



Interoffice Memorandum

June 20, 2017

TO: Mayor Teresa Jacobs and Board of County Commissioners

FROM: Mark V. Massaro, P.E., Public Works Director

CONTACT PERSON: **Mark V. Massaro, P.E., Director
Public Works Department**

PHONE NUMBER: (407) 836-7970

SUBJECT: **Granada P.D. South Entrance at Turkey Lake Road- Traffic Signal**

The Granada P.D. road agreement, approved on April 11, 2017, requires the developer to escrow funds to install a traffic signal at the Granada P.D. southern entrance along Turkey Lake Road based on a traffic study warranting and justifying the signal. The developer's requested the County allow the signal to be constructed in lieu of escrowing the funds for the signal.

Staff has reviewed a submitted preliminary signal warrant study based on projected future traffic. The study projected traffic volumes for year 2020 and assumed the full build out of the residential area within the development. Actual traffic conditions must be met before the signal can be fully warranted and operational.

Staff can support the installation of the signal in conjunction with required entrance intersection improvements. Placing the signal in full operation however will be phased. Initially, staff can support the signal's vertical support poles (uprights) being installed without placing the signal indications as an interim measure. Upon first certificate of occupancy being issued, the mast arms (horizontal) and the signals will be placed by the developer in flashing mode. Only when a traffic study certified by a registered professional engineer, using actual traffic conditions warrants and justifies full operation, will Orange County Traffic approve it for full operation. All installation costs shall be at the developer's expense.

Action Requested: Approval of phasing a traffic signal installation at the intersection of Granada P.D. southern entrance at Turkey Lake Road. District 1.

MVM/wsv

Attachment(s)

**INTERSECTION OF
TURKEY LAKE ROAD & LAKE MARIE LOOP ROAD**
Project № 15-045-3.3
April 2017

**SIGNAL WARRANT ANALYSIS
ORANGE COUNTY
FLORIDA**

Prepared by:



Traffic & Mobility Consultants

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Prepared for:

Sand Lake Investment I LLC
1316 Swann Avenue
Tampa, Florida 33606

EXECUTIVE SUMMARY

The Signal Warrant Analysis (SWA) was conducted to determine the need and justification for the installation of a traffic signal at the intersection of Turkey Lake Road and Lake Marie Loop Road in Orange County, Florida.

The SWA was conducted for projected traffic volumes occurring with the construction of Lake Marie Loop Road and the 761 residential units planned to be developed on Parcels E and F of the Granada PD.

The following summarizes the findings and recommendations of the analysis:

- Turkey Lake Road is a 4-lane divided highway with a posted limit of 45 mph and currently serves approximately 40,000 VPD. Lake Marie Loop Road is a proposed 2-lane access road with a posted speed limit of 30 mph and a projected daily volume of approximately 4,500 VPD at buildout of the residential development.
- The nearest signals to this intersection are located approximately, 1,500 feet north and south at Sand Lake Road and at the Walmart Entrance, respectively.
- The MUTCD signal warrants were tested for the projected intersection volumes. The results of the SWA analysis reveal that the thresholds for Warrant 1 and Warrant 2 are met at this location.
- Based on the MUTCD signal warrant analysis and based on required capacity and operations, traffic signal control is necessary and recommended for the intersection of Turkey Lake Road and Lake Marie Loop Road.
- Given the projected buildout and occupancy schedule of the residential development, it is recommended that the signal is installed concurrently with the construction of the Lake Marie Loop Road intersection on Turkey Lake Road.

PROFESSIONAL ENGINEERING CERTIFICATION

I hereby certify that I am a Professional Engineer properly registered in the State of Florida practicing with Traffic & Mobility Consultants, LLC, a corporation authorized to operate as an engineering business, EB-30024, by the State of Florida Department of Professional Regulation, Board of Professional Engineers, and that I have prepared or approved the evaluations, findings, opinions, conclusions, or technical advice attached hereto for:

PROJECT: Turkey Lake Road & Lake Marie Loop Road SWA

LOCATION: Orange County, Florida

CLIENT: Sand Lake Investment I LLC

I hereby acknowledge that the procedures and references used to develop the results contained in these computations are standard to the professional practice of Transportation Engineering as applied through professional judgment and experience.

NAME: Mohammed Abdallah

P.E. No.: Florida P.E. No. 56169

DATE: April 5, 2017

SIGNATURE: _____

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1.0 INTRODUCTION

This Signal Warrant Analysis (SWA) was conducted to determine the need and justification for the installation of a traffic signal at the intersection of Turkey Lake Road and the south connection of Lake Marie Loop Road, located in Orange County, Florida, as illustrated in **Figure 1**.

Turkey Lake Road is currently a 4-lane divided roadway that generally travels north-south and serves approximately 39,000 vehicles per day (vpd). The posted speed limit on this section of the road is 45 miles per hour (mph).

Lake Marie Loop Road is a proposed 2-lane road providing access to Parcels E, F, and G of the Granada PD. The road is eventually planned to connect to Sand Lake Road at an existing signal, west of Turkey Lake Road. Lake Marie Loop Road is projected to serve approximately 4,500 vpd at buildout of the residential portions of the Granada parcels. The proposed speed limit is 30 mph.

The nearest signals to the intersection of Turkey Lake Road and Lake Marie Loop Road are located approximately 1,500 feet north at Sand Lake Road and 1,500 feet south at the Walmart Entrance. The current signal locations are illustrated in **Figure 2**.

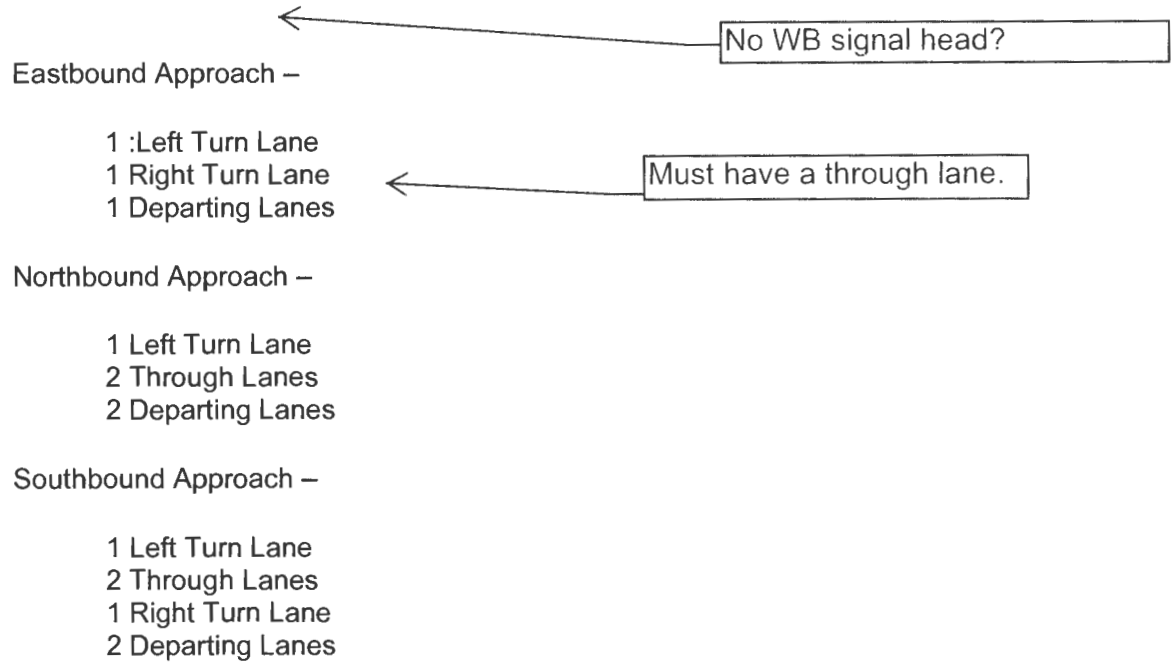
This analysis was conducted using information obtained by Traffic & Mobility Consultants LLC (TMC) from various sources, including field measured traffic volumes, data from the Institute of Transportation Engineers (ITE), and the project team. The analysis was conducted in accordance with the methods of the Manual on Uniform Traffic Control Devices (MUTCD), the Highway Capacity Manual (HCM), and standard engineering practice.





2.0 INTERSECTION CONFIGURATION

The intersection geometry was previously determined based on a traffic analysis prepared for the site. The intersection configuration is proposed to provide the following approach and departure lanes:



The conceptual intersection layout is illustrated in **Figure 3**.

This approach will cause potential issues. It must be signalized as well.

This is a preferred access point especially for safety and is as shown on the signalized distance map.

Now that this is signalized this left turn lane length will be inadequate.

Is there a need for a through lane?

This approach alignment makes it very difficult for right turning vehicles to see the oncoming vehicles from the SB approach. Is it possible to align the new EB approach perpendicular to Turkey Lake Rd and match the Center line to the existing WB approach.

3.0 DATA COLLECTION

A 24-hour traffic volume count was conducted on Turkey Lake Road to determine the current traffic volumes for use in the SWA. The traffic count was conducted on February 8, 2017. The hourly breakdown of the existing approach traffic is summarized in **Table 1**. The detailed traffic count sheets are included in **Appendix A**.

Table 1
Existing Hourly Volume on Turkey Lake Road

Begin Time	NB Through	SB Through	Hourly Total
6:00	271	821	1,092
7:00	559	1,442	2,001
8:00	791	1,350	2,141
9:00	992	1,309	2,301
10:00	1,084	1,142	2,226
11:00	1,219	1,070	2,289
12:00	1,289	1,138	2,427
13:00	1,291	1,175	2,466
14:00	1,339	1,227	2,566
15:00	1,468	1,156	2,624
16:00	1,502	1,102	2,604
17:00	1,566	1,107	2,673
18:00	1,319	1,252	2,571
19:00	1,105	1,011	2,116
Total	15,795	16,302	32,097

4.0 PROPOSED DEVELOPMENT

The proposed development of Parcel E and F of the Granada PD includes up to 761 residential units. Parcel G is approved for future development of up to 176,500 square feet of commercial. Since the timing of development of Parcel G is not currently determined, this analysis is only based on the proposed residential development, as summarized in **Table 2**. The proposed Preliminary Subdivision Plan is provided in **Appendix B**.

Table 2
Residential Development Program

Land Use	ITE Code	Size
Single Family	210	72 DU
Town Houses	230	103 DU
Apartments	220	394 DU
Age Restricted Apartments	252	192 DU

4.1 Trip Generation

The trips generated by the proposed residential development were calculated using the Institute of Transportation Engineers (ITE) *Trip Generation Manual, 9th Edition*. The trip generation of the development will be 4,539 daily trips at buildout, as summarized in **Table 3**. ITE trip generation information sheets are included in **Appendix C**.

Table 3
Trip Generation Analysis

ITE Code	Land Use	Size	Daily Rate	Daily Trips
210	Single Family	72 DU	10.8	776
230	Town Houses	103 DU	6.4	660
220	Apartments	394 DU	6.37	2,510
252	Age Restricted Apartments	192 DU	3.1	593
Total Residential Trip Generation				4,539

Trip Generation analysis based on ITE Trip Generation Manual, 9th Edition

4.2 Spatial and Temporal Trip Distribution

The overall distribution of project traffic on the transportation network indicates that generally, 70% of project traffic demand is to and from the north, while 30% is to and from the south. Based on this demand pattern, project traffic to the study intersection was assigned according to the following percentages:

NB Left -	30% of entering traffic
SB Right -	45% of entering traffic
EB Left -	65% of exiting traffic
EB Right -	30% of exiting traffic

The temporal distribution of residential traffic during the day is estimated in **Table 4**.

