chapter

3

Comparative Analysis

3 Comparative Analysis

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In 2002, VDOT and VHB developed the Route 13 / Wallops Island Access Management Study (2002 Study). This chapter provides a historic comparison to the 2002 Study safety analysis of the corridor between the three-year periods of 1997-1999 to 2012-2014 in an effort to measure how well the implemented improvements achieved the reduction in the number of crashes or the severity of crashes. The 2002 Study presented recommended system-wide safety treatments: the installation of 10-foot outside shoulders, rumble strips on the outside and inside shoulders, milepost markers at each mile, crossover closures, and turn lane improvement. Since the 2002 Study, rumble strips were installed, 16 crossovers were closed, and some intersection improvements were implemented. On the following pages, Figures 3.5 and 3.6 present some of the improvements recommended in the 2002 Study and some of the 2015 existing conditions related to safety along the corridor.

3.1 Crash History Comparison

There were a total of 80 more crashes along the study corridor. A 10% increase in crashes was shown from 1997-1999 to 2012-2014, see Figure 3.1. It can be noted that there was an increase of crashes in the north end; see Site Specific Locations 10-12. In the evaluation, the total number of crashes does not reflect the safety of the corridor relative to the volume of traffic served. While there are more crashes than before, which moves away from a desired count of zero, the corridor served more vehicles on an average daily basis in 2012 compared to the 2002 Study volume. The safety of the corridor is more accurately reflected when the increase in traffic volume is used in the measurement of the crash rate, expressed as crashes per 100 million vehicles miles traveled.

The crash rate of a specific location or along a segment is more telling of the safety of the conditions. For example, 20 crashes at a location that serves 10,000 vehicles per day is less safe than 20 crashes at a location that serves 20,000 vehicles per day. In review of the crash rates along the study corridors (see Figure 3.2), crash rates fell in 13 of the 19 segments, a reduction in 68% of the segments.

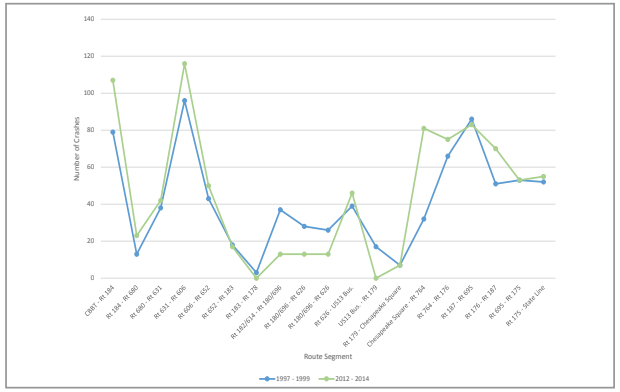


Figure 3.1.
Number of Crashes.

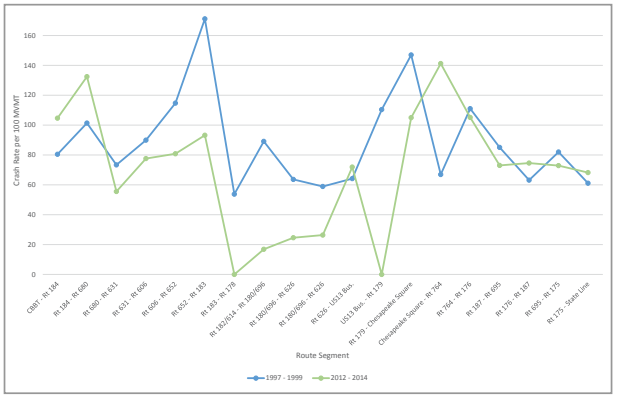


Figure 3.2.
Crash Rates.

3.1.1 Fatal Crash Evaluation

Fatal crashes are often random events; however, the locations where the events occur were investigated for environmental contributory factors. A comparison of 1997-1999 to 2012-2014 fatal crash data through the study area indicate that there has been a 54% reduction in fatal crashes. The location of the crashes are still concentrated between mileposts 115 and 125, and 135 and 140, see Figure 3.3. The site specific and systemic analyses included a detailed review of these areas and the recommendations incorporated from the findings are expected to enhance safety of these segments.

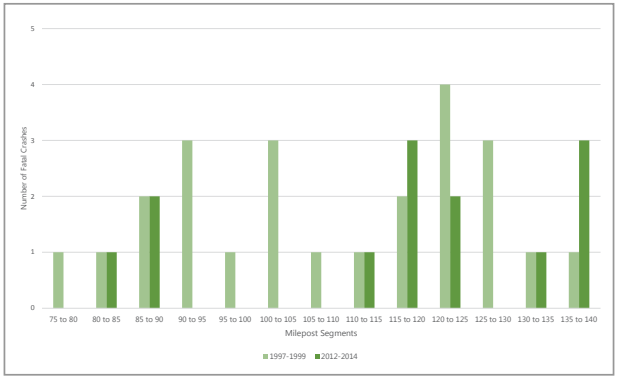


Figure 3.3.
Fatal Crashes by Segment.

3.1.2 Crossover Closure Effectiveness

The crash data at each of the 16 crossovers closed since 2002 did not show a dramatic effect on the reduction of the total crashes within the corridor. The crossovers which were closed were not heavily used and did not show repetitive crash history; therefore, the results are consistent with expectations having little to no effect on crash frequency. In recognition of the importance of how crossovers and intersections treatments are addressed within this study, Chapter 5 provides the detailed evaluation which leads to recommendations for implementation.

3.1.3 Rumble Strip Effectiveness

The rumble strips were installed just before 2014; therefore, the effectiveness of rumble strips in reducing roadway departure crashes on U.S. Route 13 was captured in data from 2010 versus 2014, see Figure 3.4. Rumble strips are the grooved edges of the travel lane which alert a driver through vibrational noise that the vehicle is drifting outside the travelway. VDOT installed rumble strips on both the left and right edges along U.S. Route 13 where it was feasible. This treatment is reported to have a crash modification factor of 0.82. It is reasonable to predict a reduction of roadway departure crashes over a three-year period by 18%. The analysis of the 2010 versus 2014 data showed an overall 27% reduction in roadway departure crashes, with reductions in nine of the 14 segments studied.

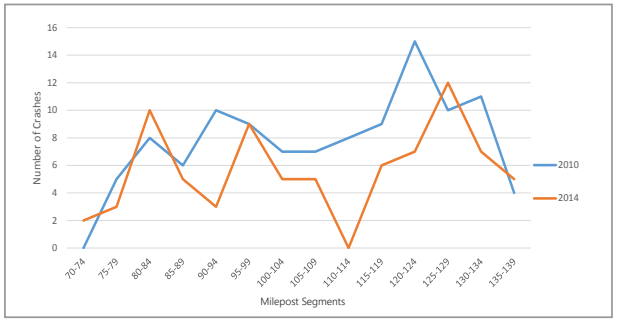


Figure 3.4.
Roadway Departure Crash Comparison.

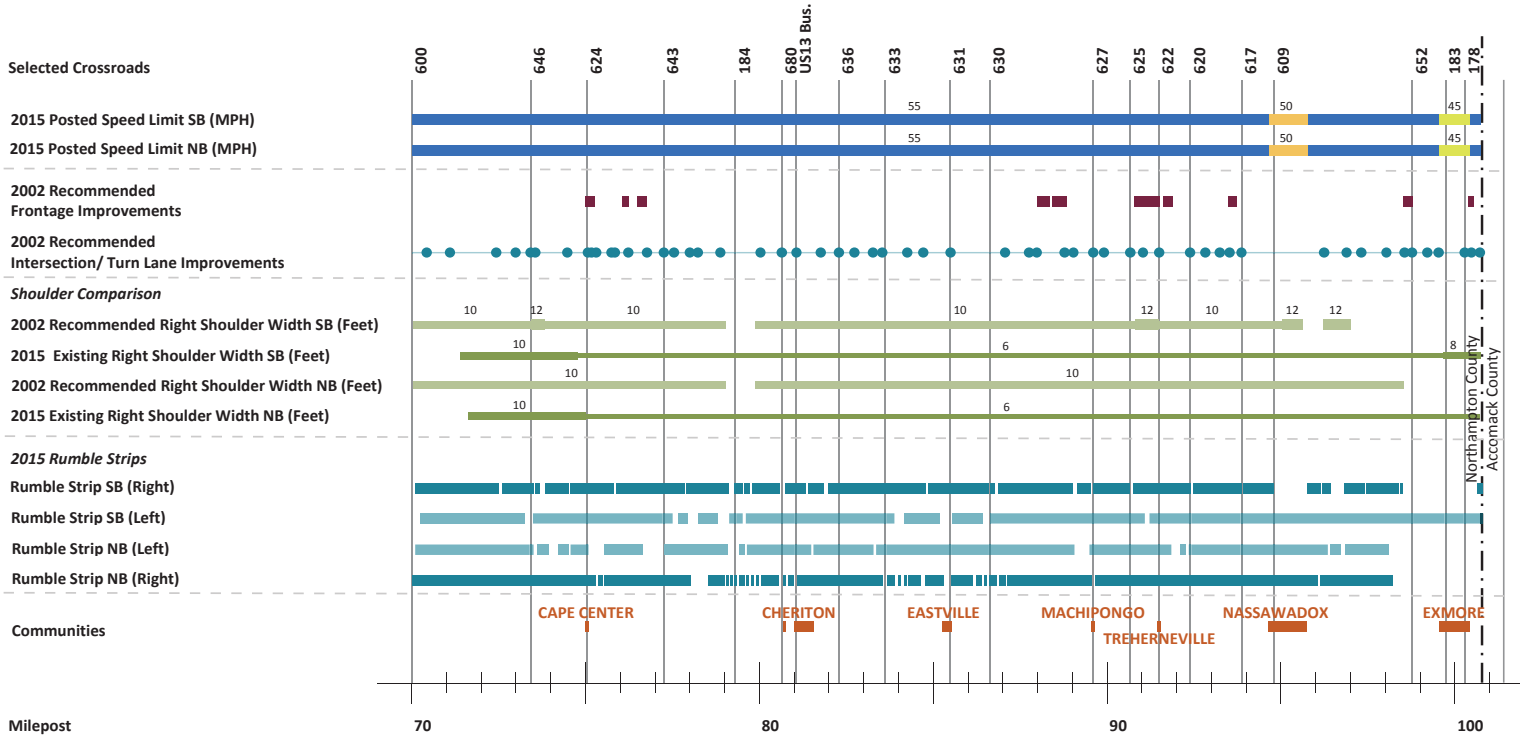
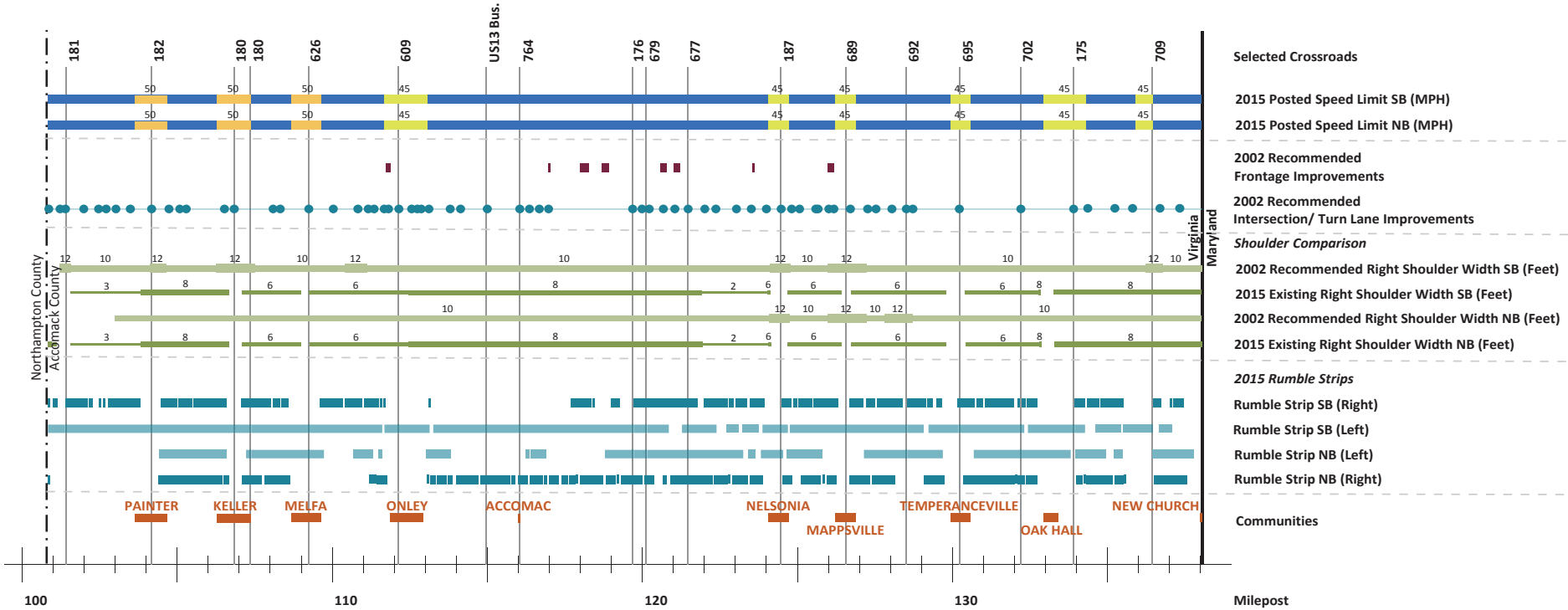


