Route 60 Mobility Study: Malden and Medford, Massachusetts

Boston Region Metropolitan Planning Organization

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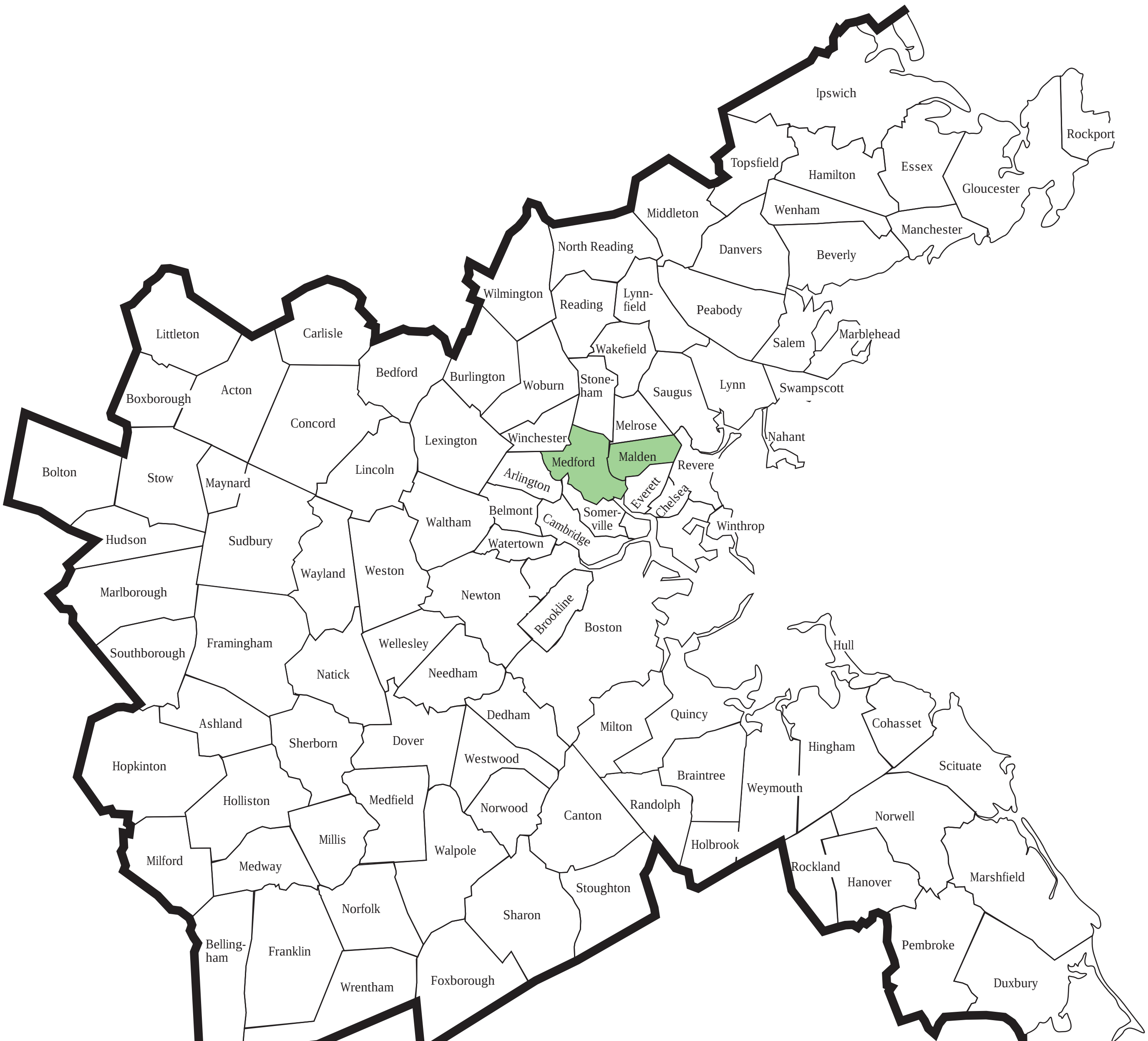

The Cities and Towns of the Boston Region Metropolitan Planning Organization Area

Communities involved in the study

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EXECUTIVE SUMMARY

High volumes, delays, and bus and pedestrian movements characterize the Route 60 corridor in the study area, which is located in Malden and Medford. These concerns were documented in the Congestion Management Process (formerly called Mobility Management System) of the Boston Region Metropolitan Planning Organization (MPO), prior Boston Region MPO studies, and public comments received about this study as part of the development of the federal fiscal year (FFY) 2007 Unified Planning Work Program (UPWP).

Route 60 in Malden and Medford is an urban principal arterial maintained and operated by the two cities. In the study area, this east–west roadway is two lanes wide for the majority of its length, and wider (four lanes), including exclusive turning lanes and a landscaped median, in the vicinity of Malden Transportation Center and Ferry Street. The roadway, which is called Salem Street in east Medford and Pleasant Street/Centre Street in west Malden, crosses major north–south key roadways and highways, including, from west to east, Interstate 93 (I-93), Fellsway West (Route 28), Highland Avenue, Commercial Street, Main Street, and Ferry Street.

MPO staff met with officials from Malden and Medford at two separate meetings on the morning of May 7, 2007, to get input for this study. At the Malden meeting, the focus of the officials was primarily on pedestrian movements at the intersection of Centre Street and Commercial Street, just south of Malden Center, which includes Malden's municipal offices and the Malden Transportation Center, which serves as an Orange Line (rapid transit) and commuter rail station, and as a bus terminal, for the Massachusetts Bay Transportation Authority (MBTA). In addition, Malden officials were concerned about pedestrian conflicts with traffic, which is allowed to turn right on the red phase at the Fellsway East, Main Street, and Ferry Street intersections. Some of their other concerns were bus mobility and service issues, including access to and connectivity with Malden Transportation Center.

At the Medford meeting, officials expressed concern about pedestrian circulation at the following locations: the Route 60 rotary under I-93, Park Street, and the vicinity of the commercial area at Spring Street. They also characterized the intersection of Route 60 and Fellsway West as a location with traffic problems and outdated traffic signals. In addition, Medford officials viewed the Boston Region MPO's study as a continuation of their urban design study of Medford Square, but with an extension to the area east of Medford Square.

STUDY PURPOSE

The purpose of this study was to identify and analyze 7 to 10 problem intersections on Route 60 and associated bus service issues in the study area in order to improve mobility and safety in the corridor. The criterion for which locations were to be studied was the ability to benefit from improved pedestrian crossings; traffic control and signal upgrades and coordination; and signage and pavement markings for pedestrians, bicyclists, and general traffic along Route 60.

SELECTION OF STUDY LOCATIONS

At the May 7, 2007, meeting in Malden, city officials identified four locations on Route 60 with pedestrian and traffic safety problems. The four intersections are:

1. Pleasant Street (Route 60) and Fellsway East
2. Centre Street (Route 60) and Commercial Street
3. Centre Street and Main Street
4. Centre Street and Ferry Street

At a separate meeting on May 7, 2007, in Medford, city officials identified five locations that were reported to have pedestrian and traffic safety problems. The five intersections are:

1. Salem Street (Route 60) rotary under I-93
2. Salem Street and Hadley Place
3. Salem Street and Park Street, including the adjacent intersection at Court Street
4. Salem Street and Spring Street
5. Salem Street and Fellsway West (Route 28)

Another concern in the Route 60 corridor is transit mobility. To develop potential improvements for bus transit operations in the corridor, particularly bus circulation to and from the Malden Transportation Center and along Route 60, staff identified three additional signalized intersections, listed below, for retiming.

1. Pleasant Street and Commercial Street/Florence Street in Malden
2. Main Street and Florence Street in Malden
3. Main Street and Salem Street/Ferry Street in Malden

SCOPE OF ANALYSIS

The analyses in this study were focused on identifying and defining the problems at each study location, as well as identifying potential improvements. Both quantitative and qualitative analyses were conducted to evaluate traffic operations and safety; pedestrian and bicycle safety; and potential bus transit service operations. For traffic operations analyses, the measures used in defining problems include control delay and associated levels of service, and queue lengths. For a safety analysis, the measures used for defining the problems are the crash frequency and rate, and collision diagrams.

In this study, the level of support provided to facilitate pedestrian and bicycle mobility at and between the study intersections was assessed qualitatively for deficiencies, for being absent, and for potential improvements. Pedestrian and bicycle mobility is defined as the ease or difficulty that a pedestrian or a bicyclist experiences while traveling along the corridor, including through intersections, and the facilities provided to help them navigate through the corridor, such as continuous sidewalks, crosswalks, bike lanes, ramps for wheelchairs, buffers and median spaces, pedestrian signals, and pedestrian-related signs. Also taken into account are right-turn-on-red and left-turn conflicts with vehicular traffic, which hinder pedestrian mobility.

For bus transit service, the primary focus was to reduce traffic signal delay (congestion) through improved traffic signal timing to improve bus operations in the corridor. Travel time savings for buses was the primary performance measure. In addition to the time savings assessment, a qualitative review of the level of support provided for passengers at bus stops, such as benches, booths, and bike racks, was undertaken, and potential improvements were proposed. Station access issues for buses and transit riders in the vicinity of the Malden Transportation Center were reviewed and potential improvements proposed.

IDENTIFIED PROBLEMS

To meet the study purpose, staff first collected and assembled data on the geometry of the intersections, traffic-volume data, pedestrian-volume data, travel-time and travel-speed data, and crash data to determine the existing travel conditions. The following problems were identified at the study locations:

- In general, the Route 60 corridor lacks bicycle and pedestrian signs and pavement markings that are needed to inform motorists that they should share the road with bicyclists and pedestrians.

- In Malden, the study intersections had concurrent pedestrian phases in which the “WALK” signal is displayed at the same time as the green signal for parallel vehicular traffic, which create conflicts between vehicles and pedestrians because of the permitted right turns.

- There were no pedestrian push buttons for activating the pedestrian signals at some of the study intersections in Malden. Their absence sometimes creates problems for pedestrians crossing north–south streets, such as Commercial Street, where this pedestrian phase turns on concurrently with the two-way through traffic on Centre Street.

- Traffic operations were unsatisfactory at many of the study intersections in Malden and Medford during both the AM and PM peak periods. Heavy traffic volumes caused queues to form, as well as congestion to occur.

- In general, the majority of the crosswalks in the vicinity of Malden Transportation Center are indicated with two parallel solid white lines at a right angle to the sidewalks, instead of the standard ladder type, which is more visible to motorists and pedestrians.

- Many of the study intersections in Malden and Medford have crash rates that exceed MassHighway’s District 4 average crash rates for signalized and unsignalized intersections. There were crashes involving pedestrians and bicycles at some of the study intersections.

- The major types and causes of the crashes in the corridor were:

    1. Right-angle crashes caused by vehicles running a red light, or angle/sideswipe crashes resulting from making permitted left turns through high-volume opposing traffic.

    2. Rear-end crashes, usually associated with signalized intersections that have traffic queues and stop-and-go conditions.

- The main problem affecting bus transit service in the study corridor is traffic signal delay, which impacts the travel time of buses during peak periods. According to the MBTA’s 2008 Service Plan, bus Routes 101 and 325 failed the schedule adherence standard on weekdays and met the schedule adherence standard only 60 percent and 43 percent of the time, respectively. According to the MBTA’s service delivery policy, 75 percent is the minimum schedule adherence standard for buses.

RECOMMENDED IMPROVEMENTS

Staff developed improvement alternatives based on the analysis and on contributions from city officials, EOT, and the MBTA. Several improvements were recommended for addressing the mobility problems identified in the corridor. The recommended improvements in Malden and Medford are shown in Exhibit 1 and Exhibit 2, respectively. The majority of the improvements are short-term or intermediate-term and low-cost improvements that improve safety and mobility for vehicles, pedestrians, bicyclists, and general traffic throughout the Route 60 corridor.

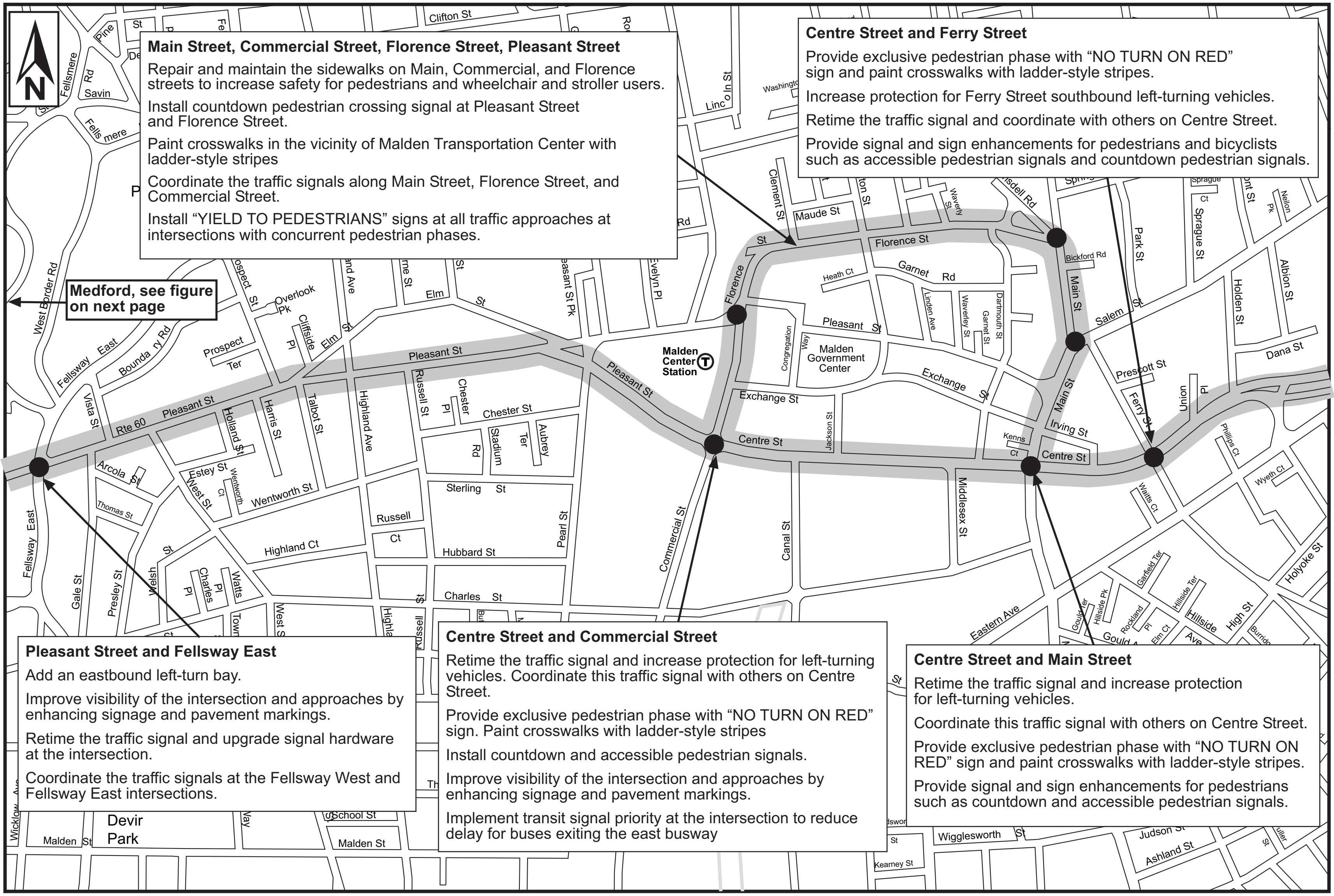

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Exhibit 1
Recommended Improvements in Malden

Route 60 Mobility Study: Malden and Medford

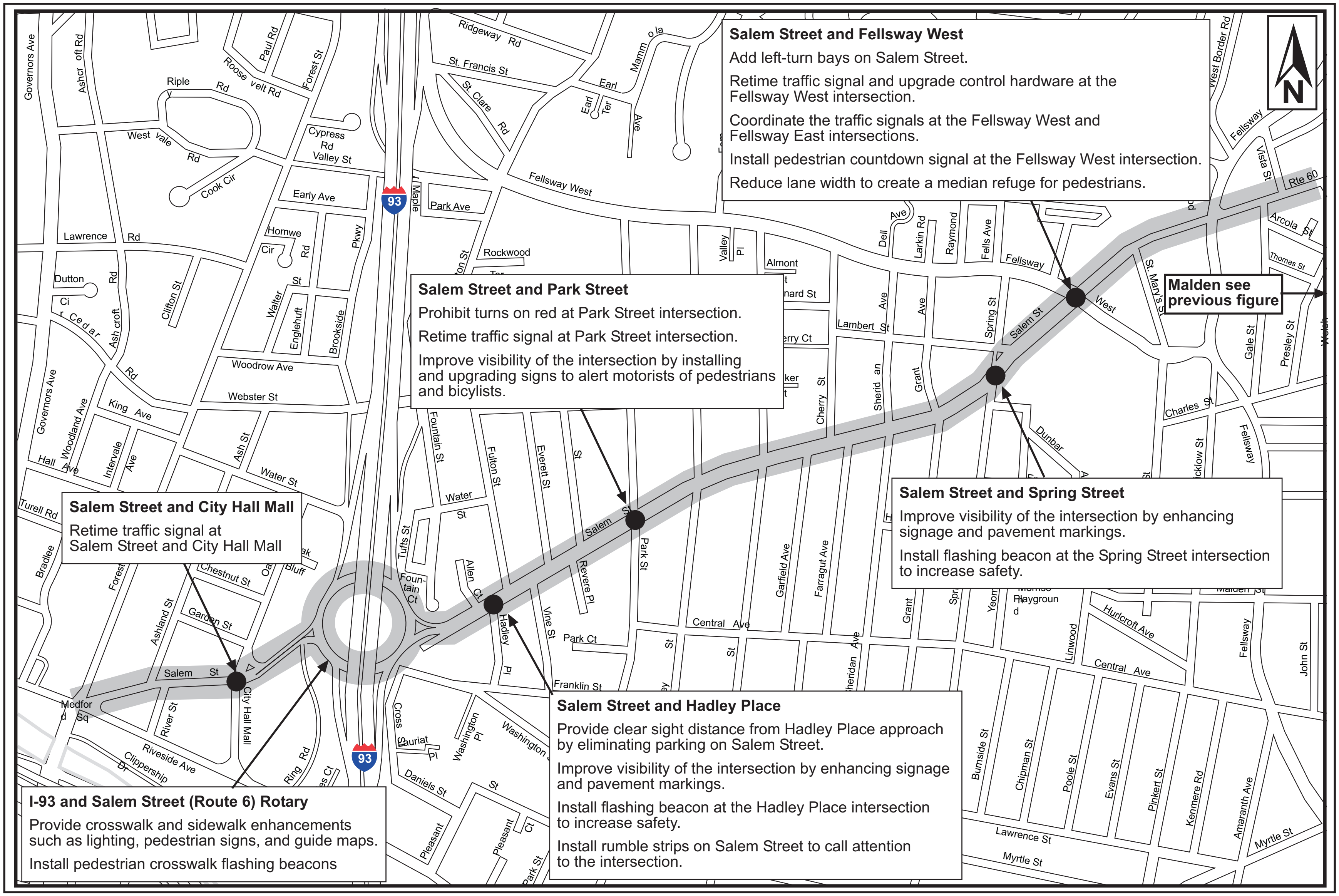

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Exhibit 2
Recommended Improvements in Medford

Route 60 Mobility Study: Malden and Medford

1. INTRODUCTION

Route 60 in Malden and Medford is an urban principal arterial maintained and operated by the two cities. In the study area, which is located in Malden and Medford, this east–west roadway is two lanes wide for the majority of its length, and wider (four lanes), including exclusive turning lanes and a landscaped median, in the vicinity of Malden Center and Ferry Street. The roadway, which is called Salem Street in Medford and Pleasant Street/Centre Street in Malden, crosses major north–south key roadways and highways, including, from west to east, Interstate 93, Fellsway West (Route 28), Highland Avenue, Commercial Street, Main Street, and Ferry Street. Figures 1 and 2 describe the general study area in Malden and Medford. The land use in this corridor is residential, commercial, and mixed. The posted speed limit in the study corridor is between 20 and 30 miles per hour.

Using information from the Route 60 monitoring performed as part of the Congestion Management Process (formerly called Mobility Management System) of the Boston Region Metropolitan Planning Organization (MPO), prior Boston Region MPO studies, and staff knowledge of the area, it was found that high volumes, delays, and bus and pedestrian movements, especially in the Malden Center area, characterize the roadway in the vicinity of the study area. Some of these concerns were documented in public comments received about this study as part of the development of the federal fiscal year (FFY) 2007 Unified Planning Work Program (UPWP).

In addition, in order to get input from Medford and Malden officials, MPO staff met with them at two separate meetings on the morning of May 7, 2007. At the Malden meeting, the focus of the officials was primarily on pedestrian movements at the intersection of Centre Street and Commercial Street, just south of Malden Center, which includes Malden's municipal offices and the Malden Transportation Center, which serves as an Orange Line (rapid transit) and commuter rail station, and as a bus terminal, for the Massachusetts Bay Transportation Authority (MBTA). In addition, Malden officials were concerned about pedestrian conflicts with traffic, which is allowed to turn right on the red phase at the Fellsway East, Main Street, and Ferry Street intersections. Some of their other concerns were bus mobility and service issues, including access to and connectivity with Malden Center.

At the Medford meeting, officials expressed concern about pedestrian circulation at the following locations: the Route 60 rotary under I-93, Park Street, and the vicinity of the commercial area at Spring Street. They also characterized the intersection of Route 60 and Fellsway West as a location with traffic problems and outdated traffic signals. In addition, Medford officials viewed the Boston Region MPO's study as a continuation of their urban design study of Medford Square, but with an extension to the area east of Medford Square.

1.1 OBJECTIVES

The purpose of this study was to identify and analyze 7 to 10 intersections on Route 60 and associated bus service issues in the study area in order to improve mobility and safety in the corridor. The criterion for which locations were to be studied was the ability to benefit from improved pedestrian crossings; traffic control and signal upgrades and coordination; and signage and pavement markings for pedestrians, bicyclists, and general traffic along Route 60. To this end, staff aimed at meeting the following objectives:

1. Community participation
2. Identification of study locations and bus mobility and service issues
3. Data collection
4. Analysis of data and recommendation of improvements
5. Documentation of findings

To meet the study objectives, staff first collected and assembled data on the geometry of the intersections, traffic-volume data, pedestrian-volume data, travel-time and travel-speed data, and crash data to determine the existing travel conditions. Staff then met with officials from both cities and developed improvement alternatives with contributions from city officials. Based on the analysis and on contributions from the city officials, staff developed several possible traffic safety and operations improvements.

The report is organized into nine sections: an executive summary and eight chapters. Chapter 1 gives the background of the study. Chapter 2 presents the data collection activities and the scope of analysis. Chapters 3 and 4 document the existing traffic operations and safety problems and the potential improvements that were developed to improve mobility and traffic safety and operations in Malden. Chapters 5 and 6 document the existing traffic operations and safety problems and the potential improvements that were developed to improve mobility and traffic safety and operations in Medford. Chapter 7 describes the potential bus transit improvements, and Chapter 8 presents the study conclusions and provides a description of the process for implementing them and for helping the two communities with the initial project development.

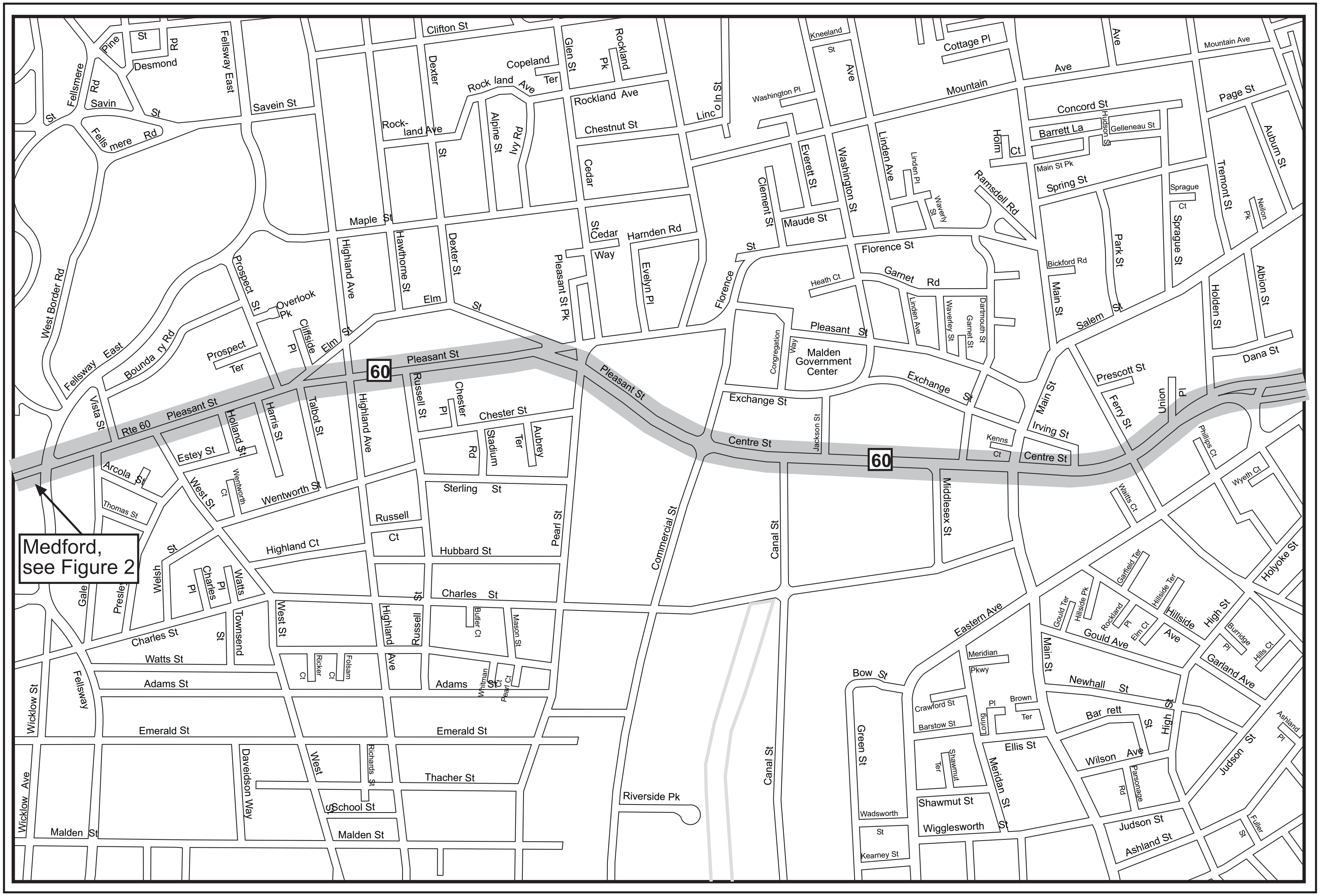

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FIGURE 1
Route 60 Study Area in Malden

Route 60 Mobility Study
Malden and Medford

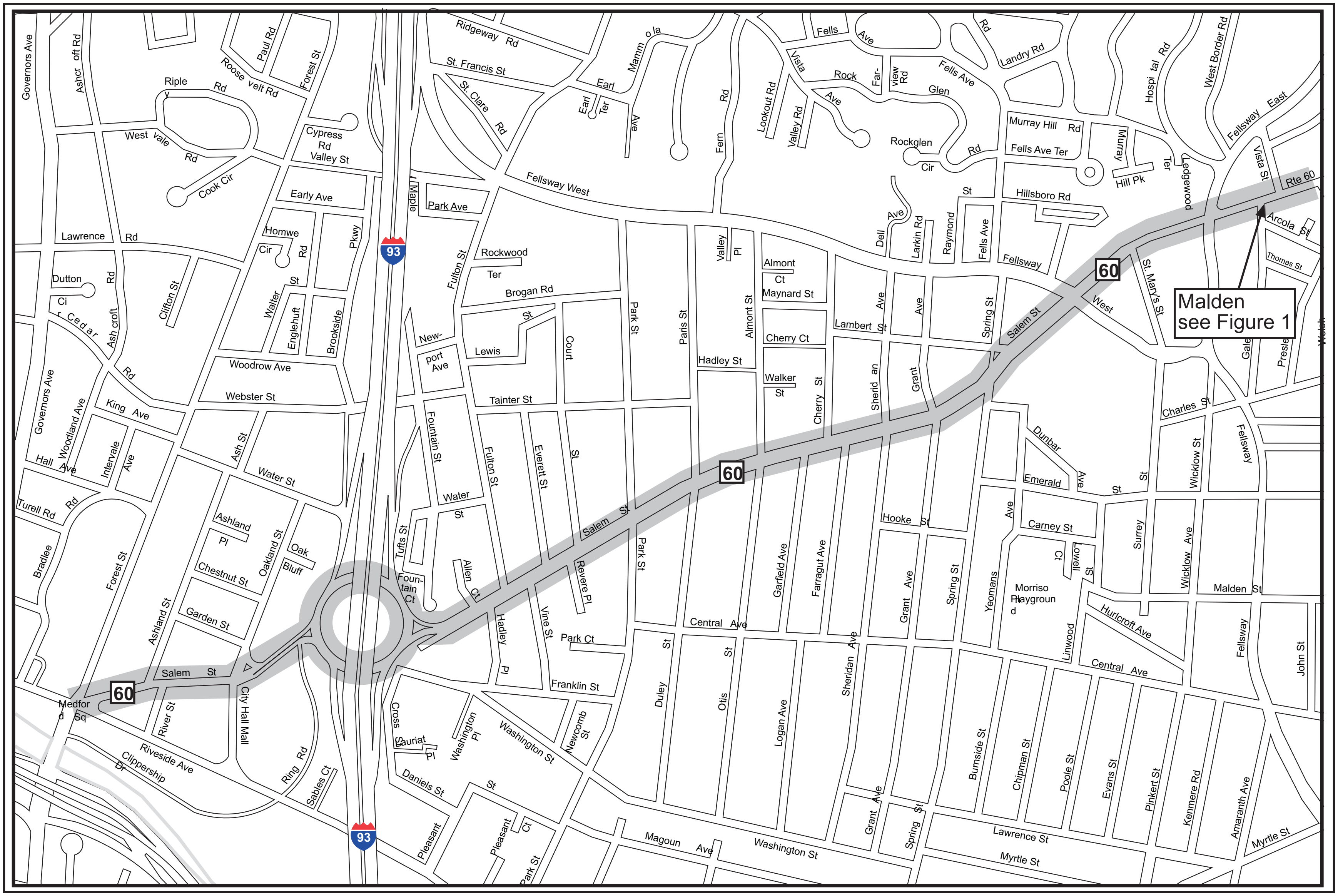

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FIGURE 2
Route 60 Study Area in Medford

Route 60 Mobility Study
Malden and Medford

2. SCOPE OF STUDY

This section addresses the selection of study locations, data collection efforts, and types of analysis performed to determine the existing conditions and evaluate potential alternatives.

2.1 SELECTION OF STUDY LOCATIONS

At a meeting on May 7, 2007, Malden officials identified four locations on Route 60 with pedestrian and traffic safety problems. Specific concerns included pedestrian conflicts with vehicular traffic. Staff conducted field reconnaissance and inspected crash statistics for the four locations and concluded that all four locations should be included in the study. The four intersections are:

1. Pleasant Street (Route 60) and Fellsway East
2. Centre Street (Route 60) and Commercial Street
3. Centre Street and Main Street
4. Centre Street and Ferry Street

At a separate meeting with MPO staff on May 7, 2007, Medford officials identified five locations that were reported to have pedestrian and traffic safety problems. Staff then conducted field investigations and reviewed crash statistics for these locations and determined that all five intersections mentioned at the meeting had pedestrian and traffic safety problems. Consequently, those intersections were included in the study:

1. Salem Street (Route 60) rotary under I-93
2. Salem Street and Hadley Place
3. Salem Street and Park Street, including the adjacent intersection at Court Street
4. Salem Street and Spring Street
5. Salem Street and Fellsway West (Route 28)

Another concern is transit mobility. To develop potential improvements for bus transit operations in the corridor, particularly bus circulation to and from the Malden Transportation Center and along Route 60, staff identified eight signalized intersections, listed below, for retiming. The purpose of this task was to identify possible ways of improving traffic operations at intersections in order to improve bus schedule adherence to reduce delays for transit users. The first five signalized intersections were already included in the list of study intersections suggested by municipal officials; the last three intersections were included in the study to improve bus circulation in the vicinity of the Malden Transportation Center.

1. Pleasant Street (Route 60) and Fellsway East in Malden
2. Centre Street (Route 60) and Commercial Street in Malden
3. Centre Street and Main Street in Malden
4. Salem Street and Park Street in Medford
5. Salem Street and Fellsway West (Route 28) in Medford
6. Pleasant Street and Commercial Street/Florence Street in Malden
7. Main Street and Florence Street in Malden
8. Main Street and Salem Street/Ferry Street in Malden

2.2 DATA COLLECTION

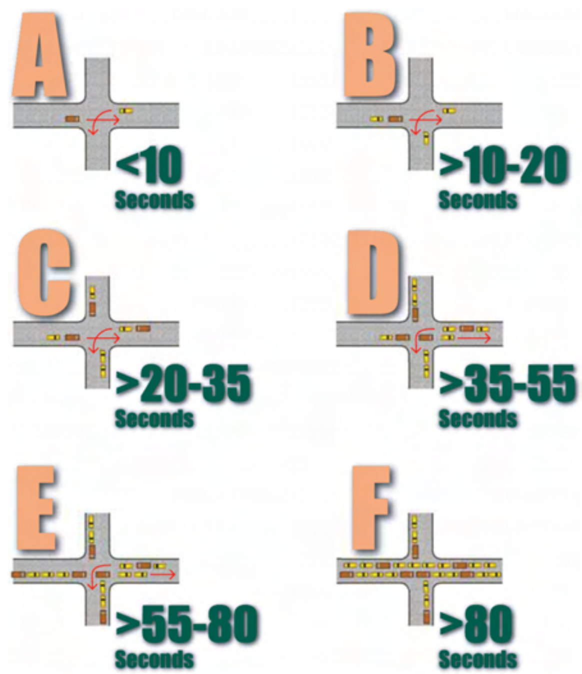
Several types of data were collected from the field or obtained from other sources in order to quantify and evaluate the existing traffic operations and safety conditions. Turning-movement counts, and pedestrian and bicycle data, were collected in the field in November 2007. These counts were conducted during the morning peak travel period (7:00 AM to 9:00 AM) and the afternoon peak travel period (4:00 PM to 6:00 PM) on weekdays, and were recorded in 15-minute intervals. On the same day that counts were conducted at a given location, staff also took inventory of the pedestrian and bicycle amenities provided, such as curb cuts for wheelchairs, crosswalks, sidewalks, and pedestrian-activated push buttons (at signalized intersections). Staff also performed a field study of intersection control information, such as traffic signal timing and phasing, signs, pavement markings, and lane configurations. The MBTA provided data on bus ridership and the locations of bus stops. Amenities provided at bus stops, such as benches, booths, and signs, were recorded manually in the field.

2.3 SCOPE OF ANALYSIS

The analyses in this study were focused on identifying and defining the problems at each study location, as well as identifying potential improvements. Both quantitative and qualitative analyses were conducted to evaluate traffic operations and safety, pedestrian and bicycle safety, and potential bus transit service improvements.

Traffic Operations and Safety

For traffic operations analyses, the measures used in defining problems include control delay and associated levels of service, and queue lengths. Control delay is measured in seconds per vehicle, and it is the component of delay that results from a traffic control at an intersection. It is the difference between the travel time that would have occurred in the absence of the intersection control, and the travel time that results because of the presence of the intersection control.



USDOT, FHWA

The concept of level of service (LOS) is used to rate the performance of peak-hour traffic operating conditions at intersections, and it is directly related to control delay. A level-of-service rating summarizes the quality of traffic flow using a grading system of six levels of service. LOS A is the optimal condition, where intersection operations are at their best, with LOS F indicating congested conditions. The range of LOS A through LOS D is considered acceptable; LOS E and LOS F are considered unacceptable—the facility is either at capacity or unable to handle traffic demands.

For a safety analysis, the measures used for defining the problems are the crash frequency and rate, and collision diagrams. A high crash frequency may be an indication of a problem; however, information on detailed characteristics of collisions, such as type, severity, roadway condition, light condition, and time of occurrence, is needed to provide an insight into the nature of safety problems and to allow the development of appropriate improvements. Therefore, in order to uncover the problems and to discover any underlying collision patterns, a collision diagram is usually constructed. Another way of analyzing collisions is to calculate the crash rate in order to evaluate an intersection based on the volume of vehicular traffic and to gain a better understanding of how a particular intersection compares to others. A crash rate is the average number of crashes on an annual basis (a three-year average in this study) divided by the annual average daily traffic volume. The formula for calculating the crash rate for an intersection is presented below. The crash rate (R) is expressed in million entering vehicles (MEV) per day, which is a standard practice. The calculated crash rates were compared to the average rates for District 4 of the Massachusetts Highway Department, where the study area is located.

$$\text{Crash rate (R)} = \frac{A * 1{,}000{,}000}{V * T}$$

A = Annual average number of collisions at the intersection
V = Annual average daily traffic volume entering the intersection
T = Time, as number of days in a year (365)

Pedestrian and Bicycle Mobility

Pedestrian and bicycle mobility is defined as the ease or difficulty that a pedestrian or a bicyclist experiences while traveling along a corridor, including through intersections, and the facilities provided to help them navigate through that corridor, such as continuous sidewalks, crosswalks, bike lanes and signs, ramps for wheelchairs, buffer and median spaces, pedestrian signals, and pedestrian-related signs. Also taken into account are right-turn-on-red and left-turn conflicts with vehicular traffic, which hinder pedestrian and bicycle mobility. In this study, the level of support provided to facilitate pedestrian and bicycle mobility at and between the study intersections was assessed qualitatively for deficiencies, for being absent, and for potential improvements.

Bus Transit Service

For bus transit service, the objective of this study was to develop potential improvements to service conditions and performance, especially schedule adherence and accessibility in the study corridor. The primary focus was to reduce traffic signal delay (congestion) through improved traffic signal timing to improve bus operations in the corridor. Therefore, the performance measure was the time savings resulting from the improved signal timing. In addition to the time savings assessment, a qualitative review of the level of support provided for passengers at bus stops, such as benches, booths, and bike racks, was undertaken, and potential improvements were proposed.

3. PROBLEMS AT STUDY LOCATIONS IN MALDEN

3.1 PLEASANT STREET AND FELLSWAY EAST

The intersection of Pleasant Street and Fellsway East is a five-legged signalized intersection. It is located in a residential area about 750 feet east of the Medford town line. Figure 3 shows the intersection's geometry and lane configuration. On-street parking is prohibited on Fellsway East north of Pleasant Street, but it is allowed south of Pleasant Street. The pavement and granite curbs are in good condition. The traffic signals are post-mounted, and the signal heads are in good condition and are visible to motorists.

Pedestrian and Bicycle Operations and Safety Problems

An exclusive pedestrian signal phase and a "NO RIGHT TURN ON RED" sign on Pleasant Street reduce conflicts between pedestrians and vehicular traffic at this intersection. Pedestrian push buttons have been provided for activating the pedestrian walk phase; once activated, the pedestrian walk signal is turned on at all approaches and all vehicular movements are stopped. A symbol of a person walking and a flashing or steady red hand designate the pedestrian "WALK" and "DON'T WALK" phases, respectively. There is no audible pedestrian signal (APS) to assist persons who are blind in crossing either street.

The pedestrian crosswalks are marked across all five approaches with parallel white stripes sufficiently visible to pedestrians and motorists, and are aligned perpendicular to each approach. The stop lines are white and are set back about four feet from the crosswalks. The sidewalks on both Pleasant Street and Fellsway East are six to eight feet wide, are made of concrete, and are in good condition. Each corner of the intersection features two sidewalk curb cuts for wheelchairs, one for each crosswalk. Street trees and street furniture, such as benches, streetlights, newspaper boxes, mailboxes, and trash receptacles, do not reduce the width of the sidewalk to less than five feet. Figure 3 shows the pedestrian crossings in green. On the day of observation, 51 pedestrians crossed at the intersection during the AM peak period (7:00–9:00 AM) and 73 pedestrians crossed during the PM peak period (4:00–6:00 PM).

Traffic Operations and Safety Problems

Table 1 presents the traffic delay, level of service, and queuing at the Pleasant Street and Fellsway East intersection. Traffic operations at this intersection are not satisfactory. During the AM peak period, traffic at the southbound approach of Fellsway East operates at LOS E. Also, a traffic queue forming at the westbound approach of Salem Street (Route 60) at the Fellsway West (Route 28) intersection in Medford extends eastward into the Fellsway East intersection, affecting its operations. During the PM peak period, traffic at the eastbound approach of Pleasant Street operates at LOS F, and its queue extends westward toward the Fellsway West (Route 28) intersection in Medford.

The crash rate, frequency, and characteristics at this intersection are presented in Table 2 and Table 3, respectively. Shading denotes intersections with higher crash rates than the MassHighway District 4 average for comparable intersections. At the Fellsway East intersection, the crash rate of 1.04 per million entering vehicles (MEV) is higher than the 0.88 crashes per MEV that is the average for MassHighway District 4 signalized intersections. Between 2004 and 2006, there were 30 crashes at the Pleasant Street and Fellsway East intersection, many of them rear-end and angle/sideswipe crashes (see Table 3). None of

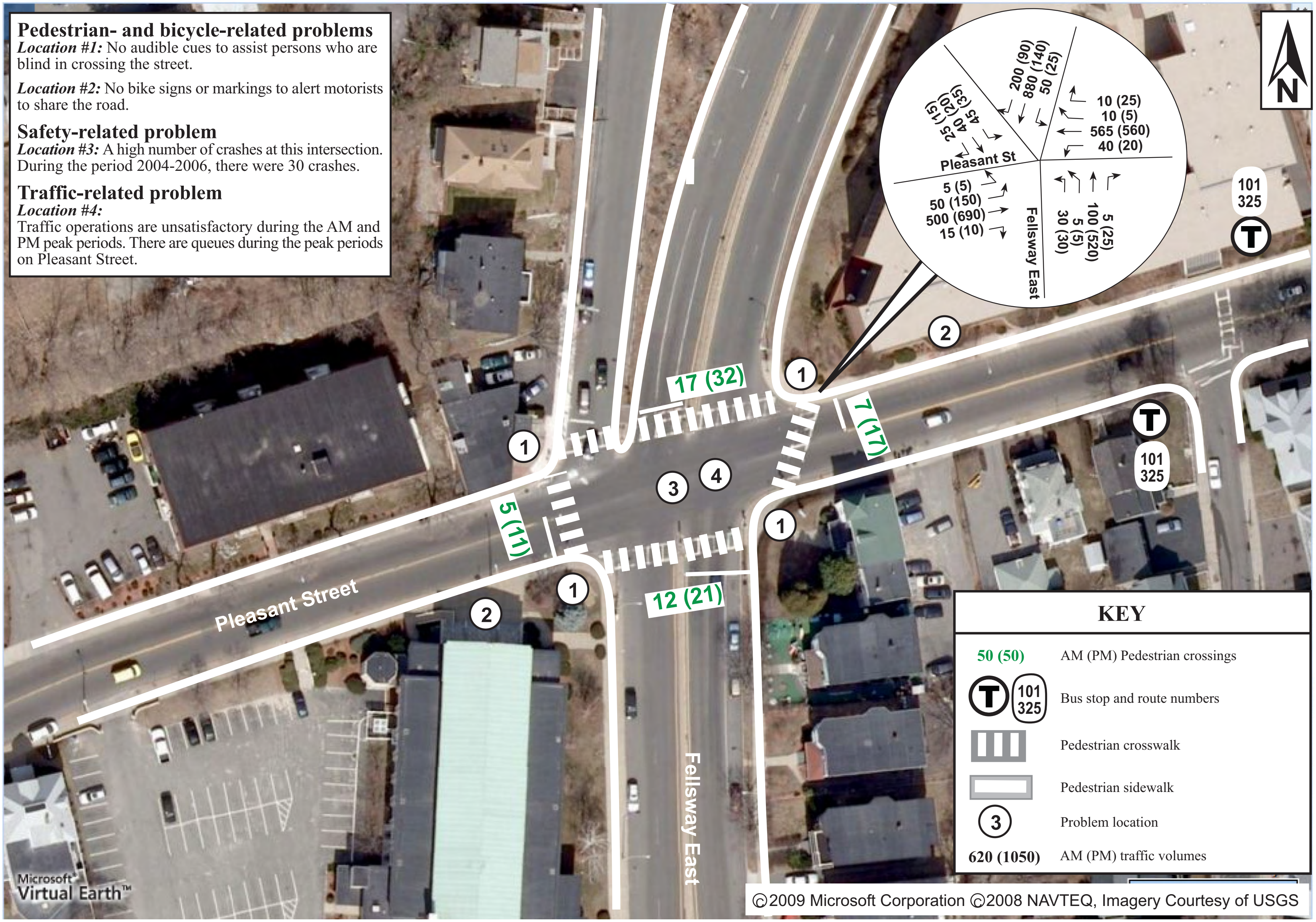


FIGURE 3
Mobility Problems at the Pleasant Street (Route 60) and Fellsway East Intersection

TABLE 1
Delay, Level of Service, and Queue Length,
Malden Intersections

Intersection	AM Peak Period Delay (sec.)	AM Peak Period LOS	AM Peak Period Queue (veh.)*	PM Peak Period Delay (sec.)	PM Peak Period LOS	PM Peak Period Queue (veh.)*
Pleasant Street and Fellsway East						
Pleasant Street Westbound	27	C	20	22	C	17
Pleasant Street Eastbound	26	C	18	>180	F	40
Fellsway East Northbound	24	C	3	28	C	5
Fellsway East Southbound	74	E	17	22	C	10
Fellsway East Local Southbound	37	D	3	36	D	4
Centre Street and Commercial Street						
Salem Street Westbound LT	48	D	10	35	C	4
Salem Street Westbound Th + RT	20	B	7	23	C	7
Salem Street Eastbound LT	13	B	4	28	C	3
Salem Street Eastbound Th + RT	12	B	5	15	B	5
Commercial Street Northbound	23	C	4	62	E	10
Commercial Street Southbound	24	C	8	17	B	6
Centre Street and Main Street						
Main Street Northbound LT	33	C	6	23	C	5
Main Street Northbound Th + RT	20	C	4	20	C	6
Main Street Southbound LT	20	C	3	22	C	4
Main Street Southbound Th + RT	24	C	8	21	C	6
Centre Street Eastbound LT	10	A	3	9	A	4
Centre Street Eastbound Th + RT	6	A	7	8	A	6
Centre Street Westbound LT	22	C	5	32	C	3
Centre Street Westbound Th + RT	12	B	4	17	B	6
Centre Street and Ferry Street						
Centre Street Eastbound LT	25	C	8	19	B	2
Centre Street Eastbound Th + RT	19	B	6	26	C	11
Centre Street Westbound LT	24	C	4	53	D	5
Centre Street Westbound Th + RT	26	C	10	20	C	4
Ferry Street Northbound LT+ Th + RT	12	B	5	16	B	5
Ferry Street Southbound LT+ Th + RT	11	B	4	24	C	4

* 95% queue length
Th = through, RT = right turn, LT = left turn

TABLE 2
Crash Rates for Malden Intersections

Intersection	Number of Crashes 3-Year Total	Number of Crashes Annual Average	Average Daily Traffic	Crash Rate*
Pleasant Street and Fellsway East	30	10.0	26,333	1.04
Centre Street and Commercial Street	54	18.0	30,333	1.63
Centre Street and Main Street	45	15.0	31,778	1.29
Centre Street and Ferry Street	31	10.3	29,000	0.97
MassHighway District 4 Average Crash Rate for Signalized Intersections				0.88
MassHighway District 4 Average Crash Rate for Unsignalized Intersections				0.63

* Crashes per million entering vehicles

TABLE 3
Crash Characteristics and Frequency, 2004–2006, Malden Intersections

	Fellsway East and Pleasant Street	Commercial Street and Centre Street	Main Street and Centre Street	Ferry Street and Centre Street
	Number of Crashes	Number of Crashes	Number of Crashes	Number of Crashes
Crash Severity				
Fatality	0	0	0	0
Injury	11	24	16	15
Property damage only	17	17	18	10
Not reported	2	12	9	5
Unknown	0	1	2	1
Total	*30*	*54*	*45*	*31*
Collision Type				
Rear-end	11	6	6	7
Angle/sideswipe	8	35	30	21
Head-on	1	5	3	1
Single-vehicle crash	2	4	2	1
Not reported	3	4	3	1
Unknown	0	0	1	0
Total	*30*	*54*	*45*	*31*
Roadway Condition				
Dry	22	41	31	22
Wet	4	11	12	7
Snow	1	1	2	2
Not reported	3	1	0	0
Other	0	0	0	0
Total	*30*	*54*	*45*	*31*
Light Condition				
Daylight	19	35	26	17
Dawn	2	0	1	0
Dusk	0	3	2	2
Dark road, lighted	7	15	16	11
Dark road, unlighted	1	0	0	1
Not Reported	1	1	0	0
Other	0	0	0	0
Total	*30*	*54*	*45*	*31*
Year				
2004	15	19	20	13
2005	7	14	9	8
2006	8	21	16	10
Total	*30*	*54*	*45*	*31*

the crashes involved a fatality; one of the crashes involved a pedestrian. Figure 4 is a collision diagram of crashes at this intersection that occurred from January 1, 2004, to December 31, 2006. About one-half of the crashes were of the rear-end type, usually associated with signalized intersections that have traffic queues and stop-and-go conditions, such as this intersection.

3.2 CENTRE STREET AND COMMERCIAL STREET

The intersection of Centre Street and Commercial Street is a signalized intersection located near the Malden Transportation Center. The intersection's geometry and lane configuration can be seen in Figure 5. This intersection is one of the main access routes to the Malden Transportation Center. On-street parking is prohibited at this intersection. The traffic signals are mast mounted and the signal heads are in good condition, placed appropriately to provide good visibility to motorists. The roadway pavement in the vicinity of the intersection is in fair condition, as is the granite curbing.

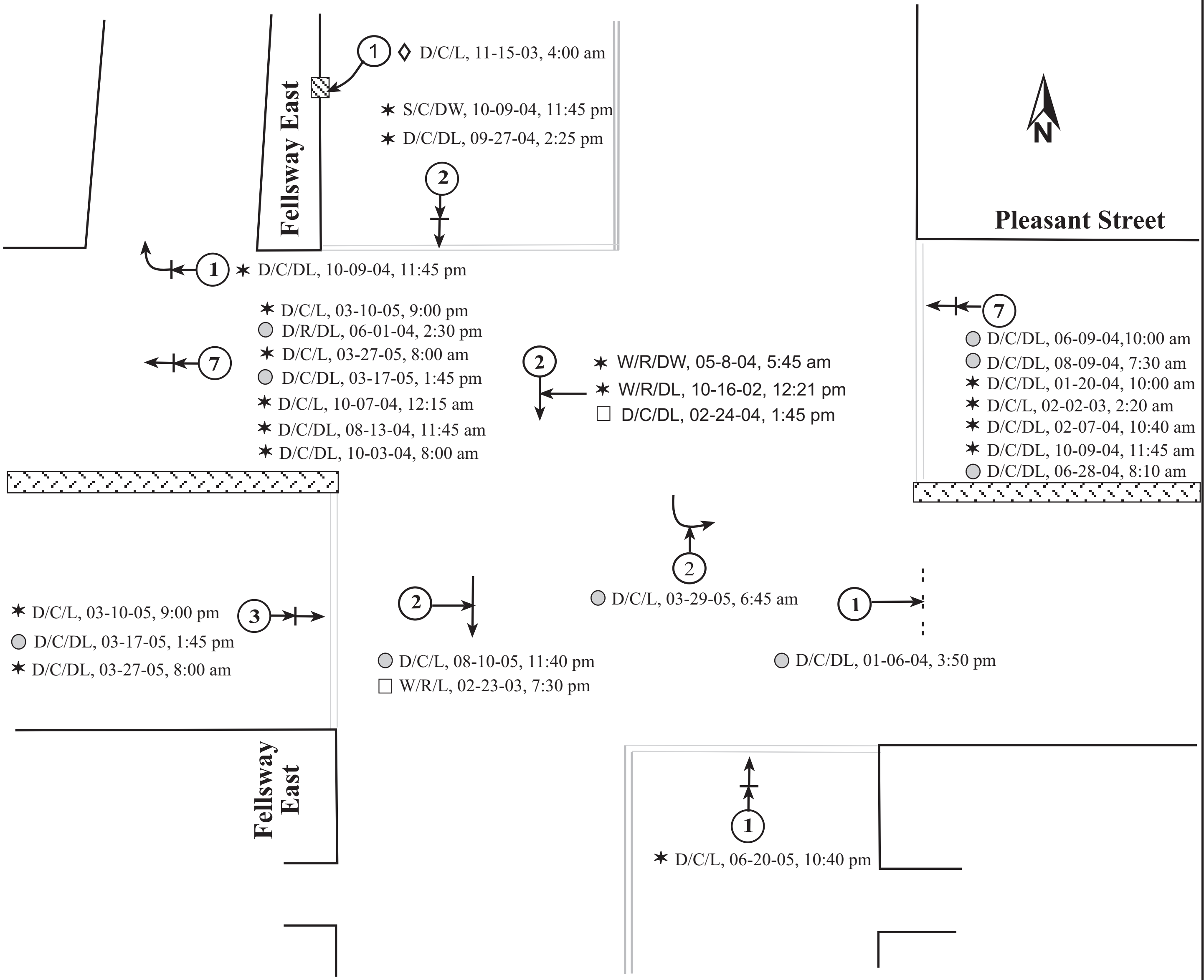
Pedestrian and Bicycle Operations and Safety Problems

Pedestrians, bicycles, buses, and cars use this intersection to get to the Malden Transportation Center, but safety is a problem at this intersection for both pedestrians and motorists. Pedestrian safety problems also occur farther along Commercial Street, especially in front of the Malden Transportation Center. Many of the pedestrians and bicyclists crossing at this intersection are transit users going to and from the Malden Transportation Center. The pedestrian crosswalks at this intersection are marked on all four approaches with parallel white stripes, sufficiently visible to pedestrians and motorists, and are aligned perpendicular to each approach. Each corner north of the intersection features two sidewalk curb cuts for wheelchairs, one for each crosswalk. Each corner south of the intersection features one sidewalk curb cut for wheelchairs, which is shared by both crosswalks. The sidewalks on both Centre Street and Commercial Streets are six to eight feet wide, are made of concrete, and are in good condition. The street furniture does not reduce the width of the sidewalk to less than five feet.

The pedestrian walk signals at this intersection turn on concurrently with the two-way through traffic on Commercial Street, during which pedestrians cross Centre Street; however, *it does not turn on concurrently* with the two-way through traffic on Centre Street for pedestrians to cross Commercial Street. The concurrent pedestrian walk phase creates vehicle-pedestrian conflicts because left- and right-turn movements are allowed during pedestrian walk phases. There are no pedestrian push buttons for activating the pedestrian signals at this intersection, which creates problems for the pedestrians crossing Commercial Street, as its pedestrian phase does not turn on concurrently with the two-way through traffic on Centre Street. Presently, pedestrians cross Commercial Street by looking for sufficient gaps and making sure there are no right-turning vehicles.

There is no audible pedestrian signal (APS) to assist persons who are blind in crossing the streets at this intersection. A sign is posted for pedestrians with the warning, "WATCH FOR TURNING VEHICLES ON WALK SIGNAL." This sign can be confusing, as it can be interpreted to mean that pedestrians are expected to yield to motor vehicles. This interpretation is contrary to state law, as conveyed by the "YIELD TO PEDESTRIANS" signs found at most intersections. The AM and PM pedestrian crossings are shown in green in Figure 5. On the day of observation, there were 88 pedestrians who crossed at the intersection during the AM peak period (7:00–9:00 AM) and 86 pedestrians during the PM peak period (4:00–6:00 PM). Field observations show that pedestrians at this intersection cross Centre Street with the pedestrian signal about half of the time; the rest cross Centre Street whenever there is a sufficient gap in the traffic stream, and some pedestrians cross half of the roadway and wait in the narrow median to make sure it is safe to cross the rest of the way.

FIGURE 4
Collision Diagram
January 1, 2004, through December 31, 2006
Pleasant Street and Fellsway East, Malden



SYMBOLS

Moving vehicle
Backing vehicle
Pedestrian or bicycle
Out-of-control vehicle
Fixed object
Property damage only
Injury
Fatality
No damage or injury
Not reported
Number of accidents

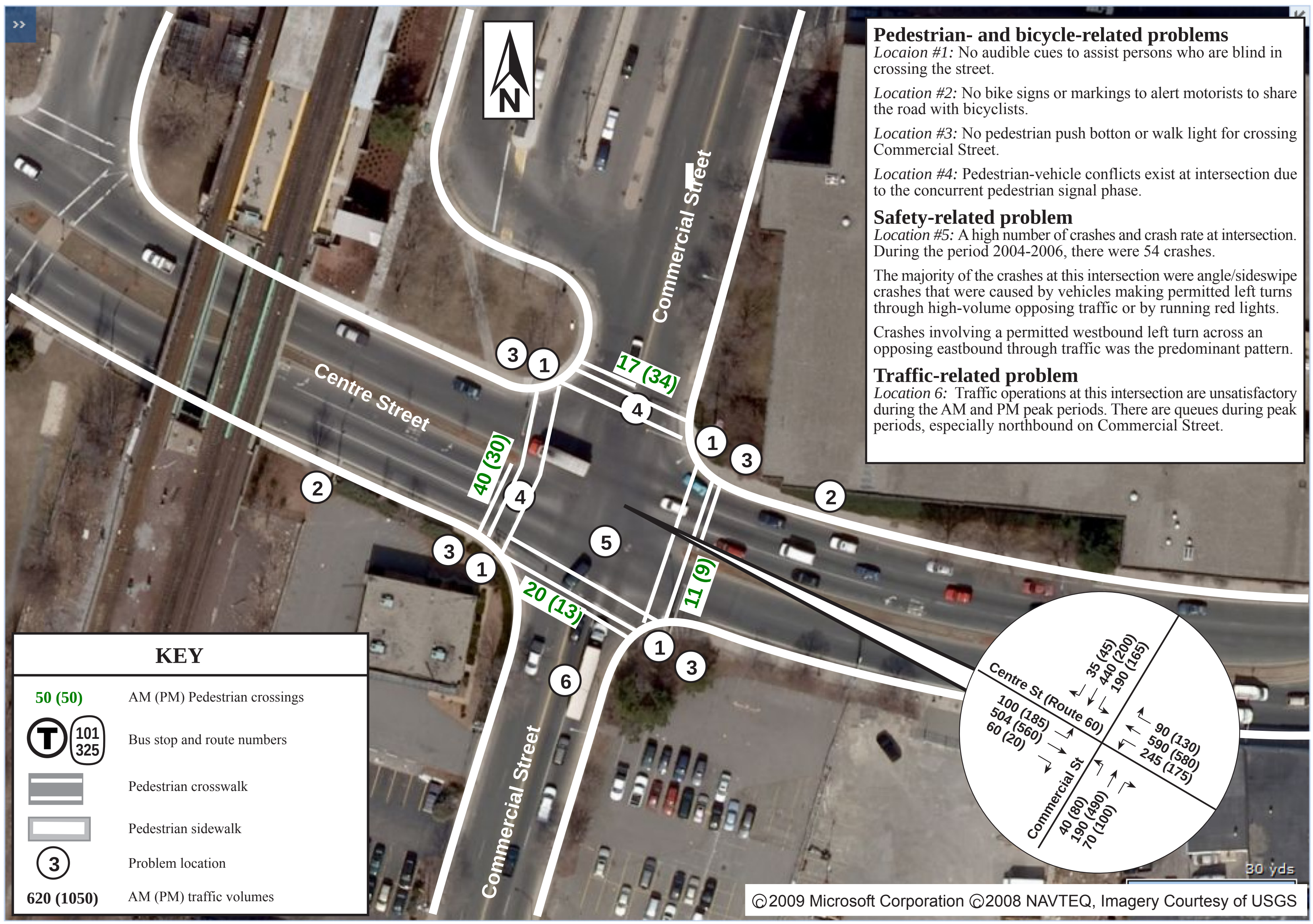
PAVEMENT/WEATHER/LIGHTING

D	Dry
W	Wet
S	Snowy, icy
--	Other
C	Clear
R	Rainy/foggy/cloudy
S	Snow/sleet
--	Other
DL	Daylight
L	Dark, lights
N	Dark, no lights
DU	Dusk
DW	Dawn

TYPES OF COLLISIONS

Head-on
Angle
Rear-end
Sideswipe
Right angle

CTPS



CTPS

FIGURE 5
Mobility Problems at the Centre Street (Route 60) and Commercial Street Intersection

Route 60 Mobility Study: Malden and Medford

Traffic Operations and Safety Problems

Table 1 (page 17) shows the traffic delay, level of service, and queuing at the Centre Street and Commercial Street intersection. In the AM peak period, all of the approaches at this intersection operate at LOS D or better. In the PM peak period, the Commercial Street northbound approach operates at LOS E, while the other approaches operate at LOS C or better. During congested periods, buses exiting the east busway to Commercial Street southbound, then traveling on Centre Street, sometimes have difficulty finding a gap in traffic. Sometimes only a single bus exits per cycle. In addition, because the MBTA busway exit on Commercial Street is located close to the intersection (about 60 feet away), it is frequently blocked by traffic queues on the southbound approach.

The crash rate, frequency, and characteristics at this intersection are presented in Tables 2 and 3, respectively (pages 17 and 18). The crash rate of 1.63 crashes per million entering vehicles (MEV) is higher than the average of 0.88 crashes per MEV for MassHighway District 4 signalized intersections. Between 2004 and 2006, there were 54 crashes at this intersection. Sixty-six percent were angle/sideswipe crashes; none of the crashes involved a fatality, but there were three pedestrian-related crashes and one bicyclist-related crash. A collision diagram of the crashes is presented in Figure 6. The majority of the crashes were angle/sideswipe crashes that were caused by vehicles running a red light or making permitted left turns through high-volume opposing traffic. The permitted westbound left turns had more crashes than the other approaches.

