NOACA
Technical Memorandum

Signal Warrant Analysis
City of Bay Village
US 6 (Lake Road) and Bradley Road

February 2018

1) Title & Subtitle Signal Warrant Analysis: City of Bay Village, US 6 Lake Road and Bradley Road	2) NOACA Report No.
3) Author(s) Brian Blayney	4) Report Date February 2018
5) Performing Organization Name & Address Northeast Ohio Areawide Coordinating Agency 1299 Superior Avenue, Cleveland, OH 44114-3204 Phone: (216) 241-2414 FAX: (216) 621-3024 Website: www.noaca.org	6) Project Task No. 6251-02 7) NOACA Contract/Grant No. ODOT/FHWA
8) Sponsoring Agency Name & Address Ohio Department of Transportation 1980 W. Broad St., Box 899 Columbus, OH 43216-0899	9) Type of Report & Period Covered 2017 10) Sponsoring Agency Code
11) Supplementary Notes Federal funding for this project was provided by the Federal Highway Administration and administered by the Ohio Department of Transportation.	
12) Abstracts This memorandum contains a signal warrant analysis at the intersection of Lake Road and Bradley Road. Existing traffic control at the intersection consists of a two-way stop on Bradley Road. The analysis will determine if conditions are present to justify the installation of a traffic signal.	
13) Key Words & Document Analysis A. Descriptors B. Identifiers/Open Ended Terms	
14) Availability Statement NOACA	15) No. Pages 16) Price

Signal Warrant Analysis
Technical Memorandum

City of Bay Village
Lake Road & Bradley Road

February 2018

NORTHEAST OHIO AREAWIDE COORDINATING AGENCY

Armond Budish
BOARD PRESIDENT

Grace Gallucci
EXECUTIVE DIRECTOR

Preparation of this publication was financed by appropriations from the counties of and municipalities within Cuyahoga, Geauga, Lake, Lorain and Medina; the U.S. Environmental Protection Agency; and the U.S. Department of Transportation, Federal Transit Administration and Federal Highway Administration, in conjunction with the Ohio Department of Transportation.

Table of Contents

Executive Summary

The Northeast Ohio Areawide Coordinating Agency (NOACA) conducted a signal warrant analysis as part of its Traffic Safety & Operations Technical Assistance program for the City of Bay Village. The analysis was done to determine whether a traffic control signal at the intersection of Lake Road and Bradley Road is justified.

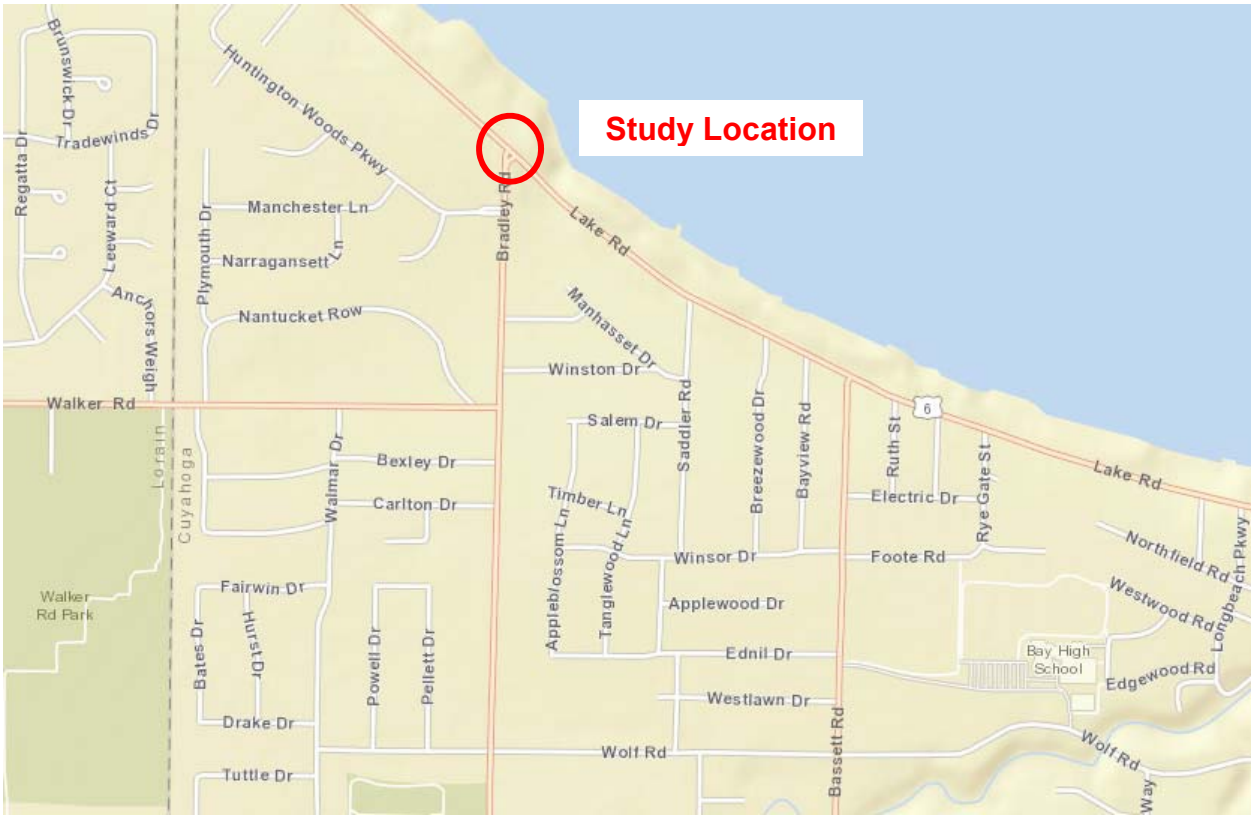
NOACA followed the signal warrant guidelines presented in the Ohio Manual of Uniform Traffic Control Devices (OMUTCD) and used the Highway Capacity Software (HCS) to analyze traffic counts to determine the need for a traffic control signal. Nine different warrants exist and were examined for this Technical Memo. Based on the existing traffic volumes and conditions, one of the nine warrants in the OMUTCD appears to be met. A traffic control signal may be warranted for installation at this intersection; however, signalization is not recommended at this time due to the generally satisfactory safety and operational performance of the intersection under existing stop control on Bradley Road.

