

NORTHAMPTON STREET CORRIDOR SIGNAL STUDY

City of Easton

Northampton County

prepared by:

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The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the views or policies of either the U.S. Department of Transportation, Federal Highway Administration (FHWA), Federal Transit Administration (FTA) or the Commonwealth of Pennsylvania at the time of publication. This report does not constitute a standard, specification, or regulation.

INTRODUCTION

The Lehigh Valley Planning Commission conducted a study of the Northampton Street corridor in the City of Easton to gauge the potential for improving traffic signals to more efficiently move people and goods. Building additional capacity in today's economic climate with transportation funds more limited now than at any point in the recent past is much more difficult, if not impossible. Instead of building additional capacity, traffic flow improvements are more likely to be obtained through improved management and operations of the existing infrastructure. Improvements to traffic signals yield a low cost/high benefit impact. Updating or modernizing signal components or entire signal heads and retiming signals reduce congestion, improve safety, improve mobility by reducing the overall number of vehicle stops thus decreasing delay, and reduce fuel consumption and the associated negative impact to air quality.

Various studies from around the country have shown that the benefits of signal retimings outweigh the costs by 40:1. According to the Federal Highway Administration's Signal Timing Manual (June 2008), signal retimings could result in reductions in traffic delay ranging from 15% – 40%, reductions in travel time up to 25%, reductions in stops ranging from 10% - 40%, reductions in fuel consumption of up to 10%, and reductions in harmful emissions (carbon monoxide, nitrogen oxides, volatile organic compounds) up to 22%.

The Pennsylvania Department of Transportation's (PennDOT) Congested Corridor Improvement Program (CCIP) was used in the past to identify some of the more severely congested corridors in the Commonwealth in order to define and implement needed improvements. The goal of the CCIP was a 20 percent reduction in peak hour travel time on the improved transportation corridor.

Nationwide, there are about 330,000 traffic signals, and according to FHWA, 75% of those signals could be improved by updating equipment or adjusting the timing. Statewide, there are 13,600 traffic signals. Lehigh and Northampton counties contain 718 traffic signals.

PennDOT does not own or maintain any traffic signals in the Commonwealth. All traffic signals are owned, maintained, and operated by the 2,566 municipalities located within Pennsylvania's 67 counties. Municipalities often treat traffic signals, with regard to revising signal timing plans, as the responsibility of PennDOT. PennDOT's authority is limited to the review and approval of signal permitting and timing plans. The consequences of poor or deferred traffic signal maintenance are numerous and may result in higher crashes, higher motorist costs, higher fuel consumption, poorer air quality, higher maintenance costs and shorter signal life to name a few.

The purpose of this report is to identify traffic signal improvements that will facilitate traffic flow. Once improvements are implemented and traffic flows have had time to adjust accordingly, an after-action review of the corridor will be conducted to determine the reduction in peak hour travel time and delay. The goal is to obtain a 10% reduction in travel time.

IDENTIFICATION OF CANDIDATE CORRIDORS

The Lehigh Valley Transportation Study (LVTS), the Metropolitan Planning Organization (MPO) for Lehigh and Northampton Counties, utilized multiple sources of data to identify can-

didate corridors for study. Corridors were first identified through a review of the Lehigh Valley Congestion Management Process report. This document identifies corridors of at least one mile in length predicted to be congested in the year 2030. Four corridors were identified as a candidate for study. The second identification of candidate corridors utilized a geographic information system for transportation (GIS-T). The GIS-T was reviewed for signalized corridors, length of corridor, number of traffic signals within the corridor, traffic signal density per linear mile, roadway functional classification of the facility, traffic volumes within the corridor, and type of signals present (fully actuated, semi-actuated, pre-timed, volume-density). Corridor field views were conducted as necessary. Ten corridors were identified through this process. The ten corridors identified are as follows:

**TABLE 1
Candidate Corridors**

Corridor Name	Municipality (ies)	Corridor Limits		Length	# of Total Signals	Functional Class.
		From	To			
Lehigh Street	Emmaus/Salisbury/Allentown	Cedar Crest Blvd.	8th St.	5.38	22	Prin./Minor Art.
Northampton St.	Easton	15th St.	7th St.	0.72	6	Prin. Art.
25th St.	L. Nazareth Twp./Palmer Twp.	Hollo Rd.	Park Ave.	2.5	9	Prin. Art.
25th St.	L. Nazareth Twp./Palmer Twp.	Hollo Rd.	Freemansburg Ave.	4.11	18	Prin./Minor Art.
Lower Macungie Rd.	L./U. Macungie Twp.	Hamilton Blvd.	Brookside Rd.	2.16	8	Minor Art.
Route 512	Hanover Twp. (N. Co.)	Jaindl Blvd.	Rt. 22 EB ramps	1.71	8	Minor Art.
Hanover Ave.	Allentown	E. Hamilton St.	N. Wahneta St.	1.87	7	Prin. Art.
Schoenersville Rd.	Airport Rd. to Eaton Ave.	Airport Rd.	Eaton Ave.	2.67	14	Minor Art.
Route 309	S. & N. Whitehall Twps.	Shankweiler Rd.	Walbert Ave.	2.89	6	Prin. Art.
Route 191	Beth. Twp./L. Nazareth Twp.	Newburg Rd.	Rt. 22 EB ramps	1.88	5	Minor Art.

