

# Lane Departure Road Safety Audit for Route 28 in Barnstable, Massachusetts



*Prepared by*  
**Cape Cod Commission**  
*and*  
**University of Massachusetts Traffic Safety Research Program**



*Prepared for*

**Massachusetts Highway Department**

**Federal Highway Administration**



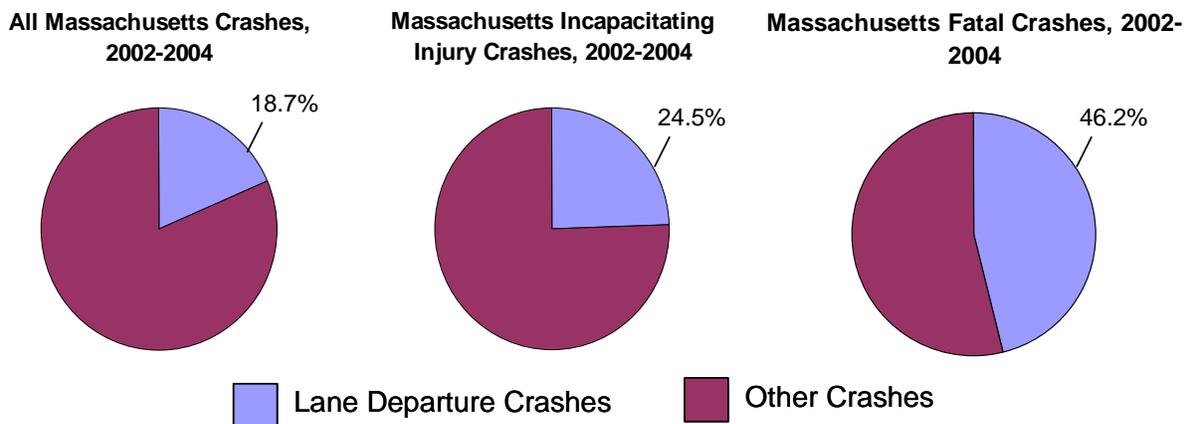
## 1.0 Introduction to Road Safety Audits & Lane Departure Crashes in Massachusetts

The Federal Highway Administration defines a Road Safety Audit (RSA) as *the formal safety examination* of an existing or future road or intersection by an *independent, multidisciplinary team*. The purpose of an RSA is to *identify potential safety issues and possible opportunities for safety improvements* considering all roadway users. Specific objectives of an RSA include, but are not limited to the following:

- Minimizing the risk and severity of road crashes that may be affected by the existing or future roadway at a specific location or nearby network;
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Although RSA's have been employed in other countries for some time, they are being fully embraced across the United States as a low cost opportunity to make significant safety improvements at any number of stages ranging from project development and planning through existing operation. Furthermore, RSA's have proven to be effective on projects of all shapes and sizes. The RSA program here in the Commonwealth presents a unique and exciting opportunity for improvements in roadway safety.

The RSA program in Massachusetts is being implemented in accordance with the Commonwealth's role as a lead state in preventing run-off the road (lane departure) crashes and in conjunction with the Strategic Highway Safety Plan (SHSP). Lane departure crashes are a notable problem area for Massachusetts, especially for crashes with high injury severities. Between 2002 and 2004, lane departure crashes accounted for nearly 20 percent of all crashes in Massachusetts and approximately one-quarter of crashes involving an incapacitating injury. Almost one-half of fatal crashes between 2002 and 2004 were lane departure crashes. As the crash severity increases, so too does the percent of crashes that are lane departures as shown in Figure 1.



**Figure 1. Relationship Between Lane Departure Crashes and Injury Severity**

In an effort to combat the lane departure problem, a strategy was developed for the SHSP to identify hot spot lane departure locations, perform road safety audits and implement low-cost comprehensive countermeasures. This location in Barnstable was selected as a result of two fatal head-on crashes that occurred in 2003. The following report summarizes the findings of a RSA focused on lane departure crashes (LD) along Route 28 in Barnstable, Massachusetts.

## 2.0 Background Material for Route 28 in Barnstable

Falmouth Road (Route 28) is an arterial roadway in the Village of Centerville, located within the municipality of Barnstable, Massachusetts. The Cape Cod town of Barnstable has approximately 50,000 year-round residents, and its population may triple with summer residents and overnight visitors at peak in the summer. The stretch of Route 28 under consideration for this RSA is a level and straight section of approximately 0.5 miles between Old Stage Road to the west and Phinney’s Lane to the east. The intersections for each of these roadways with Route 28 are signalized, and in this area, Route 28 is a four-lane undivided roadway as shown in Figure 2. Various retail land uses line the roadside with 18 total curb cuts, and two major shopping plazas. Through this area Route 28 has granite curbs on both sides, and on the south side is a designated bike route. Some of the major characteristics, including crash clusters, for Route 28 are summarized in Figure 3.

