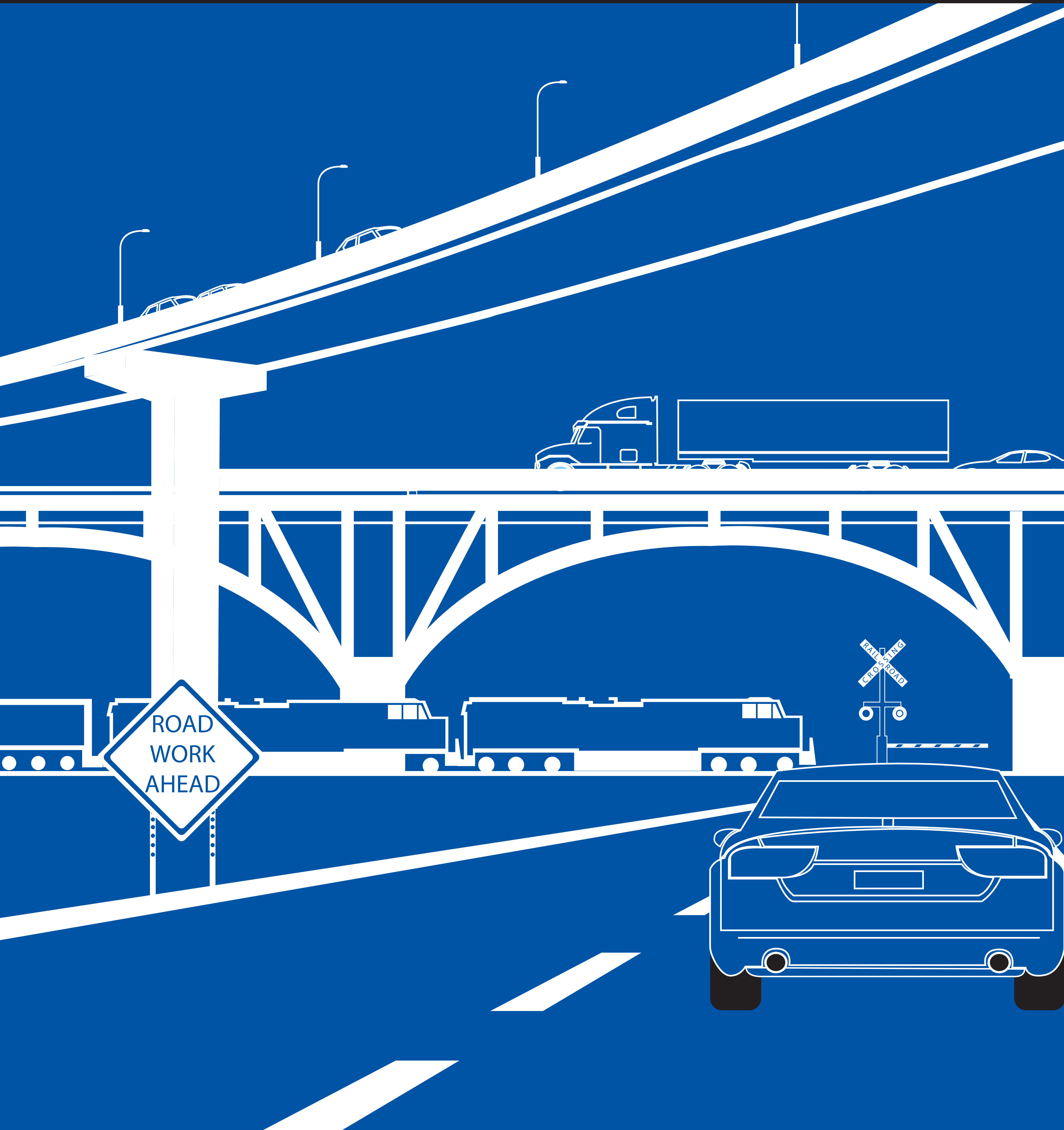
Access Management Best Practices

Report Number: KTC-19-37/SPR16-525-1F
DOI: https://doi.org/10.13023/ktc.rr.2019.37



Kentucky Transportation Center
College of Engineering, University of Kentucky, Lexington, Kentucky

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Research Report
KTC-19-37/SPR16-525-1F

Access Management Best Practices

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October 2019

1. **Report No.** KTC-19-37/SPR16-525-1F	2. **Government Accession No.**	3. **Recipient's Catalog No**
4. **Title and Subtitle** Access Management Best Practices		5. **Report Date** October 2019 6. **Performing Organization Code**
7. **Author(s):** Adam Kirk, Chris Van Dyke		8. **Performing Organization Report No.** KTC-19-37/SPR16-525-1F
9. **Performing Organization Name and Address** Kentucky Transportation Center College of Engineering University of Kentucky Lexington, KY 40506-0281		10. **Work Unit No. (TRAIS)** 11. **Contract or Grant No.** SPR 16-525
12. **Sponsoring Agency Name and Address** Kentucky Transportation Cabinet State Office Building Frankfort, KY 40622		13. **Type of Report and Period Covered** 14. **Sponsoring Agency Code**

15. Supplementary Notes
Prepared in cooperation with the Kentucky Transportation Cabinet

16. Abstract
Research has persistently demonstrated that adopting a systematic access management framework improves highway operations and bolsters safety. Many state transportation agencies have adopted formal access management programs to systematize the application of access management techniques, however, the Kentucky Transportation Cabinet (KYTC) been unable to institute such a program due to institutional, regulatory, and political constraints. Recognizing the benefits of judicious access management, the Cabinet asked researchers at the Kentucky Transportation Center (KTC) to identify access management best practices that are effective, can be easily implemented, and are compatible with existing statutes and regulations. After reviewing national-level and state-level guidance on access management, researchers devised an Access Management Toolbox which contains 14 commonly used access management techniques. Using a rating scale of 1 to 5, personnel at KYTC were then asked to rate each technique in terms of its effectiveness and ease of implementation (1 = ineffective and/or difficult to implement; 5 = highly effective and/or easy to adopt). Six techniques garnered scores of 4 or above for both effectiveness and implementation: 1) maintaining sight distance, 2) setting the maximum number of driveways per lot, 3) installing auxiliary turn lanes, 4) protecting the functional area of intersections, 5) adopting turn restrictions, and 6) conducting traffic impact studies. Consistently incorporating these access management techniques into permitting, planning, and design activities will result in the development of an efficient and safe highway system that equitably balances the needs of motorists and property owners.

17. **Key Words** access management, highway design, highway safety		18. **Distribution Statement** Unlimited with approval of the Kentucky Transportation Cabinet	
19. **Security Classification (report)** Unclassified	20. **Security Classification (this page)** Unclassified	21. **No. of Pages** 34	19. **Security Classification (report)**

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Executive Summary

Access management is concerned with planning, designing, and operating roads in a manner that preserves the safety of all road users (motorists, bicyclists, pedestrians), affords users access to interconnected road networks and adjacent properties, gives property owners sufficient although not unlimited road access from their properties to those road networks, and maintains adequate levels of service. Judicious access management balances the needs and rights of the traveling public with those of property owners, bolsters operational efficiencies, and lowers crash rates.

While many state transportation agencies have adopted formal access management plans, despite its attempts the Kentucky Transportation Cabinet (KYTC) has been unable to do so due to institutional and political constraints. In 2004, the Cabinet asked researchers at the Kentucky Transportation Center (KTC) to develop an access management plan. The resulting document, *Kentucky Access Management Plan* (Stamatiadis et al. 2004), called for the creation of a task force to study whether it could be implemented. However, its guidelines were never formally adopted as many of the lower level street regulations and minor property access issues proved difficult to regulate and implement (see House 2008). Recognizing the value of sound access management planning, the Cabinet approached KTC in 2016 to develop a set of access management best practices engineering staff could draw from when working on issues related to permitting, planning, and design.

This reviews KYTC's access management policies and practices (including the statutes and administrative regulations the agency is bound by) and then discusses two policies which have been adopted since publication of the *Kentucky Access Management Plan* – Traffic Impact Study requirements and Auxiliary Turning Lane policy. Following this, the report briefly discusses best practices inferred from national and state guidance. Next an Access Management Toolbox is presented that was developed by KTC's researchers. This toolbox includes 14 access management techniques that can be valuable for improving roadway operations and safety.

To determine which techniques are most applicable in Kentucky, members of the Study Advisory Committee rated their effectiveness and ease of implementation using a scale from 1 to 5, where 1 signifies a technique is not effective or difficult to adopt and a score of 5 applies to techniques that are highly effective or easy to implement. Six of the 14 techniques received ratings greater than equal to 4 in both effectiveness and implementation (these are highlighted in green in the table below). Highly rated techniques have been adopted through the permitting and Traffic Impact Study Process. Low-scoring techniques are standards-based and thus unable to account for unique site conditions at an access point or along a corridor, require significant coordination among property owners which renders them impractical or politically infeasible (e.g., shared driveways), or are difficult to adopt because they entail imposing standards for areas beyond the KYTC-owned right of way (e.g., setting driveway throat length). In addition to the Access Management Toolbox, this project also resulted in the development of a Traffic Impact Study Review Course. It has been delivered to Cabinet staff twice, once in 2016 and once in 2019.

Access Management Toolbox

Access Management Treatment	Effectiveness	Implementation	Notes
Maintain Sight Distance	5	5	Minimum criteria currently in use at KYTC
Unsignalized Intersection Spacing Standards	2	5	Lot size often plays significant role in spacing and clearance issues
Signalized Intersection Spacing Standards	2	4	May be more effective in planning
Interchange Area Spacing Standards	3	5	Difficult to enforce unless full control is present
Corner Clearance	3	5	Lot size often plays significant role in spacing and clearance issues
Maximum Number of Driveways Per Lot	5	5	Currently in use through permitting and TIS process
Frontage/Backage Roads	3	5	Requires coordination with local agencies through planning and zoning
Shared Driveways	2	4	Questions surrounding legality of requiring shared use driveways exist
Driveway Throat Length	3	3	Difficult to enact standards outside right of way
Auxiliary Turn Lanes	5	5	Currently in use through permitting and TIS process
Protect the Functional Area of the Intersection	4	5	Currently in use through permitting and TIS process
Turn Restrictions	4	5	Currently in use through permitting and TIS process
Traffic Impact Studies	5	5	Provides adequate flexibility to address most issues

1. Introduction and Background

The Transportation Research Board's (TRB) *Access Management Manual* (2003) defines access management as "the systematic control of the location, spacing, design, and operation of driveways, median openings, interchanges, and street connections to a roadway. It also involves roadway design applications, such as median treatments and auxiliary lanes, and the appropriate spacing of traffic signals." The Federal Highway Administration's (FHWA) *Primer on Access Management* (2006) reiterates many aspects of this definition, stating that access management entails "the careful planning of the location and spacing of driveways, street connections, median openings and traffic signals. [It] can also involve using medians to channel left turns to safe locations providing dedicated turn lanes at intersections and access points to remove turning vehicles from through lanes." Meanwhile, Gluck and Lorenz observe that "access management provides a systematic way of balancing the trade-offs between land access and through-traffic mobility functions that are implicit in the functional hierarchy of all roadways" (2010, p.5).

