Ware

Downtown Signal Coordination and Safety Study

January 2011

PREPARED UNDER THE DIRECTION OF PIONEER VALLEY MPO BY:
PIONEER VALLEY PLANNING COMMISSION
60 CONGRESS STREET
SPRINGFIELD, MA 01104

Prepared in cooperation with the Town of Ware, the Massachusetts Department of Transportation and the U.S. Department of Transportation – Federal Highway Administration and the Federal Transit Administration. The views and opinions of the Pioneer Valley Planning Commission expressed herein do not necessarily reflect those of the U.S. Department of Transportation.

TABLE OF CONTENTS

SUMMARY OF TABLES AND FIGURES

I. INTRODUCTION

The Pioneer Valley Planning Commission (PVPC) received a request from the Town of Ware to perform a Signal Coordination and Safety study along several streets within the central business district of the town. In the Town of Ware, these street segments serve a variety of residential, commercial and institutional land uses. The goal of this study is to analyze existing and future vehicle flow and to develop recommendations to reduce congestion in this area.

A. STUDY AREA

The study area focuses on the intersections described in Table I-1. Two major routes (Route 9 and Route 32) intersect within the downtown area of the Town of Ware. These roadways provide direct connections to the Town of Palmer, Amherst, Belchertown and Worcester County. The study area provides access to a variety of land uses including Country Bank for Savings, Baystate Mary Lane Hospital, Kanzaki Specialty Papers, CVS, Friendly's, the Ware Town Hall, and many local storefront shops.

Table I-1 Intersections Analyzed within Study Area

West Street (Route 32) with Pulaski Street
West Street (Route 32) with West Main Street (Route 9) and Main Street (Route 9 and Route 32)
Main Street (Route 9 and Route 32) with North Street*
Main Street (Route 9 and Route 32) with Bank Street
Main Street (Route 9 and Route 32) with South Street and Church Street*
South Street with Pulaski Street

* = *Signalized Intersections*

1. West Street (Route 32) and Pulaski Street

West Street intersects with Pulaski Street to form a three-way unsignalized intersection. One lane of traffic is provided for the northbound and southbound approaches. Pulaski Street is a one-way eastbound traveling roadway with on street parking available along the north side of the street. Parking is also provided along the east side of the southbound approach of West Street. The speed limit for every approach to the intersection was 25 MPH. Crosswalks are provided across West Street south of the intersection and across Pulaski Street. Sidewalks are also provided along every approach to the intersection. At the time of the field inventory, the crosswalks and sidewalks were noted to be in good condition. A gas station is located on the southeast corner of the intersection. Vehicles utilizing this gas station have access to both West Street and Pulaski Road. Traffic has been observed turning out of the gas station and traveling the wrong direction on Pulaski Street. An uncontrolled private residential driveway is located southwest of the intersection. Pulaski Street is classified as a Local Road and West Street is classified as an Urban Extension.

2. West Street (Route 32) with West Main Street (Route 9) and Main Street (Route 9 and Route 32)

West Street intersects with West Main Street and Main Street to form a three-way unsignalized intersection with posted speed limits of 25 MPH. The northbound approach provides one exclusive right turn lane onto Main Street. The eastbound approach provides one through lane and one exclusive right turn lane and is controlled by a 'Stop' sign and a red flashing warning beacon. The westbound approach provides one exclusive left turn lane and one through movement lane. Crosswalks are provided south and west of the intersection. Sidewalks are provided for every approach. At the time of the field inventory, the pavement markings and sidewalks were noted to be in good condition. The Ware Town Hall is located on the southeast corner of the intersection with off street parking provided off of West Street and two parking spaces provided on the south side of Main Street directly in front of the building. A vacant theater and sports bar are located north of the intersection. A package store is located at the southwest corner of the intersection providing nine perpendicular parking spaces to West Main Street. All of these approaches are classified as Urban Extensions.

3. Main Street (Route 9 and Route 32) and North Street

Main Street intersects with North Street to form a three-way signalized intersection with pedestrian actuated signals. The speed limit for all approaches is 25 MPH. The eastbound approach provides one exclusive left turn lane and one through movement lane. The westbound approach provides one shared through and right movement lane and one exclusive left turn lane that serves the intersection of West Street, West Main Street and Main Street. Crosswalks are provided at the southbound approach and across Main Street east of the intersection. Sidewalks are provided at every approach. At the time of the field inventory, the sidewalks were noted to be in good condition and the pavement markings were noted to be faded. Parking is provided on both sides of Main Street east of the intersection and in front of Friendly's Restaurant located on the northwest corner of the intersection. Store front retail space is available on the northeast corner and south of the intersection. North Street is classified as an Urban Minor Collector and Main Street is classified as an Urban Extension.

4. Main Street (Route 9 and Route 32) and Bank Street

Main Street intersects with Bank Street to form a three-way unsignalized intersection with posted speed limits of 25 MPH. The eastbound approach provides one lane of traffic. The westbound approach provides two through movement lanes but their pavement markings designate arrows for the turning movements of the adjacent intersections in the westbound direction. Crosswalks are provided at the southbound approach and across Main Street west of the intersection. Sidewalks are provided at every approach. At the time of the field inventory, the crosswalks and sidewalks were noted to be in good condition. Bank Street is a one-way street providing one lane of traffic and parking on the west side of the street. On street parking is provided at all approaches of the intersection. Country Bank is located on the northwest corner of the intersection and store front retail is located on both sides of Main Street. Sight distance from the southbound approach is limited due to the existing buildings located on the northeastern corner of the intersection. Bank Street is classified as an Urban Major Collector.

5. Main Street (Route 9 and Route 32) with South Street and Church Street

Main Street intersects with South Street and Church Street to form a four-way signalized intersection with pedestrian actuated signals. The speed limit for all approaches is 25 MPH. The northbound, southbound, and westbound approaches provide one lane of traffic. The east bound approach provides an exclusive right turn lane and one shared left turn and through movement lane. Crosswalks are provided at the southbound approach and across Main Street at the westbound approach. Sidewalks are provided at every approach. At the time of the field inventory, the crosswalks were noted to be faded and the sidewalks were noted to be in good condition. On street parking is provided on the northern side of the eastbound and westbound approaches and the east side of the southbound approach. An office is located on the southeast corner of the intersection. A library and a professional center are located on the northwest and northeast corners of the intersections. Nenameseck Square, a historically protected town green, is located on the southwest corner of the intersection. An unnamed roadway designated for one-way travel in the southbound direction provides access to Family First Bank and on street parking west of Nenameseck Square. The current intersection geometry causes problems for larger vehicles such as trucks when attempting to turn right from Main Street onto South Street. PVPC staff observed that most heavy vehicles drive over the curbing and sidewalk that surrounds Nenameseck Square. A decorative fence that surrounds Nenameseck Square has also been damaged by heavy vehicles attempting to turn right onto South Street. Both Church Street and South Street are classified as Urban Major Collectors.