Figure 3.5
Histogram
Northampton County
Eastern Shore Safety Study



Blank spaces indicate no change recommended or attribute does not exist

LEGEND

- 2015 55 mph Posted Speed Limit
- 2015 50 mph Posted Speed Limit
- 2015 45 mph Posted Speed Limit
- 2002 Recommended Frontage Improvements
- 2002 Recommended Intersection / Turn Lane Improvements
- 2002 Recommended Right Shoulder Width SB & NB (FT)
- 2015 Existing Right Shoulder Width SB & NB (FT)
- 2015 Rumble Strip SB (Right)
- 2015 Rumble Strip SB & NB (Left)
- 2015 Rumble Strip NB (Right)

Figure 3.6
Histogram
Accomack County
Eastern Shore Safety Study

3.2 Speed Limit Evaluation

The systemic analysis approach in evaluating the safety of the corridors includes speed as a contributory factor; however, stakeholder and citizen feedback identified speeding as a key concern with merits to address speed independently as well. The overarching question is whether the posted speed limits on U.S. Route 13 and on Route 175 are appropriate for the conditions of the facilities.

U.S. Route 13 is mostly signed 55 mph with some areas posted 45 mph and 50 mph. The speed limit reductions are apparently based on geometric conditions and/or land use. For example, when the median transitions into a two-way left-turn lane, the speed limit reduces to 50 mph. Route 175 has a posted speed limit of 55 mph in the study area.

3.2.1 Data Collection

The first phase of the evaluation began with the crash history. The crash data from 2010 to 2014 identified 45 crashes of which the primary factor was speed. Forty-five crashes over a study area as large as this study was considered too small of a sample; therefore, expanding the sample to include other actions that may be speed-related such as improper passing, following too closely, and failure to maintain control, resulted in a total of 737 crashes. The larger sample size was used to identify the locations for speed data collection and analysis. The segments shown on the following page in Figure 3.8 represent the areas of the highest crashes directly attributable or may be related to speed.

The schedule to perform speed data collection was established based on the seasonal variation on when the most crashes related to speed occurred. As shown in Figure 3.7, 32% of speed related crashes occurred in the fall; therefore, the speed data was collected in September 2015, once school was back in session.

Since crash data led to data collection outside town limits, in January 2016, VDOT supplemented the first data set with segments within each of the town limits.

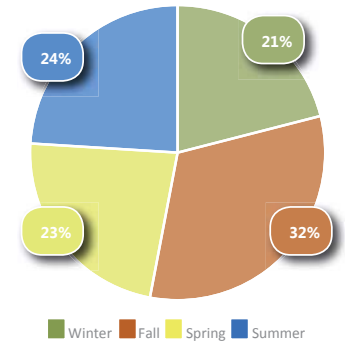


Figure 3.7.
Crashes by Season.

3.2.2 Evaluation

Speed limit evaluation on a facility such as U.S. Route 13 incorporates multiple considerations.

USLIMITS2, developed by the Federal Highway Administration (FHWA) and approved for use in the Manual of Uniform Traffic Control Devices (MUTCD), is a web based tool designed to help practitioners set reasonable, safe, and consistent speed limits for specific segments of roads. The tool utilizes statuary speed limits, 85th percentile speed data, traffic volume data, crash data, roadside conditions, development type, access points, and signalization to identify the posted speed limit for the studied segment (see Appendix C for USLIMITS2 Reports).

The two sets of data were processed and the 85th percentile speed was calculated. The 85th percentile speed is the speed at which 85 percent of the traffic is traveling at or below. The 85th percentile speed is used in establishing speed limits because it captures the speed at which a high majority of drivers feel comfortable driving based on the characteristics of the roadway. Lower speed limits are considered artificially set and are meaningless to drivers. This does not suggest that speed limits should be set to enable drivers to drive dangerously; however, it is an indicator that there are attributes of the roadway that may need to be modified to encourage drivers to feel more comfortable at a lower speed. The open flat terrain of the Eastern Shore poses a challenge on the issue of controlling speed.

On the U.S. Route 13 segments outside town limits, as shown in Figure 3.9, the 85th percentile speed exceeds 60 mph in 70 percent of the segments. The 85th percentile speed on Route 175 was between 51 and 55 mph. Inside the town limits, as presented in Figure 3.10 and Table 3.1, the 85th percentile speed was measured to be 50 mph or higher. These results are indicators that drivers are comfortable traveling at speeds higher than posted.

Based on the analyses, the posted speed limits on U.S. Route 13 are appropriate. The analysis further indicates that a 50 mph posted speed limit is appropriate for Route 175, therefore, it is recommended for the posted speed limit to be reduced from 55 mph to 50 mph.

Table 3.1.
Speed Summary.

Town	Current Speed Limit		85th Percentile Speeds		USLIMITS2 Calculated Speed		Recommended Speed Limit		Comments
	NB	SB	NB	SB	NB	SB	NB	SB	
Northampton County									
Exmore	45	45	53	53	55	55	45	45	Recommend no change.
Nassawadox	50	50	65	60	65	60	50	50	Recommend no change.
Accomack County									
Keller	50	50	64	64	65	65	50	50	Undivided with two-way left-turn. No change in speed limit recommended. Targeted speed enforcement recommended.
Mappsville	45	45	63	60	60	60	45	45	NB overall and injury crash rates exceed average for similar roads. SB crash rate is similar to average. No change in speed limit recommended. Targeted speed enforcement recommended instead.
Melfa	50	50	58	62	60	60	50	50	Undivided with two-way left-turn. No change in speed limit recommended. Targeted speed enforcement recommended.
Nelsonia	45	45	57	57	57	55	45	45	SB overall and injury crash rates exceed average for similar roads. No change in speed limit recommended. Targeted speed enforcement recommended instead.
New Church	45	45	58	58	55	55	45	45	NB and SB overall and injury crash rates exceed or equal average for similar roads. No change in speed limit recommended. Targeted speed enforcement recommended instead.
Oak Hill	45	45	56	59	55	60	45	45	NB and SB overall and injury crash rates exceed or equal average for similar roads. No change in speed limit recommended. Targeted speed enforcement recommended instead.
Onley	45	45	49	50	50	50	45	45	Recommend no change.
Painter	50	50	58	59	60	50	50	50	Undivided with two-way left-turn. No change in speed limit recommended. Targeted speed enforcement recommended.
Temperanceville	45	45	60	59	60	60	45	45	NB overall, NB injury crash and SB injury crash rates exceed average for similar roads, SB crash rate is similar to average. No change in speed limit recommended. Targeted speed enforcement for NB direction is recommended instead.