SELECTED CORRIDOR

The Northampton Street corridor in the City of Easton from 15th Street to 7th Street was chosen for study because it is operating on outdated signal timing plans and provides access to important downtown attractions. It spans a distance of 0.72 miles. The signalized intersections located east of 7th Street – 6th Street, 5th Street, 4th Street, 3rd Street/Center Square, 2nd Street, and Riverside Drive/Larry Holmes Drive – operate on a different timing plan and are affected by the pedestrian phasing of signals around Center Square. Consequently, they have not been included in this study.

Northampton Street contains a mixture of various land uses ranging from urban residential, retail/commercial, office, public school, and some manufacturing/industrial and warehousing/distribution. All of these land uses have frontage and/or access onto Northampton Street. Since the Northampton Street corridor is the main east-west travel corridor in the vicinity, traffic generated from these various land uses utilize the corridor. The corridor is an important one for the City of Easton for a number of reasons. It connects western portions of the City with the Paxinosa Elementary School (part of the Easton Area School District) as well as the State Theater, Crayola Factory, and varied businesses along the corridor and around Center Square. It also provides access to varied retail/commercial/and other important economic-generating land uses as well as urban residential developments.

The corridor is classified as a principal arterial within the study area. This higher-level classification has the primary function of moving traffic with a lesser function of providing access to properties. The entire length of the corridor from 15th Street to 7th is 0.72 miles and contains six traffic signals for a signal density of 8.33 traffic signals per mile, the highest density of any candidate corridor.

Annual Average Daily Traffic (AADT) varies throughout the corridor. Traffic volumes were obtained utilizing PennDOT's Internet Traffic Monitoring System (ITMS). The portion of the corridor west of 13th Street has the highest traffic volumes at 9,300 AADT. The portion of corridor east of 13th Street has the lower volume of 8,600 AADT. These volumes, coupled with the high density of traffic signals along the corridor, as well as the corridor functioning as the western gateway to downtown attractions such as the State Theater and Crayola Factory, made this corridor a good candidate for signal system upgrades. Some signal timing plans in the corridor date back to 1980.

MAP 1

Northampton Street (S.R. 248) Corridor
15th Street to 7th Street



SIGNAL CONTROL DEFINITIONS

In order to gain an understanding of how the signals in the corridor tie together, we must begin with definitions of various signal control types. The signal control types are listed in increasing order from the basic to the more advanced. The more sophisticated signal controllers, such as volume-density controls, can better handle traffic fluctuations than less sophisticated pre-timed signal controllers.

PRE-TIMED - Pre-timed control is ideally suited to closely spaced intersections where traffic volumes and patterns are consistent on a daily or day-of-week basis. Such conditions are often found in downtown areas. They are also better suited to intersections where three or fewer phases are needed. Pre-timed control has several advantages. For example, it can be used to provide efficient coordination with adjacent pre-timed signals, since both the start and end of green are predictable. Also, it does not require detectors, thus making its operation immune to problems associated with detector failure. Finally, it requires a minimum amount of training to set up and maintain. On the other hand, pre-timed control cannot compensate for unplanned fluctuations in traffic flows, and it tends to be inefficient at isolated intersections where traffic arrivals are random.

SEMI-ACTUATED - Semi-actuated control uses detection only for the minor movements at an intersection. The phases associated with the major-road through movements are operated as “non-actuated.” That is, these phases are not provided detection information. In this type of operation, the controller is programmed to give priority to the non-actuated phase and, thereby, sustain a green indication for the highest flow movements (normally the major street through movement). Minor movement phases are serviced after a call for their service is received. Semi-actuated control is most suitable for application at intersections that are part of a coordinated arterial street system. Semi-actuated control may also be suitable for isolated intersections with a low-speed major road and lighter crossroad volume. Semi-actuated control has several advantages. Its primary advantage is that it can be used effectively in a coordinated signal system. Also, relative to pre-timed control, it reduces the delay incurred by the major-road through movements (i.e., the movements associated with the nonactuated phases) during periods of light traffic. Finally, it does not require detectors for the major-road through movement phases and hence, its operation is not compromised by the failure of these detectors. The major disadvantage of semi-actuated operation is that continuous demand on the phases associated with one or more minor movements can cause excessive delay to the major road movements if the timings are not appropriately set. Another drawback is that detectors must be used on the minor approaches, thus requiring installation and ongoing maintenance.