6. South Street and Pulaski Street

South Street intersects Pulaski Street to form a three-way unsignalized intersection with Pulaski Street operating under stop sign control. The speed limit for all approaches is 25 MPH. One lane of traffic is provided for the northbound and southbound approaches. Pulaski Street is a one-way street in the eastbound direction and provides one exclusive left turn lane and one exclusive right turn lane. A crosswalk is provided across this eastbound approach and sidewalks are provided at every approach. At the time of the field inventory, the crosswalk was noted to be faded and the sidewalks were noted to be in good condition. On-street parking is provided on the north side of Pulaski Street. This intersection is located approximately 180 feet south of the intersection of Main Street, South Street and Church Street. The southbound one-way roadway providing access to Family First Bank exits onto Pulaski Street in close proximity to its intersection with South Street. Vehicle queues on South Street and the exiting traffic from the bank access roadway were observed to negatively impact delay for left turning traffic from Pulaski Street. Pulaski Street is classified as a Local Road.

II. EXISTING TRANPORTATION CONDITIONS

This section provides a technical evaluation of the existing traffic conditions of the study area. It includes a presentation of data collected, analysis of traffic operations, and a series of observations and conclusions derived from the analysis.

A. PEAK HOUR VOLUME AND TURNING MOVEMENT COUNTS

Turning Movement Counts (TMC's) were conducted at the intersections during the peak commuter periods between early November 2009 and early February 2010. The weekday peak commuter period occurs during the morning hours of 7:00 AM to 9:00 AM and the afternoon hours of 4:00 PM to 6:00 PM. Additionally, an eight hour TMC was conducted at the intersection of West Street (Route 32) with West Main Street (Route 9) and Main Street (Route 9 and Route 32) in order to satisfy the data collection requirements to perform a signal warrant analysis.

The TMC's identify the peak four consecutive 15 minute periods of traffic through the intersection during the peak commuter period. These consecutive peak 15 minute periods constitute a location's Peak Hour Volume. The peak hour of traffic volume represents the most critical period of operations and will be the focus for some of the analysis conducted in this study.

As traffic volumes tend to fluctuate over the course of the year the Massachusetts Department of Transportation (MassDOT) develops yearly traffic volume adjustment factors to reflect monthly variations. These factors were examined to determine how traffic conditions in the study area compare to average month conditions in accordance with the month that each intersection was studied. Based on the data and location of the TMC's, traffic counts were adjusted accordingly. TMC data for the morning and afternoon peak hours are summarized in Figures II-1 and II-2 respectively

The TMC's and field observations assist in determining the flow of traffic through the study area. Overall, volume increases during the afternoon peak hour of travel. This is particularly true at the intersections of West Street with Pulaski Street, West Street with Main Street, and Main Street with North Street. Significantly more vehicles were recorded traveling in the northbound and eastbound directions through the study area. This is likely a result of the concentrated departure times at the end of the work day as opposed to the varying morning commute times.

Figure II-1-AM Peak Turning Movement Count

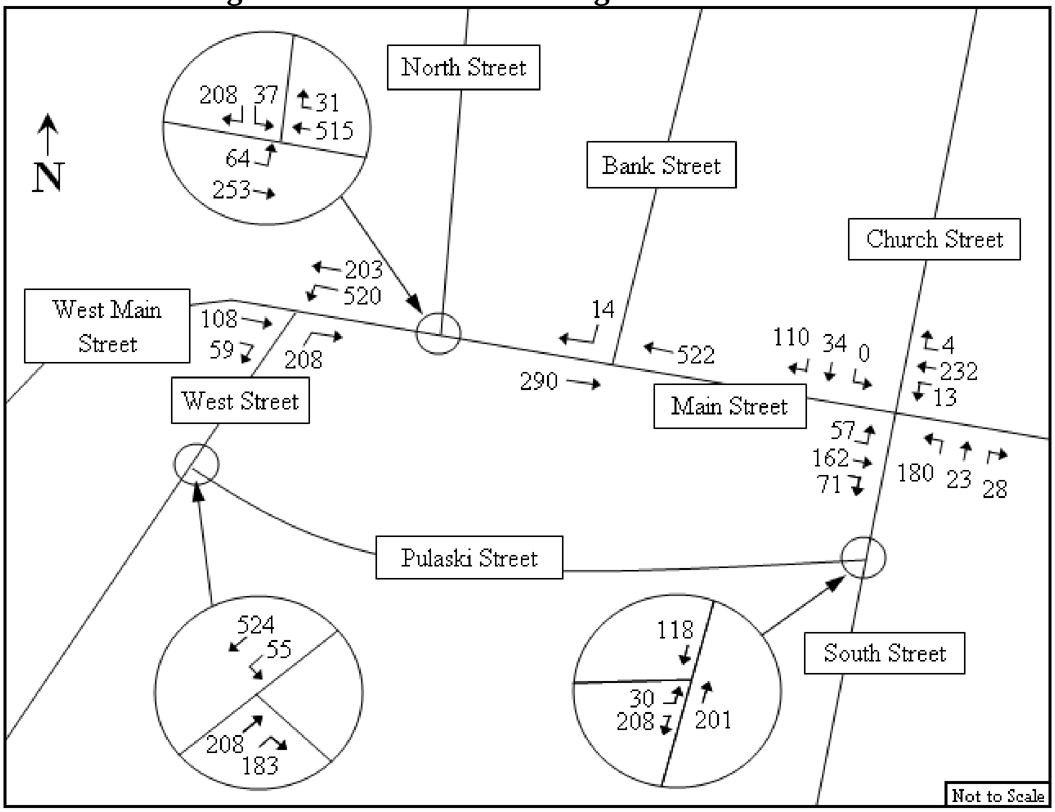
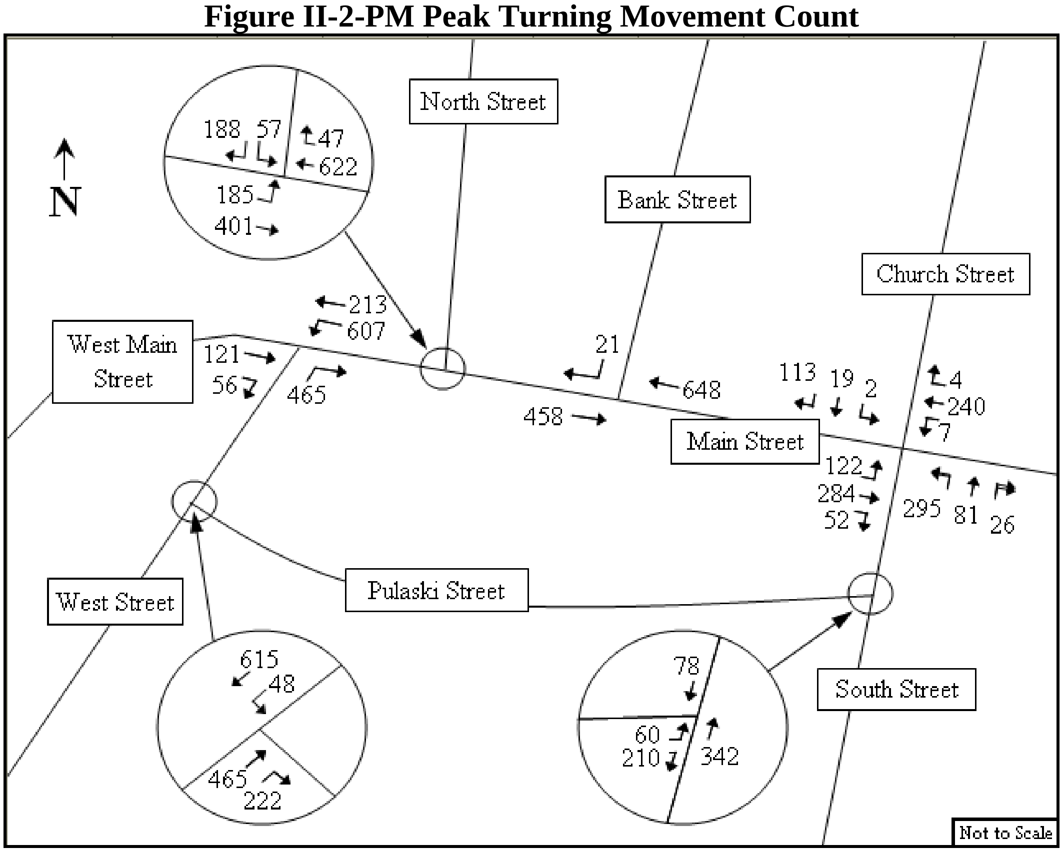


