
Monroe County Department of Transportation

Vertical Curve Safety Study

Monroe County, New York



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PREPARED FOR:

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1.0 Executive Summary

The Monroe County Vertical Curve Safety Study was initiated by the Monroe County Department of Transportation (MCDOT) to identify/investigate all vertical curve locations within the County. Monroe County Department of Transportation owns and maintains approximately 274 roads within the County, containing 663 centerline miles.

The purpose of this Vertical Curve Safety Study is to identify non-standard vertical curves on County roads and to evaluate non-standard vertical curve locations within the County that have a history of safety concerns. Non-standard vertical curves do not meet the minimum sight distance requirements for a crest vertical curve as defined by the American Association of State Highway and Transportation Officials (AASHTO). The study scope and parameters have been developed in consultation with Monroe County and the MCDOT point system for prioritizing vertical curves and the procedures conform to guidelines recommended by AASHTO. The intent is to identify vertical curves where improvements are proposed for consideration by Monroe County.

The overall project study area included all County Route roadways and intersections within Monroe County. **Figure ES-1** identifies the roadways studied.

Using data supplied by MCDOT, an inventory of vertical curve locations was compiled and rated based on a series of factors. Key factors include high incidents of accidents in the areas where the vertical curves are located, and stopping sight distances that are less than values recommended by AASHTO for the roadway's 85th percentile speeds. Locations that met the criteria were highlighted for further investigation. Survey data was used to further investigate the effect of each vertical curve location on stopping sight distance and to determine a list of locations for recommended remediation.

The steps taken to complete the project analysis are previewed below and identified in **Figure ES-2**. A predetermined series of Filters was used to pinpoint the High priority Candidate Vertical Curve Locations that were recommended for mitigation. A brief description of each filter is summarized below; further discussion follows within the text of this section.



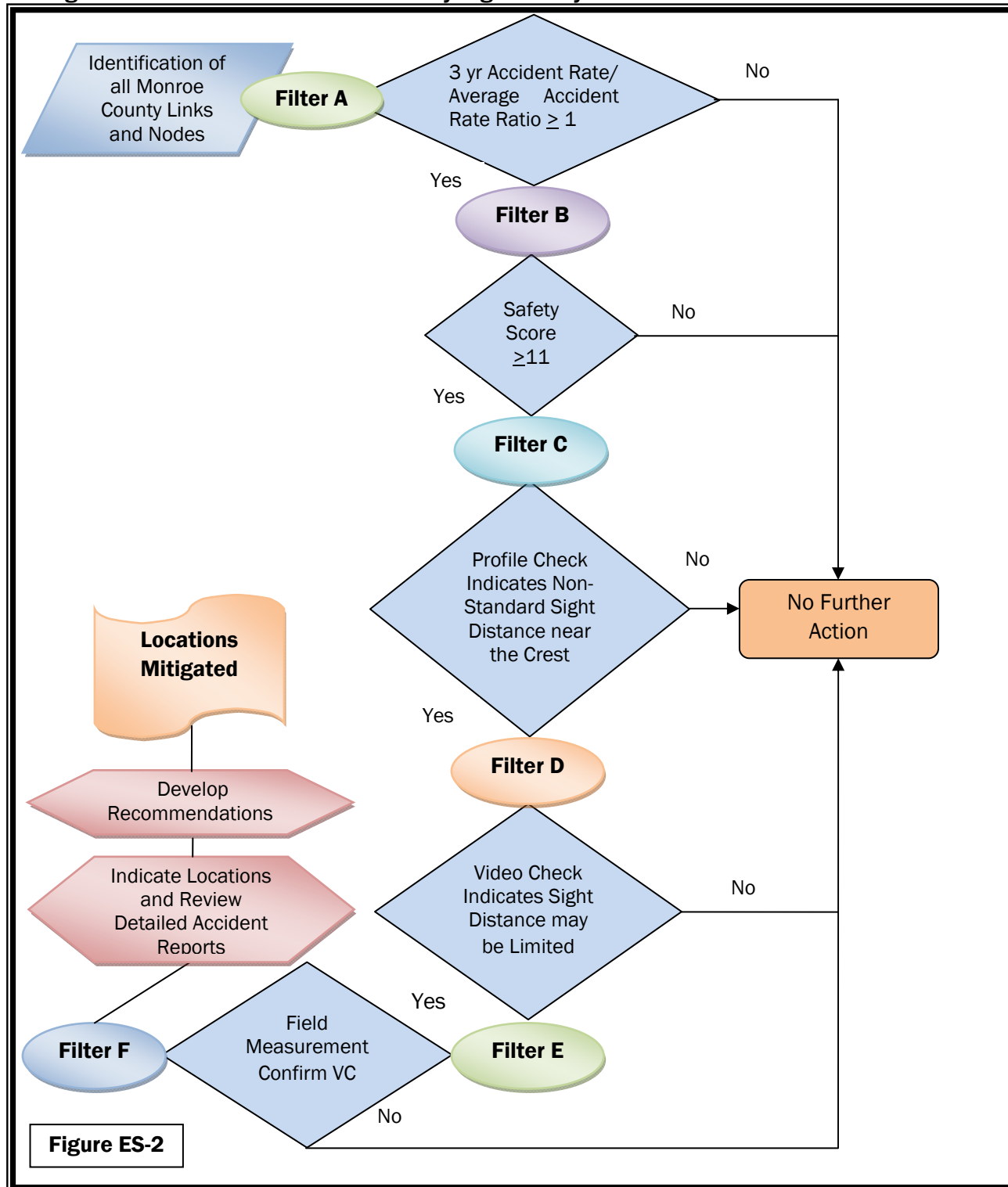
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FIGURE ES-1
Monroe County DOT
Vertical Curve Safety Study
Project Study Area



