BOSTON REGION METROPOLITAN PLANNING ORGANIZATION

Stephanie Pollack, MassDOT Secretary and CEO and MPO Chairman
Karl H. Quackenbush, Executive Director, MPO Staff

TECHNICAL MEMORANDUM

DATE: **May 21, 2015**
TO: **Jeffrey Bina, Town Engineer, Westwood**
FROM: **Seth Asante, MPO Staff**
RE: **Safety and Operations Analyses—Westwood**
Selected Intersections: High Street at Nahatan Street and High Street at Pond Street in Westwood

This memorandum summarizes the analyses and improvement strategies for two intersections: High Street at Nahatan Street and High Street at Pond Street in Westwood. The opening sections give a background of the study and describe the existing conditions and problems that concern the community. Following that is an assessment of the safety and operations problems and a discussion of the potential improvement strategies. The final section of the memo presents the study recommendations. The memorandum also includes technical appendices that cite the methods used and data applied in the study, including detailed reports of the intersection capacity analyses.

1 BACKGROUND

In November 2013, the Town of Westwood submitted a list of intersections with safety and congestion issues to the Metropolitan Planning Organization (MPO) (Appendix A[1]). The town wanted the MPO to consider these intersections when selecting various sites for Unified Planning Work Program (UPWP) studies, such as Safety and Operations Analyses at Selected Intersections—Federal Fiscal Year (FFY) 2014. In addition, the Town of Westwood expressed its intention to cooperate with and support the MPO in this planning study, and to implement the recommended improvements where appropriate, and based on the town's ability to fund them. The two intersections discussed here were chosen from the list for study under the Safety and Operations Analyses at Selected Intersections program.

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[1] Appendix A includes a letter from Michael Jaillet, Town Administrator, Westwood to Karl Quackenbush, Executive Director, CTPS, dated November 12, 2013, which supports a study at the two intersections. This appendix also contains a list of task force members, and comments from Westwood and MassDOT—which have been addressed and incorporated in this memorandum.

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The purpose of the Safety and Operations Analyses at Selected Intersections program is to identify problems at intersections in the region's arterial highways that experience many crashes, congestion, or mobility issues for buses, bicyclists, and pedestrians and develop multimodal solutions to address the problems identified. The MPO has been conducting these planning studies for the past ten years, and municipalities in the region are very receptive to them. The studies give towns the opportunity to look at the requirements of a specific location, starting at the conceptual level, before they commit funds for design and engineering. Moreover, if the project qualifies for federal funds, the study's documentation eventually would be useful to the Massachusetts Department of Transportation (MassDOT) as well.

Following a selection process,[2] four locations from a short list of 21 intersections were approved for study by the Boston Region MPO based on a series of criteria including, high crash rate, number of pedestrian and bicycle crashes, transit significance[3], regional significance[4], and implementation potential[5]. The four locations approved for study are:

- Washington Street (Route 53) and Broad Street in Weymouth
- Medway Road (Route109) at Kmart Shopping Plaza in Milford
- High Street (Route 109) at Nahatan Street in Westwood
- High Street (Route 109) and Pond Street in Westwood

The two Westwood locations were selected because of their safety and congestion problems (Figure 1).

1.1 Public Participation

An advisory task force composed of representatives from Westwood was established to participate in this study. MPO staff met with the task force two times: 1) to discuss the work scope and finalize existing conditions and problems, and 2) to present improvement concepts for comment. Working in conjunction with the task force, MPO staff collected data and conducted analyses to identify and quantify existing problems and their proposed improvement strategies. Both the task force and MassDOT Highway Division District 6 staff reviewed the study documents (Appendix A).

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[2] Seth Asante, memorandum to Boston Region MPO, Safety and Operations Analyses at Selected Intersections—FFY 2013, Task 1: Intersection Selection Procedure, December 19, 2013.

[3] Transit Significance: Location carries bus route(s) or is adjacent to a transit stop or station.

[4] Regional Significance: Location carries high proportion of regional traffic or noticeable commuter bicycle traffic.

[5] Implementation Potential: Location either is under MassDOT jurisdiction, has a Transportation Improvement Process (TIP) "conceptual" status, or has a strong commitment from a city or town.

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FIGURE 1
Study Area Map

Safety and Operations Analyses at Selected Intersections–FFY 2014

2 ROADWAY AND INTERSECTIONS

2.1 Roadway

Route 109/High Street

Route 109 is a predominantly two-lane, two-way arterial roadway that passes through eight communities from east to west: Dedham, Westwood, Dover, Walpole, Medfield, Millis, Medway, and Milford. Although Route 109 is a state-numbered route, it is locally controlled. The roadway is part of the National Highway System (NHS) program and is eligible for federal funds provided for the program. It is functionally classified as a principal arterial. In Westwood, the local name for Route 109 is High Street (henceforth, used throughout the memorandum). High Street—near the Nahatan Street intersection between Pond Street and Saint Margaret Mary Church—has 10- to 15-foot wide landscaped-curbed median and two 11-foot wide travel lanes in each direction (Figure 2). There are five- to six-foot continuous and connected sidewalks on both sides. The posted speed limit is 30 miles per hour (mph) on the segment of High Street near Nahatan Street, and 35 mph on the segment near Pond Street (close to the Sheehan School). The right-of-way is approximately 80 feet wide near the intersection of High Street with Nahatan Street.

Nahatan Street

Nahatan Street is a town-owned roadway functionally classified as an urban minor arterial. It is a two-lane, two-way roadway running in a north-south direction, generally with 11-foot wide travel lanes. A five-foot-wide continuous and connected sidewalk with a grass buffer is provided on the west side of Nahatan Street. The sidewalk on the east side of Nahatan Street has gaps; however, crosswalks have been provided at the breakpoints to connect to the sidewalk on the west side for continuity. The right-of-way generally varies between 40 and 50 feet but widens significantly to about 180 feet at the approach to High Street because of the presence of a median, traffic islands, and turn lanes to channel traffic through the intersection (Figure 2). The posted speed limit is 30 mph in both directions, although it is reduced to 20 mph when the Thurston Middle School is in session.

Pond Street

Pond Street is a town-owned roadway, functionally classified as an urban collector. Pond Street is a two-lane, two-way loop that intersects High Street at two locations: 1) about 200 feet west of Nahatan Street, and 2) about 1.1 miles west of Nahatan Street near the Sheehan School. Both intersections were included in this study. The right-of-way is approximately 50 feet wide and the land use is zoned residential.

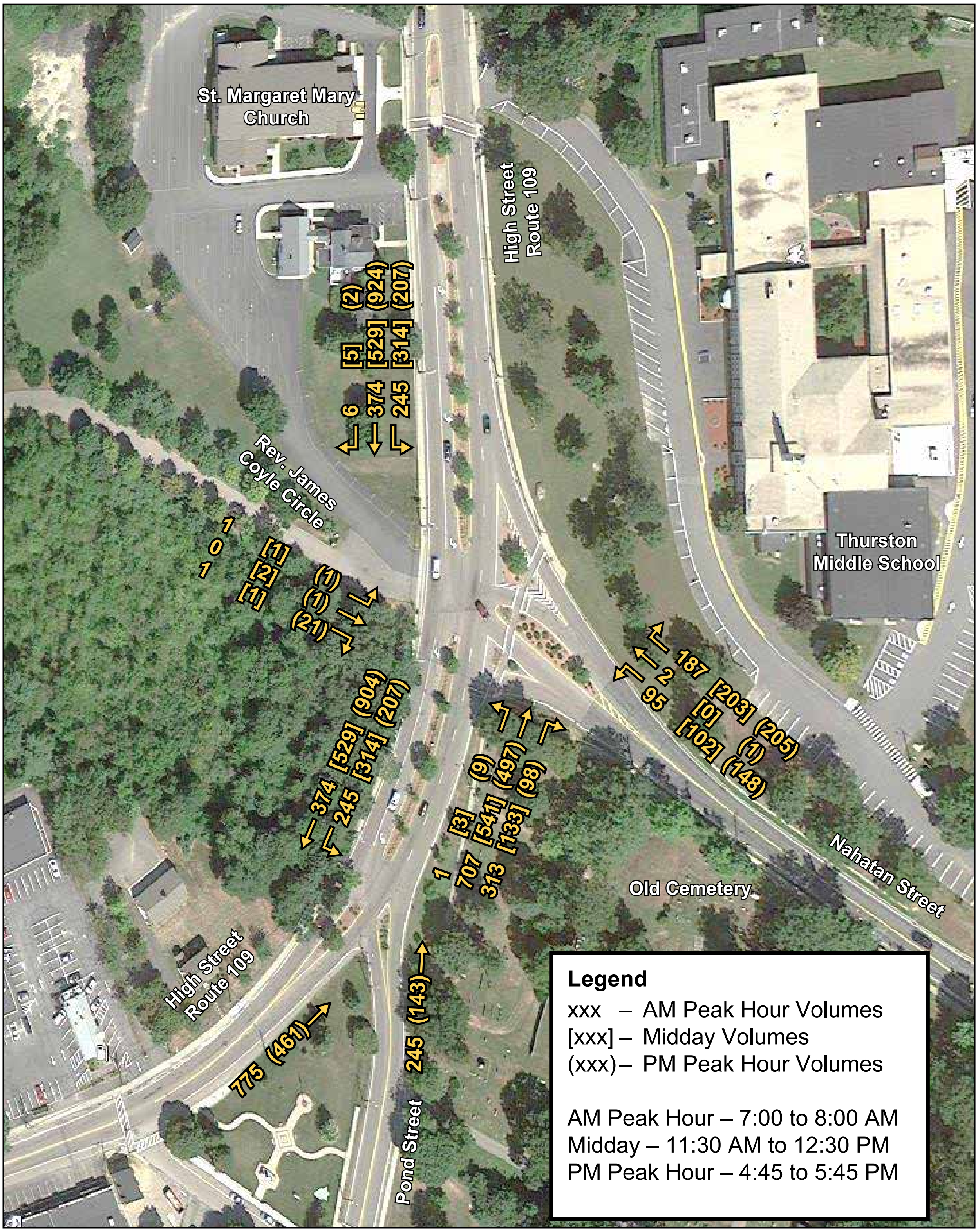

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FIGURE 2
AM, Midday, and PM Peak Hour Traffic Volumes
High Street and Nahatan Street Intersection

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There is a five-foot continuous sidewalk with a grass buffer on one side of Pond Street. There are sidewalks on both sides of Pond Street near High Street, close to the Sheehan School.

The Reverend James W. Coyle Circle

The Reverend James W. Coyle Circle is a two-way driveway and access roadway, providing entry to Westwood New Cemetery and the Saint Margaret Mary Church. The roadway is not functionally classified and generally is used when there is a church or funeral activity.

2.2 Intersections

High Street and Nahatan Street

High Street, Nahatan Street, and Reverend James W. Coyle Circle form a four-legged two-way stop-sign-controlled intersection (Figure 2). The primary traffic flow through the intersection is along High Street. The intersection has multi-lane approaches because of high traffic volume during peak periods. The High Street eastbound approach widens to two lanes approximately 200 feet prior to the intersection and continues as two lanes through the intersection until approximately 300 feet past the intersection, where it merges into a single lane. The High Street westbound approach widens into two travel lanes approximately 250 feet prior to the intersection; the left approach lane is marked for left turns to Nahatan Street. The Nahatan Street northbound approach widens to accommodate two lanes: 1) a shared left/through lane controlled with a stop sign, and 2) an exclusive right-turn lane controlled with a yield sign.

The intersection has traffic islands and medians that channel traffic through the intersection and provide refuge for pedestrians crossing Nahatan Street. Sidewalks are present along all corners of the intersection, but only one crosswalk is provided at the intersection—for crossing Nahatan Street. The existing curb ramps do not meet ADA requirements—they lack detectable warning plates. The land use near the intersection is zoned residential. The Thurston Middle School is located in the northeast corner, the Saint Margaret Mary Church in northwest corner, and the Old Westwood Cemetery in the southeast corner of the intersection. Approximately 200 feet west of the Nahatan Street intersection is Pond Street, which intersects High Street to form a three-legged unsignalized intersection. Because of its close proximity, the Pond Street intersection was evaluated as part of analyzing the Nahatan Street intersection.

Pond Street and High Street (Near Sheehan School)

Pond Street and High Street form a three-legged unsignalized intersection (Figure 3). The primary traffic flow through the intersection is along High Street. The High Street eastbound approach widens to accommodate a free right turn

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FIGURE 3
AM, Midday, and PM Peak Hour Traffic Volumes
High Street and Pond Street Intersection

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onto Pond Street; but, the westbound approach is a single-lane approach. Traffic on Pond Street is controlled with a stop sign and drivers form two lanes at the approach during peak periods—one for turning left and one for turning right—because its approach is approximately 30 feet wide. The geometry of the intersection results in a long crosswalk on Pond Street. Curb ramps are present at the intersection but they lack detectable warning plates and do not meet ADA requirements.

3 VEHICLE, PEDESTRIAN, AND BICYCLE COUNTS

Traffic volume data were collected to assess operational characteristics of the intersections. MPO staff collected turning-movement counts (TMC) at the intersections in April 2014, when schools were in session (Appendix B). The counts were conducted during weekday morning, midday, and evening peak travel periods. All TMCs were conducted from 7:00 to 9:00 AM, 11:00 AM to 2:00 PM, and 3:00 to 6:00 PM. Heavy vehicles, including school buses, and trucks, were counted separately. Pedestrian and bicycle counts were conducted simultaneously with the TMCs.

Based on the counts, the average weekday traffic volume on High Street was approximately 20,200 vehicles per day (VPD) east of Nahatan Street; 9,300 VPD on Nahatan Street near High Street; and 7,400 VPD on Pond Street near the Sheehan School. Figures 2 and 3 show the turning movement volumes at the intersections. At both intersections, the primary High Street traffic flow (peak direction) is eastbound during the AM peak period and westbound on during the PM peak period. In addition, there are high-volume traffic interchanges between High Street and Nahatan Street, and between High Street and Pond Street (near the Sheehan School). The percentage of heavy vehicles observed at the intersections during the AM and PM peak periods, ranged between 3.0% and 5.5%. These rates are not considered particularly high for peak-period traffic conditions. In addition, staff did not detect any roadway geometry—such as turning radii, which would inhibit truck or bus traffic flow.

Table 1 presents the number of pedestrians and bicyclists observed at the two intersections during the eight-hour period when the TMCs were conducted. Students at the Thurston Middle School and neighborhood residents accounted for the majority of pedestrians observed at the intersection of High Street and Nahatan Street. At the High Street and Pond Street intersection, the majority of pedestrians were residents of that neighborhood.

TABLE 1
Number of Pedestrians and Bicyclists at the Study Intersections

Intersection	Pedestrian Count	Bicyclist Count
High Street at Nahatan Street	111	30
High Street at Pond Street (near Sheehan School)	23	23

Source: Central Transportation Planning Staff.

4 SAFETY CONDITIONS

4.1 Crash Summary

A summary of the crashes in terms of severity, manner of collision, ambient light, road surface, and weather conditions—based on 2009-2013 crash reports from the Westwood Police Department—is presented in Table 2. Records show 38 crashes at the High Street and Nahatan Street intersection during the five-year period. At the intersection of High Street and Pond Street (near the Sheehan School), records show nine crashes during the same period. The prevalent types of crashes at both intersections were rear-end and angle collisions. Records show one pedestrian crash at the crosswalk in front of the Saint Margaret Mary Church near the High Street and Nahatan Street intersection.

4.2 Crash Rates

Staff calculated intersection crash rates per the MassDOT Highway Division methodology, for the entire five-year period. The most recent statewide average crash rate for unsignalized intersections—based on MassDOT crash information queried on January 23, 2013—is 0.60 crashes per million entering vehicles (MEV). For MassDOT Highway Division District 6 (which includes the Town of Westwood), the average crash rate is 0.58 per MEV for unsignalized intersections. Analyses indicate that the average crash rate of 0.92 MEV for the High Street and Nahatan Street intersection exceeds the District 6 average crash rate for unsignalized intersections. The average crash rate of 0.26 MEV for the High Street and Pond Street intersection was below the District 6 average crash rate for unsignalized intersections. See Appendix C for crash rate work sheets.

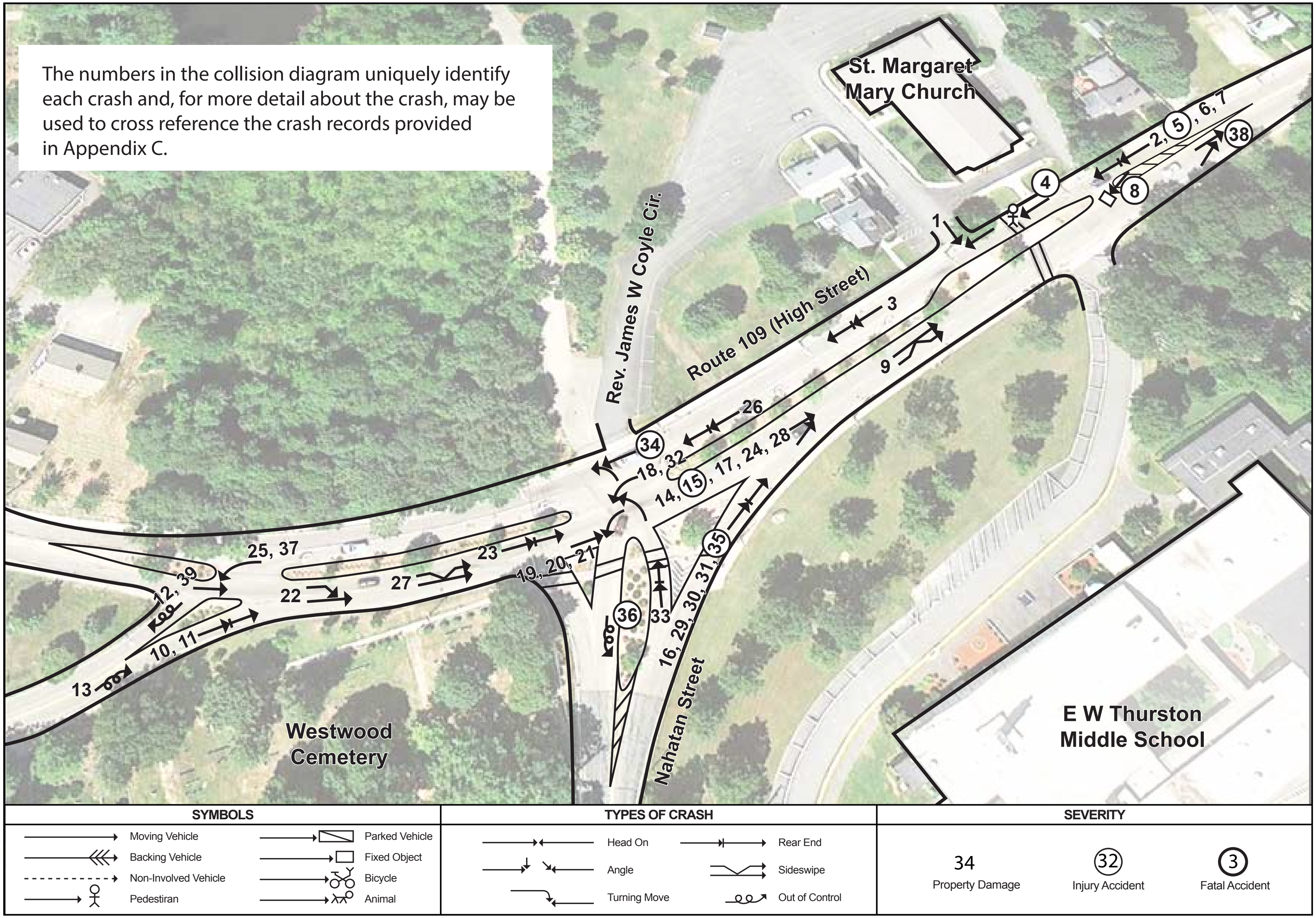
4.3 Collision Diagram

MPO staff used police crash reports to prepare collision diagrams, which are useful for examining patterns and developing safety strategies (see Figures 4 and 5 below). The numbers in the collision diagram uniquely identify each crash and, for more detail about the crash, may be used to cross reference the crash records provided in Appendix C.

TABLE 2
Crash Summary (2009-2013)

Crash Variable	High Street and Nahatan Street and Pond Street Intersection	High Street and Pond Street Intersection (near Sheehan School)
Crash Severity	--	--
Non-fatal injury	9	0
Property damage only	29	9
Manner of Collision	--	--
Angle	9	8
Rear-end	16	0
Sideswipe, same direction	7	0
Single vehicle crash	6	1
Road Surface Condition	--	--
Dry	27	8
Wet	8	1
Snow	3	0
Ambient Light Conditions	--	--
Daylight	27	7
Dark – lighted roadway	11	2
Weather Conditions	--	--
Clear	25	5
Cloudy	4	3
Rain	6	1
Snow	3	0
Travel Period	--	--
Peak-period	13	5
Off-peak	25	4
Total crashes	38	9
Five-year average (rounded)	8	2
Average crash rate	0.92	0.26
MassDOT Highway Division District 6 Crash Rate for unsignalized intersection	0.58	0.58

* The AM peak period is 7:00 AM to 9:00 AM, and the PM peak period is 4:00 PM to 6:00 PM.
Source: Central Transportation Planning Staff.



The numbers in the collision diagram uniquely identify each crash and, for more detail about the crash, may be used to cross reference the crash records provided in Appendix C.

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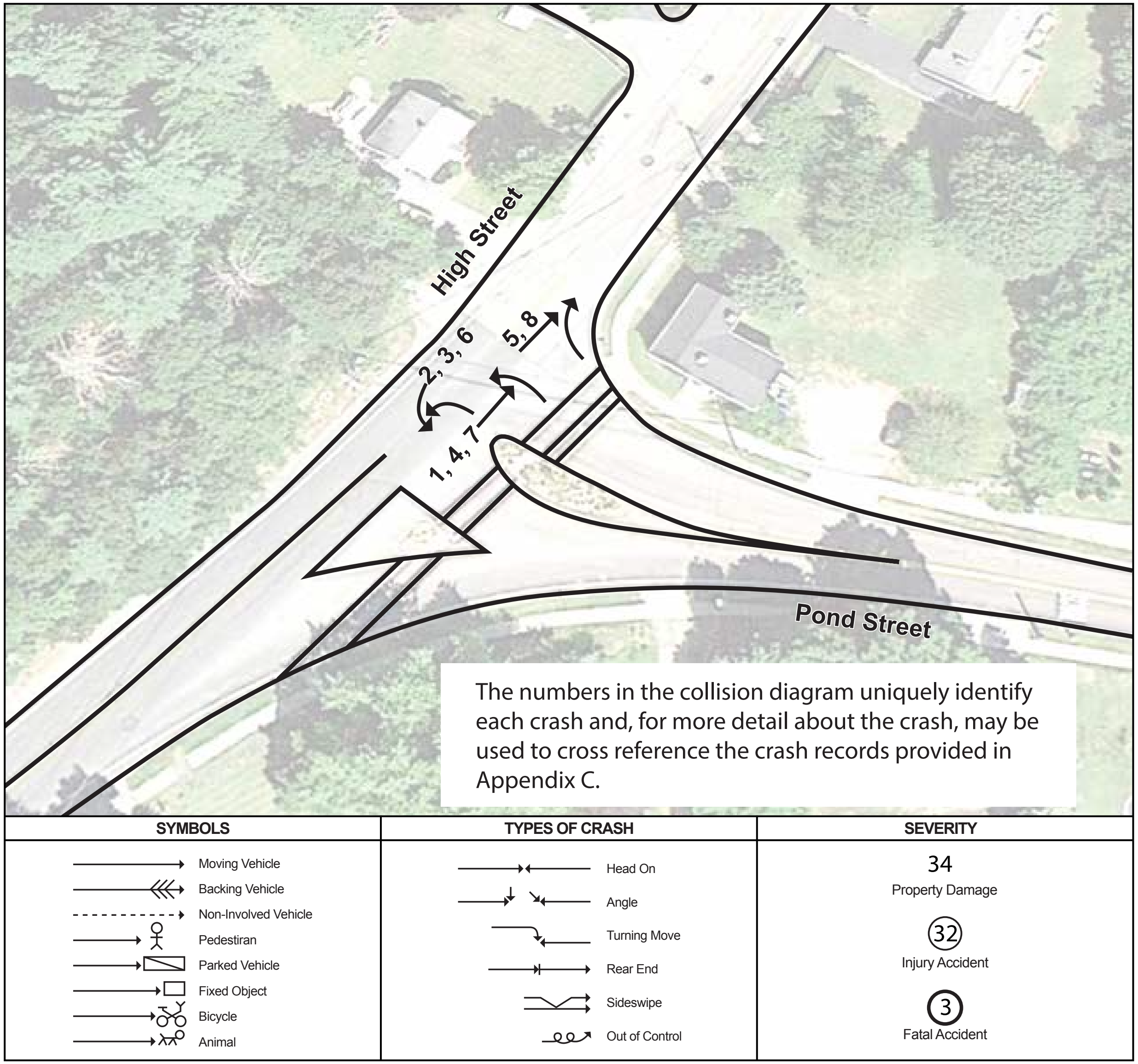
FIGURE 4
Collision Diagram for High Street and Nahatan Street Intersection (2009–2013)

Safety and Operations Analyses at Selected Intersections–FFY 2014



The numbers in the collision diagram uniquely identify each crash and, for more detail about the crash, may be used to cross reference the crash records provided in Appendix C.

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FIGURE 5
Collision Diagram for High Street and Pond Street Intersection (2009–2013)

Safety and Operations Analyses at Selected Intersections–FFY 2014

As seen in Figures 4 and 5 above, the prevalent crash patterns are:

- Angle type crashes involving High Street eastbound through movement and Nahatan Street right-turn movement (at merge point of the two movements (Figure 4)
- Rear-end type crashes involving Nahatan Street right-turn movement, near yield sign and crosswalk location (Figure 4)
- Angle type crashes involving High Street westbound left-turn movement and High Street eastbound through movement (Figure 4)
- Rear-end type crashes involving High Street westbound through movement near crosswalk connecting Thurston Middle School and Saint Margaret Mary Church (Figure 4)
- Angle type crashes involving Pond Street traffic entering High Street (Figure 5)

5 EXISTING TRAFFIC OPERATIONS CONDITIONS

Staff conducted traffic operations analyses consistent with the Highway Capacity Manual (HCM) methodologies (included in Appendix D)[6]. HCM methodology demonstrates driving conditions at signalized and unsignalized intersections in terms of level of service (LOS) ratings from A through F. LOS A represents the best operating conditions (little to no delay), while LOS F represents the worst operating conditions (very long delay). LOS E represents operating conditions at capacity (limit of acceptable delay). Table 3 presents the control delays associated with each LOS for unsignalized and signalized intersections. . Using the data collected, MPO staff built traffic analysis networks for the AM and PM peak hours with Synchro[7] to assess the capacity and quality of traffic flow through the intersections.

TABLE 3
Intersection Levels of Service Criteria

Level of Service	**Signalized Intersections Control Delay (seconds per vehicle)**	**Unsignalized Intersections Control Delay (seconds per vehicle)**
A	0-10	0-10
B	> 10-20	> 10-15
C	> 20-35	> 15-25
D	> 35-55	> 25-35
E	> 55-80	> 35-50
F	> 80	> 50

Source: Highway Capacity Manual 2010.

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[6] Highway Capacity Manual 2010, Transportation Research Board of the National Academies, Washington, DC, December 2010.

[7] Trafficware Inc., Synchro Studio 8, Synchro plus SimTraffic, Build 801, Version 563, Sugar Land, Texas.

Results of the peak-hour intersection capacity analyses (Table 4) indicate that traffic volumes on High Street are so large that drivers on Nahatan Street do not get adequate gaps to enter the intersection during peak hours—left-turn movements from Nahatan Street onto High Street operate at LOS F during peak hours. Staff observed similar traffic operations problems the High Street and Pond Street intersection during peak periods. Drivers turning left from Pond Street onto High Street experience much delay and operate at LOS F during peak hours—the 95th-percentile queue length range is 12-to-16 car lengths.

TABLE 4
Existing (2014) Peak-Hour Level of Service

Intersection / Approach	Movement	AM LOS	AM Delay	AM Queue*	PM LOS	PM Delay	PM Queue
High Street at Nahatan Street	--	--	--	--	--	--	--
High St Eastbound	L+T+R	A	0	0	A	0	0
High St Westbound	L	B	11.7	50	A	9.4	25
High St Westbound	T+R	A	0	0	A	0	0
Rev. James Coyle Circle	L+T+R	D	32.4	25	D	30.6	25
Nahatan St Northbound	L+T	F	97.5	150	F	92.8	150
Nahatan St Northbound	R	B	14.5	50	B	11.1	25
High Street at Pond Street (near Nahatan Street)	--	--	--	--	--	--	--
High St Eastbound	T	A	0	0	A	0	0
High St Westbound	L	B	10.3	20	A	9.6	50
High St Westbound	T	A	0	0	A	0	0
Pond St Northbound	R	E	35.5	125	B	13.5	50
High Street at Pond Street (near Sheehan School)	--	--	--	--	--	--	--
High St Eastbound	T+R	A	0	0	A	0	0
High St Westbound	L+T	A	0.6	0	A	0.5	0
Pond St Northbound	L	F	114.5	225	F	152.9	350
Pond St Northbound	T+R	B	14.4	25	A	9.8	5

[a] Delay in seconds per vehicle. [b] 95th percentile queue length in feet. # = the 95th-percentile volume exceeds capacity.
Source: Central Transportation Planning Staff.

6 TRAFFIC SIGNAL WARRANT ANALYSIS

Traffic control signals are valuable devices for controlling vehicular and pedestrian traffic. They assign the right-of-way to various traffic movements and thereby strongly influence traffic flow. Traffic control signals that are properly designed, located, operated, and maintained will provide orderly movement of traffic, and reduce congestion and the frequency and severity of certain types of crashes, especially right-angle collisions. Traffic control signals are not solutions to all traffic problems at intersections. Poorly designed and maintained, ineffectively placed, improperly operated, or unjustified traffic control signals can result in excessive delays, significant increase in crashes (especially rear-end type), and diversion of traffic to less adequate routes, as road users attempt to avoid the traffic control signals. Investigating the need for a traffic control signal at an unsignalized intersection includes analyzing factors related to the existing operations and safety, as well as the potential to improve these conditions. Such an investigation is called traffic signal warrant analysis.

