4:13:27 PM	4
1	37	4:14:18 PM	4:14:22 PM	4
1	38	4:14:50 PM	4:14:53 PM	3
1	39	4:16:01 PM	4:16:05 PM	4
1	40	4:16:18 PM	4:16:23 PM	5
1	41	4:16:25 PM	4:16:27 PM	2
1	42	4:16:32 PM	4:16:36 PM	4
1	43	4:18:49 PM	4:18:51 PM	2
1	44	4:19:14 PM	4:19:17 PM	3
1	45	4:20:19 PM	4:20:23 PM	4
1	46	4:20:28 PM	4:20:32 PM	4
1	47	4:20:52 PM	4:20:55 PM	3
1	48	4:21:16 PM	4:21:20 PM	4
1	49	4:21:58 PM	4:22:02 PM	4
1	50	4:22:08 PM	4:22:11 PM	3
1	51	4:22:23 PM	4:22:28 PM	5
1	52	4:22:45 PM	4:22:48 PM	3
1	53	4:23:02 PM	4:23:05 PM	3
1	54	4:23:10 PM	4:23:14 PM	4
1	55	4:23:42 PM	4:23:45 PM	3
1	56	4:23:50 PM	4:23:53 PM	3
1	57	4:26:25 PM	4:26:28 PM	3
1	58	4:26:31 PM	4:26:33 PM	2
1	59	4:27:33 PM	4:27:36 PM	3
1	60	4:27:37 PM	4:27:40 PM	3
1	61	4:29:54 PM	4:29:58 PM	4
1	62	4:30:41 PM	4:30:44 PM	3

Langan Engineering and Environmental Services, Inc.
 110 E. Broward Boulevard, Suite 1500
 Fort Lauderdale, Florida 33301

File Name : 2019-09-18 fiji visitor data
 Site Code : 00000222
 Start Date : 9/18/2019
 Page No : 2

L n.	No.	Joined Queue	Released From Queue	Delay
1	63	4:30:46 PM	4:30:49 PM	3
1	64	4:32:37 PM	4:32:39 PM	2
1	65	4:33:41 PM	4:33:44 PM	3
1	66	4:34:43 PM	4:34:46 PM	3
1	67	4:36:57 PM	4:36:59 PM	2
1	68	4:37:07 PM	4:37:10 PM	3
1	69	4:40:33 PM	4:40:35 PM	2
1	70	4:42:14 PM	4:42:17 PM	3
1	71	4:46:14 PM	4:46:17 PM	3
1	72	4:47:50 PM	4:47:54 PM	4
1	73	4:47:56 PM	4:47:58 PM	2
1	74	4:48:15 PM	4:48:18 PM	3
1	75	4:48:28 PM	4:48:30 PM	2
1	76	4:49:27 PM	4:49:29 PM	2
1	77	4:49:31 PM	4:49:33 PM	2
1	78	4:51:53 PM	4:51:55 PM	2
1	79	4:53:00 PM	4:53:03 PM	3
1	80	4:53:11 PM	4:53:14 PM	3
1	81	4:53:53 PM	4:53:56 PM	3
1	82	4:54:42 PM	4:54:45 PM	3
1	83	4:55:13 PM	4:55:17 PM	4
1	84	4:55:45 PM	4:55:48 PM	3
1	85	4:57:01 PM	4:57:03 PM	2
1	86	4:59:20 PM	4:59:23 PM	3
1	87	5:04:54 PM	5:04:56 PM	2
1	88	5:05:01 PM	5:05:04 PM	3
1	89	5:05:44 PM	5:05:47 PM	3
1	90	5:05:59 PM	5:06:02 PM	3
1	91	5:07:57 PM	5:08:00 PM	3
1	92	5:08:27 PM	5:08:30 PM	3
1	93	5:09:34 PM	5:09:37 PM	3
1	94	5:09:56 PM	5:09:59 PM	3
1	95	5:11:14 PM	5:11:17 PM	3
1	96	5:11:20 PM	5:11:23 PM	3
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1	98	5:13:07 PM	5:13:10 PM	3
1	99	5:13:13 PM	5:13:15 PM	2
1	100	5:13:20 PM	5:13:23 PM	3
1	101	5:14:32 PM	5:14:34 PM	2
1	102	5:14:57 PM	5:15:01 PM	4
1	103	5:16:49 PM	5:16:51 PM	2
1	104	5:16:56 PM	5:16:59 PM	3
1	105	5:17:38 PM	5:17:41 PM	3
1	106	5:18:04 PM	5:18:07 PM	3
1	107	5:18:10 PM	5:18:12 PM	2
1	108	5:18:15 PM	5:18:17 PM	2
1	109	5:19:04 PM	5:19:06 PM	2
1	110	5:21:28 PM	5:21:31 PM	3
1	111	5:21:45 PM	5:21:48 PM	3
1	112	5:23:12 PM	5:23:16 PM	4
1	113	5:25:16 PM	5:25:18 PM	2
1	114	5:25:22 PM	5:25:24 PM	2
1	115	5:28:34 PM	5:28:37 PM	3
1	116	5:31:28 PM	5:31:31 PM	3
1	117	5:31:48 PM	5:31:51 PM	3
1	118	5:32:17 PM	5:32:20 PM	3
1	119	5:33:06 PM	5:33:11 PM	5
1	120	5:33:19 PM	5:33:21 PM	2
1	121	5:33:27 PM	5:33:31 PM	4
1	122	5:34:39 PM	5:34:42 PM	3
1	123	5:34:46 PM	5:34:50 PM	4

