

Connectivity Improvement Tools and Recommendations

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Report prepared by Parsons Brinckerhoff by Chuck Boyd with participation by Uri Avin and Becky Blatnica.

NEW TOOLS FOR ANALYZING AREA CONNECTIVITY

1.0 INTRODUCTION

Many comprehensive plans and ordinances now reflect planners' goals to provide for more interconnected road patterns that will enhance accessibility, walking, biking and transit. While a laudable goal, there is little guidance on how to conduct such analysis in a straightforward and cost-effective way or concrete evidence on the benefits of such increased connectivity. Given the difficulty of requiring developers or jurisdictions to add more connecting roads to future (and especially existing) networks, the lack of tools and evidence hinders the implementation of this goal.

The tools described below are designed to close this gap. They use applied research findings to provide generalist planners with simple tools to address the challenges of connectivity. They are sketch applications and therefore make numerous simplifying assumptions. These assumptions and the related caveats on their use are explicitly stated in the material below. The papers on which the tools are based are provided in appendices.

The first tool addresses the amount of connectivity needed at various densities of development in order to maintain transportation levels of service. It incorporates linked spreadsheets which the user accesses in filling out a master spreadsheet. Results are expressed as the road spacing or lane miles needed. The second application, oriented to arterial corridors, allows the user to analyze and decide how much the addition of parallel collectors would reduce traffic on the arterial. These results are found by selecting the appropriate values in lookup tables. The two applications can be used in tandem to establish how much connectivity is needed for arterial-paralleling roads.

Both applications and approaches do not substitute for user judgment and common sense. Nor do they substitute for more elaborate modeling approaches that will provide more accuracy. But for the planner in the field, they can provide quick answers to technical questions that previously seemed too complex.

2.0 DENSITY - CONNECTIVITY TOOL

2.1 Overview

This tool relates development density to road capacity (road spacing or lane miles). It answers the question "How much road connectivity do I need for a given density?" Used in iterative "trial and error" mode, it can also answer the question "How much additional density can my current road system support?" Unlike earlier efforts to relate street spacing to residential density, this methodology accounts for changes in mode share, trip length, time of travel

during peak periods, and intersection capacity as residential density increases. Planners can derive their own road spacing requirements or lengths of lane miles needed for purposes of community master planning, subarea or sector planning, large planned unit developments review and approval, access management, or zoning and subdivision regulation. It is a sketch tool for general, larger area, planning purposes and does not substitute for detailed traffic impact studies for specific project reviews and approvals. As a sketch tool, it makes a series of simplifying assumptions, some of which the user can modify and customize (detailed below), so as to produce useful insights rapidly.

The tool is based on a paper published by Dr. Reid Ewing in 2000¹, included as an appendix, which explains the thinking and analysis behind the numbers in detail. Dr. Ewing has also reviewed the application tool described in this document.

2.2 Caveats and Assumptions

The tool is intended to work in primarily residential areas of between one square mile and seven square miles. At the site scale of several square miles to a few hundred square miles this tool is overly cumbersome and includes factors that relate to area-wide travel, making it less applicable for smaller sites. A more appropriate sketch approach for site planning is the Connectivity Index². For very large areas of tens or hundreds of square miles system-wide travel patterns and major traffic generators render this simple tool insufficient for determining road needs. A travel demand model is needed for those larger areas.

While the tool assumes a small amount of non-residential uses are present in the study area, where such uses are significant or transit service exists, it allows for some further adjustment, as noted in the User Guide section under Elasticities³ (Section 1.3). The elasticities vary trip generation based on density and synthesize the findings of the best research on the topic. The default setting (-0.15) can be doubled (-0.30) to incorporate extensive mixed use or significant transit service. The tool should not be used in areas dominated by nonresidential uses since trip generation rates are based on residential development. The tool assumes a plane that is similar in all areas, without concentrations of development in certain sections.

User judgment is required in applying the spacing or lane miles outputs to actual situations. Especially where the study area is more linear, like in a corridor, the distribution of east-west vs. north-south roads is a user judgment. Where arterial efficiency in corridors is the focus of the application, the user should also

¹ Ewing, Reid "Sketch Planning a Street Network", Transportation Research Record 1722, Paper No. 00-0619, 2000.

² The preferred ratio of road links to nodes (intersections or cul de sacs).

³ An elasticity relates change in one variable to change in another. Thus an elasticity of -0.15 means that for a 10% increase in mixed use development there will be a 1.5% decrease in trips generated.

consider using the arterial-collector tradeoff tables developed concurrently with this Density-Connectivity tool.

The user is responsible for applying the results to arterial and collector roads in the study area. If the jurisdiction has an adopted Major Road Plan Map or a functional classification map, these should be used. Both arterial and collectors should be through roads running from one end of the study area to the other. Where a large, linear study area is contemplated, this requirement can be relaxed subject to user judgment, because traffic volumes will be distributed less throughout the network and more on the corridor running through the linear study area. The tool assumes an even grid of alternating 4 lane arterials and 2 lane collectors because this is a fine-grained pattern that facilitates pedestrian, transit and bike trips. Users can interpolate results for different configurations (e.g. 6 lane arterials and 4 lane collectors). Where the study area's road geometry is very non-grid like, the user can approximate its grid equivalent or, preferably, use the lane miles output to determine need and plan accordingly.

The tool's Level Of Service for roadways is fixed at LOS D, which is characterized by somewhat reduced speeds and a high volume of cars. LOS D is a typical goal for urban streets during peak periods to accommodate traffic, because it allows for a reasonable through-put of cars with only slight travel delays. This permits a moderate level of congestion and so does not overstate the need for additional capacity which, say, LOS C would.

2.3 User Guide

The Density and Connectivity Analysis Tool is an Excel spreadsheet entitled Density-Connectivity.xls. This tool provides a user with a selection of input values (described below) and lookup tables to find a level of street connectivity that is appropriate in a given area.

The tool's "Master Table" has green, yellow, and orange cells (see Figure 1). The green cells are user inputs, the yellow cells are calculated values that are based on the user inputs, and the orange cells are final results. While green cells can be varied by the user at any time, the yellow and orange cells should not be edited.

Inputs

- **Area:** Enter the area, in square miles, of the study area. This value is automatically rounded to the nearest whole number, for ease of calculating the spacing between arterials and collectors.
- **Density:** Enter the density, in gross units per acre, of the study area. This number is found by taking the total number of residential units in the entire study area divided by the area in acres of the entire study area.
- **Trip Generation:** Enter the trip generation rate of the study area. The default value is an average of ten trips per household per day (without

regard to type of trip), but can be varied by the user. Institute of Transportation Engineers Trip Generation Handbook rates⁴ are the standard source for these rates.

- **Elasticity:** Open the tab that is labeled “Table 2 ELASTICITY”. Find the description that most closely resembles your study area in mix of uses and transit access. Enter that number in the main table’s cell B5.
- **Average Trip Length:** Enter the average trip length of the study area. The default value is 5 miles per trip (without regard to type of trip), but can be varied by the user. Local data for the subarea from prior surveys or a travel model is preferred.
- **Non-Home-Based Factor:** This factor accounts for trips whose origins and destinations are somewhere other than the home. It is recommended that this factor remain at the pre-set value of 1.5. This means that for every one home-based trip, there is half of a non-home based trip generated in the study area.
- **Peak to Daily Ratio:** This ratio accounts for the proportion of daily vehicle miles traveled during the peak periods. The default assumption is 10% but this can be varied based on local data which is preferred.
- **Peak Hour Factor:** This factor accounts for spreading the peak hour based on the density of an area (i.e the degree to which people avoid the rush hour by leaving earlier or later). Open the tab that is labeled “Table 3 PEAK HOUR FACTOR”. You will see the density that you entered at the top of this page. Use the chart below to find the peak hour ratio that most closely matches the density you entered. Interpolation of peak hour factors for densities not shown in column A is acceptable; however, do not extrapolate the factor beyond the lowest or highest densities provided (use 1.2 for all lower densities and 0.8 for all higher densities). These numbers account for the tendency of people in higher-density environments to avoid the rush hour by leaving earlier or later, so that the peak hour has a lower percentage of the day’s travel demand. Enter the value from column B in this worksheet in the main table’s cell B9.
- **Average Service Volume:** This factor accounts for the slowing effect of frequent intersections, and is measured as capacity of vehicles per lane per mile. Open the tab that is labeled “Table 4 AVERAGE SERVICE VOLUME”. You will see preliminary street spacing, cell B14, on this page. Use that value to find a matching average service volume: interpolation is acceptable but extrapolation is not advised. Enter that number in the main table’s cell B10. Note that for preliminary arterial spacing under 0.1 miles, it is assumed that roads will be made one-way to maximize capacity.

Calculated Values

⁴ Trip Generation Handbook, 2nd Edition, ITE, June 2004.

- **Vehicle Miles Travelled Per Household Per Day:** This is a calculated value found by multiplying the trip generation rate and the average trip length, and factoring in the elasticity value you provided.
- **Preliminary VMT Per Square Mile Per Hour:** This is a calculated value found by converting the density to square miles and multiplying it by the previously calculated value of VMT per household per day and factoring in the peak to daily ratio.
- **Preliminary Arterial Spacing:** This is a calculated value found by multiplying the area of the study area by 12,000 (which represents the service volume of a network of roads per square mile) and dividing the result by the preliminary VMT per square mile per hour.
- **Adjusted VMT Per Square Mile Per Hour:** This is a calculated value found by multiplying the preliminary VMT per square mile per hour (calculated in cell B16) by the peak hour factor, which accounts for the spreading of peak trips in dense environments.

Final Results

- **Arterial Spacing:** This result is how far apart, in miles, 4-lane arterials should be spaced to accommodate the density and other user inputs. The value is calculated by multiplying the number of lane miles per square mile (12)⁵ by the average service volume, and dividing the result by the adjusted VMT per square mile per hour.
- **Through-Street Spacing:** This result is how far apart, in miles, 2-lane collectors should be spaced to accommodate the density and other user inputs. The value is calculated by dividing the arterial spacing by two, as collectors are assumed to be spaced in between arterials.
- **Total Through Lane Miles Needed:** This result is how many total through lane miles (arterial and collector) are needed in the study area. The value is found by multiplying the area of the study area by the number of lane miles per square mile (12), and dividing that number by the arterial street spacing value.
- **Density that can be Supported:** While this is not an output of the tool, it can be approximated via a trial and error approach if the user wishes to find this out. In order to establish the density level that a given road network can support, one can enter different density values and corresponding peak hour factor values to see how the arterial and through-street spacing values change and compare this to existing or proposed network or lane miles for the study area. In this way, the tool can be used to show how much additional density an existing road network

⁵ Derived by dividing the 12,000 service volume referenced under Preliminary Spacing above by 1,000, the vehicle capacity per lane

can sustain. A more direct way of calculating Density is provided below but it requires input of VMT per square mile for the peak hour, data which may not be readily available.

Begin by entering in the values into the green cells. With every value you enter, you will see the yellow and orange calculated fields adjusting. Once you have entered all of the information in the green cells, the orange cells will show you the final result—recommended street spacing and lane miles that will accommodate the density and trips generated in the study area.

Figure 1. Default Values and Formulas in Density-Connectivity Tool – Master Table

AREA, ROUNDED TO NEAREST WHOLE:	1	square miles
DENSITY:	1	units/acre
TRIP GENERATION:	10	trips/unit/day
ELASTICITY:	-0.15	
AVERAGE TRIP LENGTH:	5	miles
NON HOME BASED FACTOR:	1.5	
PEAK TO DAILY RATIO:	0.1	
PEAK HOUR FACTOR:	1.17	
AVERAGE SERVICE VOLUME:	928	
VMT PER HH PER DAY:	$=(B6*B4)*POWER(B3,B5)$	
PRELIMINARY VMT PER SQ MI PER HOUR:	$=B3*B12*640*1.5*B8$	
PRELIMINARY ARTERIAL SPACING:	$=(12000*(ROUND(B2,0)/B13))$	miles
ADJUSTED VMT PER SQ MI PER HOUR:	$=B13*B9$	
ARTERIAL SPACING:	$=(12*B10)/B15$	miles
THROUGH-STREET SPACING:	$=B17/2$	miles
TOTAL THROUGH LANE MILES NEEDED:	$=(12*(ROUND(B2,0))/B17)$	miles

The Density and Connectivity Analysis Tool can also be used to calculate the ideal density of a residential study area, using the “Density Calculation Table” in Figure 2. The data inputs for the Density Calculation Table are exactly the same as those described for the Master Table, with the exception that the density estimate is omitted and the Volume Miles Traveled per sq mi. per peak hour a travel demand model run for the study is inserted into Cell B10. In the spreadsheet shown, the VMT value was derived from entering a density of 4 into the master table and finding the resultant VMT, which was simply transferred into Figure 2. The ideal residential density based on these parameters is shown in Cell B13. **While green cells can be varied by the user at any time, the blue and purple cells should not be edited.**

Figure 2. Density Calculation Table

WORKSHEET USES KNOWN STUDY AREA CONDITIONS AND VMT FROM TRAVEL DEMAND MODEL TO CALCULATE DENSITY, ARTERIAL SPACE & LANES NEEDED			
AREA, ROUNDED TO NEAREST WHOLE:	1	square miles	Input Study Area in Sq. Miles
TRIP GENERATION:	10	trips/unit/day	Default trip generation for Residential Use is 10 trips/unit/day
ELASTICITY:	-0.15		USE TABLE 2
AVERAGE TRIP LENGTH:	5	miles	Default Avg Trip Length is set at 5
NON HOME BASED FACTOR:	1.5		Default NHB Factor is set at 1.5
PEAK TO DAILY RATIO:	0.1		Default Peak to Daily is set at 0.1
PEAK HOUR FACTOR:	1.17		USE TABLE 3
AVERAGE SERVICE VOLUME:	928		USE TABLE 4
INPUT VMT PER SQ MI PER HOUR:	15595.24601		VMT PER SQ MI PER PEAK HOUR FROM TRAVEL DEMAND MODEL ANALYSIS
Calculated Values			
CALCULATED DENSITY:	$=POWER((B10/(640*B6*B7))/(B5*B3),1/(1+B4))$	units/acre	
PRELIMINARY ARTERIAL SPACING:	$=(12000*(ROUND(B2,0)/B10))$	miles	
ADJUSTED VMT PER SQ MI PER HOUR:	$=B10*B8$		
Final Results			
ARTERIAL SPACING:	$=(12*B9)/B15$	miles	
THROUGH-STREET SPACING:	$=B18/2$	miles	
TOTAL THROUGH LANE MILES NEEDED:	$=(12*(ROUND(B2,0))/B18)$	miles	

3.0 ARTERIAL-COLLECTOR TRADEOFF CALCULATIONS

3.1 Overview

Suburban subdivisions and road networks since the 1960's have lacked much connectivity or "griddedness". Arterial roads, often state-built and maintained, supplied the primary capacity and development-built roads tapped into these at intervals featuring some internal loops but with many cul-de sacs off these. As suburbs matured, this sparse pattern of roads loaded excessive traffic onto the arterials. These arterials grew in size and volume and incorporated more commercial land uses, further exacerbating traffic congestion.

In hindsight, most planners agree it would be more efficient to strike a better balance between arterial and collector road connectivity that spreads the traffic volumes more appropriately between arterials and major or minor collector roads. There has, however, been little technical guidance available on how much gridding is necessary or desirable.

The look up tables in this paper provide a sketch planning approach to resolving this problem of arterial/collector connectivity tradeoffs. It is meant to be applied in rural/suburbanizing areas where advance road network planning is possible and will be beneficial as development occurs over time.

3.2 Caveats and Assumptions

The look up tables are based on a case study- the analysis and findings for a 6 mile section of a 2 lane arterial corridor in an exurban area of Tallahassee, Florida⁶. The original paper is attached as an Appendix. Land uses and networks were specified and a 4-step travel demand model was run under various assumptions of speed on arterials and collectors. The applicability of the tool is therefore limited by the conditions of the original case study. That said, the analysis behind the tool is the only example of this kind of work known to the team developing the approach. Its findings, therefore, represent a real advance in our ability to balance transportation flows on networks between arterials and collectors in a simple, straightforward way. Results are expressed in percentage reductions or increases to traffic volumes on the arterial and the collector system.

The tool is to be applied in rural/suburbanizing corridors where adding connectivity to collectors via subdivision requirements or a Major Thoroughfare Plan is feasible. Traffic volumes on the arterial may be low currently but increases are expected as development occurs. In anticipation of this, the connector system is being looked at to help balance future traffic loadings. It is not intended for mature, mostly developed suburban arterials where inserting connectivity is an after-the-fact exercise. It can be applied to answer the question “How much relief does the arterial get if we interconnect parallel collectors?”

The methodology assumes *maximum* connectivity is applied and tests for that condition (see Figure 3). This may not be possible or even optimal. The approach does not allow iteration to test lesser degrees of connectivity. User judgment must be applied. Alternatively, to get at the optimal degree of connectivity and arterial/collector mix, the Density/Connectivity Tool (described earlier) can be applied as the next step to fine-tune the exact amount of collector lane miles needed.

The case study represented a corridor in various stages of development (see

⁶ Alba, A. Carlos and Edward Beimborn, “ Analysis of the Effects of Local Street Connectivity on Arterial Traffic. CD-ROM Compendium of Papers, Transportation Research Board 2005 Annual Meeting. Washington D.C.

Figure 4). Its 44 segments (each intersection created a segment) were aggregated into 3 subsections whose land use patterns could be characterized as rural-residential, emergent commercial-residential and low-intensity multi-use. Users can select the best fit to their context or use the corridor as a single overall unit.

The land use in the original case study was analyzed only for the south side of the arterial within a half mile buffer from the road. Both sides of the road are, however, developed in the western 2 segments of the corridor. To convert the findings to a more typical two-sided corridor context, the acreage of developed land within a half mile buffer on the northern side of the corridor, as a proportion of the overall developed land in the corridor, was used to factor up the percentage reductions that were derived from the south-only analysis originally. The logic of this is that the arterial volumes are influenced by land uses on both sides of the corridor (excluding for through trips) and that this proportional factoring is appropriate.

Results of the analysis are reported as percentage reductions on the arterial volumes. Effects on collector traffic volumes were not calculated. This methodology assumes the user has or can get current or projected traffic volumes (daily or peak hour) on the arterial. The user does not need to use actual traffic volumes in using the look up tables. The percentage reductions are what the user applies to his actual volumes. The volumes in the analysis were peak hour volumes and the tool assumes the analysis is a peak hour analysis. (Appendix B includes the actual volumes from the case study; the arterial volume was 12, 300 AADT.)

3.3 User Guide

The choices the user must make are presented below:

- **Land Use in the Corridor:** The user can choose to treat the corridor as a whole, based on its overall land use character within a half mile band of the corridor, or the land use can be defined as having one of three characters, with have more commercial uses and less undeveloped land as they move through this range: rural- residential; emergent commercial-residential; low intensity multi-use. The land use percentages within the half mile are given for each of these and the user must approximate to his context (see Tables 1 through 4).
- **Through traffic:** Results for traffic reductions or increases can include or exclude through trips. Such trips are called EE (External –External) trips in the Tables 5-8 below. Through trips comprised 35 % of total trips in the corridor in the original study. If the user has this information for their corridor and it is similar to the example, then the “with through trips” option can be selected. Typically and preferably, however, through trips should

be excluded and the results should be viewed as specific to that corridor segment.

- **Amount of connectivity:** The user does not need to specify or design the network before applying the tool. The tool assumes a very significant amount of connectivity paralleling the arterial (see Figure 2 as an example for the rural-residential segment). The actual amount of connectivity required can be calculated using the Density-Connectivity tool or planner judgment.
- **Speed on the arterial:** The user can select between 30, 40 and 50 mph. Where arterial speed is lower than 30 mph then providing significant collector connectivity can deflect many arterial trips through residential areas as short cuts, an undesirable outcome. Therefore this situation is not reported out and would require planning judgment.
- **Speed on the collectors:** The user can select either 15 or 25 mph. Note that the speeds selected on both arterial and collectors are critical choices because of their strong effect on trips deflection.
- **Results:** The user selects the appropriate percentage cell in Tables 5-8 and applies them to the actual arterial volumes (current or projected to match the study timeframe based on data from other sources)

4.0 LAST WORD

The two tools described in this paper represent an advance in sketch tool analysis for balancing roads and land use in subareas. They draw on applied research and apply these findings to more general conditions. As such research expands or additional factors are sought for inclusion in the analysis, the tools themselves will evolve.

Table 1. Area-Wide Land Use

Land Use	Percent of Area
Residential	22.6%
Commercial (Retail, Office, Warehouse)	6.5%
Other (Institutional, Religious, School)	4.7%
Undeveloped	66.1%

Table 2. Rural Residential Land Use

Land Use	Percent of Area
Residential	21.6%
Commercial (Retail, Office, Warehouse)	4.7%
Other (Institutional, Religious, School)	0.8%
Undeveloped	72.9%

Table 3. Emergent Commercial-Residential Land Use

Land Use	Percent of Area
Residential	22.0%
Commercial (Retail, Office, Warehouse)	3.7%
Other (Institutional, Religious, School)	12.7%
Undeveloped	61.6%

Table 4. Low Intensity Multi-Use Land Use

Land Use	Percent of Area
Residential	25.6%
Commercial (Retail, Office, Warehouse)	14.5%
Other (Institutional, Religious, School)	0.3%
Undeveloped	59.6%

Table 5. Area-Wide Traffic Reductions

Condition	Traffic Reduction	
	% (Including EE trips)	% (Without EE trips)
Assumed Speed on Local Roads = 15 mph		
Assumed Speed on Arterial = 25	6.23%	10.35%
Assumed Speed on Arterial = 30	4.81%	7.56%
Assumed Speed on Arterial = 40	3.15%	4.68%
Assumed Speed on Arterial = 50	0.99%	1.43%
Assumed Speed on Local Roads = 25 mph		
Assumed Speed on Arterial = 30	31.36%	49.46%
Assumed Speed on Arterial = 40	16.37%	24.37%
Assumed Speed on Arterial = 50	7.88%	11.47%

Table 6. Rural Residential Traffic Reductions

Condition	Traffic Reduction	
	% (Including EE trips)	% (Without EE trips)
Assumed Speed on Local Roads = 15 mph		
Assumed Speed on Arterial = 25	1.28%	2.08%
Assumed Speed on Arterial = 30	0.23%	0.36%
Assumed Speed on Arterial = 40	0.17%	0.27%
Assumed Speed on Arterial = 50	0.17%	0.27%
Assumed Speed on Local Roads = 25 mph		
Assumed Speed on Arterial = 30	16.02%	25.70%
Assumed Speed on Arterial = 40	1.54%	2.43%
Assumed Speed on Arterial = 50	-0.08%	-0.12%

Table 7. Emergent Residential-Commercial Traffic Reductions

Condition	Traffic Reduction	
	% (Including EE trips)	% (Without EE trips)
Assumed Speed on Local Roads = 15 mph		
Assumed Speed on Arterial = 25	9.16%	15.76%
Assumed Speed on Arterial = 30	7.82%	12.32%
Assumed Speed on Arterial = 40	4.75%	6.89%
Assumed Speed on Arterial = 50	0.60%	0.86%
Assumed Speed on Local Roads = 25 mph		
Assumed Speed on Arterial = 30	44.16%	68.90%
Assumed Speed on Arterial = 40	25.59%	37.08%
Assumed Speed on Arterial = 50	11.70%	16.59%

Table 8. Low Intensity Multi-Use Traffic Reductions

Condition	Traffic Reduction	
	% (Including EE trips)	% (Without EE trips)
Assumed Speed on Local Roads = 15 mph		
Assumed Speed on Arterial = 25	10.55%	16.97%
Assumed Speed on Arterial = 30	6.79%	10.17%
Assumed Speed on Arterial = 40	4.60%	6.43%
Assumed Speed on Arterial = 50	3.40%	4.61%
Assumed Speed on Local Roads = 25 mph		
Assumed Speed on Arterial = 30	30.34%	47.41%
Assumed Speed on Arterial = 40	20.32%	29.19%
Assumed Speed on Arterial = 50	12.53%	17.26%

Figure 3. Connectivity Diagram

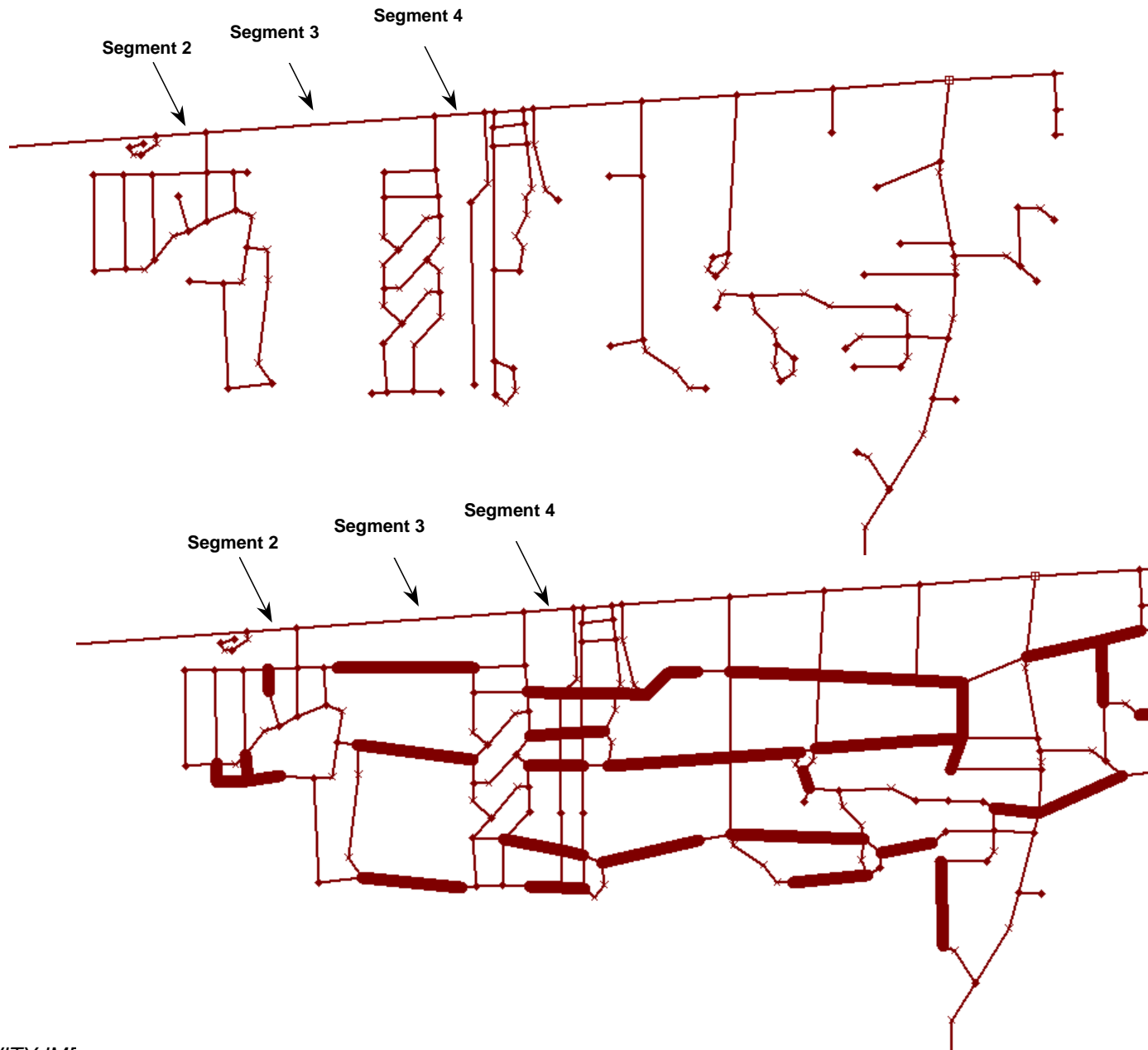
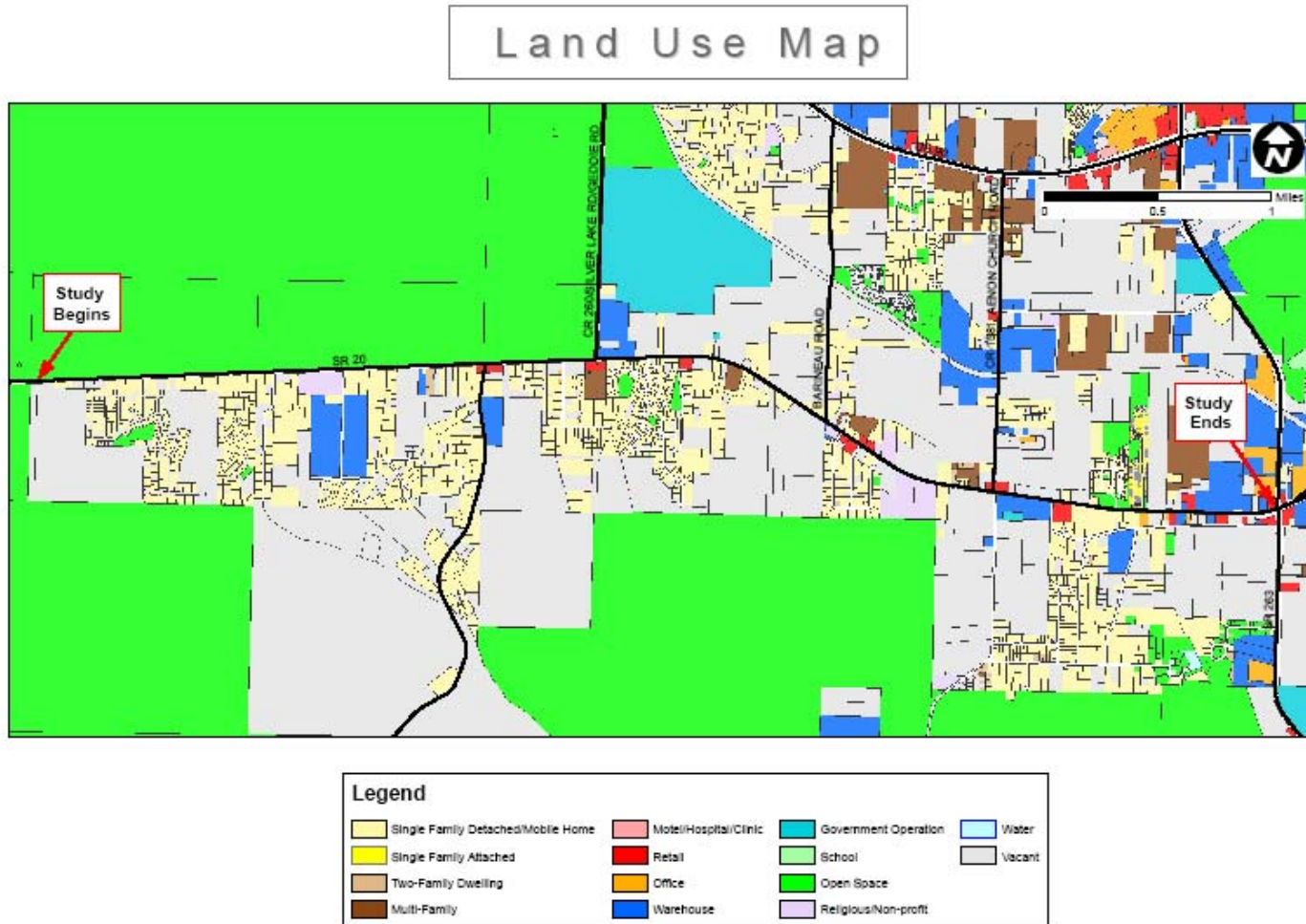


Figure 4. Land Use Map



RECOMMENDATIONS TO IMPROVE DEVELOPMENT CONNECTIVITY

5.0 INTRODUCTION

For the purposes of this report, we define “connectivity” as the degree of interconnection between roadways. The recommendations in this report are geared towards improving the efficiency of movement using the roadway system. “Mobility” (i.e. ease of movement) is one attribute of such efficiency but so is “accessibility” (i.e. the ability to go from an origin to a desired destination). The benefits of better connectivity go beyond improved mobility and accessibility and can include enhanced potential for transit (through better pedestrian connections and shorter, more direct walk trips) as well as more constant speeds and less congestion, which in turn results in lower greenhouse gas emissions. Reducing emergency response times; increasing effectiveness of municipal service delivery; and freeing up arterial capacity to better serve regional long distance travel needs are further benefits of enhanced connectivity. There are subtle tradeoffs between increased connectivity and increased speed - pedestrian safety, vehicle miles traveled and so forth, but this report will not go into these nuances. For the purposes of this work, we assume that enhanced connectivity is a clear net benefit.