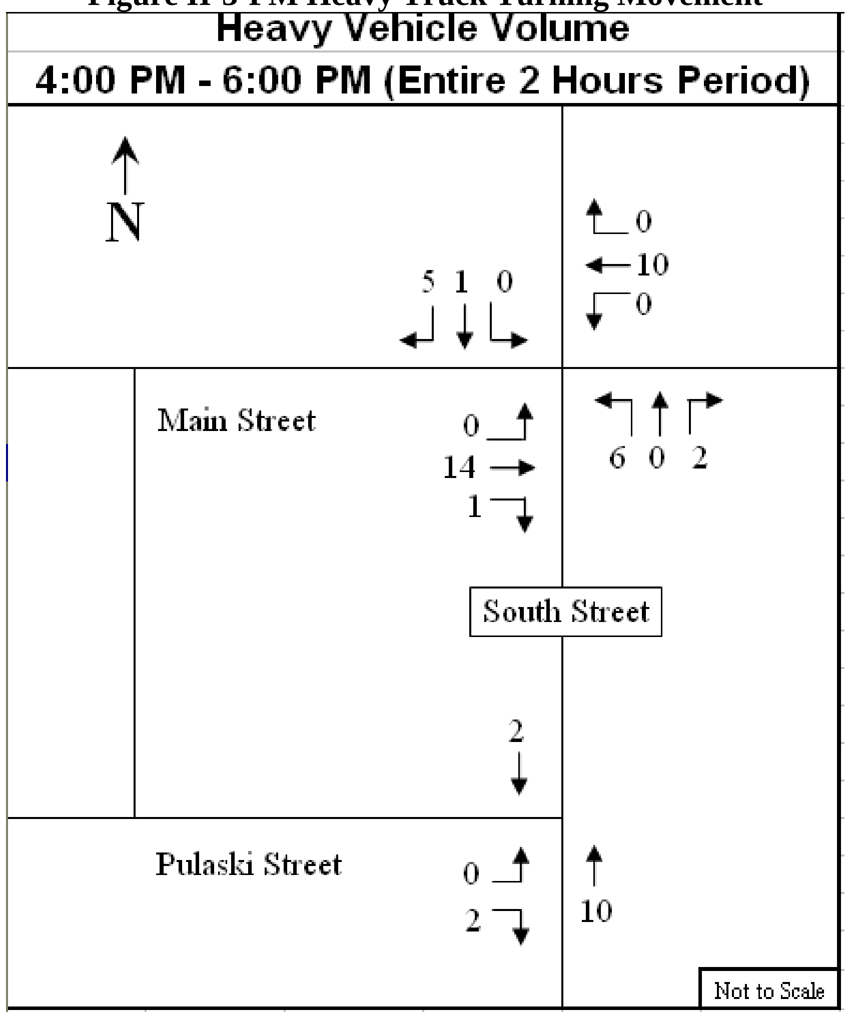
Figure II-2-PM Peak Turning Movement Count



