

# ROAD SAFETY AUDIT

Groton Road (Route 40) at Dunstable Road

Town of Westford

April 25, 2014

Prepared For:  
MassDOT



On Behalf Of:  
Town of Westford



Prepared By:  
TEC, Inc.  
65 Glenn Street  
Lawrence, MA 01843



# Table of Contents

---

<b>Background .....</b>	<b>1</b>
<b>Project Data.....</b>	<b>1</b>
<b>Project Location and Description.....</b>	<b>3</b>
<b>Audit Observations .....</b>	<b>8</b>
<b>Potential Safety Enhancements .....</b>	<b>18</b>
<b>Summary of Road Safety Audit.....</b>	<b>21</b>

## List of Appendices

Appendix A. RSA Meeting Agenda	
Appendix B. RSA Audit Team Contact List	
Appendix C. Detailed Crash Data	
Appendix D. Road Safety Audit References	

## List of Figures

Figure 1. Locus Map.....	7
--------------------------	---

## List of Tables

Table 1. Participating Audit Team Members .....	2
Table 2. Existing Traffic Volume Summary .....	4
Table 3. Existing Vehicle Speed Summary .....	5
Table 4. Existing Vehicle Classification Summary .....	6
Table 5. Estimated Time Frame and Cost Breakdown .....	18
Table 6. Potential Safety Enhancement Summary .....	23

## Background

The Town of Westford, Massachusetts is currently planning improvements along the Groton Road (Route 40) corridor, specifically at the intersection with Dunstable Road, in an effort to address existing operational and safety concerns. In conjunction with the preliminary design (pre-25% Design) stage and Functional Design Report (FDR) for these improvements, TEC, Inc. is submitting this Road Safety Audit (RSA) report for the intersection of Groton Road (Route 40) / Dunstable Road. The purpose of the RSA is to observe, identify, and report all safety issues and identify future opportunities for safety enhancement improvements for all roadway users. This includes identifying both short-term and long-term safety improvements which can be implemented through general maintenance, immediate installation/removal, or could potentially be incorporated into the defined future improvement project.

In August 2005, the Transportation Act entitled the “Safe, Accountable, Flexible, Efficient Transportation Act - A Legacy for Users” (SAFETEA-LU) was passed. This act provides guidance and funding for the implementation of a State Highway Safety Improvement Program (HSIP). As part of this program, all states are required to develop a Strategic Highway Safety Plan (SHSP). The Massachusetts Department of Transportation (MassDOT) guidelines require an RSA to be conducted where HSIP-eligible crash clusters are present within the study area of a transportation improvement project, prior to commencing or finalizing a 25% Design and FDR. An intersection is defined as HSIP-eligible if the intersection is within the top 5% of clusters in its respective Regional Planning Commission (RPC) boundaries based on Equivalent Property Damage Only (EPDO). EPDO rates crashes based on the collision severity. Based on the *published* MassDOT database, the intersection of Groton Road / Dunstable Road is NOT recognized as an HSIP-eligible intersection; however, based on the most updated crash data information from the respective RPC, the Northern Middlesex Council of Governments (NMCOG), the intersection does meet the threshold for HSIP-eligibility, as confirmed by MassDOT.

An RSA, as defined by the Federal Highway Administration (FHWA), is the *formal safety performance examination of an existing or future road or intersection by an independent, multidisciplinary team*. This RSA was conducted during the preliminary design (pre-25% Design) stage of intersection and corridor improvements along Groton Road in Westford, Massachusetts in order to incorporate safety-related design features early in the design process. The scale of the improvements at this location is projected to include, but not limited to: minor roadway widening, mill and overlay of pavement, restriping of pavement markings, the installation of a fully-actuated traffic signal (if warranted), and traffic sign improvements. Elements of the RSA will be considered for incorporation into the roadway improvement project as the design is advanced through the MassDOT and Town of Westford design development process.

## Project Data

TEC, Inc. of Lawrence, Massachusetts is the prime traffic safety investigation consultant in an RSA for the intersection of Groton Road (Route 40) / Dunstable Road in Westford, Massachusetts. The RSA was conducted on Monday, March 31, 2014 at 1:00 PM, with the pre- and post-audit meetings held at the Westford Town Hall in Westford, Massachusetts. A copy of the RSA agenda can be found in

Appendix A. TEC has also conducted various other field visits to the audit location as part of its FDR and pre-25% Design work.

As presented in Table 1, the audit team consisted of a cross-section of state, regional, and local engineering, planning, enforcement, maintenance and emergency response professionals and was assembled in conjunction with input from MassDOT's Traffic Safety Management Unit. Contact information for all participating audit team members is provided in Appendix B.

**Table 1. Participating Audit Team Members**

<b>Audit Team Member</b>	<b>Agency/Affiliation</b>
Paul Starratt, P.E.	Town of Westford Engineering
Jeremy Downs, P.E.	Town of Westford Engineering
Jeffrey Morrisette	Town of Westford Planning
Chip Barrett	Town of Westford Highway Department
Lt. Don Parsons	Town of Westford Fire Department
Capt. Mark Chambers	Town of Westford Police Department
Justin Howard	Northern Middlesex Council of Governments (NMCOG)
Mike Mauro	Northern Middlesex Council of Governments (NMCOG)
Lisa Schletzbaum	Massachusetts Department of Transportation – Traffic Safety
Corey O'Connor, E.I.T.	Massachusetts Department of Transportation – Traffic Safety
Nithin Krishna	Massachusetts Department of Transportation – Traffic Safety
Lola Campbell	Massachusetts Department of Transportation – District 3
Samuel W. Gregorio, E.I.T.	TEC, Inc.
Mikel C. Myers, P.E.	TEC, Inc.
Kerri K. Racki	TEC, Inc.

Audit participants were provided with materials to review prior to the audit meeting. The materials included a summary of collision data, collision diagrams (See Appendix), a summary of the type and severity of collisions, and speed data. Participants were encouraged to visit the site prior to the audit and were urged to consider elements on MassDOT's Safety Review Prompt List.

On the day of the audit, a pre-audit meeting was held at the Westford Town Hall to discuss the project's background, the audit process, review the distributed materials, and discuss the some of the issues that Team members had observed individually. The audit site walk consisted of field observations at the audit intersection. Handwritten notes and photographs documented the observations made by audit team members during the site walk. Following the audit site walk, a post-audit meeting was held at Westford Town Hall where the Team confirmed the observations made in the field and offered solutions to enhance the safety of areas noted in the site walk and pre-audit meeting.

## Project Location and Description

The Road Safety Audit was conducted at the intersection of Groton Road (Route 40) / Dunstable Road in the Town of Westford, Massachusetts. A Study Area Location Map is provided in Figure 1.

### ***Groton Road (Route 40)***

Groton Road, signed as Massachusetts State Route 40, generally runs in an east-west direction and is maintained by the Town of Westford. The roadway is classified as an urban principal arterial roadway and provides regional connection through the northern portion of Westford between Groton Town Center to the west and Vinyl Square / North Chelmsford Center to the east. The roadway also provides regional connection to US Route 3 (Northwest Expressway) approximately 2.5 miles to the east of Groton Road's intersection with Dunstable Road. Groton Road is designated as a primary evacuation route for both Westford and Groton by the Northeast Homeland Security Regional Advisory Council (NERAC).

Groton Road is approximately 32-feet wide in the vicinity of Dunstable Road with varying 1- to 4-foot shoulders. Directional flow along Groton Road is separated by marked centerline. The posted speed limit is 40 miles per hour (mph) and the 85th percentile speed of existing traffic was measured at 40 mph. No speed regulations for the roadway are on file with the Town of Westford or MassDOT. In the vicinity of Dunstable Road, Groton Road has multiple horizontal and vertical roadway curves. Land uses along Groton Road include: residential, light retail, and light commercial uses.

### ***Dunstable Road***

Dunstable Road generally runs in a northwest-southeast direction and is maintained by the Town of Westford. The roadway is classified as an urban minor arterial roadway north of Groton Road and an urban collector south of Groton Road. Dunstable Road provides regional connection through the northern portion of Westford between Depot Street to the south and Dunstable Town Center to the north.

Dunstable Road is approximately 30-feet wide immediately north of Groton Road and approximately 20-feet wide south of Groton Road. There is no posted speed limit along Dunstable Road south of Groton Road; however it is assumed that the speed limit is 30 mph due to nature of roadway settlement. The posted speed limit north of Groton Road is 30 mph. The 85th percentile speed of existing traffic was measured at 31 mph both north and south of the intersection with Groton Road. Land uses along Dunstable Road include primarily residential uses.

### ***Groton Road (Route 40) @ Dunstable Road***

Dunstable Road intersects Groton Road to form a four-way unsignalized intersection. Both the Dunstable Road northbound and southbound approaches are under STOP-control while the Groton Road eastbound and westbound approaches are free-flowing. A flashing warning beacon is suspended above the intersection to supplement the two-way STOP-control and cautionary free-flowing characteristics. All four intersection approaches consist of a single general purpose travel lane. Directional flow along Groton Road is separated by a marked double-yellow centerline with edge-lines providing marked shoulders. Directional flow along Dunstable Road is also separated by a marked double-yellow centerline

with edge-lines providing marked shoulders north of the intersection. Many of the pavements markings are faded. No sidewalks or crosswalks are provided at the intersection.

A BP gas station is located on the northwest corner of the intersection of Groton Road / Dunstable Road. The gas station provides a 20-foot curb-cut along the Dunstable Road southbound approach and two extensive curb-cuts ( $\pm 40$ -feet wide) along the Groton Road eastbound approach. The two curb-cuts are separated by a raised landscaped island that is offset from the roadway by 7-feet. Utility poles are present along the Groton Road northerly curb-line.

The intersection of Groton Road / Dunstable Road is abutted by multiple wetland and water resource areas, including a National Heritage Endangered Species Program (NHESP) certified vernal pool on the southwest corner of the intersection and a wetland on the southeast corner of the intersection.

### ***Automatic Traffic Recorder Count Data***

#### Traffic Volumes

Automatic Traffic Recorder (ATR) counts were conducted on Groton Road (Route 40) and on Dunstable Road on Thursday March 20 to Saturday March 22, 2013 to gather daily traffic-volume data for the study area roadways during a continuous 72-hour time period. A summary of the weekday ATR traffic data is presented in Table 2.