FULLY-ACTUATED - Fully-actuated control refers to intersections for which all phases are actuated meaning it requires detection for all traffic movements. Fully-actuated control is ideally suited to isolated intersections where the traffic demands and patterns vary widely during the course of the day. Most modern controllers in coordinated signal systems can be programmed to operate in a fully-actuated mode during low-volume periods where the system is operating in a “free” (or non-coordinated) mode. Fully-actuated control can also improve performance at intersections with lower volumes that are located at the boundary of a coordinated system and do not impact progression of the system. Fully-actuated control has also been used at the intersection of two arterials to optimize green time allocation in a critical intersection control method.

There are several advantages of fully-actuated control. First, it reduces delay relative to pre-timed control by being highly responsive to traffic demand and to changes in traffic pattern. In addition, detection information allows the cycle time to be efficiently allocated on a cycle-by-cycle basis. Finally, it allows phases to be skipped if there is no call for service, thereby allowing the controller to reallocate the unused time to a subsequent phase. The major disadvantage of fully-actuated control is that its cost (initial and maintenance) is higher than that of other control types due to the amount of detection required. It may also result in higher percentage of vehicles stopping because green time is not held for upstream platoons.

VOLUME-DENSITY – Volume-density signal control is more advanced than fully-actuated control. The signal records and retains actual traffic volumes. Vehicles queued up over a certain distance cause information to be sent to a traffic controller, and the controller adjusts the length of green time.

Table 2 shows signal control type by intersection.

Table 2
SIGNAL CONTROL TYPE BY INTERSECTION

#	Intersection	Control Type
1	Northampton Street/15th Street	Pre-Timed
2	Northampton Street/13th Street	Pre-Timed
3	Northampton Street/12th Street	Pre-Timed
4	Northampton Street/10th Street	Pre-Timed
5	Northampton Street/9th Street	Pre-Timed
6	Northampton Street/7th Street/Wood Ave.	Pre-Timed