Warrant	Result	Note
Warrant 1: Eight-Hour Vehicular Volume	**No**	Insufficient traffic volumes
Warrant 2: Four-Hour Vehicular Volume	**Yes**	Conditions met for minimum of four hours
Warrant 3: Peak Hour	**No**	The minor street is not an unusual case of facilities that attract or discharge large numbers of vehicles over a short time
Warrant 4: Pedestrian Volume	**No**	Insufficient pedestrian volume
Warrant 5: School Crossing	**No**	Insufficient school crossing volume; Lake Road, the major road, has a signalized intersection closer to the school
Warrant 6: Coordinated Signal System	**No**	The intersection is not within the limits of a coordinated signal system
Warrant 7: Crash Experience	**No**	Insufficient traffic and pedestrian volumes
Warrant 8: Roadway Network	**No**	Bradley Road is not a major route
Warrant 9: Intersection near a Grade Crossing	**No**	No nearby at-grade railroad crossing

Introduction

The City of Bay Village requested that NOACA conduct a signal warrant analysis to evaluate the necessity of installing a traffic control signal at the intersection of Lake Road (US Route 6) and Bradley Road. The intersection is currently controlled by stop signs on Bradley Road, the minor road in the analysis. To conduct this study, traffic counts were collected by Eggeman Engineering & Consulting for NOACA on Tuesday, October 17, 2017. Counts were collected for the 13-hour period between 6 a.m. and 7 p.m. NOACA staff then analyzed the data using the criteria set forth in the Ohio Manual of Uniform Traffic Control Devices (OMUTCD) in Chapter 4, Section C.[1] For evaluation purposes, the population of the City of Bay Village is considered to be 15,651, as reported in the 2010 census.

Image 1: Project Location Map



[1] Ohio Department of Transportation (ODOT) Office of Traffic Engineering, Ohio Manual of Uniform Traffic Control Devices (OMUTCD), 2012, http://www.dot.state.oh.us/Divisions/Engineering/Roadway/DesignStandards/traffic/OhioMUTCD/Documents/2012_Part04_Final_bookmarked_011712_added_bookmarks_forFiguresandTables.pdf (accessed January 11, 2018).

Image 2: Aerial View of Project Location

Lake Road, which travels roughly east-west through the study area, is considered the “major” road in the analysis due to its higher functional classification as a principal arterial (FC3) and higher traffic volumes. The posted speed limit is 35 mph with one lane in each direction. Bradley Road is classified as a major collector (FC5) and carries a posted speed limit of 35 mph, with one lane in each direction north-south. Because Lake Road is the major road, it is not controlled by any traffic-control device, while Bradley Road is controlled by “STOP” signs. It is noted that the northbound approach of Bradley includes a small channelizing island, or “pork chop,” due to the heavy skew of the approach. The channelizing island allows the northbound approach to function effectively as a two-lane approach, with a short left-turn slot capable of storing two or three passenger vehicles without blocking access to the right-turn lane to Lake Road.

Image 3: Northbound Approach of Bradley Road at Lake Road

Crash History, 2012-2016

The crash history indicates a low number of crashes per year with no obvious trend. A total of six crashes were identified between 2012 and 2016 near the intersection. On review of these crash reports, only two of the six crashes were found to be potentially correctable by signalization, a low crash frequency when considering accident experience. In comparison, signalization is not considered to enhance safety unless at least five crashes correctable by signalization occur within a 12-month period. Two correctable crashes occurred in the 60-month period reviewed for this report, for an average rate of 0.4 crashes per year.

Angle crashes are typically reduced following the installation of a traffic control signal, while rear-end crashes may be made worse. The City of Bay Village may continue to monitor the intersection for an increase in crashes or crash severity.

Table 1: Crash History, Crashes Correctable by Signalization, 2012-2016

Year	Crash Severity		Total
	Injury	Property Damage	
2012	0	0	0
2013	0	0	0
2014	1	0	1
2015	1	0	1
2016	0	0	0
5-Year Average	0.4	0.0	0.4

Methodology

The Ohio Manual of Uniform Traffic Control Devices provides nine possible justifications for a traffic signal. Chapter 4C of the Manual notes that meeting one or more is the minimum necessary to justify a traffic signal but that meeting this standard "shall not in itself require the installation of a traffic control signal."