Langan Engineering and Environmental Services, Inc.
 110 E. Broward Boulevard, Suite 1500
 Fort Lauderdale, Florida 33301

File Name : 2019-09-18 fiji visitor data
 Site Code : 00000222
 Start Date : 9/18/2019
 Page No : 3

L n.	No.	Joined Queue	Released From Queue	Delay
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1	125	5:35:07 PM	5:35:09 PM	2
1	126	5:36:00 PM	5:36:02 PM	2
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1	128	5:37:28 PM	5:37:31 PM	3
1	129	5:38:20 PM	5:38:23 PM	3
1	130	5:40:10 PM	5:40:13 PM	3
1	131	5:41:05 PM	5:41:08 PM	3
1	132	5:41:56 PM	5:41:58 PM	2
1	133	5:42:00 PM	5:42:02 PM	2
1	134	5:42:05 PM	5:42:07 PM	2
1	135	5:42:10 PM	5:42:12 PM	2
1	136	5:43:36 PM	5:43:38 PM	2
1	137	5:44:08 PM	5:44:13 PM	5
1	138	5:45:45 PM	5:45:47 PM	2
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1	140	5:46:54 PM	5:46:57 PM	3
1	141	5:48:51 PM	5:48:53 PM	2
1	142	5:48:56 PM	5:48:59 PM	3
1	143	5:49:06 PM	5:49:09 PM	3
1	144	5:49:47 PM	5:49:50 PM	3
1	145	5:50:20 PM	5:50:23 PM	3
1	146	5:50:31 PM	5:50:33 PM	2
1	147	5:50:35 PM	5:50:38 PM	3
1	148	5:50:40 PM	5:50:43 PM	3
1	149	5:50:49 PM	5:50:51 PM	2
1	150	5:50:56 PM	5:51:00 PM	4
1	151	5:51:12 PM	5:51:15 PM	3
1	152	5:52:01 PM	5:52:03 PM	2
1	153	5:52:44 PM	5:52:46 PM	2
1	154	5:52:49 PM	5:52:51 PM	2
1	155	5:53:00 PM	5:53:02 PM	2
1	156	5:53:09 PM	5:53:11 PM	2
1	157	5:53:41 PM	5:53:43 PM	2
1	158	5:53:45 PM	5:53:47 PM	2
1	159	5:54:33 PM	5:54:34 PM	1
1	160	5:54:43 PM	5:54:45 PM	2
1	161	5:55:38 PM	5:55:41 PM	3
1	162	5:55:48 PM	5:55:52 PM	4
1	163	5:55:59 PM	5:56:03 PM	4
1	164	5:56:22 PM	5:56:25 PM	3
1	165	5:56:28 PM	5:56:31 PM	3
1	166	5:59:04 PM	5:59:07 PM	3
1	167	5:59:10 PM	5:59:13 PM	3
1	168	5:59:55 PM	5:59:57 PM	2
1	169	6:01:22 PM	6:01:23 PM	1
1	170	6:01:26 PM	6:01:28 PM	2
1	171	6:02:46 PM	6:02:49 PM	3

