

IV. MAINLINE GEOMETRY/TYPICAL SECTION

The Federal Highway Administration has adopted design guidelines for streets and highways based upon *A Policy of Geometric Design of Highways and Streets*, 4th Edition, 2001, as published by the American Association of State Highway and Transportation Officials (AASHTO). This policy manual is commonly referred to as the AASHTO Green Book. Further direction related to design of highways is outlined in AASHTO's 2002 *Roadside Design Guide*. In addition, the Standing Committee on Highways, AASHTO Highway Subcommittee on Design, and Task Force on Geometric Design have developed a draft *Policy on Design Standards, Interstate System* dated August 2003 that is presently going through the approval process. This draft policy was also considered as part of this evaluation.

The AASHTO guidelines afford different levels of highway design options that have been established based upon years of proven practice and research. The AASHTO Green Book provides guidance for the design of highways by offering recommended values or ranges of values for various critical dimensions and features associated with streets and highways. The use of *minimum* standards simply implies that the lower value should be the prudent guide.

For the Ford and Breathitt Parkways to be designated as I-69, design modifications may be needed to meet the higher level of guidelines for interstate highways. To make this determination, the design information on the Parkways, based on the Kentucky Transportation Cabinet's Highway Information System (HIS) inventory data and on *As-Built Plans* for the two Parkways, has been compared to the AASHTO guidelines for interstate highway facilities. A summary of the available design information is provided in **Appendix F – Highway Information System Summary of Parkway Data**.

This chapter provides a comparison of existing parkway conditions and the AASHTO guidelines for several key design areas. Mainline geometric issues for the existing corridor are discussed in this chapter, including design speed, median widths, clear zones, horizontal and vertical alignments, superelevation rates, and sight distances. Ramp configurations, taper lengths, and lateral and vertical bridge clearances are discussed in the following chapters.

Although this chapter makes comparisons between the features of the existing Parkways and AASHTO highway design guidelines, the AASHTO guidelines also encourage using design flexibility and context sensitive design principles to best meet the project-specific situation. Due consideration of this issue is important in the final conclusions and recommendations, as presented in **Chapter IX**.

A. Design Speed

Design speed is a selected speed that, once established, serves to influence many of the other design parameters for a particular transportation facility. Other influencing factors include topography, expected operating speed, land use, and the function of the

highway. The design speed is typically established for a roadway to satisfy the level of public expectation for safety and level of service.

AASHTO guidelines recommend a minimum mainline design speed of 70 MPH for rural freeway-type sections and a minimum of 50 MPH for urban freeway sections. Based on a review of the as-built plans for the Ford and Breathitt Parkways, the design speed specified on the plans for both of the Parkways is 70 miles per hour (MPH) for the entire length. However, there have been changes made to the AASHTO guidelines since the Parkways were built, so it was necessary to evaluate geometric, structural, and operational considerations based on current guidelines, as presented in this chapter, **Chapter IV**, and in **Chapters V and VI** of this report.

AASHTO design speeds for entrance and exit ramps are 35 MPH for semi-directional ramps in rural areas, 25 MPH for semi-directional ramps in urban areas, and 25 MPH for loop ramp configurations in both rural and urban areas. An evaluation of “Interchanges and Ramps” is provided in **Chapter VI**.