Using the methodology in the 2009 edition of Manual on Uniform Traffic and Control Devices[8] (MUTCD), staff performed detailed traffic signal warrant analyses to determine whether installation of traffic control signals at the intersections is justified and if they would improve safety and traffic operations. The MUTCD lists nine traffic signal warrants that justify installing a traffic signal at a study location:

- 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

Table 5 presents the results of the signal warrant analysis; detailed traffic signal warrant analysis worksheets are included in Appendix D. Existing conditions at High Street and Nahatan Street satisfy five of the warrants. Existing conditions at

TABLE 5
Results of Traffic Signal Warrant Analysis

Warrant	High Street and Nahatan Street Intersection	High Street and Pond Street Intersection
Warrant 1, Eight-Hour Vehicular Volume	Satisfied	Not satisfied
Warrant 2, Four-Hour Vehicular Volume	Satisfied	Satisfied
Warrant 3, Peak Hour	Satisfied	Satisfied
Warrant 4, Pedestrian Volume	Not satisfied	Not satisfied
Warrant 5, School Crossing	Not satisfied	Not satisfied
Warrant 6, Coordinated Signal System	Not satisfied	Not satisfied
Warrant 7, Crash Experience	Satisfied	Not satisfied
Warrant 8, Roadway Network	Satisfied	Satisfied
Warrant 9, Intersection Near a Grade Crossing	Not satisfied	Not satisfied

Source: Central Transportation Planning Staff.

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[8] US Department of Transportation, Federal Highway Administration, Manual on Uniform Traffic Control Devices for State Streets and Highways, 2009 Edition.

High Street and Pond Street satisfy three of the warrants. The MUTCD states that satisfying traffic signal warrants alone does not require installing a traffic control signal. The intersection of High Street and Pond Street did not satisfy the major warrants, Warrants 1 and 7. Warrant 1 is for locations with a large amount of intersecting traffic or where traffic on a major street is so heavy that, as a result, traffic on a minor intersecting street suffers excessive delay. Warrant 7 is for locations with frequent and severe crashes.

7 FUTURE CONDITIONS

To forecast systematically future traffic volume based on changes in the transportation network or land use, planners generally employ a planning model. For this study, staff utilized the Boston Region MPO's "regional travel demand model set" most recently adopted for its Long-Range Transportation Plan (LRTP). This model's socioeconomic components are derived from forecasts produced by the Metropolitan Area Planning Council (MAPC). The model is calibrated at a regional level for 164 cities and towns, which includes all of the 101 cities and towns in the MPO region. For site-specific development and transportation projects, the model needs to be calibrated to replicate local travel patterns in the project area before it may be used to forecast the project's future impacts. Using this model, staff projected that traffic on High Street would grow 0.3% per year, resulting in 3% total growth between 2014 and 2024.

8 IMPROVEMENTS

MPO staff developed and analyzed short- and long-term improvements to address the problems. Staff used the projected growth factors from the regional model set to expand existing peak-hour turning-movement volumes, which were used to test the improvement strategies. The results are included in Appendix D.

8.1 High Street and Nahatan Street Intersection

The concerns at the intersections are:

- Safety of pedestrians crossing at the intersection
- Drivers turning right from Nahatan Street onto High Street drive at high speeds because of a wide curb radius; are involved in many angle and rear-end crashes
- Limited sight distance for drivers turning right from Nahatan Street and merging onto High Street
- Merging and weaving traffic at the High Street eastbound approach

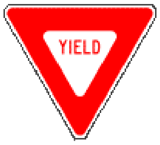
Below are the improvement strategies that staff evaluated for the intersection:

- **Alternative 1:** Replace the yield sign with a stop sign (short-term)
- **Alternative 2:** Install a pedestrian flashing beacon for crossing High Street at Saint Margaret Mary Church (short-term)
- **Alternative 3:** Reconfigure High Street eastbound approach lanes; tighten approach curb radius for Nahatan Street right-turn lane; add a stop sign (medium-term)
- **Alternative 4:** Tighten approach curb radius for Nahatan Street right-turn lane; add a stop sign (medium-term)
- **Alternative 5:** Install new traffic signal (long-term)
- **Alternative 6:** Construct a modern roundabout (long-term)

Short-Term Improvements

Alternative 1: Replace the yield sign (R1-2) on Nahatan Street with a stop sign (R1-1) and provide clear markings

The objective of Alternative 1 is to allow drivers to stop and look for adequate gaps to enter High Street. This strategy may be enhanced with targeted enforcement to reduce stop violations and supplementary pavement markings.



R1-2
Yield sign

R1-1
Stop sign

Source: MUTCD 2009 edition

The improvement would:

- Reduce angle crashes involving Nahatan Street right-turn movements and High Street eastbound through traffic movements
- Reduce rear-end crashes involving Nahatan Street right-turn movements

The improvement would not reduce traffic delays for Nahatan Street left-turn movements (Table 6).

The Federal Highway Administration[9] estimates converting yield-sign control to stop-sign control could reduce related crashes between 9-and-29 percent. The cost of implementing these improvements, including signs and pavement markings, would cost less than $5,000.

Alternative 2: Install a Pedestrian-Activated Flashing Beacon for the Crossing on High Street at Saint Margaret Mary Church

MPO staff proposes that a pedestrian-activated flashing beacon be installed for the marked crossing on High Street in front of Saint Margaret Mary Church and Thurston Middle School to give advance warning to drivers or pedestrians

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[9] Crash Modification Factors Clearinghouse, US Department of Transportation Federal Highway Administration.

TABLE 6
High Street and Nahatan Street Intersection Future Year (2024) Peak-Hour Level of Service

Improvement Alternative	Movement	AM LOS	AM Delay[a]	AM Queue[b]	PM LOS	PM Delay	PM Queue
Alternative 1: Stop Control	--	--	--	--	--	--	--
High St Eastbound	L+T+R	A	0	0	A	0	0
High St Westbound	L	B	12.2	50	A	9.6	25
High St Westbound	T+R	A	0	0	A	0	0
Rev. James Coyle Circle	L+T+R	E	40.2	25	D	32.6	25
Nahatan St Northbound	L+T	F	123	175	F	>180	300
Nahatan St Northbound	R	C	15.1	50	B	12.3	25
Total intersection	**All**	**B**	**11.2**	**--**	**E**	**41.4**	**--**
Alternative 3: Reconfigure Lanes and Tighten Curb Radius	--	--	--	--	--	--	--
High St Eastbound	L+T	A	0	0	A	0	0
High St Eastbound	R	A	0	0	A	0	0
High St Westbound	L	B	11.9	50	A	9.8	25
High St Westbound	T+R	A	0	0	A	0	0
Rev. James Coyle Circle	L+T+R	E	37.9	25	D	34.9	25
Nahatan St Northbound	L+T	F	106.1	125	F	>180	300
Nahatan St Northbound	R	A	0	75	A	A	0
Total Intersection	**All**	**A**	**7.7**	**--**	**E**	**46.1**	**--**
Alternative 4: Tighten Approach Curb Radius for Nahatan Street	--	--	--	--	--	--	--
High St Eastbound	L+T+R	A	0	0	A	0	0
High St Westbound	L	B	12.2	50	A	9.6	25
High St Westbound	T+R	A	0	0	A	0	0
Rev. James Coyle Circle	L+T+R	E	40.2	25	D	32.6	25
Nahatan St Northbound	L+T	F	123	175	F	>180	300
Nahatan St Northbound	R	C	15.1	50	B	12.3	25
Total Intersection	**All**	**B**	**11.2**	**--**	**E**	**41.4**	**--**
Alternative 5: Traffic Signal	--	--	--	--	--	--	--
High St Eastbound	L+T+R	C	21.6	#536	B	18.8	227
High St Westbound	L	C	32.2	#308	B	12.6	124
High St Westbound	T+R	A	8.3	251	C	26.9	#933
Rev. James Coyle Cir	L+T+R	C	27	12	C	26.6	12
Nahatan St Northbound	L+T	D	43.4	130	D	43	#191
Nahatan St Northbound	R	C	22.2	114	C	16.4	98
Total Intersection	**All**	**C**	**21.5**	**--**	**C**	**23.3**	**--**
Alternative 6: Roundabout	--	--	--	--	--	--	--
High St Eastbound	L+T	E	45.1	0	D	29.7	215
High St Eastbound	R	A	0		A	0	0
High St Westbound	L+T+R	A	7.6	0	C	15.9	150
Rev. James Coyle Cir	L+T+R	A	7.7	25	B	14.2	25
Nahatan St Northbound	L+T	C	16.2	130	A	9.4	25
Nahatan St Northbound	R	A	0	50	A	0	25
Total Intersection	**All**	**C**	**19.8**	**--**	**C**	**16.5**	**--**

[a] Delay in seconds per vehicle. [b] 95th percentile queue length in feet. # = the 95th percentile volume exceeds capacity.
Source: Central Transportation Planning Staff.

crossing High Street. During 2009-2013, there was one pedestrian-vehicle collision in the crosswalk and four rear-end crashes near crosswalk. According to the MUTCD, warning beacons that are actuated by pedestrians, bicyclists, or other road users may be used to provide additional warning to vehicles approaching a crossing. Pedestrian flashing beacons should be accompanied by pedestrian warning sign W11-2 or school crossing sign S1-1 and W16-7p.

S1-1
School crossing

W11-2
Pedestrian warning sign

Source: MUTCD 2009 edition

Research indicates that going from a no-beacon to a beacon system—mounted on supplementary warning signs on the right and left sides of the crossing—increased the driver-yielding rate from 18 percent to 88 percent.[10] Pedestrian flashing beacons can use manual push buttons or automated passive (i.e., video or infrared) pedestrian detection, and should be unlit when not activated. Pedestrian flashing beacons typically receive power from standalone solar panels, but also may be wired to traditional power sources. It would cost between $15,000 and $20,000 to purchase and install two units (one on either side of a street). This includes solar panels, pad lighting, indication units, signage, all posts, and either passive infrared detection, or push buttons with audio instructions. MPO staff recommends a flashing-beacon strategy as part of the short- and long-term alternatives.

Medium-Term Improvements

Alternative 3: Reconfigure High Street Eastbound Approach Lanes and Tighten Curb Radius for Nahatan Street Right-Turn Lane

This alternative suggests reconfiguring lane assignment at the eastbound approach of High Street into one through lane and one right-turn-only lane, and tightening the curb line radius of Nahatan Street to allow right-turn movements to approach High Street more perpendicularly (Figure 6). The angle of the right-turn channelized lane should be no less than 70 degrees. This improvement would:

- Increase sight lines and distances, thus improving safety
- Reduce speeds of vehicles turning right on High Street
- Make traffic operations more efficient and allow right turns from Nahatan Street to enter High Street without merging at the entry point

Alternative 3 would not reduce traffic delay for Nahatan Street left-turn movement (Table 6 above).

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[10] Sherbutt, J., R. Van Houten, and S. Turner. "An Analysis of the Effects of Stutter Flash LED Beacons to Increase Yielding to Pedestrians Using Multilane Crosswalks." Presented at the Transportation Research Board Annual Meeting, Washington, DC, 2008.

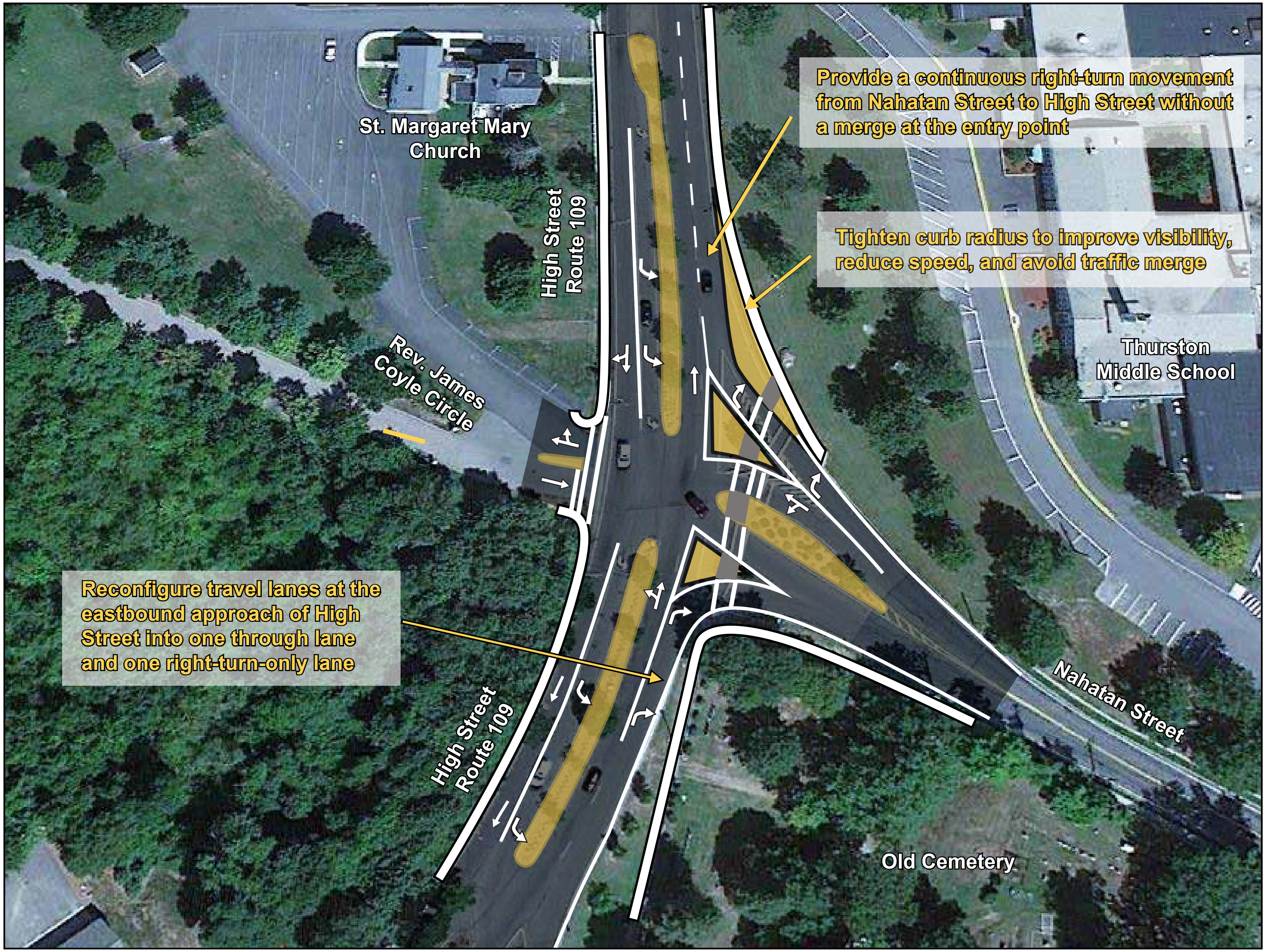

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FIGURE 6
Medium-Term Improvement: Alternative 3
Reconfigure High Street Eastbound Approach Lanes

Safety and Operations Analyses at Selected Intersections–FFY 2014

This lane reconfiguration would reduce crashes by approximately 22 percent.[11] Further, providing full sight distance where it currently does not occur would reduce related crashes by approximately 20-to-37 percent.[12] It would cost between $30,000 and $50,000 to implement these modifications, including curbing, restriping, and signing.

Alternative 4: Tighten Curb Radius for Nahatan Street Right-Turn Lane

Alternative 4 is a variation of Alternative 3; it excludes reconfiguring High Street's eastbound approach lanes (Figure 7). Alternative 4 would tighten the Nahatan Street approach curb line radius in order to allow right-turn movement to approach High Street more perpendicularly, which would improve sight lines and distances and reduce speeds. In addition, it would add a stop-sign control for that movement. As in Alternative 3, the angle of the right-turn channelized lane should be no less than 70 degrees. This strategy is more costly than replacing a yield sign with a stop sign only (Alternative 1), but it is a more effective strategy for reducing crashes at a location with poor sight distance and a persistent crash pattern that cannot be improved with less expensive methods.

As in Alternative 3, providing full sight distance where it currently does not occur would reduce related crashes by approximately 20-to-37 percent.[13] Table 6 (above) shows the results of the 2024 future year LOS analysis—Alternative 4 would not reduce traffic delays for Nahatan Street left-turn movement. It would cost between $30,000 and $50,000 to construct these improvements.

Long-Term Improvements

Alternative 5: Install New Traffic Signal

Installing a new traffic signal at the intersection would provide right-of-way assignment for traffic on Nahatan Street to enter High Street, reducing the large number of angle and rear-end crashes (Figure 8). Traffic signal warrant analysis shows that the intersection meets five of the nine warrants and justifies installing a traffic signal control (see Section 6). At present, the conduits, wiring, and interconnections for the traffic signal have been installed. In addition to the signalization, MPO staff recommends tightening the Nahatan Street approach curb-line radius in order to allow the right-turn movement to approach High Street more perpendicularly.

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[11] Crash Modification Factors Clearinghouse, US Department of Transportation Federal Highway Administration, website, http://www.cmfclearinghouse.org/, December 17, 2014.

[12] Ibid.

[13] Ibid

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FIGURE 7
Medium-Term Improvement: Alternative 4
Tighten Curb Radius for Nahatan Street Right-Turn Lane

Safety and Operations Analyses at Selected Intersections–FFY 2014

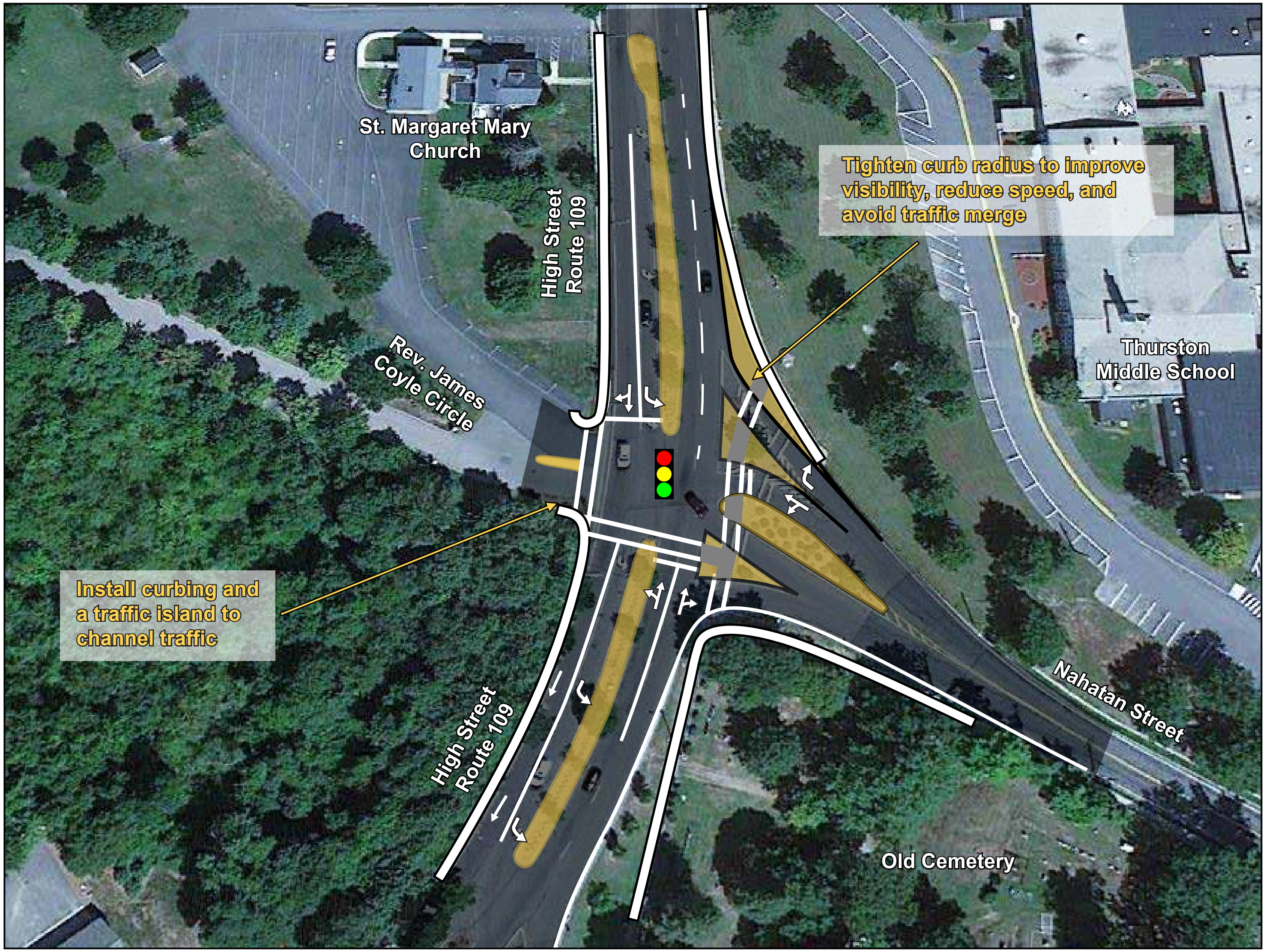

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FIGURE 8
Long-Term Improvement
Alternative 5: Signalize Intersection

Safety and Operations Analyses at Selected Intersections–FFY 2014

Converting a two-way stop-sign control to a traffic-signal control could result in a 28-to-56 percent reduction in crashes.[14] Table 6 shows the results of the 2024 future year LOS analysis, which indicate that a traffic signal would improve overall traffic operations and reduce delays and queues at the intersection. Installing a traffic signal at the intersection would cost approximately $1.5 million.

Alternative 6: Construct a Modern Roundabout

The design features of modern roundabouts encourage slower speeds, so are proven strategies for reducing severe-injury crashes. In addition, the yield-on-entry rule and one-way circulating flow of roundabouts reduce the number of conflict points and cut down on angle crashes significantly. Because of the safety and operational benefits of modern roundabouts, their appeal has risen throughout the Commonwealth in the past decade.[15]

Figure 9 shows the roundabout alternative and how it streamlines traffic circulation. The roundabout proposal includes the following features:

- A 120-foot inscribed circle diameter
- A 60-foot central-island diameter that incorporates a nine-foot mountable apron for use by trucks and emergency vehicles
- A 16- foot circulatory lane
- A two-lane entry for westbound High Street movements
- Slip lanes for Nahatan Street and High Street northbound right turns
- Additional crosswalks
- A rectangular rapid flashing beacon (RRFB) for the crosswalk across Nahatan Street

Converting a two-way stop control to a roundabout could reduce crashes by approximately 44-to-77 percent.[16] Staff used Sidra intersection roundabout analysis software to analyze the roundabout alternative.[17] Table 6 (above) shows the results of the 2024 future year analysis, which indicates that a roundabout would improve overall traffic operations and reduce delays and queues. Converting the intersection to a roundabout would cost approximately $1.5-to-$2.0 million.

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[14] Crash Modification Factors Clearinghouse, US Department of Transportation Federal Highway Administration, website, http://www.cmfclearinghouse.org/, December 17, 2014

[15] In this document, the word roundabout refers to modern roundabouts that have a smaller central island and tighter deflection angle to slow down vehicles entering the roundabout and in the circulatory lane(s) to speeds between 20 and 25 mph.

[16] Crash Modification Factors Clearinghouse, US Department of Transportation Federal Highway Administration.

[17] Sidra Intersection 6, Akcelik and Associates Pty Limited, Greythorn, Victoria, Australia.

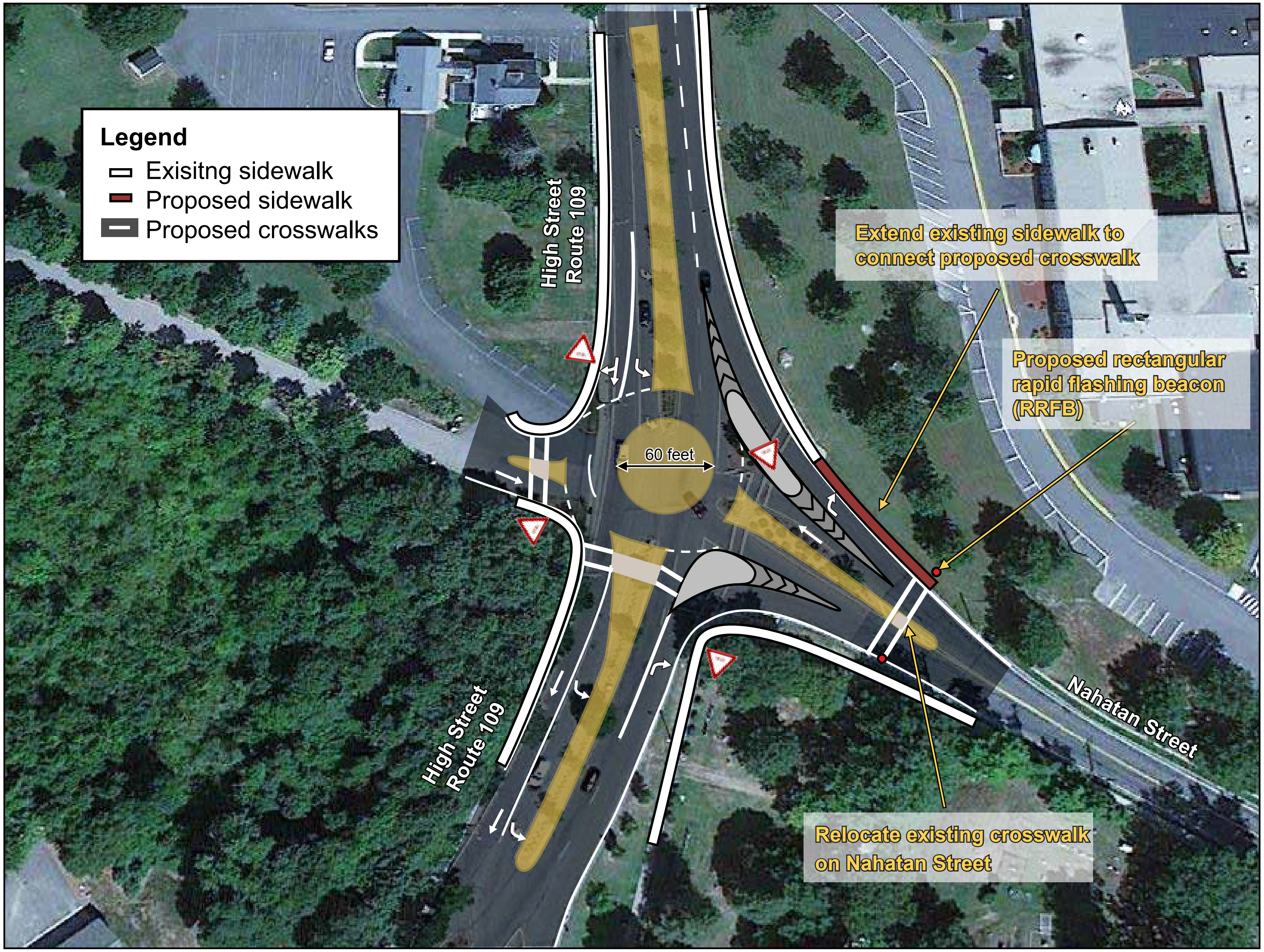

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FIGURE 9
Long-Term Improvement
Alternative 6: Install a Roundabout

Safety and Operations
Analyses at Selected
Intersections–FFY 2014

In order for a roundabout to function well, it is important to prevent traffic queues from spreading into it, causing gridlock. The recurring traffic queue eastbound on High Street, which currently extends from the Hartford Avenue intersection into the Nahatan Street intersection, would prevent a roundabout from functioning well during peak periods.

8.2 High Street and Pond Street (near Sheehan School)

The concerns at the intersections are:

- Safety of pedestrians crossing at the intersection
- High speed of drivers turning right from High Street onto Pond Street drive because of a wide curb line radius
- All crashes at the intersection involve a driver attempting to enter High Street from Pond Street
- Traffic on Pond Street experiences long delays during peak periods

MPO staff developed and analyzed three short- and long-term alternatives for addressing safety and traffic operations at the intersection.

Short-Term Improvements

Alternative 1: Improve Sight Distance, Visibility, and Awareness of Intersection

Because vehicle-pedestrian conflicts are a significant problem in the channelized right-turn lane, it might be appropriate to provide signing to remind drivers of their legal obligation to yield to pedestrians crossing in the marked crosswalk. Advance street name (D3-2) signs identify an upcoming intersection and may be installed in advance of an unsignalized intersection. In addition, intersection warning signs for side roads, T-symbols (W2-2) and advance street name plaques (W16-8P) may be used where engineering judgment indicates a need to inform the road user in advance of an intersection.

Improved driver awareness and sight distance—as viewed from the Pond Street approach—such as flashing light-emitting diode (LED) stop signs and clearing some of the vegetation would reduce the number of right angle crashes. Increasing the triangle sight distance would reduce property-damage-only crashes by as much as 11 percent.[18]

D3-2
Advance street name sign

W2-2
Intersection warning sign

W16-8P
Advance street name plaque

Source: MUTCD 2009 edition

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[18] Crash Modification Factors Clearinghouse, US Department of Transportation Federal Highway Administration.

Replacing standard stop signs with flashing LED stop signs would reduce angle-type crashes by as much as 41 percent. These improvements would cost approximately $5,000.

LED stop sign

Source: safety.fhwa.dot.gov

Alternative 2: Tighten Curb Radius for High Street Eastbound Right Turns

This alternative would increase safety by:

- Forcing drivers turning right onto Pond Street to reduce their speeds
- Reducing crossing distance for pedestrians
- Improving sight distance at the intersection, especially for drivers turning right onto Pond Street, and Pond Street drivers turning left onto High Street
- Improving awareness of the intersection by bringing all turn movements to the intersection

The proposed improvement, shown in Figure 10, would reduce vehicle-pedestrian conflicts, which are a significant problem in the channelized right-turn lane, receiving many complaints from neighborhood residents. Supplementary signing on High Street (recommended in Alternative 1) to increase driver awareness would enhance this improvement’s effectiveness. The 2024 future LOS analysis shows that the improvements would not affect the capacity of the right-turn movement (Table 7). Tightening the curb line radius and improving signage at the intersection would cost approximately $30,000.