3.3 CENTRE STREET AND MAIN STREET

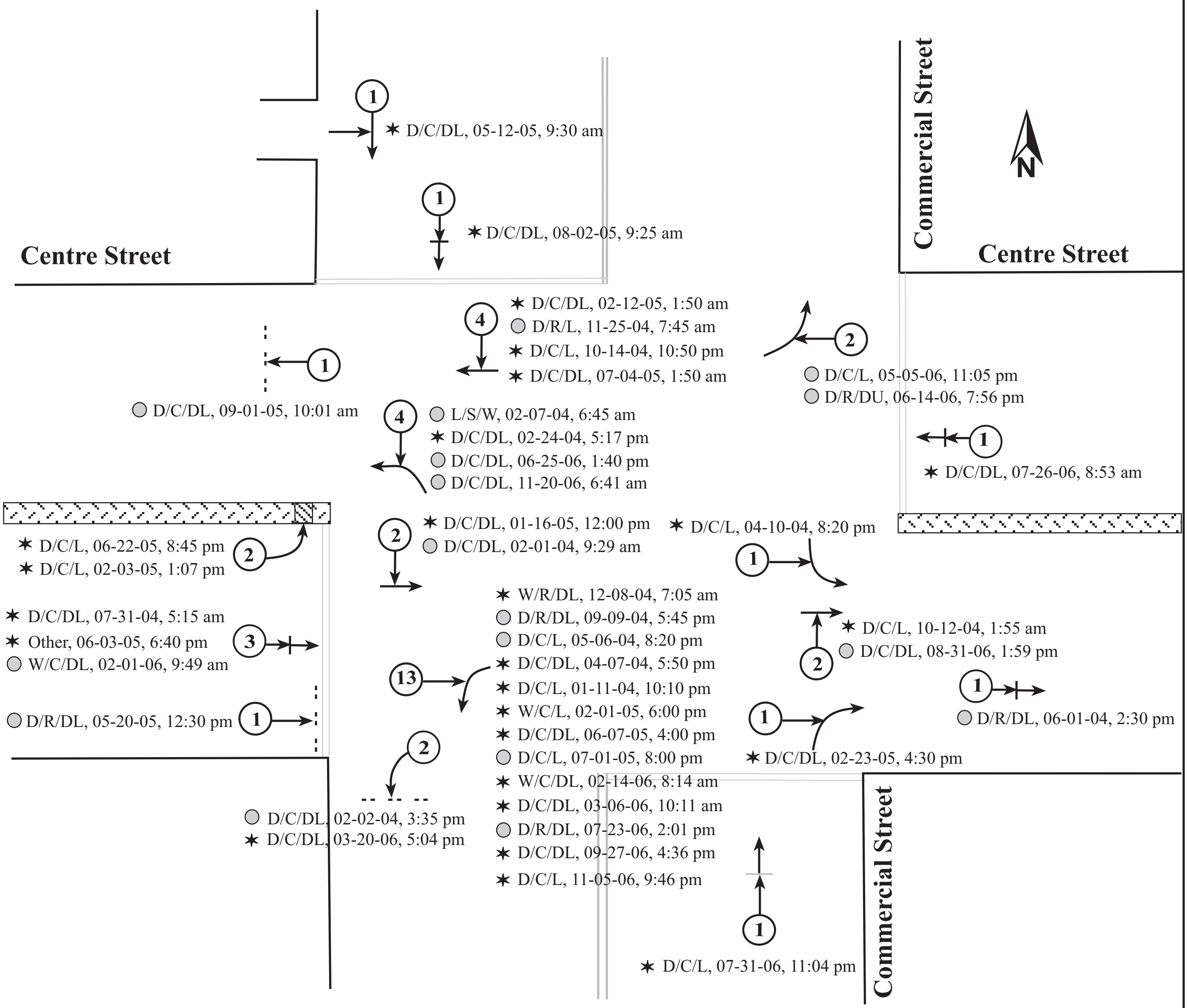
The intersection of Centre Street and Main Street is a four-legged signalized intersection located in a commercial area. The intersection’s geometry and lane configuration are presented in Figure 7. Presently, the roadway surface is in fair to good condition, as is the granite curbing. Each approach has an exclusive left-turn bay. The signals are mast mounted, except those for Centre Street left-turn movements, which are post mounted in the median. The signal heads are in good condition and are placed appropriately to provide good visibility for motorists.

Pedestrian and Bicycle Operations and Safety Problems

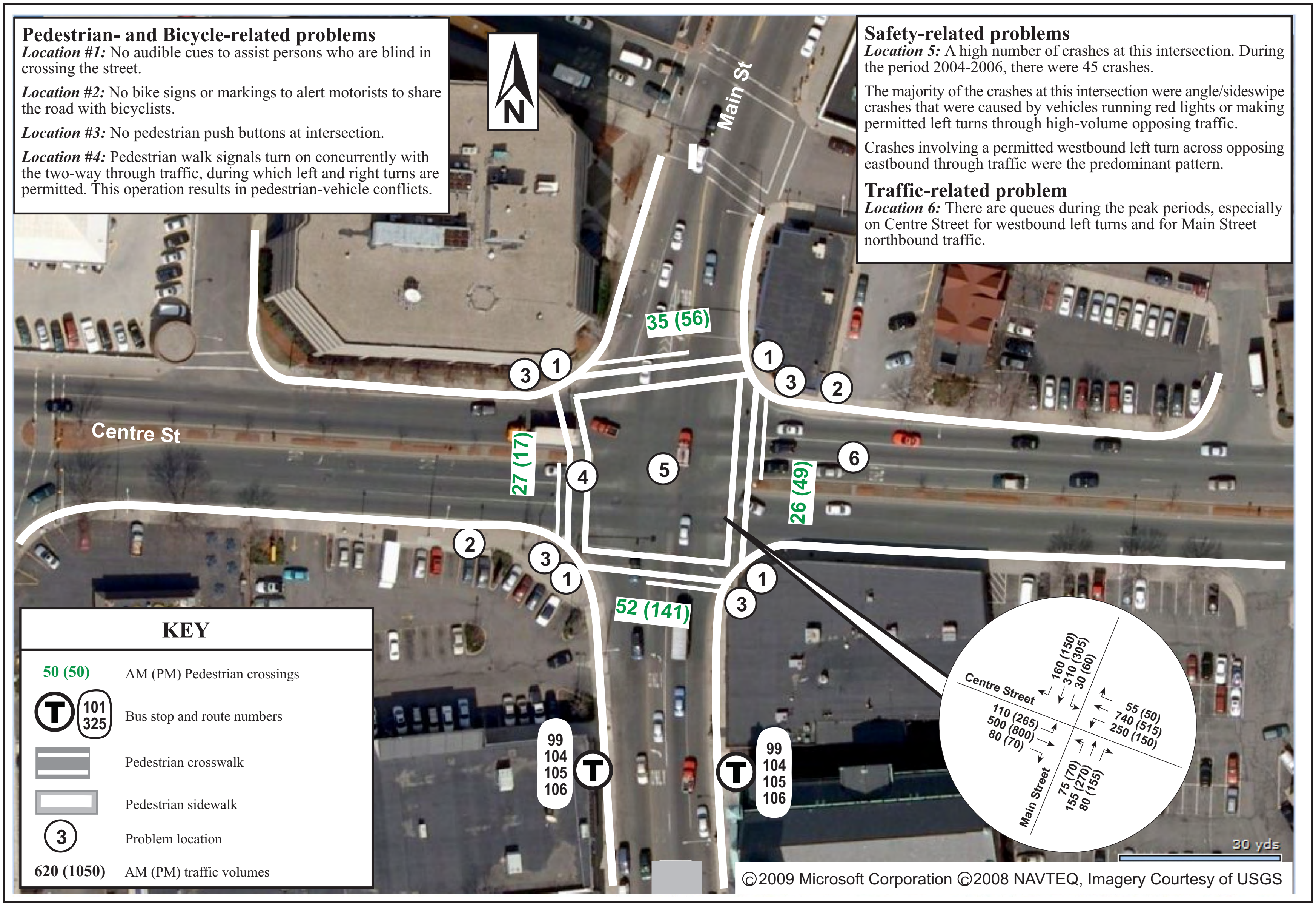
This intersection has pedestrian crosswalks marked on all four approaches, with simple, parallel white stripes, sufficiently visible to pedestrians and motorists. The sidewalks on both Centre and Main streets are six to eight feet wide, made of concrete, and in good condition. Each corner of the intersection features a sidewalk curb cut for wheelchair use, which is shared by both crosswalks. Street trees and street furniture, such as benches, streetlights, newspaper boxes, and trash receptacles, do not reduce the width of the sidewalk to less than five feet.

This intersection has pedestrian safety problems. The pedestrian walk signals turn on concurrently with the parallel two-way through traffic, during which right and left turns are permitted. This creates vehicle-pedestrian conflicts. A school crossing guard at the intersection complained that motorists fail to obey the “NO TURN ON RED” sign. A sign is posted for pedestrians with the warning, “WATCH FOR TURNING VEHICLES ON WALK SIGNAL.” This sign can be confusing, as it can be interpreted to mean that pedestrians are expected to yield to motor vehicles. This interpretation is contrary to state law, as conveyed by the “YIELD TO PEDESTRIANS” signs found at most intersections. A symbol of a person walking and a flashing or steady red hand designate the pedestrian “WALK” and “DON’T WALK” phases, respectively. However, the intersection lacks not only an audible pedestrian signal to assist persons who are blind in crossing, but also pedestrian push buttons to facilitate safe crossing. There are times when pedestrians ignore the signals and cross when they think it is safe; some pedestrians cross half of the roadway and wait in the narrow median to make sure it is safe to cross the rest of the way. The AM and PM pedestrian

FIGURE 6
Collision Diagram
January 1, 2004, through December 31, 2006
Centre Street and Commercial Street, Malden



SYMBOLS	PAVEMENT/WEATHER/LIGHTING		TYPES OF COLLISIONS
Moving vehicle	D	Dry	Head-on
Backing vehicle	W	Wet	Angle
Pedestrian or bicycle	S	Snowy, icy	Rear-end
Out-of-control vehicle	--	Other	Sideswipe
Fixed object	C	Clear	Right angle
Property damage only	R	Rainy/foggy/cloudy	
Injury	S	Snow/sleet	
Fatality	--	Other	
No damage or injury	DL	Daylight	
Not reported	L	Dark, lights	
Number of accidents	N	Dark, no lights	
	DU	Dusk	
	DW	Dawn	CTPS



CTPS

FIGURE 7
Mobility Problems at the Centre Street (Route 60) and Main Street Intersection

Route 60 Mobility Study: Malden and Medford

crossings are shown in green in Figure 7. On the day of observation, there were 140 pedestrians who crossed at the intersection during the AM peak period (7:00–9:00 AM) and 263 pedestrians during the PM peak period (4:00–6:00 PM).

Traffic Operations and Safety Problems

This intersection has traffic safety problems. The traffic delay, level of service, and queue length at this intersection are presented in Table 1 (page 17). Although, traffic operations are satisfactory (LOS C or better), there are queues during the AM and PM peak periods. A traffic queue created by intersections on Main Street north of this intersection extends southward into the intersection during peak periods, affecting its traffic operations. This queue, on some occasions, prevents the Centre Street and Main Street northbound traffic from moving.

Crash rate, frequency, and characteristics are presented in Table 2 and Table 3, respectively (pages 17 and 18). The crash rate of 1.29 crashes per million entering vehicles (MEV) is higher than the average of 0.88 crashes per MEV for MassHighway District 4 signalized intersections. There were 45 crashes at the Centre Street and Main Street intersection, many of which were angle/sideswipe crashes. None of the crashes involved a fatality, a pedestrian, or a bicyclist. Figure 8 is a collision diagram for the crashes at this intersection from 2004 to 2006. As the figure shows, the majority of the crashes at this intersection were angle/sideswipe crashes that were caused by vehicles running a red light or making permitted left turns through high-volume opposing traffic. Crashes involving a permitted westbound left turn across opposing eastbound through traffic were the predominant pattern at this intersection.

3.4 CENTRE STREET AND FERRY STREET

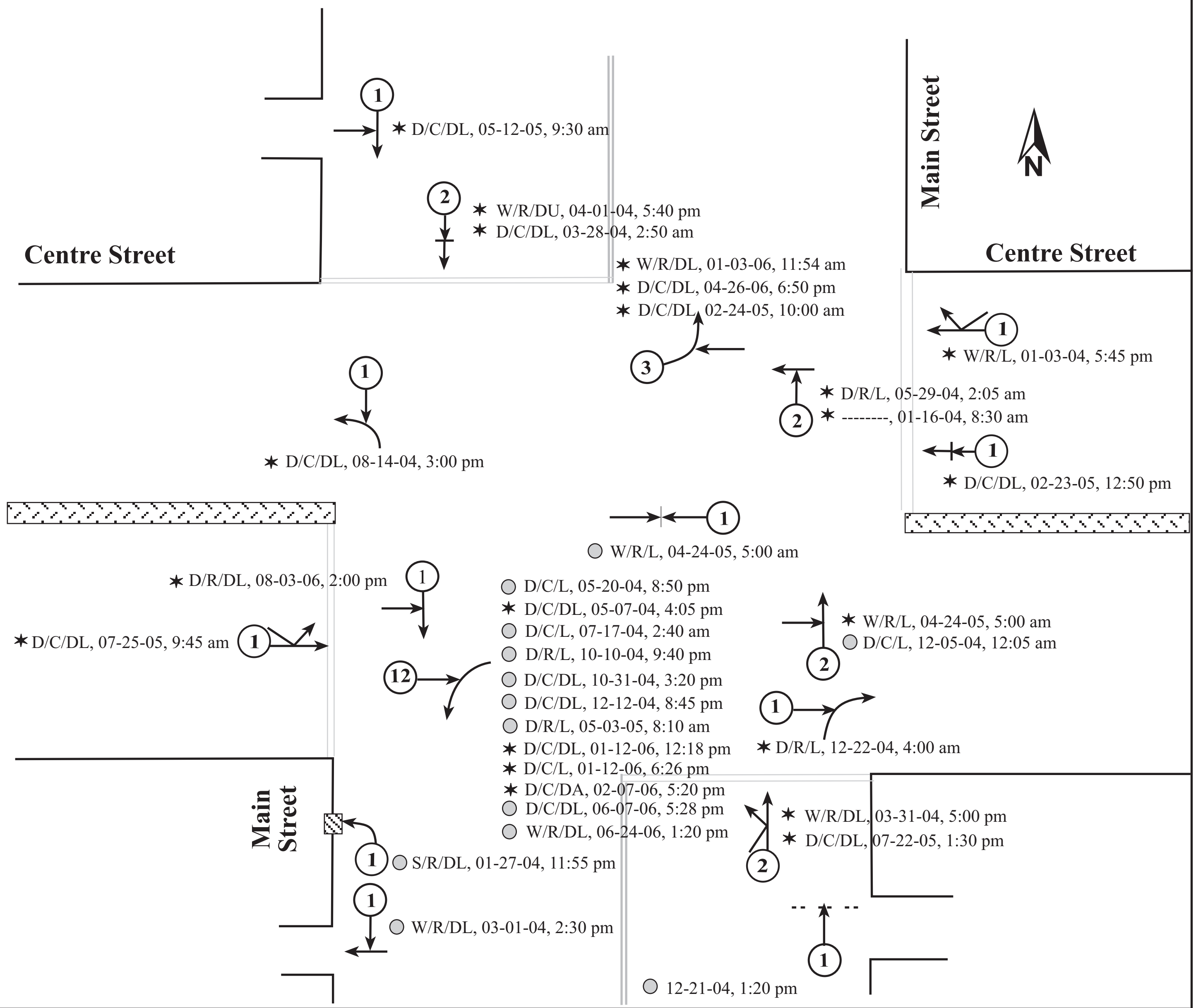
The intersection of Centre Street and Ferry Street is a signalized intersection located in an area with mixed land use: commercial, schools, and residences. The geometry and lane configurations at the intersection are shown in Figure 9. The pavement and curbing are in fair to good condition. The traffic signal equipment is in good condition, and the mast-mounted signal heads, placed so that they are visible to motorists, are in good condition. A right-turn-on-red (RTOR) is allowed from all approaches at the intersection except the westbound approach, where it is prohibited.

Pedestrian and Bicycle Operations and Problems

The pedestrian crosswalks at this intersection are marked at all four approaches, with simple, parallel white stripes, sufficiently visible to pedestrians and motorists, and are aligned perpendicular to each approach, as shown in Figure 9. The sidewalks on Centre and Ferry streets are about six to eight feet wide, made of concrete, and in good condition. Each corner of the intersection features a sidewalk curb-cut ramp for wheelchairs, which is shared by both crosswalks. The street furniture does not reduce the width of the sidewalk to less than five feet.

The pedestrian walk signal for crossing Centre Street comes on concurrently with the parallel two-way through traffic on Ferry Street, during which left and right turns are permitted. This creates conflicts between pedestrians and vehicles. There are no pedestrian push buttons for crossing Ferry Street (the pedestrian signals come on automatically and concurrently with Centre Street through traffic). A symbol of a person walking and a flashing or steady red hand designate the pedestrian “WALK” and “DON’T WALK” phases, respectively. There are no audible cues to assist persons who are blind in crossing the street at this intersection; however, signs have been posted for pedestrians with the warning “WATCH FOR TURNING VEHICLES ON WALK SIGNAL.” This sign can be confusing, as it can be interpreted to mean that pedestrians are expected to yield to motor vehicles. This interpretation is contrary to state law, as conveyed

FIGURE 8
Collision Diagram
January 1, 2004, through December 31, 2006
Centre Street and Main Street, Malden



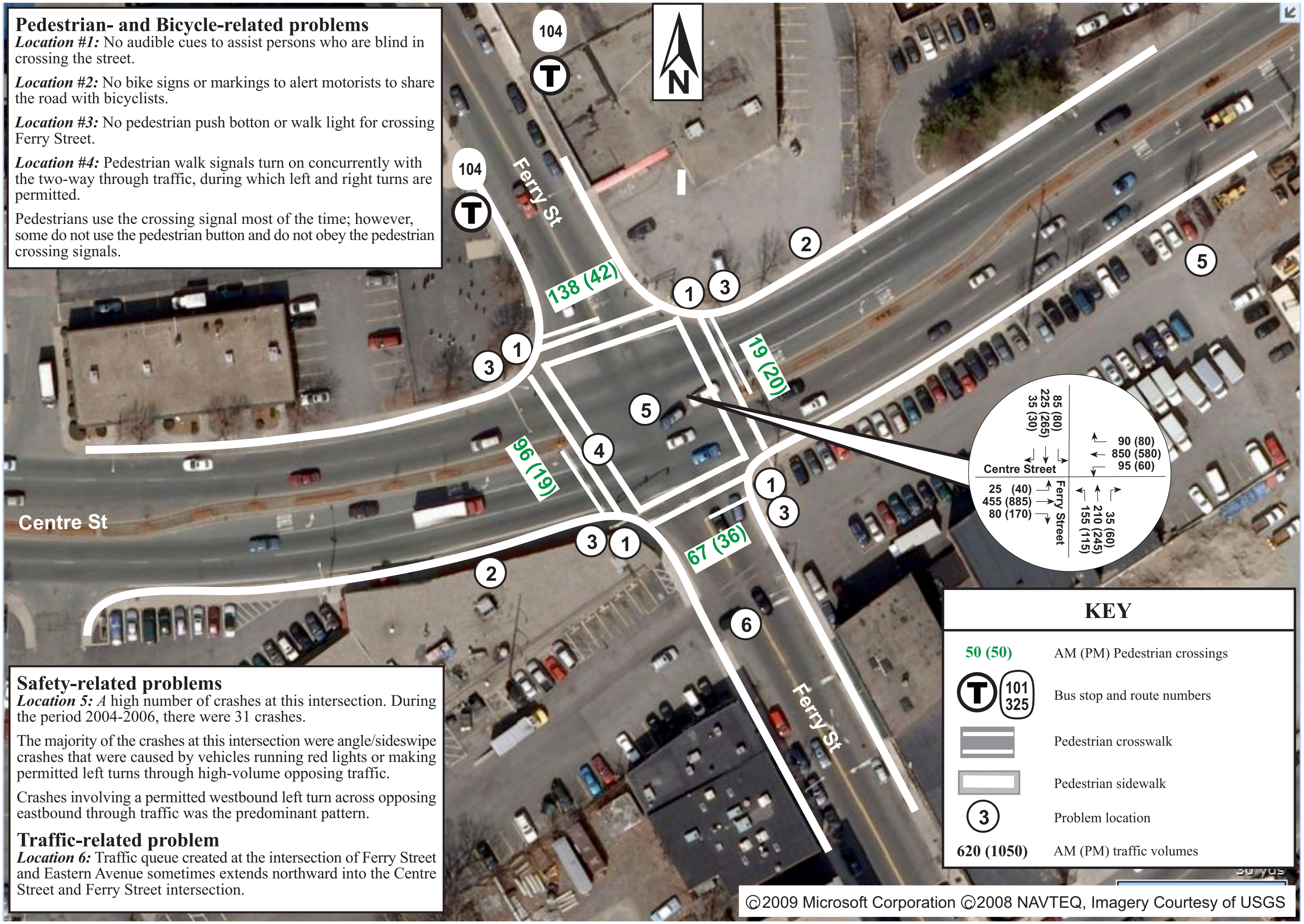
SYMBOLS	
←	Moving vehicle
←))))	Backing vehicle
-- -- --	Pedestrian or bicycle
	Out-of-control vehicle
	Fixed object
✶	Property damage only
○	Injury
●	Fatality
□	No damage or injury
◊	Not reported
(#)	Number of accidents

PAVEMENT/WEATHER/LIGHTING	
D	Dry
W	Wet
S	Snowy, icy
--	Other
C	Clear
R	Rainy/foggy/cloudy
S	Snow/sleet
--	Other
DL	Daylight
L	Dark, lights
N	Dark, no lights
DU	Dusk
DW	Dawn

TYPES OF COLLISIONS

- Head-on
- Angle
- Rear-end
- Sideswipe
- Right angle

CTPS



Pedestrian- and Bicycle-related problems

Location #1: No audible cues to assist persons who are blind in crossing the street.

Location #2: No bike signs or markings to alert motorists to share the road with bicyclists.

Location #3: No pedestrian push botton or walk light for crossing Ferry Street.

Location #4: Pedestrian walk signals turn on concurrently with the two-way through traffic, during which left and right turns are permitted.

Pedestrians use the crossing signal most of the time; however, some do not use the pedestrian button and do not obey the pedestrian crossing signals.

Safety-related problems

Location 5: *A* high number of crashes at this intersection. During the period 2004-2006, there were 31 crashes.

The majority of the crashes at this intersection were angle/sideswipe crashes that were caused by vehicles running red lights or making permitted left turns through high-volume opposing traffic.

Crashes involving a permitted westbound left turn across opposing eastbound through traffic was the predominant pattern.

Traffic-related problem

Location 6: Traffic queue created at the intersection of Ferry Street and Eastern Avenue sometimes extends northward into the Centre Street and Ferry Street intersection.

CTPS

FIGURE 9
Mobility Problems at the Centre Street (Route 60) and Ferry Street Intersection

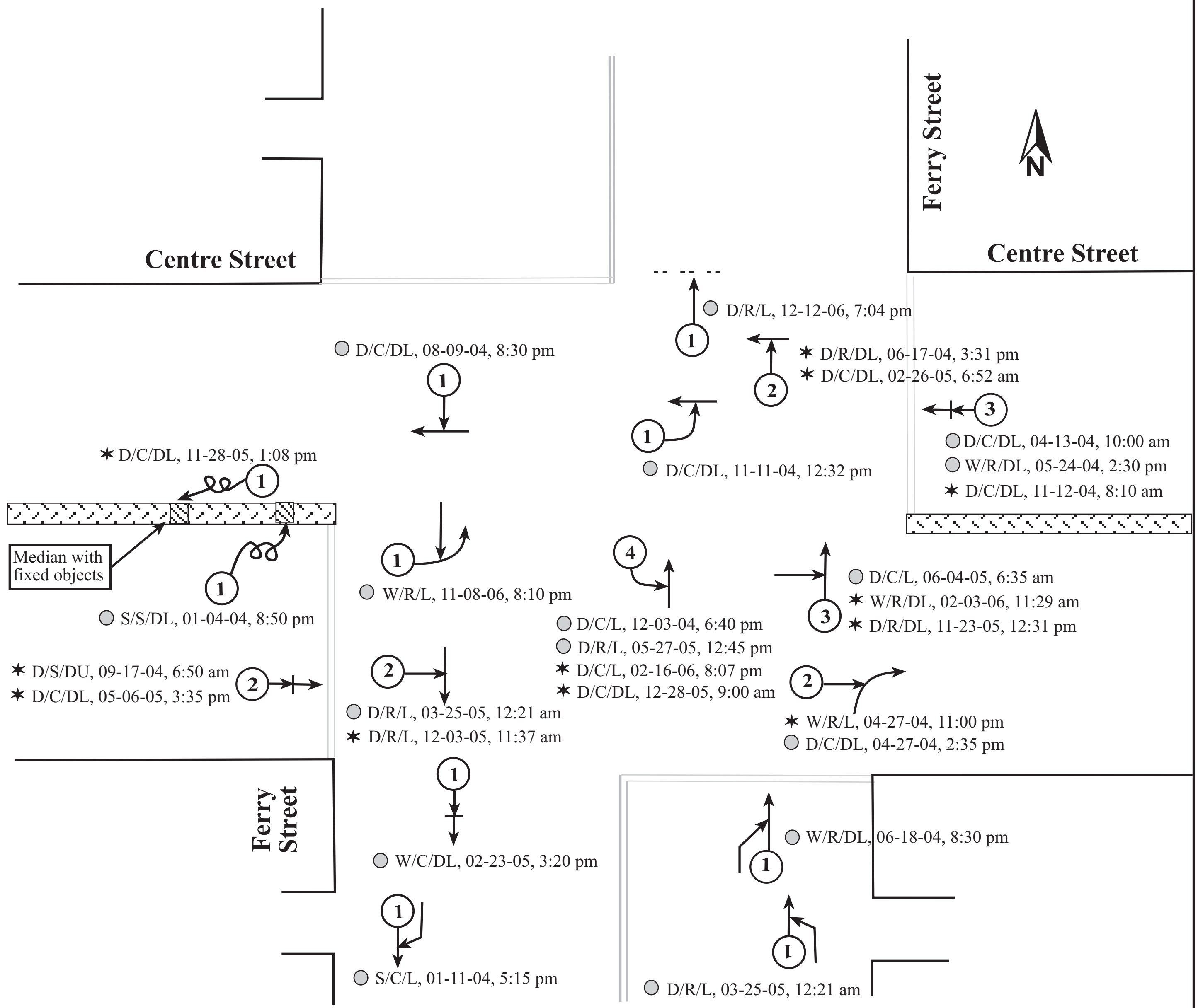
by the "YIELD TO PEDESTRIANS" signs found at most intersections. A school crossing guard assists students in crossing the streets during the morning and afternoon. The AM and PM pedestrian crossings are shown in green in Figure 9. On the day of observation, 360 pedestrians crossed at the intersection during the AM peak period (7:00–9:00 AM) and 117 pedestrians during the PM peak period (4:00–6:00 PM). Many of the pedestrians and bicyclists crossing at this intersection during the AM peak period are students of the Cheverus School and Malden High School, both of which are located north of the intersection. The PM peak-period pedestrian counts were lower because they were taken in the late afternoon, after school hours. Field observations show that pedestrians crossing at this intersection usually used the crossing signals, and motorists were observed to be yielding to pedestrians in the crosswalk on turns.

Traffic Safety and Operations

Traffic operations at this intersection are satisfactory during the AM and PM peak periods, with LOS D or better. The crash rate, frequency, and characteristics at the Ferry Street intersection are presented in Table 2 and Table 3, respectively (pages 17 and 18). The crash rate of 0.97 crashes per million entering vehicles (MEV) is somewhat higher than the average of 0.88 crashes per MEV for MassHighway District 4 signalized intersections.

Between 2004 and 2006, there were 31 crashes at the Ferry Street intersection, with many angle/sideswipe crashes. None of the crashes involved a fatality; one of the crashes at this intersection involved pedestrians. Figure 10 is a collision diagram for crashes from 2004 to 2006. As the figure shows, the majority of the crashes at this intersection were angle/sideswipe collisions that were caused by vehicles running a red light or making permitted left turns through opposing traffic.

FIGURE 10
Collision Diagram
January 1, 2004, through December 31, 2006
Centre Street and Ferry Street, Malden



SYMBOLS		PAVEMENT/WEATHER/LIGHTING		TYPES OF COLLISIONS
←	Moving vehicle	D	Dry	Head-on
←⟩⟩⟩⟩	Backing vehicle	W	Wet	Angle
-- -- --	Pedestrian or bicycle	S	Snowy, icy	Rear-end
	Out-of-control vehicle	--	Other	Sideswipe
▨	Fixed object	C	Clear	Right angle
✶	Property damage only	R	Rainy/foggy/cloudy	
○	Injury	S	Snow/sleet	
●	Fatality	--	Other	
□	No damage or injury	DL	Daylight	
◊	Not reported	L	Dark, lights	
(#)	Number of accidents	N	Dark, no lights	
		DU	Dusk	
		DW	Dawn	

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4. ROUTE 60 IMPROVEMENTS IN MALDEN

4.1 CORRIDOR IMPROVEMENTS

In general, we recommend installing bike and pedestrian signs and pavement markings in the Malden segment of Route 60 to inform motorists that they should share the road with bicyclists and pedestrians. The commercial activities and mass transportation services along Centre Street and Pleasant Street generate pedestrian and bicycle traffic throughout the corridor. One way to improve mobility for motorists, as well as for pedestrians and bicyclists, is for drivers to pay more attention to pedestrians and bicyclists to improve safety, and to encourage walking and bicycling. Also, police enforcement of motorists who fail to yield the right-of-way to pedestrians and bicyclists in crosswalks is another way to increase safety in the Route 60 corridor.

The following sections describe potential improvements for addressing the problems identified in chapter 3.

4.2 PLEASANT STREET AND FELLSWAY EAST

The following problems were identified:

- Traffic operations at this intersection are not satisfactory. During the AM and PM peak periods, heavy traffic volumes cause queues to form, as well as congestion to occur, on Pleasant Street (Route 60).

- The crash rate at this intersection, 1.04 cashes per million entering vehicles (MEV), exceeds MassHighway's District 4 average crash rate for signalized intersections, which is 0.88 crashes per MEV.

- Between 2004 and 2006, there were 30 crashes at this intersection, many of them rear-end and angle/sideswipe crashes. One of the crashes involved a pedestrian. About 50 percent of the crashes were rear-end collisions on Pleasant Street (see the collision diagram, Figure 4, page 20).

Figure 11 shows potential improvements for this intersection.

Retime the Traffic Signal and Upgrade Signal Hardware

Signal retiming is one of the most cost-effective ways to improve traffic flow along a corridor or through an intersection; it usually improves traffic flow by reducing stops and delay. Signal timing for a traffic signal is only effective as long as the traffic patterns used to generate the timing remain reasonably consistent. A review of traffic signal and system performance, in regular intervals, should be conducted in order to make spot changes in a systematic manner and retime signals. The strategies recommended for the optimization of this traffic signal are:

1. The addition of a protected left-turn phase to increase safety. The Pleasant Street eastbound approach has a high volume of left turns during the PM peak period. Because of the high volume of opposing traffic, the permitted-only phase for left turns provided on Pleasant Street causes the eastbound left-turn traffic to block the through traffic, resulting in a traffic queue at the intersection. A leading protected-left-turn phase is proposed for the Pleasant Street eastbound movements, followed by a permitted-only phase for left turns. This new sequence and the new phases would be expected to reduce delay and queues and increase safety at the intersection during the PM peak period.

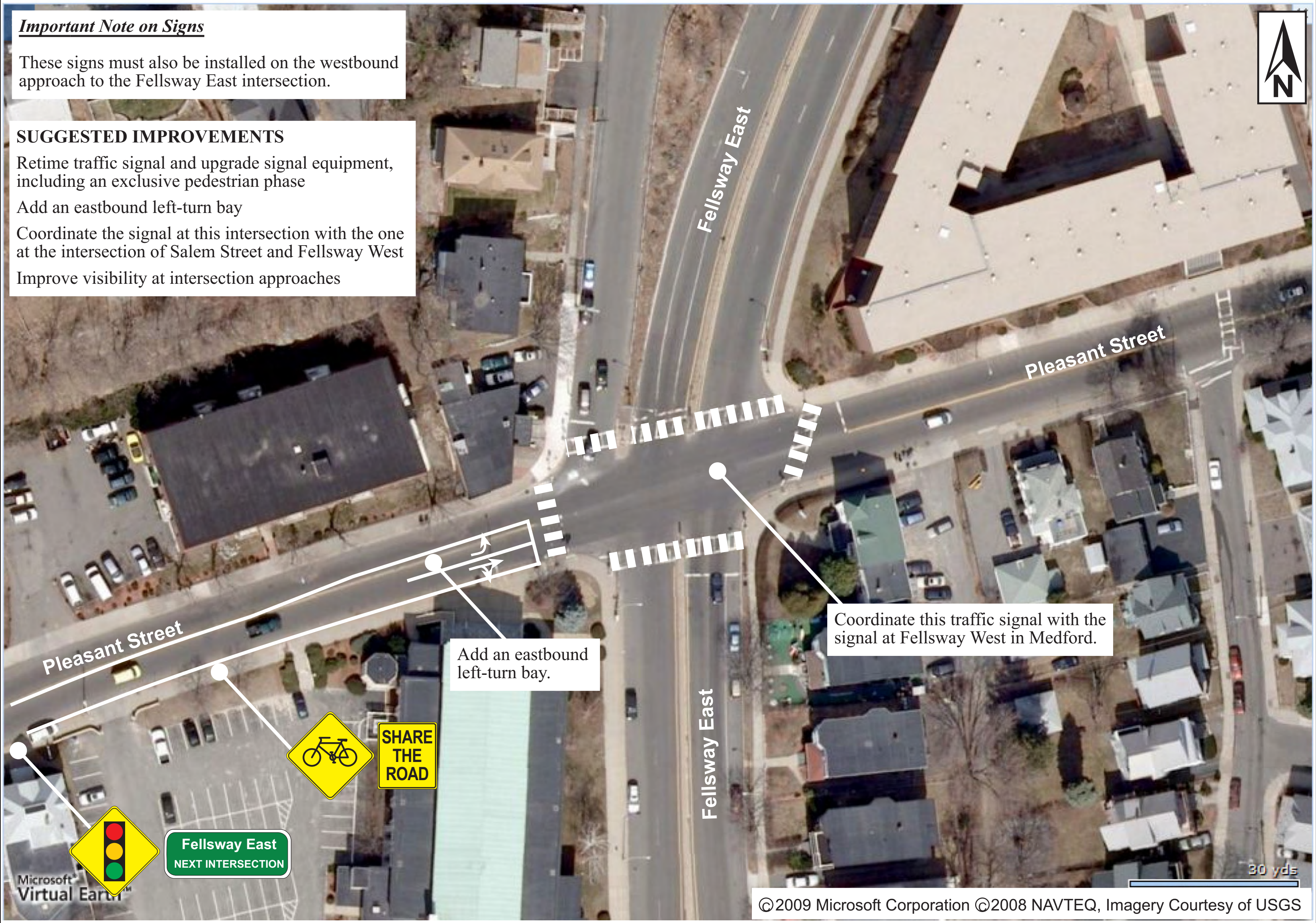

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FIGURE 11
Mobility Improvements at the Intersection of Pleasant Street and Fellsway East

Route 60 Mobility Study: Malden and Medford

2. Optimization of the signal timing for each phase to minimize delays at the intersection.

3. An exclusive pedestrian phase (no vehicular movements) for crossing at all approaches.

Finally, MPO staff recommend that the existing traffic signal control hardware be upgraded in order to accommodate enhanced signal operations.

Table 4 shows the calculated delays, levels of service, and queue lengths for the Pleasant Street and Fellsway East intersection under the optimized conditions described above. Using a four-phase actuated signal plan, the optimization does not impact the AM peak-period intersection delay, but decreases the PM peak-period delay to 34 seconds from 154 seconds. Additionally, as mentioned earlier, it is important to upgrade the existing traffic signal control hardware to accommodate enhanced signal operations at this intersection.

Add an Eastbound Left-Turn Bay

As described above, this intersection has a high volume of eastbound left-turn traffic during the PM peak period, which blocks the through traffic movement while drivers wait for a gap in opposing traffic. Geometric improvements at the Fellsway East and Pleasant Street intersection could provide both operational and safety benefits. A left-turn bay on Pleasant Street would allow separation of the left-turn and through-traffic streams, thus reducing the potential blocking of through traffic. In addition, a key strategy for minimizing collisions related to left-turning vehicles (angle, rear-end, and sideswipe) that might improve safety at this intersection would be to provide exclusive left-turn lanes.

A potential difficulty in providing an eastbound left-turn bay on Pleasant Street where one currently does not exist is the acquisition of space required for the additional lane; to avoid this difficulty, the conversion of shoulders and parking spaces may be considered. In addition, it is important to address concerns from residents or other stakeholders who are concerned about the loss of parking.

Improve Visibility of the Intersection and Approaches

D3-2

W3-3

W11-1

W16-1

W13-1

MUTCD[1]

Drivers must be able to have an adequate sight distance in the direction of travel in order to see the downstream intersection, its controls, or the back of a stopped queue with enough time to react to avoid collisions. The ability of approaching drivers to perceive an intersection immediately downstream and the visibility of control devices can be enhanced by installing or upgrading signs and pavement markings on intersection approaches. Visibility, and therefore safety, would be improved if the Massachusetts Department of Conservation and Recreation (DCR) were to install advance street name signs (type D3-2), advance traffic control signs (type W3-3), and advisory speed signs (type W13-1) here.[1] Advance street name signs and advance traffic control signs would improve awareness of this signalized intersection. In addition, installing bicycle-warning signs (type W11-1 and type W16-1) would improve safety. The improvements are shown in Figure 11.

[1] U.S, Department of Transportation, Federal Highway Administration, *Manual on Uniform Traffic Control Devices, Millennium Edition*, June 2001.

TABLE 4
Optimized Delay, Level of Service, and Queue Length
Malden Intersections*

Intersection Approach	AM Peak Period			PM Peak Period		
	Delay (sec)	LOS	Queue (veh)**	Delay (sec)	LOS	Queue (veh)**
Pleasant Street and Fellsway East						
Pleasant Street Westbound	51	D	24	20	B	17
Pleasant Street Eastbound	54	D	23	40	D	40
Fellsway East Southbound Th+ LT	51	E	14	33	C	5
Fellsway East Southbound RT	31	C	7	34	C	5
Fellsway East Northbound	26	C	4	45	D	10
Fellsway East Southbound Local	60	E	6	56	E	4
Total Intersection Delay (Existing)	47	D	n/a	154	F	n/a
Total Intersection Delay (Optimized)	48	D	n/a	34	D	n/a
Centre Street and Commercial Street						
Commercial Street Northbound	22	C	3	36	D	12
Commercial Street Southbound	36	D	10	33	C	8
Centre Street Eastbound Th+ RT	52	D	11	41	D	12
Centre Street Eastbound LT	36	D	3	55	D	8
Centre Street Westbound Th+RT	62	E	14	70	E	16
Centre Street Westbound LT	35	C	10	41	D	8
Total Intersection (Existing)	22	B	n/a	31	C	n/a
Total Intersection (Optimized)	36	D	n/a	47	D	n/a
Centre Street and Main Street						
Main Street Northbound Th+RT	13	B	3	23	C	12
Main Street Northbound LT	28	C	3	26	C	4
Main Street Southbound Th+RT	20	B	5	23	C	8
Main Street Southbound LT	18	B	2	24	C	4
Centre Street Eastbound Th+ RT	22	C	6	21	C	12
Centre Street Eastbound LT	9	A	2	14	B	8
Centre Street Westbound Th+RT	20	B	8	24	C	16
Centre Street Westbound LT	12	A	4	17	B	8
Total Intersection (Existing)	15	B	n/a	16	B	n/a
Total Intersection (Optimized)	18	B	n/a	21	C	n/a
Centre Street and Ferry Street						
Ferry Street Northbound	21	C	5	16	B	4
Ferry Street Southbound	19	B	4	15	B	4
Centre Street Eastbound Th+ RT	20	C	7	21	C	8
Centre Street Eastbound LT	28	C	2	15	B	2
Centre Street Westbound Th+RT	28	C	8	18	B	6
Centre Street Westbound LT	30	C	3	42	D	3
Total Intersection (Existing)	20	B	n/a	22	C	n/a
Total Intersection (Optimized)	23	C	n/a	17	B	n/a

* The optimized LOS, delay, and queue length reflects improvements such as signal retimimg, change in the sequence of movements, and modified change and clearance intervals.
** 95% queue length
Th = through, RT = right turn, LT = left turn, n/a = not applicable

Coordinate Signals

Staff recommend that the signal at this intersection be coordinated with the one at the intersection of Salem Street and Fellsway West in Medford to improve traffic flow on Salem Street/Pleasant Street. DCR controls both traffic signals. Coordinating these signals could help reduce the long traffic queues that form between them during peak travel periods. In addition, it would reduce the number and frequency of required stops, thereby improving safety by reducing the number of rear-end crashes at both intersections.

4.3 CENTRE STREET AND COMMERCIAL STREET

Staff identified the following problems at this intersection.

- Traffic operations at this intersection are unsatisfactory, as queues form during the PM peak period on Commercial Street.

- The Centre Street and Commercial Street intersection had the highest crash rate within the study area: 1.63 crashes per million entering vehicles (MEV), which exceeds the average crash rate of 0.88 crashes per MEV for MassHighway District 4 signalized intersections.

- Between 2004 and 2006, there were 58 crashes at the Centre Street and Commercial Street intersection; 62 percent of them were angle/sideswipe crashes (see the collision diagram, Figure 6, page 23). The majority of the angle/sideswipe crashes were caused by vehicles running red lights or making permitted, but not protected, left turns through high-volume opposing traffic. Crashes related to westbound vehicles making permitted left turns included many angle/sideswipes crashes.

- There were no pedestrian push buttons for activating the pedestrian signals. Their absence sometimes creates problems for pedestrians crossing Commercial Street, as this pedestrian phase does not turn on concurrently with the two-way through traffic on Centre Street. Two of the crashes at this intersection involved pedestrians and one a bicyclist.

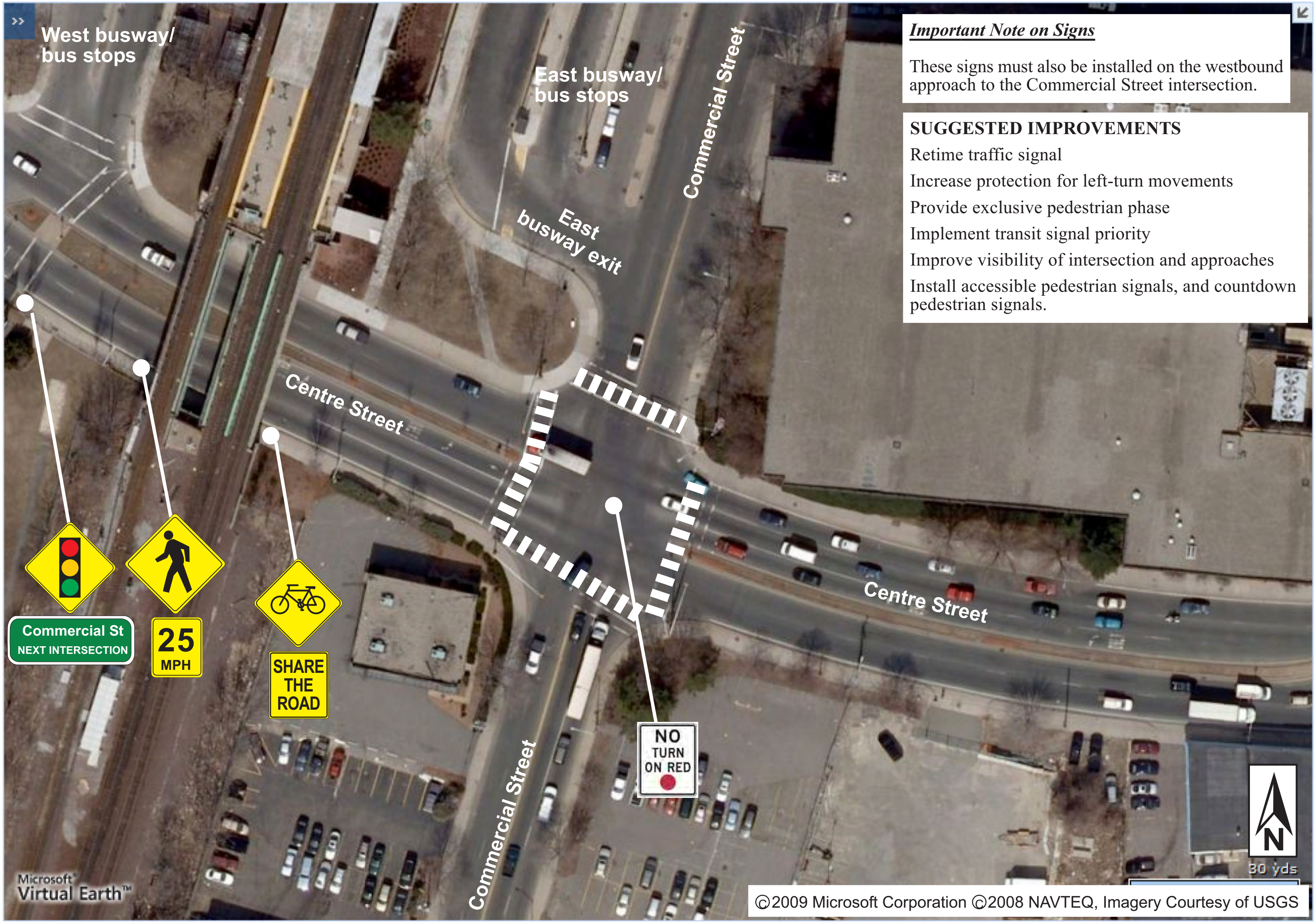
- During congested periods, buses exiting the east busway to Commercial Street southbound, then to Centre Street, sometimes have difficulty finding a gap in traffic. Sometimes only a single bus exits per cycle. In addition, because the MBTA busway exit on Commercial Street is located close to the intersection (about 60 feet away), it is frequently blocked by a traffic queue on the southbound approach.

Staff identified the following safety and operations improvements for this intersection (also see Figure 12).

Retime the Traffic Signal and Increase Protection for Left-Turning Vehicles

The objective of this signal retiming is to optimally respond to traffic and pedestrian demands at the Centre Street and Commercial Street intersection. The improvements included in the signal retiming are as follows:

1. An additional protected phase to accommodate left-turn demands on Centre Street during the peak periods. Instead of the current permitted-only phase for left turns, a leading protected phase is proposed for Centre Street eastbound and westbound left turns, after which a permitted-only phase would be allowed. A leading protected-left-turn phase is also recommended for Commercial Street southbound movements. The resulting phase sequence is as shown below.



CTPS

FIGURE 12
Mobility Improvements at the Intersection of Centre Street and Commercial Street

Route 60 Mobility Study: Malden and Medford

Proposed Phase Sequence at Centre Street and Commercial Street

2. Optimize timing to minimize delays and queues at the intersection, which would include new timing for the existing phase intervals, as well as the additional phases proposed for this intersection. This strategy would help to reduce delays for both pedestrians and drivers and also target crashes related to clearance interval lengths that are too short for this particular intersection. Such crashes include angle crashes between vehicles continuing through the intersection after one phase has ended and the vehicles entering the intersection on the following phase (running red lights).

3. An exclusive pedestrian phase, which allows pedestrians to cross at all approaches of an intersection at the same time while all vehicular movements have stopped (described in the following section).

4. Upgrade existing traffic signal control hardware and accommodate enhanced signal operations as technology continues to change in the traffic control field.

Because of the high volume of opposing traffic on Centre and Commercial streets, the current permitted-only phase for left turns does not offer enough gaps for a sufficient number of left-turning vehicles to get through the intersection. Motorists turning left sometimes misjudge the gaps in opposing traffic, resulting in angle and sideswipe collisions. The suggested improvements are expected to increase safety at this intersection because of the additional protection afforded pedestrians and left-turning motorists. However, this increased safety would be at the expense of increased delay at the intersection.

Implement Transit Signal Priority at the Intersection

The goal of implementing a transit signal priority at this intersection is to reduce delay for buses trying to exit the east busway to Commercial Street southbound to proceed to Centre Street eastbound. Buses sometimes have difficulty finding a gap in traffic during peak travel periods and sometimes only a single bus exits per cycle. Implementing a transit signal priority at this intersection would require a signal system upgrade to enable it to handle a request from buses, and buses would need to be equipped with the technology for submitting requests. For the transit signal priority to operate efficiently, the east busway exit might have to be signalized and tied to the main signal at the intersection of Centre Street and Commercial Street, or some form of signage might have to be installed at the east busway exit, to prevent Commercial Street southbound vehicles from blocking the busway exit when a bus request is submitted.

Provide an Exclusive Pedestrian Phase

Ideally, pedestrian phases and exclusive-timing schemes are most appropriate at signalized intersections with large pedestrian volumes (1,200 or more per day) or with multiphase signals (left-turn arrows and split phases), such as the intersection of Centre Street and Commercial Street, which serves a significant number of pedestrians accessing the Malden Transportation Center and Malden municipal offices. With an exclusive pedestrian phase, all vehicular traffic is stopped, and the “WALK” signal is displayed for all crosswalks at the same time. The effectiveness of an exclusive pedestrian phase can be enhanced with signs such as “NO TURN ON RED.” Providing an exclusive pedestrian phase would improve safety, but it would also increase delay at the intersection.

Table 4 (page 34) shows the results of making these improvements (signal retiming, increasing protection for left turns, and providing an exclusive pedestrian phase); these proposed changes for improving safety would increase the intersection control delay to 43 seconds from 22 seconds (to LOS D from LOS B) during the AM peak period, and to 45 seconds from 31 seconds (to LOS D from LOS C) during the PM peak period.

Accessible Pedestrian Signals (APS)

NCHRP, Report 500, Vol. 10

Accessible pedestrian signal

Install accessible pedestrian signals at the intersection of Centre Street and Commercial Street to serve pedestrians with disabilities. This busy intersection is one of the main access points for the Malden Transportation Center, and it used by pedestrians, including people with disabilities, to get to and from the Center. At signalized intersections, pedestrians who are blind or visually impaired typically start to cross the street when they hear a surge of traffic parallel to their direction of travel. Some intersection geometries and traffic conditions make it very difficult for visually impaired persons to know when to cross. These conditions include wide intersections, intersections with split-phase signal timing, and intersections with pedestrian push buttons, such as the Centre Street and Commercial Street intersection. Visually impaired pedestrians may not realize that they have to push a button, or they may have trouble finding the button. Accessible pedestrian signals (APS), which operate concurrently with visual pedestrian signals, provide audible and/or vibrotactile information to inform visually impaired pedestrians precisely when the “WALK” interval begins and when it is no longer safe to cross. Audible signals also provide directional guidance, which is particularly useful at multilane crossings. Audible signals actuated by push buttons are the most commonly used type of APS, and they often emit a chirping or “cuckoo” tone during the “WALK” interval.

Countdown Pedestrian Signal

NCHRP, Report 500, Vol. 10

Countdown pedestrian signal

A variety of traffic and pedestrian signal enhancements can benefit pedestrians; these include larger pedestrian signal heads to improve visibility and pedestrian countdown signals. A countdown signal contains a timer display and counts down the number of seconds left to finish crossing the street. Countdown signals begin counting down when the flashing “DON’T WALK” signal appears and stop when the nonflashing “DON’T WALK” signal comes on. Countdown signals inform pedestrians who are considering entering the crosswalk when the flashing “DON’T WALK” signal is on whether or not they still have time to finish crossing.

Recent studies on countdown signals have shown that a larger proportion of pedestrians are completing their crossing during the flashing “DON’T WALK” interval using countdown signals than at walk signals without countdown signals.[2,3] This result may be

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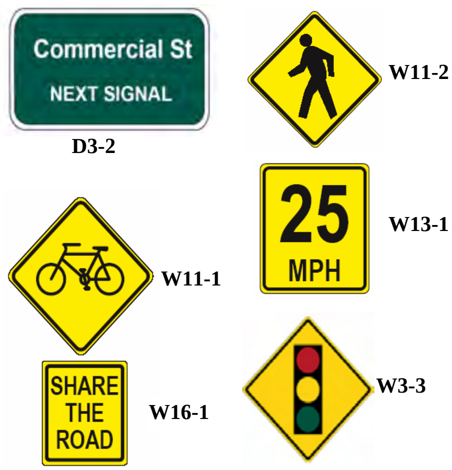
[2] Jan L. Botha and Ron L. Northouse, *Pedestrian Countdown Signals Study in the City of San Jose,* Final Report, submitted to the California Traffic Control Devices Committee, May 2002.

[3] Jeremiah P. Singer and Neil D. Lerner, *Countdown Pedestrian Signals: A Comparison of Alternative Pedestrian Change Interval Displays,* Final Report, submitted to Federal Highway Administration, March 2005.

construed as positive, since it would seem that more pedestrians get out of the crosswalk before the nonflashing “DON’T WALK” signal comes on when there is a countdown signal. Thus, pedestrians are using the additional information provided by the countdown signal to complete their crossing in the time provided. Completing a crossing before the nonflashing “DON’T WALK” signal comes on reduces the chances of pedestrians encountering conflicting vehicle movements.

Improve the Visibility of the Intersection and Approaches



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Driver awareness of both downstream intersections and traffic control devices is critical for driver and pedestrian safety at intersections. The ability of approaching drivers to perceive the Centre Street and Commercial Street intersection immediately downstream and the visibility of the signals and other control devices would be enhanced by installing or upgrading signs and pavement markings on the approaches to this intersection. Staff recommend the use of advisory speed signs (type W13-3) in combination with advance traffic control signs (type W3-3) and pedestrian warning signs (type W11-2) to alert drivers to the presence of an intersection and pedestrians crossing, as the horizontal curve in the roadway and the MBTA commuter rail bridge reduce visibility of the intersection. In addition, installing bicycle-warning signs (type W11-1 and type W16-1) would improve safety, and street name signs (type D3-2) in advance of the intersection would prepare drivers for choosing and moving into the lane they will need to use for their desired maneuver.

4.4 CENTRE STREET AND MAIN STREET

Staff identified the following problems at this intersection.

- Traffic operations at this intersection are not satisfactory; there are queues that spill into the intersection during the PM peak periods.
- The concurrent pedestrian phase, in which the “WALK” signal is displayed at the same time as the green signal for parallel vehicular traffic, creates conflicts between vehicles and pedestrians.
- This intersection had a crash rate of 1.29 crashes per million entering vehicles (MEV), which exceeds the average crash rate for MassHighway District 4 signalized intersections, 0.88 crashes per MEV. There were 45 crashes, many of which were angle/sideswipe crashes (30 crashes) caused by vehicles running red lights or making permitted left turns through high-volume opposing traffic.
- Crashes involving westbound traffic to make permitted left turns crossing opposing eastbound through traffic was the predominant pattern, a pattern similar to the one observed at the Centre Street and Commercial Street intersection.

Staff recommended the following improvements to address safety and operations problems at this intersection. They are similar to those developed for the intersection of Centre Street and Commercial Street (Figure 13).

Retime the Traffic Signal and Increase Protected Left Turns

The objectives of the proposed signal retiming are to optimally respond to traffic and pedestrian demands at the intersection and to improve safety. The following improvements were included in the retiming:

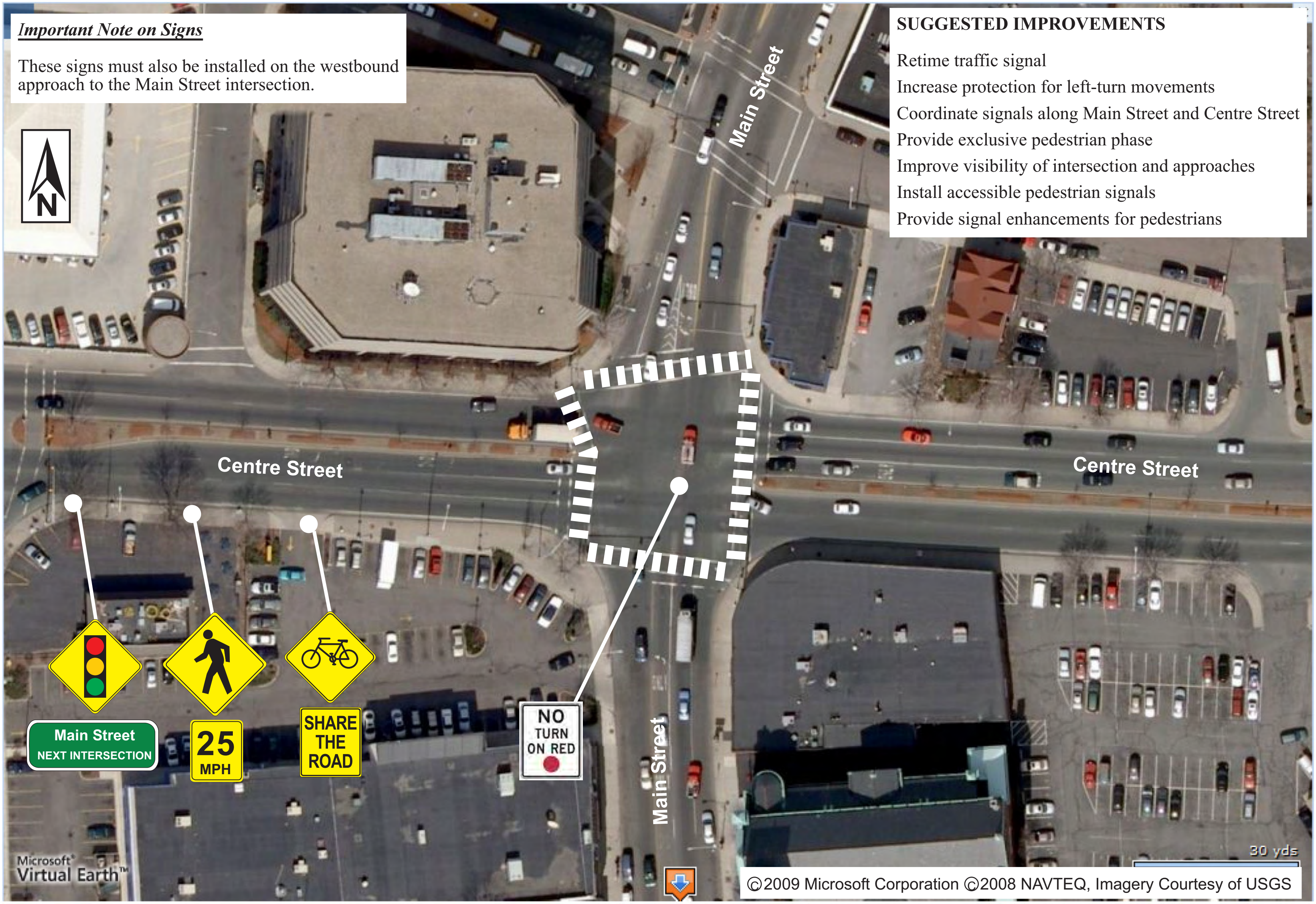

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FIGURE 13
Mobility Improvements at the Intersection of Centre Street and Main Street

Route 60 Mobility Study: Malden and Medford

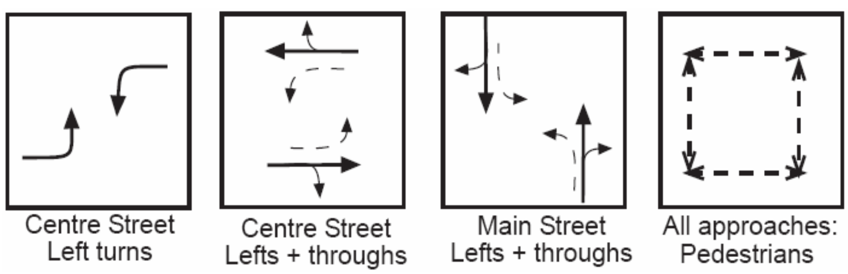
1. Add a protected-left-turn phase to accommodate left-turn demands on Centre Street during the peak periods. Instead of the current permitted-only phase for the Centre Street westbound approach, a dual leading protected left-turn phase is proposed for both westbound and eastbound Centre Street left turns after which a permitted-only phase would be allowed.

2. Optimize the signal timing to minimize delays and queues at the intersection. This would include new timing for the existing phase interval and the additional phases proposed for this intersection. The purpose of this strategy is to reduce delays for both pedestrians and drivers. Signal optimization also takes into account the clearance interval lengths that are too short for a particular intersection. Short clearance intervals can result in angle crashes between vehicles continuing through the intersection after one phase has ended and the vehicles entering the intersection on the following phase (running red lights).

3. Implement an exclusive pedestrian phase for crossing at all approaches at the same time when all vehicular movements are stopped at the intersection.

4. Upgrade existing traffic signal control hardware to accommodate enhanced signal operations as technology continues to change in the traffic control field.

One reason for the high crash rate at this intersection is that the high volume of opposing traffic on Centre Street does not offer enough gaps to allow sufficient permitted-only left-turn movements during peak periods. Motorists traveling westbound on Centre Street turning left sometimes misjudge gaps in the opposing traffic, resulting in angle/sideswipe collisions. The proposed dual leading protected left-turn phase for Centre Street, shown below, is expected to increase safety. It is important to upgrade existing traffic signal control hardware to accommodate enhanced signal operations. Pedestrian push buttons are also recommended, as they would facilitate crossing at this intersection.



Proposed Phase Sequence at Centre Street and Main Street

Coordinate the Traffic Signals along Main Street and Centre Street

Coordinating the signals along Centre Street and along Main Street could improve traffic flow, as well as increase safety, on both arterials. One of the problems at this intersection is that the northbound traffic queue that forms on Main Street north of this intersection extends southward into this intersection during peak periods, affecting traffic operations. Coordinated signals would produce platoons of vehicles that could proceed with minimal stopping at multiple signalized intersections on Main Street, preventing traffic queues from building up. Reducing the number and frequency of stops would improve safety by reducing the number of rear-end crashes.

Provide an Exclusive Pedestrian Signal Phase

The existing pedestrian signal has the standard concurrent timing, in which the “WALK” signal is displayed at the same time as the green signal for parallel vehicular traffic. Under this timing scheme, right- and left-turning motor vehicles may conflict with pedestrians crossing on the “WALK” signal. To improve safety for pedestrians and bicyclists, staff recommend an exclusive pedestrian phase at this intersection. The exclusive pedestrian phase could be supplemented with “NO TURN ON RED” signs at all of the approaches. While an exclusive pedestrian phase would improve safety at this intersection, it would also increase delays slightly.

Table 4 (page 34) shows the results of making these improvements (signal retiming, providing a dual leading protected left-turn phase, coordinating traffic signals, and providing an exclusive pedestrian phase); these proposed changes for improving safety would increase the intersection control delay slightly, to 18 seconds from 15 seconds (it would remain at LOS B), during the AM peak period, and to 21 seconds from 16 seconds (to LOS C from LOS B) during the PM peak period.

Accessible Pedestrian Signals (APS)

The multiphase traffic signal at this intersection makes it very difficult for visually impaired persons to know when to cross. Providing APS, with audible and/or vibrotactile information that operates concurrently with visual pedestrian signals, would inform visually impaired pedestrians precisely when the “WALK” interval begins and when it is no longer safe to cross. Audible tones may be used in conjunction with the vibrotactile buttons to let the pedestrian know that a button must be pushed, where the button is located, and when the “WALK” signal appears.

Signal and Sign Enhancements for Pedestrians and Bicyclists

A variety of traffic and pedestrian signal enhancements would benefit pedestrians at the intersection of Centre Street and Main Street, so staff recommend that the City of Malden explore these enhancements, such as countdown pedestrian signals. With countdown pedestrian signals, more pedestrians get out of the crosswalk before the nonflashing “DON’T WALK” signal appears than when there is no countdown signal, reducing the chances of pedestrians being confronted with conflicting vehicle movements. In addition, the ability of approaching drivers to perceive the Centre Street and Main Street intersection immediately downstream and the visibility of the signals and other control devices would be enhanced by installing or upgrading signs on the approaches to this intersection (Figure 13, page 40).

4.5 CENTRE STREET AND FERRY STREET

Staff identified the following problems at this intersection.

- Traffic operations at this intersection are satisfactory, except for a minor traffic queue created on Ferry Street southbound at the Eastern Avenue and Ferry Street intersection that occasionally extends into this intersection.

- The concurrent pedestrian phase, in which the “WALK” signal is displayed at the same time as the green signal for parallel vehicular traffic, causes conflicts between vehicles and pedestrians in the crosswalks.

- This intersection had a crash rate of 0.97 crashes per million entering vehicles (MEV), which exceeds the average crash rate for MassHighway District 4 signalized intersections, 0.88 crashes per MEV. There were 31 crashes at this intersection between 2004 and 2006, 67 percent of which were angle/sideswipe crashes.

- Unlike the intersection of Centre Street and Commercial Street and the intersection of Centre Street and Main Street, where the majority of angle/sideswipe crashes were associated with left turns from Centre Street westbound, no patterns were detected at the Centre Street and Ferry Street intersection.

Staff recommend the following safety and operations improvements at this intersection (Figure 14).

Provide an Exclusive Pedestrian Phase

The pedestrian signal timing at this intersection is the standard concurrent timing, in which the “WALK” signal is displayed at the same time as the green signal for parallel vehicular traffic. Under this timing scheme, right- and left-turning motor vehicles conflict with pedestrians crossing on the “WALK” signal, and many turning motorists do not yield to pedestrians. To compound this problem, students of the nearby Malden High School and Cheverus School use this intersection on their way to and from school.