1. Heavy Vehicle Turning Movement and Access Roadway Counts

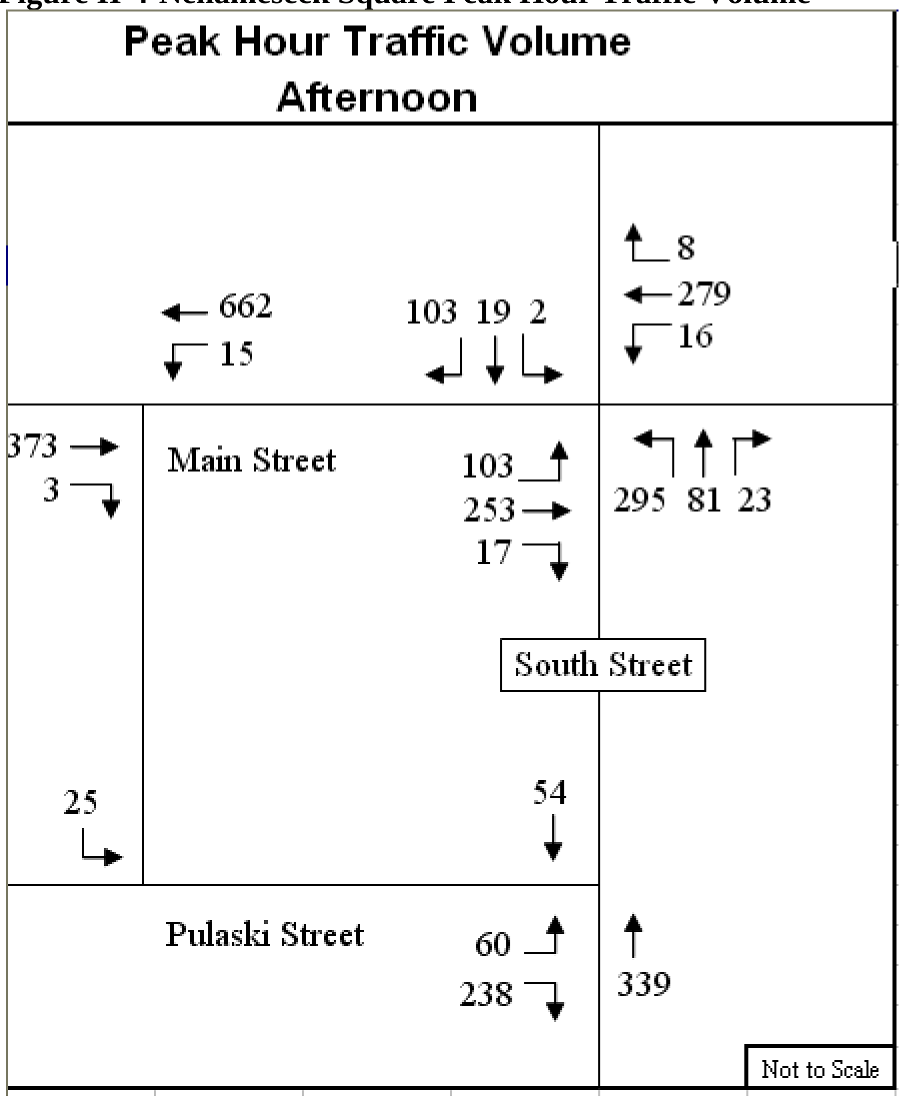
Based on information provided by Lenard Engineering Incorporated, the existing turning radius for right turns on the eastbound approach of Main Street at its intersection with South Street and Church Street does not comply with the American Association of State Highway and Transportation Officials (AASHTO) standards for larger trucks. As a result, trucks are required to complete this maneuver from the through movement lane on Main Street. Inexperienced drivers and drivers unfamiliar with this area have a history of driving over the existing curbing and sidewalk that surrounds Nenameseck Square. There is also a history of collisions with the cast iron fencing that surrounds Nenameseck Square. The PVPC conducted a turning movement count of heavy vehicle traffic at this location and the intersection of South Street with Pulaski Street. The results of this count from 4:00 PM until 6:00 PM are summarized in Figure II-3. As can be seen in the figure, heavy vehicle traffic is relatively light during the afternoon peak hour. These movements are complicated, however, by the non-standard geometry of the intersection and high volumes of traffic.

Figure II-3-PM Heavy Truck Turning Movement



Additional turning movement data was also collected for the access roadway to the Family First Bank west of Nenameseck Square. This information is presented in Figure II-4. This figure also includes the afternoon peak hour traffic data for the intersections of Main Street with Church Street and South Street and South Street with Pulaski Street. A total of 18 vehicles were recorded to utilize this access roadway during the afternoon peak hour. It is important to note that this roadway provides 3 on-street public parking spaces and access to customer parking as well as drive through ATM and teller access. This explains the discrepancy between entering and exiting vehicles on this roadway.

Figure II-4-Nenameseck Square Peak Hour Traffic Volume



B. SAFETY

Crash information was gathered for the study area intersections based on the information provided by the Ware Police Department for the 2007-2009 calendar years to identify any existing safety problems. A crash rate analysis was also performed to compare each intersection to the state average crash rate. Table II-1 summarizes the number of crashes by location and type for the 2007-2009 calendar years to identify any common conditions and possible causes.

1. Crash Experience

As can be seen by the table, the total number of crashes recorded for the study area was 41 over the three year period. The majority of the crashes reported were rear-end type collisions which accounted for 46% of all crashes. Angle-type collisions accounted for 31% of all crashes. The intersections of Main Street with South Street and Church Street, Main Street with North Street, and West Street with Pulaski Street had the highest number of crashes in the study area over this three year period. Over 50% of the crashes occurred during the 2009 calendar year. It is important to note that there were not any recorded vehicle crashes at the intersection of South Street with Pulaski Street for the 2007-2009 calendar years.

No fatal crashes occurred over the three year period, however, 17% of crashes resulted in a personal injury. A total of 65% of the crashes reported no injuries. The majority of the crashes occurred during clear weather and dry road conditions. On average, 20% of all reported crashes occurred during rainy or snowy weather conditions with wet and icy road conditions.

2. Crash Rate Analysis

Crash rates can be an effective tool to measure the relative safety at a particular location. Crash rates are expressed as crashes per Million Entering Vehicles (MEV) for intersection locations. The crash rate per MEV takes into consideration the number of crashes at an intersection and the number of vehicles that enter the intersection over the course of an average day. A crash rate analysis was performed to compare the value at the intersection to the average value developed by MassDOT District 2. In theory, crash rates can increase as the traffic volume along the roadway increases or as the potential for conflict increases. Based on MassDOT data, the average crash rate of a signalized intersection in MassDOT District 2 is 0.85. The crash rate values for each intersection can be found in Table II-1 denoted as CR. As can be seen from the table, the crash rates within the study area are relatively low. The highest crash rate occurs at the intersection of West Street with Pulaski Street with a crash rate of 0.61.