Based on our review and understanding of Texas Local Government Code, Title 7 – *Regulation of Land Use, Structures, Businesses, and Related Activities*, the most effective strategies to improve connectivity occur before and during the subdivision phase of development. Under Texas law subdivision review is an administrative function of local government – at the municipal, within the extraterritorial jurisdiction (ETJ), or unincorporated county level. To improve connectivity local governments will need to adopt standards and evaluation tools that mandate planned roadways and interconnected subdivision before the subdivision applications are submitted. Extemporaneous requirements to provide connectivity, even though supported by sound planning judgment, may encounter opposition by an applicant and may not withstand legal scrutiny. To avoid these potential challenges, the tools recommended under the Major Thoroughfare and Subdivision sections of this report will require upfront planning by the municipality or the county and necessitate amending the subdivision regulations to establish specific rules and procedures.

The suggested strategies under the Comprehensive Planning and Zoning subsections provide an opportunity to fine tune the connectivity policies of the municipalities and to implement site-specific improvements. Capital Improvement Programming (CIP) planning to fund projects connecting corridors and neighborhoods can be done at the municipal or the county level; however, the financing options available to local governments vary. The section on the CIP therefore identifies financing tools, such as impact fees, that municipalities can use to promote connectivity, and addresses the

need for long a long term financial strategy to incrementally improve connections in jurisdictions.

The examples cited at the end of each subsection represent best practices or well-developed plans and ordinances that can be used by other jurisdictions to improve connectivity in their community. Texas has a number of cities, like Sealy and Pearland, which have adopted some of these strategies. Some referenced examples in this report are from communities noted for their experience using an identified tool, such as the Town of Cary’s for its application of the connectivity index, and the City of Frederick, MD for its emphasis on urban design and adequacy of public facilities.

6.0 MAJOR THOROUGHFARE PLAN

The major thoroughfare plan (MTP) serves as the comprehensive strategy for the community’s current and future roadways. The specific composition of major thoroughfare plans varies by jurisdiction. At a minimum, the MTP identifies the location of existing and future roadways and some form of classification of those roads. Beyond this, the MTP can specify road right-of-way (ROW) and the cartway dimensions on the map or refer to the subdivision regulations for these.

Unlike some states, Texas does not mandate a particular classification system for the MTP. The Houston-Galveston Area Council (H-GAC) has prepared a major thoroughfare plan for the 8-county region. H-GAC has classified roads on its MTP map as freeway/tollway or thoroughfare. The MTPs that H-GAC has published on its web site do not define the characteristics of these roads, which is one of the first steps toward improving the opportunity to create these road connections. Some cities such as Pearland and Sealy have adopted MTP with much greater detail, depicting major/secondary thoroughfares and major/minor collectors, which help the public, developers and property owners understand what types of roads are envisioned.

6.1 MTP Functional Classification

6.1.1 Applicability of MTP Functional Classification

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJ
X	X	X

6.1.2 Description

For major thoroughfare plans to be an effective tool that improves connectivity more detail than is provided in the regional map must be included on the municipal and the county prepared MTP maps. A refined functional classification system should be used beyond the “freeway/tollway” and “thoroughfare” designations currently on H-GAC’s

MTP maps. The MTP should show freeway/tollways, thoroughfares (principal and minor arterials), and major and minor collectors. Showing the future alignment of minor collectors on the MTP map is extremely important to ensure connectivity between future residential subdivisions. The MTP functional classification system should also identify the characteristic of each road to help define its expected volume capacity. Is the road two-lane or four-lane, divided or undivided? In determining the design characteristics of the road, the principles of context-sensitive design, as described by the Federal Highway Administration at the attached link <http://www.fhwa.dot.gov/context/qualities.cfm>, should be considered. Unconventional but important and useful road types like boulevards or 3-lane arterials must be called out specifically in a classification scheme and map if there are to be realized.

The MTP should go beyond just having a refined functional classification system. Each class of road should also have the right-of-way needs specified and a typical cross-section established so a prospective developer knows the type of road that will be required when a property is subdivided. The typical cross-section should also provide guidance on the recommended block length, which will be discussed in greater detail in the next subsection dealing with access management. The MTP map should indicate whether the road is anticipated to have a rural cross-section with open swales or an urban cross-section with curb, gutter and stormwater management requirements. Additionally, the MTP functional classification should also incorporate the multi-modal purpose of the planned roads in determining needed ROW and the design standards.

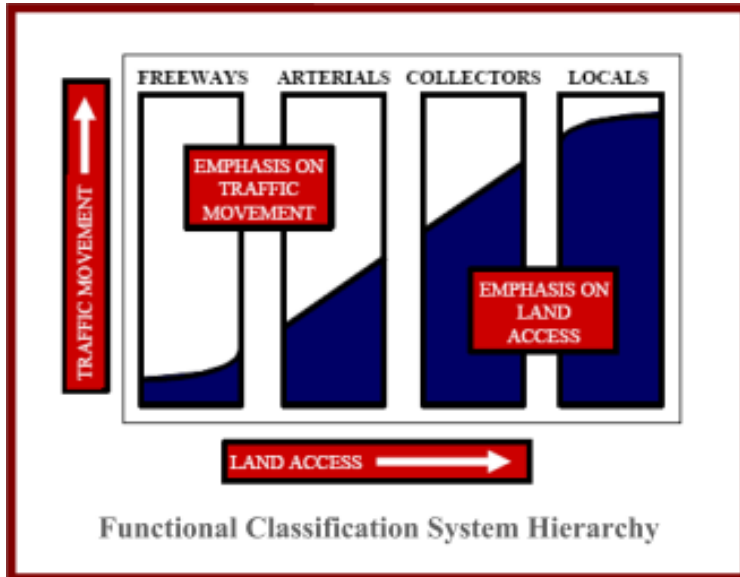
6.1.3 Benefits

Providing this level of detail in the MTP informs the community about the type of road system that is being planned. It also tells the property owner what type of road is expected when the property is subdivided. This level of specificity also helps in planning a jurisdiction's capital improvement program.

6.1.4 Challenges

Even though the H-GAC region has prepared regional travel demand models and has a good sense of future traffic volumes on the major thoroughfares, there may be a need for future traffic analysis to determine the appropriate location of the major and minor collectors. This analysis can be initially conducted using good planner judgment and tools such as PB's Density-Connectivity Tool to determine appropriate spacing of connections. It is also important to acknowledge that there are trade-offs between ease of vehicle movement and accessibility to the adjacent property. Figure 5 from the City of Sealy comprehensive plan shows the inverse relationship between accessibility to the adjacent land and the movement of traffic. As the MTP map is development and the locations of freeways, arterials, and collectors are identified, the associated limitations on access to the adjacent properties must be recognized. The access and proximity to the MTP roads will affect property values causing property owners and developers to support or oppose certain roads in the MTP. A more detailed discussion of access management is addressed in the following subsection.

Figure 5. Traffic Movement and Land Access



Generally, establishing the location of major and minor collectors should not be difficult in the municipalities or even in some of the ETJ areas. However, securing agreement as to where the major and minor collectors should be located in the unincorporated areas will likely be difficult. Property owners and elected officials may not want to commit themselves to a specific alignment. There is also the possibility of indicating an intention to locate future roads on a map without specifying exact alignments, either as a note or as dotted lines with a legend note indicating “alignment to be defined as development proposals are submitted”.

While major and minor collectors are not as expensive as arterials, there are typically more lane miles of collector roads which cost more than local streets. Property owners and developers will therefore want to shift the alignment or possibly eliminate the collector going through the subdivided property. Therefore, for a detailed MTP to be successful in creating connections, the local jurisdiction must remain committed to requiring the connections even though a developer may argue that current volumes do not warrant a fully connected road network.

6.1.5 Roles and Next Steps

MPO – The MPO may need to take the lead in coordinating the refinement of the major thoroughfare plans, since many of the arterials and collectors cross jurisdictional boundaries. The MPO has the regional travel demand modeling capabilities to test these refined major thoroughfare plans and also the transportation planning expertise to assist local governments.

Local Government – Each local government will need to evaluate their existing major thoroughfare plan and determine where the future arterials and collectors should be

located. The local governments will also need to establish the right-of-way needs and street cross-sections that reflect the character of the community.

Private Developer – Private developers should participate in the process of developing the refined major thoroughfare plans and road standards.

6.1.6 Examples/References





Example A – The City of Houston has developed a very elaborate major thoroughfare plan that includes a detailed functional classification system along with details on the number of lanes and associated right-of-way. The major thoroughfare plan can be found at <http://www.houstontx.gov/planning/DevelopmentRegs/mobility/MTFP.htm>.

Example B – The City of Pearland has adopted a major thoroughfare plan that has a more refined functional classification of roads than other similar jurisdictions.




City of Pearland Thoroughfare Plan

Approved December 11, 2006




120' Minimum ROW

-  Major Thoroughfares - Sufficient Width
-  Major Thoroughfares - To Be Widened
-  Major Thoroughfares - To Be Acquired
-  Major Thoroughfares - Proposed Frontage Road




80' Minimum ROW

-  Major Collector Streets - Sufficient Width
-  Major Collector Streets - To Be Widened
-  Major Collector Streets - To Be Acquired

100' Minimum ROW

-  Secondary Thoroughfares - Sufficient Width
-  Secondary Thoroughfares - To Be Widened
-  Secondary Thoroughfares - To Be Acquired

60' Minimum ROW

-  Minor Collector Streets - Sufficient Width
-  Minor Collector Streets - To Be Widened
-  Minor Collector Streets - To Be Acquired

6.2 MTP Access Management Standards

A major thoroughfare plan should be more than lines on a map and a functional classification system. The functional classification system should be enhanced with a series of access management standards. Some arterial roads should be denied access; while other minor collectors may allow individual driveways and closely spaced local streets. As mentioned earlier, the MTP functional classification system should be developed considering the context of the community the road will travel through. Access management is part of the context sensitive solution design.

The Sealy Comprehensive Plan points out that “Access management standards could be imposed along rural ETJ roadways consistent with or similar to those recommended by the Texas Department of Transportation. For example, if the minimum spacing limitation between driveways is 360 feet (recommended for streets with a 45 m.p.h. posted speed), then 100 to 200 foot frontage lots with individual drives would not be allowed.” This type of analysis should be performed in every jurisdiction to develop access management standards that correspond to a refined functional classification system.

It should be noted that municipalities will have greater latitude than counties to impose access management controls. Counties have been granted limited authority to regulate access along county roads and can only impose standards as stringent as TxDOT uses.

In addition to applying access management standards as part of the functional classification system, there are a number of strategies that municipalities and counties can use to control access to public streets. Physical barriers such as medians are one technique used to allow greater immediate access to the public street. They act to restrict movement to right-turn ingress and egress only and limit left-turns to controlled locations.

6.2.1 Applicability of MTP Access Management Standards

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJ
X	X	X

6.2.2 Description

As mentioned earlier, access management is an important component of an overall functional classification system. In addition to identifying the types of trips (i.e., local, community-level through, or regional-level through trips) on a road, and the design characteristics of the road, the ability to ingress and egress the facility needs to be defined. Having a major thoroughfare plan that has a refined functional classification system with the appropriate access management controls will help to create an orderly

road system that provides predictability both to the community and the affected property owners.

6.2.3 Benefits

As mentioned earlier, incorporating an access management component into the major thoroughfare plan adds clarity to the type of road facilities being proposed on the map. A person reviewing the thoroughfare plan can see whether a specific road will allow immediate or limited accessibility. Using the typical road cross-section standards associated with a detailed MTP functional classification system, recommended block length and driveway separation standards will inform the property owner and a prospective developer whether each lot can have immediate access to the public road or if a service road will be necessary to funnel traffic to properly spaced access points.

6.2.4 Challenges

There is readily available guidance on matching up the appropriate access control standards to each road classification (e.g. the ITE transportation Planning Handbook, latest edition) but these need to be applied with care and thought to local conditions. Additionally, road types like boulevards are not included in ITE so local planners will need to interpolate or create appropriate standards. The difficulty will be imposing access restrictions on a new road when there is very little traffic. There will be a tendency to relax the access management standards when traffic volumes are low and tighten access standards when traffic volumes increase. The problem becomes apparent when curb cuts to existing commercial properties need to be closed or consolidated. Commercial property owners will typically fight these types of restrictions, making the projects costly and difficult to accomplish.

6.2.5 Roles and Next Steps

- MPO – The MPO can provide technical assistance in determining the appropriate access management standards to couple with the functional classifications.
- Local Government – The local government has the difficult responsibility of determining the appropriate access management strategy along the existing and future corridors.
- Private Developer – The private developer and property owner should participate in the public debate as a jurisdiction develops the access management standards associated with the community's functional road classification system. It is important to recognize that not every property can have unfettered access or traffic will not flow. Access and mobility must be balanced, so private developers will need to compromise to develop an effective road network that allows reasonable access to property and manages traffic efficiently.

6.2.6 Examples/References

Example A – The City of Corsicana, TX has incorporated a detailed access management system, i.e. intersection spacing and median cut spacing, into its major thoroughfare plan. This can be viewed on line at

<http://www.ci.corsicana.tx.us/economic/docs/Part%20Three%20-%20The%20Thoroughfare%20Plan%20-%20Pages%2067-78.pdf>

Example B- Access management can also be incorporated into the configuration of the lot layout of the subdivision. One way to do this is via the use of “reserve strips,” where a separately platted and owned lot – usually only a few feet wide - legally separates a platted lot from the adjoining public street. While this subdivision technique is useful in preventing inappropriate connections to the public road, the reserve (sometimes called a “spite strip”) creates questions of who will be responsible for maintenance along with legal challenges when appropriate new connections to the public streets are warranted.

The City of Pearland has addressed the issue of access management using “reserve strips” by limiting their use and requiring special approval (see below).

(f) **Reserve Strips.** Reserve strips controlling access to streets shall be prohibited except where their control is required by the City and approved by the Planning and Zoning Commission.

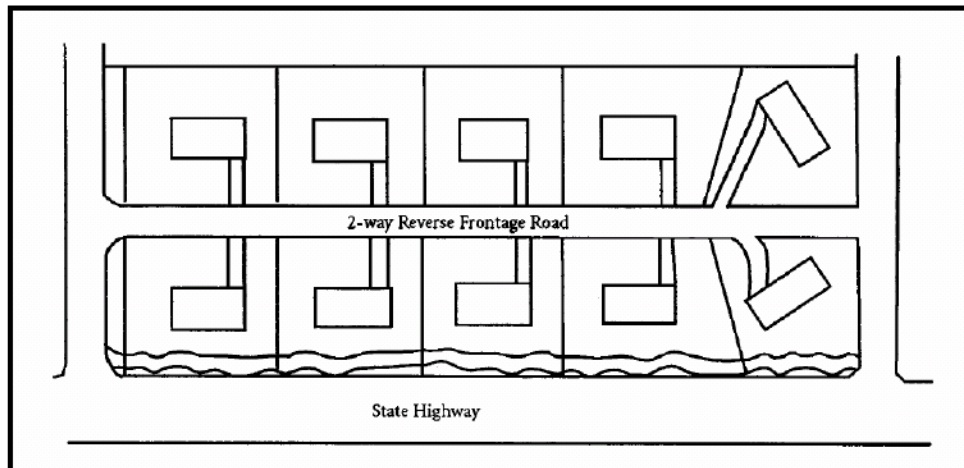
Another subdivision technique that can be as effective as “reserve strips”, without creating a separate lot, is the use of restrictive covenants recorded with the plat. Restrictive covenants (or easements) can be placed along a property boundary stipulating that no access to the street will be permitted.

Example C – Since some MTP roads are designated as limited or controlled access, the properties that front along these corridors rely on reverse frontage or backage roads to provide connectivity. These corridors should be planned prior to the development of these corridors in ensure effective and efficient connectivity. Texas Transportation Institute has included in its 2005 report, “Recommended Access Management Guidelines for Texas,” has recommended the following:

2.17.3.3 “Backage Roads”

“Reverse” frontage roads or “backage roads,” with developments along each side, are desirable in developing urban areas. A desirable separation distance is 600 feet with a minimum distance of 400 feet. The frontage road may operate either one-way or two-way as shown in Figure 6.

Figure 6. “Reverse” Frontage Road Concept



7.0 SUBDIVISION

Subdividing land is a fairly simple concept – dividing a plot of land into two or more parcels for the purpose of sale or development. But, the regulatory process a property owner must go through to record a subdivision plat will vary greatly depending upon the state’s enabling legislation and the individual jurisdiction where the property is located. It is through the subdivision process that the roads identified on the major thoroughfare plan are dedicated and built, either by a private developer or the public. However, before examining the process of subdivision used to establish road connections, it is important to first understand the legal parameters of subdivision in Texas.

7.1 Statutory Framework

Title 7 of the Texas Local Government Code provides the enabling legislation for municipalities and counties and establishes the regulatory structure for land use and development in Texas. Texas is known for its limited intervention in the use of private land. However, the State of Texas does provide for a full complement of tools that can be used during the subdivision review and approval process to promote roadway connectivity. Before exploring these individual tools, it is important to understand the context of how these tools must operate within the confines of the provision of Chapter 212 and 232 of the Texas Local Government Code.

Sections 212.002 and 212.003 establish the authority of municipalities and their associated ETJ’s to prepare rules for the review and approval of subdivision plats.

§ 212.002. Rules

After a public hearing on the matter, the governing body of a municipality may adopt rules governing plats and subdivisions of land within the municipality’s jurisdiction to promote the health, safety, morals, or general welfare of the municipality and the safe, orderly, and

healthful development of the municipality.

§ 212.003. Extension of Rules to Extraterritorial Jurisdiction

- (a) The governing body of a municipality by ordinance may extend to the extraterritorial jurisdiction of the municipality the application of municipal ordinances adopted under Section 212.002 and other municipal ordinances relating to access to public roads or the pumping, extraction, and use of groundwater by persons other than retail public utilities, as defined by Section 13.002, Water Code, for the purpose of preventing the use or contact with groundwater that presents an actual or potential threat to human health. However, unless otherwise authorized by state law, in its extraterritorial jurisdiction a municipality shall not regulate:

Section 212.004 of the Texas Local Government Code, stipulates when a subdivision plat is required in a municipality or its extraterritorial jurisdiction.

§ 212.004. Plat Required

- (a) The owner of a tract of land located within the limits or in the extraterritorial jurisdiction of a municipality who divides the tract in two or more parts to lay out a subdivision of the tract, including an addition to a municipality, to lay out suburban, building, or other lots, or to lay out streets, alleys, squares, parks, or other parts of the tract intended to be dedicated to public use or for the use of purchasers or owners of lots fronting on or adjacent to the streets, alleys, squares, parks, or other parts must have a plat of the subdivision prepared. A division of a tract under this subsection includes a division regardless of whether it is made by using a metes and bounds description in a deed of conveyance or in a contract for a deed, by using a contract of sale or other executory contract to convey, or by using any other method. A division of land under this subsection does not include a division of land into parts greater than five acres, where each part has access and no public improvement is being dedicated.

Section 212.010 establishes the criteria a municipality shall use to approve a plat within its limits or its extraterritorial jurisdiction.

§ 212.010. Standards for Approval

- (a) The municipal authority responsible for approving plats shall approve a plat if:
- (1) it conforms to the general plan of the municipality and its current and future streets, alleys, parks, playgrounds, and public utility facilities;
 - (2) it conforms to the general plan for the extension of the municipality and its roads, streets, and public highways within the municipality and in its extraterritorial jurisdiction, taking into account access to and extension of sewer and water mains and the instrumentalities of public utilities;

- (3) a bond required under Section 212.0106, if applicable, is filed with the municipality; and
- (4) it conforms to any rules adopted under Section 212.002.

Texas Local Government Code addresses the subdivision review and approval responsibility of counties in a number of different sections, depending upon the size and location of the county. The following excerpts from Chapter 232 are selected provisions applicable to the counties in the Houston-Galveston Area Council region.

Section 232.001 stipulates when a plat is required in the county.

§ 232.001. Plat Required

- (a) The owner of a tract of land located outside the limits of a municipality must have a plat of the subdivision prepared if the owner divides the tract into two or more parts to lay out:
 - (1) a subdivision of the tract, including an addition;
 - (2) lots; or
 - (3) streets, alleys, squares, parks, or other parts of the tract intended to be dedicated to public use or for the use of purchasers or owners of lots fronting on or adjacent to the streets, alleys, squares, parks, or other parts.

Section 232.002 reinforces the point that the County is required to approve a subdivision if it meets all the requirements of state law. The County has no discretion and must approve the plat; therefore, if the County wants to enhance connectivity it must work within the provisions of the State's subdivision enabling legislation.

§ 232.002. Approval by County Required

- (a) The commissioners court of the county in which the land is located must approve, by an order entered in the minutes of the court, a plat required by Section 232.001. The commissioners court may refuse to approve a plat if it does not meet the requirements prescribed by or under this chapter or if any bond required under this chapter is not filed with the county.
- (b) The commissioners court may not approve a plat unless the plat and other documents have been prepared as required by Section 232.0035, [FN1] if applicable.

Section 232.003 establishes the generic standards that counties are to use for right-of-way dedication and street design. Since Chapter 232 allows for some counties to use different standards, most of the unincorporated areas in the H-GAC area are not limited to these provisions. Walker County and some of the smaller counties have not updated their subdivision regulations to take advantage of the wider permitted right-of-way widths under Texas law, while other small counties, like Waller County, are taking advantage of the 120 feet thoroughfare widths allowed under Section 232.102. In an

urban setting, the standards of Section 232.03 do not provide for the full range of road design options such as “complete streets,” where all modes of travel are accommodated – motor vehicle, pedestrian and bicycle.

§ 232.003. Subdivision Requirements

By an order adopted and entered in the minutes of the commissioners court, and after a notice is published in a newspaper of general circulation in the county, the commissioners court may:

- (1) require a right-of-way on a street or road that functions as a main artery in a subdivision, of a width of not less than 50 feet or more than 100 feet;
- (2) require a right-of-way on any other street or road in a subdivision of not less than 40 feet or more than 70 feet;
- (3) require that the shoulder-to-shoulder width on collectors or main arteries within the right-of-way be not less than 32 feet or more than 56 feet, and that the shoulder-to-shoulder width on any other street or road be not less than 25 feet or more than 35 feet;
- (4) adopt, based on the amount and kind of travel over each street or road in a subdivision, reasonable specifications relating to the construction of each street or road;

Section 232.0031 reinforces the point that the road standards imposed on new development through the subdivision approval process must be the same as those used by the county on other projects with similar traffic conditions.

§ 232.0031. Standard for Roads in Subdivision

A county may not impose under Section 232.003 a higher standard for streets or roads in a subdivision than the county imposes on itself for the construction of streets or roads with a similar type and amount of traffic.

Section 232.003 provides the opportunity for counties to work with the Texas Department of Transportation (TDOT) and the local Metropolitan Planning Organization (MPO) to identify future Transportation Corridors and to protect the establishment of these road alignments. (The reference to Section 210.619 of the Transportation Code has been included below.)

§ 232.0033. Additional Requirements: Future Transportation Corridors

- (a) This section applies to each county in the state. The requirements provided by this section are in addition to the other requirements of this chapter.
- (b) If all or part of a subdivision for which a plat is required under this chapter is located within a future transportation corridor identified in an agreement under Section 201.619, Transportation Code:
 - (1) the commissioners court of a county in which the land is located:

- (A) may refuse to approve the plat for recordation unless the plat states that the subdivision is located within the area of the alignment of a transportation project as shown in the final environmental decision document that is applicable to the future transportation corridor; and
- (B) may refuse to approve the plat for recordation if all or part of the subdivision is located within the area of the alignment of a transportation project as shown in the final environmental decision document that is applicable to the future transportation corridor; and
- (2) each purchase contract or lease between the subdivider and a purchaser or lessee of land in the subdivision must contain a conspicuous statement that the land is located within the area of the alignment of a transportation project as shown in the final environmental decision document that is applicable to the future transportation corridor.

Transportation Code

Sec. 201.619. COOPERATIVE PLANNING WITH COUNTIES.

- (a) In this section, "corridor" means a geographical band that follows a general directional flow connecting major sources of trips.
- (b) The department and a county may enter into an agreement that identifies future transportation corridors within the county in accordance with this subsection. The corridors identified in the agreement must be derived from existing transportation plans adopted by the department or commission, the county, or a metropolitan planning organization.
- (c) The department shall publish in the Texas Register and in a newspaper of general circulation in the county with which the department has entered into an agreement under Subsection (b) a notice that states that the department and the county have entered into the agreement and that copies of the agreement and all plans referred to by the agreement are available at one or more designated department offices.

Section 232.006 enables certain counties (specifically in the H-GAC area – Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery and Waller) to use a broader range of right-of-way dedication and road design standards for non-arterial roads. This section also establishes some access management standards that the county can impose on a subdivision.

§ 232.006. Exceptions for Populous Counties or Contiguous Counties

- (a) This section applies to a county:
 - (1) that has a population of more than 3.3 million or is contiguous with a county that has a population of more than 3.3 million; and
 - (2) in which the commissioners court by order elects to operate under this section.
- (b) If a county elects to operate under this section, Section 232.005 does not apply to the county. The sections of this chapter preceding Section 232.005 do apply to the county in the same manner that they apply to other counties except that:

- (1) they apply only to tracts of land located outside municipalities and the extraterritorial jurisdiction of municipalities, as determined under Chapter 42;
- (2) the commissioners court of the county, instead of having the powers granted by Sections 232.003(2) and (3), may:
 - (A) require a right-of-way on a street or road that does not function as a main artery in the subdivision of not less than 40 feet or more than 50 feet; and
 - (B) require that the street cut on a main artery within the right-of-way be not less than 30 feet or more than 45 feet, and that the street cut on any other street or road within the right-of-way be not less than 25 feet or more than 35 feet; and
- (3) Section 232.004(5)(B) does not apply to the county.

Subchapter E (Infrastructure Planning Provisions in Certain Urban Counties) of Title 7, Chapter 232 of the Local Government Code, expands the ability of counties to plan and implement transportation improvement, and in particular furthers the objective of enhancing connectivity. In 2001, Subchapter E was limited to counties with a population of 700,000 or adjacent counties; however, in 2007 the restrictions on which counties could use these provisions were repealed. Therefore, the sections listed below § 232.101, § 232.102, § 232.103, and § 232.107 are applicable to all the counties in the H-GAC area. Section 231.101 establishes the parameters under which counties can use this expanded facility planning authority. These provisions reaffirm the long-standing prohibition against counties (with few exceptions) from regulating land use, density and dimensional standards for buildings. Section 232.102 enables counties to establish right-of-way for major thoroughfares up to 120 feet or possibly wider if those standards are approved by the MPO of the region. Section 232.103 allows counties to establish lot frontage standards which would aid access management on county roads. It is important to also note that Section 232.107 points out the addition of the right-of-way standards for major thoroughfares in addition to the previously stipulated right-of-way standards for arterials of 50-100 feet and other streets of 40-70 feet. From our review, “major thoroughfare” is not defined in Texas legislation and, therefore, it can be left to the local governments to interpret its application in the local functional classification system.

§ 232.101. Rules

- (a) By an order adopted and entered in the minutes of the commissioners court and after a notice is published in a newspaper of general circulation in the county, the commissioners court may adopt rules governing plats and subdivisions of land within the unincorporated area of the county to promote the health, safety, morals, or general welfare of the county and the safe, orderly, and healthful development of the unincorporated area of the county.
- (b) Unless otherwise authorized by state law, a commissioners court shall not regulate under this section:
 - (1) the use of any building or property for business, industrial, residential, or other

- purposes;
- (2) the bulk, height, or number of buildings constructed on a particular tract of land;
 - (3) the size of a building that can be constructed on a particular tract of land, including without limitation and restriction on the ratio of building floor space to the land square footage;
 - (4) the number of residential units that can be built per acre of land;
 - (5) a plat or subdivision in an adjoining county; or
 - (6) road access to a plat or subdivision in an adjoining county.
- (c) The authority granted under Subsection (a) is subject to the exemptions to plat requirements provided for in Section 232.0015.

§ 232.102. Major Thoroughfare Plan

By an order adopted and entered in the minutes of the commissioners court and after a notice is published in a newspaper of general circulation in the county, the commissioners court may:

- (1) require a right-of-way on a street or road that functions as a major thoroughfare of a width of not more than 120 feet; or
- (2) require a right-of-way on a street or road that functions as a major thoroughfare of a width of more than 120 feet, if such requirement is consistent with a transportation plan adopted by the metropolitan planning organization of the region.

§ 232.103. Lot Frontages

By an order adopted and entered in the minutes of the commissioners court and after a notice is published in a newspaper of general circulation in the county, the commissioners court may adopt reasonable standards for minimum lot frontages on existing county roads and establish reasonable standards for the lot frontages in relation to curves in the road.

§ 232.107. Provisions Cumulative

The authorities under this subchapter are cumulative of and in addition to the authorities granted under this chapter and all other laws to counties to regulate the subdivision of land.

7.2 Compliance with Major Thoroughfare Plan

Texas enabling legislation offers municipalities and counties in the H-GAC region a number of different ways to enhance the connectivity of roads using the subdivision approval process. While there are a limited number of right-of-way widths available to

counties identified in Chapter 232, the ability to prepare a Major Thoroughfare Plan (MTP) and use this map as a guide on alignment, right-of-way needs and other design characteristics is an important tool that counties can now use to enhance connectivity.

7.2.1 Applicability of Compliance with Major Thoroughfare Plan

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJs
X	X	X

7.2.2 Description

The MTP provides the local government with a road map for the jurisdiction, depicting existing and future roads. Using this map, proposed subdivision plats are required to both dedicate the right-of-way and build the road as specified in the MTP. The dedication of right-of-way and building of roads is always subject to the proportionality standards established in Sections 212.904 and 232.105 of the Texas Local Government Code, which is discussed in greater detail in Section 4 of this report.

7.2.3 Benefits

The MTP provides an important justification for why the local government is requiring a developer to dedicate a specific amount of right-of-way and build a certain size of road. The MTP puts in context for the property owner and a subsequent developer why a proposed road is going through the subdivided property and how this road will connect to the overall road network. The MTP will help frame discussions with the property owner concerning the exact proportionality of the right-of-way dedication and road construction. MTPs developed using regional travel demand modeling can provide estimates of future traffic volumes for comparison with traffic generated from the proposed subdivision. This information can be used to determine the fair share obligations of the subdivider and what obligations may fall to the local government in order to build this connection.

7.2.4 Challenges

For the MTP to be an effective tool guiding future road connections, it must remain current and be based on the best available traffic projections of local and regional land development. MTPs can become dated quickly and should be updated every three to five years. Given the interconnected nature of the transportation system, the MTP must factor in travel characteristics and road designs planned in surrounding municipalities and counties.

7.2.5 Roles and Next Steps

- MPO – The MPO plays an important role in providing the technical support needed to prepare the municipal or county MTP. H-GAC has already developed and maintains major thoroughfare plans for the counties from a regional perspective. However, local MTPs need to be more refined in order to provide the local connectivity needed to reduce local traffic congestion and document local policy direction on how the major and minor collector roads will fit into the regional road network. Currently, H-GAC depicts only tollways/freeways and thoroughfares on its MTP maps.
- Local Government – For the MTP to be an effective regulatory tool used in the subdivision process, the plan has to be detailed enough to determine where the new corridors are proposed and where the missing links are to be established. The MTP needs to identify not only arterial roads, but also include major and minor collectors. As will be discussed in the Section 1 of this report, the plan (or the subdivision regulations it references) must have sufficient detail on the design standards of the road to ensure that the developer builds the road to the expected engineering specifications of the community.
- Private Developer – Developers should closely examine the road alignment and design standards specified in the MTP. The land value and road construction costs associated with a proposed major thoroughfare road going through a subdivision should be factored into the overall ability of the developer to build the project. The functional classification and access management limitation of the major thoroughfare road should be considered when laying out the remaining road network in the subdivision. Land use compatibility and buffering issues should also be considered. While these issues would not be evaluated for subdivisions approved by the county, these quality of life factors should be considered by the developer in preparing the project.

7.2.6 Examples/References

Example 1: Chambers County, Texas Subdivision Regulations have several references to the County's thoroughfare plan and the requirement to conform to that plan:

Article II PROCEDURES and REQUIREMENTS

E. Preliminary Plat.

General requirements

- 4 The Preliminary Plat shall be in accordance with the land plan and all approved comprehensive, water, sewer, and thoroughfare plans.

K. Graphic Requirements for Preliminary Plats and Master Plans.

1. Preliminary Plats and Master Plans shall show the following information:
 - o. **A depiction of future public rights of way for roads, highways, ditches, canals that are included in an adopted plan for future construction including Texas Department of Transportation Long and Short Range Plans; the**

Houston Galveston Area Council Transportation Plan, Chambers County Transportation Plan, and the Thoroughfare Plans of any city that has jurisdiction of the property to be subdivided;

Article IV DESIGN STANDARDS

A. General Planning Standards

Subdivisions shall be planned to provide convenient and safe building sites without undue concentration of people, congestion of traffic, or limitations on the access for emergency vehicles and services. Block lengths, utility services, drainage, street widths and pavements **shall conform to applicable Thoroughfare Plans** and any adopted Comprehensive Plans. It is the responsibility of the subdivider to research the requirements of all planning documents and to comply with them.