The process used to complete the project analysis is illustrated in **Figure ES-2**.

Figure ES-2 – Filter Flowchart to Identify High Priority Candidate Vertical Curve Locations





“Filter A” – Accident Ratio Comparison

1. A total of **1,678** nodes and **2,803** links for a total of **4,481** locations were identified within the County Route road system.
2. A spreadsheet was created to track the entries associated with each location.
3. The accident rates for reportable accidents for each link and the average accident rates were identified.
4. The ratio between the Average Three Year Accident Rate and the Average Accident Rate was calculated.
5. All locations with ratios greater than or equal to one were identified as potential candidate locations and progressed to the next filter (Filter B). A total of **1,303** locations were progressed.

“Filter B” – Safety Score Determination

1. The total number of accidents where the terrain description included reference to a curve was logged for each location listed. The following “roadway characteristic” codes were transferred to the link calculation spreadsheet:

- 03 - Straight and Hillcrest
- 04 - Curve and Level
- 05 - Curve and Grade
- 06 - Curve and Hillcrest

All accidents with curve codes were included in the analysis to encompass accidents located on a vertical curve that may have been miscoded in the accident report.

2. The Average Daily Traffic (ADT) volume was entered for each link.
3. The 85th Percentile speed was estimated and entered into the spreadsheet for each link identified in this filter. The speed limit plus 10 mph was used to estimate the 85th Percentile speed.
4. Terrain Navigator Pro software was used to determine the vertical curve locations for each location with an accident rating ratio greater than one. After the grade variations were confirmed in a later step, the SSD and ISD were measured and entered into the calculation sheet
5. A point system was developed considering the accidents, volume, speed and estimated sight distance. The total point value was evaluated for each location identified within this filter and sorted from highest to lowest. A total of **127** locations were identified with a safety score of eleven (11) or greater and, based on statistical analysis significance, were progressed to the next level (Filter C). **Figure ES-3** outlines the point determinations scale used to determine the overall scores. Refer to **Figure ES-4** for a breakdown of the total number of locations based on the overall total score value.