More simply put, sound access management is concerned with planning, designing, and operating roads in a manner that preserves the safety of all road users (motorists, bicyclists, pedestrians), affords users access to interconnected road networks and adjacent properties, gives property owners sufficient although not unlimited road access from their properties to those road networks, and maintains adequate levels of service. Judicious access management balances the needs and rights of the traveling public with those of property owners, bolsters operational efficiencies, and lowers crash rates.

A growing number of state transportation agencies have established formal access management programs (Gluck and Lorenz 2010), however, the Kentucky Transportation Cabinet (KYTC) lacks one. Recognizing the problems inherent to managing highway access through case-by-case reviews of access permits, in the early-2000s KYTC commissioned researchers the Kentucky Transportation Center (KTC) to devise an access management program. While the *Kentucky Access Management Plan* (Stamatiadis et al. 2004) led to the creation of a task force at KYTC to study its prospects for implementation, its guidelines were not formally enacted as many of the lower level street regulations and minor property access issues proved difficult to regulate and implement (see House 2008). While instituting a formal access management program carries numerous benefits, political realities make implementation a challenge. As such, KYTC's access management strategies remain piecemeal, informed by regulations (e.g., Kentucky Revised Statutes [KRS] and Kentucky Administrative Regulations [KAR]) as well as procedures and guidance outlined in its *Permits Manual* and *Highway Design Manual* and memos.

KRS 177.315 directs the Cabinet to establish requirements for the minimum spacing of access points along limited access roadways. Under this statute, KYTC must define how landowners or occupants with a limited right or easement of access to limited access roads will be granted access to those facilities. This statute also dictates minimum spacing requirements for access control points in rural areas (1,200 feet) and urban areas (600 feet). However, the Cabinet may adjust the spacing of access control points if:

(a) The owner or occupant of land adjacent to a limited access facility or a local government requests a change, *and*

(b) Any changes in spacing are supported by an approved engineering and traffic study.

Two KARs have information relevant to access management: 603 KAR 5:120 addresses access control of highways; 603 KAR 1:020 describes regulations for constructing and maintaining highway approaches.

PE-501 of the *Permits Manual* lays out procedures KYTC must follow when processing requests to modify access to roads with full or partial access control. Permittees submit the following documentation when requesting access to a road: (1) a highway plan sheet indicating the location of the proposed entrance and the location of existing entrances within 0.5 mile of the proposed entrance, (2) a letter of support from the city or county planning and zoning agency (if applicable), and (3) a completed TC 99-1(A) form. If the Chief District Engineer does not deny the request, the permittee submits the following information to the State Highway Engineer: (1) plans stamped by a professional engineer (if applicable), (2) a traffic impact or traffic engineering study from a prequalified consultant, (3) a completed TC 99-28 form, and (4) an appraisal indicating the assessed increase in value attributable to installing a new access point. If the State Highway Engineer recommends approving the permittee's request, the decision is forwarded to the Commissioner of the Department of Highways, who grants the opportunity for a public hearing (see 603 KAR 1:030). After reviewing the public hearing's outcome, or if no hearing is conducted, the Commissioner renders a final decision on the permit and directs the State Highway Engineer proceed accordingly. Ultimately, the district-level office informs the permittee of KYTC's decision.

The *Highway Design Guidance Manual* instructs designers to incorporate access management techniques into project designs (TRB's *Access Management Manual* is referenced). On highways where access requires a permit, the Cabinet establishes criteria that must be met before it will modify existing access and/or allow additional access points. Road functional classifications is to guide highway design and management. For example, it is important to limit access to high-volume roads. Full or partial access control should be adopted on four-lane divided highways. On highways with full access control, additional access can be provided only by building new interchanges with grade separations.

HD-1103 lists what conditions need to be met to relocate or shift existing access points on partially controlled access highways. The *Highway Design Manual* also presents guidance on several access management techniques (Table 1).

Table 1 KYTC Published Access Management Guidance

Access Management Technique	KYTC Guidance
Corner Clearance	• Locate access points as far away from intersections as possible to reduce conflicts • Evaluate the four types of intersection corner clearance during design: o Upstream and downstream on the major road o Approach side and departure side on the minor road • Undertake a detailed traffic engineering analysis before approving driveway designs that may negatively impact intersection operations • Minimum corner clearance on minor crossroads is 150 feet
Fencing Controlled Access Highways	• Fencing is usually required on fully or partially controlled access roads • Use woven wire fences in rural areas and chain link fences in urban areas • Fence areas that businesses, buildings, utility companies, farming, or entrances may encroach upon
Traffic Signal Locations	• Establish minimum traffic signal spacing to achieve project goals and give priority to through traffic
Interchange Spacing	• Minimum interchange spacing for interstates is one mile in urban areas and three miles in rural areas
Driveway Spacing, Location, and Design	• Be attentive to the relationship between the location of access points and (a) intersection sight distance as well as (b) distance from adjacent intersections • Locate access points required on opposite sides of a road directly opposite of each another. • Implement access connections that maintain safe ingress and egress for developments; keep adverse road impacts to a minimum • Do not locate driveways within an intersection's functional area • On divided roadways, each side may be considered independently when spacing access points on the outside of the road
Alternate Access	• If feasible, provide access from a secondary road instead of a primary road
Frontage Roads	• The areas in which frontage roads will be constructed should be acquired as right of way • Construct frontage roads 150 feet from the main road measured from mainline edge of pavement

The foregoing discussion is not exhaustive in its treatment of KYTC's approach to access management, but it does highlight how piecemeal regulations and guidance coupled with the absence of a formal access management program make it challenging for designers and permit engineers to retrieve information needed for decision making.

To aid stakeholder decision making, this report serves as a constrained guidance document on access management. It can assist permit engineers and highway designers in maximizing the efficiency and safety of the most critical roadway components of Kentucky's road system. The guidance emphasizes treating property owners in a fair and equitable manner while remaining sensitive to the needs of the traveling public.

To prepare this document, our team reviewed best access management practices that have been adopted by other state transportation agencies as well as guidance issued by TRB and information which has appeared in other venues (e.g., NCHRP reports, state guidance). Chapter 2 briefly reviews the 2004 *Kentucky Access Management Plan* (Stamatiadis et al. 2004) and discusses policies related to auxiliary lanes and traffic impact studies that KYTC has adopted since. It also briefly surveys access management programs in other states, highlighting in particular the Florida Department of Transportation. Chapter 3 presents an Access Management Toolbox. It consists of 14 proven access management techniques that designers and permit engineers can apply. This information is organized into 14 separate entries. Each entry describes the technique and provides the Study Advisory Committee's (SAC) rating of its effectiveness and ease of implementation. The final chapter reflects on the future prospects of access management in Kentucky.

2. Review of State Practices

2.1 Access Management for Kentucky

Stamatiadis et al. (2004) authored *Access Management for Kentucky*, which presented a comprehensive set of access standards consistent informed by the principles laid out by Gluck et al. (1999) and TRB (2003). KYTC requested the plan because of its limited options for access management, which included case-by-case permit reviews for state-maintained routes and negotiated access spacing improvements that are incorporated into the design of major highway improvement project. The proposed access management program was built around four pillars: (1) using functional criteria to classify roads; (2) defining allowable levels of access for each road class, including standards for spacing signalized and unsignalized access points; (3) applying appropriate geometric design criteria and engineering analysis, and (4) adopting appropriate regulations and administrative procedures (Stamatiadis et al. 2004).

For both urban and rural locations, Stamatiadis et al. (2004) proposed five access management classes. The highest functional class – *F* – encompasses freeways and expressways with full access control whose only junctions are grade-separated intersections. Class I includes arterial roads of high importance. Stepping down through classes, the traffic volumes and speeds of the reference roadways gradually decline (Table 2). While these classes are related to the functional classification of roadways, they also account for the both the volume and speed of traffic as well as the roadway context.

Table 2 Proposed Access Management Classes (Stamatiadis et al. 2004)

Class	Location	
	Urban	**Rural**
F	Freeways, Expressways, Parkways with full access control	Freeways, Expressways, Parkways with full access control
I	Roads with high volumes and high speeds, placing a high priority on mobility, long distance travel through urban areas, typically including principal arterials, multi-lane facilities often with median.	Roads with high volumes and high speeds, placing a high priority on mobility, long distance travel between urban areas, typically including principal arterials, often multi-lane facilities.
II	Roads with moderate volumes and speeds, placing priority on mobility, used for intra-city travel, typically including minor arterials, often multi-lane facilities.	Roads with moderate volumes and speeds, placing priority on mobility, used for inter-city and interregional travel, typically including minor arterials, often two-lane facilities.
III	Roads with low volumes and speeds, balancing access and mobility, short distance travel within urban centers, typically including collectors, often two-lane facilities.	Roads with low volumes and speeds, balancing access and mobility, short distance travel in rural areas, typically including collectors, two-lane facilities.
IV	Roads with very low volumes and speeds, placing a high priority on access, travel for local access, typically including local streets.	Roads with very low volumes, placing a high priority on access, travel for local access, typically including local streets.

Figure 1 elaborates on the proposed classification system, indicating how individual classifications account for speed and traffic volume. A threshold speed limit of 45 mph is used for all classes, while threshold volumes are 2,500; 5,000; and 10,000 vehicles per day. Stamatiadis et al. (2004) observed that KYTC should expect to receive frequent requests to reclassify roadway segments into a lower access management classification to provide more liberal access to specific parcels. Although the plan cautions against revising access categories, it does not address the underlying issue of how less restrictive access can be provided if site conditions permit. Under the plan, the only method of removing access restrictions is by modifying a roadway's access classification, even if the proposed access plan does not identify negative impacts.