Long-Term Improvements

Alternative 3: Install New Traffic Signal

Installing a new traffic signal—“walk-and-don’t-walk” times for pedestrians and “green times” for traffic on High Street and Pond Street—would increase safety and reduce peak-period traffic delays. Traffic signal warrant analysis shows that the intersection meets three of the nine warrants and justifies installing a traffic signal control (see Section 6). Figure 11 shows the intersection layout for the proposed traffic signal, including tightening the curb line radius for High Street eastbound right-turn movements. Additional improvements include providing a crosswalk across High Street and pedestrian signals with pushbuttons and countdown timers.

Table 7 presents results of the 2024 future year LOS analysis, which indicate that installing a traffic signal would improve overall traffic operations. Converting a two-way stop control to a traffic signal would reduce total crashes by about 28-to-56 percent.[19] These improvements would cost approximately $1.5 million.

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[19] Ibid.

Tighten curb radius on High Street eastbound right-turn movements to reduce speed and shorten crossing distance

Extend sidewalks to new curb line

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FIGURE 10
Medium-Term Improvement: Alternative 2
Tighten Curb Radius for High Street Eastbound Right Turns

Safety and Operations Analyses at Selected Intersections–FFY 2014

TABLE 7
High Street and Pond Street Intersection (Near Sheehan School)
Future Year (2024) Peak-Hour Level of Service

Intersection/Approach	Movement	AM LOS	AM Delay[a]	AM Queue[b]	PM LOS	PM Delay	PM LOS
2014 Existing Conditions	--	--	--	--	--	--	--
High St Eastbound	T+R	A	0	0	A	0	0
High St Westbound	L+T	A	0	0	A	0	0
Pond St Northbound	L	F	114.5	225	F	152.9	350
Pond St Northbound	T+R	B	14.4	25	A	9.8	5
Total Intersection	**All**	**C**	**17.8**	**--**	**D**	**28.6**	**--**
2024 Alternative 2: Reduce Curb Line	--	--	--	--	--	--	--
High St Eastbound	T+R	A	0	0	A	0	0
High St Westbound	L+T	A	0.1	0	A	8.5	25
Pond St Northbound	L	F	149.7	275	F	>180	425
Pond St Northbound	T+R	B	14.8	10	A	9.9	25
Total Intersection	**All**	**C**	**23.5**	**--**	**D**	**34.8**	**--**
2024 Alternative 3: Install Traffic Signal	--	--	--	--	--	--	--
High St Eastbound	T	B	18	#590	B	14.2	305
High St Eastbound	R	A	6.1	145	A	4.6	63
High St Westbound	L	B	11.2	26	A	12.1	42
High St Westbound	T	A	9.8	198	C	26.1	#750
Pond St Northbound	L	D	42.6	#290	D	48.5	#365
Pond St Northbound	R	A	0.1	13	A	8.8	31
Total Intersection	**All**	**B**	**16.2**	**--**	**C**	**23.6**	**--**

[a] Delay in seconds per vehicle. [b] 95th percentile queue length in feet. # = The 95th percentile volume exceeds capacity.

Source: Central Transportation Planning Staff.

Tighten curb radius on High Street eastbound right-turn movements to reduce speed and shorten crossing distance

Extend sidewalks to new curb line

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FIGURE 11
Long-Term Improvement
Alternative 3: Install Traffic Signal

Safety and Operations
Analyses at Selected
Intersections–FFY 2014

9 RECOMMENDATIONS AND DISCUSSIONS

The above evaluations indicate that the intersections of High at Nahatan Streets and Pond Street need improvements to increase safety and reduce congestion. MPO staff has developed six alternatives to improve safety and traffic operations at the Nahatan Street intersection, and three alternatives to improve safety at the Pond Street intersection. Cost and effectiveness are primary factors in selecting the preferred alternatives.

9.1 High Street and Nahatan Street Intersection

- **Alternative 1** is a short-term, low-cost improvement—it does not fully address the safety and traffic operations problems at the intersection.
- **Alternative 2** is a short-term, low-cost improvement that addresses safety for pedestrians crossing High Street at Saint Margaret Mary Church. We also recommended it as a medium- and long-term alternative. This alternative does not address safety and operations at the intersection.
- **Alternatives 3 and 4** are medium-term, low-cost improvements—they address the safety and operations problems at the intersection and are more cost effective than the short-term improvements. **Alternative 3 is preferable** to Alternative 4 because it has more safety benefits and simplifies traffic movements through the intersection.
- **Alternatives 5 and 6** are long-term, high-cost improvements—they address the safety and operations problems. **Alternative 5 is preferable** to Alternative 6 because the improvements are within the right-of-way and do not alter intersection layout as much as Alternative 6. In addition, Alternative 6 would not function well unless an eastbound traffic queue downstream of the intersection was addressed.

MPO staff recommends Alternative 3 for short- and medium-term improvements. These modifications would improve safety by increasing sight lines and distances; reduce speeds of vehicles turning right onto High Street, and make traffic operations more efficient by reducing merging maneuvers.

For long-term improvements, MPO staff recommend Alternative 5, which would provide all of the safety benefits of Alternative 3. In addition, Alternative 5 would provide orderly movement of traffic (vehicular and pedestrian) and reduce the frequency and severity of crashes. Alternative 5 also would reduce traffic congestion, but Alternative 3 would not. The conduits, wiring, and interconnections required for installing a traffic signal already have been installed, which would facilitate implementation.

9.2 High Street and Pond Street Intersection (near Sheehan School):

- **Alternative 1** is a short-term, low-cost improvement; however, it does not fully address pedestrian safety problems.
- **Alternative 2** is a medium-term, low-cost improvement, and it does address pedestrian safety and traffic operations problems. **Alternative 2** is the most cost-effective improvement and is recommended by MPO staff.
- **Alternative 3** is a long-term, high-cost improvement, and it addresses safety and operations problems. Alternative 3 should be considered if the improvements in Alternative 2 do not address the pedestrian safety problem.

9.3 Next Steps

This study gives the Town of Westwood an opportunity look at the needs of these intersections and plan for design and engineering. Following this planning study, the next steps are to implement the preferred low-cost, short-term improvements. Implementation of the long-term, high-cost improvements hinge upon cooperation between MassDOT, Westwood, and the MPO to begin the project notification and review process, complete a project initiation form, and initiate the preliminary design and engineering necessary to place the project on the Transportation Improvement Program (TIP). Appendix E contains MassDOT project development process for highway projects. Finally, the study supports the MPO’s visions and goals, which include increasing transportation safety, preserving and maintaining the transportation system, and advancing mobility, access and congestion reduction.

SA/sa

Cc: Michael Jaillet, Town Administrator, Westwood

APPENDIX A

Public Participation

1. Letter from Town of Westwood
2. Advisory Task Force
3. Comments from Advisory Task Force and MassDOT Highway Division District 6

TOWN OF WESTWOOD

COMMONWEALTH OF MASSACHUSETTS

BOARD OF SELECTMEN

Nancy C. Hyde, Chairman
Philip N. Shapiro, Clerk
Patrick J. Ahearn, Third Member

Michael A. Jaillet, Town Administrator
Pamela M. Dukeman, Finance Director
Christine E. McCarthy, Executive Assistant

November 12, 2013

RECEIVED
NOV 15 2013
CTPS

Karl Quackenbush, Executive Director
Central Transportation Planning Staff
10 Park Plaza, Suite 2150
Boston, MA 02116-3968

Dear Karl:

The Board of Selectmen, the Planning Board, the DPW, the Police Department, and the Pedestrian/Bicycle Safety Committee of the Town of Westwood have recently reviewed the list of problem intersections in Westwood. The following intersections have all been suggested by Town representatives in the past as being in need of study to address existing safety and congestion problems. The Town desires to make this list available to CTPS so that these problem intersections may be considered by MPO staff when selecting intersections or corridor segments for study under various UPWP studies, such as *Safety and Operations Analyses at Selected Intersections – FFY 2014.*

The purpose of this letter is to reaffirm that these intersections are in need of study, and to express the Town's intention to cooperate with and support the MPO in any MPO planning effort. The Town will strive to implement improvements recommended by any such studies, given the appropriateness of the improvements and the Town's ability to fund them.

The intersections are as follows:

- High Street (Route 109) and Nahatan Street – safety/congestion
- High Street (Route 109) and Pond Street - safety
- Washington Street (Route 1A) and Everett Street/Clapboardtree Street safety and congestion
- Washington Street (Route 1A), East Street and School Street – safety and congestion
- High Street (Route 109) and Summer Street – congestion
- Winter Street and Clapboardtree Street - safety

The intersection of Nahatan Street and Clapboardtree Street has been previously listed as a problem intersection, but planning for improvements to this intersection is being pursued by local means at this time, and so it no longer needs to be considered for MPO study.

Sincerely,

Michael Jaillet

Michael Jaillet
Town Administrator

Westwood Town Hall • 580 High Street • Westwood, MA 02090 ☎ (781) 326-6450 • Fax: (781) 329-8030

e-mail: selectmen@townhall.westwood.ma.us
e-mail: mjaillet@townhall.westwood.ma.us

Study Advisory Task Force

Michael Jaillet, Town Administrator

Todd Korchin, DPW Director

Jeffrey Bina, Town Engineer

Paul Sicard, Westwood Police Department

Steve Olanoff, Westwood Pedestrian and Bicycle Committee

TOWN OF WESTWOOD
COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF PUBLIC WORKS

TODD KORCHIN, *DPW DIRECTOR*
BRENDAN RYAN, *STREETS & GROUNDS SUPERINTENDENT*

JEFFREY BINA, P.E., *TOWN ENGINEER*

October 10, 2014

Seth A. Asante, P.E.
Principal Transportation Planner
Central Transportation Planning Staff
10 Park Plaza, Suite 2150
Boston, MA 02116

Re: Review Comments, Safety and Operations Analysis in Westwood, MA at,
High Street (Route 109) at Nahatan Street and,
High Street (Route 109) at Pond Street

Dear Mr. Asante,

Thank you for coming on September 29, 2014 to present your findings on the analysis of the above referenced intersections. We have summarized the items we discussed in order to further the development of proposed improvements at those intersections.

High Street at Nahatan Street

Of the options presented the group agreed to the dedicated lanes on High St. NB for the right turn onto Nahatan Street and the dedicated lane for vehicles coming onto High St. NB from Nahatan St. This configuration was shown on Fig. 4 of the analysis. The group also recommended a new curbing layout that would be installed in the locations that show the white pavement marking gore lines on that same Fig. 4. One modification to that layout was the addition of the stop sign and curbing relocation recommended in Fig. 5 for the vehicles approaching High St. NB from Nahatan St.

High Street at Pond Street

Both the short and medium term strategy presented emphasize increasing the visibility of the movement at the intersection. This would obviously help with the driver approaching the intersection however, the group was concerned that neither of them addressed the main concern of pedestrian safety. The consensus was that vehicles traveling High St. NB turning onto Pond St. would enter the turn at a high rate of speed thereby making the pedestrian crossing undesireable. A better alternative suggested was to decrease the radius of the curve along the curb at the High St. NB/Nahatan St. right turn. This would serve two purposes: 1—shorten the distance pedestrians would have to travel and 2 – cause vehicles to decrease their speed to negotiate the sharper turn onto Pond St.

Very truly yours,

Jeff J Bina

Jeffrey J. Bina, PE
Town Engineer

cc: Michael Jaillet, Town Administrator
Todd Korchin, DPW director
Paul Sicard, Westwood Police Department
Steve Olanoff, Westwood Pedestrian and Bicycle Committee

Seth Asante

From: Lipton, Amitai (DOT)
Sent: Thursday, December 11, 2014 2:29 PM
To: 'Seth Asante'
Cc: Kulen, Raj (DOT)
Subject: RE: Safety and Operations Analyses at Selected Intersections: Westwood Intersections

Hi Seth,

The District 6 Traffic section has reviewed the CTPS memorandum dated 11/20/2014 regarding two intersections in the Town of Westwood, and offers the following comments:

1. Table 4 - LOS F at stop-controlled approaches is very common, and does not necessarily constitute an unacceptable situation. The queues on Nahatan St do not exceed 6 vehicles (150 ft), indicating that there may not be severe congestion. However, the longer queues on Pond St (14 vehicles) and excessive control delay (2 minutes or more) could be considered unacceptable.

2. Section 7.1 - Other short- and long-term alternatives should be considered. From aerial photography, it appears that inconsistent and/or confusing signage and pavement markings in the existing condition may be a contributing factor to the safety problem. A short-term measure could include replacing signs and markings with a clearer design.

It is not clear, given the geometry, that drivers would take heed of a STOP sign (Alt. 1). A PHB or RRFB may be appropriate at the existing CW in front of the church (Alt. 2), but the proximity of driveways should be taken into account. It is not clear what the benefit of adding STOP control to High St would be (Alt. 3). Alternatives 4, 5, and particularly 6 appear to have merit, although Alt. 4 might be modified to tighten up the entire intersection. For all alternatives, the intersection design should consider a 4-legged intersection, with the driveway as the fourth leg. Visibility screening, while typically used for approaches to circular intersections, may be an effective tool in lowering speeds on the Nahatan St RT approach, and may also reduce the incidence of rear-end collisions.

3. Figure 6 - We do not agree with the concept plan of installing STOP control at an added-lane condition. We also do not agree with placing a crosswalk before a stop line. If the desire is to improve pedestrian safety, the angle of a right-turn channelized lane should be no less than 70 degrees.

4. Figure 9 - This concept plan appears to provide a good solution to the safety and operational concerns at this location. It also has the added benefit of providing an opportunity for adjacent Pond St traffic to effectively turn left onto High St, a movement that is not allowed at the existing intersection. Certain modified design features should be considered: (a) SB approach having L+TR lanes, with only 1 departing lane to the south; (b) spiral lane design; (c) 70 degree channelized turn lane for NB approach; and (d) Danish-style crossing on southerly and possibly easterly leg of the roundabout.

5. Section 7.2 - The R10-15 signs are intended solely for use at signalized intersection, and should not be used at unsignalized locations, nor in advance of an intersection. An interim option for enhanced visibility STOP signs would be to install red reflective stripe on the sign post. As a short-term measure, additional advance signage on High St (D3-2, W2-2, W2-3, W16-8P, etc.) would notify drivers of an approaching intersection. An additional alternative scenario should consider whether a roundabout would be appropriate at this location.

6. Figure 11 - A crosswalk should also be provided across High St.

If you have any questions, or would like further information about these comments, please do not hesitate to contact me.

Amitai Lipton
District 6 Traffic Engineer
MassDOT Highway Division
185 Kneeland St
Boston MA 02111
amitai.lipton@state.ma.us
857.368.6313 (office)
617.892.3171 (mobile)

APPENDIX B

Turning-Movement Count Data

Central Transportation Planning Staff
High St (Rte 109) at Nahatan St
04/08/14

File Name : Nahatan AM+MID+PM
Site Code : 04081422
Start Date : 4/8/2014

Groups Printed- Autos - Heavy Vehicle - Bicycles

	High St From North					Nahatan St From East					High St From South					Rev Coyle Cir From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:00 AM	5	93	64	0	162	25	0	16	0	41	81	184	0	0	265	0	0	0	1	1	469
07:15 AM	0	83	77	0	160	62	0	30	1	93	81	177	0	0	258	1	0	0	0	1	512
07:30 AM	1	111	67	0	179	54	0	27	1	82	91	181	1	0	273	0	0	0	11	11	545
07:45 AM	0	87	37	0	124	46	2	22	0	70	60	165	0	0	225	0	0	0	0	0	419
Total	6	374	245	0	625	187	2	95	2	286	313	707	1	0	1021	1	0	0	12	13	1945
08:00 AM	0	91	21	0	112	42	0	8	0	50	39	193	0	0	232	1	0	0	0	1	395
08:15 AM	0	119	43	0	162	41	0	16	0	57	34	187	3	0	224	0	0	0	0	0	443
08:30 AM	2	99	32	0	133	29	0	14	0	43	55	205	1	0	261	1	0	0	2	3	440
08:45 AM	4	84	37	0	125	37	2	18	0	57	33	225	0	0	258	1	0	0	4	5	445
Total	6	393	133	0	532	149	2	56	0	207	161	810	4	0	975	3	0	0	6	9	1723
*** BREAK ***																					
11:00 AM	1	98	36	0	135	24	1	22	0	47	16	109	1	3	129	1	0	0	2	3	314
11:15 AM	0	115	23	0	138	26	2	11	0	39	24	135	1	2	162	0	1	0	0	1	340
11:30 AM	3	134	45	1	183	50	0	14	0	64	29	138	1	0	168	1	1	0	0	2	417
11:45 AM	1	126	73	0	200	35	0	18	0	53	64	127	2	1	194	0	1	0	1	2	449
Total	5	473	177	1	656	135	3	65	0	203	133	509	5	6	653	2	3	0	3	8	1520
12:00 PM	0	131	58	0	189	65	0	48	3	116	22	137	0	0	159	0	0	0	2	2	466
12:15 PM	1	138	38	0	177	53	0	22	0	75	18	139	0	0	157	0	0	1	0	1	410
12:30 PM	1	121	41	0	163	42	0	12	5	59	25	137	0	2	164	0	0	0	2	2	388
12:45 PM	1	151	47	0	199	30	0	13	0	43	24	139	0	0	163	0	0	0	0	0	405
Total	3	541	184	0	728	190	0	95	8	293	89	552	0	2	643	0	0	1	4	5	1669
01:00 PM	1	111	32	1	145	70	1	25	0	96	17	109	0	0	126	0	0	0	1	1	368
01:15 PM	0	114	35	0	149	27	0	10	4	41	16	113	0	0	129	0	0	1	0	1	320
01:30 PM	3	133	32	0	168	42	0	19	0	61	12	152	1	0	165	1	0	0	4	5	399
01:45 PM	2	155	31	0	188	37	0	16	0	53	10	124	0	0	134	0	0	1	1	2	377
Total	6	513	130	1	650	176	1	70	4	251	55	498	1	0	554	1	0	2	6	9	1464
*** BREAK ***																					
03:00 PM	0	202	47	0	249	41	1	16	0	58	15	122	1	2	140	0	0	1	5	6	453
03:15 PM	0	202	58	0	260	50	0	22	6	78	31	144	0	5	180	1	0	0	1	2	520
03:30 PM	0	174	60	0	234	38	0	29	1	68	33	134	1	3	171	0	0	0	1	1	474
03:45 PM	1	195	57	0	253	43	1	14	0	58	31	134	7	0	172	1	0	0	1	2	485
Total	1	773	222	0	996	172	2	81	7	262	110	534	9	10	663	2	0	1	8	11	1932
04:00 PM	0	188	35	0	223	35	1	24	3	63	29	131	4	0	164	5	1	0	8	14	464
04:15 PM	0	200	46	0	246	46	0	24	1	71	9	128	1	0	138	1	0	0	0	1	456
04:30 PM	0	211	56	0	267	42	0	26	0	68	22	122	0	0	144	0	1	0	2	3	482

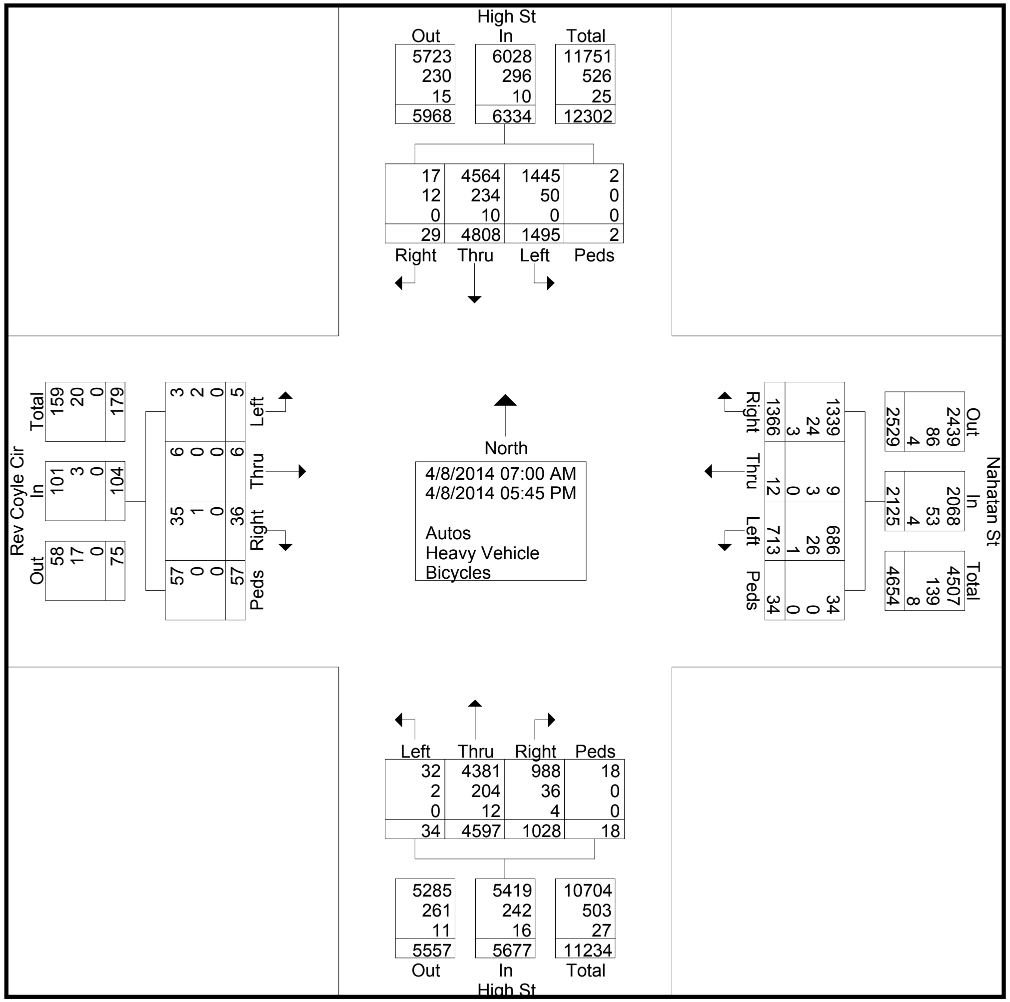
Central Transportation Planning Staff
High St (Rte 109) at Nahatan St
04/08/14

File Name : Nahatan AM+MID+PM
Site Code : 04081422
Start Date : 4/8/2014
Page No : 2

Groups Printed- Autos - Heavy Vehicle - Bicycles

	High St From North					Nahatan St From East					High St From South					Rev Coyle Cir From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
04:45 PM	2	231	56	0	289	54	0	36	3	93	24	114	7	0	145	3	0	0	1	4	531
Total	2	830	193	0	1025	177	1	110	7	295	84	495	12	0	591	9	2	0	11	22	1933
05:00 PM	0	224	54	0	278	49	1	31	0	81	22	126	2	0	150	18	1	1	0	20	529
05:15 PM	0	216	48	0	264	46	0	34	3	83	20	135	0	0	155	0	0	0	0	0	502
05:30 PM	0	233	49	0	282	56	0	47	1	104	23	122	0	0	145	0	0	0	6	6	537
05:45 PM	0	238	60	0	298	29	0	29	2	60	18	109	0	0	127	0	0	0	1	1	486
Total	0	911	211	0	1122	180	1	141	6	328	83	492	2	0	577	18	1	1	7	27	2054
Grand Total	29	4808	1495	2	6334	1366	12	713	34	2125	1028	4597	34	18	5677	36	6	5	57	104	14240
Apprch %	0.5	75.9	23.6	0		64.3	0.6	33.6	1.6		18.1	81	0.6	0.3		34.6	5.8	4.8	54.8		
Total %	0.2	33.8	10.5	0	44.5	9.6	0.1	5	0.2	14.9	7.2	32.3	0.2	0.1	39.9	0.3	0	0	0.4	0.7	
Autos	17	4564	1445	2	6028	1339	9	686	34	2068	988	4381	32	18	5419	35	6	3	57	101	13616
% Autos	58.6	94.9	96.7	100	95.2	98	75	96.2	100	97.3	96.1	95.3	94.1	100	95.5	97.2	100	60	100	97.1	95.6
Heavy Vehicle	12	234	50	0	296	24	3	26	0	53	36	204	2	0	242	1	0	2	0	3	594
% Heavy Vehicle	41.4	4.9	3.3	0	4.7	1.8	25	3.6	0	2.5	3.5	4.4	5.9	0	4.3	2.8	0	40	0	2.9	4.2
Bicycles	0	10	0	0	10	3	0	1	0	4	4	12	0	0	16	0	0	0	0	0	30
% Bicycles	0	0.2	0	0	0.2	0.2	0	0.1	0	0.2	0.4	0.3	0	0	0.3	0	0	0	0	0	0.2

Central Transportation Planning Staff
High St (Rte 109) at Nahatan St
04/08/14



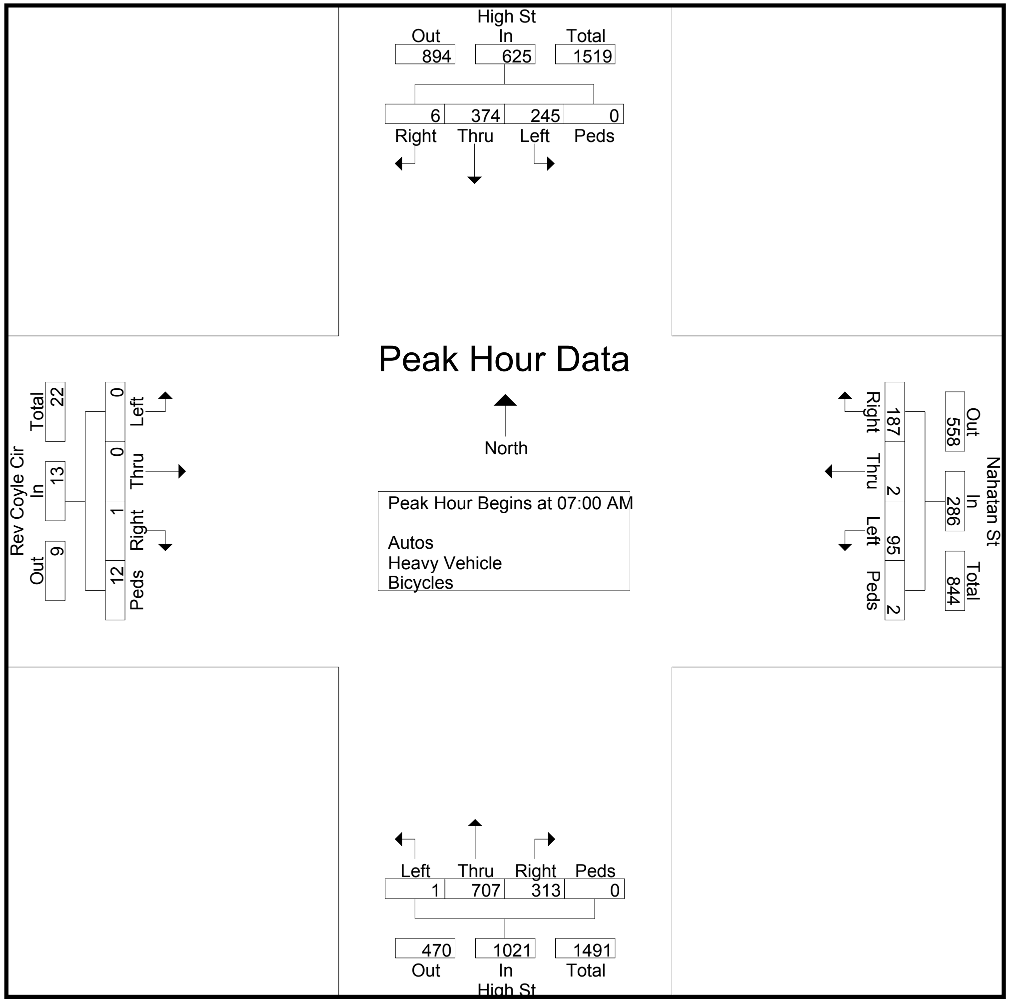
Central Transportation Planning Staff
High St (Rte 109) at Nahatan St
04/08/14

File Name : Nahatan AM+MID+PM
Site Code : 04081422
Start Date : 4/8/2014
Page No : 5

	High St From North					Nahatan St From East					High St From South					Rev Coyle Cir From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 09:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:00 AM																					
07:00 AM	**5**	93	64	0	162	25	0	16	0	41	81	**184**	0	0	265	0	0	0	1	1	469
07:15 AM	0	83	**77**	0	160	**62**	0	**30**	**1**	**93**	81	177	0	0	258	**1**	0	0	0	1	512
07:30 AM	1	**111**	67	0	**179**	54	0	27	1	82	**91**	181	**1**	0	**273**	0	0	0	**11**	**11**	**545**
07:45 AM	0	87	37	0	124	46	**2**	22	0	70	60	165	0	0	225	0	0	0	0	0	419
Total Volume	6	374	245	0	625	187	2	95	2	286	313	707	1	0	1021	1	0	0	12	13	1945
% App. Total	1	59.8	39.2	0		65.4	0.7	33.2	0.7		30.7	69.2	0.1	0		7.7	0	0	92.3		
PHF	.300	.842	.795	.000	.873	.754	.250	.792	.500	.769	.860	.961	.250	.000	.935	.250	.000	.000	.273	.295	.892