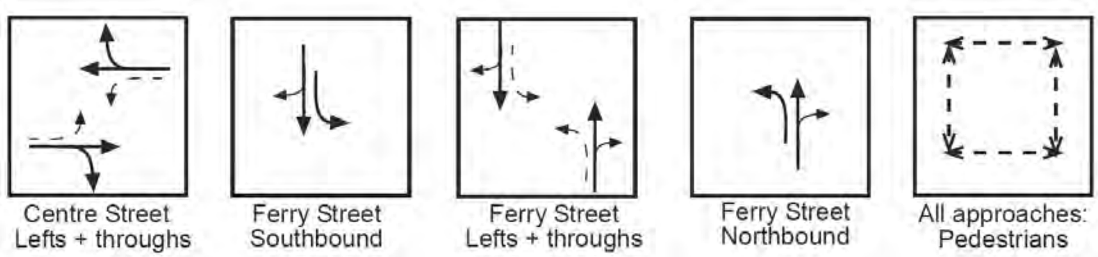
To improve safety for students of the nearby schools and other pedestrians, it is proposed that an exclusive pedestrian phase be included in the signal plan for this intersection. An exclusive pedestrian phase would reduce conflicts, as vehicular movements are stopped when pedestrians are crossing. The exclusive pedestrian phase could be supplemented with “NO TURN ON RED” signs to be more effective. While an exclusive pedestrian phase would improve safety at this intersection, it would also increase delay slightly.

Retime the Traffic Signal

The objectives of retiming at this intersection are to optimally respond to traffic and pedestrian demands at the intersection, as well as improve safety by increasing the clearance intervals (yellow and all-red intervals). The collision diagram shows that many of the crashes at the Ferry Street intersection are the right-angle type of collision involving a vehicle from Centre Street and a vehicle from Ferry Street. Such crashes are the result of vehicles running red lights, an inadequate clearance interval, or driver inattentiveness. Increasing the yellow and all-red intervals sometimes improves safety where the existing clearance intervals do not allow drivers adequate time to react to the reassignment of right-of-way. According to the procedures recommended by the Institute of Transportation Engineers, a four-second yellow interval and a two-second all-red interval would be appropriate.

Increase Protection for Ferry Street Southbound Left-Turning Vehicles

Some form of protection for Ferry Street southbound left-turn maneuvers could increase safety at this intersection. This option would involve replacing the current permitted-only phase for left turns for the Ferry Street southbound approach with a lead-lag protected left-turn phase. Under a lead-lag phase, one approach of Ferry Street would be protected at the beginning of the green phase and left turns from the opposing approach would be protected at the end. A lead-lag phase would allow some protection for left-turning vehicles from both approaches of Ferry Street, and would therefore improve safety. This improvement would be expected to increase safety with a minimal increase in delay.



Proposed Phase Sequence at Centre Street and Ferry Street

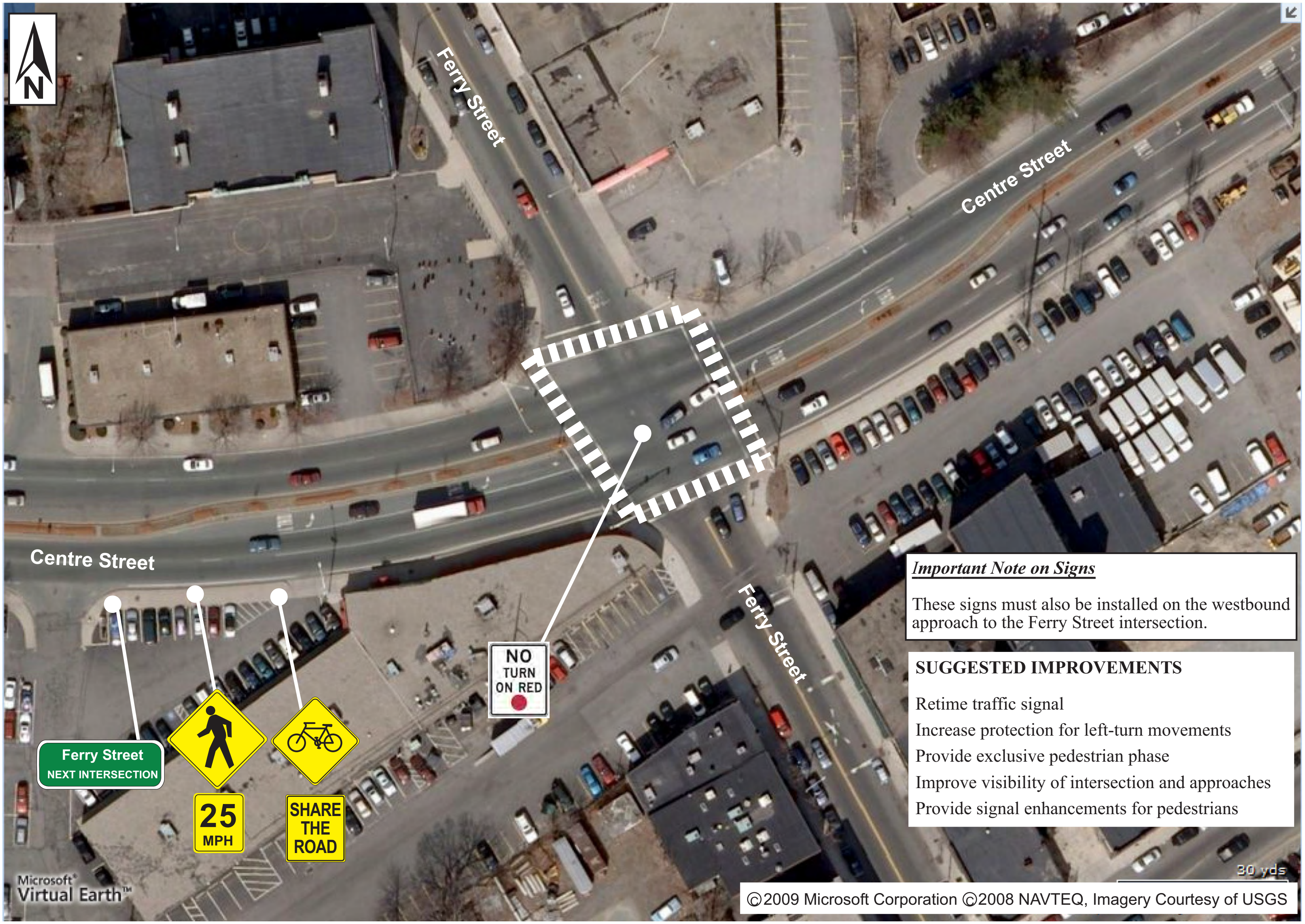


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FIGURE 14
Mobility Improvements at the Intersection of Centre Street and Ferry Street

Route 60 Mobility Study: Malden and Medford

Table 4 (page 34)shows the results of making these improvements (an exclusive pedestrian phase, signal retiming, and increasing protection for Ferry Street southbound left turns). These proposed changes for improving safety would increase the AM peak-hour intersection delay to 24 seconds from 20 seconds (to LOS C from LOS B), and would decrease the PM peak-hour delay to 17 seconds from 22 seconds (to LOS B from LOS C).

Signal and Sign Enhancements for Pedestrians and Bicyclists

A variety of traffic and pedestrian signal enhancements could benefit pedestrians and bicyclists at this intersection. Among the enhancements that are recommended are larger traffic signal heads; installing or upgrading signs on the approaches to this intersection to improve visibility; countdown pedestrian signals; and accessible pedestrian signals on the approaches to the intersection (Figure 14, previous page).

4.6 SUMMARY OF RECOMMENDED IMPROVEMENTS

This study has identified several improvements to address the issues of mobility and safety in the Route 60 corridor for motorists, pedestrians, bicyclists, and transit users. Table 5 summarizes the potential benefits of the various improvements and the estimated cost. All of the improvements are short-term or intermediate-term and could be implemented within 5 to 10 years. There are several agencies that operate transportation facilities in the corridor, including the Massachusetts Highway Department, the Massachusetts Bay Transportation Authority, and the Massachusetts Department of Conservation and Recreation, in addition to the City of Malden. Successful implementation of the projects advancing from this study is dependent on coordination among the stakeholders, sufficient public participation, and securing funding for the projects.

TABLE 5
Summary of Improvements along Route 60 in Malden

Intersection	Improvement	Expected Benefits	Cost	Implementing Agency
Pleasant Street and Fellsway East	Add an eastbound left-turn bay.	Reduce the blocking of through traffic. Minimize collisions related to left-turning vehicles (angle, rear-end, sideswipe).	$100,000	Department of Conservation and Recreation
	Improve visibility of intersection and approaches with installation of advance street name, advance traffic control, and bicycle-warning signs.	Improve awareness of the signalized intersection and safety.		
	Retime traffic signal and upgrade hardware.	Improve safety and facilitate traffic flow at the intersection.		
	Employ signal coordination at Fellsway West and Fellsway East intersections.	Improve traffic flow by reducing stops, and increase safety by reducing rear-end collisions.		
Centre Street and Commercial Street	Retime traffic signal and coordinate this signal with others on Centre Street. Increase protection for left-turning vehicles.	Improve safety as a result of the additional protection given to left-turning vehicles. Prevent traffic queues from building up.	$150,000	MBTA/City of Malden
	Provide exclusive pedestrian phase with push buttons and "NO TURN ON RED" signs on all approaches. Paint the crosswalks with ladder-style stripes.	Improve safety for pedestrians. Reduce vehicle-pedestrian conflicts.		
	Install countdown and accessible pedestrian signals.	Increase pedestrian safety by giving useful information to pedestrians on how long they have to complete a crossing.		
	Improve visibility of intersection and approaches.	Call attention to presence of intersection and traffic control.		
	Implement transit signal priority at the intersection	Reduce waiting times for buses trying to exit the east busway during congested periods		
Centre Street and Main Street	Retime traffic signal and coordinate this signal with others on Centre Street. Increase protection for left-turning vehicles.	Improve safety as a result of the additional protection given to pedestrians and left-turning vehicles. Prevent traffic queues from building up.	$50,000	City of Malden
	Provide exclusive pedestrian phase with push buttons and "NO TURN ON RED" signs on all approaches. Paint the crosswalks with ladder-style stripes.	Improve safety for pedestrians. Reduce vehicle-pedestrian conflicts.		
	Provide signal enhancement for pedestrians such as countdown pedestrian signals and accessible pedestrian signals.	Improve pedestrian safety by giving useful information to pedestrians on how long they have to complete a crossing.		
Centre Street and Ferry Street	Retime traffic signal and coordinate this signal with others on Centre Street to reduce delay.	Improve safety and prevent traffic queues from building up.	$50,000	City of Medford
	Provide exclusive pedestrian phase and supplement phase with "NO TURN ON RED" sign. Paint the crosswalks with ladder-style stripes.	Improve safety at intersection for students of the nearby schools and other pedestrians. Reduce vehicle-pedestrian conflicts.		
	Increase protection for Ferry Street southbound left-turning vehicles.	Improve safety by reducing crashes related to left turns.		
	Install countdown and accessible pedestrian signals.	Increase pedestrian safety by giving useful information to pedestrians on how long they have to complete a crossing.		

5. PROBLEMS AT STUDY LOCATIONS IN MEDFORD

5.1 SALEM STREET (ROUTE 60) AND THE I-93 ROTARY INTERCHANGE[4]

The juncture of Salem Street (Route 60) and the Interstate 93 ramps is a busy rotary interchange located in a residential area close to Medford City Hall and Medford Square. Figure 15 shows the geometric configuration of the interchange and the intersection of Salem Street and Hadley Place. This interchange serves as the main access point to Medford from I-93 and from Route 60 east. All of the approaches at the rotary interchange have a single entry lane with a posted speed limit of 25 mph and are controlled by yield signs. Medford officials have complained about pedestrian safety at this interchange. In 2006 there was a pedestrian fatality at the southbound I-93 on-ramp of this rotary interchange.

Pedestrian and Bicycle Operations and Problems

There are four pedestrian crossings at the interchange, all of which are located on the ramps to and from I-93. The crosswalks are all marked with simple, parallel white stripes (ladder type), sufficiently visible to pedestrians and motorists. Each crosswalk has a pedestrian warning sign that alerts motorists to look for pedestrians crossing. Pedestrians cross the street by looking for sufficient gaps in traffic or for motorists stopping to yield to pedestrians. The pedestrian-crossing activity for the AM and PM peak periods is shown in green in Figure 15; on the day of observation, there were 96 pedestrians who crossed at the intersection during the AM peak period (7:00–9:00 AM) and 100 pedestrians during the PM peak period (4:00–6:00 PM), demonstrating moderate pedestrian activity. Field observations show that pedestrians at the interchange used the crosswalks and sidewalks most of the time, and motorists who were making turns were observed to be yielding to pedestrians in the crosswalks. Curb cuts and wheelchair ramps are provided at the crosswalks, and the street furniture, such as streetlights, does not reduce the width of the sidewalks in this area to less than five feet. On-street parking is not allowed in the vicinity of this rotary interchange and therefore does not pose problems for bicyclists. One of the crashes at the Hadley Place intersection involved a pedestrian.

The following pedestrian and bicyclist problems were observed at the site:

- Because of the high volume of traffic at the interchange, crossing is particularly difficult for pedestrians and bicyclists during peak periods of travel.
- The sidewalks connecting the crosswalks (see Figure 15) at the south side of the interchange are not clearly defined and can be confusing to navigate.
- The sidewalks are about six feet wide, made of concrete, and are in fair condition, but are dirty and weedy in some sections, especially under the I-93 bridge.
- Sections of the sidewalks under the I-93 bridge lack security lights.
- The circular roadway is not wide enough for a separate bike lane. Presently, bicycles either share the travel lane with automobiles or share the sidewalks with pedestrians.

[4] Includes the intersection of Salem Street and Hadley Place.

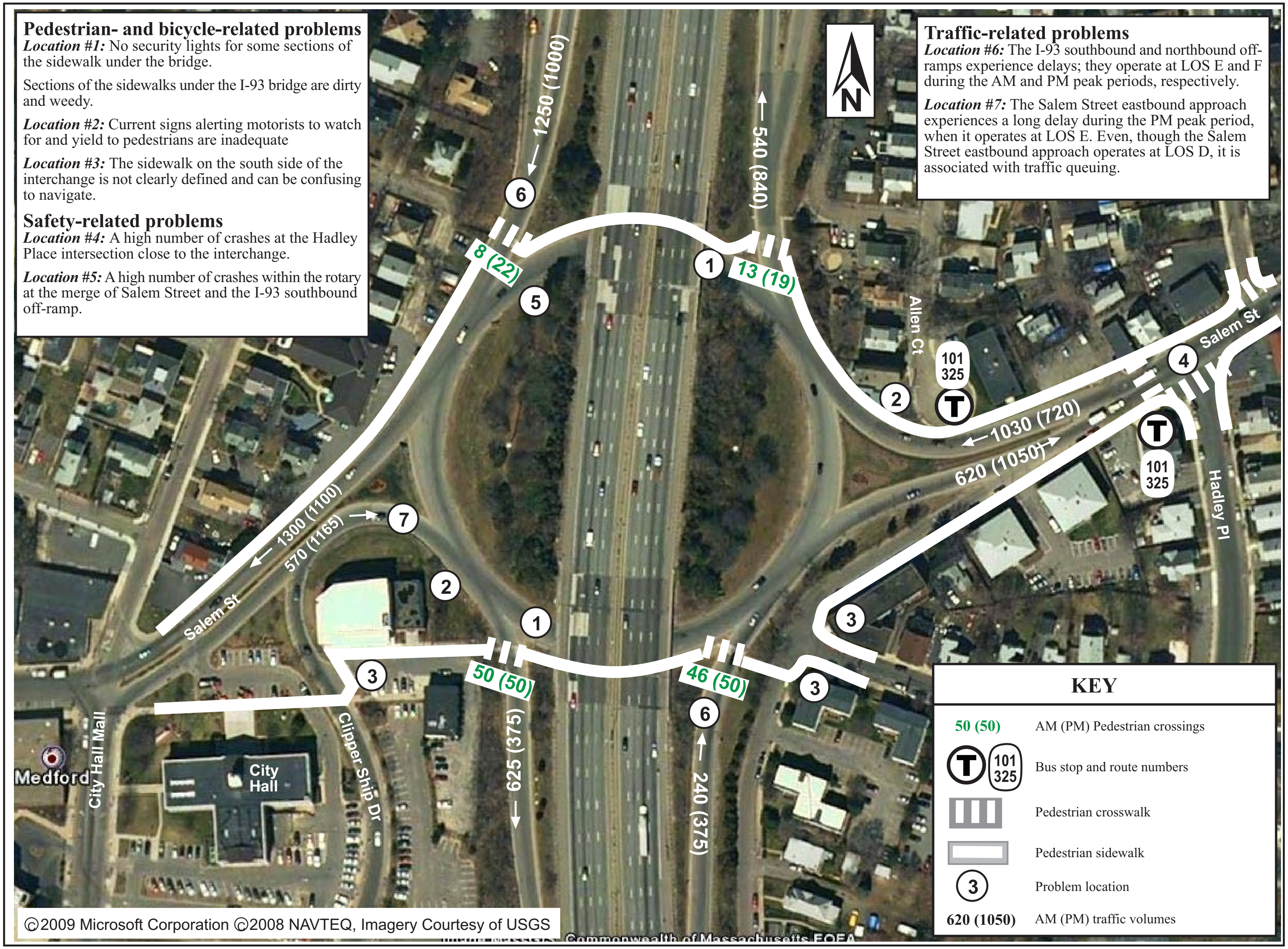

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FIGURE 15
Mobility Problems at the Salem Street (Route 60) and I-93 Rotary Interchange

Route 60 Mobility Study: Malden and Medford

Traffic Safety and Operations

Table 6 shows the delay, level of service, and amount of queuing at the interchange. During the AM peak period, the I-93 southbound off-ramp to the rotary operates at an unacceptable LOS F. High off-ramp traffic volumes, coupled with a traffic queue created at the City Hall Mall intersection, which extends eastward on Salem Street into the rotary interchange, contribute to the poor level of service at the off-ramp. In the PM peak period, traffic at the eastbound approach of the rotary and on the I-93 northbound off-ramp operates at LOS E or F.

No collision diagrams were prepared for the intersections selected for study in Medford. MPO staff were unsuccessful in obtaining crash reports from the Medford Police Department. Collision diagrams help display and identify crash patterns, and they are used to evaluate specific sites for possible causes of crashes. On the other hand, Table 7 shows the crash rates for the rotary interchange. Shading denotes intersections with higher crash rates than the MassHighway District 4 averages for unsignalized and signalized intersections. [5]

TABLE 6
Delay, Level of Service, and Queue Length
Medford Intersections

Intersection Approach	AM Peak Period			PM Peak Period		
	Delay (sec)	LOS	Queue (veh.)*	Delay (sec)	LOS	Queue (veh.) *
Salem Street (Route 60) and I-93 Rotary						
Salem Street Westbound	3	A	6	52	D	14
Salem Street Eastbound	6	A	6	59	E	16
I-93 Northbound Exit Ramp	6	A	3	54	E	11
I-93 Southbound Exit Ramp	105	F	+30	38	D	11
Salem Street, Park Street, and Court Street						
Salem Street Westbound	28	C	25	11	B	20
Salem Street Eastbound	6	A	8	11	B	18
Park Street Northbound	19	B	2	18	B	1
Park Street Southbound	24	C	1	23	C	4
Salem Street Eastbound (Court Street)	2	A	2	2	A	2
Salem Street and Spring Street						
Spring Street Northbound	50	E	5	No PM peak-period data were collected.		
Spring Street Southbound	17	C	2			
Salem Street Eastbound	2	A	1			
Salem Street Westbound	2	A	1			
Salem Street at Fellsway West						
Salem Street Westbound	>180	F	45	52	F	34
Salem Street Eastbound	43	D	19	108	F	31
Fellsway West Southbound Th + RT	30	C	15	26	C	11
Fellsway West Southbound LT	48	D	14	77	E	18
Fellsway West Northbound Th + RT	36	D	18	52	D	10
Fellsway West Northbound LT	47	D	11	51	D	24

* 95% queue length
Th = through, RT = right turn, LT = left turn

[5] Note that MassHighway does not calculate crash rates for interchanges. In this case, MPO staff calculated a rate for the rotary interchange as if it were an unsignalized intersection and compared it the District 4 average for unsignalized intersections.

TABLE 7
Crash Rates for Medford Intersections

Intersection	Number of Crashes		Average Daily Traffic	Crash Rate*
	3-Year Total	Annual Average		
Route 60 and I-93 Rotary Interchange	22	7.33	36,122	0.56
Salem Street and Hadley Place	17	5.67	21,889	0.71
Salem Street and Park Street	22	7.33	16,667	1.20
Salem Street and Spring Street	21	7.00	14,398	1.33
Salem Street and Fellsway West	32	10.67	26,333	1.11
MassHighway District 4 Average Crash Rate for Signalized Intersections				0.88
MassHighway District 4 Average Crash Rate for Unsignalized Intersections				0.63

* Crashes per million entering vehicles

The crash rate of 0.56 crashes per million entering vehicles (MEV) at the rotary interchange is lower than the 0.63 crashes per MEV average for a MassHighway District 4 unsignalized intersection. Table 7 presents the frequency and characteristics of the crashes at the same locations. Between 2004 and 2006, there were 22 crashes at the interchange. One of the crashes at the interchange involved a pedestrian fatality; the rest were injury and property-damage-only crashes. The majority of the crashes were rear-end crashes that occurred on dry pavement and under daylight conditions. Many of the crashes at the rotary were clustered at an area near the merge of Salem Street and the I-93 southbound off-ramp, an area with frequent AM peak-period traffic queues that extend from the City Hall Mall intersection.

On the east side of the interchange, close to the westbound approach on Salem Street, is the Hadley Place intersection. This intersection had 17 crashes over the three-year period (Tables 7 and 8). The crash rate of 0.71 crashes per million entering vehicles (MEV) at the intersection of Hadley Place is higher than the 0.63 crashes per MEV for MassHighway District 4 unsignalized intersections. One of the crashes at the Hadley Place intersection involved a pedestrian. Its close proximity to the interchange, high traffic volumes on Salem Street, peak-period traffic queues on Salem Street, parking, and sight distance problems are some of the factors contributing to the unusually high number of crashes at the Hadley Place intersection.

5.2 SALEM STREET (ROUTE 60) AND PARK STREET

The intersection of Salem Street and Park Street is a four-legged signalized intersection controlled by an actuated traffic signal. It is located in an area with mixed land use: retail stores, a school, and residences. Figure 16 shows the intersection's geometry and lane configuration. The signals are mast-mounted, which is good, and the heads are in good condition, placed appropriately to provide good visibility for motorists. In the vicinity of this intersection, the roadway surface is in good condition, as is the granite curbing. On-street parking is allowed on Salem Street in the vicinity of the intersection for commercial activities, and on Park Street for residential and school activities. A "DO NOT ENTER, 8:10–8:40 AM" sign is posted at the entrance to Park Street north of the intersection because of school activities. In addition, a "BICYCLE STOP ON LINE FOR GREEN" sign is posted at each approach on Park Street to improve safety for students who bike to school. This bicycle sign also benefits pedestrians walking in the crosswalk by reducing pedestrian and bicycle conflicts. The Park Street intersection serves many students, who cross there before and after school in the morning and afternoon.

TABLE 8
Crash Characteristics and Frequency
2004–2006, Medford Intersections

	Salem Street Rotary	Salem Street and Hadley Place	Salem Street and Park Street	Salem Street and Spring Street	Salem Street and Fellsway West
	Number of Crashes	Number of Crashes	Number of Crashes	Number of Crashes	Number of Crashes
Crash Severity					
Fatality	1	0	0	0	0
Injury	9	3	4	5	8
Property damage only	7	8	6	9	17
Not reported	5	6	12	7	6
Unknown	0	0	0	0	1
Total	*22*	*17*	*22*	*21*	*32*
Collision Type					
Rear-end	13	4	9	6	10
Angle/sideswipe	3	4	10	10	20
Head-on	1	0	0	0	0
Single-vehicle crash	1	2	1	1	0
Not reported	4	7	2	3	2
Unknown	0	0	0	1	0
Total	*22*	*17*	*22*	*21*	*32*
Roadway Condition					
Dry	16	10	12	11	24
Wet	2	1	8	8	5
Snow	1	0	0	0	1
Not reported	2	6	2	2	2
Other	1	0	0	0	0
Total	*22*	*17*	*22*	*21*	*32*
Light Condition					
Daylight	10	8	9	11	24
Dawn	1	0	1	1	0
Dusk	1	1	2	1	0
Dark road, lighted	7	1	7	6	5
Dark road, unlighted	0	1	1	0	0
Not reported	3	6	2	2	3
Total	*22*	*17*	*22*	*21*	*32*
Year					
2004	8	5	12	3	7
2005	8	7	4	8	12
2006	6	5	6	10	13
Total	*22*	*17*	*22*	*21*	*32*

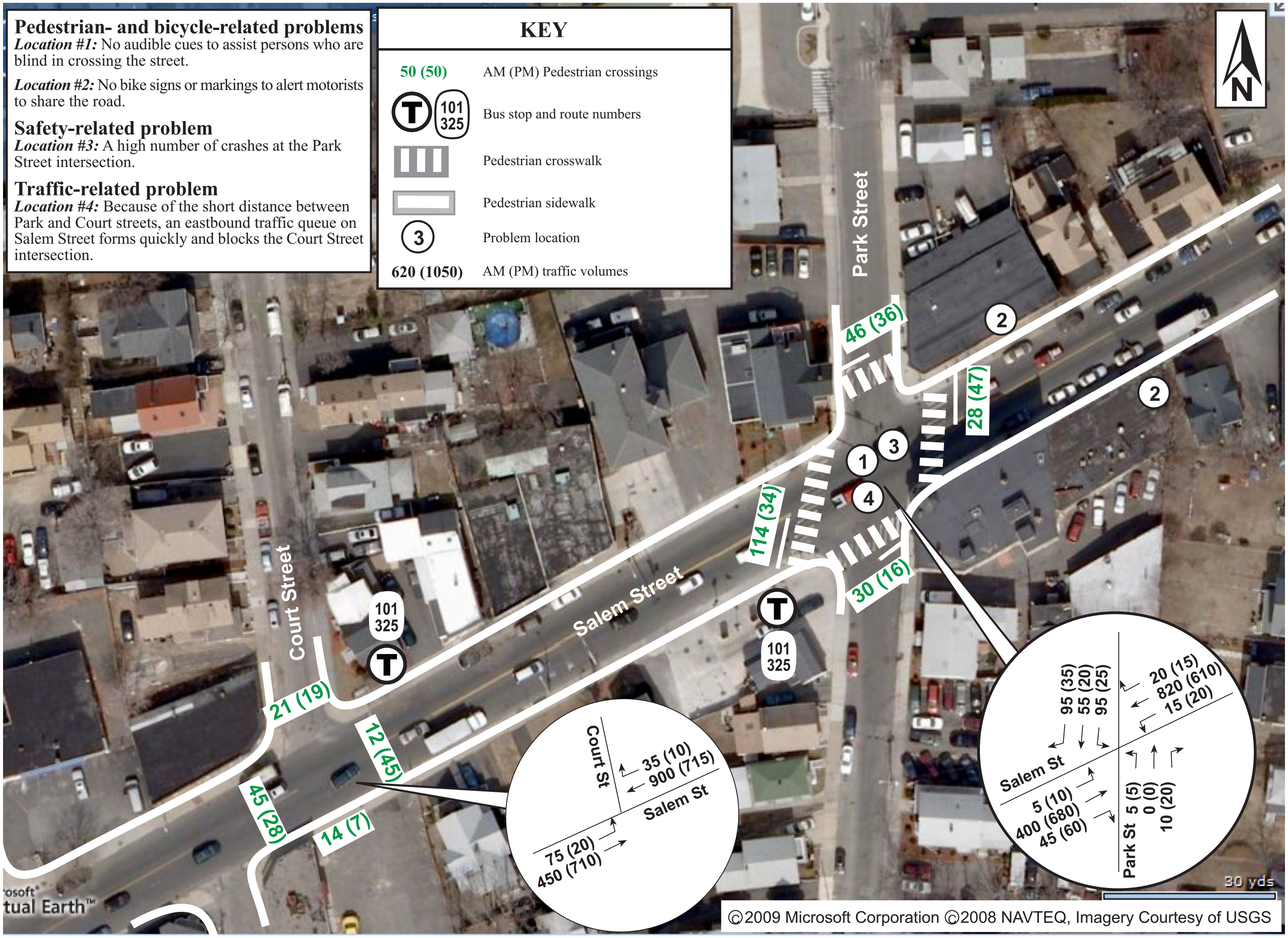

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FIGURE 16
Mobility Problems at the Salem Street (Route 60) and Park Street Intersection

Route 60 Mobility Study: Malden and Medford

Pedestrian and Bicycle Operations and Problems

The sidewalks at the intersection are in good condition, are made of concrete, and are five to seven feet wide. Street trees and street furniture on the sidewalks, such as streetlights, newspaper boxes, mailboxes, and trash receptacles, reduce the width of the sidewalks to less than five feet on Salem Street, but not to the extent of adversely impacting pedestrian and bicycle activities. The crosswalks are striped across all four approaches with parallel white stripes sufficiently visible to pedestrians and motorists. They are aligned obliquely to each approach and parallel to the roadways and are set back about three to four feet from the stop lines (see Figure 16). Each corner of the Park Street intersection features two sidewalk curb cuts for wheelchairs, one for each crosswalk.

The pedestrian signals at the Park Street intersection are in good working condition. The signal design includes an exclusive pedestrian phase—the pedestrian signal turns on when all traffic at the intersection is stopped. This eliminates vehicle-pedestrian conflicts. A symbol of a person walking and a flashing or steady red hand designate the pedestrian “WALK” and “DON’T WALK” phases, respectively. There is no audible pedestrian signal (APS) at this intersection to provide audible cues to assist persons who are blind in crossing the street. Figure 16 shows the AM and PM pedestrian crossing activity in green; on the day of observation, there were 218 pedestrians who crossed at the intersection during the AM peak period (7:00–9:00 AM) and 133 pedestrians during the PM peak period (4:00–6:00 PM), demonstrating high pedestrian activity in the morning due to the school located north of the intersection between Park and Court streets. A school crossing guard assists students in crossing the street in the morning and afternoon. Field observations show that pedestrians at this intersection usually use the crosswalk and push buttons. None of the crashes at this intersection involved a fatality or a pedestrian or bicyclist.

Traffic Operations and Safety Problems

Traffic operations at this intersection are satisfactory during the AM and PM peak periods, although there are occasions when queues form at this intersection. For both the AM and PM peak periods, the Park Street intersection operates at LOS C or better (see Table 6, page 49). Because of the very low volumes of traffic on Park Street, the actuated traffic signal provided at the intersection allows the green to stay on for Salem Street until it receives a call to serve traffic on Park Street. However, cars parked on the Park Street southbound approach for dropping off children at a bus stop or to go to school kept activating the green light for Park Street when it was not needed, sometimes causing a traffic queue to form on Salem Street.

Park Street approaches have sight distance problems due to the skewed intersection and on-street parking on Salem Street. Tables 7 and 8 (pages 50 and 51) present the crash rates, frequencies, and characteristics at the Park Street intersection. The rate of 1.20 crashes per million entering vehicles (MEV) is higher than the average of 0.88 crashes per MEV for MassHighway District 4 signalized intersections. Between 2004 and 2006, 22 crashes occurred at the Park Street intersection; the majority of them were rear-end and angle/sideswipe crashes. None of the crashes at this intersection involved a fatality or a pedestrian or a bicyclist. Also, 50 percent of the crashes occurred during nighttime.

5.3 SALEM STREET (ROUTE 60) AND SPRING STREET

The intersection of Salem Street and Spring Street is a complex, five-legged unsignalized intersection, located in an area with mixed land use: commercial, small industries, and residences. The intersection’s geometry and lane configuration are shown in Figure 17. At the intersection, Salem Street is uncontrolled, while Spring Street has stop signs posted at its approaches and marked on the pavement. Spring Street has an offset in its alignment; the northbound and southbound approaches are separated by about 100 feet, creating two T-intersections with Salem Street.

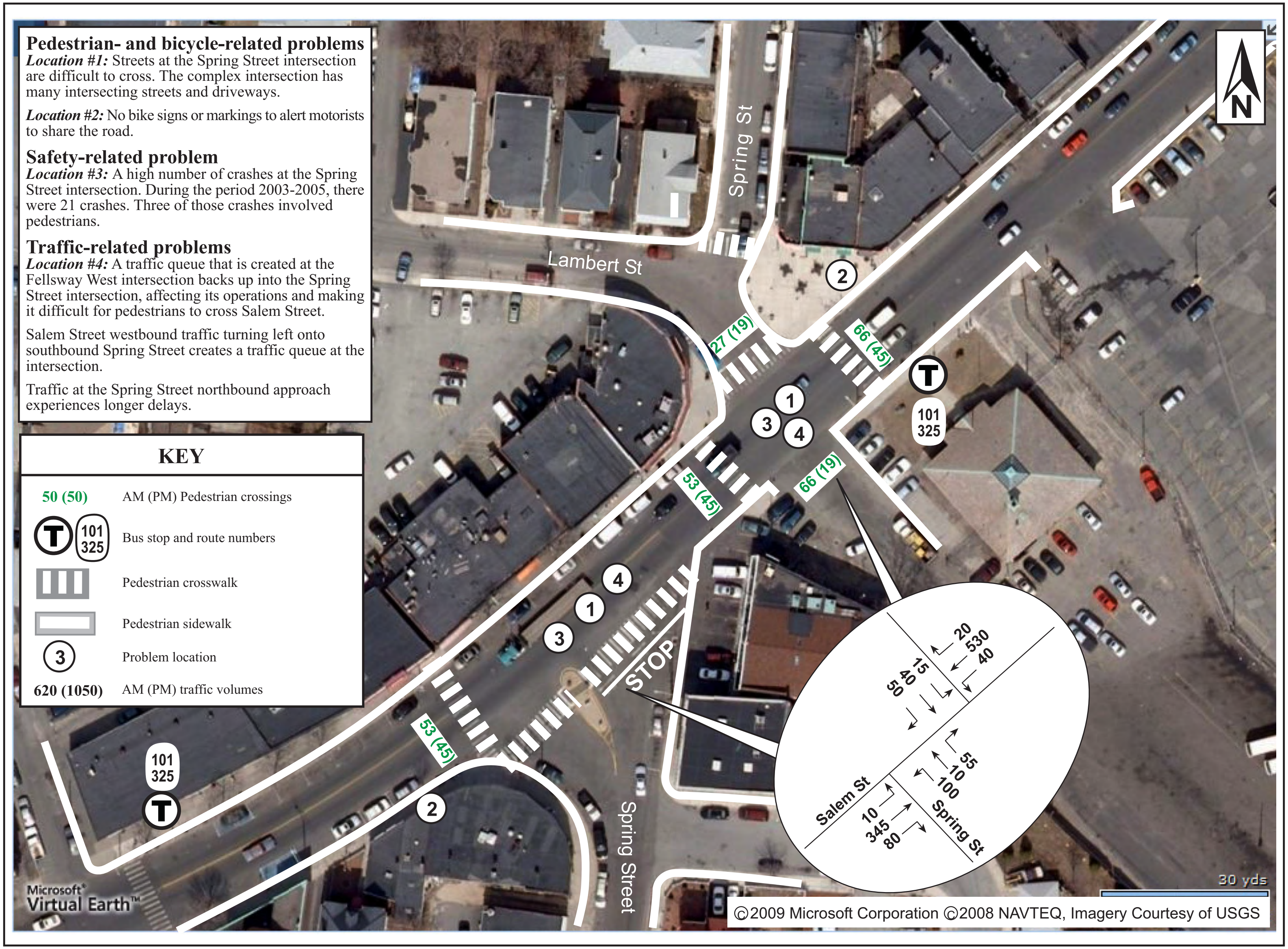

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FIGURE 17
Mobility Problems at the Salem Street (Route 60) and Spring Street Intersection

Route 60 Mobility Study: Malden and Medford

The pavement in the vicinity of the intersection is in fair to good condition, as are the granite curbs. On-street parking is allowed on both sides of Salem Street in the vicinity of the intersection for the commercial activities it serves, and on Spring Street for residential parking.

Pedestrian and Bicycle Operations and Problems

Figure 17 shows the pedestrian crossings at this intersection. They are marked with simple, parallel white stripes perpendicular to the pedestrian traffic flow, sufficiently visible to pedestrians and motorists. The crosswalks are aligned perpendicular to each approach. The stop lines at the approaches of Spring Street are marked with white paint, sufficiently visible to motorists, and are set back about four feet from the crosswalk. The sidewalks on both Salem Street and Spring Street are five to seven feet wide, are made of concrete, and are in fair to good condition. Each corner of the intersection features two sidewalk curb cuts for wheelchairs, one for each crosswalk. The street furniture reduces the width of the sidewalk to less than five feet at certain locations, but not to the extent that it impacts pedestrian traffic flow.

The AM and PM pedestrian crossing activities are shown in green in Figure 17. On the day of observation, 212 pedestrians crossed at the intersection during the AM peak period (7:00–9:00 AM) and 128 pedestrians during the PM peak period (4:00–6:00 PM). Crossing at the Spring Street intersection is difficult for motorists and pedestrians because of the complexity of the intersection (there are many intersecting streets and driveways) and high peak-period traffic volumes on Salem Street. Pedestrians were observed crossing the street at this intersection by looking for gaps of sufficient length in traffic or for motorists yielding to pedestrians. None of the crashes involved fatalities, but there were three crashes involving pedestrians; two of the pedestrian crashes occurred at the Spring Street intersection to the west and one at the intersection to the east.

Traffic Operations and Safety Problems

There are some concerns about traffic operations at this intersection during the AM and PM peak periods. An eastbound traffic queue created at the Fellsway West intersection extends into the Spring Street intersection. This queue creates traffic problems for pedestrians crossing Salem Street, as well as for motorists turning left onto Spring Street. A level-of-service analysis presented in Table 6 (page 49) indicates that during the AM peak period the Spring Street southbound approach operates at LOS C, while the northbound approach operates at LOS E.

The crash rates at the Spring Street intersection and the characteristics and frequency of the crashes are presented in Table 7 and Table 8 (pages 50 and 51), respectively. At the Spring Street intersection, the crash rate of 1.33 crashes per million entering vehicles (MEV) is higher than the average of 0.63 crashes per MEV for District 4 unsignalized intersections. As referred to earlier, crossing activities at the Spring Street intersection are problematic for motorists and pedestrians; there were 21 crashes at this intersection between 2004 and 2006, most of them angle/sideswipe and rear-end crashes. None of the crashes involved fatalities, but there were three crashes involving pedestrians; two of the pedestrian crashes occurred at the Spring Street intersection to the west and one at the intersection to the east. The majority of the crashes (14) occurred at the Spring Street westbound approach of the intersection.

5.4 SALEM STREET (ROUTE 60) AND FELLSWAY WEST (ROUTE 28)

The Salem Street and Fellsway West intersection is a four-legged signalized intersection, located in an area with retail stores, grocery stores, and residences. It is controlled by the Department of Conservation and Recreation. The intersection's geometry and lane configuration are shown in Figure 18. Both the westbound and eastbound approaches of Salem Street are used as two travel lanes, especially during peak

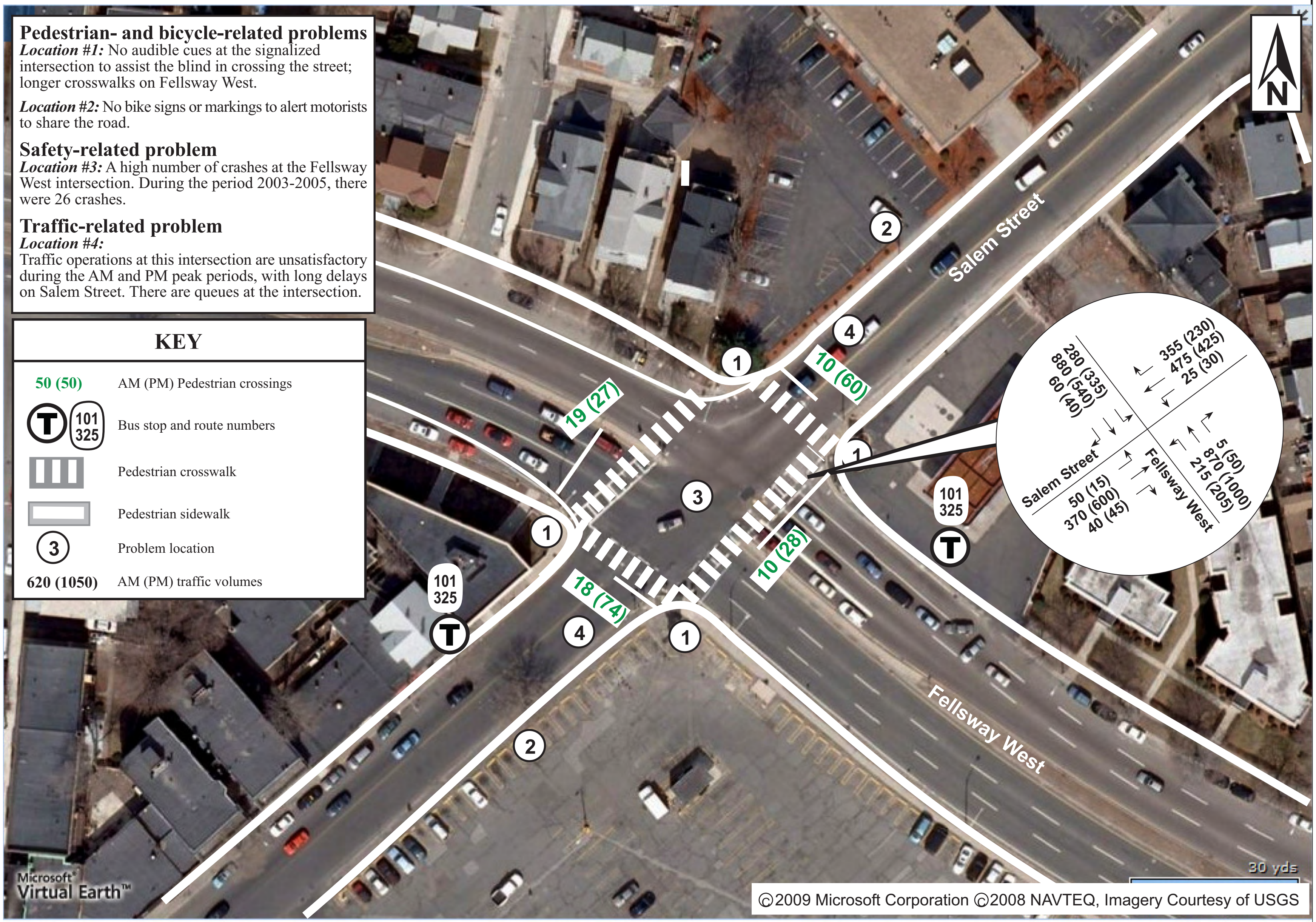

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FIGURE 18
Mobility Problems at the Salem Street (Route 60) and Fellsway West Intersection

Route 60 Mobility Study: Malden and Medford

periods, even though they are each striped as one lane. On-street parking is allowed only on the westbound side of Salem Street west of the intersection, for commercial activities. Residential on-street parking is allowed on both sides of Fellsway West north of the intersection. The street pavement and curbs in the vicinity of the intersection are in good condition. The traffic signals at the intersection are mast mounted for Fellsway West, which is good, as it provides good visibility. The traffic signals for Salem Street are post mounted in the sidewalks and in the median for Fellsway West left-turn traffic. The signal heads are placed appropriately to provide good visibility for motorists, but the signal equipment and heads need to be upgraded. Right turns on red from Salem Street are prohibited because of poor sight distance resulting from the curvature of Fellsway West at the intersection (see Figure 18).

Pedestrian and Bicycle Operations and Safety Problems

The traffic signal design at this intersection includes an exclusive pedestrian signal phase, which eliminates vehicle-pedestrian conflicts. A symbol of a person walking and a flashing or steady red hand designate the pedestrian “WALK” and “DON’T WALK” phases, respectively. There are no accessible pedestrian signals to provide audible cues to assist persons who are blind in crossing the street. The pedestrian crosswalks are marked across all four approaches with simple parallel white stripes perpendicular to the direction of pedestrian flow. When the field inspection took place, the crosswalk markings and the stop lines were moderately faded but sufficiently visible to pedestrians and motorists. The sidewalks are made of concrete and are in good condition; they are five to eight feet wide. The street furniture reduces the width of the sidewalks to less than four feet on westbound Salem Street west of the intersection. Each corner of the intersection features a single sidewalk curb cut for wheelchairs, which serves crosswalks on both Salem Street and Fellsway West.

AM and PM pedestrian crossing activity is shown in green in Figure 18. On the day of observation, 57 pedestrians crossed at the intersection during the AM peak period (7:00–9:00 AM), and 189 pedestrians during the PM peak period (4:00–6:00 PM). Pedestrians were observed using the crosswalk and push buttons most of the time. Very long pedestrian crosswalks on Fellsway West (six travel lanes and no usable median) create problems for pedestrians. None of the crashes at this intersection involved a fatality, a pedestrian, or bicycle.

Traffic Operations and Safety Problems

A level-of-service analysis presented in Table 6 (page 49) indicates that traffic operations at this intersection are unsatisfactory during the AM and PM peak periods, as reflected in the long traffic queues, especially on Salem Street. The traffic queues that form at this intersection often extend into the Spring Street intersection in Medford and into the Fellsway East intersection in Malden, impacting their traffic operations and safety. The absence of left-turn bays on Salem Street and the lack of adequate acceptable gaps in the opposing traffic on Salem Street do not only cause the permitted left turns to block the intersection, but also contribute to vehicles moving during the all-red clearance phase. Field observations indicate that too much green time is allocated for the Fellsway West through movements, which contributes partly to the long queues on Salem Street. The high volume of right turns on westbound Salem Street during the peak travel period needs some treatment to improve traffic operations at that approach.

The crash rates, frequencies, and characteristics at this intersection are presented in Table 7 and Table 8 (pages 50 and 51), respectively. The crash rate of 1.11 crashes per million entering vehicles (MEV) is higher than the average rate of 0.88 crashes per MEV for MassHighway District 4 signalized intersections. There were 32 crashes at this intersection between 2004 and 2006; most were angle/sideswipe and rear-end crashes. None of the crashes at this intersection involved a fatality, a pedestrian, or a bicyclist, and the majority occurred in daylight and under dry conditions.

6. ROUTE 60 IMPROVEMENTS IN MEDFORD

6.1 CORRIDOR IMPROVEMENTS

In general, MPO staff recommend installing bicycle and pedestrian signs and pavement markings in the corridor to inform motorists that they should share the road with bicyclists and pedestrians, who are numerous in the corridor because the commercial activities and mass transportation services in this corridor are a draw to pedestrians and bicyclists. One way to improve mobility is to improve safety by drawing motorists' attention to pedestrians and bicyclists. Bicycle-warning signs (types W11-1 and W16-1) are needed in this corridor to alert motorists to the presence of bicyclists and let them know that they need to share the road with bicyclists, as the lack of bicycle facilities in the corridor forces bicyclists to use the travel lanes.

W11-2

W13-1

R1-6

W11-1 and W16-1

MUTCD

Driver awareness is critical to improving safety; such awareness could be enhanced at these intersections and throughout the corridor by installing or upgrading signs and pavement markings on the approaches using larger letters to prepare motorists approaching a busy pedestrian area. Installing nonvehicular warning signs (type W11-2) in combination with advisory speed signs (type W13-1) and in-street pedestrian crossing signs (type R1-6) would alert motorists approaching an area with a high level of pedestrian activity.

The following sections describe potential improvements for addressing the problems that were identified in Chapter 5.

6.2 SALEM STREET AND THE I-93 ROTARY INTERCHANGE

The following is a summary of problems at the interchange.

- Sidewalks leading to and around the interchange are in poor condition, are dirty and weedy in some sections, and are in need of security lights, especially under the I-93 bridge.

- Traffic operations at the rotary are unsatisfactory; there are traffic queues on the southbound off-ramp as well as on Route 60.

- Crashes at the interchange were clustered at an area near the merge of Salem Street and the I-93 southbound off-ramp.

Figure 19 shows potential improvements recommended by MPO staff in consultation with the City of Medford for the I-93 interchange.

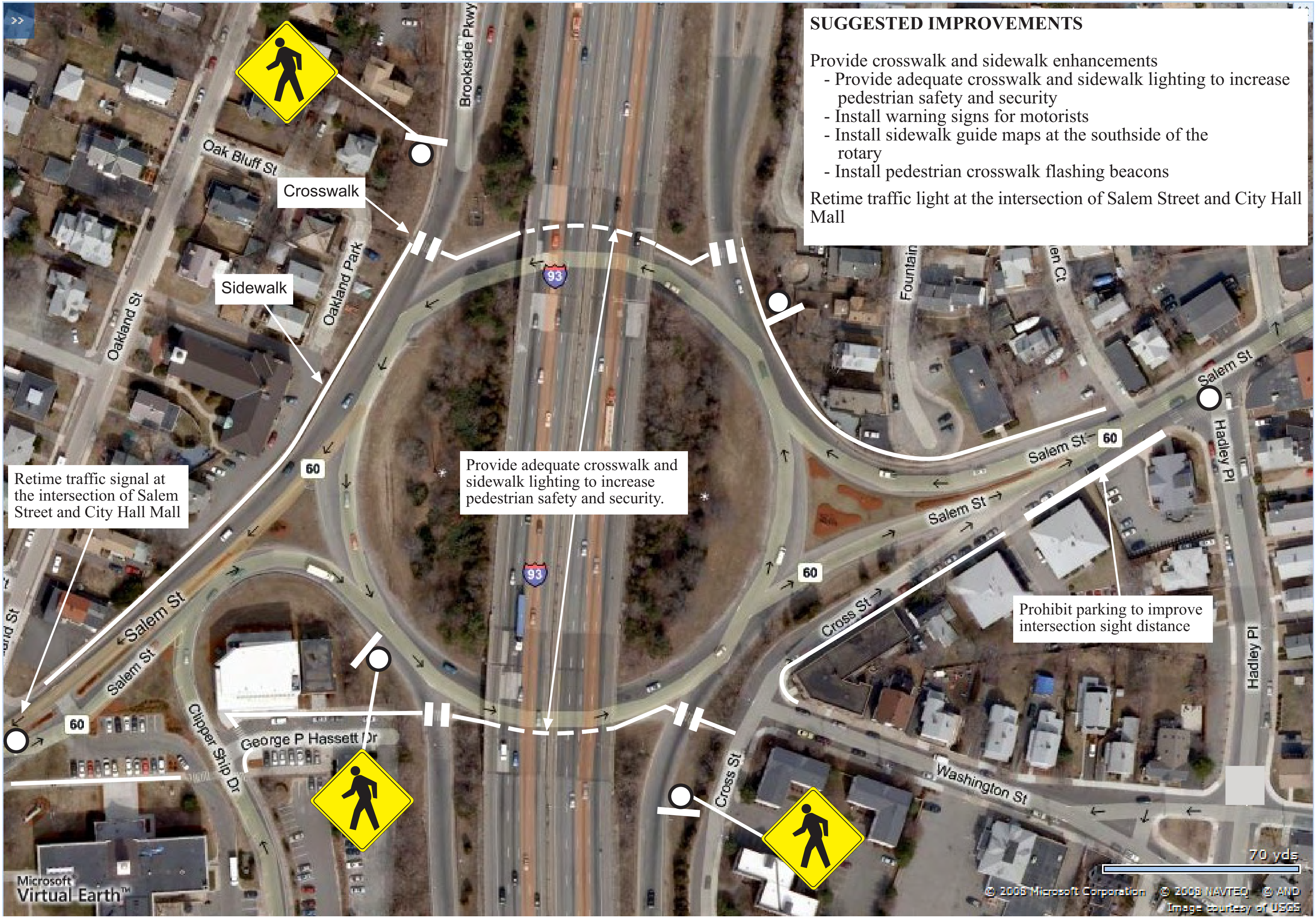

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FIGURE 19
Mobility Improvements at Salem Street and the I-93 Rotary Interchange

Route 60 Mobility Study: Malden and Medford

Provide Crosswalk and Sidewalk Enhancements

This strategy is directed at pedestrians; it is designed to guide them to the best location for crossing a high-volume street when a pedestrian signal is not present. Presently, the crosswalks within the rotary are all marked, in order to indicate to pedestrians the preferred locations for them to cross. However, it is useful to supplement crosswalk markings with warning signs for motorists, especially at locations with traffic volumes above 10,000 per day, to encourage motorists to yield to pedestrians (a 2008 traffic count performed by staff indicated average daily traffic of 25,000 vehicles at the rotary). Substantial pedestrian crossing treatments are needed at the rotary to help pedestrians cross safely. The following enhancements are suggested for the rotary:

- Appropriate placement of lighting and adequate lighting levels for the sidewalks and crosswalks in the vicinity of the rotary enhance the environment for walking, as well as increasing pedestrian safety and security. Pedestrians often incorrectly assume that motorists can see them at night, since a pedestrian can see the oncoming headlights. Therefore, it is necessary to provide adequate lighting at the intersection so that drivers can see pedestrians in time to stop. Marked crosswalks should be visible to motorists, particularly at night.

Solar pedestrian crosswalk flashing beacon

We suggest that the City of Medford and MassHighway consider installing pedestrian crosswalk flashing beacons at the crosswalks within the rotary that a pedestrian activates by pushing a button. Solar-powered pedestrian crosswalk flashing beacons are a stand-alone solution with an easy retrofit onto existing signposts. As a push-button-activated solution, solar beacons draw attention to the presence of pedestrians at uncontrolled crosswalks, preserving the safe and efficient flow of both vehicles and pedestrians.

Another pedestrian safety device that could improve safety is flashing lights embedded along the edge of the crosswalk that faces traffic.

- Installing warning signs for motorists to yield to pedestrians would also encourage motorists to look for pedestrians.

- Installing a sidewalk guide map at the crosswalks on the south side of the rotary showing the layout of the sidewalks at the rotary interchange is important for pedestrians, since the sidewalk on that side of the rotary can be confusing to navigate because it crosses many roadways and changes direction in some locations.

Retime the Salem Street Traffic Signal at City Hall Mall

Retiming the traffic light at Salem Street and City Hall Mall would reduce delay and the resulting traffic queue that sometimes extends into the rotary, which affect traffic operations at the rotary. Although this intersection was not included in this study, it has an impact on safety and traffic operations at the rotary.

6.3 SALEM STREET AND HADLEY PLACE

The intersection of Salem Street and Hadley Place had 17 crashes in three years (2004–2006), a higher number of crashes than many other unsignalized intersections in the vicinity. The following potential improvements are suggested for addressing safety issues at the Hadley Place intersection.

Provide Clear Sight Distance from the Hadley Place Stop-Controlled Approach to the Intersection

Many of the crashes at this intersection involve a northbound vehicle from Hadley Place and a vehicle traveling eastbound or westbound on Salem Street, resulting in angle and sideswipe crashes. These crashes may be related to restricted sight distance due to the fact that Hadley Place intersects Salem Street at an oblique angle. This situation may be compounded by on-street parking near the intersection (see Figure 20). Adequate sight distance for drivers at stop-controlled approaches has long been recognized as among the most important factors contributing to safety at unsignalized intersections. It is estimated that correcting for sight distance at intersections can result in up to a 37 percent reduction in injury-related crashes.[6]

Sight distance improvements for drivers at the Hadley Place stopped-controlled approach could be achieved by eliminating parking on Salem Street after it merges with Cross Street, and also in the vicinity of the Hadley Place intersection, where parking restricts the sight distance. Increased enforcement of existing parking prohibitions may be needed to ensure successful implementation of this strategy. The most difficult aspect of this strategy is the possible response of adjacent property owners and users who might be negatively impacted by stricter enforcement, which would effectively reduce the number of nearby parking spaces. Public compliance with increased enforcement of parking restrictions might present a problem.

Improve the Visibility of the Intersection by Providing Enhanced Signage

D3-2

W13-1

W2-4

MUTCD

The Hadley Place intersection is not clearly visible to approaching drivers, particularly drivers approaching from Salem Street in both directions. The visibility of an intersection to approaching drivers could be enhanced by signage and pavement markings. Such improvements could include: advance street name signs (type D3-2), intersection warning signs (type W2-4), and advisory speed signs (type W13-1). Such improvements contribute to a better driving environment. Advance warning signs and intersection warning signs also alert drivers to the presence of an intersection. Making drivers aware that they are approaching an intersection through the use of enhanced signage and pavement markings should improve safety at the intersection because drivers would be alerted to vehicles approaching from the cross streets. This heightened awareness quickens drivers' reaction times when conflicts occur. However, care should be taken not to overuse traffic signage because excessive signage tends to distract drivers.

Install Flashing Beacons at This Stop-Controlled Intersection

Standard overhead flashing beacon

Post-mounted flashing beacon with stop sign

www.tfhrc.gov

Flashing beacons at unsignalized intersections can be a cost-effective safety improvement. Overhead flashing beacons or post-mounted flashing beacons with stop signs could be used at the Salem Street and Hadley Place intersection to call drivers' attention to the intersection. Flashing beacons are used to reinforce driver awareness to help mitigate patterns of right-angle crashes. At two-way stop-controlled intersections such as this intersection, flashing beacons could be used with red flashers

[6] U.S. Department of Transportation, Federal Highway Administration, *Desktop Reference for Crash Reduction Factors*, Publication No. FHWA-SA-07-015, September 2007.

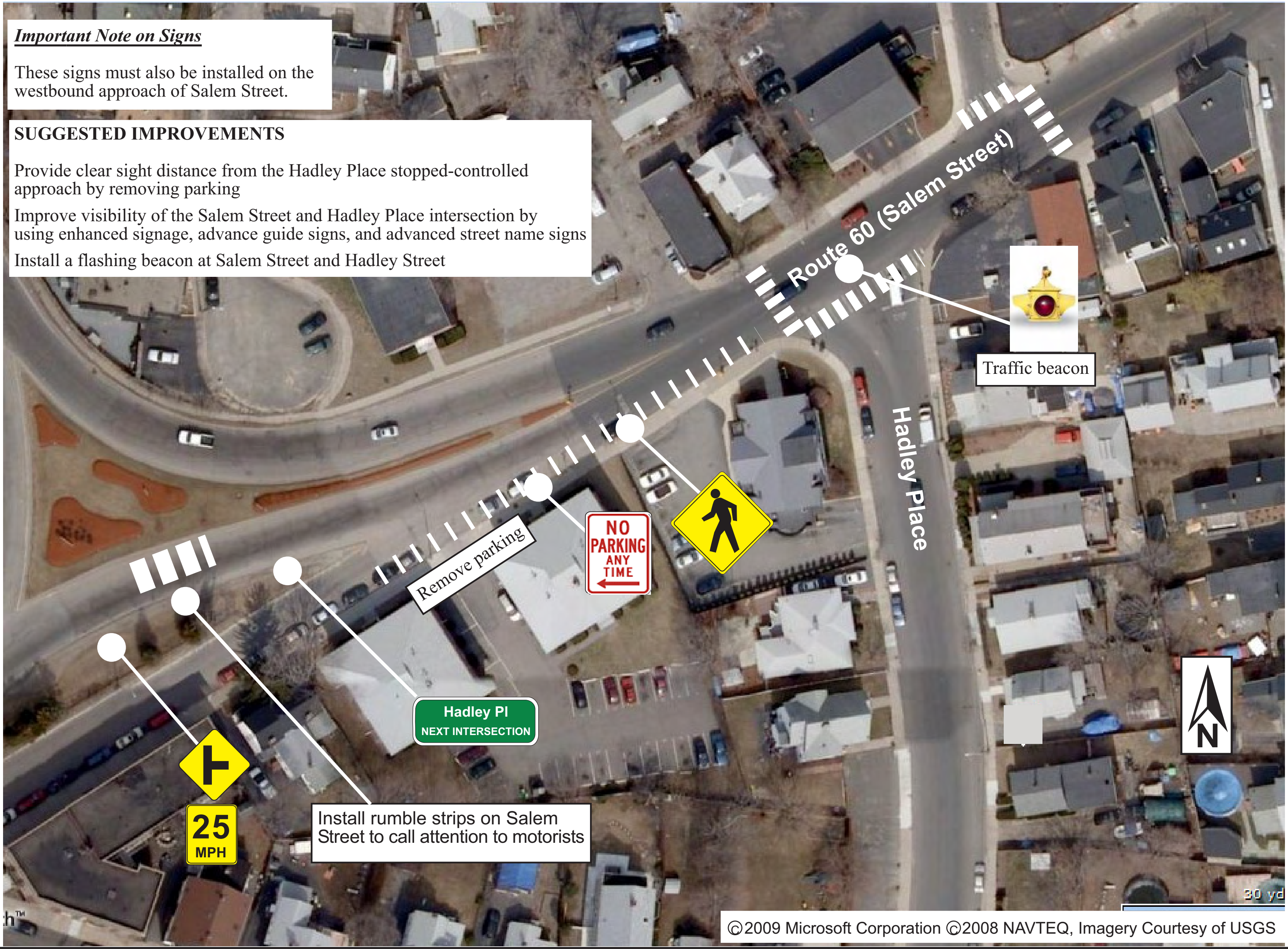

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FIGURE 20
Mobility Improvements at the Intersection of Salem Street and Hadley Street

Route 60 Mobility Study: Malden and Medford

facing the Hadley Place stop-controlled approach and yellow flashers facing the Salem Street uncontrolled approaches. Use of flashing beacons increases the visibility of intersections for approaching drivers, thus supplementing the signage and marking improvements and calling attention to stop signs.

Install Rumble Strips on Salem Street to Call Attention to the Intersection

www.dublin.oh.us

Rumble strips

The Salem Street and Hadley Place intersection is about 150 feet east of the I-93 interchange; thus crashes may occur because one or more drivers may be unaware of the intersection as it is so close to the interchange. Installing rumble strips at the approaches would call attention to the presence of the intersection and the traffic control in use at the intersection. Rumble strips are appropriate on stop-controlled approaches to intersections where a pattern of crashes is related to the drivers' lack of attention to certain traffic activity, control measures, or a change in the geometry of the intersection.

Rumble strips are normally applied when less intrusive measures—such as pavement markings like "STOP AHEAD," other pavement markings, signage, or flashing signals—have been tried and have failed to correct the crash pattern. A rumble strip could be located so that when a driver crosses the rumble strip, a key traffic control device such as a "STOP AHEAD" sign or a speed limit sign, such as "25 MPH SPEED LIMIT," is directly in view. Rumble strips in a travel lane have several potential pitfalls that should be considered carefully when considering whether or not to implement them. They include: (1) noise that may disturb nearby residents; (2) potential loss of control for motorcyclists and bicyclists; (3) difficulties created for snowplow operations; and (4) inappropriate driver responses, such as using the opposing travel lanes to drive around the rumble strip.

6.4 SALEM STREET AND PARK STREET

Staff identified the following safety problems at the intersection of Salem Street and Park Street.

- The crash rate of 1.20 crashes per million entering vehicles (MEV) is higher than the average of 0.88 crashes per MEV for MassHighway District 4 signalized intersections.
- The predominant types of crashes at the intersection were angle/sideswipe and rear-end crashes (combined, 91 percent of the crashes). Also, 50 percent of the crashes occurred during nighttime.
- Sight distance problems due to the skewed intersection and on-street parking.

None of the crashes involved a fatality, a pedestrian, or a bicyclist. In consultation with the City of Medford, staff recommend the following improvements for increasing safety at this intersection (see Figure 21).

Prohibit Turns on Red on Park Street

Prohibition of right-turn-on-red (RTOR) can help reduce crashes related to limited sight distance. The safety problems that RTOR vehicles encounter at the Park Street intersection arise from the limited sight distance resulting from the skewed geometric design of the intersection and from the presence of on-street parking on Salem Street that blocks drivers who are turning right from Park Street from viewing vehicles that are westbound on Salem Street. This strategy could help reduce the frequency and severity of crashes between vehicles turning right on red from Park Street and westbound vehicles on Salem Street. This strategy could be implemented with improved signage, although enforcement would be needed to realize the potential benefits of the new regulation.