Figure 3.8
Segments with High Frequency of Speeding Crashes
Eastern Shore Safety Study

Figure 3.9
Speed Survey Data Points
Eastern Shore Safety Study

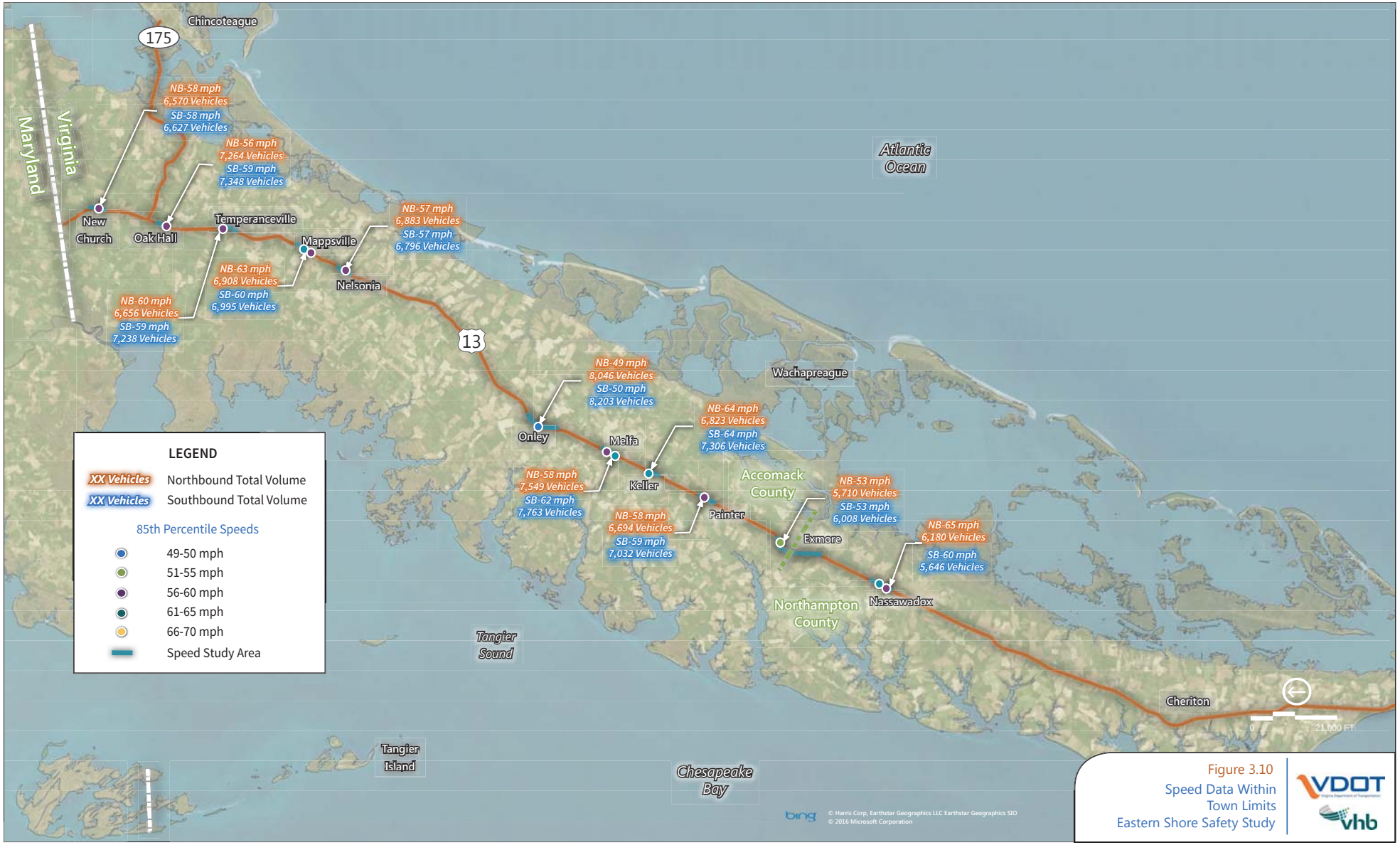


Figure 3.10
Speed Data Within Town Limits
Eastern Shore Safety Study

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chapter

4

Systemic Analysis

4 Systemic Analysis

4.1 Introduction and Methodology

There are two primary approaches to addressing safety: using a site specific approach to address locations with a history of high or severe crashes, and using a systemic approach to proactively address safety by identifying and targeting specific risk factors. This chapter describes how the systemic analysis was applied to the study area.

The project team used the methodology created for the VDOT CSA for CoSS whereby a set of risk reducing templates are provided for intersections and for corridors throughout the study area. A full series of templates are provided in Appendix A. The countermeasures in the templates are grouped into tiers and are applied to the intersections and corridors based upon the presence of systemic risk factors, crash risk, and their Potential for Safety Improvement (PSI). Each of these three factors and how they impact tier selection are described in this chapter. The AASHTO Highway Safety Manual and FHWA systemic methodology guided the analysis and identification of systemic risk factors present throughout the study area.[1,2]

- The call-out boxes in this chapter highlight elements related to the focus area risk factor determination.

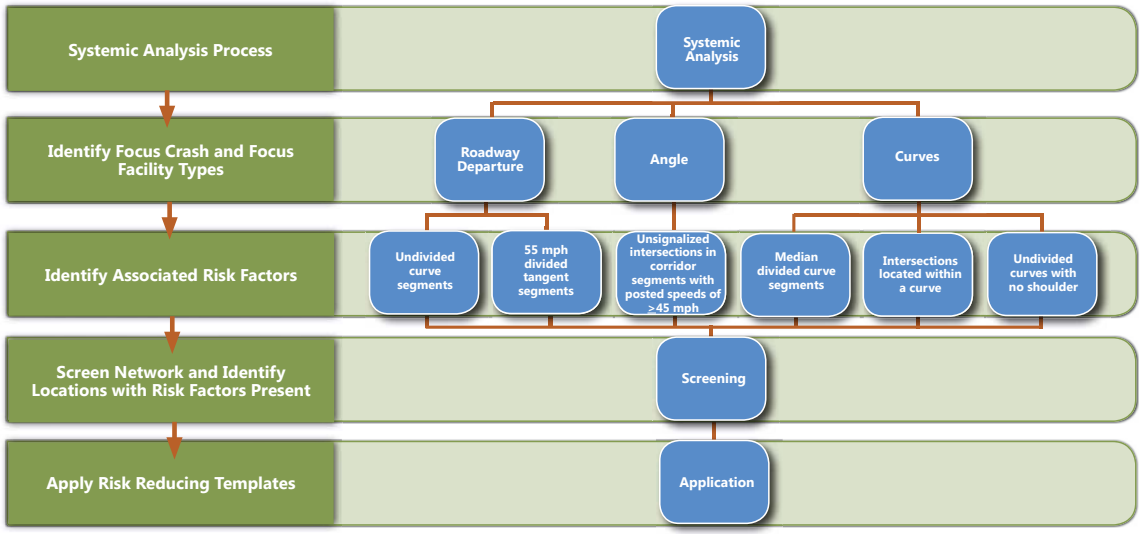

Figure 4.1.
Systemic Process.

4.2 Systemic Risk Factor Analysis

The following analysis involves the identification of focus areas and the associated risk factors. The data set used in the analysis includes 1,574 crashes for the five year period 2010-2014 over 78 miles, an average of four crashes per year/mile.

4.2.1 Primary Focus Areas

There are two types of focus areas in systemic data analysis: focus crash types and focus facility types. The following describes which focus areas were selected and what factors were used in that determination.

4.2.2 Focus Crash Types

The highest proportion of crashes are roadway departure followed by angle crash types as shown in Table 4.1. Together these two crash types comprised 54 percent of the total crashes and 70 percent of the severe crashes within the study area. (Note: KAB Crashes are fatal and severe crashes as noted by the KABCO scale: K = fatal crash, A = incapacitating injury, B = non-incapacitating injury, C = possible injury, and O = no injury.) Animal related crashes were the second most prevalent crash type within the study area. However, the animal related crash type was not included as a focus crash type as animal crashes only comprised three percent (3%) of the KAB crashes.

- The highest proportion of crashes are roadway departure followed by angle crash types.

Table 4.1.
Focus Crash Types.

	Focus Crash Types													
	Rear End	Deer	Other Animal	Ped	Backed Into	Other	Angle	Head-On	Sideswipe - Same Direction	Sideswipe - Opposite Direction	Fixed Object in Road	Train	Roadway Departure	Total
All Crashes	276	343	5	15	4	13	333	12	45	2	7	1	518	1,574
KAB Crashes	75	11		13		5	129	10	11		1	1	169	425
% of Total (n=1,574)	18%	22%	0%	1%	0%	1%	21%	1%	3%	0%	0%	0%	33%	
KAB % of Total (n=425)	18%	3%	0%	3%	0%	1%	30%	2%	3%	0%	0%	0%	40%	

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

1 American Association of State Highway and Transportation Officials. Highway Safety Manual. U.S. Department of Transportation, Federal Highway Administration

2 Federal Highway Administration Office of Safety. Systemic Safety Project Selection Tool. U.S. Department of Transportation, Federal Highway Administration.

4.2.3 Focus Facility Types:

- Curves

Table 4.2 contains a summary of the crashes and crash rates by facility type. While median divided segments had the highest number of total crashes, when looking at the length of the facility type, curves had the highest crash rate with 7.1 crashes per mile. There were 429 crashes and 123 severe crashes on curve segments throughout the study area.

4.3 Risk Factor Determination

The following is a description and overview of the risk factor determination for the focus crash types, roadway departure and angle crashes, and the focus facility type, curves. Included with the analysis are callout boxes highlighting elements related to the focus area risk factors.

4.3.1 Roadway Departure Crashes

Roadway departure crashes were the most prevalent crash type with 33 percent of the total crashes and 40 percent of the severe crashes. There were 518 total roadway departure crashes of which 169 were severe roadway departure crashes. Table 4.3 presents roadway departure crashes and total crashes with respect to the corridor type (divided or undivided) and the presence of shoulder. The crash distribution between divided and undivided corridor segments is slightly different between all crashes in the study area and roadway departure crashes specifically; there are slightly more crashes on divided segments for roadway departure than there are for all crash types. It is important to note that most of the roadway departure crashes occurred on divided roadway segments and both the percentage of crashes and the crash rate are higher for this type of corridor.

Table 4.2.
Focus Facility Types.

	Focus Crash Types					
	Median Divided Segments	Undivided Segments	Curves	Unsignalized Intersections	Signalized Intersections	Crossovers
All Crashes	1,270	270	429	269	152	489
KAB Crashes	345	71	123	87	42	
Mileage	61.7	16.72	17.4	-	-	-
Crashes/Mile	20.6	16.2	24.7	-	-	-
KAB Crashes/Mile	5.6	4.3	7.1	-	-	-

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.3.
Crashes by Corridor Type and Shoulder Presence.