**Table 2. Existing Traffic Volume Summary**

Location	Weekday Traffic Volume <sup>a</sup>	Weekday Morning Peak Hour			Weekday Evening Peak Hour		
		Traffic Volume <sup>b</sup>	K Factor <sup>c</sup>	Directional Distribution <sup>d</sup>	Traffic Volume	K Factor	Directional Distribution
Groton Road (east of Dunstable Road)	10,637	981	9.2	56.0% EB	984	9.3	54.5% WB
Groton Road (west of Dunstable Road)	10,066	747	7.4	58.4% EB	910	9.0	52.2% WB
Dunstable Road (north of Groton Road)	2,887	264	9.1	83.0% SB	296	10.3	73.6% NB
Dunstable Road (south of Groton Road)	1,405	158	11.2	79.1% SB	155	11.0	68.4% NB

<sup>a</sup>Daily traffic expressed in vehicles per day.

<sup>b</sup>Expressed in vehicles per hour.

<sup>c</sup>Percent of daily traffic volumes which occurs during the peak hour.

<sup>d</sup>Percent of peak-hour volume in the predominant direction of travel.

EB – eastbound; WB = westbound; NB = northbound; SB = southbound

Groton Road (Route 40) carries approximately 10,640 vehicles per day (vpd) on an average weekday east of Dunstable Road and approximately 10,065 vpd on an average weekday west of Dunstable Road. The majority of vehicles along Groton Road (Route 40) are travelling eastbound in the weekday morning peak period and westbound during the weekday evening peak period. This is consistent with commuter flows travelling to / from US Route 3 Interchange 33 east of the intersection.

Dunstable Road carries approximately 2,890 vpd on an average weekday north of Groton Road (Route 40) and approximately 1,405 vpd on an average weekday south of Groton Road (Route 40). The majority of vehicles along Dunstable Road north of Groton Road (Route 40) are travelling southbound in the

weekday morning peak period and northbound during the weekday evening peak period. This is consistent with commuter flows travelling to / from US Route 3 Interchange 33 east of the intersection. South of the intersection, the majority of vehicles along Dunstable Road are travelling southbound in the weekday morning peak period and northbound during the weekday evening peak period. This suggests that Dunstable Road south of Groton Road (Route 40) is used as a cut-through roadway to/from Groton Road (Route 40) and Westford Town Center. It also suggests that commuter flow to/from US Route 3 may likely be utilizing Depot Street or Oak Hill Road to/from Westford Town Center.

The traffic volume counts showed little or no pedestrian and bicycle traffic during the 72-hour continuous study period. Audit participants noted that there is traditionally little to no pedestrian traffic along Groton Road or Dunstable Road in this area; however, bicycle traffic is significant during the spring, summer, and fall and has been continuously increasing over the past few years.

### Vehicle Speeds

Vehicle travel speeds on Groton Road (Route 40) and Dunstable Road on the approaches to the unsignalized intersection were collected as part of the ATRs in March 2014. Table 2 summarizes the measured travel speed data. Roadway surface conditions were dry and weather conditions were generally clear / cloudy during the collection of roadway speeds. Therefore, vehicle travel speeds can be assumed to be at or near prevailing conditions.

**Table 3. Existing Vehicle Speed Summary**

Location	Average Speed (mph)		85 <sup>th</sup> Percentile Speed (mph)		% Vehicles > Speed Limit	
	EB or NB	WB or SB	EB or NB	WB or SB	EB or NB	WB or SB
Groton Road (east of Dunstable Road)	33	36	38	42	8.4%	30.1%
Groton Road (west of Dunstable Road)	34	33	40	38	17.8%	6.5%
Dunstable Road (north of Groton Road)	27	28	31	32	19.4%	26.4%
Dunstable Road (south of Groton Road)	26	28	30	32	14.1%	26.9%

The data shows that the average travel speeds on the approaches of Groton Road are consistently below the posted speed limit of 40 mph. The 85th percentile speed on these approaches was consistently approximately 40 mph. On both Groton Road approaches, the vehicle speeds exiting the intersection were higher than the vehicle speeds entering the intersection.

The data shows that the average travel speeds on the approaches of Dunstable Road, similar to Groton Road, are consistently below the posted speed limit of 30 mph. Although there is shown to be approximately 6 to 30 percent of vehicles operating above the speed limit, the 85th percentile speeds on these approaches were only slightly above the posted speed limit (32 mph vs. 30 mph).

Vehicle Classification

Vehicle classification was reviewed along Groton Road (Route 40) and Dunstable Road based on data collected within the ATR counts in March 2014. Table 3 summarizes the percent of heavy vehicles (trucks and buses) for the average weekday daily traffic.

**Table 4. Existing Vehicle Classification Summary**

Location	Weekday Daily HV%		Weekday Morning Peak Hour HV%		Weekday Evening Peak Hour HV%	
	EB or NB	WB or SB	EB or NB	WB or SB	EB or NB	WB or SB
Groton Road (east of Dunstable Road)	1.3%	1.4%	1.0%	1.7%	0.8%	0.5%
Groton Road (west of Dunstable Road)	2.0%	1.2%	1.9%	1.8%	1.7%	0.3%
Dunstable Road (north of Groton Road)	1.0%	0.4%	4.9%	0.5%	0.6%	0.0%
Dunstable Road (south of Groton Road)	1.2%	1.2%	3.8%	1.5%	0.0%	0.0%

Table 3 shows that the percent of daily heavy vehicles on Groton Road (Route 40) in the vicinity of the study area intersection ranges between 1.2 to 2.0 percent. On Dunstable Road, heavy vehicles represent 0.4 to 1.2 percent of total vehicles.

Truck and bus traffic accounted for approximately 1.0 to 1.9 percent of the total traffic volume during the weekday morning peak period and approximately 0.3 to 1.7 percent during the weekday evening peak period. Along Dunstable Road, truck and bus traffic accounted for approximately 0.5 to 4.9 percent of the total traffic volume during the weekday morning peak period and approximately 0.0 to 0.6 percent during the weekday evening peak period. A majority of the weekday morning peak period heavy vehicle traffic was classified as buses (school buses).

Town of Westford staff noted during the audit meeting that Groton Road (Route 40) is utilized as a cut-through for heavy vehicles between US Route 3 and Devens. This includes many vehicle transports.



Figure 1

Audit Study Area Map



TEC, Inc.  
65 Glenn Street | 169 Ocean Blvd, Unit 101  
Lawrence, MA 01843 | Hampton, NH 03842

## Audit Observations

Prior to the RSA site walk, a pre-audit meeting was held at the Westford Town Hall. This pre-audit meeting included brief introductions, an overview of the project and RSA process, and a summary of volume, speed, and safety characteristics at the intersection of Groton Road (Route 40) / Dunstable Road. Audit participants then conducted a site walk as a group to observe the intersection. Each participant was advised to offer their concerns and comments related to safety issues at the study area intersection.

Based on these field observations and discussions, the RSA team determined that the intersection of Groton Road / Dunstable Road has several general concerns that may negatively impact safety. The following sections describe in more detail the safety issues identified during the RSA. Several of these require further evaluation and design work to develop appropriate safety enhancements. More specific safety challenges located at specific audit area intersections are also included.

### *Crash History*

The intersection of Groton Road / Dunstable Road is considered HSIP-eligible. Collision data for this intersection was provided by NMCOG for the period of January 2009 to December 2012 and supplemented by the Town of Westford Police Department for the period of January 2013 to December 2013. The data shows a total of 53 reported collisions (10.6 per year) in the area of the intersection during the five-years of complete collision data. All but one (1) collision [*noted as Collision #8*] was locatable. The crash rate for this intersection is significantly higher (3.5 times higher) than the statewide and district-wide averages for unsignalized intersections with 2.32 crashes per MEV.

There were twelve (12) rear-end collisions (23%) at the intersection over the five-year study period. Of the locatable rear-end collisions, more than three-quarters (9 of 12) occurred on the Groton Road eastbound approach to the intersection, of which four (4) collisions were the result of motorists following too closely. Two (2) of the rear-end collisions occurred on the westbound approach of Groton Road to the BP gas station curb-cut as vehicles attempted to exit the gas station.

There were nine (9) single vehicle collisions (17%) at the intersection over the five-year study period. Of the locatable single vehicle collisions, more than half (5 of 9) occurred during the night between 7:00 PM and 1:00 AM.

There were twenty-nine (29) angled collisions (55%) at the intersection over the five-year period which represents the vast majority of collisions at the intersection of Groton Road / Dunstable Road. Approximately two-thirds (19 of 29) of these angled collisions were a result of failing to yield the right-of-way to the operator along Groton Road according to the narratives provided. All angled collisions at the intersection occurred during periods of daylight between 6:50 AM and 7:05 PM. Only one (1) of the angled collisions resulted in a non-fatal injury. Eighteen (18) of the angled collisions (62%) involved a vehicle exiting Dunstable Road southbound north of the intersection.

The crash data noted five (5) collisions that occurred along Groton Road at one of the two BP gas station driveways, which both are within 170 feet of the Groton Road / Dunstable Road intersection. These

collisions included two (2) rear-end crashes (as previously mentioned), one (1) single vehicle collision, and two (2) angled collisions.

### ***Safety Concerns***

The RSA team noted safety concerns at the intersection of Groton Road / Dunstable Road. Some specific safety related concerns are mentioned in multiple bullets within the summary. Based on these field observations and discussions, the RSA team determined that the intersection and approaches had the following issues that negatively impact safety:

- Traffic Control
- Dunstable Road Approach Alignment,
- Proximity of Adjacent BP Driveways,
- BP Gas Station Driveways Entering Movements,
- BP Gas Station Driveways for Cut-Through Traffic,
- Visibility and Sight Distance,
- Roadway Profiles / Grades,
- Dunstable Road Tree within Right-of-Way,
- By-Passing Stopped Traffic,
- Pavement and Surface Conditions,
- Stormwater Drainage and Ponding,
- Utility Poles within Pavement,
- Solar Glare,
- Advanced Warning Signage,
- STOP sign locations,
- Driver Inattention and Indecision,
- Traffic Patterns,
- Pedestrian and Bicyclist Accommodations, and
- Lack of Speed Regulations

The following provides a detailed summary of the identified safety concerns at the intersection:

- *Traffic Control* – The current unsignalized intersection of Groton Road / Dunstable Road is two-way STOP-controlled. Several safety concerns are related to the current traffic control at this intersection, including:
  - *Traffic Control Violations / Failure to Yield the Right-of-Way* - Approximately two-thirds (19 of 29) of these angled collisions were a result of failing to yield the right-of-way to the operator along Groton Road (Route 40) according to the narratives provided by the Westford Police Department. Many drivers attempted to enter the traffic flow along Groton Road (Route 40) and were immediately struck by an oncoming, free-flowing vehicle. Although STOP signs are provided on the Dunstable Road approach and vehicles generally comply and stop, many advance into the intersection without proper caution.