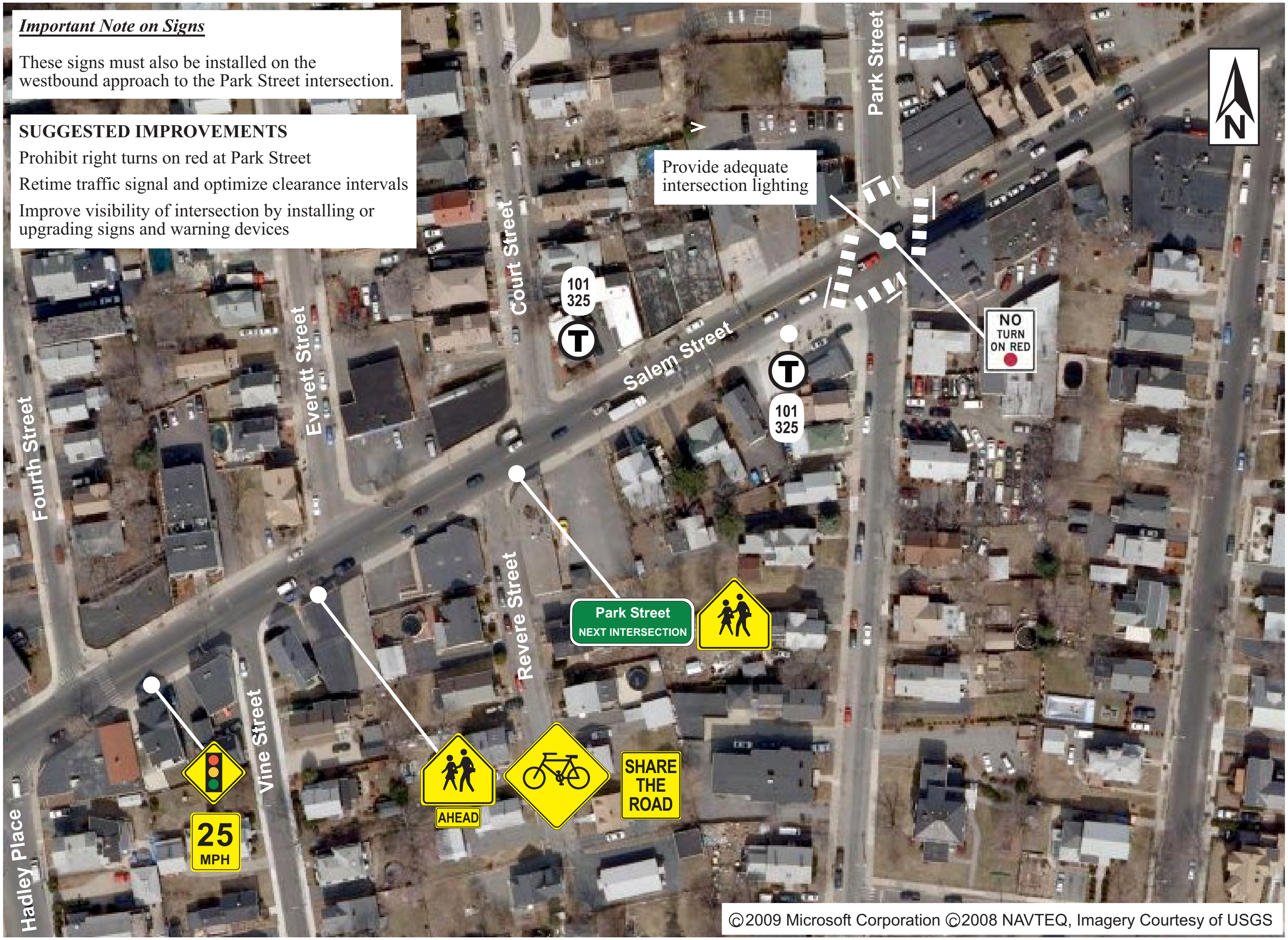

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FIGURE 21
Mobility Improvements at the Intersection of Salem Street and Park Street

Route 60 Mobility Study: Malden and Medford

Retime the Traffic Signal

Signal retiming is one of the most cost-effective ways to improve traffic flow along a corridor or at an intersection. It is the process that optimizes the operation of the signalized intersection to improve traffic flow by reducing stops and delays. It is also done to improve safety and save time for emergency vehicles and for bus transit service. One goal of this strategy is to reduce stops at the signalized intersection to reduce traffic queuing, which in turn would reduce rear-end crashes.

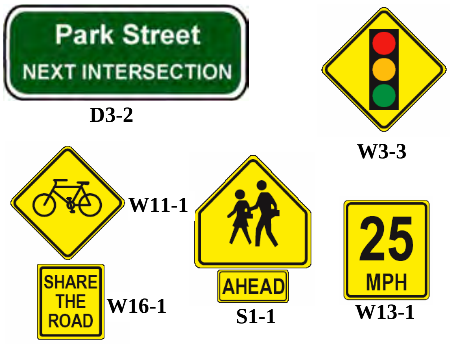
Signal retiming includes optimizing the clearance intervals (yellow and all-red intervals) to improve safety. Clearance intervals provide safe, orderly transitions in right-of-way assignment between conflicting streams of traffic. Another goal of this strategy is to reduce crashes related to clearance interval lengths that are too short for a particular intersection. Rear-end crashes may be a symptom of short clearance intervals. A vehicle stopping at a signal may be rear-ended by a vehicle following it when the following driver expects to be able to proceed through the intersection during a longer clearance interval. Based on methods suggested by the Institute of Transportation Engineers (ITE), this intersection would require a total of at least five seconds for the yellow and red clearance intervals combined. Table 9 shows the simulated results of the signal optimization.

TABLE 9
Optimized Delay, Level of Service, and Queue Length,
Medford Intersections*

	AM Peak Period			**PM Peak Period**		
Intersection Approach	**Delay (sec)**	**LOS**	**Queue (veh)****	**Delay (sec)**	**LOS**	**Queue (veh)****
Salem Street and Park Street Intersection						
Salem Street Westbound	24	C	20	17	B	22
Salem Street Eastbound	10	A	9	18	B	22
Park Street Northbound	39	D	2	27	C	2
Park Street Southbound	58	E	6	37	D	4
Total Intersection Delay (Existing)	21	B	n/a	12	B	n/a
Total Intersection Delay (Optimized)	21	B	n/a	18	B	n/a
Salem Street and Fellsway West Intersection						
Salem Street Westbound Th + RT	54	D	20	35	D	17
Salem Street Westbound LT	29	C	1	40	D	2
Salem Street Eastbound Th + RT	46	D	18	108	F	26
Salem Street Eastbound LT	57	E	4	39	D	5
Fellsway West Southbound Th + RT	36	D	15	35	C	12
Fellsway West Southbound LT	54	D	14	87	F	18
Fellsway West Northbound Th + RT	50	D	18	130	F	11
Fellsway West Northbound LT	50	D	11	54	D	24
Total Intersection Delay (Existing)	105	F	n/a	80	F	n/a
Total Intersection Delay (Optimized)	54	D	n/a	80	F	n/a

n/a = not applicable
* The optimized delay, LOS, and queue length reflect improvements such as signal retimimg, change in sequence of movements and clearance interval
** 95% queue length
Th = through, RT = right turn, LT = left turn

Improve the Visibility of the Intersection from the Approaches



MUTCD

Driver awareness of both downstream intersections and traffic control devices is critical to intersection safety. Inability to perceive an intersection or its control, or the back of a stopped queue, in time to avoid a collision can result in safety problems. Installing or upgrading signs with larger letters on intersection approaches can prepare drivers for the intersection in advance. This may include advance street name signs (type D3-2), advance traffic control signs (type W3-3), and advisory speed signs (type W13-1). Advance street name signs and advance traffic control signs can improve awareness of a downstream signalized intersection. In addition, installing advance-warning signs, such as school-ahead signs (type S1-1) and bicycle warning signs (type W11-1 and W16-1), would improve safety. These potential improvements are shown in Figure 21 (page 65).

About half of the crashes at the Salem Street and Park Street intersection occurred during nighttime. Of these crashes, the majority were reported to have occurred under “dark, road lighted” conditions. Providing adequate lighting at the intersection itself and on its approaches can make drivers aware of the presence of the intersection and reduce nighttime crashes.

6.5 SALEM STREET AND SPRING STREET

Staff identified the following problems at this intersection.

- Crossing at the intersection is a problem for motorists and pedestrians because of the complexity of the intersection and the high volume of traffic on Salem Street.
- There were 21 crashes at this intersection between 2004 and 2006, of which 10 were angle/sideswipe crashes and 6 were rear-end crashes. The majority of the crashes (14) occurred at the Spring Street westbound intersection.
- Three of crashes at this intersection involved pedestrians; two of those crashes occurred at the Spring Street westbound intersection and one at the eastbound intersection.
- Twelve of the crashes occurred in daylight and eight at night.
- There are traffic operations problems at this intersection during the peak periods, when an eastbound traffic queue at the Fellsway West intersection extends into this intersection and creates traffic problems for pedestrians and motorists turning left onto Spring Street.

Staff recommend the following improvements for addressing safety and operations concerns at this intersection (Figure 22).

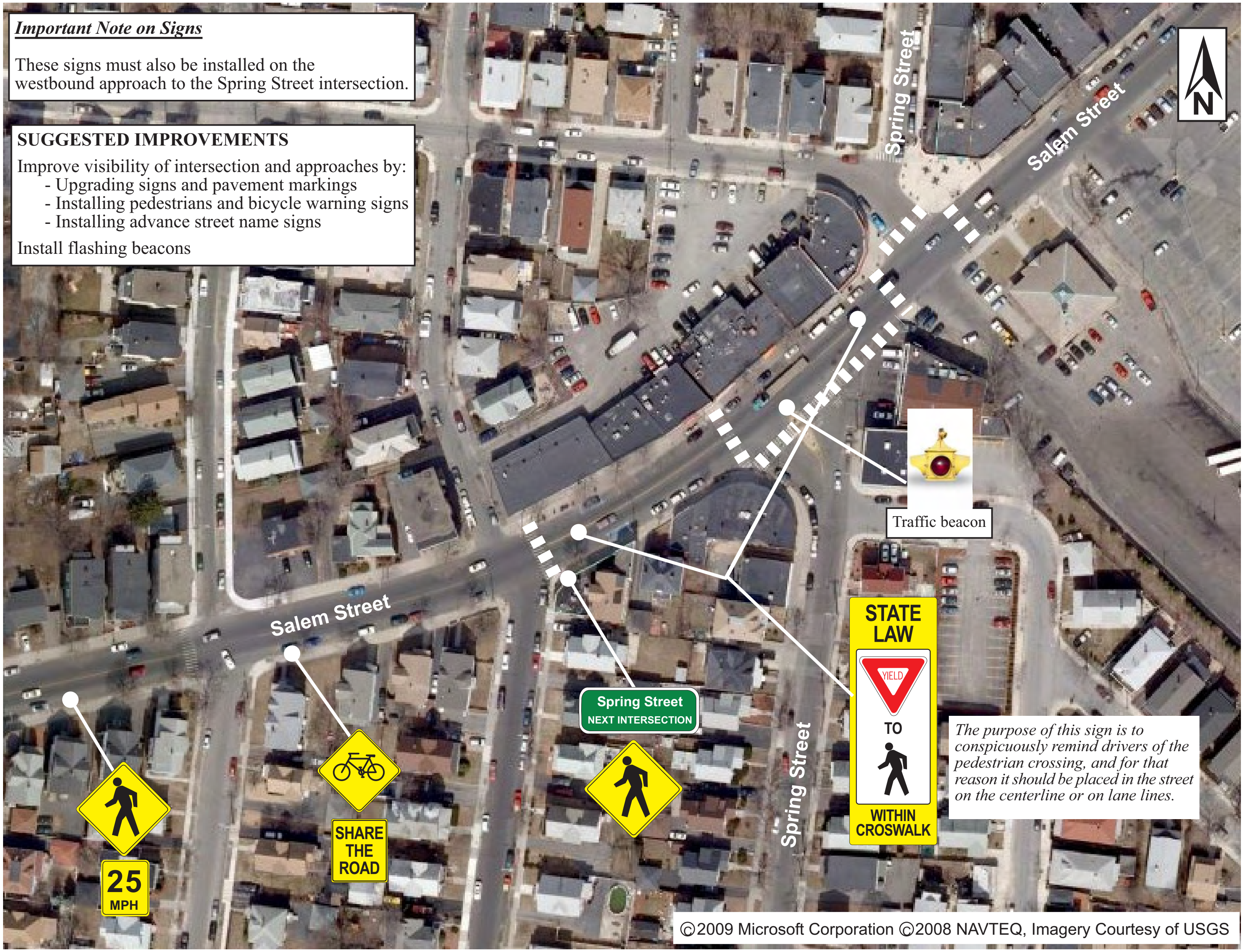


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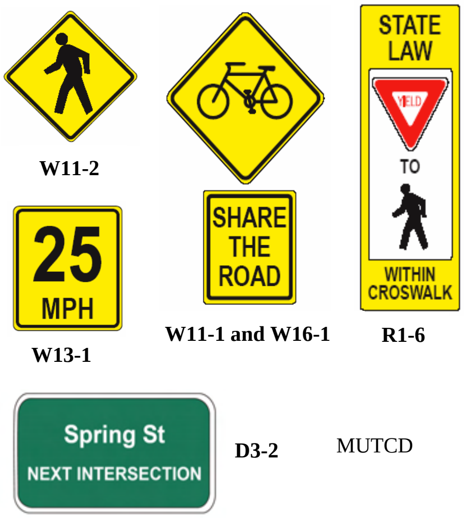
FIGURE 22
Mobility Improvements at the Intersection of Salem Street and Spring Street

Route 60 Mobility Study: Malden and Medford

Improve the Visibility of the Intersection from the Approaches



Driver awareness of this intersection is critical to improving safety. Such awareness could be enhanced at this intersection by installing or upgrading signs and pavement markings on the approaches using larger letters to prepare motorists approaching a busy pedestrian area. Installing nonvehicular warning signs (type W11-2) in combination with advisory speed signs (type W13-1) and in-street pedestrian crossing signs (type R1-6) would alert motorists approaching an area with high pedestrian activity. The purpose of an R1-6 sign is to remind drivers of the pedestrian crossing, and for that reason these signs should be placed in the street on the centerline or on lane lines. In addition, bicycle-warning signs (types W11-1 and W16-1) are needed in the vicinity to alert motorists to the presence of bicyclists and let them know that they need to share the road with bicyclists, as the lack of bicycle facilities in the corridor forces bicyclists to use the travel lanes. Advance street name signs (type D3-2) could be used to identify the intersection in advance.

Install Flashing Beacons

The City of Medford should also consider installing flashing beacons at this intersection to supplement the stop-control at approaches and call motorists' attention to stop signs. Flashing beacons help to mitigate patterns of right-angle crashes related to stop-sign violations and increase the visibility of the intersection for approaching drivers. Crash types mitigated by flashing beacons include angle, sideswipe, and rear-end. The shortcoming of flashing beacons is that drivers generally understand the signal indications of flashing beacons, but at times, drivers on a minor street are confused about the nature of the signal showing on the major street.

6.6 SALEM STREET AND FELLSWAY WEST

This intersection, which is under the jurisdiction of the Massachusetts Department of Conservation and Recreation (DCR), had the following problems.

- Very long pedestrian crosswalks on Fellsway West (six travel lanes and no usable median).
- Unsatisfactory traffic operations during peak periods. There are queues on Salem Street that on some occasions extend into the adjacent intersections due to the lack of turning bays.
- Field observations show that Fellsway West seems to have too much green time for the through traffic, which contributes to the long queues on Salem Street.
- The crash rate at this intersection exceeds the average rate of MassHighway District 4 signalized intersections.
- There were 32 crashes at the Salem Street and Fellsway West intersection between 2004 and 2006; 20 (67 percent) were angle/sideswipe crashes.

The following potential improvements are suggested for addressing problems at this intersection (see Figure 23).

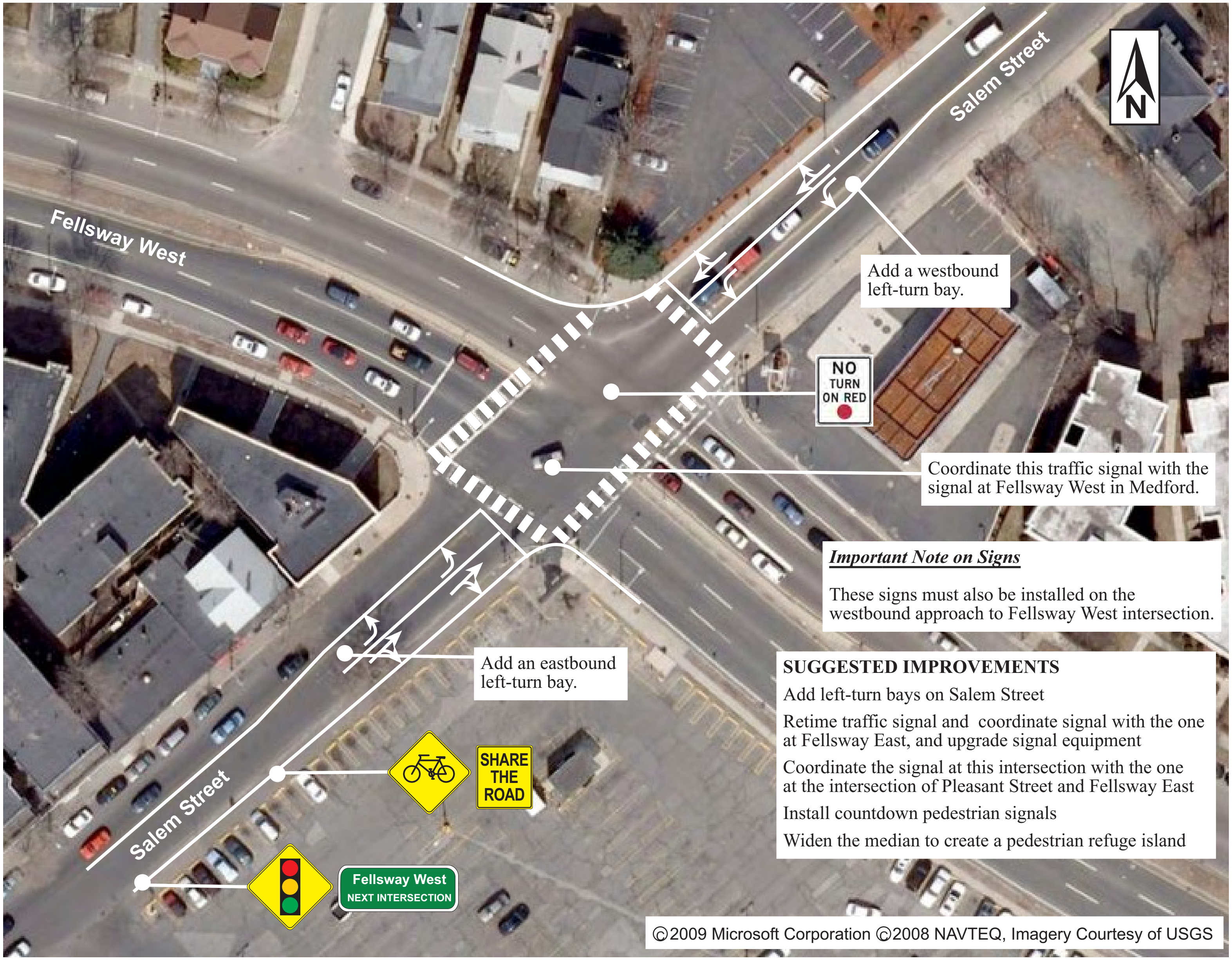


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FIGURE 23
Mobility Improvements at the Intersection of Salem Street and Fellsway West

Route 60 Mobility Study: Malden and Medford

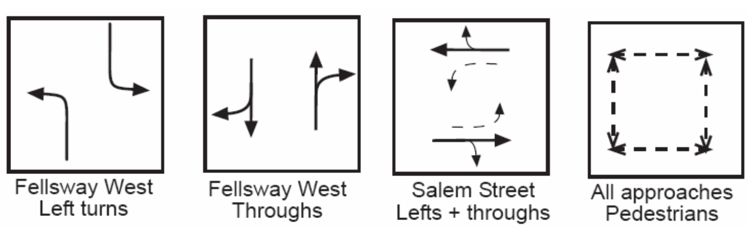
Add Turn Bays on Salem Street

Many intersection safety and operations problems can be traced to difficulties in accommodating turning vehicles. A key strategy for minimizing collisions related to turning vehicles and for facilitating traffic flow is to provide exclusive right-turn and left-turn bays, particularly on a high-volume arterial such as Salem Street. A left-turn bay on Salem Street eastbound would allow for separation of left-turn and through-traffic streams to prevent vehicles turning left from blocking through traffic. A right-turn bay on Salem Street westbound would reduce delays and prevent the long queue on that approach that results from the high volumes of right turns at that approach. Turn bays provide sheltered locations for motorists to wait for acceptable gaps in oncoming vehicles, minimizing the potential for collisions with those vehicles. Potential challenges to providing turn bays on Salem Street include the cost and acquisition of the space required for the modifications. In addition, it would be important to address the concerns of business owners and other stakeholders concerned about the loss of parking. Adding turn bays on Salem Street would also increase the lengths of the crosswalks, assuming the minor widening required (6 feet or less), which works against pedestrians. However, in this case the resulting roadway and crosswalk widths (3 lanes or 33 feet), would not be expected to impact pedestrians adversely.

Retime the Traffic Signal and Upgrade Control Hardware

Signal retiming is one of the most cost-effective ways to improve traffic flow along a corridor or at an intersection. The objective of this retiming is to optimally respond to traffic conditions and pedestrian demands at the intersection by reconfiguring the timing to minimize delays for all movements at the intersection, including those of pedestrians and bicyclists. Another objective of the retiming is to optimally respond to the geometric improvements proposed for this intersection, described above. The proposed signal phasing is shown below.

Table 9 (page 66) presents the amount of delay, level of service, and queue length that would result from optimizing the signal-timing plan. The signal optimization, coupled with the proposed geometric improvements at this intersection, would result in shorter delays. For the AM peak period, signal optimization and geometric improvements would decrease the intersection control delay from 105 to 51 seconds (to LOS D from LOS F). For the PM peak, they would keep it constant, at around 80 seconds (LOS F). It is also important to upgrade the existing traffic signal control hardware to accommodate enhanced signal operations.



Phase Sequence at Fellsway West and Salem Street

Coordinate the Traffic Signals at the Fellsway West and Fellsway East Intersections

To improve traffic flow along Route 60, staff recommend that the traffic signals at these intersections be coordinated. DCR controls both traffic signals. Good signal coordination can generate measurable safety benefits in two ways. First, coordinated signals produce platoons of vehicles that can proceed without stopping at multiple signalized intersections, thus reducing delay. Second, reducing the number and frequency of required stops improves safety by reducing the number of rear-end conflicts and crashes.

Widen the Median on Fellsway West to Create a Pedestrian Refuge

Very long crosswalks on Fellsway West (six travel lanes and no usable median) create problems for pedestrians crossing Fellsway West. Staff suggest that Medford and DCR consider reducing the width of the travel lanes and shoulders to create an eight-foot-wide raised median pedestrian refuge island. Pedestrian refuge islands improve safety for pedestrians by providing a rest area for pedestrians, particularly those who use wheelchairs or who are elderly, who are unable to completely cross an intersection within the provided signal time. It also reduces the total distance over which pedestrians are exposed to conflicts with motor vehicles. In general, 50 feet is the longest uninterrupted crossing a pedestrian should encounter at a crosswalk, but this crosswalk is about 100 feet long.

Install Countdown Pedestrian Signals

NCHRP 500, Report, Vol. 10

Countdown pedestrian signal

The very long pedestrian crosswalks on Fellsway West (six or more travel lanes to cross at one time with no usable median) need to be improved to be pedestrian friendly. Installing countdown pedestrian signals would make it easier to cross Fellsway West and would increase pedestrian safety by giving useful information to pedestrians on how long they have to complete a crossing. Current standards call for a pedestrian countdown signal timer display to begin counting down when the flashing “DON’T WALK” signal appears and stop when the steady “DON’T WALK” signal appears. Countdown pedestrian signals provide useful information to pedestrians by showing the number of seconds left to finish crossing the street. Thus, they could indicate to pedestrians who are in the crosswalk at the Fellsway West and Salem Street intersection when the flashing “DON’T WALK” signal appears how much time they have to finish crossing the roadway.

Recent studies on countdown signals have shown indications that a larger percentage of pedestrians are now completing their crossings during the flashing “DON’T WALK” signal than without the countdown signal.[7,8] This result may be construed as positive, since it indicates that with the countdown signal, more pedestrians get out of the crosswalk before the steady “DON’T WALK” interval shows up. Thus, pedestrians are using the additional information provided by the countdown signal to complete their crossings in the time provided. It should be noted that completing a crossing before the steady “DON’T WALK” interval is shown reduces the chance of pedestrians being confronted with conflicting vehicle movements. This reduction appears to be greater when a greater proportion of pedestrians had been entering the crosswalk during the flashing “DON’T WALK” interval than during the “WALK” interval.

6.7 SUMMARY OF RECOMMENDED IMPROVEMENTS

This study has identified several improvements to address the issues of mobility and safety in the Route 60 corridor for motorists, bicyclists, pedestrians, and transit users. Table 10 summarizes the potential benefits and estimated costs of the various improvements. All of the improvements are short-term or

[7] Jan L. Botha and Ron L. Northouse, *Pedestrian Countdown Signals Study in the City of San Jose,* Final Report, submitted to the California Traffic Control Devices Committee, May 2002.

[8] Jeremiah P. Singer and Neil D. Lerner, *Countdown Pedestrian Signals: A Comparison of Alternative Pedestrian Change Interval Displays*, Final Report, submitted to the Federal Highway Administration, March 2005.

intermediate-term, and could be implemented within 5 to 10 years. There are several agencies that operate transportation facilities in the corridor, including the Massachusetts Highway Department, the Massachusetts Bay Transportation Authority, and the Massachusetts Department of Conservation and Recreation, in addition to the City of Medford. Successful implementation of the projects advancing from this study is dependent on coordination among the stakeholders, sufficient public participation, and securing funding for the projects.

TABLE 10
Summary of Improvements along Route 60 in Medford

Intersection	Improvement	Expected Benefits	Costs	Implementing Agency
I-93/Salem Street (Route 60) Rotary	Provide crosswalk and sidewalk enhancements (lighting, warning signs, guide maps).	Encourage motorists to look for pedestrians and guide pedestrians to best locations to cross at the rotary.	$50,000	MassHighway
	Retime traffic signal at Salem Street and City Hall Mall.	Facilitate traffic flow at the rotary by reducing queues.		
Salem Street and Hadley Place	Provide clear sight distances from Hadley Place stop approach.	Reduce crashes improving visibility of intersection.	$50,000	City of Medford
	Improve visibility of intersection by providing enhanced signs such as advance warning and street name signs.	Reduce crashes by providing a better driving environment and by increasing driver awareness of the intersection.		
	Install flashing beacon at the intersection.	Reduce crashes by increasing visibility of intersection and improving signage and street markings.		
	Install rumble strips on Salem Street to call attention to the intersection.	Call attention to presence of intersection and traffic control.		
Salem Street and Park Street	Prohibit turns on red light at Park Street intersection.	Reduce crashes related to limited sight distance caused by skewed intersection and on-street parking.	$25,000	City of Medford
	Retime traffic signal.	Improve safety and traffic flow, and improve travel times for emergency vehicles and bus transit services.		
	Improve visibility of intersection at the approaches by installing advance street name, advance traffic control, advisory speed signs, and lighting.	Reduce crashes by providing a better driving environment and by increasing driver awareness of the intersection.		
Salem Street and Spring Street	Install flashing beacon at the intersection.	Reduce crashes by increasing visibility of intersection and increasing signage and street markings.	$50,000	City of Medford
	Improve visibility of intersection and approaches by installing nonvehicular warning, advisory speed, and in-street pedestrian-crossing signs.	Reduce crashes by alerting motorists approaching a high-pedestrian-activity area.		
Salem Street and Fellsway West	Add turn bays on Salem Street.	Minimize collisions related to turning vehicles and facilitate traffic flow.	$200,000	Department of Conservation and Recreation
	Retime the traffic signal and upgrade signal control hardware.	Improve safety and traffic flow, and improve travel times for emergency vehicles and bus transit services.		
	Coordinate traffic signals at Fellsway West and Fellsway East intersections.	Improve traffic flow by reducing stops, and increase safety by reducing rear-end collisions.		
	Widen median on Fellsway West to create a pedestrian refuge area and shorten the crosswalk.	Increase safety for pedestrians.		
	Install countdown pedestrian signals.	Increase pedestrian safety by giving useful information to pedestrians on how long they have to complete a crossing.		

7. BUS TRANSIT IMPROVEMENTS

7.1 TRANSIT PROBLEMS

Malden Transportation Center Area Accessibility Issues

Pedestrian and bicycle needs are important considerations for the Route 60 corridor because of the high density of destinations, such as transit services, supermarkets, restaurants, schools, residences, and other businesses, along Route 60 in Malden and Medford. The Malden Transportation Center is the main transportation hub in the area; it is served by the MBTA Orange Line rapid transit, commuter rail, and buses, making it a multimodal transportation center (see Figure 24). The Malden Transportation Center was recently updated as part of an accessibility improvement program.[9] As part of the Center's accessibility improvement project, the MBTA constructed concrete wheelchair ramps on the west side of the station. The MBTA also replaced the existing sidewalk and wheelchair ramps at the ends of the crosswalks along the MBTA busway at the end of Pleasant Street, the two midblock crosswalks, and the entrance to the station on Centre Street.

The Malden Transportation Center has a commuter parking lot for riders; however, this lot is full (at capacity) early in the morning. The 2003 MBTA Program for Mass Transportation rated parking expansion at Malden Center as "low" in priority, primarily due to the lack of available land for at-grade parking.[10] According to a 2005–2006 bicycle parking inventory conducted by MPO staff, the Malden Transportation Center provides 152 bicycle parking spaces, a 130 percent increase over the 66 spaces in a 1999–2002 inventory. However, the bicycle parking areas are outdoors and are not sheltered.[11] The 2005–2006 inventory indicated that only 9 percent of the bicycle parking spaces were utilized; the low utilization rate could be due, in part, to the fact that the parking is not sheltered. Another accessibility problem is that segments of the sidewalks in the vicinity of the Malden Transportation Center, including sidewalks on Centre Street, Florence Street, and Pleasant Street, need to be repaired.

In general, the majority of the crosswalks in the vicinity of the Malden Transportation Center are indicated with two parallel white solid lines at a right angle to the sidewalks, instead of the standard ladder-type crosswalks, which are more visible to motorists and pedestrians. Also, some of the pedestrian push buttons are not functioning well at the signalized intersections in the vicinity of the station. At the Centre Street and Commercial Street intersection, there are no pedestrian push buttons for activating the pedestrian signals, which creates problems for the pedestrians crossing Commercial Street since its pedestrian phase does not turn on concurrently with the two-way through traffic on Centre Street.

Presently, pedestrians cross Commercial Street by looking for sufficient gaps in the traffic and making sure there are no right-turning vehicles. This creates problems for pedestrians and bicyclists. In addition, right turns on red at traffic lights are allowed during the exclusive pedestrian phase at the intersections of

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9 Malden Center Station Accessibility Improvements, Site Plan, MBTA Contract Number A32CN01.

10 Program for Mass Transportation, Prepared for the Massachusetts Bay Transportation Authority by the Central Transportation Planning Staff, May 2003, revised January 2004.

11 Jared Fijalkowski and Justin Yaitanes, of the Central Transportation Planning Staff to the Transportation Planning and Programming Committee of the Boston Region Metropolitan Planning Organization, December 20, 2007, technical memorandum, "2005–2006 Inventory of Bicycle Parking Spaces and Number of Parked Bicycles at MBTA Stations."

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FIGURE 24
Malden Transportation Center

Route 60 Mobility Study:
Malden and Medford

Centre and Commercial streets, Centre and Pearl streets, and Centre and Main streets, creating vehicle-pedestrian conflicts. The "WATCH FOR TURNING VEHICLES ON WALK SIGNALS" signs that have been installed at the signalized intersections in the vicinity contradict the "YIELD TO PEDESTRIANS" signs found at most intersections in Massachusetts, which are sometimes accompanied by a sign stating that state law requires motor vehicles to stop for pedestrians who are in a crosswalk.

Another accessibility problem at the Malden Transportation Center is that during congested periods, buses exiting the east busway to Commercial Street southbound to proceed to Centre Street eastbound sometimes have difficulty finding a gap in traffic. Sometimes only a single bus exits per cycle. In addition, because the MBTA busway exit on Commercial Street is located close to the intersection (about 60 feet away), it is frequently blocked by traffic queues on the southbound approach.

Bus Transit Service

Several bus transit routes run through the study corridor, but the majority of them have only a short segment on Route 60. The two bus routes that traverse a major portion of the corridor are bus Route 101 (Malden Center–Sullivan Square) and bus Route 325 (Elm Street, Medford–Haymarket Station). The MBTA has service standards that perform two important functions: (1) establish the minimum or maximum acceptable levels of service that the MBTA must provide to achieve its service objectives, and (2) provide a framework for measuring the performance of services as a part of its service evaluation process. The following are some of the standards used in evaluating bus service:

- Span of service refers to the hours during which service is accessible. The span-of-service standards define the minimum period of time that any given service will operate. This provides customers with the confidence that particular types of services will be available throughout the day. The minimum span of service for local routes are: weekdays 7:00 AM – 6:30 PM; and in high-density areas, Saturday 8:00 AM – 6:30 PM and Sunday 10:00 AM – 6:30 PM.

- Schedule adherence standards provide the tools for evaluating the on-time performance of individual MBTA routes. The schedule adherence standards vary, based on frequency of service; passengers using high-frequency services are generally more interested in regular, even headways than in strict adherence to published timetables, whereas passengers on less frequent services expect arrivals and departures to occur as published. The schedule adherence standard for bus service is that 75 percent of all time-points on the route over the entire service day must pass their on-time tests.

- The frequency-of-service standards establish the minimum frequency of service levels by time of day to maintain accessibility to the transportation network within a reasonable waiting period. On less heavily traveled services, these minimum levels dictate the frequency of service, regardless of customer demand. The minimum frequencies for local and community routes are: 30 minutes headway for AM and PM peak periods, 60 minutes headway for other periods, and 60 minutes headway for Saturday and Sunday. The MBTA also has a midday policy objective of 30 minutes headway in high-density areas.

- The vehicle load standards, which vary by mode and time of day, establish the average maximum number of passengers allowed per vehicle to provide a safe and comfortable ride. The vehicle load standards for buses is 140 percent for early AM, AM peak, midday school, and PM peak; 100 percent for other time periods.

Bus Route 101 operates between Malden Center Station and Sullivan Square Station, in Charlestown, via Medford Square and Winter Hill. The route serves communities along Centre and Pleasant streets in

Malden, and along Salem Street in Medford. According to the MBTA's 2008 Service Plan, Route 101 barely failed the loading standard when the standard was evaluated using 2005 ridecheck data.[12] However, current automated-passenger-count data confirm that while Route 101 is often filled to capacity, it very rarely violates the loading standard of 140 percent during peak periods. Route 101 also fails the frequency standard on weekends, which is 60 minutes.

Route 325 operates only on weekdays, from Elm Street at Fellsway West in Medford via Roosevelt Circle, Salem Street, and I-93 to Haymarket Station in Boston. Trips operating in the reverse peak direction (outbound in the morning and inbound in the afternoon) run express between Roosevelt Circle and Haymarket, while peak-direction trips (inbound in the morning and outbound in the afternoon) provide service along Fellsway West and Salem Streets between I-93 and Roosevelt Circle. A recent change, made in the spring of 2008, slightly decreased the frequency, but it addressed the failure to meet the span-of-service (time from the start of service in the morning to the end of service at night) standard on weekdays by moving the last outbound departure to 6:30 PM.

Figures 25 and 26 show the locations of the bus stops and the average weekday boarding and alighting counts at each stop for both inbound and outbound trips. An inventory of the amenities at the bus stops indicated that many of the stops had benches, and many had signs indicating which bus routes have a stop at that particular location. The bus stops do not have bus shelters or bus bays, except for the stop located in front of the Stop and Shop Supermarket on Centre Street in Malden. This bus stop also has a bus bay, which is separated from the travel lanes. At the rest of the bus stops, on-street parking is restricted to allow buses to use the shoulders for passenger boarding and alighting. The MBTA has a process for determining the placement of bus shelters; this process is described below under the section on bus shelters.

Travel Time

The main problem affecting bus transit service in the study corridor is traffic signal delay, which impacts the travel time of buses during peak periods. There are long traffic queues at some of the signalized intersections in the corridor during peak periods, and because buses receive no preferential treatment, it is difficult to achieve schedule adherence standards of 75 percent for all time-points on the route over the entire service day. According to the MBTA's 2008 Service Plan, Routes 101 and 325 fail the schedule adherence standard on weekdays, and Route 101 and Route 325 meet the schedule adherence standard only 60 percent and 43 percent of the time, respectively. About one half of this problem may be attributed to congestion in the Route 60 portion of these routes. Thus, traffic congestion in the Route 60 corridor appears to contribute to longer travel times and less reliable service for bus transit.

7.2 IMPROVEMENTS TO BUS TRANSIT

There are several performance measures that can be altered to improve quality of service. This study did not look at altering quality of service standards, such as service delivery, safety, security, and service availability, to improve service on those routes. The MBTA's Service Plan, updated every two years, deals with service delivery and availability changes. Every two years the MBTA Service Planning Department reviews the level of usage of bus services and reallocates services based on consumer demand. Service standards, as defined in the MBTA's Service Delivery Policy, are used to evaluate route performance. These standards measure ridership, loading, reliability, and other factors. The MBTA held a number of community workshops throughout the greater Boston area in May and June of 2007 to solicit suggestions from the public for the 2008 Service Plan. The MBTA also held community workshops to present the 2008 Service

[12] Final 2008 Service Plan: Bus, Rapid Transit, and Boat Service Changes and Service Delivery Policy Modifications, Massachusetts Bay Transportation Authority, Fall 2008.

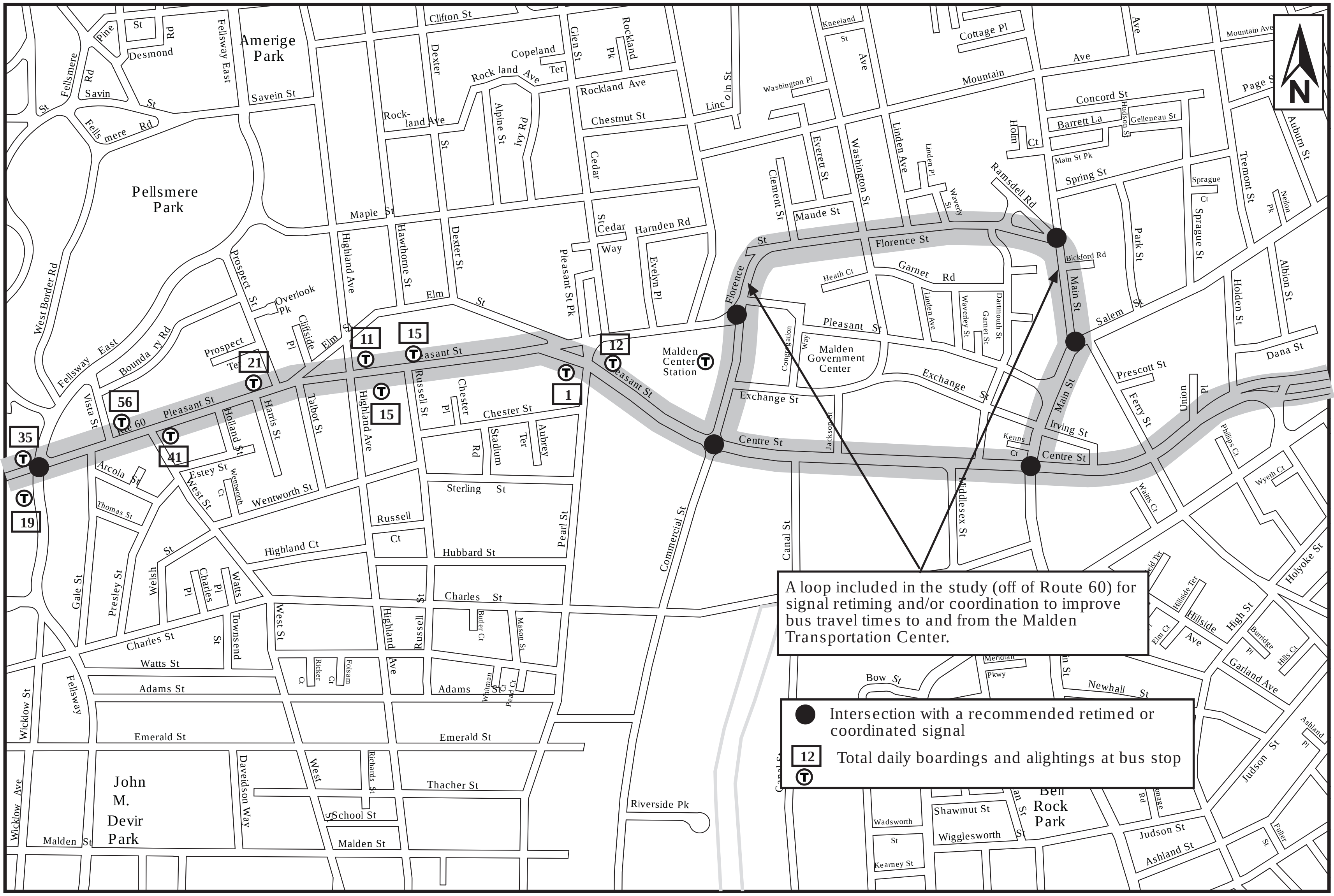

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FIGURE 25
Daily Boardings and Alightings at Bus Stops on Route 60 in Malden

Route 60 Mobility Study: Malden and Medford

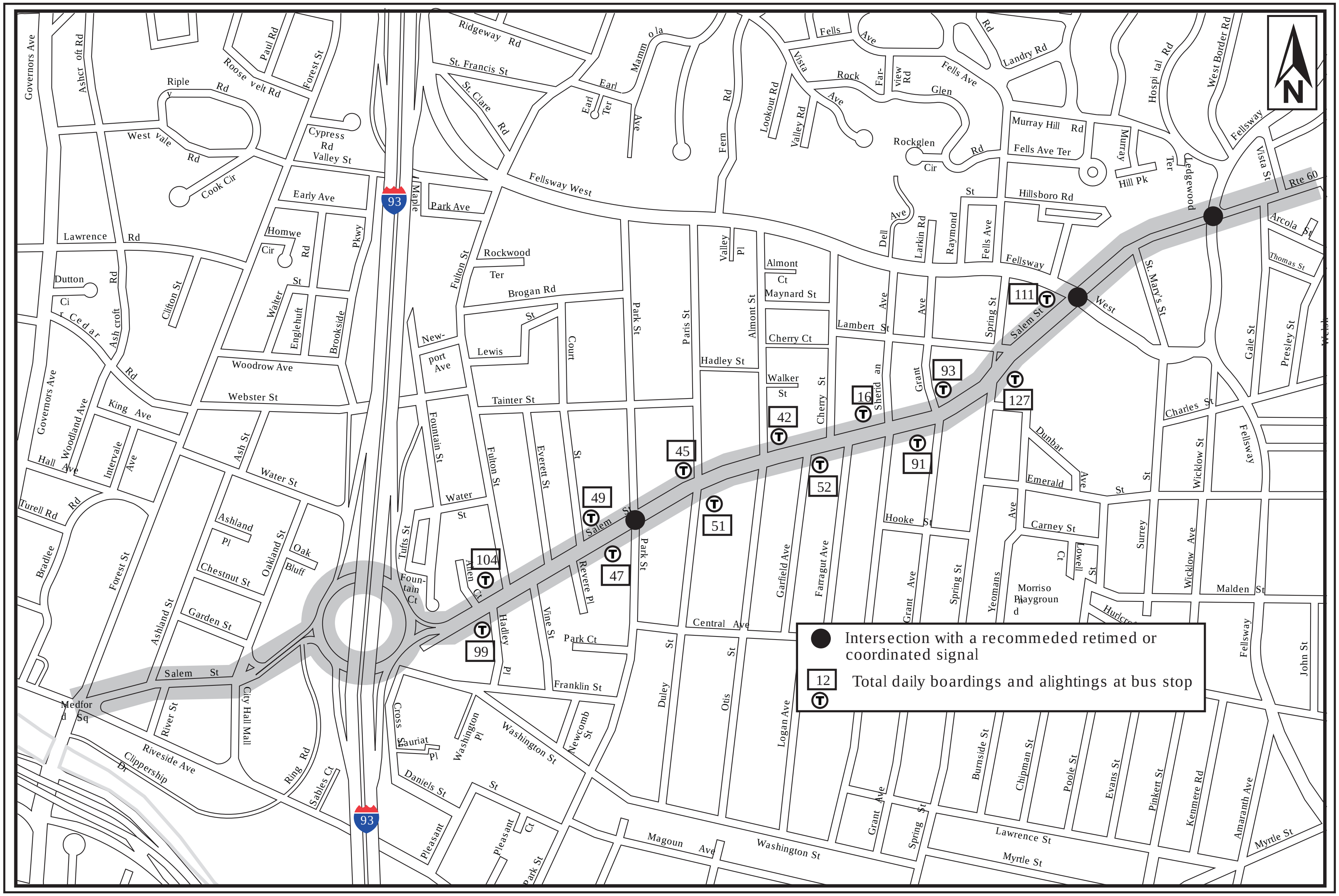

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FIGURE 26
Daily Boardings and Alightings at Bus Stops on Route 60 in Medford

Route 60 Mobility Study: Malden and Medford

Plan and solicit feedback from the public regarding service changes that were proposed in the Plan. The Final 2008 Service Plan is located on the MBTA's website at www.mbta.com/uploadedfiles/About_the_T/T_Projects/T_Projects_List/Final_2008_Service_Plan.pdf.

2008 Service Plan (Recommendations for Routes 101 and 325)

The 2008 Service Plan had the following recommendations for bus Routes 101 and 325.

1. Route 101 technically fails the load standard on weekdays and the frequency of service standard on Saturday and Sunday, as buses operate every 65 minutes rather than every 60 minutes. Route 101 meets the schedule adherence standard 60 percent of the time instead of 75 percent of the time. According to the 2008 Service Plan, no change is recommended for this route for the following reasons:

    a. Although the bus is often filled to capacity, it very rarely violates the load standards. The MBTA will monitor ridership closely.

    b. Tightening the headway would require adding a bus to the route on weekends, but ridership levels at those times do not warrant this additional expense.

2. According to the 2008 Service Plan, Route 325 meets the schedule adherence standard on weekdays 43 percent of the time instead of 75 percent of the time, and technically fails the weekday span-of-service standard, which is service from 7:00 AM to 6:30 PM. According to the 2008 Service Plan, the following changes have already been implemented:

    a. The changes to the route in the spring of 2008 addressed the failure of the span-of-service standard by moving the last outbound departure from 6:29 PM to 6:30 PM. The changes also eliminated the failure of the cost standard.

    b. Run times were modified for the summer 2008 schedules to create more accurate arrival times on the schedule, allowing customers to better plan their travel.

Bus Shelters

The MBTA Operations department is responsible for evaluating bus shelter placement requests and ensuring compliance with the federal Title VI regulations. The first step in the evaluation process is a determination of whether or not the bus stop conforms to shelter eligibility standards (see Appendix A). The number of boardings at a bus stop is a major determinant of eligibility for having a bus shelter. A number of other criteria are also considered. To standardize the process, the criteria have been given numeric values. A site must receive a total of 70 points to be considered eligible for a shelter under this policy. The second step in the evaluation process is the site suitability test; there are physical and practical requirements that must be met before a shelter can be placed. These include: property ownership, abutter approval, compliance with the Americans with Disabilities Act requirements, adequate physical space and clearances, close proximity to an existing bus stop, and community approval.

As Figures 25 and 26 show, some of the bus stops in the study corridor may be eligible for a shelter based on the number of boardings described in the first step of the evaluation process. Such bus stops in the Medford section include #5282 Salem Street, at Grant Avenue, and #5287 Salem Street, at Allen Court, for the inbound direction. However, site suitability tests in the second step of the evaluation process may prove challenging because of lack of space on the sidewalks and other issues. Bus shelters would significantly decrease the width of sidewalks and therefore might create problems for pedestrians and bicycles. Therefore, no recommendation is made in this report about installing bus shelters.

Bicycle Parking

The 2005–2006 bicycle-parking inventory indicated that only 9 percent of the bicycle parking spaces at the Malden Transportation Center Station were utilized. However, the utilization rate is expected to increase when high gas prices result in ridership increases on the MBTA system. Improvements suggested for bicycle parking include adding a roof or other shelter over each bicycle rack. This should be easiest at locations closest to the station building. Adding lights to illuminate bicycle racks would increase safety and security.

Station Access

Pedestrian safety and access improvements were developed for the signalized intersections on Route 60 in the Malden section of this report; they include the intersections of Centre Street at Commercial Street and Centre Street at Main Street in the vicinity of the Malden Transportation Center (see Chapter 4 for more details). In addition to these two intersections, the streets of the loop formed by Centre Street, Main Street, Florence Street, and Commercial Street were evaluated for pedestrian and accessibility improvements in a previous study.[13] In that study, staff recommended the following improvements to increase ease of access to the Malden Transportation Center for all pedestrians and bicyclists in the area, as well as for all transit users, including bicyclists and pedestrians.

- Repair and maintain the sidewalks on Centre Street, Pleasant Street, and Florence Street to increase safety for pedestrians, wheelchair users, and stroller users.

- Add exclusive pedestrian phases and “NO TURN ON RED” signs at the intersection of Centre Street and Commercial Street to increase safety and reduce vehicle-pedestrian conflicts.

  An alternative to an exclusive pedestrian phase and “NO TURN ON RED” signs at Centre Street and Commercial Street would be to have concurrent crossings and add “YIELD TO PEDESTRIANS” signs. This would reduce delay for all users. This could also allow for the elimination of all pedestrian-activated push buttons. However, this would not reduce vehicle-pedestrian conflicts; hence it would not provide the same level of safety as an exclusive pedestrian phase.

- Install pedestrian-crossing signals that have a countdown display at the following intersections: Centre Street at Commercial Street, and Pleasant Street at Commercial Street/Florence Street.

- Fix the malfunctioning pedestrian-activated push buttons and install the missing pedestrian crossing signals at the intersections of Centre Street at Commercial Street and of Centre Street at Pearl Street that had been removed.

- Install “YIELD TO PEDESTRIANS” signs at all traffic approaches at intersections with concurrent pedestrian phases in the vicinity of the Malden Transportation Center. Replace “WATCH FOR TURNING VEHICLES ON WALK SIGNALS” signs with “YIELD TO PEDESTRIANS” signs, which place an emphasis on motorists yielding for pedestrians in crosswalks, which is required by state law.

- Paint the crosswalks at the intersections in the vicinity of the Malden Transportation Center that have only two white parallel stripes with ladder-style stripes, which are more visible to both motorists and pedestrians (at Centre Street and Commercial Street, and at Pleasant Street and Florence Street/ Commercial Street).

[13] Improving Pedestrian and Bicycle Access to Selected Transit Stations, a report produced by the Central Transportation Planning Staff for the Massachusetts Highway Department and the Massachusetts Bay Transportation Authority, September 2005.

- Implement transit signal priority at this intersection to reduce delay for buses trying to exit the east busway to Commercial Street southbound to get to Centre Street eastbound. Implementing a transit signal priority at this intersection would require a signal system upgrade to enable it handle a request from buses, and buses would need to be equipped with technology to submit a request. For transit signal priority to operate efficiently, the east busway exit might have to be signalized and tied to the main signal at the intersection of Centre Street and Commercial Street, or some form of signage might have to be installed at the east busway exit, to prevent Commercial Street southbound vehicles from blocking the busway exit when a bus request is submitted.

Travel-Time Improvements

Because the 2008 Service Plan dealt with service span, frequency, load, and cost failures, efforts in this study were concentrated on improving travel times in the study corridor to improve schedule adherence to the on-time standard. To improve bus transit operations in the corridor, particularly bus circulation to and from Malden Transportation Center and in the Route 60 study corridor, staff recommend signal retiming and coordination for the following eight signalized intersections.

1. Pleasant Street (Route 60) and Fellsway East in Malden
2. Centre Street (Route 60) and Commercial Street in Malden
3. Centre Street and Main Street in Malden
4. Salem Street and Park Street in Medford
5. Salem Street and Fellsway West in Medford
6. Pleasant Street and Commercial/Florence Street in Malden
7. Main Street and Florence Street in Malden
8. Main Street, Salem Street, and Ferry Street in Malden

Traffic signal coordination is suggested for the abovementioned signals except for the intersection Salem Street and Park Street in Medford, which is an isolated signalized intersection. The first five signalized intersections were already part of the list of study intersections suggested by municipal officials as locations with pedestrian and vehicular safety and operations problems. The last three intersections were added to the study later on to improve bus circulation at the station area, particularly in the loop consisting of Centre Street, Main Street, Florence Street, and Commercial Street (see Figure 25). Figures 27 through 29 show the traffic volumes and pedestrian counts for the three intersections in the loop, where upgrades can be made cost-effectively. The traffic volumes and pedestrian counts were conducted during the peak travel periods, 7:00–9:00 AM and 4:00–6:00 PM.

Tables 11 and 12 show that signal retiming and coordination could improve travel time in the study corridor by approximately 5 to 7 percent in the peak direction of travel (inbound in the AM peak period and outbound in the PM peak period). The results also show that travel time in the study corridor could be improved by approximately 11 to 14 percent in the off-peak direction (outbound in the AM peak period and inbound in the PM peak period). Thus, traffic signal retiming and coordination improvements should reduce congestion and delays for all roadway users, including bus riders.

7.3 SUMMARY OF IMPROVEMENTS

Table 13 summarizes the recommended improvements for bus transit in the corridor. Successful implementation of the projects advancing from this study is dependent on coordination between the City of Malden and the Massachusetts Bay Transportation Authority, and on securing funding for the projects.

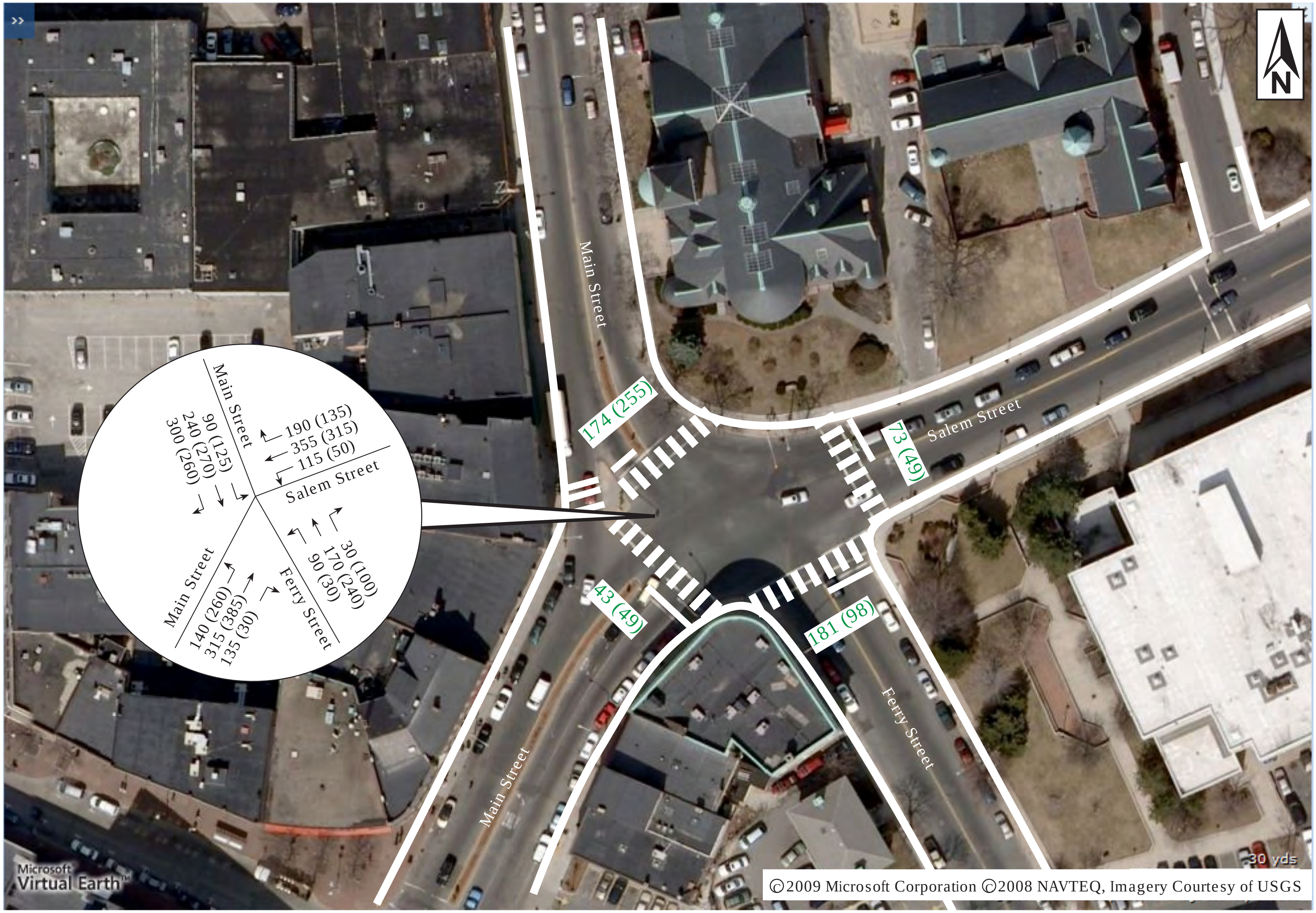

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FIGURE 27
Pedestrian and Vehicular Volumes at the
Main Street, Salem Street, and Ferry Street Intersection in Malden

Route 60 Mobility Study: Malden and Medford

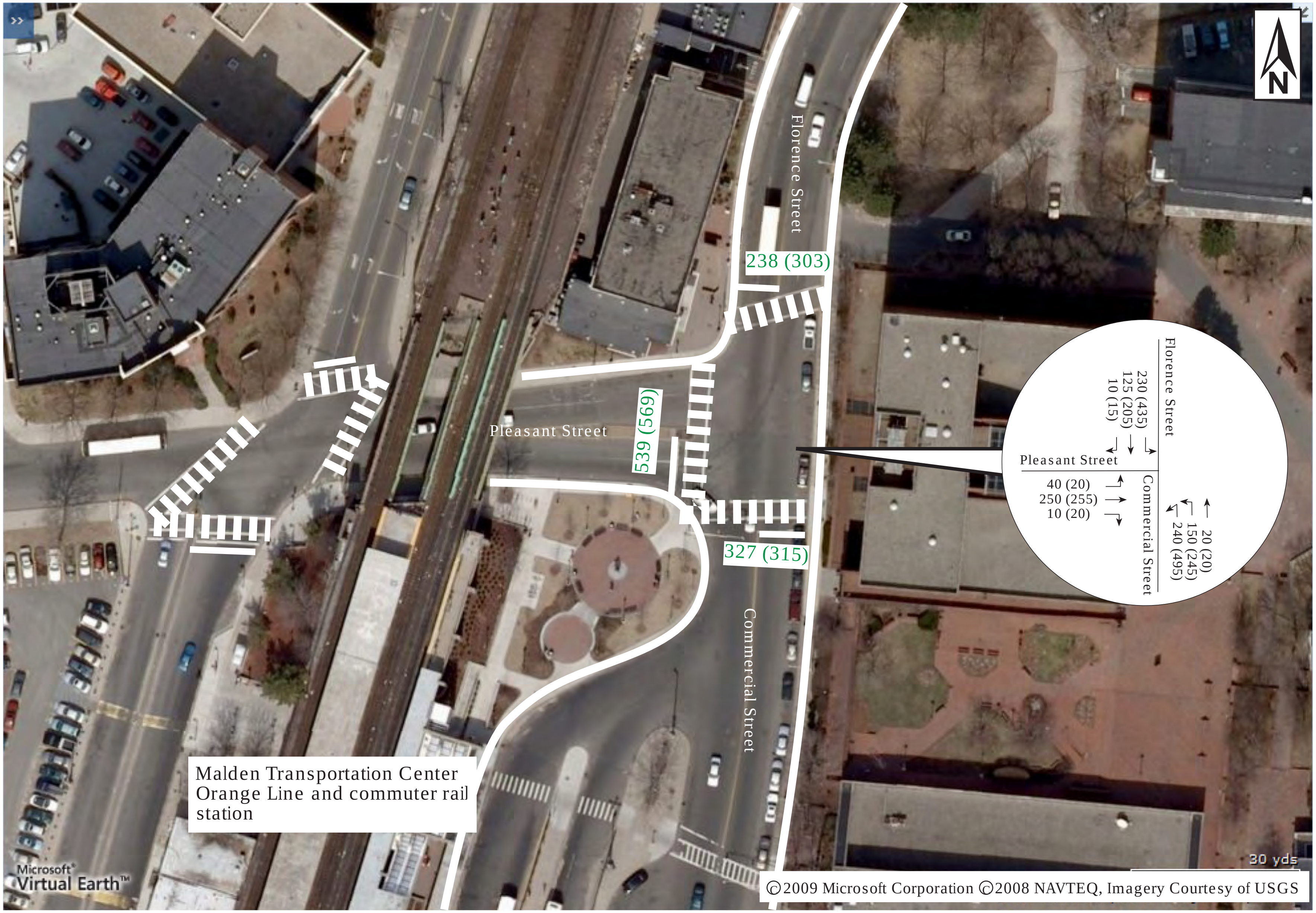

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FIGURE 28
Pedestrian and Vehicular Volumes at the
Pleasant Street and Commercial/Florence Street Intersection in Malden

Route 60 Mobility Study:
Malden and Medford

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FIGURE 29
Pedestrian and Vehicular Volumes at the
Main Street and Florence Street Intersection in Malden

Route 60 Mobility Study: Malden and Medford

TABLE 11
Results of Signal Retiming and Coordination:
AM Peak Hour

AM Peak Hour (Inbound)						
			Travel Time (seconds)		Arterial Speed (mph)	
Arterial Segment	**City**	**Distance**	**Optimized**	**Existing**	**Optimized**	**Existing**
Commercial Street From Florence Street to Centre Street	Malden	0.10	47.4	38.8	11	11
Centre Street From Commercial Street to Pearl Street	Malden	0.15	36.8	34.8	13	13
Pleasant Street From Pearl Street to Mary Street	Malden	0.65	207.0	245.0	12	10
Salem Street From Mary Street to Medford City Hall	Medford	1.05	434.0	450.0	11	12
Total		**1.95**	**725.2**	**768.6**	**11**	**11**
			Difference = 43.4 sec (5.7%)		**Difference = 0**	
AM Peak Hour (Outbound) **Including the loop on Main Street and Florence Street**						
Salem Street From Medford City Hall to Mary Street	Medford	1.05	229.0	232.0	15	15
Pleasant Street From Mary Street to Pearl Street	Malden	0.65	152.3	156.7	16	15
Centre Street From Pearl Street to Main Street	Malden	0.40	76.5	92.3	19	17
Main Street From Centre Street to Florence Street	Malden	0.30	103.2	182.0	10	6
Florence Street From Main Street to Pleasant Street	Malden	0.40	66.4	66.9	20	20
Total		**2.80**	**627.4**	**729.9**	**16**	**14**
			Difference = 102.5 sec (14%)		**Difference = 2 mph (12%)**	

TABLE 12
Results of Signal Retiming and Coordination:
PM Peak Hour

PM Peak Hour (Inbound)						
			Travel Time (seconds)		**Arterial Speed (mph)**	
Arterial Segment	**City**	**Distance**	**Optimized**	**Existing**	**Optimized**	**Existing**
Commercial Street From Florence Street to Centre Street	Malden	0.10	37.5	37.7	11	11
Centre Street From Commercial Street to Pearl Street	Malden	0.15	25.6	40.7	17	11
Pleasant Street From Pearl Street to Mary Street	Malden	0.65	172.3	196.7	15	14
Salem Street From Mary Street to Medford City Hall	Medford	1.05	566.2	627.0	12	11
Total		**1.95**	**801.6**	**902.1**	**13**	**12**
			Difference = 100 sec (11%)		**Difference = 1 mph (8.3%)**	
PM Peak Hour (Outbound) **Including the loop on Main Street and Florence Street**						
Salem Street From Medford City Hall to Mary Street	Medford	1.05	458.4	467.9	14	12
Pleasant Street From Mary Street to Pearl Street	Malden	0.65	307.0	345.0	10	9
Centre Street From Pearl Street to Main Street	Malden	0.40	112.6	113.0	14	14
Main Street From Centre Street to Florence Street	Malden	0.30	128.6	141.9	8	7
Florence Street From Main Street to Pleasant Street	Malden	0.40	56.6	71.6	23	18
Total		**2.80**	**1063.2**	**1139.4**	**14**	**13**
			Difference = 76.0 sec (6.6%)		**Difference = 1 mph (7.7%)**	

TABLE 13
Summary of Improvements Related to Bus Transit

Location	Improvement	Expected Benefits	Costs	Implementing Agency
Centre Street and Commercial Street	Add exclusive pedestrian phase and “NO TURN ON RED” signs. Fix malfunctioning pedestrian-activated push buttons and install missing pedestrian crossing signals.	Increase safety and reduce vehicle-pedestrian conflicts.	See footnote[14]	City of Malden/ MBTA
	Install countdown pedestrian signals.	Increase pedestrian safety by giving useful information to pedestrians.		
	Implement transit signal priority.	Reduce waiting times for buses to exit from the east busway.		
	Paint the crosswalks with ladder-style stripes.	Make crosswalks safer for pedestrians by making them more visible to both motorists and pedestrians.		
Pleasant Street and Commercial Street/Florence Street	Install countdown pedestrian signals.	Increase pedestrian safety by giving useful information to pedestrians.	$20,000	City of Malden
	Paint the crosswalks with ladder-style stripes.	Make crosswalks safer for pedestrians by making them more visible to both motorists and pedestrians.		
	Install “YIELD TO PEDESTRIANS” signs.	Increase motorists’ awareness of pedestrians.		
Centre Street and Pearl Street	Fix the malfunctioning pedestrian-activated push buttons and install missing pedestrian crossing signals.	Increase pedestrian safety by providing better equipments.	$50,000	City of Malden
	Install “YIELD TO PEDESTRIANS” signs	Increase motorists’ awareness of pedestrians.		
	Align wheelchair ramps, curb cuts, and crosswalks in the direction of pedestrian flow, parallel to Centre Street.	Increase pedestrian safety by providing better equipments		
Centre Street, Pleasant Street, Commercial Street, and Florence Street in the vicinity of the Malden Transportation Center Station	Repair and maintain sidewalks.	Make sidewalks safer and help prevent injuries caused by defective sidewalks to users of wheelchairs and strollers, pedestrians, and bicyclists.	$50,000	City of Malden/ MBTA
	Paint the crosswalks with ladder-style stripes.	Make crosswalks safer for pedestrians by making them more visible to both motorists and pedestrians.		
Malden Center Station	Add a roof/shelter over the bike racks Add lights to illuminate bicycle racks at night.	Improve safety and quality of service for bicyclists.		MBTA
Centre Street, Main Street, Florence Street, and Commercial Street	Retime and/or coordinate the traffic signals along the loop.	Assist bus operations, particularly circulation to and from Malden Center Station. Improve bus transit schedule adherence and on-time performance.	$100,000	City of Malden

[14] Already accounted for in the summary of improvements for Malden in Table 5.