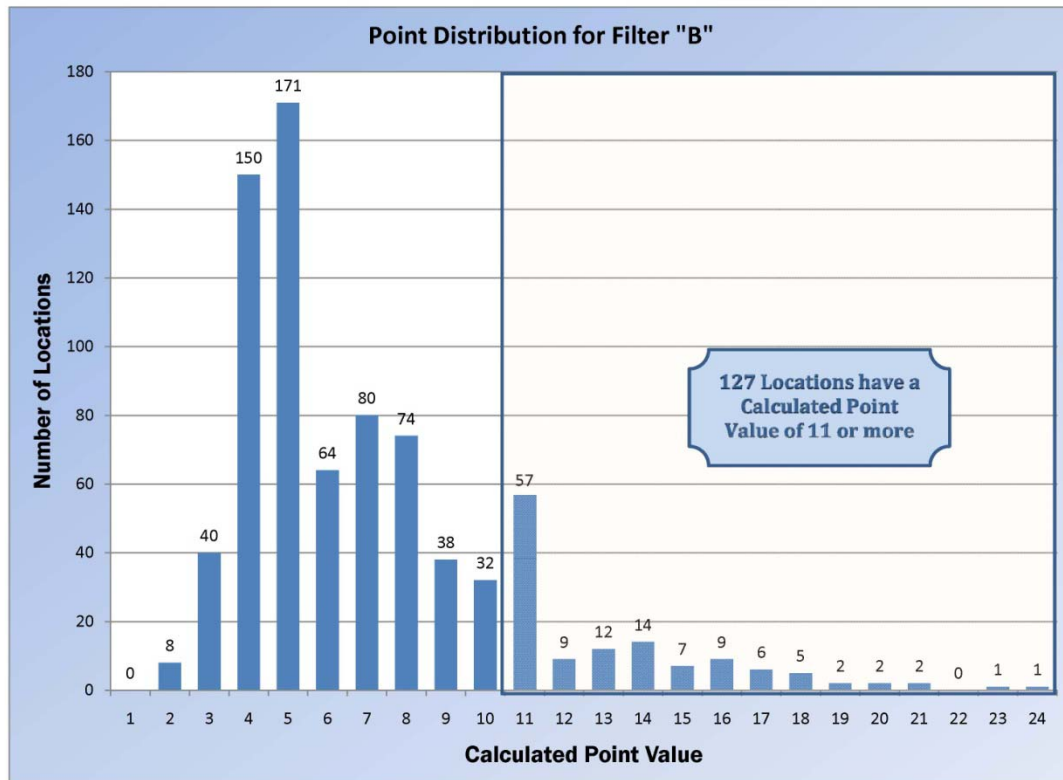


Figure ES-3 - Scoring System for Vertical Curves

1. Estimated sight distance (0-6 points, add points as outlined below)
 - a. Exceeds minimum intersection sight distance (ISD) - 0 points
 - b. Less than ISD but exceeds stopping sight distance (SSD) - 2 points
 - c. Less than minimum SSD - 4 points
 - d. If the critical SD is less than ISD and an intersection exists - add 2 points
2. Reportable Only Accident Rates over Three Years 2005-2007 (0-8 points)
 - a. Less than average rate - 0 points
 - b. Over average but closer to average than critical - 2 points
 - c. Less than critical but closer to critical than average - 5 points
 - d. Over the critical rate - 8 points
3. All accidents related to the Curve Over Three Years – add 2 Points for each accident
4. Miscellaneous Factors (0-5 points, add points as outlined below)
 - a. Approach speed 45 MPH or more - 2 points
 - b. ADT (intersection ADT or linear ADT if at a driveway)
 - over 1000 vpd - 1 point,
 - over 3000 - 2 points,
 - over 9000 - 3 points

Note: A score of 11 or more points rates consideration for an improvement.