Several audit participants acknowledged frequent “courtesy” extended to the drivers exiting the side street; where one driver with the right-of-way, waves the side street driver to proceed even when the right-of-way may not be with that driver. This may cause the side street driver to pull out without consideration of other mainline vehicles on Groton Road. In addition, it was

suggested that extending “courtesy” to the drivers exiting the side street may result in rear-end collisions for vehicles along Groton Road who are unaware of the aforementioned “courtesy.”

- *Peak Hour Commuter Congestion* – Groton Road serves as a major commuter artery to/from US Route 3 to the east. Traffic volumes in the area generally increase during the weekday morning and weekday evening peak periods and cause a steady and constant flow of traffic. With no controlled intersections to the immediate east or west of the Groton Road / Dunstable Road intersection, gaps in the constant flow are not regularly occurring during the peak periods. This lack of gaps adds to queues and increase driver frustration on the STOP controlled streets and many residential driveways.
- *Queuing* – During the weekday morning and weekday evening peak commuter periods, audit participants noted that it was not uncommon for six to ten vehicles to queue on Dunstable Road southbound north of the intersection. On occasion, queued vehicles honk their horns in frustration. Queuing puts a perceived pressure on the driver at the front of the queue and causes the occasional quick judgment to enter the intersection.

Stopping sight distance along Dunstable Road approaching the intersection may be insufficient around the horizontal curvature to allow adequate distance for a driver to perceive and react to the back of queue extending from the Groton Road intersection. Although no rear-end or single vehicle collisions were reported along this approach as a result of queuing or congestion, the potential of queuing or unexpected traffic congestion remains a safety concern.

- *Dunstable Road Approach Alignment* – The Dunstable Road approaches to Groton Road are slightly offset, and therefore vehicles exiting the Dunstable Road approaches do not have a direct path to access the opposing Dunstable Road receiving lane. These movements may be difficult for unfamiliar users attempting to cross Groton Road. During multiple field visits, vehicles were observed encroaching over the double-yellow centerline (DYCL) prior to completing the maneuver into the appropriate receiving lane. No head-on collisions have occurred during the study period in the north-south direction; however the alignment was still identified as a safety issue.

Multiple audit participants described how vehicles travelling southbound on Dunstable Road will utilize the roadway as two lanes for which some motorists may be confused to which lane is acting as the through lane if a left-turning vehicle has not properly indicated a left-turn signal. As vehicles attempting to travel straight across the intersection are far-left up against the DYCL, it becomes more difficult to track across the intersection. The side-by-side vehicles on the approach presents a safety issue because of the limited sight distance, especially if the adjacent vehicle is a larger vehicle that blocks the driver’s view.



**Image 1: View of Roadway Alignment from Dunstable Road Southbound Approach**

- *Proximity of Adjacent BP Driveways* – Two driveways to the adjacent BP gas station located on the northwest corner of the intersection provide access/egress to/from Groton Road. A third curb-cut is provided along Dunstable Road north of the intersection. These driveways along Groton Road are both within 170 feet of the intersection providing additional conflict points and minimal separation distance from the intersection. Five (5) collisions that occurred within the study area involved or resulted from a vehicle entering or exiting one of the BP gas station driveways.

Town of Westford representatives noted that the separated curb-cuts were established approximately 15 years ago. Previously, the pavement was open on both Groton Road (Route 40) and Dunstable Road.

- *BP Gas Station Driveways Entering Movements* - The owner of the BP gas station noted that vehicles will sometimes enter the Dunstable Road driveway straight from Groton Road westbound without performing the appropriate legal turning maneuvers (right-turn onto Dunstable Road then left-turn into driveway). While making this maneuver, vehicles entering the driveway cross the path of vehicles approaching the STOP line on Dunstable Road southbound. This provides a potential for conflicts with vehicles travelling southbound on Dunstable Road who may be queued or approaching the intersection with limited visibility of the driveway and turning traffic due to vegetation and curves restricting sight distances.
- *BP Gas Station Driveways for Cut-Through Traffic* - It was also mentioned that the gas station driveways are used as a “cut-through” for southbound vehicles along Dunstable Road turning into the gas station only to turn left out of the gas station onto Groton Road. This indicates there are limited gaps within Groton Road traffic and an increase frustration level with queued vehicles.



**Image 2: BP Gas Station Curb-cuts in Relation to Intersection of Groton Road / Dunstable Road**

- *Visibility and Sight Distance* – Audit participants noted several challenges in regards to sight distance on all four approaches to the intersection, including:
  - *Set Back STOP Lines* – STOP lines along Dunstable Road are set back 15 feet from the edge of travel-way along Groton Road. This forces vehicles to pull-up beyond the STOP bar to view Groton Road to the east and west before proceeding.
  - *Shrubbery Along North Edge of Groton Road* – There are shrubbery/bushes located within the curb-cut island for the BP gas station and inside the granite/wood fence to the #270 Groton Road property. In season, bushes may provide obstruction to intersection sight lines from Dunstable Road southbound for smaller vehicles.



**Image 3: View of Bushes within Sightline from Dunstable Road Southbound**

- *Gas Station Sign* – The existing BP gas station sign may block sightlines for larger vehicles on Dunstable Road southbound looking west.
- *Wooden Fence (Private)* – A wooden fence at #259 Groton Road, west of the intersection, blocks the view for vehicles exiting Dunstable Road northbound looking west if not pulled-up to the edge of travel-way.



**Image 4: View of Sight Line on Dunstable Road Northbound Looking West**

- *Summer Village Sign / Flashing Beacon Pole* – The southeast corner of the intersection includes multiple obstructions, including: a guardrail, a sign for the “Summer Homes” development along Dunstable Road north of the intersection, and the pole for the flashing warning beacon. These obstructions block the view of Dunstable Road northbound traffic looking east. In season, the vegetation tree line also contributes to sight line concerns on this corner.
- *BP Northerly Site Driveway* – Sight lines exiting the BP Gas Station driveway looking north are heavily restricted by the horizontal curvature in the roadway and an existing tree on the westerly edge of roadway. The audit team observed that a majority of patrons to the BP Gas Station enter and exit the site from the Groton Road curb-cuts.
- *Roadway Profile / Grades* – Throughout the Town of Westford, Groton Road is a rolling thoroughway with multiple horizontal curves and multiple crest/sag vertical curves. Crest vertical curves are present both immediately east and west of the intersection with Dunstable Road which are limiting factors for sightlines from Dunstable Road. It was observed during the audit field visit that passenger vehicles are hidden in the sag curve to the east of the intersection. The steep grade on Dunstable Road northbound also contributes to delay for vehicles turning onto Groton Road.
- *Dunstable Road Tree within Right-Of-Way* – Immediately south of Groton Road along the easterly edge of Dunstable Road, a large tree (>4’ diameter) encroaches into the right-of-way. Although the STOP sign on the approach is visible further upstream and a second STOP sign is placed on the opposing edge of pavement, the tree temporarily

blocks the STOP sign from a point approximately 200-feet to 100-feet from the painted STOP bar.

Immediately north of Groton Road along the westerly edge of Dunstable Road, a large tree (>4' diameter) encroaches into the right-of-way and completely blocks the view of the intersection upstream on horizontal curvature of the roadway. These two trees on either side of Groton Road contribute to the side-street alignment offset at Groton Road.



**Image 5: View of Dunstable Road Northbound From Center of Travel Lane**

- *By-Passing Stopped Traffic* – Groton Road eastbound, west of Dunstable Road, includes a 12-foot travel lane with a 1.5-foot shoulder. The roadway cross-section does not allow for sufficient room for through vehicles to by-pass stopped turning vehicles within the free-flowing condition. Eight (8) rear-end collisions were identified on the Groton Road eastbound approach as the front vehicle was stopped in traffic presumably turning left. These included collisions as a result of attempting to by-pass the stopped vehicle, following too closely, and driver inattention.

It was mentioned during the audit field visit that some of these rear-end collisions could be related to the gas station driveways. A vehicle slowing to turn into the gas station driveway could be perceived by a following vehicle as turning onto Dunstable Road. This creates the potential for collision in the following drivers does not anticipate the turning vehicle to slow so abruptly to turn into the driveway.

- *Pavement and Surface Conditions* – The Town of Westford Highway Department indicated that Groton Road was last paved in 2000. Dunstable Road has recently been paved. There are several locations, especially near the edge-lines, where pavement is fragmented. An audit participant noted that the age of pavement may be a factor in many collisions that occurred on wet pavement.

Vehicles travelling northbound on Dunstable Road were observed spinning wheels upon acceleration after STOP. This may be a result of the wet pavement at the time of observation in addition to the presence of gravel and sand on the edge-lines of Groton Road (Route 40).

Both Groton Road and Dunstable Road lack a constant and noticeable edge line, whether pavement to soil or pavement to curbing. Where no curbing exists along most of the approaches to the intersection, annual debris build-up and broken pavement have resulted in an inconsistent roadway width. In addition, there is pavement scouring from open pavement runoff.

- *Stormwater Drainage and Ponding* – Stormwater drainage structures have been in place prior to the Dunstable Road southbound widening and the BP gas station separated curb-cuts. As a result the drainage structures along Dunstable Road southbound are offset 4-feet from the curb line. Based on the existing roadway crowning, the curb line acts as a gutter for Dunstable Road stormwater by-passing the existing catch basin north of the BP gas station curb-cut. The stormwater continues to the catch basin near the edge line of Groton Road, which is also 5-feet from the curb line. Minor ponding was observed near this catch basin. The crash data indicated that 26% of collisions during the study period involved wet surface roadway.