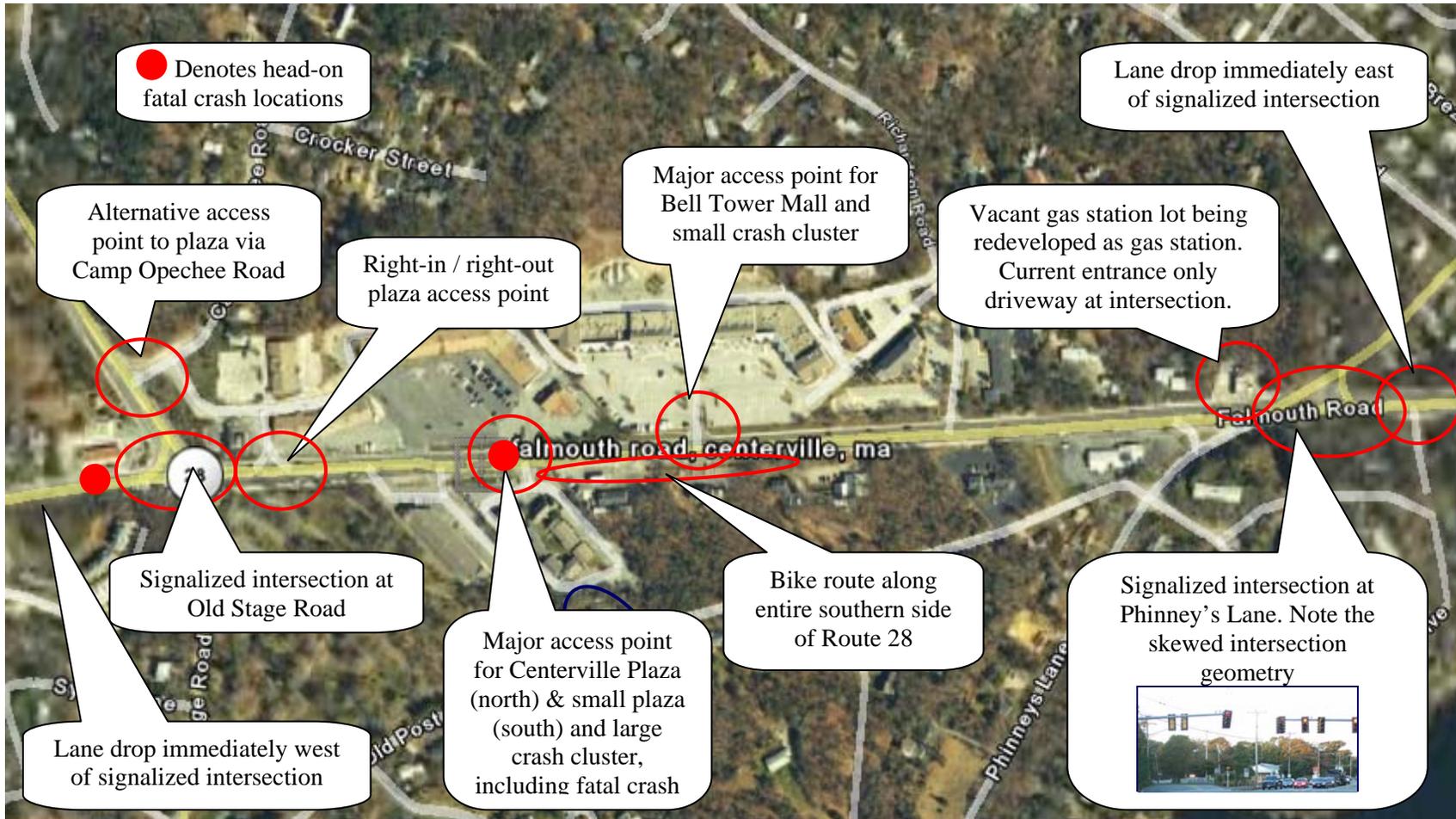


**Figure 2. Route 28 in Barnstable**

The LD-RSA for Route 28 was held on October 30, 2007 at the Barnstable Police Station. In total, 17 team members participated in the road safety audit as listed in Table 1. As indicated in Table 1 representatives were present from Federal, State, Regional and Local agencies and included a cross-section of engineering/planning, education, and enforcement expertise.

**Table 1 Participating Audit Team Members**

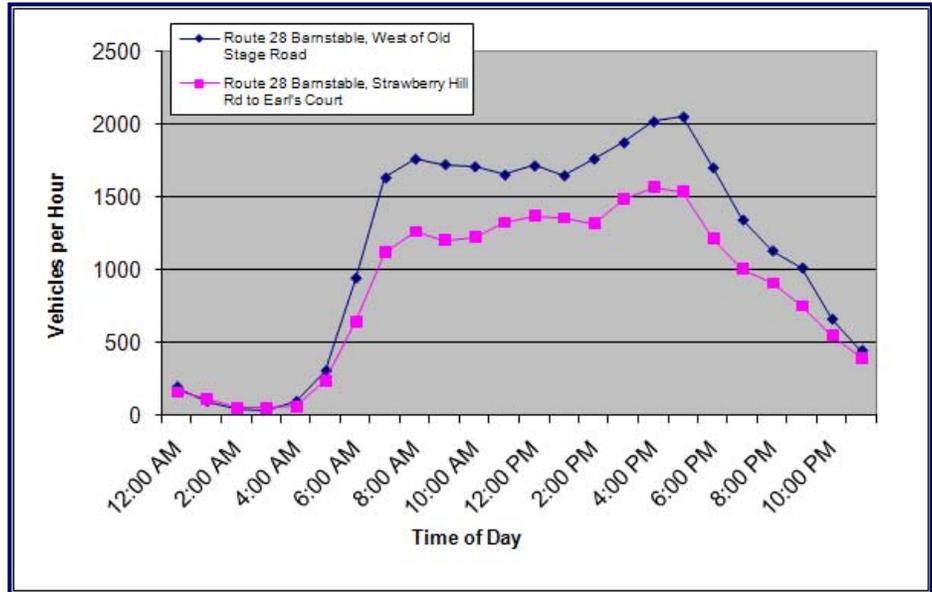
<b>Audit Team Members<sup>a</sup></b>	<b>Agency/Affiliation</b>
Bonnie Polin	Massachusetts Highway Department – Safety Section
Jennifer Inzana	Massachusetts Highway Department – Safety Section
Lisa Schletzbaum	Massachusetts Highway Department – Safety Section
Neil Boudreau	Massachusetts Highway Department – Traffic Engineering
One Hwang	Massachusetts Highway Department – Highway Design
Robert Burgmann, P.E.	Engineering, Town of Barnstable
Priscilla Leclerc	Barnstable County / Cape Cod Commission
Robert Gregory	Massachusetts Highway Department, District 5
Tim White	Federal Highway Administration
Steve Seymour	Growth Management Dept., Town of Barnstable
Roland W. Breault Jr.	Public Works Department, Town of Barnstable
John Farrington	Centerville-Osterville-Marstons Mills Fire-Rescue
Roger Parsons	Public Works Department, Town of Barnstable
Craig Tamash	Barnstable Police Department
Andrew McKenna	Barnstable Police Department
Dan Mulkern	Massachusetts State Police
Michael Knodler	University of Massachusetts - Amherst



**Figure 3. Characterization of Major Roadway Features for Route 28**

Prior to the RSA meeting, audit team members were asked to visit the site and familiarize themselves with the major roadway attributes and characteristics. A copy of the meeting agenda and instructions as well as a packet of pertinent information was distributed to meeting invitees prior to the meeting (this information is included in Appendix A of this report). Specifically, the additional information provided was pertinent to the LD-RSA safety initiative and included traffic volumes and a description of recent major construction along the roadway. Crashes along the corridor were summarized at the actual RSA meeting and are also described below.