Principal Arterial

Rural

Speed	Volume <5,000	Volume ≥5,000
≥45	I	I
<45	II	I

Urban

Speed	Volume <10,000	Volume ≥10,000
≥45	I	I
<45	II	I

Minor Arterial

Rural

Speed	Volume <2,500	Volume ≥2,500	Volume ≥5,000
≥45	II	II	I
<45	III	II	II

Urban

Speed	Volume <5,000	Volume ≥5,000	Volume ≥10,000
≥45	II	II	I
<45	III	II	II

Collector

Rural

Speed	Volume <2,500	Volume ≥2,500
≥45	III	II
<45	III	III

Urban

Speed	Volume <5,000	Volume ≥5,000
≥45	III	II
<45	III	III

Local

Rural		Urban	
All speeds & volumes	IV	All speeds & volumes	IV

Figure 1 Roadway Classifications in Relation to Traffic Volumes and Speed Limits (Stamatiadis et al. 2004)

The primary focus of *Access Management for Kentucky* was the creation of access spacing standards by access type, and roadway access management classification. The spacing standards Stamatiadis et al. (2004) adopted were based on 600-foot increments; this was done to ensure the plan would be compatible with existing statutes (KRS 177.135) and regulations (603 KAR 5:120). Table 3 summarizes the proposed spacing standards. Along with spacing standards, Stamatiadis et al. (2004) proposed a set of best practices to improve traffic flow and increase safety. These practices are presented in bulleted list located beneath Table 3.

Table 3 Proposed Access Spacing Standards (Stamatiadis et al. 2004)

Access Class	Typical Functional Class	Interchange Spacing (ft) To Interchange	A[1]	B[2]	C[3]	D[4]	Signalized Intersection (ft)	Unsignalized Intersection (ft)	Median Type Traversable	Median Type Non-traversable	Median Opening (ft) Full	Median Opening (ft) Directional	Corner Clearance (ft)[8]
Urban I	Principal Arterial	1 mile	900	900	2,400	900	2,400	1,200/600[6]		X	2,400	1,200	1,200/600[6]
Urban II	Minor Arterial	NA	600	900	2,400	900	2,400	450	X	X	2,400	1,200	450
Urban III	Collector	NA	600	600	1,200	600	1,800	300	NA	X[7]	1,800	600	300
Urban IV	Local	NA	NA	NA	NA	NA	NA[5]	150	NA	NA	NA	NA	150
Rural I	Principal Arterial	2 miles	1,200	1,200	2,400	1,200	4,800	1,200		X	2,400	2,400	1,200
Rural II	Minor Arterial	NA	1,200	1,200	2,400	1,200	2,400	600	X	X	1,200	1,200	600
Rural III	Collector	NA	NA	NA	NA	NA	2,400	450	NA	X[7]	1,200	600	450
Rural IV	Local	NA	NA	NA	NA	NA	NA	150	NA	NA	NA	NA	150

- Examine spacing distances conjunction with sight distance requirements. These findings should take precedence over the recommended distances listed in Table 3.
- Evaluate existing signals along reconstructed roadways to determine if they are still needed. Remove signals that are unnecessary and/or unwarranted.
- Encourage corner properties that has frontage on roadways with different access classifications to obtain access via the roadway of the lower functional class. Provide a non-traversable median to eliminate left turns when it is necessary to provide access via the higher-class roadway.
- Locate access points to corner properties as far from the intersection as possible.
- Consolidate driveways of adjacent properties whenever feasible.
- Eliminate left-turn egress and ingress within the influence area of an intersection along undivided major highways.
- Complete detailed studies for driveway permits focused on the influence area of an intersection to ensure undisturbed operations at the intersection.
- Provide access for outparcels at a large development from within the site. Prohibit direct access to outparcel developments.

Stamatiadis et al. (2004) recognized that complying with standards in developed areas is challenging. They observed that "it would be highly desirable that the access be modified to be consistent with the new standards. In cases where full compliance is not practical because of development that has already occurred, efforts should be made to increase access spacing and improve access design" (p. 86). Stamatiadis et al. (2004) also recommended that KYTC establish an Access Management Implementation Task Force to spearhead the development of a formal access management program. They suggested assigning the task force the following duties:

- Preparing a public involvement plan,
- Finalizing and overseeing the adoption of spacing and design standards,
- Initiating the classification system, and
- Crafting administrative regulations for consideration by the Kentucky Legislature.

While the document also identified areas in which traffic engineering analysis may be beneficial, the authors argued specifics as to how this analysis should be executed should be addressed by the task force.

Stamatiadis et al. (2004) described 12 access management techniques that could be integrated into a formal access management program. Table 4 summarizes each. Despite the Access Management Implementation Task Force being formed, no formal access management program was adopted, for the reasons specified in Chapter 1.

Table 4 Access Management Techniques (Stamatiadis et al. 2004)

Techniques	Description
Signalized Spacing	This spacing identifies the minimum desirable distance between signalized intersections. The gap between each signal combined with the number of signals on a given stretch has a significant effect on the operational performance of highways. Signals can account for a great deal of delay and increasing the number of signals along the road often can lead to more congestion. Studies completed on the effect of signal density showed the relationship between delays and safety (39, 40, 41). The conclusions of these studies indicate that long and uniform signal spacing are desirable in order to achieve efficient traffic signal progression at desired travel speeds.
Unsignalized Access Spacing	This spacing examines the desirable distances between non-signalized intersections. Access points are the places of conflict causing friction to the traffic stream. By increasing the space between access points, the number of conflict points can be reduced, thus increasing safety. Research has shown that the greater the access control, the lower the crash rates. Similarly, the greater the frequency of driveways and streets, the higher the number of crashes (42, 43). A key focal area of access management is driveway spacing. The deleterious effect of driveway traffic on arterial operations and on safety is well established by a number of studies including those completed in Denver, Oregon, and Florida (12, 44, 45, 46). Good access management can be attained by proper placement of access points along with proper design of the access points. The addition of an acceleration lane to driveways along an arterial roadway is beneficial to the driveway traffic. Allowing room for driveway traffic to speed up will eliminate the danger of extremely slow moving vehicles entering the traffic flow (47).
Interchange Spacing	Interchanges are the connections for the traffic between freeways and arterial streets. These are points of activity in urban locations and also are the reason for a great deal of roadside development. If an intersection is too close to the arterial/freeway interchange, then it may cause heavy volumes, higher crash rates, and more congestion. Land development at interchanges should be sufficiently separated from ramp terminals in order to avoid heavy weaving volumes, complex traffic signal operations, frequent crashes, and recurrent congestion (44, 48). The spacing should be such that it allows proper merging, diverging, and weaving of ramp and arterial traffic.
Corner Clearance	The corner clearance represents the distance between an intersection and the next access point along the roadway, either upstream or downstream of the intersection. Use of adequate corner clearances removes driveways from the functional area of at-grade intersections. The lack of appropriate corner clearances can result in traffic-operation, safety, and capacity problems (49, 50).
Traversable Median	Traversable medians are medians without physical control over left turns and are typically either flush separation between the directions of travel or two-way left-turn lanes (TWLTL). For highway capacity purposes roadways with TWLTL's are considered as divided highways and there is no need for free flow speed adjustment (51). TWLTLs also improve safety, reducing crashes by up to 34% when placed on a 4-lane undivided highway (52). The center lane also provides operational flexibility for emergency vehicles and reduces left turns from the through lanes. However, the safety gains from TWLTL are lower than when a non-traversable median is present. Moreover, TWLTL do not discourage strip development which is often accompanied by frequent access points (43).
Non-Traversable Median	Medians are widely used for managing access along highways. Divided highways typically experience lower crash rates than undivided highways because they allow fewer opportunities for conflicts and erratic movements. They also provide a pedestrian refuge and have the potential to reduce pedestrian crashes. With the presence of medians it is often necessary to provide median openings periodically to allow for left turn or U-turn movements. Roadways with non-traversable medians showed significantly lower crash rates (30-45%) than roads with TWLTL (12, 40).

Left Turn Lanes	The main problems posed by left turns are increased conflicts, increased delays, and the complication of traffic signal timing (53, 54). The potential for this problem is greater at major highway intersections. This problem is illustrated by the fact that more than two-thirds of all driveway related crashes involve left turning vehicles (55). Left turn lanes are normally provided by offsetting the centerline or by recessing the physical median. The addition of left turn lanes has been shown to be very cost effective. The removal of left turns from the through traffic lanes resulted in crash rate reductions ranging from 18 to 77 percent (56). A Michigan study cited capacity gains of 20 to 50 percent as a result of a permitted two-phase signal operation. This two-phase signal decreases the stopped time for vehicles, thus decreasing the delay (57). Guidelines have been recognized when considering whether a left-turn lane is needed for signalized intersections in Kentucky (58). Additional guidelines for when left-turn lanes should be provided are set forth in several documents for both signalized and un-signalized intersections (54, 59).
U-Turns	To reduce conflicts and improve safety, U-turns are being used as an alternative to direct left turns. U-turn alternatives create about 50 percent fewer conflicts than direct left turns. Additionally, conflicts associated with direct left turns have the potential to be more severe (60). Reducing the number of conflicts decreases the crash risk for drivers (47). The U-turn makes it possible to prohibit left turns from driveway connections onto multilane highways and to eliminate traffic signals that would not fit into time-space patterns along arterial roads. There is an increase in capacity and a reduction in delay when U-turns were provided as an alternative to direct left turns (47, 61). The safety effects of U-turns have been examined through a number of different studies, which have shown a significant reduction in crashes (62, 63).
Roundabouts	Roundabouts are considered an alternative solution for intersection design that could reduce the number of conflict points. Roundabouts have been used extensively in several countries and several have been introduced recently in the US. Roundabouts reduce the number of conflicts at a typical four-leg intersection by 75 percent: from 32 potential conflict points at an unsignalized intersection to 8 points. Roundabouts are considered a very safe form of intersection design and recent studies have documented the savings from their installation (64, 65). These facilities can also improve intersection capacity over signalization; those with single lane approaches seem to perform very well with volumes of up to 2,500 vehicles per hour due to their simplicity (65, 66).
Frontage & Backage Roads	Frontage roads reduce the number of connections to main lines thus reducing the frequency and severity of conflict points along the main travel lanes. Direct property access is provided through the frontage road. The use of frontage roads along arterials that connect with freeways can reduce left turns and weaving, avoid double loading of arterial roads, and improve property access. Commercial development along frontage roads may potentially create congestion and increase the potential for crashes due to the overlapping of maneuver areas, close conflict points, and the complex movements needed to enter and leave the main travel lanes. Therefore, great care must be taken in the design of arterial frontage roads to protect both the arterial and crossroad operations (12). Backage or service roads provide access and connectivity to properties while providing greater separation between the major roadway and the circulation road. Such roads are typically preferred over frontage roads because they provide a better grid system and allow for development on both sides of the road.
Alternative Access	This approach encourages the use and identification of alternative ways that a property can be accessed (43). Such alternative concepts include joint and cross access and internal access to outparcels. Joint access has the potential of reducing the number of direct access points and removes short local trips from the major road to the interior of the development. Access to outparcels is probably one of the largest problems with developments, since each one desires a separate entry. Consolidation of driveways and circulation within the development are desirable to reduce potential conflicts and number of access points.
Administrative	There are few administrative techniques that could be used to enhance and control access management (43). Acquisition of access rights has been used to limit and control access of properties along a roadway. This approach is typically used when safety or operational concerns exist. Land and subdivision regulations are another type of such controls and are used to ensure proper access and street layout of subdivisions. The need for such regulations is essential in ensuring proper connectivity of the subdivision to the major thoroughfares as well as reducing the number of direct access points. The need for interagency coordination is imperative, since often subdivisions are registered with local governments and not necessarily with state agencies. Access management overlay districts have been also used to ensure and preserve access control for designated corridors.