**Image 6: View of Stormwater By-Passing Catch Basin on Dunstable Road**

- *Utility Poles within Pavement* – There is currently a utility pole outside the existing curb line along the northerly edge of Groton Road, west of the intersection, in front of the BP gas station raised landscaped island, and offset 7-feet from the travel-way. The utility pole is not within the existing path of travel along Groton Road (Route 40); however the pole does provide an obstruction to any user who has even a minor crossover of the existing edge line. Although no collisions indicated the placement of this utility pole as a contributing factor, the current placement poses potential future safety risks.
- *Solar Glare*– Narratives from the motor vehicle crash reports and field observations indicate that solar glare may be an issue along the Groton Road east-west corridor and the southbound approach of Dunstable Road. Although the roadway is bordered by extensive vegetation and trees, solar glare increases at the intersection of Groton Road / Dunstable Road as a result of the set-back of vegetation from the roadway based on the adjacent development. Two (2) collisions defined solar glare as a contributing factor.

- *Advanced Warning Signage* - Advanced warning signs were recently installed along Groton Road (Route 40) [W2-1 – Intersection Warning] and along Dunstable Road [W3-1 - STOP ahead] by MassDOT in 2013. The MUTCD Section 2C.05 indicates that advanced warning signage should be placed at appropriate locations to provide adequate perception-reaction time (PRT) without being too far in advance that the message being conveyed is forgotten. The advance STOP warning signage on the Dunstable Road southbound approach is approximately 325 feet from the STOP line and may be too far back from the intersection to provide a memorable message.



**Image 7: Advanced Warning Signage Along Dunstable Road Southbound Approach**

In addition, the Dunstable Road northbound approach has three (3) separate advanced STOP warning signs. This includes two (2) signs directly opposing one another approximately 160 feet from the intersection and one (1) approximately 400 feet south of the intersection, bolted to an adjacent tree. Since the additional advance warning signage has been implemented, there is no clear indication that a reduction in collisions has occurred.

- *STOP Sign Locations* – The MUTCD Section 2A.16 indicates that the outer edge of roadside signage at a minor crossroad intersection should be a minimum of 6 feet offset from the edge of pavement. The edges of STOP signs on both the northbound and southbound approaches to the intersection are located within the 6 foot minimum zone and slightly over-hang into the roadway. Although the collision occurrence does not indicate that the lateral offset of the STOP signs is a contributing factor to collisions, the current signage offset may contribute to the existing sight line constraints.
- *Driver* – Audit participants and collision reports indicated several challenges in regards to the driver at the intersection, including:
  - *Driver Inattention* - Multiple collisions were a result of driver inattention or distracted driving. Seven (7) of the collisions reported over the study period were listed as directly caused by inattention, distracted driving, or cell phone use. Many other collisions, as described in the narrative, had driver inattention characteristics as a contributing factor to the collision.

- *Driver Indecision* – During the audit field visit, participants observed driver hesitation between two vehicles stopped on each Dunstable Road approach to the intersection trying to determine who had the right-of-way. This wasted valuable time in the “gap” of traffic along Groton Road.
- *Traffic Patterns* – Several audit participants suggested that potential crashes along Groton Road may be a result of increased unfamiliar traffic to the roadways. This includes increased cut-through traffic between US Route 3 in Tyngsboro (Interchange 34) to Interstate 495 in both Westford (Interchange 32) and Littleton (Interchange 31), increased passenger car and heavy vehicle traffic between US Route 3 (Interchange 33) to Devens, and the new seasonal home development along Dunstable Road north of the intersection. Traffic volumes have also increased due to an increase in school traffic, which may be a result of the municipal fees associated with school busing. Although the collision data did not specify the unfamiliar user as the cause to these collisions, unfamiliarity with the roadway may be a contributing factor in some collisions.

It was noted during the audit field visit that some drivers avoid the intersection and use adjacent signalized intersections, such as Groton Road / Tyngsboro Road / Depot Street, to avoid the turning movements in and out of Dunstable Road.

- *Pedestrian and Bicyclist Accommodations* - The intersection of Groton Road / Dunstable Road lacks any accommodations for pedestrian and bicycle users. No sidewalks are present along either Groton Road (Route 40) or Dunstable Road in the vicinity of the intersection. In addition, with narrow roadway shoulders, there are poor accommodations for bicyclists. Although pedestrian traffic is typically limited at the intersection, bicycle traffic has increased considerably in recent years as reported by Town of Westford officials. No collisions at the intersection involved a pedestrian or a bicyclist.
- *Speed Regulations* – There are currently no speed regulations along Groton Road on file with the Town of Westford or MassDOT.

## Potential Safety Enhancements

After the site visit, audit participants returned to the meeting location to discuss the safety issues and consider improvements. Audit participants were encouraged to consider both short and long term improvements for each issue. Each improvement considered has been categorized as short-term, midterm, or long-term based. Additionally, a cost category has been assigned to each improvement based on the definitions shown in Table 5.

**Table 5. Estimated Time Frame and Cost Breakdown**

Time Frame		Costs	
Short-Term	<1 year	Low	<\$10,000
Mid-Term	1-3 years	Medium	\$10,000 - \$50,000
Long-Term	>3 years	High	>\$50,000

The following improvements were suggested by audit participants to improve safety issues associated with the intersection of Groton Road (Route 40) / Dunstable Road.

- Consider improvement strategies related to traffic control. Two separate strategies were discussed during the audit:
  - Consider installation of a fully-actuated traffic signal. A traffic signal would provide protected turning movements and reduce the number of angled crashes at the intersection by creating less conflict between major-street and minor-street movements. The installation of a traffic signal will also assist in eliminating the need for gaps in traffic, and assist in the reduction of queues and driver frustration from the existing two-way STOP control. Investigation of traffic signal warrants should be conducted before proposing a traffic signal. Installation of a traffic signal is a long-term, high-cost improvement.
  - Consider construction of a roundabout. A roundabout traditionally lowers speed and calms traffic resulting in a reduction in major collisions. The installation of a roundabout will also assist in eliminating the need for gaps in traffic, and assist in the reduction of queues and driver frustration from the existing two-way STOP control. The construction of a roundabout may require significant takings of adjacent private properties and may require the relocation of underground fuel storage tanks at the BP gas station, relocation of a private well on the northeast corner of the intersection, may impact access to the BP gas station, and may affect potential wetland boundaries south of the intersection. A roundabout is a long-term, high-cost improvement.
- Consider realignment of Dunstable Road on both the northbound and southbound approaches to create improvement tracking for through vehicles and reduce encroachment into oncoming approach lanes. This will require the removal of several large trees (>4' diameter) along Dunstable Road both north and south of the intersection. Realignment of Dunstable Road approaches may not be needed if a roundabout is

proposed as a change in intersection control. This safety enhancement is a long-term, high-cost improvement.

- Consider installation of pavement markings to Dunstable Road through the intersection to improve vehicle tracking across Groton Road. This safety enhancement is a short-term, low-cost improvement.
- Explore the closure or reconfiguration of the BP Gas Station curb-cuts to reduce the number of vehicle conflict points at and near the Groton Road / Dunstable Road intersection and reduce the number of cut-through maneuvers for queued vehicles along Dunstable Road. Investigate driveway restrictions to limit which vehicles may enter or exit certain driveways to prevent courtesy collisions with vehicle queued if a signal is installed. This safety enhancement is a long-term, medium-cost improvement.
- Remove or better maintain shrubbery/bushes within the BP Gas Station raised landscape island and on the property of #270 Groton Road. This will improve sightlines when the plants are in season. Vegetation and obstruction removal is a short-term, low-cost solution and should be conducted in coordination with the abutters.
- Trim and maintain vegetation along the southerly edge of Groton Road to provide better sightlines for vehicles exiting Dunstable Road from the south. In addition, remove or reset the “Summer Village” signage further back from the intersection. This will allow northbound traffic to view oncoming traffic without “creeping up” too far beyond the STOP bar. Sight triangles should be calculated for the intersection to make sure the brush and other potential obstructions are trimmed and maintained appropriately. Vegetation and obstruction removal is a short-term, low-cost solution and should be conducted in coordination with the Town of Westford and abutters.
- Move the mast arm shaft for the flashing beacon back away from the roadway edge to improve the sight lines for Dunstable Road northbound vehicles looking to the east. Similarly, be sure that if installing a new traffic signal that the mast arm shafts are not obstructing sight lines on this intersection corner. This improvement is a long-term, medium-cost improvement.
- Consider the removal or relocation of the BP Gas Station sign. It was noted that similar gas stations in Westford removed their signage from roadway sightlines and replaced the signage on the fueling station canopy allowing for continued viewing. Signage removal is a short-term, medium-cost solution and should be conducted in coordination with the property owner.
- Consider reconstruction of Groton Road to establish a more consistent profile and improve sight lines at the intersection and along the Groton Road corridor. Improving the grades and vertical curvature of Groton Road is a long-term, high-cost improvement.
- Consider reconstruction of Dunstable Road southbound approaching Groton Road to provide a consistent grade. Improving the grades and vertical curvature of Dunstable Road is a long-term, high-cost improvement.
- Remove the large shade trees (>4' diameter) within the Right-of-Way along both Dunstable Road northbound and southbound to improve sight lines to/from the intersection along the approaches. This safety enhancement is a mid-term, medium-cost improvement.