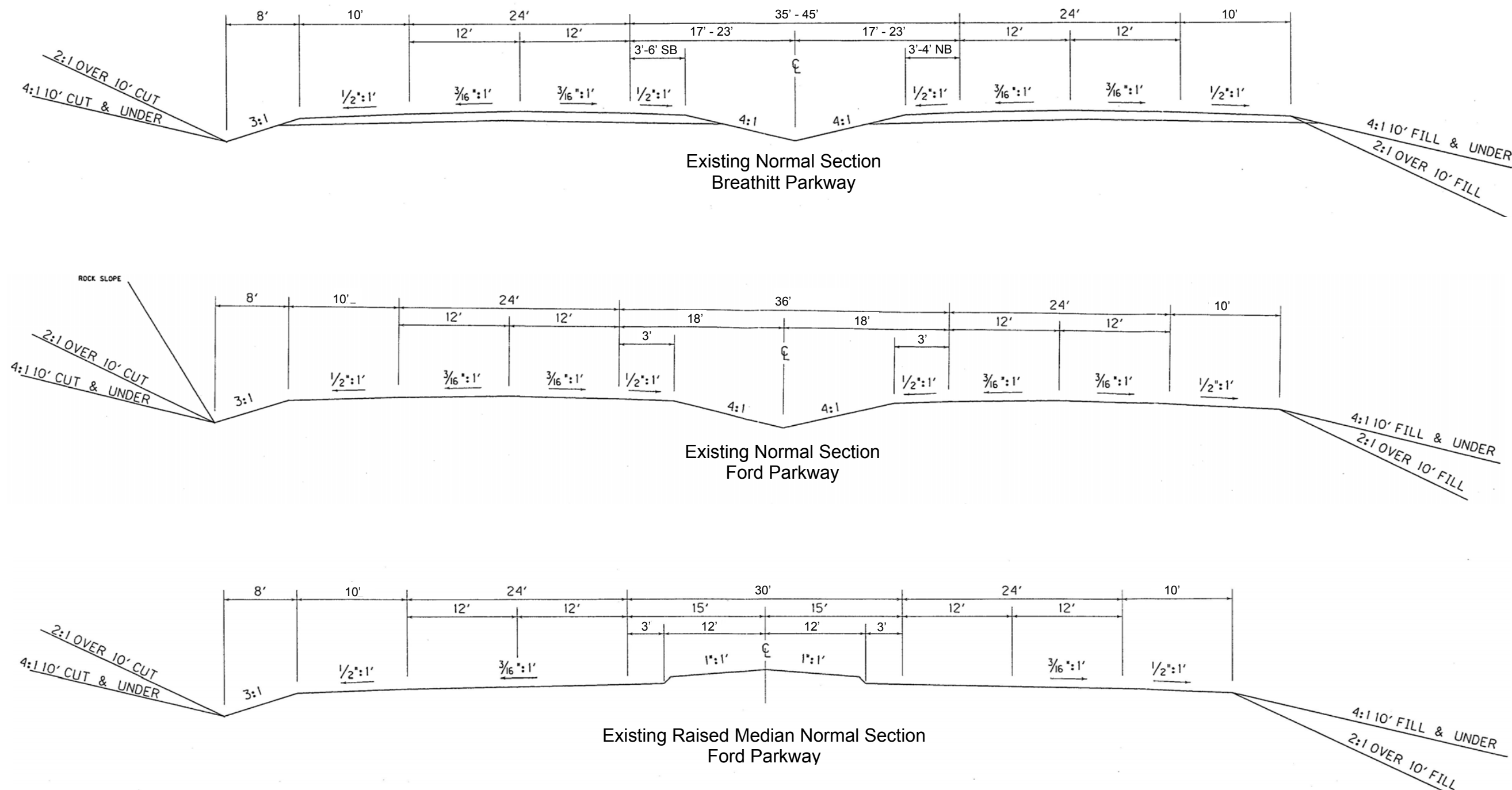
B. Typical Roadway Sections

Existing typical roadway cross-sections along the Ford and Breathitt Parkways are shown in **Figure 7**. These are generally representative of existing conditions along the Parkways, based on a review of as-built plans; however, any spot improvements, roadway improvements, or maintenance activities over the life of the Parkways may have resulted in changes to highway inventory data or as-built design conditions. Therefore, despite the comprehensiveness or quality of information shown in the HIS database and the as-built plans, variations from the data presented in this report may exist in some areas from actual conditions along either Parkway, since minimum field checks were conducted as part of this study.

Following is a summary of existing typical highway cross-section design elements and a comparison of these elements with current AASHTO freeway design guidelines.

1. Lane Widths

The minimum AASHTO guideline for the width of freeway traffic lanes is 12 feet. The freeway traffic lanes along the mainline sections of the Ford and Breathitt Parkways have been designed and constructed with a lane width of 12 feet. Therefore, the lane width on the Parkways meets the minimum AASHTO guidelines for freeway design.



Note: Typical Sections are based upon As-Built Plans provided by the Kentucky Transportation Cabinet.