- Figure 4 presents an hourly distribution of traffic volumes along Route 28 both east and west of the RSA location. As shown in Figure 4, the total roadway volumes west of the location (collected Wed. 6/21/06 by Cape Cod Commission) were higher than those east of the segment (collected Thur. 7/27/06 by Precision Data) with reported ADTs of 27,534 and



**Figure 4. Hourly Distributions of Volumes along Route 28**

- At the location just west of the segment under consideration, Route 28 carried approximately 2,000 vehicles during the PM peak hour.
- This area of Route 28 was targeted for a major construction project within the past 10 years. Specifically, a \$1.75 million (project #601396) was spent on roadway reconstruction, which included the addition of traffic signals at the intersection of Phinney's Lane and the widening of the roadway from 2 to 4 lanes. The current configuration is 4 lanes (2 in each direction) with no turn lanes except for left-turn lanes at both of the Old Stage Road and Phinney's Lane signalized intersections on either end of the segment.
- Specific speed data was not reported prior to, or during, the RSA meeting; however it should be noted that local audit team members reported anecdotally that speeds are an issue in this area given the numerous curb cuts and frequency with which motorists unnecessarily change lanes. The regulated speed through this stretch is supposed to be consistent in both the EB and WB directions. The speed limit through this area is predominantly 40 mph (total stretch approximately west of Richardson Road), which covers both major plazas. On the eastern portion of this roadway the speed limit changes from (WB) or to (EB) 45 mph. It should be noted that these regulatory limits do not appear to be consistent with current signage which provides a 40 mph speed limits through in the EB direction and 45 mph throughout in the WB direction. The existing speed regulations for the entire length of Route 28 through Barnstable are provided in the Appendix.
- Over the 4-year period spanning between 2003 and 2006 there were 30 reported crashes along this segment of Route 28. Not surprisingly, the crashes were clustered in the vicinity of the signalized intersections and major plaza access locations, and included mostly turning vehicles.

Collision diagrams for these locations are presented in the Appendix. Interestingly, only 5 of the reported crashes occurred during the summer months. It should also be noted that 3 crashes were reported at the merge areas just beyond Old Stage (2 crashes, including 1 fatal) and Phinney's Lane (1 crash).

### 3.0 Characterization of Major Traffic Safety Challenges

Following a brief introduction to the RSA process in general, the meeting participants were asked to summarize and characterize potential safety considerations along Route 28. The initial characterization of the major safety considerations focused on several key elements as follows:

- The majority of the discussion centered upon the access points for the various plazas along this stretch of Route 28. Of primary concern was the access point at the Centerville Plaza, which was associated with a significant number of crashes. The specific two scenarios by which the crashes typically occur at these locations were summarized as follows:
  - Vehicles that travel EB and attempt to turn left are involved in crashes with opposing WB vehicles proceeding straight through the intersection. Of concern to some RSA team members was the inability of driver's to select appropriate gaps due in part to 1) difficulty and variation in judging speeds of vehicles approaching, and 2) drivers seeking smaller gaps due to aggressive maneuver which results from having been queued on Route 28 while waiting to complete the turn.
  - Vehicles exiting the plaza crash with the WB through vehicles. The primary cause was attributed to driver's selecting inappropriate gaps in traffic, based in part on vehicles speeds; however, another multi-threat crash scenario was also cited. In this multi-threat scenario drivers traveling WB in the curbside lane will stop to allow vehicles to exit (i.e. turn left) from the plaza parking lot, and WB through driver's in the center lane are not able to see / comprehend why the vehicle has stopped.

It is also worth noting that the RSA team members reported a significant number of conflicts and near crashes that do not surface as reported crashes, but are still indicative of a traffic safety problem at this location.

- Driving behavior in the area was also cited as a contributing factor to traffic crashes and the overall degradation of safety. Specifically, speeds, as well as unnecessary and frequent lane changes, were mentioned by RSA team members as a concern. On either side of this specific segment, Route 28 is one lane in each direction. Entering this segment Route 28 transitions from 1 lane to 2 lanes per direction, and exiting this stretch there is a transition from 2 lanes to 1 lane per direction. There was a belief among RSA team members that drivers may see this particular stretch as an opportunity to speed up and pass slower vehicles.
- As noted, immediately outside of this segment of Route 28, the roadway is reduced to 2 lanes (1 per direction) with the merge point just beyond the signalized intersection on each end. The immediacy of the merge and lack of an expanded taper was cited as a safety concern by several RSA team members.
- The two signalized intersection were discussed given their prevalence as high crash locations within the corridor. Specific discussion points included the lack of a protected left-turn phase for EB left-turn vehicles at the intersection of Old Stage. Also mentioned at this intersection was the accommodation of pedestrians; although there are pedestrian signals it was reported that they may not be operating efficiently or properly. At the Phinney's Lane intersection the skewed intersection geometry was discussed as a challenge at this location, as limited sight

distance can make selected turning maneuvers difficult to complete. At both intersections, there is a gas station on the NW corner, which results in concern regarding the access to these sites and the impact on safety. Please note that the gas station at Phinney's Lane was not operational at the time of the RSA meeting, but was in the process of being redeveloped as a gas station. At this location there is an access point that is within the intersection itself; however there is currently a "Do Not Enter" sign at this access point for vehicles attempting to exit the site.

- The impact of plaza access again surfaced during the characterization of major safety challenges, resulting this time from the number of curb cuts or access points. Although there is a one right-in / right-out drive there all others are bidirectional. At this stage concern was also raised about access to Old Stage behind (i.e. north side) of the plaza. Also of concern at selected driveways was the availability of adequate sight distance.
- Other significant factors mentioned at the outset of the meeting that are discussed in further detail later in this report also included the following:
  - Drainage;
  - Condition of pavement markings and existing signage; and
  - Pedestrian and bicycle safety throughout the corridor

#### **4.0 Summary of Short Term Recommendations for Route 28**

The formal review of potential safety concerns along Route 28 was completed by the entire audit team. Following identification of a potential safety issue the dialogue subsequently focused on possible countermeasures with some preliminary discussion regarding the feasibility of implementation (timeframe and cost) as well as the potential payoff of safety benefits. Given the potential for an immediate impact there was an added focus on short term (less than 1 year) and low cost (less than \$10,000) improvements that could be done almost instantaneously resulting in a positive safety impact. Please note that the major safety challenges characterized are primarily addressed through longer-term solutions, and will be addressed in greater detail later in this report. Nevertheless, several resulting recommendations for immediate actions along Route 28 were suggested and include the following:

- An initial recommendation is to inspect sight distance for vehicles exiting all driveways along the corridor as some locations have vegetation which significantly inhibits sight distance of vehicles as well as pedestrians and bicycles. There is a need to maintain landscaping so that the sight distance will not be obstructed. Similarly, there was a recommendation for necessary tree-trimming along the north side of the roadway closer to the Phinney's Lane intersection.
- Enforcement was identified by the RSA team as one countermeasure which could address several of the existing safety problems along Route 28, including enforcement centered upon speeding, aggressive driving, and red-light running (specifically at Old Stage Road). It is also recommended that speed data collection be completed by the state, Cape Cod Commission, or the Town of Barnstable to track current operating speeds throughout the year; this may also prove useful in the establishment of enforcement thresholds.
- The gas station under development at Phinney's Lane has a curb cut located within the intersection. Consistent with the previous operation of the gas station, it is critical that this driveway remain an "entrance only."
- One recommendation suggested at the RSA meeting was to explore the possibility of converting the existing lane usage at the intersection of Phinney's Lane. For consideration would be the designation of an exclusive right turn lane, which once reconfigured would make

the center lane a shared left/through lane. This request was based upon a perceived dominant movement and would better utilize the existing slip lane. At a minimum this idea warrants further consideration.