- Consider the construction of exclusive left-turn lanes along Groton Road in both the eastbound and westbound directions. This will assist in the reduction of rear-end crashes for vehicles that unexpectedly stop to make turning movements onto Dunstable Road by providing a separate lane for left-turns to decelerate and wait for a gap. This treatment may increase the number of courtesy crashes and angle crashes at the intersection if traffic control is to remain two-way STOP control. Investigation of left-turn lane warrants should be conducted before proposing left-turn lanes. This safety enhancement is a long-term, high-cost improvement.
- Mill and overlay Groton Road at the intersection with Dunstable Road. Consideration should also be given to mill and overlay the Groton Road corridor. This will improve vehicle traction on the intersection approaches during poor weather conditions and provide a consistent roadway edge line and correct the ponding issue. This improvement is a mid-term, high-cost improvement.
- Reconstruct the drainage system by locating catch basins along the existing or future roadway edge lines to improve stormwater drainage and remove unnecessary ponding at the BP Gas Station curb-cuts and at the corners to the intersection. This safety enhancement is a long-term, high-cost improvement.
- Reset the curbing and widen the BP Gas Station raised landscaped island adjacent to the fueling stations to encompass the utility pole within the Groton Road pavement. This will remove the obstruction from the potential path of travel and decrease the amount of impervious area in front of the BP Gas Station. This safety enhancement is a short-term, medium-cost improvement. *[This improvement may be subject to potential widening on Groton Road for auxiliary turn lanes]*
- If a traffic signal is implemented at the intersection and rear-end collisions are still prevalent, consider the installation of advanced electronic signage that conveys a message of “RED” signal ahead to motorists who cannot view the upcoming signal due to the rolling roadway profile. These signs are similar to the advance signage present at the intersection of Groton Road / Tyngsboro Road / Depot Street to the east. This safety enhancement is a long-term, mid-cost improvement (mid-cost due to potential conduit interconnect between electronic sign and the traffic signal).
- Examine the spacing and distances of the existing advance warning signage and reset signage as needed. The construction or installation of a roundabout or traffic signal will require new advanced signage and the recalculating of spacing and advanced distance based on PRT and queue lengths. Properly spaced advanced warning signs will increase traffic control compliance. This improvement is a short-term, low-cost improvement.
- Reset STOP signage on Dunstable Road to be compliant with MUTCD lateral offset standards. This improvement is subject to any change in intersection control and would be a short-term, low-cost improvement. *[Confirm proper lateral offset at all present and future signage at and near the intersection]*
- Consider adding pavement markings to the Dunstable Road southbound approach to formalize the lane(s) leading to the stop bar. This will prevent two cars next to each other attempting to go straight at the same time. It should be decided if one general purpose lane is sufficient or if an additional turning lane is warranted. Either way, lane use



markings may help to formalize lane usage. This improvement is a short-term, low-cost improvement.

- Reset STOP bar pavement markings along Dunstable Road closer to intersection to allow for maximum sightlines to/from Groton Road. STOP bars should be striped at a location that still provides a safe distance from the edge of travel-way and provide trucks the ability to turn from Groton Road onto Dunstable without encroaching into the Dunstable Road approach traffic. This improvement is a short-term, low-cost improvement.
- Consider the construction of sidewalks and bicycle shoulders/lanes along Groton Road and shared lane markings along Dunstable Road to improve multi-modal access through the intersection and comply with MassDOT's Healthy Transportation Policy Directive. The construction of sidewalks and bicycle shoulders/lanes will require the acquisition of additional Right-of-Way on private property and may result in significant environmental impacts to adjacent wetlands and water resource areas. This safety enhancement is a long-term, high-cost improvement.
- The Town of Westford should consider utilizing its online public social networking accounts to educate the public on the intersection; such as crash history, advisories, and speed. This is a low-cost, short-term education tool.
- Conduct a speed study to establish a legal speed limit on Groton Road to allow for easier enforcement. Based on current traffic speeds collected by ATR counts, the posted speed limit may not change from its current 40 MPH. Conducting a speed study is a short-term, low-cost measure and should be conducted by the Town of Westford Police Department who have jurisdiction.
- Increase enforcement of traffic control measures at the intersection of Groton Road / Dunstable Road. Continue enforcement of the 40 MPH speed limit along Groton Road. Enforcement of traffic controls is a short-term, low cost improvement and should be conducted by the Town of Westford Police Department who have jurisdiction.

## Summary of Road Safety Audit

Based on the observations and discussions, the RSA team identified safety issues at the intersection of Groton Road (Route 40) / Dunstable Road. Further evaluation and design work may be necessary to develop safety enhancements to the roadway and intersections. The safety issues are summarized in Table 6.

For each safety issue, the RSA team has described the potential safety enhancement, its potential safety payoff, the estimated time frame for completion, the estimated construction cost, and the jurisdictional agency. The current scope of improvements will continue to be refined through coordination between the Project Team, the Town of Westford, and MassDOT. As design plans are in the 25% Design phase, all potential safety enhancements noted in this report will be incorporated into the design to the greatest extent possible or justification provided within the FDR or Design Exception Report as to why each item is not included.

The potential safety enhancements are summarized in Table 6. As the design plans progress, safety enhancements identified by the RSA will be incorporated into the design to the extent feasible based upon agreements between the Project Team, NMCOG, the Town of Westford and MassDOT.

**Table 6. Potential Safety Enhancement Summary**

Safety Issue	Potential Safety Enhancement	Safety Payoff	Time Frame	Cost	Responsibility
Traffic Control	Consider installation of a roundabout. This requires further study and may require the acquisition of substantial Right-of-Way.	High	Long-Term	High	Town
	Consider installation of a traffic signal. This requires further study.	High	Long-Term	High	Town
Dunstable Road Approach Alignment	Consider geometric modifications to Dunstable Road to improve alignment across Groton Road. Realignment of Dunstable Road approaches may not be needed if a roundabout is proposed.	Medium	Long-Term	High	Town
	Consider installation of pavement markings to Dunstable Road through intersection to improve vehicle tracking across Groton Road.	Medium	Short-Term	Low	Town
BP Gas Station Driveways	Consider site driveway closings, reconstruction or restrictions to reduce conflicts at the intersection and reduce cut-through traffic.	High	Long-Term	Medium	Town / BP Gas Station
	Reset STOP bar pavement markings along Dunstable Road closer to the intersection while maintaining a safe distance from the edge of travel-way.	Low	Short-Term	Low	Town
Sight Lines and Visibility	Remove or maintain shrubbery/bushes within the BP Gas Station landscaped island and along the #270 Groton Road property.	Medium	Short-Term	Low	Town
	Trim and maintain vegetation along the southerly edge of Groton Road.	Medium	Short-Term	Low	Town
	Consider relocation of BP Gas Station signage and replace with signage on fueling station canopy.	Medium	Short-Term	Mid	Town / BP Gas Station
	Move the mast arm shaft for the flashing beacon back away from the roadway edge to improve the sight lines for Dunstable Road northbound vehicles looking to the east.	Medium	Long-Term	Mid	Town

**Table 7. Potential Safety Enhancement Summary**

Safety Issue	Potential Safety Enhancement	Safety Payoff	Time Frame	Cost	Responsibility
Sight Lines and Visibility (Continued)	Consider relocation of BP Gas Station signage and replace with signage on fueling station canopy.	Medium	Short-Term	Mid	Town / BP Gas Station
Roadway Profiles and Grades	Reconsider regrading Groton Road to establish a more consistent profile and improve sightlines.	High	Long-Term	High	Town
	Reconsider regrading Dunstable Road southbound to establish a more consistent profile and improve sightlines.	High	Long-Term	High	Town
Dunstable Road Tree within Right-Of-Way	Remove the shade trees within the Right-of-Way along Dunstable Road both immediately north and south of Groton Road.	High	Mid-Term	Medium	Town
By-Passed Stopped Traffic	Consider the construction of exclusive left-turn lanes along Groton Road in the eastbound and westbound directions.	Medium	Long-Term	High	Town
Pavement Conditions	Mill and overlay Groton Road to improve traction on the intersection approaches during poor weather conditions and provide consistent roadway cross-slopes and edge lines.	Medium	Mid-Term	High	Town / Property Owners
Drainage	Reconstruct new drainage structures along the existing or future roadway edge.	Medium	Long-Term	High	Town
Utility Poles within Pavement	Widen the BP Gas Station raised landscaped island to encompass the utility pole within the Groton Road curb line.	Low	Short-Term	Medium	Town / BP Gas Station
	Consider the installation of advanced electronic traffic signal signage if a traffic signal is installed at the intersection.	Medium	Long-Term	High	Town
Advanced Warning Signage	Examine the spacing and distances of the existing advance warning signage and reset signage as needed. Remove and reset Dunstable Road SB advanced signage to a location closer to the intersection with Groton Road (Route 40).	Medium	Short-Term	Low	Town
	Remove third advanced STOP warning sign on Dunstable Road northbound approach (currently bolted to adjacent tree).	Low	Short-Term	Low	Town

**Table 6. Potential Safety Enhancement Summary (Continued)**

Safety Issue	Potential Safety Enhancement	Safety Payoff	Time Frame	Cost	Responsibility
Advanced Warning Signage (Continued)	Investigate the removal and replacement of ALL advanced warning signage based on appropriate visibility and queues for the potential installation of roundabout control or traffic signal control.	Medium	Long-Term	Low	Town
Lateral Offset of Signage	Reset STOP signage (pending no change in traffic control) on Dunstable Road to be compliant with MUTCD lateral offset standards.	Low	Short-Term	Low	Town
Pedestrian and Bicycle Accommodations	Consider installation of sidewalks along Groton Road and Dunstable Road and bicycle lanes / shoulders along Groton Road.	Medium	Long-Term	High	Town / Property Owners
Public Education	Utilize Town of Westford online social networks (such as Twitter) to inform public on intersection crashes, advisories, and speed.	Medium	Short-Term	Low	Town
Enforcement	Conduct a speed study to establish a legal speed limit on Groton Road to allow for easier enforcement. Based on current traffic speeds collected by ATR counts, the posted speed limit may not change from its current 40 MPH.	Medium	Short-Term	Low	Town / MassDOT
	Increase enforcement of traffic control measures and continue speed enforcement at intersection	Medium	Short-Term	Low-Cost	Town

## Appendix A. RSA Meeting Agenda

---

# Agenda

## Road Safety Audit

### LOCATION

Meeting Location:

Westford Town Hall – Meeting Room  
55 Main Street  
Westford, Massachusetts  
Monday March 31, 2014  
1:00 PM – 3:00 PM

Type of meeting: High Crash Location – Road Safety Audit  
Attendees: Invited Participants to Comprise a Multidisciplinary Team  
Please bring: Thoughts and Enthusiasm!!

1:00 PM Welcome and Introductions

1:15 PM Review of Site Specific Material

- Crash and Speed Summaries– provided in advance
- Existing Geometries and Conditions

1:45 PM Visit the Site

- Drive to Groton Road (Route 40) @ Dunstable Road
- As a group, identify areas for improvement

2:30 PM Post Visit Discussion / Completion of RSA

- Discuss observations and finalize findings
- Discuss potential improvements and finalize recommendations

3:00 PM Adjourn for the Day – but the RSA has not ended

### Instructions for Participants:

- Before attending the RSA on March 31, participants are encouraged to drive through the intersection and complete/consider elements on the RSA Prompt List with a focus on safety.
- All participants will be actively involved in the process throughout. Participants are encouraged to come with thoughts and ideas, but are reminded that the synergy that develops and respect for others' opinions are key elements to the success of the overall RSA process.
- After the RSA meeting, participants will be asked to comment and respond to the document materials to assure it is reflective of the RSA completed by the multidisciplinary team.