Langan Engineering and Environmental Services, Inc.
110 E. Broward Boulevard, Suite 1500
Fort Lauderdale, Florida 33301

File Name : 2019-09-18 fiji visitor data
Site Code : 00000222
Start Date : 9/18/2019
Page No : 4

Summary Information:

3:30:00 PM - 6:03:00 PM	Resident Entrance
Total Vehicle Count:	168
Delayed Vehicle Count:	168
Through Vehicle Count:	0
Average Stopped Time:	2.76
Maximum Stopped Time:	5
Min. Secs. for Delay:	0
Average Queue:	0.05
Queue Density:	1.00
Maximum Queue:	1
Delay in Vehicle Hour:	0.05
Total Delay:	464

Langan Engineering and Environmental Services, Inc.
 110 E. Broward Boulevard, Suite 1500
 Fort Lauderdale, Florida 33301

Fiji at the Oasis (Homestead, Florida)
 Call Box Visitor Entrance
 Afternoon Peak Hour

File Name : 2019-09-18 fiji visitor data
 Site Code : 00000222
 Start Date : 9/18/2019
 Page No : 1

L n.	No.	Joined Queue	Released From Queue	Delay
2	1	3:30:32 PM	3:31:34 PM	62
2	2	3:33:14 PM	3:33:59 PM	45
2	3	3:34:17 PM	3:34:23 PM	14
2	4	3:36:21 PM	3:36:37 PM	16
2	5	3:41:05 PM	3:41:07 PM	18
2	6	3:44:35 PM	3:44:42 PM	21
2	7	3:44:50 PM	3:44:58 PM	16
2	8	3:50:28 PM	3:50:51 PM	23
2	9	3:58:42 PM	3:58:56 PM	14
2	10	3:59:51 PM	4:00:36 PM	45
2	11	4:01:49 PM	4:02:07 PM	18
2	12	4:02:15 PM	4:02:30 PM	15
2	13	4:04:32 PM	4:04:45 PM	13
2	14	4:04:55 PM	4:05:04 PM	16
2	15	4:05:08 PM	4:05:32 PM	24
2	16	4:05:51 PM	4:06:06 PM	15
2	17	4:07:39 PM	4:07:52 PM	13
2	18	4:09:12 PM	4:09:47 PM	35
2	19	4:14:33 PM	4:14:45 PM	12
2	20	4:18:09 PM	4:18:19 PM	14
2	21	4:25:44 PM	4:26:10 PM	26
2	22	4:27:17 PM	4:27:32 PM	15
2	23	4:27:42 PM	4:28:02 PM	20
2	24	4:28:48 PM	4:29:04 PM	16
2	25	4:32:21 PM	4:32:34 PM	13
2	26	4:35:47 PM	4:36:05 PM	18
2	27	4:37:59 PM	4:38:55 PM	56
2	28	4:40:47 PM	4:41:01 PM	14
2	29	4:55:52 PM	4:56:06 PM	14
2	30	5:09:46 PM	5:10:02 PM	16
2	31	5:14:55 PM	5:15:24 PM	29
2	32	5:20:01 PM	5:20:15 PM	14
2	33	5:22:05 PM	5:22:35 PM	30
2	34	5:25:25 PM	5:25:38 PM	13
2	35	5:27:26 PM	5:27:52 PM	26
2	36	5:28:31 PM	5:28:59 PM	28
2	37	5:31:33 PM	5:31:56 PM	23
2	38	5:34:05 PM	5:34:23 PM	18
2	39	5:36:41 PM	5:37:13 PM	32
2	40	5:40:24 PM	5:40:38 PM	14
2	41	5:40:44 PM	5:41:01 PM	17
2	42	5:46:41 PM	5:46:52 PM	11