Figure ES-4 – “Filter B” Vertical Curve Point Distribution





“Filter C” – USGS Profile Check

The **127** locations isolated in the previous filter with the highest overall total point values were evaluated for sight distance with United States Geotechnical Survey (USGS) maps to isolate vertical curve locations. A total of **86** locations with potential sight distance issues were progressed to the next filter (Filter D).

“Filter D” – Video Check

Vertical curve locations analyzed within this filter were verified with video. If the video inspection revealed limited sight distance over the vertical curve’s crest and the safety score was eleven (11) or greater, the locations were further investigated. A total of **15** locations were progressed to the next filter (Filter E).

“Filter E” – Survey Check

1. Each of the **15** vertical curve locations was profiled with survey data using LIDAR to obtain detailed contour points.
2. Based on MCDOT speed data (which replaced the estimated 85th Percentile speed used in Filter B), the preferable Stopping Sight Distances (SSD) and Intersection Sight Distances (ISD) were overlaid onto each profile.
3. Out of the **15** locations analyzed with the video check, **14** were determined to have vertical curve crest profiles that conflict with the preferable Stopping Sight Distances (SSD) and Intersection Sight Distances (ISD). These **14** locations were progressed to the next filter (Filter F) for identification and mitigation recommendation.

“Filter F” - Recommendations

Short term and long term recommendations were considered and identified if appropriate for each of the vertical curve locations isolated within this filter. A total of **14** locations were detected and plotted on Geographic Information System (GIS) map to display the High Priority Candidate Vertical Curve Locations within the County.

Within this filter, details of the MV104 accident reports were checked. Information pertaining to the type of accident, location of the vehicle(s) before the collision, traffic condition, light condition, weather, road surface condition, and collision type were investigated to isolate accident patterns and to determine corrective mitigation measures.

Each candidate vertical curve location recommended for remediation through this filter was plotted on a GIS map to identify cluster locations and recommend mitigation measures to improve safety at the vertical curve. **Figure ES-5** illustrates clusters of vertical curve locations with respect to the overall vertical curve locations identified in the beginning of this study. A majority of the High Priority Candidate Vertical Curve Locations recommended for mitigation are located on the southeast side of Monroe County in eight different towns.



Figure ES-5 includes a list of the **14** candidate vertical curve locations rated from highest priority to lowest priority based on the total overall score. Information pertaining to the road name and the location of the vertical curve are reported in this table.

To remediate the High Priority Candidate Vertical Curve Locations within the County, a series of mitigation measures ranging from “short term” to “long term” are recommended. The mitigation measures recommended for each priority vertical curve location is intended to increase the existing sight distance and/or reduce the driver speeds while minimizing physical change to cross street profiles and driveway grading. Based on record data, survey data, geometrical configurations and surrounding terrain, short term and long term mitigation measures are suggested to improve current safety conditions for the candidate vertical curve locations.

No Action Required

At 8 of the 14 curve locations, the safety record indicates that the existing conditions are adequate, even though the sight distance may be limited. Warning signs are posted where required, passing is prohibited, and no accident patterns related to the curves were found.

Short Term Mitigation

Improvements such as new sign panels and passing zone restrictions can be implemented within a short period that may address and reduce the potential for accidents related to the vertical curve. The following short term mitigation measures can be applied immediately minimal planning:

Passing zone restriction

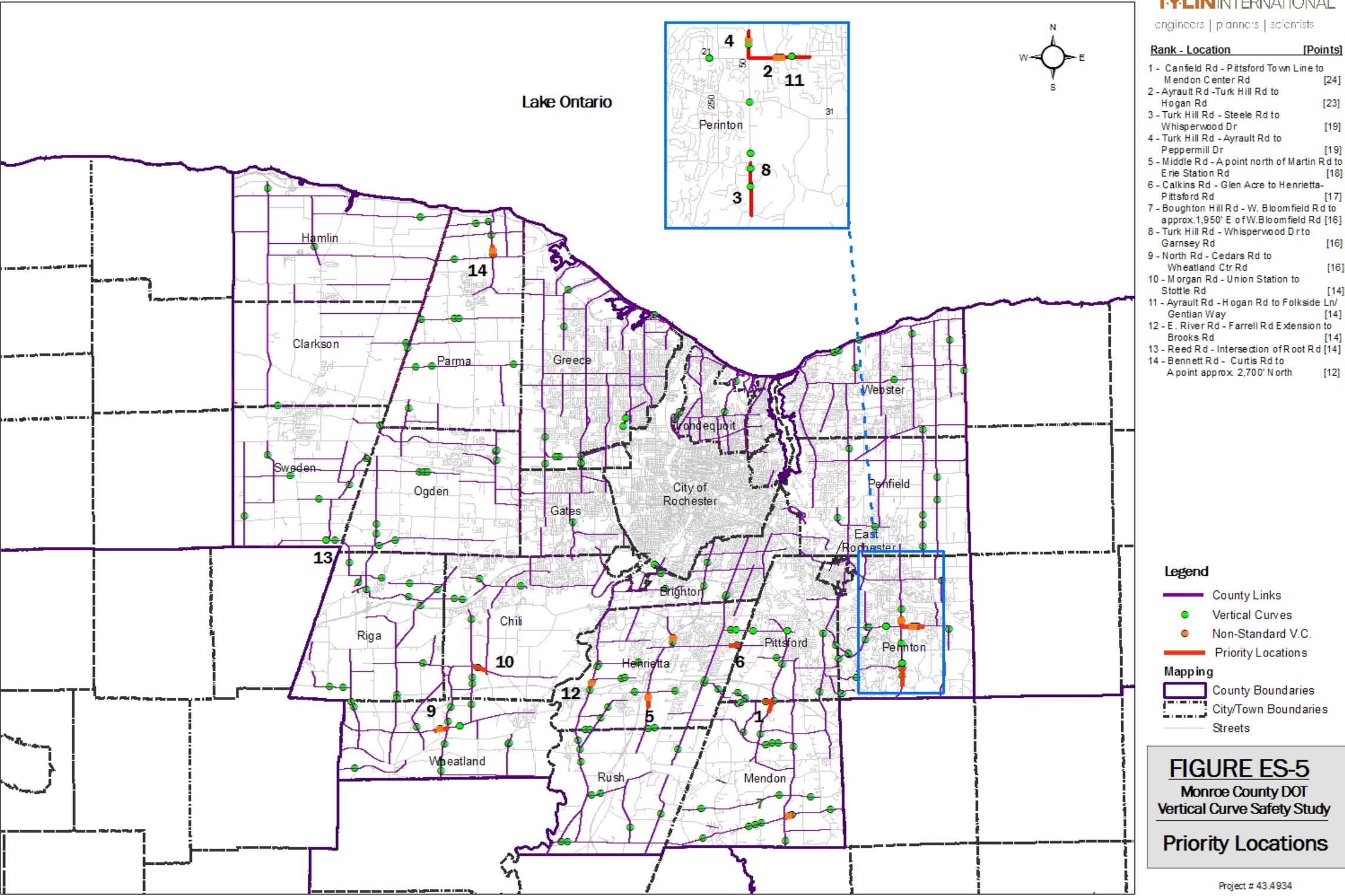
Elimination of existing passing zones within the vertical curve minimizes the potential for head on collisions. This measure is recommended for four locations as identified in **Figure ES-6**.

Advisory speed limit plaque

An advisory speed limit sign is used to supplement an intersection warning sign with a speed recommendation based on the operating characteristic and condition of the road section. As illustrated in **Figure ES-6**, a 40 MPH advisory speed is recommended in one location based on Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) requirements.

Intersection warning signs

An Intersection warning sign is positioned before an intersection to notify the driver of an upcoming intersection and the possibility of turning or entering traffic. An intersection warning sign is recommended in one location based on MUTCD requirements.