Table II-1-Intersection Crash Data

Intersection	Year	# of Crashes	Type		Severity		Weather Condition		Road Condition	
West Street (Route 32) and Pulaski Street	2007	1	Single Vehicle	1	Fatal Injury	0	Clear	8	Wet	3
	2008	3	Rear End	5	Incapacitating	0	Rain	1	Dry	6
	2009	6	Angle	1	Non-Incapacitating	0	Snow	1	Ice	1
	Total	10	Sideswipe	3	Possible	3	Fog	0	Snow	0
			Head On	0	No Injury	5	Overcast	0	Sand, Mud	0
	CR	**0.61**	Unknown	0	Unknown	2	Unknown	0	Unknown	0
Main Street (Route 9 and Route 32), West Main Street (Route 9) and West Street (Route 32)	2007	1	Single Vehicle	0	Fatal Injury	0	Clear	4	Wet	0
	2008	1	Rear End	1	Incapacitating	0	Rain	0	Dry	4
	2009	2	Angle	1	Non-Incapacitating	0	Snow	0	Ice	0
	Total	4	Sideswipe	2	Possible	0	Fog	0	Snow	0
			Head On	0	No Injury	2	Overcast	0	Sand, Mud	0
	CR	**0.22**	Unknown	0	Unknown	2	Unknown	0	Unknown	0
Main Street (Route 9 and Route 32) and North Street	2007	1	Single Vehicle	0	Fatal Injury	0	Clear	6	Wet	2
	2008	1	Rear End	4	Incapacitating	0	Rain	1	Dry	6
	2009	6	Angle	3	Non-Incapacitating	0	Snow	0	Ice	0
	Total	8	Sideswipe	1	Possible	0	Fog	0	Snow	0
			Head On	0	No Injury	8	Overcast	1	Sand, Mud	0
	CR	**0.44**	Unknown	0	Unknown	0	Unknown	0	Unknown	0
Main Street (Route 9 and Route 32) and Bank Street	2007	2	Single Vehicle	0	Fatal Injury	0	Clear	3	Wet	1
	2008	1	Rear End	2	Incapacitating	0	Rain	1	Dry	3
	2009	1	Angle	1	Non-Incapacitating	0	Snow	0	Ice	0
	Total	4	Sideswipe	1	Possible	0	Fog	0	Snow	0
			Head On	0	No Injury	4	Overcast	0	Sand, Mud	0
	CR	**0.29**	Unknown	0	Unknown	0	Unknown	0	Unknown	0
Main Street (Route 9 and Route 32), East Main Street (Route 9 and Route 32), Church Street and South Street	2007	5	Single Vehicle	1	Fatal Injury	0	Clear	5	Wet	1
	2008	1	Rear End	5	Incapacitating	1	Rain	1	Dry	8
	2009	3	Angle	3	Non-Incapacitating	1	Snow	0	Ice	0
	Total	9	Sideswipe	0	Possible	2	Fog	0	Snow	0
			Head On	0	No Injury	2	Overcast	3	Sand, Mud	0
	CR	**0.59**	Unknown	0	Unknown	3	Unknown	0	Unknown	0

CR = Crash Rate

C. CAPACITY ANALYSIS

The study area was examined with regard to capacity and delay characteristics to determine the existing Level of Service (LOS). LOS is an indicator of the operating conditions which occur on a roadway under different volumes of traffic and is defined in the 2000 Highway Capacity Manual by six levels, “A” through “F”. A number of operational factors can influence the LOS including geometry, travel speeds, and delay.

Depending on the time of the day and year, a roadway may operate at varying levels. LOS ‘A’ represents the best operating conditions and is an indicator of ideal travel conditions with vehicles operating at or above posted speed limits with little or no delays.

Conversely, LOS ‘F’, or failure, generally indicates forced flow conditions illustrated by long delays and vehicle queues. LOS ‘C’ indicates a condition of stable flow and is generally considered satisfactory in rural areas. Under LOS ‘D’ conditions, delays are considerably longer than under LOS ‘C’, but are considered acceptable in urban areas. At LOS ‘E’ conditions, the roadway begins to operate at unstable flow conditions as the facility is operating at or near its capacity. Table II-2 presents a summary of the LOS at signalized intersections.

Table II-2-Level of Service Designation, Signalized Intersections

Category	Description	Delay (in seconds)
LOS A	Describes a condition of free flow, with low volumes and relatively high speeds. There is little or no reduction in maneuverability due to the presence of other vehicles and drivers can maintain their desired speeds. Little or no delays result for side street motorists.	< 10.0
LOS B	Describes a condition of stable flow, with desired operating speeds relatively unaffected, but with a slight deterioration of maneuverability within the traffic stream. Side street motorists experience short delays.	>10.0 to 20.0
LOS C	Describes a condition still representing stable flow, but speeds and maneuverability begin to be restricted. Motorists entering from side streets experience average delays.	>20.0 to 35.0
LOS D	Describes a high-density traffic condition approaching unstable flow. Speeds and maneuverability become more restricted. Side street motorists may experience longer delays.	>35.0 to 55.0
LOS E	Represents conditions at or near the capacity of the facility. Flow is usually unstable, and freedom to maneuver within the traffic stream becomes extremely difficult. Very long delays may result for side street motorists.	>55.0 to 80.0
LOS F	Describes forced flow or breakdown conditions with significant queuing along critical approaches. Operating conditions are highly unstable as characterized by erratic vehicle movements along each approach.	> 80.0

Source: 2000 Highway Capacity Manual

The basic assumption at an unsignalized intersection is that through moving traffic on the major street is not hindered by other movements. In reality, as minor street delays increase, vehicles are more likely to accept smaller gaps in the traffic stream causing through-moving vehicles to reduce speed and experience some delay. The left turn movement off the minor street approach is the most heavily opposed movement and typically experiences the greatest delay. Therefore, this movement is used as a gauge to determine the overall operations at an unsignalized intersection. Table II-3 presents a summary of the LOS for an unsignalized intersection.

Table II-3-Level of Service Designation, Unsignalized Intersections

Category	Description	Average Delay (second/vehicle)
LOS A	Little or no delay	0.0 to 10.0
LOS B	Short traffic delays	>10.0 to 15.0
LOS C	Average Traffic Delays	>15.0 to 25.0
LOS D	Long Traffic Delays	>25.0 to 35.0
LOS E	Very Long delays	>35.0 to 50.0
LOS F	Extreme delays	>50.0

Based on the 2000 Highway Capacity Manual, PVPC evaluated the performance of all intersections within the study area. Both AM and PM peak hour data was utilized to compile Table II-4 and II-5 which summarizes the LOS for each intersection. It is important to note that the signal timing and phasing plans utilized to compile this analysis were recorded by field observations.