Table 4
Temporal Distribution of Project Trips

Time	Hourly Distribution	
	Enter	Exit
6:00	1.50%	8.40%
7:00	2.60%	11.00%
8:00	3.00%	7.60%
9:00	2.60%	5.50%
10:00	3.50%	5.80%
11:00	3.00%	5.10%
12:00	4.50%	5.10%
13:00	4.90%	4.40%
14:00	5.40%	5.20%
15:00	8.00%	5.90%
16:00	9.00%	5.30%
17:00	11.60%	5.60%
18:00	9.00%	4.90%
19:00	7.80%	3.70%
% of Daily	74.9%	75.1%

5.0 PROJECTED TRAFFIC VOLUME

5.1 Background Traffic

Existing traffic volumes were grown to the proposed buildout year of the development using the historical growth rate on Turkey Lake Road, which was determined to be approximately 4% annually. The growth rate calculation is included in **Appendix D**. Using this growth rate, the projected background volumes on Turkey Lake Road in 2020 are summarized in **Table 5**.

Table 5
Projected Background Traffic Volume

Begin Time	NB Through	SB Through	Hourly Total
6:00	304	920	1,224
7:00	626	1,615	2,241
8:00	886	1,512	2,398
9:00	1,111	1,466	2,577
10:00	1,214	1,279	2,493
11:00	1,365	1,198	2,563
12:00	1,444	1,275	2,719
13:00	1,446	1,316	2,762
14:00	1,500	1,374	2,874
15:00	1,644	1,295	2,939
16:00	1,682	1,234	2,916
17:00	1,754	1,240	2,994
18:00	1,477	1,402	2,879
19:00	1,238	1,132	2,370
Total	17,387	17,338	34,725

5.2 Development Traffic

The trips generated by the proposed development were assigned to the intersection based on the distribution pattern described in the previous section. The resulting project traffic volumes at the intersection are summarized in **Table 6**.

Table 6
Project Volume at Intersection

Begin Time	NB Left	SB Right	EB Left	EB Right	Hourly Total
6:00	10	15	124	57	196
7:00	18	27	162	75	264
8:00	20	31	112	52	195
9:00	18	27	81	37	145
10:00	24	36	86	39	161
11:00	20	31	75	35	141
12:00	31	46	75	35	156
13:00	33	50	65	30	145
14:00	37	55	77	35	167
15:00	54	82	87	40	209
16:00	61	92	78	36	206
17:00	79	118	83	38	239
18:00	61	92	72	33	197
19:00	53	80	55	25	160
Total	509	767	1,108	510	2,385

5.3 Total Projected Intersection Traffic

The total projected intersection traffic is calculated by combining the projected background and project traffic volumes on all movements of the intersection of Turkey Lake Road and Lake Marie Loop Road. The projected hourly volumes used in the SWA are summarized in **Table 7**.

Table 7
Projected Intersection Volume

Begin Time	NB		SB		EB		Hourly Total
	Left	Through	Through	Right	Left	Right	
6:00	10	304	920	15	124	57	1,420
7:00	18	626	1,615	27	162	75	2,505
8:00	20	886	1,512	31	112	52	2,593
9:00	18	1,111	1,466	27	81	37	2,722
10:00	24	1,214	1,279	36	86	39	2,654
11:00	20	1,365	1,198	31	75	35	2,704
12:00	31	1,444	1,275	46	75	35	2,875
13:00	33	1,446	1,316	50	65	30	2,907
14:00	37	1,500	1,374	55	77	35	3,041
15:00	54	1,644	1,295	82	87	40	3,148
16:00	61	1,682	1,234	92	78	36	3,122
17:00	79	1,754	1,240	118	83	38	3,233
18:00	61	1,477	1,402	92	72	33	3,076
19:00	53	1,238	1,132	80	55	25	2,530
Total	509	17,387	17,338	767	1,108	510	37,110

6.0 ANALYSIS METHODOLOGY

The SWA was conducted in accordance with the procedures of the *Manual on Uniform Traffic Control Devices (MUTCD)*. According to the *MUTCD*, traffic signals should not be considered for installation unless one or more of the eight warrants specified therein are met and an engineering study justifies the need.

Applicable Signal Warrants ← No Crash Warrant?

The following warrants were determined to be applicable to this intersection's warrant analysis:

Warrant 1 (A&B) ←	Eight Hour Vehicular Volume	How can Warrant 1-B be used if delay is not known just hypothesized. (should use 30 Sec/veh during peak hour)
Warrant 2	- Four-Hour Vehicular Volume	

According to the *MUTCD*, each of the warrants is intended for the following conditions:

- Warrant 1, Condition A – “intended for application at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic control signal.”
- Warrant 1, Condition B – “intended for application at locations where Condition A is not satisfied and where the traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict in entering or crossing the major street.”

The traffic thresholds established by the *MUTCD* for this warrant are summarized in **Table 8**. In this case, Turkey Lake Road (Major Road) is posted 45 mph and Lake Marie Loop Road (Minor Road) is posted 30 mph. Therefore, the 70% volume thresholds are applicable. Considering the geometry of the intersection, the major road is a multi-lane facility, while the minor road is a single-lane (left turns only) approach. The hourly thresholds are:

Condition	Total Major Approaches	Highest Minor Approach
A	420 VPH	105 VPH
B	630 VPH	53 VPH

- Warrant 2 – “intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal.”

**Table 8
Warrant 1 Traffic Thresholds**

Condition A-Minimum Vehicular Volume											
Number of lanes for moving traffic on each approach				Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street		Minor Street		100%	80%	70%	56%	100%	80%	70%	56%
1	Lane	1	Lane	500	400	350	280	150	120	105	84
2+	Lanes	1	Lane	600	480	420	336	150	120	105	84
2+	Lanes	2+	Lanes	600	480	420	336	200	160	140	112
1	Lane	2+	Lanes	500	400	350	280	200	160	140	112

Condition B-Interruption of Continuous Traffic											
Number of lanes for moving traffic on each approach				Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
<u>Major Street</u>		<u>Minor Street</u>		<u>100%</u>	<u>80%</u>	<u>70%</u>	<u>56%</u>	<u>100%</u>	<u>80%</u>	<u>70%</u>	<u>56%</u>
1	Lane	1	Lane	750	600	525	420	75	60	53	42
2+	Lanes	1	Lane	900	720	630	504	75	60	53	42
2+	Lanes	2+	Lanes	900	720	630	504	100	80	70	56
1	Lane	2+	Lanes	750	600	525	420	100	80	70	56

Source: **Manual on Uniform Traffic Control Devices**, 2009 Edition, U.S. Department of Transportation, Federal Highway Administration.

7.0 SIGNAL WARRANT ANALYSIS

The SWA was conducted for the proposed intersection with the projected traffic volumes and the methods of the MUTCD. Detailed MUTCD SWA worksheets are included in **Appendix E**.

Warrant 1 (A & B) – Eight-Hour Vehicular Volume

The projected hourly traffic volumes in **Table 7** were analyzed with the warrant thresholds summarized in **Table 8**. The analysis of Warrant 1, summarized in **Table 9**, reveals that the projected traffic volumes exceed the thresholds of Warrant 1, Condition B, for a total of 13 hours during the study period. Therefore, the thresholds for Warrant 1 are satisfied.

Warrant 2 – Four-Hour Vehicular Volume

The MUTCD thresholds for Warrant 2 with projected volumes are illustrated on the graph in **Figure 4**. The highest four hours of projected traffic volumes at the intersection exceed the thresholds for Warrant 2. Therefore, Warrant 2 is satisfied.

Summary Results

The signal warrants were tested for the proposed intersection of Turkey Lake Road and Lake Marie Loop Road in accordance with MUTCD requirements. The results of the SWA are summarized as follows:

	<u>Warrant 1</u>	<u>Warrant 2</u>
Meets Warrants	Yes	Yes

Based on the results of the SWA and based on projected traffic operations, signal control is warranted and recommended for this intersection. Development on Parcels E & F of the Granada PD is proposed to occur simultaneously and building is anticipated to occur shortly after commencement. Therefore, it is recommended that the signal is installed with the construction of Lake Marie Loop Road intersection to ensure safe and adequate operations at the intersection on opening day.

**Table 9
Warrant 1 Summary**

Time	Turkey Lake Rd	Lake Marie Loop Rd	Warrant 1	
			A	B
6:00 AM	1,249	124	1	1
7:00 AM	2,286	162	1	1
8:00 AM	2,449	112	1	1
9:00 AM	2,622	81		1
10:00 AM	2,553	86		1
11:00 AM	2,614	75		1
12:00 PM	2,796	75		1
1:00 PM	2,845	65		1
2:00 PM	2,966	77		1
3:00 PM	3,075	87		1
4:00 PM	3,069	78		1
5:00 PM	3,191	83		1
6:00 PM	3,032	72		1
7:00 PM	2,503	55		
Hours Required			8	8
Hours Satisfied			3	13
Volume Thresholds Met?			N	Y

Warrant 1A - 70% Thresholds: 420 vph on Major & 105 vph on Minor

Warrant 1B - 70% Thresholds: 630 vph on Major & 53 vph on Minor

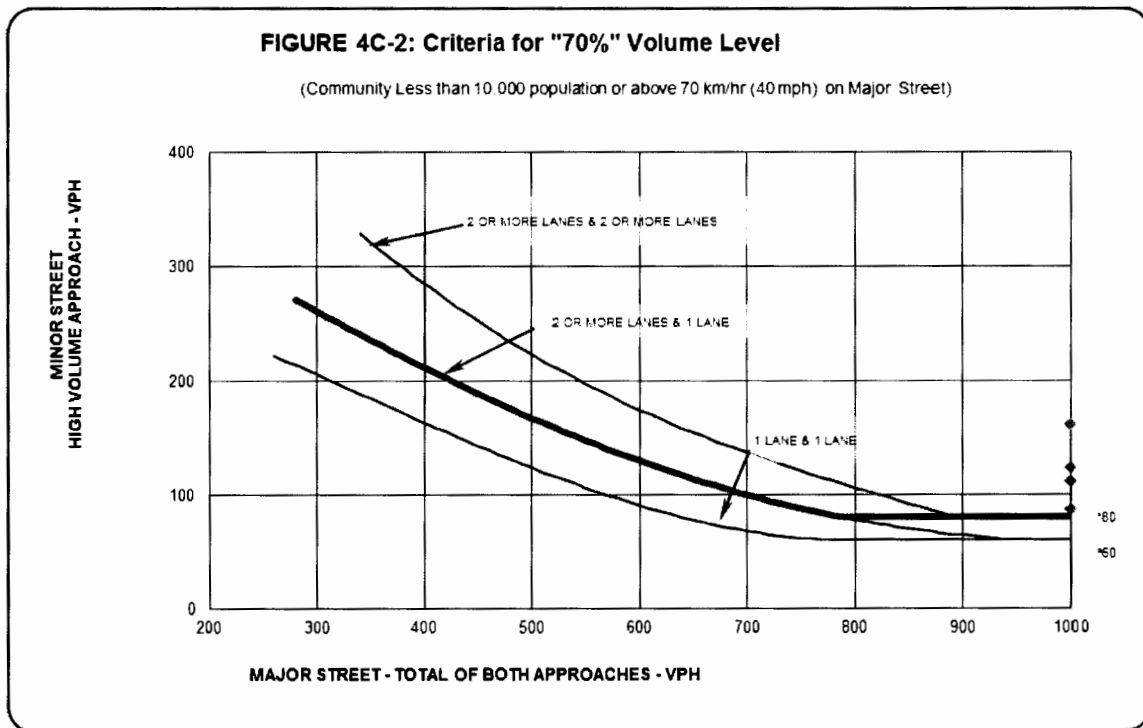


Figure 4 Warrant 2 Plot

8.0 FINDINGS AND RECOMMENDATIONS

The SWA was conducted to determine the need and justification for the installation of a traffic signal at the intersection of Turkey Lake Road and Lake Marie Loop Road in Orange County, Florida. The SWA was conducted for projected traffic volumes occurring with the construction of Lake Marie Loop Road and the 761 residential units planned to be developed on Parcels E and F of the Granada PD.