8. CONCLUSION

This study has identified several improvements to address the issues of mobility and safety in the Route 60 corridor for motorists, bicyclists, pedestrians, and transit users. All of the improvements are short-term or intermediate-term and could be implemented within five years. There are several agencies that operate transportation facilities in the corridor, including the Massachusetts Highway Department, the Massachusetts Department of Conservation and Recreation, and the MBTA, in addition to the Cities of Malden and Medford. Successful implementation of the projects advancing from this study is dependent on coordination among the stakeholders, sufficient public participation, and securing funding for the projects.

For reference, a description of the implementation process of the Massachusetts Highway Department is provided (see Appendix B). The process for implementing new and modified MBTA services is based on the service planning process defined in the 2006 Update of the MBTA Service Delivery Policy (see Appendix C).

Appendix A

Massachusetts Bay Transportation Authority: Bus Shelter Policy

BUS SHELTER POLICY
(Effective: April 2005)

A. Purpose

The purpose of this policy is to provide guidance for the placement of MBTA bus shelters and to establish a procedure for evaluating shelter requests. In areas or locations where the MBTA, or its contractors, are the primary suppliers of shelters at bus stops, placements will be evaluated using two steps:

1. Conformance with eligibility standards, and
2. A site suitability test.

Central to any placement decision will be a commitment to meeting the requirements of Title VI of 1964 Civil Rights Act as defined in the FTA Circular C 4702.1. Title VI ensures that MBTA services are distributed in such as manner that minority communities receive benefits in the same proportion as the total service area.

This policy in no way establishes a requirement for placement, since all placements will be dependent on available resources.

B. Background

The previous shelter policy was established in 1984, having been extracted from the 1977 Service Policy for Surface Public Transportation. This older policy considered three major factors when evaluating stops: number of boardings, frequency of service, and percentage of persons using the stop that were elderly or had disabilities.

The current policy continues to include these important measures; however, it more systematically quantifies each factor in determining eligibility.

C. Evaluation Procedure

MBTA Operations will be responsible for evaluating placement requests and ensuring compliance with Title VI.

The first step in the evaluation process is a determination if the bus stop conforms with shelter eligibility standards. As in the previous shelter policy, the number of boardings at a bus stop is a major determinant for eligibility. As described in the table below, all bus stops that meet the required number of boardings will be eligible. However, a number of other criteria can also be considered. To standardize the process, the various types of criteria have been given values. The following table lists all criteria to be factored into an assessment of eligibility for each bus stop and the value associated with each criterion. A site must receive a total of 70 points to be considered eligible under this policy.

Any bus stop that has more than 60 boardings is eligible for a shelter, with an automatic score of 70 points. For bus stops with fewer boardings, a combination of the factors listed above will be considered in determining eligibility. Operations will keep records of all requests that document the assignment of scores. All bus stops that currently have shelters will be grandfathered into the program without need for additional analysis.

Eligibility Criteria	Points
60+ Average weekday daily boardings (ADB)	70
50-59 ADB	60
20-49 ADB	40
Less than 20 ADB	30
MBTA initiative to strengthen route identity	20
Seniors, disabled, medical, social service, or key municipal facility in close proximity to stop	15
Official community recommendation	10
Bus route transfer point	10
Infrequent service (minimum of 30minute peak/60minute off peak headway)	10
Poor site conditions (weather exposure etc.)	5
Shelter promotes adjacent development/increased ridership	5

Passing Score: **70**

The second step in the evaluation process is the site suitability test. There are physical and practical requirements that must be met before a shelter can be placed. These include:

(1) Property ownership,
(2) Abutter approval,
(3) Compliance with the Americans with Disabilities Act requirements,
(4) Adequate physical space and clearances,
(5) Close proximity to an existing bus stop, and
(6) Community approval

D. Reporting

The Operations Department will retain the necessary documents to ensure correct application of the policy. The Service Planning Department and CTPS will submit the required Title VI reports. Title VI ensures that MBTA services are distributed in such as manner that minority communities receive benefits in the same proportion as the total service area.

In terms of the shelter policy, once a bus stop is eligible for a shelter it will be included in all analyses for Title VI purposes, until such time that it is indicated otherwise. Consequently, all bus stops with 60 or more boardings will be included in Title VI reports, as well as any bus stops with less than 60 boardings that meet the 70-point eligibility requirement. Any bus stop that meets the eligibility standard, but is found not to meet the site suitability test, will be noted and not included in the analysis. Bus stops in the MBTA service area that have pre-existing shelters, but do not meet the policy requirements, will be noted and included in the total comparisons.

Appendix B

Massachusetts Highway Department Project Implementation Process

The following description of the implementation process is based on Chapter 2 of the *Massachusetts Highway Department Project Development and Design Guide (2005)*. The text below borrows heavily from that document.

Needs Identification

For each of the locations at which an improvement is to be implemented, MassHighway 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, MassHighway meets with potential participants, such as the Boston Region Metropolitan Planning Organization (MPO) and community members, to allow for an informal review of the project.

The PNF is reviewed by the MassHighway district office whose jurisdiction includes the location of the proposed project. MassHighway 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.

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.

Project Initiation

At this point in the process, the proponent, MassHighway, fills out, for each improvement, a Project Initiation Form (PIF), 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 Capital Expenditure Program Office (CEPO). 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 Executive Office of Transportation and Public Works's statewide priorities and criteria. If the result is positive, MassHighway 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 a project evaluation criteria score, a Transportation Improvement Program (TIP) year, a tentative project category, and a tentative funding category.

Environmental, 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.

Programming

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, where the MPO receives preliminary information on the proposed project, the proponent requests that the MPO place the project in the region's TIP. The MPO considers the project in terms of 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.

Procurement

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

Construction

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

Project Assessment

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

Appendix C

Massachusetts Bay Transportation Authority Service Delivery Policy

Chapter 4: Service Planning Process

Chapter 4: Service Planning Process

The MBTA regularly evaluates the performance of its services through the service planning process. The primary objective of the service planning process is to ensure that the MBTA uses available resources in the most effective manner by developing strategies to improve performance and/or to reallocate service within the system.

The service planning process varies somewhat by mode and is affected by whether or not the service is operated directly by the MBTA (bus and rapid transit), or is operated for the MBTA by a contractor (commuter rail and boat). Following is a discussion of the process for each mode. The final section of this chapter outlines the procedures for public participation in the service planning process.

Directly Operated Services

- **Bus Service Planning Process**
  The bus service planning process takes place on two levels. One is the on-going evaluation and implementation of incremental service changes that occur on a quarterly basis. The other is a two-year planning cycle for development of the biennial Service Plan, which can include major restructuring of existing bus routes and proposals for new bus services.

  The data used for all service evaluations are collected on a regular basis through various means to track and evaluate the performance of services against each of the Service Standards (as defined in Chapter 3).

  The primary differences between the on-going service planning process and the planning process used to develop the Biennial Service Plan include:
  - the magnitude of the service changes considered (minor or major—as defined below);
  - the extent and type of analysis used;
  - the level of public participation; and
  - whether the effort is incremental or comprehensive in nature.

  Minor changes to bus services are made through the on-going service planning process and can be implemented with existing equipment, within the adopted budget, and without significantly affecting route structure or service delivery.

  Major changes are ones that will have a significant effect on riders, resource requirements, route structure, or service delivery (as defined in Table 1). These are evaluated and implemented only through development of the Biennial Service Plan (with the exception of new services associated with a major capital investment).

Table 12: Minor & Major Service Changes

Magnitude:	Type:	Resource Implications:
Minor	• Running time adjustments • Departure time adjustments • Headway changes to match ridership and service levels (provided the frequency and loading standards are still met) • Changes to bus stop locations • Alignment changes • Span of service changes within 1 hour or less • Route extensions of 1 mile or less • Route variation modifications	Changes that can be implemented with existing equipment and within the adopted budget
Major	• Major service restructuring • Implementation of new routes or services • Elimination of a route or service • Elimination of part of a route • Span of service changes greater than 1 hour	Changes that will have a significant affect on resources and may potentially have a significant affect on riders

The On-going Bus Service Planning Process: The service changes that are evaluated in the on-going service planning process can be initiated in a variety of ways. These include, but are not limited to:

- service requests and/or complaints from the public;
- feedback from MBTA Bus Operations staff, such as drivers, garage superintendents or schedule makers;
- proposals made by the MBTA Service Planning staff; and
- studies completed by CTPS (for the Boston MPO), by other regional entities, or by municipalities.

Service Planning staff screen all potential service changes to determine whether they are minor or major in nature (as defined above). In addition, each potential change is considered using the criteria listed below (not all criteria are necessarily used in every evaluation).

- Performance measured against the Service Standards
- The rationale for the change
- Net cost per new passenger
- Net savings per lost passenger
- Changes in ridership
- Changes in travel time for existing riders
- Changes in operating costs
- Changes in fare revenue
- Key characteristics and demographics of the market
- Contribution to the achievement of external mandates, such as Title VI
- Other factors, as appropriate

Proposed minor changes that have been analyzed by the Service Planning Department are presented to the Service Committee, which is chaired by the Manager of Service Planning and includes representatives of the following departments:

- Service Planning
- Plans and Schedules
- Bus Operations
- Operations Support
- Customer Communications Center
- Office for Transportation Access
- Public Affairs,
- Intergovernmental Affairs
- Other Departments, as appropriate

Minor changes that are approved by the Service Committee, and that can be made within the adopted budget, are implemented as soon as possible—usually in the next quarterly schedule change.

The Biennial Service Plan Process: Every two years, the MBTA develops a biennial Service Plan that describes the performance of the system and the services that will be operated in the upcoming two years. The plan encompasses all fixed-route services and includes:

- a description of the performance of existing services;
- recommendations for major service changes;
- a discussion of service changes that were considered and/or evaluated, but are not recommended at the time; and
- a general review of the effectiveness of previous major service changes (major service changes would not be reported on in the service planning cycle immediately after their implementation, but would be evaluated in the following planning cycle to allow time for ridership to build).

As with the on-going service planning process, a major goal in the development of the biennial Service Plan is to ensure that the MBTA uses available funds in the most effective manner. However, this planning process can also identify major service changes and enhancements that have merit, but that cannot be funded within the existing operating budget. In such cases, the need for additional operating funds can be identified for request, and the service can be implemented when sufficient resources become available.

A key component of the biennial service planning process is an evaluation of the performance of existing services, as measured using the Service Standards found in Chapter 3 of this policy. Based on this analysis, the Service Planning Department proposes major service changes that will improve the performance of services that fail any of the Service Standards. (Minor service changes may also be identified at this time; however, they may be implemented as soon as possible, rather than waiting for the full acceptance of the Service Plan.)

Service changes considered in the biennial Service Plan can also be proposed through all of the same avenues as those considered in the on-going service planning process. Indeed, many may be identified through the on-going screening of projects. In addition, public input for the biennial Service Plan is sought through public meetings and public hearings, as described later in this chapter.

During development of the biennial Service Plan, potential major changes are evaluated through a comparative evaluation to determine which represent the best allocation of available resources. To complete the comparative evaluation, the Service Planning Department creates a list of all proposed service increases and reductions. The proposed service increases are ranked using the net cost per new passenger: those that garner the most new passengers at the lowest incremental cost are ranked highest priority for implementation. The proposed service reductions are ranked using the net savings per lost passenger: those that save the most money with the lowest loss of passengers are ranked highest priority for implementation.

Other evaluation criteria are also used in the comparative evaluation, as appropriate, to determine the rank of service change proposals. For example, higher priority would be given to a proposed change that improved a route's performance on one or more of the service standards (as defined in Chapter 3).

After the rankings are completed, the savings from the major service reductions are compared to the cost of major service enhancements to help select the proposed service changes. The goal is to maximize ridership and service performance in a cost-effective manner. The recommendations that result from this process are reviewed by the Service Committee to assess the feasibility of implementation before they are included in the Preliminary Service Plan. Each Preliminary Service Plan is made available to the public for review and comment (as described later in this chapter). A list of the final recommendations, an indication of the routes that still violate one or more of the service standards, and the Title VI analysis are then submitted to the MBTA Board of Directors for final approval before the changes are implemented.

Table 13: Summary of Service Planning Processes

	On-going Service Planning Process	Biennial Service Plan Process
Magnitude of changes:	• Minor	• Major
Initiation of changes:	• Requests/complaints from public • Bus Operations feedback • Service Planning Staff • Service Studies	• Requests/complaints from public • Bus Operations feedback • Service Planning Staff • Service Studies • Public Meetings
Evaluation of changes:	• Route or garage level analysis using the Evaluation Criteria • Review by Service Committee	• Route or garage level analysis using the Evaluation Criteria (including performance review of all services using Service Standards) • Comparative evaluation of proposed service changes, and possible new services • Review by Service Committee • Public review and comment • Title VI analysis
Implementation of changes:	• Quarterly with regular schedule changes	• Biennially, upon approval of the Service Plan by the MBTA Board of Directors

- **Light Rail/Heavy Rail Service Planning Process (to be completed)**

Contract Services

- **Commuter Rail Service Planning Process (to be completed)**
- **Commuter Boat Service Planning Process (to be completed)**

Public Participation

Public participation in the service planning process varies somewhat by mode and occurs as both an on-going process and as a Service Plan specific process. The purpose of public involvement in the service planning process is to promote a regular dialogue with existing and potential riders, elected officials, and communities regarding their ever-changing service needs

- **On-Going Public Outreach**
  The MBTA provides avenues for on-going communication through the MBTA's website, as well as the customer complaints phone line and comments sent to individual MBTA officials. Service related comments/requests are directed to the appropriate department for consideration and response. Upon request, MBTA staff also attend public meetings held by municipalities and meetings with public

officials to address specific service issues. In addition, from time to time, the MBTA may conduct specific market or route-based surveys to gather direct input on a major service change or potential new service.

- **Biennial Service Plan Public Outreach**
  Service Plan outreach efforts are intended to provide members of the public with the opportunity to submit service requests to the MBTA for consideration in development of the Biennial Service Plan. To this end, the MBTA solicits ideas for service changes through written comments (submitted on-line or via the mail), as well as through public meetings throughout the service area, before a draft plan is written.

  Upon completion of the draft biennial Service Plan, the MBTA schedules a second round of public meetings in appropriate locations. At these open meetings the MBTA presents the analysis and issues behind the proposed service changes and solicits public comments on them. In addition, at least one Public Hearing is held to receive formal public comments on the draft Biennial Service Plan. MBTA staff then assess and analyze the suggestions made through the public comments and, as appropriate, incorporate them into the final recommendations that go to the MBTA Board of Directors for approval before implementation.

  All Service Plan public notifications, meetings, and hearings will conform to the requirements of the Americans with Disabilities Act, Title VI of the Civil Rights Act of 1964, and MBTA policies associated with these laws.

3. PROBLEMS AT STUDY LOCATIONS IN MALDEN

3.1 PLEASANT STREET AND FELLSWAY EAST

The intersection of Pleasant Street and Fellsway East is a five-legged signalized intersection. It is located in a residential area about 750 feet east of the Medford town line. Figure 3 shows the intersection's geometry and lane configuration. On-street parking is prohibited on Fellsway East north of Pleasant Street, but it is allowed south of Pleasant Street. The pavement and granite curbs are in good condition. The traffic signals are post-mounted, and the signal heads are in good condition and are visible to motorists.

Pedestrian and Bicycle Operations and Safety Problems

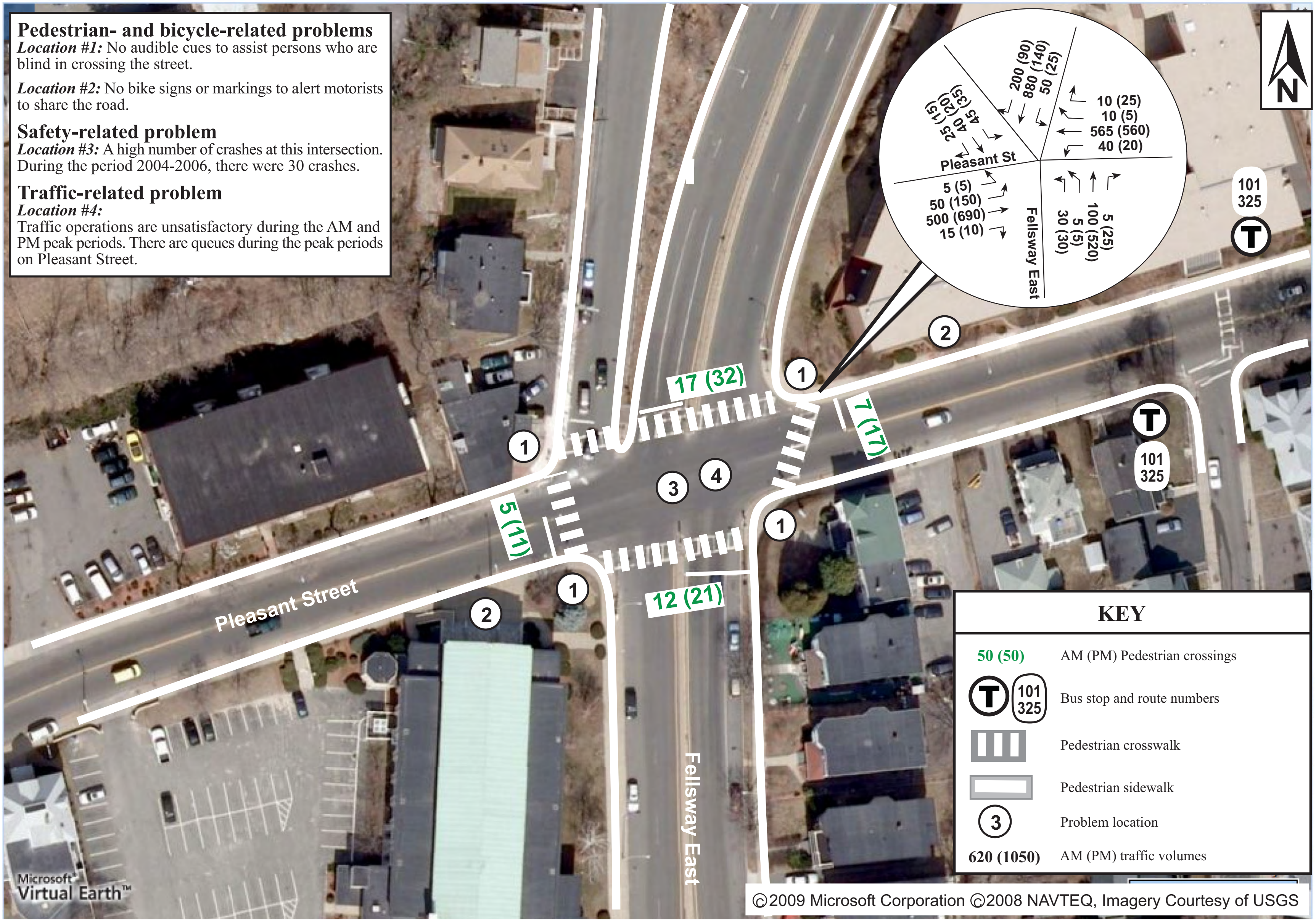
An exclusive pedestrian signal phase and a "NO RIGHT TURN ON RED" sign on Pleasant Street reduce conflicts between pedestrians and vehicular traffic at this intersection. Pedestrian push buttons have been provided for activating the pedestrian walk phase; once activated, the pedestrian walk signal is turned on at all approaches and all vehicular movements are stopped. A symbol of a person walking and a flashing or steady red hand designate the pedestrian "WALK" and "DON'T WALK" phases, respectively. There is no audible pedestrian signal (APS) to assist persons who are blind in crossing either street.

The pedestrian crosswalks are marked across all five approaches with parallel white stripes sufficiently visible to pedestrians and motorists, and are aligned perpendicular to each approach. The stop lines are white and are set back about four feet from the crosswalks. The sidewalks on both Pleasant Street and Fellsway East are six to eight feet wide, are made of concrete, and are in good condition. Each corner of the intersection features two sidewalk curb cuts for wheelchairs, one for each crosswalk. Street trees and street furniture, such as benches, streetlights, newspaper boxes, mailboxes, and trash receptacles, do not reduce the width of the sidewalk to less than five feet. Figure 3 shows the pedestrian crossings in green. On the day of observation, 51 pedestrians crossed at the intersection during the AM peak period (7:00–9:00 AM) and 73 pedestrians crossed during the PM peak period (4:00–6:00 PM).

Traffic Operations and Safety Problems

Table 1 presents the traffic delay, level of service, and queuing at the Pleasant Street and Fellsway East intersection. Traffic operations at this intersection are not satisfactory. During the AM peak period, traffic at the southbound approach of Fellsway East operates at LOS E. Also, a traffic queue forming at the westbound approach of Salem Street (Route 60) at the Fellsway West (Route 28) intersection in Medford extends eastward into the Fellsway East intersection, affecting its operations. During the PM peak period, traffic at the eastbound approach of Pleasant Street operates at LOS F, and its queue extends westward toward the Fellsway West (Route 28) intersection in Medford.

The crash rate, frequency, and characteristics at this intersection are presented in Table 2 and Table 3, respectively. Shading denotes intersections with higher crash rates than the MassHighway District 4 average for comparable intersections. At the Fellsway East intersection, the crash rate of 1.04 per million entering vehicles (MEV) is higher than the 0.88 crashes per MEV that is the average for MassHighway District 4 signalized intersections. Between 2004 and 2006, there were 30 crashes at the Pleasant Street and Fellsway East intersection, many of them rear-end and angle/sideswipe crashes (see Table 3). None of



CTPS

FIGURE 3
Mobility Problems at the Pleasant Street (Route 60) and Fellsway East Intersection

Route 60 Mobility Study: Malden and Medford

TABLE 1
Delay, Level of Service, and Queue Length,
Malden Intersections

Intersection	AM Peak Period			PM Peak Period		
	Delay (sec.)	LOS	Queue (veh.)*	Delay (sec.)	LOS	Queue (veh.)*
Pleasant Street and Fellsway East						
Pleasant Street Westbound	27	C	20	22	C	17
Pleasant Street Eastbound	26	C	18	>180	F	40
Fellsway East Northbound	24	C	3	28	C	5
Fellsway East Southbound	74	E	17	22	C	10
Fellsway East Local Southbound	37	D	3	36	D	4
Centre Street and Commercial Street						
Salem Street Westbound LT	48	D	10	35	C	4
Salem Street Westbound Th + RT	20	B	7	23	C	7
Salem Street Eastbound LT	13	B	4	28	C	3
Salem Street Eastbound Th + RT	12	B	5	15	B	5
Commercial Street Northbound	23	C	4	62	E	10
Commercial Street Southbound	24	C	8	17	B	6
Centre Street and Main Street						
Main Street Northbound LT	33	C	6	23	C	5
Main Street Northbound Th + RT	20	C	4	20	C	6
Main Street Southbound LT	20	C	3	22	C	4
Main Street Southbound Th + RT	24	C	8	21	C	6
Centre Street Eastbound LT	10	A	3	9	A	4
Centre Street Eastbound Th + RT	6	A	7	8	A	6
Centre Street Westbound LT	22	C	5	32	C	3
Centre Street Westbound Th + RT	12	B	4	17	B	6
Centre Street and Ferry Street						
Centre Street Eastbound LT	25	C	8	19	B	2
Centre Street Eastbound Th + RT	19	B	6	26	C	11
Centre Street Westbound LT	24	C	4	53	D	5
Centre Street Westbound Th + RT	26	C	10	20	C	4
Ferry Street Northbound LT+ Th + RT	12	B	5	16	B	5
Ferry Street Southbound LT+ Th + RT	11	B	4	24	C	4

* 95% queue length
Th = through, RT = right turn, LT = left turn

TABLE 2
Crash Rates for Malden Intersections

Intersection	Number of Crashes		Average Daily Traffic	Crash Rate*
	3-Year Total	Annual Average		
Pleasant Street and Fellsway East	30	10.0	26,333	1.04
Centre Street and Commercial Street	54	18.0	30,333	1.63
Centre Street and Main Street	45	15.0	31,778	1.29
Centre Street and Ferry Street	31	10.3	29,000	0.97
MassHighway District 4 Average Crash Rate for Signalized Intersections				0.88
MassHighway District 4 Average Crash Rate for Unsignalized Intersections				0.63

* Crashes per million entering vehicles

TABLE 3
Crash Characteristics and Frequency,
2004–2006, Malden Intersections

	Fellsway East and Pleasant Street	Commercial Street and Centre Street	Main Street and Centre Street	Ferry Street and Centre Street
	Number of Crashes	Number of Crashes	Number of Crashes	Number of Crashes
Crash Severity				
Fatality	0	0	0	0
Injury	11	24	16	15
Property damage only	17	17	18	10
Not reported	2	12	9	5
Unknown	0	1	2	1
Total	*30*	*54*	*45*	*31*
Collision Type				
Rear-end	11	6	6	7
Angle/sideswipe	8	35	30	21
Head-on	1	5	3	1
Single-vehicle crash	2	4	2	1
Not reported	3	4	3	1
Unknown	0	0	1	0
Total	*30*	*54*	*45*	*31*
Roadway Condition				
Dry	22	41	31	22
Wet	4	11	12	7
Snow	1	1	2	2
Not reported	3	1	0	0
Other	0	0	0	0
Total	*30*	*54*	*45*	*31*
Light Condition				
Daylight	19	35	26	17
Dawn	2	0	1	0
Dusk	0	3	2	2
Dark road, lighted	7	15	16	11
Dark road, unlighted	1	0	0	1
Not Reported	1	1	0	0
Other	0	0	0	0
Total	*30*	*54*	*45*	*31*
Year				
2004	15	19	20	13
2005	7	14	9	8
2006	8	21	16	10
Total	*30*	*54*	*45*	*31*

the crashes involved a fatality; one of the crashes involved a pedestrian. Figure 4 is a collision diagram of crashes at this intersection that occurred from January 1, 2004, to December 31, 2006. About one-half of the crashes were of the rear-end type, usually associated with signalized intersections that have traffic queues and stop-and-go conditions, such as this intersection.

3.2 CENTRE STREET AND COMMERCIAL STREET

The intersection of Centre Street and Commercial Street is a signalized intersection located near the Malden Transportation Center. The intersection's geometry and lane configuration can be seen in Figure 5. This intersection is one of the main access routes to the Malden Transportation Center. On-street parking is prohibited at this intersection. The traffic signals are mast mounted and the signal heads are in good condition, placed appropriately to provide good visibility to motorists. The roadway pavement in the vicinity of the intersection is in fair condition, as is the granite curbing.

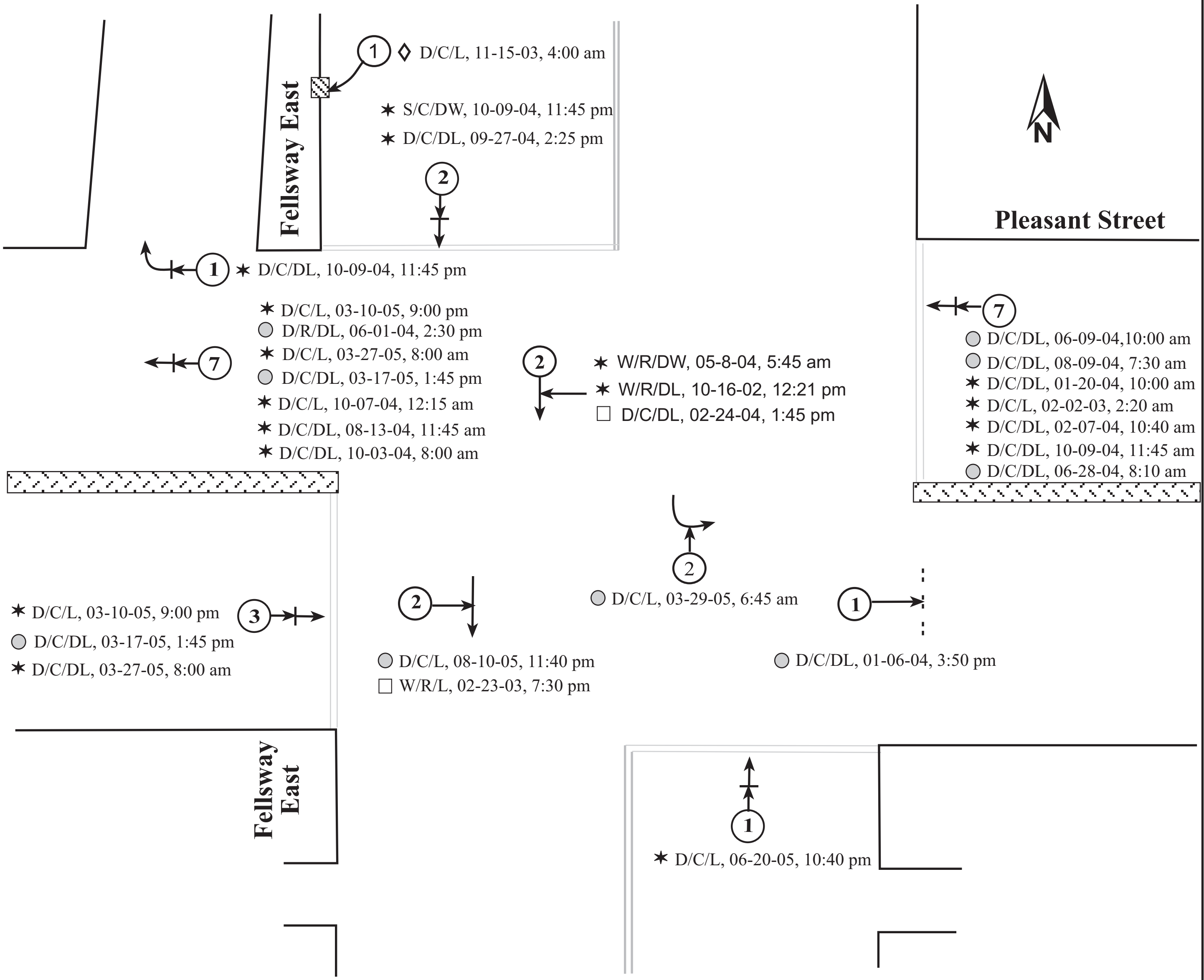
Pedestrian and Bicycle Operations and Safety Problems

Pedestrians, bicycles, buses, and cars use this intersection to get to the Malden Transportation Center, but safety is a problem at this intersection for both pedestrians and motorists. Pedestrian safety problems also occur farther along Commercial Street, especially in front of the Malden Transportation Center. Many of the pedestrians and bicyclists crossing at this intersection are transit users going to and from the Malden Transportation Center. The pedestrian crosswalks at this intersection are marked on all four approaches with parallel white stripes, sufficiently visible to pedestrians and motorists, and are aligned perpendicular to each approach. Each corner north of the intersection features two sidewalk curb cuts for wheelchairs, one for each crosswalk. Each corner south of the intersection features one sidewalk curb cut for wheelchairs, which is shared by both crosswalks. The sidewalks on both Centre Street and Commercial Streets are six to eight feet wide, are made of concrete, and are in good condition. The street furniture does not reduce the width of the sidewalk to less than five feet.

The pedestrian walk signals at this intersection turn on concurrently with the two-way through traffic on Commercial Street, during which pedestrians cross Centre Street; however, *it does not turn on concurrently* with the two-way through traffic on Centre Street for pedestrians to cross Commercial Street. The concurrent pedestrian walk phase creates vehicle-pedestrian conflicts because left- and right-turn movements are allowed during pedestrian walk phases. There are no pedestrian push buttons for activating the pedestrian signals at this intersection, which creates problems for the pedestrians crossing Commercial Street, as its pedestrian phase does not turn on concurrently with the two-way through traffic on Centre Street. Presently, pedestrians cross Commercial Street by looking for sufficient gaps and making sure there are no right-turning vehicles.

There is no audible pedestrian signal (APS) to assist persons who are blind in crossing the streets at this intersection. A sign is posted for pedestrians with the warning, "WATCH FOR TURNING VEHICLES ON WALK SIGNAL." This sign can be confusing, as it can be interpreted to mean that pedestrians are expected to yield to motor vehicles. This interpretation is contrary to state law, as conveyed by the "YIELD TO PEDESTRIANS" signs found at most intersections. The AM and PM pedestrian crossings are shown in green in Figure 5. On the day of observation, there were 88 pedestrians who crossed at the intersection during the AM peak period (7:00–9:00 AM) and 86 pedestrians during the PM peak period (4:00–6:00 PM). Field observations show that pedestrians at this intersection cross Centre Street with the pedestrian signal about half of the time; the rest cross Centre Street whenever there is a sufficient gap in the traffic stream, and some pedestrians cross half of the roadway and wait in the narrow median to make sure it is safe to cross the rest of the way.

FIGURE 4
Collision Diagram
January 1, 2004, through December 31, 2006
Pleasant Street and Fellsway East, Malden

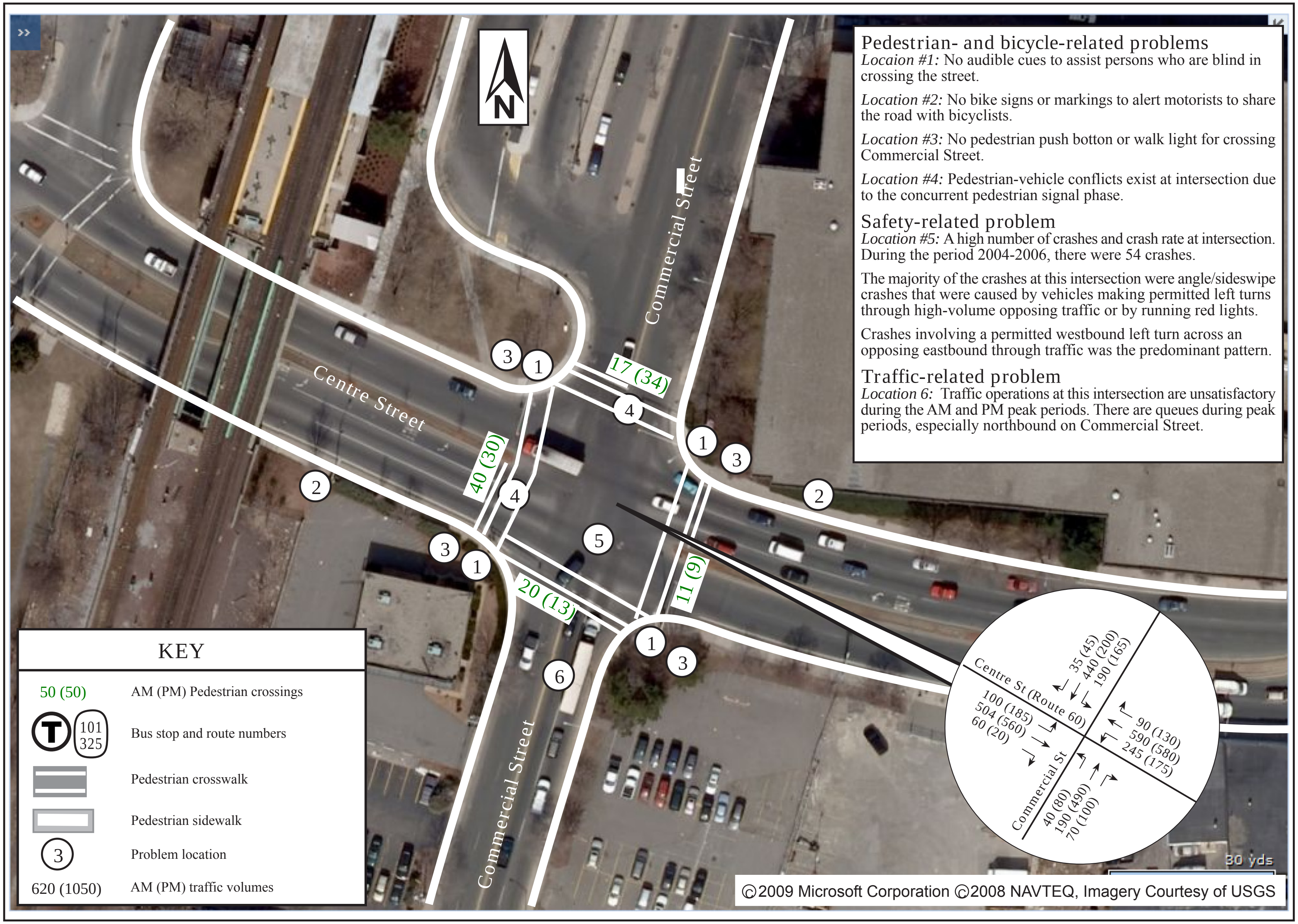


SYMBOLS	
	Moving vehicle
	Backing vehicle
	Pedestrian or bicycle
	Out-of-control vehicle
	Fixed object
	Property damage only
	Injury
	Fatality
	No damage or injury
	Not reported
#	Number of accidents

PAVEMENT/WEATHER/LIGHTING	
D	Dry
W	Wet
S	Snowy, icy
--	Other
C	Clear
R	Rainy/foggy/cloudy
S	Snow/sleet
--	Other
DL	Daylight
L	Dark, lights
N	Dark, no lights
DU	Dusk
DW	Dawn

TYPES OF COLLISIONS	
	Head-on
	Angle
	Rear-end
	Sideswipe
	Right angle

CTPS



Pedestrian- and bicycle-related problems

Location #1: No audible cues to assist persons who are blind in crossing the street.

Location #2: No bike signs or markings to alert motorists to share the road with bicyclists.

Location #3: No pedestrian push botton or walk light for crossing Commercial Street.

Location #4: Pedestrian-vehicle conflicts exist at intersection due to the concurrent pedestrian signal phase.

Safety-related problem

Location #5: A high number of crashes and crash rate at intersection. During the period 2004-2006, there were 54 crashes.

The majority of the crashes at this intersection were angle/sideswipe crashes that were caused by vehicles making permitted left turns through high-volume opposing traffic or by running red lights.

Crashes involving a permitted westbound left turn across an opposing eastbound through traffic was the predominant pattern.

Traffic-related problem

Location 6: Traffic operations at this intersection are unsatisfactory during the AM and PM peak periods. There are queues during peak periods, especially northbound on Commercial Street.

CTPS

FIGURE 5
Mobility Problems at the Centre Street (Route 60) and Commercial Street Intersection

Route 60 Mobility Study: Malden and Medford

Traffic Operations and Safety Problems

Table 1 (page 17) shows the traffic delay, level of service, and queuing at the Centre Street and Commercial Street intersection. In the AM peak period, all of the approaches at this intersection operate at LOS D or better. In the PM peak period, the Commercial Street northbound approach operates at LOS E, while the other approaches operate at LOS C or better. During congested periods, buses exiting the east busway to Commercial Street southbound, then traveling on Centre Street, sometimes have difficulty finding a gap in traffic. Sometimes only a single bus exits per cycle. In addition, because the MBTA busway exit on Commercial Street is located close to the intersection (about 60 feet away), it is frequently blocked by traffic queues on the southbound approach.

The crash rate, frequency, and characteristics at this intersection are presented in Tables 2 and 3, respectively (pages 17 and 18). The crash rate of 1.63 crashes per million entering vehicles (MEV) is higher than the average of 0.88 crashes per MEV for MassHighway District 4 signalized intersections. Between 2004 and 2006, there were 54 crashes at this intersection. Sixty-six percent were angle/sideswipe crashes; none of the crashes involved a fatality, but there were three pedestrian-related crashes and one bicyclist-related crash. A collision diagram of the crashes is presented in Figure 6. The majority of the crashes were angle/sideswipe crashes that were caused by vehicles running a red light or making permitted left turns through high-volume opposing traffic. The permitted westbound left turns had more crashes than the other approaches.

3.3 CENTRE STREET AND MAIN STREET

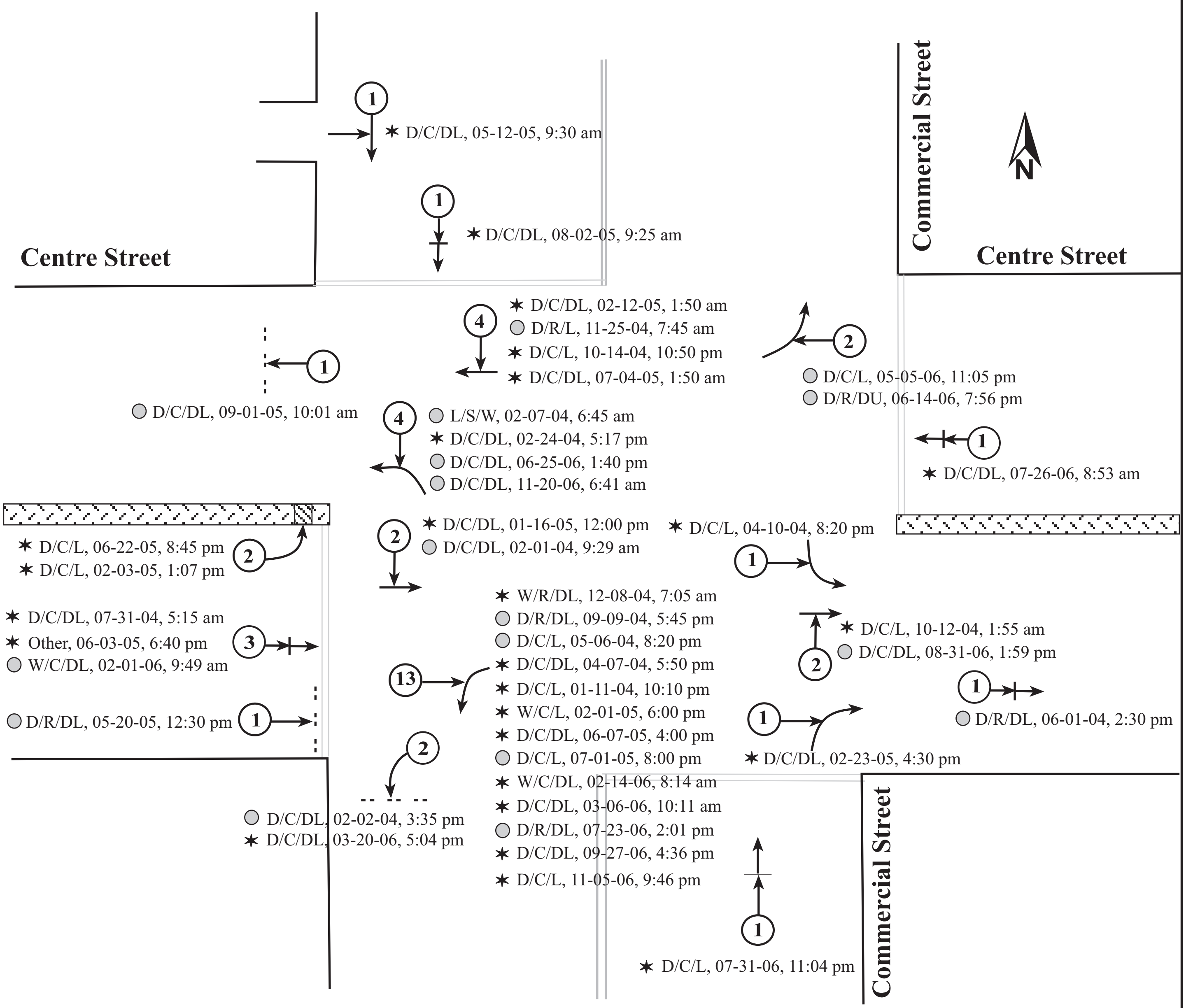
The intersection of Centre Street and Main Street is a four-legged signalized intersection located in a commercial area. The intersection's geometry and lane configuration are presented in Figure 7. Presently, the roadway surface is in fair to good condition, as is the granite curbing. Each approach has an exclusive left-turn bay. The signals are mast mounted, except those for Centre Street left-turn movements, which are post mounted in the median. The signal heads are in good condition and are placed appropriately to provide good visibility for motorists.

Pedestrian and Bicycle Operations and Safety Problems

This intersection has pedestrian crosswalks marked on all four approaches, with simple, parallel white stripes, sufficiently visible to pedestrians and motorists. The sidewalks on both Centre and Main streets are six to eight feet wide, made of concrete, and in good condition. Each corner of the intersection features a sidewalk curb cut for wheelchair use, which is shared by both crosswalks. Street trees and street furniture, such as benches, streetlights, newspaper boxes, and trash receptacles, do not reduce the width of the sidewalk to less than five feet.

This intersection has pedestrian safety problems. The pedestrian walk signals turn on concurrently with the parallel two-way through traffic, during which right and left turns are permitted. This creates vehicle-pedestrian conflicts. A school crossing guard at the intersection complained that motorists fail to obey the "NO TURN ON RED" sign. A sign is posted for pedestrians with the warning, "WATCH FOR TURNING VEHICLES ON WALK SIGNAL." This sign can be confusing, as it can be interpreted to mean that pedestrians are expected to yield to motor vehicles. This interpretation is contrary to state law, as conveyed by the "YIELD TO PEDESTRIANS" signs found at most intersections. A symbol of a person walking and a flashing or steady red hand designate the pedestrian "WALK" and "DON'T WALK" phases, respectively. However, the intersection lacks not only an audible pedestrian signal to assist persons who are blind in crossing, but also pedestrian push buttons to facilitate safe crossing. There are times when pedestrians ignore the signals and cross when they think it is safe; some pedestrians cross half of the roadway and wait in the narrow median to make sure it is safe to cross the rest of the way. The AM and PM pedestrian

FIGURE 6
Collision Diagram
January 1, 2004, through December 31, 2006
Centre Street and Commercial Street, Malden



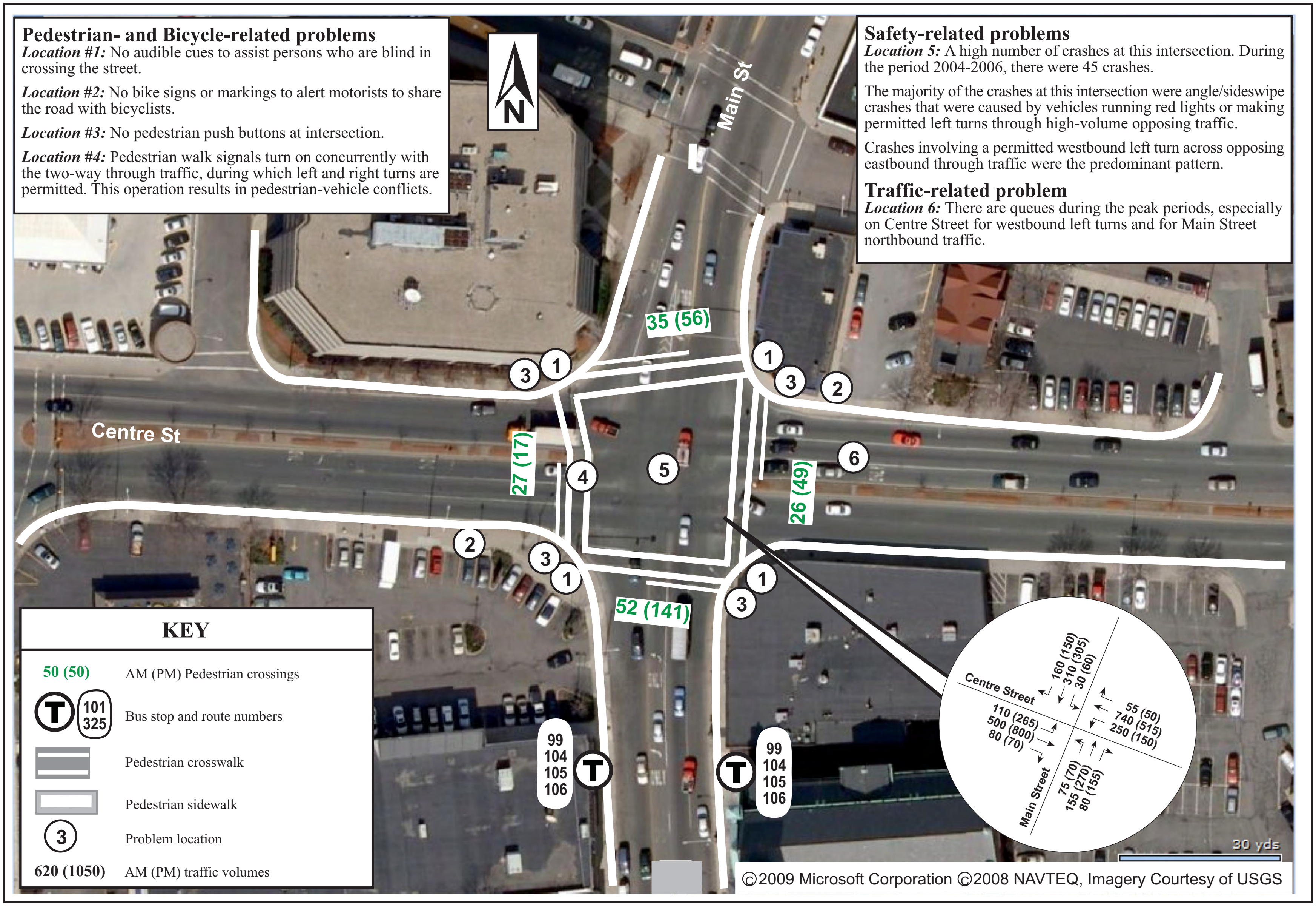
SYMBOLS	
	Moving vehicle
	Backing vehicle
-- -- --	Pedestrian or bicycle
	Out-of-control vehicle
	Fixed object
✶	Property damage only
	Injury
●	Fatality
□	No damage or injury
◊	Not reported
(#)	Number of accidents

PAVEMENT/WEATHER/LIGHTING	
D	Dry
W	Wet
S	Snowy, icy
--	Other
C	Clear
R	Rainy/foggy/cloudy
S	Snow/sleet
--	Other
DL	Daylight
L	Dark, lights
N	Dark, no lights
DU	Dusk
DW	Dawn

TYPES OF COLLISIONS

- Head-on
- Angle
- Rear-end
- Sideswipe
- Right angle

CTPS



CTPS

FIGURE 7
Mobility Problems at the Centre Street (Route 60) and Main Street Intersection

Route 60 Mobility Study: Malden and Medford

crossings are shown in green in Figure 7. On the day of observation, there were 140 pedestrians who crossed at the intersection during the AM peak period (7:00–9:00 AM) and 263 pedestrians during the PM peak period (4:00–6:00 PM).

Traffic Operations and Safety Problems

This intersection has traffic safety problems. The traffic delay, level of service, and queue length at this intersection are presented in Table 1 (page 17). Although, traffic operations are satisfactory (LOS C or better), there are queues during the AM and PM peak periods. A traffic queue created by intersections on Main Street north of this intersection extends southward into the intersection during peak periods, affecting its traffic operations. This queue, on some occasions, prevents the Centre Street and Main Street northbound traffic from moving.

Crash rate, frequency, and characteristics are presented in Table 2 and Table 3, respectively (pages 17 and 18). The crash rate of 1.29 crashes per million entering vehicles (MEV) is higher than the average of 0.88 crashes per MEV for MassHighway District 4 signalized intersections. There were 45 crashes at the Centre Street and Main Street intersection, many of which were angle/sideswipe crashes. None of the crashes involved a fatality, a pedestrian, or a bicyclist. Figure 8 is a collision diagram for the crashes at this intersection from 2004 to 2006. As the figure shows, the majority of the crashes at this intersection were angle/sideswipe crashes that were caused by vehicles running a red light or making permitted left turns through high-volume opposing traffic. Crashes involving a permitted westbound left turn across opposing eastbound through traffic were the predominant pattern at this intersection.

3.4 CENTRE STREET AND FERRY STREET

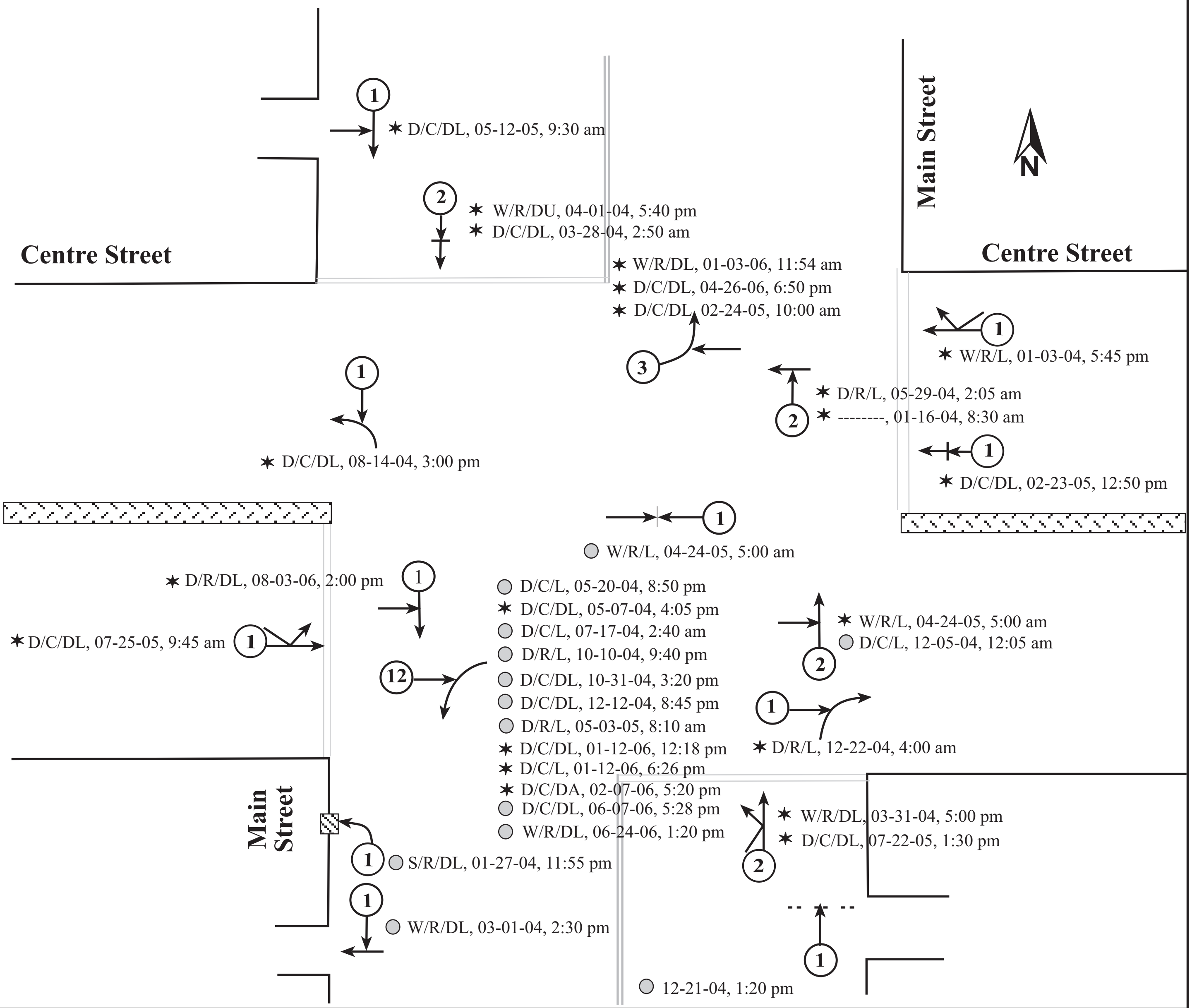
The intersection of Centre Street and Ferry Street is a signalized intersection located in an area with mixed land use: commercial, schools, and residences. The geometry and lane configurations at the intersection are shown in Figure 9. The pavement and curbing are in fair to good condition. The traffic signal equipment is in good condition, and the mast-mounted signal heads, placed so that they are visible to motorists, are in good condition. A right-turn-on-red (RTOR) is allowed from all approaches at the intersection except the westbound approach, where it is prohibited.

Pedestrian and Bicycle Operations and Problems

The pedestrian crosswalks at this intersection are marked at all four approaches, with simple, parallel white stripes, sufficiently visible to pedestrians and motorists, and are aligned perpendicular to each approach, as shown in Figure 9. The sidewalks on Centre and Ferry streets are about six to eight feet wide, made of concrete, and in good condition. Each corner of the intersection features a sidewalk curb-cut ramp for wheelchairs, which is shared by both crosswalks. The street furniture does not reduce the width of the sidewalk to less than five feet.

The pedestrian walk signal for crossing Centre Street comes on concurrently with the parallel two-way through traffic on Ferry Street, during which left and right turns are permitted. This creates conflicts between pedestrians and vehicles. There are no pedestrian push buttons for crossing Ferry Street (the pedestrian signals come on automatically and concurrently with Centre Street through traffic). A symbol of a person walking and a flashing or steady red hand designate the pedestrian “WALK” and “DON’T WALK” phases, respectively. There are no audible cues to assist persons who are blind in crossing the street at this intersection; however, signs have been posted for pedestrians with the warning “WATCH FOR TURNING VEHICLES ON WALK SIGNAL.” This sign can be confusing, as it can be interpreted to mean that pedestrians are expected to yield to motor vehicles. This interpretation is contrary to state law, as conveyed

FIGURE 8
Collision Diagram
January 1, 2004, through December 31, 2006
Centre Street and Main Street, Malden

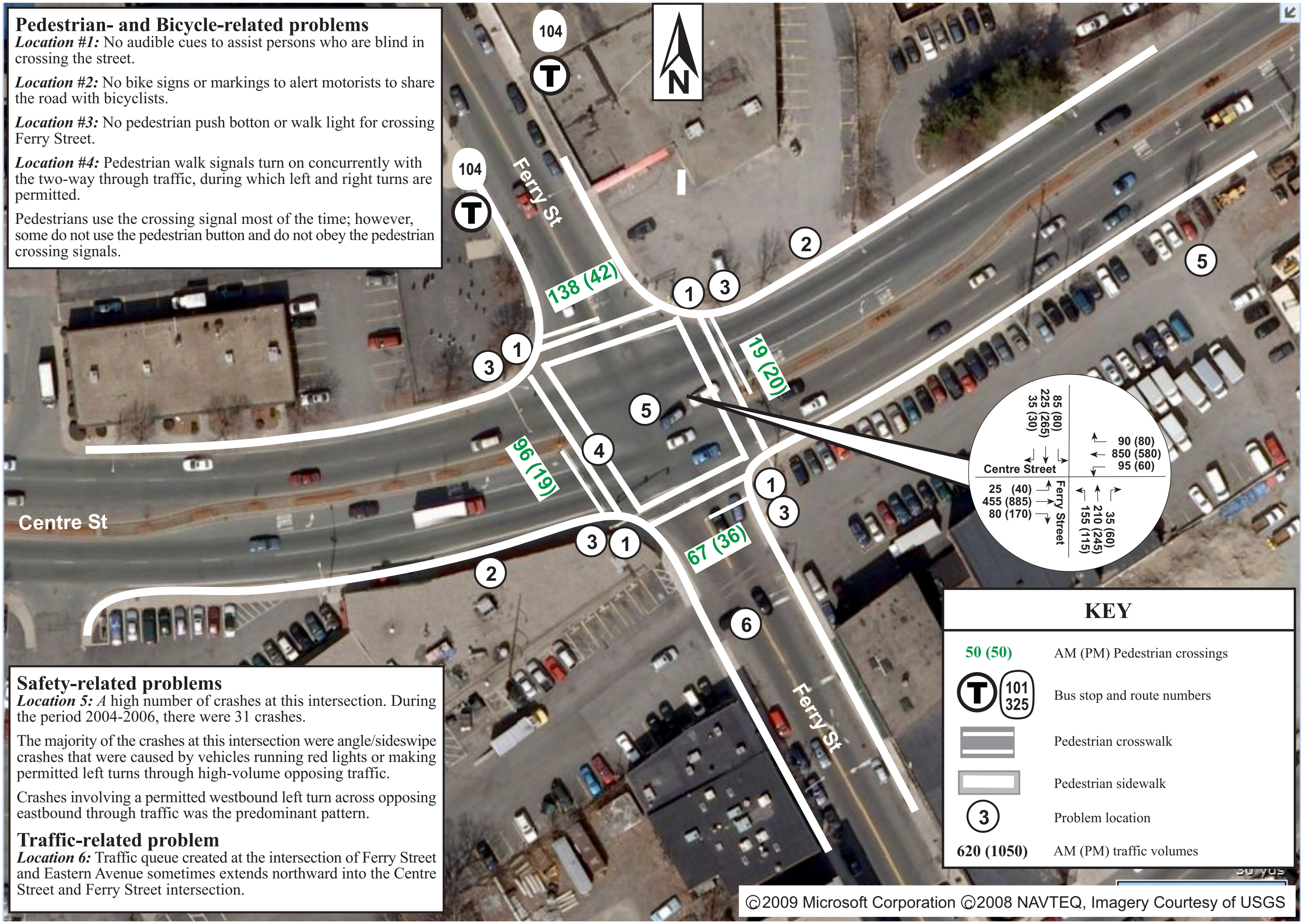


SYMBOLS	
←	Moving vehicle
←⟫⟫⟫	Backing vehicle
-- -- --	Pedestrian or bicycle
	Out-of-control vehicle
▨	Fixed object
✶	Property damage only
○	Injury
●	Fatality
□	No damage or injury
◊	Not reported
(#)	Number of accidents

PAVEMENT/WEATHER/LIGHTING	
D	Dry
W	Wet
S	Snowy, icy
--	Other
C	Clear
R	Rainy/foggy/cloudy
S	Snow/sleet
--	Other
DL	Daylight
L	Dark, lights
N	Dark, no lights
DU	Dusk
DW	Dawn

TYPES OF COLLISIONS
Head-on
Angle
Rear-end
Sideswipe
Right angle

CTPS



Pedestrian- and Bicycle-related problems

Location #1: No audible cues to assist persons who are blind in crossing the street.