Long Term Mitigation

Other safety enhancements require funding to be identified and to allocate design and construction time. The costs associated with each of the long term recommendations presented in this study are based on isolated locations. Spot improvements are typically more costly per linear foot to construct than more extensive construction projects. **Therefore, it is recommended that the long term modifications outlined in this study be implemented during the next road improvement project opportunity.** The following examples demonstrate long term improvements that facilitate improved maneuverability and/or enhanced sight distance:

Widen shoulder sections

Five (5) to eight (8) foot wide paved shoulders along both sides of the road provide a refuge area for parked vehicles or for a car to pass a stopped vehicle. Five (5) foot wide paved shoulders along both sides of the road improve the driver's maneuverability and ability to avoid a crash. Approximately twenty percent of the candidate vertical curve locations identified within this study are recommended for this type of mitigation.

Profile adjustment

Adjustments made to a vertical curve crest to lengthen the curve can increase the stopping sight distance within the vertical curve. Based on accident histories and the level of potential physical impacts and costs, profile adjustments are not recommended for the candidate vertical curve locations.

A range of mitigation options and the projected costs associated with the improvements for the short term and long term time frames are identified in **Figure ES-6**. The table collectively represents the short term and long term recommendations for each of the **14** High Priority Candidate Vertical Curve Locations identified. An estimate of the cost (in current dollars) to implement each improvement is included in the table for Monroe County Department of Transportation's consideration.

Conclusion

Shoulder improvements are recommended in three locations. Canfield Road has a high occurrence of parking and pedestrian activity within the area of two vertical curves. The other two locations were selected based on high operating speeds within areas with ineffective shoulder sections limiting driver maneuverability.

Out of the **4,481** link and node locations analyzed in this Report, **14** High Priority Candidate Vertical Curve Locations were identified. These locations were prioritized based on an overall score comprised of accident data, Annual Daily Traffic (ADT) volumes, 85th percentile speed and stopping sight distances. Using a sensitivity analysis, an eleven (11) point cut-off value was identified. As such, based on the criteria used for this study, **14** High Priority Candidate Vertical Curve Locations are studied and **6** are recommended to Monroe County Department of Transportation for mitigation consideration. No action is required for the other **8**. Specific locations are identified in **Figure ES-6**.