Shoulder Presence	(Unknown)		Divided		Undivided		Total		% of Total (n=518)		KAB Total		% of KAB Total (n=169)	
	Roadway Departure	All Crash Types	Roadway Departure	All Crash Types	Roadway Departure	All Crash Types	Roadway Departure	All Crash Types	Roadway Departure	All Crash Types	Roadway Departure	All Crash Types	Roadway Departure	All Crash Types
Both Sides			417	1,188	23	63	440	1,251	85%	79%	141	341	83%	80%
Left Side Only			2	3	2	4	4	7	1%	0%	2	3	1%	1%
No Shoulder	10	34	14	64	46	200	70	298	14%	19%	25	77	15%	18%
Right Side Only			3	15	1	3	4	18	1%	1%	1	4	1%	1%
Total	**10**	**34**	**436**	**1,270**	**72**	**270**	**518**	**1,574**			**169**	**425**		
% Total (n=518)	2%	2%	84%	81%	14%	17%					33%	27%		
Mileage			61.7	61.7	16.72	16.72								
Crashes/Mile			7.1	20.6	4.3	16.1								
KAB Total	**2**	**9**	**146**	**345**	**21**	**71**	**169**	**425**						
% of KAB (n=169)	1%	2%	86%	81%	12%	17%								
KAB Crashes/Mile			2.4	5.6	1.3	4.2								

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

- Roadway Departure Crashes on Curves

Table 4.4 contains a summary of roadway departure crashes by curve or tangent segments. The majority of roadway departure crashes occurred on divided tangent segments; however, the roadway departure crash rate was higher for curve segments. Divided curve segments had the highest crash rate with 7.78 crashes per mile followed by undivided curve segments with 7.73 crashes per mile. In undivided segments, curves have a crash rate that is over three times that of tangent segments.

> The majority of roadway departure crashes occurred on divided tangent segments; however, the roadway departure crash rate was higher for curve segments.

Regarding the light conditions for roadway departure crashes on curve and tangent segments, Table 4.5 presents the crash rate was highest for undivided curves followed by divided curves both in daylight.

A comparison of crashes by weather condition for all crash types and roadway departure crash types is provided in Table 4.6. The table presents that drivers are more susceptible to roadway departure crashes in adverse weather conditions. There was a higher percentage of roadway departure crashes during rain or snow conditions compared to total crashes.

Table 4.7 provides the crashes for each corridor type and posted speed. The highest percentage of total and severe roadway departure crashes occurred in zones with 55 mph posted speed limits. Of all the corridor types (divided and undivided) and speed limits, divided corridor segments with posted speed limits of 55 mph experienced the most crashes at 48 percent of the total crashes and 51 percent of the severe crashes. Table 4.8 further compares these results with corridor types (tangent versus curve) other roadway departure speed and severity combinations.

As shown in Table 4.8, of all severe crashes on divided corridors with a posted speed of 55 mph, the majority of the crashes occurred on tangent sections (82 percent) rather than curves (16 percent). Similarly, tangent sections had a higher proportion of crashes for all roadway departure crashes, all severe roadway departure crashes, all roadway departure crashes on divided corridors, and all severe roadway departure crashes on divided corridor.

> Roadway departure crashes on 55 mph divided tangent segments experienced the most crashes.

Table 4.4.
Roadway Departure Crashes by Curve and Tangent Segments.

	Unknown				Divided						Undivided						Total			
	Crashes	% of Total	KAB Crashes	KAB % of Total	Crashes	% of Total	Crashes/ Mi	KAB Crashes	KAB % of Total	KAB crashes/ Mi	Crashes	% of Total	Crashes/ Mi	KAB Crashes	KAB % of Total	KAB crashes/ Mi	Total	% of Total	KAB Total	KAB % of Total
Curve	0	0%	0	0%	105	20%	7.78	31	18%	2.30	30	6%	7.73	10	6%	2.58	135	26%	41	24%
Tangent	10	2%	2	0%	331	64%	5.36	115	68%	1.86	42	8%	2.51	11	7%	0.66	383	74%	128	76%
Total	**10**	**2%**	**2**	**0%**	**436**	**84%**		**146**	**86%**		**72**	**14%**		**21**	**12%**		**518**		**169**	
Curve Mileage					13.5						3.88									
Tangent Mileage					61.7						16.72									

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.5.
Roadway Departure Crashes by Light Condition.

	Light Conditions	Unknown		Divided				Undivided				Total		Total KAB	
		Crashes	KAB Crashes	Crashes	Crashes/ Mi	KAB Crashes	KAB Crashes/ Mi	Crashes	Crashes/ Mi	KAB Crashes	KAB Crashes/ Mi	Crashes	Crashes/ Mi	Crashes	Crashes/ Mi
Tangent	Dark	5		149	3.09	50	1.04	21	1.65	4	0.31	175	2.87	54	0.89
	Daylight	5	2	182	3.78	65	1.35	21	1.65	7	0.55	208	3.41	74	1.21
	Total	**10**	**2**	**331**	**6.87**	**115**	**2.39**	**42**	**3.30**	**11**	**0.86**	**383**	**6.28**	**128**	**2.10**
Curve	Dark	-	-	50	3.70	16	1.19	13	3.35	5	1.29	63	3.62	21	1.21
	Daylight	-	-	55	4.07	15	1.11	17	4.38	5	1.29	72	4.14	20	1.15
	Total	-	-	**105**	**7.78**	**31**	**2.30**	**30**	**7.73**	**10**	**2.58**	**135**	**7.77**	**41**	**2.36**

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.6.
Crashes by Weather Conditions.

Weather Conditions	All Crashes	% of Total (n=1,574)	All KAB Crashes	% of Total (n=425)	Roadway Departure Crashes	% of Total (n=518)	KAB Roadway Departure Crashes	% of Total (n=169)
No Adverse Condition (Clear/Cloudy)	1,359	86%	376	88%	414	80%	145	86%
Blowing Sand, Soil, Dirt, or Snow	5	0%	1	0%	4	1%	1	1%
Severe Crosswinds	3	0%	0	0%	0	0%	0	0%
Fog	10	1%	3	1%	3	1%	0	0%
Mist	17	1%	5	1%	6	1%	1	1%
Rain	140	9%	31	7%	64	12%	16	9%
Snow	32	2%	6	1%	23	4%	5	3%
Sleet/Hail	5	0%	2	0%	3	1%	1	1%
Smoke/Dust	2	0%	1	0%	1	0%	0	0%
Other	1	0%	0	0%	0	0%	0	0%
Total	**1,574**		**425**		**518**		**169**	

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.7.
Roadway Departure Crashes by Corridor Type and Posted Speed.

Posted Speed	Unknown				Divided				Undivided				Total			
	Crashes	% of Total (n=518)	KAB Crashes	% of KAB (n=169)	Crashes	% of Total (n=518)	KAB Crashes	% of KAB (n=169)	Crashes	% of Total (n-518)	KAB Crashes	% of KAB (n=169)	Crashes	% of Total (n-518)	KAB Crashes	% of KAB (n=169)
0	1	0%	0	0%	172	33%	54	32%	34	7%	10	6%	207	40%	64	38%
25	0	0%	0	0%	1	0%	1	1%	0	0%	0	0%	1	0%	1	1%
35	3	1%	2	1%	1	0%	1	1%	1	0%		0%	5	1%	3	2%
45	1	0%	0	0%	9	2%	3	2%	9	2%	2	1%	19	4%	5	3%
50	0	0%	0	0%	2	0%	0	0%	0	0%	0	0%	2	0%	0	0%
55	5	1%	0	0%	251	48%	87	51%	28	5%	9	5%	284	55%	96	57%
Total	**10**		**2**		**436**		**146**		**72**		**21**		**518**		**169**	

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.8.
Comparison of Roadway Departure Crashes for Tangent and Curve Segments.

	KAB Crashes - Divided Corridor - Posted Speed 55 MPH	% of Total (n=87)	All Roadway Departure	% of Total (n=518)	All KAB Roadway Departure	% of Total (n=169)	All Roadway Departure - Divided Corridor	% of Total (n=436)	All KAB Roadway Departure - Divided Corridor	% of Total (n=146)
Tangent	71	82%	383	74%	128	76%	331	76%	115	79%
Curve	16	18%	135	26%	41	24%	105	24%	31	21%
Grand Total	**87**		**518**		**169**		**436**		**146**	

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

4.3.2 Angle Crashes

Angle crashes were the second most prevalent crash type in the study area. There were 333 total angle crashes, of which 129 were severe angle crashes. Relative to all other crash types, angle crashes comprised 21 percent of all the total crashes and 30 percent of the severe crashes.

As shown in Table 4.9, approximately half of the total and severe angle crashes occurred at non-intersection locations, most likely driveways or crossovers. A slightly higher percentage of severe crashes occurred at unsignalized intersections than did total crashes (36 percent of severe crashes versus 33 percent of total crashes).

- Angle crashes most prevalent at non-intersection locations.
- Unsignalized intersections have higher percentage of KAB crashes.

- Angle Crashes at Non-Intersection Locations

Roughly half of all angle crashes occurred at non-intersection locations. Although there were more crashes on divided corridors, as shown in Table 4.10, the crash rate was roughly 1.75 times higher for undivided corridors. This difference was less pronounced for severe angle crashes. At non-intersection locations the areas most at risk are those locations with high driveway/access point density.

Implementing geometric changes, such as modifying/combining access points, are measures that could be used to address this risk factor. However, those are not systemic countermeasures that can be applied on a wide-spread scale and would instead be addressed through site specific analysis. Chapter 5 of this report addresses crossover and intersection crashes and suggestions for modifying median openings and Chapter 6 addresses site specific locations.

- Roughly half of angle crashes occurred at non-intersection locations and most of those crashes were on undivided corridors.

- Angle Crashes at Unsignalized Intersections

Roughly two thirds (68 percent) of all angle crashes at unsignalized intersections occurred during the daylight as shown in Table 4.11. That proportion increased for KAB crashes with 77 percent occurring during daylight hours. This indicates that lack of roadway lighting is not a significant contributory factor to the crashes in the study area.

Table 4.9.
Angle Crashes by Intersection Type.