Central Transportation Planning Staff
High St (Rte 109) at Nahatan St
04/08/14

File Name : Nahatan AM+MID+PM
Site Code : 04081422
Start Date : 4/8/2014



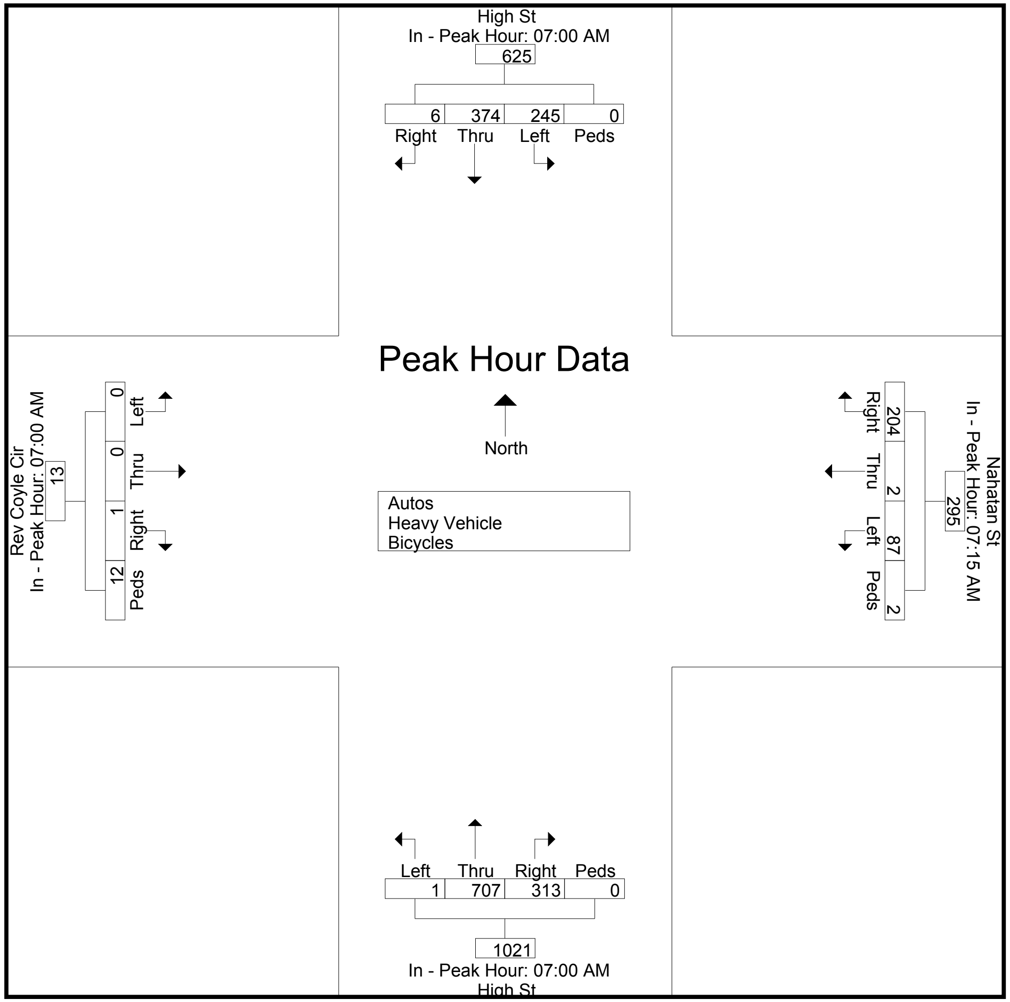
Central Transportation Planning Staff
High St (Rte 109) at Nahatan St
04/08/14

File Name : Nahatan AM+MID+PM
Site Code : 04081422
Start Date : 4/8/2014
Page No : 8

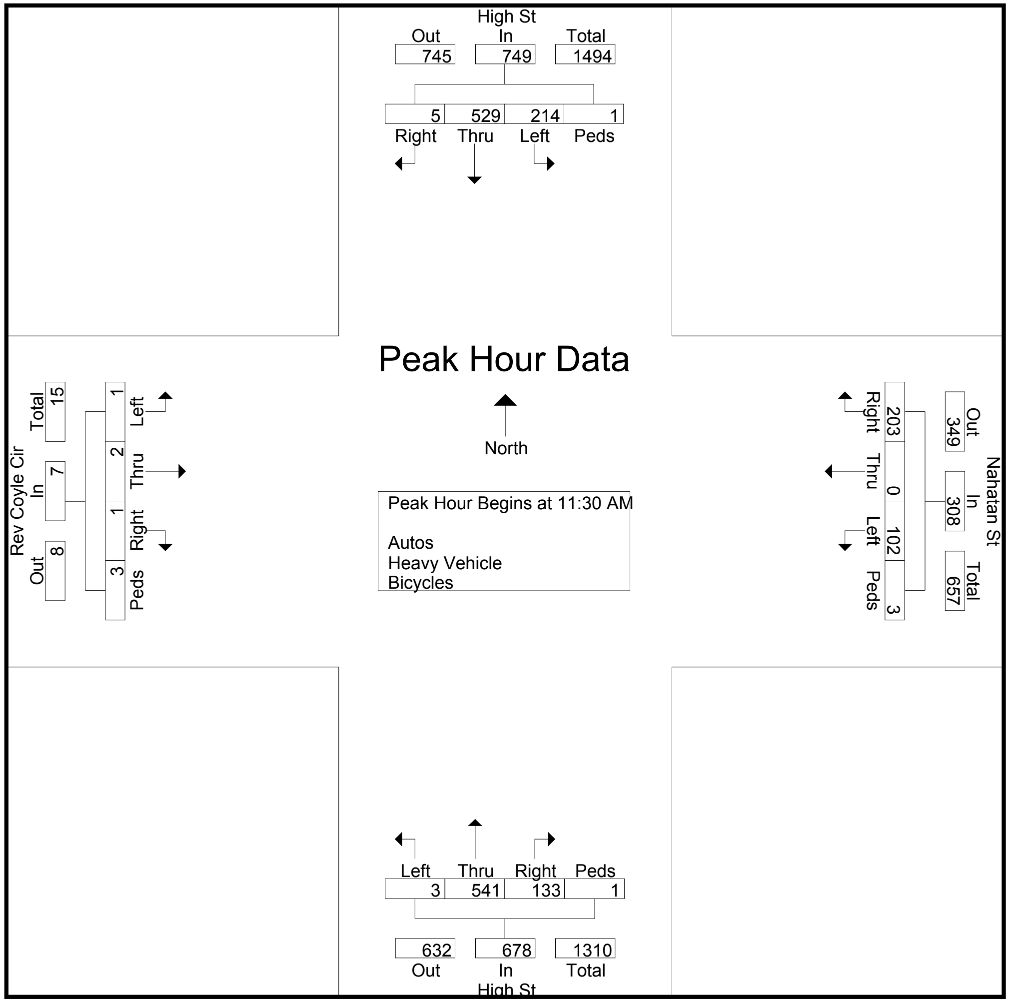
	High St From North					Nahatan St From East					High St From South					Rev Coyle Cir From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 09:45 AM - Peak 1 of 1																					
Peak Hour for Each Approach Begins at:																					
	07:00 AM					07:15 AM					07:00 AM					07:00 AM					
+0 mins.	**5**	93	64	0	162	**62**	0	**30**	**1**	**93**	81	**184**	0	0	265	0	0	0	1	1	
+15 mins.	0	83	**77**	0	160	54	0	27	1	82	81	177	0	0	258	**1**	0	0	0	1	
+30 mins.	1	**111**	67	0	**179**	46	**2**	22	0	70	**91**	181	**1**	0	**273**	0	0	0	**11**	**11**	
+45 mins.	0	87	37	0	124	42	0	8	0	50	60	165	0	0	225	0	0	0	0	0	
Total Volume	6	374	245	0	625	204	2	87	2	295	313	707	1	0	1021	1	0	0	12	13	
% App. Total	1	59.8	39.2	0		69.2	0.7	29.5	0.7		30.7	69.2	0.1	0		7.7	0	0	92.3		
PHF	.300	.842	.795	.000	.873	.823	.250	.725	.500	.793	.860	.961	.250	.000	.935	.250	.000	.000	.273	.295	

Central Transportation Planning Staff
High St (Rte 109) at Nahatan St
04/08/14

File Name : Nahatan AM+MID+PM
Site Code : 04081422
Start Date : 4/8/2014
Page No : 9



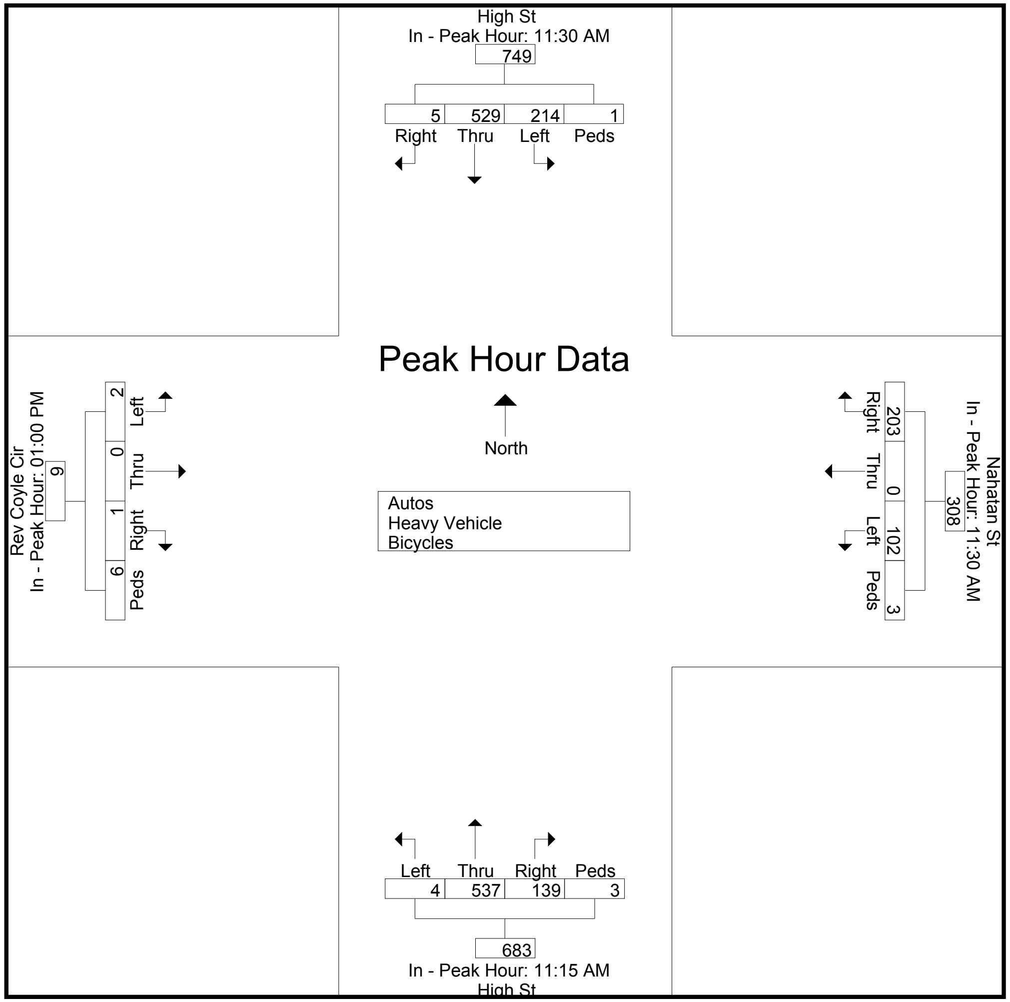
	High St From North					Nahatan St From East					High St From South					Rev Coyle Cir From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 10:00 AM to 01:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 11:30 AM																					
11:30 AM	**3**	134	45	**1**	183	50	0	14	0	64	29	138	1	0	168	**1**	**1**	0	0	**2**	417
11:45 AM	1	126	**73**	0	**200**	35	0	18	0	53	**64**	127	**2**	**1**	**194**	0	1	0	1	2	449
12:00 PM	0	131	58	0	189	**65**	0	**48**	**3**	**116**	22	137	0	0	159	0	0	0	**2**	2	**466**
12:15 PM	1	**138**	38	0	177	53	0	22	0	75	18	**139**	0	0	157	0	0	**1**	0	1	410
Total Volume	5	529	214	1	749	203	0	102	3	308	133	541	3	1	678	1	2	1	3	7	1742
% App. Total	0.7	70.6	28.6	0.1		65.9	0	33.1	1		19.6	79.8	0.4	0.1		14.3	28.6	14.3	42.9		
PHF	.417	.958	.733	.250	.936	.781	.000	.531	.250	.664	.520	.973	.375	.250	.874	.250	.500	.250	.375	.875	.935


High St
Out 745
In 749
Total 1494
Right 5
Thru 529
Left 214
Peds 1
Peak Hour Data
North
Peak Hour Begins at 11:30 AM
Autos
Heavy Vehicle
Bicycles
Rev Coyle Cir
Total 15
In 7
Out 8
Left 1
Thru 2
Right 1
Peds 3
Nahatan St
Out 349
In 308
Total 657
Right 203
Thru 0
Left 102
Peds 3
Left 3
Thru 541
Right 133
Peds 1
Out 632
In 678
Total 1310
High St

	High St From North					Nahatan St From East					High St From South					Rev Coyle Cir From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 10:00 AM to 01:45 PM - Peak 1 of 1																					
Peak Hour for Each Approach Begins at:																					
	11:30 AM					11:30 AM					11:15 AM					01:00 PM					
+0 mins.	**3**	134	45	**1**	183	50	0	14	0	64	24	135	1	**2**	162	0	0	0	1	1	
+15 mins.	1	126	**73**	0	**200**	35	0	18	0	53	29	**138**	1	0	168	0	0	**1**	0	1	
+30 mins.	0	131	58	0	189	**65**	0	**48**	**3**	**116**	**64**	127	**2**	1	**194**	**1**	0	0	**4**	**5**	
+45 mins.	1	**138**	38	0	177	53	0	22	0	75	22	137	0	0	159	0	0	1	1	2	
Total Volume	5	529	214	1	749	203	0	102	3	308	139	537	4	3	683	1	0	2	6	9	
% App. Total	0.7	70.6	28.6	0.1		65.9	0	33.1	1		20.4	78.6	0.6	0.4		11.1	0	22.2	66.7		
PHF	.417	.958	.733	.250	.936	.781	.000	.531	.250	.664	.543	.973	.500	.375	.880	.250	.000	.500	.375	.450	

Central Transportation Planning Staff
High St (Rte 109) at Nahatan St
04/08/14

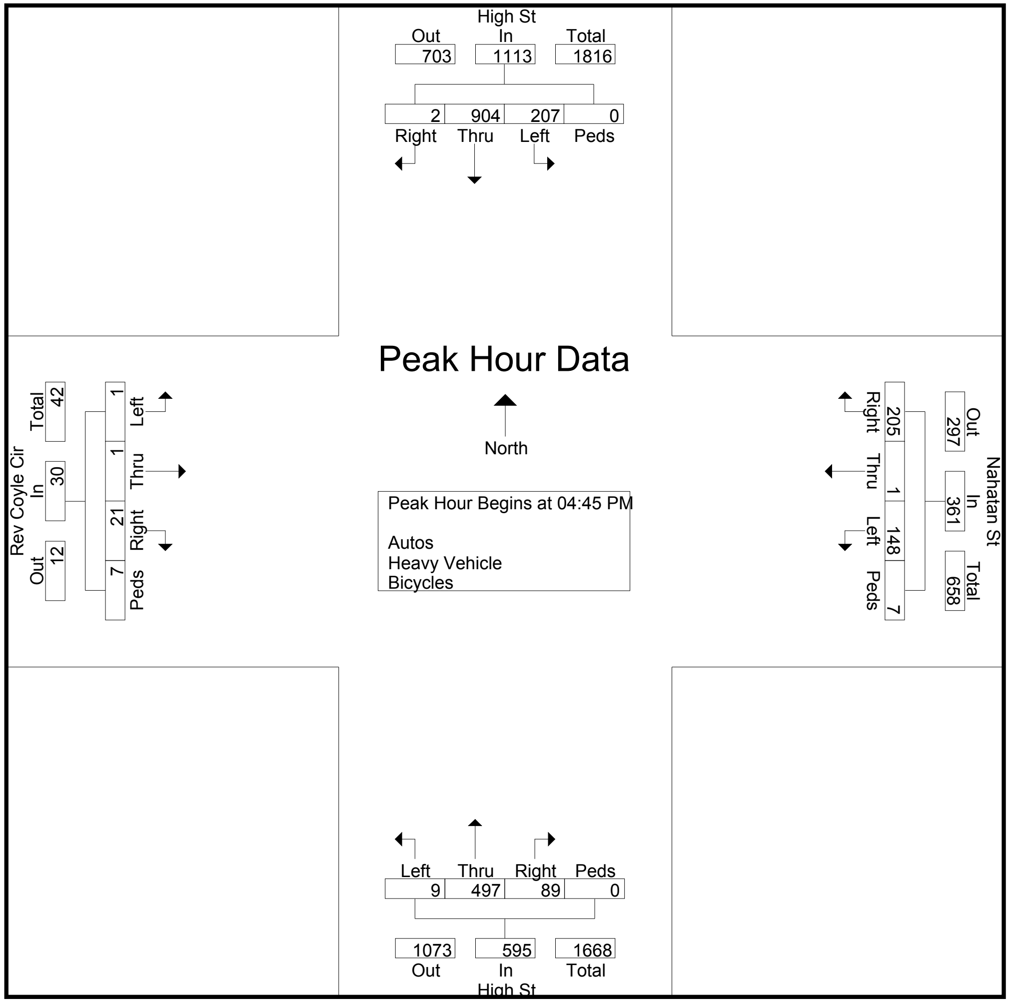
File Name : Nahatan AM+MID+PM
Site Code : 04081422
Start Date : 4/8/2014
Page No : 15



	High St From North					Nahatan St From East					High St From South					Rev Coyle Cir From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 02:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:45 PM																					
04:45 PM	**2**	231	**56**	0	**289**	54	0	36	**3**	93	**24**	114	**7**	0	145	3	0	0	1	4	531
05:00 PM	0	224	54	0	278	49	**1**	31	0	81	22	126	2	0	150	**18**	**1**	**1**	0	**20**	529
05:15 PM	0	216	48	0	264	46	0	34	3	83	20	**135**	0	0	**155**	0	0	0	0	0	502
05:30 PM	0	**233**	49	0	282	**56**	0	**47**	1	**104**	23	122	0	0	145	0	0	0	**6**	6	**537**
Total Volume	2	904	207	0	1113	205	1	148	7	361	89	497	9	0	595	21	1	1	7	30	2099
% App. Total	0.2	81.2	18.6	0		56.8	0.3	41	1.9		15	83.5	1.5	0		70	3.3	3.3	23.3		
PHF	.250	.970	.924	.000	.963	.915	.250	.787	.583	.868	.927	.920	.321	.000	.960	.292	.250	.250	.292	.375	.977

Central Transportation Planning Staff
High St (Rte 109) at Nahatan St
04/08/14

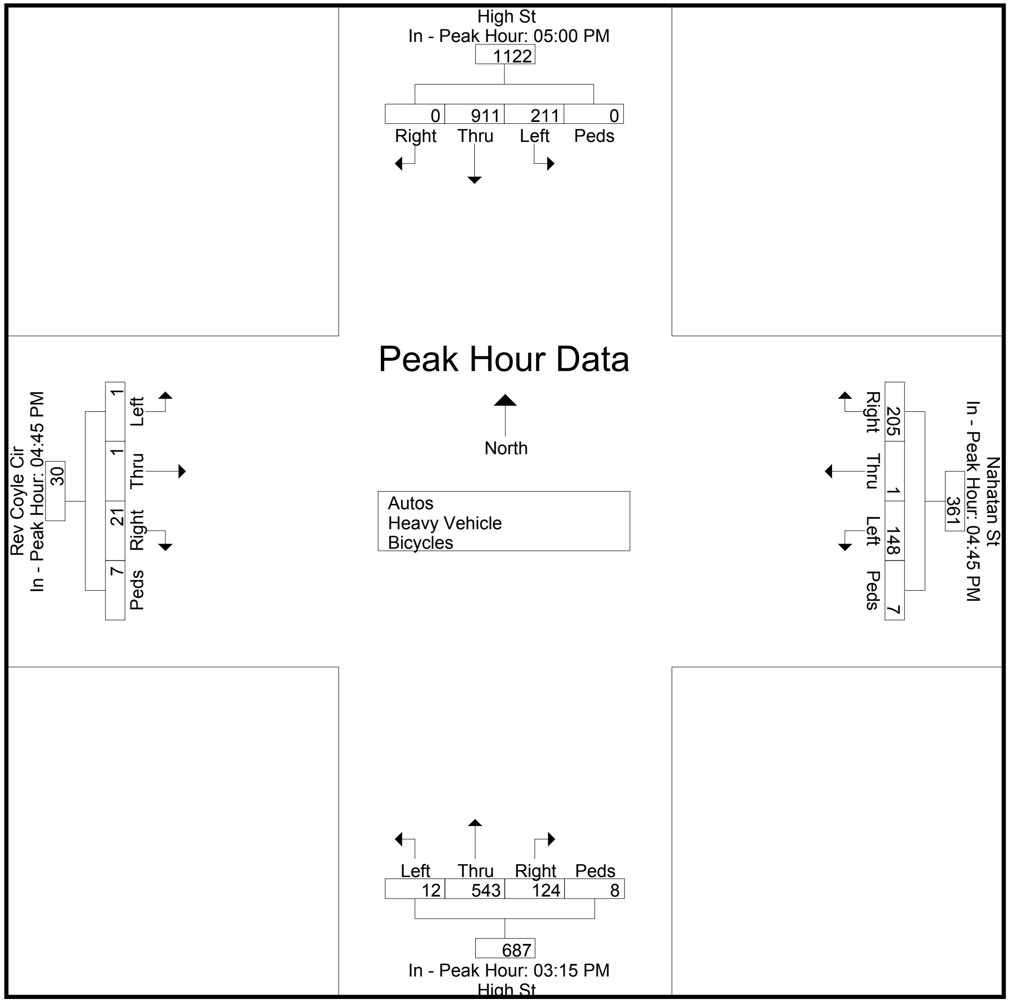
File Name : Nahatan AM+MID+PM
Site Code : 04081422
Start Date : 4/8/2014
Page No : 18



Central Transportation Planning Staff
High St (Rte 109) at Nahatan St
04/08/14

File Name : Nahatan AM+MID+PM
Site Code : 04081422
Start Date : 4/8/2014
Page No : 20

	High St From North					Nahatan St From East					High St From South					Rev Coyle Cir From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 02:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Each Approach Begins at:																					
	05:00 PM					04:45 PM					03:15 PM					04:45 PM					
+0 mins.	0	224	54	0	278	54	0	36	**3**	93	31	**144**	0	**5**	**180**	3	0	0	1	4	
+15 mins.	0	216	48	0	264	49	**1**	31	0	81	**33**	134	1	3	171	**18**	**1**	**1**	0	**20**	
+30 mins.	0	233	49	0	282	46	0	34	3	83	31	134	**7**	0	172	0	0	0	0	0	
+45 mins.	0	**238**	**60**	0	**298**	**56**	0	**47**	1	**104**	29	131	4	0	164	0	0	0	**6**	6	
Total Volume	0	911	211	0	1122	205	1	148	7	361	124	543	12	8	687	21	1	1	7	30	
% App. Total	0	81.2	18.8	0		56.8	0.3	41	1.9		18	79	1.7	1.2		70	3.3	3.3	23.3		
PHF	.000	.957	.879	.000	.941	.915	.250	.787	.583	.868	.939	.943	.429	.400	.954	.292	.250	.250	.292	.375	


High St
In - Peak Hour: 05:00 PM
1122
0
911
211
0
Right
Thru
Left
Peds
Peak Hour Data
North
Autos
Heavy Vehicle
Bicycles
Rev Coyle Cir
In - Peak Hour: 04:45 PM
30
1
Left
1
Thru
21
Right
7
Peds
Nahatan St
In - Peak Hour: 04:45 PM
361
205
Right
1
Thru
148
Left
7
Peds
Left
Thru
Right
Peds
12
543
124
8
687
In - Peak Hour: 03:15 PM
High St

Central Transportation Planning Staff
High St (Rte 109) at Pond St (near Nahatan St)
04/08/14 PM and 04/17/14 AM

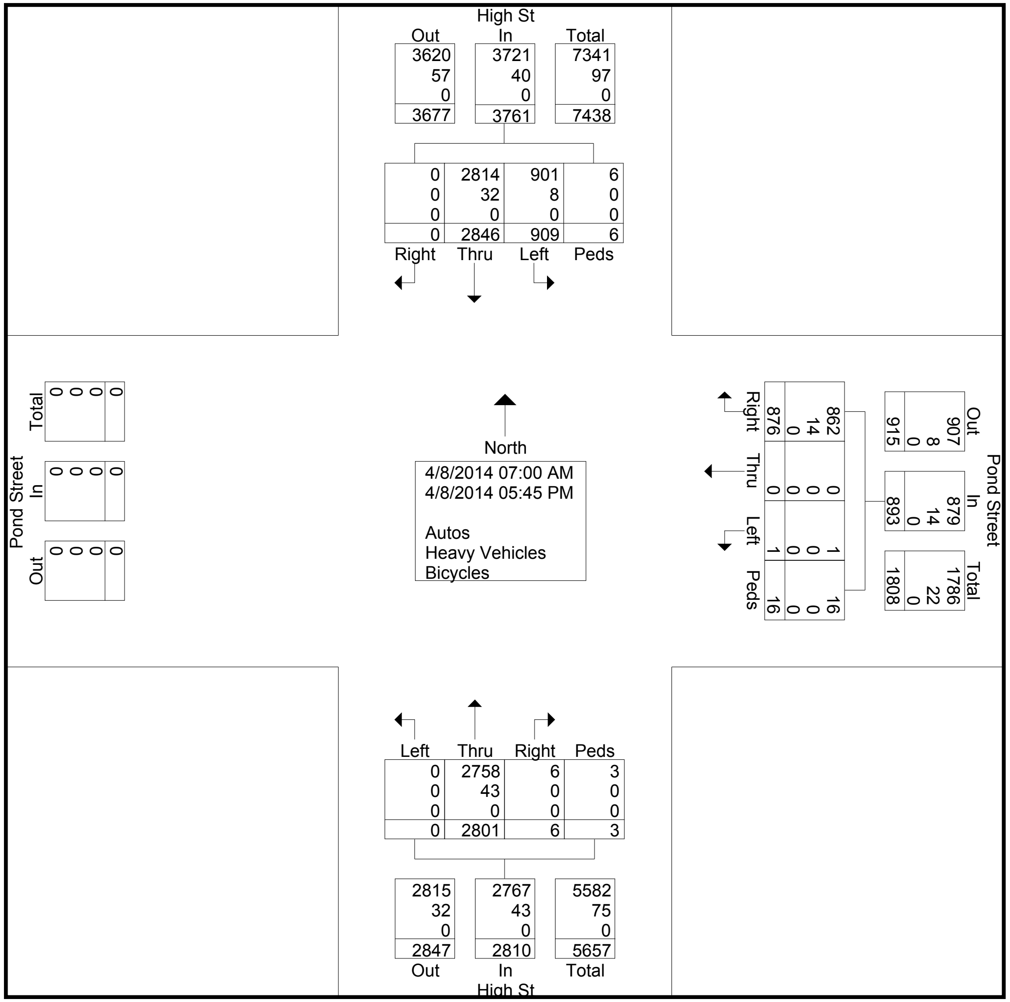
File Name : Pond near Nahatan AM and PM
Site Code : 04081423
Start Date : 4/8/2014
Page No : 1

Groups Printed- Autos - Heavy Vehicles - Bicycles

	High St From North					Pond Street From East					High St From South					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:00 AM	0	77	12	0	89	57	0	0	1	58	0	219	0	0	219	366
07:15 AM	0	83	18	0	101	70	0	0	0	70	0	176	0	0	176	347
07:30 AM	0	89	33	0	122	71	0	0	0	71	0	188	0	0	188	381
07:45 AM	0	81	28	0	109	45	0	0	0	45	0	164	0	0	164	318
Total	0	330	91	0	421	243	0	0	1	244	0	747	0	0	747	1412
08:00 AM	0	82	18	0	100	63	0	0	0	63	0	169	0	0	169	332
08:15 AM	0	95	42	0	137	46	0	0	1	47	0	172	0	0	172	356
08:30 AM	0	82	26	0	108	72	0	0	0	72	3	182	0	0	185	365
08:45 AM	0	84	22	0	106	45	0	0	0	45	0	218	0	0	218	369
Total	0	343	108	0	451	226	0	0	1	227	3	741	0	0	744	1422
*** BREAK ***																
03:00 PM	0	154	61	0	215	25	0	0	3	28	1	94	0	2	97	340
03:15 PM	0	171	50	4	225	31	0	0	0	31	0	119	0	0	119	375
03:30 PM	0	149	44	0	193	31	0	0	1	32	0	126	0	0	126	351
03:45 PM	0	153	53	0	206	43	0	0	0	43	1	122	0	1	124	373
Total	0	627	208	4	839	130	0	0	4	134	2	461	0	3	466	1439
04:00 PM	0	175	48	0	223	36	0	0	2	38	0	126	0	0	126	387
04:15 PM	0	172	53	0	225	36	0	0	3	39	0	84	0	0	84	348
04:30 PM	0	172	54	0	226	37	0	0	2	39	1	111	0	0	112	377
04:45 PM	0	226	56	0	282	46	0	0	0	46	0	105	0	0	105	433
Total	0	745	211	0	956	155	0	0	7	162	1	426	0	0	427	1545
05:00 PM	0	195	90	1	286	35	0	1	1	37	0	117	0	0	117	440
05:15 PM	0	192	57	0	249	34	0	0	1	35	0	114	0	0	114	398
05:30 PM	0	223	68	1	292	28	0	0	0	28	0	108	0	0	108	428
05:45 PM	0	191	76	0	267	25	0	0	1	26	0	87	0	0	87	380
Total	0	801	291	2	1094	122	0	1	3	126	0	426	0	0	426	1646
Grand Total	0	2846	909	6	3761	876	0	1	16	893	6	2801	0	3	2810	7464
Apprch %	0	75.7	24.2	0.2		98.1	0	0.1	1.8		0.2	99.7	0	0.1		
Total %	0	38.1	12.2	0.1	50.4	11.7	0	0	0.2	12	0.1	37.5	0	0	37.6	
Autos	0	2814	901	6	3721	862	0	1	16	879	6	2758	0	3	2767	7367
% Autos	0	98.9	99.1	100	98.9	98.4	0	100	100	98.4	100	98.5	0	100	98.5	98.7
Heavy Vehicles	0	32	8	0	40	14	0	0	0	14	0	43	0	0	43	97
% Heavy Vehicles	0	1.1	0.9	0	1.1	1.6	0	0	0	1.6	0	1.5	0	0	1.5	1.3
Bicycles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% Bicycles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Central Transportation Planning Staff
High St (Rte 109) at Pond St (near Nahatan St)
04/08/14 PM and 04/17/14 AM

File Name : Pond near Nahatan AM and PM
Site Code : 04081423
Start Date : 4/8/2014
Page No : 2



High St (north)

Out	In	Total
3620	3721	7341
57	40	97
0	0	0
3677	3761	7438

Right	Thru	Left	Peds
0	2814	901	6
0	32	8	0
0	0	0	0
0	2846	909	6

Pond Street (east)

Right	Thru	Left	Peds
862	0	1	16
14	0	0	0
0	0	0	0
876	0	1	16

Out	In	Total
907	879	1786
8	14	22
0	0	0
915	893	1808

Pond Street (west)