C. Streets and Highways.

1. The arrangement, character, extent, width, grade, and location of all streets shall **conform to the Chambers County Thoroughfare Plan**, the current design standards, and shall be considered in their relation to existing and planned streets or driveways, to topographical conditions, to public safety and in their appropriate relation to the proposed uses of the land to be served by such streets. Unless required by the county, strips of land controlling access to or egress from other property, or to or from any street or alley, or having the effect of restricting or damaging the adjoining property for subdivision purposes, or which will not be taxable or accessible for special improvements, shall not be permitted in any subdivision. All streets shall be paved in accordance with the current design standard. All lots, tracts, and reserves shall have frontage on an approved public right-of-way or access easement(s).

7.3 Traffic Impact Analysis

Sections 212.002 and 212.003 of the Local Government Code establish that municipalities must adopt rules to govern the review of proposed subdivisions. Similarly, Section 232.003 of the County Subdivision Requirements states, “(4) adopt, based on the amount and kind of travel over each street or road in a subdivision, reasonable specifications relating to the construction of each street or road.” These enabling provisions allow municipalities and counties to establish review procedures to evaluate the impacts of proposed developments to ensure the proposed roads can accommodate the anticipated impact.

7.3.1 Applicability of Traffic Impact Analysis

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJs
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X	X	X
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7.3.2 Description

A traffic impact analysis (TIA) examines how the construction of a proposed development will affect the traffic on the surrounding roadways. It also determines what alterations to the road network would be necessary to maintain traffic flows if the proposed development was constructed. Usually, local governments prepare traffic impact analysis guidelines to inform developers and the engineering profession on what threshold of development triggers a TIA, what submittal requirements are needed, and what minimum level of service is to be maintained. The TIA should be as comprehensive as possible, examining other modes of travel that can be used to possibly mitigate the anticipated new trips.

7.3.3 Benefits

Preparing a TIA as part of the submittal requirements for the subdivision plat provides the local government valuable information on whether the existing road network can accommodate the proposed development. Utilizing the major thoroughfare plan and other historic data on existing and approved developments, the TIA will evaluate how the proposed development will fit into the future road network of the jurisdiction. The TIA should be used to identify where on-site improvements will be needed and if off-site traffic problems directly associated with this project need to be addressed. If traffic mitigation is needed, the TIA may identify link connections that could be built to re-route traffic or improve intersection efficiency. TIAs also provide up-to-date information that can be used by the local government to plan for other needed capital improvements.

7.3.4 Challenges

Reviewing TIAs requires professional staff or consultants trained in traffic engineering; therefore the jurisdiction will need to have the technical resources available to evaluate these analyses submitted by developers. The TIA may also identify existing deficiencies with the road system that would not be the responsibility of the developer to correct. While a developer may be required to make on-site and off-site improvements that are directly related to the impacts of the proposed development, a developer cannot be held responsible to make road improvements attributable to regional or pass-through traffic. Sections 212.904 and 232.105 of the Texas Local Government Code provide guidance on the rough proportionality of developer improvements, which are addressed in greater detail in Section 4.

7.3.5 Roles and Next Steps

- MPO – The MPO can provide technical support in assisting local governments develop TIA guidelines. The MPO is usually an important source for regional traffic count information. Additionally, some MPOs serve as a repository for previously submitted TIAs that can be used to update traffic count databases and

incorporate developer-required capital improvements into the regional transportation network.

- Local Government – The local government uses the TIA to evaluate the proposed subdivision plat to determine the adequacy of the proposed road system and confirm that right-of-ways as well as associated sidewalks, utilities, and drainage are adequate to accommodate the planned number of travel lanes. The TIA also provides the background analysis used to design and build the required road improvements.
- Private Developer – The private developer uses the TIA to document that the proposed roadways are sufficient or how the proposed or existing roads can be improved to mitigate the impact of the proposed development. The TIA also provides valuable information on needed improvements, which factor into the overall development cost of the project; and ultimately affect whether or not the project proceeds.

7.3.6 Examples/References

Example A: Section 2.15 of the subdivision regulations from Fort Bend County, TX require that a traffic impact analysis be conducted if the proposed development exceeds 5,000 vehicles per day.

2.15 Traffic Impact Study

A. A traffic impact study shall be required for any development proposal expected to generate traffic volumes that will significantly impact the capacity and/or safety of the street system. All proposed developments generating volumes of 5,000 trips per day or greater shall meet this criteria. The trip estimates shall be based on the latest version of the Institute of Transportation Engineers, Trip Generation Manual.

Example B: The City of Murphy, TX specifies in its Subdivision Ordinance when a traffic impact analysis is required.

City of Murphy, TX Subdivision Ordinance. Section 3.1(c)3.

3. Road Network. New subdivisions shall be supported by a road network having adequate capacity, ingress/egress, and safe and efficient traffic circulation. The adequacy of the road network for developments of one hundred (100) or more dwelling units, or for developments generating one thousand (1,000) or more "one-way" trips per day, or for developments involving collector or arterial streets not appearing on the City's adopted Thoroughfare Plan, shall be demonstrated by preparation and submission, prior to or along with the construction plat application, of a traffic impact analysis prepared in accordance with Subsection (f), Traffic Impact Analysis, which takes into consideration the need to accommodate traffic generated by the development, land to be developed in common ownership and other developed property. In the event that the property to

be developed is intended as a phase in a larger development project, or constitutes a portion of the land to be ultimately developed, the City Council may require a demonstration of adequacy pursuant to this Section for additional phases or portions of the property as a condition of approval for the proposed construction plat. In the event that the applicant submits a traffic impact analysis for an entire phased development project, the City may require an update of the study for each subsequent phase of the development which reflects any applicable changed conditions. If the construction plat is in conformance with the Thoroughfare Plan and if the construction plat is for a development of less than one hundred (100) dwelling units or for a development generating less than one thousand (1,000) "one-way" trips per day, then a traffic impact analysis is not required.

Example C: The City of Frederick, MD provides a more detail description of when a traffic impact study is required.

1203 TRAFFIC IMPACT STUDIES

Purpose: The purpose of these guidelines is to establish criteria by which the traffic impacts of new development proposals will be evaluated by Planning Department staff. They define submission requirements, the need to prepare a study, study scope and methodology, and the format of the study.

(a) Applicability

The total trips that would be generated by a proposed development is the basis for determining whether a traffic impact study is required to be performed by the Applicant. An applicant will be required to submit a traffic impact study when a proposed development will generate more than fifty (50) peak hour trips on a weekday and 100 peak hour trips on a weekend day. The basis for trip generation estimates will be the latest edition of ITE Trip Generation. Development of a project in stages, or on a piecemeal basis, will not avoid this requirement. The trips expected to be produced by the ultimate build-out of the development will be the basis for such study. However, even if a development generates less than fifty (50) peak hour trips, it is not totally excluded from the adequacy requirements of these guidelines unless site traffic generation is anticipated to be de minimus (less than five (5) peak hour trips). All submissions must include an evaluation of anticipated trip generation; however staff may perform its own evaluation of traffic impacts and determine the need for minor improvements or contributions to other needed improvements. A traffic impact study will be required for at least one the following stages of development:

- Rezoning
- Planned Neighborhood Development, Planned Unit Development
- Preliminary Plan of Subdivision
- Final Subdivision (if not completed with Preliminary Subdivision)
- Site Plan (if not completed with Preliminary Subdivision)

Except for rezoning applications, all approvals based on transportation adequacy shall expire after four (4) years if subdivision has not been recorded and/or development is not substantially underway.

Exemptions may be permitted by the Planning Department; if it is determined that site traffic generation is anticipated to be minimal except for irregular or seasonal events.

7.4 Connectivity Index and External Connections

The major thoroughfare plan can facilitate regional and community linkages but does very little to promote internal neighborhood connections. One subdivision review tool that is gaining popularity, which focuses on neighborhoods, is a “Connectivity Index.” This tool measures how well the proposed subdivision connects internally and to a limited extent to the adjacent road network. In addition to using the Connectivity Index some communities are requiring that a set number of connections be established between the proposed subdivision and the existing road network. For example, for up to 100 units, a single connection to an external road must be in place; between 101 and 150 a second access point must be in place etc. By establishing requirements in the subdivision regulations to achieve a certain Connectivity Index and external access connection as part of the subdivision review process, municipalities and counties can improve the overall neighborhood connectivity.

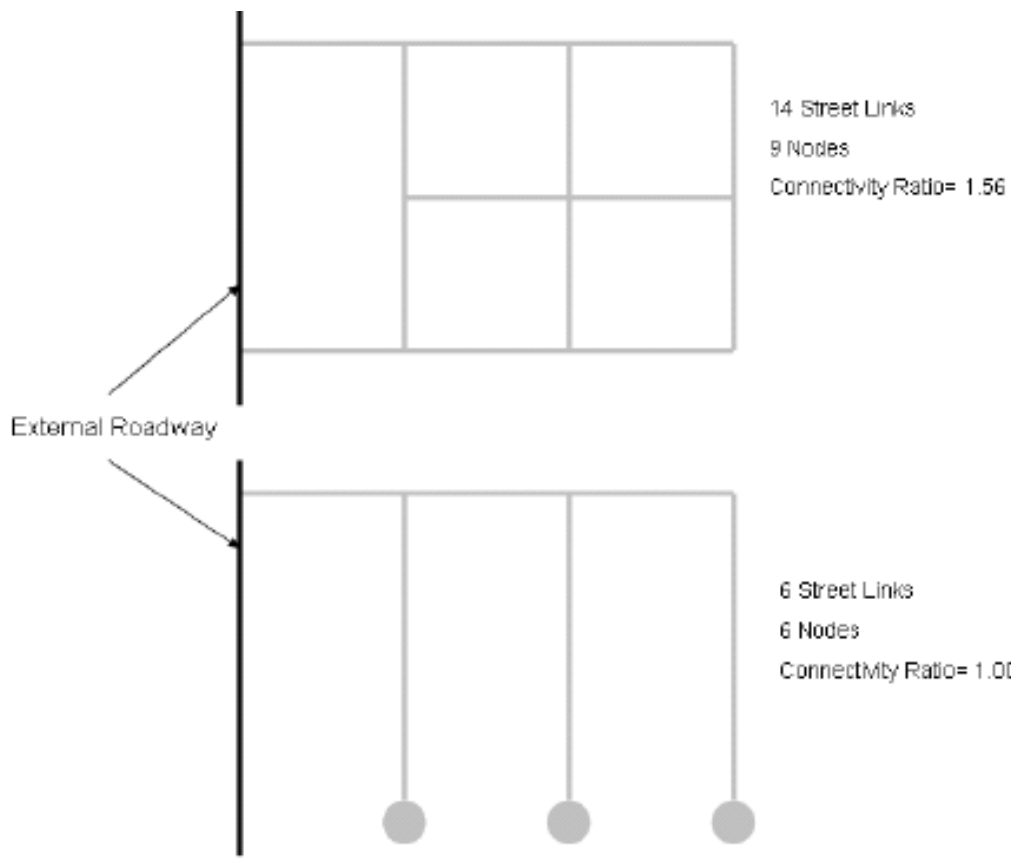
7.4.1 Applicability of Connectivity Index and External Connections

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJ
X	X	X

7.4.2 Description

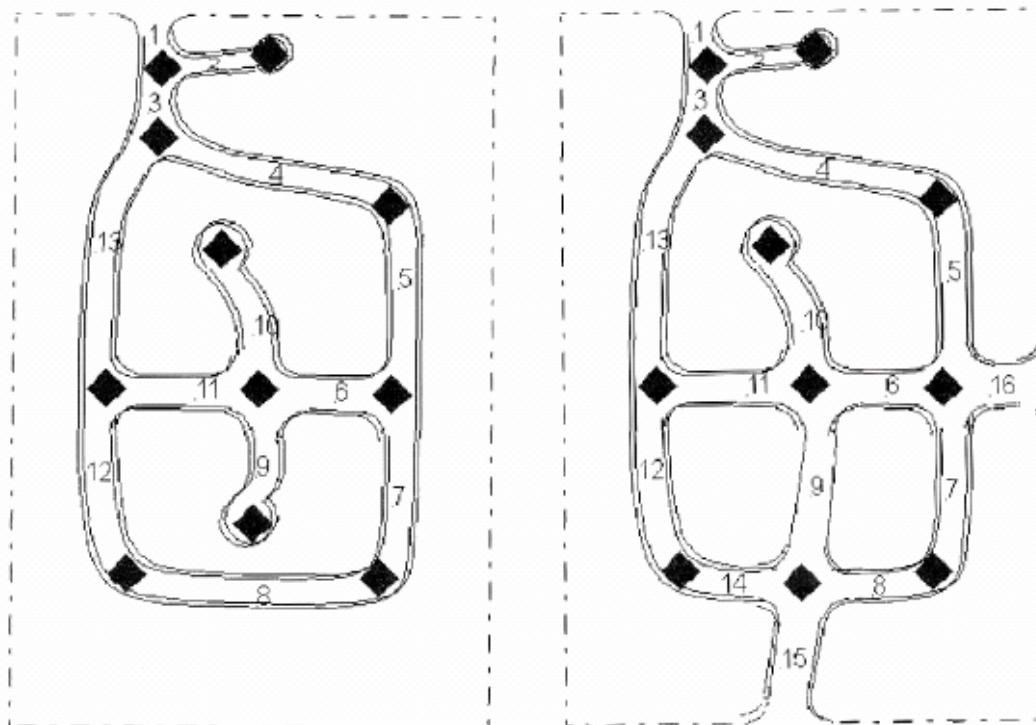
The most common approach to calculating a “Connectivity Index” is the number of roadway links divided by the number of roadway nodes (Ewing, 1996). In this method, links are the segments between intersections, nodes the intersections themselves. Cul-de-sac heads count the same as any other link end point. A higher index means that travelers have increased route choice, allowing more direct connections for access between any two locations. According to this index, a simple box is scored a 1.0. A four-square grid scores a 1.33 while a nine-square scores a 1.5. Dead-end and cul-de-sac streets reduce the index value. This sort of connectivity is particularly important for non-motorized accessibility. A score of 1.4 is the minimum needed for a “walkable community.”

The following two illustrations from Kentucky’s Street Connectivity Zoning and Subdivision Model Ordinance demonstrate how the Connectivity Index is calculated.



(13 links/11 nodes = 1.18 ratio)

(16 links/11 nodes = 1.45 ratio)



This Connectivity Index has been incorporated into many comprehensive plans and subdivision ordinances. In Section 2.4.6 of this report, there are several examples that use this technique. While the Connectivity Index does help measure internal connectivity of a proposed subdivision, it does little to ensure connectivity with the surrounding road system. Interestingly there is less agreement on how best to address the issue of external connectivity. A review of best practices suggests that a jurisdiction should establish a minimum threshold for second means of access for a subdivision. This standard is often based on fire code requirements. Some jurisdictions advocate that proposed subdivisions should connect in all directions to abutting subdivisions, such as the excerpt from Kentucky's Street Connectivity Zoning and Subdivision Model Ordinance on external connectivity proposes (below). The complete report is attached as Appendix C:

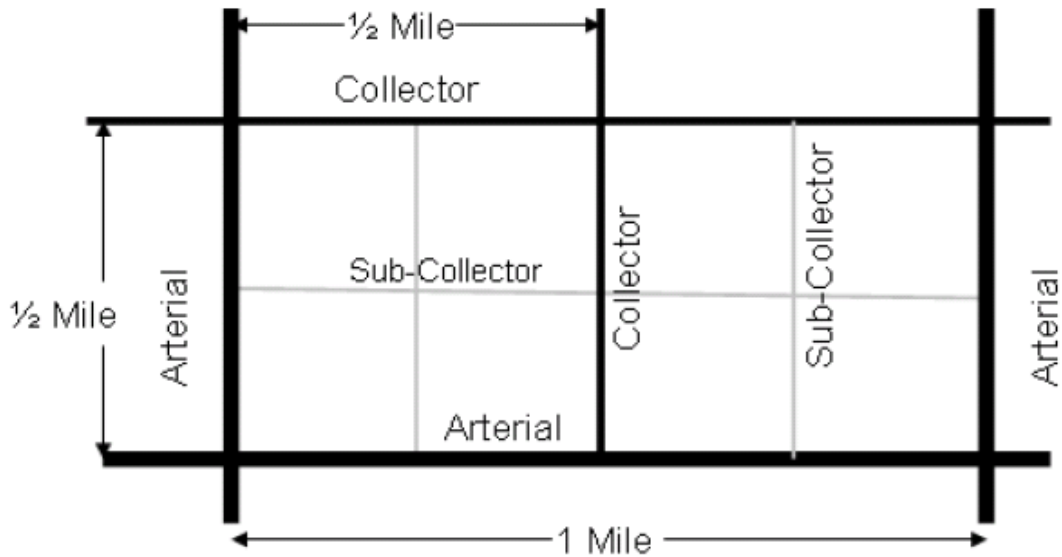
Connectivity (External)

1. To ensure future street connections where a proposed development abuts unplatted land or a future development phase of the same development, street stubs shall be provided to provide access to all abutting properties or to logically extend the street system into the surrounding area. All street stubs shall be provided with temporary turn-around or cul-de-sacs and the restoration and extension of the street shall be the responsibility of any future developer of the abutting land.

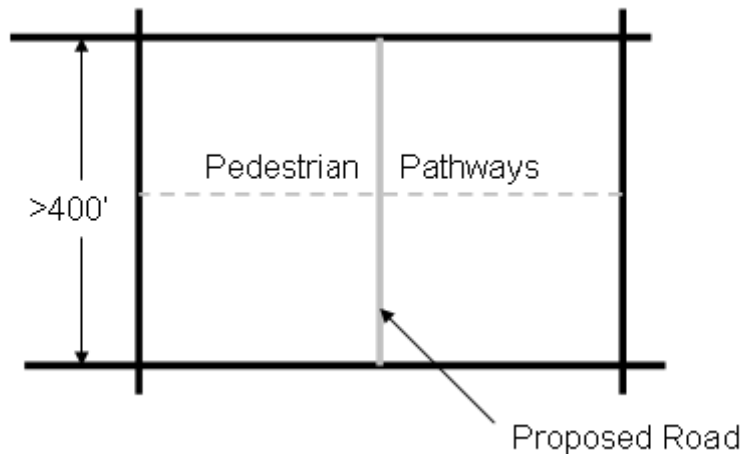
The Kentucky mode ordinance also provides useful rules of thumb that can be applied toward arterial and collector spacing, as well as local road spacing.

In addition to the following connectivity ordinance, it is recommended that cities and counties plan their transportation network to have an acceptable roadway (arterials, collectors and sub-collectors) network density. It is recommended that through streets be spaced no more than ½ mile apart, although spacing of sub-collectors (throughstreets that feed collectors typically with volumes less than 500 vehicles per day) at ¼ mile spacing is even better (Figure 7). Lower densities result in a higher strain on the existing highway system, often resulting in needed capacity improvements and inefficient operations.

Figure 7. Arterial and Collector Road Density



3. Street connections shall be spaced at intervals not to exceed [six hundred sixty (660)] feet (1/8 mile) along each boundary that abuts potentially developable or redevelopable land. Blocks longer than [four hundred (400)] feet in length shall have a mid-block pedestrian pathway connecting adjacent blocks. See Figure 7.



7.4.3 Benefits

Without any measures of connectivity effectiveness, a local government can only subjectively evaluate whether or not a developer's proposed subdivision provides adequate internal circulation and external connections. Since subdivision approval in Texas is administrative, without standards like a Connectivity Index there is no justification for a local government to deny a proposed subdivision regardless of the lot

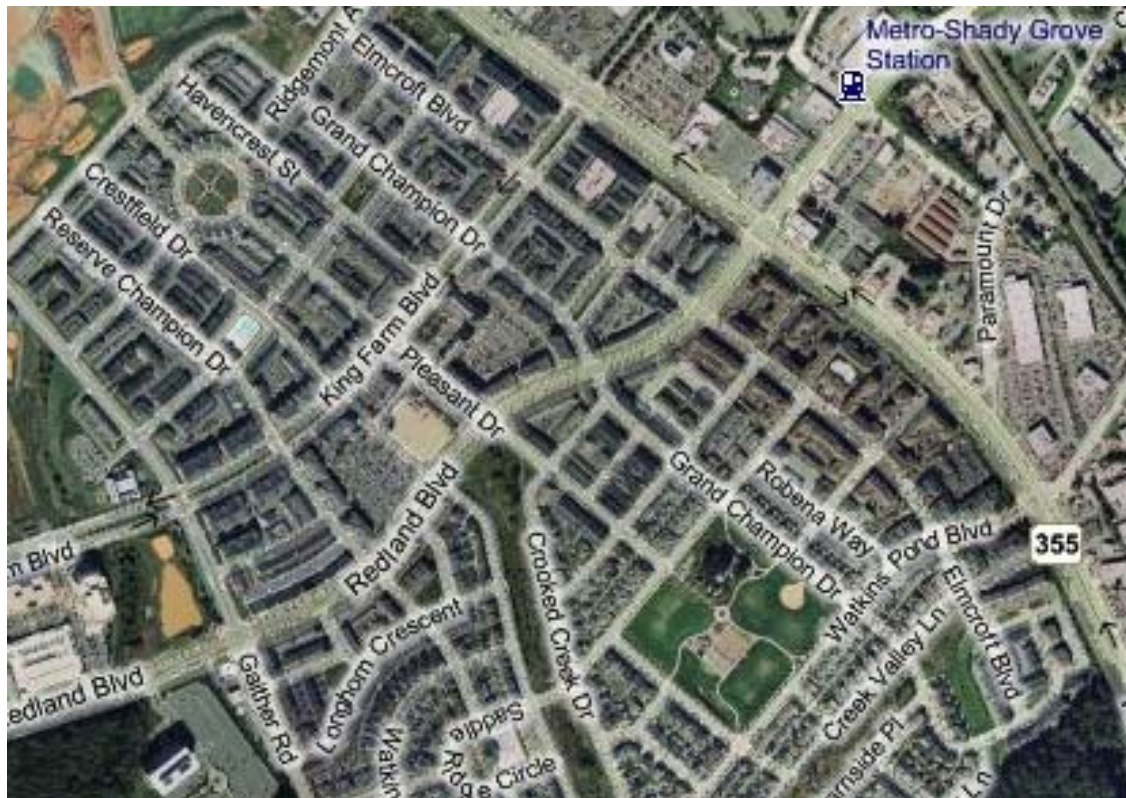
layout or road configuration. But, with subdivision review tools like the Connectivity Index and some of the suggested external connections standards listed in this report, a local government has the factual basis to approve or deny a proposed subdivision and has stronger defense if legally challenged.

The important caveat on these benefits is striking the right balance between connectivity and keeping traffic on residential streets to acceptable levels. User judgment is needed to avoid having to calm a street grid to mitigate too much direct through traffic. Short streets and T-intersections help in preventing the creation of attractive short cuts for longer distance trips.

The Street Connectivity Index is especially useful in comparing alternative subdivision designs. For example, the conventional subdivision (left picture below) has nine (9) links and nine (9) nodes for a Connectivity Index of 1. The traditional interconnected neighborhood (right picture below) has 17 links and 11 nodes for a Connectivity Index of 1.55.



Neotraditional residential subdivisions depicted in the next two aerial photographs provide its residents a similar level of traffic calmed environment that residents of conventional cul-de-sac neighborhoods experience.



7.4.4 Challenges

While the Connectivity Index and External Connection standards are very useful tools, their effectiveness should not be overemphasized. The most commonly used index is a mathematical calculation of the links divided by the nodes. This index does not factor into the equation the density of development, quality of the links or the attractiveness of the nodes. It is important to also examine the capacity of the links and nodes to handle new traffic.

The density/lane miles tool developed for H-GAC as part of this same work effort is another way to strike the right balance on connectivity since it factors in density and gives answers by line miles or grid spacing thus giving the planner some flexibility in how connectivity is achieved.

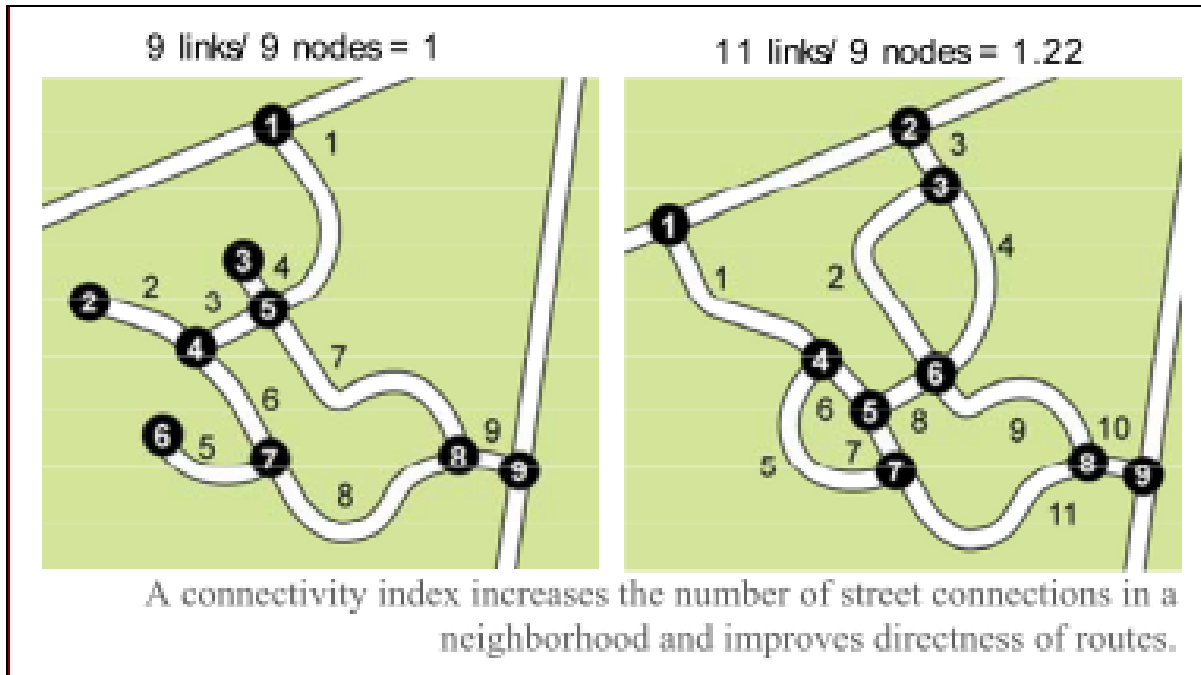
7.4.5 Roles and Next Steps

- MPO – The MPO can provide technical assistance in advising local governments on the application of this tool and how it can be integrated into their subdivision regulations.
- Local Government – To use the Street Connectivity Index in the subdivision review process, the local government must first become familiar with the tool – possibly applying it to recently approved subdivisions. The next step would be to incorporate the index evaluation into the subdivision regulations and use it as one of its tools to evaluate the internal and external connectivity of proposed subdivisions.
- Private Developer – Private developers should work with the tool and evaluate different conceptual configurations of the proposed subdivision with a recognition that a higher value index should promote a more efficient transportation circulation system.

7.4.6 Examples/References

Example A: The City of Sealy has included recommendations in its recently adopted comprehensive plan to incorporate a Street Connectivity Index into its subdivision regulations.

Figure 8. Street Connectivity Index Recommendation



Source: Street Connectivity Index recommendation from the City of Sealy, TX Comprehensive Plan, 2009

Example B: Section 7.10.3 of the Town of Cary, NC Land Development Ordinance, 2009 has the language on the Street Connectivity Index in its subdivision regulations for residential developments. (Note that the language below excludes links to existing adjacent streets, an omission that should be addressed in crafting such ordinances and in thinking through the MTP). This same approach can be broadened to apply to all types of subdivisions to evaluate the connectivity of the proposed internal road system for like uses:

7.10.3 Standards for Streets/On-Site Vehicular Circulation

The following standards shall be met in all new residential development in order to increase connectivity:

(A) Street Connectivity

Any residential development shall be required to achieve a connectivity index of 1.2 or greater unless the Planning Director determines that this requirement is impractical due to topography, existing development, and/or natural features. In the event that this requirement is waived, a six (6)-foot pedestrian trail shall be provided to link any cul-de-sacs within a residential development in which the required connectivity index has been waived. A connectivity index is a ratio of the number of street links (road sections between intersections and cul-de-sacs) divided by the number of street nodes (intersections and cul-de-sac heads). The following illustration provides an example of how to calculate the index. Street links on existing adjacent streets that are not part of the proposed subdivision are not included in the connectivity index calculation.

Attached as an appendix to this report is a memorandum from the Planning Director for the Town of Cary, NC summarizing their experience using the Street Connectivity Index.

Example C: Lincoln County, NC has adopted both a Connectivity Index and an External Connections requirement as part of the subdivision regulations. Section 5.4.4. C. & D. states:

C. Internal Connectivity Ratio

1. In all districts except in the R-R district, the road network for any subdivision with internal roads or access to any public right-of-way shall achieve a connectivity ratio of not less than 1.40, measured within the subdivision.
2. Within the R-R district, the road network for any subdivision with internal roads or access to any public right-of-way shall achieve a connectivity ratio of not less than 1.20, measured within the subdivision.
3. Road links and nodes along a collector or arterial road providing access to a proposed subdivision shall not be considered in computing the connectivity ratio.

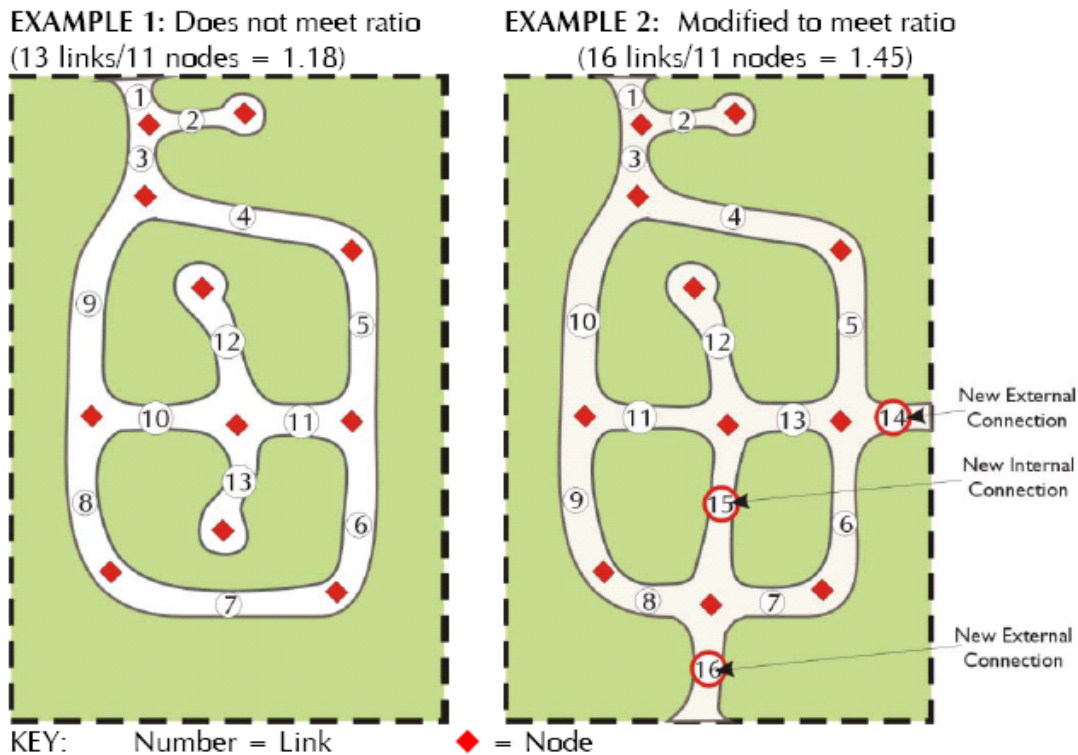


Figure 79. Internal Connectivity Ratio

Commentary: The internal connectivity ratio in this subsection C provides a formula that ensures a consistent number of links within a development. But, one could design a subdivision with a sufficient number of internal connections to meet the ratio standard and only one external connection; hence the "double standard". See External Access Required in D,

below.

D. External Access Required

In order to accommodate emergency and service vehicles, the following standards shall apply:

1. Any residential subdivision of greater than 20 lots shall include at least two access points. The second access may consist of a stub road.
2. Any residential subdivision of greater than 50 lots shall include a minimum of two access points.
3. Residential subdivisions of 250 or more lots shall provide three separate access points. Where three or more access points are required, the Board of Commissioners may waive the requirement for immediate construction of more than two access points, provided that subdivision phasing and design illustrates the additional required connections. For those subdivisions large enough to require a third access, a stub-out road may be credited as a required access if the two functioning access roads are both connected to a collector road.
4. A waiver (see §9.6.9.F) of these standards may be allowed by the Board of Commissioners during approval of the preliminary subdivision plat only in extreme cases where limited frontage, natural features (slope, topography), or similar circumstances preclude the required connections and there is no substantial impact noted regarding emergency service delivery.