- Pedestrian concerns at the intersection of Old Stage Road and Route 28 should be addressed. One recommendation was the inclusion of pedestrian placards, which explain the meaning of pedestrian indications. It was also noted that the time allocated to pedestrians at this intersection was inadequate and/or not functioning properly. The resulting recommendation is to verify current field timing versus phase plans, and adjust as necessary.
- It is recommended that the intersection of Old Stage Road and Route 28 be further analyzed. Of specific concern from a safety perspective would be the demand associated with justification of an EB left-turn phase to allow protected-permissive left-turn signal phasing (PPLT). An additional consideration would be the reconfiguration of existing lane usage, based upon the resulting signal phasing changes. It is also recommended the adjacent intersection of Old Stage Road and Camp Opechee Road be studied in a similar fashion and at the same time.
- The merge at each end of the corridor was mentioned as a concern. At the intersection of Phinney's Road the taper on the east side of the intersection was reportedly short because of the adjacent herring run. Although potential redesign options should be considered (e.g. lengthen existing taper if possible) the existing markings and signage could be improved to alert drivers of the merge condition. Specifically, there appears to be an EB merge ahead warning sign missing from this location. Similar recommendations would be beneficial for the merge and existing taper on the west side of Old Stage Road, and should be addressed during any intersection study (see previous bullet).
- Utility poles are in close proximity to the traveled way along Route 28, which is in part negated by the presence of curbing. Nevertheless, it is recommended that the poles be reflectorized to add conspicuity. Although, it may be a longer-term solution, it is also recommended that plans to relocate the utility pole from the center of the shared pedestrian/bicycle route (see Figure 5 – located near intersection with Old Stage) be initiated in the near future.
- Maintenance along Route 28 appeared to be adequate at the time of the RSA meeting; however, given the prevalence of pedestrian and bicycles, it is recommended that pavement markings remain visible. Although most markings, also including all longitudinal markings, the crosswalk markings across the Centerville Plaza site drive were faded and should be refreshed. A similar, sustained approach is suggested for signage in the area as well. Routine maintenance of drainage features in the area is also recommended.
- Although the safety impacts resulting from the number of existing curb cuts and their respective volumes are better addressed through long-term solutions, it is recommended that short-term strategies resulting in the consolidation of curb cuts be further explored.
- The next section discusses longer-term strategies based in part on the time required to implement; however a short-term recommendation is to consider these alternatives as some of them could prove effective for a relatively low cost (e.g. conversion from 4 to 3 lanes).



**Figure 5. Hazardous Pole Location for Bicycles**

## 5.0 Summary of Additional Route 28 Countermeasures

Although an emphasis was initially placed upon short term and low cost improvements that could be carried out immediately, there did not appear to be many of these countermeasures. As a result, all types of solutions were discussed. The following section details countermeasures discussed by the team, which are reflective of all costs and timeframes and includes both general (entire corridor) and specific safety opportunities. Please note that with respect to the timeframe there are some unknown variables that must be further explored. Additionally, some of the potential treatments discussed were experimental in nature resulting in an unknown level of safety benefits. Several definitions exist for low, mid, and high cost as well as for short, mid and long term implementation timeframes. For purposes of this report, low cost improvements will be under \$10,000, mid costs will be under \$50,000, and high costs will be above \$50,000. From a timeframe perspective short term will refer to less than 1 year while mid and long term will refer to countermeasures that will take 1 to 3, and greater than 3 years, respectively.

As documented in the American Association of State Highway and Transportation Officials' (AASHTO) *A Policy on Geometric Design of Highways and Streets* (AASHTO Green Book), the crash rate on multilane undivided arterials is typically higher because of the increased traffic, access points, and adjacent development. The Green Book continues to state that, "turn lanes and adequate intersection sight distance greatly improve the safety of intersection operations." The majority of the countermeasure discussion was focused upon improving these specific issues, while continuing to provide adequate access to the various retail establishments. Although they are beyond the scope of this current RSA, it is recommended that long-term solutions be further explored in greater detail. Some of the significant points of discussion included the following:

- *Consolidation of access drives* It is important to note that many of the strategies discussed at the RSA meeting and described below are either predicated on the need for consolidation of existing access point, or will result in safer and improved flow based upon consolidation of access points. The notion is that traffic will move within the plazas and will be processed at a fixed number of access points at Route 28. For example, there is currently no access between the two main plazas (Centerville Plaza and Bell Tower Mall) on the north side of Route 28; however, access between them could be useful in implementing several of the countermeasures discussed.
- *Addition of a center median* – The addition of a divided median would not only separate the major flows of traffic, which will prevent cross-over the centerline crashes, but will also eliminate crashes at all plaza drives between left-turning vehicles. As a result of a center median all plaza drives would become right-in / right-out movements only. Several variations of a median approach were discussed including the application of curbed islands as well as the possibility of guard rail.
- *Reconfiguration of signalized intersections at Old Stage Road and Phinney's Lane* The addition of a center median that eliminate left turn maneuvers throughout this segment of Route 28 would result in an increased demand at the two existing signalized intersections. Specifically, there would be an added demand for u-turn maneuvers. Based upon the existing geometry and available right-of-way there is some concern about the feasibility of accommodating u-turn maneuvers. Two variations which aim to accommodate these maneuvers would be as follows:
  - The design of jughandles (north side at Old Stage and south side at Phinney's) that would allow for storage of the u-turn vehicles and provide a sufficient radius for all