Intersection Type	Total Angle Crashes					KAB Angle Crashes				
	Divided Corridor	Undivided Corridor	Unknown	Total	% of Total Angle Crashes	Divided	Undivided	Unknown	Total	% of Total KAB Angle Crashes
Signalized	46	6		52	16%	17			17	13%
Unsignalized	94	17		111	33%	40	7		47	36%
Non-intersection*	112	52	6	170	51%	49	14	2	65	50%
Total	**252**	**75**	**6**	**333**		**106**	**21**	**2**	**129**	

*Non-intersection is a driveway or crossover.
Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.10.
Non-Intersection Angle Crashes and Crash Rates.

Intersection Type	Total Angle Crashes		KAB Angle Crashes	
	Divided Corridor	Undivided Corridor	Divided	Undivided
Non-intersection*	112	52	49	14
Mileage	61.7	16.62	61.7	16.62
Crash Rate (Crashes/Mile)	1.82	3.13	0.79	0.84

*Non-intersection is a driveway or crossover.
Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.11.
Light Conditions of Angle Crashes at Unsignalized Intersections.

Light Condition	Total Angle Crashes				KAB Angle Crashes			
	Divided	Undivided	Total Crashes	% of Total (n=111)	Divided	Undivided	Grand Total	% of Total KAB (n=47)
Daylight	64	12	76	68%	30	6	36	77%
Dark	30	5	35	32%	10	1	11	23%
Total			**134**				**47**	

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.12 shows the crashes by posted speed limit for angle crashes at unsignalized intersections, all unsignalized intersection crashes, and all crashes in the study area. Angle crashes at unsignalized intersections are most prevalent in corridor segments with posted speeds of 55 mph; however, the percentage of severe angle crashes at unsignalized intersections with 45 mph posted speed limits is almost double the percentage for all crashes in the study area (13 percent versus 7 percent).

- Severe angle crashes at unsignalized intersections with 45 mph posted speed limits account for almost double those occurring throughout the rest of the study area.

In reviewing the driver actions in Table 4.13, the majority of total and severe angle crashes at unsignalized intersections (77 percent and 72 percent respectively) involved drivers failing to yield or failing to obey the intersection control. These actions are most likely tied to gaps in traffic; in periods of high volumes it may be difficult for drivers to find an acceptable gap to enter traffic and may be willing to enter traffic rather than wait for an acceptable gap, or high speeds may make it more difficult for drivers to judge acceptable gaps in traffic.

The factors influencing drivers' ability to judge acceptable gaps may be related to sight distance, speed, time of day, vehicle type, and point of departure/maneuver within the intersection. Review and evaluation of the posted speed limit is addressed in Chapter 3 of this report. Education and enforcement of the posted speed limit throughout the study area could also help to address speed related crashes. Implementing geometric changes, such as modifying access or realigning a skewed intersection, or changing the intersection control from stop controlled to signalized, or from full movement to a restricted crossing u-turn (RCUT) intersection, are measures that could be used to address these risk factors. However, except for education and enforcement targeting speeding, the other measures are not systemic-countermeasures that can be applied on a wide-spread scale and would instead be addressed through site specific analysis.

- The majority of total and severe angle crashes at unsignalized intersections involved drivers failing to yield or failing to obey the intersection control indicating there may be issues with gap judgment at unsignalized intersections.

Table 4.12.
Crashes by Posted Speed.

Posted Speed Limit	Angle - Unsignalized Intersection				All Unsignalized Intersection Crashes				All Crashes			
	All Crashes	% of Total (n=111)	KAB Crashes	% of Total (n=47)	All Crashes	Percent of Total (n=269)	KAB Crashes	% of Total (n=87)	All Crashes	Percent of Total (n=1,574)	KAB Crashes	% of Total (n=425)
(Unknown)	72	65%	27	57%	155	58%	42	48%	722	46%	195	46%
15	0	0%	0	0%	0	0%	0	0%	1	0%	0	0%
25	0	0%	0	0%	0	0%	0	0%	3	0%	1	0%
35	3	3%	3	6%	5	2%	3	3%	21	1%	8	2%
45	10	9%	6	13%	21	8%	10	11%	98	6%	29	7%
50	0	0%	0	0%	1	0%	1	1%	9	1%	3	1%
55	26	23%	11	23%	87	32%	31	36%	720	46%	189	44%
Total	**111**		**47**		**269**		**87**		**1,574**		**425**	

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.13.
Driver Action in Angle Crashes at Unsignalized Intersections.

Action (Driver 1)	All Crashes	% of Total (n=111)	KAB Crashes	% of KAB Total (n=47)
Did Not Have Right of Way	77	69%	29	62%
Disregarded Intersection Control	6	5%	4	9%
Fail to Stop at Through Highway - No Sign	1	1%	1	2%
Exceeded Speed Limit	1	1%	1	2%
Fail to maintain proper control	6	5%	4	9%
Following Too Close	2	2%	1	2%
Improper or unsafe lane change	2	2%	0	0%
Improper Turn from Wrong Lane	2	2%	1	2%
No Improper Action	12	11%	5	11%
Other	2	2%	1	2%
Grand Total	**111**		**47**	

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

4.3.3. Curves

There were 429 total and 123 severe crashes on curve segments. There are approximately 17 miles of curves resulting in 25.2 total crashes per mile and 7.1 severe crashes per mile as presented in Table 4.14. While the crashes per mile are fairly evenly split between crashes on divided and undivided segments for both fatal and severe crashes, there is a higher percentage of total and severe crashes on divided segments.

- The majority of curve crashes occurred on divided corridor segments.

As shown in Table 4.15, the direction of travel related to crashes on curves is relatively evenly split between the north and southbound directions with only 14 more crashes in the northbound direction. Between the east and westbound directions, there are significantly more crashes in the eastbound direction. However, after reviewing the crash information, it appears that many of the east and westbound direction of travel have been incorrectly identified in the crash reports.

- Curves - Divided Corridor

There is little difference in light condition for crashes that occurred on median divided curve segments. For both total and severe crashes, roughly 50 percent of the crashes occurred during both dark and daylight conditions.

Within median divided curves the most prevalent crash types were related to intersections (rear end and angle crash types) and roadway departure with 49 percent and 33 percent of severe crashes respectively as shown in Table 4.17. A majority of the deer, pedestrian, head-on, and roadway departure crashes occurred during dark conditions.

Roadway departure crashes comprised 31 percent of total crashes and 33 percent of severe median divided curve crashes throughout the study area. Rumble strips are a countermeasure designed to reduce roadway departure crashes and were installed in various locations throughout the study area as recommended in the 2002 Study. The rumble strip installation was completed in 2014 and as such, it is too soon to determine the effect on crashes.

Shoulders can also have an effect on roadway departure crashes as they provide recovery area for drivers who leave their travel lane. Table 4.18 provides the number of roadway departure crashes on undivided and divided curve corridors by shoulder presence. On median divided curves almost all of the crashes occurred where both left and right shoulders were present. On undivided curve sections most of the crashes occurred on sections with no shoulder.

- On undivided curve sections most of the crashes occurred on sections with no shoulder.

4.4 Summary

The previous section discussed findings related to the focus crash and facility types and investigated trends and risk factors related to study area geometric features and crash data. The following is a summary of the systemic risk factors or locations where the risk factors are present along the corridor.

- Focus Crash Type: Roadway Departure
  - Undivided curve segments
  - 55 mph divided tangent segments
- Focus Crash Type: Angle
  - Unsignalized intersections in higher speed corridor segments (those with posted speeds of 45 mph or greater)
- Facility Types: Curves
  - Median divided curve segments
  - Intersections located within a curve
  - Undivided curves with no shoulder

Table 4.14.
Divided and Undivided Curve Crashes.

	Divided			Undivided			Total	
	Number of Crashes	% of Total	Crashes/Mile	Number of Crashes	% of Total	Crashes/Mile	Number of Crashes	Crashes/Mile
All Crashes	340	79%	25.2	89	21%	22.9	429	24.7
KAB Crashes	95	77%	7.0	28	23%	7.2	123	7.1
Mileage	13.5			3.9			17.4	

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.15.
Curve Crashes by Corridor Type and Direction of Travel.

Direction of Travel	Divided						Undivided						(Unknown)		Grand Total
	Total Crashes	KAB	% of Total	Curve Crashes	KAB Curve Crashes	KAB % of Total	Total Crashes	KAB	% of Total	Curve Crashes	KAB Curve Crashes	KAB % of Total	Total Crashes	KAB (Unknown) Crashes	
EB	1	0	0%	0	0	0%	112	33	29%	21	7	33%	0	0	113
WB	0	0	0%	0	0	0%	9	2	22%	1	0	0%	0	0	9
NB	620	167	27%	169	48	28%	85	20	24%	36	12	33%	25	7	730
SB	643	176	27%	170	47	28%	64	16	25%	31	9	29%	9	2	716
(blank)	6	2	0%	1											6
Total	**1,270**						**270**						**34**		**1,574**

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.16.
Curve Crashes on Median Divided Corridors by Crash-Type and Light Condition.

Crash Type	Total Crashes		Crashes During Dark Conditions		Crashes During Light Conditions		KAB Crashes		KAB Crashes During Dark Conditions		KAB Crashes During Light Conditions	
	Number of Crashes	% of Total Crashes	Number of Crashes	% of Total Crashes per Crash Type	Number of Crashes	% of Total Crashes per Crash Type	Number of Crashes	% of Crashes	Number of Crashes	% of Crashes per Crash Type	Number of Crashes	% of Crashes per Crash Type
Rear End	62	18%	12	19%	50	81%	14	15%	4	29%	10	71%
Deer	69	20%	60	87%	9	13%	3	3%	2	67%	1	33%
Ped	5	1%	3	60%	2	40%	5	5%	3	60%	2	40%
Other	4	1%	0	0%	4	100%	2	2%	0	0%	2	100%
Angle	79	23%	30	38%	49	62%	33	35%	11	33%	22	67%
Head On	2	1%	2	100%	0	0%	2	2%	2	100%	0	0%
Sideswipe - Same Direction	13	4%	5	38%	8	62%	5	5%	1	20%	4	80%
Fixed Object in Road	1	0%	0	0%	1	100%	0	0%	0	0%	0	0%
Roadway Departure	105	31%	50	48%	55	52%	31	33%	16	52%	15	48%
Total	**340**		**162**	**48%**	**178**	**52%**	**95**		**39**	**41%**	**56**	**59%**

	% of Total Crashes	% of KAB Crashes
Intersection-type crashes	41%	49%
Roadway Departure	31%	33%

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.17.
Intersection Crashes on Median Divided Curves.