Warrant 1: Eight-Hour Vehicular Volume
Warrant 2: Four-Hour Vehicular Volume
Warrant 3: Peak Hour
Warrant 4: Pedestrian Volume
Warrant 5: School Crossing
Warrant 6: Coordinated Signal System
Warrant 7: Crash Experience
Warrant 8: Roadway Network
Warrant 9: Intersection near a Grade Crossing

Warrant 1: Eight-Hour Vehicular Volume

Condition A: Applied at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

Condition B: Applied at locations where condition A is not satisfied and the minor road traffic experiences high delays and conflict in entering or crossing the major road.

Either Condition A or B must be met for eight hours. For each of any eight hours of an average day, the total volume in vehicles per hour (VPH) of the major road and the higher VPH of the two approaches of the minor road should exceed the minimum threshold traffic volumes defined in the OMUTCD.

If neither Condition A nor Condition B is met for a minimum of eight hours, a combination of Condition A and Condition B may be considered after an adequate trial of less restrictive alternatives. Applicable values for both condition are reduced to 80% of their full values, and both conditions must be met for a minimum of eight hours.

NOACA used the eight hours of highest traffic volumes for this location. The thresholds are shown in the worksheet in Table 4 (Appendix B). For normal (100%) thresholds, four hours were met for Condition A and five hours were met for Condition B. The combination of Conditions A and B at 80% thresholds was evaluated. Both Condition A and Condition B was met for six hours each.

The 100% traffic volume thresholds can be decreased to the 70% level if the posted speed limit exceeds 40 mph or the intersection is in a community with a population under 10,000. The posted speed limit at the subject intersection is 35 mph, and the population of the City of Bay Village exceeds 10,000. Therefore, the option for a 70% level analysis is not applicable.

Warrant 1 is not satisfied for this intersection due to insufficient traffic volumes.

Warrant 2: Four-Hour Vehicular Volume

This warrant is applied where the volume of intersecting traffic is the main reason to consider installing a traffic control signal. The volume of at least four hours should exceed the minimum threshold outlined in the OMUTCD to justify this warrant. The plotted points that represent the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) all must fall above the applicable curve from the OMUTCD.

Hourly volumes exceeded the minimum threshold for four hours as shown in Table 5 (Appendix B).

Warrant 2 appears to be satisfied for this intersection due to the combination of major and minor street traffic volumes.

Warrant 3: Peak Hour

This warrant is applied where traffic conditions are such that for at least one hour, the minor road traffic suffers undue delay. This signal warrant is applied only in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time. The need for a traffic control signal would be considered if either of the following two categories are met:

- **Category A:** If all three of the following conditions exist for the same one hour:
    1. The total stopped time delay experienced by traffic on the minor street approach equals or exceeds OMUTCD thresholds; and
    2. The volume on the same minor street approach equals or exceeds 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour (VPH) for two moving lanes; and
    3. The total entering volume serviced during the hour equals or exceeds 650 vehicles per hour for intersections with three approaches or 800 vehicles per hour for intersections with four or more approaches.
- **Category B:** The point representing the VPH (in both directions) on the major street and the corresponding VPH on the higher-volume minor street approach (one direction only) for any one hour of an average day falls above the applicable OMUTCD thresholds.

Warrant 3 is not satisfied for this intersection as the minor street is not an unusual case where facilities attract or discharge large numbers of vehicles over a short time.

Warrant 4: Pedestrian Volume

The pedestrian volume warrant is intended for situations where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street. Bicyclists may be counted as pedestrians in cases where they use bicycle or pedestrian crossings rather than sharing the lane with vehicular traffic. The need for a traffic control signal at an intersection or midblock crossing would be considered if both of the following criteria are met:

- The pedestrian volume crossing the major road meets minimum thresholds for either four-hour or peak-hour volumes based on the number of vehicles on the major road; and
- There is no existing traffic control signal or stop sign on the major street within 300 feet of the intersection under study, unless the proposed traffic control signal will not restrict the progressive movement of traffic.

For the four-hour and peak-hour warrants, the number of pedestrians who cross the road to satisfy the warrant is inversely proportional to the number of vehicles per hour. In other words, the number of pedestrians necessary decreases as the number of vehicles increases. Note, however, that for the four-hour criteria, at least 107 pedestrians are needed to cross per hour, and for the peak-hour criteria, at least 133 pedestrians are needed, regardless of traffic volumes.

The highest number of pedestrians per hour crossing the major street at the subject intersection was two (Table 3, Appendix A), which is well below these minimum values. The graphs for pedestrian values are shown in Appendix D. As previously stated in Warrant 1, the option for 70% level analysis is not applicable.

Warrant 4 is not satisfied for this intersection due to low pedestrian volumes.

Warrant 5: School Crossing

The school crossing warrant is intended for cases where the principal reason to consider installing a traffic control signal is schoolchildren crossing the major street. For purposes of this warrant, “schoolchildren” includes elementary through high-school students. A signal may be considered if the number of adequate gaps in the vehicular traffic stream during the period when children are using an established school crossing is less than the number of minutes in the same period and there are a minimum of 20 students during the highest crossing hour. As with the pedestrian volume warrant, the school crossing warrant is to be applied only if there is no existing traffic control signal or stop sign on the major street within 300 feet of the intersection under study, unless the proposed traffic control signal will not restrict the progressive movement of traffic.