Example C: In March of 2009 the State of Virginia adopted new regulations that require new subdivisions to be evaluated using the Street Connectivity Index. The Virginia Department of Transportation (VDOT) is ultimately responsible for the maintenance of almost all public roads in the state, including the secondary road system. As a result, VDOT has developed an extensive regulatory process to phase-in the implementation of the Connectivity Index into the subdivision review process, the design of roads and the acceptance of improvements. The specifics of the [new regulations](http://leg1.state.va.us/000/reg/TOC24030.HTM#C0092), can be found in the attached hyperlink. (<http://leg1.state.va.us/000/reg/TOC24030.HTM#C0092>). MaineDOT has recently gone so far as to allow the use of State monies for local road connections, as an incentive for locals adopting appropriate land use controls in their US1 Gateway corridor, if these connections relieve traffic burdens on the State arterials.

The arterial/local collector tradeoff tool, one of the products of this work effort for H-GAC, can be a useful tool in evaluating such tradeoffs.

Example D: Attached as an appendix is an excerpt from the Model Smart Land Development Regulations prepared by the American Planning Association, 2006, Section 4.8.4 Street Connectivity Ordinance.

Another way to achieve similar outcomes to the Connectivity Index is through regulating block lengths - the subject of the next section.

7.5 Lot Width and Block Length

Texas law permits municipalities that have adopted zoning regulations to regulate lot width and block length through zoning. In addition, municipalities may use the provisions of the subdivision regulations through Sections 212.002 and 212.003 of the Texas Local Government Code to regulate the creation of subdivisions within the municipal boundaries and its ETJ. Municipalities such as Sugar Land and Alvin have included standards on lot width and block length.

In Subchapter E (Infrastructure Planning Provisions in Certain Urban Counties), Section 232.103 of the Texas Local Government Code, counties are allowed to establish minimum lot frontage.

§ 232.103. Lot Frontages

By an order adopted and entered in the minutes of the commissioners court and after a notice is published in a newspaper of general circulation in the county, the commissioners court may adopt reasonable standards for minimum lot frontages on existing county roads and establish reasonable standards for the lot frontages in relation to curves in the road.

7.5.1 Applicability of Lot Width and Block Length

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJ
X	X	X

7.5.2 Description

The “Minimum Lot Width” is defined as the minimum permissible width of a lot measured horizontally, usually along the property line with a public road or at the front building setback line. The City of Alvin defines “Block” as an area of land bounded by a street, or by a combination of streets and public land, waterways, exterior boundaries of a subdivision, corporate boundaries, or any other barrier to the continuity of development. The “Maximum Block Length” would be the maximum permissible block measured horizontally, along the property lines of the intersecting streets. One of purposes in controlling lot width is to prevent lots from having individual driveways access the street too close together. At the other extreme the maximum block length provision addresses the neighborhood circulation and network connectivity issue.

7.5.3 Benefits

Establishing a minimum lot width is one way to control access to the public street, reducing the number of driveways and curb cuts. Mandating a maximum block length is another approach to enhance connectivity in a proposed subdivision. The concept of having a grid pattern with shorter blocks, instead of long dead end streets or cul-de-sacs, makes it easier to get from place to place within a community, and provides

several alternative routes. Using shorter blocks will help reduce traffic congestion as well as increase options for pedestrian activity.

7.5.4 Challenges

Minimum lot width and maximum block length standards are easy dimensional standards to understand and apply. The challenge will be to not create cookie-cutter subdivisions. These standards are intended to help create a balance between accessibility and mobility; however, variation and interest in design and layout should not be sacrificed. The State of Wisconsin developed A Model Traditional Neighborhood Development Ordinance that provides local jurisdictions guidance on lot widths and block length that are appropriate (excerpts to this model ordinance can be found in Appendix F.

7.5.5 Roles and Next Steps

- MPO – The MPO can provide guidance to the local government on appropriate minimum lot widths and maximum block lengths. State law does not provide any direction or limitation on block length. The only dimensions standards referenced in state law concern county right-of-way widths and the width of street cuts on arterials and other streets.
- Local Government – The local government should review its subdivision regulations and determine if minimum lot widths and maximum block lengths should be established or updated.
- Private Developer – Private developers should become familiar with a jurisdictions lot and block standards. The developer should also be aware of the need to balance property access and mobility in designing the subdivision.

7.5.6 Examples/References

Example A – The following is an excerpt from the Town of Cary, NC Land Development Ordinance addressing street design. (Note that this is a very strong statement on connectivity policy and that many places may want to ease into such standards more incrementally or only apply them in more urban context of densities over 3 dwellings per gross acre for example, the equivalent of lot sizes less than 10, 000 square feet. The standards on connectivity in section 2 below also do not relate to functional classification and this should be a consideration for such ordinances. The limitations on cul-de-sacs in section 4 below are also on the very strict end of the spectrum)

(B) Street Arrangement

- (1) The proposed public or private street system shall be designed to provide vehicular interconnections to facilitate internal and external traffic movements in the area. Such connections shall be provided during the initial phase of the project approximately every 1,250 to 1,500 linear feet for each direction (north, south, east, west) in which the subject property abuts. If the common property boundary in any direction is less than 1,250 linear

feet, the subject property will be required to provide an interconnection if it is determined by the Planning Director that the interconnection in that direction can best be accomplished through the subject property. When the Planning Director deems a vehicular connection impractical, he/she can increase the length requirement and/or require pedestrian connections. The Planning Director may delay the interconnection if such interconnection requires state approval or will result in significant hardship to the property owner. The intent of this standard is to improve access/egress for Town neighborhoods, provide faster response time for emergency vehicles, and improve the connections between neighborhoods.

- (2) Any development of more than one hundred (100) residential units or additions to existing developments such that the total number of units exceeds one hundred (100) shall be required to provide vehicular access to at least two (2) public streets unless such provision is deemed impractical by the Planning Director or Town Engineer due to topography, natural features, or the configuration of adjacent developments.
- (3) Where new development is adjacent to vacant land likely to be divided in the future, all streets, bicycle paths, and access ways in the development's proposed street system shall continue through to the boundary lines of the area under the same ownership as the subdivision, as determined by the Planning Director or the Town Engineer, to provide for the orderly subdivision of such adjacent land or the transportation and access needs of the community. In addition, all redevelopment and street improvement projects shall take advantage of opportunities for retrofitting existing streets to provide increased vehicular and pedestrian connectivity.

[Please note the requirement that ALL STREETS be interconnected may be appropriate for Cary, NC, but may not be appropriate for all jurisdictions. A planner's judgment is needed to evaluate the appropriateness of connecting streets. The goal of connecting as many streets as possible should be the overarching intent, but is not absolute.]

- (4) In general, permanent cul-de-sacs are discouraged in the design of street systems, and should only be used when topography, the presence of natural features, and/or vehicular safety factors make a vehicular connection impractical. Where cul-de-sacs are unavoidable, site and/or subdivision plans shall incorporate provisions for future vehicular connections to adjacent, undeveloped properties, and to existing adjacent development where existing connections are poor.
- (5) Permanent cul-de-sacs shall comply with the length limits and design standards set forth in the Town's Standard Specifications and Details Manual, and shall be provided with a turnaround at the closed street end.

Example B – The City of Pearland, TX has adopted the following standards for lot layout:

Division 14 – Lot Design & Improvement Standards

Section 3.2.14.1 Blocks - Determination and Regulation of Size

- (a) **Determination Criteria.** The length, width, placement, and shape of blocks shall be determined with due regard to the following:
 - (1) Provision of adequate building sites suitable to the special needs of the type of use contemplated;
 - (2) Zoning requirements as to lot sizes, setbacks and dimensions (if within the City's corporate limits); and
 - (3) Needs for convenient access, circulation, control and safety of street traffic and for pedestrians or bicyclists traveling to a public park or school site or other facility within or close to the neighborhood.
- (b) **Streets.** Intersecting streets, which determine the lengths and widths of blocks, shall be provided at such intervals as to serve cross-traffic adequately, to provide adequate fire protection, and to conform to customary subdivision practices.
- (c) **Block Lengths.** Where no existing subdivision or topographical constraints control, the block lengths shall not exceed 1,600 feet in length along major thoroughfares and 1,200 feet along other streets. Where no existing subdivision or topographical constraints control, the blocks shall not be less than 600 feet in length; however, in cases where physical barriers or property ownership creates conditions where it is appropriate that these standards be varied, the length may be increased or decreased (through issuance of a variance with plat approval) to meet the existing conditions having due regard for connecting streets, circulation of traffic and public safety.

Example C – The City of League City, TX has adopted the following standards for lot layout in the Subdivision and Development Ordinance - Section 102-5 of the Subdivision and Development Ordinance

- (g) *Maximum length between intersections.*
 - (1) Maximum length between intersections is 1,200 feet, except for cul-de-sacs.
 - (2) Maximum length is 880 feet for cul-de-sac (see Subsection (a)(5) of this Section).
 - (3) Maximum length is 200 feet for stub streets.
- (h) *Conformity to major street plan.* Provisions must be made for the uninterrupted extension of main thoroughfares as shown on the City's master transportation plan. Streets must provide for free circulation within the subdivision.
- (i) *Connectivity.* A proposed development shall provide multiple direct connections in its local street system to and between local destinations, such as parks, schools, and shopping. Each development shall incorporate and continue all collector or local streets stubbed to the boundary of the development plan by previously approved, but unbuilt development or existing development. The street system for the subdivision, except in unusual cases, must connect with streets already dedicated in adjacent

subdivisions. Where no adjacent connections are platted, the streets must be, in general, reasonable projections of streets in the nearest subdivided tract and must be continued to the boundaries of the tract being subdivided so that future subdivisions may connect thereto. The maximum distance between streets which are to align with existing or future planned City streets shall be 1,200 feet in residential areas.

- (j) *Points of access.* Developments of one- or two-family dwellings where the number of dwelling units exceeds 30 shall be provided with separate and approved fire apparatus roads, and shall meet the requirements of Section D104.3 of the 2000 International Fire Code. Exceptions:
 - (1) Where there are 30 or fewer dwelling units on a single public or private access way and all dwelling units are protected by approved residential sprinkler systems, access from two directions shall not be required.
 - (2) The number of dwelling units on a single fire apparatus access road shall not be increased unless fire apparatus access roads will connect with future development, as determined by the Fire Marshal.
- (k) *Cul-de-sac streets.* Streets designed to leave one end permanently closed shall not exceed 880 feet in length and shall be provided at the closed end with a turnaround. The street right-of-way for the turnaround shall have a minimum diameter of 100 feet; the surfaced portion of the road at the turnaround shall have a minimum diameter of 80 feet.

7.6 Design Guidelines and Neighborhood or Sector Plans

Texas statutes dictate much of what can and cannot be regulated by local governments. Ideally local governments should adopt regulations on the principles of street connectivity and the preferred street design standards to facilitate the desired vision of the community. Unfortunately, this may not always be possible legally or politically. However, there is a lot that local governments can do to affect development and improve connectivity without mandating it. Much of that influence is through education, and informing developers of alternatives ways of meeting their objectives. Locally prepared design guidelines expose developers to the best practices in the industry which have been fine tuned to the character of the community. Similarly, neighborhood planning efforts provide an opportunity for the community to come together and identify their concerns and develop solutions that can be implemented in partnership with private developers. These types of local government efforts will often attract developers that have a similar interest in building great projects.

While promoting more connected residential subdivisions it is important to recognize the reality that gridding and more connectivity affects the costs of development. Typically, Traditional Neighborhood Design (TND) subdivisions may add 15-20% more roadway, and as such generates resistances from homebuilders (i.e. "will raise housing prices,

etc.”). The counter strategy to this concern is to tie these requirements to revised street standards that reduce paving and slow traffic. This brings costs back into line.

7.6.1 Applicability of Design Guidelines and Neighborhood or Sector Plans

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJ
X	X	X

7.6.2 Description

Design guidelines are discretionary statements and illustrations used to guide land development and achieve a desired quality of physical improvement. In the context of road connectivity, locally prepared design guidelines may address issues such items as the road cross-section, lane widths, sidewalks, intersection curb radii, pavement types, and streetscape appurtenances. Neighborhood plans can investigate the long-standing problems a community has been facing and develop innovative solutions. Road connectivity concerns are often catalysts for change in neighborhoods. Plans that propose re-routing truck routes outside of the town center or building that missing road segment to the interstate highway create opportunities for economic development and improvements in the community’s quality of life.

7.6.3 Benefits

Preparing design guidelines and neighborhood plans create a consensus on direction and the energy for change. These planning efforts often provide the momentum and direction for further actions in the areas of capital improvements and financial incentives. These planning efforts also provide a starting point (listing concerns and expressing desired outcomes) for private developers to consider as they begin to prepare their preliminary subdivision plat.

7.6.4 Challenges

Given that these plans are recommendations without the force of law they need to be flexible enough to accommodate the desires of the developer that would be tasked with implementing them. However, since the public will become deeply invested in these planning documents, they will be reluctant to deviate from their vision. For the plans to become reality the public and the developer will need to work together to resolve differences and create a win-win scenario.

7.6.5 Roles and Next Steps

- MPO – The MPO can provide technical support and financial assistance in preparing design guidelines and neighborhood plans. Assistance from the MPO

can be the spark that gets communities interested in taking the next step forward. H-GAC has been providing these types of assistance for many years.

- Local Government – Local governments need to be the champions for these planning efforts. In addition to providing financial and staff support to prepare these planning documents, the local government must be an advocate in attracting developers that want to implement the plans. To promote redevelopment and retrofit street connectivity, a local government may also need to commit capital investment to fill the void between what state agencies may provide and what the developers are willing to invest.
- Private Developer – Property owners and private developers should be active participants throughout the planning process. Early involvement will ensure the planning objectives are not outside the realm of possibilities for having a financially successful development. Once design guidelines and neighborhood plans are developed, the private developer should closely review these documents and attempt to incorporate as many of the recommendations as possible into the development proposal. When differences do arise, it will be crucial to have an open dialogue with the community on why changes from these plans are necessary in order to create a financially viable project that can be built and become an asset for the community.

7.6.6 Examples/References

Example A: The H-GAC has worked with local governments and prepared a number of useful planning tools. H-GAC's web-based "Best Practices Toolbox" and the Subregional Plans initiative are two examples of planning efforts that get communities to think about their future and formulate a strategy to achieve their vision.

Example B: The "Neighborhood Street Design Guidelines: An Oregon Guide for Reducing Street Widths" prepared in 2000 is an excellent example of a design guideline that addresses connectivity issues and urban design issues. The guidelines can be downloaded from the following link

(<http://www.oregon.gov/LCD/docs/publications/neighstreet.pdf>). These guidelines were funded by the Transportation and Growth Management Program through the Oregon Department of Transportation and the Department of Land Conservation and Development.

Example C: The City of Pearland has developed a development guide that provides property owners and developers useful information about the development review process and recommendations to promote well planned, quality developments. The link to this document is listed below.

(<http://www.cityofpearland.com/vertical/Sites/%7BCA80BAF8-A883-4878-AB6D-7FC8DAE7D62E%7D/uploads/%7B35287D28-177F-4C3B-8419-2351A5743769%7D.PDF>)

7.7 Related Issues: Subdivision Review Procedures, Traffic Calming and Private Streets

There are several other issues which should be considered during the subdivision process that can influence the success of road connectivity in a community. The process of reviewing the proposed subdivision plat itself can help or hinder the success of enhancing road connections between adjacent subdivisions. Example A demonstrates how the subdivision review process needs to have a broader context than just simply reviewing the subject property being subdivided. A process that does not look beyond the property boundaries to a major thoroughfare map will miss opportunities to connect to adjacent properties. Examining existing conditions and observing where sidewalks end and cul-de-sacs align are important considerations that should be investigated as possibilities for connecting neighborhoods. To provide this broader perspective, a local government's subdivision regulations should be modified to require preliminary subdivision plans to extend beyond the boundaries of the subject property a set distance, so that these feature can be assessed.

In preparing the subdivision plats and exploring opportunities to connect neighborhoods, it is equally important to consider the unintended consequences of connecting adjacent subdivisions. The purpose of making road connections is to improve traffic flow and change traffic patterns, but those shifts in traffic should not re-route regional traffic through residential neighborhoods. The road connections need to be planned to connect similar areas with similar travel characteristics. Connecting residential neighborhood provides more options for people living there to get into and out of the area. There are ways to create these connections and limit the cut-through traffic that may occur. Traffic calming techniques should be considered when reviewing proposed subdivision plats that connect neighborhoods or extend major thoroughfare roads through the subdivision. Using information from the projected traffic volumes and information from the traffic impact analysis, the developer and the local government should determine if traffic calming measures should be incorporated into the proposed development. (The box on the following page contains traffic calming warrant examples published in ITE's Traffic Calming: State of the Practice.) If traffic calming measures are needed they should be put in place as part of the initial construction of the roads. Traffic calming is easier to implement as part of the initial construction. It is much more controversial and expensive to retrofit at a later point.

Texas law expressly provides for the option of private streets. However, problems with the substandard design of private streets and the desire of property owners who request local government to take over the maintenance of private streets are well documented. Most local governments take steps to encourage private streets to be designed and built to the highest standards possible. Local governments typically will not accept roads that do not meet their adopted standards. Upgrading a private street after-the-fact to municipal or county standards could place a significant financial burden on the homeowner's association – which may mean the road will deteriorate over time due to lack of maintenance. During the review of a proposed subdivision, if private streets are proposed, it is important to consider the viability of any connections between the private

and public streets. Will the private street be maintained and passable at all times? Is there potential for the road connections to be closed or gated in the future? A community should carefully consider the ramifications of including private streets as part of the community's overall road network.

Figure 9. Examples of Traffic Calming Warrants from ITE's *Traffic Calming: State of Practice*

Table 8.3. General Warrants. (Sarasota, FL)

Warrant	Major Collectors	Minor Collectors	Local Residential Streets
1. Minimum traffic volume	>8,000 vpd or 800 vph	>4,000 vpd or 400 vph	>1,000 vpd or 100 vph
2. Anticipated cut-through traffic	50%	40%	25%
3. 85th percentile speed	10 mph > speed limit	10 mph > speed limit	> speed limit
4. Pedestrian crossing volume	>100 per hour	>50 per hour	>25 per hour
5. Accidents per year	6	6	3

vpd = vehicles per day; vph = vehicles per hour

Source: Engineering Department, City of Sarasota, FL.

Table 8.4. Speed Hump Warrants. (Montgomery County, MD)

Criterion	Original	Interim	Present
Minimum volume	60 vph	100 vph	100 vph
Minimum 85th percentile speed Secondary street Primary street	31 mph 34 mph	31 mph 31 or 36 mph (depending on speed limit)	32 mph 34 or 39 mph (depending on speed limit)
Minimum length of segment	None	1,000 feet	1,000 feet
Resident concurrence	67%	80% on treated street	80% on treated street 50% on side streets

vph = vehicles per hour; mph = miles per hour

Source: Department of Public Works and Transportation, Montgomery County, MD.

Table 8.5. Speed Hump Eligibility Requirements. (Survey of 42 Agencies)

Requirement	Number of Agencies Setting Requirement	Median Value for Agencies with Requirement
Resident approval by petition	30	67%
Maximum street width	8	40 feet
Minimum traffic volume	11	1,000 vehicles per day
Maximum traffic volume	12	5,000 vehicles per day
Maximum grade	12	6%
Prohibition on emergency routes	27	
Prohibition on transit routes	7	

Source: Kimley-Horn and Associates, Inc., *Road Hump Evaluation Program "Final,"* Prepared for the City of San Diego, CA, 1997.

Classification	Collector	Local Streets		Other Considerations										Control Device Use May be Considered	
		Neighborhood Collector	Local Access	Curbs & Gutters	% Grade	Curvature of Stretch	School Bus Route/Metro	Adjacent Arterials	Previous Traffic Eng. Improve. Unsuccessful	Impacts to Police/Fire	Delay Accident	Homes Front Street	Acceptable Impacts		
Land Use	Small Commercial Residential	Residential	Residential												
Traffic Engineering & Specialized Improvements	Yes	Yes	Yes	—	—	—	—	—	—	—	—	—	—	—	High Speeds
Police Enforcement Neighborhood Speed Watch Program	Yes	Yes	Yes	—	—	—	—	—	—	—	—	—	—	—	High Speeds
Speed Humps	No	Vol ≤ 3000 vpd 85% ≥ 35	Vol ≥ 300 85% ≥ 35	Yes	Not > 10%	300—	Yes	Yes	Yes	Yes	—	Yes	Yes	High Speeds & Cut-through Volumes	
Traffic Circles	No	Vol ≤ 3000 vpd 85% ≥ 35	Vol ≥ 300 85% ≥ 35	Yes	Not > 10%	—	Yes	Yes	Yes	Yes	—	Yes	Yes	Speeds or Accident History	
Stop Signs	MUTCD	MUTCD	MUTCD	—	—	—	—	—	—	—	—	—	—	Accident History	
Diverter	No	No	Vol ≥ 300	Yes	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High cut-through Volumes	
One-Way/Chokers	No	Vol ≥ 2,500	Vol ≥ 300	Yes	—	—	Yes	Yes	Yes	Yes	Yes	—	Yes	High cut-through Volumes	
Street Closure	No	Yes, If Vol ≥ 6,000 Non-Local ≥ 20%	Yes, If Vol ≥ 3,000 Non-Local ≥ 20%	—	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High cut-through Volumes	

Notes:

1. All volumes in units of typical daily traffic volumes.
2. Source for street type designation—City of Bellevue Street Classification.
3. Control devices may be considered when either the speed criteria, volume criteria or both criteria are exceeded.

MUTCD = Manual on Uniform Traffic Control Devices for Streets and Highways; vpd = vehicle per day

Figure 8.5. Traffic Calming Control Matrix. (Bellevue, WA)

Source: City of Bellevue, Transportation Department, Bellevue, WA.

7.7.1 Applicability of Subdivision Review Procedures, Traffic Calming & Private Streets

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJ
X	X	X

7.7.2 Description

When evaluating a proposed subdivision for possible connections between neighboring subdivisions there are three perspectives that you should consider – Contextual Review, Traffic Calming and the impact of private streets. Counties, municipalities and ETJs of the municipalities can incorporate these tools into their subdivision regulations.

Examining a subdivision in the context of its surroundings means to first look at the surrounding subdivisions, roads and planned improvements to see how connections could be made to this proposed development.

“Traffic Calming” is defined by the Institute of Traffic Engineers as “the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior and improve conditions for non-motorized street users.” Road Traffic-Technology.com defines traffic calming as “...a technique aimed at significantly reducing vehicle speeds in residential areas, without restricting access. It is to protect vulnerable road users and residents, and improves the quality of life for those living in the neighborhood....” It is important to remember that concerns over increased speed and traffic through a neighborhood should not be a justification for not making those connections. It does mean that road design considerations need to be factored in to the mix to protect the quality of life in the areas being connected. Traffic calming also has the potential of deflecting traffic from one area to another. It is important to examine the effects of traffic calming holistically and anticipate where the deflections of traffic may go. Ideally, traffic calming should deflect the traffic to commercial corridors or to major collectors and above.

Subdivisions that propose to use private streets should be critically evaluated to determine how community travel patterns would be affected by excluding these roads from the community’s road network. Use of private streets to provide critical connections between subdivisions or to benefit a community-wide road network should be avoided. It should be acknowledged that there are times when private streets that connect similar uses, particularly commercial developments, can improve traffic circulation and help to preserve road capacity on the major public roads.

7.7.3 Benefits

Evaluating a subdivision from these different perspectives will highlight potential deficiencies and create the opportunity to improve a community’s overall connectivity.

7.7.4 Challenges

Critically assessing a subdivision from these perspectives takes both time and resources in order to be successful. Texas law places a deadline on subdivision approvals, so staff will need to be properly trained to incorporate these assessments during its routine review. To help in addressing these issues, the subdivision regulations may need to be amended to require the developer to perform the initial

assessment of these issues and provide a written response to the local government, as part of the subdivision application.

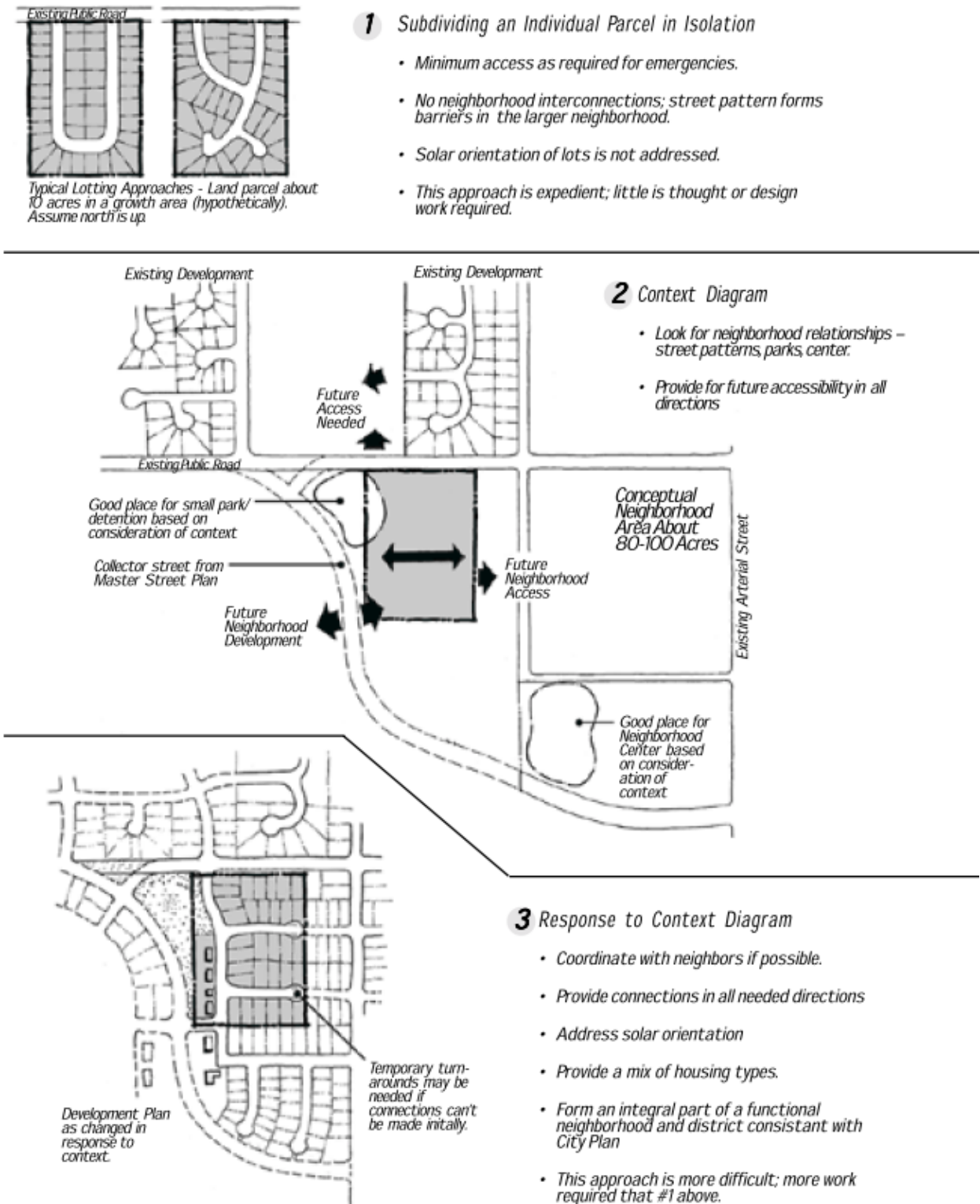
7.7.5 Roles and Next Steps

- MPO – The MPO can research and report to its regional members on issues such as subdivision review procedures, best practices in traffic calming, and the use of private streets. The MPO can also produce educational materials and conduct training sessions on these matters. The MPO should also serve as a repository for ordinances that have been successfully adopted in the region to provide real examples where communities applied these best practices.
- Local Government – Local governments should become aware of these issues and consider them when reviewing proposed subdivisions. Local government could add these issues to their check lists of items requiring review. The local government may consider amending the subdivision regulations to require context review, traffic calming and impact of private streets as issues that the developer must address as part of the application process.
- Private Developer – The private developer should also be aware of these issues and recognize the effect that context, traffic calming and private streets may have upon road connections between neighboring subdivisions.

7.7.6 Examples/References

Example A: Figure 10 is from the Fort Collins Design Manual and documents how contextual review of a proposed subdivision can improve the quality of the design and the effectiveness of the connections with neighboring subdivisions.

Figure 10. Example Context Diagram for a Residential Development Subdividing a Piece of Land vs. Building Up a Neighborhood or District



Source: Fort Collins, Colorado, Community Planning and Environmental Services, Fort Collins Design Manual: Explanations of Fort Collins' Land Use Code Standards (May 2000).

Example B: Chambers County, Texas has established policies in its subdivision regulations on how to address private streets. Subsection IV, C, 2, c of the subdivision regulations specifically prohibits private streets that are classified as arterial or collector streets or would affect local circulation and through traffic.

Article IV DESIGN STANDARDS

C. Streets and Highways.

2. Private streets are prohibited except that the Commissioner's Court may approve private streets if they meet the following regulations:
 - a. The private street complies with the County's design and construction standards;
 - b. The private street is so designated on the plat;
 - c. The private street is not an arterial or collector street, does not affect the circulation of local or through traffic or have a negative impact on planning for the area;
 - d. There are natural or manmade boundaries contiguous to the subdivision, including creeks, lakes, levees, utility easements or golf courses that would make it difficult or undesirable to extend the streets beyond the subdivision;
 - e. The subdivision contains no more than twenty-five (25) lots;
 - f. The subdivision is not within one mile of another subdivision with private streets and would not result in an undesirable concentration of private street subdivisions in one area of the county. The developer shall disclose to the county all other land the developer owns within one mile of the private street subdivision;
 - g. The maximum travel distance along the private street is two thousand (2,000) feet from a connecting public street;
 - h. A portion of the private street shall be designated on the plat as a fire lane in accordance with the design standards and the developer shall properly mark or post notice of the designated fire lane;
 - i. Access control devices shall be designed and located to accommodate the normal turning characteristics of a single unit bus (BUS) and accommodate the combined stacking length of a BUS and passenger car (P) with normal separation between, as a BUS and P are defined by American Association of State Highway and Transportation Official standards. The design of the entryway shall allow a vehicle to pass around the front and side of a BUS stopped at the entry control device;
 - j. Access control devices for a private street shall meet regulations adopted by the county, including redundancy requirements. The description and specifications for the access control devices shall be submitted for approval with the plat. The developer shall provide all equipment necessary to operate the access control devices, as determined by fire authorities, at no cost to the local volunteer or professional fire department.

- k. The developer, his successor and assigns shall agree to install and maintain a readily visible sign where any public street provides access to a private street, giving notice that the street is private prior to the sale of any lot.

8.0 LAND USE-TRANSPORTATION COORDINATION

Texas provides communities with a limited number of options to coordinate land use with transportation. Comprehensive planning is the one of first option that a community should considering when trying to coordinate land use and transportation issues. Texas does not appear to mandate comprehensive planning for counties, but does require any municipality adopting zoning to have prepared a comprehensive plan. Chapter 211 of Title 7 of the Texas Local Government Code allows municipalities the authority to adopt zoning regulations to govern the use of land within the limits of the jurisdiction. Municipalities cannot regulate uses or building form in its ETJ. With a few exceptions, county governments are not permitted by Texas law to regulate the use (and dimensions) of buildings in the unincorporated county. Despite this limitation on coordinating land use and transportation facilities, there are a few options that municipalities and counties can pursue.

8.1 Comprehensive Planning

Chapter 213 of Texas Local Government Code provides guidance to municipalities on purpose and general content of a comprehensive plan. There are no references in Title 7 of the Local Government Code granting counties the authority to prepare and adopted a comprehensive plan.

8.1.1 Applicability of Comprehensive Planning

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJ
X	X	

8.1.2 Description

The American Planning Association’s Planner Dictionary defines the Comprehensive Plan as “the adopted official statement of a legislative body of a local government that sets forth (in words, maps, illustrations, and/or tables) goals, policies, and guidelines intended to direct the present and future physical, social, and economic development that occurs within its planning jurisdiction and that includes a unified physical design for the public and private development of land and water.” Comprehensive plans are as varied as their communities. The essence of the comprehensive plan is a holistic investigation of the issues and concerns, identification of alternatives to be pursued and strategies to achieve the community’s desired future. One important function of the

comprehensive plan is to evaluate the relationship of land use and transportation facilities in the community.