Summary Information:

3:30:00 PM - 6:00:00 PM	Visitor Entrance
Total Vehicle Count:	42
Delayed Vehicle Count:	42
Through Vehicle Count:	0
Average Stopped Time:	21.71
Maximum Stopped Time:	62
Min. Secs. for Delay:	0
Average Queue:	0.10
Queue Density:	1.00
Maximum Queue:	1
Delay in Vehicle Hour:	0.11
Total Delay:	912

APPENDIX I
ITE EXCERPTS AND QUEUING ANALYSIS CALCULATIONS

QUEUING ANALYSIS 1440 MICHIGAN AVENUE

Estimated Service Time

Entrance Type	Time (min)
Resident Only	0.50

Peak Hour Trip Generation

Ingress Type	Inbound
Residents	30
Total	30

Afternoon Peak Hour Resident Lane (NW 170 St.) Queuing Analysis

Peak Hour Arrival Rate (veh/hr): **30**
 Probability of Back-up on Adjacent Street: **5%**
 Service Time (min): **0.50**

N	Q	q	r	Q _m	M
1	120	30	0.2500	0.2500	0.2

Table of Q_m Values

r	N=1	2	3	4	6	8	10
0.1	0.1000	0.0182	0.0037	0.0008	0.0000	0.0000	0.0000
0.2	0.2000	0.0666	0.0247	0.0093	0.0015	0.0002	0.0000
0.3	0.3000	0.1385	0.0700	0.0370	0.0111	0.0036	0.0011
0.4	0.4000	0.2286	0.1411	0.0907	0.0400	0.0185	0.0088
0.5	0.5000	0.3333	0.2368	0.1739	0.0991	0.0591	0.0360
0.6	0.6000	0.4501	0.3548	0.2870	0.1965	0.1395	0.1013
0.7	0.7000	0.5766	0.4923	0.4286	0.3359	0.2706	0.2218
0.8	0.8000	0.7111	0.6472	0.5964	0.5178	0.4576	0.4093
0.9	0.9000	0.8526	0.8172	0.7878	0.7401	0.7014	0.6687
1.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

* ITE Transportation and Development Table 8.11

Visitor versus Resident Trip Generation Calculation

Highest Ingress & Egress Percent Visitors	30
Number of Total Visitor Peak Hour Inbound & Outbound	0
Number of Total Residents Peak Hour Inbound & Outbound	30

Required queuing storage equation:

$$M = \frac{\ln(0.05) - \ln(Q_m)}{\ln \rho} - 1$$

where:

- N** = Number of Lanes
- Q** = Average Service Rate (veh/hr)
- q** = Peak Hour Arrival Rate (veh/hr)
- r** = Coefficient of Utiliation (q/NQ)
- Q_m** = ITE table value of relationship between queue length, number of attendants and utilization factor (ITE Transportation and Land Development Table 8.11)
- M** = Queue length which is exceeded 5% of the time (veh)

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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) = $\frac{60}{Q}$ = mean service time expressed in minutes per vehicle
- ρ = $\frac{q}{Nq}$ = 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
Queuing System Equations

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

* 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, $\text{Avg}(t) = 2.1$ 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 $E(m) = (3)(1.0) = 3$

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)

$\rho = \frac{\text{demand rate}}{\text{service rate}} = \frac{q}{NQ} = \text{utilization factor}$

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

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

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:

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

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

The number of vehicles in the queue would be expected to exceed 23 more than 5% of the time. Since the site plan will accommodate a queue of 18 vehicles, the storage is not sufficient for the conditions stated.