Location #2: No bike signs or markings to alert motorists to share the road with bicyclists.

Location #3: No pedestrian push botton or walk light for crossing Ferry Street.

Location #4: Pedestrian walk signals turn on concurrently with the two-way through traffic, during which left and right turns are permitted.

Pedestrians use the crossing signal most of the time; however, some do not use the pedestrian button and do not obey the pedestrian crossing signals.

Safety-related problems

Location 5: A high number of crashes at this intersection. During the period 2004-2006, there were 31 crashes.

The majority of the crashes at this intersection were angle/sideswipe crashes that were caused by vehicles running red lights or making permitted left turns through high-volume opposing traffic.

Crashes involving a permitted westbound left turn across opposing eastbound through traffic was the predominant pattern.

Traffic-related problem

Location 6: Traffic queue created at the intersection of Ferry Street and Eastern Avenue sometimes extends northward into the Centre Street and Ferry Street intersection.

KEY

50 (50)	AM (PM) Pedestrian crossings
T 101 325	Bus stop and route numbers
	Pedestrian crosswalk
	Pedestrian sidewalk
3	Problem location
620 (1050)	AM (PM) traffic volumes

CTPS

FIGURE 9
Mobility Problems at the Centre Street (Route 60) and Ferry Street Intersection

Route 60 Mobility Study: Malden and Medford

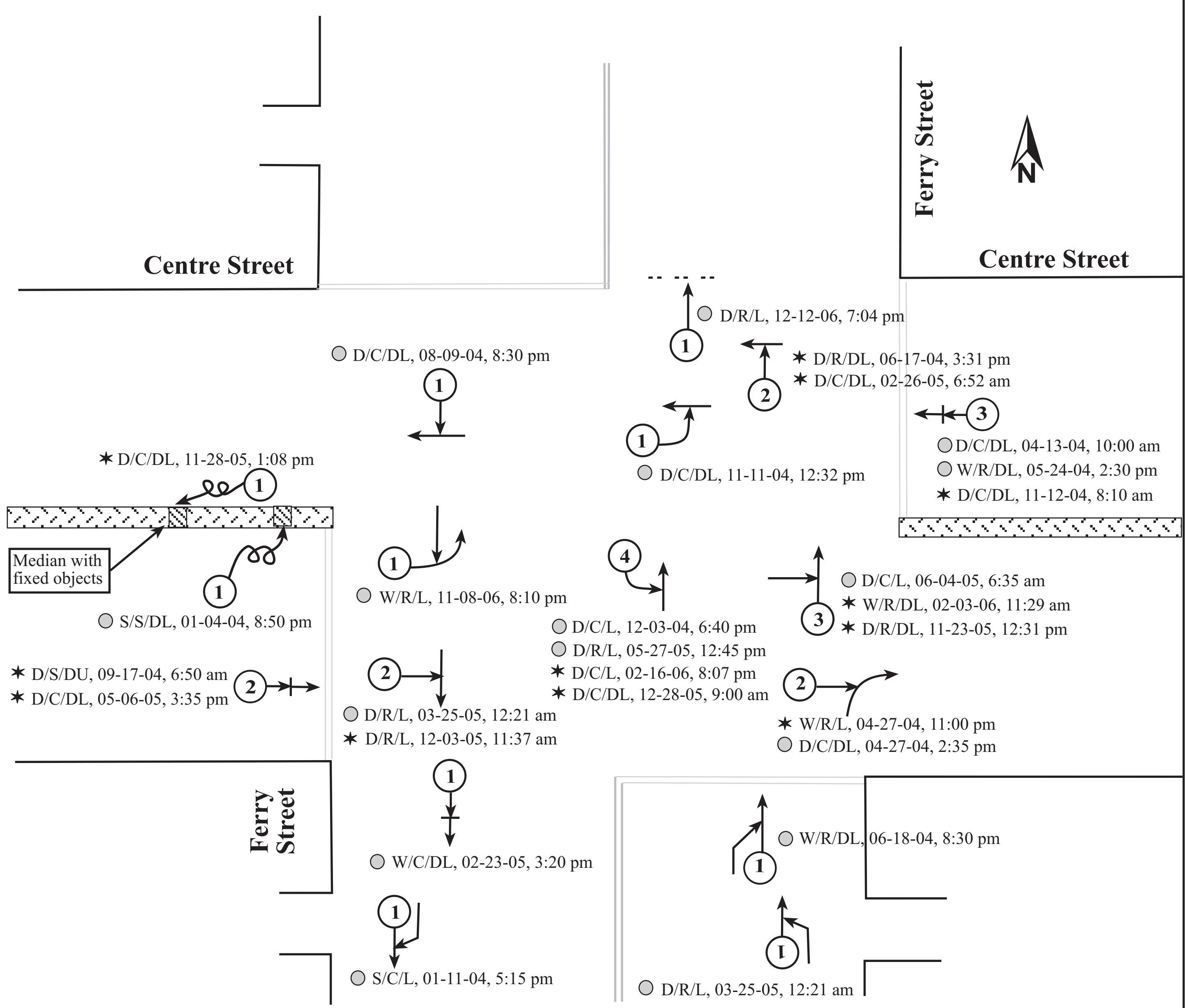
by the “YIELD TO PEDESTRIANS” signs found at most intersections. A school crossing guard assists students in crossing the streets during the morning and afternoon. The AM and PM pedestrian crossings are shown in green in Figure 9. On the day of observation, 360 pedestrians crossed at the intersection during the AM peak period (7:00–9:00 AM) and 117 pedestrians during the PM peak period (4:00–6:00 PM). Many of the pedestrians and bicyclists crossing at this intersection during the AM peak period are students of the Cheverus School and Malden High School, both of which are located north of the intersection. The PM peak-period pedestrian counts were lower because they were taken in the late afternoon, after school hours. Field observations show that pedestrians crossing at this intersection usually used the crossing signals, and motorists were observed to be yielding to pedestrians in the crosswalk on turns.

Traffic Safety and Operations

Traffic operations at this intersection are satisfactory during the AM and PM peak periods, with LOS D or better. The crash rate, frequency, and characteristics at the Ferry Street intersection are presented in Table 2 and Table 3, respectively (pages 17 and 18). The crash rate of 0.97 crashes per million entering vehicles (MEV) is somewhat higher than the average of 0.88 crashes per MEV for MassHighway District 4 signalized intersections.

Between 2004 and 2006, there were 31 crashes at the Ferry Street intersection, with many angle/sideswipe crashes. None of the crashes involved a fatality; one of the crashes at this intersection involved pedestrians. Figure 10 is a collision diagram for crashes from 2004 to 2006. As the figure shows, the majority of the crashes at this intersection were angle/sideswipe collisions that were caused by vehicles running a red light or making permitted left turns through opposing traffic.

FIGURE 10
Collision Diagram
January 1, 2004, through December 31, 2006
Centre Street and Ferry Street, Malden



SYMBOLS	
←	Moving vehicle
←))))	Backing vehicle
-- -- --	Pedestrian or bicycle
← ✆✆	Out-of-control vehicle
▨	Fixed object
✶	Property damage only
◯ (grey)	Injury
●	Fatality
□	No damage or injury
◊	Not reported
(#)	Number of accidents

PAVEMENT/WEATHER/LIGHTING	
D	Dry
W	Wet
S	Snowy, icy
--	Other
C	Clear
R	Rainy/foggy/cloudy
S	Snow/sleet
--	Other
DL	Daylight
L	Dark, lights
N	Dark, no lights
DU	Dusk
DW	Dawn

TYPES OF COLLISIONS

- Head-on
- Angle
- Rear-end
- Sideswipe
- Right angle

CTPS

4. ROUTE 60 IMPROVEMENTS IN MALDEN

4.1 CORRIDOR IMPROVEMENTS

In general, we recommend installing bike and pedestrian signs and pavement markings in the Malden segment of Route 60 to inform motorists that they should share the road with bicyclists and pedestrians. The commercial activities and mass transportation services along Centre Street and Pleasant Street generate pedestrian and bicycle traffic throughout the corridor. One way to improve mobility for motorists, as well as for pedestrians and bicyclists, is for drivers to pay more attention to pedestrians and bicyclists to improve safety, and to encourage walking and bicycling. Also, police enforcement of motorists who fail to yield the right-of-way to pedestrians and bicyclists in crosswalks is another way to increase safety in the Route 60 corridor.

The following sections describe potential improvements for addressing the problems identified in chapter 3.

4.2 PLEASANT STREET AND FELLSWAY EAST

The following problems were identified:

- Traffic operations at this intersection are not satisfactory. During the AM and PM peak periods, heavy traffic volumes cause queues to form, as well as congestion to occur, on Pleasant Street (Route 60).

- The crash rate at this intersection, 1.04 cashes per million entering vehicles (MEV), exceeds MassHighway's District 4 average crash rate for signalized intersections, which is 0.88 crashes per MEV.

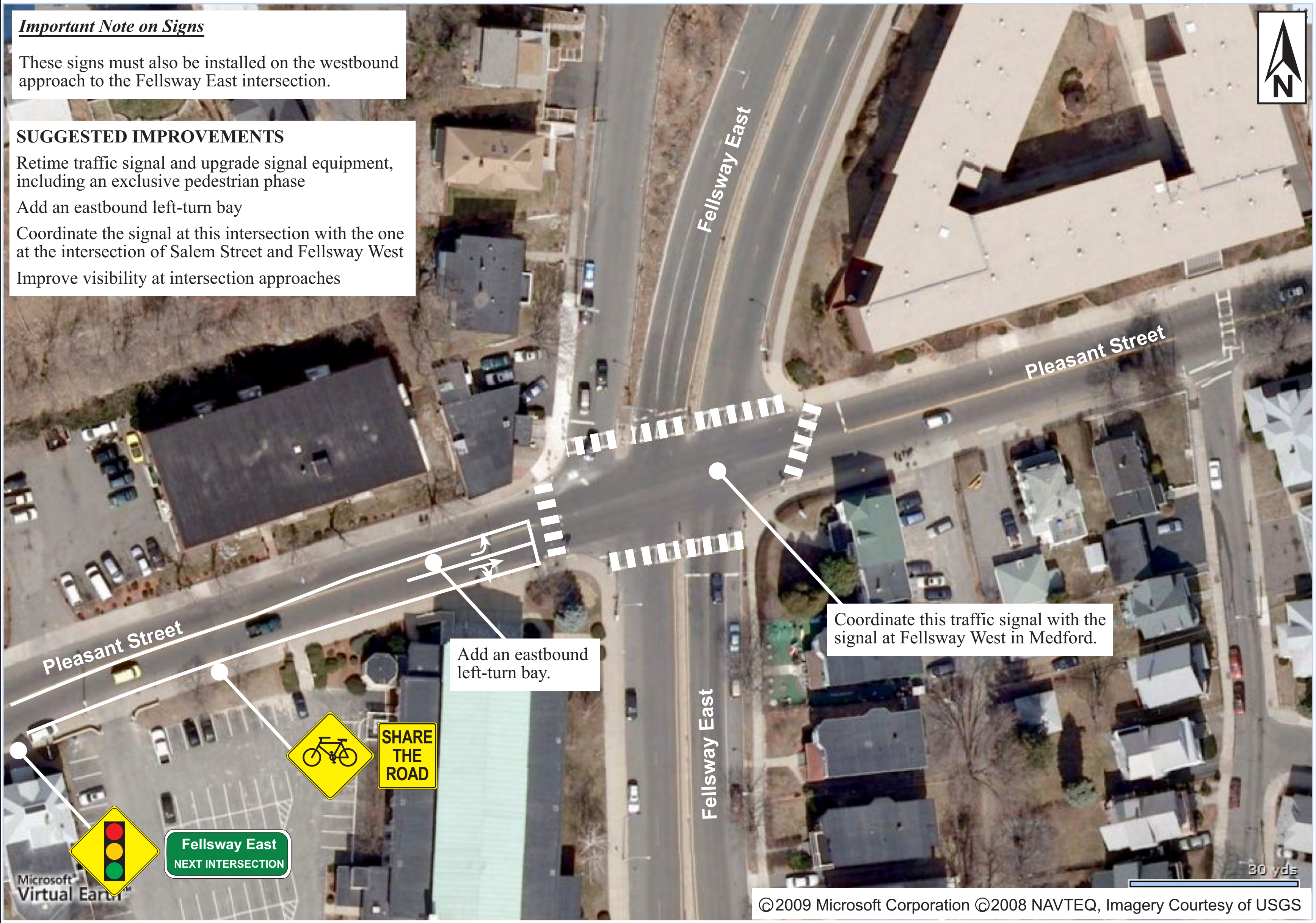
- Between 2004 and 2006, there were 30 crashes at this intersection, many of them rear-end and angle/sideswipe crashes. One of the crashes involved a pedestrian. About 50 percent of the crashes were rear-end collisions on Pleasant Street (see the collision diagram, Figure 4, page 20).

Figure 11 shows potential improvements for this intersection.

Retime the Traffic Signal and Upgrade Signal Hardware

Signal retiming is one of the most cost-effective ways to improve traffic flow along a corridor or through an intersection; it usually improves traffic flow by reducing stops and delay. Signal timing for a traffic signal is only effective as long as the traffic patterns used to generate the timing remain reasonably consistent. A review of traffic signal and system performance, in regular intervals, should be conducted in order to make spot changes in a systematic manner and retime signals. The strategies recommended for the optimization of this traffic signal are:

1. The addition of a protected left-turn phase to increase safety. The Pleasant Street eastbound approach has a high volume of left turns during the PM peak period. Because of the high volume of opposing traffic, the permitted-only phase for left turns provided on Pleasant Street causes the eastbound left-turn traffic to block the through traffic, resulting in a traffic queue at the intersection. A leading protected-left-turn phase is proposed for the Pleasant Street eastbound movements, followed by a permitted-only phase for left turns. This new sequence and the new phases would be expected to reduce delay and queues and increase safety at the intersection during the PM peak period.



CTPS

FIGURE 11
Mobility Improvements at the Intersection of Pleasant Street and Fellsway East

Route 60 Mobility Study: Malden and Medford

2. Optimization of the signal timing for each phase to minimize delays at the intersection.

3. An exclusive pedestrian phase (no vehicular movements) for crossing at all approaches.

Finally, MPO staff recommend that the existing traffic signal control hardware be upgraded in order to accommodate enhanced signal operations.

Table 4 shows the calculated delays, levels of service, and queue lengths for the Pleasant Street and Fellsway East intersection under the optimized conditions described above. Using a four-phase actuated signal plan, the optimization does not impact the AM peak-period intersection delay, but decreases the PM peak-period delay to 34 seconds from 154 seconds. Additionally, as mentioned earlier, it is important to upgrade the existing traffic signal control hardware to accommodate enhanced signal operations at this intersection.

Add an Eastbound Left-Turn Bay

As described above, this intersection has a high volume of eastbound left-turn traffic during the PM peak period, which blocks the through traffic movement while drivers wait for a gap in opposing traffic. Geometric improvements at the Fellsway East and Pleasant Street intersection could provide both operational and safety benefits. A left-turn bay on Pleasant Street would allow separation of the left-turn and through-traffic streams, thus reducing the potential blocking of through traffic. In addition, a key strategy for minimizing collisions related to left-turning vehicles (angle, rear-end, and sideswipe) that might improve safety at this intersection would be to provide exclusive left-turn lanes.

A potential difficulty in providing an eastbound left-turn bay on Pleasant Street where one currently does not exist is the acquisition of space required for the additional lane; to avoid this difficulty, the conversion of shoulders and parking spaces may be considered. In addition, it is important to address concerns from residents or other stakeholders who are concerned about the loss of parking.

Improve Visibility of the Intersection and Approaches

D3-2

W3-3

W11-1

W16-1

W13-1

MUTCD[1]

Drivers must be able to have an adequate sight distance in the direction of travel in order to see the downstream intersection, its controls, or the back of a stopped queue with enough time to react to avoid collisions. The ability of approaching drivers to perceive an intersection immediately downstream and the visibility of control devices can be enhanced by installing or upgrading signs and pavement markings on intersection approaches. Visibility, and therefore safety, would be improved if the Massachusetts Department of Conservation and Recreation (DCR) were to install advance street name signs (type D3-2), advance traffic control signs (type W3-3), and advisory speed signs (type W13-1) here.[1] Advance street name signs and advance traffic control signs would improve awareness of this signalized intersection. In addition, installing bicycle-warning signs (type W11-1 and type W16-1) would improve safety. The improvements are shown in Figure 11.

1 U.S, Department of Transportation, Federal Highway Administration, *Manual on Uniform Traffic Control Devices, Millennium Edition*, June 2001.

TABLE 4
Optimized Delay, Level of Service, and Queue Length
Malden Intersections*

Intersection Approach	AM Peak Period			PM Peak Period		
	Delay (sec)	LOS	Queue (veh)**	Delay (sec)	LOS	Queue (veh)**
Pleasant Street and Fellsway East						
Pleasant Street Westbound	51	D	24	20	B	17
Pleasant Street Eastbound	54	D	23	40	D	40
Fellsway East Southbound Th+ LT	51	E	14	33	C	5
Fellsway East Southbound RT	31	C	7	34	C	5
Fellsway East Northbound	26	C	4	45	D	10
Fellsway East Southbound Local	60	E	6	56	E	4
Total Intersection Delay (Existing)	47	D	n/a	154	F	n/a
Total Intersection Delay (Optimized)	48	D	n/a	34	D	n/a
Centre Street and Commercial Street						
Commercial Street Northbound	22	C	3	36	D	12
Commercial Street Southbound	36	D	10	33	C	8
Centre Street Eastbound Th+ RT	52	D	11	41	D	12
Centre Street Eastbound LT	36	D	3	55	D	8
Centre Street Westbound Th+RT	62	E	14	70	E	16
Centre Street Westbound LT	35	C	10	41	D	8
Total Intersection (Existing)	22	B	n/a	31	C	n/a
Total Intersection (Optimized)	36	D	n/a	47	D	n/a
Centre Street and Main Street						
Main Street Northbound Th+RT	13	B	3	23	C	12
Main Street Northbound LT	28	C	3	26	C	4
Main Street Southbound Th+RT	20	B	5	23	C	8
Main Street Southbound LT	18	B	2	24	C	4
Centre Street Eastbound Th+ RT	22	C	6	21	C	12
Centre Street Eastbound LT	9	A	2	14	B	8
Centre Street Westbound Th+RT	20	B	8	24	C	16
Centre Street Westbound LT	12	A	4	17	B	8
Total Intersection (Existing)	15	B	n/a	16	B	n/a
Total Intersection (Optimized)	18	B	n/a	21	C	n/a
Centre Street and Ferry Street						
Ferry Street Northbound	21	C	5	16	B	4
Ferry Street Southbound	19	B	4	15	B	4
Centre Street Eastbound Th+ RT	20	C	7	21	C	8
Centre Street Eastbound LT	28	C	2	15	B	2
Centre Street Westbound Th+RT	28	C	8	18	B	6
Centre Street Westbound LT	30	C	3	42	D	3
Total Intersection (Existing)	20	B	n/a	22	C	n/a
Total Intersection (Optimized)	23	C	n/a	17	B	n/a

* The optimized LOS, delay, and queue length reflects improvements such as signal retimimg, change in the sequence of movements, and modified change and clearance intervals.
** 95% queue length
Th = through, RT = right turn, LT = left turn, n/a = not applicable

Coordinate Signals

Staff recommend that the signal at this intersection be coordinated with the one at the intersection of Salem Street and Fellsway West in Medford to improve traffic flow on Salem Street/Pleasant Street. DCR controls both traffic signals. Coordinating these signals could help reduce the long traffic queues that form between them during peak travel periods. In addition, it would reduce the number and frequency of required stops, thereby improving safety by reducing the number of rear-end crashes at both intersections.

4.3 CENTRE STREET AND COMMERCIAL STREET

Staff identified the following problems at this intersection.

- Traffic operations at this intersection are unsatisfactory, as queues form during the PM peak period on Commercial Street.
- The Centre Street and Commercial Street intersection had the highest crash rate within the study area: 1.63 crashes per million entering vehicles (MEV), which exceeds the average crash rate of 0.88 crashes per MEV for MassHighway District 4 signalized intersections.
- Between 2004 and 2006, there were 58 crashes at the Centre Street and Commercial Street intersection; 62 percent of them were angle/sideswipe crashes (see the collision diagram, Figure 6, page 23). The majority of the angle/sideswipe crashes were caused by vehicles running red lights or making permitted, but not protected, left turns through high-volume opposing traffic. Crashes related to westbound vehicles making permitted left turns included many angle/sideswipes crashes.
- There were no pedestrian push buttons for activating the pedestrian signals. Their absence sometimes creates problems for pedestrians crossing Commercial Street, as this pedestrian phase does not turn on concurrently with the two-way through traffic on Centre Street. Two of the crashes at this intersection involved pedestrians and one a bicyclist.
- During congested periods, buses exiting the east busway to Commercial Street southbound, then to Centre Street, sometimes have difficulty finding a gap in traffic. Sometimes only a single bus exits per cycle. In addition, because the MBTA busway exit on Commercial Street is located close to the intersection (about 60 feet away), it is frequently blocked by a traffic queue on the southbound approach.

Staff identified the following safety and operations improvements for this intersection (also see Figure 12).

Retime the Traffic Signal and Increase Protection for Left-Turning Vehicles

The objective of this signal retiming is to optimally respond to traffic and pedestrian demands at the Centre Street and Commercial Street intersection. The improvements included in the signal retiming are as follows:

1. An additional protected phase to accommodate left-turn demands on Centre Street during the peak periods. Instead of the current permitted-only phase for left turns, a leading protected phase is proposed for Centre Street eastbound and westbound left turns, after which a permitted-only phase would be allowed. A leading protected-left-turn phase is also recommended for Commercial Street southbound movements. The resulting phase sequence is as shown below.

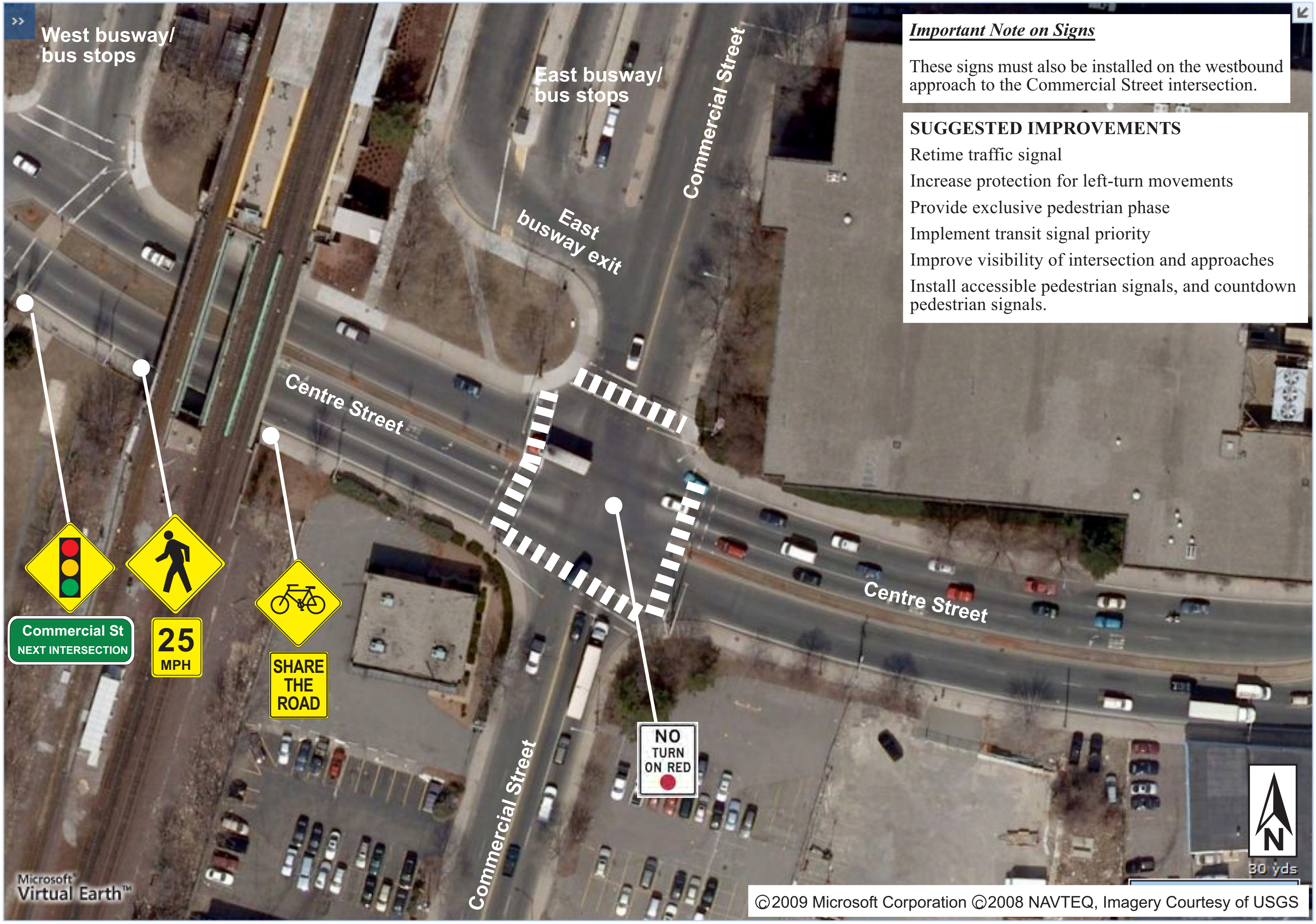


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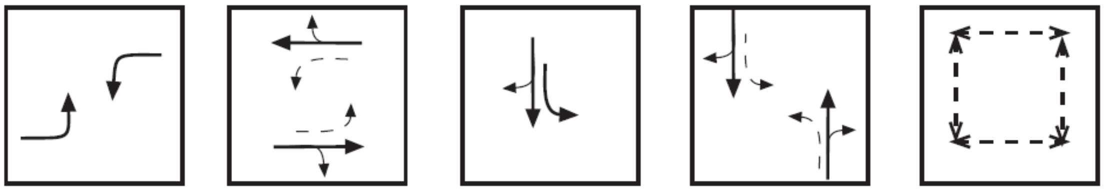
FIGURE 12
Mobility Improvements at the Intersection of Centre Street and Commercial Street

Route 60 Mobility Study: Malden and Medford



Proposed Phase Sequence at Centre Street and Commercial Street

2. Optimize timing to minimize delays and queues at the intersection, which would include new timing for the existing phase intervals, as well as the additional phases proposed for this intersection. This strategy would help to reduce delays for both pedestrians and drivers and also target crashes related to clearance interval lengths that are too short for this particular intersection. Such crashes include angle crashes between vehicles continuing through the intersection after one phase has ended and the vehicles entering the intersection on the following phase (running red lights).

3. An exclusive pedestrian phase, which allows pedestrians to cross at all approaches of an intersection at the same time while all vehicular movements have stopped (described in the following section).

4. Upgrade existing traffic signal control hardware and accommodate enhanced signal operations as technology continues to change in the traffic control field.

Because of the high volume of opposing traffic on Centre and Commercial streets, the current permitted-only phase for left turns does not offer enough gaps for a sufficient number of left-turning vehicles to get through the intersection. Motorists turning left sometimes misjudge the gaps in opposing traffic, resulting in angle and sideswipe collisions. The suggested improvements are expected to increase safety at this intersection because of the additional protection afforded pedestrians and left-turning motorists. However, this increased safety would be at the expense of increased delay at the intersection.

Implement Transit Signal Priority at the Intersection

The goal of implementing a transit signal priority at this intersection is to reduce delay for buses trying to exit the east busway to Commercial Street southbound to proceed to Centre Street eastbound. Buses sometimes have difficulty finding a gap in traffic during peak travel periods and sometimes only a single bus exits per cycle. Implementing a transit signal priority at this intersection would require a signal system upgrade to enable it to handle a request from buses, and buses would need to be equipped with the technology for submitting requests. For the transit signal priority to operate efficiently, the east busway exit might have to be signalized and tied to the main signal at the intersection of Centre Street and Commercial Street, or some form of signage might have to be installed at the east busway exit, to prevent Commercial Street southbound vehicles from blocking the busway exit when a bus request is submitted.

Provide an Exclusive Pedestrian Phase

Ideally, pedestrian phases and exclusive-timing schemes are most appropriate at signalized intersections with large pedestrian volumes (1,200 or more per day) or with multiphase signals (left-turn arrows and split phases), such as the intersection of Centre Street and Commercial Street, which serves a significant number of pedestrians accessing the Malden Transportation Center and Malden municipal offices. With an exclusive pedestrian phase, all vehicular traffic is stopped, and the “WALK” signal is displayed for all crosswalks at the same time. The effectiveness of an exclusive pedestrian phase can be enhanced with signs such as “NO TURN ON RED.” Providing an exclusive pedestrian phase would improve safety, but it would also increase delay at the intersection.

Table 4 (page 34) shows the results of making these improvements (signal retiming, increasing protection for left turns, and providing an exclusive pedestrian phase); these proposed changes for improving safety would increase the intersection control delay to 43 seconds from 22 seconds (to LOS D from LOS B) during the AM peak period, and to 45 seconds from 31 seconds (to LOS D from LOS C) during the PM peak period.

Accessible Pedestrian Signals (APS)

NCHRP, Report 500, Vol. 10

Accessible pedestrian signal

Install accessible pedestrian signals at the intersection of Centre Street and Commercial Street to serve pedestrians with disabilities. This busy intersection is one of the main access points for the Malden Transportation Center, and it used by pedestrians, including people with disabilities, to get to and from the Center. At signalized intersections, pedestrians who are blind or visually impaired typically start to cross the street when they hear a surge of traffic parallel to their direction of travel. Some intersection geometries and traffic conditions make it very difficult for visually impaired persons to know when to cross. These conditions include wide intersections, intersections with split-phase signal timing, and intersections with pedestrian push buttons, such as the Centre Street and Commercial Street intersection. Visually impaired pedestrians may not realize that they have to push a button, or they may have trouble finding the button. Accessible pedestrian signals (APS), which operate concurrently with visual pedestrian signals, provide audible and/or vibrotactile information to inform visually impaired pedestrians precisely when the “WALK” interval begins and when it is no longer safe to cross. Audible signals also provide directional guidance, which is particularly useful at multilane crossings. Audible signals actuated by push buttons are the most commonly used type of APS, and they often emit a chirping or “cuckoo” tone during the “WALK” interval.

Countdown Pedestrian Signal

NCHRP, Report 500, Vol. 10

Countdown pedestrian signal

A variety of traffic and pedestrian signal enhancements can benefit pedestrians; these include larger pedestrian signal heads to improve visibility and pedestrian countdown signals. A countdown signal contains a timer display and counts down the number of seconds left to finish crossing the street. Countdown signals begin counting down when the flashing “DON’T WALK” signal appears and stop when the nonflashing “DON’T WALK” signal comes on. Countdown signals inform pedestrians who are considering entering the crosswalk when the flashing “DON’T WALK” signal is on whether or not they still have time to finish crossing.

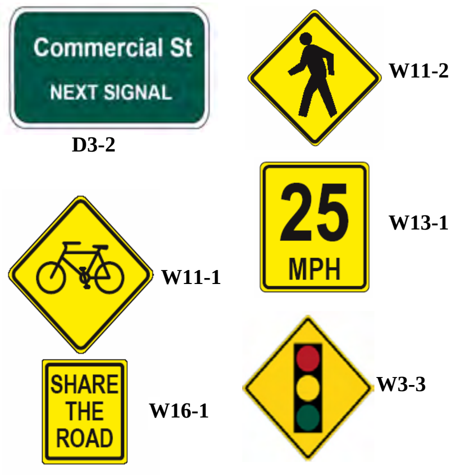
Recent studies on countdown signals have shown that a larger proportion of pedestrians are completing their crossing during the flashing “DON’T WALK” interval using countdown signals than at walk signals without countdown signals.[2,3] This result may be

[2] Jan L. Botha and Ron L. Northouse, *Pedestrian Countdown Signals Study in the City of San Jose,* Final Report, submitted to the California Traffic Control Devices Committee, May 2002.

[3] Jeremiah P. Singer and Neil D. Lerner, *Countdown Pedestrian Signals: A Comparison of Alternative Pedestrian Change Interval Displays,* Final Report, submitted to Federal Highway Administration, March 2005.

construed as positive, since it would seem that more pedestrians get out of the crosswalk before the nonflashing “DON’T WALK” signal comes on when there is a countdown signal. Thus, pedestrians are using the additional information provided by the countdown signal to complete their crossing in the time provided. Completing a crossing before the nonflashing “DON’T WALK” signal comes on reduces the chances of pedestrians encountering conflicting vehicle movements.

Improve the Visibility of the Intersection and Approaches



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Driver awareness of both downstream intersections and traffic control devices is critical for driver and pedestrian safety at intersections. The ability of approaching drivers to perceive the Centre Street and Commercial Street intersection immediately downstream and the visibility of the signals and other control devices would be enhanced by installing or upgrading signs and pavement markings on the approaches to this intersection. Staff recommend the use of advisory speed signs (type W13-3) in combination with advance traffic control signs (type W3-3) and pedestrian warning signs (type W11-2) to alert drivers to the presence of an intersection and pedestrians crossing, as the horizontal curve in the roadway and the MBTA commuter rail bridge reduce visibility of the intersection. In addition, installing bicycle-warning signs (type W11-1 and type W16-1) would improve safety, and street name signs (type D3-2) in advance of the intersection would prepare drivers for choosing and moving into the lane they will need to use for their desired maneuver.

4.4 CENTRE STREET AND MAIN STREET

Staff identified the following problems at this intersection.

- Traffic operations at this intersection are not satisfactory; there are queues that spill into the intersection during the PM peak periods.
- The concurrent pedestrian phase, in which the “WALK” signal is displayed at the same time as the green signal for parallel vehicular traffic, creates conflicts between vehicles and pedestrians.
- This intersection had a crash rate of 1.29 crashes per million entering vehicles (MEV), which exceeds the average crash rate for MassHighway District 4 signalized intersections, 0.88 crashes per MEV. There were 45 crashes, many of which were angle/sideswipe crashes (30 crashes) caused by vehicles running red lights or making permitted left turns through high-volume opposing traffic.
- Crashes involving westbound traffic to make permitted left turns crossing opposing eastbound through traffic was the predominant pattern, a pattern similar to the one observed at the Centre Street and Commercial Street intersection.

Staff recommended the following improvements to address safety and operations problems at this intersection. They are similar to those developed for the intersection of Centre Street and Commercial Street (Figure 13).

Retime the Traffic Signal and Increase Protected Left Turns

The objectives of the proposed signal retiming are to optimally respond to traffic and pedestrian demands at the intersection and to improve safety. The following improvements were included in the retiming:

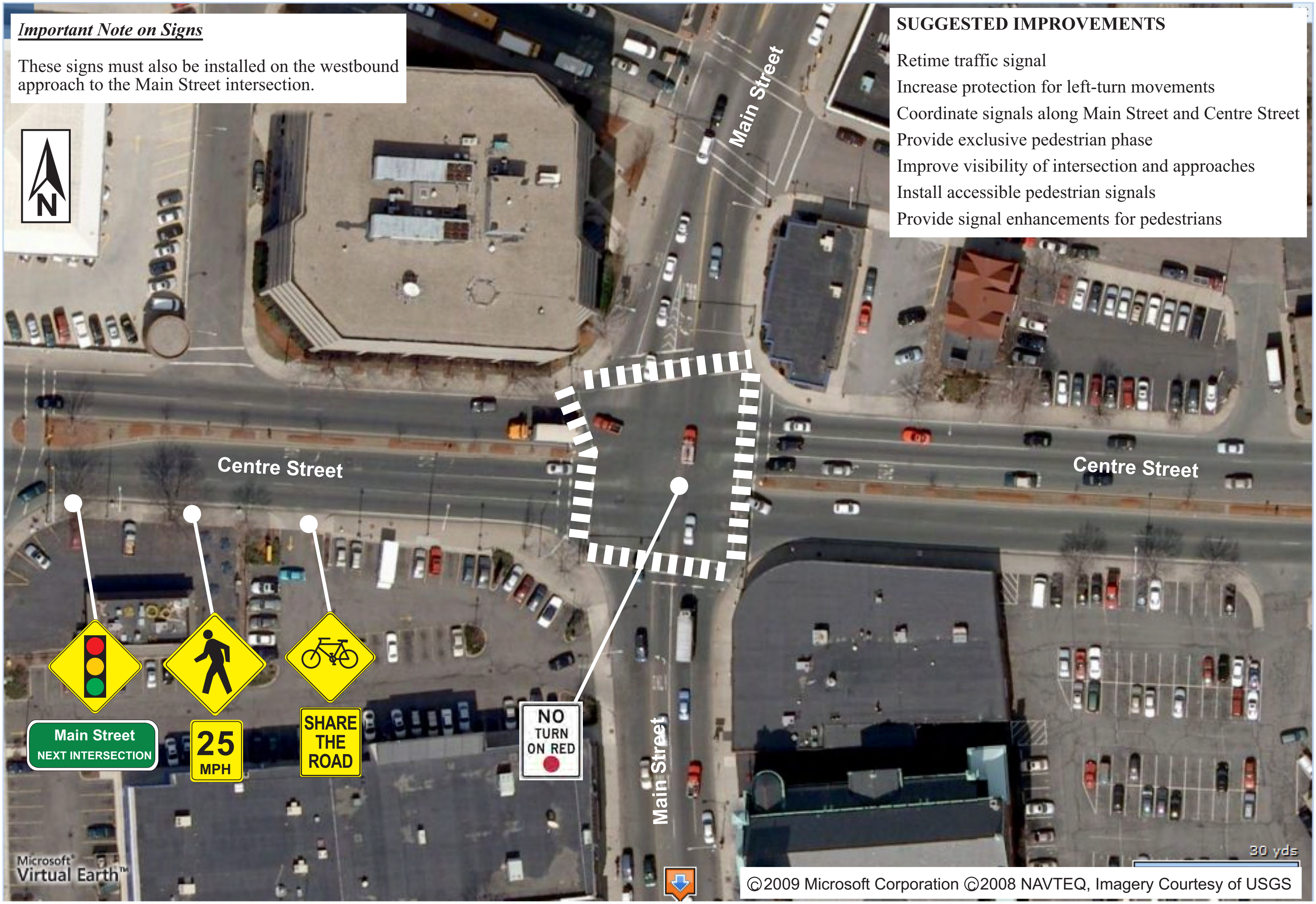

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FIGURE 13
Mobility Improvements at the Intersection of Centre Street and Main Street

Route 60 Mobility Study: Malden and Medford

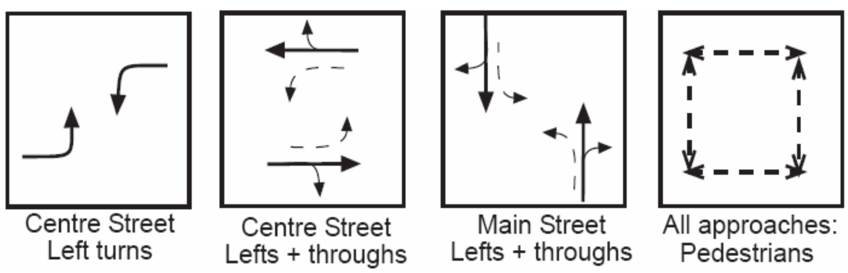
1. Add a protected-left-turn phase to accommodate left-turn demands on Centre Street during the peak periods. Instead of the current permitted-only phase for the Centre Street westbound approach, a dual leading protected left-turn phase is proposed for both westbound and eastbound Centre Street left turns after which a permitted-only phase would be allowed.

2. Optimize the signal timing to minimize delays and queues at the intersection. This would include new timing for the existing phase interval and the additional phases proposed for this intersection. The purpose of this strategy is to reduce delays for both pedestrians and drivers. Signal optimization also takes into account the clearance interval lengths that are too short for a particular intersection. Short clearance intervals can result in angle crashes between vehicles continuing through the intersection after one phase has ended and the vehicles entering the intersection on the following phase (running red lights).

3. Implement an exclusive pedestrian phase for crossing at all approaches at the same time when all vehicular movements are stopped at the intersection.

4. Upgrade existing traffic signal control hardware to accommodate enhanced signal operations as technology continues to change in the traffic control field.

One reason for the high crash rate at this intersection is that the high volume of opposing traffic on Centre Street does not offer enough gaps to allow sufficient permitted-only left-turn movements during peak periods. Motorists traveling westbound on Centre Street turning left sometimes misjudge gaps in the opposing traffic, resulting in angle/sideswipe collisions. The proposed dual leading protected left-turn phase for Centre Street, shown below, is expected to increase safety. It is important to upgrade existing traffic signal control hardware to accommodate enhanced signal operations. Pedestrian push buttons are also recommended, as they would facilitate crossing at this intersection.



Proposed Phase Sequence at Centre Street and Main Street

Coordinate the Traffic Signals along Main Street and Centre Street

Coordinating the signals along Centre Street and along Main Street could improve traffic flow, as well as increase safety, on both arterials. One of the problems at this intersection is that the northbound traffic queue that forms on Main Street north of this intersection extends southward into this intersection during peak periods, affecting traffic operations. Coordinated signals would produce platoons of vehicles that could proceed with minimal stopping at multiple signalized intersections on Main Street, preventing traffic queues from building up. Reducing the number and frequency of stops would improve safety by reducing the number of rear-end crashes.

Provide an Exclusive Pedestrian Signal Phase

The existing pedestrian signal has the standard concurrent timing, in which the "WALK" signal is displayed at the same time as the green signal for parallel vehicular traffic. Under this timing scheme, right- and left-turning motor vehicles may conflict with pedestrians crossing on the “WALK” signal. To improve safety for pedestrians and bicyclists, staff recommend an exclusive pedestrian phase at this intersection. The exclusive pedestrian phase could be supplemented with “NO TURN ON RED” signs at all of the approaches. While an exclusive pedestrian phase would improve safety at this intersection, it would also increase delays slightly.

Table 4 (page 34) shows the results of making these improvements (signal retiming, providing a dual leading protected left-turn phase, coordinating traffic signals, and providing an exclusive pedestrian phase); these proposed changes for improving safety would increase the intersection control delay slightly, to 18 seconds from 15 seconds (it would remain at LOS B), during the AM peak period, and to 21 seconds from 16 seconds (to LOS C from LOS B) during the PM peak period.

Accessible Pedestrian Signals (APS)

The multiphase traffic signal at this intersection makes it very difficult for visually impaired persons to know when to cross. Providing APS, with audible and/or vibrotactile information that operates concurrently with visual pedestrian signals, would inform visually impaired pedestrians precisely when the “WALK” interval begins and when it is no longer safe to cross. Audible tones may be used in conjunction with the vibrotactile buttons to let the pedestrian know that a button must be pushed, where the button is located, and when the “WALK” signal appears.

Signal and Sign Enhancements for Pedestrians and Bicyclists

A variety of traffic and pedestrian signal enhancements would benefit pedestrians at the intersection of Centre Street and Main Street, so staff recommend that the City of Malden explore these enhancements, such as countdown pedestrian signals. With countdown pedestrian signals, more pedestrians get out of the crosswalk before the nonflashing “DON’T WALK” signal appears than when there is no countdown signal, reducing the chances of pedestrians being confronted with conflicting vehicle movements. In addition, the ability of approaching drivers to perceive the Centre Street and Main Street intersection immediately downstream and the visibility of the signals and other control devices would be enhanced by installing or upgrading signs on the approaches to this intersection (Figure 13, page 40).

4.5 CENTRE STREET AND FERRY STREET

Staff identified the following problems at this intersection.

- Traffic operations at this intersection are satisfactory, except for a minor traffic queue created on Ferry Street southbound at the Eastern Avenue and Ferry Street intersection that occasionally extends into this intersection.

- The concurrent pedestrian phase, in which the “WALK” signal is displayed at the same time as the green signal for parallel vehicular traffic, causes conflicts between vehicles and pedestrians in the crosswalks.

- This intersection had a crash rate of 0.97 crashes per million entering vehicles (MEV), which exceeds the average crash rate for MassHighway District 4 signalized intersections, 0.88 crashes per MEV. There were 31 crashes at this intersection between 2004 and 2006, 67 percent of which were angle/sideswipe crashes.

- Unlike the intersection of Centre Street and Commercial Street and the intersection of Centre Street and Main Street, where the majority of angle/sideswipe crashes were associated with left turns from Centre Street westbound, no patterns were detected at the Centre Street and Ferry Street intersection.

Staff recommend the following safety and operations improvements at this intersection (Figure 14).

Provide an Exclusive Pedestrian Phase

The pedestrian signal timing at this intersection is the standard concurrent timing, in which the "WALK" signal is displayed at the same time as the green signal for parallel vehicular traffic. Under this timing scheme, right- and left-turning motor vehicles conflict with pedestrians crossing on the "WALK" signal, and many turning motorists do not yield to pedestrians. To compound this problem, students of the nearby Malden High School and Cheverus School use this intersection on their way to and from school.

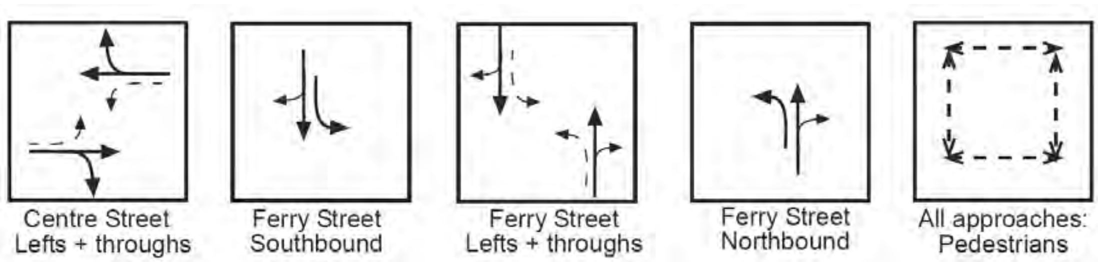
To improve safety for students of the nearby schools and other pedestrians, it is proposed that an exclusive pedestrian phase be included in the signal plan for this intersection. An exclusive pedestrian phase would reduce conflicts, as vehicular movements are stopped when pedestrians are crossing. The exclusive pedestrian phase could be supplemented with "NO TURN ON RED" signs to be more effective. While an exclusive pedestrian phase would improve safety at this intersection, it would also increase delay slightly.

Retime the Traffic Signal

The objectives of retiming at this intersection are to optimally respond to traffic and pedestrian demands at the intersection, as well as improve safety by increasing the clearance intervals (yellow and all-red intervals). The collision diagram shows that many of the crashes at the Ferry Street intersection are the right-angle type of collision involving a vehicle from Centre Street and a vehicle from Ferry Street. Such crashes are the result of vehicles running red lights, an inadequate clearance interval, or driver inattentiveness. Increasing the yellow and all-red intervals sometimes improves safety where the existing clearance intervals do not allow drivers adequate time to react to the reassignment of right-of-way. According to the procedures recommended by the Institute of Transportation Engineers, a four-second yellow interval and a two-second all-red interval would be appropriate.

Increase Protection for Ferry Street Southbound Left-Turning Vehicles

Some form of protection for Ferry Street southbound left-turn maneuvers could increase safety at this intersection. This option would involve replacing the current permitted-only phase for left turns for the Ferry Street southbound approach with a lead-lag protected left-turn phase. Under a lead-lag phase, one approach of Ferry Street would be protected at the beginning of the green phase and left turns from the opposing approach would be protected at the end. A lead-lag phase would allow some protection for left-turning vehicles from both approaches of Ferry Street, and would therefore improve safety. This improvement would be expected to increase safety with a minimal increase in delay.



Proposed Phase Sequence at Centre Street and Ferry Street

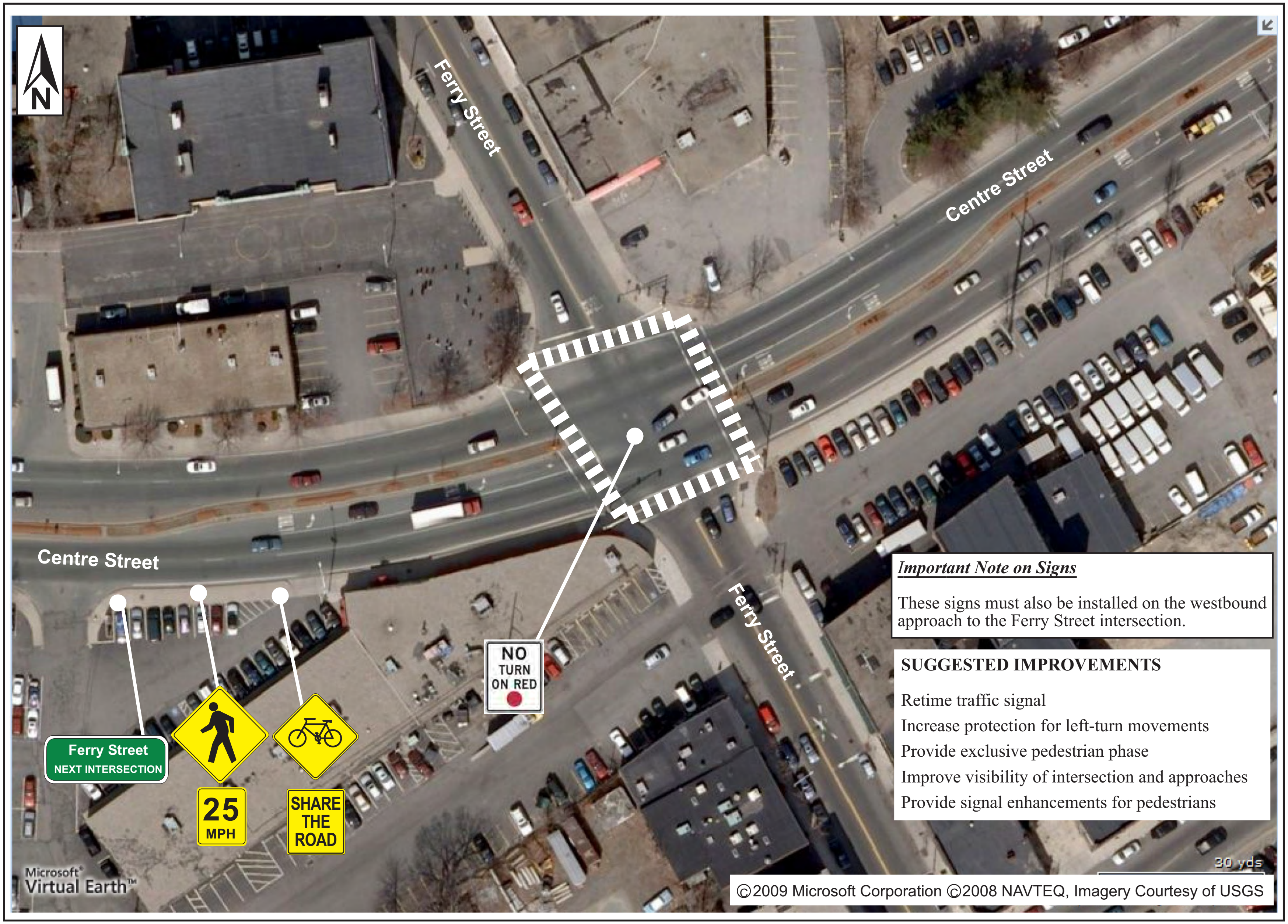


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FIGURE 14
Mobility Improvements at the Intersection of Centre Street and Ferry Street

Route 60 Mobility Study: Malden and Medford

Table 4 (page 34)shows the results of making these improvements (an exclusive pedestrian phase, signal retiming, and increasing protection for Ferry Street southbound left turns). These proposed changes for improving safety would increase the AM peak-hour intersection delay to 24 seconds from 20 seconds (to LOS C from LOS B), and would decrease the PM peak-hour delay to 17 seconds from 22 seconds (to LOS B from LOS C).

Signal and Sign Enhancements for Pedestrians and Bicyclists

A variety of traffic and pedestrian signal enhancements could benefit pedestrians and bicyclists at this intersection. Among the enhancements that are recommended are larger traffic signal heads; installing or upgrading signs on the approaches to this intersection to improve visibility; countdown pedestrian signals; and accessible pedestrian signals on the approaches to the intersection (Figure 14, previous page).

4.6 SUMMARY OF RECOMMENDED IMPROVEMENTS

This study has identified several improvements to address the issues of mobility and safety in the Route 60 corridor for motorists, pedestrians, bicyclists, and transit users. Table 5 summarizes the potential benefits of the various improvements and the estimated cost. All of the improvements are short-term or intermediate-term and could be implemented within 5 to 10 years. There are several agencies that operate transportation facilities in the corridor, including the Massachusetts Highway Department, the Massachusetts Bay Transportation Authority, and the Massachusetts Department of Conservation and Recreation, in addition to the City of Malden. Successful implementation of the projects advancing from this study is dependent on coordination among the stakeholders, sufficient public participation, and securing funding for the projects.

TABLE 5
Summary of Improvements along Route 60 in Malden

Intersection	Improvement	Expected Benefits	Cost	Implementing Agency
Pleasant Street and Fellsway East	Add an eastbound left-turn bay.	Reduce the blocking of through traffic. Minimize collisions related to left-turning vehicles (angle, rear-end, sideswipe).	$100,000	Department of Conservation and Recreation
	Improve visibility of intersection and approaches with installation of advance street name, advance traffic control, and bicycle-warning signs.	Improve awareness of the signalized intersection and safety.		
	Retime traffic signal and upgrade hardware.	Improve safety and facilitate traffic flow at the intersection.		
	Employ signal coordination at Fellsway West and Fellsway East intersections.	Improve traffic flow by reducing stops, and increase safety by reducing rear-end collisions.		
Centre Street and Commercial Street	Retime traffic signal and coordinate this signal with others on Centre Street. Increase protection for left-turning vehicles.	Improve safety as a result of the additional protection given to left-turning vehicles. Prevent traffic queues from building up.	$150,000	MBTA/City of Malden
	Provide exclusive pedestrian phase with push buttons and “NO TURN ON RED” signs on all approaches. Paint the crosswalks with ladder-style stripes.	Improve safety for pedestrians. Reduce vehicle-pedestrian conflicts.		
	Install countdown and accessible pedestrian signals.	Increase pedestrian safety by giving useful information to pedestrians on how long they have to complete a crossing.		
	Improve visibility of intersection and approaches.	Call attention to presence of intersection and traffic control.		
	Implement transit signal priority at the intersection	Reduce waiting times for buses trying to exit the east busway during congested periods		
Centre Street and Main Street	Retime traffic signal and coordinate this signal with others on Centre Street. Increase protection for left-turning vehicles.	Improve safety as a result of the additional protection given to pedestrians and left-turning vehicles. Prevent traffic queues from building up.	$50,000	City of Malden
	Provide exclusive pedestrian phase with push buttons and “NO TURN ON RED” signs on all approaches. Paint the crosswalks with ladder-style stripes.	Improve safety for pedestrians. Reduce vehicle-pedestrian conflicts.		
	Provide signal enhancement for pedestrians such as countdown pedestrian signals and accessible pedestrian signals.	Improve pedestrian safety by giving useful information to pedestrians on how long they have to complete a crossing.		
Centre Street and Ferry Street	Retime traffic signal and coordinate this signal with others on Centre Street to reduce delay.	Improve safety and prevent traffic queues from building up.	$50,000	City of Medford
	Provide exclusive pedestrian phase and supplement phase with “NO TURN ON RED” sign. Paint the crosswalks with ladder-style stripes.	Improve safety at intersection for students of the nearby schools and other pedestrians. Reduce vehicle-pedestrian conflicts.		
	Increase protection for Ferry Street southbound left-turning vehicles.	Improve safety by reducing crashes related to left turns.		
	Install countdown and accessible pedestrian signals.	Increase pedestrian safety by giving useful information to pedestrians on how long they have to complete a crossing.		

5. PROBLEMS AT STUDY LOCATIONS IN MEDFORD

5.1 SALEM STREET (ROUTE 60) AND THE I-93 ROTARY INTERCHANGE[4]

The juncture of Salem Street (Route 60) and the Interstate 93 ramps is a busy rotary interchange located in a residential area close to Medford City Hall and Medford Square. Figure 15 shows the geometric configuration of the interchange and the intersection of Salem Street and Hadley Place. This interchange serves as the main access point to Medford from I-93 and from Route 60 east. All of the approaches at the rotary interchange have a single entry lane with a posted speed limit of 25 mph and are controlled by yield signs. Medford officials have complained about pedestrian safety at this interchange. In 2006 there was a pedestrian fatality at the southbound I-93 on-ramp of this rotary interchange.

Pedestrian and Bicycle Operations and Problems

There are four pedestrian crossings at the interchange, all of which are located on the ramps to and from I-93. The crosswalks are all marked with simple, parallel white stripes (ladder type), sufficiently visible to pedestrians and motorists. Each crosswalk has a pedestrian warning sign that alerts motorists to look for pedestrians crossing. Pedestrians cross the street by looking for sufficient gaps in traffic or for motorists stopping to yield to pedestrians. The pedestrian-crossing activity for the AM and PM peak periods is shown in green in Figure 15; on the day of observation, there were 96 pedestrians who crossed at the intersection during the AM peak period (7:00–9:00 AM) and 100 pedestrians during the PM peak period (4:00–6:00 PM), demonstrating moderate pedestrian activity. Field observations show that pedestrians at the interchange used the crosswalks and sidewalks most of the time, and motorists who were making turns were observed to be yielding to pedestrians in the crosswalks. Curb cuts and wheelchair ramps are provided at the crosswalks, and the street furniture, such as streetlights, does not reduce the width of the sidewalks in this area to less than five feet. On-street parking is not allowed in the vicinity of this rotary interchange and therefore does not pose problems for bicyclists. One of the crashes at the Hadley Place intersection involved a pedestrian.

The following pedestrian and bicyclist problems were observed at the site:

- Because of the high volume of traffic at the interchange, crossing is particularly difficult for pedestrians and bicyclists during peak periods of travel.
- The sidewalks connecting the crosswalks (see Figure 15) at the south side of the interchange are not clearly defined and can be confusing to navigate.
- The sidewalks are about six feet wide, made of concrete, and are in fair condition, but are dirty and weedy in some sections, especially under the I-93 bridge.
- Sections of the sidewalks under the I-93 bridge lack security lights.
- The circular roadway is not wide enough for a separate bike lane. Presently, bicycles either share the travel lane with automobiles or share the sidewalks with pedestrians.

[4] Includes the intersection of Salem Street and Hadley Place.

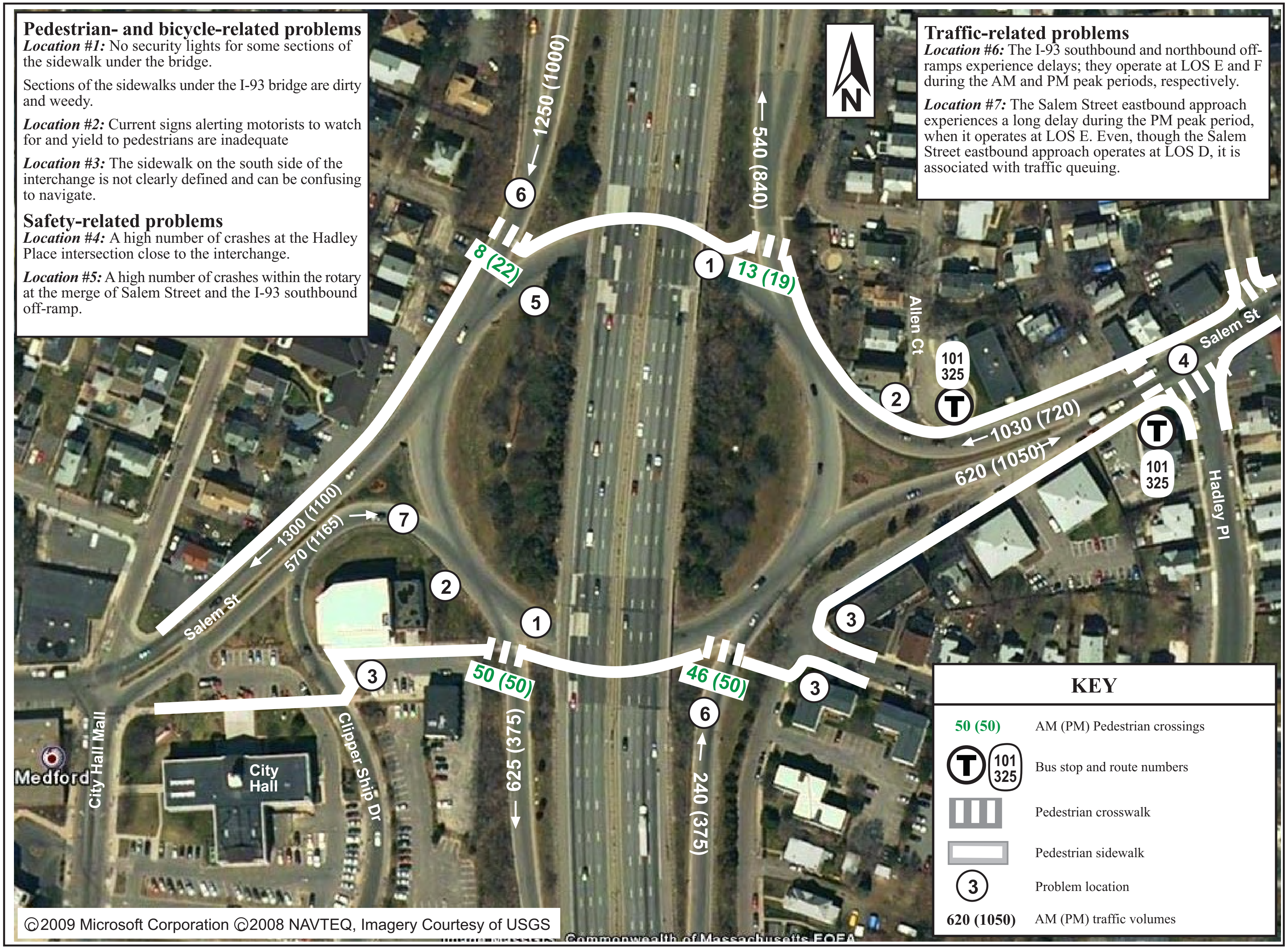

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FIGURE 15
Mobility Problems at the Salem Street (Route 60) and I-93 Rotary Interchange

Route 60 Mobility Study: Malden and Medford

Traffic Safety and Operations

Table 6 shows the delay, level of service, and amount of queuing at the interchange. During the AM peak period, the I-93 southbound off-ramp to the rotary operates at an unacceptable LOS F. High off-ramp traffic volumes, coupled with a traffic queue created at the City Hall Mall intersection, which extends eastward on Salem Street into the rotary interchange, contribute to the poor level of service at the off-ramp. In the PM peak period, traffic at the eastbound approach of the rotary and on the I-93 northbound off-ramp operates at LOS E or F.