## Appendix B. RSA Audit Team Contact List

---

## Participating Audit Team Members

Date:

Location:

Audit Team Members	Agency/Affiliation	Email Address	Phone Number
Name	Agency	Email	xxx-xxx-xxxx
Samuel W. Gregorio, E.I.T.	TEC, Inc.	sgregorio@theengineeringcorp.com	978-794-1792
Mikel C. Myers, P.E.	TEC, Inc.	mmyers@theengineeringcorp.com	978-794-1792
Kerri K. Racki	TEC, Inc.	kracki@theengineeringcorp.com	978-794-1792
Paul Starratt, P.E.	Town of Westford Engineering	pstarratt@westfordma.gov	978-692-5520
Jeremy Downs, P.E.	Town of Westford Engineering	jdowns@westfordma.gov	978-692-5520
Jeffrey Morrissette	Town of Westford Planning	jmorrissette@westfordma.gov	978-692-5524
Chip Barrett	Town of Westford Highway Department	rbarrett@westfordma.gov	978-692-5520
Lt. Don Parsons	Town of Westford Fire Department	dparsons@westfordma.gov	978-692-5542
Capt. Mark Chambers	Town of Westford Police Department	mchambers@westfordma.gov	978-692-2161
Justin Howard	NMCOG	jhoward@nmcog.org	978-454-8021
Mike Mauro	NMCOG	mmauro@nmcog.org	978-454-8021
Lisa Schletzbaum	MassDOT – Traffic Safety Section	Lisa.schletzbaum@state.ma.us	857-368-9634
Corey O'Connor	MassDOT – Traffic Safety Section	Corey.oconnor@state.ma.us	857-368-9638
Nithin Krishna	MassDOT – Traffic Safety Section	Nithinkrishnalinga.reddy@dot.state.ma.us	
Lola Campbell	MassDOT – District 3	adade.campbell@state.ma.us	

## Appendix C. Detailed Crash Data

---

## INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : WESTFORD, MASSACHUSETTS      COUNT DATE : MARCH 2014

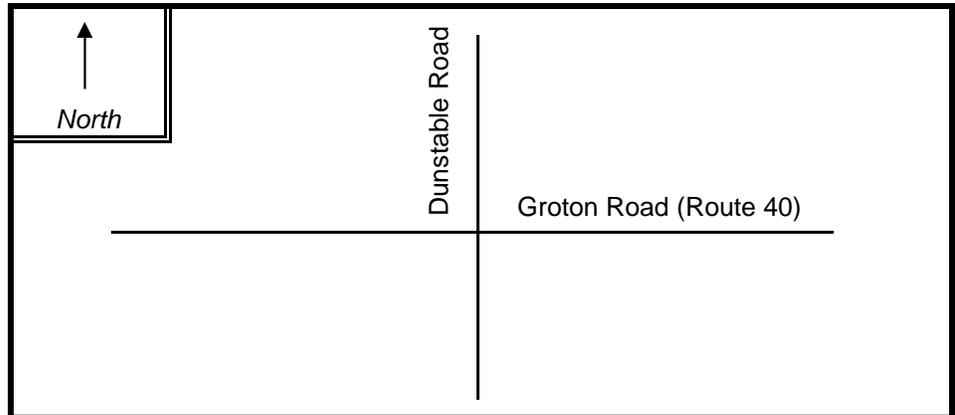
DISTRICT : 3      UNSIGNALIZED :  **YES**      SIGNALIZED :  **NO**

~ INTERSECTION DATA ~

MAJOR STREET : GROTON ROAD (ROUTE 40)

MINOR STREET(S) : DUNSTABLE ROAD

**INTERSECTION  
DIAGRAM  
(Label Approaches)**



**Peak Hour Volumes**

APPROACH :	1	2	3	4	5	Total Entering Vehicles
DIRECTION :	NB	SB	EB	WB		
VOLUMES (PM) :	105	66	488	525		<b>1,184</b>

" K " FACTOR :       APPROACH ADT :       ADT = TOTAL VOL/"K" FACT.

TOTAL # OF CRASHES :       # OF YEARS :       AVERAGE # OF CRASHES ( A ) :

**CRASH RATE CALCULATION :**

**2.23**

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

Comments : K DETERMINED FROM ATRs ON GROTON ROAD

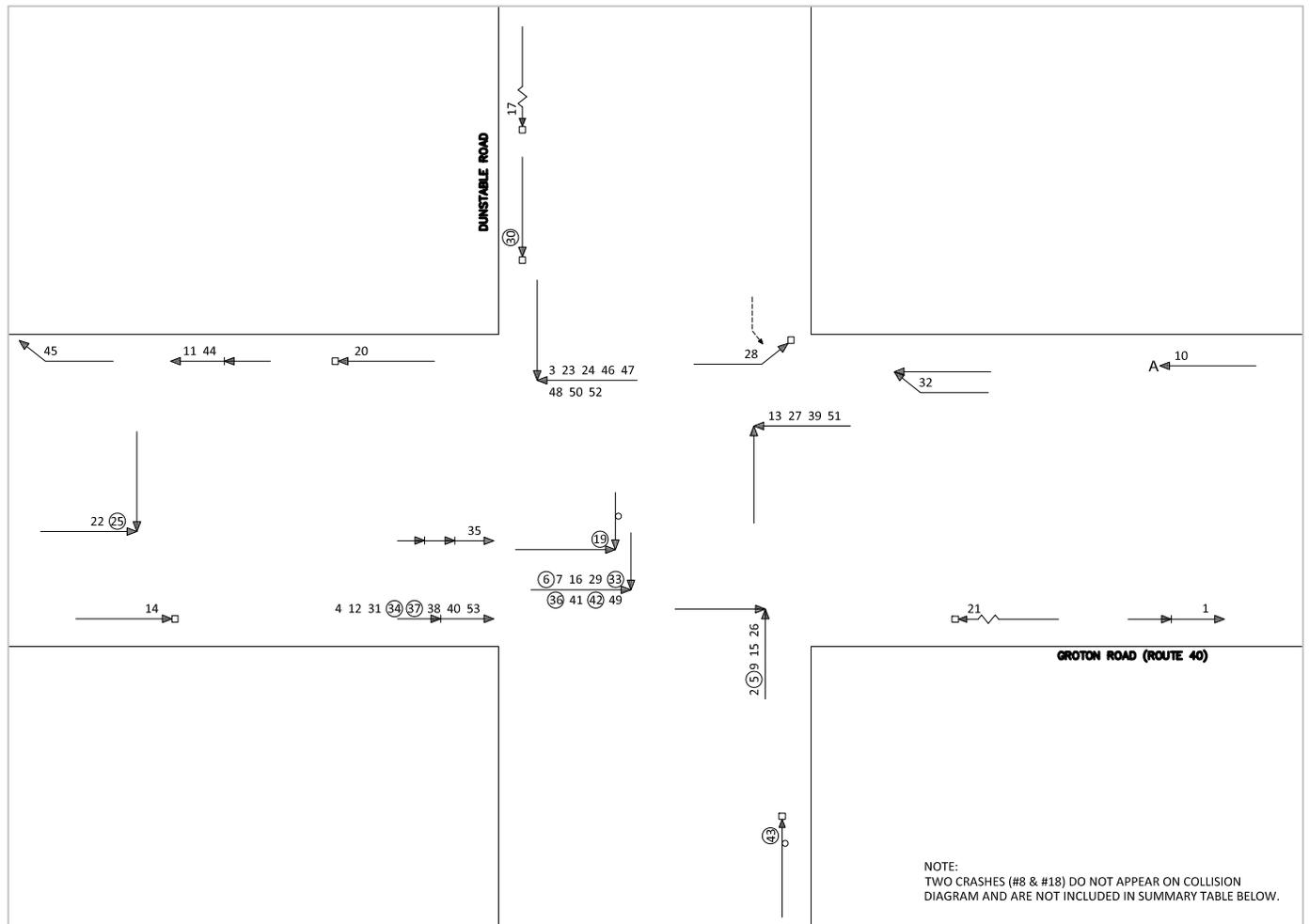
Project Title & Date : GROTON ROAD (ROUTE 40) @ DUNSTABLE ROAD RSA - WESTFORD, MASSACHUSETTS



**Not to Scale**

**Groton Road (Route 40) @ Dunstable Road - Westford, Massachusetts**  
Road Safety Audit

LOCATION: Groton Road (Route 40) @ Dunstable Road  
 CITY/STATE: Westford, Massachusetts  
 TIME PERIOD: 2009 - 2013  
 PREPARED BY: TEC, Inc. / Samuel W. Gregorio, E.I.T.  
 SOURCE: Westford Police Dept, NMCOG



LEGEND		SHOW FOR COLLISION						
→ VEHICLE PATH	↔ HEAD-ON COLLISION	□ FIXED OBJECT	1. Approximate location of collision, 2. Direction of collision, 3. Type of collision and vehicles involved, 4. Time, Day, Date 5. Any other pertinent factors mentioned on the report.					
←←← BACKING VEHICLE	↘ ANGLED COLLISION	⊠ MOVEABLE OBJECT						
↔ SIDESWIPE COLLISION	→□ FIXED OBJECT COLLISION	▭ PARKED VEHICLE						
→p PEDESTRIAN COLLISION	→○ OVERTURNED VEHICLE	○ PERSONAL INJURY						
→→ REAR-END COLLISION	~ OUT-OF-CONTROL VEHICLE	○ FATALITY						
		A ANIMAL						
SUMMARY OF CRASHES ON DIAGRAM [no fatal collisions]								
	REAR-END	SIDESWIPE	HEAD-ON	ANGLED	SINGLE VEH	PED/BIKE	OTHER / UNK	TOTAL
PROPERTY DAMAGE ONLY	10	0	1	22	6	0	1	40
NON-FATAL INJURY	2	0	0	7	2	0	0	11
UNKNOWN / NOT REPORTED	0	0	0	0	0	0	0	0
<b>TOTAL</b>	<b>12</b>	<b>0</b>	<b>1</b>	<b>29</b>	<b>8</b>	<b>0</b>	<b>1</b>	<b>51</b>