It is important to realize that, for any $P(x > M)$ value, the queue length required increases very rapidly for values of $\rho > 0.85$ (see Figure 8-9). When $\rho > 1.0$, the solution is indeterminate and the queue length theoretically becomes infinite.

Analysis of Service Times. In many instances it is effective to demonstrate that a proposed design not only is inadequate to store vehicles waiting for service but will result in unacceptable wait times as well. The necessary equations are given in Table 8-10.

For purposes of checking computations it is convenient to know that the limit of $P(0)$, as the number of channels approaches infinity (in practical terms when $N > 10$), is:

$$\lim_{N \rightarrow \infty} P(0) = e^{-\lambda} \quad \text{where } \lambda = q/Q$$

Drive-In Bank Example: Under the site-development approval requirements, representatives of a bank presented a site plan for the construction of a new bank having three service positions. Information provided by bank officials and observations at other local banks provided the following data:

- Expected average arrival rate during the design hour (4:30–5:30 p.m. on Fridays) = 70 vehicles per hour (vph)
- Average service time per customer = 2.1 minutes

Does the site plan provide for sufficient storage to accommodate all vehicles arriving 95% of the time?

$$q = 70 \text{ vph arrival rate}$$

$$Q = \frac{60 \text{ minutes per hour}}{2.1 \text{ minutes per service}} = 28.6 \text{ vph service rate}$$

$$\rho = \frac{70}{(3)(28.6)} = 0.816$$

$$\frac{q}{Q} = \frac{70}{28.6} = 2.45$$

$$Q_M = 0.674 \text{ by interpolation from Table 8-11}$$

$$P(x > M) = 1.00 - 0.95 = 0.05$$

By Equation (8-9b)

$$M = \left[\frac{\ln 0.05 - \ln 0.674}{\ln 0.816} \right] - 1 = \left[\frac{-2.996 - (-0.396)}{-0.203} \right] - 1 = 11.8, \text{ say } 12$$

Thus, it would be necessary to store 12 vehicles, exclusive of the three service positions, in order to accommodate the arriving vehicles 95% of the time; or alternatively, to have waiting vehicles extending back into the adjacent street no more than 5% of the time between 4:30 and 5:30 p.m. on Fridays. Since the site plan provides for six spaces, the site plan as submitted is inadequate and should be disapproved.

A solution to the problem would be to increase the storage, or if this is not possible add a service position in order to reduce the average service time.

Addition of a service position would reduce the number of storage spaces needed to three (three storage plus four service positions)—assuming the same arrival rate and service time:

$$M = \left[\frac{\ln 0.05 - \ln 0.301}{\ln 0.612} \right] - 1 = 2.7, \text{ say } 3$$

A redesign to provide four service positions would have the additional benefit of substantially reducing the expected waiting time (from over 4 minutes to less than $\frac{1}{2}$ minute) for the bank customers using the drive-in windows:

With Three Service Positions:

$$q = 70 \text{ vph}$$

$$Q = 28.6 \text{ vph}$$

$$\frac{q}{Q} = 2.45$$

$$\rho = \frac{70}{(3)(28.6)} = 0.816$$

$$P(0) = \left[\frac{(2.45)^0}{0!} + \frac{(2.45)^1}{1!} + \frac{(2.45)^2}{2!} + \frac{(2.45)^3}{3! \left[1 - \left(\frac{2.45}{3} \right) \right]} \right]^{-1}$$

$$= [1 + 2.45 + 3.00 + 13.37]^{-1} = 0.0505$$

$$E(m) = \left[\frac{(0.816) \left(\frac{70}{28.6} \right)^3}{3!(1 - 0.816)^2} \right] 0.0505 = 2.97$$

$$E(n) = 2.97 + \frac{70 \cdot 28.6}{2.45} = 5.42$$

$$E(t) = \frac{2.97}{70} = 0.0424 \text{ hours or } 2.55 \text{ minutes}$$

$$E(w) = 0.0424 + \frac{1}{28.6} = 0.0774 \text{ hours or } 4.64 \text{ minutes}$$