Figure ES-6 –Table of Recommended Improvements

				Short Term Recommendations		Long Term Recommendations		Total Costs per Location	Comments
	Road/Town	Description	Points	Improvement Description	Costs	Improvement Description	Costs		
1	Canfield Road, Mendon	V. C. "A" is approx. 2,050' west of Mendon Center Rd.	24	No Action Recommended	\$0	Install new 3,300 LF 8' wide shoulder on both sides of Canfield Road at Vertical A-B	\$584,430		Two vertical curves exist within this section. Roadside parking occurs on the shoulder and pedestrian activity is high.
		V. C. "B" is approx. 1,460' west of Mendon Center Road.		No Action Recommended	\$0				
					\$0		\$584,430	\$584,430	
2	Ayrault Road, Perinton	Intersection of Ayrault Rd. and Willowick Dr.	23	Add a W2-2 "Intersection Warning" sign on Ayrault Road (EB), west of Willowick Drive	\$350	No Action Recommended	\$0		The shoulder width and clear zone within the studied area is appropriate for the road and the actual stopping sight distance is within 5 feet of the recommended intersection sight distance.
					\$350		\$0	\$350	
3	Turk Hill Road, Perinton	460 ft' south of Whisperwood Dr.	19	No Action Recommended	\$0	No Action Recommended	\$0		The road section within the proximity of the vertical curve is clearly signed/marked and the pavement section is adequate.
					\$0		\$0	\$0	
4	Turk Hill Road, Perinton	720' north of Ayrault Rd.	19	No Action Recommended	\$0	No Action Recommended	\$0		The road section is clearly signed/marked and the pavement section is appropriate for the road. The actual stopping sight distance is within 15 feet of the recommended stopping sight distance.
					\$0		\$0	\$0	
5	Middle Road, Henrietta	1,025' south of Erie Station Road	18	No Action Recommended	\$0	No Action Recommended	\$0		The road section is clearly signed/marked and the shoulder width and clear zone are appropriate for the road. Because several driveways are located within the vertical curve, there would be substantial impacts to adjust the profile.
					\$0		\$0	\$0	
6	Calkins Road, Henrietta	Approximately 900' west of Henrietta-Pittsford Rd.	17	No Action Recommended	\$0	No Action Recommended	\$0		The road section is clearly signed/marked and the pavement section is appropriate for the road.
					\$0		\$0	\$0	
7	Boughton Hill Road, Mendon	Approximately 1,000' east of West Bloomfield Rd.	16	Eliminate the existing eastbound passing zone within the proximity of the curve (approximately 300').	\$225	Install new 3,800 LF 6' wide shoulder on both sides of Boughton Hill Road at the Vertical Curve	\$564,470		Within the vertical curve section, a passing zone exists. The speed limit is 55 mph and the pavement section is narrow without a paved shoulder section.
					\$225		\$564,470	\$564,695	
8	Turk Hill Road, Perinton	Approx. 500' north of Whisperwood Dr.	16	No Action Recommended	\$0	No Action Recommended	\$0		The road section within the vertical curve is clearly signed/marked and the shoulder width and clear zone are appropriate for the road.
					\$0		\$0	\$0	
9	North Road, Wheatland	Approx. 1,100' west of Wheatland Center Road.	16	Eliminate the existing westbound passing zone within the proximity of the curve (approximately 700').	\$525	Install new 3,000 LF 5' wide shoulder on both sides of North Road between Cedar Ave. and Wheatland Center Road	\$388,400		Within the vertical curve section, a passing zone exists. The speed limit is 55 mph and the lane widths and shoulder sections are narrow.
					\$525		\$388,400	\$388,925	
10	Morgan Road, Chili	1,340' east of Union Station	15	Eliminate the existing eastbound passing zone within the proximity of the curve (approximately 400').	\$300	No Action Recommended	\$0		A passing zone is located within the vertical curve section and the shoulder width and clear zone are appropriate for the road.
					\$300		\$0	\$300	
11	Ayrault Road, Perinton	Approx. 800' east of Hogan Road	14	No Action Recommended	\$0	No Action Recommended	\$0		The road section is clearly signed/marked and the shoulder width and clear zone are appropriate for the road.
					\$0		\$0	\$0	
12	East River Road, Henrietta	Intersection of East Henrietta Road and Brooks Rd.	14	No Action Recommended	\$0	No Action Recommended	\$0		Intersection warning signs are present and the pavement section within the proximity of the vertical curve is adequate.
					\$0		\$0	\$0	
13	Reed Road, Sweden	Vertical curve "A" is approx. 215' west of Root Rd.	14	Eliminate the existing westbound passing zone within the proximity of the curve (approximately 700').	\$375	No Action Recommended	\$0		Due to the intersection, a passing zone restriction and an advisory speed on the advanced intersection warning sign is recommended. The lane widths and shoulder sections are narrow in this section.
		Vertical curve "B" is approx. 800' west of Root Rd.		Add W13-1P, "40 MPH" advisory speed panel to the existing W2-2 sign on Reed Road, west of Root Road in the eastbound direction near V.C. "B".	\$150	No Action Recommended			
					\$525		\$0	\$525	
14	Bennett Road, Parma	Approx. 530' north of Curtis Rd.	12	No Action Recommended	\$0	No Action Recommended	\$0		The southbound approach is well signed before the stop sign and speeds are low on the approach.
					\$0		\$0	\$0	

* Include accidents involving deer and accidents outside of the vertical curve

TOTAL COSTS: \$1,925 \$1,537,300 \$1,539,225