8.1.3 Benefits

Municipalities that prepare a comprehensive plan will have quantified anticipated growth in the community and evaluated what the transportation needs will be to meet that expected growth. A comprehensive plan will focus a community's attention on where land uses should be placed and how the transportation network should be developed to best serve this future land use pattern.

8.1.4 Challenges

For a comprehensive plan to be effective a significant amount of background research and data must be collect to understand the current conditions in the community and to know what development trends have transpired. The planning effort will require an assessment of existing public facilities and services, along with a financial evaluation of how public services and facilities are funded currently and into the future. The comprehensive plan also requires the community to develop a shared vision of where a community wants to go. The public participation and consensus building process associated with a comprehensive plan requires time and commitment by elected officials. All of these efforts require the financial funding from the municipality to be accomplished.

8.1.5 Roles and Next Steps

- MPO – The MPO can provide technical assistance to a local government wanting to prepare a comprehensive plan, particularly in the area of traffic forecasting and transportation facility assessment. In addition, the MPO can serve as a repository of other comprehensive planning documents prepared in neighboring jurisdictions and help resolve transportation and land use conflicts that may exist between adjacent jurisdictions. The MPO can also facilitate inter-governmental coordination of issues, such as transportation and land use.
- Local Government – The municipal government must take the lead in recognizing the benefits of preparing a comprehensive plan and allocate the resources.
- Private Developer – Citizens, property owners and developers should all participate in the comprehensive planning process to ensure all viewpoints are heard and concern raised as the plan is developed.

8.1.6 Examples/References

Example A: The City of Sealy, TX has recently prepared a new comprehensive plan that incorporates a number of planning best practices. A link to the plan is attached.

http://www.ci.sealy.tx.us/forms_docs/comm_dev/sealycompplan_20090513.pdf

Example B: The City of Mesquite focused on the challenges of planning its ETJ area and developed a specific element evaluating alternative development patterns. This plan won Texas APA's 2009 award for comprehensive planning. The plan element can be found at this attached link.

<http://www.ci.mesquite.tx.us/planning/planningdocs/Comp%20Plan%20Element%20ETJ.pdf>

8.2 Zoning

While there are a few instances where portions of counties in Texas have been granted zoning authority, this tool to implement a community's comprehensive plan and coordinate transportation with land use has been granted to municipalities under Chapter 211 of the Texas Local Government Code.

8.2.1 Applicability of Zoning

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJ
X		

8.2.2 Description

Zoning is described as regulating land use, preventing land-use conflict, and allowing growth to occur in an orderly manner. The typical list of zoning benefits are:

- Use land for its most suitable purpose.
- Protect or maintain property values.
- Promote public health and safety.
- Protect the environment.
- Manage traffic.
- Manage density.
- Encourage housing for a variety of lifestyles and economic levels.
- Manage aesthetics.
- Provide for more orderly development.
- Help attract business and industry.

For the purposes of this report, the focus of zoning is to help facilitate the implementation of the comprehensive plan by coordinating land use and transportation facilities. Zoning provides a framework for designated land uses to be served by

appropriately sized transportation facilities. Zoning can control the land uses along the roadways to minimize congestion (i.e. zone properties at commercial nodes rather than allowing strip commercial or require joint access in site plan review, etc.). With greater connectivity mandated through zoning, the depth of the commercial nodes can be greater at these designated locations. Zoning can facilitate the use of internal roads within the commercial nodes rather than allowing commercial uses to front and access from the main arterial.

Zoning districts will also allow a municipality to express its intentions about connectivity between uses, which is typically cited in the purpose clauses of districts. Zoning regulations can promote the development of mixed-use projects, using techniques such as floating zonings, that allow a developer to prepare a site specific plan where pedestrian movement between the uses onsite do not need to cross a major roadways.

Zoning also allows a municipality the opportunity to create zoning districts where the design of the roads can be changed – deemphasizing the importance of vehicles and enhancing pedestrian comfort and safety. Standards can be incorporated into the zoning ordinance to address building design and public amenities that promote a multi-modal environment. Particularly in suburbanizing areas, locating transit stops at concentrations of activity is a key land use/transportation goal.

Zoning allows a municipality to scrutinize the operations of a proposed use more closely. The internal traffic circulation of the site and access to the public streets can be evaluated to ensure the design is safe and efficient. Pedestrian and bicycle access can also be evaluated as part of the site plan review process.

8.2.3 Benefits

Through the zoning and site plan review of proposed developments, on-site traffic operation improvements can be required to improve traffic flow. Zoning allows a municipality to evaluate a proposed use on a property, regardless of whether the development is going through the subdivision process. A proposed development on a previously platted lot can be evaluated to determine if addition access management controls need to be applied during the site plan review process. Providing cross-access between properties can benefit businesses, add road capacity, and increase transportation efficiency are some of the measures that can be taken during the site plan review process as part of the municipalities zoning authority. Additionally, zoning enables a community to coordinate the traffic generating characteristics of uses with existing and planned road facilities. Uses that generate higher traffic volumes can be located through zoning adjacent to higher capacity road facilities. Utilizing the MTP, zoning and subdivision enables a municipality to plan its land uses, direct uses to the appropriate parts of the community, plan for the needed roads and require the developer to dedicate and build the connections planned in the MTP.

8.2.4 Challenges

Zoning is not universally accepted as a needed government intervention in Texas. Therefore introducing zoning to a community will require education and assurances that giving local government control of land use is beneficial to the community in addressing problems that affect the quality of life in the area.

8.2.5 Roles and Next Steps

- MPO – The MPO can provide technical planning support for a local government that is considering adopting a zoning ordinance.
- Local Government – The local government would have to champion the effort to adopt zoning regulations by first adopting a comprehensive plan that establishes a community vision. Once the comprehensive plan has been prepared a zoning ordinance is one of the tools that can be used to help achieve that community vision.
- Private Developer – Private developers should participate in the process to ensure that their interests are heard.

8.2.6 Examples/References

Example A: The City of San Antonio has a Unified Development Code that includes Smart Growth principles, Use Patterns, infill development incentives, maximum parking ratios, transfer of development rights, and liveable street design. It has received an award from the Texas American Planning Association. A link to this code is listed below:

http://library7.municode.com/default-test/home.htm?infobase=14228&doc_action=whatsnew

Example B: The City of Frederick, MD has adopted Sec. 411 (Traditional Neighborhood Development) standards to regulate large scale planned developments. Section 411(d)(3) regulates the location of uses relative to specifically designed streets. Table 611-2 provides for alternative road design for TND projects.

(3) Location of Uses

The location of uses is governed by street frontage, as follows:

Table 411-2 Traditional Neighborhood Development Use Location

(A) Street	(B) Civic Buildings	(C) Commercial Buildings	(D) Multiple-Family Dwellings	(E) Detached Dwellings
Parkways	P	—	—	—
Boulevard	P	P	P	—

Main Street	P	P	P	—
Avenue	P	P	P	—
Local	—	—	P	P
Lanes	—	—	—	P

Rules of Interpretation for Table 412-2: A "P" means that the use of building type is permitted. A dash ("—") means that the use or building type is not permitted. The street design standards are established in §611.

- (2) The geometric design of streets for TND developments (See §411) and MU developments (See §417) shall conform to Table 611-2, below, unless modified by the Planning Commission through the Master Plan approval process:

Table 611-2 Community Design Streets (for TND/MU)

Design factor (see subsections below for explanation)	Reference	Path	Promenade	Greenway	Lane	Road	Large Road	Small Street	Street	Large Street	Rural Street	Avenue	Main Street	Boulevard	Parkway
Right-of-Way (minimum - ft)	(r)	5-10	30-45	14	17-23	24-40	32-40	18-30	36-50	42-52	38	50-156	56-120	62-100	62-120
Travel Lanes (number required)	(v)	-	-	-	1	2	2	2	2		2	2	2-4	4-6	4-6
Parking Lanes (number required)	(v)	-	0-1	0	0	0-1	2	0-1	0-1		0	2	2	0-2	0
Pavement Width (minimum - ft)	(o)	5-9	18-24	8	9-12	12-19	18-24	10-19	10-19	30-36	20	30-56	38-60	44-82	44-66
Corner Radius (minimum - ft)	(m)	-	15	-	10	10	10	10	15	15	15	15	15	25	25
Centerline Radius (minimum - ft)	(i)	-	-	95	90	90	90	90	90	90	90	250	600	500	1000
Drainage	(l)	CG, SH, SW	CG (1 or both sides)	-	CG, SH, SW	CG, SH, SW	CG, SH, SW	CG, SH, SW	CG	CG	CG	CG	CG	CG	CG or SH
Median	(n)	-	-	-	-	-	-	-	-	-	-	-	-	Yes	Yes
Block Length (ft)	(h)	-	-	-	150	300	300	300	400	400	-	-	300	1000	-
Sidewalks (number required)	(s)	-	-	-	-	0-1	0-2	2	2	2	-	2	2	2	-
Planting Strip (ft)	(p)	-	-	-	4	4	4	4	4	4	-	6	-	8	10
Bike Lanes	(g)	-	-	-	-	-	-	-	-	-	-	Yes	-	Yes	Yes
Street Trees	605(f)	-	-	Yes	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maximum Grade (degrees)	(l)	-	-	15	15	15	15	15	15	15	15	8	8	8	8

8.3 Development Plat

Texas law does not permit municipalities to extend zoning authority or building code requirements to its ETJ area. However, one option that Texas law does grant municipalities is limited oversight of proposed development in the ETJ using a

“development plat.” This provision is also applicable to municipalities that have not adopted zoning ordinances, and would regulate developments in the municipal limits that are not subject to a subdivision plat. The submission requirements for a development plat listed in Section 212.045 focus on regulatory control over future right-of-way needs and utilities. Section 212.047 establishes the criteria for municipal approval of a development plat, while Section 212.048 clarifies that dedication of land pursuant to a development plat is not accepted until the municipality uses or improves the land.

§ 212.044. Plans, Rules, and Ordinances

After a public hearing on the matter, the municipality may adopt general plans, rules, or ordinances governing development plats of land within the limits and in the extraterritorial jurisdiction of the municipality to promote the health, safety, morals, or general welfare of the municipality and the safe, orderly, and healthful development of the municipality.

§ 212.045. Development Plat Required

- (a) Any person who proposes the development of a tract of land located within the limits or in the extraterritorial jurisdiction of the municipality must have a development plat of the tract prepared in accordance with this subchapter and the applicable plans, rules, or ordinances of the municipality.
- (b) A development plat must be prepared by a registered professional land surveyor as a boundary survey showing:
 - (1) each existing or proposed building, structure, or improvement or proposed modification of the external configuration of the building, structure, or improvement involving a change of the building, structure, or improvement;
 - (2) each easement and right-of-way within or abutting the boundary of the surveyed property; and
 - (3) the dimensions of each street, sidewalk, alley, square, park, or other part of the property intended to be dedicated to public use or for the use of purchasers or owners of lots fronting on or adjacent to the street, sidewalk, alley, square, park, or other part.
- (c) New development may not begin on the property until the development plat is filed with and approved by the municipality in accordance with Section 212.047.
- (d) If a person is required under Subchapter A or an ordinance of the municipality to file a subdivision plat, a development plat is not required in addition to the subdivision plat.

§ 212.047. Approval of Development Plat

The municipality shall endorse approval on a development plat filed with it if the plat conforms to:

- (1) the general plans, rules, and ordinances of the municipality concerning its current and future streets, sidewalks, alleys, parks, playgrounds, and public utility facilities;
- (2) the general plans, rules, and ordinances for the extension of the municipality or the extension, improvement, or widening of its roads, streets, and public highways within the municipality and in its extraterritorial jurisdiction, taking into account access to and extension of sewer and water mains and the instrumentalities of public utilities; and
- (3) any general plans, rules, or ordinances adopted under Section 212.044.

§ 212.048. Effect of Approval on Dedication

The approval of a development plat is not considered an acceptance of any proposed dedication for public use or use by persons other than the owner of the property covered by the plat and does not impose on the municipality any duty regarding the maintenance or improvement of any purportedly dedicated parts until the municipality's governing body makes an actual appropriation of the dedicated parts by formal acceptance, entry, use, or improvement.

8.3.1 Applicability of Development Plat

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJ
X	X	

8.3.2 Description

The development plat requirement is a way for the municipality to regulate development within its jurisdiction and its ETJ for those proposed developments that may otherwise be exempt from the subdivision plat process. A development plat may provide the municipality the opportunity to require the developer to dedicate right-of-way and construct public improvements to meet municipal standards. In other instances, a development plat allows the municipality the opportunity to require a developer to reserve and agree to dedicate the needed right-of-way for planned road connections when the municipality is ready to use and improve this right-of-way. The development plat also precludes improper placement of buildings that may hinder future road extensions.

8.3.3 Benefits

The development plat is another tool that the municipality can use to protect future roadway alignments established in the major thoroughfare plan. The development plat allows the municipality to evaluate the adequacy of public facilities that may be affected by the proposed development.

8.3.4 Challenges

Unlike a subdivision plat, the development plat may not trigger the requirement that a developer dedicate and build a road. While the commitment to future dedication of right-of-way is important and avoids the cost and legal delays of property acquisition, the municipality may have to use other means to construct the future street to municipal standards.

8.3.5 Roles and Next Steps

- MPO – The MPO can provide the municipality technical assistance by explaining the benefits of adopting development plat regulations. The MPO can also assist the municipality in preparing a comprehensive plan and major thoroughfare plan, which are the basis for requiring future reservations of land.
- Local Government – For the local government to use the development plat provisions effectively, the municipality should have its comprehensive plan (general plan) and major thoroughfare plan up to date so that planned roads, paths, parks and other needed public facilities are considered during the review process.
- Private Developer – The private developer should participate in the preparation of the municipal comprehensive plan and major thoroughfare plan to provide input on how these plans can help further quality development of the developer's property.

8.3.6 Examples/References

Example A: The City of Pearland has adopted regulations that govern the submission and the processing of development plats. The following are excerpts from the subdivision regulations concerning the preliminary development plat review and the requirement of adequacy of facility evaluation.

Division 4: Preliminary Development Plats

Section 3.1.4.1 Purpose and Effect

- (a) **Purpose.** The purpose of the Preliminary Development Plat is to assure the adequacy of public facilities needed to serve the intended development and the overall compliance of such development with applicable requirements of this Unified Development Code.

- (b) **Exceptions.** A Preliminary Development Plat is not required when a Minor Subdivision Plat is submitted (Chapter 3, Article 1, Division 6).

It should be noted here that there is a potential problem with the incremental nature of minor subdivisions. Local governments should include provisions in their regulations to prevent piecemeal minor subdivisions that do not have to meet the standards and conditions of a major subdivision. While minor subdivision in theory should be simpler because less property is involved, minor subdivision should not have any lower standards of design or required right-of-way dedication or construction of public improvements.

- (c) **Effect.** Approval of a Preliminary Development Plat shall authorize the applicant to submit construction plans for approval by the City Engineer under Division 8 of this Article. Approval of a Preliminary Development Plat also shall authorize the applicant to seek approval of a Final Development Plat for the land subject to the Preliminary Development Plat. The installation of public improvements on the land subject to the development plat, however, may not begin prior to approval of a Site Preparation Permit (Chapter 4, Article 1, Division 2) for the land.

Section 3.1.4.4 Criteria for Approval

- (a) The following criteria shall be used to determine whether the application for a Preliminary Development Plat shall be approved, approved with conditions, or denied:
- (1) The Preliminary Development Plat is consistent with all zoning requirements for the property, and any approved development agreement;
 - (2) The plat conforms to the general layout of the approved Master Plat, if any, and is consistent with the phasing plan approved therein;
 - (3) The proposed provision and configuration of roads, water, wastewater, drainage and park facilities to serve the development site conform to the master facilities plans for such facilities, including without limitation the water facilities, wastewater facilities, transportation, drainage and other master facilities plans;
 - (4) The proposed provision and configuration of roads, water, wastewater, drainage and park facilities are adequate to serve the development and meet the standards of this Chapter;
 - (5) Easements or rights-of-way for all public water, sanitary sewer, roadway and drainage facilities have been designated;
 - (6) Fire lanes access easements or street rights-of-way have been provided for access to all fire hydrants and fire department connections;
 - (7) Easements have been designated for all landscaped buffers and open space;
 - (8) The ownership, maintenance, and allowed uses of all designated easements have been stated on the plat.

- (9) The plat meets any county standards to be applied under an interlocal agreement between the City and a county under Texas Local Government Code, Chapter 242, where the proposed development is located in whole or in part in the extraterritorial jurisdiction of the City and in the county, or drainage district rules, where the land is located in whole or in part within a drainage district; and,
- (10) The plat is consistent with the adopted Comprehensive Plan, except where application of the Plan conflicts with state law.

Article 2 – Subdivision Standards

Division 1 – Adequate Public Facilities

Section 3.2.1.1 General Policy

- (a) **Adequate Service for Areas Proposed for Development.** Land proposed for development in the City and in the City's extraterritorial jurisdiction must be served adequately by essential public facilities and services, including water facilities, wastewater facilities, roadway and pedestrian facilities, drainage facilities and park facilities. Land shall not be approved for platting or development unless and until all public facilities necessary to serve the development exist or provision has been made for the facilities, whether the facilities are to be located within the property being developed or offsite.

9.0 CAPITAL IMPROVEMENT PROGRAMMING

While local governments want private development to pay their fair share to install needed infrastructure, there are times when local governments will need to take the initiative to build new roads. This is especially true when communities are retrofitting connections between subdivisions or expanding existing roads to accommodate regional traffic growth. For those local governments interested in making the connections between existing subdivisions, building secondary corridors or providing sidewalks that connect residential neighborhoods with local commercial centers, the capital improvements program is the financial tool that can implement a long-term connectivity strategy.

In some instances, private developers and the local governments can partner to further these connectivity objectives. Sections 212.904 and 232.105 of the Texas Local Government Code provide guidance on how private development and local governments should work together to build infrastructure needed by growth.

§ 212.904. Apportionment of Municipal Infrastructure Costs

- (a) If a municipality requires as a condition of approval for a property development project that the developer bear a portion of the costs of municipal infrastructure improvements

by the making of dedications, the payment of fees, or the payment of construction costs, the developer's portion of the costs may not exceed the amount required for infrastructure improvements that are roughly proportionate to the proposed development as approved by a professional engineer who holds a license issued under Chapter 1001, Occupations Code, and is retained by the municipality.

§ 232.105. Developer Participation Contracts

- (a) Without complying with the competitive sealed bidding procedure of Chapter 262, a commissioners court may make a contract with a developer of a subdivision or land in the unincorporated area of the county to construct public improvements, not including a building, related to the development. If the contract does not meet the requirements of this subchapter, Chapter 262 applies to the contract if the contract would otherwise be governed by that chapter.
- (b) Under the contract, the developer shall construct the improvements, and the county shall participate in the cost of the improvements.
- (c) The contract must establish the limit of participation by the county at a level not to exceed 30 percent of the total contract price. In addition, the contract may also allow participation by the county at a level not to exceed 100 percent of the total cost for any oversizing of improvements required by the county, including but not limited to increased capacity of improvements to anticipate other future development in the area. The county is liable only for the agreed payment of its share, which shall be determined in advance either as a lump sum or as a factor or percentage of the total actual cost as determined by an order of the commissioners court.
- (d) The developer must execute a performance bond for the construction of the improvements to ensure completion of the project. The bond must be executed by a corporate surety in accordance with Chapter 2253, Government Code.
- (e) In the order adopted by the commissioners court under Subsection (c), the county may include additional safeguards against undue loading of cost, collusion, or fraud.

9.1 Impact Fees

One of the financing alternatives that municipalities can consider in paying for transportation improvements, including retrofitting critical connections in the road system, is using impact fees. An impact fee is a charge by local government on a new or proposed development to help assist or pay for a portion of the costs that the new development may cause for public services or facilities. Typically, an impact fee is a charge on new development to help fund and pay for the construction or needed expansion of offsite capital improvements. Chapter 395 of the Texas Local Government Code is the enabling legislation that municipalities can use to help finance transportation improvements attributable to new growth. Section 395.011 further clarifies that municipalities can use impact fees for roadway facilities within the municipal limits but not for facilities in the ETJ.

Chapter 395. Financing Capital Improvements Required by New Development in Municipalities, Counties, and Certain Other Local Governments

Subchapter B. Authorization of Impact Fee

Sec. 395.011. Authorization of Fee

- (a) Unless otherwise specifically authorized by state law or this chapter, a governmental entity or political subdivision may not enact or impose an impact fee.
- (b) Political subdivisions may enact or impose impact fees on land within their corporate boundaries or extraterritorial jurisdictions only by complying with this chapter, except that impact fees may not be enacted or imposed in the extraterritorial jurisdiction for roadway facilities.
- (c) A municipality may contract to provide capital improvements, except roadway facilities, to an area outside its corporate boundaries and extraterritorial jurisdiction and may charge an impact fee under the contract, but if an impact fee is charged in that area, the municipality must comply with this chapter.

9.1.1 Applicability of Impact Fees

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJs
X		

9.1.2 Description

Municipalities can adopt an impact fee requirement to help pay for needed growth-induced transportation improvements, including the retrofitting of connections in the existing road network that will add overall capacity to the system.

9.1.3 Benefits

Impact fees provide municipalities another revenue source to pay for needed transportation improvements. A transportation impact fee can be a flexible funding source that allows a local government to partner with a developer to oversize road construction projects that will accommodate not only the traffic from the proposed development but also expected municipal-wide traffic growth. Working with the developer, impact fees can be used to build missing connections with the neighboring subdivision, assuming that these connections improve the overall capacity of the road network.

9.1.4 Challenges

One of the inherent problems with transportation impact fees is that they do not cover all of the costs of needed transportation improvements that are attributable to growth. Communities often find that the general fund has to augment transportation capital investment. Impact fees can only be used to add road network capacity and cannot be used to correct existing deficiencies. In some instances, capital projects that connect existing subdivisions may add capacity to the network, but in many, perhaps most, situations retrofitting a connection will not add capacity – making them ineligible for impact fee applications. It is also worth noting that impact fees are an elastic funding source – if there is no development there is no impact fee collected. In mature communities in Florida, for example, local governments are going to other revenue sources to fund needed road improvements because there is insufficient new development generating significant impact fee funds.

9.1.5 Roles and Next Steps

- MPO – The MPO can provide technical support to municipalities interested in adopting transportation impact fees. As part of the required impact fees study, the MPO can provide capital improvement information related to the unit construction costs of new roads, and estimated capacity expansions due to proposed road improvements.
- Local Government – The local government will need to take the lead in preparing the transportation impact fee study and adopting an impact fee ordinance. The history of impact fees is that the actual fees adopted are well under the real impact fees warranted, usually by 50% or more, because of opposition from the development community. The homework done to calculate and justify impact fees must be well documented to sustain legal challenge. Once adopted, the local government will need to administer the impact fee fund, allocating funding to eligible capital improvements.
- Private Developer – The private developer should work with the local government in preparing an equitable impact fee ordinance. Additionally, the private developer should look for opportunities to partner with the local government on impact fee funded projects that benefit the proposed development and the community-at-large.

9.1.6 Examples/References

Example A – The City of McKinney, TX has prepared a very useful “Frequently Asked Questions” about Impact Fees explaining issues like – what impact fees are; who is authorized to charge impact fees; who pays impact fees; and how are impact fees prepared? The link to this information can be found at - <http://www.mckinneytexas.org/Agendas/councilmeetings/061708/Joint%20Work%20Session/Impact%20Fees-FAQs.pdf>

Example B – The City of Midlothian, TX recently prepared an update to their Road Impact Fee Study. Midlothian first adopted a road impact fee in 2001. This report evaluates existing conditions, projects future demand, and calculates an updated fee schedule. A copy of the report can be found at <http://www.midlothian.tx.us/DocumentView.aspx?DID=364>.

9.2 Priority Funding of Corridor Connections/Infill Projects

While many towns and cities look to impact fees as the solution to their transportation problems, in most instances impact fees are only a small part of the revenue stream for needed capital improvements. Texas counties that do not have the benefit of impact fees must look to federal, state and county funding to fill the road improvement funding gap. In fact, local transportation funding is the most flexible funding alternative to address system deficiencies, missing corridor links or retrofitting connections between subdivisions.

9.2.1 Applicability of Priority Funding Corridor Connections/Infill Projects

Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJs
X	X	X

9.2.2 Description

Studies have shown that increased street connectivity improves public service efficiency and saves money. A more connected street system allows a fire station to serve about three times the area as one in an area with unconnected streets. Increased connectivity also increases the efficiency and safety of services such as garbage collection and street sweeping (crash rates and insurance costs for such vehicles tend to increase if they are frequently required to back up), and tends to reduce water quality problems that result from stagnant water in dead-end pipes at the end of cul-de-sacs (Handy, Paterson and Butler, 2004, p. 37 and p. 56). Once a community recognizes these benefits, a systematic investment program can be developed that: (1) identifies opportunities to connect subdivisions, (2) secures the necessary right-of-way, (3) designs the roadway facilities, and (4) builds the facilities.

9.2.3 Benefits

A local government that is committed to improving roadway connectivity will see increased efficiency of municipal services, reduced vehicle miles traveled, and improved pedestrian and bicycle mobility.

9.2.4 Challenges

Funding to improve connectivity between subdivisions must compete against other transportation priorities in a community. Community concern is typically focused on congested highways and intersections. Convincing the public and elected officials that allocating funds to connect neighborhoods can alleviate traffic on the major highways and intersections is not easy. The Arterial/Collector tradeoff tool, developed as part of this project, can be helpful here.

9.2.5 Roles and Next Steps

- MPO – The MPO can provide the technical research to document the general financial benefits of committing funding to retrofitting connections between subdivisions. The MPO can also help to educate the public and elected officials on the benefits of connecting subdivisions and creating alternative routes of travel rather than directing most vehicle trips to the arterial road network.
- Local Government – The local government should examine what options are available to improve mobility in the community and consider the benefits of establishing a program to systematically improve the connections between subdivisions.
- Private Developer – Private developers should assist the local government in identifying opportunities to retrofit subdivision connections as part of infill development projects.

9.2.6 Examples/References

Example A – The State of Virginia, which is responsible for all public roads in the Commonwealth, has recently adopted new, trailblazing regulations that place a high priority on interconnecting residential subdivisions. The new regulations stipulate that if a residential subdivision does not connect to adjacent subdivisions the Virginia Department of Transportation (VDOT) has the authority to allocate district funding to retrofit the connections. VDOT's web site on Secondary Road Acceptance provides greater details on this new initiative <http://virginiadot.org/projects/ssar/>.

Example B – The City of Charlotte, NC can serve as an example of prioritizing pedestrian connectivity. In 2005, Charlotte embarked on an ambitious effort to evaluate city sidewalk deficiencies and develop a program to create a more “walkable” city. The following link reports on this initiative:

<http://www.walk21.com/papers/Coleman,%20Vivian%20-Development%20and%20Implementation%20of%20the%20City%20.pdf>

10.0 CONCLUSIONS

This report has identified a number of different strategies that can be employed by municipalities and counties to improve connectivity in their community. The report includes the necessary background information on the legislative basis for municipal and county authority to use these tools. Most of the strategies identified are tied to the subdivision review process and its associated use with the major thoroughfare plan as a guide to improve connectivity. As the summary table shows most of the strategies are available to municipalities and counties, so they can mix and match them to fit the character and resources of their community.

	Connectivity Tool	Municipalities	Extraterritorial Jurisdiction (ETJ) of County	Unincorporated County outside ETJs
Subdivision	Compliance with Major Thoroughfare Plan	X	X	X
	Traffic Impact Analysis	X	X	X
	Connectivity Index	X	X	X
	Lot Width and Block Length	X	X	X
	Design Guidelines and Plan Recommendations	X	X	X
	Subdivision Review Procedures	X	X	X
	Traffic Calming	X	X	X
	Private Streets	X	X	X
Major Thoroughfare Plan	Functional Classification	X	X	X
	Access Management Standards	X	X	X
Land Use-Transportation Coordination	Zoning	X		
	Development Permits	X	X	

Capital Improvement Programming	Impact Fees	X	X	X
	Priority Funding of Corridor Connections/Infill Projects	X	X	X

APPENDIX A

Sketch Planning a Street Network

Reid Ewing

A sketch planning methodology is used to determine the optimal spacing of through streets as a function of residential density. Unlike earlier efforts to relate street spacing to residential density, this methodology accounts for changes in mode share, trip length, time of travel, and intersection capacity as residential density increases. The methodology is transferable to other areas by modifying assumptions relating to travel demand and street network characteristics. Planners can derive their own spacing requirements for purposes of community master planning, site-plan review and approval, access management, or zoning and subdivision regulation.

The National Transit Institute (NTI) offers a training course in “Coordinating Transportation and Land Use.” Much time is spent exploring the concept of coordination—what it means in practice. There are obvious examples, such as achieving sufficient densities in transit corridors to reach ridership goals or fostering a sufficient mix of land uses in activity centers to make walking attractive. The concept has application to the automobile mode as well. Adequate public facilities requirements are an attempt to coordinate land use and transportation with respect to roadways. As new developments are proposed, traffic conditions are analyzed to determine if adequate roadway capacity exists to serve them. If not, development must be denied or capacity must be added.

These requirements, which have become commonplace, are neutral with respect to the form additional capacity takes. No distinction is made between six-lane roads every 1.61 km (1 mi) and two-lane roads every .53 km (.33 mi). Yet, the two options are not equivalent in other respects. From the standpoints of transit access, walkability, traffic calming, and other livability considerations, there is a preference for closer spacing of through streets.

On these grounds, the book *Best Development Practices* makes a case for .805 km (.5 mi)—or less—spacing of through streets in suburban communities (1). It also makes a case for street sections of four lanes or less, at least for sections that run through communities. These recommended practices assume suburban densities, suburban land use mixes, suburban mode shares, and so forth. They are rules of thumb, not highly calibrated planning guidelines. They are designed to promote a denser network of narrower streets than usually found in the suburbs.

In connection with the NTI course, an attempt has been made to more closely calibrate street network density with residential development density. Naturally, as residential density rises so must street network density in order to maintain adequate roadway levels of service. However, the relationship is not a simple linear one since higher residential densities are associated with changes in mode and trip length. Also, higher street network densities are associated with less capacity to move through traffic due to delays at signalized

intersections. It is the combined effect of these phenomena that the NTI course has sought to capture with sketch planning methodology.

PAST STUDIES

In a recent paper entitled “Street Spacing and Scale,” Herb Levinson reviews past efforts to define appropriate spacing of major roadways (2). Such efforts date back to a 1961 study in which freeway spacing was related to population density (3). The most recent study, published in 1997, derives arterial spacing requirements for assumed densities; recommended spacing varies from .20 to .40 km (.125 to .25 mi) in central business districts to 1.61 to 3.22 km (1 to 2 mi) in outlying areas (4).

The studies cited by Levinson have one thing in common. None accounts for changes in travel patterns nor street performance as densities rise. The sketch planning methodology presented here fills this void.

BASE CASE

To meet the NTI definition of “coordinated,” the street network must have enough capacity to avoid serious congestion at peak hours, but not so much capacity as to leave much of it idle at peak hours. In the simplest case, residential density, vehicle trip rates and lengths, and roadway capacity are assumed to be fixed as follows:

- A gross density of 4 units per 0.405 ha (1 acre);
- 10 vehicle trips per dwelling unit per day;
- An average trip length of 8.05 km (5 mi);
- A ratio of peak-to-daily traffic volumes of 0.10;
- Roadway capacity of 1,000 vehicles per lane per hour; and
- Arterials with a maximum of four lanes in a grid pattern, and collectors with a maximum of two lanes midway between arterials, also in a grid pattern.

To simplify the analysis, we will assume an endless plain of identical subdivisions, all at the same gross density. The existence of non-residential uses on the endless plain will affect results, but not too much. Most trips are home based, and they are fully accounted for in our assumptions. That is, the 10 vehicle trips per dwelling unit per day, and the average trip length of 8.05 km (5 mi), represent the total travel demands associated with home-based trips, from home to nonresidential destinations and back again.

Each dwelling unit will generate the following mileage, expressed as vehicle miles traveled (VMT):

$$\begin{aligned} \text{Vehicle miles traveled/unit} &= 10 \text{ vehicle trips/day} \times 5 \text{ mi/trip} & (1) \\ &= 50 \text{ VMT/day} \end{aligned}$$

Rutgers University, 33 Livingston Avenue, Suite 400, New Brunswick, NJ 08901, and Surface Transportation Policy Project, 1100 17th Street, NW, Washington, DC 20036.