Total	In	Out
0	0	0
0	0	0
0	0	0
0	0	0

High St (south)

Left	Thru	Right	Peds
0	2758	6	3
0	43	0	0
0	0	0	0
0	2801	6	3

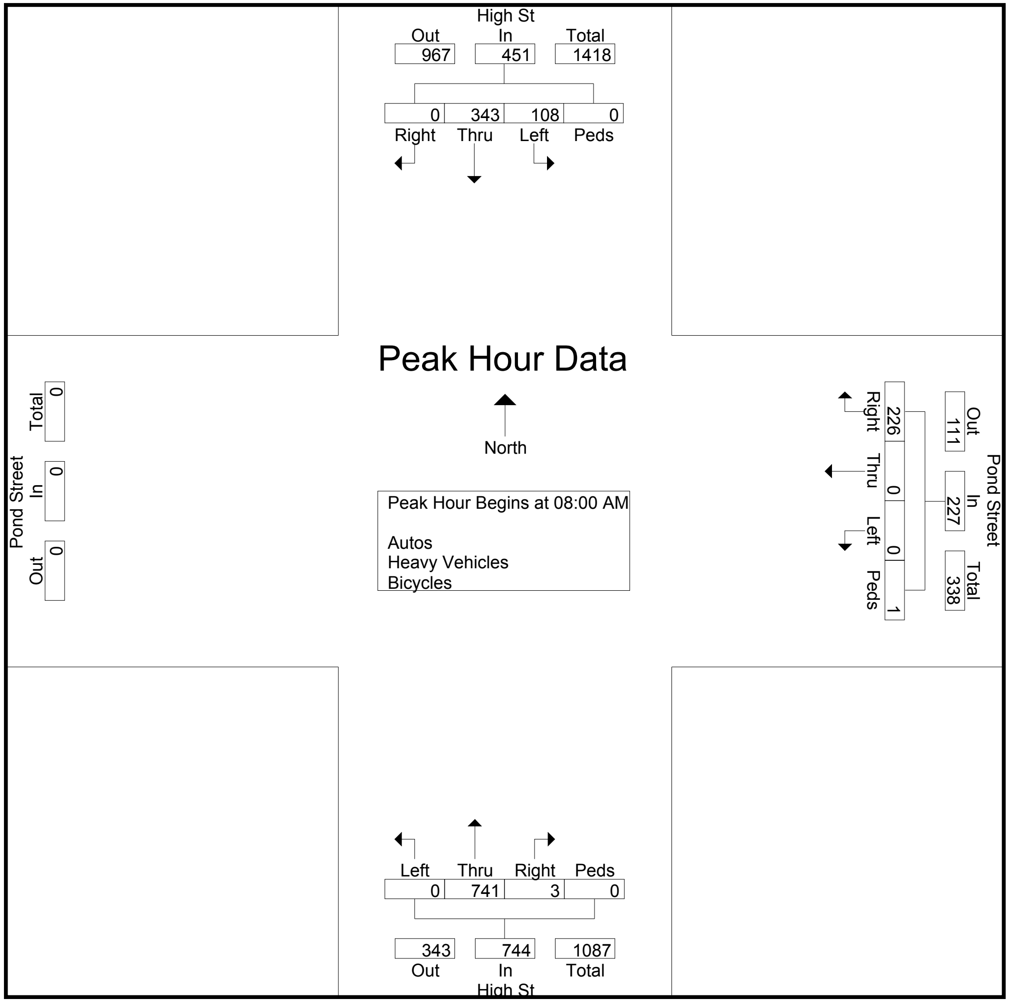
Out	In	Total
2815	2767	5582
32	43	75
0	0	0
2847	2810	5657

Central Transportation Planning Staff
High St (Rte 109) at Pond St (near Nahatan St)
04/08/14 PM and 04/17/14 AM

	High St From North					Pond Street From East					High St From South					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 11:45 AM - Peak 1 of 1																
Peak Hour for Entire Intersection Begins at 08:00 AM																
08:00 AM	0	82	18	0	100	63	0	0	0	63	0	169	0	0	169	332
08:15 AM	0	**95**	**42**	0	**137**	46	0	0	**1**	47	0	172	0	0	172	356
08:30 AM	0	82	26	0	108	**72**	0	0	0	**72**	**3**	182	0	0	185	365
08:45 AM	0	84	22	0	106	45	0	0	0	45	0	**218**	0	0	**218**	**369**
Total Volume	0	343	108	0	451	226	0	0	1	227	3	741	0	0	744	1422
% App. Total	0	76.1	23.9	0		99.6	0	0	0.4		0.4	99.6	0	0		
PHF	.000	.903	.643	.000	.823	.785	.000	.000	.250	.788	.250	.850	.000	.000	.853	.963

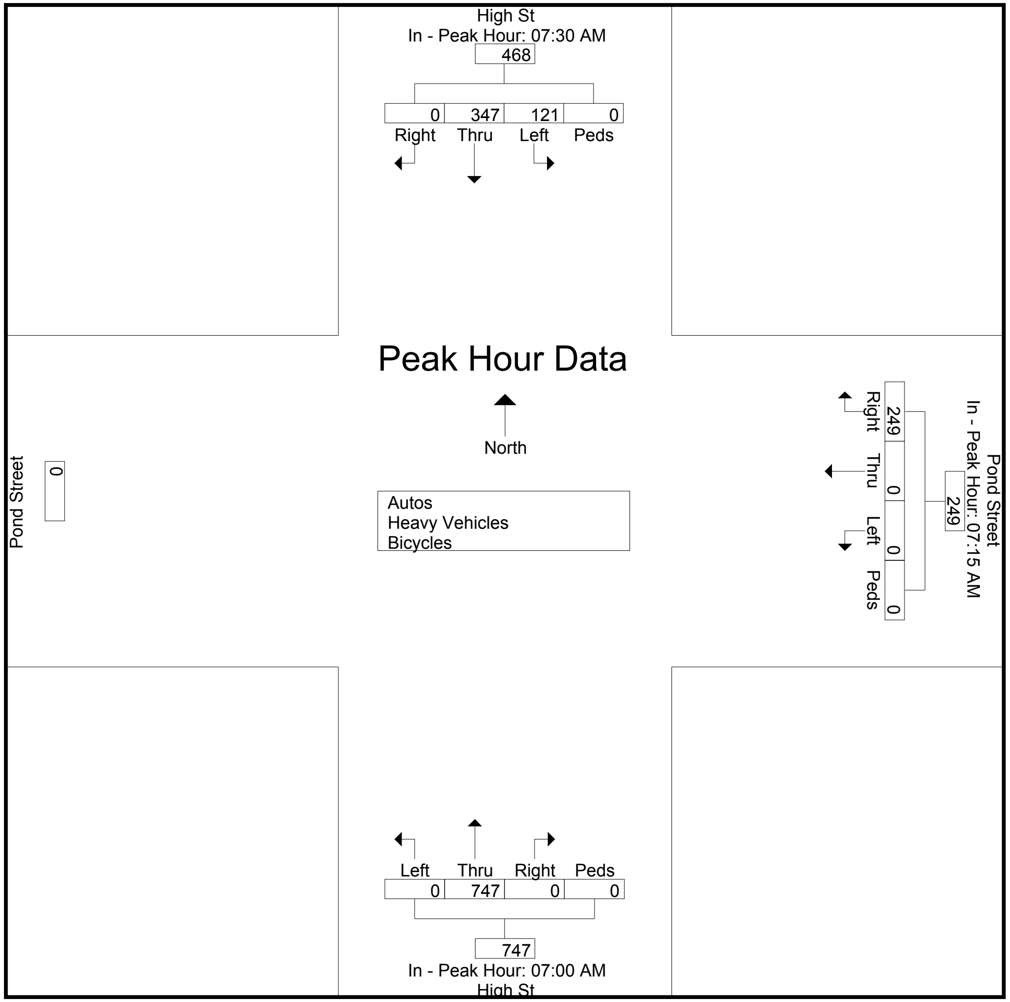
Central Transportation Planning Staff
High St (Rte 109) at Pond St (near Nahatan St)
04/08/14 PM and 04/17/14 AM

File Name : Pond near Nahatan AM and PM
Site Code : 04081423
Start Date : 4/8/2014



Central Transportation Planning Staff
High St (Rte 109) at Pond St (near Nahatan St)
04/08/14 PM and 04/17/14 AM

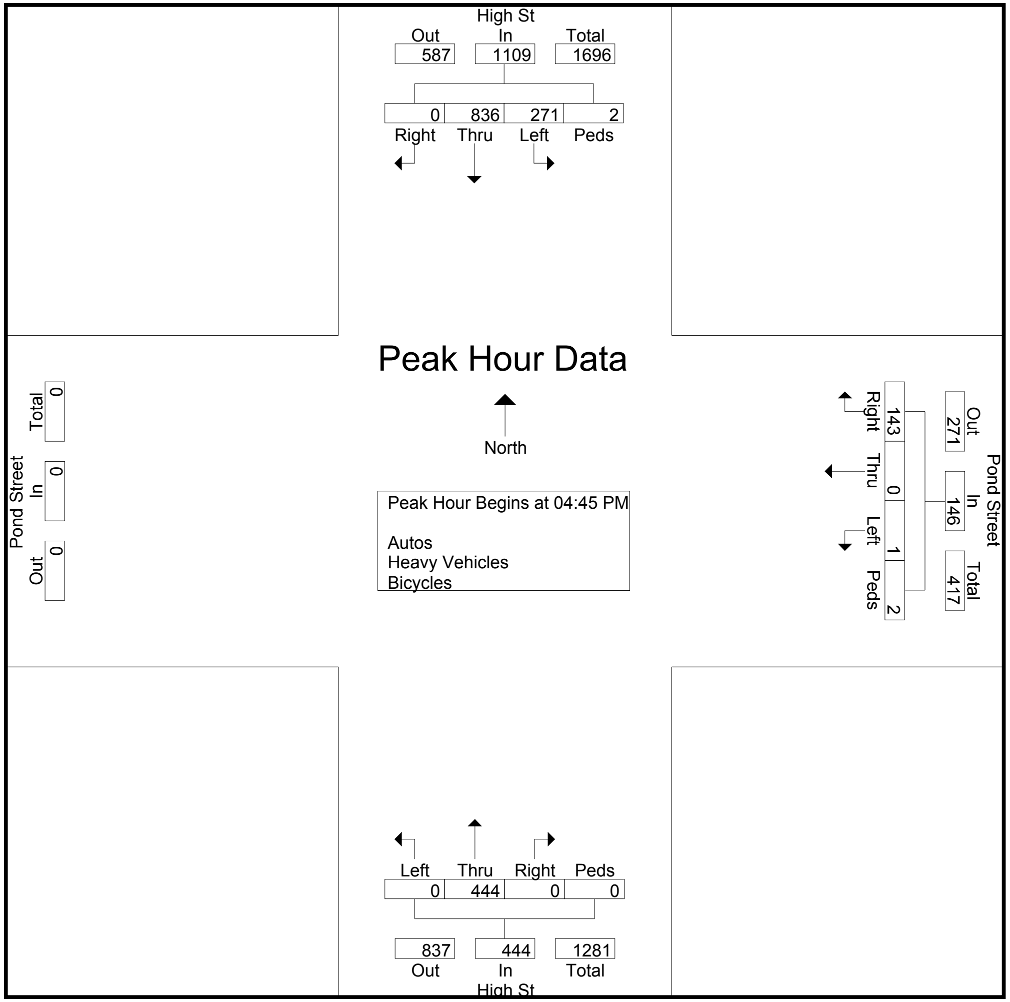
	High St From North					Pond Street From East					High St From South					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 11:45 AM - Peak 1 of 1																
Peak Hour for Each Approach Begins at:																
	07:30 AM					07:15 AM					07:00 AM					
+0 mins.	0	89	33	0	122	70	0	0	0	70	0	**219**	0	0	**219**	
+15 mins.	0	81	28	0	109	**71**	0	0	0	**71**	0	176	0	0	176	
+30 mins.	0	82	18	0	100	45	0	0	0	45	0	188	0	0	188	
+45 mins.	0	**95**	**42**	0	**137**	63	0	0	0	63	0	164	0	0	164	
Total Volume	0	347	121	0	468	249	0	0	0	249	0	747	0	0	747	
% App. Total	0	74.1	25.9	0		100	0	0	0		0	100	0	0		
PHF	.000	.913	.720	.000	.854	.877	.000	.000	.000	.877	.000	.853	.000	.000	.853	


High St
In - Peak Hour: 07:30 AM
468
0
347
121
0
Right
Thru
Left
Peds
Peak Hour Data
North
Autos
Heavy Vehicles
Bicycles
Pond Street
0
Pond Street
In - Peak Hour: 07:15 AM
249
249
Right
0
Thru
0
Left
0
Peds
Left
Thru
Right
Peds
0
747
0
0
747
In - Peak Hour: 07:00 AM
High St

Central Transportation Planning Staff
High St (Rte 109) at Pond St (near Nahatan St)
04/08/14 PM and 04/17/14 AM

File Name : Pond near Nahatan AM and PM
Site Code : 04081423
Start Date : 4/8/2014

	High St From North					Pond Street From East					High St From South					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1																
Peak Hour for Entire Intersection Begins at 04:45 PM																
04:45 PM	0	**226**	56	0	282	**46**	0	0	0	**46**	0	105	0	0	105	433
05:00 PM	0	195	**90**	**1**	286	35	0	**1**	**1**	37	0	**117**	0	0	**117**	**440**
05:15 PM	0	192	57	0	249	34	0	0	1	35	0	114	0	0	114	398
05:30 PM	0	223	68	1	**292**	28	0	0	0	28	0	108	0	0	108	428
Total Volume	0	836	271	2	1109	143	0	1	2	146	0	444	0	0	444	1699
% App. Total	0	75.4	24.4	0.2		97.9	0	0.7	1.4		0	100	0	0		
PHF	.000	.925	.753	.500	.949	.777	.000	.250	.500	.793	.000	.949	.000	.000	.949	.965


High St
Out 587
In 1109
Total 1696
Right 0
Thru 836
Left 271
Peds 2
Peak Hour Data
North
Pond Street
Total 0
In 0
Out 0
Pond Street
Out 271
In 146
Total 417
Right 143
Thru 0
Left 1
Peds 2
Peak Hour Begins at 04:45 PM
Autos
Heavy Vehicles
Bicycles
Left 0
Thru 444
Right 0
Peds 0
Out 837
In 444
Total 1281
High St

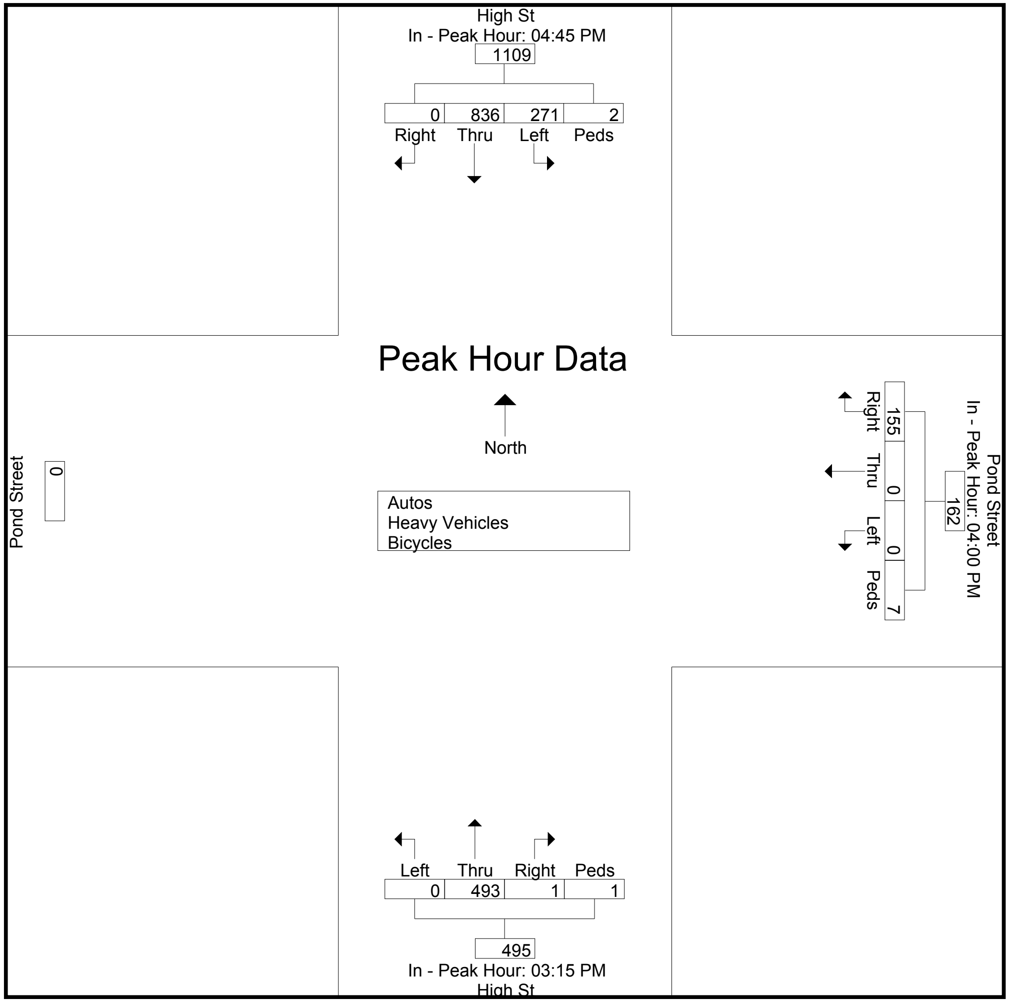
Central Transportation Planning Staff
High St (Rte 109) at Pond St (near Nahatan St)
04/08/14 PM and 04/17/14 AM

File Name : Pond near Nahatan AM and PM
Site Code : 04081423
Start Date : 4/8/2014
Page No : 13

	High St From North					Pond Street From East					High St From South					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1																
Peak Hour for Each Approach Begins at:																
	04:45 PM					04:00 PM					03:15 PM					
+0 mins.	0	**226**	56	0	282	36	0	0	2	38	0	119	0	0	119	
+15 mins.	0	195	**90**	**1**	286	36	0	0	**3**	39	0	**126**	0	0	**126**	
+30 mins.	0	192	57	0	249	37	0	0	2	39	**1**	122	0	**1**	124	
+45 mins.	0	223	68	1	**292**	**46**	0	0	0	**46**	0	126	0	0	126	
Total Volume	0	836	271	2	1109	155	0	0	7	162	1	493	0	1	495	
% App. Total	0	75.4	24.4	0.2		95.7	0	0	4.3		0.2	99.6	0	0.2		
PHF	.000	.925	.753	.500	.949	.842	.000	.000	.583	.880	.250	.978	.000	.250	.982	

Central Transportation Planning Staff
High St (Rte 109) at Pond St (near Nahatan St)
04/08/14 PM and 04/17/14 AM

File Name : Pond near Nahatan AM and PM
Site Code : 04081423
Start Date : 4/8/2014



Central Transportation Planning Staff
High St (Rte 109) at Pond St (Sheehan School)
04/10/14

File Name : Pond near Sheehan AM+MID+PM
Site Code : 04101402
Start Date : 4/10/2014

Groups Printed- Autos - Heavy Vehicles - Bicycles

	High St From North					Pond St From East					High St From South					Driveway From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:00 AM	1	67	2	0	70	9	0	36	0	45	75	195	0	0	270	0	0	1	0	1	386
07:15 AM	0	59	2	0	61	6	0	48	0	54	99	181	0	0	280	0	0	0	0	0	395
07:30 AM	0	89	3	0	92	5	0	49	0	54	99	185	0	0	284	0	0	0	0	0	430
07:45 AM	0	94	7	0	101	5	0	59	0	64	110	173	0	1	284	0	0	0	0	0	449
Total	1	309	14	0	324	25	0	192	0	217	383	734	0	1	1118	0	0	1	0	1	1660
08:00 AM	0	86	8	0	94	11	0	48	0	59	91	164	0	0	255	0	0	0	0	0	408
08:15 AM	0	76	5	0	81	8	0	40	0	48	94	177	0	1	272	0	0	0	0	0	401
08:30 AM	0	64	18	0	82	29	0	58	0	87	103	148	0	0	251	1	0	0	0	1	421
08:45 AM	0	77	7	0	84	26	0	38	0	64	85	175	0	1	261	0	0	0	0	0	409
Total	0	303	38	0	341	74	0	184	0	258	373	664	0	2	1039	1	0	0	0	1	1639
*** BREAK ***																					
11:00 AM	0	87	3	0	90	7	0	36	0	43	36	94	0	1	131	0	0	0	0	0	264
11:15 AM	0	75	6	0	81	6	0	29	0	35	31	92	0	0	123	0	0	0	0	0	239
11:30 AM	0	94	4	0	98	9	0	27	0	36	25	119	0	0	144	0	0	0	0	0	278
11:45 AM	0	99	4	0	103	6	0	30	0	36	35	112	0	0	147	0	0	0	0	0	286
Total	0	355	17	0	372	28	0	122	0	150	127	417	0	1	545	0	0	0	0	0	1067
12:00 PM	0	110	3	0	113	8	0	35	0	43	38	118	0	0	156	0	0	0	0	0	312
12:15 PM	0	101	7	0	108	1	0	28	0	29	28	114	0	0	142	0	0	0	0	0	279
12:30 PM	0	104	4	0	108	8	0	24	0	32	38	104	0	0	142	0	0	0	0	0	282
12:45 PM	0	92	11	1	104	7	0	42	0	49	40	81	0	0	121	0	0	0	0	0	274
Total	0	407	25	1	433	24	0	129	0	153	144	417	0	0	561	0	0	0	0	0	1147
01:00 PM	0	96	4	0	100	7	0	39	0	46	32	88	0	0	120	0	0	0	0	0	266
01:15 PM	0	89	3	0	92	10	0	40	0	50	26	79	0	2	107	0	0	0	0	0	249
01:30 PM	0	100	8	0	108	9	0	45	0	54	51	115	0	0	166	0	0	0	0	0	328
01:45 PM	0	104	6	1	111	7	0	30	0	37	49	94	0	0	143	0	0	0	0	0	291
Total	0	389	21	1	411	33	0	154	0	187	158	376	0	2	536	0	0	0	0	0	1134
*** BREAK ***																					
03:00 PM	0	141	6	0	147	10	0	60	0	70	41	108	0	0	149	0	0	0	0	0	366
03:15 PM	1	141	9	0	151	14	1	69	0	84	34	107	0	0	141	1	0	0	0	1	377
03:30 PM	2	159	4	0	165	10	0	58	0	68	40	127	1	0	168	0	0	0	0	0	401
03:45 PM	0	148	6	0	154	10	0	65	0	75	43	89	0	0	132	0	0	0	0	0	361
Total	3	589	25	0	617	44	1	252	0	297	158	431	1	0	590	1	0	0	0	1	1505
04:00 PM	1	140	11	0	152	17	0	82	2	101	50	88	0	0	138	0	0	0	0	0	391
04:15 PM	0	170	7	0	177	15	0	87	2	104	49	101	0	8	158	0	0	0	0	0	439
04:30 PM	1	189	10	0	200	8	0	77	0	85	52	111	0	0	163	2	0	0	0	2	450
04:45 PM	1	197	5	0	203	12	0	65	0	77	36	95	0	0	131	0	0	0	0	0	411
Total	3	696	33	0	732	52	0	311	4	367	187	395	0	8	590	2	0	0	0	2	1691

Central Transportation Planning Staff
High St (Rte 109) at Pond St (Sheehan School)
04/10/14

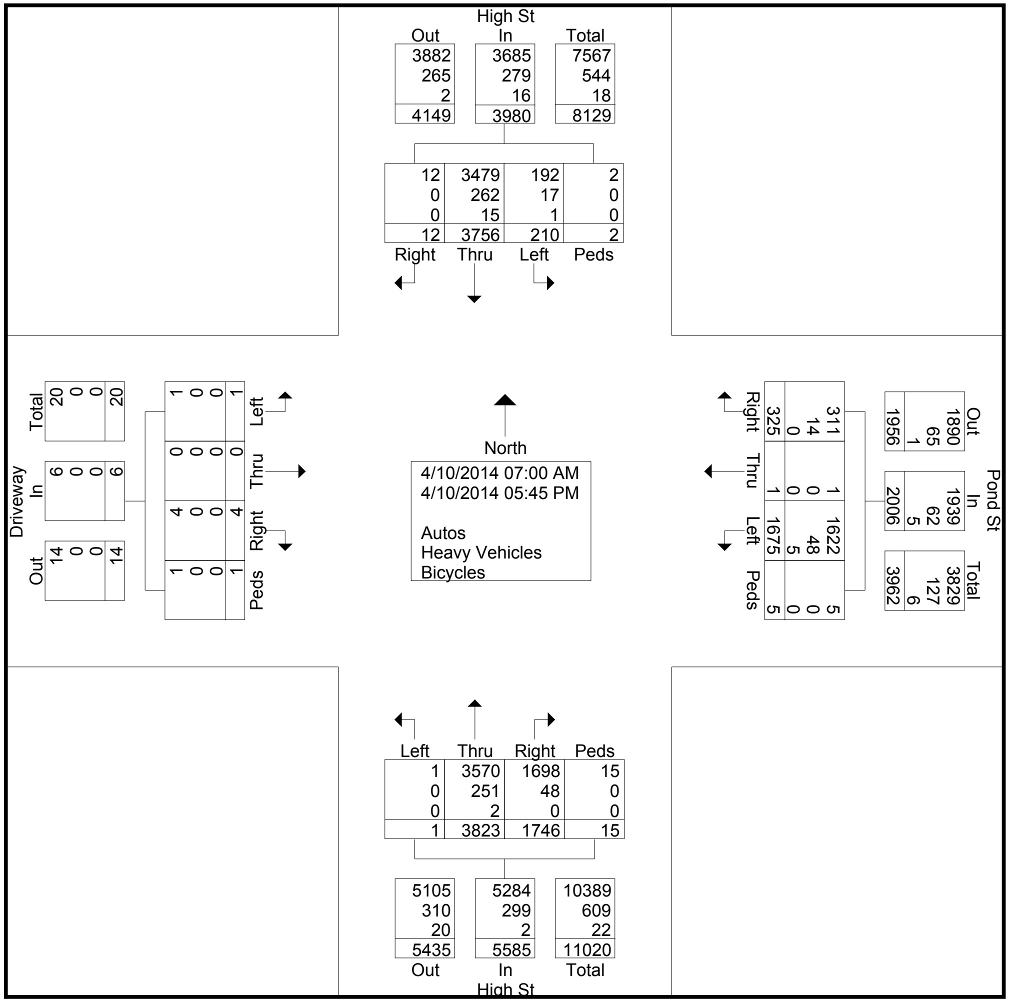
File Name : Pond near Sheehan AM+MID+PM
Site Code : 04101402
Start Date : 4/10/2014
Page No : 2

Groups Printed- Autos - Heavy Vehicles - Bicycles

	High St From North					Pond St From East					High St From South					Driveway From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
05:00 PM	5	186	15	0	206	6	0	67	0	73	59	97	0	0	156	0	0	0	1	1	436
05:15 PM	0	178	12	0	190	24	0	82	0	106	55	129	0	0	184	0	0	0	0	0	480
05:30 PM	0	187	6	0	193	5	0	82	0	87	60	91	0	0	151	0	0	0	0	0	431
05:45 PM	0	157	4	0	161	10	0	100	1	111	42	72	0	1	115	0	0	0	0	0	387
Total	5	708	37	0	750	45	0	331	1	377	216	389	0	1	606	0	0	0	1	1	1734
Grand Total	12	3756	210	2	3980	325	1	1675	5	2006	1746	3823	1	15	5585	4	0	1	1	6	11577
Apprch %	0.3	94.4	5.3	0.1		16.2	0	83.5	0.2		31.3	68.5	0	0.3		66.7	0	16.7	16.7		
Total %	0.1	32.4	1.8	0	34.4	2.8	0	14.5	0	17.3	15.1	33	0	0.1	48.2	0	0	0	0	0.1	
Autos	12	3479	192	2	3685	311	1	1622	5	1939	1698	3570	1	15	5284	4	0	1	1	6	10914
% Autos	100	92.6	91.4	100	92.6	95.7	100	96.8	100	96.7	97.3	93.4	100	100	94.6	100	0	100	100	100	94.3
Heavy Vehicles	0	262	17	0	279	14	0	48	0	62	48	251	0	0	299	0	0	0	0	0	640
% Heavy Vehicles	0	7	8.1	0	7	4.3	0	2.9	0	3.1	2.7	6.6	0	0	5.4	0	0	0	0	0	5.5
Bicycles	0	15	1	0	16	0	0	5	0	5	0	2	0	0	2	0	0	0	0	0	23
% Bicycles	0	0.4	0.5	0	0.4	0	0	0.3	0	0.2	0	0.1	0	0	0	0	0	0	0	0	0.2

Central Transportation Planning Staff
High St (Rte 109) at Pond St (Sheehan School)
04/10/14

File Name : Pond near Sheehan AM+MID+PM
Site Code : 04101402
Start Date : 4/10/2014
Page No : 3



North

4/10/2014 07:00 AM
4/10/2014 05:45 PM

Autos
Heavy Vehicles
Bicycles

High St (north)

Out	In	Total
3882	3685	7567
265	279	544
2	16	18
4149	3980	8129

Right	Thru	Left	Peds
12	3479	192	2
0	262	17	0
0	15	1	0
12	3756	210	2

Driveway

Out	In	Total
14	6	20
0	0	0
0	0	0
14	6	20

Left	Thru	Right	Peds
1	0	4	1
0	0	0	0
0	0	0	0
1	0	4	1

Pond St

Out	In	Total
1890	1939	3829
65	62	127
1	5	6
1956	2006	3962

Right	Thru	Left	Peds
311	1	1622	5
14	0	48	0
0	0	5	0
325	1	1675	5

High St (south)