No school children were observed crossing Lake Road at Bradley Road.

Warrant 5 is not satisfied for this intersection due to low crossing volumes.

Warrant 6: Coordinated Signal System

This analysis determines if a signal is warranted to maintain proper platooning through a series of coordinated signals. A signal may be warranted if the adjacent traffic control signals do not provide the necessary degree of platooning and the addition of a new signal will provide a progressive operation in conjunction with existing signals; however, this warrant should not be applied where the resultant spacing of traffic control signals would be less than 1,000 feet.

Warrant 6 is not applicable because the intersection is not within the limits of a coordinated signal system along Lake Road.

Warrant 7: Crash Experience

The crash experience warrant is intended for application where the frequency and severity of crashes are the principal reasons to consider installing a traffic-control signal. A signal is considered warranted if all three criteria are met:

1. An adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce crash frequency; and
2. Five or more reported crashes, of types susceptible to correction by a traffic-control signal, have occurred within a 12-month period. Crashes susceptible to correction by a traffic-control signal typically include angle and left-turn crashes. Engineering judgment is used to determine if other crash types could be prevented by a signal at the location in question (e.g., pedestrian and failure-to-yield crashes). Rear-end crashes are typically expected to increase after installation of a traffic-control signal.
3. For each of any eight hours of an average day, the traffic volume given in both of the 80% columns of Warrant 1 Condition A must be met as defined in the OMUTCD; or the traffic volume given in both of the 80% columns for Condition B must be met; or the volume of pedestrian traffic is not less than 80% of the requirements specified in the Pedestrian Volume Warrant 4.

A review of the crash history under Condition 2 indicates that an average of 0.4 crashes per year correctable by signalization occurred over the trailing five-year period from 2012 to 2016. This is well below the minimum of five crashes within a 12-month period. Condition 2 of Warrant 7 is therefore not met for this intersection.

Warrant 7 is not satisfied for this intersection because all three criteria are not met. The frequency of crashes is below the minimum threshold.

Warrant 8: Roadway Network

A traffic-control signal may be justified to encourage concentration and organization of traffic flow on a roadway network. The common intersection of two or more major routes must meet at least one of the following criteria:

- The intersection has an existing or immediately projected entering volume of at least 1,000 VPH during the peak hour of a typical weekday and has five-year projected traffic volumes, based on an engineering study, that meet one or more of warrants 1, 2, and 3 during an average weekday; or
- The intersection has an existing or immediately projected entering volume of at least 1,000 VPH for each of any five hours of a non-normal business day.

Note that for this warrant, a “major route” is defined as having at least one of the following conditions:

- It is part of a street or highway system that serves as the principal roadway network for through traffic.
- It includes rural or suburban highways outside, entering, or traversing a city.
- It appears as a major route on an official plan, such as a major street plan in an urban area traffic study.

Warrant 8 is not satisfied because Bradley Road is classified as a local road to the south and does not meet the definition of a “major route.”

Warrant 9: Intersection near a Grade Crossing

This warrant is intended for use at a location where none of the other eight warrants are met but the proximity to the intersection of a railroad crossing at grade on an intersection approach controlled by a STOP or YIELD sign is the principal reason to consider installing a signal.

Warrant 9 is not satisfied due to no at-grade railroad crossings near the intersection.

Warrant Analysis Summary

Warrant	Result	Note
Warrant 1: Eight-Hour Vehicular Volume	**No**	Insufficient traffic volumes
Warrant 2: Four-Hour Vehicular Volume	**Yes**	Conditions met for minimum of four hours
Warrant 3: Peak Hour	**No**	The minor street is not an unusual case of facilities that attract or discharge large numbers of vehicles over a short time
Warrant 4: Pedestrian Volume	**No**	Insufficient pedestrian volume
Warrant 5: School Crossing	**No**	Insufficient school crossing volume
Warrant 6: Coordinated Signal System	**No**	The intersection is not within the limits of a coordinated signal system
Warrant 7: Crash Experience	**No**	Insufficient traffic and pedestrian volumes
Warrant 8: Roadway Network	**No**	Bradley Road is not a major route
Warrant 9: Intersection near a Grade Crossing	**No**	No nearby at-grade railroad crossing

Warrant 1 is not satisfied due to low traffic volumes over the course of the day, but Warrant 2 is met based on traffic volumes present for the four highest hours (see Appendix B). Warrant 3 is also not satisfied as the minor street is not an unusual case of facilities that attract or discharge large numbers of vehicles over a short time.

Pedestrian volume is insufficient to satisfy Warrant 4, and Warrant 5 is not satisfied due to a low volume of pedestrian schoolchildren.

Warrant 6 is not satisfied because the intersection is not within the limits of coordinated signal system.

Warrant 7 is not satisfied because only 0.4 crashes per year occur at the intersection that are of the type that may be prevented by a signal. Furthermore, traffic and pedestrian volume is too low to meet the criteria.

Warrant 8 is not satisfied because Bradley Road is a local road and not considered a major route.

Finally, Warrant 9 is not satisfied because no rail crossing exists within the immediate vicinity of the intersection.