Figure 7. Existing Typical Section for Ford and Breathitt Parkways

2. Shoulder Widths

The minimum AASHTO guidelines for freeway shoulders recommend paved shoulders on both the left and right side of each direction of travel. This includes a usable paved shoulder of 10' provided on the outside or right shoulder, or 12' where the Directional Design Hourly Volume (DDHV) for truck traffic exceeds 250 vehicles per hour (vph).



Both lane widths and outside shoulder widths along the two Parkways generally meet Interstate design guidelines.

The existing outside or right shoulder widths on the as-built plans show an outside shoulder width of 10 feet along both the Ford and Breathitt Parkways. This was confirmed by a review of the HIS data. The existing truck volumes along this corridor are well below the DDHV of 250 vehicles per hour (see discussion in **Chapter III**). Thus, it is anticipated that all of the existing outside shoulders meet interstate highway criteria for shoulder width. One consideration is using the shoulder as the traveled way during maintenance and construction activities. To function as a drivable shoulder, depth should be considered. Based on the as-built plans, the depth of the original shoulder was the same as the travel lanes but as the picture above highlights, in some locations subsequent overlays did not include overlaying the entire pavement section. Additional information provided by the KYTC shows a shoulder depth of 2" of asphalt on stone along the Ford Parkway and approximately 9" of asphalt on stone along the Breathitt Parkway.

The AASHTO guidelines also specify that the inside or left shoulder width should be a minimum of 4' of paved shoulder. On freeways with more than two lanes in each direction, the left shoulder should be 10' (and preferably 12' if the DDHV for truck traffic exceeds 250 vph). The additional width allows for (a) a storage area for disabled vehicles that were unable to maneuver to the right shoulder, (b) drainage control, and/or (c) a storage area for snow removal, if needed.

According to the typical sections from the as-built plans and a review of the HIS data, all of the inside shoulder widths on the Breathitt Parkway are at least 3 feet with a few sections of 4 and 6 feet. Also, all of the inside shoulder widths on the Ford Parkway are 3 feet. Therefore, the Parkways do not fully conform to AASHTO design guidelines for the inside shoulder width on freeways.

A more detailed summary of the inside and outside shoulder widths is presented in **Table 8** and graphically depicted in **Figure 8**.

Table 8 - Summary of Inside and Outside Shoulder Widths along Parkways

BREATHITT PARKWAY	COUNTY	BEGIN MP	END MP	LENGTH (miles)	SHOULDER WIDTH (ft)	AASHTO Minimum
Outside Shoulders	Hopkins	34.271	55.003	20.732	10	10 ft. (if truck DDHV <=250 vph)
	Webster	55.003	65.305	10.302	10	
	Henderson	65.305	76.258	10.953	10	
Inside Shoulders	Hopkins	34.271	39.550	5.279	4	4 ft.
	Hopkins	39.550	42.437	2.887	3 NB/4 SB	
	Hopkins	42.437	44.713	2.276	3	
	Hopkins	44.713	45.460	0.747	3 NB/6 SB	
	Hopkins	45.460	46.200	0.740	3	
	Hopkins	46.200	55.003	8.803	3	
	Webster	55.003	65.305	10.302	3	
	Henderson	65.305	76.258	10.953	3	
FORD PARKWAY	COUNTY	BEGIN MP	END MP	LENGTH (miles)	SHOULDER WIDTH (ft)	AASHTO Minimum
Outside Shoulders	Lyon	0.000	5.610	5.610	10	10 ft. (if truck DDHV <=250 vph)
	Caldwell	5.610	21.764	16.154	10	
	Hopkins	21.764	38.332	16.568	10	
Inside Shoulders	Lyon	0.000	5.610	5.610	3	4 ft.
	Caldwell	5.610	21.764	16.154	3	
	Hopkins	21.764	38.332	16.568	3	

Source: Kentucky Transportation Cabinet Highway Information System, 2002

3. Medians

Medians are separations between opposing traffic flow that add to vehicular safety and driver comfort. AASHTO design guidelines recommend median widths for both rural and urban sections to best accomplish these purposes. Medians are measured from the edge of the travelway (yellow line) in one direction to the edge of the travelway in the other direction. Therefore the median includes the inside shoulders and any grass or paved area between.



Median widths along the parkways range from 30 to 45 feet.