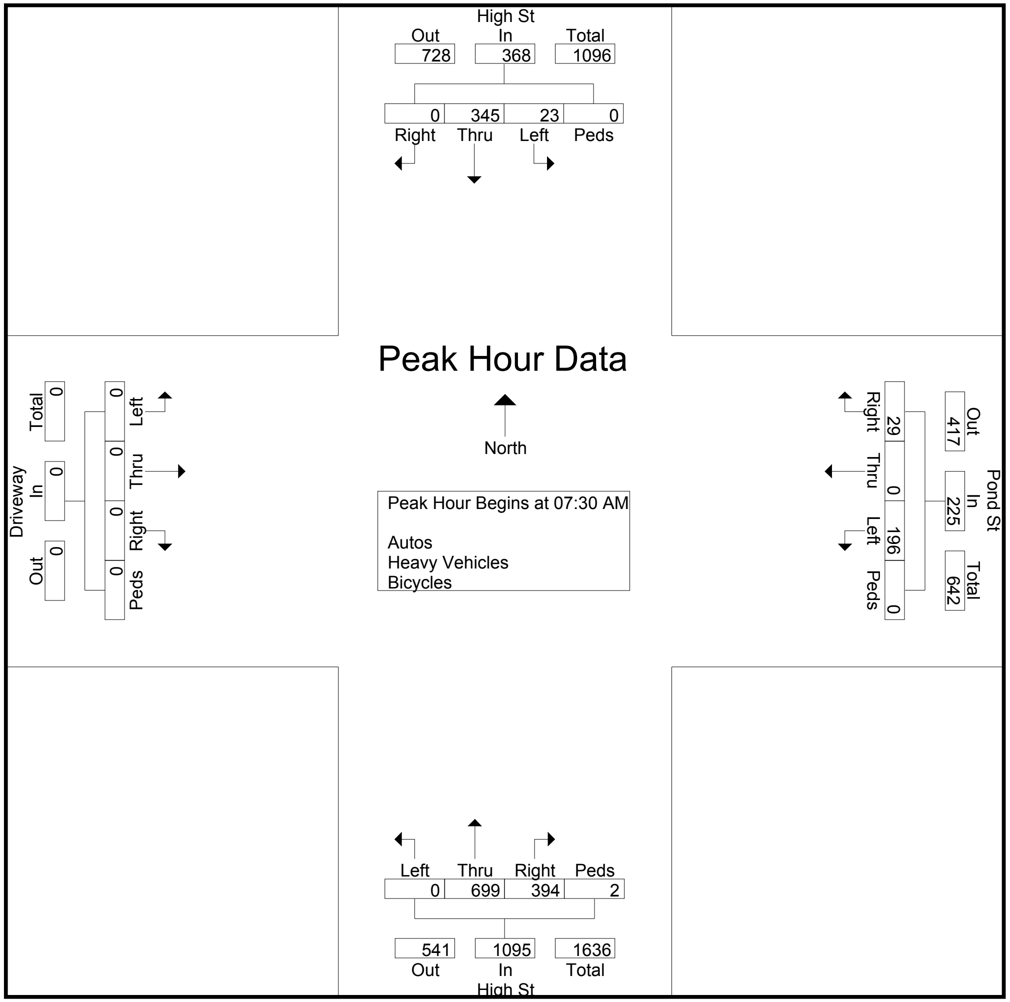
Left	Thru	Right	Peds
1	3570	1698	15
0	251	48	0
0	2	0	0
1	3823	1746	15

Out	In	Total
5105	5284	10389
310	299	609
20	2	22
5435	5585	11020

	High St From North					Pond St From East					High St From South					Driveway From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 09:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:30 AM																					
07:30 AM	0	89	3	0	92	5	0	49	0	54	99	**185**	0	0	**284**	0	0	0	0	0	430
07:45 AM	0	**94**	7	0	**101**	5	0	**59**	0	**64**	**110**	173	0	**1**	284	0	0	0	0	0	**449**
08:00 AM	0	86	**8**	0	94	**11**	0	48	0	59	91	164	0	0	255	0	0	0	0	0	408
08:15 AM	0	76	5	0	81	8	0	40	0	48	94	177	0	1	272	0	0	0	0	0	401
Total Volume	0	345	23	0	368	29	0	196	0	225	394	699	0	2	1095	0	0	0	0	0	1688
% App. Total	0	93.8	6.2	0		12.9	0	87.1	0		36	63.8	0	0.2		0	0	0	0		
PHF	.000	.918	.719	.000	.911	.659	.000	.831	.000	.879	.895	.945	.000	.500	.964	.000	.000	.000	.000	.000	.940

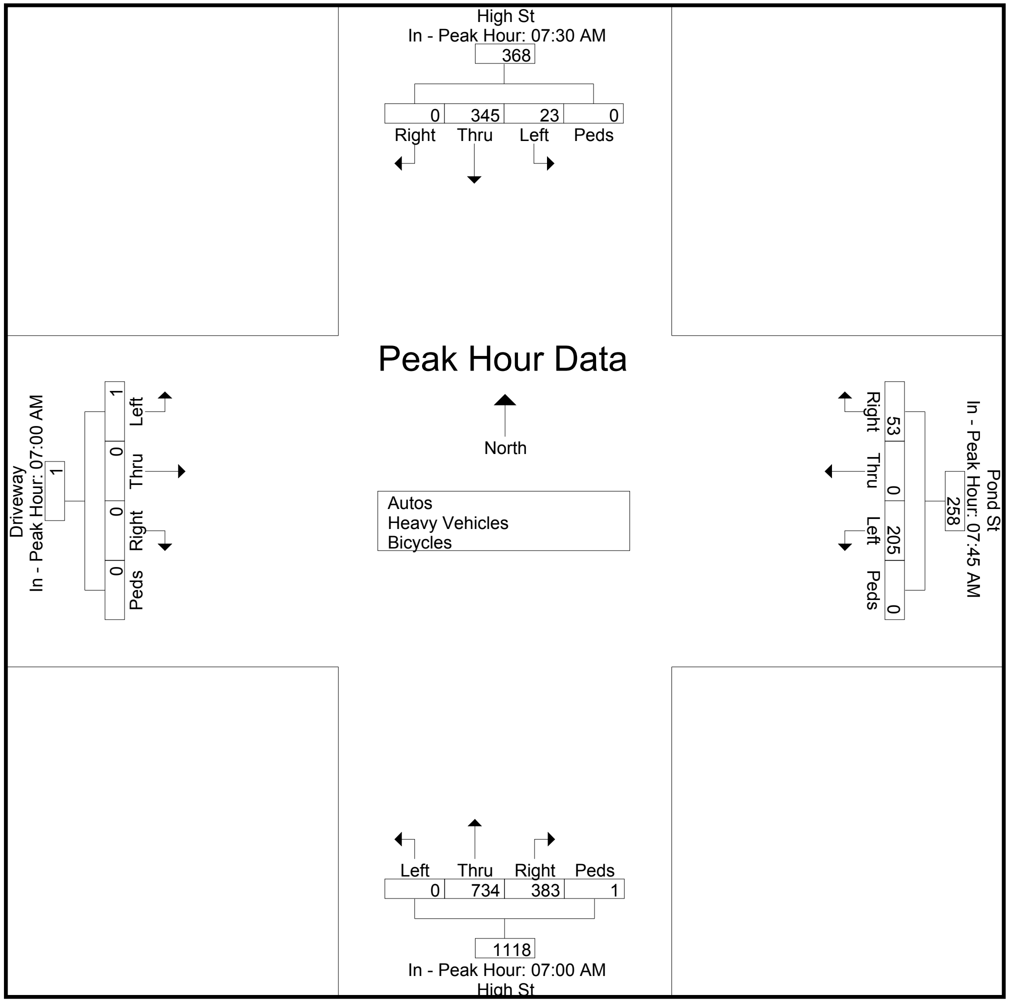
Central Transportation Planning Staff
High St (Rte 109) at Pond St (Sheehan School)
04/10/14

File Name : Pond near Sheehan AM+MID+PM
Site Code : 04101402
Start Date : 4/10/2014
Page No : 6



Central Transportation Planning Staff
High St (Rte 109) at Pond St (Sheehan School)
04/10/14

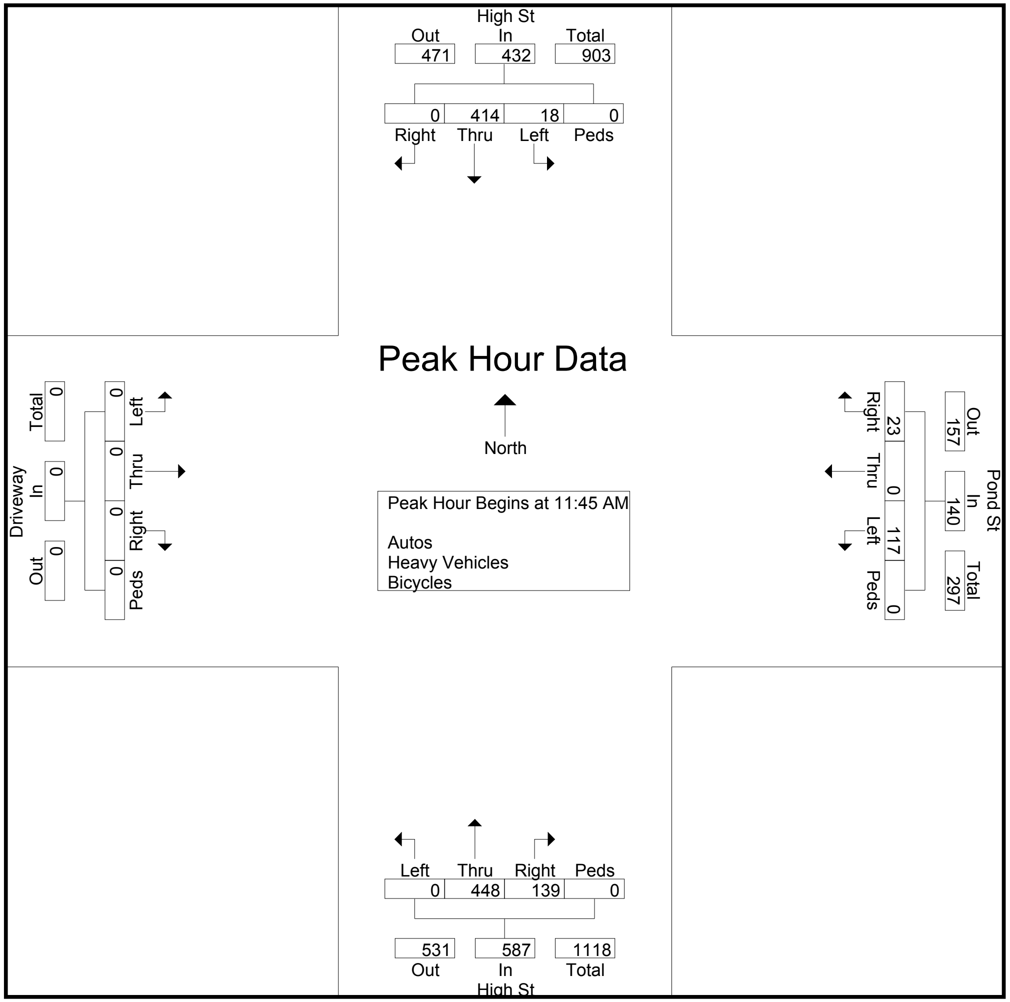
	High St From North					Pond St From East					High St From South					Driveway From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 09:45 AM - Peak 1 of 1																					
Peak Hour for Each Approach Begins at:																					
	07:30 AM					07:45 AM					07:00 AM					07:00 AM					
+0 mins.	0	89	3	0	92	5	0	**59**	0	64	75	**195**	0	0	270	0	0	**1**	0	**1**	
+15 mins.	0	**94**	7	0	**101**	11	0	48	0	59	99	181	0	0	280	0	0	0	0	0	
+30 mins.	0	86	**8**	0	94	8	0	40	0	48	99	185	0	0	**284**	0	0	0	0	0	
+45 mins.	0	76	5	0	81	**29**	0	58	0	**87**	**110**	173	0	**1**	284	0	0	0	0	0	
Total Volume	0	345	23	0	368	53	0	205	0	258	383	734	0	1	1118	0	0	1	0	1	
% App. Total	0	93.8	6.2	0		20.5	0	79.5	0		34.3	65.7	0	0.1		0	0	100	0		
PHF	.000	.918	.719	.000	.911	.457	.000	.869	.000	.741	.870	.941	.000	.250	.984	.000	.000	.250	.000	.250	


High St
In - Peak Hour: 07:30 AM
368
0
345
23
0
Right
Thru
Left
Peds
Peak Hour Data
North
Autos
Heavy Vehicles
Bicycles
Driveway
In - Peak Hour: 07:00 AM
1
1
Left
0
Thru
0
Right
0
Peds
Pond St
In - Peak Hour: 07:45 AM
258
53
Right
0
Thru
205
Left
0
Peds
Left
Thru
Right
Peds
0
734
383
1
1118
In - Peak Hour: 07:00 AM
High St

Central Transportation Planning Staff
High St (Rte 109) at Pond St (Sheehan School)
04/10/14

File Name : Pond near Sheehan AM+MID+PM
Site Code : 04101402
Start Date : 4/10/2014
Page No : 11

	High St From North					Pond St From East					High St From South					Driveway From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 10:00 AM to 01:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 11:45 AM																					
11:45 AM	0	99	4	0	103	6	0	30	0	36	35	112	0	0	147	0	0	0	0	0	286
12:00 PM	0	**110**	3	0	**113**	**8**	0	**35**	0	**43**	**38**	**118**	0	0	**156**	0	0	0	0	0	**312**
12:15 PM	0	101	**7**	0	108	1	0	28	0	29	28	114	0	0	142	0	0	0	0	0	279
12:30 PM	0	104	4	0	108	8	0	24	0	32	38	104	0	0	142	0	0	0	0	0	282
Total Volume	0	414	18	0	432	23	0	117	0	140	139	448	0	0	587	0	0	0	0	0	1159
% App. Total	0	95.8	4.2	0		16.4	0	83.6	0		23.7	76.3	0	0		0	0	0	0		
PHF	.000	.941	.643	.000	.956	.719	.000	.836	.000	.814	.914	.949	.000	.000	.941	.000	.000	.000	.000	.000	.929

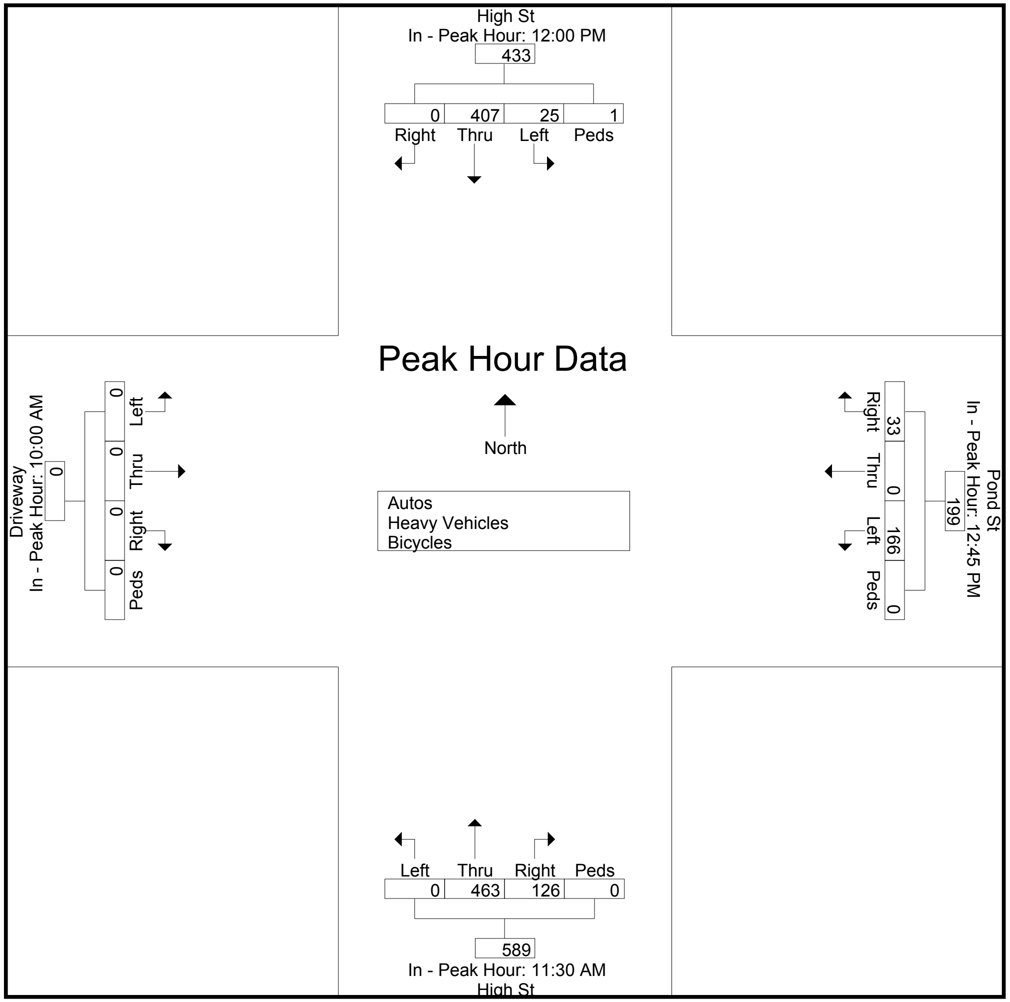

High St
Out
471
In
432
Total
903
0
414
18
0
Right
Thru
Left
Peds
Peak Hour Data
North
Peak Hour Begins at 11:45 AM
Autos
Heavy Vehicles
Bicycles
Driveway
Total
0
In
0
Out
0
0
Left
0
Thru
0
Right
0
Peds
Pond St
Out
157
In
140
Total
297
23
Right
0
Thru
117
Left
0
Peds
Left
Thru
Right
Peds
0
448
139
0
531
Out
587
In
1118
Total
High St

Central Transportation Planning Staff
High St (Rte 109) at Pond St (Sheehan School)
04/10/14

File Name : Pond near Sheehan AM+MID+PM
Site Code : 04101402
Start Date : 4/10/2014

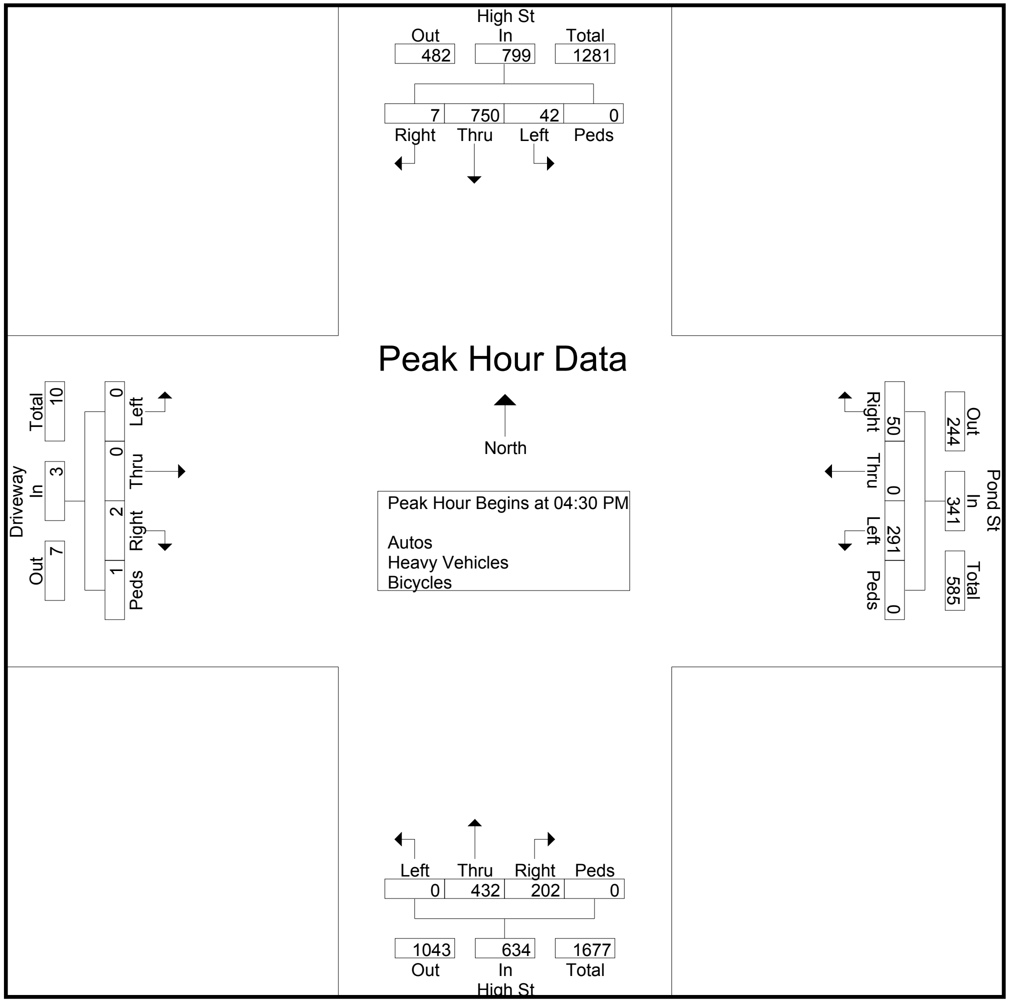
	High St From North					Pond St From East					High St From South					Driveway From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 10:00 AM to 01:45 PM - Peak 1 of 1																					
Peak Hour for Each Approach Begins at:																					
	12:00 PM					12:45 PM					11:30 AM					10:00 AM					
+0 mins.	0	**110**	3	0	**113**	7	0	42	0	49	25	**119**	0	0	144	0	0	0	0	0	
+15 mins.	0	101	7	0	108	7	0	39	0	46	35	112	0	0	147	0	0	0	0	0	
+30 mins.	0	104	4	0	108	**10**	0	40	0	50	**38**	118	0	0	**156**	0	0	0	0	0	
+45 mins.	0	92	**11**	**1**	104	9	0	**45**	0	**54**	28	114	0	0	142	0	0	0	0	0	
Total Volume	0	407	25	1	433	33	0	166	0	199	126	463	0	0	589	0	0	0	0	0	
% App. Total	0	94	5.8	0.2		16.6	0	83.4	0		21.4	78.6	0	0		0	0	0	0		
PHF	.000	.925	.568	.250	.958	.825	.000	.922	.000	.921	.829	.973	.000	.000	.944	.000	.000	.000	.000	.000	

Central Transportation Planning Staff
High St (Rte 109) at Pond St (Sheehan School)
04/10/14



Central Transportation Planning Staff
High St (Rte 109) at Pond St (Sheehan School)
04/10/14

	High St From North					Pond St From East					High St From South					Driveway From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 02:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:30 PM																					
04:30 PM	1	189	10	0	200	8	0	77	0	85	52	111	0	0	163	**2**	0	0	0	**2**	450
04:45 PM	1	**197**	5	0	203	12	0	65	0	77	36	95	0	0	131	0	0	0	0	0	411
05:00 PM	**5**	186	**15**	0	**206**	6	0	67	0	73	**59**	97	0	0	156	0	0	0	**1**	1	436
05:15 PM	0	178	12	0	190	**24**	0	**82**	0	**106**	55	**129**	0	0	**184**	0	0	0	0	0	**480**
Total Volume	7	750	42	0	799	50	0	291	0	341	202	432	0	0	634	2	0	0	1	3	1777
% App. Total	0.9	93.9	5.3	0		14.7	0	85.3	0		31.9	68.1	0	0		66.7	0	0	33.3		
PHF	.350	.952	.700	.000	.970	.521	.000	.887	.000	.804	.856	.837	.000	.000	.861	.250	.000	.000	.250	.375	.926


High St
Out 482
In 799
Total 1281
Right 7
Thru 750
Left 42
Peds 0
Peak Hour Data
North
Peak Hour Begins at 04:30 PM
Autos
Heavy Vehicles
Bicycles
Driveway
Total 10
In 3
Out 7
Left 0
Thru 0
Right 2
Peds 1
Pond St
Out 244
In 341
Total 585
Right 50
Thru 0
Left 291
Peds 0
Left 0
Thru 432
Right 202
Peds 0
Out 1043
In 634
Total 1677
High St

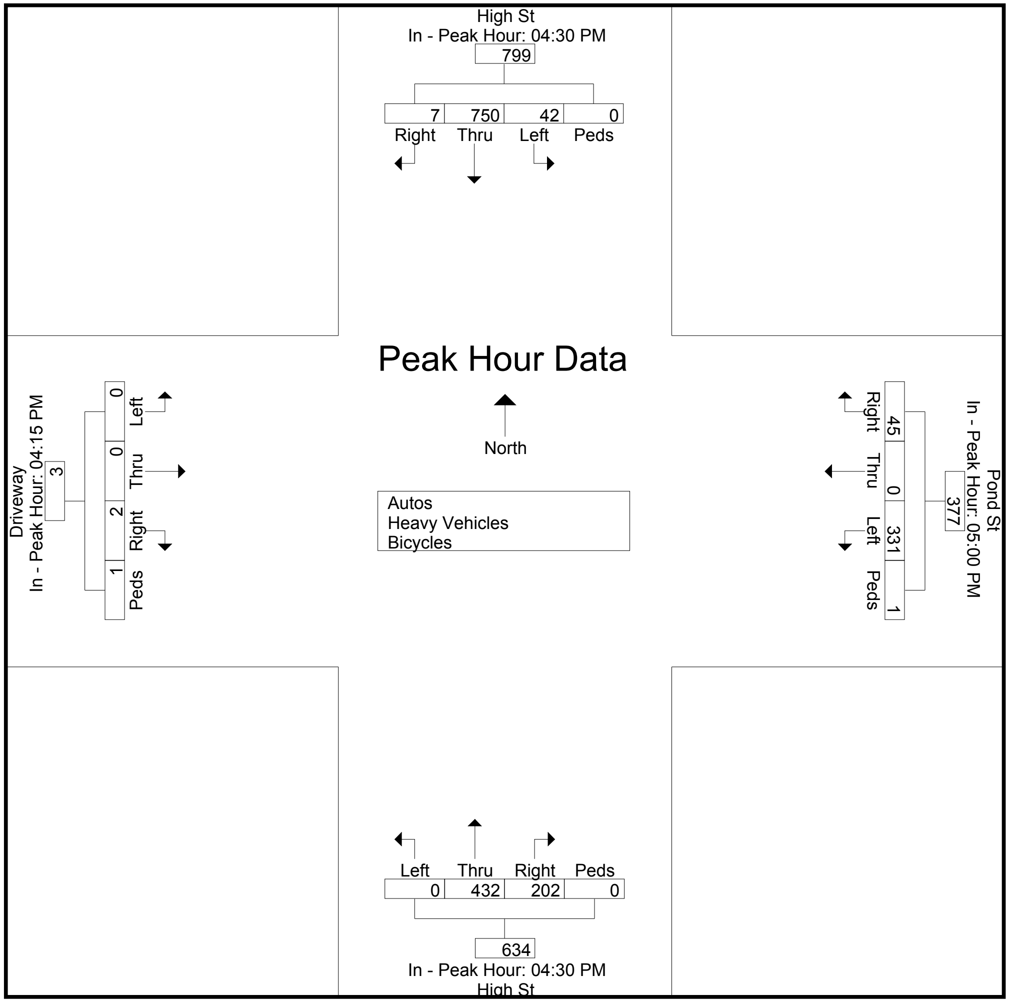
Central Transportation Planning Staff
High St (Rte 109) at Pond St (Sheehan School)
04/10/14

File Name : Pond near Sheehan AM+MID+PM
Site Code : 04101402
Start Date : 4/10/2014

	High St From North					Pond St From East					High St From South					Driveway From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 02:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Each Approach Begins at:																					
	04:30 PM					05:00 PM					04:30 PM					04:15 PM					
+0 mins.	1	189	10	0	200	6	0	67	0	73	52	111	0	0	163	0	0	0	0	0	
+15 mins.	1	**197**	5	0	203	**24**	0	82	0	106	36	95	0	0	131	**2**	0	0	0	**2**	
+30 mins.	**5**	186	**15**	0	**206**	5	0	82	0	87	**59**	97	0	0	156	0	0	0	0	0	
+45 mins.	0	178	12	0	190	10	0	**100**	**1**	**111**	55	**129**	0	0	**184**	0	0	0	**1**	1	
Total Volume	7	750	42	0	799	45	0	331	1	377	202	432	0	0	634	2	0	0	1	3	
% App. Total	0.9	93.9	5.3	0		11.9	0	87.8	0.3		31.9	68.1	0	0		66.7	0	0	33.3		
PHF	.350	.952	.700	.000	.970	.469	.000	.828	.250	.849	.856	.837	.000	.000	.861	.250	.000	.000	.250	.375	

Central Transportation Planning Staff
High St (Rte 109) at Pond St (Sheehan School)
04/10/14

File Name : Pond near Sheehan AM+MID+PM
Site Code : 04101402
Start Date : 4/10/2014
Page No : 21



APPENDIX C

Crash Data

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Westwood

COUNT DATE : 4/10/2014

DISTRICT : 3

UNSIGNALIZED : ☒

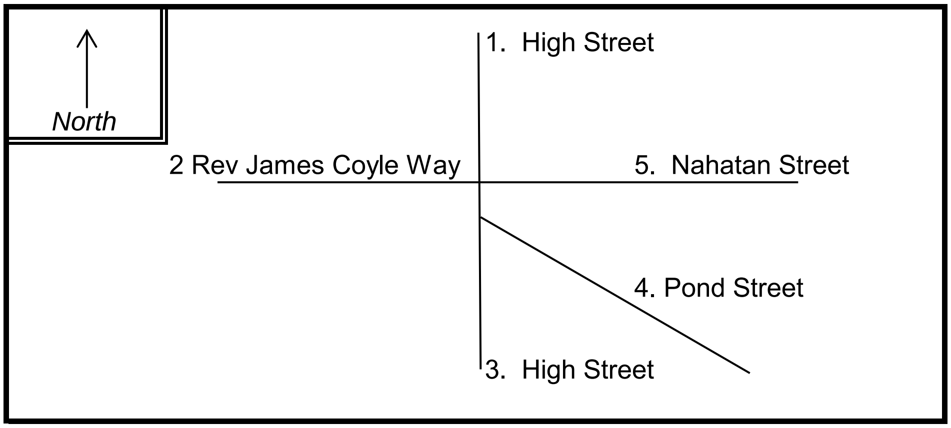
SIGNALIZED : ☐

~ INTERSECTION DATA ~

MAJOR STREET : Route 109 (High Street)

MINOR STREET(S) : Nahatan Street, Pond Street and Rev. James Coyle Way

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	SB	EB	NB	NWB	WB	
PEAK HOURLY VOLUMES (AM/PM) :	1,113	23	461	143	354	**2,094**