- vehicles classifications to complete the maneuver. This had been discussed previously, but was eliminated as possibility given the availability of existing right-of-way.
- The redesign of each existing intersection as a roundabout would allow for the accommodation of all intersection maneuvers, including the added u-turns. Initial concerns related to this concept are again related to the available right-of-way as well as the public's acceptance of roundabouts.
  - *Controlled access from Centerville Plaza* – Adding control at the intersection of Centerville Plaza and Route 28 would undoubtedly improve safety along the corridor. Please note this option would be feasible either with or without the addition of a center median. Several alternatives were discussed at the RSA meeting and warrant consideration:
    - One approach could be to signalize the intersection and totally control vehicles flows to provide an orderly flow. Please note that a traffic signal warrant analysis would be required to determine if this alternative is indeed feasible. Nevertheless, this configuration would likely allow for the creation of turn lanes with storage. It should be noted that this plan has been discussed, but was referred to as a “dead issue” at the time of the RSA meeting. Given its potential on both safety and efficiency this should be considered to the extent possible.
    - Another alternative was to design and construct a roundabout at this location. In addition to the previous stated concerns of available right-of-way and public acceptance another possible concern would be the unbalanced nature of vehicle flows for the developed approaches, which may hinder the operational efficiency of a roundabout. Nevertheless, this warrants further consideration.
  - *4 to 3 Conversion* Conceptually this alternative would eliminate one of the existing four lanes and provide a single through lane in both the eastbound and westbound directions. The center lane could be either a series of alternating turn pockets which would improve sight distance, add storage, and force drivers to cross only a single lane when turning, or a two-way left turn lane could be employed. One concern would be the impact on overall efficiency and the resulting availability in sufficient gaps for left-turning vehicles that may result from creating a single lane of through traffic. Among all of the consideration listed in this section, this strategy could be implemented relatively quickly and likely at a lower cost. As such it probably warrants further consideration in the short-term as a possible countermeasure.
  - *Creation of northern access road* An idea that had been considered previously was discussed again at the RSA meeting. Specifically, the plan called for the creation of an access road that would provide connection to both Old Stage Road and Phinney's Lane. This plan would eliminate the need for left-turn maneuvers from Route 28 to Phinney's Lane and would eliminate the overall burden on the various plaza access points. As noted, this was discussed previously and was deemed not feasible given requirements associated with acquiring right-of-way.
  - *Route 28 at Phinney's Lane* The current skewed intersection results in sight distance challenges and is a likely contributor to existing crashes. Another long-term consideration would be any potential for realignment which would allow for the northbound and southbound approaches to be squared. In the meantime, some considerations should crashes remain problematic would be to fully split the phasing for the skewed approaches.

As noted, the possible countermeasures discussed above are considered long-term as compared to other countermeasures which could be implemented immediately. Nevertheless, it is recommended that a short-term strategy be the consideration of these alternatives, which may prove to be feasible and cost-effective strategies for improved safety and efficiency along this corridor.

## 6.0 Discussion

With respect to the safety improvement opportunities described in the previous section it is important to consider the following: 1) there are several countermeasures that are both low cost and short term, which should be considered immediately and 2) there is a complimentary nature of many of the safety strategies in that one improvement will aid with multiple safety issues.

The long term improvements that are likely to have significant safety and efficiency impacts over time should be further considered. In the short-term it is advised that several of these long-term alternatives be evaluated to determine their feasibility, level of desirability, potential costs, and overall effectiveness. A precursor to this evaluation will likely be expanded study of the existing corridor, which may include any or all of the following:

- Volume and speed studies;
- Continued crash documentation;
- Conflict analyses – specifically suggest Centerville Plaza and Bell Tower Plaza site drives
- Capacity analyses

## **7.0 Appendix: Distributed RSA Meeting Materials**

Materials provided to RSA team members in advance or during the meeting included the following:

1. Agenda
2. RSA and Lane Departure Introduction
3. Summary of Route 28 Speed Regulations through Barnstable
4. Crash Summary – Collision Diagrams (presented from west to east)
5. LD-RSA Checklist

# Agenda

## Road Safety Audit for Falmouth Rd (Rte 28) between Phinney's Lane and Old Sate Road

Meeting Location: Barnstable Police Station, 1200 Phinney's Lane  
Hyannis, MA

Tuesday, October 30, 2007  
10:00 AM to 12:00 noon

Type of meeting:	Lane Departure – Road Safety Audit
Attendees:	Invited Participants to Comprise a Multidisciplinary Team
Please bring:	Thoughts and Enthusiasm!!
10:00 AM	Welcome and Introductions
10:15 AM	Introduction to Road Safety Audits and Lane Departure Crashes
10:30 AM	Review of Site Specific Material <ul style="list-style-type: none"><li>• Crash &amp; Volume – provided in advance</li><li>• Existing Geometries and Conditions</li><li>• Video and Images</li></ul>
11:00 AM	Completion of RSA <ul style="list-style-type: none"><li>• Identification of Safety Concerns – using checklists as a guide</li><li>• Identification of Possible Countermeasures</li></ul>
12:00 noon	Adjourn for the Day – but the RSA has not ended

### Instructions for Participants:

- Before attending the RSA on October 30th participants are encouraged to drive Falmouth Road (Route 28) between Phinney's Lane and Old Stage Road, in Barnstable, MA and complete/consider elements on the RSA advisory checklist with a focus on safety factors affecting roadway departure crashes.
- 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 initial 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.