The following summarizes the findings and recommendations of the analysis:

- Turkey Lake Road is a 4-lane divided highway with a posted limit of 45 mph and currently serves approximately 40,000 VPD. Lake Marie Loop Road is a proposed 2-lane access road with a posted speed limit of 30 mph and a projected daily volume of approximately 4,500 VPD at buildout of the residential development.
- The nearest signals to this intersection are located approximately, 1,500 feet north and south at Sand Lake Road and at the Walmart Entrance, respectively.
- The MUTCD signal warrants were tested for the projected intersection volumes. The results of the SWA analysis reveal that the thresholds for Warrant 1 and Warrant 2 are met at this location.
- Based on the MUTCD signal warrant analysis and based on required capacity and operations, traffic signal control is necessary and recommended for the intersection of Turkey Lake Road and Lake Marie Loop Road.
- Given the projected buildout and occupancy schedule of the residential development, it is recommended that the signal is installed concurrently with the construction of the Lake Marie Loop Road intersection on Turkey Lake Road.

APPENDICES

Appendix A
Existing Traffic Volume Counts

Roadway Count Summary

Start Date 8-Feb-17 Start Time 00:00
 Stop Date 8-Feb-17 Stop Time 24:00
 County Orange Station ID 1
 Location Turkey Lake Road, 2000 ft S. of Sand Lake Direction: Northbound

8-Feb-17 (Wed)						Northbound						
End Time	00	01	02	03	04	05	06	07	08	09	10	11
15	101	68	32	15	14	21	36	124	151	243	269	232
30	99	53	38	27	17	32	56	122	194	250	254	352
45	97	49	19	14	18	27	67	147	224	283	273	327
00	74	41	18	16	13	31	112	166	222	216	288	308
Hr Total	371	211	107	72	62	111	271	559	791	992	1084	1219

End Time	12	13	14	15	16	17	18	19	20	21	22	23
15	289	334	337	400	386	466	352	346	188	172	160	149
30	272	276	342	341	364	382	348	316	209	137	106	138
45	354	336	330	398	395	376	312	214	217	126	145	130
00	374	345	330	329	357	342	307	229	157	153	139	83
Hr Total	1289	1291	1339	1468	1502	1566	1319	1105	771	588	550	500

24 Hour Total 19,138
 AM Peak Hour (7-9) 735
 PM Peak Hour (4-6) 1,566

8-Feb-17 (Wed)						Southbound						
End Time	00	01	02	03	04	05	06	07	08	09	10	11
15	92	30	27	15	27	37	122	275	334	330	310	269
30	52	45	21	32	29	40	200	374	327	308	261	276
45	50	39	14	18	34	86	222	376	361	342	296	237
00	41	32	19	33	38	145	277	417	328	329	275	288
Hr Total	235	146	81	98	128	308	821	1442	1350	1309	1142	1070

End Time	12	13	14	15	16	17	18	19	20	21	22	23
15	317	333	301	250	277	257	316	243	270	198	136	94
30	264	271	290	311	252	278	355	231	242	218	174	111
45	279	248	322	264	291	297	286	294	188	178	158	86
00	278	323	314	331	282	275	295	243	202	194	131	70
Hr Total	1138	1175	1227	1156	1102	1107	1252	1011	902	788	599	361

24 Hour Total 19,948
 AM Peak Hour (7-9) 1,350
 PM Peak Hour (4-6) 1,107

8-Feb-17 (Wed)						Combined						
End Time	00	01	02	03	04	05	06	07	08	09	10	11
15	193	98	59	30	41	58	158	399	485	573	579	501
30	151	98	59	59	46	72	256	496	521	558	515	628
45	147	88	33	32	52	113	289	523	585	625	569	564
00	115	73	37	49	51	176	389	583	550	545	563	596
Hr Total	606	357	188	170	190	419	1092	2001	2141	2301	2226	2289

End Time	12	13	14	15	16	17	18	19	20	21	22	23
15	606	667	638	650	663	723	668	589	458	370	296	243
30	536	547	632	652	616	660	703	547	451	355	280	249
45	633	584	652	662	686	673	598	508	405	304	303	216
00	652	668	644	660	639	617	602	472	359	347	270	153
Hr Total	2427	2466	2566	2624	2604	2673	2571	2116	1673	1376	1149	861

24 Hour Total 39,086
 AM Peak Hour (7-9) 2,141
 PM Peak Hour (4-6) 2,673

Appendix B
Preliminary Subdivision Plan

Appendix C
Trip Generation Sheets

Single-Family Detached Housing (210)

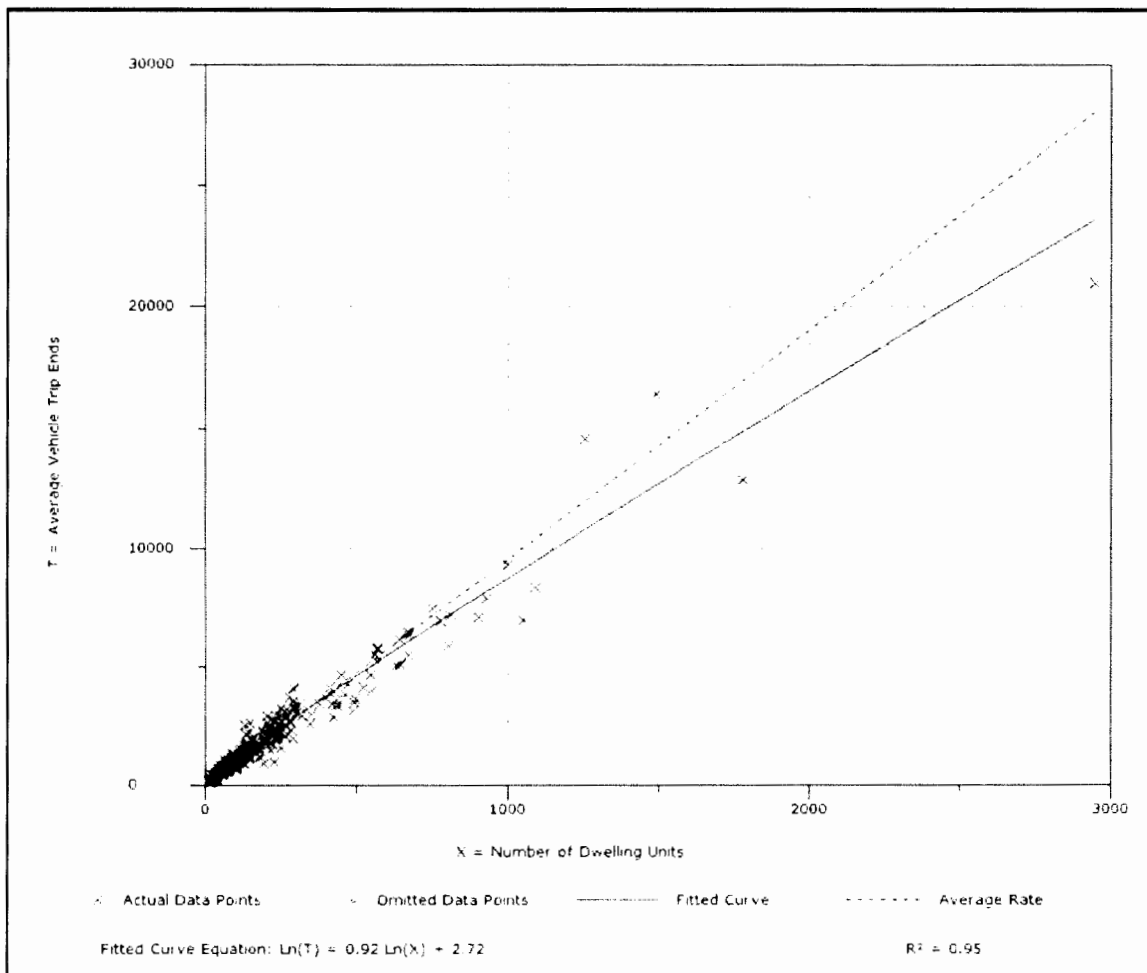
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Number of Studies: 355
Avg. Number of Dwelling Units: 198
Directional Distribution: 50% entering, 50% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
9.52	4.31 - 21.85	2.05

Data Plot and Equation



Single-Family Detached Housing (210)

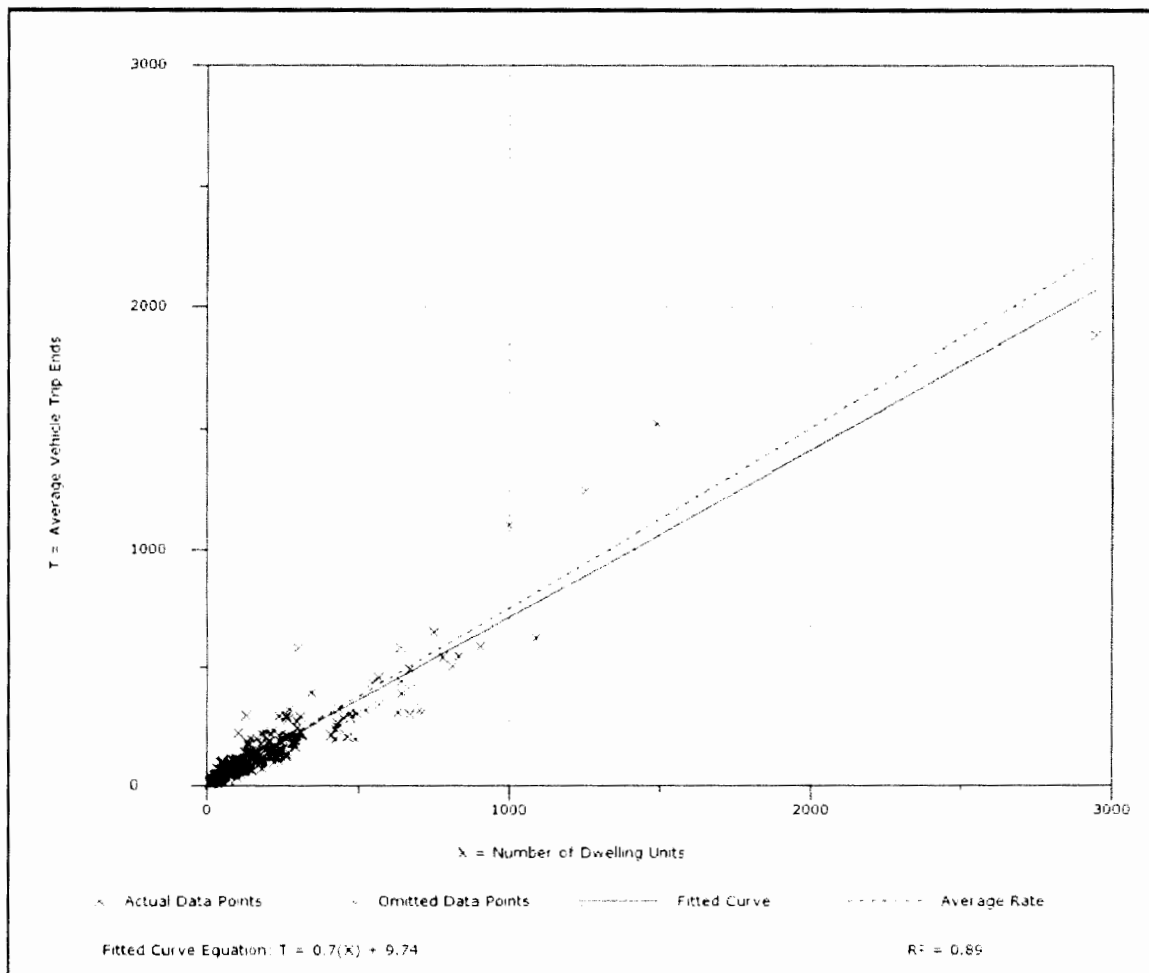
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.