No collision diagrams were prepared for the intersections selected for study in Medford. MPO staff were unsuccessful in obtaining crash reports from the Medford Police Department. Collision diagrams help display and identify crash patterns, and they are used to evaluate specific sites for possible causes of crashes. On the other hand, Table 7 shows the crash rates for the rotary interchange. Shading denotes intersections with higher crash rates than the MassHighway District 4 averages for unsignalized and signalized intersections. [5]

TABLE 6
Delay, Level of Service, and Queue Length
Medford Intersections

	AM Peak Period			PM Peak Period		
Intersection Approach	**Delay (sec)**	**LOS**	**Queue (veh.)***	**Delay (sec)**	**LOS**	**Queue (veh.) ***
Salem Street (Route 60) and I-93 Rotary						
Salem Street Westbound	3	A	6	52	D	14
Salem Street Eastbound	6	A	6	59	E	16
I-93 Northbound Exit Ramp	6	A	3	54	E	11
I-93 Southbound Exit Ramp	105	F	+30	38	D	11
Salem Street, Park Street, and Court Street						
Salem Street Westbound	28	C	25	11	B	20
Salem Street Eastbound	6	A	8	11	B	18
Park Street Northbound	19	B	2	18	B	1
Park Street Southbound	24	C	1	23	C	4
Salem Street Eastbound (Court Street)	2	A	2	2	A	2
Salem Street and Spring Street						
Spring Street Northbound	50	E	5	No PM peak-period data were collected.		
Spring Street Southbound	17	C	2			
Salem Street Eastbound	2	A	1			
Salem Street Westbound	2	A	1			
Salem Street at Fellsway West						
Salem Street Westbound	>180	F	45	52	F	34
Salem Street Eastbound	43	D	19	108	F	31
Fellsway West Southbound Th + RT	30	C	15	26	C	11
Fellsway West Southbound LT	48	D	14	77	E	18
Fellsway West Northbound Th + RT	36	D	18	52	D	10
Fellsway West Northbound LT	47	D	11	51	D	24

* 95% queue length
Th = through, RT = right turn, LT = left turn

[5] Note that MassHighway does not calculate crash rates for interchanges. In this case, MPO staff calculated a rate for the rotary interchange as if it were an unsignalized intersection and compared it the District 4 average for unsignalized intersections.

TABLE 7
Crash Rates for Medford Intersections

Intersection	Number of Crashes 3-Year Total	Number of Crashes Annual Average	Average Daily Traffic	Crash Rate*
Route 60 and I-93 Rotary Interchange	22	7.33	36,122	0.56
Salem Street and Hadley Place	17	5.67	21,889	0.71
Salem Street and Park Street	22	7.33	16,667	1.20
Salem Street and Spring Street	21	7.00	14,398	1.33
Salem Street and Fellsway West	32	10.67	26,333	1.11
MassHighway District 4 Average Crash Rate for Signalized Intersections				0.88
MassHighway District 4 Average Crash Rate for Unsignalized Intersections				0.63

* Crashes per million entering vehicles

The crash rate of 0.56 crashes per million entering vehicles (MEV) at the rotary interchange is lower than the 0.63 crashes per MEV average for a MassHighway District 4 unsignalized intersection. Table 7 presents the frequency and characteristics of the crashes at the same locations. Between 2004 and 2006, there were 22 crashes at the interchange. One of the crashes at the interchange involved a pedestrian fatality; the rest were injury and property-damage-only crashes. The majority of the crashes were rear-end crashes that occurred on dry pavement and under daylight conditions. Many of the crashes at the rotary were clustered at an area near the merge of Salem Street and the I-93 southbound off-ramp, an area with frequent AM peak-period traffic queues that extend from the City Hall Mall intersection.

On the east side of the interchange, close to the westbound approach on Salem Street, is the Hadley Place intersection. This intersection had 17 crashes over the three-year period (Tables 7 and 8). The crash rate of 0.71 crashes per million entering vehicles (MEV) at the intersection of Hadley Place is higher than the 0.63 crashes per MEV for MassHighway District 4 unsignalized intersections. One of the crashes at the Hadley Place intersection involved a pedestrian. Its close proximity to the interchange, high traffic volumes on Salem Street, peak-period traffic queues on Salem Street, parking, and sight distance problems are some of the factors contributing to the unusually high number of crashes at the Hadley Place intersection.

5.2 SALEM STREET (ROUTE 60) AND PARK STREET

The intersection of Salem Street and Park Street is a four-legged signalized intersection controlled by an actuated traffic signal. It is located in an area with mixed land use: retail stores, a school, and residences. Figure 16 shows the intersection's geometry and lane configuration. The signals are mast-mounted, which is good, and the heads are in good condition, placed appropriately to provide good visibility for motorists. In the vicinity of this intersection, the roadway surface is in good condition, as is the granite curbing. On-street parking is allowed on Salem Street in the vicinity of the intersection for commercial activities, and on Park Street for residential and school activities. A "DO NOT ENTER, 8:10–8:40 AM" sign is posted at the entrance to Park Street north of the intersection because of school activities. In addition, a "BICYCLE STOP ON LINE FOR GREEN" sign is posted at each approach on Park Street to improve safety for students who bike to school. This bicycle sign also benefits pedestrians walking in the crosswalk by reducing pedestrian and bicycle conflicts. The Park Street intersection serves many students, who cross there before and after school in the morning and afternoon.

TABLE 8
Crash Characteristics and Frequency
2004–2006, Medford Intersections

	Salem Street Rotary	Salem Street and Hadley Place	Salem Street and Park Street	Salem Street and Spring Street	Salem Street and Fellsway West
	Number of Crashes	**Number of Crashes**	**Number of Crashes**	**Number of Crashes**	**Number of Crashes**
Crash Severity					
Fatality	1	0	0	0	0
Injury	9	3	4	5	8
Property damage only	7	8	6	9	17
Not reported	5	6	12	7	6
Unknown	0	0	0	0	1
Total	*22*	*17*	*22*	*21*	*32*
Collision Type					
Rear-end	13	4	9	6	10
Angle/sideswipe	3	4	10	10	20
Head-on	1	0	0	0	0
Single-vehicle crash	1	2	1	1	0
Not reported	4	7	2	3	2
Unknown	0	0	0	1	0
Total	*22*	*17*	*22*	*21*	*32*
Roadway Condition					
Dry	16	10	12	11	24
Wet	2	1	8	8	5
Snow	1	0	0	0	1
Not reported	2	6	2	2	2
Other	1	0	0	0	0
Total	*22*	*17*	*22*	*21*	*32*
Light Condition					
Daylight	10	8	9	11	24
Dawn	1	0	1	1	0
Dusk	1	1	2	1	0
Dark road, lighted	7	1	7	6	5
Dark road, unlighted	0	1	1	0	0
Not reported	3	6	2	2	3
Total	*22*	*17*	*22*	*21*	*32*
Year					
2004	8	5	12	3	7
2005	8	7	4	8	12
2006	6	5	6	10	13
Total	*22*	*17*	*22*	*21*	*32*

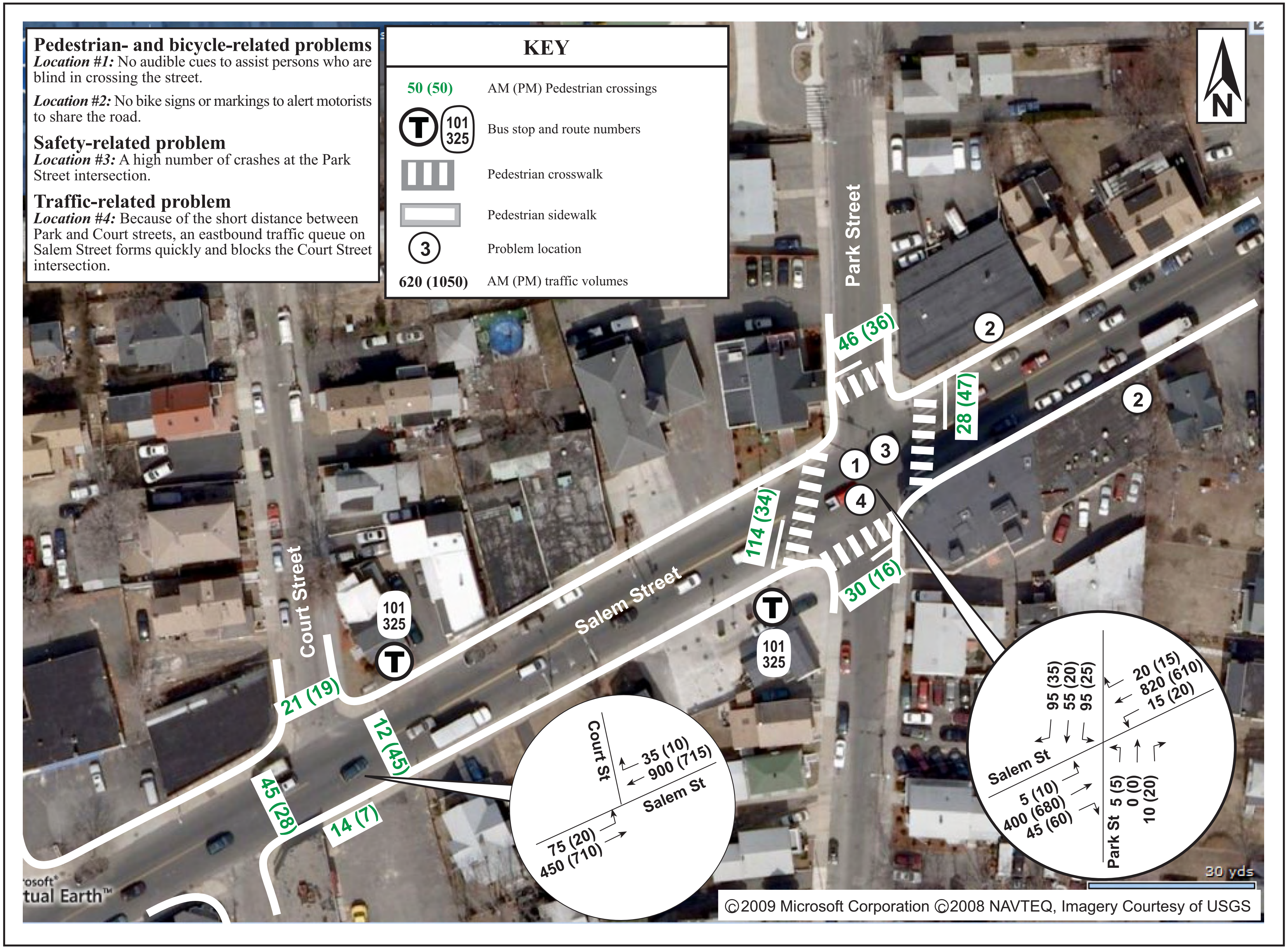

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FIGURE 16
Mobility Problems at the Salem Street (Route 60) and Park Street Intersection

Route 60 Mobility Study: Malden and Medford

Pedestrian and Bicycle Operations and Problems

The sidewalks at the intersection are in good condition, are made of concrete, and are five to seven feet wide. Street trees and street furniture on the sidewalks, such as streetlights, newspaper boxes, mailboxes, and trash receptacles, reduce the width of the sidewalks to less than five feet on Salem Street, but not to the extent of adversely impacting pedestrian and bicycle activities. The crosswalks are striped across all four approaches with parallel white stripes sufficiently visible to pedestrians and motorists. They are aligned obliquely to each approach and parallel to the roadways and are set back about three to four feet from the stop lines (see Figure 16). Each corner of the Park Street intersection features two sidewalk curb cuts for wheelchairs, one for each crosswalk.

The pedestrian signals at the Park Street intersection are in good working condition. The signal design includes an exclusive pedestrian phase—the pedestrian signal turns on when all traffic at the intersection is stopped. This eliminates vehicle-pedestrian conflicts. A symbol of a person walking and a flashing or steady red hand designate the pedestrian “WALK” and “DON’T WALK” phases, respectively. There is no audible pedestrian signal (APS) at this intersection to provide audible cues to assist persons who are blind in crossing the street. Figure 16 shows the AM and PM pedestrian crossing activity in green; on the day of observation, there were 218 pedestrians who crossed at the intersection during the AM peak period (7:00–9:00 AM) and 133 pedestrians during the PM peak period (4:00–6:00 PM), demonstrating high pedestrian activity in the morning due to the school located north of the intersection between Park and Court streets. A school crossing guard assists students in crossing the street in the morning and afternoon. Field observations show that pedestrians at this intersection usually use the crosswalk and push buttons. None of the crashes at this intersection involved a fatality or a pedestrian or bicyclist.

Traffic Operations and Safety Problems

Traffic operations at this intersection are satisfactory during the AM and PM peak periods, although there are occasions when queues form at this intersection. For both the AM and PM peak periods, the Park Street intersection operates at LOS C or better (see Table 6, page 49). Because of the very low volumes of traffic on Park Street, the actuated traffic signal provided at the intersection allows the green to stay on for Salem Street until it receives a call to serve traffic on Park Street. However, cars parked on the Park Street southbound approach for dropping off children at a bus stop or to go to school kept activating the green light for Park Street when it was not needed, sometimes causing a traffic queue to form on Salem Street.

Park Street approaches have sight distance problems due to the skewed intersection and on-street parking on Salem Street. Tables 7 and 8 (pages 50 and 51) present the crash rates, frequencies, and characteristics at the Park Street intersection. The rate of 1.20 crashes per million entering vehicles (MEV) is higher than the average of 0.88 crashes per MEV for MassHighway District 4 signalized intersections. Between 2004 and 2006, 22 crashes occurred at the Park Street intersection; the majority of them were rear-end and angle/sideswipe crashes. None of the crashes at this intersection involved a fatality or a pedestrian or a bicyclist. Also, 50 percent of the crashes occurred during nighttime.

5.3 SALEM STREET (ROUTE 60) AND SPRING STREET

The intersection of Salem Street and Spring Street is a complex, five-legged unsignalized intersection, located in an area with mixed land use: commercial, small industries, and residences. The intersection’s geometry and lane configuration are shown in Figure 17. At the intersection, Salem Street is uncontrolled, while Spring Street has stop signs posted at its approaches and marked on the pavement. Spring Street has an offset in its alignment; the northbound and southbound approaches are separated by about 100 feet, creating two T-intersections with Salem Street.

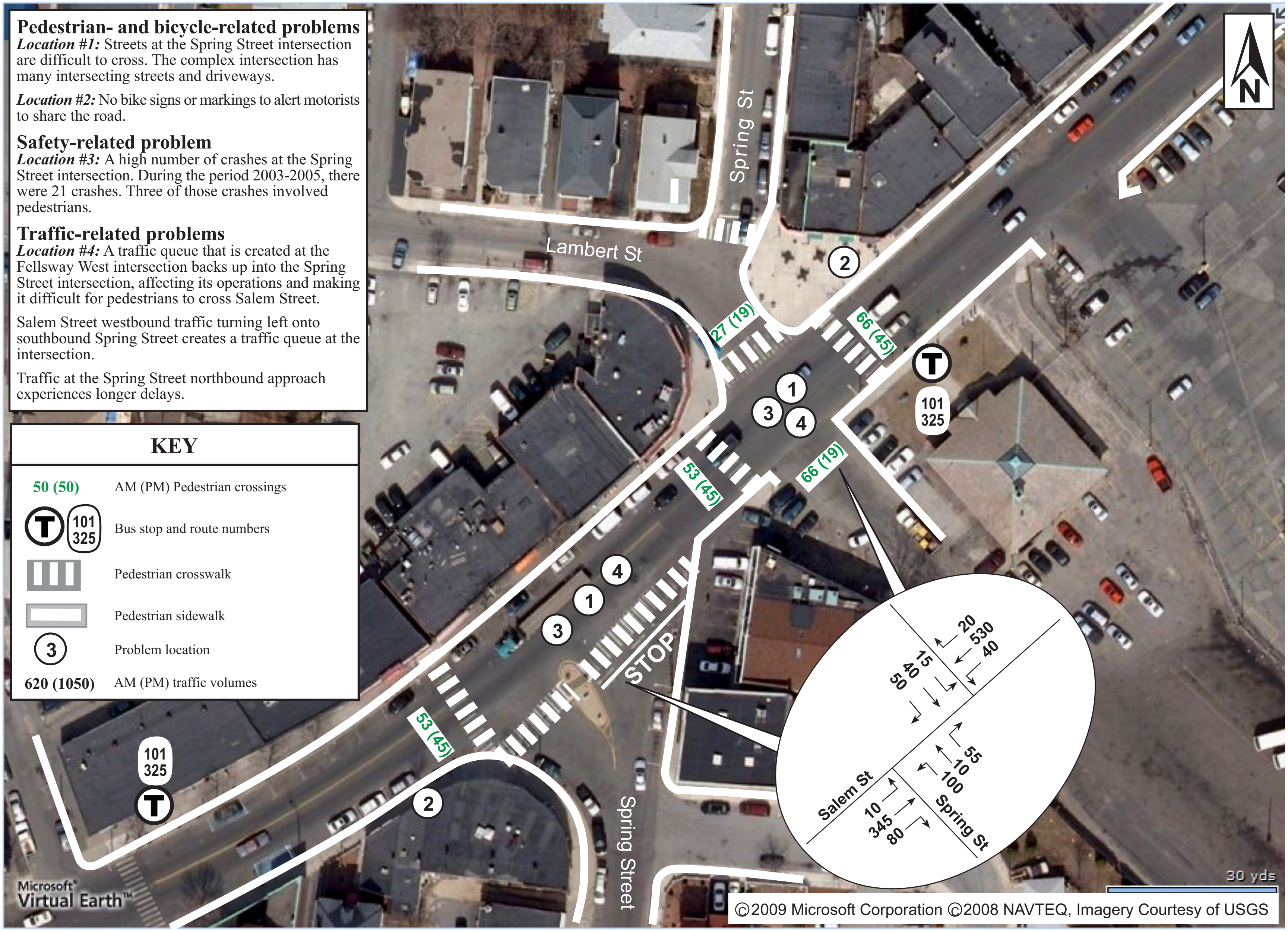

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FIGURE 17
Mobility Problems at the Salem Street (Route 60) and Spring Street Intersection

Route 60 Mobility Study: Malden and Medford

The pavement in the vicinity of the intersection is in fair to good condition, as are the granite curbs. On-street parking is allowed on both sides of Salem Street in the vicinity of the intersection for the commercial activities it serves, and on Spring Street for residential parking.

Pedestrian and Bicycle Operations and Problems

Figure 17 shows the pedestrian crossings at this intersection. They are marked with simple, parallel white stripes perpendicular to the pedestrian traffic flow, sufficiently visible to pedestrians and motorists. The crosswalks are aligned perpendicular to each approach. The stop lines at the approaches of Spring Street are marked with white paint, sufficiently visible to motorists, and are set back about four feet from the crosswalk. The sidewalks on both Salem Street and Spring Street are five to seven feet wide, are made of concrete, and are in fair to good condition. Each corner of the intersection features two sidewalk curb cuts for wheelchairs, one for each crosswalk. The street furniture reduces the width of the sidewalk to less than five feet at certain locations, but not to the extent that it impacts pedestrian traffic flow.

The AM and PM pedestrian crossing activities are shown in green in Figure 17. On the day of observation, 212 pedestrians crossed at the intersection during the AM peak period (7:00–9:00 AM) and 128 pedestrians during the PM peak period (4:00–6:00 PM). Crossing at the Spring Street intersection is difficult for motorists and pedestrians because of the complexity of the intersection (there are many intersecting streets and driveways) and high peak-period traffic volumes on Salem Street. Pedestrians were observed crossing the street at this intersection by looking for gaps of sufficient length in traffic or for motorists yielding to pedestrians. None of the crashes involved fatalities, but there were three crashes involving pedestrians; two of the pedestrian crashes occurred at the Spring Street intersection to the west and one at the intersection to the east.

Traffic Operations and Safety Problems

There are some concerns about traffic operations at this intersection during the AM and PM peak periods. An eastbound traffic queue created at the Fellsway West intersection extends into the Spring Street intersection. This queue creates traffic problems for pedestrians crossing Salem Street, as well as for motorists turning left onto Spring Street. A level-of-service analysis presented in Table 6 (page 49) indicates that during the AM peak period the Spring Street southbound approach operates at LOS C, while the northbound approach operates at LOS E.

The crash rates at the Spring Street intersection and the characteristics and frequency of the crashes are presented in Table 7 and Table 8 (pages 50 and 51), respectively. At the Spring Street intersection, the crash rate of 1.33 crashes per million entering vehicles (MEV) is higher than the average of 0.63 crashes per MEV for District 4 unsignalized intersections. As referred to earlier, crossing activities at the Spring Street intersection are problematic for motorists and pedestrians; there were 21 crashes at this intersection between 2004 and 2006, most of them angle/sideswipe and rear-end crashes. None of the crashes involved fatalities, but there were three crashes involving pedestrians; two of the pedestrian crashes occurred at the Spring Street intersection to the west and one at the intersection to the east. The majority of the crashes (14) occurred at the Spring Street westbound approach of the intersection.

5.4 SALEM STREET (ROUTE 60) AND FELLSWAY WEST (ROUTE 28)

The Salem Street and Fellsway West intersection is a four-legged signalized intersection, located in an area with retail stores, grocery stores, and residences. It is controlled by the Department of Conservation and Recreation. The intersection’s geometry and lane configuration are shown in Figure 18. Both the westbound and eastbound approaches of Salem Street are used as two travel lanes, especially during peak

Pedestrian- and bicycle-related problems

Location #1: No audible cues at the signalized intersection to assist the blind in crossing the street; longer crosswalks on Fellsway West.

Location #2: No bike signs or markings to alert motorists to share the road.

Safety-related problem

Location #3: A high number of crashes at the Fellsway West intersection. During the period 2003-2005, there were 26 crashes.

Traffic-related problem

Location #4:
Traffic operations at this intersection are unsatisfactory during the AM and PM peak periods, with long delays on Salem Street. There are queues at the intersection.

KEY

50 (50)	AM (PM) Pedestrian crossings
T 101 325	Bus stop and route numbers
	Pedestrian crosswalk
	Pedestrian sidewalk
3	Problem location
620 (1050)	AM (PM) traffic volumes

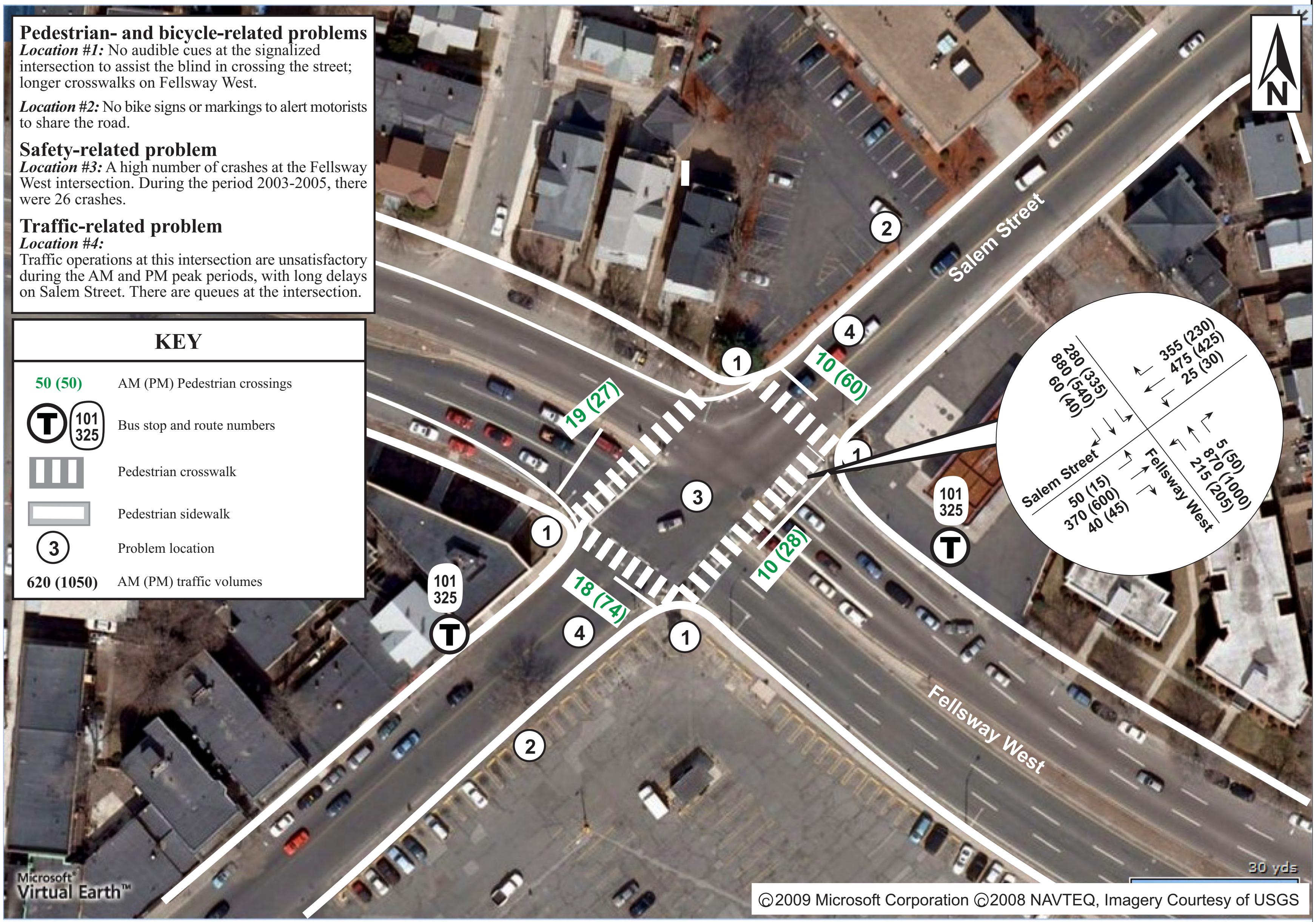

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FIGURE 18
Mobility Problems at the Salem Street (Route 60) and Fellsway West Intersection

Route 60 Mobility Study: Malden and Medford

periods, even though they are each striped as one lane. On-street parking is allowed only on the westbound side of Salem Street west of the intersection, for commercial activities. Residential on-street parking is allowed on both sides of Fellsway West north of the intersection. The street pavement and curbs in the vicinity of the intersection are in good condition. The traffic signals at the intersection are mast mounted for Fellsway West, which is good, as it provides good visibility. The traffic signals for Salem Street are post mounted in the sidewalks and in the median for Fellsway West left-turn traffic. The signal heads are placed appropriately to provide good visibility for motorists, but the signal equipment and heads need to be upgraded. Right turns on red from Salem Street are prohibited because of poor sight distance resulting from the curvature of Fellsway West at the intersection (see Figure 18).

Pedestrian and Bicycle Operations and Safety Problems

The traffic signal design at this intersection includes an exclusive pedestrian signal phase, which eliminates vehicle-pedestrian conflicts. A symbol of a person walking and a flashing or steady red hand designate the pedestrian “WALK” and “DON’T WALK” phases, respectively. There are no accessible pedestrian signals to provide audible cues to assist persons who are blind in crossing the street. The pedestrian crosswalks are marked across all four approaches with simple parallel white stripes perpendicular to the direction of pedestrian flow. When the field inspection took place, the crosswalk markings and the stop lines were moderately faded but sufficiently visible to pedestrians and motorists. The sidewalks are made of concrete and are in good condition; they are five to eight feet wide. The street furniture reduces the width of the sidewalks to less than four feet on westbound Salem Street west of the intersection. Each corner of the intersection features a single sidewalk curb cut for wheelchairs, which serves crosswalks on both Salem Street and Fellsway West.

AM and PM pedestrian crossing activity is shown in green in Figure 18. On the day of observation, 57 pedestrians crossed at the intersection during the AM peak period (7:00–9:00 AM), and 189 pedestrians during the PM peak period (4:00–6:00 PM). Pedestrians were observed using the crosswalk and push buttons most of the time. Very long pedestrian crosswalks on Fellsway West (six travel lanes and no usable median) create problems for pedestrians. None of the crashes at this intersection involved a fatality, a pedestrian, or bicycle.

Traffic Operations and Safety Problems

A level-of-service analysis presented in Table 6 (page 49) indicates that traffic operations at this intersection are unsatisfactory during the AM and PM peak periods, as reflected in the long traffic queues, especially on Salem Street. The traffic queues that form at this intersection often extend into the Spring Street intersection in Medford and into the Fellsway East intersection in Malden, impacting their traffic operations and safety. The absence of left-turn bays on Salem Street and the lack of adequate acceptable gaps in the opposing traffic on Salem Street do not only cause the permitted left turns to block the intersection, but also contribute to vehicles moving during the all-red clearance phase. Field observations indicate that too much green time is allocated for the Fellsway West through movements, which contributes partly to the long queues on Salem Street. The high volume of right turns on westbound Salem Street during the peak travel period needs some treatment to improve traffic operations at that approach.

The crash rates, frequencies, and characteristics at this intersection are presented in Table 7 and Table 8 (pages 50 and 51), respectively. The crash rate of 1.11 crashes per million entering vehicles (MEV) is higher than the average rate of 0.88 crashes per MEV for MassHighway District 4 signalized intersections. There were 32 crashes at this intersection between 2004 and 2006; most were angle/sideswipe and rear-end crashes. None of the crashes at this intersection involved a fatality, a pedestrian, or a bicyclist, and the majority occurred in daylight and under dry conditions.

6. ROUTE 60 IMPROVEMENTS IN MEDFORD

6.1 CORRIDOR IMPROVEMENTS

In general, MPO staff recommend installing bicycle and pedestrian signs and pavement markings in the corridor to inform motorists that they should share the road with bicyclists and pedestrians, who are numerous in the corridor because the commercial activities and mass transportation services in this corridor are a draw to pedestrians and bicyclists. One way to improve mobility is to improve safety by drawing motorists' attention to pedestrians and bicyclists. Bicycle-warning signs (types W11-1 and W16-1) are needed in this corridor to alert motorists to the presence of bicyclists and let them know that they need to share the road with bicyclists, as the lack of bicycle facilities in the corridor forces bicyclists to use the travel lanes.

W11-2

W13-1

R1-6

W11-1 and W16-1

MUTCD

Driver awareness is critical to improving safety; such awareness could be enhanced at these intersections and throughout the corridor by installing or upgrading signs and pavement markings on the approaches using larger letters to prepare motorists approaching a busy pedestrian area. Installing nonvehicular warning signs (type W11-2) in combination with advisory speed signs (type W13-1) and in-street pedestrian crossing signs (type R1-6) would alert motorists approaching an area with a high level of pedestrian activity.

The following sections describe potential improvements for addressing the problems that were identified in Chapter 5.

6.2 SALEM STREET AND THE I-93 ROTARY INTERCHANGE

The following is a summary of problems at the interchange.

- Sidewalks leading to and around the interchange are in poor condition, are dirty and weedy in some sections, and are in need of security lights, especially under the I-93 bridge.

- Traffic operations at the rotary are unsatisfactory; there are traffic queues on the southbound off-ramp as well as on Route 60.

- Crashes at the interchange were clustered at an area near the merge of Salem Street and the I-93 southbound off-ramp.

Figure 19 shows potential improvements recommended by MPO staff in consultation with the City of Medford for the I-93 interchange.

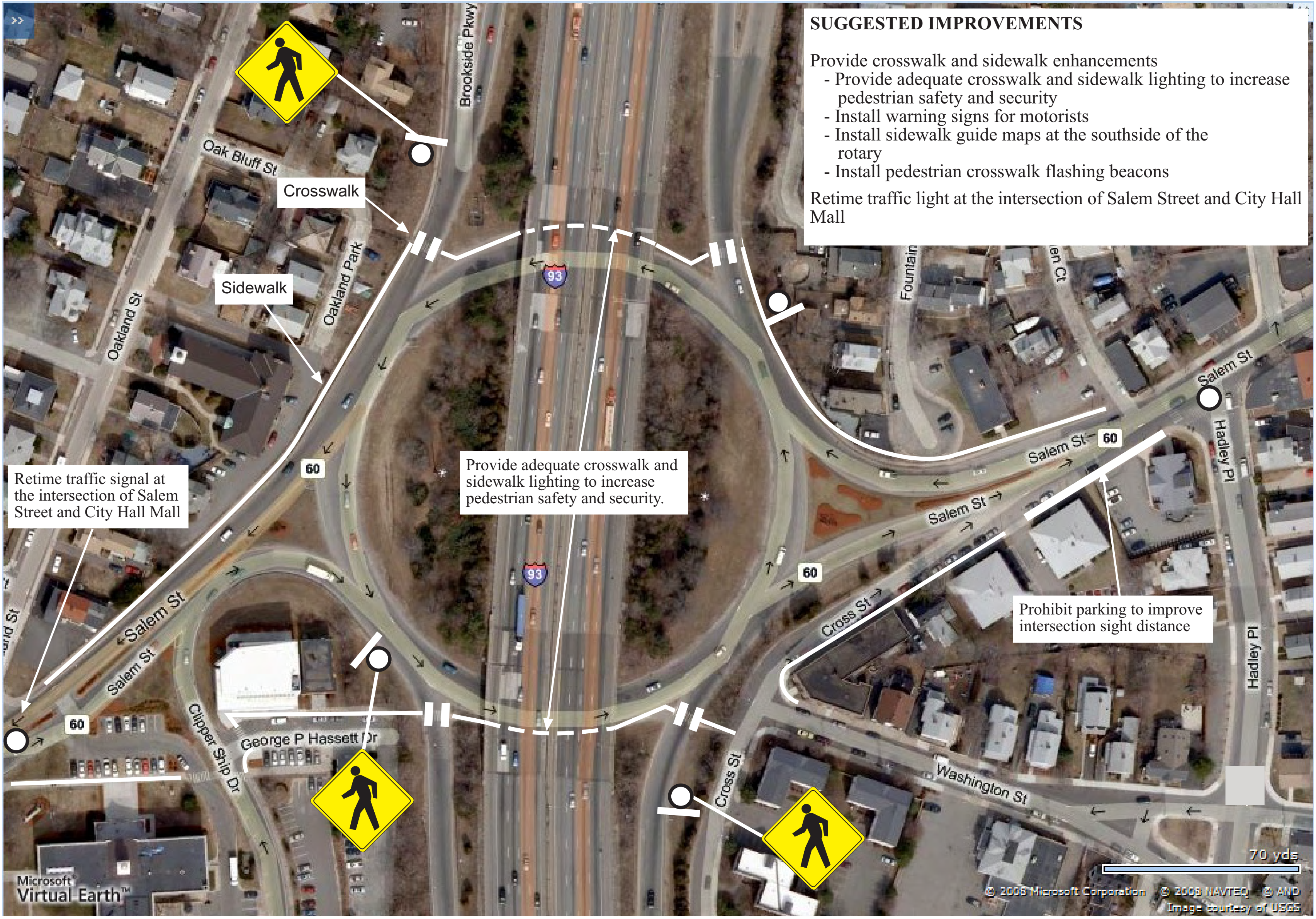

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FIGURE 19
Mobility Improvements at Salem Street and the I-93 Rotary Interchange

Route 60 Mobility Study: Malden and Medford

Provide Crosswalk and Sidewalk Enhancements

This strategy is directed at pedestrians; it is designed to guide them to the best location for crossing a high-volume street when a pedestrian signal is not present. Presently, the crosswalks within the rotary are all marked, in order to indicate to pedestrians the preferred locations for them to cross. However, it is useful to supplement crosswalk markings with warning signs for motorists, especially at locations with traffic volumes above 10,000 per day, to encourage motorists to yield to pedestrians (a 2008 traffic count performed by staff indicated average daily traffic of 25,000 vehicles at the rotary). Substantial pedestrian crossing treatments are needed at the rotary to help pedestrians cross safely. The following enhancements are suggested for the rotary:

- Appropriate placement of lighting and adequate lighting levels for the sidewalks and crosswalks in the vicinity of the rotary enhance the environment for walking, as well as increasing pedestrian safety and security. Pedestrians often incorrectly assume that motorists can see them at night, since a pedestrian can see the oncoming headlights. Therefore, it is necessary to provide adequate lighting at the intersection so that drivers can see pedestrians in time to stop. Marked crosswalks should be visible to motorists, particularly at night.

Solar pedestrian crosswalk flashing beacon

We suggest that the City of Medford and MassHighway consider installing pedestrian crosswalk flashing beacons at the crosswalks within the rotary that a pedestrian activates by pushing a button. Solar-powered pedestrian crosswalk flashing beacons are a stand-alone solution with an easy retrofit onto existing signposts. As a push-button-activated solution, solar beacons draw attention to the presence of pedestrians at uncontrolled crosswalks, preserving the safe and efficient flow of both vehicles and pedestrians.

Another pedestrian safety device that could improve safety is flashing lights embedded along the edge of the crosswalk that faces traffic.

- Installing warning signs for motorists to yield to pedestrians would also encourage motorists to look for pedestrians.

- Installing a sidewalk guide map at the crosswalks on the south side of the rotary showing the layout of the sidewalks at the rotary interchange is important for pedestrians, since the sidewalk on that side of the rotary can be confusing to navigate because it crosses many roadways and changes direction in some locations.

Retime the Salem Street Traffic Signal at City Hall Mall

Retiming the traffic light at Salem Street and City Hall Mall would reduce delay and the resulting traffic queue that sometimes extends into the rotary, which affect traffic operations at the rotary. Although this intersection was not included in this study, it has an impact on safety and traffic operations at the rotary.

6.3 SALEM STREET AND HADLEY PLACE

The intersection of Salem Street and Hadley Place had 17 crashes in three years (2004–2006), a higher number of crashes than many other unsignalized intersections in the vicinity. The following potential improvements are suggested for addressing safety issues at the Hadley Place intersection.

Provide Clear Sight Distance from the Hadley Place Stop-Controlled Approach to the Intersection

Many of the crashes at this intersection involve a northbound vehicle from Hadley Place and a vehicle traveling eastbound or westbound on Salem Street, resulting in angle and sideswipe crashes. These crashes may be related to restricted sight distance due to the fact that Hadley Place intersects Salem Street at an oblique angle. This situation may be compounded by on-street parking near the intersection (see Figure 20). Adequate sight distance for drivers at stop-controlled approaches has long been recognized as among the most important factors contributing to safety at unsignalized intersections. It is estimated that correcting for sight distance at intersections can result in up to a 37 percent reduction in injury-related crashes.[6]

Sight distance improvements for drivers at the Hadley Place stopped-controlled approach could be achieved by eliminating parking on Salem Street after it merges with Cross Street, and also in the vicinity of the Hadley Place intersection, where parking restricts the sight distance. Increased enforcement of existing parking prohibitions may be needed to ensure successful implementation of this strategy. The most difficult aspect of this strategy is the possible response of adjacent property owners and users who might be negatively impacted by stricter enforcement, which would effectively reduce the number of nearby parking spaces. Public compliance with increased enforcement of parking restrictions might present a problem.

Improve the Visibility of the Intersection by Providing Enhanced Signage

D3-2


W2-4

W13-1

MUTCD

The Hadley Place intersection is not clearly visible to approaching drivers, particularly drivers approaching from Salem Street in both directions. The visibility of an intersection to approaching drivers could be enhanced by signage and pavement markings. Such improvements could include: advance street name signs (type D3-2), intersection warning signs (type W2-4), and advisory speed signs (type W13-1). Such improvements contribute to a better driving environment. Advance warning signs and intersection warning signs also alert drivers to the presence of an intersection. Making drivers aware that they are approaching an intersection through the use of enhanced signage and pavement markings should improve safety at the intersection because drivers would be alerted to vehicles approaching from the cross streets. This heightened awareness quickens drivers' reaction times when conflicts occur. However, care should be taken not to overuse traffic signage because excessive signage tends to distract drivers.

Install Flashing Beacons at This Stop-Controlled Intersection

Standard overhead flashing beacon

Post-mounted flashing beacon with stop sign

www.tfhrc.gov

Flashing beacons at unsignalized intersections can be a cost-effective safety improvement. Overhead flashing beacons or post-mounted flashing beacons with stop signs could be used at the Salem Street and Hadley Place intersection to call drivers' attention to the intersection. Flashing beacons are used to reinforce driver awareness to help mitigate patterns of right-angle crashes. At two-way stop-controlled intersections such as this intersection, flashing beacons could be used with red flashers

[6] U.S. Department of Transportation, Federal Highway Administration, *Desktop Reference for Crash Reduction Factors*, Publication No. FHWA-SA-07-015, September 2007.

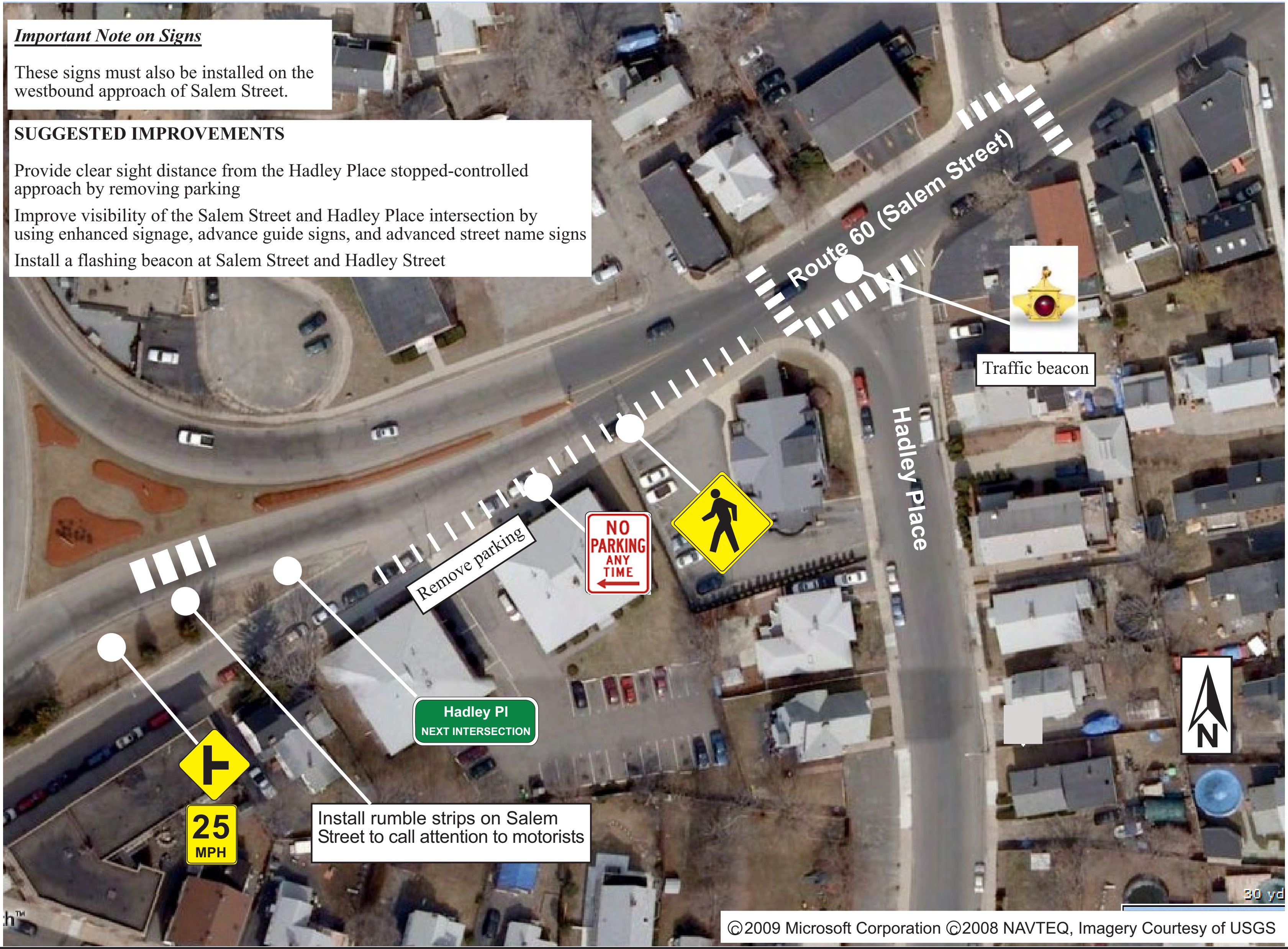

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FIGURE 20
Mobility Improvements at the Intersection of Salem Street and Hadley Street

Route 60 Mobility Study: Malden and Medford

facing the Hadley Place stop-controlled approach and yellow flashers facing the Salem Street uncontrolled approaches. Use of flashing beacons increases the visibility of intersections for approaching drivers, thus supplementing the signage and marking improvements and calling attention to stop signs.

Install Rumble Strips on Salem Street to Call Attention to the Intersection


www.dublin.oh.us

Rumble strips

The Salem Street and Hadley Place intersection is about 150 feet east of the I-93 interchange; thus crashes may occur because one or more drivers may be unaware of the intersection as it is so close to the interchange. Installing rumble strips at the approaches would call attention to the presence of the intersection and the traffic control in use at the intersection. Rumble strips are appropriate on stop-controlled approaches to intersections where a pattern of crashes is related to the drivers' lack of attention to certain traffic activity, control measures, or a change in the geometry of the intersection.

Rumble strips are normally applied when less intrusive measures—such as pavement markings like "STOP AHEAD," other pavement markings, signage, or flashing signals—have been tried and have failed to correct the crash pattern. A rumble strip could be located so that when a driver crosses the rumble strip, a key traffic control device such as a "STOP AHEAD" sign or a speed limit sign, such as "25 MPH SPEED LIMIT," is directly in view. Rumble strips in a travel lane have several potential pitfalls that should be considered carefully when considering whether or not to implement them. They include: (1) noise that may disturb nearby residents; (2) potential loss of control for motorcyclists and bicyclists; (3) difficulties created for snowplow operations; and (4) inappropriate driver responses, such as using the opposing travel lanes to drive around the rumble strip.

6.4 SALEM STREET AND PARK STREET

Staff identified the following safety problems at the intersection of Salem Street and Park Street.

- The crash rate of 1.20 crashes per million entering vehicles (MEV) is higher than the average of 0.88 crashes per MEV for MassHighway District 4 signalized intersections.

- The predominant types of crashes at the intersection were angle/sideswipe and rear-end crashes (combined, 91 percent of the crashes). Also, 50 percent of the crashes occurred during nighttime.

- Sight distance problems due to the skewed intersection and on-street parking.

None of the crashes involved a fatality, a pedestrian, or a bicyclist. In consultation with the City of Medford, staff recommend the following improvements for increasing safety at this intersection (see Figure 21).

Prohibit Turns on Red on Park Street

Prohibition of right-turn-on-red (RTOR) can help reduce crashes related to limited sight distance. The safety problems that RTOR vehicles encounter at the Park Street intersection arise from the limited sight distance resulting from the skewed geometric design of the intersection and from the presence of on-street parking on Salem Street that blocks drivers who are turning right from Park Street from viewing vehicles that are westbound on Salem Street. This strategy could help reduce the frequency and severity of crashes between vehicles turning right on red from Park Street and westbound vehicles on Salem Street. This strategy could be implemented with improved signage, although enforcement would be needed to realize the potential benefits of the new regulation.

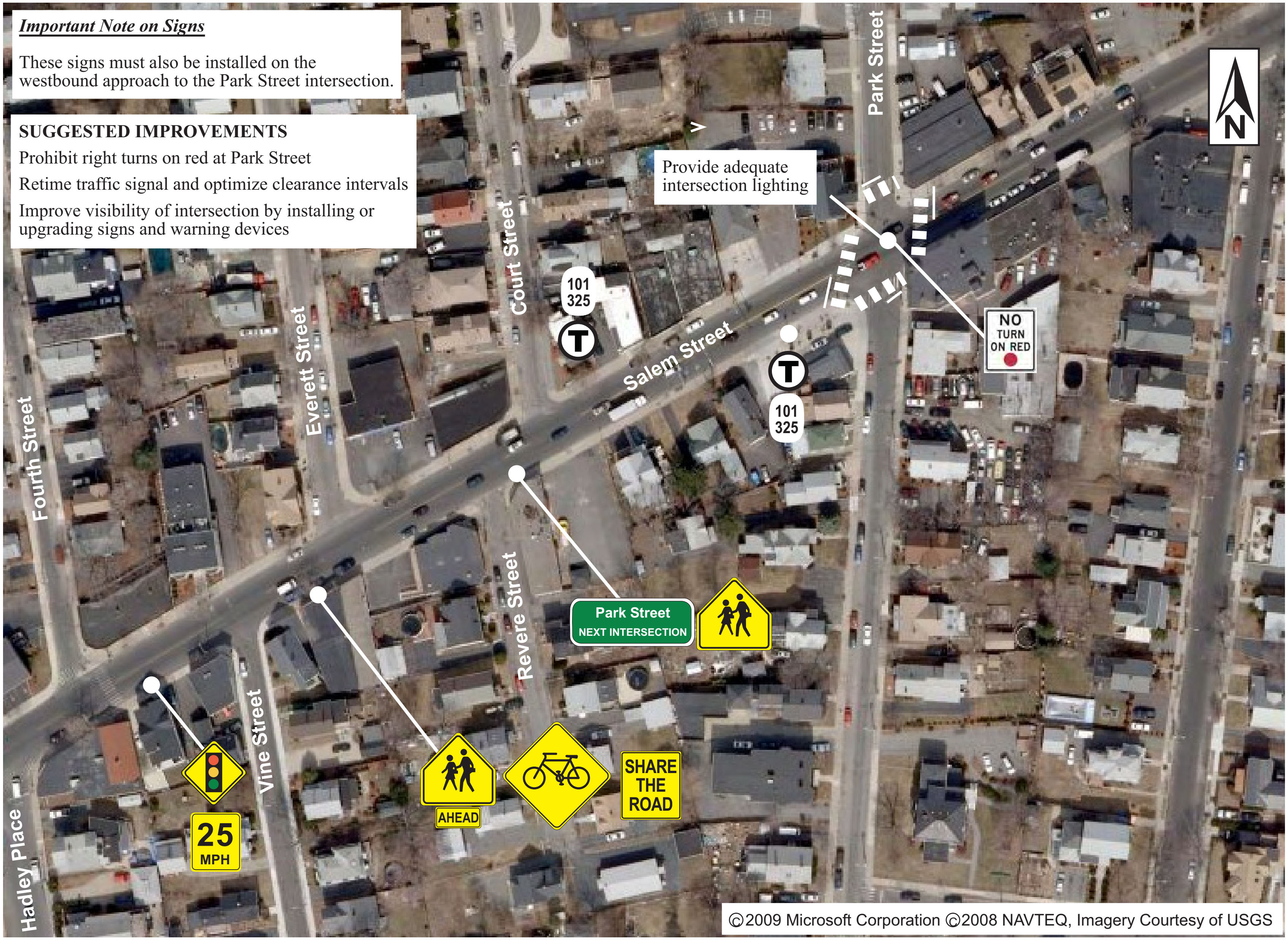

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FIGURE 21
Mobility Improvements at the Intersection of Salem Street and Park Street

Route 60 Mobility Study: Malden and Medford

Retime the Traffic Signal

Signal retiming is one of the most cost-effective ways to improve traffic flow along a corridor or at an intersection. It is the process that optimizes the operation of the signalized intersection to improve traffic flow by reducing stops and delays. It is also done to improve safety and save time for emergency vehicles and for bus transit service. One goal of this strategy is to reduce stops at the signalized intersection to reduce traffic queuing, which in turn would reduce rear-end crashes.

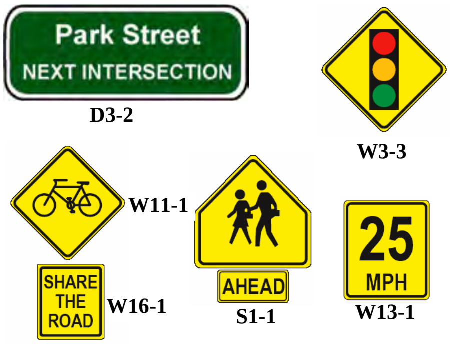
Signal retiming includes optimizing the clearance intervals (yellow and all-red intervals) to improve safety. Clearance intervals provide safe, orderly transitions in right-of-way assignment between conflicting streams of traffic. Another goal of this strategy is to reduce crashes related to clearance interval lengths that are too short for a particular intersection. Rear-end crashes may be a symptom of short clearance intervals. A vehicle stopping at a signal may be rear-ended by a vehicle following it when the following driver expects to be able to proceed through the intersection during a longer clearance interval. Based on methods suggested by the Institute of Transportation Engineers (ITE), this intersection would require a total of at least five seconds for the yellow and red clearance intervals combined. Table 9 shows the simulated results of the signal optimization.

TABLE 9
Optimized Delay, Level of Service, and Queue Length,
Medford Intersections*

	AM Peak Period			**PM Peak Period**		
Intersection Approach	**Delay (sec)**	**LOS**	**Queue (veh)****	**Delay (sec)**	**LOS**	**Queue (veh)****
Salem Street and Park Street Intersection						
Salem Street Westbound	24	C	20	17	B	22
Salem Street Eastbound	10	A	9	18	B	22
Park Street Northbound	39	D	2	27	C	2
Park Street Southbound	58	E	6	37	D	4
Total Intersection Delay (Existing)	21	B	n/a	12	B	n/a
Total Intersection Delay (Optimized)	21	B	n/a	18	B	n/a
Salem Street and Fellsway West Intersection						
Salem Street Westbound Th + RT	54	D	20	35	D	17
Salem Street Westbound LT	29	C	1	40	D	2
Salem Street Eastbound Th + RT	46	D	18	108	F	26
Salem Street Eastbound LT	57	E	4	39	D	5
Fellsway West Southbound Th + RT	36	D	15	35	C	12
Fellsway West Southbound LT	54	D	14	87	F	18
Fellsway West Northbound Th + RT	50	D	18	130	F	11
Fellsway West Northbound LT	50	D	11	54	D	24
Total Intersection Delay (Existing)	105	F	n/a	80	F	n/a
Total Intersection Delay (Optimized)	54	D	n/a	80	F	n/a

n/a = not applicable
* The optimized delay, LOS, and queue length reflect improvements such as signal retimimg, change in sequence of movements and clearance interval
** 95% queue length
Th = through, RT = right turn, LT = left turn

Improve the Visibility of the Intersection from the Approaches



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Driver awareness of both downstream intersections and traffic control devices is critical to intersection safety. Inability to perceive an intersection or its control, or the back of a stopped queue, in time to avoid a collision can result in safety problems. Installing or upgrading signs with larger letters on intersection approaches can prepare drivers for the intersection in advance. This may include advance street name signs (type D3-2), advance traffic control signs (type W3-3), and advisory speed signs (type W13-1). Advance street name signs and advance traffic control signs can improve awareness of a downstream signalized intersection. In addition, installing advance-warning signs, such as school-ahead signs (type S1-1) and bicycle warning signs (type W11-1 and W16-1), would improve safety. These potential improvements are shown in Figure 21 (page 65).

About half of the crashes at the Salem Street and Park Street intersection occurred during nighttime. Of these crashes, the majority were reported to have occurred under “dark, road lighted” conditions. Providing adequate lighting at the intersection itself and on its approaches can make drivers aware of the presence of the intersection and reduce nighttime crashes.

6.5 SALEM STREET AND SPRING STREET

Staff identified the following problems at this intersection.

- Crossing at the intersection is a problem for motorists and pedestrians because of the complexity of the intersection and the high volume of traffic on Salem Street.
- There were 21 crashes at this intersection between 2004 and 2006, of which 10 were angle/sideswipe crashes and 6 were rear-end crashes. The majority of the crashes (14) occurred at the Spring Street westbound intersection.
- Three of crashes at this intersection involved pedestrians; two of those crashes occurred at the Spring Street westbound intersection and one at the eastbound intersection.
- Twelve of the crashes occurred in daylight and eight at night.
- There are traffic operations problems at this intersection during the peak periods, when an eastbound traffic queue at the Fellsway West intersection extends into this intersection and creates traffic problems for pedestrians and motorists turning left onto Spring Street.

Staff recommend the following improvements for addressing safety and operations concerns at this intersection (Figure 22).

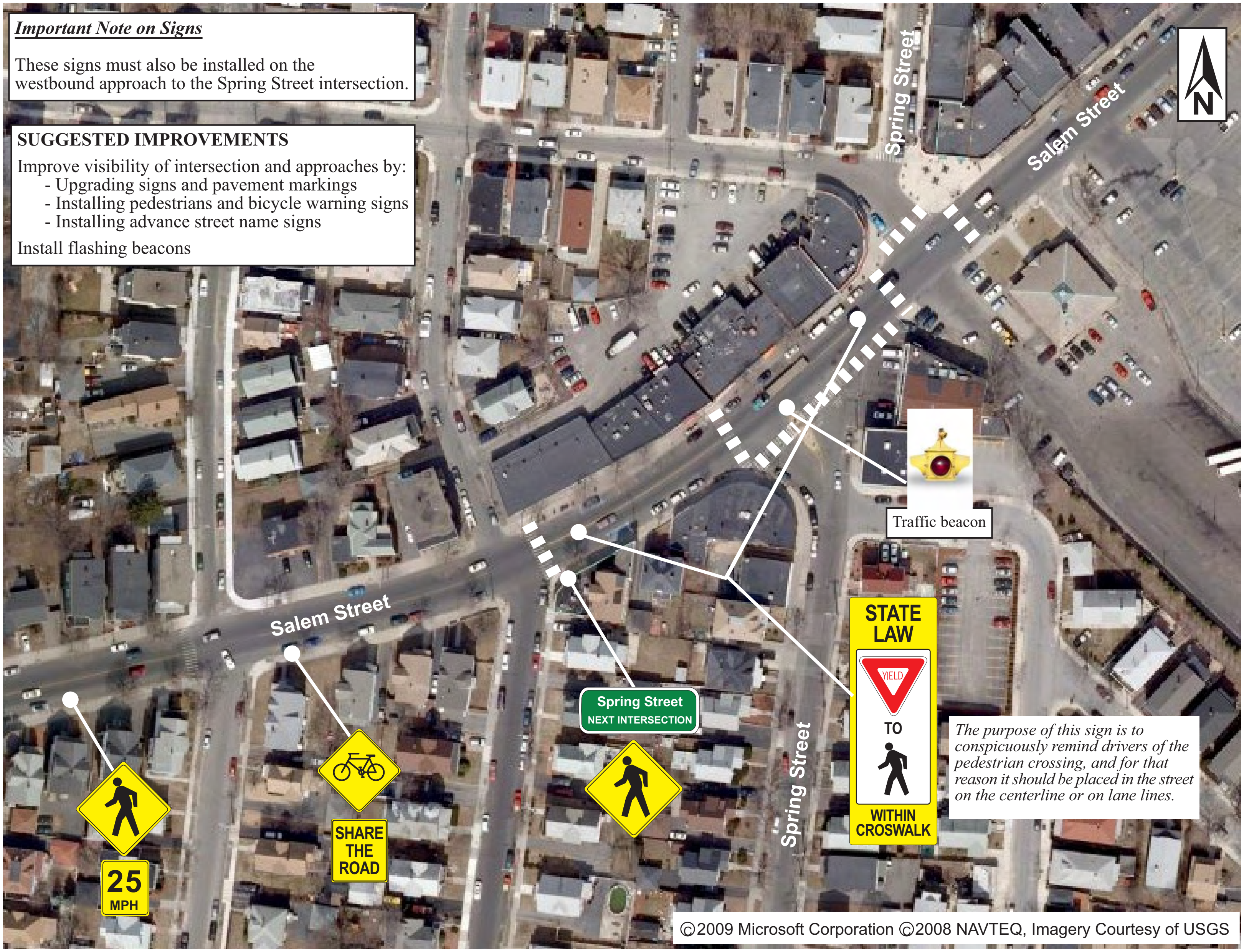

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FIGURE 22
Mobility Improvements at the Intersection of Salem Street and Spring Street

Route 60 Mobility Study: Malden and Medford

Improve the Visibility of the Intersection from the Approaches

W11-2

W13-1

W11-1 and W16-1

R1-6

D3-2

MUTCD

Driver awareness of this intersection is critical to improving safety. Such awareness could be enhanced at this intersection by installing or upgrading signs and pavement markings on the approaches using larger letters to prepare motorists approaching a busy pedestrian area. Installing nonvehicular warning signs (type W11-2) in combination with advisory speed signs (type W13-1) and in-street pedestrian crossing signs (type R1-6) would alert motorists approaching an area with high pedestrian activity. The purpose of an R1-6 sign is to remind drivers of the pedestrian crossing, and for that reason these signs should be placed in the street on the centerline or on lane lines. In addition, bicycle-warning signs (types W11-1 and W16-1) are needed in the vicinity to alert motorists to the presence of bicyclists and let them know that they need to share the road with bicyclists, as the lack of bicycle facilities in the corridor forces bicyclists to use the travel lanes. Advance street name signs (type D3-2) could be used to identify the intersection in advance.

Install Flashing Beacons

The City of Medford should also consider installing flashing beacons at this intersection to supplement the stop-control at approaches and call motorists' attention to stop signs. Flashing beacons help to mitigate patterns of right-angle crashes related to stop-sign violations and increase the visibility of the intersection for approaching drivers. Crash types mitigated by flashing beacons include angle, sideswipe, and rear-end. The shortcoming of flashing beacons is that drivers generally understand the signal indications of flashing beacons, but at times, drivers on a minor street are confused about the nature of the signal showing on the major street.

6.6 SALEM STREET AND FELLSWAY WEST

This intersection, which is under the jurisdiction of the Massachusetts Department of Conservation and Recreation (DCR), had the following problems.

- Very long pedestrian crosswalks on Fellsway West (six travel lanes and no usable median).
- Unsatisfactory traffic operations during peak periods. There are queues on Salem Street that on some occasions extend into the adjacent intersections due to the lack of turning bays.
- Field observations show that Fellsway West seems to have too much green time for the through traffic, which contributes to the long queues on Salem Street.
- The crash rate at this intersection exceeds the average rate of MassHighway District 4 signalized intersections.
- There were 32 crashes at the Salem Street and Fellsway West intersection between 2004 and 2006; 20 (67 percent) were angle/sideswipe crashes.

The following potential improvements are suggested for addressing problems at this intersection (see Figure 23).