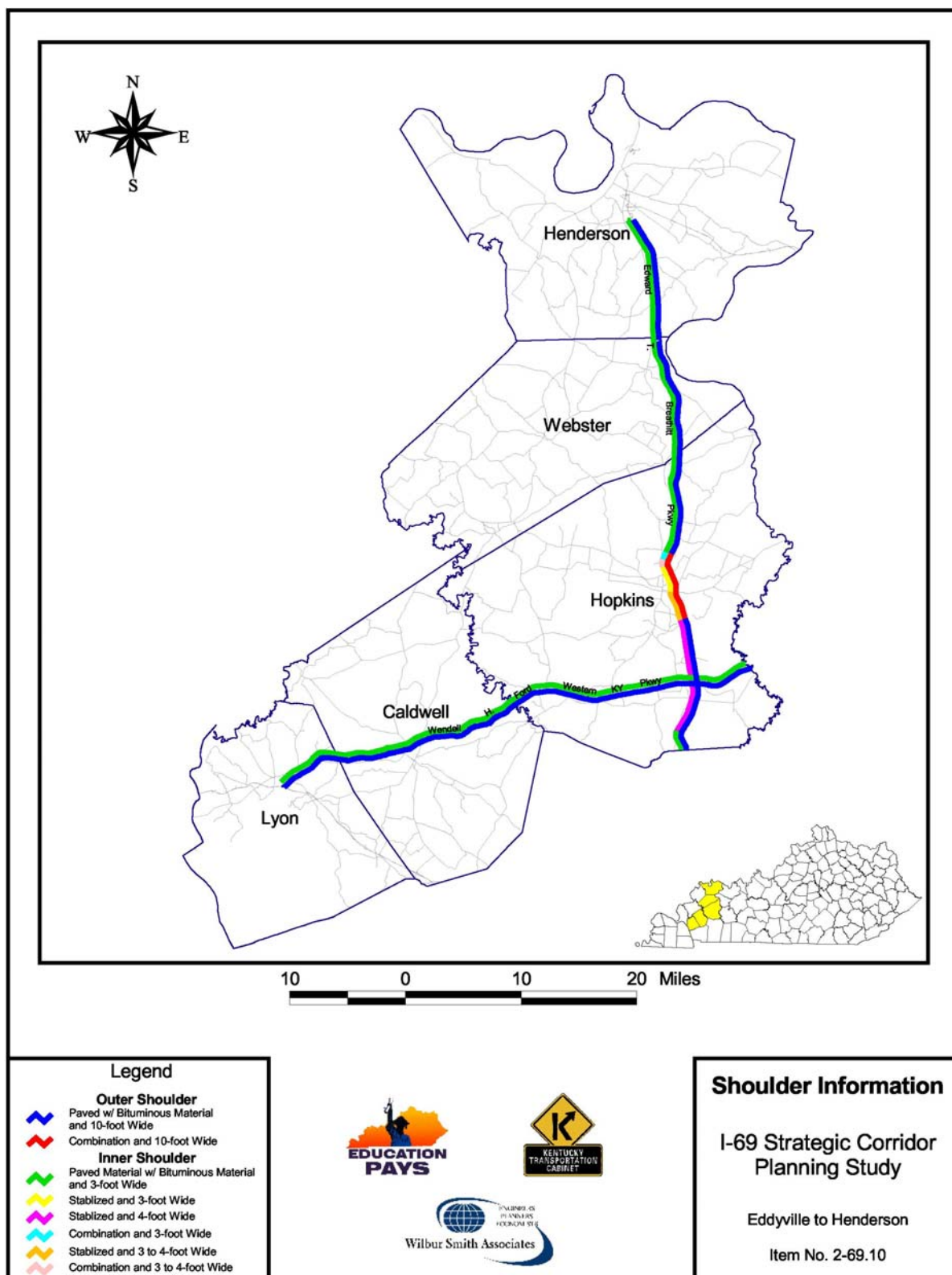
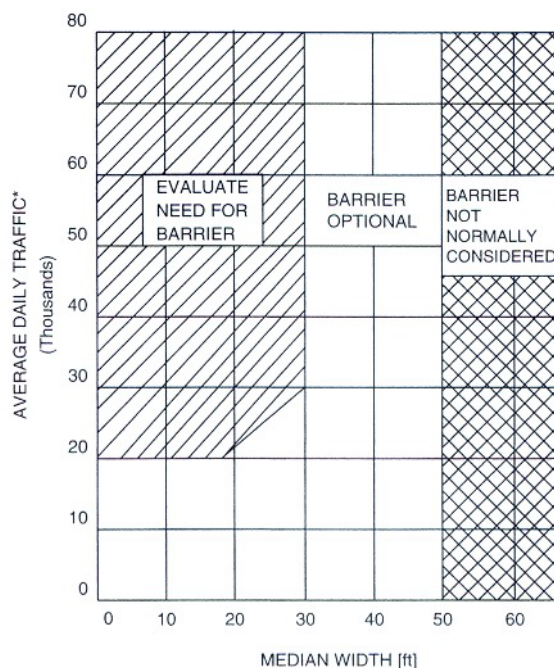