Number of Studies: 292
 Avg. Number of Dwelling Units: 194
 Directional Distribution: 25% entering, 75% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.75	0.33 - 2.27	0.27

Data Plot and Equation



Single-Family Detached Housing (210)

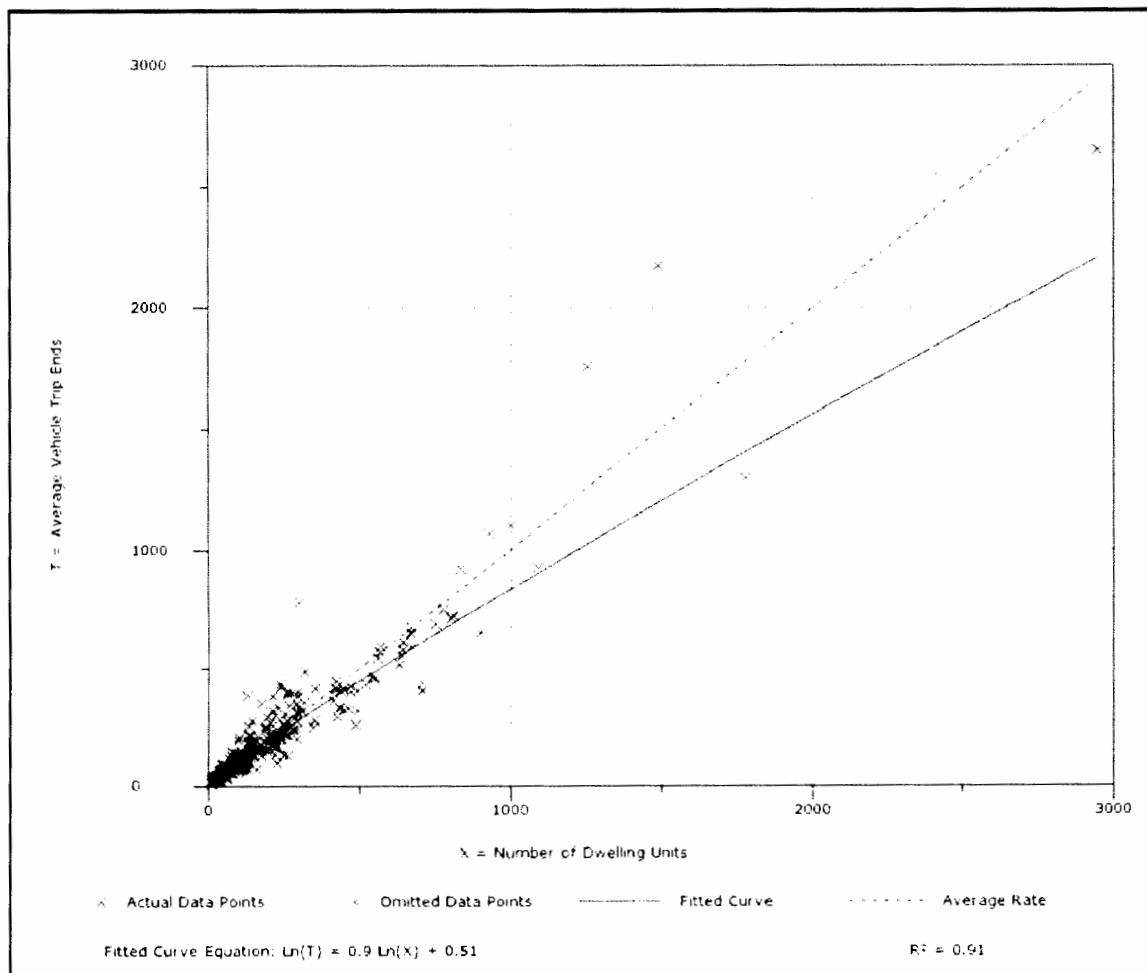
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.

Number of Studies: 321
 Avg. Number of Dwelling Units: 207
 Directional Distribution: 63% entering, 37% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
1.00	0.42 - 2.96	0.31

Data Plot and Equation



Apartment (220)

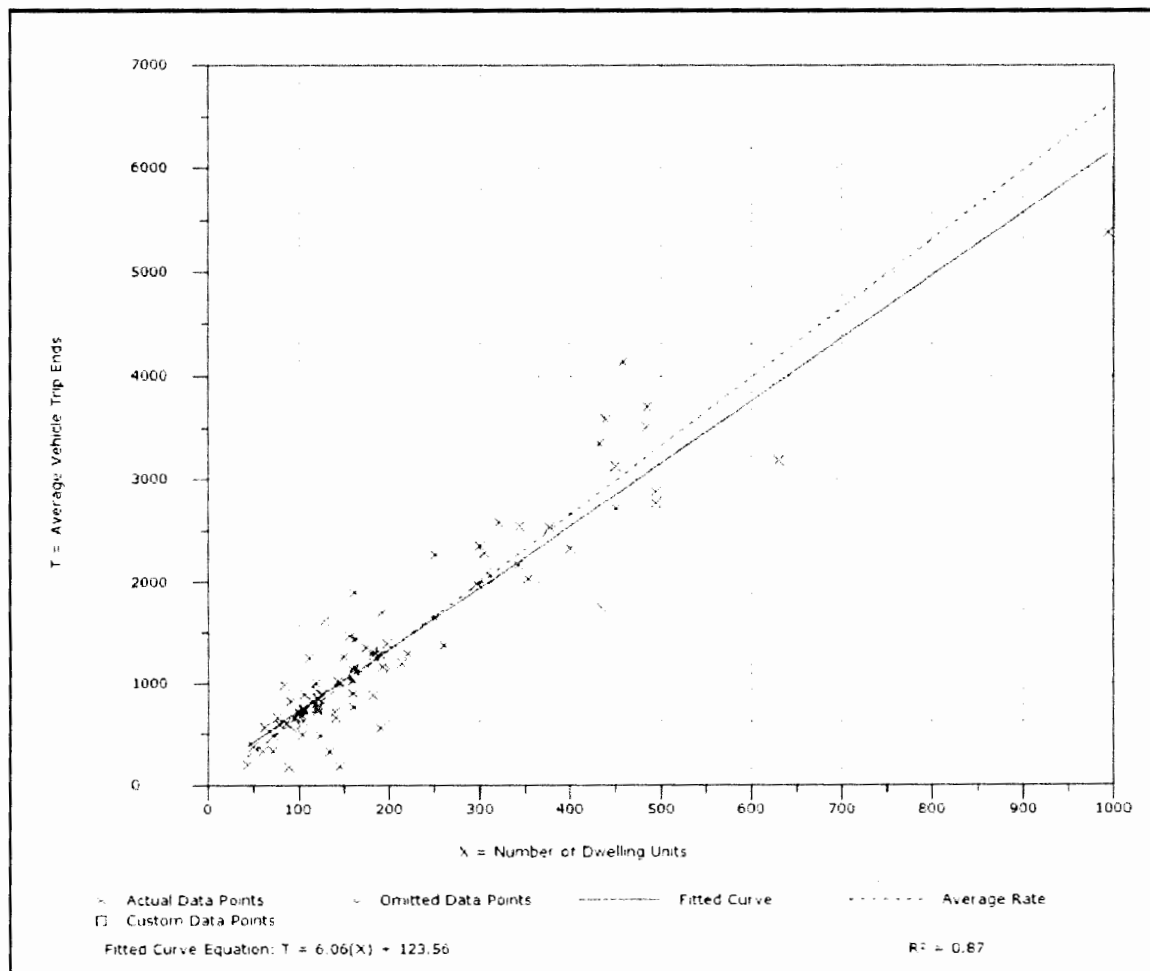
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Number of Studies: 88
Avg. Number of Dwelling Units: 210
Directional Distribution: 50% entering, 50% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
6.65	1.27 - 12.50	3.07

Data Plot and Equation



Trip Generation: 5th Edition

Apartment (220)

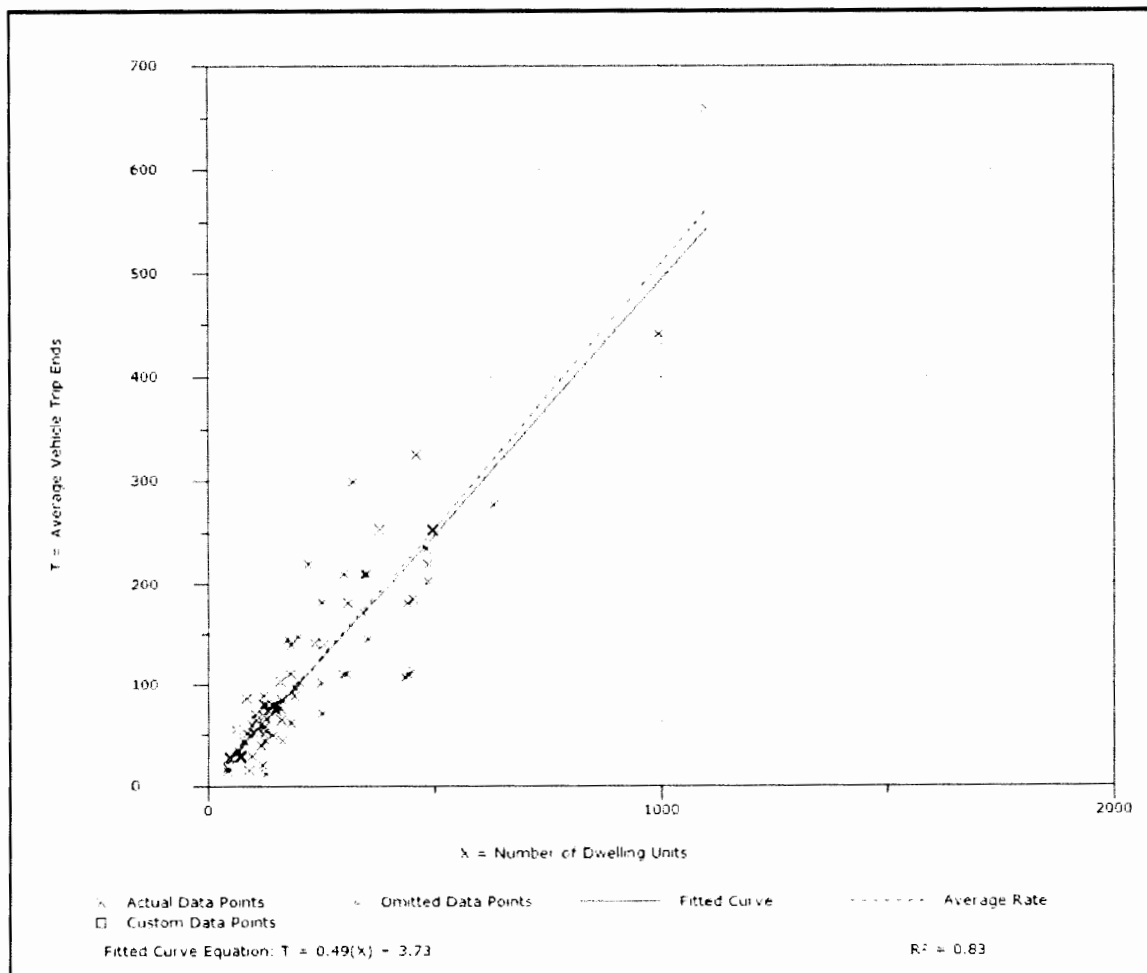
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday
Peak Hour of Adjacent Street Traffic
One Hour Between 7 and 9 a.m.