Discussion and Conclusion

Based on Chapter 4, Traffic Control Signal Needs Studies, of the OMUTCD and using traffic counts performed on Tuesday, October 17, 2017, a traffic signal may be warranted at the intersection of Lake Road and Bradley Road since the conditions for Warrant 2 appear to have been met.

NOACA advises careful consideration of a decision to move forward with signalization. The OMUTCD does not require signalization simply because one or more warrants are met (Section 4C.01, Paragraph 03): "The satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control system." Subsequent paragraphs go on to discuss the effects of right-turn vehicles from minor street approaches and the application of engineering judgment due to site-specific traffic characteristics. In addition, the FHWA publication "Intersection Safety Briefs, Issue 5, Traffic Signals" notes the disadvantages associated with installing traffic signals, including increased delays, potential disobedience of signal indications, and increases in frequency of crashes.[2]

Traffic volume data show that the prevailing movement for traffic headed northbound on Bradley Road is to make a right turn at Lake Road. The percentage of right turns to total approach volume was 80% over all hours counted, with 93% of Bradley Road traffic turning right in the morning (AM) peak hour and 70% turning right in the afternoon/evening (PM) peak hour.

A review of site-specific traffic characteristics of the intersection shows that Bradley Road operates as a two-lane approach, with a short left-turn lane with sufficient physical space to store at least two passenger vehicles before blocking access to the right-turn lane to Lake Road eastbound. This short left-turn slot ensures that right-turning traffic is rarely blocked by left turners.

NOACA staff reviewed the video of traffic movements used to extract turning movement count data, concluding that the primary operational problems by Bradley Road users fall into two categories:

1. Relatively heavy eastbound volumes make it difficult to find sufficient gaps to make a right turn (a concern usually in the AM peak).
2. Relatively heavy westbound volumes (including westbound left turns) make it difficult to find adequate gaps to turn left (a concern usually in the PM peak).

These two conditions are presented in screen captures in the figure below, with the worst observed queuing conditions highlighted by red and white arrows.

[2] Federal Highway Administration (FHWA), Intersection Safety Briefs, Issue 5, Traffic Signals, November 2009, https://safety.fhwa.dot.gov/intersection/conventional/signalized/fhwasa10005/docs/brief_5.pdf (accessed January 11, 2018).

Images 4 and 5: Queuing Conditions on Bradley and Lake Roads

NOACA staff does not recommend signalization without further investigation considering the potential trade-offs for operations and safety. Lake Road provides long-distance connectivity within the region, and it appears desirable to minimize delays through the corridor, unless it can be demonstrated the lack of signalization adversely affects other roadways that make up the public highway network. Observations suggest the turning movements at Bradley Road are acceptable. Further, the crash performance of the intersection under two-way stop control appears to be satisfactory, and it is likely that installation of a traffic signal will increase the frequency of crashes at this intersection.

Appendix A

Traffic Counts

Table 3: Traffic Counts

104581 - TMC
Tue Oct 17, 2017
Full Length (6AM-6:45AM, 6:45AM-8:15AM, 8:15AM-9:45AM, 9:45AM-11:30AM, 11:30AM-1:30PM, 1:30PM-3:15PM, 3:15PM-4:45PM, 4:45PM-6:15PM, 6:15PM-7PM)
All Classes (Lights, Single-Unit Trucks, Articulated Trucks, Buses, Pedestrians, Bicycles on Road, Bicycles on Crosswalk)
All Movements
ID: 465670, Location: 41.498078, -81.959427, Site Code: 104581

Provided by: Eggeman Engineering & Consulting
5152 S. Tecumseh Rd,
Springfield, OH, 45502, US