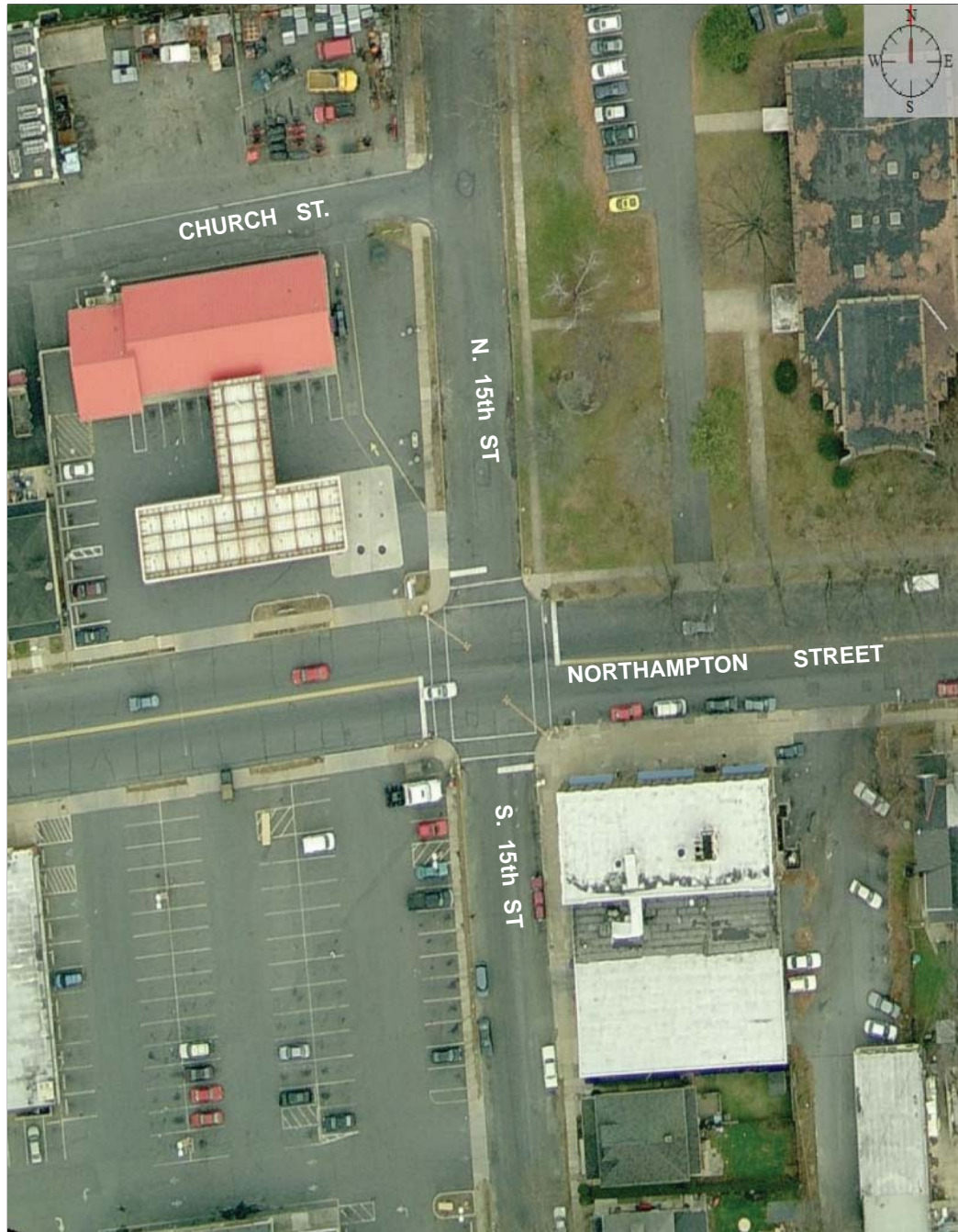
INTERSECTION AND LANE GEOMETRY

The following is a description of each signalized intersection including aerial reviews

Northampton Street (SR 248) is classified as a principal arterial and runs in an east to west manner through the City of Easton. The speed limit is 35 mph throughout the corridor.

Northampton Street/15th Street Intersection

This intersection is a four-way, pre-timed signalized intersection. Both the east-bound and west-bound approaches provide for one lane of travel. On-street parking is allowed on both the north (west-bound) and south (eastbound) sides of Northampton Street. No dedicated turning movement lanes exist at this intersection. 15th Street is a locally-owned road.



Northampton Street/13th Street Intersection

This intersection is a four-way, pre-timed intersection. All approaches provide for a dedicated left turn only lane and a shared through/right turn lane. On-street parking is allowed on both the north (westbound) and south (eastbound) sides of Northampton Street. 13th Street is a state-owned road (SR 2020).



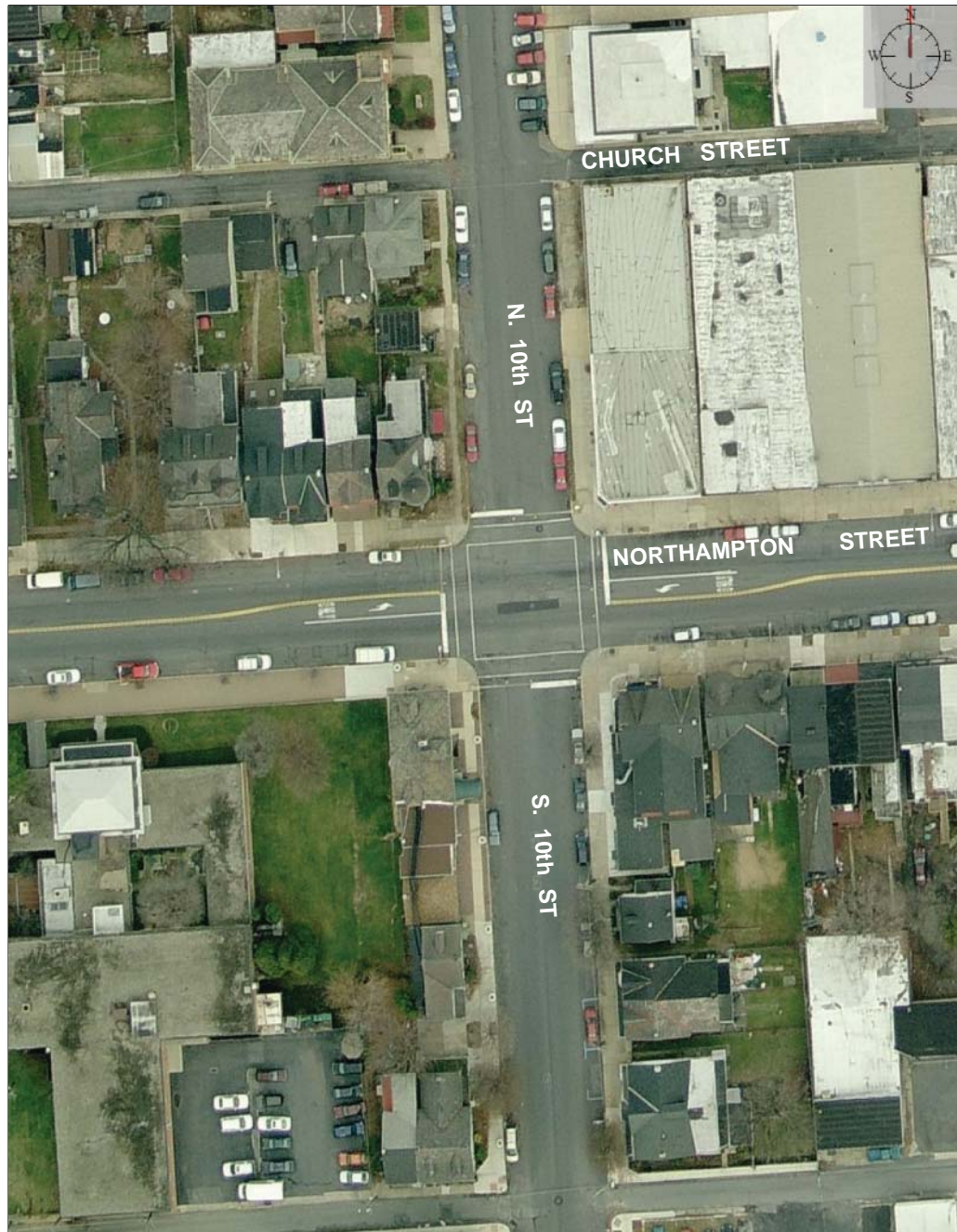
Northampton Street/12th Street Intersection