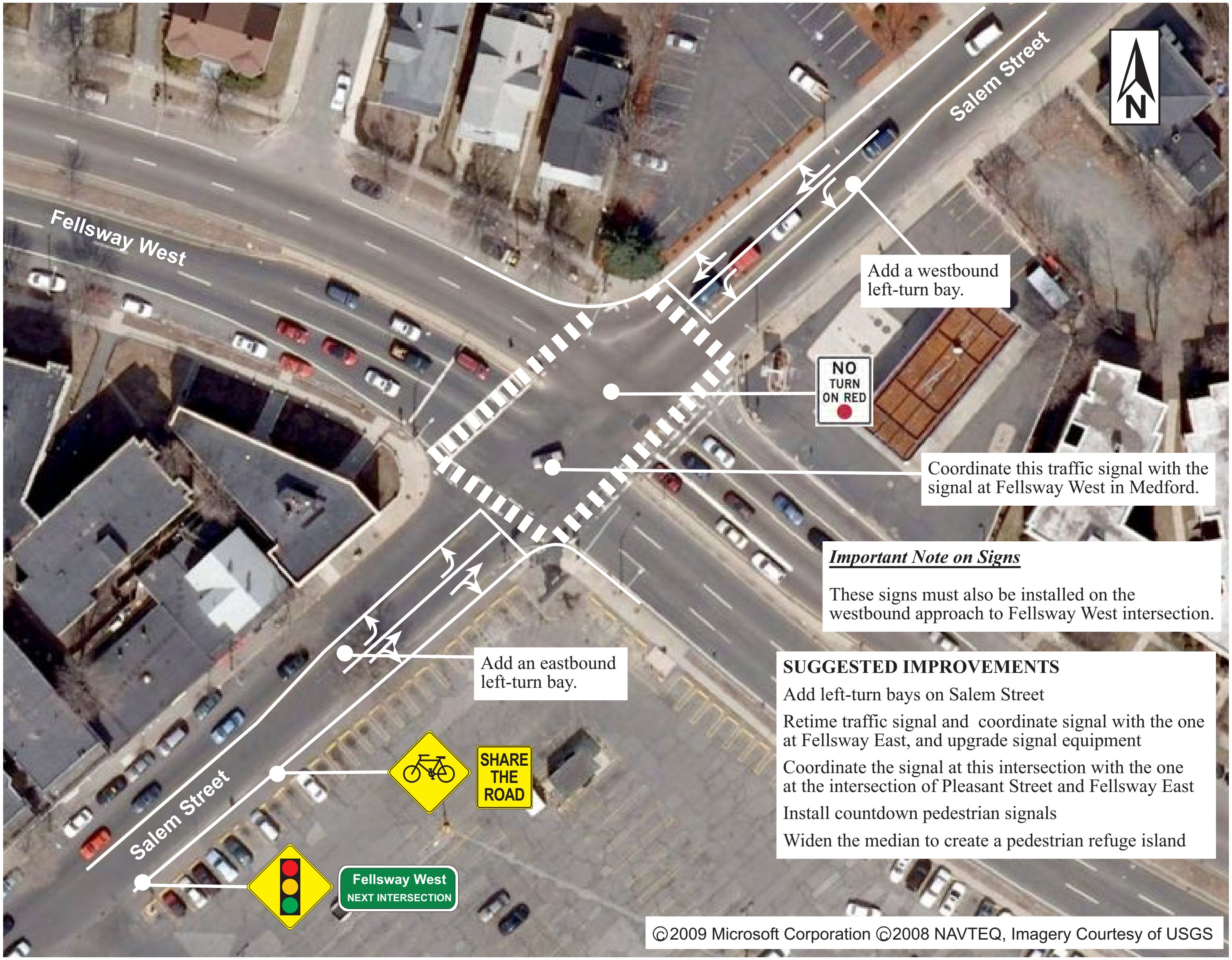

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FIGURE 23
Mobility Improvements at the Intersection of Salem Street and Fellsway West

Route 60 Mobility Study: Malden and Medford

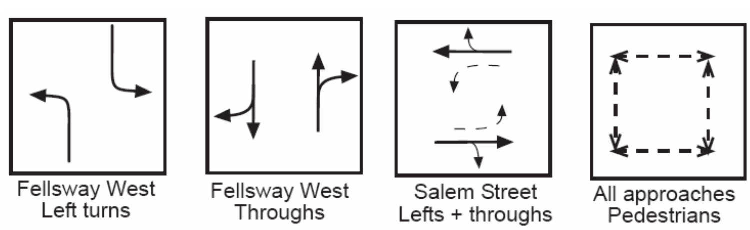
Add Turn Bays on Salem Street

Many intersection safety and operations problems can be traced to difficulties in accommodating turning vehicles. A key strategy for minimizing collisions related to turning vehicles and for facilitating traffic flow is to provide exclusive right-turn and left-turn bays, particularly on a high-volume arterial such as Salem Street. A left-turn bay on Salem Street eastbound would allow for separation of left-turn and through-traffic streams to prevent vehicles turning left from blocking through traffic. A right-turn bay on Salem Street westbound would reduce delays and prevent the long queue on that approach that results from the high volumes of right turns at that approach. Turn bays provide sheltered locations for motorists to wait for acceptable gaps in oncoming vehicles, minimizing the potential for collisions with those vehicles. Potential challenges to providing turn bays on Salem Street include the cost and acquisition of the space required for the modifications. In addition, it would be important to address the concerns of business owners and other stakeholders concerned about the loss of parking. Adding turn bays on Salem Street would also increase the lengths of the crosswalks, assuming the minor widening required (6 feet or less), which works against pedestrians. However, in this case the resulting roadway and crosswalk widths (3 lanes or 33 feet), would not be expected to impact pedestrians adversely.

Retime the Traffic Signal and Upgrade Control Hardware

Signal retiming is one of the most cost-effective ways to improve traffic flow along a corridor or at an intersection. The objective of this retiming is to optimally respond to traffic conditions and pedestrian demands at the intersection by reconfiguring the timing to minimize delays for all movements at the intersection, including those of pedestrians and bicyclists. Another objective of the retiming is to optimally respond to the geometric improvements proposed for this intersection, described above. The proposed signal phasing is shown below.

Table 9 (page 66) presents the amount of delay, level of service, and queue length that would result from optimizing the signal-timing plan. The signal optimization, coupled with the proposed geometric improvements at this intersection, would result in shorter delays. For the AM peak period, signal optimization and geometric improvements would decrease the intersection control delay from 105 to 51 seconds (to LOS D from LOS F). For the PM peak, they would keep it constant, at around 80 seconds (LOS F). It is also important to upgrade the existing traffic signal control hardware to accommodate enhanced signal operations.



Phase Sequence at Fellsway West and Salem Street

Coordinate the Traffic Signals at the Fellsway West and Fellsway East Intersections

To improve traffic flow along Route 60, staff recommend that the traffic signals at these intersections be coordinated. DCR controls both traffic signals. Good signal coordination can generate measurable safety benefits in two ways. First, coordinated signals produce platoons of vehicles that can proceed without stopping at multiple signalized intersections, thus reducing delay. Second, reducing the number and frequency of required stops improves safety by reducing the number of rear-end conflicts and crashes.

Widen the Median on Fellsway West to Create a Pedestrian Refuge

Very long crosswalks on Fellsway West (six travel lanes and no usable median) create problems for pedestrians crossing Fellsway West. Staff suggest that Medford and DCR consider reducing the width of the travel lanes and shoulders to create an eight-foot-wide raised median pedestrian refuge island. Pedestrian refuge islands improve safety for pedestrians by providing a rest area for pedestrians, particularly those who use wheelchairs or who are elderly, who are unable to completely cross an intersection within the provided signal time. It also reduces the total distance over which pedestrians are exposed to conflicts with motor vehicles. In general, 50 feet is the longest uninterrupted crossing a pedestrian should encounter at a crosswalk, but this crosswalk is about 100 feet long.

Install Countdown Pedestrian Signals

NCHRP 500, Report, Vol. 10

Countdown pedestrian signal

The very long pedestrian crosswalks on Fellsway West (six or more travel lanes to cross at one time with no usable median) need to be improved to be pedestrian friendly. Installing countdown pedestrian signals would make it easier to cross Fellsway West and would increase pedestrian safety by giving useful information to pedestrians on how long they have to complete a crossing. Current standards call for a pedestrian countdown signal timer display to begin counting down when the flashing “DON’T WALK” signal appears and stop when the steady “DON’T WALK” signal appears. Countdown pedestrian signals provide useful information to pedestrians by showing the number of seconds left to finish crossing the street. Thus, they could indicate to pedestrians who are in the crosswalk at the Fellsway West and Salem Street intersection when the flashing “DON’T WALK” signal appears how much time they have to finish crossing the roadway.

Recent studies on countdown signals have shown indications that a larger percentage of pedestrians are now completing their crossings during the flashing “DON’T WALK” signal than without the countdown signal.[7,8] This result may be construed as positive, since it indicates that with the countdown signal, more pedestrians get out of the crosswalk before the steady “DON’T WALK” interval shows up. Thus, pedestrians are using the additional information provided by the countdown signal to complete their crossings in the time provided. It should be noted that completing a crossing before the steady “DON’T WALK” interval is shown reduces the chance of pedestrians being confronted with conflicting vehicle movements. This reduction appears to be greater when a greater proportion of pedestrians had been entering the crosswalk during the flashing “DON’T WALK” interval than during the “WALK” interval.

6.7 SUMMARY OF RECOMMENDED IMPROVEMENTS

This study has identified several improvements to address the issues of mobility and safety in the Route 60 corridor for motorists, bicyclists, pedestrians, and transit users. Table 10 summarizes the potential benefits and estimated costs of the various improvements. All of the improvements are short-term or

[7] Jan L. Botha and Ron L. Northouse, *Pedestrian Countdown Signals Study in the City of San Jose,* Final Report, submitted to the California Traffic Control Devices Committee, May 2002.

[8] Jeremiah P. Singer and Neil D. Lerner, *Countdown Pedestrian Signals: A Comparison of Alternative Pedestrian Change Interval Displays*, Final Report, submitted to the Federal Highway Administration, March 2005.

intermediate-term, and could be implemented within 5 to 10 years. There are several agencies that operate transportation facilities in the corridor, including the Massachusetts Highway Department, the Massachusetts Bay Transportation Authority, and the Massachusetts Department of Conservation and Recreation, in addition to the City of Medford. Successful implementation of the projects advancing from this study is dependent on coordination among the stakeholders, sufficient public participation, and securing funding for the projects.

TABLE 10
Summary of Improvements along Route 60 in Medford

Intersection	Improvement	Expected Benefits	Costs	Implementing Agency
I-93/Salem Street (Route 60) Rotary	Provide crosswalk and sidewalk enhancements (lighting, warning signs, guide maps).	Encourage motorists to look for pedestrians and guide pedestrians to best locations to cross at the rotary.	$50,000	MassHighway
	Retime traffic signal at Salem Street and City Hall Mall.	Facilitate traffic flow at the rotary by reducing queues.		
Salem Street and Hadley Place	Provide clear sight distances from Hadley Place stop approach.	Reduce crashes improving visibility of intersection.	$50,000	City of Medford
	Improve visibility of intersection by providing enhanced signs such as advance warning and street name signs.	Reduce crashes by providing a better driving environment and by increasing driver awareness of the intersection.		
	Install flashing beacon at the intersection.	Reduce crashes by increasing visibility of intersection and improving signage and street markings.		
	Install rumble strips on Salem Street to call attention to the intersection.	Call attention to presence of intersection and traffic control.		
Salem Street and Park Street	Prohibit turns on red light at Park Street intersection.	Reduce crashes related to limited sight distance caused by skewed intersection and on-street parking.	$25,000	City of Medford
	Retime traffic signal.	Improve safety and traffic flow, and improve travel times for emergency vehicles and bus transit services.		
	Improve visibility of intersection at the approaches by installing advance street name, advance traffic control, advisory speed signs, and lighting.	Reduce crashes by providing a better driving environment and by increasing driver awareness of the intersection.		
Salem Street and Spring Street	Install flashing beacon at the intersection.	Reduce crashes by increasing visibility of intersection and increasing signage and street markings.	$50,000	City of Medford
	Improve visibility of intersection and approaches by installing nonvehicular warning, advisory speed, and in-street pedestrian-crossing signs.	Reduce crashes by alerting motorists approaching a high-pedestrian-activity area.		
Salem Street and Fellsway West	Add turn bays on Salem Street.	Minimize collisions related to turning vehicles and facilitate traffic flow.	$200,000	Department of Conservation and Recreation
	Retime the traffic signal and upgrade signal control hardware.	Improve safety and traffic flow, and improve travel times for emergency vehicles and bus transit services.		
	Coordinate traffic signals at Fellsway West and Fellsway East intersections.	Improve traffic flow by reducing stops, and increase safety by reducing rear-end collisions.		
	Widen median on Fellsway West to create a pedestrian refuge area and shorten the crosswalk.	Increase safety for pedestrians.		
	Install countdown pedestrian signals.	Increase pedestrian safety by giving useful information to pedestrians on how long they have to complete a crossing.		

7. BUS TRANSIT IMPROVEMENTS

7.1 TRANSIT PROBLEMS

Malden Transportation Center Area Accessibility Issues

Pedestrian and bicycle needs are important considerations for the Route 60 corridor because of the high density of destinations, such as transit services, supermarkets, restaurants, schools, residences, and other businesses, along Route 60 in Malden and Medford. The Malden Transportation Center is the main transportation hub in the area; it is served by the MBTA Orange Line rapid transit, commuter rail, and buses, making it a multimodal transportation center (see Figure 24). The Malden Transportation Center was recently updated as part of an accessibility improvement program.[9] As part of the Center's accessibility improvement project, the MBTA constructed concrete wheelchair ramps on the west side of the station. The MBTA also replaced the existing sidewalk and wheelchair ramps at the ends of the crosswalks along the MBTA busway at the end of Pleasant Street, the two midblock crosswalks, and the entrance to the station on Centre Street.

The Malden Transportation Center has a commuter parking lot for riders; however, this lot is full (at capacity) early in the morning. The 2003 MBTA Program for Mass Transportation rated parking expansion at Malden Center as "low" in priority, primarily due to the lack of available land for at-grade parking.[10] According to a 2005–2006 bicycle parking inventory conducted by MPO staff, the Malden Transportation Center provides 152 bicycle parking spaces, a 130 percent increase over the 66 spaces in a 1999–2002 inventory. However, the bicycle parking areas are outdoors and are not sheltered.[11] The 2005–2006 inventory indicated that only 9 percent of the bicycle parking spaces were utilized; the low utilization rate could be due, in part, to the fact that the parking is not sheltered. Another accessibility problem is that segments of the sidewalks in the vicinity of the Malden Transportation Center, including sidewalks on Centre Street, Florence Street, and Pleasant Street, need to be repaired.

In general, the majority of the crosswalks in the vicinity of the Malden Transportation Center are indicated with two parallel white solid lines at a right angle to the sidewalks, instead of the standard ladder-type crosswalks, which are more visible to motorists and pedestrians. Also, some of the pedestrian push buttons are not functioning well at the signalized intersections in the vicinity of the station. At the Centre Street and Commercial Street intersection, there are no pedestrian push buttons for activating the pedestrian signals, which creates problems for the pedestrians crossing Commercial Street since its pedestrian phase does not turn on concurrently with the two-way through traffic on Centre Street.

Presently, pedestrians cross Commercial Street by looking for sufficient gaps in the traffic and making sure there are no right-turning vehicles. This creates problems for pedestrians and bicyclists. In addition, right turns on red at traffic lights are allowed during the exclusive pedestrian phase at the intersections of

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9 Malden Center Station Accessibility Improvements, Site Plan, MBTA Contract Number A32CN01.

10 Program for Mass Transportation, Prepared for the Massachusetts Bay Transportation Authority by the Central Transportation Planning Staff, May 2003, revised January 2004.

11 Jared Fijalkowski and Justin Yaitanes, of the Central Transportation Planning Staff to the Transportation Planning and Programming Committee of the Boston Region Metropolitan Planning Organization, December 20, 2007, technical memorandum, "2005–2006 Inventory of Bicycle Parking Spaces and Number of Parked Bicycles at MBTA Stations."

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FIGURE 24
Malden Transportation Center

Route 60 Mobility Study: Malden and Medford

Centre and Commercial streets, Centre and Pearl streets, and Centre and Main streets, creating vehicle-pedestrian conflicts. The “WATCH FOR TURNING VEHICLES ON WALK SIGNALS” signs that have been installed at the signalized intersections in the vicinity contradict the “YIELD TO PEDESTRIANS” signs found at most intersections in Massachusetts, which are sometimes accompanied by a sign stating that state law requires motor vehicles to stop for pedestrians who are in a crosswalk.

Another accessibility problem at the Malden Transportation Center is that during congested periods, buses exiting the east busway to Commercial Street southbound to proceed to Centre Street eastbound sometimes have difficulty finding a gap in traffic. Sometimes only a single bus exits per cycle. In addition, because the MBTA busway exit on Commercial Street is located close to the intersection (about 60 feet away), it is frequently blocked by traffic queues on the southbound approach.

Bus Transit Service

Several bus transit routes run through the study corridor, but the majority of them have only a short segment on Route 60. The two bus routes that traverse a major portion of the corridor are bus Route 101 (Malden Center–Sullivan Square) and bus Route 325 (Elm Street, Medford–Haymarket Station). The MBTA has service standards that perform two important functions: (1) establish the minimum or maximum acceptable levels of service that the MBTA must provide to achieve its service objectives, and (2) provide a framework for measuring the performance of services as a part of its service evaluation process. The following are some of the standards used in evaluating bus service:

- Span of service refers to the hours during which service is accessible. The span-of-service standards define the minimum period of time that any given service will operate. This provides customers with the confidence that particular types of services will be available throughout the day. The minimum span of service for local routes are: weekdays 7:00 AM – 6:30 PM; and in high-density areas, Saturday 8:00 AM – 6:30 PM and Sunday 10:00 AM – 6:30 PM.

- Schedule adherence standards provide the tools for evaluating the on-time performance of individual MBTA routes. The schedule adherence standards vary, based on frequency of service; passengers using high-frequency services are generally more interested in regular, even headways than in strict adherence to published timetables, whereas passengers on less frequent services expect arrivals and departures to occur as published. The schedule adherence standard for bus service is that 75 percent of all time-points on the route over the entire service day must pass their on-time tests.

- The frequency-of-service standards establish the minimum frequency of service levels by time of day to maintain accessibility to the transportation network within a reasonable waiting period. On less heavily traveled services, these minimum levels dictate the frequency of service, regardless of customer demand. The minimum frequencies for local and community routes are: 30 minutes headway for AM and PM peak periods, 60 minutes headway for other periods, and 60 minutes headway for Saturday and Sunday. The MBTA also has a midday policy objective of 30 minutes headway in high-density areas.

- The vehicle load standards, which vary by mode and time of day, establish the average maximum number of passengers allowed per vehicle to provide a safe and comfortable ride. The vehicle load standards for buses is 140 percent for early AM, AM peak, midday school, and PM peak; 100 percent for other time periods.

Bus Route 101 operates between Malden Center Station and Sullivan Square Station, in Charlestown, via Medford Square and Winter Hill. The route serves communities along Centre and Pleasant streets in

Malden, and along Salem Street in Medford. According to the MBTA's 2008 Service Plan, Route 101 barely failed the loading standard when the standard was evaluated using 2005 ridecheck data.[12] However, current automated-passenger-count data confirm that while Route 101 is often filled to capacity, it very rarely violates the loading standard of 140 percent during peak periods. Route 101 also fails the frequency standard on weekends, which is 60 minutes.

Route 325 operates only on weekdays, from Elm Street at Fellsway West in Medford via Roosevelt Circle, Salem Street, and I-93 to Haymarket Station in Boston. Trips operating in the reverse peak direction (outbound in the morning and inbound in the afternoon) run express between Roosevelt Circle and Haymarket, while peak-direction trips (inbound in the morning and outbound in the afternoon) provide service along Fellsway West and Salem Streets between I-93 and Roosevelt Circle. A recent change, made in the spring of 2008, slightly decreased the frequency, but it addressed the failure to meet the span-of-service (time from the start of service in the morning to the end of service at night) standard on weekdays by moving the last outbound departure to 6:30 PM.

Figures 25 and 26 show the locations of the bus stops and the average weekday boarding and alighting counts at each stop for both inbound and outbound trips. An inventory of the amenities at the bus stops indicated that many of the stops had benches, and many had signs indicating which bus routes have a stop at that particular location. The bus stops do not have bus shelters or bus bays, except for the stop located in front of the Stop and Shop Supermarket on Centre Street in Malden. This bus stop also has a bus bay, which is separated from the travel lanes. At the rest of the bus stops, on-street parking is restricted to allow buses to use the shoulders for passenger boarding and alighting. The MBTA has a process for determining the placement of bus shelters; this process is described below under the section on bus shelters.

Travel Time

The main problem affecting bus transit service in the study corridor is traffic signal delay, which impacts the travel time of buses during peak periods. There are long traffic queues at some of the signalized intersections in the corridor during peak periods, and because buses receive no preferential treatment, it is difficult to achieve schedule adherence standards of 75 percent for all time-points on the route over the entire service day. According to the MBTA's 2008 Service Plan, Routes 101 and 325 fail the schedule adherence standard on weekdays, and Route 101 and Route 325 meet the schedule adherence standard only 60 percent and 43 percent of the time, respectively. About one half of this problem may be attributed to congestion in the Route 60 portion of these routes. Thus, traffic congestion in the Route 60 corridor appears to contribute to longer travel times and less reliable service for bus transit.

7.2 IMPROVEMENTS TO BUS TRANSIT

There are several performance measures that can be altered to improve quality of service. This study did not look at altering quality of service standards, such as service delivery, safety, security, and service availability, to improve service on those routes. The MBTA's Service Plan, updated every two years, deals with service delivery and availability changes. Every two years the MBTA Service Planning Department reviews the level of usage of bus services and reallocates services based on consumer demand. Service standards, as defined in the MBTA's Service Delivery Policy, are used to evaluate route performance. These standards measure ridership, loading, reliability, and other factors. The MBTA held a number of community workshops throughout the greater Boston area in May and June of 2007 to solicit suggestions from the public for the 2008 Service Plan. The MBTA also held community workshops to present the 2008 Service

[12] Final 2008 Service Plan: Bus, Rapid Transit, and Boat Service Changes and Service Delivery Policy Modifications, Massachusetts Bay Transportation Authority, Fall 2008.

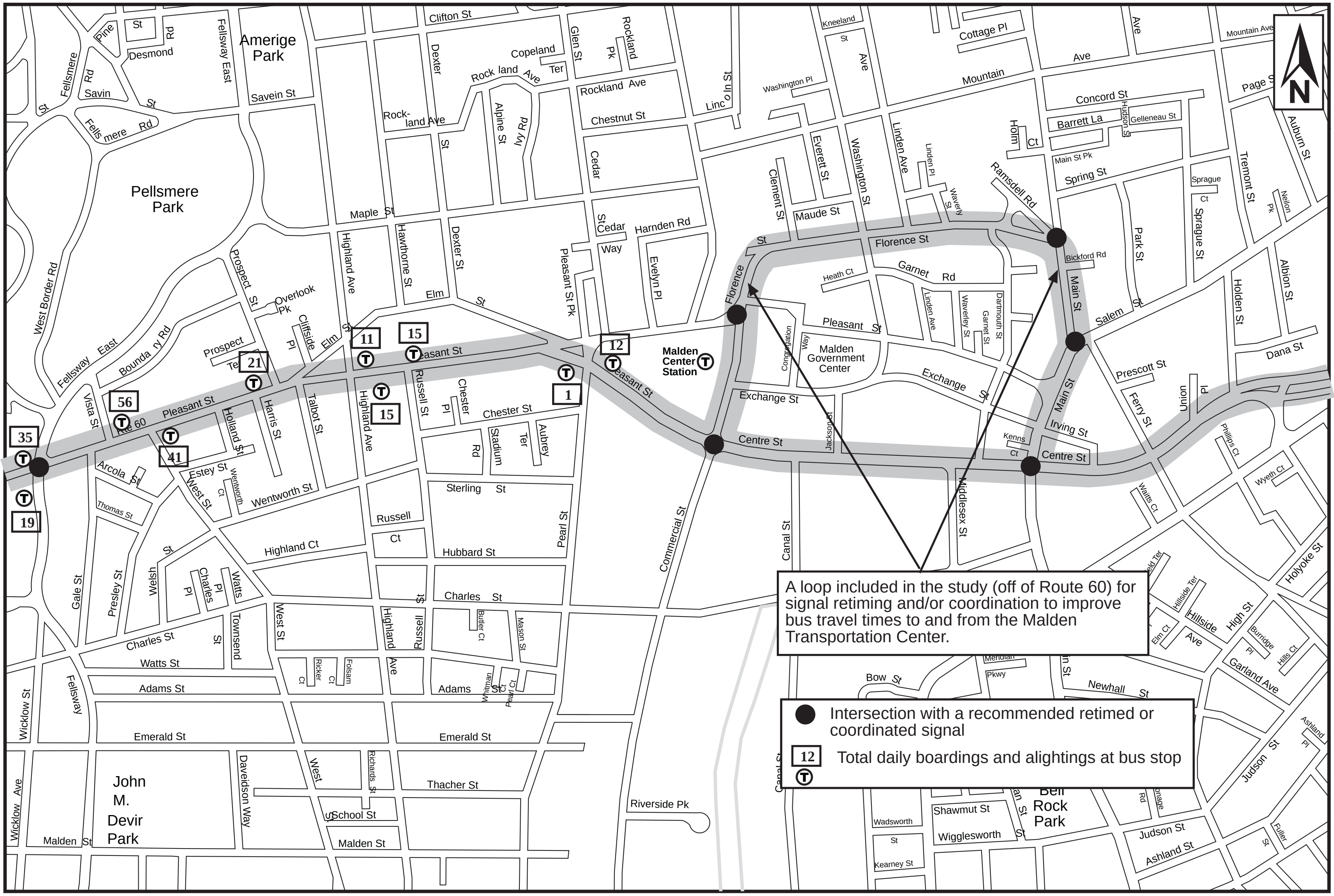

FIGURE 25
Daily Boardings and Alightings at Bus Stops on Route 60 in Malden

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Route 60 Mobility Study: Malden and Medford

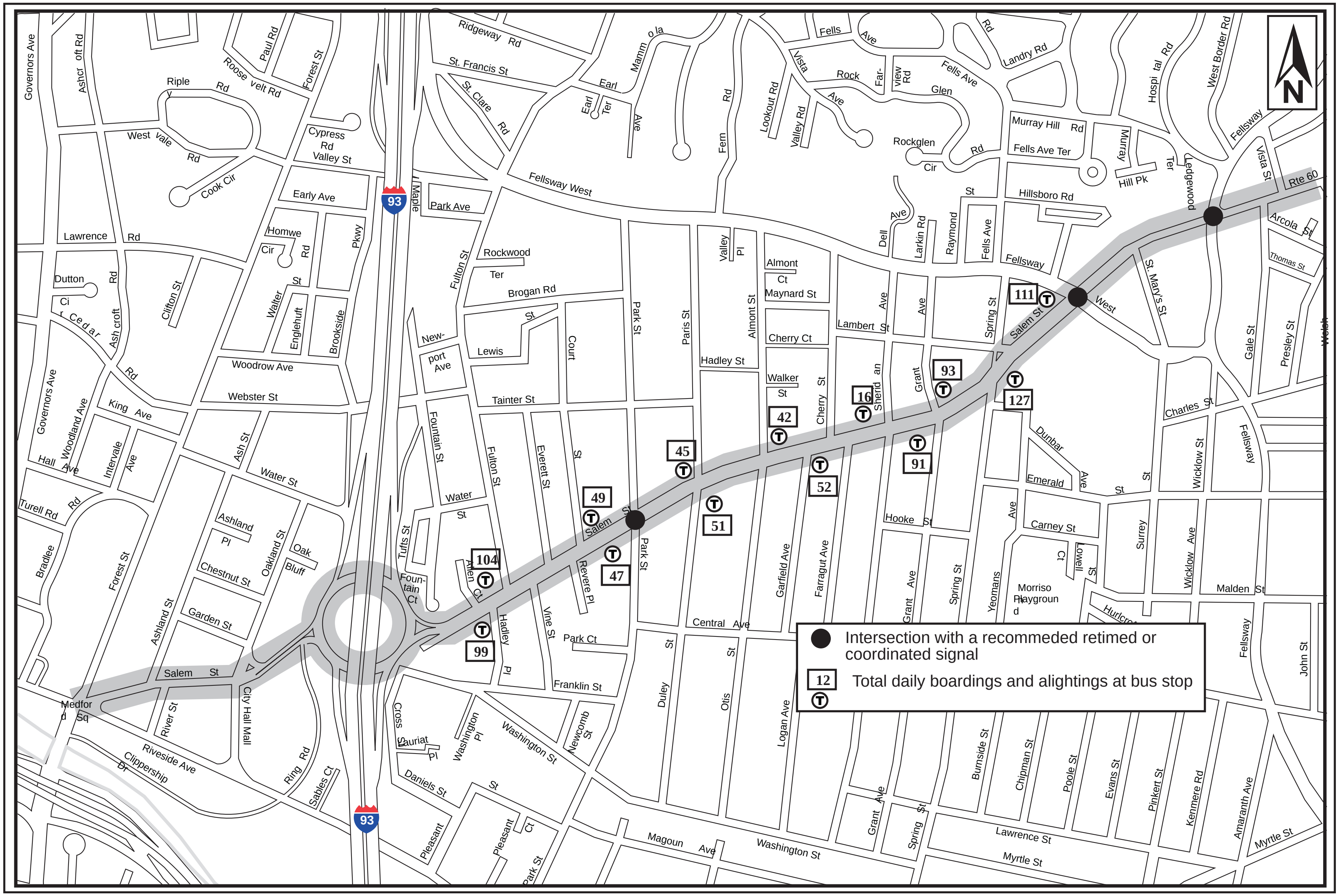

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FIGURE 26
Daily Boardings and Alightings at Bus Stops on Route 60 in Medford

Route 60 Mobility Study: Malden and Medford

Plan and solicit feedback from the public regarding service changes that were proposed in the Plan. The Final 2008 Service Plan is located on the MBTA's website at www.mbta.com/uploadedfiles/About_the_T/T_Projects/T_Projects_List/Final_2008_Service_Plan.pdf.

2008 Service Plan (Recommendations for Routes 101 and 325)

The 2008 Service Plan had the following recommendations for bus Routes 101 and 325.

1. Route 101 technically fails the load standard on weekdays and the frequency of service standard on Saturday and Sunday, as buses operate every 65 minutes rather than every 60 minutes. Route 101 meets the schedule adherence standard 60 percent of the time instead of 75 percent of the time. According to the 2008 Service Plan, no change is recommended for this route for the following reasons:

    a. Although the bus is often filled to capacity, it very rarely violates the load standards. The MBTA will monitor ridership closely.

    b. Tightening the headway would require adding a bus to the route on weekends, but ridership levels at those times do not warrant this additional expense.

2. According to the 2008 Service Plan, Route 325 meets the schedule adherence standard on weekdays 43 percent of the time instead of 75 percent of the time, and technically fails the weekday span-of-service standard, which is service from 7:00 AM to 6:30 PM. According to the 2008 Service Plan, the following changes have already been implemented:

    a. The changes to the route in the spring of 2008 addressed the failure of the span-of-service standard by moving the last outbound departure from 6:29 PM to 6:30 PM. The changes also eliminated the failure of the cost standard.

    b. Run times were modified for the summer 2008 schedules to create more accurate arrival times on the schedule, allowing customers to better plan their travel.

Bus Shelters

The MBTA Operations department is responsible for evaluating bus shelter placement requests and ensuring compliance with the federal Title VI regulations. The first step in the evaluation process is a determination of whether or not the bus stop conforms to shelter eligibility standards (see Appendix A). The number of boardings at a bus stop is a major determinant of eligibility for having a bus shelter. A number of other criteria are also considered. To standardize the process, the criteria have been given numeric values. A site must receive a total of 70 points to be considered eligible for a shelter under this policy. The second step in the evaluation process is the site suitability test; there are physical and practical requirements that must be met before a shelter can be placed. These include: property ownership, abutter approval, compliance with the Americans with Disabilities Act requirements, adequate physical space and clearances, close proximity to an existing bus stop, and community approval.

As Figures 25 and 26 show, some of the bus stops in the study corridor may be eligible for a shelter based on the number of boardings described in the first step of the evaluation process. Such bus stops in the Medford section include #5282 Salem Street, at Grant Avenue, and #5287 Salem Street, at Allen Court, for the inbound direction. However, site suitability tests in the second step of the evaluation process may prove challenging because of lack of space on the sidewalks and other issues. Bus shelters would significantly decrease the width of sidewalks and therefore might create problems for pedestrians and bicycles. Therefore, no recommendation is made in this report about installing bus shelters.

Bicycle Parking

The 2005–2006 bicycle-parking inventory indicated that only 9 percent of the bicycle parking spaces at the Malden Transportation Center Station were utilized. However, the utilization rate is expected to increase when high gas prices result in ridership increases on the MBTA system. Improvements suggested for bicycle parking include adding a roof or other shelter over each bicycle rack. This should be easiest at locations closest to the station building. Adding lights to illuminate bicycle racks would increase safety and security.

Station Access

Pedestrian safety and access improvements were developed for the signalized intersections on Route 60 in the Malden section of this report; they include the intersections of Centre Street at Commercial Street and Centre Street at Main Street in the vicinity of the Malden Transportation Center (see Chapter 4 for more details). In addition to these two intersections, the streets of the loop formed by Centre Street, Main Street, Florence Street, and Commercial Street were evaluated for pedestrian and accessibility improvements in a previous study.[13] In that study, staff recommended the following improvements to increase ease of access to the Malden Transportation Center for all pedestrians and bicyclists in the area, as well as for all transit users, including bicyclists and pedestrians.

- Repair and maintain the sidewalks on Centre Street, Pleasant Street, and Florence Street to increase safety for pedestrians, wheelchair users, and stroller users.

- Add exclusive pedestrian phases and “NO TURN ON RED” signs at the intersection of Centre Street and Commercial Street to increase safety and reduce vehicle-pedestrian conflicts.

  An alternative to an exclusive pedestrian phase and “NO TURN ON RED” signs at Centre Street and Commercial Street would be to have concurrent crossings and add “YIELD TO PEDESTRIANS” signs. This would reduce delay for all users. This could also allow for the elimination of all pedestrian-activated push buttons. However, this would not reduce vehicle-pedestrian conflicts; hence it would not provide the same level of safety as an exclusive pedestrian phase.

- Install pedestrian-crossing signals that have a countdown display at the following intersections: Centre Street at Commercial Street, and Pleasant Street at Commercial Street/Florence Street.

- Fix the malfunctioning pedestrian-activated push buttons and install the missing pedestrian crossing signals at the intersections of Centre Street at Commercial Street and of Centre Street at Pearl Street that had been removed.

- Install “YIELD TO PEDESTRIANS” signs at all traffic approaches at intersections with concurrent pedestrian phases in the vicinity of the Malden Transportation Center. Replace “WATCH FOR TURNING VEHICLES ON WALK SIGNALS” signs with “YIELD TO PEDESTRIANS” signs, which place an emphasis on motorists yielding for pedestrians in crosswalks, which is required by state law.

- Paint the crosswalks at the intersections in the vicinity of the Malden Transportation Center that have only two white parallel stripes with ladder-style stripes, which are more visible to both motorists and pedestrians (at Centre Street and Commercial Street, and at Pleasant Street and Florence Street/ Commercial Street).

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[13] Improving Pedestrian and Bicycle Access to Selected Transit Stations, a report produced by the Central Transportation Planning Staff for the Massachusetts Highway Department and the Massachusetts Bay Transportation Authority, September 2005.

- Implement transit signal priority at this intersection to reduce delay for buses trying to exit the east busway to Commercial Street southbound to get to Centre Street eastbound. Implementing a transit signal priority at this intersection would require a signal system upgrade to enable it handle a request from buses, and buses would need to be equipped with technology to submit a request. For transit signal priority to operate efficiently, the east busway exit might have to be signalized and tied to the main signal at the intersection of Centre Street and Commercial Street, or some form of signage might have to be installed at the east busway exit, to prevent Commercial Street southbound vehicles from blocking the busway exit when a bus request is submitted.

Travel-Time Improvements

Because the 2008 Service Plan dealt with service span, frequency, load, and cost failures, efforts in this study were concentrated on improving travel times in the study corridor to improve schedule adherence to the on-time standard. To improve bus transit operations in the corridor, particularly bus circulation to and from Malden Transportation Center and in the Route 60 study corridor, staff recommend signal retiming and coordination for the following eight signalized intersections.

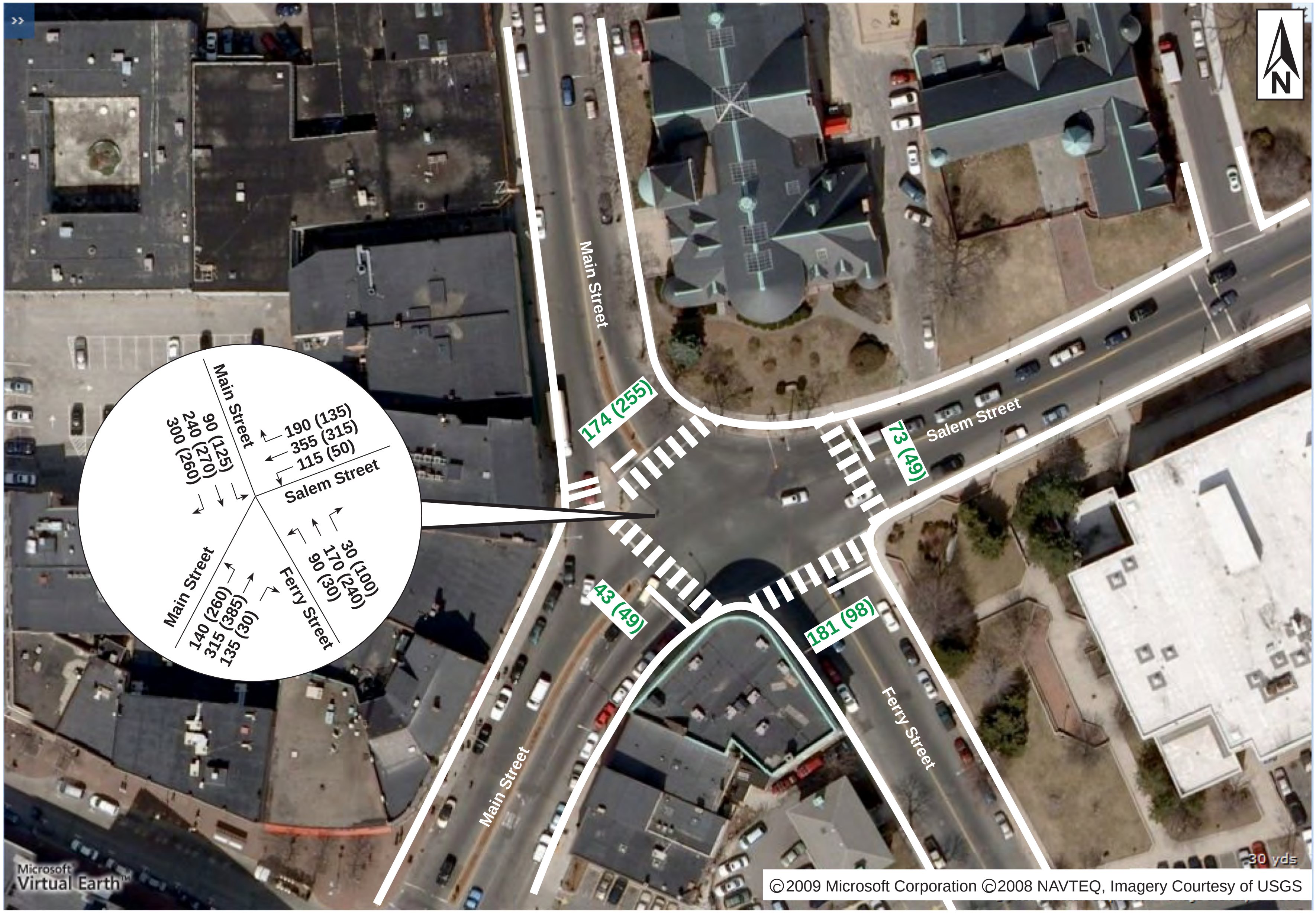
1. Pleasant Street (Route 60) and Fellsway East in Malden
2. Centre Street (Route 60) and Commercial Street in Malden
3. Centre Street and Main Street in Malden
4. Salem Street and Park Street in Medford
5. Salem Street and Fellsway West in Medford
6. Pleasant Street and Commercial/Florence Street in Malden
7. Main Street and Florence Street in Malden
8. Main Street, Salem Street, and Ferry Street in Malden

Traffic signal coordination is suggested for the abovementioned signals except for the intersection Salem Street and Park Street in Medford, which is an isolated signalized intersection. The first five signalized intersections were already part of the list of study intersections suggested by municipal officials as locations with pedestrian and vehicular safety and operations problems. The last three intersections were added to the study later on to improve bus circulation at the station area, particularly in the loop consisting of Centre Street, Main Street, Florence Street, and Commercial Street (see Figure 25). Figures 27 through 29 show the traffic volumes and pedestrian counts for the three intersections in the loop, where upgrades can be made cost-effectively. The traffic volumes and pedestrian counts were conducted during the peak travel periods, 7:00–9:00 AM and 4:00–6:00 PM.

Tables 11 and 12 show that signal retiming and coordination could improve travel time in the study corridor by approximately 5 to 7 percent in the peak direction of travel (inbound in the AM peak period and outbound in the PM peak period). The results also show that travel time in the study corridor could be improved by approximately 11 to 14 percent in the off-peak direction (outbound in the AM peak period and inbound in the PM peak period). Thus, traffic signal retiming and coordination improvements should reduce congestion and delays for all roadway users, including bus riders.

7.3 SUMMARY OF IMPROVEMENTS

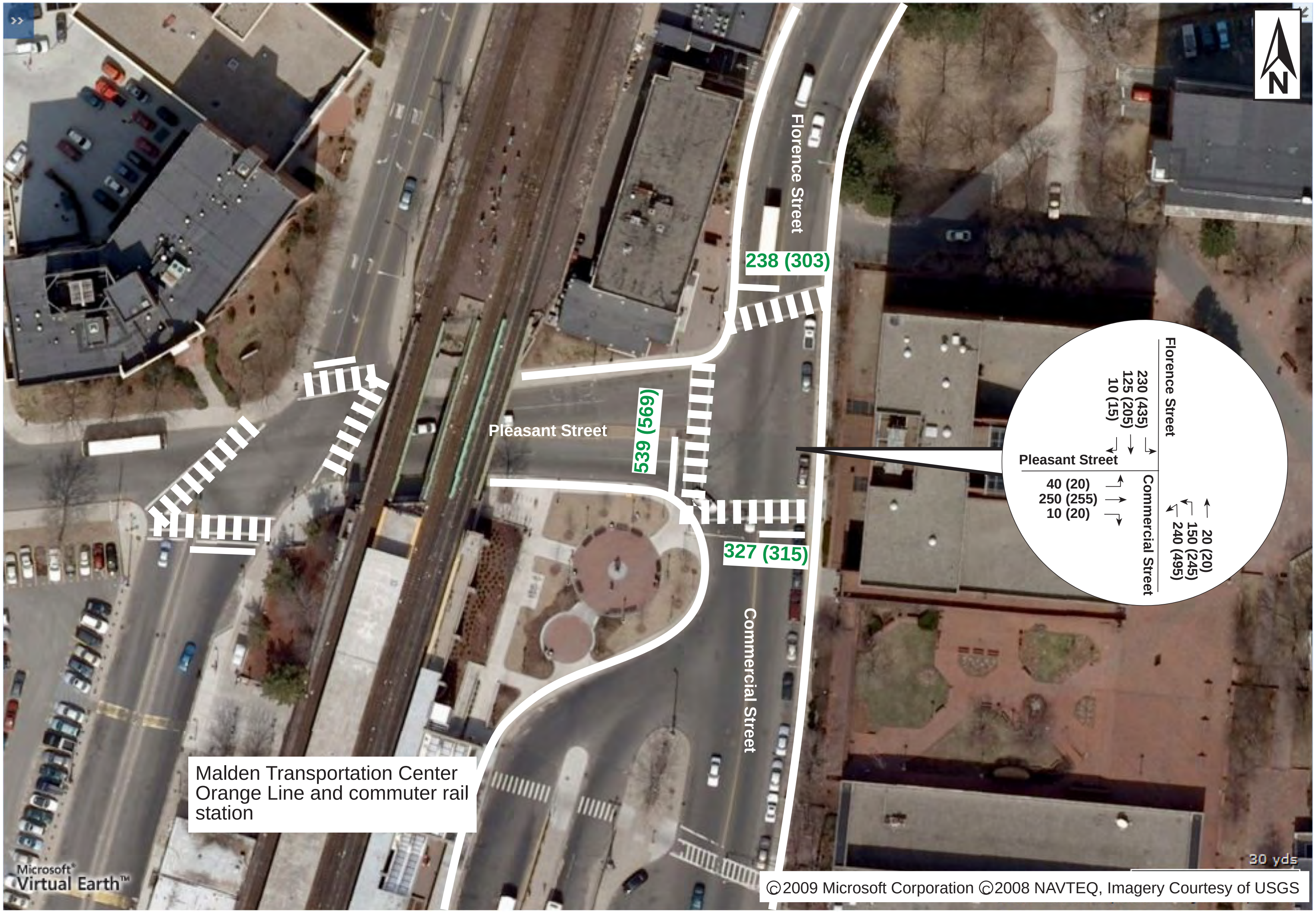
Table 13 summarizes the recommended improvements for bus transit in the corridor. Successful implementation of the projects advancing from this study is dependent on coordination between the City of Malden and the Massachusetts Bay Transportation Authority, and on securing funding for the projects.



CTPS

FIGURE 27
Pedestrian and Vehicular Volumes at the Main Street, Salem Street, and Ferry Street Intersection in Malden

Route 60 Mobility Study: Malden and Medford



CTPS

FIGURE 28
Pedestrian and Vehicular Volumes at the
Pleasant Street and Commercial/Florence Street Intersection in Malden

Route 60 Mobility Study:
Malden and Medford

CTPS

FIGURE 29
Pedestrian and Vehicular Volumes at the Main Street and Florence Street Intersection in Malden

Route 60 Mobility Study: Malden and Medford

TABLE 11
Results of Signal Retiming and Coordination:
AM Peak Hour

AM Peak Hour (Inbound)						
			Travel Time (seconds)		Arterial Speed (mph)	
Arterial Segment	**City**	**Distance**	**Optimized**	**Existing**	**Optimized**	**Existing**
Commercial Street From Florence Street to Centre Street	Malden	0.10	47.4	38.8	11	11
Centre Street From Commercial Street to Pearl Street	Malden	0.15	36.8	34.8	13	13
Pleasant Street From Pearl Street to Mary Street	Malden	0.65	207.0	245.0	12	10
Salem Street From Mary Street to Medford City Hall	Medford	1.05	434.0	450.0	11	12
Total		**1.95**	**725.2**	**768.6**	**11**	**11**
			Difference = 43.4 sec (5.7%)		**Difference = 0**	
AM Peak Hour (Outbound) **Including the loop on Main Street and Florence Street**						
Salem Street From Medford City Hall to Mary Street	Medford	1.05	229.0	232.0	15	15
Pleasant Street From Mary Street to Pearl Street	Malden	0.65	152.3	156.7	16	15
Centre Street From Pearl Street to Main Street	Malden	0.40	76.5	92.3	19	17
Main Street From Centre Street to Florence Street	Malden	0.30	103.2	182.0	10	6
Florence Street From Main Street to Pleasant Street	Malden	0.40	66.4	66.9	20	20
Total		**2.80**	**627.4**	**729.9**	**16**	**14**
			Difference = 102.5 sec (14%)		**Difference = 2 mph (12%)**	

TABLE 12
Results of Signal Retiming and Coordination:
PM Peak Hour

PM Peak Hour (Inbound)						
			Travel Time (seconds)		**Arterial Speed (mph)**	
Arterial Segment	**City**	**Distance**	**Optimized**	**Existing**	**Optimized**	**Existing**
Commercial Street From Florence Street to Centre Street	Malden	0.10	37.5	37.7	11	11
Centre Street From Commercial Street to Pearl Street	Malden	0.15	25.6	40.7	17	11
Pleasant Street From Pearl Street to Mary Street	Malden	0.65	172.3	196.7	15	14
Salem Street From Mary Street to Medford City Hall	Medford	1.05	566.2	627.0	12	11
Total		**1.95**	**801.6**	**902.1**	**13**	**12**
			Difference = 100 sec (11%)		**Difference = 1 mph (8.3%)**	
PM Peak Hour (Outbound) **Including the loop on Main Street and Florence Street**						
Salem Street From Medford City Hall to Mary Street	Medford	1.05	458.4	467.9	14	12
Pleasant Street From Mary Street to Pearl Street	Malden	0.65	307.0	345.0	10	9
Centre Street From Pearl Street to Main Street	Malden	0.40	112.6	113.0	14	14
Main Street From Centre Street to Florence Street	Malden	0.30	128.6	141.9	8	7
Florence Street From Main Street to Pleasant Street	Malden	0.40	56.6	71.6	23	18
Total		**2.80**	**1063.2**	**1139.4**	**14**	**13**
			Difference = 76.0 sec (6.6%)		**Difference = 1 mph (7.7%)**	

TABLE 13
Summary of Improvements Related to Bus Transit

Location	Improvement	Expected Benefits	Costs	Implementing Agency
Centre Street and Commercial Street	Add exclusive pedestrian phase and "NO TURN ON RED" signs. Fix malfunctioning pedestrian-activated push buttons and install missing pedestrian crossing signals.	Increase safety and reduce vehicle-pedestrian conflicts.	See footnote[14]	City of Malden/ MBTA
	Install countdown pedestrian signals.	Increase pedestrian safety by giving useful information to pedestrians.		
	Implement transit signal priority.	Reduce waiting times for buses to exit from the east busway.		
	Paint the crosswalks with ladder-style stripes.	Make crosswalks safer for pedestrians by making them more visible to both motorists and pedestrians.		
Pleasant Street and Commercial Street/Florence Street	Install countdown pedestrian signals.	Increase pedestrian safety by giving useful information to pedestrians.	$20,000	City of Malden
	Paint the crosswalks with ladder-style stripes.	Make crosswalks safer for pedestrians by making them more visible to both motorists and pedestrians.		
	Install "YIELD TO PEDESTRIANS" signs.	Increase motorists' awareness of pedestrians.		
Centre Street and Pearl Street	Fix the malfunctioning pedestrian-activated push buttons and install missing pedestrian crossing signals.	Increase pedestrian safety by providing better equipments.	$50,000	City of Malden
	Install "YIELD TO PEDESTRIANS" signs	Increase motorists' awareness of pedestrians.		
	Align wheelchair ramps, curb cuts, and crosswalks in the direction of pedestrian flow, parallel to Centre Street.	Increase pedestrian safety by providing better equipments		
Centre Street, Pleasant Street, Commercial Street, and Florence Street in the vicinity of the Malden Transportation Center Station	Repair and maintain sidewalks.	Make sidewalks safer and help prevent injuries caused by defective sidewalks to users of wheelchairs and strollers, pedestrians, and bicyclists.	$50,000	City of Malden/ MBTA
	Paint the crosswalks with ladder-style stripes.	Make crosswalks safer for pedestrians by making them more visible to both motorists and pedestrians.		
Malden Center Station	Add a roof/shelter over the bike racks Add lights to illuminate bicycle racks at night.	Improve safety and quality of service for bicyclists.		MBTA
Centre Street, Main Street, Florence Street, and Commercial Street	Retime and/or coordinate the traffic signals along the loop.	Assist bus operations, particularly circulation to and from Malden Center Station. Improve bus transit schedule adherence and on-time performance.	$100,000	City of Malden

[14] Already accounted for in the summary of improvements for Malden in Table 5.

8. CONCLUSION

This study has identified several improvements to address the issues of mobility and safety in the Route 60 corridor for motorists, bicyclists, pedestrians, and transit users. All of the improvements are short-term or intermediate-term and could be implemented within five years. There are several agencies that operate transportation facilities in the corridor, including the Massachusetts Highway Department, the Massachusetts Department of Conservation and Recreation, and the MBTA, in addition to the Cities of Malden and Medford. Successful implementation of the projects advancing from this study is dependent on coordination among the stakeholders, sufficient public participation, and securing funding for the projects.

For reference, a description of the implementation process of the Massachusetts Highway Department is provided (see Appendix B). The process for implementing new and modified MBTA services is based on the service planning process defined in the 2006 Update of the MBTA Service Delivery Policy (see Appendix C).

Appendix A

Massachusetts Bay Transportation Authority: Bus Shelter Policy

BUS SHELTER POLICY
(Effective: April 2005)

A. Purpose

The purpose of this policy is to provide guidance for the placement of MBTA bus shelters and to establish a procedure for evaluating shelter requests. In areas or locations where the MBTA, or its contractors, are the primary suppliers of shelters at bus stops, placements will be evaluated using two steps:

1. Conformance with eligibility standards, and
2. A site suitability test.

Central to any placement decision will be a commitment to meeting the requirements of Title VI of 1964 Civil Rights Act as defined in the FTA Circular C 4702.1. Title VI ensures that MBTA services are distributed in such as manner that minority communities receive benefits in the same proportion as the total service area.

This policy in no way establishes a requirement for placement, since all placements will be dependent on available resources.

B. Background

The previous shelter policy was established in 1984, having been extracted from the 1977 Service Policy for Surface Public Transportation. This older policy considered three major factors when evaluating stops: number of boardings, frequency of service, and percentage of persons using the stop that were elderly or had disabilities.

The current policy continues to include these important measures; however, it more systematically quantifies each factor in determining eligibility.

C. Evaluation Procedure

MBTA Operations will be responsible for evaluating placement requests and ensuring compliance with Title VI.

The first step in the evaluation process is a determination if the bus stop conforms with shelter eligibility standards. As in the previous shelter policy, the number of boardings at a bus stop is a major determinant for eligibility. As described in the table below, all bus stops that meet the required number of boardings will be eligible. However, a number of other criteria can also be considered. To standardize the process, the various types of criteria have been given values. The following table lists all criteria to be factored into an assessment of eligibility for each bus stop and the value associated with each criterion. A site must receive a total of 70 points to be considered eligible under this policy.

Any bus stop that has more than 60 boardings is eligible for a shelter, with an automatic score of 70 points. For bus stops with fewer boardings, a combination of the factors listed above will be considered in determining eligibility. Operations will keep records of all requests that document the assignment of scores. All bus stops that currently have shelters will be grandfathered into the program without need for additional analysis.

Eligibility Criteria	Points
60+ Average weekday daily boardings (ADB)	70
50-59 ADB	60
20-49 ADB	40
Less than 20 ADB	30
MBTA initiative to strengthen route identity	20
Seniors, disabled, medical, social service, or key municipal facility in close proximity to stop	15
Official community recommendation	10
Bus route transfer point	10
Infrequent service (minimum of 30minute peak/60minute off peak headway)	10
Poor site conditions (weather exposure etc.)	5
Shelter promotes adjacent development/increased ridership	5

Passing Score: **70**

The second step in the evaluation process is the site suitability test. There are physical and practical requirements that must be met before a shelter can be placed. These include:

(1) Property ownership,
(2) Abutter approval,
(3) Compliance with the Americans with Disabilities Act requirements,
(4) Adequate physical space and clearances,
(5) Close proximity to an existing bus stop, and
(6) Community approval

D. Reporting

The Operations Department will retain the necessary documents to ensure correct application of the policy. The Service Planning Department and CTPS will submit the required Title VI reports. Title VI ensures that MBTA services are distributed in such as manner that minority communities receive benefits in the same proportion as the total service area.

In terms of the shelter policy, once a bus stop is eligible for a shelter it will be included in all analyses for Title VI purposes, until such time that it is indicated otherwise. Consequently, all bus stops with 60 or more boardings will be included in Title VI reports, as well as any bus stops with less than 60 boardings that meet the 70-point eligibility requirement. Any bus stop that meets the eligibility standard, but is found not to meet the site suitability test, will be noted and not included in the analysis. Bus stops in the MBTA service area that have pre-existing shelters, but do not meet the policy requirements, will be noted and included in the total comparisons.

Appendix B

Massachusetts Highway Department Project Implementation Process

The following description of the implementation process is based on Chapter 2 of the *Massachusetts Highway Department Project Development and Design Guide (2005)*. The text below borrows heavily from that document.

Needs Identification

For each of the locations at which an improvement is to be implemented, MassHighway 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, MassHighway meets with potential participants, such as the Boston Region Metropolitan Planning Organization (MPO) and community members, to allow for an informal review of the project.

The PNF is reviewed by the MassHighway district office whose jurisdiction includes the location of the proposed project. MassHighway 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.

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.

Project Initiation

At this point in the process, the proponent, MassHighway, fills out, for each improvement, a Project Initiation Form (PIF), 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 Capital Expenditure Program Office (CEPO). 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 Executive Office of Transportation and Public Works's statewide priorities and criteria. If the result is positive, MassHighway 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 a project evaluation criteria score, a Transportation Improvement Program (TIP) year, a tentative project category, and a tentative funding category.

Environmental, 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.

Programming

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, where the MPO receives preliminary information on the proposed project, the proponent requests that the MPO place the project in the region's TIP. The MPO considers the project in terms of 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.

Procurement

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

Construction

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

Project Assessment

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

Appendix C

Massachusetts Bay Transportation Authority Service Delivery Policy

Chapter 4: Service Planning Process

Chapter 4: Service Planning Process

The MBTA regularly evaluates the performance of its services through the service planning process. The primary objective of the service planning process is to ensure that the MBTA uses available resources in the most effective manner by developing strategies to improve performance and/or to reallocate service within the system.

The service planning process varies somewhat by mode and is affected by whether or not the service is operated directly by the MBTA (bus and rapid transit), or is operated for the MBTA by a contractor (commuter rail and boat). Following is a discussion of the process for each mode. The final section of this chapter outlines the procedures for public participation in the service planning process.

Directly Operated Services

- **Bus Service Planning Process**
  The bus service planning process takes place on two levels. One is the on-going evaluation and implementation of incremental service changes that occur on a quarterly basis. The other is a two-year planning cycle for development of the biennial Service Plan, which can include major restructuring of existing bus routes and proposals for new bus services.

  The data used for all service evaluations are collected on a regular basis through various means to track and evaluate the performance of services against each of the Service Standards (as defined in Chapter 3).

  The primary differences between the on-going service planning process and the planning process used to develop the Biennial Service Plan include:
  - the magnitude of the service changes considered (minor or major—as defined below);
  - the extent and type of analysis used;
  - the level of public participation; and
  - whether the effort is incremental or comprehensive in nature.

  Minor changes to bus services are made through the on-going service planning process and can be implemented with existing equipment, within the adopted budget, and without significantly affecting route structure or service delivery.

  Major changes are ones that will have a significant effect on riders, resource requirements, route structure, or service delivery (as defined in Table 1). These are evaluated and implemented only through development of the Biennial Service Plan (with the exception of new services associated with a major capital investment).

Table 12: Minor & Major Service Changes

Magnitude:	Type:	Resource Implications:
Minor	• Running time adjustments • Departure time adjustments • Headway changes to match ridership and service levels (provided the frequency and loading standards are still met) • Changes to bus stop locations • Alignment changes • Span of service changes within 1 hour or less • Route extensions of 1 mile or less • Route variation modifications	Changes that can be implemented with existing equipment and within the adopted budget
Major	• Major service restructuring • Implementation of new routes or services • Elimination of a route or service • Elimination of part of a route • Span of service changes greater than 1 hour	Changes that will have a significant affect on resources and may potentially have a significant affect on riders

The On-going Bus Service Planning Process: The service changes that are evaluated in the on-going service planning process can be initiated in a variety of ways. These include, but are not limited to:

- o service requests and/or complaints from the public;
- o feedback from MBTA Bus Operations staff, such as drivers, garage superintendents or schedule makers;
- o proposals made by the MBTA Service Planning staff; and
- o studies completed by CTPS (for the Boston MPO), by other regional entities, or by municipalities.

Service Planning staff screen all potential service changes to determine whether they are minor or major in nature (as defined above). In addition, each potential change is considered using the criteria listed below (not all criteria are necessarily used in every evaluation).

- o Performance measured against the Service Standards
- o The rationale for the change
- o Net cost per new passenger
- o Net savings per lost passenger
- o Changes in ridership
- o Changes in travel time for existing riders
- o Changes in operating costs
- o Changes in fare revenue
- o Key characteristics and demographics of the market
- o Contribution to the achievement of external mandates, such as Title VI
- o Other factors, as appropriate

Proposed minor changes that have been analyzed by the Service Planning Department are presented to the Service Committee, which is chaired by the Manager of Service Planning and includes representatives of the following departments:

- Service Planning
- Plans and Schedules
- Bus Operations
- Operations Support
- Customer Communications Center
- Office for Transportation Access
- Public Affairs,
- Intergovernmental Affairs
- Other Departments, as appropriate

Minor changes that are approved by the Service Committee, and that can be made within the adopted budget, are implemented as soon as possible—usually in the next quarterly schedule change.

The Biennial Service Plan Process: Every two years, the MBTA develops a biennial Service Plan that describes the performance of the system and the services that will be operated in the upcoming two years. The plan encompasses all fixed-route services and includes:

- a description of the performance of existing services;
- recommendations for major service changes;
- a discussion of service changes that were considered and/or evaluated, but are not recommended at the time; and
- a general review of the effectiveness of previous major service changes (major service changes would not be reported on in the service planning cycle immediately after their implementation, but would be evaluated in the following planning cycle to allow time for ridership to build).

As with the on-going service planning process, a major goal in the development of the biennial Service Plan is to ensure that the MBTA uses available funds in the most effective manner. However, this planning process can also identify major service changes and enhancements that have merit, but that cannot be funded within the existing operating budget. In such cases, the need for additional operating funds can be identified for request, and the service can be implemented when sufficient resources become available.

A key component of the biennial service planning process is an evaluation of the performance of existing services, as measured using the Service Standards found in Chapter 3 of this policy. Based on this analysis, the Service Planning Department proposes major service changes that will improve the performance of services that fail any of the Service Standards. (Minor service changes may also be identified at this time; however, they may be implemented as soon as possible, rather than waiting for the full acceptance of the Service Plan.)

Service changes considered in the biennial Service Plan can also be proposed through all of the same avenues as those considered in the on-going service planning process. Indeed, many may be identified through the on-going screening of projects. In addition, public input for the biennial Service Plan is sought through public meetings and public hearings, as described later in this chapter.

During development of the biennial Service Plan, potential major changes are evaluated through a comparative evaluation to determine which represent the best allocation of available resources. To complete the comparative evaluation, the Service Planning Department creates a list of all proposed service increases and reductions. The proposed service increases are ranked using the net cost per new passenger: those that garner the most new passengers at the lowest incremental cost are ranked highest priority for implementation. The proposed service reductions are ranked using the net savings per lost passenger: those that save the most money with the lowest loss of passengers are ranked highest priority for implementation.

Other evaluation criteria are also used in the comparative evaluation, as appropriate, to determine the rank of service change proposals. For example, higher priority would be given to a proposed change that improved a route’s performance on one or more of the service standards (as defined in Chapter 3).

After the rankings are completed, the savings from the major service reductions are compared to the cost of major service enhancements to help select the proposed service changes. The goal is to maximize ridership and service performance in a cost-effective manner. The recommendations that result from this process are reviewed by the Service Committee to assess the feasibility of implementation before they are included in the Preliminary Service Plan. Each Preliminary Service Plan is made available to the public for review and comment (as described later in this chapter). A list of the final recommendations, an indication of the routes that still violate one or more of the service standards, and the Title VI analysis are then submitted to the MBTA Board of Directors for final approval before the changes are implemented.

Table 13: Summary of Service Planning Processes

	On-going Service Planning Process	Biennial Service Plan Process
Magnitude of changes:	• Minor	• Major
Initiation of changes:	• Requests/complaints from public • Bus Operations feedback • Service Planning Staff • Service Studies	• Requests/complaints from public • Bus Operations feedback • Service Planning Staff • Service Studies • Public Meetings
Evaluation of changes:	• Route or garage level analysis using the Evaluation Criteria • Review by Service Committee	• Route or garage level analysis using the Evaluation Criteria (including performance review of all services using Service Standards) • Comparative evaluation of proposed service changes, and possible new services • Review by Service Committee • Public review and comment • Title VI analysis
Implementation of changes:	• Quarterly with regular schedule changes	• Biennially, upon approval of the Service Plan by the MBTA Board of Directors

- **Light Rail/Heavy Rail Service Planning Process (to be completed)**

Contract Services

- **Commuter Rail Service Planning Process (to be completed)**
- **Commuter Boat Service Planning Process (to be completed)**

Public Participation

Public participation in the service planning process varies somewhat by mode and occurs as both an on-going process and as a Service Plan specific process. The purpose of public involvement in the service planning process is to promote a regular dialogue with existing and potential riders, elected officials, and communities regarding their ever-changing service needs

- **On-Going Public Outreach**
  The MBTA provides avenues for on-going communication through the MBTA's website, as well as the customer complaints phone line and comments sent to individual MBTA officials. Service related comments/requests are directed to the appropriate department for consideration and response. Upon request, MBTA staff also attend public meetings held by municipalities and meetings with public

officials to address specific service issues. In addition, from time to time, the MBTA may conduct specific market or route-based surveys to gather direct input on a major service change or potential new service.

- **Biennial Service Plan Public Outreach**
  Service Plan outreach efforts are intended to provide members of the public with the opportunity to submit service requests to the MBTA for consideration in development of the Biennial Service Plan. To this end, the MBTA solicits ideas for service changes through written comments (submitted on-line or via the mail), as well as through public meetings throughout the service area, before a draft plan is written.

  Upon completion of the draft biennial Service Plan, the MBTA schedules a second round of public meetings in appropriate locations. At these open meetings the MBTA presents the analysis and issues behind the proposed service changes and solicits public comments on them. In addition, at least one Public Hearing is held to receive formal public comments on the draft Biennial Service Plan. MBTA staff then assess and analyze the suggestions made through the public comments and, as appropriate, incorporate them into the final recommendations that go to the MBTA Board of Directors for approval before implementation.

  All Service Plan public notifications, meetings, and hearings will conform to the requirements of the Americans with Disabilities Act, Title VI of the Civil Rights Act of 1964, and MBTA policies associated with these laws.