2.1.1 Kentucky Traffic Impact Study Requirements

In response to changes in KARs related to partial control of access roadways, in 2012 the Cabinet enacted traffic impact study (TIS) requirements to help guide traffic engineering analysis requested through the driveway access permit process. These studies have two objectives: 1) determine the appropriate location, spacing, and design of access points necessary to mitigate the traffic and operational impacts on the highway, and 2) assess if the adjacent and nearby road system needs improvements to maintain a satisfactory level of service and safety while protecting highway functions and affording appropriate and necessary access to a proposed development (KYTC 2012). The requirements specify criteria for determining if a TIS is necessary as well as conditions under which a district permit engineer may waive study requirements.

In addition to the primary objectives stated above, a TIS also must document the operational and safety impacts of a proposed development and access plan. To evaluate the impact of a development on traffic conditions in a study area, a TIS looks at 1) existing conditions, and 2) conditions before and after a proposed development opens. More specifically, the study employs *Build* and *No Build* analyses. The baseline year for *Build* and *No Build* analyses is the year a development is expected to open. Traffic conditions for the baseline year are compared to the projected traffic conditions for a design year, which is set at 10 years after a development opens.

While KYTC's requirements for conducting a TIS principally deal with capacity issues that will result from additional traffic coming onto a highway system as a result of a development, they also mandate performance of a TIS when a proposed access location does not meet certain access spacing requirements. The Cabinet adopted these access spacing requirements from Stamatiadis et al. (2004), however, they reference highway functional classifications, not that report's access management classifications (Table 5). KYTC reserves the right to waive the TIS requirement if 1) the required spacing that does not meet the spacing standard results from a pre-existing condition, and 2) complying with the standard would preclude access.

Table 5 Access Spacing Requirements for Traffic Impact Studies

Table 2: Access Spacing[1]

Functional Classification	Signalized Intersection Spacing	Full Access	Directional Access[1]	Restricted Access[2]
Urban Roadways				
Principal Arterial	2,400	2,400	1,200	1200/600[3]
Minor Arterial	2,400	2,400/1,200[3]	1,200/600[3]	600
Collector	1,200	600	300	300
Local	1,200	150	150	150
Rural Roadways				
Principal Arterial	2,400	2,400	1,200	1200
Minor Arterial	2,400	2,400	1,200	600
Collector	1,800	900	450	450
Local	1,200	150	150	150

Notes:
1. Directional access only provides for left-in, right-in and right-out movements only.
2. Restricted access only provides for right-in and right-out movements only.
3. For roadways with an 85th percentile speed greater than or equal to 45mph, use larger values. For roadways with an 85th percentile speed less than or equal to 45 mph, the larger values should be utilized where feasible but the lower values may be applied, where necessary.

2.1.2 Auxiliary Turn Lane Policy

In 2009 the Cabinet adopted a new auxiliary turn lane policy for state highways to eliminate the inconsistent practices which existed across divisions and implement a uniform process for developing auxiliary turn lanes. The policy contains 1) warrants for left and right turn lanes for all state highways and 2) updated design guidance. Its primary turn-lane warrants are based on the original Harmelink Methodology published in Highway Research Record 211 in 1967, however, they were updated using improved capacity analysis. Nomographs generated using the Harmelink Methodology generate an estimate of the probability that an advancing vehicle will arrive behind a stopped turning vehicle. Figures 2 and 3 illustrate left-turn lane warrants for low and high-speed roadways, respectively. When the *Highway Design Guidance Manual* was updated in in 2016, the auxiliary turn lane policy was revised as well.

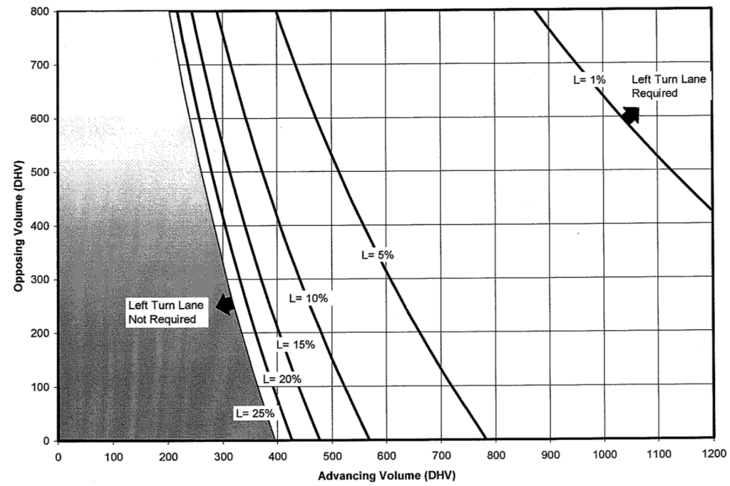


Figure 2 Uncontrolled Approach — Left-Turn Lane Warrants for Low Speed Roadways

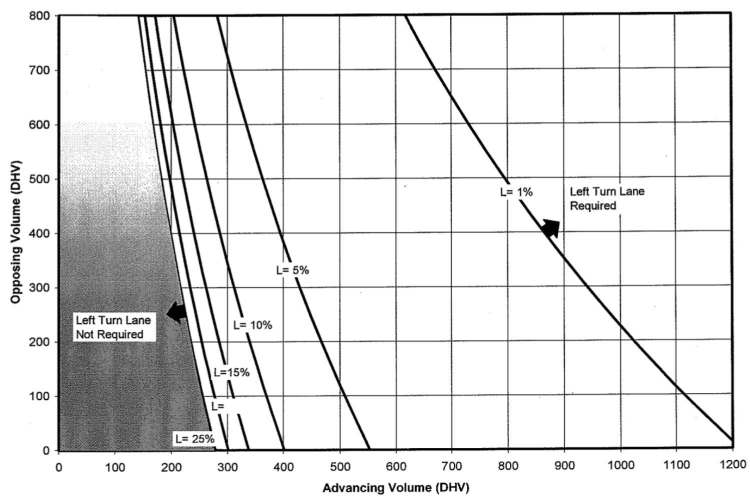


Figure 3 Uncontrolled Approach — Left-Turn Lane Warrants for High Speed Roadways

2.2 Access Management Practices in Other States

In addition to reviewing current DOT access management policies (the results of which are reflected in the discussion of specific techniques in Chapter 3), we examined recent literature published on the topic (e.g., Dixon et al. 2013; Chowdhury et al. 2018). The work by Chowdhury et al. (2018) is particularly valuable because it documents the operational and economic implications of different access management treatments. Relying on a literature review, a survey of agency officials, and operational and economic analyses, this report offers an illuminating snapshot of the access management practices most frequently used across the US. The most common access management strategies are:

- Limiting/separating access points,
- Restricting driveways close to intersections,
- Installing raised medians, and
- Modifying full driveway access to restricted driveway access

The most popular access management techniques for spot improvement are driveway consolidation, adding a median, adding a median opening, closing a median opening

The survey of state DOTs uncovered a number of useful findings. While most agencies consider the operational impacts of access management techniques, just seven (7) of the 32 which responded assess their economic impacts (with more respondents saying they will consider doing so in the future). Twenty-six agencies leverage driveway spacing strategies for access management; six (6) respondents mentioned evaluating or modifying signal spacing as a technique their organizations rely upon. Asked about the issues associated with modifying existing driveways, 26 of 27 respondents cited opposition from businesses as the number one challenge. Respondents from agencies which do not eliminate driveways said this decision is in response to challenges related to retrofitting driveways, the lack of an access policy, too many non-confirming corners, grandfather clauses, and cost. Additional challenges of this technique are small isolated corner lots, no alternative access, site geometry, and topology. Of the 23 respondents replying to a question about a minimum ADT or driveway volume needed to keep a driveway open, most said their agencies have not established a threshold value.

When deciding on access management techniques to implement or when to allow variances from median opening criteria, 31 of 36 respondents said their agency made a determination after an exhaustive traffic impact study of the property and access points. Most respondents commented that their agencies do not actively seek driveway closures, however, they may review conditions due to a high crash frequency or high mainline through traffic. Seventy-three percent of respondents said their agencies look to driveway consolidation to reduce driveway density, but also noted facing difficulties when implementing this technique. One strategy of pursuing driveway consolidation it to make an effort when there is a change in business type or ownership; 16 of the 18 interviewees observed this can provide an opportunity to eliminate or consolidate driveways. In most states business owners have recourse to appeal decisions regarding access to their businesses. Generally, these appeals are made to district engineers, an access management appeal committee, or directly to the district court. (It is worth noting that economic analysis performed for this study did not find that businesses were adversely impacted by changes in access management).

As part of their operational analyses, Chowdhury et al. (2018) evaluated four access management strategies for testing corridor-wide improvement: 1) driveway consolidation, 2) providing sufficient corner clearance distance from an intersection, 3) access restriction near signalized intersections, and 4) raised median implementation. Using microscopic travel simulations to assess the impacts of these techniques, they found that driveway consolidation consistently reduces travel times, non-traversable medians increase mainline travel times and stop delays compared to two-way left-turn lanes, and that providing adequate corner clearances may significantly reduce travel time for right-in and left-in driveway traffic. On the whole, however, Chowdhury et al. (2018) argued that because the effects of access management are site-specific, DOTs should conduct simulation analyses where possible to evaluate the operational impacts of techniques. Furthermore, while agencies frequently cite the safety and operational benefits to justify changes in access, as their survey indicated, most do not undertake before-and-after studies to empirically validate the effects of access management. These studies can be valuable for deepening our understanding of how access management techniques function in different contexts.