Number of Studies: 78
 Avg. Number of Dwelling Units: 235
 Directional Distribution: 20% entering, 80% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.51	0.10 - 1.02	0.73

Data Plot and Equation



Trip Generation - 8th Edition

Apartment (220)

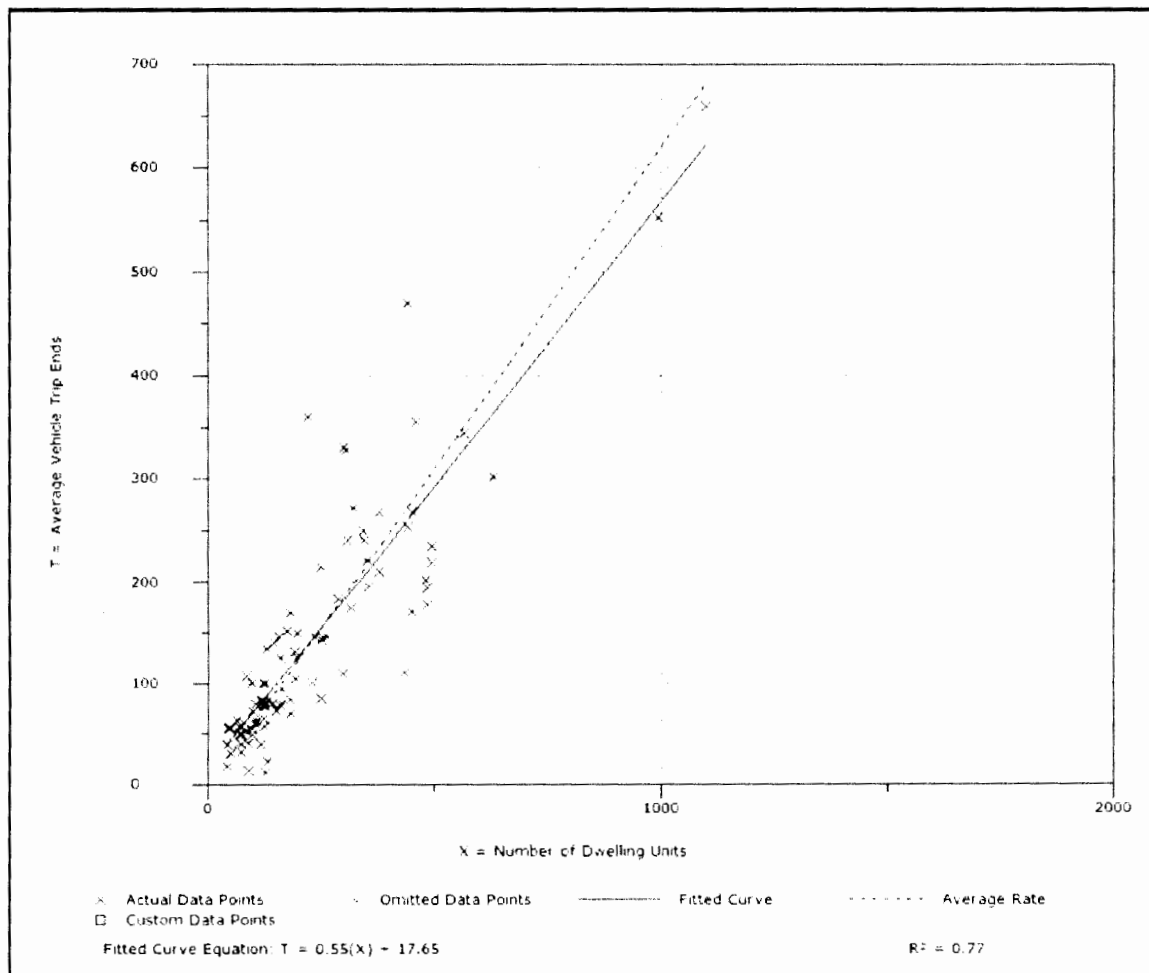
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday
Peak Hour of Adjacent Street Traffic
One Hour Between 4 and 6 p.m.

Number of Studies: 90
 Avg. Number of Dwelling Units: 233
 Directional Distribution: 65% entering, 35% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.62	0.10 - 1.64	0.82

Data Plot and Equation



Trip Generation: 9th Edition

Residential Condominium/Townhouse (230)

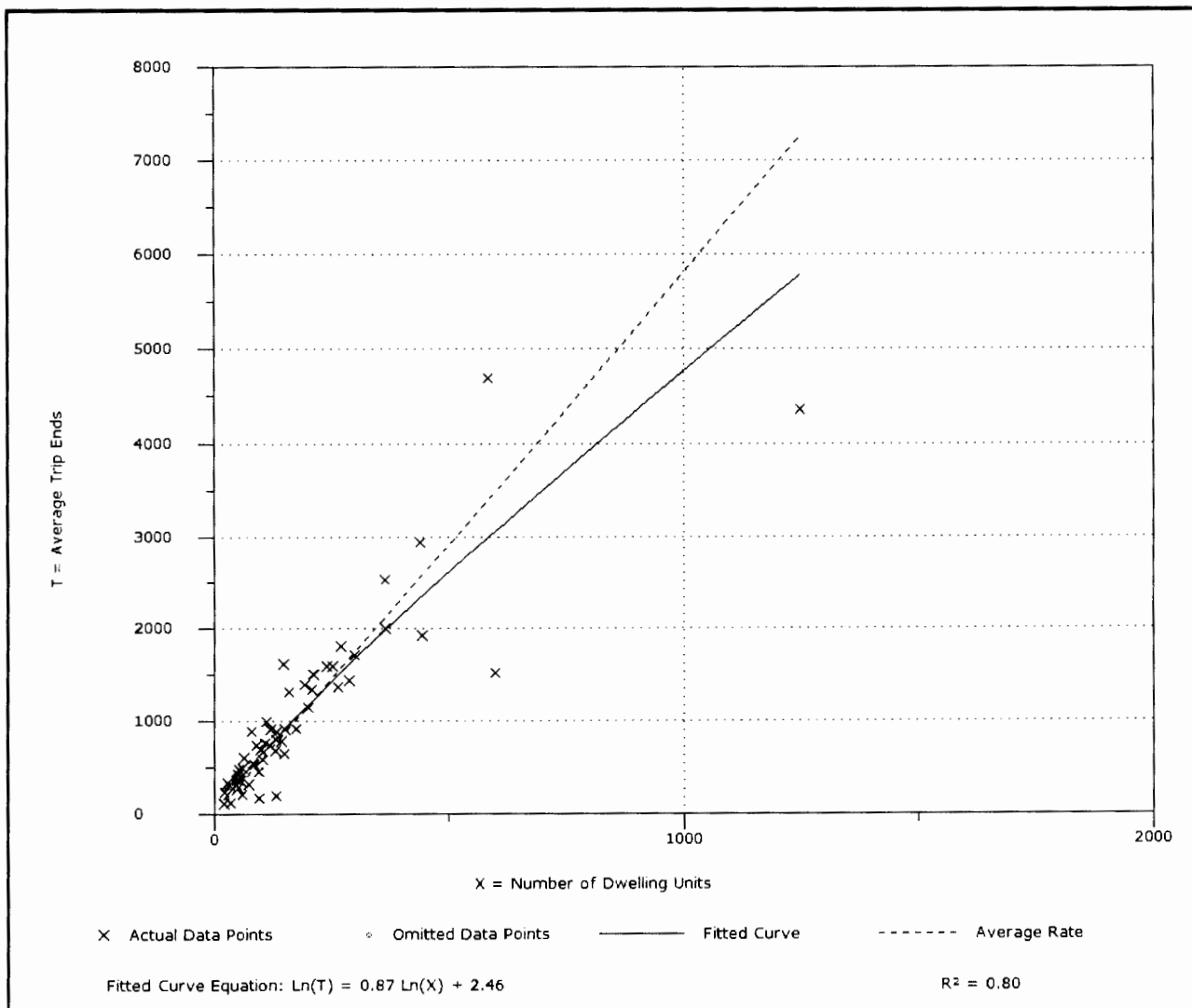
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Number of Studies: 56
Avg. Number of Dwelling Units: 179
Directional Distribution: 50% entering, 50% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
5.81	1.53 - 11.79	1.99

Data Plot and Equation



Residential Condominium/Townhouse (230)

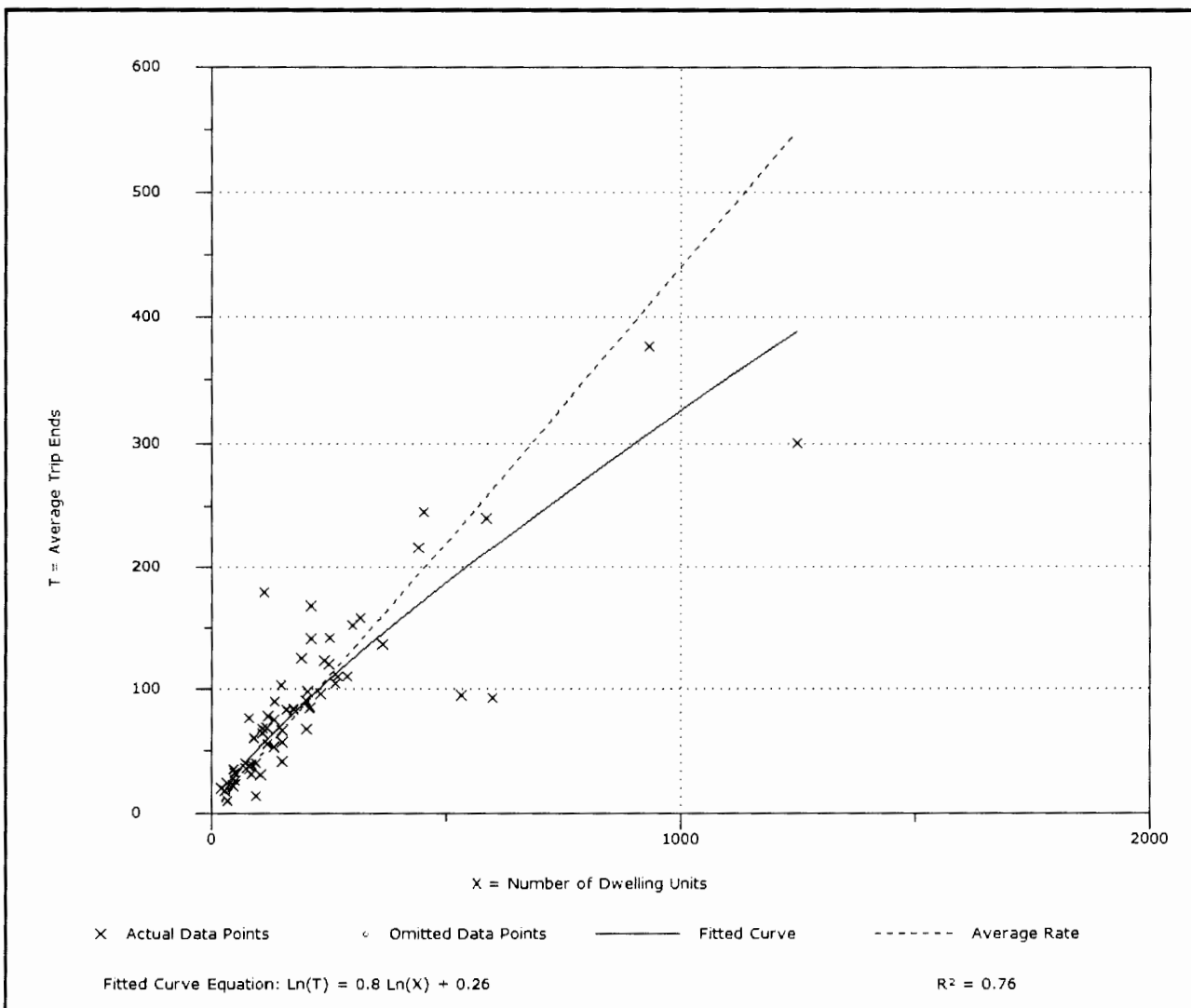
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.