With Four Service Positions:

$$q = 70 \text{ vph}$$

$$Q = 28.6 \text{ vph}$$

$$\frac{q}{Q} = 2.45$$

$$\rho = \frac{70}{(4)(28.6)} = 0.612$$

$$P(0) = \left[\frac{(2.45)^0}{0!} + \frac{(2.45)^1}{1!} + \frac{(2.45)^2}{2!} + \frac{(2.45)^3}{3!} + \frac{(2.45)^4}{4! \left[1 - \left(\frac{2.45}{4} \right) \right]} \right]^{-1}$$

$$= 0.0783$$

$$E(m) = \left[\frac{(0.612)(2.45)^4}{4!(1 - 0.612)^2} \right] 0.0783 = 0.48$$

$$E(n) = 0.48 + 2.45 = 2.93$$

$$E(t) = 0.007 + \frac{1}{28.6} = 0.042 \text{ hours or } 2.51 \text{ minutes}$$

$$E(w) = \frac{0.48}{70} = 0.007 \text{ hours or } 0.41 \text{ minutes}$$

However, the service time would increase somewhat unless an additional teller were also added. Nevertheless, an increase to 2.5 minutes, or more, would still reduce the storage space required and result in better service (less time in the system). Besides, time spent being served is less irritating to the customer than an equal time spent waiting.

Conversion of a Residence. An existing single-family residence was situated on a 2.5-acre tract fronting on the major north-south arterial in the urbanizing fringe of a metropolitan area of 100,000 population. The 85th percentile speed exceeded 50 mph; however, it was anticipated that the speed limit would be reduced to 45 mph as further urbanization occurred.

Requests for rezoning from single-family residential to general commercial had received negative recommendations from the Planning and Zoning Commission and denied by the City Council. Nevertheless, the fact that changing conditions in the vicinity of the site were making the property less desirable as a single-family residence was generally recognized. Therefore, when an application was submitted for a Conditional Use Permit to establish a private school using the existing residence for classrooms, the Planning and Zoning Commission was very favorably disposed to the request. The applicant provided the following information prior to the public hearing.

1. The completed application for a conditional use
2. A statement that the intended use was for a Montessori school using the existing structure
3. A site plan as required for all proposed development, other than single-family and duplex residential development, before a building permit will be issued for a new structure and for remodeling of an existing one

The following information was presented at the public hearing by the applicant:

1. At least 40 students would be enrolled before any change would be made in the site circulation.
2. Eighty percent of the students were expected to be picked up within a 20-minute period—a substantial additional fee was to be charged for children picked up more than 30 minutes after school.
3. A strong parent-school relationship was intended, so that average pick-up time of at least 2 minutes and visits of 5 minutes or longer would not be unusual.

The following were agreed upon at the public hearing:

1. The probability of vehicles backing up onto the main lane of the major arterial should be negligible, less than 1%.
2. The site plan, with no change in the circulation pattern, would provide for four service positions and three storage positions.

Based upon these conditions, the following analysis was performed using Equation (8-9b):

$$M = 3$$

$$N = 4$$

$$Q = 60 \text{ minutes per hour} \div 2 \text{ minutes per service} = 30 \text{ vph}$$

$$q = (40 \text{ students}) (80\% \text{ in } 20 \text{ minutes}) \left(\frac{60}{20}\right) = 96 \text{ vph}$$

$$\rho = \frac{96}{(4)(30)} = 0.8000$$

$$P(x > 3) = 0.01 \text{ (a 1\% chance of vehicles backing up onto the arterial)}$$