Following our review of state policies and published literature, we interviewed Gary Sokolow who led the Florida Department of Transportation's (FDOT) access management initiative for over 20 years. The agency is widely recognized as a leader in access management policy and has had success applying access management techniques throughout Florida. While FDOT continues to pursue a traditional access management strategy, staff enjoy considerable flexibility in their use of access management techniques. Mr. Sokolow observed that FDOT in recent years has shifted its focus from joint/shared access, access closures to median access control on retrofit projects for low-volume driveways. Furthermore FDOT pursues closure or consolidation of driveways in areas where doing so yields significant impact (e.g., within the functional area of an intersection). Although courts have ruled these practices are legal, focusing time, efforts and money on access controls has significant impacts. On new construction projects FDOT limits access spacing in addition to median break spacing. Nonetheless, developments typically receive some form of access to the state highway system, although it is frequently in the form of a right-in/right-out or even a right-in only. Permits are reviewed at the district level by staff, however, there is a district access review committee, consisting of a branch manager and department heads, which hears and adjudicates disputes that are not resolved by staff prior to them being advanced to Chief District Engineer or the central office. This process has performed well in that two levels of technical review must be conducted before an issue is elevated the political level. The higher level of technical review and support relieves pressure on Chief District Engineers and the State Highway Engineer. With respect to full and partial control of access standards, Mr. Sokolow noted that controlling access is not possible unless it is purchased. During our conversations, he noted other keys to successfully implementing an access management program:

- Concentrate on building medians rather than closing driveways
- Emphasize the safety aspect of access management
- Provide property connection through the permit process and working directly with local government
- Using District level Access Management Review Committees.
- Process should be consistent
- Use of creativity and flexibility to resolve issues. "Working toward a 'Yes'"

3. Access Management Toolbox

Based on our review of national guidance on access management practices and other state practices, we assembled an *Access Management Toolbox* that was presented to the SAC. The toolbox contains 14 treatments used for access management. After distributing the toolbox to the SAC, we asked the committee to rank each treatment with respect to its overall effectiveness in preserving roadway capacity and safety as well as their perceived ease of implementation. Rankings each treatment were done on a scale of 1 to 5, where 1 signaled the treatment is either ineffective or difficult to implement and 5 indicated the treatment is either very effective or easy to adopt. This chapter briefly reviews each treatment in turn along with SAC rankings. The techniques in the Access Management Toolbox are listed below, while Table 6 lists each technique, effectiveness and ease of implementation ratings, and any considerations that readers should bear in mind.

Access Management Toolbox

- Maintain Sight Distance
- Unsignalized Intersection Spacing Standards
- Signalized Intersection Spacing Standards
- Interchange Area Spacing Standards
- Corner Clearance
- Maximum Number of Driveways per Lot
- Frontage/Backage Roads
- Shared Driveways
- Median Type Standards
- Driveway Throat Length
- Auxiliary Turn Lanes
- Protect the Functional Area of the Intersection
- Turn Restrictions
- Traffic Impact Studies

Table 6 Access Management Techniques and SAC Ratings

Access Management Treatment	Effectiveness	Implementation	Notes
Maintain Sight Distance	5	5	Minimum criteria currently in use at KYTC
Unsignalized Intersection Spacing Standards	2	5	Lot size often plays significant role in spacing and clearance issues
Signalized Intersection Spacing Standards	2	4	May be more effective in planning
Interchange Area Spacing Standards	3	5	Difficult to enforce unless full control is present
Corner Clearance	3	5	Lot size often plays significant role in spacing and clearance issues
Maximum Number of Driveways Per Lot	5	5	Currently in use through permitting and TIS process
Frontage/Backage Roads	3	5	Requires coordination with local agencies through planning and zoning
Shared Driveways	2	4	Questions surrounding legality of requiring shared use driveways exist
Driveway Throat Length	3	3	Difficult to enact standards outside right of way
Auxiliary Turn Lanes	5	5	Currently in use through permitting and TIS process
Protect the Functional Area of the Intersection	4	5	Currently in use through permitting and TIS process
Turn Restrictions	4	5	Currently in use through permitting and TIS process
Traffic Impact Studies	5	5	Provides adequate flexibility to address most issues

3.1 Maintain Sight Distance

Study Advisory Committee Rankings	
Effectiveness: 5	Implementation: 5

Sight distance is informally defined as the length of roadway visible to a driver. More specifically, it is "the distance along a roadway throughout which an object of specified height is continuously visible to the driver" (AASHTO 2011, 3-14). There are four types of sight distance: intersection sight distance, stopping sight distance, passing sight distance, and decision sight distance (NACTO 20xx). In the context of access management, the most critical forms of sight distance are intersection sight distance and stopping sight distance. Stopping sight distance is the minimum sight distance required for a vehicle traveling at or near a road's design speed to come to a stop before it reaches a stationary object in its path (AASHTO 2011). Intersection sight distance is the sight distance provided at intersections and driveways to let motorists discern where potentially conflicting vehicles are located (AASHTO 2011). Sight distance is calculated assuming a motorist's eye is positioned 3.5 feet above the road surface and that the object that is supposed to be continuously visible to the motorist is either 2.5 feet above the road surface (for stopping sight distance) or 3.5 feet above the road surface (for intersection sight distance). Any object that obstructs a driver's view in the sight triangle should be removed (e.g. parking, landscaping, structures). Figure 4 shows examples of adequate versus inadequate sight distance. During the rating process, SAC members noted that maintaining minimum sight is the minimum requirement for all access points on state-maintained highways; it is checked during permitting. Maintaining sight distance and placing access points in locations to maximize sight distance significantly improves safety and is an action that can be readily justified to property owners.

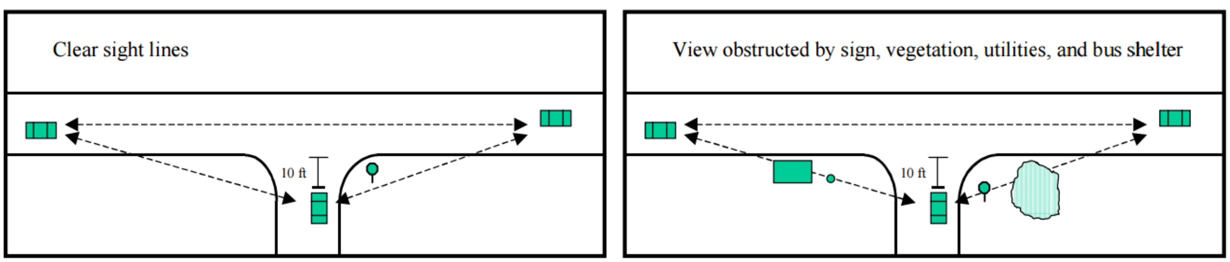


Figure 4 Adequate (Left) and Inadequate (Right) Sight Distances

3.2 Unsignalized Intersection Spacing Standards

Study Advisory Committee Rankings	
Effectiveness: 5	Implementation: 2

Previous research has demonstrated that access points, such as public streets and driveways, introduce conflicts and friction into the traffic stream. Vehicles entering and leaving the main road often slow through traffic; the difference in speeds between through traffic and turning traffic increases crash potential. Gluck et al. (1999) demonstrated that increasing the spacing between access points improves arterial flow and safety by reducing the number of conflicts per mile as this offers drivers greater distance to anticipate and recover from turning (Figure 5). Stamatiadis et al. (2004) proposed unsignalized access spacings of between 100 (feet for residential/farm access on local roads) and 1,200 feet (for higher volume access points on arterial highways) (Table 7).

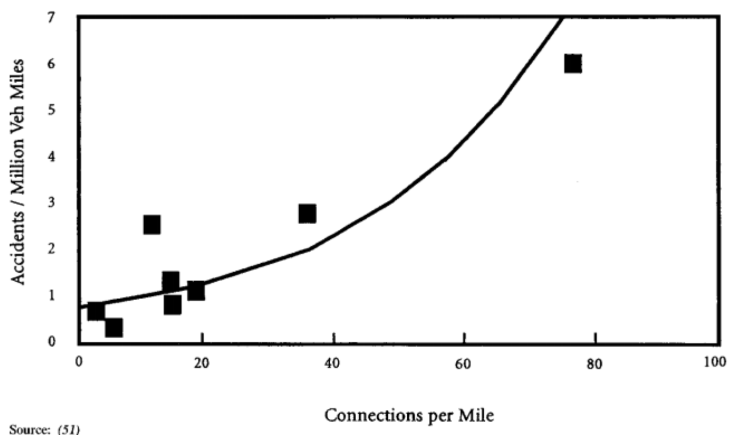


Figure 5 Accident Rate by Unsignalized Access Density (Gluck et al. 1999)

The SAC gave two explanations for its low implementation rating: 1) roadway locations which intersect highways generally are pre-existing while new roadways may be influenced by other factors, and 2) driveway access points must account for several other factors in addition to spacing standards (topography, lot size, roadway geometrics). It was noted that rigid spacing standards do not reflect the engineering judgment required for siting specific driveway and access locations.

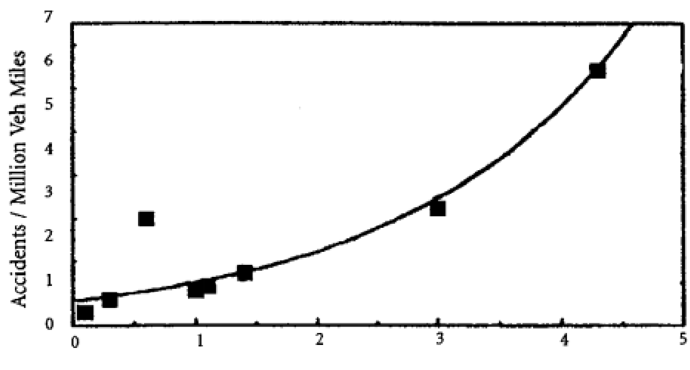
Table 7 Proposed Unsignalized Intersection Spacing Standards for Kentucky

Access Classification	Type A Access*	Type B Access**
Freeway – U	NA	NA
Freeway – R	**NA**	**NA**
Urban I	1,200/600 ***	300
Urban II	600	150
Urban III	300	150
Urban IV	150	100
Rural I	1,200	300
Rural II	600	300
Rural III	450	150
Rural IV	150	150

3.3 Signalized Intersection Spacing Standards

Study Advisory Committee Rankings	
Effectiveness: 2	Implementation: 4

One of the most basic and important access management techniques is establishing traffic signal spacing criteria for arterial roadways. Traffic signal spacing directly impacts the performance of urban and suburban highways as signals account for most delays. When signals are closely and/or irregularly spaced, arterial travel speeds may decline, which produces an excessive number of stops even under moderate traffic volume conditions. Researchers have generally confirmed that a high density of signalized intersections produces longer delays and high crash rates, although both can be influenced by site-contingent factors such as roadway geometrics and the presence of other access management treatments (Dixon et al. 2013; Figure 6). Table 8 contains the signal spacing standards proposed by the Stamatiadis et al. (2004).



Source: 3-22

Figure 6 Relationship Between Signal Frequency and Crash Rates (Gluck et al. 1999)

During the rating process, SAC members observed that prescribed signal spacing does not always provide optimal signal progression. Traffic signal spacing standards are typically set to maximize available bandwidth on the primary street. However, optimal signal spacing is a function of roadway speed and progression cycle length. Most spacing standards applied in the US are based on 90-120 second cycle lengths. As traffic volumes and/or control strategies change, cycle lengths can be modified along a corridor. The primary reason for the low implementation rating (2) is that road locations which intersect highways have generally already been established while new signal locations are determined primarily by signal warrants. As it is difficult to direct traffic away from access points of existing land uses, signal installations are often used to address operational or safety issues at existing locations. Signal spacing guidance may be beneficial during planning so that it may be considered when setting the location of new roadways.