At a gross density of 4 units per acre, a square mile of development will generate

$$\begin{aligned} \text{VMT}/\text{mi}^2 &= 50 \text{ VMT}/\text{day} \times 4 \text{ units}/\text{acre} \times 640 \text{ acres}/\text{mi}^2 \\ &= 128,000 \text{ VMT}/\text{day} \end{aligned} \quad (2)$$

The only travel not included in the 128,000 vehicle miles traveled is non-home-based trips from one nonresidential use to another. Generally, such uses would be farther apart at lower densities, reinforcing the effects of low residential densities on travel demands. We will assume that non-home-based travel inflates home-based travel by 50 percent across the board, since non-home-based trips are about a third of all trips. Increasing the VMT by 50 percent to account for non-home-based trips, a total of 192,000 VMT would be generated per square mile per day. Assuming a peak-to-daily ratio of 0.10, 19,200 of those vehicle miles would be generated during the peak hour.

Since our flat plain is identical at all points, and each square mile generates a total of 19,200 VMT per peak hour, each square mile also must have roadway capacity sufficient to carry 19,200 VMT per hour. It does not matter that some of the VMT occurs within the square mile and some occurs outside. Only if each square mile has enough capacity for 19,200 VMT per hour will the region as a whole have enough capacity.

With each lane mile carrying 1,000 VMT per hour, a square mile of development will require 19.2 lane miles of roadway to operate at capacity, not below or above capacity. If four-lane arterials are spaced a mile apart in north-south and east-west directions, and two-lane collectors are spaced midway between them in both directions, each square mile will have 12 lane miles of roadway capacity. To have 19.2 lane miles per square mile, arterials must be spaced 1 mi \times 12/19.2, or 0.625 mi, apart. The optimal spacing of through streets, both arterial and collector, would be 0.312 mi. Even at a mere 4 units per gross acre, half-mile spacing of through streets is too far apart for the assumed street cross sections.

ADJUSTMENT FOR VARYING DENSITY

The relationship between residential density and street spacing can be generalized. Initially, we assume a constant vehicle trip rate and

trip length. With DENSITY representing gross density in units per acre, a square mile of development will generate

$$\begin{aligned} \text{VMT}/\text{mi}^2 &= 50 \text{ VMT}/\text{day} \times \text{DENSITY} \\ &\times 640 \text{ acres}/\text{mi}^2 \times 1.5 \times 0.10 \\ &= 4,800 \times \text{DENSITY} \end{aligned} \quad (3)$$

The 1.5 is included in Equation 3 to account for non-home-based travel. The 0.10 is included to convert from daily to peak-hour VMT.

To serve this travel demand, 4.8 \times DENSITY lane miles of roadway capacity are required for every square mile of development. Arterials must be spaced 12/(4.8 \times DENSITY) or 2.5/DENSITY miles apart. Through streets, both arterials and collectors, must be spaced 1.25/DENSITY miles apart.

Based on this simple formula, Table 1 relates street spacing to gross density.

Given these assumptions, at a mere 20 units per gross acre, streets must be spaced no more than 100.6 m (330 ft) apart, a block length associated with dense, older urban areas. At 50 units per acre, the required spacing is 40.2 m (132 ft), an unworkable spacing found nowhere in the United States.

ADJUSTMENT FOR VARYING VEHICLE TRIP RATE AND LENGTH

When we relax assumptions about vehicle trip rate and length and allow both to vary with residential density, higher densities appear more viable from the standpoint of street network density. Were it not for mode shifts and shorter trips, the island of Manhattan could not function at its prevailing density levels. Streets (and parking) would have to be so closely spaced as to leave no room for buildings.

Many research studies have related vehicle trip rates, trip lengths, and overall VMT to residential densities. Some early studies failed to control for other variables, such as household income. More recent studies have tended to control for these important variables. Studies without controls tend to overstate the effect of densities on travel behavior. Because these other variables are correlated with density, their effects get partially absorbed by density when models are underspecified.

TABLE 1 Street Spacing at Different Densities—Fixed VMT per Household

Gross Density	Arterial Spacing	Through-Street Spacing
1 unit/acre	2.5 miles	1.25 miles
4	0.625	0.312
7	0.357	0.179
10	0.25	0.125
15	0.167	0.083
20	0.125 (660')	0.063 (330')
30	0.083 (440')	0.042 (220')
50	0.05 (264')	0.025 (132')

1 mile (mi.) = 1.61 kilometers (km)
1 acres (ac) = 0.405 Hectares (ha)

TABLE 2 Elasticity Estimates from Different Studies

	VMT _{total}
Schimek (5) gross density	-.07
Dunphy and Fisher (6) gross density	-.219
Parsons Brinckerhoff (7) zonal density	-.06
Holtzelaw (8) net household density	-.27

Table 2 presents elasticity estimates from a subset of travel research studies. Only those studies dealing with density as an independent variable, and VMT as a dependent variable, are included. In some cases, elasticities were provided by the authors; in other cases, elasticities had to be computed based on data contained in the reports or papers.

A midpoint estimate of the elasticity of overall VMT with respect to residential density is -0.15. In this analysis compared to the last, VMT goes from a flat 50 mi per household per day to a variable value dependent on density.

From the definition of elasticity, we have the following expression for VMT as a function of density:

$$VMT/unit = 50 \times DENSITY^{0.15} \tag{4}$$

At a gross density of 1 unit per acre, Equation 4 predicts a VMT of 50 vehicle-mi per unit per day. This is the same value we used in the previous analysis. At any higher density, Equation 4 predicts a lower VMT down to 27.8 vehicle-mi per unit per day at 50 units/acre (see Table 3).

The total VMT generated by a square mile of development at different densities is

$$VMT/mi^2 = VMT/unit \times DENSITY \times 640 \text{ acres}/mi^2 \times 1.5 \times 0.10 \tag{5}$$

The 1.5 is included in Equation 5 to account for non-home-based travel. The 0.10 is included to convert from daily to peak-hour VMT. Substituting Equation 4 for VMT/unit in Equation 5, we obtain

$$VMT/mi^2 = (50 \times DENSITY^{0.15}) \times DENSITY \times 640 \text{ acres}/mi^2 \times 1.5 \times 0.10 = 4,800 \times DENSITY^{0.65} \tag{6}$$

The resulting VMT per square mile per day—with required spacing of streets—is shown in Table 3. With adjustments for VMT per household, the spacing of through streets becomes workable at high densities.

OTHER ADJUSTMENTS

Two other adjustments can be made to more accurately reflect the relationship between residential density and street spacing. One adjustment accounts for the tendency of travel to shift from the peak hour to the “shoulders” of the peak as congestion increases. The result is a lower peak-to-base ratio at high densities and the need for less closely spaced streets than otherwise predicted. Although not a perfect surrogate for congestion, density was deemed good enough to be used originally for peak-hour travel demand modeling in Montgomery County, Maryland (see Figure 1).

The second adjustment accounts for changes in the capacity of streets as density increases. The closer spacing of streets at higher densities has two countervailing effects. Most importantly, it reduces the

TABLE 3 VMT and Street Spacing at Different Densities—Fixed VMT per Household

Gross Density	VMT per household per day	VMT per square mile per hour	Arterial Spacing	Through-Street Spacing
1 unit/acre	50 vehicle miles	4,800 vehicle miles	2.5 miles	1.25 miles
4	40.6	15,955	0.769	0.385
7	37.3	25,094	0.478	0.239
10	35.4	33,981	0.353	0.177
15	33.3	47,964	0.250	0.125
20	31.9	61,252	0.196 (1035')	0.098 (517')
30	30.0	86,456	0.139 (618')	0.069 (366')
50	27.8	133,465	0.090 (475')	0.045 (237')

1 mile (mi.) = 1.61 kilometers (km)
 1 acres (ac) = 0.405 hectares (ha)
 1 square mile (mi²) = 2.59 kilometers squared (km²)

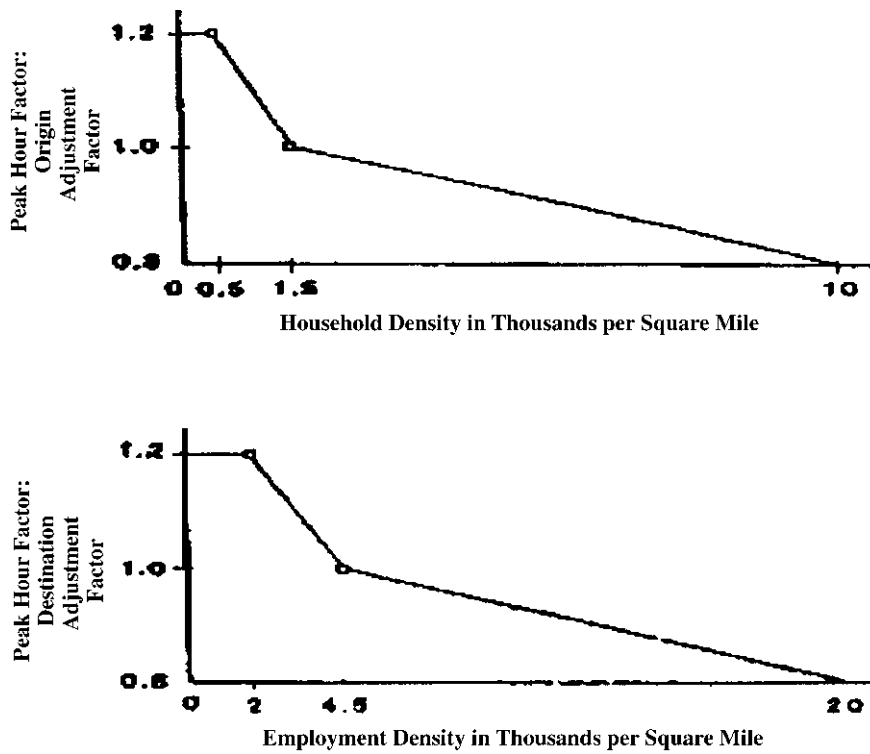


FIGURE 1 Peak spreading at higher densities, Montgomery County, Maryland (1 mi = 1.61 km; 1 mi² = 2.59 km²) (9).

TABLE 4 Peak-Hour Directional Maximum Volumes (State of Florida)

Distance Between Signalized Intersections	Maximum Volume per Lane (Two-Way Operation)	Maximum Volume per Lane (One-Way Operation)
1 mile	927	
0.5 miles	927	
0.33 miles	877	
0.25 miles	867	
0.20 miles	797	
0.15 miles	690	
0.10 miles (528')	377	710
0.05 miles (264')	N/A	613

* Calculations assume FDOT's default values of the peak hour factor (0.925), adjusted saturation flow rate (1850 vph), % turns from exclusive lanes (12%), and weighted g/C ratio (0.44). Values of free flow speed and signal cycle length are chosen for each signal spacing so as to maximize progression efficiency. The arrival type is assumed to vary from a value of 3 for signal spacing every mile, to a value of 4 for signal spacing every half mile or closer in two-way operation, to a value of 5 for signal spacing every 1/10 mile in one-way operation, and a value to 6 for signal spacing every 1/20 mile in one-way operation. For the sake of comparability, all roadways are treated as Class III arterials. Maximum service volumes are all evaluated at LOS D. Values represent a weighted average of capacity per lane for 4-lane arterials and 2-lane collectors.

1 mile (mi.) = 1.61 kilometers (km)

TABLE 5 Street Spacing at Different Densities—Adjusting for Peak Spreading and Street Capacity Changes

Gross Density	VMT per square mile per hour	Street Operation	Arterial Spacing	Through-Street Spacing
1 unit/acre	5,760 vehicle miles	two way	1.93 miles	0.96 miles
4	15,127	two way	0.696	0.348
7	23,212	two way	0.412	0.206
10	29,972	two way	0.276	0.138
15	38,803	two way	0.117 (616')	0.058 (308')
20	49,001	one way	0.174 (918')	0.087 (459')
30	69,165	one way	0.106 (562')	0.053 (281')
50	106,772	one way	0.069 (364')	0.034 (182')

1 mile (mi.) = 1.61 kilometers (km)

1 acres (ac) = 0.405 Hectares (ha)

1 square mile (mi²) = 2.59 kilometers squared (km²)

effective capacity of streets by increasing delay at signalized intersections. Secondly, it allows conversion from two-way to one-way operation, which boosts the effective capacity of the system. This is why one-way couplets are so common in dense urban areas. The net effect of these changes in capacity can be predicted using methodology developed by the Florida Department of Transportation and incorporated into the most recent edition of the Transportation Research Board's *Highway Capacity Manual* (10).

With the use of the peak-hour adjustments from Montgomery County, and maximum service volumes from the state of Florida (Table 4), street spacing requirements have been recalculated. It was assumed that conversion from two-way to one-way street operation would occur when streets would otherwise be spaced less than 91.4 m (300 ft) apart. Results are presented in Table 5.

Using the same sketch planning methodology, but tailoring assumptions to local conditions and policy preferences, planners can derive their own spacing requirements for purposes of community master planning, site plan review and approval, access management, or zoning and subdivision regulation.

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APPENDIX B

ANALYSIS OF THE EFFECTS OF LOCAL STREET CONNECTIVITY ON ARTERIAL TRAFFIC

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ABSTRACT

Perhaps one of the most difficult issues a community can face is the question of street widening. This topic can create extensive debate between local government officials, transportation engineers and citizens. Road expansion is opposed because of concerns about the costs and impacts of widening by some communities while it is ironic that same communities often take steps in their land development process that inevitably lead to the widening they oppose. This is the case of the street connectivity in residential developments located in suburban areas. In recent years such developments have been built using a street design concept that uses poor street connectivity. This street pattern does not provide travelers with alternative paths to complete their trips and therefore the traffic concentrates on the arterials. This phenomenon reduces the capacity of the entire network and may make it necessary to use highway widening to provide extra capacity and avoid congestion.

The objective of this paper is to examine how the connectivity of local residential streets relates to the traffic volumes on nearby arterials. For that purpose a method to assess how local connectivity affects nearby arterial traffic volumes was developed. Detailed network descriptions of local streets and land use were used with in conjunction with a regional travel forecasting model to assess traffic shifts under different conditions on local and arterial streets. This was done using a case study of Tallahassee, Florida region. The study revealed that improved connectivity can reduce arterial traffic levels depending on the relative speed on the arterial vs. that on local roads and the extent to which the arterial road carries through traffic. Impacts are the greatest when the speed differential between the arterial and local streets is small and there is limited through traffic.

ANALYSIS OF THE EFFECTS OF LOCAL STREET CONNECTIVITY ON ARTERIAL TRAFFIC

by: Carlos A. Alba
and Edward Beimborn

1. INTRODUCTION

Over the past half century the street design concept in American cities has changed from the interconnected street pattern to a fragmented street pattern characterized by the use of cul-de-sacs. Safety and privacy are some of the principal reasons why people prefer a fragmented design despite of its disadvantages in terms of the convenience to reach destinations, especially when using alternative transportation modes, and the overall traffic performance.

Advocates of New Urbanism and Smart Growth have indicated that better connectivity and accessibility can be a key method to control or reduce traffic. Although accessibility and mobility are similar in some ways, it is important to make a distinction between them. Accessibility is defined as the ability to connect activities, while mobility is a measure of the vehicle-miles involved in travel. In most cases higher values for mobility could be an indication of congestion whereas increasing accessibility is usually associated with reduction of congestion. Providing better connections in local streets has been cited as a way to improve accessibility. This can also generate a number of benefits, such as encouraging bicycle and pedestrian trips and decreasing vehicle miles. It can make developments more livable and sustainable in the future.

Accessibility could be as broad as one can imagine because it deals with different topics, such as street connectivity, land use mix and building orientation. This report concentrates in street connectivity where two street designs, Neotraditional Design and Conventional Design, are compared and analyzed in detail. For the purpose of this study, Neotraditional Design (NTD) will be defined as the interconnected rectilinear grid commonly used before World War II and Conventional Design as the discontinuous patterns of cul-de-sacs preferred since the 1950s.

As Southworth and Ben-Joseph stated “American conceptions of the residential street network have changed dramatically from the interconnected rectilinear grid of the turn-of-the-century, to the fragmented grid and warped parallel streets of the 1930s and 1940s, to the discontinuous, insular patterns of cul-de-sacs and loops that have preferred since the 1950s”(1). However, it has been demonstrated that Neotraditional Design and Conventional Design both have advantages and disadvantages.

Traffic modeling work by Kulash, Anglin and Marks (1990) predicts that a connected road network reduces VMT within a neighborhood by 75% compared with conventional designs(2). Kulash states that more capacity can be attained in an interconnected street pattern since there are more intersections per unit area in a neighborhood with a Neotraditional Design (grid pattern) than in one with Conventional Design (cul-de-sacs). The increasing number of intersections available in the NTD makes traffic spread out in a more uniform manner throughout the network and therefore only a small portion of the total volume concentrates at a particular intersection. For that reason, larger gaps between vehicles in the opposing flow are expected and it would be easier for vehicles to make left turns without the use of traffic signals that increase the delay at intersections (3).

Other authors (Knack, 1989) however, state that trips made on a daily basis are usually completed within a 3000-4000 acres area and for that reason few automobile trips would ever use the arterials in neighborhoods with Neotraditional Design. Some other critics also argue that road networks with improved accessibility might encourage people to make more trips to the point of having the same levels of congestion found in street patterns with poor connectivity.

Littman (4) argues that better connectivity can reduce vehicle travel by reducing distances and supporting alternative modes such as bicycle and walking. In addition, it can provide more route options for travel reducing problems is a particular link is closed. He goes on to say that it can lead to conflicts with nearby residents who may be concerned with increased traffic and that it should be done in conjunction with street layouts and designs that use traffic calming, T intersections and short block lengths.

While these debates continue, there has been little quantitative analysis of the subject and limited information on exactly how connectivity could affect traffic conditions in neighborhoods and adjacent arterials. The effectiveness of street connectivity as a measure to reduce congestion in a corridor is seldom seriously considered as a planning practice or policy as cities expand and develop. This paper will attempt to add some insight on the topic.

It is clear, that there is a critical balance between connectivity and through traffic. Enough connectivity has to be provided so that residents of a neighborhood can easily move to all edges of the neighborhood and adjacent land uses, but not so much that neighborhood streets become attractive choices for through traffic to avoid congestion and delay on arterials. There needs to be a balance between the extremes of poor connectivity and too many opportunities for through traffic. The importance of this balance is that transportation facilities could be used in a more efficient manner without affecting the livability of the residential developments. By doing that, highway widening can be avoided or delayed and the transportation facilities would be more sustainable in the future.

2. OBJECTIVES

The objective of this paper is to examine how the connectivity of local residential streets relates to the traffic volumes on nearby arterials. However, the hypothesis of this paper is that improved connectivity of neighborhood streets or in other words, using a grid pattern will reduce the traffic volumes on nearby arterials. For that purpose a method to assess how local connectivity affects nearby arterial traffic volumes was developed. Detailed network descriptions of local streets and land use were used with in conjunction with a regional travel forecasting model to assess traffic shifts under different conditions on local and arterial streets. This was done using a case study of Tallahassee, Florida region. This paper is part of a larger work that analyzes the relationship between land use patterns and road widening (5).

3. METHODOLOGY

The process used in this study involved the development of a detailed travel demand analysis of local street networks as part of a regional analysis. First the demographic and employment information had to be disaggregated to provide detailed information on trip origins and destinations. Then local streets were coded in greater detail to show existing street patterns and then new links were added to provide better connectivity. The two networks were then compared using QRSII travel demand software. A network in Tallahassee, Florida, was chosen for the study. This area was used because of readily available data and the fact that the network was calibrated.

Demographic Information

The demographic and geographic characteristics of the area selected for the connectivity analysis have a significant influence on the magnitude of the traffic reduction. A reduction in the traffic on the arterials is expected when the following criteria are met before connectivity is improved:

- Mixed land use. When there is land use mix the trip length for shopping, personal business and recreational trips can decrease. People usually prefer to make those trips where origins are close to destinations, which means that within an ideally connected network these trips could be completed using local roads thereby reducing the traffic volume on the arterial.
- High levels of activity. When an area surrounding an arterial has high levels of activity (number of households, retail and nonretail) more vehicles will use that arterial due to the high number of trips produced and attracted in that area. In this way, the gross reduction of trips after connectivity is improved will be higher.
- Poor connectivity. If the area under analysis has poor connectivity of local streets, a large percentage of the traffic has to use the arterials because there is not a direct path in the local roads. With improved connectivity some of those trips will no longer need to use the arterial and a reduction on traffic levels on the arterial will take place.

Based on the criteria described above a corridor located on the west side of Tallahassee, Florida was selected for the connectivity analysis. It was identified as an area with poor connectivity and relatively high levels of activity. In order to measure the impact of street connectivity it was necessary to increase the spatial precision in the study area. Traffic analysis zones in the study corridor were subdivided into smaller zones. Multiple centroids were created from the original Traffic Analysis Zones (TAZs) so that they contained information that was more spatially detailed. Demographic information in the desired format was found from the City of Tallahassee GIS web site. Detailed property information data was used to identify properties with the same land use and group them in separate centroids.

Network Construction:

The corridor selected for this analysis was divided in 44 segments. Each of these segments corresponds to a road portion between intersections. Figure 1 shows the western portion of the study area before and after connectivity was improved. The network generated after the new links that are shown as wider lines were added is a hypothetical network. It may be that less connectivity could cause a considerable traffic reduction on the arterial but this was not initially analyzed in this project.

The geometry configuration for all the 44 segments is constant in both conditions. That means that the principal arterial has the same operational conditions as far as the number and separation of access points is concerned for both conditions. This is an important consideration since traffic volumes are compared before and after connectivity on each of the 44 segments on the arterial.

The original network of the City of Tallahassee did not have all local roads coded. It was necessary to add detail to the network and draw all roads within the study area. There were numerous cul-de-sacs in the area that lead to the arterial with very few connections between adjacent roadways. Local roads were coded using the General Network Editor (GNE) as two-way streets. There were no concerns about capacity restrictions on those links and the speed was set at 15 and 25 mph. Since the speed on the arterial will also have an impact on the travelers route selection it was set to: 25 mph, 30 mph, 40 mph and 50 mph. Multiple runs were made with different speed assumptions to determine how they would affect flows. Major intersections were left as intersections with delay and new intersections connecting local streets were set as intersections without delay.

The connectivity analysis evaluates the traffic impact on arterials under two circumstances: including external-external trips and without them. E-E trips were calculated using the select link analysis technique available in QRS II. Select link analysis calculates the trips between pairs of selected links and places that information in the file "SelectM.txt." For the purpose of this paper the selected links corresponds to the links located at both extremes of the corridor under analysis.

4. EVALUATION AND ANALYSIS OF THE RESULTS

When the traffic volume difference is calculated for each of the segments along the arterial it almost always shows a traffic volume reduction on the arterial after connectivity improvements. The magnitude of the reduction depends on the relative speed of the arterial vs. that on the local roads. Very few of these segments experience a traffic volume increase. As the connectivity of the local roads is improved, some segments along the arterial could experience higher levels of congestion.

Traffic Volume Results

The traffic impact along the arterial can be compared by looking to the traffic volume of the 44 segments considered in the analysis as shown in Figure 2 and in Table 1. Figure 2 illustrates the decline in traffic on the arterial with improved connectivity. Traffic declines along much of the route and the impact depends on local land use along the route, especially employment in sub zones. Table 1 is a summary of average traffic volumes calculated by QRS II under different speed assumptions.

The traffic volumes shown in Table 1 confirm the hypothesis that improvements in connectivity of the local streets reduce traffic volumes along the principal arterials. The amount of reduction depends on the relative speed assumed on the arterials vs. that on local streets. When the speed on the residential streets is considerably high (25 mph), more travelers will use the local streets instead of the arterial to reach their destinations. Consequently, there will be a larger traffic volume reduction on the arterial. In contrast, when the speed on the residential street is 15 mph, fewer travelers will take the local roads to complete their trips and there will be a lower traffic reduction on the arterial. Figures 3 and 4 show this effect. This occurs because of the path finding process of the travel demand software. Travelers are assigned to the minimum time path between their origin and destination. If there is a large speed differential, travelers will shift to the higher speed links and away from the slower links. If the speeds are nearly the same travelers will use the shortest distance paths and will use more internal links.

External-External trips account for an important percentage of the total vehicles traveling along the corridor and if they are not included, it makes a difference in terms of how the results are interpreted. If external-external trips are excluded from the analysis the traffic impact on the arterial evaluated as a percentage will seem to be higher after connectivity is improved. Changes in connectivity will reduce trips on the arterial by a fixed amount, but it will appear as a low percentage reduction if there is a lot of through traffic and as a high percentage if there is little through traffic.

As it is shown in Figure 5 the traffic volume reduction on the arterial is highly sensitive to the relative speed of the arterial and the residential streets. The highest reduction occurs with an arterial speed of 25 mph and a local roads speed of 25 mph. When the traffic reduction on the arterial is evaluated as a percentage it is important to

consider both scenarios (including E-E trips and without E-E trips). The traffic reduction will seem to be higher when E-E trips are not considered in the analysis. This is illustrated in Figures 6 and 7.

As it is shown in Figure 5 when the speed on the arterial is close to the speed on the local roads, there is a major traffic volume reduction on the arterial. This is because the travel time between origins and destinations is shorter when people use the local roads. When both the speed on the arterial and the local roads is 25 mph the total traffic volume reduction on the arterial is 644 veh/h. In contrast, when the speed on the arterial is 50 mph and the speed on the local roads is 15 mph the traffic volume reduction drops down to only 10 veh/h.

Figures 6 and 7 provide a different interpretation for the traffic volume reduction on the arterial. In this case the traffic impact is measured as a percentage for the two scenarios: with or without external-external trips. The traffic volume reduction has the same tendency as in Figure 6. When the speed in the local roads and the arterial are similar the traffic volume reduction on the arterial is higher. In this case, the most significant traffic reduction on the arterial (85.65%) occurs when the E-E trips are excluded from the analysis and when the speed on the arterial and the local roads is 25 mph. Thus, the effect of connectivity is dependent upon the amount of through traffic on the arterial vs. the amount that takes place within the corridor.

How much connectivity?

The case study analyzed added an extensive network of local streets to maximize the interconnectivity in the neighborhood. A lesser amount of connectivity may be able to accomplish the same goals and at the same time avoid the potential for increased traffic. Detailed analysis of traffic volumes on the new links revealed that several had very little volume and are not necessary to gain the benefits of better connectivity. For example, in the test network analyzed, approximately one fourth of the added links had essentially no traffic volume and could be deleted from the network with no affect on arterial traffic. This could be used in further analysis to reach a balance between connectivity and the need to avoid through traffic in the neighborhood.

5. SUMMARY AND CONCLUSIONS

This paper identifies the relationship between local street connectivity and highway traffic flow on nearby arterial streets. Connectivity was evaluated by looking at changes in traffic on arterials before and after connectivity improvements on local streets. It was demonstrated that arterials could experience more than a 50 percent traffic reduction with better neighborhood street connectivity depending on the speeds on both the local roads and the arterial. For example, when the speed on the local roads is 25 mph and on the arterial 40 mph, the traffic volume reduction including the external-external trips would be 10.59 %. If external-external trips are not included in the analysis this traffic reduction is 15.78%. The effect varies from 4.04% when there is a large speed differential to 85.65% when speeds on the local roads and the arterial are equal.

There is a critical balance between connectivity and through traffic. Enough connectivity has to be provided so that residents of a neighborhood can easily move to all edges of the neighborhood and adjacent land uses but not to an extreme so that residential streets become attractive choices for through traffic.

The major benefit of street connectivity is that it redistributes traffic on a network providing an overall increase in the capacity of the system. Consequently, improving street connectivity of residential streets could reduce the need for arterial highway widening by providing more options for local trips.

Based on the results from the case study it is clear that planning for better street connectivity can avoid or delay the need for roadway widening in growing areas. Downtowns and central business districts that have interconnected grid patterns may not be able to make connectivity improvements to provide more capacity. It is also evident that much of the area in downtowns is dedicated to streets and therefore street widening is not normally a feasible solution for the problem of congestion. Other options such as improving the public transit, better job/housing balance, and encouraging shorter trip lengths may be considered.

Planning organizations and government officials could adapt the methodology presented in this paper to deal with congestion and minimize the use of roadway widening in their own communities. This methodology may be adjusted based on the particular conditions of the study area. For example, most travel forecasting models do not require a detail traffic network. For the street connectivity analysis, at least in the area where connectivity is being evaluated, residential streets must be coded in the network. Demographic information refinement is also needed to obtain precise information on how street connectivity of the local roads affect the traffic volume on the arterials.

Results from this paper reveal that enough connectivity has to be provided on local streets so that traffic volumes can be spread out more efficiently throughout a network. The question remains open regarding how much traffic neighborhood streets could take so that they do not become attractive choices for through traffic. In that respect more studies about safety and livability levels of residential areas with grid patterns are needed so that an appropriate level of traffic will occur.