Number of Studies: 59
 Avg. Number of Dwelling Units: 213
 Directional Distribution: 17% entering, 83% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.44	0.15 - 1.61	0.19

Data Plot and Equation



Residential Condominium/Townhouse (230)

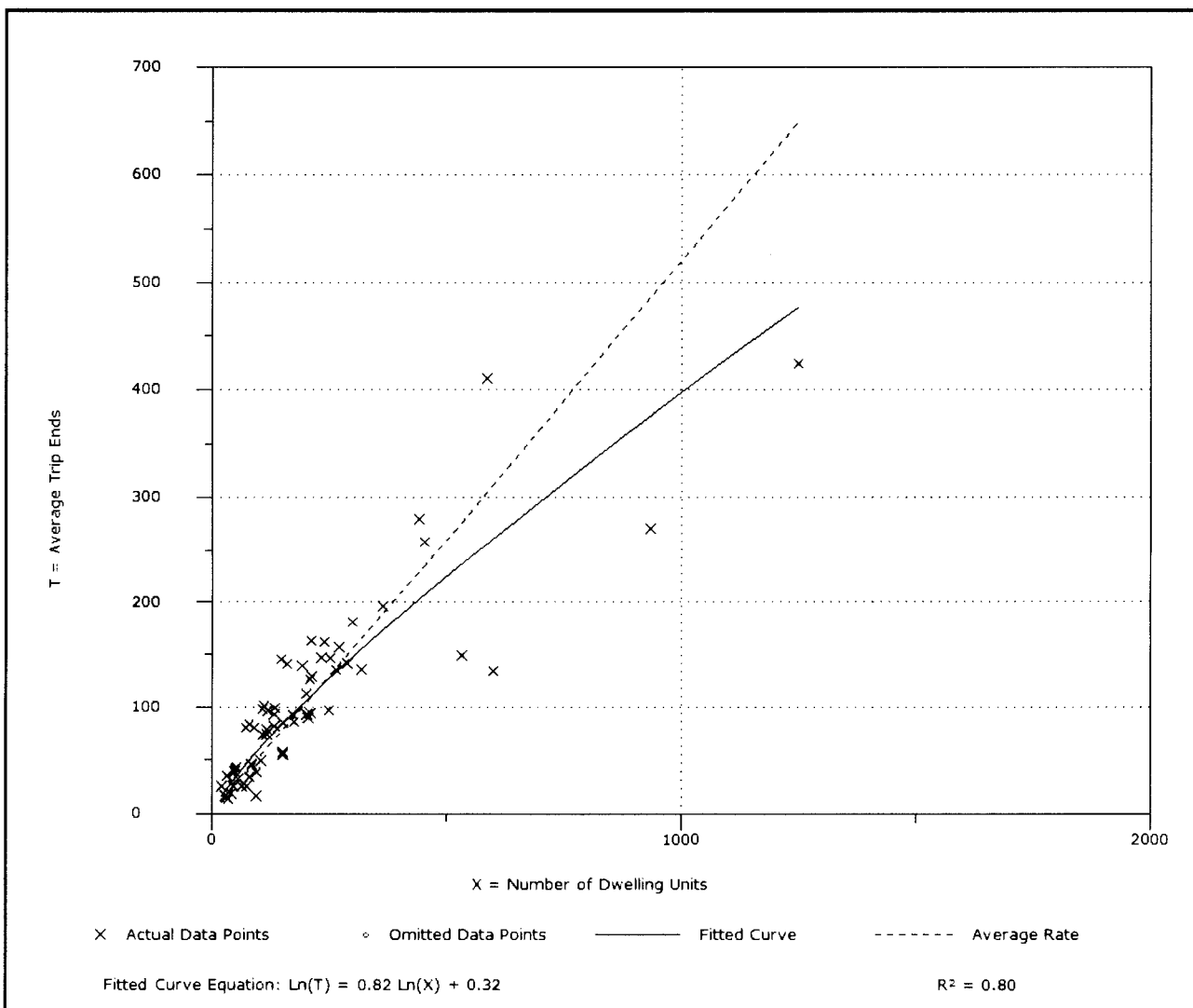
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.

Number of Studies: 62
 Avg. Number of Dwelling Units: 205
 Directional Distribution: 67% entering, 33% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.52	0.18 - 1.24	0.20

Data Plot and Equation



Senior Adult Housing - Attached (252)

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

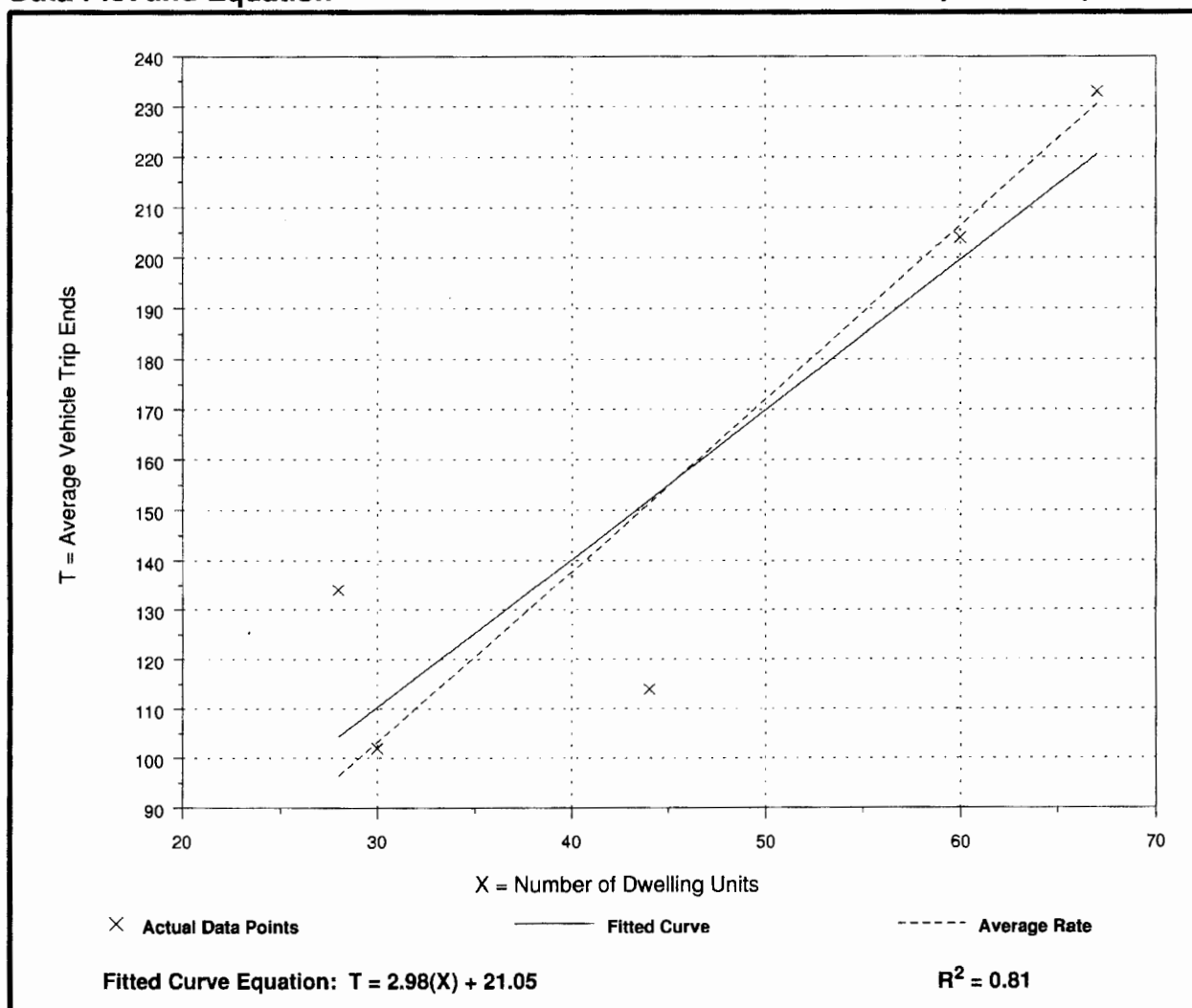
Number of Studies: 5
Avg. Number of Dwelling Units: 46
Directional Distribution: 50% entering, 50% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
3.44	2.59 - 4.79	1.93

Data Plot and Equation

Caution - Use Carefully - Small Sample Size



Senior Adult Housing - Attached (252)

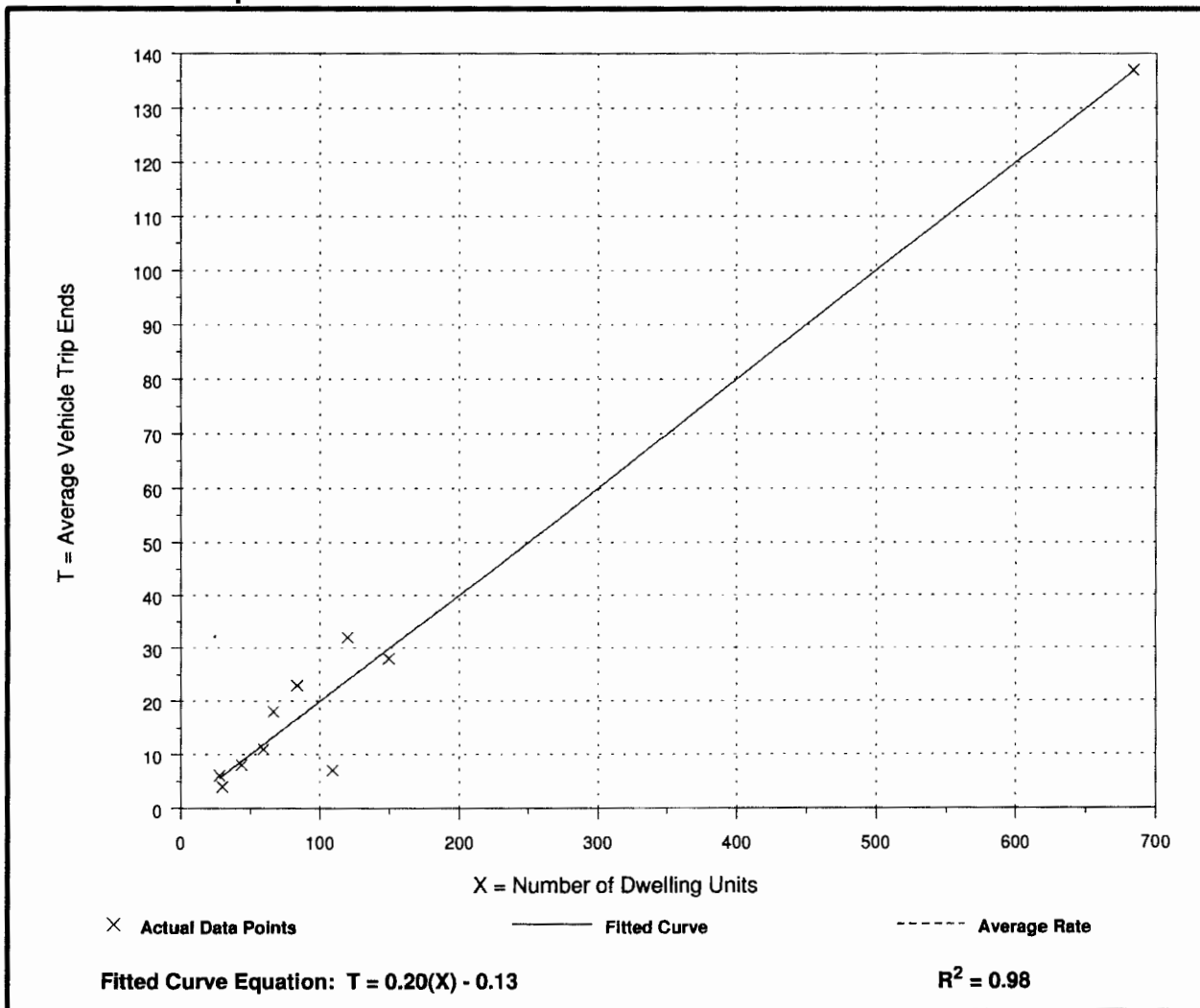
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.