Intersection Type	Total Crashes	% of Total Crashes	Total Crashes During Dark Conditions	% of Crashes During Dark Conditions	KAB Crashes	% of KAB Crashes	KAB Crashes During Dark Conditions	% of Crashes During Dark Conditions
Signalized	51	15%	16	31%	16	17%	7	44%
Unsignalized	74	22%	32	43%	21	22%	5	24%
Non-intersection	215	63%	114	53%	58	61%	27	47%

	% of Total Crashes	% of KAB Crashes
Intersection-type crashes	37%	39%

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.18.
Roadway Departure Curve Crashes by Corridor Type and Shoulder Presence.

Shoulder Presence	Divided Curve Crashes	Undivided Curve Crashes	Total Crashes
Both sides	100	5	105
No Shoulder	2	25	27
Right side only	3		3
Left side only	3		3
Total	**105**	**30**	**135**

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

4.5 Countermeasure Selection

The countermeasures to be applied are included in the risk reducing templates; a set of documents containing specific sets of sign, pavement marking, or other traffic control device applications that correspond to various roadway sections (i.e., intersection, curve, and corridor segment). Most templates have three (3) tiers or levels of measures. The first tier is the application of signs and pavement markings to be installed to bring the road section in compliance with the MUTCD and to provide a consistent look and feel to the corridor. Each subsequent tier includes additional signs, markings, Traffic Control Devices (TCD), or other safety mitigation measures that builds upon the base nature of Tier 1 in degree of investment. Any additional improvement measures would be considered on a site-by-site basis and are included in the site specific analysis in Chapter 6.

The following Templates are applied to the study area and are included in Appendix A:

- Template 1 – Unsignalized Intersection – 4-leg (2-way stop controlled), undivided
- Template 2 – Unsignalized Intersection – 4-leg (2-way stop controlled)
- Template 3 – Unsignalized Intersection – 3-leg (1-way stop controlled), undivided
- Template 4 – Unsignalized Intersection – 3-leg (1-way stop controlled), median separated (with crossover)
- Template 5 – Unsignalized Intersection – 3-leg (1-way stop controlled), median separated (no crossover)
- Template 7 – Signalized Intersection – 3-leg
- Template 8 – Signalized Intersection – 4-leg
- Template 9 – Corridor – Undivided Roadway
- Template 10 – Corridor – Divided Roadway
- Template 11 – Curve – Undivided Roadway
- Template 12 – Curve – Divided Roadway
- Template 16 – Pedestrian Measures

Selection of the tiers is based on combinations of the following elements: the systemic risk factors, Potential for Safety Improvement (PSI), and crash rate.

4.5.1 Systemic Risk Factors

Systemic risk factor selection is described in the systemic data analysis section of this chapter.

4.5.2 Potential for Safety Improvement

A PSI is the difference between the expected crashes of a roadway segment or intersection and the amount of crashes experienced. Locations with the greatest PSI, or the greatest difference between expected and experienced crashes, indicate a higher priority need for highway safety improvements.

The PSI locations used in this analysis relate to the risk factors shown in Figure 4.1 and were created by VDOT using the top 100 PSI locations for the Hampton Roads District between 2011 and 2013.

4.5.3 Crash Rate

Table 4.19 contains crash rate information related to the 2002 Study and current crash rates. The crash rates used to determine which tier of countermeasure to apply are those segments with high crash rates (see "2010-2014 Crash Rate") and also those segments where the crash rates have increased (see "Change in Crash Rate" and "% Change in Crash Rate").

4.5.4 Tier Selection

The tier selection methodology is as follows:

- **Tier 1:** This tier is applied to each corridor segment and intersection.
- **Tier 2:** This tier is applied anywhere a combination of two of the tier selection elements (PSI location and systemic risk factor present; crash risk and systemic risk factor present; or crash risk and PSI location).
- **Tier 3:** This tier is applied anywhere all three tier selection elements are present (crash risk, PSI location, and systemic risk factor present).

4.5.5 Results

Table 4.20 and Table 4.21 contain the summary of the template tier application for intersections and corridor segments. Figures 4.2 – 4.15 depict the intersection and corridor template and tiers by location. It is important to note that some of the corridor templates overlap each other resulting in the total length of template application being greater than the length of corridor found in the study area. A complete listing of template and tier application locations are provided in Appendix A.

Table 4.19.
Light Conditions of Angle Crashes at Unsignalized Intersections.

Segment	Miles	1997-1999 Crash Rate (Crashes per 100 Million VMT)	2010-2014 Crash Rate (Crashes per 100 Million VMT)	Crash Rate Difference	% Change in Crash Rate
Rt 175 - State Line	4.09	61	64	3	4.7%
Rt 695 - Rt 175	3.69	82	69	-13	-18.8%
Rt 187 - Rt 695	5.77	85	86	1	1.2%
Rt 176 - Rt 187	4.76	63	68	5	7.4%
Rt 764 - Rt 176	3.62	111	93	-18	-19.4%
Chesapeake Square - Rt 764	2.91	67	117	50	42.7%
Rt 179 - Chesapeake Square	0.29	147	90	-57	-63.3%
US13 Bus. - Rt 179	0.74	110	106	-4	-3.8%
Rt 626 - US13 Bus.	2.92	64	66	2	3.0%
Rt 180/696 - Rt 626	2.37	59	38	-21	-55.3%
Rt 180/696 - Rt 626	2.68	64	35	-29	-82.9%
Rt 182/614 - Rt 180/696	3.91	89	19	-70	-368.4%
Rt 183 - Rt 178	0.52	54	6	-48	-800.0%
Rt 652 - Rt 183	0.98	171	102	-69	-67.6%
Rt 606 - Rt 652	3.53	115	66	-49	-74.2%
Rt 631 - Rt 606	9.75	90	74	-16	-21.6%
Rt 680 - Rt 631	4.93	73	60	-13	-21.7%
Rt 184 - Rt 680	1.22	101	135	34	25.2%
CBBT - Rt 184	9.34	80	107	27	25.2%

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.20.
Intersection Template Tier Summary.

Template	Tier 1	Tier 2	Tier 3	Total
Template 1	5			5
Template 2	18	11	3	32
Template 3	27	1		28
Template 4	68	20		88
Template 5	63	26	1	90
Template 7	2			2
Template 8	18	7	2	27
Template 16	8			8
Total	**209**	**65**	**6**	**280**

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

Table 4.21.
Corridor Template Tier Summary.

Template	Tier 1 Length (Mi)	Tier 2 Length (Mi)	Tier 3 Length (Mi)	Total
Template 9	18	11	3	32
Corridor – Undivided Roadway	16.61	0	0	16.61
Template 10	68	20		88
Corridor – Divided Roadway	43.72	17.03	0.94	61.69
Template 11				
Curve – Undivided Roadway	3.88	0	0	3.88
Template 12				
Curve – Divided Roadway	8.63	4.53	0.34	13.5
Grand Total	**72.84**	**21.56**	**1.28**	**95.68**

Sources: VDOT Tableau (2010-2014), VDOT Roadway Inventory, VHB aerial and video data collection.

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Figure 4.2
Potential for Safety Improvement Locations
Eastern Shore Safety Study

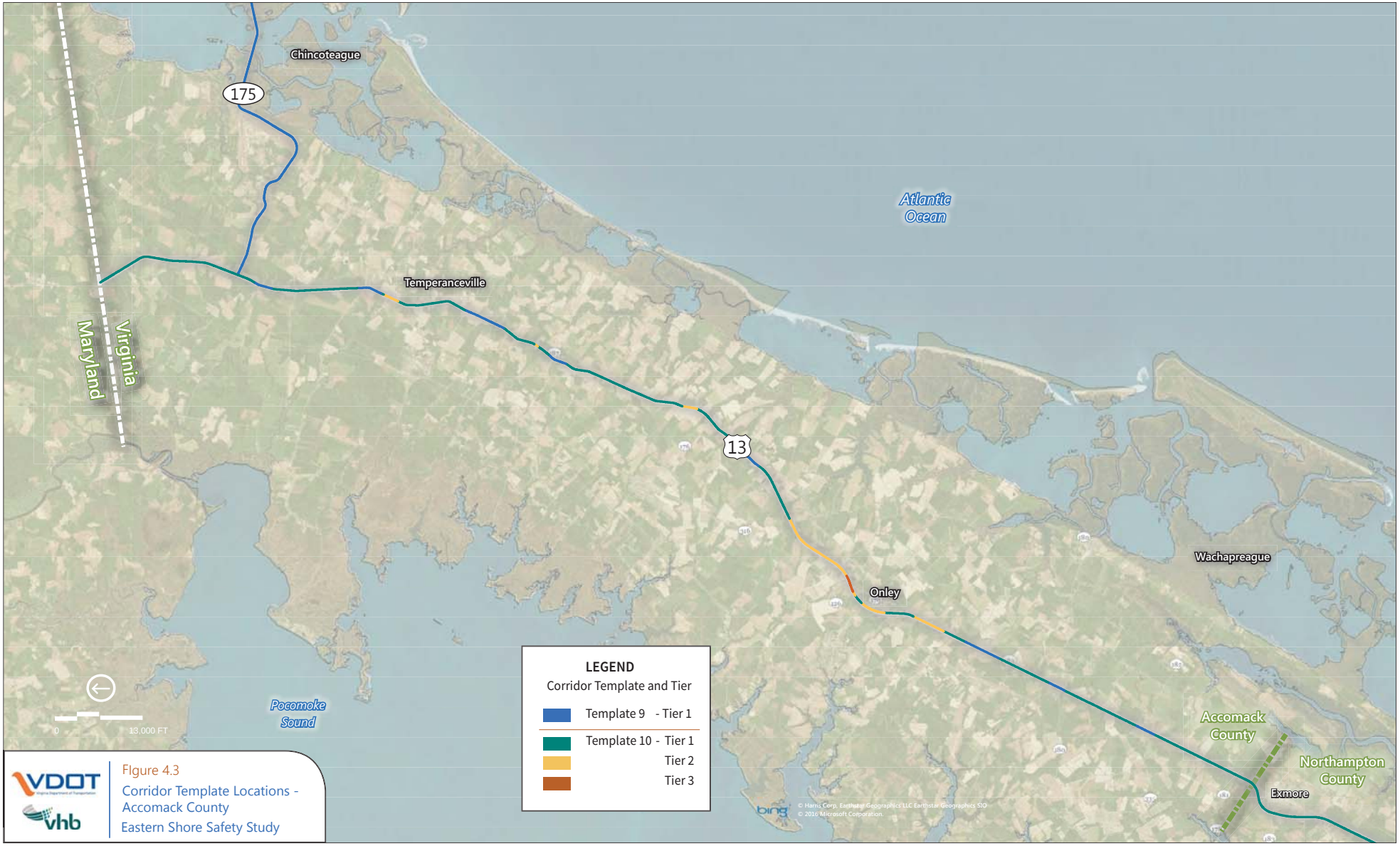

Figure 4.3
Corridor Template Locations - Accomack County
Eastern Shore Safety Study