" K " FACTOR : **0.090**

INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **23,267**

TOTAL # OF CRASHES : 38

OF YEARS : 5

AVERAGE # OF CRASHES PER YEAR (**A**) : **7.80**

CRASH RATE CALCULATION : **0.92**

$$\text{RATE} = \frac{(A * 1{,}000{,}000)}{(V * 365)}$$

Comments :

Project Title & Date: Safety and Operations Analyses at Selected Intersections--FFY 2014

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Westwood

COUNT DATE : 4/11/2014

DISTRICT : 3

UNSIGNALIZED : X

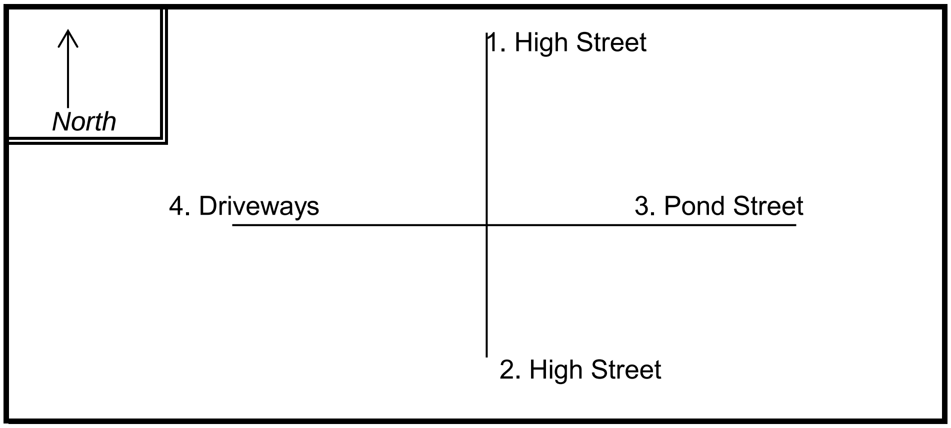
SIGNALIZED :

~ INTERSECTION DATA ~

MAJOR STREET : High Street

MINOR STREET(S) : Pond Street

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	**1**	**2**	**3**	**4**	**5**	**Total Peak Hourly Approach Volume**
DIRECTION :	SB	NB	WB	EB		
PEAK HOURLY VOLUMES (AM/PM) :	792	634	270	2		**1,698**

" K " FACTOR : **0.090**

INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **18,867**

TOTAL # OF CRASHES : 9

OF YEARS : 5

AVERAGE # OF CRASHES PER YEAR (**A**) : **1.80**

CRASH RATE CALCULATION : **0.26**

$$\text{RATE} = \frac{(A * 1{,}000{,}000)}{(V * 365)}$$

Comments :

Project Title & Date:

Crash Data 2009 to 2013
High Street at Nahatan Street Intersection

ID	Crash Number	Crash Year	Crash Time	Crash Date2	Crash Severity	Total Nonfatal Injury	Total Fatal Injury	Manner of Collision	Road Surface Condition	Ambient Light Condition	Weather Condition	Non Motorist Collision	Vehicle Action
1		2010	9:19 PM	40241	Property damage only	0	0	Angle	Wet	Dark - lighted roadway	Cloudy		V1: Travelling straight ahead / V2:Turning right
2	2607022	2010	2:55 PM	11-May-2010	Property damage only (n	0	0	Rear-end	Dry	Daylight	Clear		V1: Slowing or stopped in traffic / V2:Slowing or sto
3	2652305	2010	6:28 PM	04-Oct-2010	Property damage only (n	0	0	Rear-end	Wet	Dark - lighted roadway	Rain		V1: Slowing or stopped in traffic / V2:Travelling stra
4	2683451	2011	2:34 PM	10-Jan-2011	Non-fatal injury	1	0	Single vehicle crash	Dry	Daylight	Clear	P1:Pedestrian	V1: Travelling straight ahead
5	2815234	2011	6:44 PM	13-Nov-2011	Non-fatal injury	2	0	Rear-end	Dry	Dark - lighted roadway	Clear		V1: Slowing or stopped in traffic / V2:Travelling stra
6		2012	7:50 PM	07-May-2012	Non-fatal injury	0	0	Rear-end	Dry	Daylight	Clear		V1: Slowing or stopped in traffic / V2:Travelling stra
7		2012	5:29 PM	24-Dec-2012	Property damage only (n	0	0	Rear-end	Dry	Dark - lighted roadway	Clear		V1: Slowing or stopped in traffic / V2:Travelling stra
8		2013	3:39 AM	25-May-2013	Non-fatal injury	1	0	Single vehicle crash	Wet	Dark - lighted roadway	Cloudy		V1: Travelling straight ahead
9		2013	9:07 AM	29-Oct-2013	Non-fatal injury	0	0	Sideswipe, same direction	Dry	Daylight	Rain		V1: Travelling straight ahead / V2:Travelling straigh
10	2478189	2009	11:06 AM	04-Jun-2009	Property damage only (n	0	0	Rear-end	Dry	Daylight	Clear		V1: Entering traffic lane / V2:Entering traffic lane
11	2594527	2009	4:00 PM	24-Aug-2009	Non-fatal injury	1	0	Rear-end	Dry	Daylight	Clear		V1: Entering traffic lane / V2:Entering traffic lane
12	2594648	2010	9:04 PM	16-Feb-2010	Property damage only (n	0	0	Single vehicle crash	Snow	Dark - lighted roadway	Snow		V1: Turning left
13		2013	4:31 PM	16-Oct-2013	Property damage only (n	0	0	Single vehicle crash	Dry	Daylight	Clear		V1: Travelling straight ahead
14	2455419	2009	4:07 PM	08-Apr-2009	Property damage only (n	0	0	Sideswipe, same direction	Dry	Daylight	Cloudy		V1: Travelling straight ahead / V2:Entering traffic la
15	2471063	2009	9:33 PM	15-May-2009	Non-fatal injury	2	0	Rear-end	Dry	Dark - lighted roadway	Clear		V1: Entering traffic lane / V2:Entering traffic lane
16	2594677	2010	2:14 PM	22-Mar-2010	Property damage only (n	0	0	Rear-end	Wet	Daylight	Rain		V1: Travelling straight ahead / V2:Travelling straigh
17	2594686	2010	9:14 AM	14-Apr-2010	Property damage only (n	0	0	Sideswipe, same direction	Dry	Daylight	Clear		V1: Changing lanes / V2:Travelling straight ahead
18	2600078	2010	10:42 AM	07-May-2010	Property damage only (n	0	0	Angle	Dry	Daylight	Clear		V1: Turning left / V2:Turning left
19	2629955	2010	8:22 AM	10-Aug-2010	Property damage only (n	0	0	Angle	Dry	Daylight	Clear		V1: Overtaking/passing / V2:Turning left
20	2652309	2010	8:05 AM	13-Oct-2010	Property damage only (n	0	0	Single vehicle crash	Dry	Daylight	Clear		V1: Travelling straight ahead / V2:Travelling straigh
21	2662471	2010	5:15 PM	08-Nov-2010	Property damage only (n	0	0	Angle	Wet	Dark - lighted roadway	Rain		V1: Turning left / V2:Travelling straight ahead
22	2716642	2011	12:54 PM	18-Apr-2011	Property damage only (n	0	0	Sideswipe, same direction	Dry	Daylight	Clear		V1: Turning right / V2:Travelling straight ahead
23	2740002	2011	9:41 AM	24-Jun-2011	Property damage only (n	0	0	Rear-end	Wet	Daylight	Cloudy		V1: Travelling straight ahead / V2:Slowing or stopp
24	2649263	2010	2:08 PM	02-Oct-2010	Property damage only (n	0	0	Sideswipe, same direction	Dry	Daylight	Clear		V1: Travelling straight ahead / V2:Travelling straigh
25	2750636	2011	5:42 PM	28-Jul-2011	Property damage only (n	0	0	Angle	Dry	Daylight	Clear		V1: Turning left / V2:Travelling straight ahead
26		2012	6:44 PM	01-Mar-2012	Property damage only (n	0	0	Rear-end	Snow	Dark - lighted roadway	Snow		V1: Travelling straight ahead / V2:Travelling straigh
27		2012	9:32 PM	23-Apr-2012	Property damage only (n	0	0	Sideswipe, same direction	Dry	Dark - lighted roadway	Clear		V1: Changing lanes / V2:Travelling straight ahead
28		2012	8:50 AM	21-May-2012	Property damage only (n	0	0	Angle	Wet	Daylight	Rain		V1: Turning left / V2:Travelling straight ahead
29		2012	2:24 PM	24-May-2012	Property damage only (n	0	0	Rear-end	Dry	Daylight	Clear		V1: Turning right / V2:Turning right
30		2012	2:49 PM	17-Sep-2012	Property damage only (n	0	0	Rear-end	Dry	Daylight	Clear		V1: Turning right / V2:Turning right
31		2012	7:34 AM	21-Sep-2012	Property damage only (n	0	0	Rear-end	Dry	Daylight	Clear		V1: Turning right / V2:Turning right
32		2012	5:44 PM	10-Dec-2012	Property damage only (n	0	0	Angle	Wet	Dark - lighted roadway	Rain		V1: Turning left / V2:Turning left
33		2013	6:44 AM	19-Mar-2013	Property damage only (n	0	0	Rear-end	Snow	Daylight	Snow		V1: Slowing or stopped in traffic / V2:Travelling stra
34		2013	11:00 AM	15-Nov-2013	Non-fatal injury	1	0	Angle	Dry	Daylight	Clear		V1: Travelling straight ahead / V2:Travelling straigh
35		2013	1:03 PM	20-Dec-2013	Non-fatal injury	1	0	Rear-end	Dry	Daylight	Clear		V1: Entering traffic lane / V2:Travelling straight ahe
36		2013	8:36 AM	09-Aug-2013	Property damage only (n	0	0	Single vehicle crash	Dry	Daylight	Clear		V1: Travelling straight ahead
37		2011	5:42 PM	28-Jul-2011	Property damage only (n	0	0	Angle	Dry	Daylight	Clear		V1: Turning left / V2:Travelling straight ahead
38		2010	2:08 PM	02-Oct-2010	Property damage only (n	0	0	Sideswipe, same direction	Dry	Daylight	Clear		V1: Travelling straight ahead / V2:Travelling straigh
39		2010	11:13 PM	10-Feb-2010	Property damage only (n	0	0	Single vehicle crash	Snow	Dark - lighted roadway	Snow		V1: Travelling straight ahead

Source: MassDOT Registry of Motor Vehicles and Westwood Police Department

Crash Data 2009 to 2013

High Street at Pond Street (near Sheehan School)

ID	Crash Number	Crash Year	Crash Time	Crash Date	Crash Severity	Total Nonfatal Injury	Total Fatal Injury	Manner of Collision	Road Surface	Ambient Light	Weather Condition	Vehicle Action
1	2444033	2009	9:51 AM	05-Mar-2009	Property damage only (n	0	0	Angle	Dry	Daylight	Clear	V1: Travelling straight ahead / V2:Turning left
2	2646813	2010	4:14 PM	18-Sep-2010	Property damage only (n	0	0	Angle	Dry	Daylight	Cloudy	V1: Turning left / V2:Turning left
3	2702033	2011	3:08 PM	04-Mar-2011	Property damage only (n	0	0	Angle	Dry	Daylight	Clear	V1: Turning left / V2:Turning left
4	2789517	2011	6:47 PM	06-Oct-2011	Property damage only (n	0	0	Single vehicle crash	Dry	Dark - lighted roadway	Clear	V1: Travelling straight ahead / V2:Travelling straight ah
5		2012	7:43 AM	14-May-2012	Property damage only (n	0	0	Angle	Wet	Daylight	Rain	V1: Turning right / V2:Travelling straight ahead
6		2012	12:23 PM	28-Nov-2012	Property damage only (n	0	0	Angle	Dry	Daylight	Cloudy	V1: Turning left / V2:Turning left
7		2013	4:07 PM	02-Feb-2013	Property damage only (n	0	0	Angle	Dry	Daylight	Clear	V1: Travelling straight ahead / V2:Turning left
8		2013	8:30 PM	17-Apr-2013	Property damage only (n	0	0	Angle	Dry	Dark - lighted roadway	Clear	V1: Turning right / V2:Travelling straight ahead
9	2612528	2010	8:15 AM	10-Jun-2010	Property damage only (n	0	0	Angle	Dry	Daylight	Cloudy	V1: Turning right / V2:Travelling straight ahead

Source: MassDOT Registry of Motor Vehicles and Westwood Police Department

APPENDIX D

Level of Service Analysis

Intersection	
Int Delay, s/veh	9.4

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	0	707	313	245	374	5	95	2	187	2	1	2
Conflicting Peds, #/hr	0	0	5	0	0	5	10	0	10	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	Free	-	-	None	-	-	Yield	-	-	None
Storage Length	-	-	-	250	-	-	-	-	150	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	1	-	-	1	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	90	90	90	90	90	90	90	90	90	90	90	90
Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3
Mvmt Flow	0	786	348	272	416	6	106	2	208	2	1	2

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	421	0	-	796	0	0	1760	1762	408	1367	1759	418
Stage 1	-	-	-	-	-	-	796	796	-	963	963	-
Stage 2	-	-	-	-	-	-	964	966	-	404	796	-
Critical Hdwy	4.13	-	-	4.16	-	-	7.345	6.545	6.945	7.345	6.545	6.245
Critical Hdwy Stg 1	-	-	-	-	-	-	6.545	5.545	-	6.145	5.545	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.145	5.545	-	6.545	5.545	-
Follow-up Hdwy	2.227	-	-	2.23	-	-	3.5285	4.0285	3.3285	3.5285	4.0285	3.3285
Pot Cap-1 Maneuver	1133	-	0	815	-	-	~ 59	83	591	114	84	631
Stage 1	-	-	0	-	-	-	346	396	-	305	331	-
Stage 2	-	-	0	-	-	-	304	330	-	593	396	-
Platoon blocked, %		-			-	-						
Mov Cap-1 Maneuver	1133	-	-	812	-	-	~ 43	55	584	54	55	631
Mov Cap-2 Maneuver	-	-	-	-	-	-	133	151	-	89	93	-
Stage 1	-	-	-	-	-	-	343	393	-	305	220	-
Stage 2	-	-	-	-	-	-	200	219	-	378	393	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	4.6	42.8	32.4
HCM LOS			E	D

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	133	584	1133	-	812	-	-	137
HCM Lane V/C Ratio	0.81	0.356	-	-	0.335	-	-	0.041
HCM Control Delay (s)	97.5	14.5	0	-	11.7	-	-	32.4
HCM Lane LOS	F	B	A	-	B	-	-	D
HCM 95th %tile Q(veh)	5	1.6	0	-	1.5	-	-	0.1

Notes

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

Intersection	
Int Delay, s/veh	9.1

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	9	497	98	210	940	2	148	1	205	2	1	2
Conflicting Peds, #/hr	10	0	10	0	0	0	10	0	10	10	0	10
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	Free	-	-	None	-	-	Yield	-	-	None
Storage Length	-	-	-	250	-	-	-	-	150	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	1	-	-	1	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	96	96	96	96	96	96	96	96	96	96	96	96
Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3
Mvmt Flow	9	518	102	219	979	2	154	1	214	2	1	2

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	991	0	-	528	0	0	1975	1975	269	1716	1974	1000
Stage 1	-	-	-	-	-	-	546	546	-	1428	1428	-
Stage 2	-	-	-	-	-	-	1429	1429	-	288	546	-
Critical Hdwy	4.13	-	-	4.16	-	-	5.3	5.3	5.5	7.345	6.545	6.245
Critical Hdwy Stg 1	-	-	-	-	-	-	5.3	5.3	-	6.145	5.545	-
Critical Hdwy Stg 2	-	-	-	-	-	-	5.3	5.3	-	6.545	5.545	-
Follow-up Hdwy	2.227	-	-	2.23	-	-	2.5	4.0285	3.3285	3.5285	4.0285	3.3285
Pot Cap-1 Maneuver	694	-	0	1028	-	-	~ 145	121	810	64	61	292
Stage 1	-	-	0	-	-	-	774	535	-	166	198	-
Stage 2	-	-	0	-	-	-	277	218	-	694	515	-
Platoon blocked, %		-			-	-						
Mov Cap-1 Maneuver	688	-	-	1028	-	-	~ 116	92	803	38	46	287
Mov Cap-2 Maneuver	-	-	-	-	-	-	176	138	-	110	110	-
Stage 1	-	-	-	-	-	-	754	521	-	162	155	-
Stage 2	-	-	-	-	-	-	213	170	-	499	502	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.3	1.7	45.5	30.6
HCM LOS			E	D

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	176	803	688	-	1028	-	-	146
HCM Lane V/C Ratio	0.882	0.266	0.014	-	0.213	-	-	0.036
HCM Control Delay (s)	92.8	11.1	10.3	0.1	9.4	-	-	30.6
HCM Lane LOS	F	B	B	A	A	-	-	D
HCM 95th %tile Q(veh)	6.4	1.1	0	-	0.8	-	-	0.1

Notes

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

Intersection	
Int Delay, s/veh	11.2

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	0	710	315	245	375	5	95	5	190	2	1	2
Conflicting Peds, #/hr	0	0	5	0	0	5	10	0	10	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	Free	-	-	None	-	-	Yield	-	-	None
Storage Length	-	-	-	250	-	-	-	-	0	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	1	-	-	1	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	90	90	90	90	90	90	90	90	90	90	90	90
Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3
Mvmt Flow	0	813	360	280	429	6	109	6	217	2	1	2

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	435	0	-	823	0	0	1818	1819	421	1412	1816	432
Stage 1	-	-	-	-	-	-	823	823	-	993	993	-
Stage 2	-	-	-	-	-	-	995	996	-	419	823	-
Critical Hdwy	4.13	-	-	4.16	-	-	7.345	6.545	6.945	7.345	6.545	6.245
Critical Hdwy Stg 1	-	-	-	-	-	-	6.545	5.545	-	6.145	5.545	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.145	5.545	-	6.545	5.545	-
Follow-up Hdwy	2.227	-	-	2.23	-	-	3.5285	4.0285	3.3285	3.5285	4.0285	3.3285
Pot Cap-1 Maneuver	1119	-	0	796	-	-	~ 54	77	580	106	77	620
Stage 1	-	-	0	-	-	-	333	385	-	293	321	-
Stage 2	-	-	0	-	-	-	292	320	-	581	385	-
Platoon blocked, %		-			-	-						
Mov Cap-1 Maneuver	1119	-	-	793	-	-	~ 38	49	573	46	49	620
Mov Cap-2 Maneuver	-	-	-	-	-	-	125	143	-	65	81	-
Stage 1	-	-	-	-	-	-	330	382	-	293	208	-
Stage 2	-	-	-	-	-	-	187	207	-	354	382	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	4.7	52.3	40.2
HCM LOS			F	E

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	126	573	1119	-	793	-	-	108
HCM Lane V/C Ratio	0.908	0.379	-	-	0.354	-	-	0.053
HCM Control Delay (s)	123	15.1	0	-	12	-	-	40.2
HCM Lane LOS	F	C	A	-	B	-	-	E
HCM 95th %tile Q(veh)	5.9	1.8	0	-	1.6	-	-	0.2

Notes

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

High St at Nahatan St
2024 PM Alternative 1 Stop Sign

Intersection	
Int Delay, s/veh	41.4

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	9	497	98	210	940	2	150	5	205	2	1	2
Conflicting Peds, #/hr	10	0	10	0	0	0	10	0	10	10	0	10
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	Free	-	-	None	-	-	Yield	-	-	None
Storage Length	-	-	-	250	-	-	-	-	0	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	1	-	-	1	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	96	96	96	96	96	96	96	96	96	96	96	96
Heavy Vehicles, %	3	3	3	3	3	3	2	2	2	0	0	0
Mvmt Flow	10	533	105	225	1009	2	161	5	220	2	1	2

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	1021	0	-	543	0	0	2035	2034	277	1769	2033	1030
Stage 1	-	-	-	-	-	-	563	563	-	1470	1470	-
Stage 2	-	-	-	-	-	-	1472	1471	-	299	563	-
Critical Hdwy	4.13	-	-	4.16	-	-	7.33	6.53	6.93	7.3	6.5	6.2
Critical Hdwy Stg 1	-	-	-	-	-	-	6.53	5.53	-	6.1	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.13	5.53	-	6.5	5.5	-
Follow-up Hdwy	2.227	-	-	2.23	-	-	3.519	4.019	3.319	3.5	4	3.3
Pot Cap-1 Maneuver	676	-	0	1015	-	-	~ 37	57	721	60	58	286
Stage 1	-	-	0	-	-	-	479	508	-	160	193	-
Stage 2	-	-	0	-	-	-	~ 157	190	-	691	512	-
Platoon blocked, %		-			-	-						
Mov Cap-1 Maneuver	670	-	-	1015	-	-	~ 29	43	715	32	43	281
Mov Cap-2 Maneuver	-	-	-	-	-	-	~ 88	110	-	100	105	-
Stage 1	-	-	-	-	-	-	465	493	-	155	149	-
Stage 2	-	-	-	-	-	-	~ 119	147	-	463	497	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.3	1.7	226.4	32.6
HCM LOS			F	D

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	89	715	670	-	1015	-	-	136
HCM Lane V/C Ratio	1.869	0.308	0.014	-	0.222	-	-	0.039
HCM Control Delay (s)	$ 509.6	12.3	10.5	0.1	9.6	-	-	32.6
HCM Lane LOS	F	B	B	A	A	-	-	D
HCM 95th %tile Q(veh)	14.1	1.3	0	-	0.8	-	-	0.1

Notes

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

Intersection	
Int Delay, s/veh	7.7

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	0	707	313	245	374	5	95	2	187	2	1	2
Conflicting Peds, #/hr	0	0	5	0	0	5	10	0	10	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	Yield	-	-	None	-	-	Free	-	-	None
Storage Length	-	-	0	250	-	-	-	-	0	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	1	-	-	1	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	90	90	90	90	90	90	90	90	90	90	90	90
Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3
Mvmt Flow	0	809	358	280	428	6	109	2	214	2	1	2

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	434	0	0	819	0	0	1812	1814	-	1812	1811	436
Stage 1	-	-	-	-	-	-	819	819	-	992	992	-
Stage 2	-	-	-	-	-	-	993	995	-	820	819	-
Critical Hdwy	4.13	-	-	4.13	-	-	7.13	6.53	-	7.13	6.53	6.23
Critical Hdwy Stg 1	-	-	-	-	-	-	6.13	5.53	-	6.13	5.53	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.13	5.53	-	6.13	5.53	-
Follow-up Hdwy	2.227	-	-	2.227	-	-	3.527	4.027	-	3.527	4.027	3.327
Pot Cap-1 Maneuver	1120	-	-	805	-	-	~ 60	78	0	60	78	618
Stage 1	-	-	-	-	-	-	368	388	0	295	322	-
Stage 2	-	-	-	-	-	-	294	321	0	368	388	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	1115	-	-	802	-	-	~ 43	50	-	43	50	615
Mov Cap-2 Maneuver	-	-	-	-	-	-	131	144	-	71	83	-
Stage 1	-	-	-	-	-	-	365	385	-	295	210	-
Stage 2	-	-	-	-	-	-	189	209	-	364	385	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	4.7	106.1	37.9
HCM LOS			F	E

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	131	-	1115	-	-	802	-	-	115
HCM Lane V/C Ratio	0.847	-	-	-	-	0.35	-	-	0.05
HCM Control Delay (s)	106.1	0	0	-	-	11.9	-	-	37.9
HCM Lane LOS	F	A	A	-	-	B	-	-	E
HCM 95th %tile Q(veh)	5.3	-	0	-	-	1.6	-	-	0.2

Notes

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

Intersection	
Int Delay, s/veh	46.1

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	0	497	98	210	940	2	148	1	205	2	1	2
Conflicting Peds, #/hr	0	0	5	0	0	5	10	0	10	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	Yield	-	-	None	-	-	Free	-	-	None
Storage Length	-	-	0	250	-	-	-	-	0	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	1	-	-	1	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	90	90	90	90	90	90	90	90	90	90	90	90
Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3
Mvmt Flow	0	569	112	240	1076	2	169	1	235	2	1	2

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	1078	0	0	579	0	0	2138	2138	-	2137	2137	1082
Stage 1	-	-	-	-	-	-	579	579	-	1558	1558	-
Stage 2	-	-	-	-	-	-	1559	1559	-	579	579	-
Critical Hdwy	4.13	-	-	4.13	-	-	7.13	6.53	-	7.13	6.53	6.23
Critical Hdwy Stg 1	-	-	-	-	-	-	6.13	5.53	-	6.13	5.53	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.13	5.53	-	6.13	5.53	-
Follow-up Hdwy	2.227	-	-	2.227	-	-	3.527	4.027	-	3.527	4.027	3.327
Pot Cap-1 Maneuver	643	-	-	990	-	-	~ 35	49	0	35	49	263
Stage 1	-	-	-	-	-	-	499	499	0	140	172	-
Stage 2	-	-	-	-	-	-	~ 140	172	0	499	499	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	640	-	-	986	-	-	~ 28	37	-	28	37	262
Mov Cap-2 Maneuver	-	-	-	-	-	-	~ 85	104	-	94	93	-
Stage 1	-	-	-	-	-	-	495	495	-	140	130	-
Stage 2	-	-	-	-	-	-	~ 104	130	-	496	495	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	1.8	$ 572.9	34.9
HCM LOS			F	D

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	85	-	640	-	-	986	-	-	126
HCM Lane V/C Ratio	2.006	-	-	-	-	0.244	-	-	0.045
HCM Control Delay (s)	$ 572.9	0	0	-	-	9.8	-	-	34.9
HCM Lane LOS	F	A	A	-	-	A	-	-	D
HCM 95th %tile Q(veh)	15	-	0	-	-	1	-	-	0.1

Notes

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

Intersection	
Int Delay, s/veh	11.2

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	0	710	315	245	375	5	95	5	190	2	1	2
Conflicting Peds, #/hr	0	0	5	0	0	5	10	0	10	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	Free	-	-	None	-	-	Yield	-	-	None
Storage Length	-	-	-	250	-	-	-	-	0	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	1	-	-	1	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	90	90	90	90	90	90	90	90	90	90	90	90
Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3
Mvmt Flow	0	813	360	280	429	6	109	6	217	2	1	2

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	435	0	-	823	0	0	1818	1819	421	1412	1816	432
Stage 1	-	-	-	-	-	-	823	823	-	993	993	-
Stage 2	-	-	-	-	-	-	995	996	-	419	823	-
Critical Hdwy	4.13	-	-	4.16	-	-	7.345	6.545	6.945	7.345	6.545	6.245
Critical Hdwy Stg 1	-	-	-	-	-	-	6.545	5.545	-	6.145	5.545	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.145	5.545	-	6.545	5.545	-
Follow-up Hdwy	2.227	-	-	2.23	-	-	3.5285	4.0285	3.3285	3.5285	4.0285	3.3285
Pot Cap-1 Maneuver	1119	-	0	796	-	-	~ 54	77	580	106	77	620
Stage 1	-	-	0	-	-	-	333	385	-	293	321	-
Stage 2	-	-	0	-	-	-	292	320	-	581	385	-
Platoon blocked, %		-			-	-						
Mov Cap-1 Maneuver	1119	-	-	793	-	-	~ 38	49	573	46	49	620
Mov Cap-2 Maneuver	-	-	-	-	-	-	125	143	-	65	81	-
Stage 1	-	-	-	-	-	-	330	382	-	293	208	-
Stage 2	-	-	-	-	-	-	187	207	-	354	382	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	4.7	52.3	40.2
HCM LOS			F	E

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	126	573	1119	-	793	-	-	108
HCM Lane V/C Ratio	0.908	0.379	-	-	0.354	-	-	0.053
HCM Control Delay (s)	123	15.1	0	-	12	-	-	40.2
HCM Lane LOS	F	C	A	-	B	-	-	E
HCM 95th %tile Q(veh)	5.9	1.8	0	-	1.6	-	-	0.2

Notes

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

Intersection	
Int Delay, s/veh	41.4

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	9	497	98	210	940	2	150	5	205	2	1	2
Conflicting Peds, #/hr	10	0	10	0	0	0	10	0	10	10	0	10
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	Free	-	-	None	-	-	Yield	-	-	None
Storage Length	-	-	-	250	-	-	-	-	0	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	1	-	-	1	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	96	96	96	96	96	96	96	96	96	96	96	96
Heavy Vehicles, %	3	3	3	3	3	3	2	2	2	0	0	0
Mvmt Flow	10	533	105	225	1009	2	161	5	220	2	1	2

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	1021	0	-	543	0	0	2035	2034	277	1769	2033	1030
Stage 1	-	-	-	-	-	-	563	563	-	1470	1470	-
Stage 2	-	-	-	-	-	-	1472	1471	-	299	563	-
Critical Hdwy	4.13	-	-	4.16	-	-	7.33	6.53	6.93	7.3	6.5	6.2
Critical Hdwy Stg 1	-	-	-	-	-	-	6.53	5.53	-	6.1	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.13	5.53	-	6.5	5.5	-
Follow-up Hdwy	2.227	-	-	2.23	-	-	3.519	4.019	3.319	3.5	4	3.3
Pot Cap-1 Maneuver	676	-	0	1015	-	-	~ 37	57	721	60	58	286
Stage 1	-	-	0	-	-	-	479	508	-	160	193	-
Stage 2	-	-	0	-	-	-	~ 157	190	-	691	512	-
Platoon blocked, %		-			-	-						
Mov Cap-1 Maneuver	670	-	-	1015	-	-	~ 29	43	715	32	43	281
Mov Cap-2 Maneuver	-	-	-	-	-	-	~ 88	110	-	100	105	-
Stage 1	-	-	-	-	-	-	465	493	-	155	149	-
Stage 2	-	-	-	-	-	-	~ 119	147	-	463	497	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.3	1.7	226.4	32.6
HCM LOS			F	D

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	89	715	670	-	1015	-	-	136
HCM Lane V/C Ratio	1.869	0.308	0.014	-	0.222	-	-	0.039
HCM Control Delay (s)	$ 509.6	12.3	10.5	0.1	9.6	-	-	32.6
HCM Lane LOS	F	B	B	A	A	-	-	D
HCM 95th %tile Q(veh)	14.1	1.3	0	-	0.8	-	-	0.1