Table II-4-Level of Service of Signalized Intersections

Signalized Intersections	AM Peak		PM Peak	
	Dealy*	LOS**	Delay*	LOS**
Main Street (Route 9 and Route 32), with Church Street and South Street				
South Street, NB All Movements	34.7	C	93.2	F
Church Street, SB All Movements	16.9	B	17.6	B
Main Street (Route 9 and Route 32, WB All Movements	23.6	C	25.0	C
Main Street (Route 9 and Route 32), EB All Movement	12.2	B	23.9	C
Overall	22.4	C	45.4	D
Main Street (Route 9 and Route 32), with Church Street and South Street				
North Street, SB All Movement	4.4	A	2.6	A
Main Street (Route 9 and Route 32, WB All Movements	13.8	B	14	B
Main Street (Route 9 and Route 32), EB All Movement	16.2	B	15.8	B
Overall	12.1	B	11.9	B
West Street (Route 32) with Vernon Street				
West Street (Route 32), NB All Movements	9.6	A	8.9	A

Table II-5-Level of Service Designation of Unsignalized Intersections

Unsignalized Intersections	AM Peak		PM Peak	
	Dealy*	LOS**	Delay*	LOS**
Main Street (Route 9 and Route 32), with West Main Street (Route 9) and West Street (Route 32)				
West Street, Rute 32), NB All Movements	10	B	14.3	B
West Main Street (Route 9 and Route 32), WB All Movements	23.5	C	47.8	E
West Main Street (Route 9 and Route 32), EB All Movements	10.1	B	13.4	B
Main Street (Route 9 and Route 32) with Bank Street				
Bank Street, SB All Movements	10.3	B	10.2	B
Main Street (Route 9 and Route 32), WB All Movements	0	A	0	A
Main Street (Route 9 and Route 32), EB All Movements	0	A	0.0	A
South Street with Pulaski Street				
South Street, NB All Movements	0	A	0	A
South Street, Sb All Movements	0	A	0	A
Pulaski Sktreet, EB Right Movements	11.6	B	10.9	B
Pulaski Sktreet, EB Left Movements	12.2	B	10.3	B

Based on the results of the analysis Main Street (Route 9 and Route 32) with Church Street and South Street suffers the longest delay during the PM peak hour. The intersection was calculated to operate at LOS of “D” with a delay of 45 seconds. South Street experiences the longest delays and was calculated to operate at LOS “F”. While not reflected in the Level of Service, traffic along Main Street does not always flow uniformly and vehicles queues often can interfere with turning movements and parking maneuvers.

D. Travel Time Data

Travel time data was gathered for this report in order to examine the actual average driving time a motorist would expect to encounter when driving through the study area. The LOS tabulated for the study area suggests a stable flow of traffic for each major approach and average delays for minor approaches at each intersection. The actual travel time data incorporates contributing factors to delay such as traffic generated from unsignalized intersections, parking maneuvers, pedestrians, and delay created by heavy vehicles such as trucks and buses. Most importantly, the travel time data measures the efficiency and coordination of the current signal timing plans between all of the intersections in the study area.

Travel time index is an equation utilized to measure the congestion intensity along a corridor. This index is a ratio between the average peak travel time and the free-flow travel time. The free-flow travel time is defined as the amount of time in seconds it takes to travel a particular corridor at the posted speed limit without any delay. The actual travel time data collected is compared with the free-flow travel time to determine the travel time index. Travel time index values are an indicator of the additional travel time required over ideal conditions. For example, a value of 1.20 signifies that the average peak travel time takes 20 percent longer than free-flow travel time. Table II-6 represents the data utilized to determine the travel time index for the study area.

Table II-6-Travel Time-Afternoon Peak Hour

	Actual Travel Time (in seconds)						Average	Travel
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Travel Time	Time
EB	39	37.8	40.2	40.8	36	36	38.3	**1.66**
WB	52.8	66	61.8	66	64.2	63	62.3	**2.70**
Posted Speed Limit=25			Corridor Distance= 0.16 miles			Free flow Travel Time=23.04 sec		

It is important to note that the travel time index is tabulated using the average actual travel times for each run for the corridor. The average is then divided by the free-flow travel time to create the travel time index. As can be seen in the table above, the travel time index suggests vehicles should expect delays when traveling on Main Street though the study area during the afternoon peak hour. Factors that contribute to these findings include the amount of signalized intersections, curb cuts and volume of traffic. As previously mentioned, afternoon traffic volumes are significantly higher than morning traffic volumes. The afternoon volumes induce congestion and prevent ease of flow for vehicles on Main Street.

The calculated travel time index for eastbound and westbound travel was 1.66 and 2.70 respectively. This indicates that traffic experiences significant delay when attempting to travel through the study area during the afternoon peak hour.

E. Signal Warrant Analysis

The intersection of Main Street (Route 9 and 32) and West Street (Route 32) was analyzed to determine whether a traffic signal is required. The Manual on Uniform Traffic Control Devices (MUTCD) identifies eight different warrants to evaluate if an intersection meets the minimum requirements for signalization. One or more warrants must be satisfied to justify a traffic signal however engineering judgment dictates if an intersection warrants the installation of a signal. The installation of a traffic signal must improve the safety and operation of the location under study. Table II-7 presents the results of the signal warrant analysis.

Of the eight total warrants for the installation of a traffic signal, Warrant1 – Eight Hour Vehicular Volume is generally considered the most important as it requires minimum volumes to be met on both the major and minor streets for at least eight hours. Warrant 2 – Four Hour Vehicular Volume also requires minimum volumes to be met but over shorter timeframes.

Table II-7-Signal Warrant Analysis Results

Warrant	Description	Status
1	Eight Hour Volume	Satisfied
2	Four Hour Volume	Satisfied
3	Peak Hour	Not Satisfied
4	Pedestrian Volume	Not Applicable
5	School Crossing	Not Applicable
6	Coordinated Signal System	Not Applicable
7	Crash Experience	Not Applicable
8	Roadway Network	Not Applicable

Source: PVPC

The results of the warrant analysis for the intersection of Main Street and West Street show that the minimum traffic volume requirements are satisfied for both Warrants 1 and 2. Under traffic signal control, this intersection could be expected to operate at LOS B. It was also assumed that left turns would no longer be prohibited from the northbound approach of West Street. For the purpose of this analysis, it was estimated that a total of 52 vehicles would turn left at this intersection during the afternoon peak hour.