This intersection is a four-way, pre-timed intersection. The eastbound and westbound approaches provide for a dedicated left turn only lane and a shared through/right turn lane. The northbound and southbound travel lanes on 12th Street provide for one lane for all movements. On-street parking is allowed on all approaches. 12th Street is a locally-owned road.



Northampton Street/10th Street Intersection

This intersection is a four-way, pre-timed signalized intersection. The eastbound and westbound approaches provide for a dedicated left turn only lane and a shared through/right turn lane. The northbound and southbound travel lanes on 10th Street provide for one lane for all movements. On-street parking is allowed on all approaches. 10th Street is a locally-owned road.



Northampton Street/9th Street Intersection

This intersection is a four-way, pre-timed signalized intersection. The eastbound and westbound approaches provide for a dedicated left turn only lane and a shared through/right turn lane. The northbound and southbound travel lanes on 9th Street provide for one lane for all movements. On-street parking is allowed on all approaches. 9th Street is a locally-owned road.



Northampton Street/7th Street/Wood Avenue Intersection

This intersection is a five-leg intersection. The four main legs are formed by the intersection of Northampton Street with 7th Street, which is under pre-timed signalized control. The eastbound approach provides for one dedicated left turn lane and one shared through/right turn lane. The westbound approach provided for one shared left/through/right turn lane. Both the northbound and southbound approaches on 7th Street provide for one shared right/through/left turn lane. On-street parking is allowed on both the eastern, western and southern approaches to the intersection.



Wood Avenue intersects Northampton Street at a skewed angle from the north at a point just west of 7th Street. Wood Avenue at this location is one-way westbound. 7th Street is a locally-owned road while Wood Avenue (SR 1017) is a state-owned road.

CRASH ANALYSIS

Crash data was compiled using the LVPC's GIS-T and PennDOT's CDART system. The most recent crash data from years 2006 through 2010 was utilized. According to the crash analysis, there were 66 reportable crashes along Northampton Street (SR 248) from 15th Street to 7th Street including one fatality and two major injuries. The most prone crash area was between 15th Street and 13th Street. 26 (39%) of crashes occurred along this segment including one major injury, three pedestrian and one bicycle-related crash. The most severe crash segment was between 9th Street and 7th Street where one fatality occurred. The Northampton Street/15th Street intersection was the only intersection to experience a major injury crash. Crashes 100 feet from the intersection were included in the intersection crash analysis. A general rule of thumb is intersections with ten or more crashes over a 5-year period are candidates for safety improvement reviews unless fatal or major crashes occur. The six intersections are:

- Northampton Street/15th Street – This intersection contained 8 crashes including one major injury.
- Northampton Street/13th Street – This intersection contained 17 crashes including one pedestrian and one bicycle-related crash. This area should be reviewed for adequate pedestrian facilities. Eight (47%) of crashes involve running a red light. The signals should be reviewed for possible upgrades to increase visibility of the signals.
- Northampton Street/12th Street – This intersection contained 9 crashes. Two (22%) of crashed involve running a red light.
- Northampton Street/10th Street – This intersection contained 4 crashes.
- Northampton Street/9th Street – This intersection contained 7 crashes.
- Northampton Street/7th Street – This intersection contained 2 crashes.

Detailed crash data will be provided to PennDOT for their consideration.

SPEED AND DELAY RUNS

LVPC conducted speed and delay runs in the fall of 2011. Data collected first involved contact with the City of Easton to inquire about recent traffic count data along Northampton Street. No recent count data was available. The LVPC subsequently conducted a traffic count on Northampton Street between 12th Street and 11th Street on Thursday, September 15, 2011. This data was used to determine the AM and PM peak hour of traffic (the four consecutive 15-minute intervals of highest traffic volumes) to ensure the speed and delay runs were conducted at the proper time of day. The AM peak hour started at 9:30 while the PM peak hour started at 3:15.