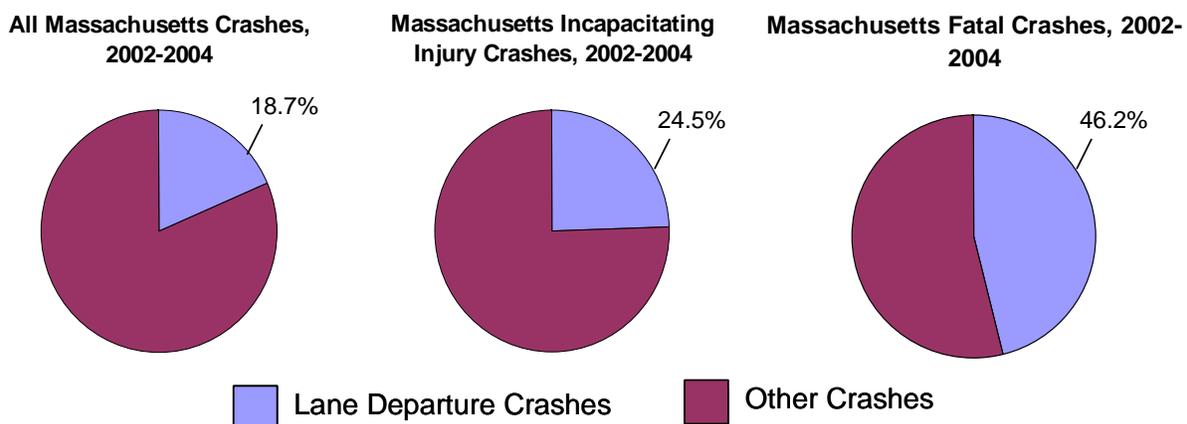
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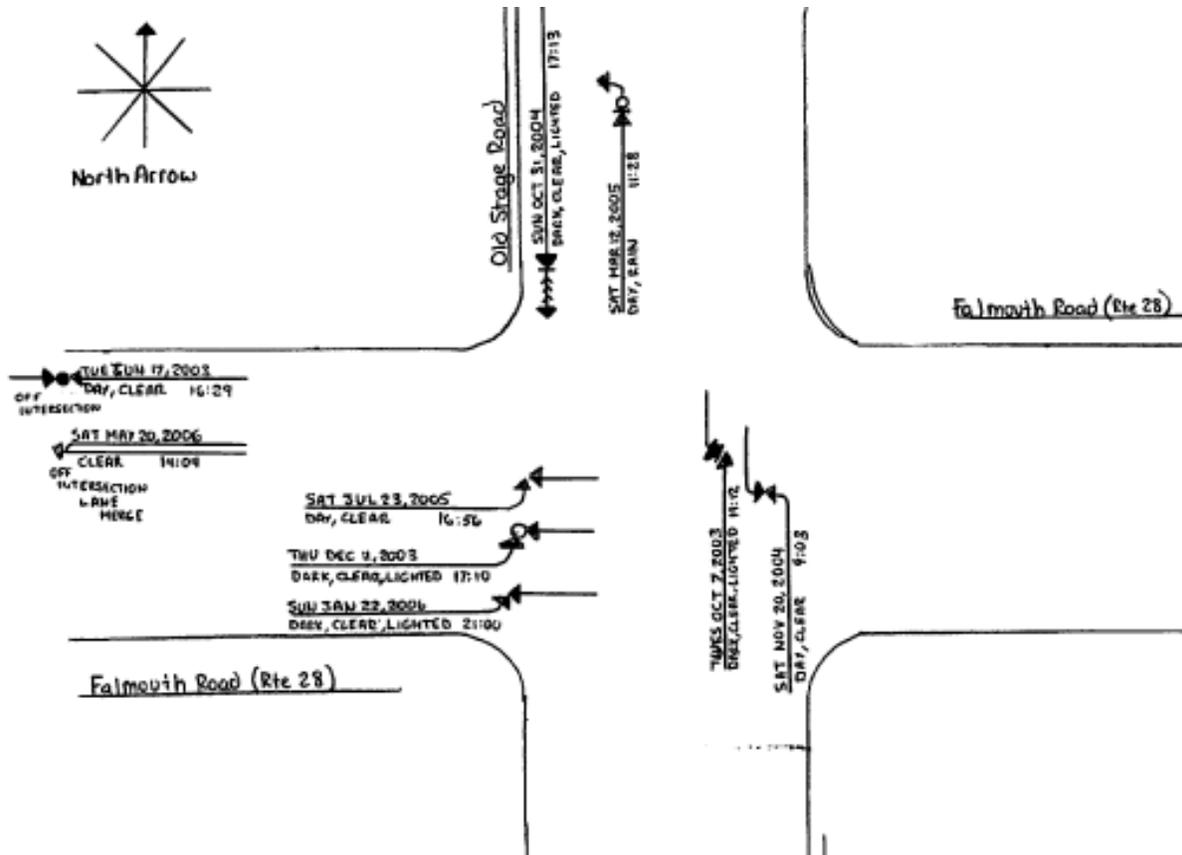
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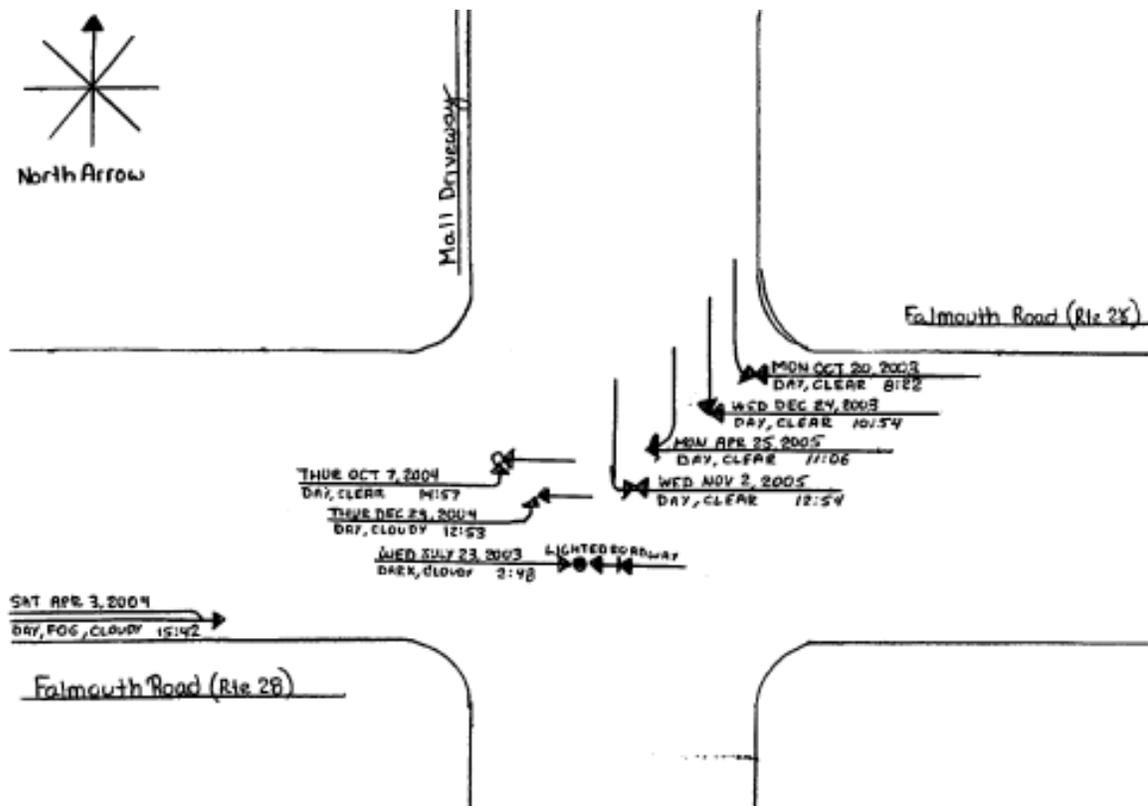
In an effort to combat the lane departure problem, a strategy was developed for the SHSP to identify hot spot lane departure location, perform road safety audits and implement low-cost comprehensive countermeasures.