**Figure C-1**

**Collision Diagram**  
2009-2013 Collision Data



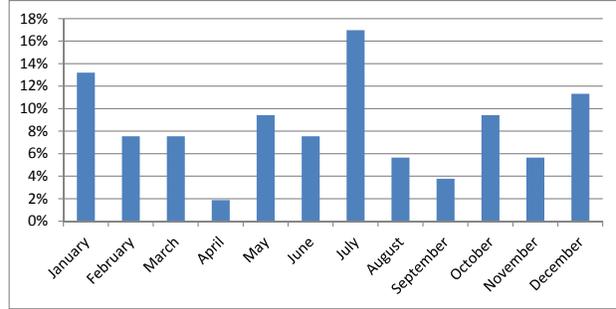
TEC, Inc.  
 65 Glenn Street | 169 Ocean Blvd, Unit 101  
 Lawrence, MA 01843 | Hampton, NH 03842

**Crash Data Summary Charts**  
Groton Road and Dunstable Road - Westford, Massachusetts  
1/1/2009 - 12/31/2013

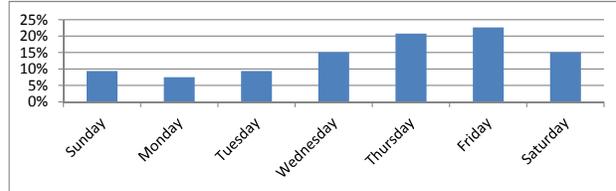
**Groton Road (Route 40) @ Dunstable Road**

53

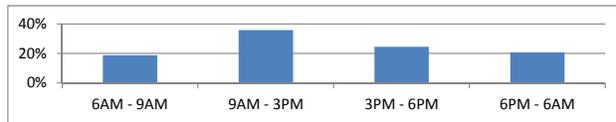
Month	#	%
January	7	13%
February	4	8%
March	4	8%
April	1	2%
May	5	9%
June	4	8%
July	9	17%
August	3	6%
September	2	4%
October	5	9%
November	3	6%
December	6	11%



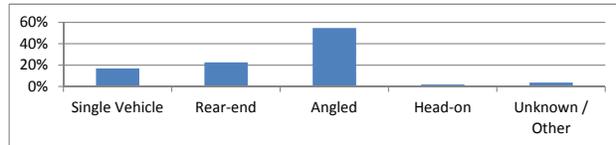
Day of Week	#	%
Sunday	5	9%
Monday	4	8%
Tuesday	5	9%
Wednesday	8	15%
Thursday	11	21%
Friday	12	23%
Saturday	8	15%



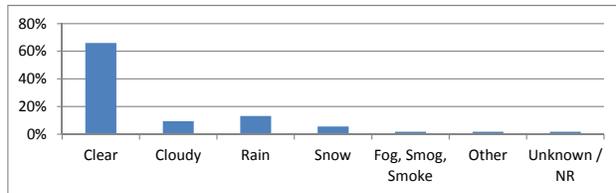
Time of Day	#	%
6AM - 9AM	10	19%
9AM - 3PM	19	36%
3PM - 6PM	13	25%
6PM - 6AM	11	21%



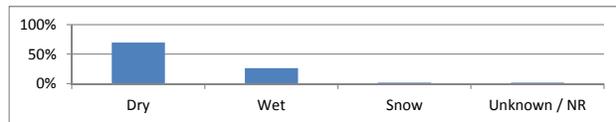
Manner of Collision	#	%
Single Vehicle	9	17%
Rear-end	12	23%
Angled	29	55%
Head-on	1	2%
Unknown / Other	2	4%



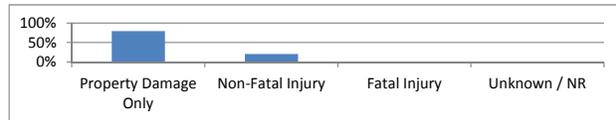
Weather Conditions	#	%
Clear	35	66%
Cloudy	5	9%
Rain	7	13%
Snow	3	6%
Fog, Smog, Smoke	1	2%
Other	1	2%
Unknown / NR	1	2%



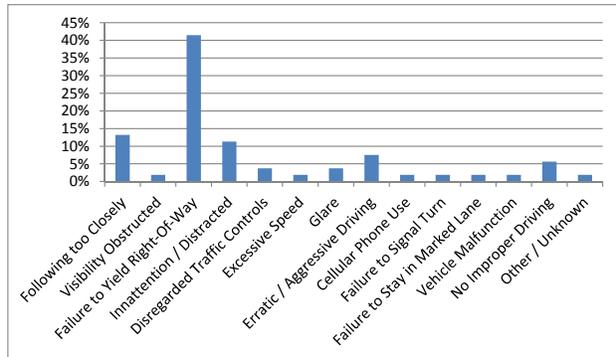
Road Surface	#	%
Dry	37	70%
Wet	14	26%
Snow	1	2%
Unknown / NR	1	2%



Crash Severity	#	%
Property Damage Only	42	79%
Non-Fatal Injury	11	21%
Fatal Injury	0	0%
Unknown / NR	0	0%



Main Contributing Factor from Narrative	#	%
Following too Closely	7	13%
Visibility Obstructed	1	2%
Failure to Yield Right-Of-Way	22	42%
Innattention / Distracted	6	11%
Disregarded Traffic Controls	2	4%
Excessive Speed	1	2%
Glare	2	4%
Erratic / Aggressive Driving	4	8%
Cellular Phone Use	1	2%
Failure to Signal Turn	1	2%
Failure to Stay in Marked Lane	1	2%
Vehicle Malfunction	1	2%
No Improper Driving	3	6%
Other / Unknown	1	2%



**Crash Data Summary Table**

Groton Road and Dunstable Road - Westford, Massachusetts

1/1/2009 - 12/31/2013

Crash Diagram Reference	Crash Date	Day of Week	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code (by Narrative Description)	Crash Severity	Ages			Comments
										D1	D2	D3	
1	1/2/2009	Friday	4:27 PM	Rear-end	Dark-Lighted	Cloudy	Wet	Followed to closely	Property Damage Only	22	51		MV1 traveling behind MV2 slid on ice and was unable to stop before rear-ending MV2
2	2/5/2009	Thursday	7:10 PM	Angle	Dark-Lighted	Clear	Dry	Visibility Obstructed	Property Damage Only	28	49		MV2 did not see MV1 due to a snow bank in the way.
3	3/9/2009	Monday	8:06 AM	Angle	Daylight	Snow	Snow	No Improper Driving	Property Damage Only	64	21		Operator of MV1 attempted to stop at the intersection but was unable to do so and collided with MV2. Snowy roads made it difficult to stop.
4	5/8/2009	Friday	2:12 PM	Rear-end	Daylight	Clear	Dry	Inattention	Property Damage Only	54	46		MV1 stopped in a line of traffic on Groton Road. Operator of MV2 stated she was distracted and failed to stop in time to avoid MV1.
5	7/2/2009	Thursday	2:30 PM	Angle	Daylight	Snow	Wet	Inattention	Non-Fatal Injury	46	23		MV1 was traveling north and drove into the lane of traffic of MV2. This caused MV2 to strike the side of MV1.
6	7/8/2009	Wednesday	5:42 PM	Angle	Daylight	Rain	Wet	Disregarded Traffic Controls	Non-Fatal Injury	66	39	42	Operator of MV3 stated that he thought he stopped at the stop sign. Operator of MV1 saw MV3 and slowed down, then started to speed up. MV3 came through the stop sign and then hit MV1 which caused MV1 to collide with MV2.
7	11/25/2009	Wednesday	12:05 PM	Angle	Daylight	Rain	Wet	Failed to yield to right-of-way	Property Damage Only	17	17		MV1 did not see MV2 traveling east which resulted in a collision.
8	12/19/2009	Saturday	9:35 AM	Unknown	Unknown	Unknown	Unknown	Unknown	Property Damage Only	62	34		Incident only. Drivers exchanged information no officer needed.
9	1/9/2010	Saturday	1:55 PM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	43	50		MV2 made a complete stop at the intersection. Operator of MV1 saw MV2 come out at the last minute and did not have enough time to stop. MV2 stated there were multiple cars making turns and did not see MV1 traveling straight until it was too late.
10	2/18/2010	Thursday	7:17 PM	Single Vehicle	Dark-Lighted	Clear	Dry	No Improper Driving	Property Damage Only	66			MV1 was headed west near # 270 Groton Road when deer ran out into the road.
11	3/24/2010	Wednesday	8:07 AM	Rear-end	Daylight	Clear	Dry	Inattention	Property Damage Only	65	49		MV1 was stopped in a line of traffic due to a school bus that had its lights flashing and stop sign out by the BP gas station. MV2 didn't realize that the cars were stopped and misjudged her timing and distance and struck MV1.
12	5/21/2010	Friday	5:10 PM	Rear-end	Daylight	Clear	Dry	Excessive Speed	Property Damage Only	42	19		MV2 was traveling behind MV1 and was traveling too fast and too close. MV1 slowed down when approaching the intersection causing MV2 to strike the back of MV1.
13	6/11/2010	Friday	3:30 PM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	61	49		MV1 stopped at the intersection at the stop sign then pulled out in front of MV2. Intersection is controlled by blinking yellow light on Groton Road and by blinking red light on Dunstable Road.
14	6/24/2010	Thursday	11:19 AM	Single Vehicle	Daylight	Clear	Dry	No Improper Driving / Following too close	Property Damage Only	38			Unknown vehicle traveling in front of MV1 slammed on the brakes for a flashing yellow light causing MV1 to crash into a support pole.
15	7/8/2010	Thursday	3:36 PM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	47	50		MV2 attempting to cross the road after stopping at a stop sign collided with MV3 (MV1 is a motorcycle pulling a trailer).
16	7/9/2010	Friday	3:09 PM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	21	23		Both MV1 and MV2 drove into the road and both operators stated that a white van blocked MV1's view which resulted in the crash.
17	7/16/2010	Friday	9:32 PM	Single Vehicle	Dark-Lighted	Fog, Smog	Wet	Vehicle Malfunction	Property Damage Only	18			Operator of MV1 stated he noticed a vibration in the steering wheel right before he lost control and hit a tree stump.