F. COORDINATABILITY FACTOR

The Coordinatability Factor (CF) measures the feasibility of coordinating movements between traffic signals along a corridor. The factors used to determine Coordinatability include travel times, the ratio of traffic to storage space, the proportion of traffic that travels in a platoon, main street traffic volume, and the increase in cycle length needed to implement coordination. The CF is represented on a scale from 0 to 100 or more where 80 or above represents intersections that must be coordinated, 20 through 80 represents locations that are desirable for coordination and 20 or below represents intersections that are too far apart to coordinate. Figure II-5 illustrates the CF formula and specifies the criteria utilized to determine the results.

Figure II-5-Coordinability Factor Equation

CF = Max (CF1, CF2) + Ap + Av + Ac

Where:

CF = Coordinatability Factor
CF1 = Initial Coordinatability Factor from Travel Time
CF2 = Initial Coordinatability Factor from Volume per Distance
Ap = Platoon Adjustment
Av = Volume Adjustment
Ac = Cycle Length Adjustment

The signals along the Main Street corridor are currently uncoordinated. As a result, the CF was evaluated for the study area under an improved cycle length of 75 seconds for both signalized intersections and the intersection of Main Street with West Street. It is important to note that the CF was applied to the afternoon peak hour periods as these volumes are much higher than the morning peak hour volumes.

Table II-8-Coordinability Factor of Main Street Intersections

Intersection	CF*	Comment	CF1*	CF2*	Ap*	Av*	Ac*
Main Street(Route 9 and 32) and West Street(Route 32) coordinated with North Street	100	Coordination definitely recommended	97	100	-13	13	0
North Street coordinated with Main(Route 9 and 32) and Church Street	88	Coordination definitely recommended	88	53	-11	11	0

As can be seen in Table II-8, signal coordination is definitely recommended for both the Main Street and West Street intersection as well as the Main Street and North Street intersection. The Main Street and West Street intersection is approximately 272 feet from the intersection of Main Street and North Street. This short distance between intersections is a major factor in determining the need for coordination. This limited distance between the two intersections is not adequate to allow vehicles to queue. It is also desirable to coordinate both intersections with the intersection of Main Street with Church Street and South Street. The close proximity of the three intersections, lack of storage capacity and the presence of unsignalized intersections create a need for coordination of these intersections.

III. Conclusion

The data collected as part of this Signal Coordination Study suggests that the current signal timing plans for the individual intersections does not satisfy current demands. In addition, the intersection of Main Street with West Street currently satisfies the requirements for the installation of a traffic signal. Due to the high volumes of traffic on the Main Street corridor and lack of adequate spacing between intersections along Main Street, the corridor is viewed as a desirable location to implement traffic signal coordination.

The purpose of signal coordination is to move vehicles through a corridor safely and efficiently while enhancing traffic flow with minimal delay. It can be difficult to maintain signal progression, or the ability to travel through multiple green lights without stopping, on two-way streets while simultaneously maintaining favorable LOS on minor streets. However, signal coordination positively impacts the LOS of minor approaches by creating vehicle platoons on the major road and larger gaps in traffic.

The PVPC developed a signal coordination scenario for Main Street during the afternoon peak hour. This scenario includes changes to the existing timing and phasing at the two existing traffic signals as well as the installation of a new traffic signal at the intersection of Main Street with West Street. An exclusive left turn lane was added to the northbound approach of West Street. All other intersection approaches would retain their existing lane configuration.

Table III-1 presents a summary of the calculated LOS of the study area intersections under this scenario. As can be seen by the table, the intersections greatly benefit from the new cycle lengths and phasing plans as the LOS for each intersection improved and delays were reduced.

Table III-1-Level of Service with Signal Coordination along Main Street

Intersection	PM Peak	
	Delay*	LOS**
Main Street (Route 9 and Route 32), with Church Street and South Street		
South Street, NB All Movements	32.4	C
Church Street, SB All Movements	18.1	B
Main Street (Route 9 and Route 32), WB All Movements	34.1	C
Main Street (Route 9 and Route 32), EB All Movement	36.3	D
Overall	32.4	C
Main Street (Route 9 and Route 32) with North Street		
North Street, SB All Movement	7.6	A
Main Street (Route 9 and Route 32, WB All Movements	4.4	A
Main Street (Route 9 and Route 32), EB All Movement	6.6	A
Overall	11.9	A
Main Street (Route 9 and Route 32), with West Main Street and West Street		
West Street, (Route 32), NB All Movements	10.7	B
Main Street (Route 9 and Route 32), WB All Movements	8.3	A
West Main Street (Route 9 and Route 32), EB All Movements	20.7	C
Overall	10.7	B

After careful review of this scenario, signal coordination for both westbound and eastbound traffic is recommended for the entire Main Street corridor. The distance between the intersections is limited and can not accommodate the queuing of vehicles. The signalization of West and Main Street could create congestion and queuing for westbound traffic into the intersection of Main and North Street if progression is not utilized. Currently, that movement is uncontrolled, meaning that vehicles are not stopped or delayed by other movements. The approximately 272 feet separating these two intersections is not adequate to accommodate vehicle queuing. In addition, eastbound traffic queued at North and Main Street could have similar impacts on Main Street and West Street.

IV. Recommendations

A. Short Term vs. Long Term

PVPC has developed a series of short term and long term recommendations for improvement of the traffic conditions in downtown Ware. The short term recommendations are low cost improvements expected to require 0-3 years to implement. Long term recommendations would require more than 3 years and are anticipated to have a higher expense due to the additional design services needed. Short term recommendations would provide a quick fix to issues with a moderate improvement on traffic conditions. Long term recommendations would require an overhaul of the existing conditions through construction and investment in new traffic control devices. The benefits from long term recommendations would be much more significant than the short term recommendations.

B. Short Term

1. Retiming of Main Street and South Street

The intersection of South Street and Main Street needs to be retimed to eliminate the 7 seconds all red pedestrian crossing phase. This phase is redundant with the push button actuated signal for Main Street. This retiming will improve the overall LOS by reducing the amount of time vehicles are delayed as well as reducing the queue of vehicles created by the 7 seconds when all vehicles are stopped.

2. Pavement Markings

At the time of the field inventory, the lane markings were slightly faded at the various intersections. Re-painting these lines can direct traffic more efficiently and safely. This will increase the visibility of the Main Street Crosswalks, stop lines, and lane markings.