Speed and delay are two principle measures of highway system performance. A speed and delay study provides valuable data prior to implemented improvements that may be compared to data obtained after the implementation of improvements to show a net benefit through increased speeds and reduced delay. Speed and delay data collection involves conducting travel runs along the corridor in a test vehicle, documenting travel times between signals, stopped delay, and delay-causing events. The test vehicle driver travels at a speed dictated by the platoon speed (not the posted speed limit) of vehicles along the corridor. This is accomplished by attempting to safely pass as many vehicles as pass the test vehicle. Queue lengths at signalized intersections as well as the number of traffic signal cycle failures were captured (vehicles not discharging from the queue during a signal cycle).

Speed and Delay runs were conducted for the morning and evening peak periods on Tuesday, September 27, 2011. Table 3 depicts the summation of all directional travel runs conducted in the corridor for both the AM and PM peak periods. The speed limit in the corridor is 35 mph. In order to accurately report on the percentage of travel speed to posted speed, summary data is displayed by intersection, by direction, by time period. The cumulative travel time and cumulative stopped delay depicts the travel time and stopped delay of all five speed and delay runs conducted in the corridor.

The cumulative travel times and cumulative stopped delay are relatively short in most instances. Travel speeds, however, are in most instances less than half the posted speed limit. The only significant exception to this pattern occurred during the eastbound afternoon runs where the travel speed was 59.4% of the posted speed limit. The cumulative travel time for all eastbound runs during the morning peak was 12 minutes 50 seconds while the cumulative stopped delay was 2 minutes 50 seconds. This resulted in an average travel speed of 16.8 mph which represents just 48.0% of the posted speed limit. The cumulative travel time for all westbound runs during the morning peak was 17 minutes 17 seconds while the cumulative stopped delay was 3 minutes 46 seconds. This resulted in an average travel speed of 15.1 mph. The cumulative travel time for all eastbound afternoon runs was 10 minutes 24 seconds while the cumulative stopped delay was only 49 seconds which resulted in an average travel speed of 20.8 mph. The cumulative travel time for all westbound afternoon runs was 15 minutes and 57 seconds while the cumulative stopped delay was 4 minutes 45 seconds. This resulted in an average travel speed of 13.5 mph. Average queue lengths are depicted. It represents the average number of vehicles queued at a traffic signal for all six signals in the corridor from all five speed and delay runs conducted. Most of the PM delay experienced in the western portion of the corridor resulted from the discharge of Paxinosa Elementary School students. Also, considering that there is a fairly steady progression of traffic in the corridor, the traffic moves well below the speed limit. This can be a result of the urban environment. Both north and south sides of Northampton Street and many side streets allow for on-street parking. The corridor also has a fair amount of both general and school pedestrian activity. In addition, the distances between signalized intersections are rather short. These elements have a tendency to calm traffic. The intersections should be evaluated for possible signal timing improvements or optimization.

Detailed speed and delay run data by intersection for the entire corridor may be found in Appendix A. Information presented includes cumulative travel time, stopped delay, running speed, travel speed, causes of delay, queue lengths, and number of cycle failures.

RECOMMENDATIONS

The results of this study indicate that the Northampton Street corridor, from South 15th Street to 7th Street, generally operates sufficiently to allow for the smooth but slow flow of vehicular traffic given the volumes utilizing corridor. However, excessive delay occurs during the discharge of school students. Considering that signals within this corridor are operating on timing plans from the 1980s, signal retimings and optimization should be considered.

Municipalities should utilize the Automated Red Light Enforcement (ARLE) program to apply for 100% State funds for the replacement, upgrading, and retiming of traffic signals, controllers, and other signal-related components. The City of Allentown has applied to this program for just this purpose.

Table 3
NORTHAMPTON STREET CORRIDOR STUDY SUMMARY

Corridor	Direction	Time Period AM/PM	Cumulative Travel Time (min) : (sec)		Cumulative Stopped Delay (min) : (sec)		Travel Speed (mph)	Posted Speed (mph)	% of Intersections Experiencing Stops	% Travel Speed of Posted Speed	Average Queue Lengths		# of Cycle Failures
Northampton Street (15th St. - 7th St.)	Eastbound	AM	12	: 50	2	: 50	16.8	35	44.0%	48.0%	1.2	0	
	Westbound	AM	17	: 17	3	: 46	15.1	35	72.0%	43.1%	2.1	0	
	Eastbound	PM	10	: 24	0	: 49	20.8	35	12.0%	59.4%	0.5	0	
	Westbound	PM	15	: 57	4	: 54	13.5	35	64.0%	38.6%	2.1	2	

NEXT STEPS

Contingent upon approval and programming of this project, additional data collection in the form of intersection traffic counts will be needed for the purpose of developing alternative signal timing plans. Once improvements are implemented and traffic flows have had time to adjust accordingly, an after-action review of the corridor will be conducted to determine the reduction in peak hour travel time and delay. The goal is to obtain a 10% reduction in travel time.