Figure 8. Illustration of Inside and Outside Shoulder Widths along Parkways

According to KYTC records, there are 80.319 miles of freeway in the I-69 study corridor on the Ford and Breathitt Parkways, which includes 7.061 (8.8%) miles of urban freeway and 73.258 (91.2%) miles of rural freeway. Of the 7.061 miles of urban freeway, 0.591 miles is in Caldwell County, and 6.47 miles is in Hopkins County. Of the 73.258 miles of rural freeway 5.610 miles is in Lyon County, 15.563 miles in Caldwell County, 30.830 miles in Hopkins County, 10.302 miles in Webster County, and 10.953 miles in Henderson County.

A review of the as-built typical sections and the HIS data for the existing Breathitt Parkway indicates that the median width varies from 35' to 45'. Along the Ford Parkway, there is a median of 30' in Hopkins County as well as in part of Caldwell County. In the remainder of Caldwell County and in Lyon County, there is a 36' median.

The AASHTO Green Book recommends a minimum median width for rural freeway of 50'. This allows for 6' inside shoulders and a 38' depressed median with 6:1 back slopes. The median ditch would be approximately 3' in depth to handle roadway drainage. The recommended minimum median width for urban freeways is dependent upon the number of freeway lanes and the number of large trucks. Where an urban freeway is four-lane, a minimum median width of 10' is recommended, which allows for 4' inside shoulders and a 2' concrete median barrier. Where the urban freeway is more than two lanes in each direction, the minimum median width should be 22' (and preferably 26' if the number of heavy trucks exceeds 250 vph). Another consideration for minimum acceptable median widths is the draft AASHTO *Policy on Design Standards, Interstate System*. The draft document recommends that medians in rural areas be at least 36' wide while consulting AASHTO's *Roadside Design Guide* to determine the warrants, based on consideration of average daily traffic, median width and crash history, for barrier installation in the median. The AASHTO *Roadside Design Guide* discusses the criteria for the installation of a median barrier in Chapter 6. The chart to the left (Figure 6.1 in the *Roadside Design Guide*) highlights the suggested guidelines for the installation of median barrier on high-speed roadways. The *Roadside Design Guide* also has a detailed discussion on curbs and their application. The recommended practice is not to use curbs on high-speed facilities.



Suggested guidelines for median barriers on high-speed roadways. Figure 6.1 from AASHTO's Roadside Design Guide

The median types and dimensions are presented in **Table 9** and graphically depicted in **Figure 9**.

Table 9 - Summary of Median Types and Widths along Parkways

BREATHITT PARKWAY	COUNTY	BEGIN MP	END MP	LENGTH (miles)	MEDIAN TYPE	MEDIAN WIDTH (ft)	Minimum Median Width
Rural	Hopkins	34.271	39.550	5.279	Depressed	36	36 ft (depressed) 10 ft. (barrier)
Rural	Hopkins	39.550	41.002	1.452	Depressed	35	
Urban	Hopkins	41.002	42.437	1.435	Depressed	35	
Urban	Hopkins	42.437	44.713	2.276	Depressed	36	
Urban	Hopkins	44.713	45.460	0.747	Depressed	45	
Urban	Hopkins	45.460	47.472	2.012	Depressed	42	
Rural	Hopkins	47.472	53.278	5.806	Depressed	42	
Rural	Hopkins	53.278	55.003	1.725	Depressed	36	
Rural	Webster	55.003	65.305	10.302	Depressed	36	
Rural	Henderson	65.305	76.258	10.953	Depressed	36	
FORD PARKWAY	COUNTY	BEGIN MP	END MP	LENGTH (miles)	MEDIAN TYPE	MEDIAN WIDTH (ft)	Minimum Median Width
Rural	Lyon	0.000	5.610	5.610	Depressed	36	36 ft. (depressed) 10 ft. (barrier)
Rural	Caldwell	5.610	9.880	4.270	Depressed	36	
Rural	Caldwell	9.880	21.764	11.884	Depressed	30	
Rural	Hopkins	21.764	25.000*	3.236	Depressed	30	
Rural	Hopkins	25.000*	38.332	13.332	Raised Mountable	30	
Source: Kentucky Transportation Cabinet Highway Information System, 2002 * Approximate Location							