**Appendix Table 1 Summary of Speed Regulations for Route 28 in Barnstable**

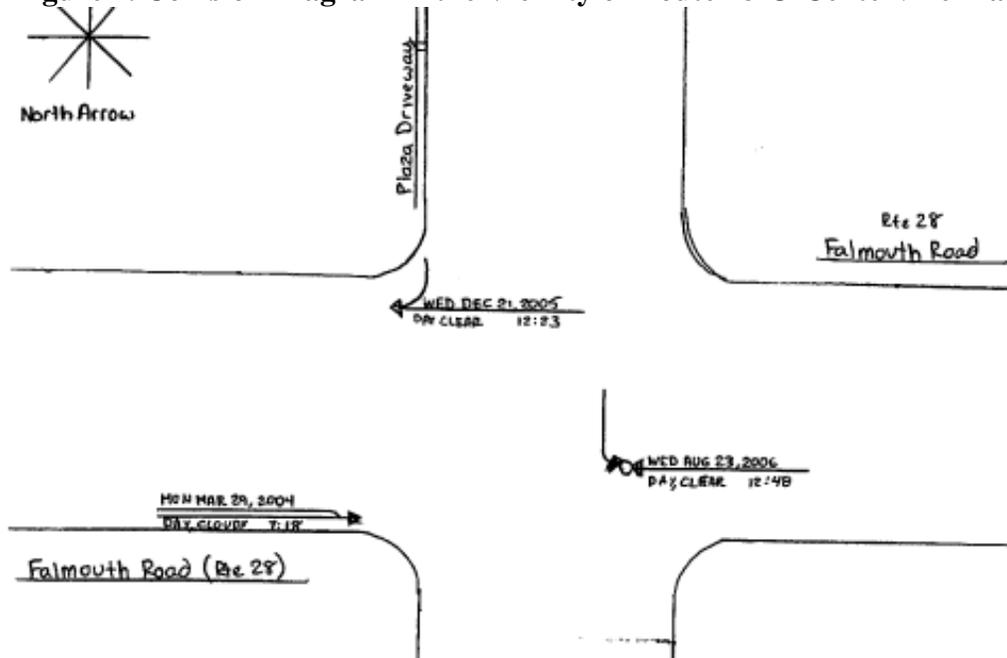
Eastbound		Westbound	
Beginning at the Barnstable-Mashpee line		Beginning at the Barnstable-Yarmouth line	
0.40 miles	At 50 mph	0.90 miles	At 35 mph
0.27 miles	At 35 mph	0.17 miles	At 25 mph
0.38 miles	At 40 mph	0.69 miles	At 35 mph
1.45 miles	At 50 mph	0.47 miles	At 45 mph
0.25 miles	At 45 mph	1.08 miles	At 45 mph
1.00 miles	At 50 mph	0.19 miles	At 40 mph
0.16 miles	At 45 mph	0.57 miles	At 45 mph
2.05 miles	At 50 mph	0.34 miles	At 40 mph
0.34 miles	At 40 mph	2.05 miles	At 50 mph
0.56 miles	At 45 mph	0.16 miles	At 45 mph
0.19 miles	At 40 mph	1.00 miles	At 50 mph
1.08 miles	At 45 mph	0.25 miles	At 45 mph
0.49 miles	At 45 mph	1.43 miles	At 50 mph
0.67 miles	At 35 mph	0.40 miles	At 40 mph
0.17 miles	At 25 mph	0.27 miles	At 35 mph
0.90 miles	At 35 mph	0.40 miles	At 50 mph
Ending at the Yarmouth-Barnstable		Ending at the Mashpee-Barnstable line	



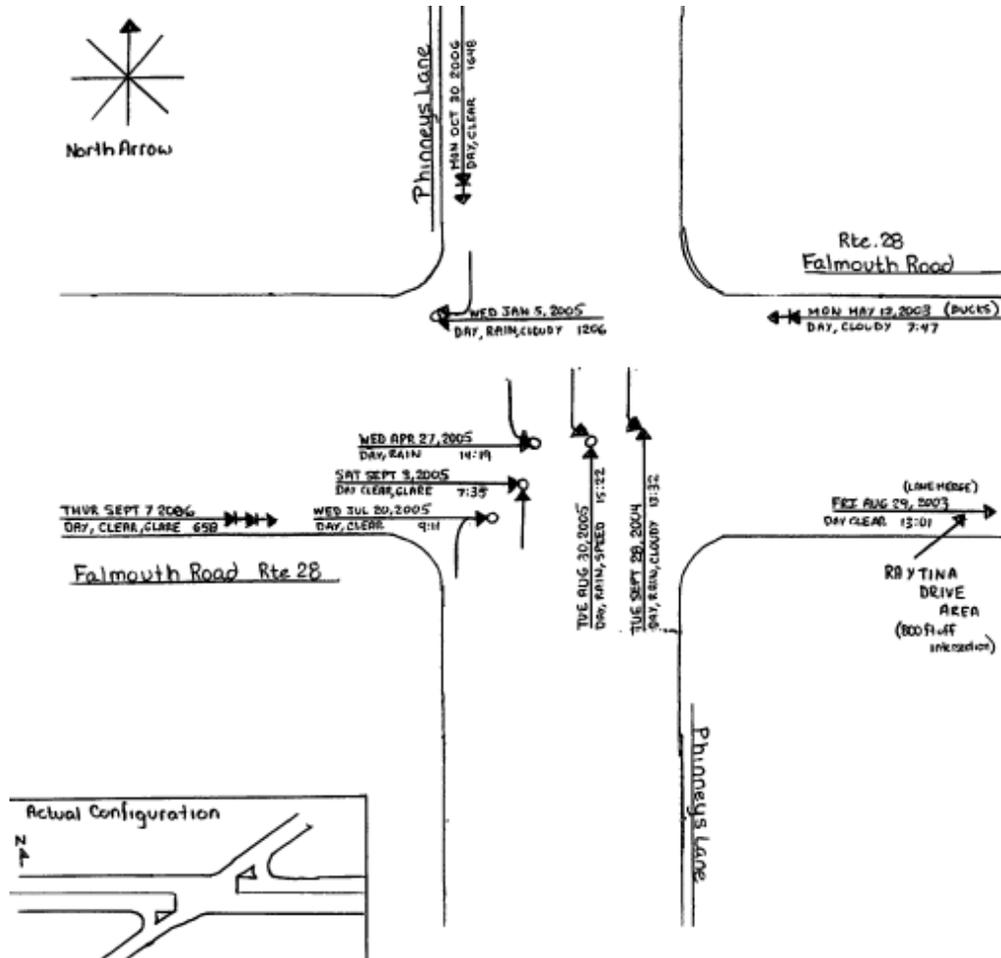
Appendix Figure 1. Collision Diagram in the Vicinity of Route 28 @ Old Stage Road