Considering that many traffic signals function on outdated timing plans, are owned and maintained by Pennsylvania's local municipalities, coupled with the historically robust population growth of the area which has continued to add traffic to the regional road network, a new smarter approach is being considered. This approach introduces the concept of "Priority Arterial Corridors" which are a selected set of regionally critical highways where the state has a greater role in operation of traffic signals. This role could include PennDOT contracts to review and optimize these selected signals on a routine basis as part of their asset management systems approach to highway operations and maintenance. This new role might be funded through the state's capital program as a continuing program. Much of this proposal has been discussed in one form or another among members of the State Transportation Advisory Committee and the two funding commissions. Pennoni Associates, Inc. has been retained by PennDOT to develop a Traffic Signal Operations and Maintenance Plan that addresses this issue. The consultant has conducted a review of best practices from Georgia, New Jersey, North Carolina, Ohio, and Virginia and is currently obtaining input from municipal officials, vendors/contractors, design engineers, planning officials, PennDOT Central and District offices, and Federal Highway Administration representatives. A completed plan is anticipated by May 2012.

APPENDIX A

Table 4 depicts a summation of all five eastbound travel runs conducted during the AM peak period for Northampton Street. The distance in miles depicted between intersections is cumulative for all 5 travel runs conducted. For example, the distance between 15th Street and 13th Street is 0.2 miles. This distance traveled for 5 runs equates to a total of 1 mile. The posted speed limit is 35 mph. Average travel speeds, which is a calculated vehicle speed that includes stopped delay times and acceleration/deceleration times, vary from 10.1 mph to 25.7 mph representing 28.9% and 73.4% of the posted speed limit respectively. Delay may be caused by numerous factors such as bus or delivery vehicle loading/unloading, double parked vehicles, vehicles making turns, pedestrians, traffic signals, etc. The only eastbound delay experienced in this corridor was as a result of traffic signals. The intersections should be evaluated for possible signal timing improvements or optimization.

Table 4
AM SPEED & DELAY RUN SUMMARY FOR NORTHAMPTON STREET - EASTBOUND
TRAVEL TIME AND DELAY STUDY - FIELD SHEET

Road: Northampton Street Direction: EastBound RUN: EastBound Summary of All Runs
 Project: Signal Corridor Study Date: 9/27/2011 Performed by: JG & MD
 Location: Easton Day of Wk: Tuesday Peak Period: AM
 Weather: Overcast

Control Point	Posted Speed (mph)	Distance (mi.)	Cumulative Travel Time (Seconds)	Stop Delay (min : sec)		Running Speed (mph)	Travel Speed (mph)	Delay Factors	Queue Lengths	# of Cycle Failures	
15th St.					:						
13th St.	35	1.00	278	1	:	43	20.57	12.95	TS	14	0
12th St.	35	0.50	457	1	:	6	15.93	10.06	TS	21	0
10th St.	35	1.00	607		:	1	24.16	24.00	TS	1	0
9th St.	35	0.35	665		:	0	21.72	21.72			
7th St./Wood Ave.	35	0.75	770		:	0	25.71	25.71			
		3.60	770	2	:	50	21.60	16.83		36	0

Delay Factor Codes:

BS = Bus Loading/Unloading	PK = Parked Cars	LO = Delivery Loading/Unloading
DP = Double Parking	PD = Pedestrians	CY = Cyclist
EV = Emergency Vehicle	RR = Railroad Crossing	RT = Right Turn
GC = General Congestion	SS = Stop Sign	DV = Disabled Vehicle
LT = Left Turns	TK = Truck	GT = Garbage Truck
OT = Other	TS = Traffic Signal	

Table 5 depicts a summation of all five westbound travel runs conducted during the AM peak period for Northampton Street. The posted speed limit is 35 mph. Average travel speeds, which is a calculated vehicle speed that includes stopped delay times and acceleration/deceleration times, vary from 10.9 mph to 21.6 mph representing 31.1% and 61.7% of the posted speed limit respectively. Delay may be caused by numerous factors such as bus or delivery vehicle loading/unloading, double parked vehicles, vehicles making turns, pedestrians, traffic signals, etc. The only eastbound delay experienced in this corridor was as a result of traffic signals. The intersections should be evaluated for possible signal timing improvements or optimization.

Table 6 depicts a summation of all five eastbound travel runs conducted during the PM peak period for Northampton Street. The posted speed limit is 35 mph. Average travel speeds, which is a calculated vehicle speed that includes stopped delay times and acceleration/deceleration times, vary from 14.5 mph to 28.8 mph representing 41.1% and 82.3% of the posted speed limit respectively. Delay may be caused by numerous factors such as bus or delivery vehicle loading/

**Table 5
AM SPEED & DELAY RUN SUMMARY FOR NORTHAMPTON STREET - WESTBOUND
TRAVEL TIME AND DELAY STUDY - FIELD SHEET**

Road: Northampton Street Direction: WestBound RUN: WestBound Summary of All Runs
 Project: Signal Corridor Study Date: 9/27/2011 Performed by: JG & MD
 Location: Easton Day of Wk: Tuesday Peak Period: AM
 Weather: Overcast