Leg / Direction	Southeast Northwestbound					South Northbound					Northwest Southeastbound					
Time	T	HL	U	App	Ped*	HR	BL	U	App	Ped*	BR	T	U	App	Ped*	Int
2017-10-17 6:00AM	44	17	0	**61**	0	59	7	0	**66**	3	51	369	0	**420**	0	**547**
7:00AM	142	40	0	**182**	1	208	17	0	**225**	1	68	710	0	**778**	0	**1185**
8:00AM	155	56	0	**211**	1	214	23	0	**237**	3	55	590	0	**645**	0	**1093**
9:00AM	145	52	0	**197**	0	98	15	0	**113**	0	40	286	0	**326**	1	**636**
10:00AM	154	52	0	**206**	0	87	13	0	**100**	1	37	201	0	**238**	0	**544**
11:00AM	205	87	0	**292**	2	89	24	0	**113**	0	40	181	1	**222**	0	**627**
12:00PM	200	88	0	**288**	0	83	35	0	**118**	0	42	215	0	**257**	2	**663**
1:00PM	185	80	2	**267**	0	82	33	0	**115**	0	46	202	0	**248**	0	**630**
2:00PM	228	94	0	**322**	0	99	31	0	**130**	1	28	224	0	**252**	0	**704**
3:00PM	373	152	0	**525**	0	90	28	0	**118**	0	29	294	0	**323**	0	**966**
4:00PM	517	142	0	**659**	0	108	44	0	**152**	1	46	248	0	**294**	0	**1105**
5:00PM	559	169	1	**729**	0	125	46	1	**172**	1	25	315	0	**340**	0	**1241**
6:00PM	374	148	0	**522**	1	104	37	0	**141**	0	27	198	0	**225**	0	**888**
Total	3281	1177	3	**4461**	5	1446	353	1	**1800**	11	534	4033	1	**4568**	3	**10829**
% Approach	73.5%	26.4%	0.1%	-	-	80.3%	19.6%	0.1%	-	-	11.7%	88.3%	0%	-	-	-
% Total	30.3%	10.9%	0%	**41.2%**	-	13.4%	3.3%	0%	**16.6%**	-	4.9%	37.2%	0%	**42.2%**	-	-
Lights	3188	1146	3	**4337**	-	1402	336	1	**1739**	-	513	3948	1	**4462**	-	10538
% Lights	97.2%	97.4%	100%	**97.2%**	-	97.0%	95.2%	100%	**96.6%**	-	96.1%	97.9%	100%	**97.7%**	-	97.3%
Single-Unit Trucks	61	20	0	**81**	-	27	12	0	**39**	-	12	64	0	**76**	-	196
% Single-Unit Trucks	1.9%	1.7%	0%	**1.8%**	-	1.9%	3.4%	0%	**2.2%**	-	2.2%	1.6%	0%	**1.7%**	-	1.8%
Articulated Trucks	8	1	0	**9**	-	0	1	0	**1**	-	0	9	0	**9**	-	19
% Articulated Trucks	0.2%	0.1%	0%	**0.2%**	-	0%	0.3%	0%	**0.1%**	-	0%	0.2%	0%	**0.2%**	-	0.2%
Buses	14	8	0	**22**	-	15	1	0	**16**	-	1	6	0	**7**	-	45
% Buses	0.4%	0.7%	0%	**0.5%**	-	1.0%	0.3%	0%	**0.9%**	-	0.2%	0.1%	0%	**0.2%**	-	0.4%
Bicycles on Road	10	2	0	**12**	-	2	3	0	**5**	-	8	6	0	**14**	-	31
% Bicycles on Road	0.3%	0.2%	0%	**0.3%**	-	0.1%	0.8%	0%	**0.3%**	-	1.5%	0.1%	0%	**0.3%**	-	0.3%
Pedestrians	-	-	-	-	5	-	-	-	-	9	-	-	-	-	3	
% Pedestrians	-	-	-	-	100%	-	-	-	-	81.8%	-	-	-	-	100%	-
Bicycles on Crosswalk	-	-	-	-	0	-	-	-	-	2	-	-	-	-	0	
% Bicycles on Crosswalk	-	-	-	-	0%	-	-	-	-	18.2%	-	-	-	-	0%	-

*Pedestrians and Bicycles on Crosswalk. BL: Bear left, BR: Bear right, HL: Hard left, HR: Hard right, T: Thru, U: U-Turn

Appendix B

Signal Warrant Evaluation

Table 4: Signal Warrant Analysis Summary

Intersection: Lake Road and Bradley Road
Location: Bay Village, Cuyahoga County
Number of Lanes per approach: N= 1 S= 1 E= 1 W= 1
Does 70% warrant apply? No
Major Street speed limit: 35

Analysis By: NOACA
Traffic count date: 10/17/2017

		Hourly volumes			WARRANT #1								WARRANT	
					Condition A				Condition B				#2	#3
Condition	No. of Lanes	Major St. 2-way	Minor St. 1-way	Minor St. 1-way	100%		80%		100%		80%		FOUR HOUR	PEAK HOUR
					Major	Minor	Major	Minor	Major	Minor	Major	Minor		
Normal	1				500	150	400	120	750	75	600	60		
	2+				600	200	480	160	900	100	720	80		
70%*	1				350	105	280	84	525	53	420	42		
	2+				420	140	336	112	630	70	504	56		
MID to 1 AM														
1 AM to 2 AM														
2 AM to 3 AM														
3 AM to 4 AM														
4 AM to 5 AM														
5 AM to 6 AM														
6 AM to 7 AM		481		66			*					*		
7 AM to 8 AM		960		225	*	*	*	*	*	*	*	*	*	
8 AM to 9 AM		856		237	*	*	*	*	*	*	*	*	*	
9 AM to 10 AM		523		113	*					*		*		
10 AM to 11 AM		444		100			*			*		*		
11 AM to 12 Noon		514		113	*		*			*		*		
12 Noon to 1 PM		545		118	*		*			*		*		
1 PM to 2 PM		515		115	*		*			*		*		
2 PM to 3 PM		574		130	*		*	*		*		*		
3 PM to 4 PM		848		118	*		*		*	*	*	*		
4 PM to 5 PM		953		152	*	*	*	*	*	*	*	*	*	
5 PM to 6 PM		1069		172	*	*	*	*	*	*	*	*	*	
6 PM to 7 PM		747		141	*		*	*		*	*	*		
7 PM to 8 PM														
8 PM to 9 PM														
9 PM to 10 PM														
10 PM to 11 PM														
11 PM to MID														
Hours Met					4		6		5		6		4	0
WARRANT SATISFIED					No		No		No		No		Yes	No

* Condition is determined by envirnoment: Use 70% values if the speed limit exceeds 40 mph on the major road or if the location is in a build up area of an isolated community with a population of less than 10,000.