Number of Studies: 10
 Avg. Number of Dwelling Units: 138
 Directional Distribution: 34% entering, 66% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.20	0.06 - 0.27	0.45

Data Plot and Equation



Senior Adult Housing - Attached (252)

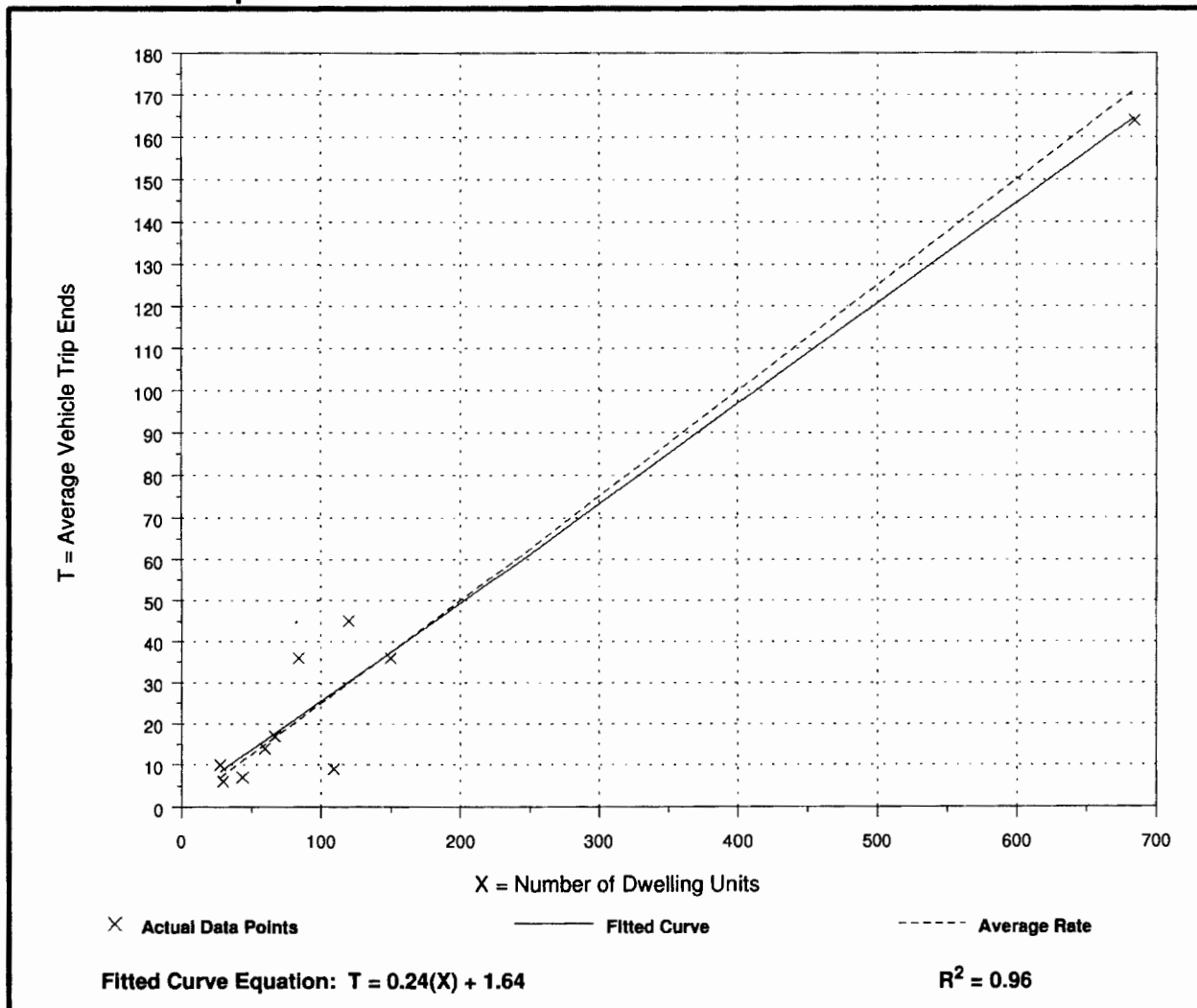
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.

Number of Studies: 10
 Avg. Number of Dwelling Units: 138
 Directional Distribution: 54% entering, 46% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.25	0.08 - 0.43	0.50

Data Plot and Equation



Appendix D
Historical Growth Rate

TRAFFIC TRENDS

Turkey Lake Road -- S. of Sand Lake Road

County:

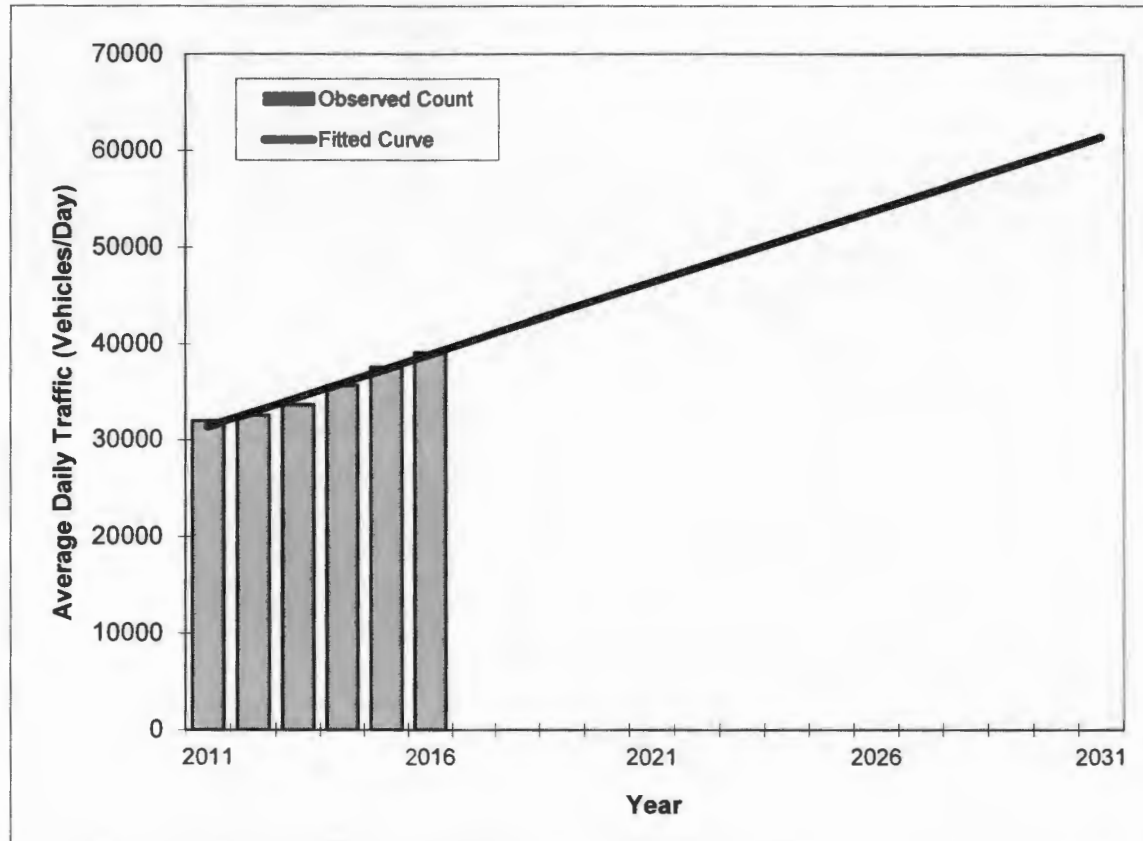
Orange

Station #:

0

Highway:

Turkey Lake Road



Year	Traffic (ADT/AADT)	
	Count*	Trend**
2011	32000	31400
2012	32600	32900
2013	33700	34400
2014	35700	35900
2015	37600	37400
2016	39100	38900
2020 Opening Year Trend		
2020	N/A	44900
2021 Mid-Year Trend		
2021	N/A	46400
2022 Design Year Trend		
2022	N/A	47900
TRANPLAN Forecasts/Trends		

** Annual Trend Increase: 1,500

Trend R-squared: 97.4%

Trend Annual Historic Growth Rate: 4.78%

Trend Growth Rate (2016 to Design Year): 3.86%

Printed: 28-Mar-17

Straight Line Growth Option

*Axle-Adjusted

Appendix E
MUTCD SWA Worksheets

TRAFFIC SIGNAL WARRANT SUMMARY

City: Orlando Engineer: TMC
County: Orange Date: March 27, 2017
Major Street: Turkey Lake Road Lanes: 2 Critical Approach Speed: 45
Minor Street: Lake Marie Loop Road (Proposed) Lanes: 1 Scenario: Buildout - 2020

Volume Level Criteria

1. Is the critical speed of major street traffic > 70 km/h (40 mph)? ☒ Yes ☐ No
2. Is the intersection in a built-up area of isolated community of <10,000 population? ☐ Yes ☒ No
If Question 1 or 2 above is answered "Yes", then use "70%" volume level ☒ 70% ☐ 100%

WARRANT 1 - EIGHT-HOUR VEHICULAR VOLUME

Warrant 1 is satisfied if Condition A or Condition B is "100%" satisfied.
Warrant is also satisfied if both Condition A and Condition B are "80%" satisfied.

Applicable: ☒ Yes ☐ No
Satisfied: ☐ Yes ☐ No

Condition A - Minimum Vehicular Volume

100% Satisfied: ☐ Yes ☐ No
80% Satisfied: ☐ Yes ☐ No

(volumes in veh/hr)	Minimum Requirements (80% Shown in Brackets)				Eight Highest Hours											
	1		2 or more		6:00 AM -	7:00 AM -	7:00 AM -	8:00 AM -	8:00 AM -	9:00 AM -	9:00 AM -	10:00 AM -	10:00 AM -	11:00 AM -	3:00 PM -	4:00 PM -
	100%	70%	100%	70%	6:00 AM -	7:00 AM -	7:00 AM -	8:00 AM -	8:00 AM -	9:00 AM -	9:00 AM -	10:00 AM -	10:00 AM -	11:00 AM -	3:00 PM -	4:00 PM -
Both Approaches on Major Street	500 (400)	350	600 (480)	420	1,249	2,286	2,449	2,622	2,553	3,075	3,069	3,191				
Highest Approach on Minor Street	150 (120)	105	200 (160)	140	124	162	112	81	86	87	78	83				

Record 8 highest hours and the corresponding volumes in boxes provided. Condition is 100% satisfied if the minimum volumes are met for eight hours. Condition is 80% satisfied if parenthetical volumes are met for eight hours.

Condition B - Interruption of Continuous Traffic

Condition B is intended for application where the traffic volume is so heavy that traffic on the minor street suffers excessive delay.

Applicable: ☒ Yes ☐ No
Excessive Delay: ☒ Yes ☐ No
100% Satisfied: ☒ Yes ☐ No
80% Satisfied: ☒ Yes ☐ No

(volumes in veh/hr)	Minimum Requirements (80% Shown in Brackets)				Eight Highest Hours											
	1		2 or more		6:00 AM -	7:00 AM -	7:00 AM -	8:00 AM -	8:00 AM -	9:00 AM -	9:00 AM -	10:00 AM -	10:00 AM -	11:00 AM -	3:00 PM -	4:00 PM -
	100%	70%	100%	70%	6:00 AM -	7:00 AM -	7:00 AM -	8:00 AM -	8:00 AM -	9:00 AM -	9:00 AM -	10:00 AM -	10:00 AM -	11:00 AM -	3:00 PM -	4:00 PM -
Both Approaches on Major Street	750 (600)	525	900 (720)	630	1,249	2,286	2,449	2,622	2,553	3,075	3,069	3,191				
Highest Approach on Minor Street	75 (60)	53	100 (80)	70	124	162	112	81	86	87	78	83				

Record 8 highest hours and the corresponding volumes in boxes provided. Condition is 100% satisfied if the minimum volumes are met for eight hours. Condition is 80% satisfied if parenthetical volumes are met for eight hours.