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TABLE 1 Summary of the Average Traffic Volumes Before and After Connectivity

Condition	Average Arterial Volume (Before Connectivity)		Average Arterial Volume (After Connectivity)	
	Including EE trips	Without EE trips	Including EE trips	Without EE trips
Assumed Speed on Local Roads = 15 mph				
Assumed Speed on Arterial = 25 mph	1,254	755	1,204	705
Assumed Speed on Arterial = 30 mph	1,370	871	1,328	829
Assumed Speed on Arterial = 40 mph	1,532	1,033	1,500	1,001
Assumed Speed on Arterial = 50 mph	1,601	1,102	1,591	1,092
Assumed Speed on Local Roads = 25 mph				
Assumed Speed on Arterial = 25 mph	1,251	752	607	108
Assumed Speed on Arterial = 30 mph	1,364	865	1,087	588
Assumed Speed on Arterial = 40 mph	1,519	1,020	1,358	859
Assumed Speed on Arterial = 50 mph	1,597	1,098	1,515	1,016

TABLE 2 Summary of the Traffic Volume Reduction After Connectivity Improvements in the Local Roads

Condition	Traffic Volume Reduction		
	Veh/h	% (Including EE trips)	% (Without EE trips)
Assumed Speed on Local Roads = 15 mph			
Assumed Speed on Arterial = 25 mph	51	4.04	6.70
Assumed Speed on Arterial = 30 mph	43	3.11	4.89
Assumed Speed on Arterial = 40 mph	31	2.04	3.03
Assumed Speed on Arterial = 50 mph	10	0.64	0.93
Assumed Speed on Local Roads = 25 mph			
Assumed Speed on Arterial = 25 mph	644	51.49	85.65
Assumed Speed on Arterial = 30 mph	277	20.30	32.01
Assumed Speed on Arterial = 40 mph	161	10.59	15.78
Assumed Speed on Arterial = 50 mph	81	5.10	7.42

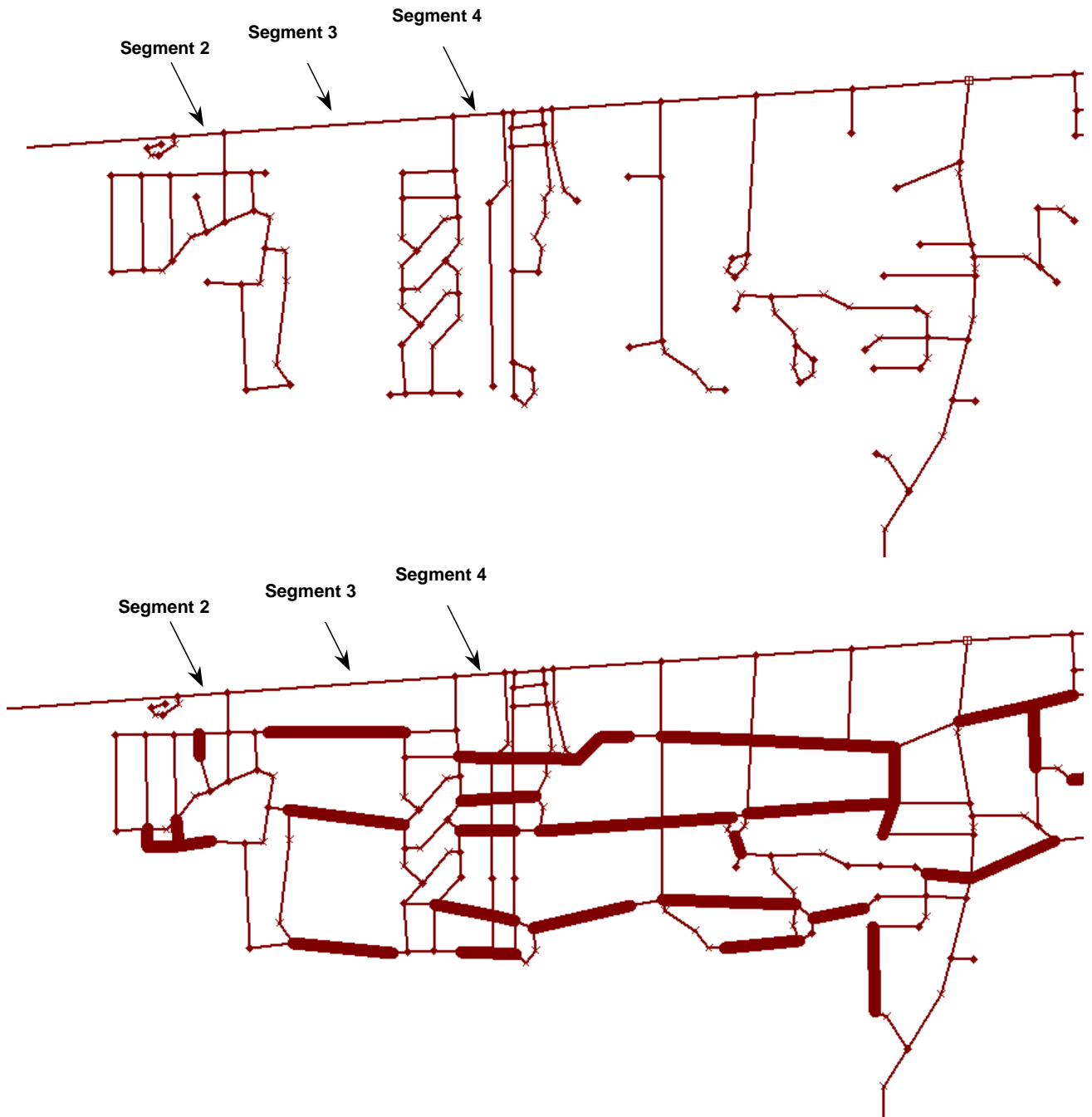


FIGURE 1 Western Portion of the Study Area before and after connectivity Improvements

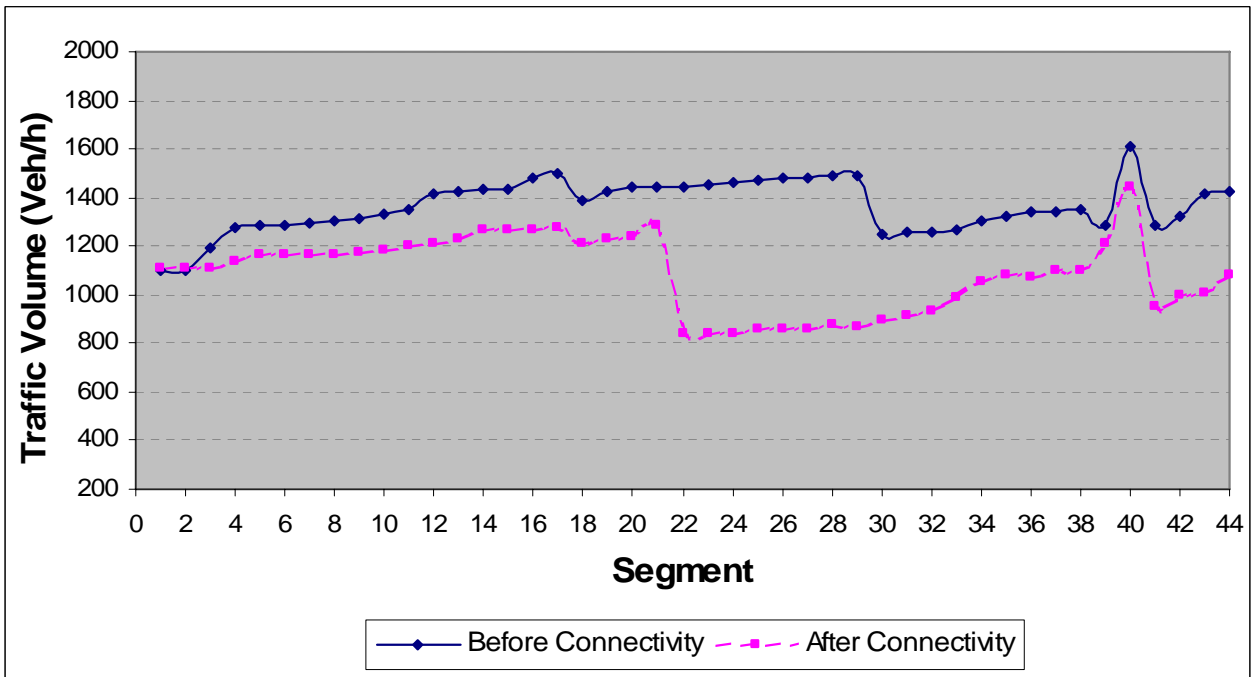


FIGURE 2 Traffic Volumes Before and After Connectivity (Speed on the Arterial = 30 mph, Speed on Local Roads = 25 mph)

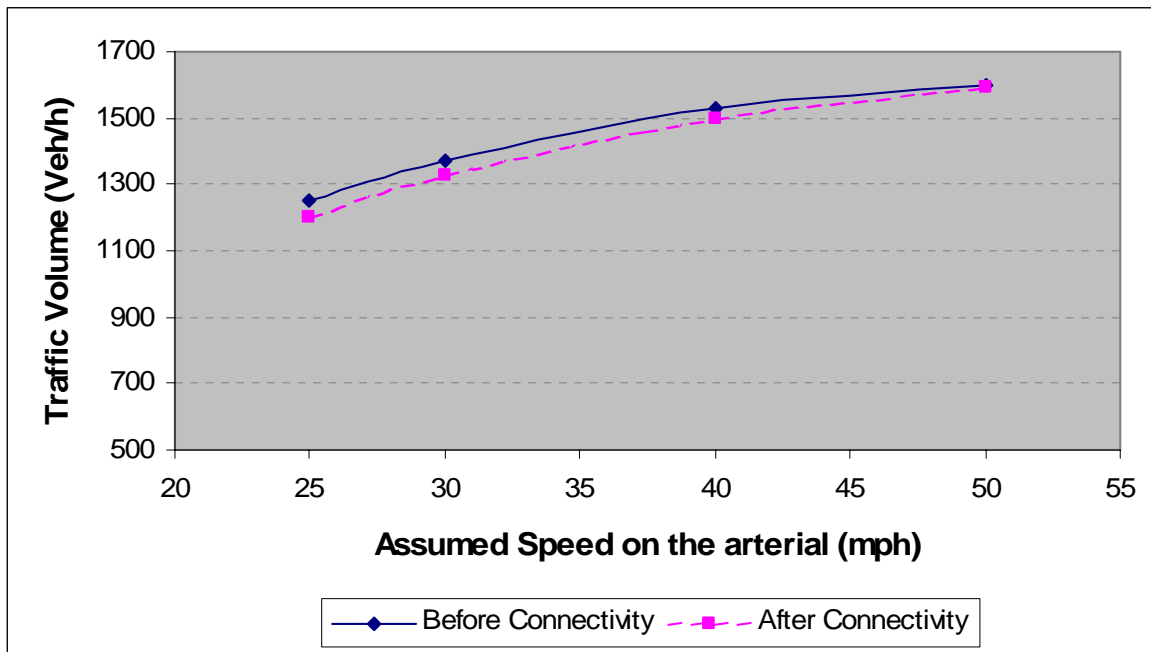


FIGURE 3 Traffic Volume Before and After Connectivity (Speed on the Local Roads = 15 mph)

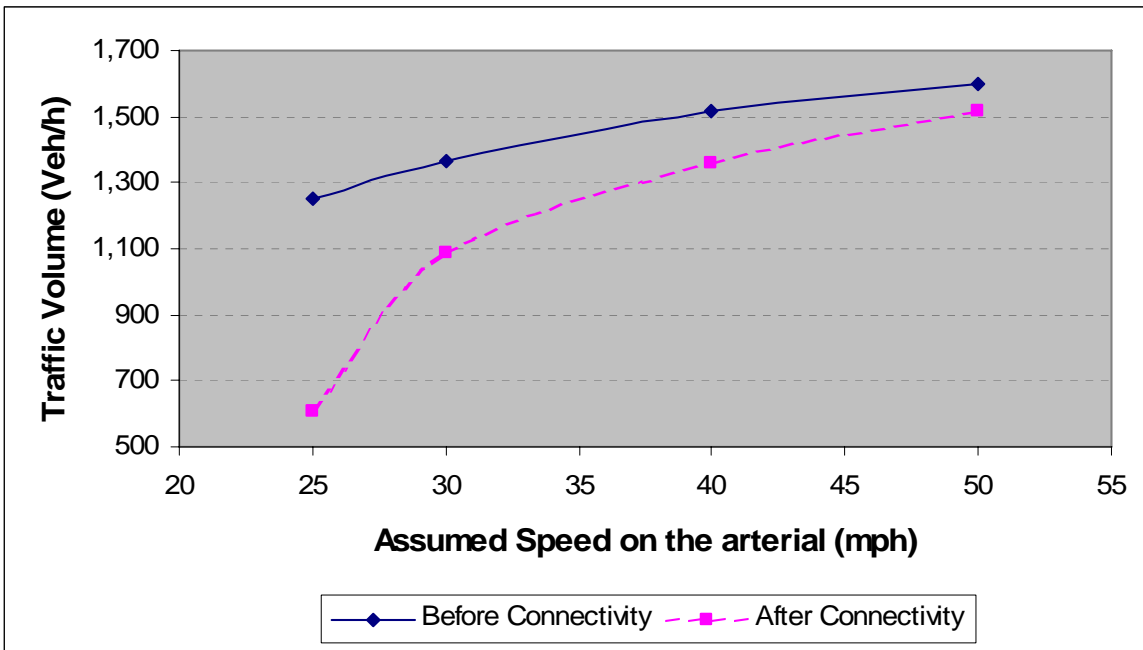


FIGURE 4 Traffic Volume Before and After Connectivity (Speed on the Local Roads = 25 mph)

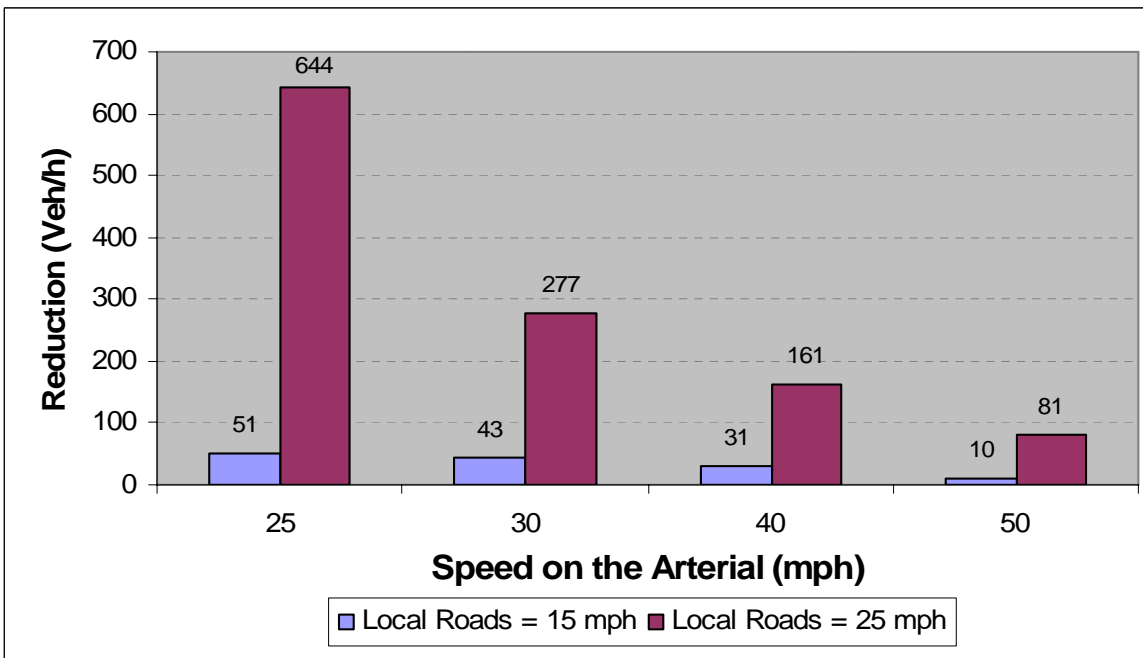


FIGURE 5 Traffic Volume Reduction After Connectivity Improvements

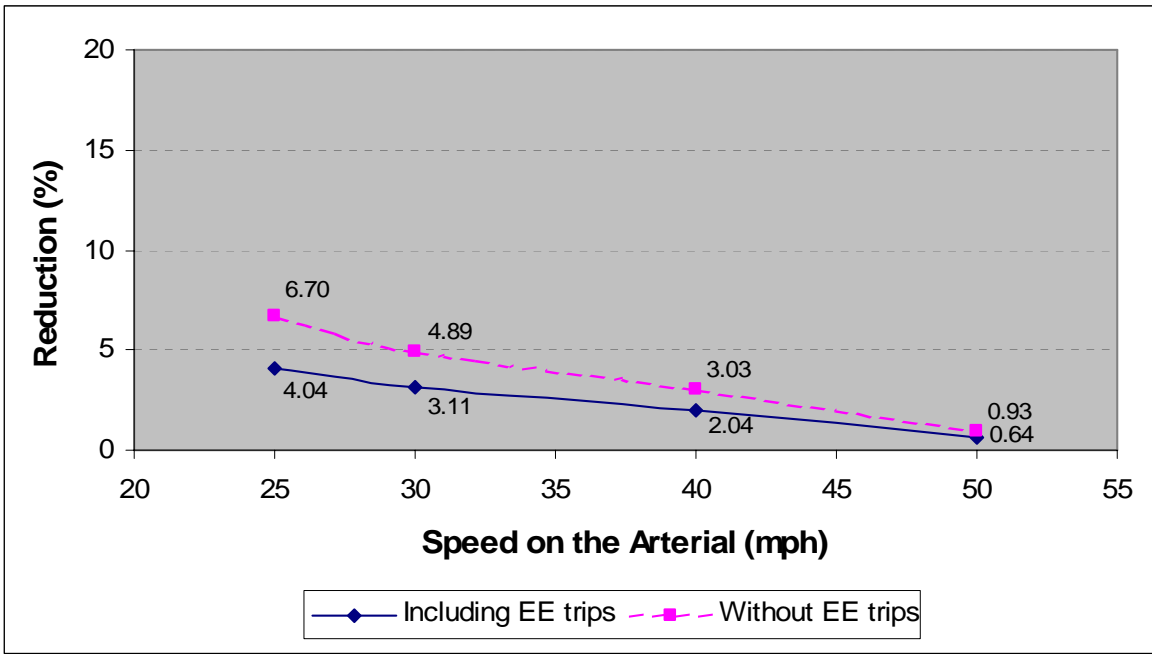


FIGURE 6 Percentage Reduction of Vehicles on the Arterial After Connectivity Improvements (Speed on Local Roads = 15 mph)

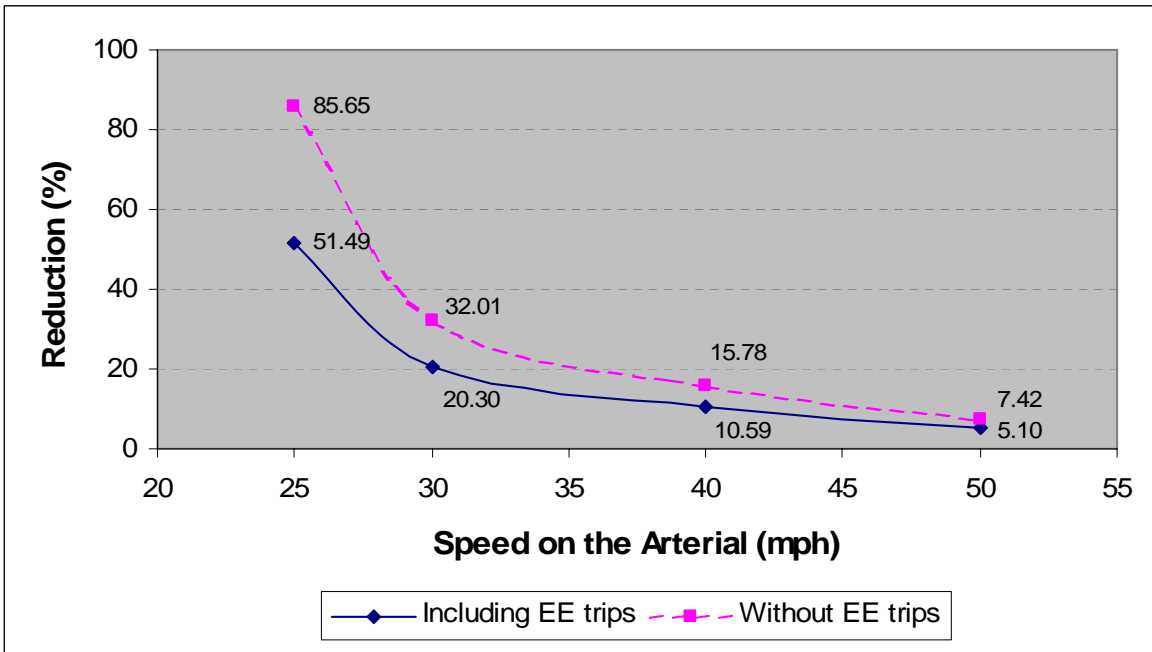
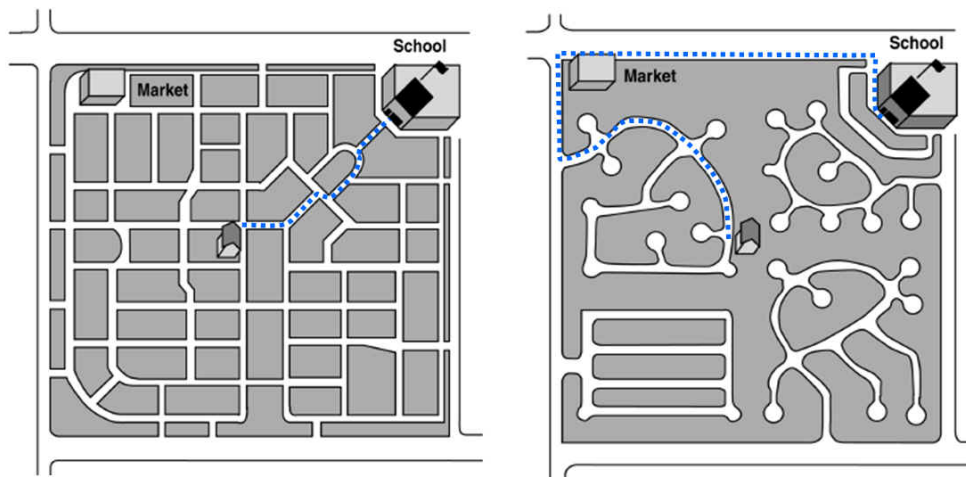


FIGURE 7 Percentage Reduction of Vehicles on the Arterial After Connectivity Improvements (Speed on Local Roads = 25 mph)

APPENDIX C

Street Connectivity Zoning and Subdivision Model Ordinance



Prepared by
Division of Planning
Kentucky Transportation Cabinet

March 2009



Street Connectivity Zoning and Subdivision Model Ordinance

Background & Purpose

The term “street connectivity” suggests a system of streets with multiple routes and connections serving the same origins and destinations. Connectivity not only relates to the number of intersections along a segment of street, but how an entire area is connected by the transportation system. A well-designed, highly-connected network helps reduce the volume of traffic and traffic delays on major streets (arterials and major collectors), and ultimately improves livability in communities by providing parallel routes and alternative route choices. By increasing the number of street connections or local street intersections in communities, bicycle and pedestrian travel also is enhanced. A well-planned, connected network of collector roadways allows a transit system to operate more efficiently.

Over the last forty to fifty years, residential and non-residential development patterns have been created that lack internal vehicular and pedestrian connectivity. The lack of connectivity has created a physical environment that lacks mobility options and pedestrian friendly features. Development trends during the 1960s and '70s encouraged building residential communities with few street connections and numerous cul-de-sacs. It was assumed that communities built with this type of street design had less traffic and fewer traffic delays on neighborhood streets. A recent Metro Portland study found these assumptions to be false. Residential subdivisions that are dominated by cul-de-sacs provide discontinuous street networks, reduces the number of sidewalks, provides few alternate travel routes and forces all trips onto a limited number of arterial roads.

Figure 1 illustrates a more traditional, interconnected development pattern compared to a disconnected, development pattern of the late 20th century.

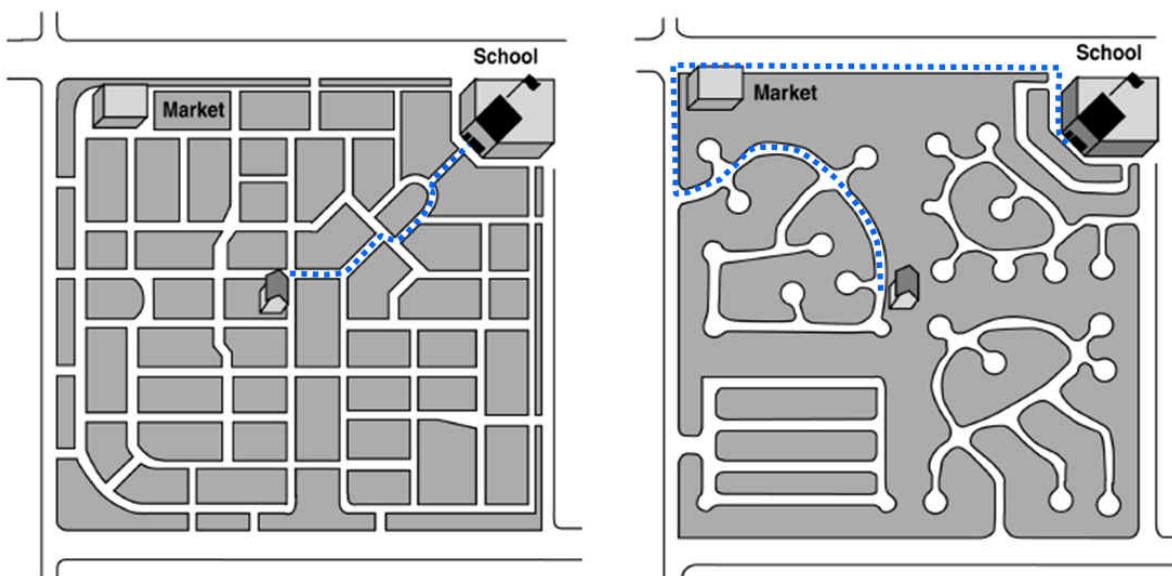


Figure 1: Shorter trip distance with connected network

The blue, dashed line represents the travel path a vehicle or pedestrian would have to take from home to school under the two different configurations. The path in the second scenario is two and a half times the length and requires travel on the major streets.

Local street connectivity provides for both intra- and inter-neighborhood connections to knit developments together, rather than forming barriers between them. The street configuration within each parcel must contribute to the street system of the neighborhood.

Research has shown that high roadway connectivity can result in:

- Reduction in travel distance (VMT) for drivers
- Reduction in travel times for drivers;
- Better and redundant emergency vehicle access;
- More efficient public services access (mail, garbage, transit)
- Improved bicycle and pedestrian routes and accessibility.
- Higher percentage mode share for transit, bicycling and walking
- Safer roads

A 2008 study of California cities compared “safe” road networks (fatal/severe rates less than 1/3 state average) to “less safe” networks (fatal/severe crash rates close to the state average). The results, shown in Table 1, demonstrate that with a higher intersection density i.e., higher connectivity, mode share for transit and non-motorized modes is higher while the fatality rate due to automobile crashes is much lower.

	Less safe	Safe
Average intersection density (#/square mile)	63	106
Walking/bicycling/transit mode share (%)	4	16
Fatality rate per 100,000 population	10.5	3.2

Table 1

In addition to the following connectivity ordinance, it is recommended that cities and counties plan their transportation network to have an acceptable roadway (arterials, collectors and sub-collectors) network density. It is recommended that through streets be spaced no more than ½ mile apart, although spacing of sub-collectors (through-streets that feed collectors typically with volumes less than 500 vehicles per day) at ¼ mile spacing is even better (Figure 2). Lower densities result in a higher strain on the existing highway system, often resulting in needed capacity improvements and inefficient operations.

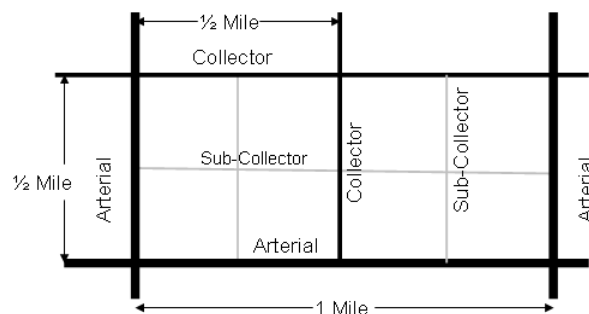


Figure 2: Arterial & collector road density

Connectivity Model Ordinance

The following model ordinance may be adopted in whole or amended to fit local conditions by a planning commission or local government. It consists of two primary components: the internal and external connectivity requirements. Both are critical to ensuring an efficient roadway system.

Purpose

The *[elected body]* hereby finds and determines that an interconnected street system is necessary in order to protect the public health, safety, and welfare in order to ensure that streets will function in an interdependent manner, to provide adequate access for emergency and service vehicles, to connect neighborhoods, to promote walking and biking, to reduce miles of travel that result in lower air emissions and wear on the roadway, and to provide continuous and comprehensible traffic routes.

General Standards

1. A proposed development shall provide multiple direct connections in its local street system to and between local destinations, such as parks, schools, and shopping, without requiring the use of arterial streets.
2. Each development shall incorporate and continue all collector or local streets stubbed to the boundary of the development plan by previously approved but unbuilt development or existing development.

Connectivity Index (Internal)

1. To provide adequate internal connectivity within a subdivision or planned development, the street network shall have a minimum connectivity index of *[1.40]*. The desired minimum connectivity index is *[1.60]*. The connectivity index is defined as the number of street links divided by the number of nodes and link ends (including cul-de-sacs and sharp curves with 15 mph design speed or lower).

Commentary: The higher the connectivity index, the more connected the road network. A connectivity index of 1.40 is a reasonable standard to ensure a connected roadway network; however, there are some cities that require a smaller index, sometimes as low as 1.20. Figures 3 and 4 demonstrate how to calculate the connectivity index.

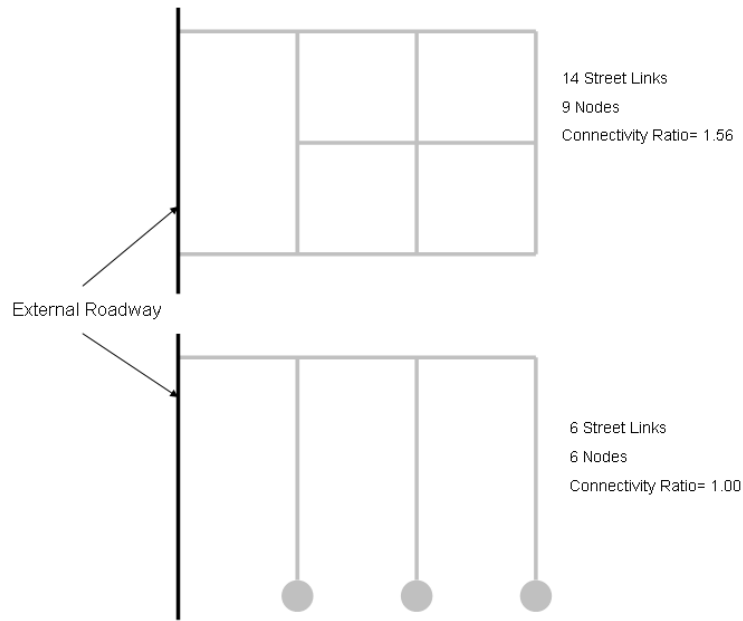


Figure 3: Example Connectivity Index Calculation

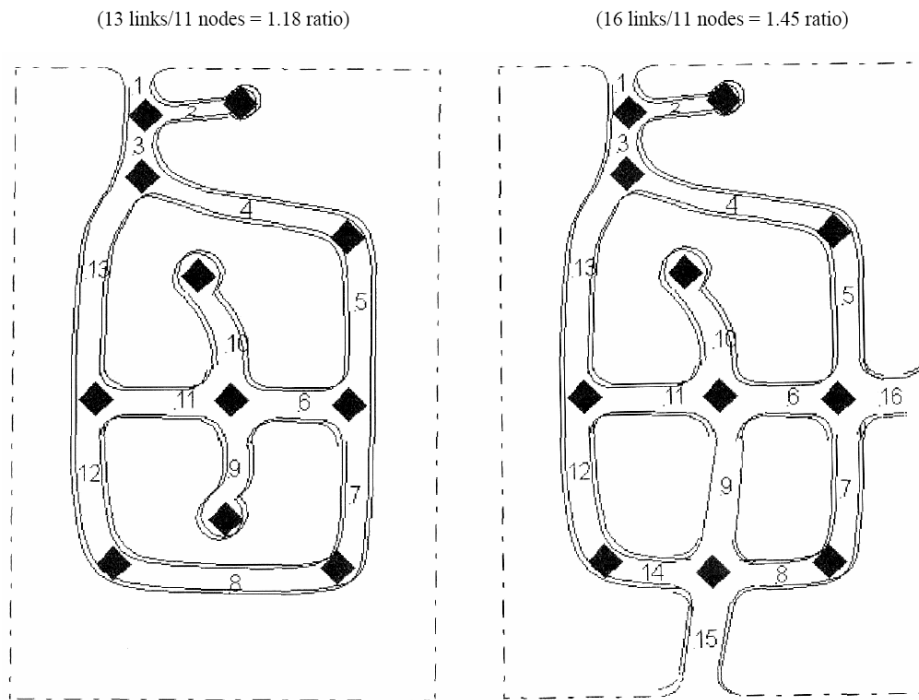


Figure 4: Example Connectivity Index Calculation

2. A link is defined as a segment of road between two intersections or from an intersection to a cul-de-sac/stub-out. This includes road segments leading from the adjoining highway network or adjacent development.
3. Nodes are defined as intersections and cul-de-sacs. They do not include the end of a stub-out at the property line or intersection with the adjoining highway network.
4. No dead-end streets shall be permitted except in cases where such streets are designed to connect with future streets on abutting land, in which case a temporary turnaround easement at the end of the street with a diameter of at least *[one hundred (100)]* feet must be dedicated and constructed.
5. Cul-de-sacs shall only be permitted if they are:
 - a. less than *[four hundred (400)]* feet in length (See Figure 5 on how to measure cul-de-sac length.) or
 - b. less than *[six hundred sixty (660)]* feet in length and have a pedestrian connection from the end of the cul-de-sac to another street. (See Figure 6.)

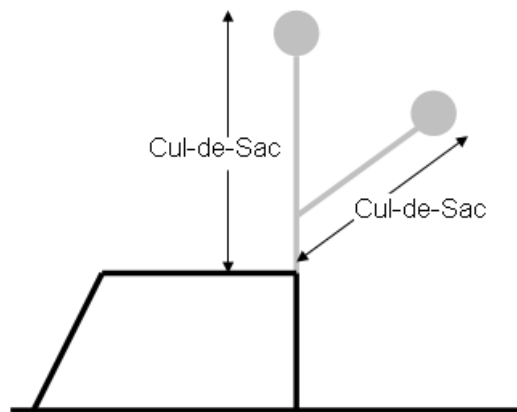


Figure 5: Measuring cul-de-sac length

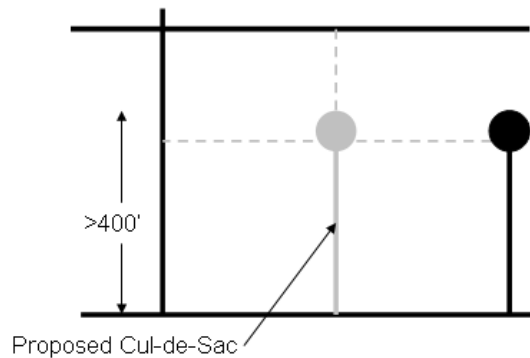


Figure 6: Providing pedestrian connections from cul-de-sac

Connectivity (External)

1. To ensure future street connections where a proposed development abuts unplatted land or a future development phase of the same development, street stubs shall be provided to provide access to all abutting properties or to logically extend the street system into the surrounding area. All street stubs shall be provided with temporary turn-around or cul-de-sacs and the restoration and extension of the street shall be the responsibility of any future developer of the abutting land.

Commentary: A street stub may either be a local road, collector, or frontage road. The planning director and developer should take into account the purpose of each stub and future traffic patterns that may exist once adjacent land develop occurs and a street connection is made. Cut-through traffic and speeding on local residential streets should be discouraged through proper location and inclusion of traffic calming measures. In contrast, collectors and frontage roads should have logical, direct routes that make cross parcel driving possible. This may include a road that traverses the land from one property line to the opposite property line.