A review of vehicle crashes along the Parkways indicates that there is not a history of cross-over accidents (see discussion in **Chapter III**). 2002 Average Daily Traffic (ADT) along the Parkways ranges from 9,000 to 26,400 vehicles per day with a 2030 projected ADT of between 19,100 to 50,500 vehicles per day.

Based on this analysis, the median along the Breathitt Parkway is in substantial compliance with the accepted practice with the exception of the roadway segment between milepoints 39.55 and 42.437 in Hopkins County. Additionally, the median along the Ford Parkway is in substantial compliance with accepted practice in Lyon County and for the first 4.27 miles in Caldwell County. The remainder of the Ford Parkway in Caldwell and Hopkins County are not in compliance with the accepted practice in terms of width of the median.

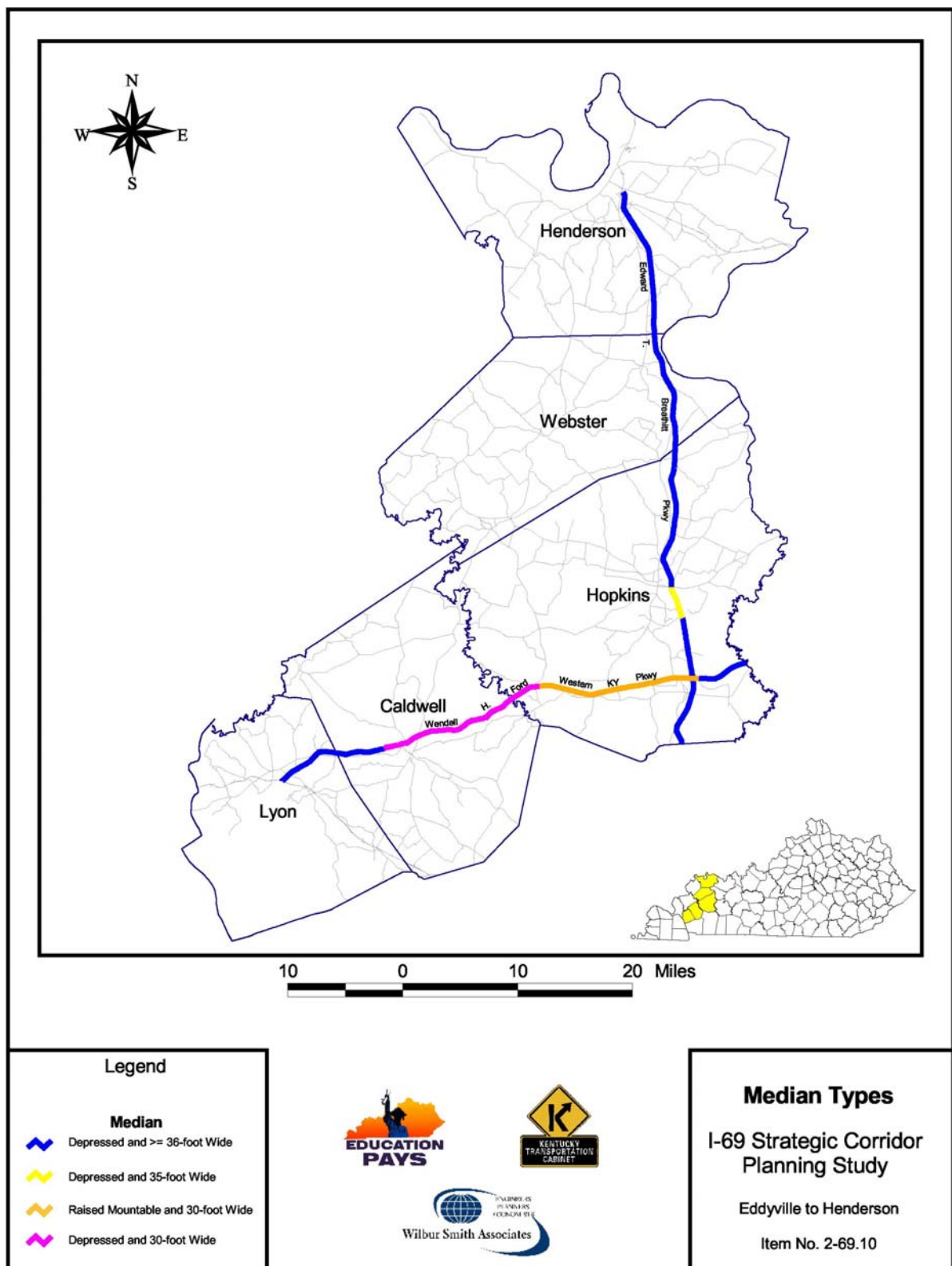


Figure 9. Illustration of Median Types and Widths along Parkways

4. Clear Zones

The clear zone is defined as the unobstructed area outside the edge of the travel lane that is used for vehicle recovery, including any available shoulders or parallel auxiliary lanes. Issues with clear zones involve design speed, magnitude of traffic volumes, steepness of fill/cut slopes, ditch slopes, and distances to fixed objects such as bridge piers, sign supports, culvert headwalls, and naturally occurring objects such as trees, rock outcrops, and drainage channels.

For design speeds of 70 mph and average daily traffic greater than 6,000 vehicles per day, the *AASHTO Roadside Design Guide* recommends a clear zone width ranging from 30 to 46 feet in fill sections. This applies to fill slopes ranging from 1V:4H or flatter. For slopes steeper than 1V:4H, it may be unreasonable to expect a driver to recover control of the vehicle within the desirable clear zone. Therefore, additional safety measures may be required, such as extending the clear zone or installing barriers. For cut slopes, the recommended clear zone width varies from 22 feet to 30 feet. This applies to cut slopes that vary from 1V:3H to 1V:6H.



Clear zones and guardrail placement may require upgrades at many locations along the parkways.

According to the as-built plans, the fill and cut slopes vary from 1V:2H to 1V:4H depending on the height of fill or depth of cut required. However, it is not possible to evaluate the applicability of current design guidelines and availability of acceptable clear zones with the information currently available.