Control Point	Posted Speed (mph)	Distance (mi.)	Cumulative Travel Time (Seconds)	Stop Delay		Running Speed (mph)	Travel Speed (mph)	Delay Factors	Queue Lengths	# of Cycle Failures
				(min)	(sec)					
7th St./Wood Ave.										
9th St.	35	0.75	178		45	20.30	15.17	TS	18	0
10th St.	35	0.35	290		37	16.80	11.25	TS	7	0
12th St.	35	1.00	457		32	26.67	21.56	TS	1	0
13th St.	35	0.50	622		55	16.36	10.91	TS	21	0
15th St.	35	1.00	857		57	20.22	15.32	TS	17	0
		3.60	857	3	46	20.54	15.12		64	0

Delay Factor Codes:

BS = Bus Loading/Unloading
 DP = Double Parking
 EV = Emergency Vehicle
 GC = General Congestion
 LT = Left Turns
 OT = Other

PK = Parked Cars
 PD = Pedestrians
 RR = Railroad Crossing
 SS = Stop Sign
 TK = Truck
 TS = Traffic Signal

LO = Delivery Loading/Unloading
 CY = Cyclist
 RT = Right Turn
 DV = Disabled Vehicle
 GT = Garbage Truck

unloading, double parked vehicles, vehicles making turns, pedestrians, traffic signals, etc. The only eastbound delay experienced in this corridor was as a result of traffic signals. The intersections should be evaluated for possible signal timing improvements or optimization.

Table 7 depicts a summation of all five westbound travel runs conducted during the PM peak period for Northampton Street. The posted speed limit is 35 mph. Average travel speeds, which is a calculated vehicle speed that includes stopped delay times and acceleration/deceleration

**Table 6
PM SPEED & DELAY RUN SUMMARY FOR NORTHAMPTON STREET - EASTBOUND
TRAVEL TIME AND DELAY STUDY - FIELD SHEET**

Road: Northampton Street Direction: EastBound RUN: EastBound Summary of All Runs
 Project: Signal Corridor Study Date: 9/27/2011 Performed by: JG & MD
 Location: Easton Day of Wk: Tuesday Peak Period: PM
 Weather: Overcast

Control Point	Posted Speed (mph)	Distance (mi.)	Cumulative Travel Time (Seconds)	Stop Delay		Running Speed (mph)	Travel Speed (mph)	Delay Factors	Queue Lengths	# of Cycle Failures
				(min)	(sec)					
15th St.										
13th St.	35	1.00	125		0	28.80	28.80			
12th St.	35	0.50	230		15	20.00	17.14	TS	14	0
10th St.	35	1.00	386		0	23.08	23.08			
9th St.	35	0.35	438		0	24.23	24.23			
7th St./Wood Ave.	35	0.75	624		34	17.76	14.52	TS	1	0
		3.60	624		49	22.54	20.77		15	0

Delay Factor Codes:

BS = Bus Loading/Unloading
 DP = Double Parking
 EV = Emergency Vehicle
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times, vary from 6.45 mph to 21.0 mph representing 18.4% and 60.0% of the posted speed limit respectively. Delay may be caused by numerous factors such as bus or delivery vehicle loading/unloading, double parked vehicles, vehicles making turns, pedestrians, traffic signals, etc. The westbound delay experienced in this corridor was as a result of both traffic signals and left turning vehicles. The intersections should be evaluated for possible signal timing improvements or optimization.

**Table 7
PM SPEED & DELAY RUN SUMMARY FOR NORTHAMPTON STREET - WESTBOUND
TRAVEL TIME AND DELAY STUDY - FIELD SHEET**

Road: Northampton Street Direction: WestBound RUN: WestBound Summary of All Runs
 Project: Signal Corridor Study Date: 9/27/2011 Performed by: JG & MD
 Location: Easton Day of Wk: Tuesday Peak Period: PM
 Weather: Overcast

Control Point	Posted Speed (mph)	Distance (mi.)	Cumulative Travel Time (Seconds)	Stop Delay		Running Speed (mph)	Travel Speed (mph)	Delay Factors	Queue Lengths	# of Cycle Failures
				(min)	(sec)					
7th St./Wood Ave.										
9th St.	35	0.75	184		48	19.85	14.67	TS	14	0
10th St.	35	0.35	244		0	21.00	21.00			
12th St.	35	1.00	477	1	11	22.22	15.45	TS	8	0
13th St.	35	0.50	758	2	9	11.84	6.41	TS	29	2
15th St.	35	1.00	957		46	23.53	18.09	TS LT	12	0
		3.60	957	4	54	19.55	13.54		63	2

Delay Factor Codes:

BS = Bus Loading/Unloading
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 OT = Other

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 PD = Pedestrians
 RR = Railroad Crossing
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