$$Q_M = 0.8585, \text{ from Table 8-11}$$

$$3 = \left[\frac{\ln P(x > 3) - \ln 0.5964}{\ln 0.8000} \right] - 1$$

$$3 = \left[\frac{\ln P(x > 3) - (-0.5168)}{-0.2231} \right] - 1$$

Then,

$$\ln P(x > 3) = (4)(-0.2231) - 0.5168 = -1.4092$$

and

$$P(x > 3) = e^{-1.4092} = 0.244 \text{ or } 24\%$$

Thus, the calculated probability that the queue could back up onto the arterial is 24% (given the stated conditions), which is considerably greater than the acceptable probability of less than 1%, and the application was denied. The Planning and Zoning Commission suggested various compromises of redesign of the site and issuance of a conditional use permit for a school (under the ordinance, a school can be located in any zoning district by condition) with the condition that the maximum enrollment would not exceed 24 students, which is the number necessary to achieve a value of $P(x > 3) < 0.01$. All such proposals were rejected by the applicant. The site was subsequently rezoned to the Administrative and Professional District (a restricted office district) and is now being used as a dentist's office.

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APPENDIX J
MIAMI BEACH PARKING CODE

5.2.14 ALTERNATIVE PARKING INCENTIVES

In order to encourage the use of alternatives modes of transportation, the minimum off-street parking requirements identified in this article maybe reduced as follows:

- a. *Bicycle parking long-term:* The minimum off-street parking requirements may be reduced by one off-street parking space for every five long-term bicycle parking spaces provided off-street, not to exceed 15 percent of the off-street parking spaces that would otherwise be required in tier 1, 20 percent in tier 2 and 25 percent in tier 3. Notwithstanding the foregoing, in no case shall the proximity of an available bike share program be counted in any ways towards private property parking reductions.
- b. *Bicycle parking short-term:* The minimum off-street parking requirements may be reduced by one off-street parking space for every ten short-term bicycle parking spaces provided off-street, not to exceed 15 percent of the off-street parking spaces that would otherwise be required in tier 1, 20 percent in tier 2 and 25 percent in tier 3. Notwithstanding the foregoing, in no case shall the proximity of an available bike share program be counted in any ways towards private property parking reductions.
- c. *Carpool/vanpool parking:* The minimum off-street parking requirements may be reduced by three off-street parking spaces for every one parking space reserved for carpool or vanpool vehicles sanctioned by the City of Miami Beach, not to exceed a reduction of more than ten percent of the off-street parking spaces that would otherwise be required. The property manager must submit an annual report to the planning director documenting the carpool/vanpool registration and ongoing participation by registered users.
- d. *Drop-off and loading zones for transportation for compensation vehicles:* The minimum off-street parking requirements may be reduced at a ratio of three off-street parking spaces for every one curb side drop off stall. Developments over 50,000 square feet may increase their drop off area to a maximum of three drop-off stalls for a maximum reduction of nine off-street parking spaces. Vehicles stopped in such areas shall not stop in the drop-off and loading zones for no more than the time necessary to drop-off or load passengers and their belongings.
- e. *Scooter, moped and motorcycle parking:* The minimum off-street parking requirements may be reduced by one off-street parking space for every three scooter, moped, or motorcycle parking space provided off-street, not to exceed 15 percent of the off-street parking spaces that would otherwise be required.
- f. *Showers:* The minimum off-street parking requirements for nonresidential uses that provide showers and changing facilities for bicyclists may be reduced by two off-street parking spaces for each separate shower facility up to a maximum of eight parking spaces. Where possible, clothes lockers should be provided for walking and biking commuters.
- g. *Calculation of reductions:* Each of the reductions identified above shall be calculated independently from the pre-reduction off-street parking requirement. The reductions shall then be added together to determine the overall required off-street parking reduction. The sum of all reductions shall not exceed 50 percent of the pre-reduction off-street parking. This limit is not applicable in the Tier 3 area d.
- h. *Facilities are encouraged:* All developments are encouraged to provide the aforementioned facilities to the extent possible. Any building or structure incorporating any of the aforementioned facilities may provide required off-street parking on site up to the level specified in its applicable parking tier. Such required parking, if provided, shall be exempt from FAR, in accordance with the regulations specified in section 1.2.1 (definition of FAR), of these land development regulations.