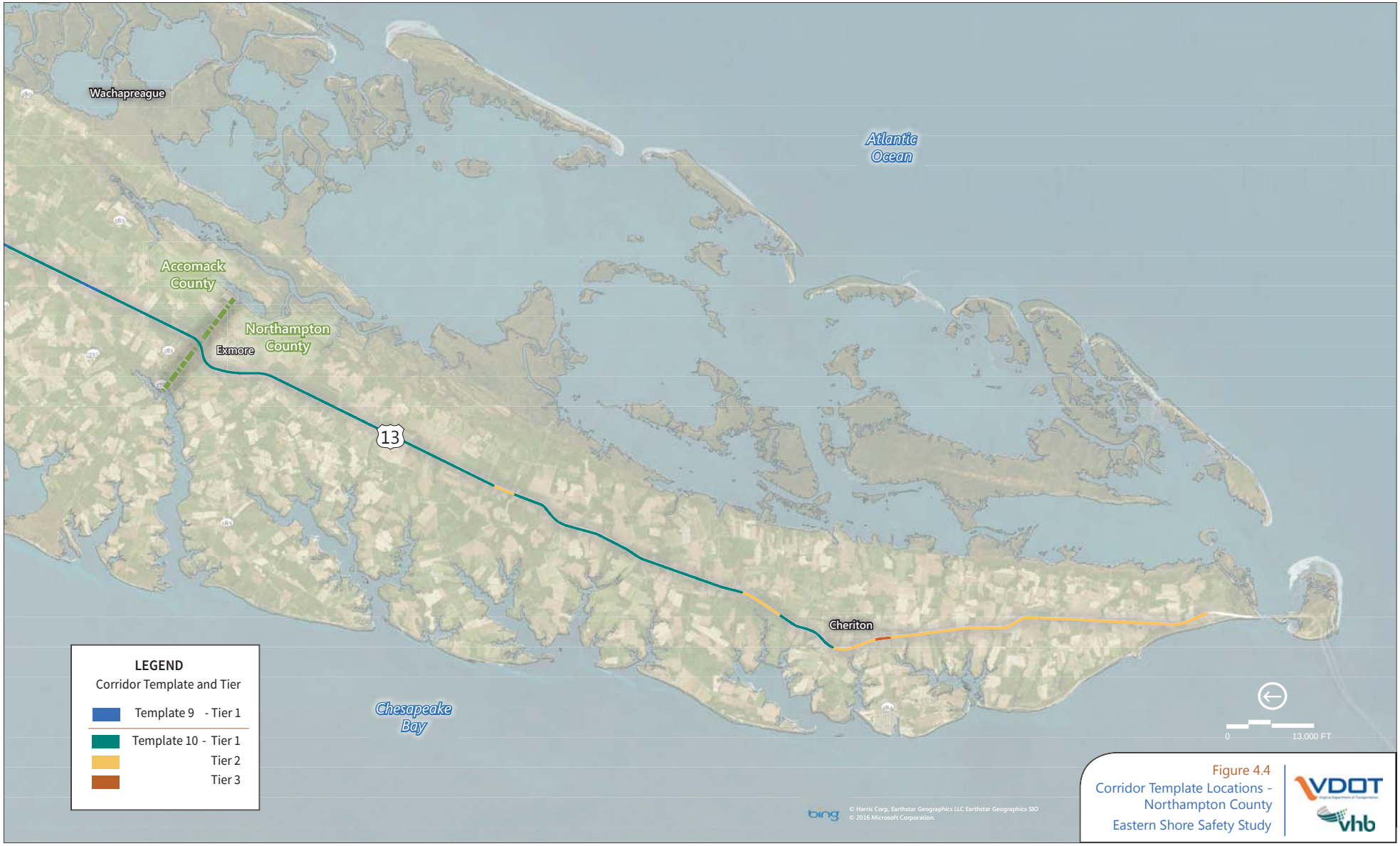

Figure 4.4
Corridor Template Locations - Northampton County
Eastern Shore Safety Study

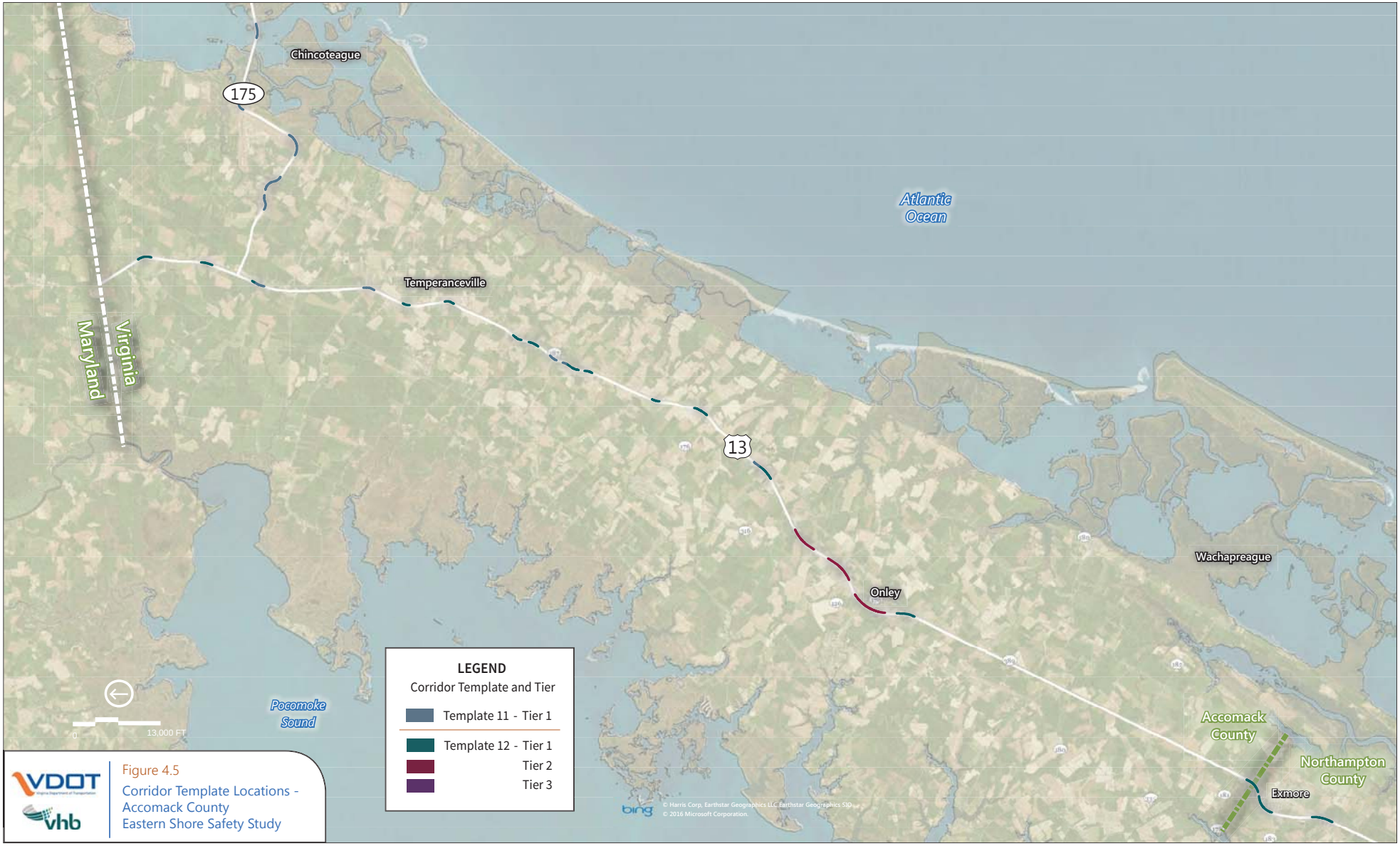

Figure 4.5
Corridor Template Locations - Accomack County
Eastern Shore Safety Study

Figure 4.6
Corridor Template Locations - Northampton County
Eastern Shore Safety Study