**Crash Data Summary Table**

Groton Road and Dunstable Road - Westford, Massachusetts

1/1/2009 - 12/31/2013

Crash Diagram Reference	Crash Date	Day of Week	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code (by Narrative Description)	Crash Severity	Ages			Comments
										D1	D2	D3	
18	7/16/2010	Friday	10:35 PM	Single Vehicle	Dark-Lighted	Rain	Wet	Operating in erratic/egressive manner	Property Damage Only	54			Operator of MV1 states that he came around the corner, sneezed, refocused his eyes and then hit a utility pole.
19	10/18/2010	Monday	9:26 AM	Angle	Daylight	Clear	Dry	Disregarded Traffic Controls	Non-Fatal Injury	51	45		MV1 and MV2 were both traveling slow and MV1 tried to swerve out of the way to avoid contact. Operator of MV2 was cited for a stop sign violation.
20	12/31/2010	Friday	1:47 PM	Single Vehicle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	47			An uninvolved vehicle was attempting to make a left hand turn into the gas station almost colliding with MV1. MV1 avoided contact but struck a fence post and rock wall.
21	1/5/2011	Wednesday	9:31 PM	Single Vehicle	Dark-Lighted	Clear	Dry	Operating in erratic/egressive manner	Property Damage Only	21			Operator of MV1 glanced down at the radio and lost control of the vehicle. MV1 went across the east bound travel lane into a rock wall and a tree.
22	2/4/2011	Friday	7:31 AM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	29	17		Operator of MV2 was making a left hand turn out of the BP gas station and struck MV1. Operator of MV2 stated he was waved on by another driver and that's why he entered the roadway.
23	2/6/2011	Sunday	9:44 AM	Angle	Daylight	Other	Wet	Failed to yield to right-of-way	Property Damage Only	51	43		Operator of MV1 violated a stop sign which resulted in the crash.
24	3/3/2011	Thursday	6:51 AM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	39	57		MV1 stated that he had stopped at the stop sign then entered the intersection. MV2 collided with MV1 in the intersection; speed may have been a factor.
25	3/25/2011	Friday	8:07 AM	Angle	Daylight	Clear	Dry	Distracted	Non-Fatal Injury	58	50		MV1 was exiting from the gas station onto Groton Road. MV2 (motorcycle) traveling east on Groton Road was struck by MV1 who didn't see the motorcycle.
26	4/2/2011	Saturday	4:45 PM	Angle	Daylight	Cloudy	Dry	Failed to yield to right-of-way	Property Damage Only	20	81		MV2 was stopped at the stop sign when he decided to cross the street and put himself in the path of MV1 which caused a collision.
27	5/19/2011	Thursday	6:12 PM	Angle	Daylight	Rain	Wet	Failed to yield to right-of-way	Property Damage Only	33	29		Operator of MV2 stated that he did not see MV1 due to a blind spot in his vehicle. While attempting to cross the road he drove into MV1's path resulting in the crash.
28	6/6/2011	Monday	4:18 PM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	60			MV1 was attempting to make a left hand turn onto Dunstable Road. Uninvolved vehicle pulled out in front of MV1. Operator of MV1 tried to avoid contact and lost control and hit a granite fence post in front of 266 Groton Road.
29	7/19/2011	Tuesday	1:23 PM	Head-On	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	48	18		MV1 was traveling east on Groton Road. MV2 was stopped at the stop sign and then failed to make a safe lane change while crossing Groton Road causing MV2 to strike MV1.
30	7/23/2011	Saturday	4:27 PM	Single Vehicle	Daylight	Clear	Dry	Cellular Telephone Use	Non-Fatal Injury	33			Driver was distracted by her cell phone ringing and drove off of the right side of the road.
31	9/7/2011	Wednesday	7:02 PM	Rear-end	Dusk	Rain	Wet	Followed to closely	Property Damage Only	46	17		MV1 was waiting for a vehicle in front of it to turn when MV2 slid on the wet ground and struck MV1.
32	9/16/2011	Friday	4:13 PM	Angle	Daylight	Clear	Dry	Failure to Signal Turn	Property Damage Only	50	42		MV2 had its left turn signal on when MV1 attempted to go around to the right. MV2 then decided to take a right turn and caused a collision.
33	10/25/2011	Tuesday	3:39 PM	Angle	Daylight	Clear	Dry	Glare	Non-Fatal Injury	31	18		MV2 had limited visibility due to glare.

**Crash Data Summary Table**  
Groton Road and Dunstable Road - Westford, Massachusetts  
1/1/2009 - 12/31/2013

Crash Diagram Reference	Crash Date	Day of Week	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code (by Narrative Description)	Crash Severity	Ages			Comments
										D1	D2	D3	
34	12/14/2011	Wednesday	6:09 PM	Rear-end	Dark-Lighted	Clear	Dry	Followed to closely	Non-Fatal Injury	69	19		MV1 slowed down due to vehicles crossing the intersection. MV2 stated he took his eyes off of the roadway to talk to his sister and when he looked back it was too late to stop.
35	12/29/2011	Thursday	3:17 PM	Rear-end	Dusk	Clear	Dry	Followed to closely	Property Damage Only	55	47	18	MV3 failed to stop and collided with MV2 who then collided with MV1
36	1/1/2012	Sunday	10:31 AM	Angle	Daylight	Clear	Dry	Glare	Non-Fatal Injury	52	48		MV2 may have had limited visibility due to glare.
37	1/7/2012	Saturday	2:24 PM	Rear-end	Daylight	Cloudy	Dry	Operating in erratic/egressive manner	Non-Fatal Injury	29	60		MV1 was stopped on Groton Road to turn left onto Dunstable Road. MV2 (motorcycle) tried to go around MV1 but instead rear ended it.
38	1/13/2012	Friday	2:13 PM	Rear-end	Daylight	Clear	Wet	Followed to closely	Property Damage Only	52	64		MV2 was traveling east on Groton Road, while waiting to turn left onto Dunstable Road MV1 crashed into MV2.
39	5/9/2012	Wednesday	8:46 AM	Angle	Daylight	Rain	Wet	Failed to yield to right-of-way	Property Damage Only	40	29		MV1 was entering traffic, MV1 did not see MV2 and MV2 was unable to avoid the collision with MV1.
40	5/15/2012	Tuesday	2:30 PM	Rear-end	Daylight	Rain	Dry	Followed to closely	Property Damage Only	17	52		MV2 rear-ended MV1.
41	7/17/2012	Tuesday	7:06 AM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	43	67		MV2 cut across the road resulting in MV1 colliding with MV2. Operator of MV2 advised that she had stopped and looked both ways but did not see MV1 until it was too late.
42	8/4/2012	Saturday	2:22 PM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Non-Fatal Injury	17	48		MV2 had stopped and looked both ways before proceeding through the intersection but did not see MV1.
43	8/25/2012	Saturday	12:17 AM	Single Vehicle	Dark-Lighted	Clear	Dry	Operating in erratic/egressive manner	Non-Fatal Injury	44			MV1 was traveling south when it hit telephone pole 12 on Dunstable Road.
44	12/1/2012	Saturday	12:40 PM	Rear-end	Daylight	Snow	Wet	Followed to closely	Property Damage Only	29	41		MV1 stopped quickly in response to a vehicle in front that also had to stop quickly.
45	12/2/2012	Sunday	9:49 AM	Single Vehicle	Daylight	Cloudy	Wet	Failure to keep in marked lane	Property Damage Only	25			MV1 drove off of the road into ditch near #238 Groton Road due to a flat tire.
46	1/17/2013	Thursday	7:43 AM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	50	53		MV2 went around unknown MV at STOP line who was turning left, proceeded into intersection and did not see MV 1.
47	6/19/2013	Wednesday	7:04 PM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	52	22		MV2 travelling south on Dunstable Road slowing for blinking red flasher. MV2 pulls into Groton Road and causes collisions with MV1.
48	8/8/2013	Thursday	8:40 PM	Angle	Dusk	Clear	Dry	Driver Inattention / Failed to yield to right-of-way	Property Damage Only	19	25		MV1 driving west on Groton Road when MV2 pulls out from Dunstable Road SB in attempt to turn left. MV1 and MV2 collide.
49	10/7/2013	Monday	7:46 AM	Angle	Daylight	Cloudy	Wet	Failed to yield to right-of-way / Inattention	Property Damage Only	49	51		MV1 travelling east on Groton Road struck by MV2 entering from Dunstable Road southbound.
50	10/13/2013	Sunday	4:43 PM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way	Property Damage Only	29	22		MV1 travelling west on Groton Road struck by MV2 entering from Dunstable Road southbound after stopping.
51	10/20/2013	Sunday	1:54 PM	Angle	Daylight	Clear	Dry	Failed to yield to right-of-way / Inattention	Property Damage Only	19	64		MV1 travelling east on Groton Road. MV2 stopped on Dunstable Road southbound proceeds into intersection attempting to travel straight across. MV1 crashes into MV2. MV2 complains of solar glare.
52	11/5/2013	Tuesday	8:59 AM	Other	Daylight	Clear	Dry	Failed to yield to right-of-way / Failure to stop	Property Damage Only	60	33		MV1 travelling west on Groton Road comes to abrupt stop as MV2 enters intersection from Dunstable Road southbound. No collision. Unsecured lumber from MV1 falls on hood of MV2.
53	11/21/2013	Thursday	2:37 PM	Rear-end	Daylight	Clear	Dry	Inattention	Property Damage Only	17	24		MV1 stopped in traffic on Groton Road struck in rear by MV2. MV2 produced 60 feet skid mark.

## Appendix D. Road Safety Audit References

---

## Road Safety Audit References

*Massachusetts Traffic Safety Toolbox*, Massachusetts Highway Department,  
[www.mhd.state.ma.us/safetytoolbox](http://www.mhd.state.ma.us/safetytoolbox).

*Road Safety Audits, A Synthesis of Highway Practice*. NCHRP Synthesis 336. Transportation Research Board, National Cooperative Highway Research Program, 2004.

*Road Safety Audits*. Institute of Transportation Engineers and U.S. Department of Transportation, Federal Highway Administration, [www.roadwaysafetyaudits.org](http://www.roadwaysafetyaudits.org).

*FHWA Road Safety Audit Guidelines*. U.S. Department of Transportation, Federal Highway Administration, 2006.

*Road Safety Audit*, 2<sup>nd</sup> edition. Austroads, 2000.

*Road Safety Audits*. ITE Technical Council Committee 4S-7. Institute of Transportation Engineers, February 1995.