Table 8 Proposed Signalized Intersection Spacing Standards for Kentucky

Access Classification	Signalized Intersection Spacing
Freeway – U	NA
Freeway – R	NA
Urban I	2,400
Urban II	2,400
Urban III	1,200
Urban IV	1,200
Rural I	2,400
Rural II	2,400
Rural III	1,800
Rural IV	1,200

3.4 Interchange Area Spacing Standards

Study Advisory Committee Rankings	
Effectiveness: 5	Implementation: 3

Interchange area spacing standards are similar to unsignalized intersection spacing standards, however, they offer a greater degree of protection for locations in the immediate vicinity of freeway and interstate interchanges on surface streets. Because widespread spacing standards initially elicited considerable resistance, it was proposed that focusing on interchange area spacing standards may allow limited access management applications while serving areas with the greatest traffic concentration and Kentucky's highest priority roads. Table 9 summarizes proposed interchange area spacing standards for the state.

Table 9 Kentucky Interchange Area Spacing Standards

Access Classification	Full Access Intersection (2)	Limited Access Connection (3)	Right-In/Right-Out Access Only (4)
Freeway – U	NA	NA	NA
Freeway – R	NA	NA	NA
Urban I	1,200/600*	300	300
Urban II	600	150	150
Urban III	300	150	150
Urban IV	150	100	100
Rural I	1,200	300	300
Rural II	600	300	300
Rural III	450	150	150
Rural IV	150	150	150

While SAC members regarded interchange area spacing standards as highly effective, implementation, they felt, can be challenging. The implementation rating, however, was slightly higher than other spacing standards due to the limited extent of where the standards would be applied. The SAC also felt a strong case can be made that the safety and operational integrity of the roadway must be maintained in the vicinity of interchanges. Yet, limitations with respect to lot size, topography, and roadway geometrics, the SAC argued, continue to play a large role in providing consistent application of the spacing standards even in a limited application.

3.5 Corner Clearances

Study Advisory Committee Rankings	
Effectiveness: 5	Implementation: 3

Corner clearance is defined as “the minimum distance between the extended curbline at an intersection and the edge of the nearest driveway” (Dixon et al. 2013). AASHTO (2011) notes that driveways should not be positioned within the functional boundary of at-grade intersections, inclusive of the longitudinal limits of auxiliary lanes. Inadequate corner clearances may produce difficulties with traffic operations, safety, and capacity. Sources of these problems include blocked driveway ingress and egress movements, conflicting and confusing turns at intersections, insufficient weaving distances, and backups from far-side driveways into intersections. Figure 7 exhibits the benefits of adequate corner clearances as well as the problems associated with insufficient corner clearances. Table 10 includes proposed corner clearance requirements from Stamatiadis et al. (2004).

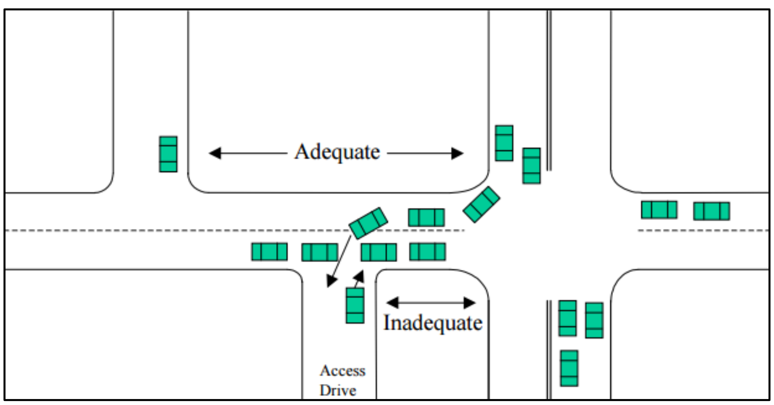


Figure 7 Implications of Adequate and Inadequate Corner Clearances

The SAC’s implementation rating was slightly higher than for other spacing standards due to the limited contexts in which the standards are applied. Members of the SAC highlighted that a stronger case can be made that the safety and operational integrity of a road must be maintained near intersections. However, they felt that limitations with respect to lot size, topography and geometrics play a large role in enabling the consistent application of spacing standards even in a limited application. Also, heavy vehicles deliveries often govern driveway access and internal circulation on small lots (e.g., gasoline delivery at corner gas stations).

Table 10 Proposed Corner Clearance Standards for Kentucky

Access Classification	Type A Access	Type B Access
Freeway – U	NA	NA
Freeway – R	NA	NA
Urban I	1,200/600*	300
Urban II	600	150
Urban III	300	150
Urban IV	150	100
Rural I	1,200	300
Rural II	600	300
Rural III	450	150
Rural IV	150	150

3.6 Maximum Number of Driveways Per Lot

Study Advisory Committee Rankings	
Effectiveness: 5	Implementation: 5

Limiting the number of driveways per parcel has a significant effect on limiting the total number of access points on a corridor. Typically the maximum number of driveways is limited to 1, unless parcels have significant frontage that would enable it to meet concurrent spacings standards. Providing adequate on-site circulation and proper placement of the limited access points is critical in ensuring its success.

Members of the SAC gave the use of maximum number of drvieways per lot the highest possible rating for effectiveness as well as implementation. The high rating for both metrics reflects the widespread use of the Cabinet's existing policy which limits the number of driveways and the confidence of permit engineers in upholding this standard. On-site circulation patterns can often be address through site review and the existing permit and TIS process.

3.7 Frontage/Backage Roads

Study Advisory Committee Rankings	
Effectiveness: 4	Implementation: 2

Frontage roads and backage roads are types of service roads situated parallel to the main roadway (generally arterials) whose purpose is to establish a direct connection to properties located adjacent to the main roadway (Butorac et al. 2018). A frontage road is positioned in between the main roadway and developed land, while backage roads are located behind developed land. Service roads may be continuous or extend for only short distances. Likewise, they can be one-way or two-way roads, however, with respect to operations and safety, one-way frontage-roads perform better than two-way frontage roads. By separating through traffic and local land-service traffic, service roads improve free-flow and travel speeds and reduce crash rates on the main roadway (Gluck et al. 1999; Butorac et al. 2018). However, if the intersection of a service road and crossroad is too close to the intersection of a crossroad and arterial, the former may suffer considerable queueing. Figures 8 and 9 illustrate a frontage and backage road, respectively.

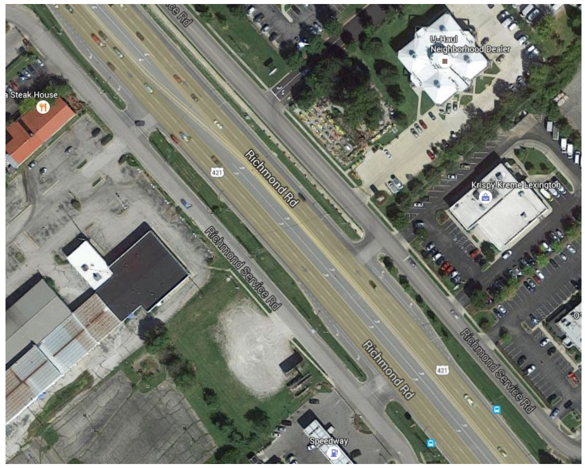


Figure 8 Frontage Road in Lexington, Kentucky

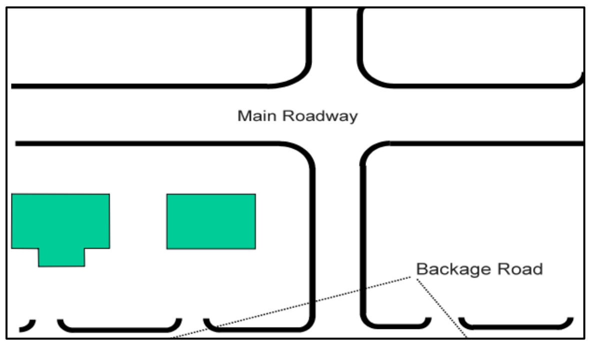


Figure 9 Generalized Representation of a Backage Road

Members of the SAC ranked frontage roads as having a high effectiveness (4/5) based on the ability to remove turning traffic from the primary roadway and consolidate movements at primary intersections. It was noted that frontage roads, which did not provide high levels of separation and adequate throat lengths can experience queuing interference and increased congestion. The implementation potential was rated as a 2/5 due to the significant right of way purchases are necessary to effectively enact frontage roads. It was noted that when identified early in the project development process, accommodations could be made to incorporate frontage roads on high priority roadways.

3.8 Shared Driveways

Study Advisory Committee Rankings	
Effectiveness: 4	Implementation: 2

It is common for two or more adjacent properties to share driveways, which limits access points to an arterial. Shared driveways are particularly valuable when lot frontages are narrow and no alternative access is available. In newer commercial developments, shared driveways are very common. Shopping plazas often provide one or two driveways for all stores. Adjacent shopping centers can also be linked together, letting drivers avoid exiting onto main arterials when visiting adjacent properties. Consolidating driveways on an individual property or between adjacent properties greatly improves ease of ingress and egress for customers, employees, emergency vehicles, and delivery trucks by making it easier and safer to find the right driveway. Safety is improved through a reduction in conflict points along a road. Figure 10 illustrates how driveways can be shared between two properties along a property line.

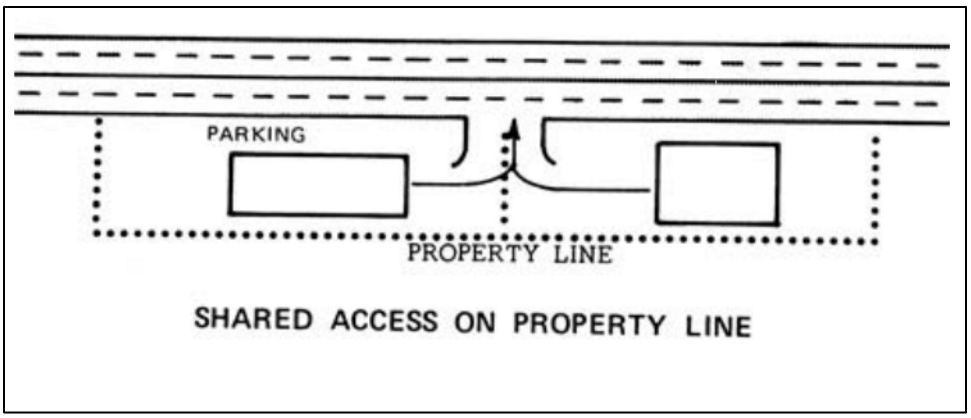


Figure 10 Example of Shared Driveway (Source: Michigan DOT *Access Management Guidebook*)

SAC members gave shared driveways a low implementation rating because of the extensive problems associated with the arrangement. Property owners often express resistance to shared driveways as well. Many on the SAC questioned the legality of requiring property owners to share access and mentioned it is unclear who has the authority to mandate use of shared driveways.