WARRANT #1 (Combination)
Conditions A & B are each met at the 80% level: No

WARRANT #4 (Pedestrian Volume)
Hours with 107 or more pedestrians: 0
Hours with 133 or more pedestrians: 0
Distance to nearest traffic control on major street: 1.4 Miles
Warrant Satisfied? No

WARRANT #5 (School Crossing)
At least 20 children crossing during highest volume hour: No
Gap analysis made during period: N/A
Pedestrian crossing time (t): N/A
Number of gaps greater than (t) during period: N/A
Distance to nearest traffic control on major street: 1.4 Miles
Warrant Satisfied? No

WARRANT #6 (COORDINATED SIGNAL SYSTEM)
Distance to nearest signal in each direction on major street: 1.4 Miles
Time space diagram (attached) shows that this location can be implemented into a system: N/A
Warrant Satisfied? No

WARRANT #7 (CRASH EXPERIENCE)
Adequate trial of less restrictive measures: No
Number of crashes per year which could be prevented: 0.4
80% of Warrant 1 Condition A or B: No
Warrant Satisfied? No

WARRANT #8 (ROADWAY NETWORK)
Both streets are considered major routes: No
At least 1000 V.P.H. during weekday peak hour: No
5-Year projection meets Warrant 1, 2, or 3: N/A
At least 1000 V.P.H. for any 5 hours on a Saturday or Sunday: N/A
Meets Characteristic requirements? N/A
Warrant Satisfied? No

Warrant # 9 (Intersection Near a Grade Crossing)
Distance to nearest crossing on street with existing control: N/A
Warrant Satisfied? No

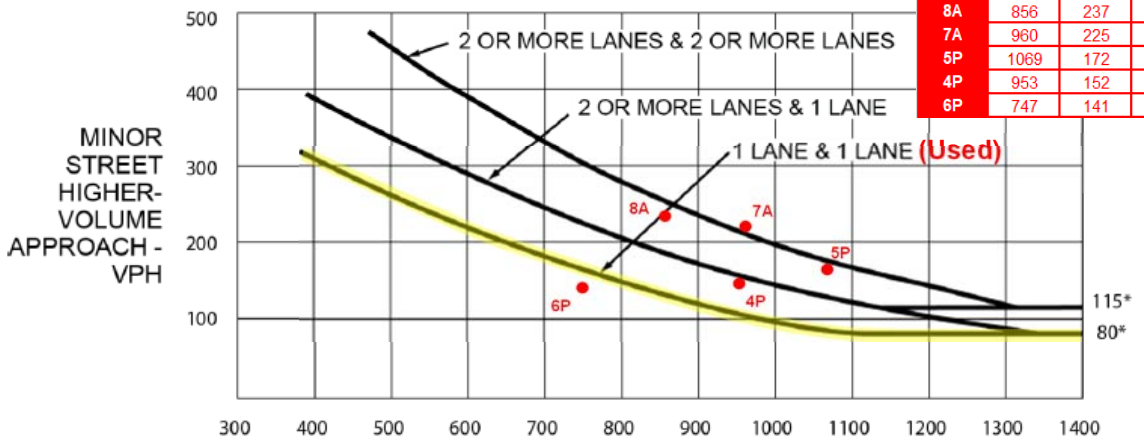
Table 5: OMUTCD Graphical Evaluation, Warrant 2

2012 Edition

Page 497

Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume

Hour	Major	Minor	Met?
8A	856	237	Yes
7A	960	225	Yes
5P	1069	172	Yes
4P	953	152	Yes
6P	747	141	No



*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 for a minor-street approach with one lane.

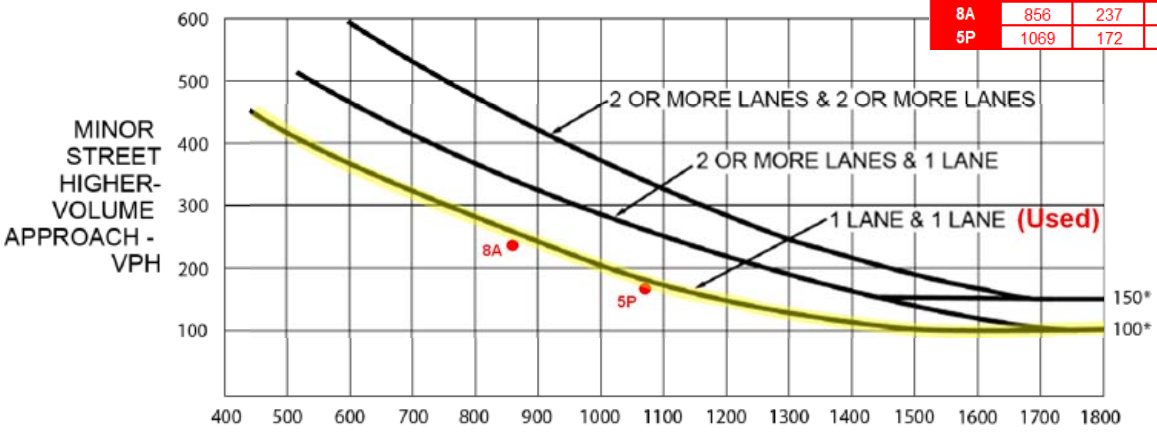
Table 6: OMUTCD Graphical Evaluation, Warrant 3

Page 498

2012 Edition

Figure 4C-3. Warrant 3, Peak Hour

Hour	Major	Minor	Met?
8A	856	237	No
5P	1069	172	No



*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 for a minor-street approach with one lane.