5. Guardrail Placement and Condition

The primary purpose of guardrail or barrier rail installations is to provide an energy absorption device that will contain or redirect an errant vehicle before it has the potential to leave the roadway and strike a fixed object or a topographic feature that may be considered a greater hazard than the device itself. Similar to the evaluation of clear zones, the effective evaluation of guardrail placement and guardrail end treatments requires a detailed review of the highway cross-sections and extensive field review of existing topographic features and field conditions. Therefore, sufficient information does not exist on the as-built plans to evaluate the placement of guardrail or the status of guardrail end treatments along the I-69 corridor.

At the request of the KYTC, additional information was provided by the KYTC Highway District 1 office. They confirmed that guardrail along the Ford Parkway within District 1 had been upgraded to meet guardrail policy except from US 62 to the Caldwell County

line. This section would need to be inventoried including the ramps on the east side of US 62. In particular, guardrail post spacing would need to be verified. Existing 12'-6" installations are allowed to remain on the Parkways, but would need to be replaced if designated as an Interstate. In addition, turned down end treatments and obsolete flared end treatments would need to be replaced if a reconstruction or rehabilitation project were to be conducted. No additional information was available from the KYTC Highway District 2 office, and those sections would also need to be inventoried.

C. Horizontal Alignment

The following sections outline primary assumptions and considerations for the analysis of horizontal alignment factors, analytical findings, and summary conclusions.

1. Superelevation Rate

Superelevation is the physical tilting of the pavement surface through a curve so the vehicle will not slide off the roadway at the selected design speed under normal operating conditions. Under adverse conditions, such as rain and snow, motorists are expected to reduce operating speeds to correspond to the driving conditions. The superelevation cannot be so steep that a stalled or stopped vehicle under icing conditions would slide down the slope.