3.9 Median Type Standards

Study Advisory Committee Rankings	
Effectiveness: 2	Implementation: 3

Medians are used to channelize traffic flow control and the provision of left-turn access to adjacent properties, thereby reducing vehicle conflicts. Left turns increase conflicts between vehicles as well as vehicle conflicts with pedestrians and bicyclists. When vehicles have the ability to make left turns at any location along a corridor, delays increase, signal timings are complicated, and collisions are more frequent. These problems are especially acute on major roads. More than two-thirds of all access-related collisions involve left-turning vehicles. Furthermore, when left turns are made from a through lane, virtually all through vehicles in the shared lane are blocked by vehicles turning left. Median types are grouped into three categories:

- **Two-way left-turn lane (TWLTL):** A continuous lane located between opposing traffic flows that provides a refuge area from which vehicles may complete a left turn from a roadway,
- **Traversable median:** A median that by its design does not physically discourage or prevent vehicles from entering upon or crossing over it (e.g., painted medians and two-way left-turn lanes), and
- **Nontraversable median:** A physical barrier in the roadway, such as a concrete barrier or landscaped island, that separates traffic traveling in opposite directions and restricts left-turn movements at mid-block locations.

Numerous studies have demonstrated the installation TWLTLs on previously undivided roads lowers collision rates and facilitates traffic flow. Non-traversable medians tend to be even more effective than TWLTLs at improving the safety of vehicles as well as bicyclists and pedestrians while also bolstering the level of service (Dixon et al. 2013). Non-traversable medians are particularly effective on roads with high posted speeds (e.g., 45 mph or greater) and high traffic volumes, whereas TWLTLs perform better on roads with low or medium traffic volumes and high driveway densities (Margiotta and Chatterjee 1995). Stamatiadis et al. (2004) proposed using medians on all urban roads, except for Local Class IV streets, and on all multi-lane highways in rural areas on Class I and II roadways (Table 11).

Table 11 Access Management for Kentucky Proposed Median Standards

Access Classification	Preferred Median Type*
Freeway – U	Nontraversable
Freeway – R	Nontraversable
Urban I	Nontraversable
Urban II	Nontraversable (multilane facility) TWLTL (2-lane facility)
Urban III	TWLTL (typical) Nontraversable (high control situations)
Urban IV	NA
Rural I	Nontraversable Undivided w/Left Turn (2-lane facility) TWLTL (suburban environment)
Rural II	Nontraversable Undivided w/Left Turn (2-lane facility) TWLTL (suburban environment)
Rural III	NA
Rural IV	NA

SAC members assigned a low effectiveness rating to median type standards because a standard median type does not account for the access conditions on individual corridors; widespread median use would also be required even in locations where they are not needed to improve operations or safety. The moderate implementation rating was the result of SAC members observing that the ability to require median construction is high and frequently used. Opportunities for installing medians, however, are limited on roads without adequate pavement and/or median right of way.

3.10 Driveway Throat Length

Study Advisory Committee Rankings	
Effectiveness: 3	Implementation: 3

Driveway throat length is defined as "the distance from the outer edge of the traveled way of the roadway to the first point along the driveway at which there are conflicting vehicular traffic movements" (Butorac et al. 2018). Having a sufficient driveway throat length is critical for maintaining safe and efficient operations on roads and adjacent sites. The throat should be long enough so that vehicles can enter, exit, or circulate a site without excess queuing disrupting roadway operations. Similarly, its length should be such that drivers may reorient themselves as the enter the site and to prevent vehicles from interfering on another on the site. Adequate throat length also gives motorists entering a site the opportunity to clear a road intersection and access connection before encountering the intersection of the access connection and on-site circulation. Figures 11 and 12 exemplify poor and good driveway throat lengths, respectively.

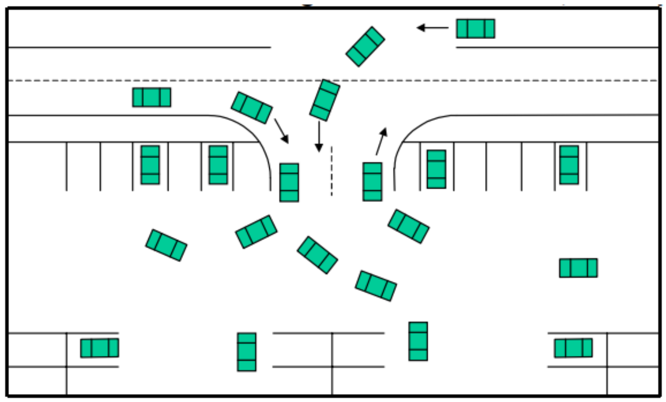


Figure 11 Inadequately Long Driveway Throat Disrupts Operations

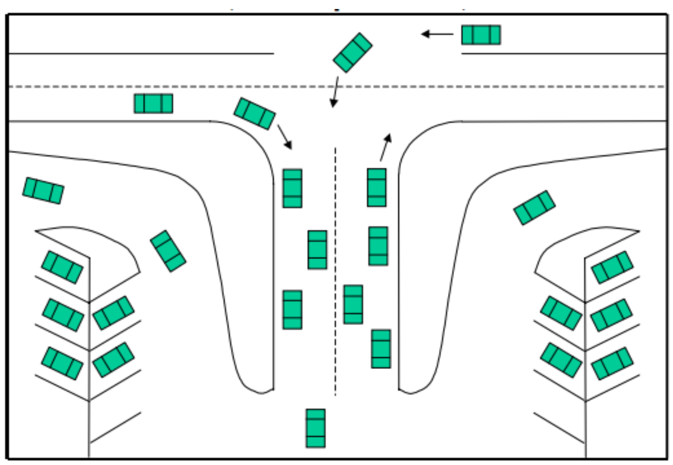


Figure 12 Sufficient Driveway Throat Length Provides for Safe and Efficient Operations

SAC members marked down the effectiveness rating of this technique because congestion and queuing from internal parking are not frequent or critical problems. The low implementation rating was the consequence of it being difficult to enact standards outside of Cabinet-owned ROW (i.e., within a development). However, this can be done through local planning and zoning efforts.

3.11 Auxiliary Turn Lanes

Study Advisory Committee Rankings	
Effectiveness: 5	Implementation: 5

Adding left-turn lanes at intersections reduces crash frequencies and optimizes traffic operations, mitigating delays and growing capacity. Turn lanes provide space for through vehicles to decelerate and then accelerate. They can also significantly reduce fuel consumption and vehicle emissions. Placing a deceleration lane upstream of locations where turning vehicles queue removes slower vehicles from the path through vehicles traveling at a higher speed. Such, building turn lanes can significantly lower the number of crashes at intersection approaches. As noted in Chapter 2, KYTC adopted a comprehensive Auxiliary Turn Lane policy under joint Permits, Operations & Design Memorandum 03-09. This policy provides warrants for turn lanes as well as design guidance. Figure 13 shows the high speed left-turn lane warrant for Kentucky.

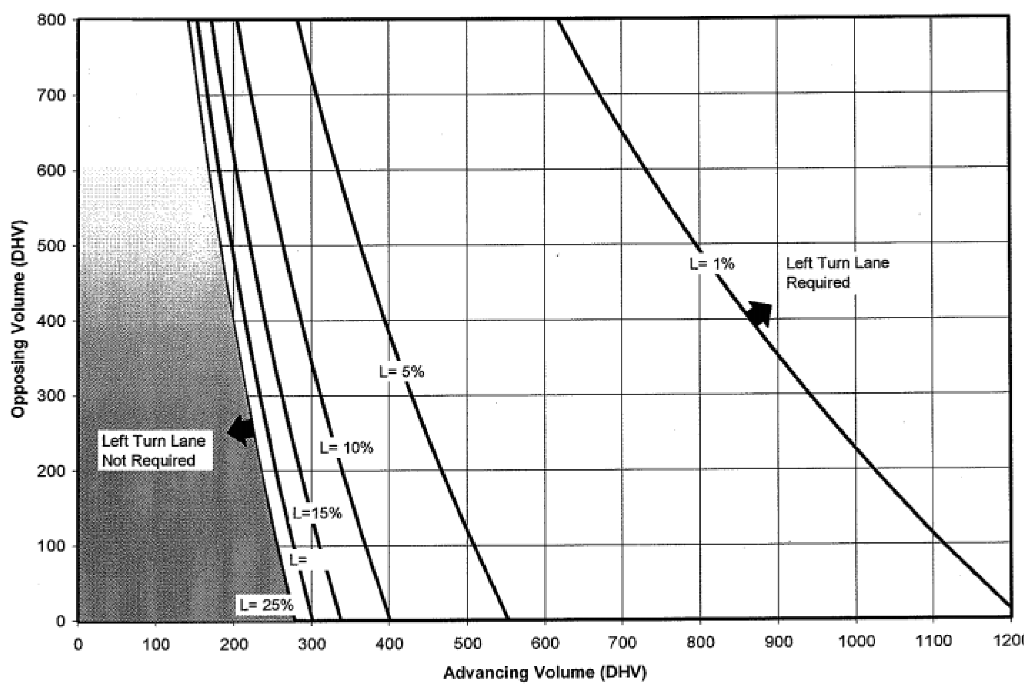


Figure 13 Kentucky High-Speed Left-Turn Lane Warrant

Members of the SAC gave the use of auxiliary turn lanes the highest possible rating for effectiveness as well as implementation. The high rating for both metrics reflects the widespread use of the Cabinet's existing policy and its adoption through the existing permit and TIS process.

3.12 Protect the Functional Area of the Intersection

Study Advisory Committee Rankings	
Effectiveness: 4	Implementation: 5

An intersection's functional area extends upstream and downstream of the physical intersection area; it includes the longitudinal limits of auxiliary lanes. As the influence area associated with a driveway encompasses (a) the impact length (the distance back from a driveway at which cars begin to be affected), (b) the perception–reaction distance, and (c) the car length, an intersection's functional area includes any area upstream or downstream of an intersection where intersection operation and conflicts significantly influence driver behavior, vehicle operations, and/or traffic conditions. Consequently, the functional intersection always subsumes an area larger than the physical intersection (Figure 14). Ideally, no access should be granted in functional areas. When access must be provided, the challenge lies in determining the best location and the type of access that may be permitted.