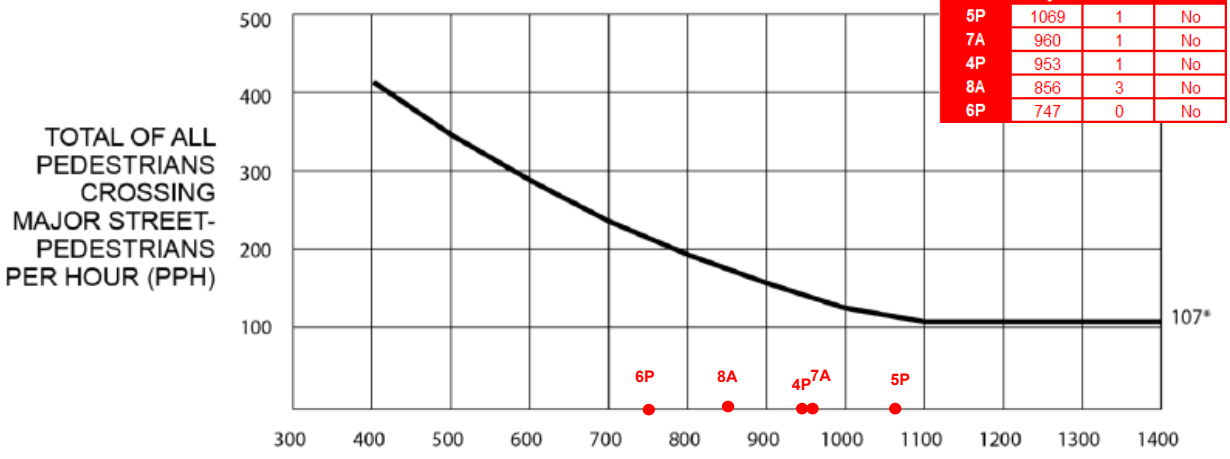
Table 7: OMUTCD Graphical Evaluation, Warrant 4, 4-Hour Volumes

2012 Edition

Page 501

Figure 4C-5. Warrant 4, Pedestrian Four-Hour Volume

Hour	Major	Peds	Met?
5P	1069	1	No
7A	960	1	No
4P	953	1	No
8A	856	3	No
6P	747	0	No



*Note: 107 pph applies as the lower threshold volume.

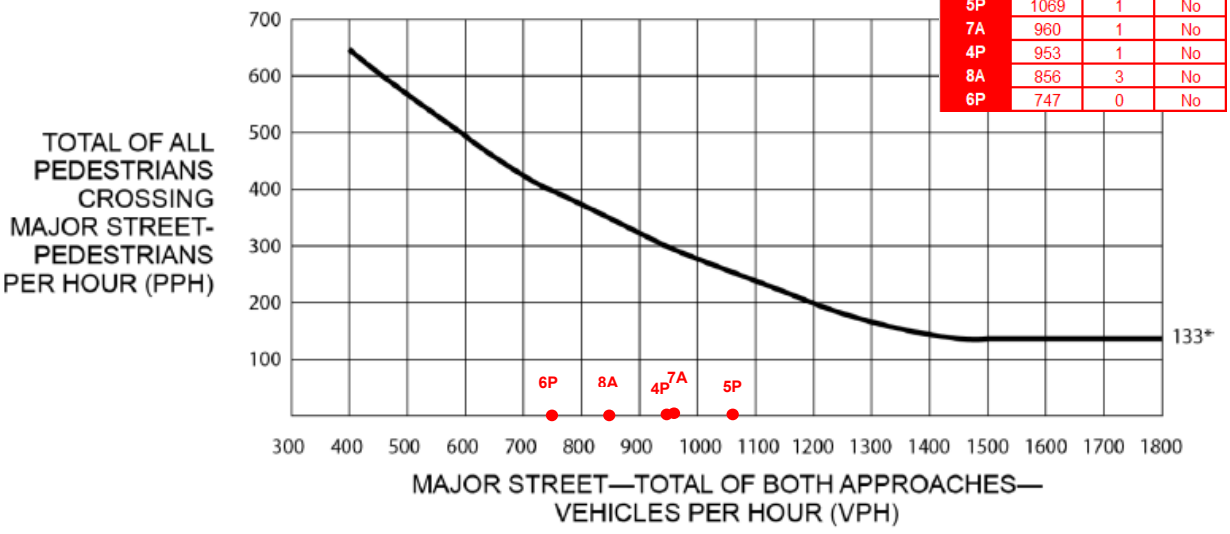
Table 8: OMUTCD Graphical Evaluation, Warrant 4, Peak Hour Volumes

Page 502

2012 Edition

Figure 4C-7. Warrant 4, Pedestrian Peak Hour

Hour	Major	Peds	Met?
5P	1069	1	No
7A	960	1	No
4P	953	1	No
8A	856	3	No
6P	747	0	No



*Note: 133 pph applies as the lower threshold volume.