3. Nenameseck Square

Nenameseck Square requires an improved radius to allow for right turns by heavy vehicles onto South Street. Trucks making right turns onto South Street from Main Street do not have adequate space to make this movement and utilize part of the sidewalk. Pedestrians are not allowed to use this sidewalk due to the dangers these trucks present when making these turns. To improve the movement of trucks PVPC has developed a conceptual drawing of the Nenameseck square to allow for truck movement without using the sidewalk (Figure IV-1). This plan reduces the sidewalk width in order to increase the turning radius directly abutting the intersection of South Street and Main Street. Additional green space is proposed on the Bank Access Road side of the square to make up for any loss.

Figure IV-1-Proposed Nenameseck Square Improvements

4. Truck Exclusion

The town is encouraged to investigate the feasibility of a truck exclusion on Pulaski Street. Pulaski Street lacks the capacity and turning radius to allow for heavy vehicles to use this roadway. The town will need to determine an alternate route that is wide enough to accommodate trucks and the pavement must be able to withstand truck traffic. This suggested route would be Main Street which most trucks currently utilize. Truck exclusions can only be authorized by the Massachusetts Department of Transportation.

5. Suggested Truck Route

With heavy movement of trucks through the downtown of Ware, the town could enact a suggested truck route in the short term. Using a standardized sign seen in Figure IV-2 a non-enforceable suggested truck route could be established. While use of a designated truck route is not mandatory, these advisory signs encourage trucks drivers to stick to the labeled truck route. Ultimately, these signs aid truck drivers by avoiding hazardous obstacles that they would encounter using roads such as Pulaski Street.

Figure IV-2-Suggested Truck Route Sign

6. Truck Signage

Limited turning capacity for heavy trucks is an issue at the intersection of South Street and Main Street as well as West Street and Main Street. A non-standardized sign reading "Trucks Make Wide Turns" will forewarn the turning movement challenge to truck drivers as well as the motorists using the roadway.

C. Long Term

1. Main Street at West Street

This intersection meets requirements for signalization due to the existing traffic volumes and turning movements. An engineering study is recommended to determine the feasibility of constructing traffic lights due to the intersections limited turning radii, steep grade, and provision of on-street parking within the intersection. The small intersection radii would impact the ability of turning movement and there may be a need to increase the road width to allow for additional turning lanes. The intersections steep grade may inhibit motorist's ability to stop northbound on West Street. It is also recommended that the services of a registered professional engineer be sought in order to determine the ADA accessibility requirement in the downtown and for this intersection

a. Driveway of Business and Veterans Park North of Main Street

The current intersection configuration of West Street and Main Street does not allow drivers traveling northbound on West Street to turn onto Route 9 westbound. A driveway for Veterans Park and Friendly's® north of Main Street corridor is used by drivers to reverse their travel direction in order to access Route 9 westbound. Signalization of West Street and Main Street would allow for left turns onto Route 9 and reduce the frequency of drivers reversing their direction of travel with this driveway.

b. Town Hall Mid-Block Crosswalk Relocation

Access to the Ware Town Hall is through the buildings parking lot on West Street. Originally a crosswalk was provided at the intersection of West Street and Main Street to allow for pedestrian access. This crosswalk was relocated to West Street to better correspond to where people actually crossed the street to access the Town Hall. An engineering study is recommend for this location to determine how the crosswalk would be handled if the intersection of West Street and Main Street were signalized. At a minimum, this crosswalk should be reviewed to determine if it would be safe to move the crosswalk back closer to the intersection and operating on an exclusive pedestrian phase. This may have to be done in combination with a "No Turn on Red" sign for West Street right turns.

2. Implement Signal Coordination along Main Street

If signalization is determined to be feasible at the intersection of Main Street with West Street the town should consider developing a project to upgrade the existing equipment at Main Street and West Street, Main Street and North Street, and Main Street and South Street.

a. Coordination

Signal Coordination is recommended for Main Street from West Street to South Street. Coordination will allow a platoon of vehicles to move through the Main Street corridor and received a green light at each intersection. Coordination is needed due to the limited distance between intersections and the heavy volumes that Main Street carries. If not properly coordinated, vehicle queues along Main Street could block surrounding intersections.

b. Time of Day Phasing Plans

New traffic control devices allow for signal timing plans to be set for specific times during the day. According to data collection performed by PVPC, the morning volumes do not require the same timing plan as the afternoon. Upgrading the devices would allow for multiple signal timing plans to provide the optimal timing for the volume anticipated during specific times of day.

c. Pedestrian Actuated Signals

Newer signals allow for pedestrian actuation to provide pedestrian crossing time on demand. Currently signals in the downtown are pre-timed with built in pedestrian crossing times for each phasing cycle. According to field observation, pedestrians do not cross during each cycle length. Allowing this pedestrian time in each cycle length causes unnecessary delay for vehicles approaching the intersection. Providing pedestrian actuation will allow for crossing to be established as needed for pedestrians.

3. South Street Capacity

South Street requires additional capacity to adequately carry the heavy volume of traffic that turn left onto Main Street during the afternoon peak hour. This afternoon volume warrants the addition of an exclusive left turn lane. This lane could potentially be added with modifications to Nenameseck Square and reduction of the width of the Bank Access Road. The current roadway configuration and vehicle volume creates long vehicle queues along South Street. To reduce the delay experienced on South Street an exclusive left turn lane is required. Installation of an exclusive left turn lane would help to reduce the vehicle queues and extend the service life of intersections improvements in the downtown area.

V. Public Participation

The Draft Ware Downtown Signal Coordination and Safety Study was presented at the town the November 4, 2010 Board of Selectman meeting. Two significant comments on the study were made during this meeting and are summarized below:

1. The intersection of West Street and Main Street does not allow drivers traveling northbound on West Street to turn left onto Route 9 westbound. Many drivers instead turn right from West Street onto Main Street and use the driveway for Veterans Park and Friendly's® east of the intersection to reverse their travel direction and to access Route 9 westbound. This comment was addressed in Section IV.C.a, titled "Driveway of Business and Veterans Park North of Main Street."

2. A crosswalk, originally located at the intersection of West Street (Route 32) with Main Street (Route 9 and Route 32), was moved east on Main Street to reduce conflict with right turning vehicles. This crosswalk placement also provides direct access to the town hall parking lot, where most pedestrians cross. This comment was addressed in Section IV.C.b, titled "Town Hall Mid-Block Crosswalk Relocation."

The Pioneer Valley Planning Commission (PVPC) conducted a 30 day public participation process for the Draft Ware Downtown Signal Coordination and Safety Study from December 6, 2010 to January 5, 2011. No Comments were received during the 30 day public review period.