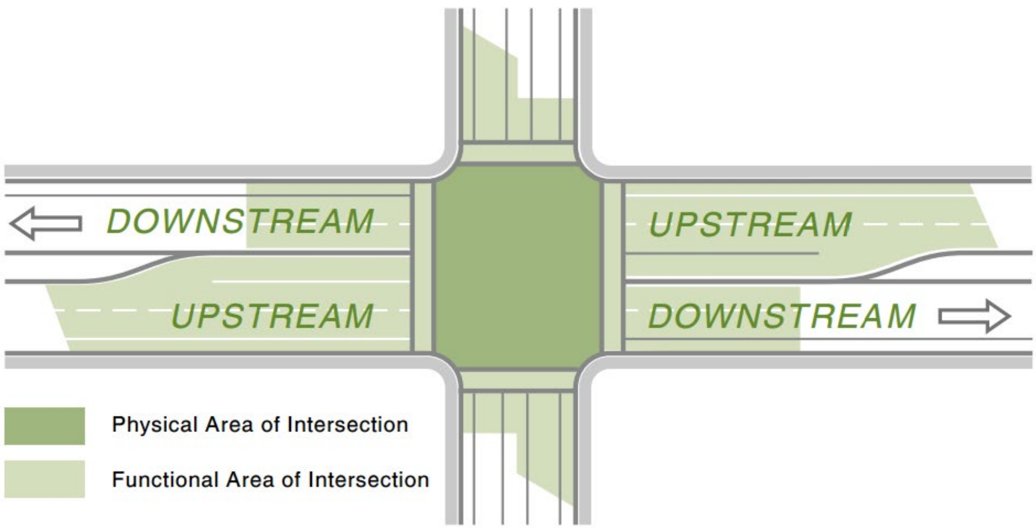


Figure 14 Functional Area of Intersection

While protecting an intersection's functional area received the highest rating (5) from SAC members, they rated its effectiveness slightly lower (4). The latter was attributed the perception that driveways are proposed within the functional areas of major intersections somewhat infrequently. Nonetheless, the SAC regarded the practice as highly effective because protecting the functional intersection area is currently addressed through existing permit and TIS practices. SAC members noted that short lot depths and/or widths can require the placement of access points inside the functional area of an intersection. However, establishing turn restrictions (e.g., right-in/right-out restrictions) lessens the impact of access points on road operations.

3.13 Turn Restrictions

Study Advisory Committee Rankings	
Effectiveness: 4	Implementation: 5

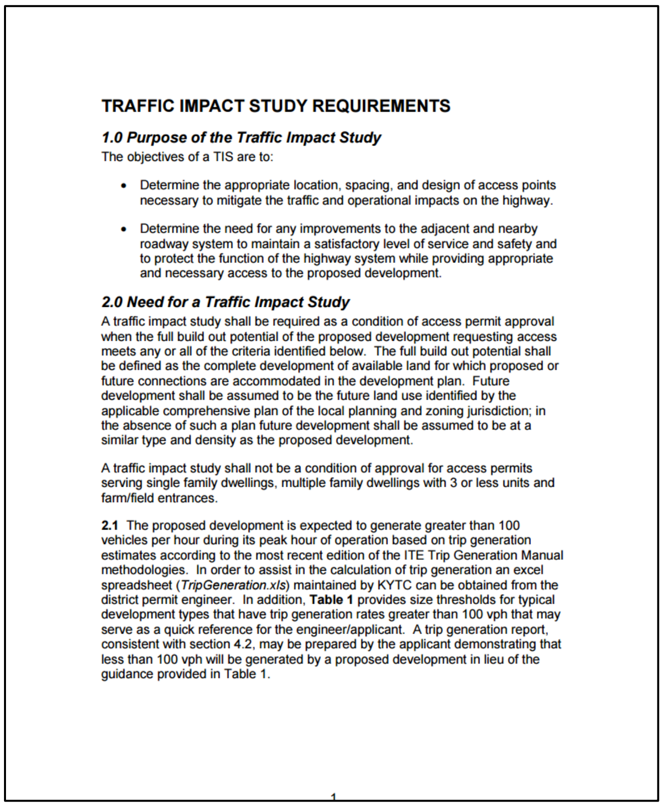
Given that most access-related crashes involve left turns, introducing turning restrictions that minimize left turns or reduce driver workloads can be particularly effective at improving roadway safety. Turn restrictions limit the exposure of through traffic and pedestrians or bicyclists to left-turning vehicles. Also, they may limit left-turn ingress or egress to a site; implementing a partial restriction can allow for left-turn ingress only in addition to right-in/right-out movements. Full access movements may be appropriate in areas where analysis indicates that traffic operations and safety would be improved. Turn restrictions may be implemented through channelization on the access or side-street or construction of a non-traversable median. Adopted in isolation, channelization measures are less effective than constructing a non-traversable median because motorists can execute prohibited maneuvers in low-traffic conditions.

SAC members rated both the effectiveness and implementation of turn restrictions highly. They observed that restrictions which eliminate left-turn maneuvers can mitigate impacts to access points within the functional area of intersections or on congested streets. Yet some issues may still exist due to the overall number of access points and/or proximity to major intersections. The SAC rated the implementation so highly because turn restrictions are currently used through the permitting and TIS process. Members commented that most turn restrictions are adopted through the construction of a non-traversable median and do not provide channelization on private driveways due to ROW limitations. This is the preferred approach because medians are very effective. Additionally, it was noted that quick-curbs have grown in popularity due to their effectiveness and ease of use when there is not sufficient pavement to build a larger non-traversable median. However, maintenance issues have also been noted with their use.

3.14 Traffic Impact Study (TIS)

Study Advisory Committee Rankings	
Effectiveness: 5	Implementation: 5

Traffic impact studies evaluate the impacts a proposed development on the surrounding transportation network, the ability to move traffic into and out of a site, and the need for off-site mitigation. The need for a TIS often arises during the permitting process for state highway access, as this is the principal opportunity for the Cabinet to assess and manage the effects of development on the state highway system. In 2009 KYTC adopted a statewide TIS policy that contains guidance on 1) when a TIS is required, 2) study area requirements, 3) trip generation estimates, and 4) operational parameters (Figure 15).



TRAFFIC IMPACT STUDY REQUIREMENTS

1.0 Purpose of the Traffic Impact Study

The objectives of a TIS are to:

- Determine the appropriate location, spacing, and design of access points necessary to mitigate the traffic and operational impacts on the highway.
- Determine the need for any improvements to the adjacent and nearby roadway system to maintain a satisfactory level of service and safety and to protect the function of the highway system while providing appropriate and necessary access to the proposed development.

2.0 Need for a Traffic Impact Study

A traffic impact study shall be required as a condition of access permit approval when the full build out potential of the proposed development requesting access meets any or all of the criteria identified below. The full build out potential shall be defined as the complete development of available land for which proposed or future connections are accommodated in the development plan. Future development shall be assumed to be the future land use identified by the applicable comprehensive plan of the local planning and zoning jurisdiction; in the absence of such a plan future development shall be assumed to be at a similar type and density as the proposed development.

A traffic impact study shall not be a condition of approval for access permits serving single family dwellings, multiple family dwellings with 3 or less units and farm/field entrances.

2.1 The proposed development is expected to generate greater than 100 vehicles per hour during its peak hour of operation based on trip generation estimates according to the most recent edition of the ITE Trip Generation Manual methodologies. In order to assist in the calculation of trip generation an excel spreadsheet (*TripGeneration.xls*) maintained by KYTC can be obtained from the district permit engineer. In addition, **Table 1** provides size thresholds for typical development types that have trip generation rates greater than 100 vph that may serve as a quick reference for the engineer/applicant. A trip generation report, consistent with section 4.2, may be prepared by the applicant demonstrating that less than 100 vph will be generated by a proposed development in lieu of the guidance provided in Table 1.

1

Figure 15 Cabinet TIS Requirements

The effectiveness and ease of implementation of these studies garnered ratings of 5 from SAC members. High ratings were the product of KYTC having adopted TIS requirements, which support the use of the study as part of the highway access permit process. Additionally, the committee noted that a TIS is effective in providing additional scrutiny when poor access placement or design is proposed. Analysis contained in a TIS can justify decisions to prohibit or restrict access. SAC members also remarked that sufficient regulatory flexibility exists to empower the permit engineer. However, they expressed concern that some KYTC districts lack the requisite knowledge base to effectively review a TIS.

4. Conclusions

A sound access management program fosters efficient traffic operations and improves roadway safety. Research studies have consistently verified the operational and safety benefits of access management, however, in many cases implementing an exhaustive access management program is challenging due to patchwork regulatory systems and opposition from businesses and other stakeholders which fear that access management will harm their livelihoods. Bearing this constraint in mind, we worked with the SAC to identify effective access management techniques that are highly effective and can be implemented easily. Six of the 14 techniques evaluated by SAC members during the rating process garnered a score of 4 or higher for both effectiveness and ease of implementation. The Cabinet uses these six techniques as part of the existing access permit process. These are:

- Maintain Sight Distance
- Maximum Number of Driveways Per Lot
- Auxiliary Turn Lanes
- Protect Functional Area of the Intersection
- Turn Restrictions, and
- Traffic Impact Studies

Some of the access management practices that received lower ratings were standards-based techniques which are unable to account for unique site conditions at an access point or along a corridor. Other low-scoring measures were those, which because of the high level of coordination they require among property owners render them impractical or politically infeasible (e.g., shared driveways), or difficult to adopt because they require mandating standards for areas beyond the KYTC-owned right of way (e.g., setting driveway throat length).

One benefit of the Cabinet's present approach to access management is that relies on evaluation of site and traffic conditions through a Traffic Impact Study. This offers permit engineers ample flexibility tailor a context-sensitive access solution for a given corridor. Such an approach is consistent with those used in other states, such as Florida, where engineers prioritize the use of creativity and flexibility when tackling access management challenges. Imposing a set of access management standards which are too rigid stifles creativity and potentially thwarts personnel's ability to exercise their engineering judgment when devising access management solutions.

Despite their benefits, SAC members observed that the heavy reliance on Traffic Impact Studies for evaluating the safety and operational impacts of proposed developments and access plans on the adjacent network is sometimes problematic. Often, the studies are densely packed with information; because some districts receive Traffic Impact Studies rarely, it is challenging for staff to effectively review them and process all of their information. Further, as the studies are generally prepared by applicants seeking access permits, their interpretation can be slanted in favor of the proposed plans. To address these issues, SAC members recommended development of Traffic Impact Study training for permit engineers. Our research team subsequently designed a Traffic Impact Study Review Course, which has been offered twice to KYTC personnel, in April 2016 and March 2019. However, while in-house review of Traffic Impact Studies is preferable, in more rural districts that receive the studies infrequently, it may still be appropriate to outsource review capabilities to central office.

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