Appendix Figure 2. Collision Diagram in the Vicinity of Route 28 @ Centerville Plaza Drive



Appendix Figure 3. Collision Diagram in the Vicinity of Route 28 @ East Plaza Drive



Appendix Figure 4. Collision Diagram in the Vicinity of Route 28 @ Phinney's Lane

<b>GEOMETRIC DESIGN</b>	
<b>Issue</b>	<b>Comment</b>
<b>A. Speed – (Design Speed; Speed Limit &amp; Zoning; Sight Distance; Overtaking)</b>	
<p>Are there speed-related issues along the corridor? Please consider the following elements:</p> <ul style="list-style-type: none"> <li>• Horizontal and vertical alignment;</li> <li>• Posted and advisory speeds</li> <li>• Driver compliance with speed limits</li> <li>• Approximate sight distance</li> <li>• Safety passing opportunities</li> </ul>	
<b>B. Road alignment and cross section</b>	
<p>With respect to the roadway alignment and cross-section please consider the appropriateness of the following elements:</p> <ul style="list-style-type: none"> <li>• Functional class (Urban Principal Arterial)</li> <li>• Delineation of alignment;</li> <li>• Widths (lanes, shoulders, medians);</li> <li>• Sight distance for access points;</li> <li>• Cross-slopes</li> <li>• Curbs and gutters</li> </ul> <p>Drainage features</p>	
<b>C. Intersections</b>	
<p>For intersections along the corridor please consider all potential safety issues. Some specific considerations should include the following:</p> <ul style="list-style-type: none"> <li>• Intersections fit alignment (i.e. curvature)</li> <li>• Traffic control devices’ alert motorists as necessary</li> <li>• Sight distance and sight lines seem appropriate</li> <li>• Vehicles can safely slow/stop for turns</li> <li>• Conflict point management</li> <li>• Adequate spacing for various vehicle types</li> </ul> <p>Capacity problems that result in safety problems</p>	
<b>D. Auxiliary lanes</b>	
<ul style="list-style-type: none"> <li>• Do auxiliary lanes appear to be adequate?</li> </ul>	
<ul style="list-style-type: none"> <li>• Could the taper locations and alignments be causing safety deficiencies?</li> <li>• Are should widths at merges causing safety deficiencies?</li> </ul>	

<b>E. Clear zones and crash barriers</b>	
<p>For the roadside the major considerations are clear zone issues and crash barriers. Consider the following:</p> <ul style="list-style-type: none"> <li>• Do there appear to be clear zones issues? <ul style="list-style-type: none"> <li>— Are hazards located too close the road?</li> <li>— Are side slopes acceptable?</li> </ul> </li> <li>• Are suitable crash barriers (i.e, guard rails, curbs, etc.) appropriate for minimizing crash severity?</li> <li>• Barrier features: end treatments, visibility, etc.</li> </ul>	
<b>F. Bridges and culverts – (if necessary)</b>	
Are there specific issues related to bridges and culverts that may result in safety concerns?	
<b>G. Pavement – (Defects, Skid Resistance, and Flooding)</b>	
<ul style="list-style-type: none"> <li>• Is the pavement free of defects including excessive roughness or rutting, potholes, loose material, edge drop-offs, etc.) that could result in safety problems (for example, loss of steering control)?</li> <li>• Does the pavement appear to have adequate skid resistance, particularly on curves, step grades and approaches to intersections?</li> <li>• Is the pavement free of areas where flooding or sheet flow of water could contribute to safety problems?</li> <li>• In general, is the pavement quality sufficient for safe travel of heavy and oversized vehicles?</li> </ul>	
<b>H. Lighting (Lighting and Glare)</b>	
<p>It is important to consider to the impacts of lighting. Some specifics include the following:</p> <p>Is lighting required and, if so, has it been adequately provided?</p> <p>Are there glare issues resulting from headlights during night time operations or from sunlight?</p>	

<b>TRAFFIC CONTROL DEVICES</b>	
<b>Issue</b>	<b>Comment</b>
<b>I. Signs</b>	
<p>Signage is a critical element in providing a safe roadway environment. Please consider the following:</p> <ul style="list-style-type: none"> <li>• Are all current signs visible? Are they conspicuous and clear? Are the correct signs used for each situation?</li> </ul>	
<ul style="list-style-type: none"> <li>• Are signs visible (consider both night and day)?</li> <li>• Does the retroreflectivity or illumination appear satisfactory?</li> <li>• Are there any concerns regarding sign supports?</li> </ul>	
<b>J. Traffic signals</b>	
<p>Although the focus of this RSA are lane departures, this does present an opportunity for us to consider any traffic signals. Specifically:</p> <ul style="list-style-type: none"> <li>• If present, do the traffic signals appear to be designed, installed, and operating correctly?</li> <li>• Is the controller located in a safe position? (where it is unlikely to be hit, but maintenance access is safe)</li> <li>• Is there adequate sight distance to the ends of possible vehicle queues?</li> </ul>	
<b>K. Marking and delineation</b>	
<ul style="list-style-type: none"> <li>• Is the line marking and delineation: <ul style="list-style-type: none"> <li>— appropriate for the function of the road?</li> <li>— consistent along the route?</li> <li>— likely to be effective under all expected conditions? (day, night, wet, dry, fog, rising and setting sun, oncoming headlights, etc.)</li> </ul> </li> <li>• Are centerlines, edgelines, and lane lines provided? If not, do drivers have adequate guidance?</li> </ul>	

<b>ROADWAY ACTIVITY</b>	
<b>Issue</b>	<b>Comment</b>
<p>With respect to roadway activity please consider safety elements related to the following:</p> <ul style="list-style-type: none"> <li>• Pedestrians</li> <li>• Bicycles</li> <li>• Public transportation vehicles and riders</li> <li>• Emergency vehicles</li> <li>• Commercial vehicles</li> <li>• Slow moving vehicles</li> </ul>	

<b>ENVIRONMENTAL CONSIDERATIONS</b>	
<b>Issue</b>	<b>Comment</b>
<b>Weather &amp; Animals</b>	
<p>From an environmental perspective it is important to consider any potential impacts. Most notably is likely to be the impacts of weather or animals, including:</p> <ul style="list-style-type: none"> <li>• Possible effects of rain, fog, snow, ice, wind on design features.</li> <li>• Has snow fall accumulation been considered in the design (storage, sight distance around snowbanks, etc.)?</li> <li>• Are there any known animal travel/migration routes in surrounding areas which could affect design?</li> </ul>	