Notes

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

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↰↱		↰	↱			↰	↱		✥	
Volume (vph)	0	710	315	245	375	5	95	5	190	2	1	2
Satd. Flow (prot)	0	3311	0	1752	1840	0	0	1762	1568	0	1710	0
Flt Permitted				0.111				0.734			0.883	
Satd. Flow (perm)	0	3311	0	205	1840	0	0	1330	1525	0	1541	0
Satd. Flow (RTOR)					1						2	
Adj. Flow (vph)	0	813	360	280	429	6	109	6	217	2	1	2
Lane Group Flow (vph)	0	1173	0	280	435	0	0	115	217	0	5	0
Turn Type		NA		pm+pt	NA		Perm	NA	pm+ov	Perm	NA	
Protected Phases		2		1	6			8	1		4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	41.0	41.0		15.0	56.0		21.0	21.0	15.0	21.0	21.0	
Total Lost Time (s)		5.0		5.0	5.0			5.0	5.0		5.0	
Act Effct Green (s)		36.1		51.8	53.3			11.4	19.8		11.0	
Actuated g/C Ratio		0.49		0.70	0.72			0.15	0.27		0.15	
v/c Ratio		0.72		0.77	0.33			0.56	0.52		0.02	
Control Delay		21.6		32.2	8.3			43.4	22.2		27.0	
Queue Delay		0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay		21.6		32.2	8.3			43.4	22.2		27.0	
LOS		C		C	A			D	C		C	
Approach Delay		21.6			17.7			29.6			27.0	
Approach LOS		C			B			C			C	
Queue Length 50th (ft)		202		61	61			48	70		1	
Queue Length 95th (ft)		#536		#308	251			127	114		12	
Internal Link Dist (ft)		226			305			1179			272	
Turn Bay Length (ft)				250					150			
Base Capacity (vph)		1696		364	1333			302	417		352	
Starvation Cap Reductn		0		0	0			0	0		0	
Spillback Cap Reductn		0		0	0			0	0		0	
Storage Cap Reductn		0		0	0			0	0		0	
Reduced v/c Ratio		0.69		0.77	0.33			0.38	0.52		0.01	

Intersection Summary

Cycle Length: 100

Actuated Cycle Length: 73.6

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.77

Intersection Signal Delay: 21.5 Intersection LOS: C

Intersection Capacity Utilization 75.7% ICU Level of Service D

Analysis Period (min) 15

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

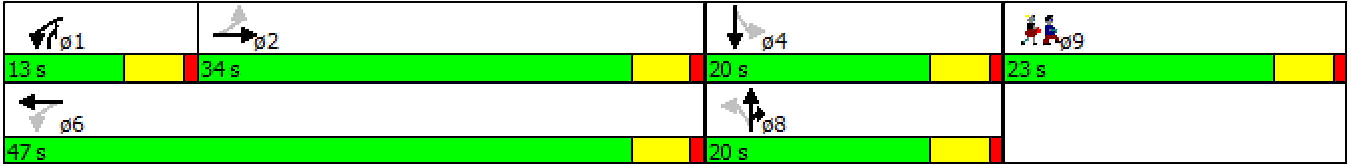
Splits and Phases: 1: Nahatan St/Rev Coyle Cir & High St

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	500	90	210	940	5	150	5	205	2	1	2
Satd. Flow (prot)	0	3402	0	1752	1843	0	0	1760	1568	0	1690	0
Flt Permitted		0.861		0.289				0.729			0.900	
Satd. Flow (perm)	0	2932	0	533	1843	0	0	1321	1568	0	1544	0
Satd. Flow (RTOR)												
Adj. Flow (vph)	11	536	97	225	1009	5	161	5	220	2	1	2
Lane Group Flow (vph)	0	644	0	225	1014	0	0	166	220	0	5	0
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	pt+ov	Perm	NA	
Protected Phases		2		1	6			8	8 1		4	
Permitted Phases	2			6			8			4		
Total Split (s)	34.0	34.0		13.0	47.0		20.0	20.0		20.0	20.0	
Total Lost Time (s)		5.0		5.0	5.0			5.0			5.0	
Act Effct Green (s)		29.8		42.8	42.8			13.1	25.4		13.1	
Actuated g/C Ratio		0.43		0.61	0.61			0.19	0.36		0.19	
v/c Ratio		0.51		0.48	0.90			0.67	0.39		0.02	
Control Delay		18.6		12.6	26.9			43.0	16.4		26.6	
Queue Delay		0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay		18.6		12.6	26.9			43.0	16.4		26.6	
LOS		B		B	C			D	B		C	
Approach Delay		18.6			24.3			27.8			26.6	
Approach LOS		B			C			C			C	
Queue Length 50th (ft)		94		33	287			61	59		2	
Queue Length 95th (ft)		227		124	#933			#191	98		12	
Internal Link Dist (ft)		256			298			1197			272	
Turn Bay Length (ft)				250					150			
Base Capacity (vph)		1251		469	1131			289	546		338	
Starvation Cap Reductn		0		0	0			0	0		0	
Spillback Cap Reductn		0		0	0			0	0		0	
Storage Cap Reductn		0		0	0			0	0		0	
Reduced v/c Ratio		0.51		0.48	0.90			0.57	0.40		0.01	

Intersection Summary

Cycle Length: 90
Actuated Cycle Length: 69.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.90
Intersection Signal Delay: 23.3 Intersection LOS: C
Intersection Capacity Utilization 96.9% ICU Level of Service F
Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Nahatan St/Rev Coyle Cir & High St



MOVEMENT SUMMARY

Site: High St at Nahatan St AM

Single Lane Roundabout
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: High St											
3	L2	1	3.0	0.961	45.1	LOS E	21.4	548.8	1.00	1.31	21.2
8	T1	777	3.0	0.961	45.1	LOS E	21.4	548.8	1.00	1.31	21.2
18	R2	345	3.0	0.212	0.0	LOS A	0.0	0.0	0.00	0.00	36.5
Approach		1123	3.0	0.961	31.3	LOS D	21.4	548.8	0.69	0.91	24.3
East: Nahatan St											
1	L2	104	3.0	0.309	16.2	LOS C	1.3	33.3	0.76	0.77	27.7
6	T1	5	0.0	0.309	16.2	LOS C	1.3	33.3	0.76	0.77	27.8
16	R2	208	2.0	0.127	0.0	LOS A	0.0	0.0	0.00	0.00	36.5
Approach		318	2.3	0.309	5.6	LOS A	1.3	33.3	0.26	0.26	32.8
North: High St											
7	L2	268	3.0	0.358	7.6	LOS A	2.0	51.5	0.37	0.22	31.2
4	T1	410	3.0	0.358	7.6	LOS A	2.0	51.5	0.37	0.22	32.5
14	R2	5	3.0	0.358	7.6	LOS A	2.0	51.5	0.37	0.22	32.0
Approach		683	3.0	0.358	7.6	LOS A	2.0	51.5	0.37	0.22	32.0
West: Rev Coyle Cir											
5	L2	2	0.0	0.011	7.7	LOS A	0.0	0.9	0.59	0.50	31.9
2	T1	1	0.0	0.011	7.7	LOS A	0.0	0.9	0.59	0.50	32.0
12	R2	2	0.0	0.011	7.7	LOS A	0.0	0.9	0.59	0.50	31.4
Approach		5	0.0	0.011	7.7	LOS A	0.0	0.9	0.59	0.50	31.7
All Vehicles		2129	2.9	0.961	19.8	LOS C	21.4	548.8	0.52	0.59	27.5

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

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SIDRA INTERSECTION 6.0.24.4877

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SIDRA INTERSECTION 6

MOVEMENT SUMMARY

Site: High St at Nahatan St PM

Single Lane Roundabout
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: High St											
3	L2	11	0.0	0.827	29.7	LOS D	8.3	213.6	0.90	1.10	24.8
8	T1	547	3.0	0.827	29.7	LOS D	8.3	213.6	0.90	1.10	24.8
18	R2	99	3.0	0.061	0.0	LOS A	0.0	0.0	0.00	0.00	36.5
Approach		657	2.9	0.827	25.3	LOS D	8.3	213.6	0.76	0.94	26.0
East: Nahatan St											
1	L2	165	3.0	0.275	9.4	LOS A	1.0	25.9	0.58	0.58	30.1
6	T1	5	0.0	0.275	9.4	LOS A	1.0	25.9	0.58	0.58	30.3
16	R2	224	3.0	0.138	0.0	LOS A	0.0	0.0	0.00	0.00	36.5
Approach		394	3.0	0.275	4.1	LOS A	1.0	25.9	0.25	0.25	33.4
North: High St											
7	L2	230	3.0	0.694	15.6	LOS C	6.2	155.6	0.65	0.54	28.7
4	T1	1028	3.0	0.694	15.9	LOS C	6.2	155.6	0.64	0.53	29.0
14	R2	5	0.0	0.694	16.1	LOS C	5.7	147.9	0.62	0.52	28.6
Approach		1264	3.0	0.694	15.9	LOS C	6.2	155.6	0.64	0.53	29.0
West: Rev Coyle Cir											
5	L2	2	0.0	0.020	14.2	LOS B	0.1	1.5	0.77	0.77	29.3
2	T1	1	0.0	0.020	14.2	LOS B	0.1	1.5	0.77	0.77	29.4
12	R2	2	0.0	0.020	14.2	LOS B	0.1	1.5	0.77	0.77	28.8
Approach		5	0.0	0.020	14.2	LOS B	0.1	1.5	0.77	0.77	29.1
All Vehicles		2320	3.0	0.827	16.5	LOS C	8.3	213.6	0.61	0.60	28.7

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

SIDRA INTERSECTION 6

Intersection	
Int Delay, s/veh	17.8

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Vol, veh/h	700	400	25	345	196	30
Conflicting Peds, #/hr	0	2	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	Free	-	Free	-	None
Storage Length	-	-	-	-	50	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	94	94	94	94	94	94
Heavy Vehicles, %	4	4	4	4	2	2
Mvmt Flow	745	426	27	367	209	32

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	-	745	0	1165	745
Stage 1	-	-	-	-	745	-
Stage 2	-	-	-	-	420	-
Critical Hdwy	-	-	4.14	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.236	-	3.518	3.318
Pot Cap-1 Maneuver	-	0	854	-	215	414
Stage 1	-	0	-	-	469	-
Stage 2	-	0	-	-	663	-
Platoon blocked, %	-			-		
Mov Cap-1 Maneuver	-	-	854	-	~ 206	414
Mov Cap-2 Maneuver	-	-	-	-	~ 206	-
Stage 1	-	-	-	-	469	-
Stage 2	-	-	-	-	636	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.6	101.2
HCM LOS			F

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	WBL	WBT
Capacity (veh/h)	206	414	-	854	-
HCM Lane V/C Ratio	1.012	0.077	-	0.031	-
HCM Control Delay (s)	114.5	14.4	-	9.4	0
HCM Lane LOS	F	B	-	A	A
HCM 95th %tile Q(veh)	9	0.2	-	0.1	-

Notes

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

Intersection	
Int Delay, s/veh	28.6

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Vol, veh/h	435	200	45	760	290	50
Conflicting Peds, #/hr	0	2	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	Free	-	Free	-	None
Storage Length	-	-	-	-	50	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	94	94	94	94	94	94
Heavy Vehicles, %	4	4	4	4	2	2
Mvmt Flow	463	213	48	809	309	53

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	-	463	0	1367	463
Stage 1	-	-	-	-	463	-
Stage 2	-	-	-	-	904	-
Critical Hdwy	-	-	4.14	-	5.3	5.3
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.236	-	2.7	2.7
Pot Cap-1 Maneuver	-	0	1088	-	~ 285	798
Stage 1	-	0	-	-	786	-
Stage 2	-	0	-	-	471	-
Platoon blocked, %	-			-		
Mov Cap-1 Maneuver	-	-	1088	-	~ 262	798
Mov Cap-2 Maneuver	-	-	-	-	~ 262	-
Stage 1	-	-	-	-	786	-
Stage 2	-	-	-	-	433	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.5	131.9
HCM LOS			F

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	WBL	WBT
Capacity (veh/h)	262	798	-	1088	-
HCM Lane V/C Ratio	1.178	0.067	-	0.044	-
HCM Control Delay (s)	152.9	9.8	-	8.5	0
HCM Lane LOS	F	A	-	A	A
HCM 95th %tile Q(veh)	14	0.2	-	0.1	-

Notes

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

Intersection	
Int Delay, s/veh	23.5

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Vol, veh/h	700	400	25	345	200	30
Conflicting Peds, #/hr	0	2	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	Free	-	Free	-	None
Storage Length	-	-	-	-	50	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	94	94	94	94	94	94
Heavy Vehicles, %	4	4	4	4	2	2
Mvmt Flow	767	438	27	378	219	33

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	-	767	0	1200	767
Stage 1	-	-	-	-	767	-
Stage 2	-	-	-	-	433	-
Critical Hdwy	-	-	4.14	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.236	-	3.518	3.318
Pot Cap-1 Maneuver	-	0	838	-	~ 204	402
Stage 1	-	0	-	-	458	-
Stage 2	-	0	-	-	654	-
Platoon blocked, %	-			-		
Mov Cap-1 Maneuver	-	-	838	-	~ 196	402
Mov Cap-2 Maneuver	-	-	-	-	~ 196	-
Stage 1	-	-	-	-	458	-
Stage 2	-	-	-	-	627	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.6	132.1
HCM LOS			F

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	WBL	WBT
Capacity (veh/h)	196	402	-	838	-
HCM Lane V/C Ratio	1.118	0.082	-	0.033	-
HCM Control Delay (s)	149.7	14.8	-	9.4	0
HCM Lane LOS	F	B	-	A	A
HCM 95th %tile Q(veh)	10.6	0.3	-	0.1	-

Notes

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

Intersection	
Int Delay, s/veh	34.8

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Vol, veh/h	435	200	45	750	290	50
Conflicting Peds, #/hr	0	2	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	Free	-	Free	-	None
Storage Length	-	-	-	-	50	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	94	94	94	94	94	94
Heavy Vehicles, %	4	4	4	4	2	2
Mvmt Flow	477	219	49	822	318	55

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	-	477	0	1397	477
Stage 1	-	-	-	-	477	-
Stage 2	-	-	-	-	920	-
Critical Hdwy	-	-	4.14	-	5.3	5.3
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.236	-	2.7	2.7
Pot Cap-1 Maneuver	-	0	1075	-	~ 275	786
Stage 1	-	0	-	-	773	-
Stage 2	-	0	-	-	462	-
Platoon blocked, %	-			-		
Mov Cap-1 Maneuver	-	-	1075	-	~ 252	786
Mov Cap-2 Maneuver	-	-	-	-	~ 252	-
Stage 1	-	-	-	-	773	-
Stage 2	-	-	-	-	423	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.5	159.7
HCM LOS			F

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	WBL	WBT
Capacity (veh/h)	252	786	-	1075	-
HCM Lane V/C Ratio	1.261	0.07	-	0.046	-
HCM Control Delay (s)	185.5	9.9	-	8.5	0
HCM Lane LOS	F	A	-	A	A
HCM 95th %tile Q(veh)	15.8	0.2	-	0.1	-

Notes

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

	↗	→	↘	↙	←	↖	↖	↑	↗	↘	↓	↙
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑	↱	↰	↑		↰	↱			✥	
Volume (vph)	0	700	400	25	345	0	200	0	30	2	2	2
Satd. Flow (prot)	0	1827	1553	1736	1827	0	1770	1583	0	0	1750	0
Flt Permitted				0.173			0.754				0.939	
Satd. Flow (perm)	0	1827	1519	316	1827	0	1405	1583	0	0	1670	0
Satd. Flow (RTOR)			228					414			2	
Adj. Flow (vph)	0	767	438	27	378	0	219	0	33	2	2	2
Lane Group Flow (vph)	0	767	438	27	378	0	219	33	0	0	6	0
Turn Type		NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases			2	6			8			4		
Total Split (s)		50.0	50.0	50.0	50.0		17.0	17.0		17.0	17.0	
Total Lost Time (s)		5.0	5.0	5.0	5.0		5.0	5.0			5.0	
Act Effct Green (s)		32.4	32.4	32.4	32.4		12.8	12.8			12.8	
Actuated g/C Ratio		0.55	0.55	0.55	0.55		0.22	0.22			0.22	
v/c Ratio		0.76	0.47	0.16	0.38		0.72	0.05			0.02	
Control Delay		18.0	6.1	11.2	9.8		42.6	0.1			24.2	
Queue Delay		0.0	0.0	0.0	0.0		0.0	0.0			0.0	
Total Delay		18.0	6.1	11.2	9.8		42.6	0.1			24.2	
LOS		B	A	B	A		D	A			C	
Approach Delay		13.7			9.9			37.1			24.2	
Approach LOS		B			A			D			C	
Queue Length 50th (ft)		147	27	3	53		65	0			1	
Queue Length 95th (ft)		#590	145	26	198		#290	0			13	
Internal Link Dist (ft)		548			727			534			42	
Turn Bay Length (ft)			100	75			50					
Base Capacity (vph)		1467	1265	254	1467		306	668			365	
Starvation Cap Reductn		0	0	0	0		0	0			0	
Spillback Cap Reductn		0	0	0	0		0	0			0	
Storage Cap Reductn		0	0	0	0		0	0			0	
Reduced v/c Ratio		0.52	0.35	0.11	0.26		0.72	0.05			0.02	

Intersection Summary

Cycle Length: 90

Actuated Cycle Length: 58.9

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.76

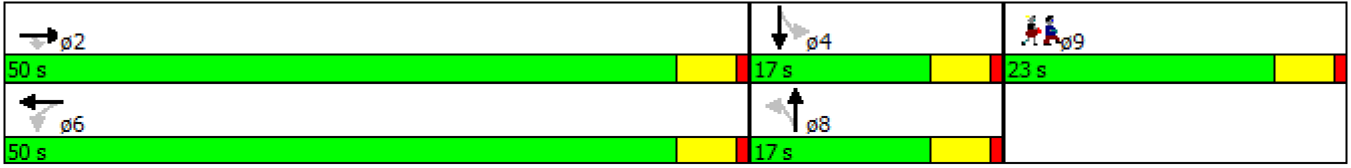
Intersection Signal Delay: 16.0 Intersection LOS: B

Intersection Capacity Utilization 64.4% ICU Level of Service C

Analysis Period (min) 15

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

Splits and Phases: 1: Pond St /Driveway & High St (Rte 109)



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑	↱	↰	↱		↰	↱			✥	
Volume (vph)	0	430	200	45	750	5	290	1	50	2	2	2
Satd. Flow (prot)	0	1827	1553	1736	1825	0	1770	1589	0	0	1750	0
Flt Permitted				0.388			0.754				0.951	
Satd. Flow (perm)	0	1827	1553	709	1825	0	1405	1589	0	0	1692	0
Satd. Flow (RTOR)			161					55			2	
Adj. Flow (vph)	0	471	219	49	822	5	318	1	55	2	2	2
Lane Group Flow (vph)	0	471	219	49	827	0	318	56	0	0	6	0
Turn Type		NA	Prot	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2	2		6			8			4	
Permitted Phases				6			8			4		
Total Split (s)		43.0	43.0	43.0	43.0		24.0	24.0		24.0	24.0	
Total Lost Time (s)		5.0	5.0	5.0	5.0		5.0	5.0			5.0	
Act Effct Green (s)		38.5	38.5	38.5	38.5		19.3	19.3			19.3	
Actuated g/C Ratio		0.54	0.54	0.54	0.54		0.27	0.27			0.27	
v/c Ratio		0.48	0.24	0.13	0.84		0.84	0.12			0.01	
Control Delay		14.2	4.6	12.1	26.1		48.5	8.8			20.8	
Queue Delay		0.0	0.0	0.0	0.0		0.0	0.0			0.0	
Total Delay		14.2	4.6	12.1	26.1		48.5	8.8			20.8	
LOS		B	A	B	C		D	A			C	
Approach Delay		11.1			25.3			42.5			20.8	
Approach LOS		B			C			D			C	
Queue Length 50th (ft)		102	10	8	242		120	0			1	
Queue Length 95th (ft)		305	63	42	#750		#365	31			12	
Internal Link Dist (ft)		545			749			514			42	
Turn Bay Length (ft)			100	75			50					
Base Capacity (vph)		983	910	381	982		378	468			456	
Starvation Cap Reductn		0	0	0	0		0	0			0	
Spillback Cap Reductn		0	0	0	0		0	0			0	
Storage Cap Reductn		0	0	0	0		0	0			0	
Reduced v/c Ratio		0.48	0.24	0.13	0.84		0.84	0.12			0.01	

Intersection Summary

Cycle Length: 90

Actuated Cycle Length: 71.6

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.84

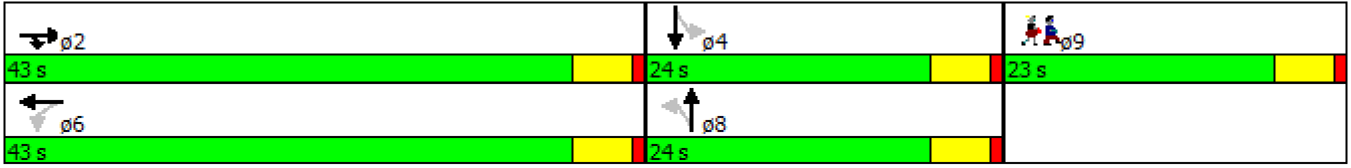
Intersection Signal Delay: 23.6 Intersection LOS: C

Intersection Capacity Utilization 72.5% ICU Level of Service C

Analysis Period (min) 15

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

Splits and Phases: 1: Pond St /Driveway & High St (Rte 109)



APPENDIX E

MassDOT Highway Division Project Development Process

Overview of the Project Development Process

Transportation decision making is complex and can be influenced by legislative mandates, environmental regulations, financial limitations, agency programmatic commitments, and partnering opportunities. Decision makers and reviewing agencies, when consulted early and often throughout the project development process, can ensure that all participants understand the potential impact these factors can have on project implementation. Project development is the process that takes a transportation improvement from concept through construction.

The MassDOT Highway Division has developed a comprehensive project-development process, which is contained in Chapter 2 of the *MassDOT Highway Division's Project Development and Design Guide*. The eight-step process covers a range of activities extending from identification of a project need, through completion of a set of finished contract plans, to construction of the project. The sequence of decisions made through the project-development process progressively narrows the project focus and, ultimately, leads to a project that addresses the identified needs. The descriptions provided below are focused on the process for a highway project, but the same basic process will need to be followed for non-highway projects as well.

1. Needs Identification

For each of the locations at which an improvement is to be implemented, MassDOT leads an effort to define the problem, establishes project goals and objectives, and defines the scope of the planning needed for implementation. To that end, it has to complete a Project Need Form (PNF), which states in general terms the deficiencies or needs related to the transportation facility or location. The PNF documents the problems and explains why corrective action is needed. For this study, the information defining the need for the project will be drawn primarily, perhaps exclusively, from the present report. Also, at this point in the process, MassDOT meets with potential participants, such as the Metropolitan Planning Organization (MPO) and community members, to allow for an informal review of the project.

The PNF is reviewed by the MassDOT Highway Division district office whose jurisdiction includes the location of the proposed project. MassDOT also sends the PNF to the MPO, for informational purposes. The outcome of this step determines whether the project requires further planning, whether it is already well supported by prior planning studies, and, therefore, whether it is ready to move forward into the design phase, or whether it should be dismissed from further consideration.

2. Planning

This phase will likely not be required for the implementation of the improvements proposed in this planning study, as this planning report should constitute the outcome of this step. However, in general, the purpose of this implementation step is for the project proponent to identify issues, impacts, and approvals that may need to be obtained, so that the subsequent design and permitting processes are understood.

The level of planning needed will vary widely, based on the complexity of the project. Typical tasks include: define the existing context, confirm project need, establish goals and objectives, initiate public outreach, define the project, collect data, develop and analyze alternatives, make recommendations, and provide documentation. Likely outcomes include consensus on the project definition to enable it to move forward into environmental documentation (if needed) and design, or a recommendation to delay the project or dismiss it from further consideration.

3. Project Initiation

At this point in the process, the proponent, MassDOT Highway Division, fills out a Project Initiation Form (PIF) for each improvement, which is reviewed by its Project Review Committee (PRC) and the MPO. The PRC is composed of the Chief Engineer, each District Highway Director, and representatives of the Project Management, Environmental, Planning, Right-of-Way, Traffic, and Bridge departments, and the MassDOT Federal Aid Program Office (FAPO). The PIF documents the project type and description, summarizes the project planning process, identifies likely funding and project management responsibility, and defines a plan for interagency and public participation. First the PRC reviews and evaluates the proposed project based on the MassDOT’s statewide priorities and criteria. If the result is positive, MassDOT Highway Division moves the project forward to the design phase and to programming review by the MPO. The PRC may provide a Project Management Plan to define roles and responsibilities for subsequent steps. The MPO review includes project evaluation based on the MPO’s regional priorities and criteria. The MPO may assign project evaluation criteria score, a Transportation Improvement Program (TIP) year, a tentative project category, and a tentative funding category.

4. Environmental Permitting, Design, and Right-of-Way Process

This step has four distinct but closely integrated elements: public outreach, environmental documentation and permitting (if required), design, and right-of-way acquisition (if required). The outcome of this step is a fully designed and permitted project ready for construction. However, a project does not have to be fully designed in order for the MPO to program it in the TIP. The sections below provide more detailed information on the four elements of this step of the project development process.

Public Outreach

Continued public outreach in the design and environmental process is essential to maintain public support for the project and to seek meaningful input on the design elements. The public outreach is often in the form of required public hearings, but can also include less formal dialogues with those interested in and affected by a proposed project.

Environmental Documentation and Permitting

The project proponent, in coordination with the Environmental Services section of the MassDOT Highway Division, will be responsible for identifying and complying with all applicable federal, state, and local environmental laws and requirements. This includes determining the appropriate project category for both the Massachusetts Environmental Protection Act (MEPA) and the National Environmental Protection Act (NEPA). Environmental documentation and permitting is often completed in conjunction with the Preliminary Design phase described below.

Design

There are three major phases of design. The first is **Preliminary Design,** which also is referred to as the 25-percent submission. The major components of this phase include full survey of the project area, preparation of base plans, development of basic geometric layout, development of preliminary cost estimates, and submission of a functional design report. Preliminary Design, although not required to be, often is completed in conjunction with the Environmental Documentation and Permitting. The next phase is **Final Design**, which also is referred to as the 75-percent and 100-percent submission. The major components of this phase include preparation of a subsurface exploratory plan (if required), coordination of utility relocations, development of traffic management plans through construction zones, development of final cost estimates, and refinement and finalization of the construction plans. Once Final Design is complete, a full set of **Plans, Specifications, and Estimates (PS&E)** is developed for the project.

Right-of-Way Acquisition

A separate set of Right-of-Way plans are required for any project that requires land acquisition or easements. The plans must identify the existing and proposed layout lines, easements, property lines, names of property owners, and the dimensions and areas of estimated takings and easements.

5. Programming (Identification of Funding)

Programming, which typically begins during the design phase, can actually occur at any time during the process, from planning to design. In this step, which is distinct from project initiation, the proponent requests that the MPO place the project in the region’s Transportation Improvement Program (TIP). The proponent requesting the project’s listing on the TIP can be the community or it can be one of the MPO member agencies (the Regional Planning Agency, MassDOT, and the Regional Transit Authority). The MPO then considers the project in terms of state and regional needs, evaluation criteria, and compliance with the regional Transportation Plan and decides whether to place it in the draft TIP for public review and then in the final TIP.

6. Procurement

Following project design and programming of a highway project, the MassDOT Highway Division publishes a request for proposals. It then reviews the bids and awards the contract to the qualified bidder with the lowest bid.

7. Construction

After a construction contract is awarded, MassDOT Highway Division and the contractor develop a public participation plan and a management plan for the construction process.

8. Project Assessment

The purpose of this step is to receive constituents’ comments on the project development process and the project’s design elements. MassDOT Highway Division can apply what is learned in this process to future projects.

Project Development Schematic Timetable

Step	Schedule Influence	Typical Duration
Step I: Problem/Need/Opportunity Identification The proponent completes a PNF. This form is reviewed by the MassDOT district office, which guides the proponent in subsequent steps of the process.	The PNF may be prepared quickly by the proponent to include any readily available supporting data. The district office will return comments to the proponent within one month of receiving the PNF.	One-to-three months
Step II: Planning Project planning can range from agreeing on a clear solution to a detailed analysis of alternatives and their impacts.	For some projects, no planning beyond preparation of the PNF is required. Some projects require a planning study centered on specific issues associated with a proposed solution or a narrow family of alternatives. Complex projects likely would require a detailed alternatives analysis.	Project Planning Report: three-to-24+ months
Step III: Project Initiation The proponent prepares and submits a PIF and a TEC form. The MPO and MassDOT district office informally review the PIF and TEC; and the PRC formally reviews them.	The PIF includes refinement of the preliminary information contained in the PNF. Additional information summarizing the results of the planning process, such as the project planning report, is included with the PIF and TEC. The schedule is determined by PRC staff (depending on project complexity) and meeting schedule.	One-to-four months
Step IV: Design, Environmental, and Right-of-Way The proponent completes the project design. Concurrently, the proponent completes necessary environmental permitting analyses and files permit applications. Any right-of-way needed for the project is identified and the acquisition process begins.	The schedule depends upon the size of the project and the complexity of the design, permitting, and right-of-way issues. The MassDOT district and appropriate sections complete the design review.	Three- to-48+ months
Step V: Programming The MPO considers the project in terms of its regional priorities and determines whether to include the project in the draft TIP, which is made available for public comment, and includes a project description and funding source.	The schedule for this step is subject to each MPO's programming cycle and meeting schedule. It is possible that the MPO will not include a project in its draft TIP based on its review and approval procedures.	Three-to-12+ months

Step	Schedule Influence	Typical Duration
Step VI: Procurement The project is advertised for construction and a contract is awarded.	Administration of competing projects can influence the advertising schedule.	One-to-12 months
Step VII: Construction The construction process is initiated including public notification and any anticipated public involvement. Construction continues to project completion.	The duration of this step is entirely dependent upon project complexity and phasing.	Three-to-60+ months
Step VIII: Project Assessment The construction period is complete and project elements and processes are evaluated on a voluntary basis.	The duration of this step is dependent upon the proponent's approach and any required follow-up.	One month

Source: MassDOT Highway Division Project Development and Design Guide.