TRAFFIC SIGNAL WARRANT SUMMARY

City: Orlando Engineer: TMC
County: Orange Date: March 27, 2017
Major Street: Turkey Lake Road Lanes: 2 Critical Approach Speed: 45
Minor Street: Lake Marie Loop Road (Proposed) Lanes: 1 Scenario: Buildout - 2020

Volume Level Criteria

1. Is the critical speed of major street traffic > 70 km/h (40 mph)? ☒ Yes ☐ No
 2. Is the intersection in a built-up area of isolated community of <10,000 population? ☐ Yes ☒ No
- If Question 1 or 2 above is answered "Yes", then use "70%" volume level ☒ 70% ☐ 100%

WARRANT 2 - FOUR-HOUR VEHICULAR VOLUME

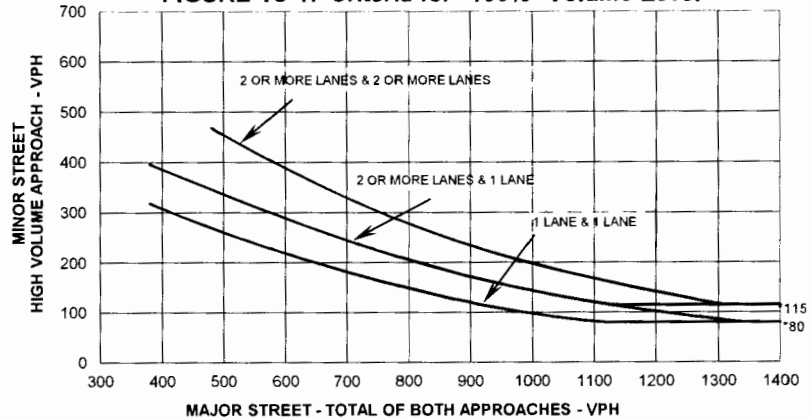
If all four points lie above the appropriate line, then the warrant is satisfied.

Applicable: ☒ Yes ☐ No
Satisfied: ☒ Yes ☐ No

Plot four volume combinations on the applicable figure below.

Four Highest Hours	Volumes	
	Major Street	Minor Street
6:00 AM	1,249	124
7:00 AM		
8:00 AM	2,286	162
9:00 AM	2,449	112
3:00 PM		
4:00 PM	3,075	87

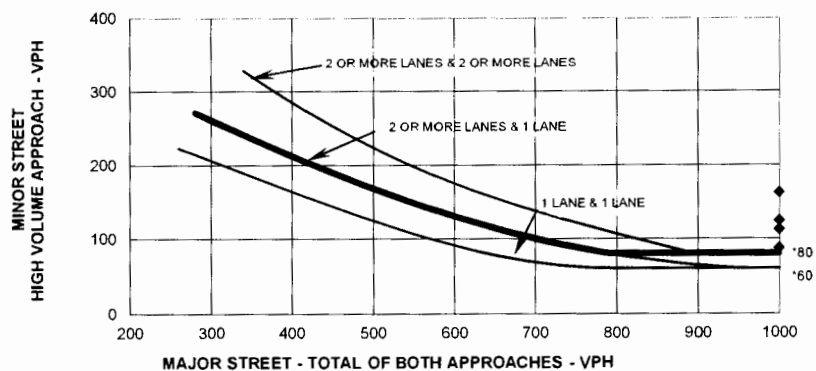
FIGURE 4C-1: Criteria for "100%" Volume Level



* Note: 115 vph applies as the lower threshold volume for a minor street approach with two or more lanes and 80 vph applies as the lower threshold volume threshold for a minor street approach with one lane.

FIGURE 4C-2: Criteria for "70%" Volume Level

(Community Less than 10,000 population or above 70 km/hr (40 mph) on Major Street)



* Note: 80 vph applies as the lower threshold volume for a minor street approach with two or more lanes and 60 vph applies as the lower threshold volume threshold for a minor street approach with one lane.

TRAFFIC SIGNAL WARRANT SUMMARY

City: Orlando Engineer: TMC
County: Orange Date: March 27, 2017
Major Street: Turkey Lake Road Lanes: 2 Critical Approach Speed: 45
Minor Street: Lake Marie Loop Road (Proposed) Lanes: 1 Scenario: Buildout - 2020

Volume Level Criteria

1. Is the critical speed of major street traffic > 70 km/h (40 mph)? ☒ Yes ☐ No
 2. Is the intersection in a built-up area of isolated community of <10,000 population? ☐ Yes ☒ No
- If Question 1 or 2 above is answered "Yes", then use "70%" volume level ☒ 70% ☐ 100%

WARRANT 3 - PEAK HOUR

If all three criteria are fulfilled or the plotted point lies above the appropriate line, then the warrant is satisfied.

Applicable: ☐ Yes ☒ No
Satisfied: ☐ Yes ☐ No

Unusual condition justifying
use of warrant:

Record hour when criteria are fulfilled
and the corresponding delay or volume
in boxes provided.

Peak Hour		

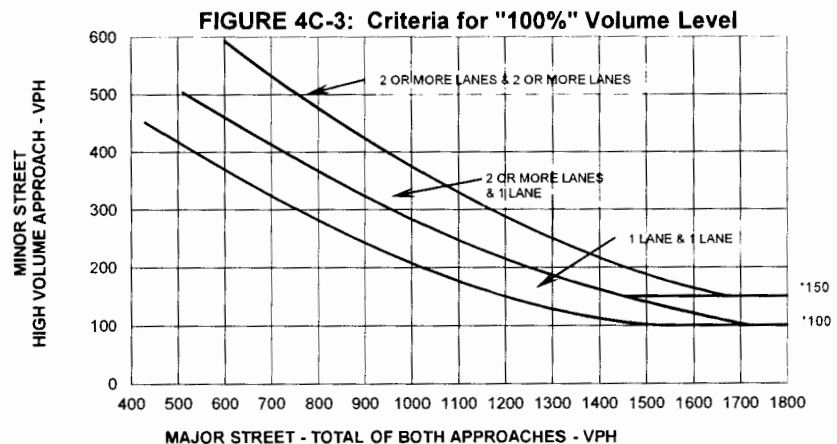
Criteria

1. Delay on Minor Approach *(vehicle-hours)		
Approach Lanes		
Delay Criteria*		
Delay*		
Fulfilled?:	☐ Yes	☐ No

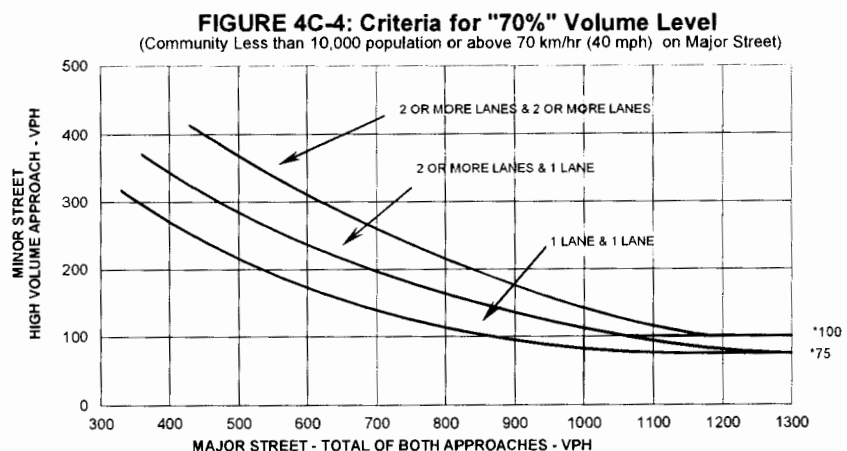
2. Volume on Minor Approach *(vehicles per hour)		
Approach Lanes		
Volume Criteria*		
Volume*		
Fulfilled?:	☐ Yes	☐ No

3. Total Entering Volume *(vehicles per hour)		
No. of Approaches		
Volume Criteria*		
Volume*		
Fulfilled?:	☐ Yes	☐ No

Plot volume combination on the applicable figure below.



* Note: 150 vph applies as the lower threshold volume for a minor street approach with two or more lanes and 100 vph applies as the lower threshold volume threshold for a minor street approach with one lane.



* Note: 100 vph applies as the lower threshold volume for a minor street approach with two or more lanes and 75 vph applies as the lower threshold volume threshold for a minor street approach with one lane.

Lanes: 2 Critical Approach Speed: 45
Lanes: 1 Scenario: Buildout - 2020

Criteria	Fulfilled?	
	Yes	No
1. On a one-way street or a street that has traffic predominately in one direction, the adjacent signals are so far apart that they do not provide the necessary degree of vehicle platooning.		
2. On a two-way street, adjacent signals do not provide the necessary degree of platooning, and the proposed and adjacent signals will collectively provide a progressive operation.		

TRAFFIC SIGNAL WARRANT SUMMARY

City: Orlando Engineer: TMC
County: Orange Date: March 27, 2017
Major Street: Turkey Lake Road Lanes: 2 Critical Approach Speed: 45
Minor Street: Lake Marie Loop Road (Proposed) Lanes: 1 Scenario: Buildout - 2020

WARRANT 7 - CRASH EXPERIENCE

Record hours where criteria are fulfilled, the corresponding volume, and other information in the boxes provided. The warrant is satisfied if all three of the criteria are fulfilled.

Applicable: ☐ Yes ☒ No
Satisfied: ☐ Yes ☐ No

Criteria	Hour	Volume	Met?		Fulfilled?	
			Yes	No	Yes	No
1. One of the warrants to the right is met.	Warrant 1, Condition A (80% satisfied)					
	Warrant 1, Condition B (80% satisfied)					
	Warrant 4, Pedestrian Volume at 80% of volume requirements:					
	80 ped/hr for four (4) hours or 152 ped/hr for one (1) hour					
2. Adequate trial of other remedial measure has failed to reduce crash frequency.	Measure tried:					
3. Five or more reported crashes, of types susceptible to correction by signal, have occurred within a 12-mo. period.	Number of crashes per 12 months:					

WARRANT 8 - ROADWAY NETWORK

Record hours where criteria are fulfilled, and the corresponding volume or other information in the boxes provided. The warrant is satisfied if at least one of the criteria is fulfilled and if all intersecting routes have one or more of the characteristics listed.

Applicable: ☐ Yes ☒ No
Satisfied: ☐ Yes ☐ No

Criteria			Met?		Fulfilled?	
			Yes	No	Yes	No
1. Both of the criteria to the right are met.	a. Total entering volume of at least 1,000 veh/hr during a typical weekday peak hour.	Entering Volume:				
	b. Five-year projected volumes that satisfy one or more of Warrants 1, 2, or 3.	Warrant:				
		Satisfied?:				
2. Total entering volume at least 1,000 veh/hr for each of any 5 hrs of a non-normal business day (Sat. or Sun.)			← Hour			
			← Volume			

Characteristics of Major Routes		Met?		Fulfilled?	
		Yes	No	Yes	No
1. Part of the street or highway system that serves as the principal roadway network for through traffic flow.	Major Street:				
	Minor Street:				
2. Rural or suburban highway outside of, entering, or traversing a city.	Major Street:				
	Minor Street:				
3. Appears as a major route on an official plan.	Major Street:				
	Minor Street:				

CONCLUSIONS

Warrants Satisfied: 1 2 ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Remarks: Signal meets warrants based on projected traffic. To ensure safe and adequate operations, it is recommended that the signal is installed with the construction of the intersection.