Figure 4.7
Intersection Template Locations
Eastern Shore Safety Study

Figure 4.8
Intersection Template Locations
Eastern Shore Safety Study

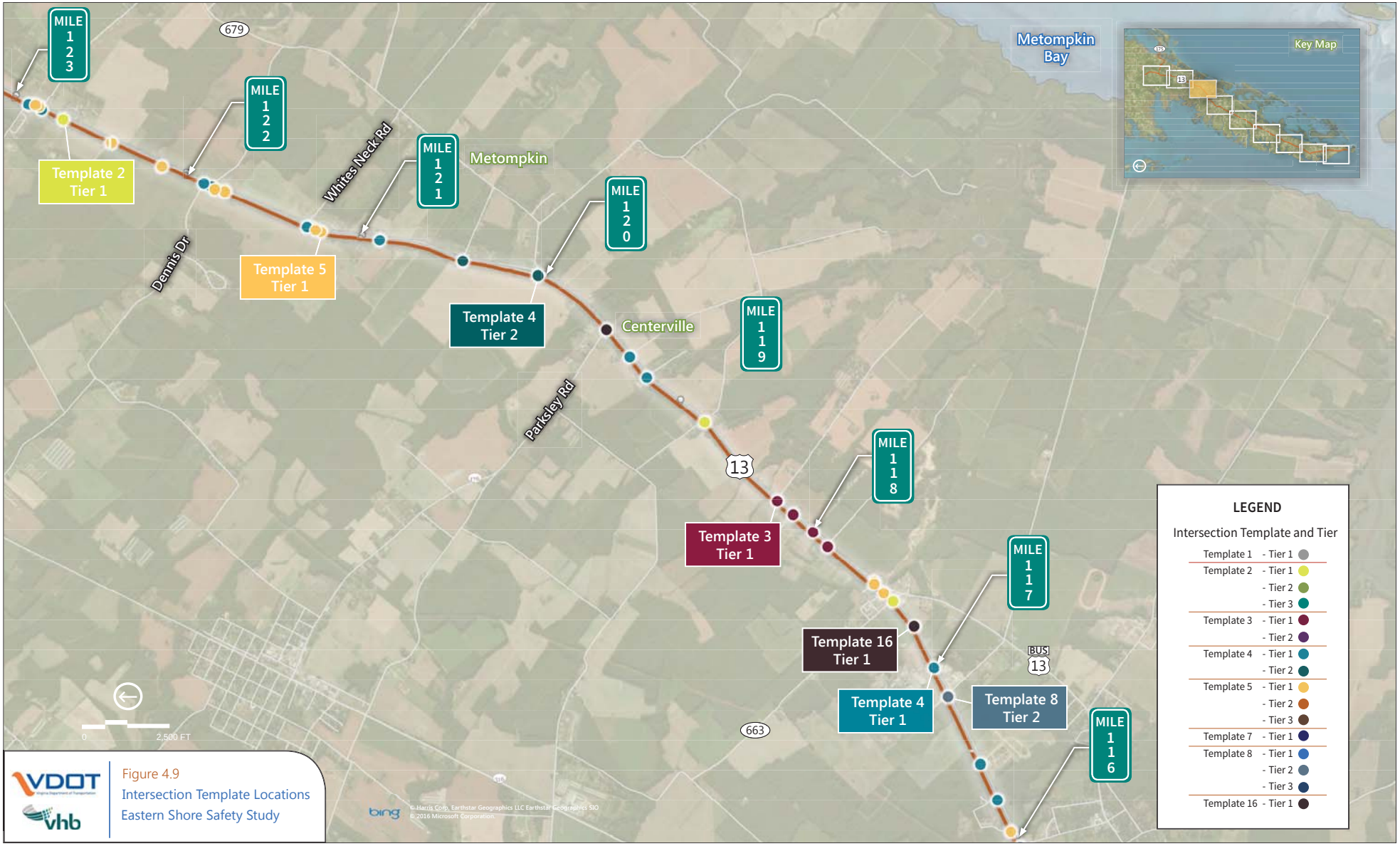

Figure 4.9
Intersection Template Locations
Eastern Shore Safety Study

Figure 4.10
Intersection Template Locations
Eastern Shore Safety Study

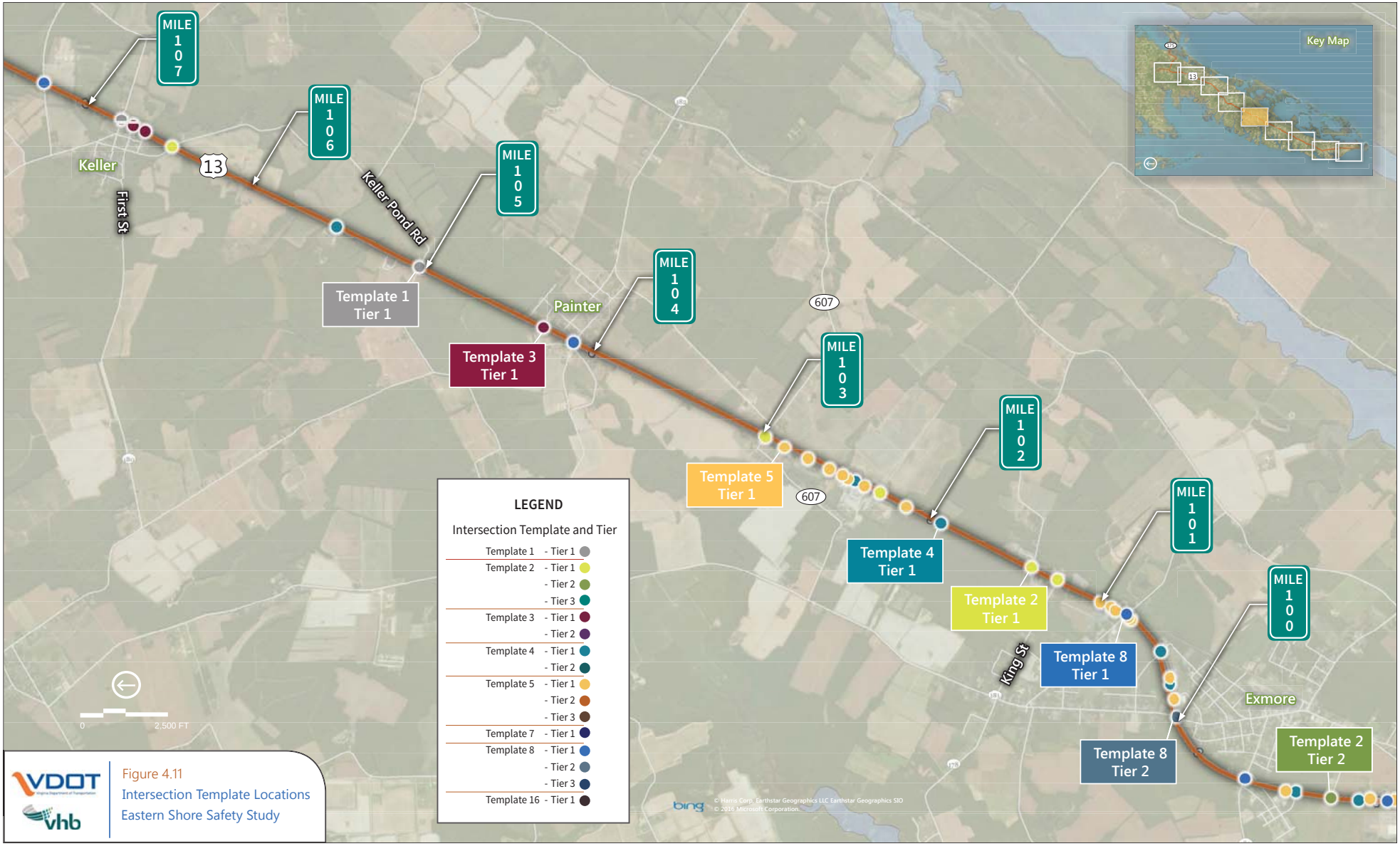

Figure 4.11
Intersection Template Locations
Eastern Shore Safety Study

Figure 4.12
Intersection Template Locations
Eastern Shore Safety Study

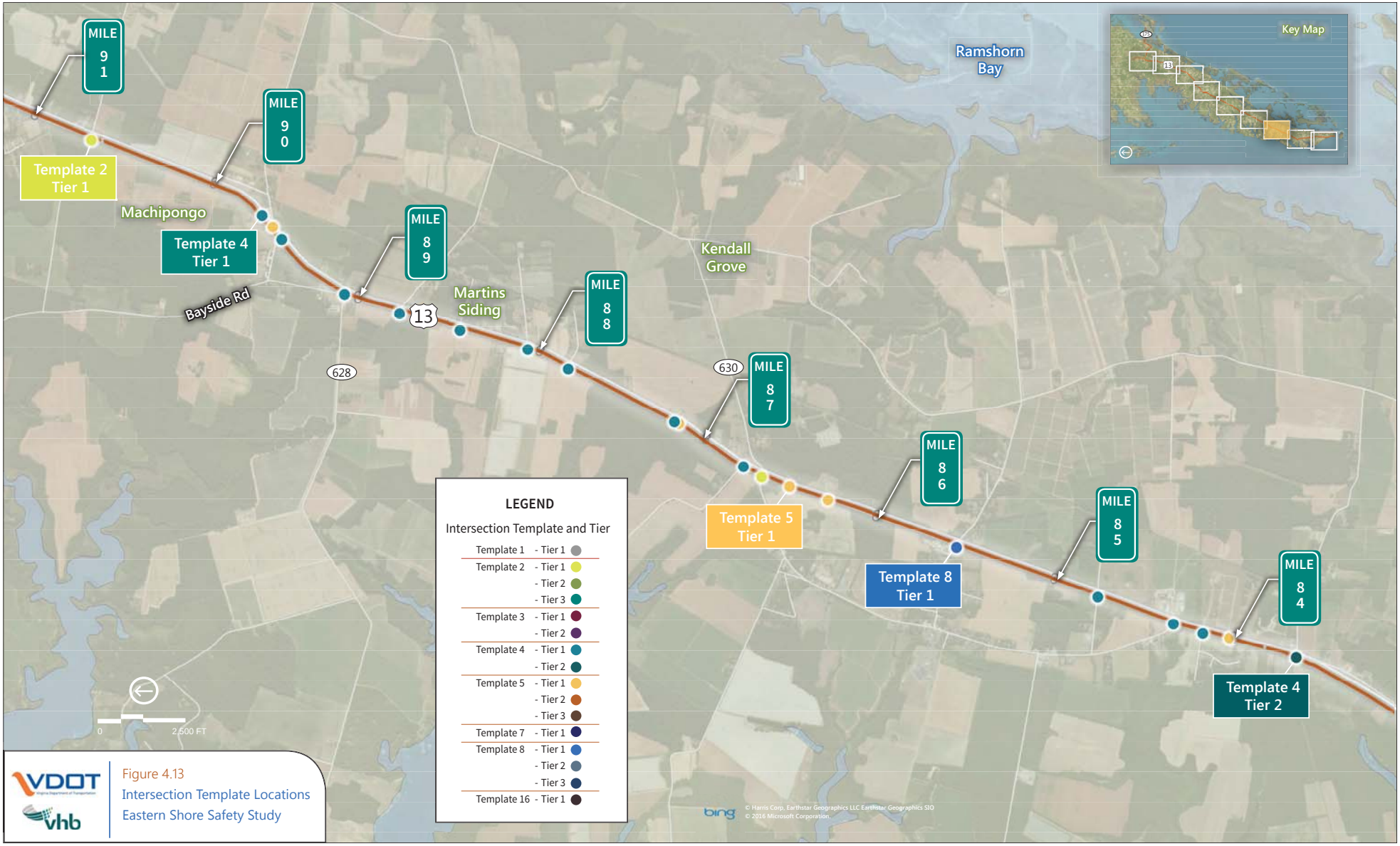

Figure 4.13
Intersection Template Locations
Eastern Shore Safety Study

Figure 4.14
Intersection Template Locations
Eastern Shore Safety Study

Figure 4.15
Intersection Template Locations
Eastern Shore Safety Study