Because of the geographic location of the proposed I-69 corridor, it may be subject to snow and ice conditions. With the possibility of snow and ice conditions, superelevation rates ranging from 6% to 8% are recommended as maximum design parameters. This maximum rate applies to the mainline roadway features and directional and loop ramps.

According to the as-built plans, the maximum superelevation rate for the mainline of the Ford and Breathitt Parkways is 8 percent. Therefore, the superelevation rate on the existing parkways is acceptable and in general compliance with the AASHTO design guidelines.

2. Degree of Horizontal Curvature

Given the 70 MPH design speed of the existing parkways, a maximum degree of horizontal curvature of 3°-00' was used, which equates to a maximum horizontal curve radius of approximately 1,910 feet. At the time the Ford and Breathitt Parkways were constructed, the limiting value of curvature of the roadway features, based on a given maximum superelevation, was reported as degree of curvature. However, the newly adopted AASHTO guidelines depict the limiting value of curvature as



The parkways generally meet interstate requirements for the basic design elements of horizontal and vertical alignment.

the value of the radius of the curve itself. Accordingly, the minimum radius for a 70 MPH mainline design speed with a maximum superelevation of 8% is approximately 1,820' (3°-00'). The corresponding radius for 50 MPH mainline design speed for urban areas is 750' (5°-00').

Appendix F provides a summary of all the horizontal curves on both the Ford and Breathitt Parkways. The smallest radius of curve is on the Ford Parkway at two locations with a radius of 2,864.93' (milepost 6.416 and 8.421) which is well above the minimum for a rural freeway. Based on this information, the horizontal curvature for the Parkways is acceptable and in general compliance with current AASHTO design guidelines.

D. Vertical Alignment

Roadways are not typically constructed on flat terrain where there is no need to introduce uphill or downhill grades. Because of changes in the terrain, it has been necessary to construct sections of the parkways with varying degrees of uphill and downhill grades. One of the most important design features of variable grades is the need to provide smooth transitions across hills (referred to as “Crest Vertical Curves”) and through valleys (referred to as “Sag Vertical Curves”). These transitions need to be of sufficient length to provide adequate stopping sight distance due to objects in the roadway or to avoid stalled or stopped vehicles. However, the lengths do not need to be so flat as to impede the flow of water from the roadway surface. The design parameters that control the length of the crest and sag vertical curves are dependent on the selected design speed, the assumed vehicle light beam distance, and the percent grade of the approach and departing roadways of the crest or sag vertical curve.

AASHTO guidelines designate a maximum grade based on the type of terrain and design speed. For a rural section with rolling terrain (defined as most of the parkways), the maximum grade is 4%. In the urban sections, the maximum grade is 5%. The as-built plans show that no sections have higher than a 4% grade; however, three sections along the Ford Parkway are at the maximum grade of 4%.

The controlling factors for the design of vertical curves are the design speed, the grades and stopping sight distance. For the review of the existing conditions along the parkways, using the minimum stopping sight distance (730' rural, 425' urban), the existing grades and the design speeds, the minimum length of vertical curve was calculated. This was then compared to the actual length of vertical curve. This information is shown in **Appendix F**. Along the Ford Parkway, the actual length of vertical curve is less than the calculated minimum at three (3) locations:

- Milepoint 11.714 in Caldwell County (actual 400', calculated minimum 496')
- Milepoint 32.733 in Hopkins County (actual 1,200', calculated minimum 1206')
- Milepoint 37.357 in Hopkins County (actual 600', calculated minimum 631')

Along the Breathitt Parkway there are only two (2) locations where the actual vertical curve is less than the calculated minimum:

- Milepoint 54.122 in Hopkins County (600' actual, calculated minimum 613')
- Milepoint 68.500 in Henderson County (500' actual, calculated minimum 562')

The differences between actual and calculated minimums at milepoint 32.733 on the Ford and milepoint 54.122 on the Breathitt are not great enough to consider possible mitigation. Further study of the other three (3) locations may be warranted to determine if mitigation is warranted.



Milepoint 32.733 in Hopkins County along the Ford Parkway was one of five locations identified where the vertical curve is less than the calculated minimum.