2. Streets within and contiguous to the subdivision shall be coordinated with other existing or planned streets within the general area as to location, widths, grades, and drainage. Such streets shall be aligned and coordinated with existing or planned streets in existing or future adjacent or contiguous to adjacent subdivisions. All streets, alleys, and pedestrian pathways in any subdivision or site plan shall connect to other streets and to existing and projected streets outside the proposed subdivision or other development.
3. Street connections shall be spaced at intervals not to exceed [six hundred sixty (660)] feet (1/8 mile) along each boundary that abuts potentially developable or redevelopable land. Blocks longer than [four hundred (400)] feet in length shall have a mid-block pedestrian pathway connecting adjacent blocks. See Figure 7.

Commentary: Minimizing the block length of local streets allows better access for pedestrians, bicyclists and automobiles. The number may be changed to lower than 660 feet. The appropriate length may be determined based from a typical block length based on historical precedence in the area. It is common for American cities to have block lengths between 200 and 400 feet.

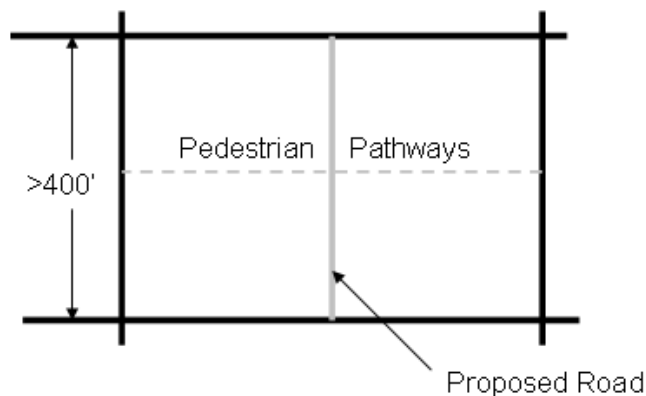


Figure 7: Mid-block pedestrian pathways

4. The *[City Engineer]* may require any limited movement collector or local street intersections to include an access control median or other acceptable access control device. The *[City Engineer]* may also allow limited movement intersection to be initially constructed to allow full movement access.

Commentary: Local and state access management regulations will regulate the minimum spacing and design. Full intersection access on an arterial should be between ¼ and ½ mile. Partial intersection access, controlled by a median, may be at shorter distances. More frequent access improves overall roadway connectivity but may impact the operations on an arterial roadway.

5. Gated street entryways into residential developments shall be prohibited.

References

1. Street Connectivity: An Evaluation of Case Studies in the Portland Region, Metro Regional Government, June, 2004.
2. Best Development Practices: Doing the Right Thing and Making Money at the Same Time, Florida Department of Community Affairs, May 1995.
3. Pedestrian and Transit Friendly Design, Florida Department of Transportation, March 1996.
4. Model Street Connectivity Standards Ordinance, Washington Department of Transportation , 2006.
5. Unified Development Ordinance, Section 31-612, Street Improvement Standards, City of Suffolk, Virginia. (from website August 2008)
6. Unified Development Ordinance, Section 10-1, Street Improvement Standards, City of Kannapolis, North Carolina. (from website August 2008)
7. Fort Collins, Colorado, Land Use Code, Division 3.6, Transportation and Circulation. (from website August 2008; last changes to regs in 2006)
8. Connectivity, Safe Routes to Schools Guide, Pedestrian and Bicycle Information Center (from website August 2008).
9. Street Network Types and Road Safety: A Study of 24 California Cities, Wesley E. Marshall and Norman Garrick, University of Connecticut, 2008

APPENDIX D

Memo



To: Town Council
Cc: Planning & Zoning Board
From: Jeff Ulma, AICP, Planning Director
Date: July 24, 2003
Re: Connectivity Summary

Recently, during the Upchurch Rezoning (03-REZ-05) public hearing, one of the Town Council members requested a summary of the Town's connectivity requirements. This memorandum describes the requirements, the rationale for them, and some information from other communities addressing connectivity. Staff has used this pending rezoning case to illustrate the impacts and benefits of the requirements.

What are the Town's Connectivity Requirements?

The Land Development Ordinance requires any new subdivision to be designed to have a connectivity index of 1.2. The index is calculated by dividing the number of street links (street sections between intersections, including cul-de-sacs) by the number of street nodes (intersections and cul-de-sacs). A grid street network would yield an index of 2.0. The ordinance also requires connections to compatible adjacent land uses spaced no more than 1,250 to 1,500 feet apart in each direction, a requirement that ensures a minimum level of external connectivity. It should be noted that these standards can be waived if meeting them "is impractical due to topography or other natural features."

The ordinance has been in place since 1999 and was adopted following an extensive public involvement process. It was also included in the recently adopted Land Development Ordinance update. From 1999 to the present, the Town has applied this ordinance to all new developments.

What is the Purpose of the Connectivity Requirements?

The purposes of the ordinances are to:

- Support the creation of a highly connected transportation system within the Town, in order to provide choices for drivers, bicyclists, and pedestrians;
- Promote walking and cycling;
- Connect neighborhoods to each other and to local destinations such as schools, parks, and shopping centers;
- Reduce vehicles miles of travel and travel times;
- Improve air quality;
- Reduce emergency response times;
- Increase effectiveness of municipal service delivery; and
- Free up arterial road capacity to better serve regional long distance travel needs.

TOWN of CARY

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tel 919-469-4082 • fax 919-460-4935 • www.townofcary.org

How are other Communities Addressing Connectivity?

Last month, the American Planning Association published a report on “*Planning for Street Connectivity*.” The Town of Cary is one of the communities highlighted in the report along with eleven other communities. As the table below indicates, communities are using one of two approaches to improve connectivity in their cities, block length limits or connectivity indices. Based on the sampling shown in the table, Cary’s connectivity standards are not as restrictive as in other communities and allow for more cul-de-sacs than are permitted in the other sampled jurisdictions. The following table summarizes the different requirements.

Table 1: Connectivity Requirements

<i>Community</i>	<i>Max. local street intersection spacing</i>	<i>Are street stubs required?</i>	<i>Are cul-de-sacs allowed?</i>	<i>Max. cul-de-sac length</i>
Metro, Oregon	530	No	No (with exceptions)	200
Portland, Oregon	530	Yes	No (with exceptions)	200
Beaverton, Oregon	530	Yes	No (with exceptions)	200
Eugene, Oregon	600	Yes	No (with exceptions)	400
Fort Collins, CO	Uses max. block size acreage	Yes	Yes, limited	660
Boulder, CO	Not regulated, practice is 300-350 feet	Yes	Yes, limited	600
Huntersville, NC	250-500	Yes	No (with exceptions)	350
Cornelius, NC	200-1,200	Yes	No (with exceptions)	250
Conover, NC	400-1,200	Yes	yes	500
Raleigh, NC	1,500	Yes	yes	400 ft. for residential, 800 ft. for commercial
Orlando, FL	Uses 1.4 connectivity index	Yes	yes	700 ft. or max. 30 units
Middletown, DE	Uses 1.4 connectivity index	Yes	yes	1,000
Cary, NC	Uses 1.2 connectivity index	Yes	yes	900

An Example of the Application of Cary’s Connectivity Requirements:

To illustrate the connectivity ordinance in practice, staff conducted an analysis of the pending rezoning for Mr. Upchurch’s property between the existing Berkeley and Somerset subdivisions. Staff’s review

of the connectivity for this case includes a quantitative analysis that illustrates the value of connectivity from a traffic, accident information, service delivery and public safety perspective.

1. Traffic

The Town’s traffic engineer performed an analysis of the implications of making a street connection between the Berkeley and Somerset subdivisions via the property subject to the rezoning. The conclusions reached by the technical analysis include the following:

- In the peak hours, it will be almost 30 seconds faster for motorists to use High House Road and NC 55 than it will be to drive through the neighborhoods using Sir Walker Lane and Connemara Drive. Travel times in the off-peak hours will be about 60 seconds faster.
- Connectivity will create a reduction of over five percent in existing traffic volumes from Berkeley and Somerset subdivisions due to internal trip reductions. The addition of the twenty-five (25) new homes will only increase overall trips to the area less than six (6) percent with the connection.
- Since the Somerset subdivision is the larger of the two subdivisions, Connemara Drive will benefit with a reduction of more than ten (10) percent in existing traffic volume. This reduction is created by the second means of egress. The Berkeley subdivision will have an increase in traffic volume of twenty-eight (28) percent.
- The future traffic volumes on Connemara Drive at NC 55 and Sir Walker Lane at High House Road will be equal.
- The Sir Walker/Connemara connection will save the 81 units in Berkeley 130-150 miles of driving per day or 47,000-55,000 miles per year. The 120 units in Somerset will save 200-220 miles of driving per day and almost 70,000-80,000 miles per year. This translates to 117,000-135,000 miles of travel saved each year for the existing residents. In addition, this linkage yields positive air quality benefits. Based on these mileage savings, an annual reduction in vehicle emissions could range between 405,000-880,000 pounds per year.

2. Accident Information

One of the concerns expressed by some residents was that the connection could increase the number of accidents with pedestrians. Based on existing town-wide data from 1998-2002, residential streets have experienced considerably less pedestrian and bicycle accidents than thoroughfares or parking lots. The following table summarizes this information:

Accident Type	Thoroughfares	Parking Lots	Residential Streets	Totals
# of pedestrian accidents	33	47	21	101
# of bicycle accidents	37	8	8	53
Totals	70 (45% of total)	55 (36% of total)	29 (19% of total)	154

3. Service Delivery

An important reason for the Town’s connectivity ordinance is efficiency benefits for solid waste, recycling and yard waste delivery to Cary residents. Based on an analysis conducted by the Public Works Department, savings in time and money are achieved by a well-connected street system.

In the sample case, staff has estimated that it will take approximately 10 less minutes per service pick-up for the Berkeley and Somerset subdivisions if the street system were connected. The time savings equates to 26 hours over the course of the year. The reduced travel distance savings for the three

service deliveries is over 550 miles per year. The reduced distance also provides the Town with cost savings from fuel purchases and from lifecycle costs for the service delivery equipment.

Based on an analysis conducted by the Public Works Department, connectivity also has positive impacts to public water quality in two specific areas (hydrant flushing program and customer service calls). From a customer service perspective, over 30% of the residential water quality complaints come from households on dead end lines (cul-de-sacs). On average, it takes about 12 minutes to handle the complaint and substantially more time if a crew needs to be dispatched to determine the problem and correct it. One way that the Town has responded to some of the water quality issues on dead ends has been to institute a hydrant flushing program. Based on the review of the case example, the dead ending of the subdivisions will add almost 50 hours of additional hydrant flushing time per year.

4. Public Safety Response

In discussing the case project with the Cary Police Department, connection of the two subdivisions (Berkeley and Somerset) could reduce response times for the police in responding to emergencies in these areas. While the reduction is difficult to quantify since the response time is dependent on where the police vehicle is coming from, a reduction in response time by up to 1 minute could be realized if the police vehicle had to respond to a call at one end of the subdivision.

From a Cary Fire Department perspective, response times are also reduced with well-connected street systems. According to the Fire Department analysis of the case project, connectivity for Sir Walker Lane and Connemara Drive and the other streets in Somerset and Berkeley subdivisions will improve response time from the fire station on High House Road by 2-3 minutes for the Somerset subdivision.

5. Case Study Conclusions

Based on the analysis performed by the Fire, Public Works and Utilities, Police, Engineering and Planning Departments, providing a connection between the Somerset, Berkeley and the future adjacent subdivision will be beneficial from an overall traffic, public safety, service delivery, and environmental perspective.

While the analysis yields the conclusion that connectivity is beneficial, the design of the connection will be important in ensuring that connectivity is made in a manner that reduces convenience for non-neighborhood related traffic. There are numerous ways to address the design of the linkage including some of the options that consultant Walter Kulash discussed at this year's retreat. Staff is working with the applicant to address the design during the rezoning and subdivision processes.

Please feel free to contact me if you need further information.

JU/jp

APPENDIX E

4.8.4. MODEL STREET CONNECTIVITY STANDARDS ORDINANCE

Street connectivity ordinances are designed to increase the number of street connections in a neighborhood and to improve the directness of routes (Handy 2003, 68). The purpose is to achieve an open street network that provides multiple routes to and from destinations. Such a network is key to supporting walking and bicycling as a convenient, safe, and healthy form of transportation. It also discourages the proliferation of limited access street designs where residential subdivisions have but one or two points of entry and exit, and where commercial developments have access only onto arterial streets with no connections to adjacent properties.

The growing trend in cities enacting connectivity requirements is reflective of several larger trends and forces shaping planning and land development. These trends include the following:

- Acknowledgment that bicycling and walking need to be routinely accommodated as transportation modes in regional and local transportation plans, models, and funding formulas
- Recognition that the traditional street hierarchy of arterial, collector, and local streets has reinforced the problems caused by conventional single-use zoning, including neighborhood isolation and inaccessibility (by all modes, but in particular walking) between origins and destinations.
- Inclusion of traditional town planning principles (i.e., New Urbanism) in the mainstream of community planning and design whether on a communitywide or project-level scale.
- Growing recognition of the relationship between neighborhood design and residents' level of physical activity and rates of overweight and obesity (Dannenberg, Jackson, et al. 2003; Frank, Andresen, & Schmid 2004; Frank, Engleke, and Schmid 2003).
- The desire of residents, local officials, and others to tame the effects of the automobile on communities and to provide alternative transportation modes at the neighborhood, city, and regional levels.

In general, connectivity requirements have the purposes of creating multiple, alternate routes for automobiles and creating more route options for people on foot and on bicycles.

Additional requirements can be added to the ordinances to establish pedestrian routes and passageways between land uses that can link isolated subdivisions to each other and create the shortest, safest routes possible between origins and destinations. Almost all communities that have pursued street connectivity also prohibit or greatly limit gated streets or gated communities.

Handy (2003) describes what supporters of connectivity point to as its potential benefits and what those who oppose it see as its potential detriments.

- Perceived benefits:

Section 4.8 Four Model Ordinances to Help Create Physically Active Communities: 4.8.1 Pedestrian Overlay District; 4.8.2 On-Site Access, Parking, and Circulation Ordinance; 4.8.3 Shared Parking Ordinance; 4.8.4 Street Connectivity Ordinance

Model Smart Land Development Regulations

Interim PAS Report, © American Planning Association, March 2006

- Decreased traffic on arterial streets
- Continuous and more direct routes for travel by walking and biking
- Greater emergency vehicle access
- Improved utility connections, easier maintenance, and more efficient trash and recycling pick up
- Perceived detriments:
 - Increased traffic on residential streets
 - Increased infrastructure costs and impervious cover
 - The need for more land for development, thus increasing housing costs and threatening the profitability of housing development

Handy says these potential outcomes have not been adequately studied to fully determine which assertions are most supportable. Furthermore, what research there is on connectivity has generally compared the extremes—the traditional grid with a conventional suburban curvilinear pattern—ignoring the fact that many communities have a hybrid of the two systems. She concludes that connectivity requirements should be aimed at increasing connections without significantly increasing through-traffic in residential areas. This can be done by avoiding long, straight streets that may encourage speeding, using curves to slow traffic, and allowing cul-de-sacs as well as bicycle cut-throughs where natural or built features prevent connectivity.

Connectivity ordinances generally use one of two methods to evaluating proposed developments. The first and most common method is to establish a maximum block length. In Portland, Oregon, the maximum block length is 530 feet; in Austin, Texas, 600 feet; and in Ft. Collins, Colorado, 660 feet. The appropriate block length for any community can be determined by examining and measuring the dimensions of blocks in residential areas of the city that reflect the desired scale, character, and connectivity the municipality is hoping to achieve within new developments. For example, consider the specific block lengths of identifiable areas of these cities: the mean block length in San Francisco’s city center is 353 feet; in Lower Manhattan, 274 feet; and in areas of Boston built as of 1895, 190 feet (Jacobs 1993).

The second measurement method is a connectivity index. Such indices are calculated by dividing the number of streets links (i.e., street sections between intersections, including cul-de-sacs) by the number of street nodes (i.e., intersections and cul-de-sacs). The city of Cary, North Carolina, for example, requires a street connectivity index of 1.2 or higher. That means a neighborhood with 50 street links would need to have approximately 41 street nodes to meet the standard.

The model ordinance below uses the more common block-length approach rather than the index approach. The model is sufficiently flexible for a jurisdiction to apply the index measurement if it so desires.

(A note regarding one-way streets: Although not addressed in the ordinances reviewed for this model, the use of one-way streets can affect street connectivity and more importantly pedestrian, bicyclist, and motorist safety. On the one hand, one-way streets can simplify crossings for pedestrians, who must look for traffic in only one direction; however, studies have shown that conversion of two-way streets to one-way generally reduces pedestrian

crashes, but one-way streets tend to result in higher auto speeds, which creates other safety problems.)

As a system, one-way streets can also increase travel distances for motorists and bicyclists, and can create confusion, especially for nonlocal residents. For pedestrians, provided they are on a grid or modified grid pattern, one-way streets should not increase the length of a route. One common factor that can make a one-way street system confusing to pedestrians is signage identifying street names. Often cities will install street signs that face only in the direction of oncoming traffic.

According to the Pedestrian and Bicycle Information Center, one-way streets operate best in pairs, separated by no more than 0.4 km (0.25 mi) (www.pedbikeinfo.org, 2004/). If one-way streets are being present in the area in which street connectivity requirements are being applied, this standard should be considered.

Primary Smart Growth Principle Addressed: Walkable neighborhoods

Secondary Smart Growth Principle Addressed: Variety of transportation choices

101. Purpose

(1) The purpose of this ordinance is to support the creation of a highly connected transportation system within the [municipality name] to:

- (a) provide choices for drivers, bicyclists, and pedestrians;
- (b) promote walking and bicycling;
- (c) connect neighborhoods to each other and to destinations, such as schools, parks, shopping, libraries, and post offices, among others;
- (d) provide opportunities for residents to increase their level of physical activity each day by creating walkable neighborhoods with adequate connections to destinations;
- (e) reduce vehicle miles traveled and travel time to improve air quality and mitigate the effects of auto emissions on the health of residents;
- (f) reduce emergency response times;
- (g) increase effectiveness of municipal service delivery; and
- (h) restore arterial street capacity to better service regional long-distance travel needs.

102. Definitions

As used in this ordinance, the following words and terms shall have the meanings specified herein:

Section 4.8 Four Model Ordinances to Help Create Physically Active Communities: 4.8.1 Pedestrian Overlay District; 4.8.2 On-Site Access, Parking, and Circulation Ordinance; 4.8.3 Shared Parking Ordinance; 4.8.4 Street Connectivity Ordinance

Model Smart Land Development Regulations

Interim PAS Report, © American Planning Association, March 2006

“Arterial street” means a street that primarily accommodates through-traffic movement between areas and across the local government, and that secondarily provides direct access to abutting property.

“Connectivity” means a system of streets with multiple routes and connections serving the same origins and destinations.

“Development” means a subdivision, resubdivision, planned unit development, [insert name of any other type of development], or any other type of land-use change that results in the creation of public or private streets.

“Local Street System” means the interconnected system of collector and local streets providing access to a development from an arterial street.

“Resubdivision” means [cite to definition of resubdivision in local subdivision regulations].

“Subdivision” means [cite to definition of “subdivision” in subdivision regulations].

103. Relationship to other Adopted Plans and Ordinances

The design and evaluation of vehicular, bicycle, and pedestrian circulation systems built in conjunction with new residential and nonresidential development and the application of the street connectivity requirements to those developments shall conform to [list all applicable ordinances and plans].

104. General Standards

- (1) A proposed development shall provide multiple direct connections in its local street system to and between local destinations, such as parks, schools, and shopping, without requiring the use of arterial streets. Each development shall incorporate and continue all collector or local streets stubbed to the boundary of the development plan by previously approved but unbuilt development or existing development.
- (2) To ensure future street connections to adjacent developable parcels, a proposed development shall provide a local street connection spaced at intervals not to exceed [660] feet along each boundary that abuts potentially developable or redevelopable land.
- (3) A proposed development shall provide a potentially signalized, full-movement intersection of a collector or a local street with arterial street at an interval of at least every 1,320 feet or one-quarter mile along arterial streets. A proposed development shall provide an additional nonsignalized, potentially limited movement, intersection of a collector or local

street with an arterial street at an interval not to exceed 660 feet between the full movement collector and the local street intersection.

(4) The [local government] engineer may require any limited movement collector or local street intersections to include an access control median or other acceptable access control device.

(5) The requirements of paragraphs (1), (2), and (3) above may be waived if, in the written opinion of the [local government] engineer, they are infeasible due to unusual topographic features, existing development, or a natural area or feature.

(6) Gated street entryways into residential developments are prohibited.

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APPENDIX F

A Model Ordinance for a Traditional Neighborhood Development



Prepared by Brian W. Ohm, James A. LaGro, Jr., and Chuck Strawser
April 2001

Approved by the Wisconsin Legislature, July 28, 2001

UW
Extension

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4.4 Stormwater Management. The design and development of the traditional neighborhood development should minimize off-site stormwater runoff, promote on-site filtration, and minimize the discharge of pollutants to ground and surface water. Natural topography and existing land cover should be maintained/protected to the maximum extent practicable. New development and redevelopment shall meet the following requirements:

1. Untreated, direct stormwater discharges to wetlands or surface waters are not allowed.
2. Post development peak discharge rates should not exceed pre-development peak rates.
3. Erosion and sediment controls must be implemented to remove 80% of the average annual load of total suspended solids.
4. Areas for snow storage should be provided unless the applicant provides an acceptable snow removal plan.
5. Redevelopment stormwater management systems should improve existing conditions and meet standards to the extent practicable.
6. All treatment systems or BMPs must have operation and maintenance plans to ensure that systems function as designed.

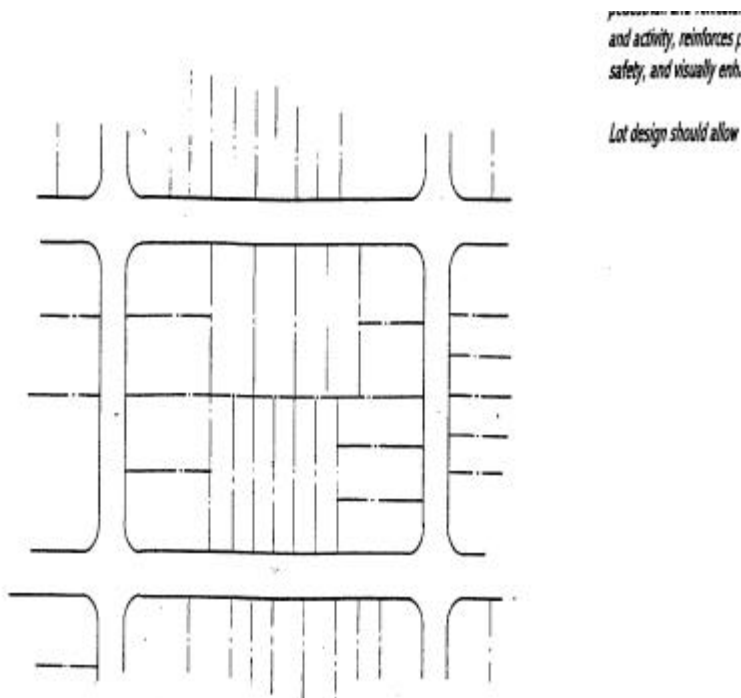
4.5 Lot and Block Standards.

COMMENTARY: Providing diversity in block and lot size can help to create an urban structure that is pedestrian friendly. Short blocks in traditional grids create multiple routes and more direct ones for pedestrians, bicyclists, and motorists.

Lot and block design should promote development that is compatible with natural features, minimizes pedestrian and vehicular conflict, promotes street life and activity, reinforces public spaces, promotes public safety, and visually enhances development.

Lot design should allow for passive solar designs.

1. **Block and lot size diversity.** Street layouts should provide for perimeter blocks that are generally in the range of 200-400 feet deep by 400-800 feet long. A variety of lot sizes should be provided to facilitate housing diversity and choice and meet the projected requirements of people with different housing needs.



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Figure 4. Plan-view diagram of a street grid showing a diversity of lot (parcel) sizes.

2. **Lot Widths.** Lot widths should create a relatively symmetrical street cross section that reinforces the public space of the street as a simple, unified public space.

COMMENTARY: Cities and villages should establish minimum and/or maximum lot sizes and setbacks that meet traditional neighborhood development design principles within the context of their community.

3. **Building Setback, Front - Mixed Use Area.** Structures in the mixed use area have no minimum setback. Commercial and civic or institutional buildings should abut the sidewalks in the mixed use area.

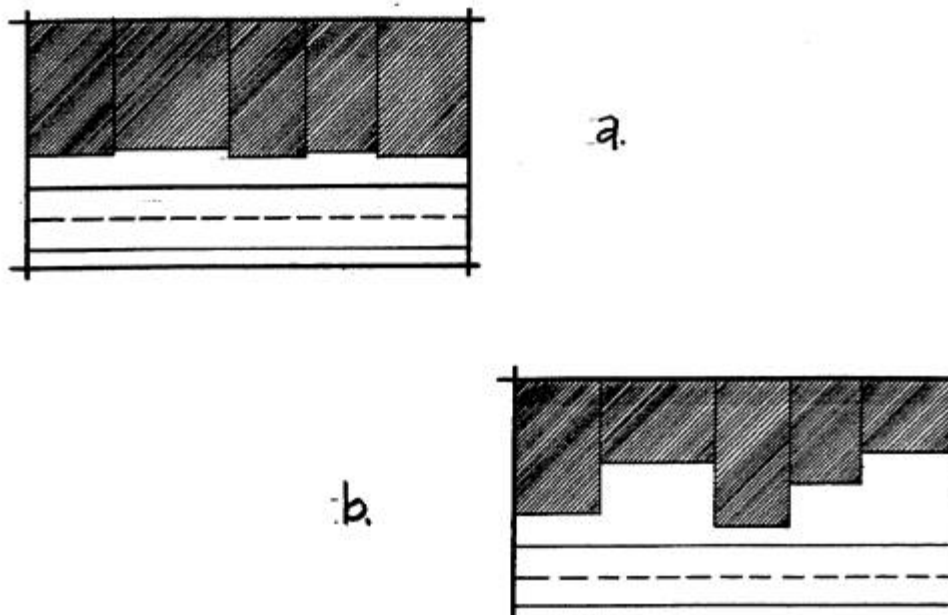


Figure 5. Plan-view diagrams showing two alternatives for building setbacks from the street right-of-way in mixed-use areas. Relatively uniform setbacks (a) are preferable to widely varying building setbacks (b).

4. **Building Setback, Front - Areas of Mixed Residential Uses.** Single-family detached residences shall have a building setback in the front between [0 and 25] feet. Single-family attached residences and multifamily residences shall have a building setback in the front between [0 and 15] feet.
5. **Building Setback, Rear - Areas of Mixed Residential Uses.** The principal building on lots devoted to single-family detached residences shall be setback no less than [30] feet from the rear lot line.

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- Side Setbacks.** Provision for zero lot-line single-family dwellings should be made, provided that a reciprocal access easement is recorded for both lots and townhouses or other attached dwellings, provided that all dwellings have pedestrian access to the rear yard through means other than the principal structure.

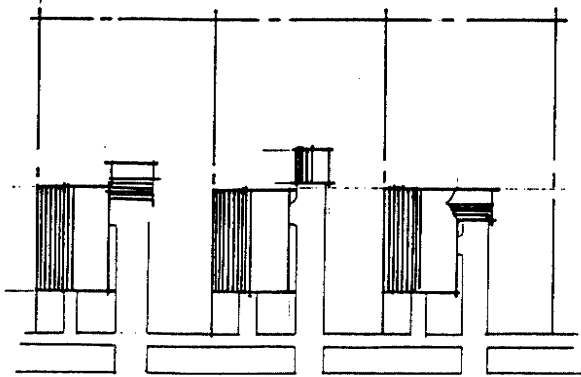


Figure 6. Plan-view diagram of the zero-lot line concept. A large side-yard on each parcel is created by uniformly eliminating one of the side-yard setbacks.

- 4.6 Circulation Standards.** The circulation system shall allow for different modes of transportation. The circulation system shall provide functional and visual links within the residential areas, mixed use area, and open space of the traditional neighborhood development and shall be connected to existing and proposed external development. The circulation system shall provide adequate traffic capacity, provide connected pedestrian and bicycle routes (especially off street bicycle or multi-use paths or bicycle lanes on the streets), control through traffic, limit lot access to streets of lower traffic volumes, and promote safe and efficient mobility through the traditional neighborhood development.

COMMENTARY: A goal of a traditional neighborhood development is a vehicle circulation system that provides for access generally by way of an interconnected network of streets (such as a grid pattern). The interconnected street pattern is meant to limit the use of isolated cul-de-sacs which force the major circulation pattern of a community onto a few major roads.

- 1. Pedestrian Circulation.** Convenient pedestrian circulation systems that minimize pedestrian-motor vehicle conflicts shall be provided continuously throughout the Traditional Neighborhood Development. Where feasible, any existing pedestrian routes through the site shall be preserved and enhanced. All streets, except for alleys, shall be bordered by sidewalks on both sides in accordance with the specifications listed in Table 1. The following provisions also apply:
 - Sidewalks in residential areas.** Clear and well-lighted sidewalks, [3-5 feet] in width, depending on projected pedestrian traffic, shall connect all dwelling entrances to the adjacent public sidewalk.
 - Sidewalks in mixed use areas.** Clear and well-lighted walkways shall connect building entrances to the adjacent public sidewalk and to associated parking areas. Such walkways shall be [a minimum of 5 feet] in width.

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- c. Disabled Accessibility. Sidewalks shall comply with the applicable requirements of the Americans with Disabilities Act.
- d. Crosswalks. Intersections of sidewalks with streets shall be designed with clearly defined edges. Crosswalks shall be well lit and clearly marked with contrasting paving materials at the edges or with striping.

COMMENTARY: Traditional neighborhoods should also be "pedestrian friendly," meaning they provide for pedestrian safety and convenience. An independent network of sidewalks and bikeways can also promote walking and reduce reliance on private vehicles.

2. **Bicycle Circulation**. Bicycle circulation shall be accommodated on streets and/or on dedicated bicycle paths. Where feasible, any existing bicycle routes through the site shall be preserved and enhanced. Facilities for bicycle travel may include off-street bicycle paths (generally shared with pedestrians and other non motorized users) and separate, striped, 4 foot bicycle lanes on streets. If a bicycle lane is combined with a lane for parking, the combined width should be 14 feet.
3. **Public Transit Access**. Where public transit service is available or planned, convenient access to transit stops shall be provided. Where transit shelters are provided, they shall be placed in highly visible locations that promote security through surveillance, and shall be well-lighted.
4. **Motor Vehicle Circulation**. Motor vehicle circulation shall be designed to minimize conflicts with pedestrians and bicycles. Traffic calming features such as "queuing streets," curb extensions, traffic circles, and medians may be used to encourage slow traffic speeds.
 1. Street Hierarchy. Each street within a traditional neighborhood development shall be classified according to the following (arterial streets should not bisect a traditional neighborhood development):
 - i. **Collector**. This street provides access to commercial or mixed -use buildings, but it is also part of the [city/village]'s major street network. On-street parking, whether diagonal or parallel, helps to slow traffic. Additional parking is provided in lots to the side or rear of buildings.
 - ii. **Subcollector**. This street provides primary access to individual residential properties and connects streets of lower and higher function. Design speed is 25 mph.
 - iii. **Local Street**. This street provides primary access to individual residential properties. Traffic volumes are relatively low, with a design speed of 20 mph.
 - iv. **Alley**. These streets provide secondary access to residential properties where street frontages are narrow, where the street is designed with a narrow width to provide limited on-street parking, or where alley access development is desired to increase residential densities. Alleys may also provide delivery access or alternate parking access to commercial properties.

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COMMENTARY: A goal of traditional neighborhood developments is narrower streets than what is required in conventional subdivision ordinances. Narrow streets and other traffic calming techniques help slow traffic down to promote pedestrian safety.

Local street widths utilize a concept called **Queueing** the use of one travel lane on local streets with parking (usually an intermittent parking pattern) on both sides. At low traffic volumes, with intermittent parking, cars traveling in opposite directions must occasionally use the parking lane as a travel lane or wait for another car to pass. The debate over the potential benefits of narrower streets are discussed in the Institute of Transportation Engineers= 1997 publication, **A Traditional Neighborhood Street Design Guidelines**.

Table 1: Attributes of Streets in a Traditional Neighborhood Development

	Collector	Subcollector	Local Street	Alley
Average Daily Trips	750 or more	750-1500	Less than 250	Not applicable
Right-of-Way	76-88 feet	48-72 feet	35-50 feet	12-16 feet
Auto travel lanes	Two or three 12 feet lanes	Two 10 feet lanes	Two 10 feet lanes, or one 14 feet (queueing) lane	Two 8 feet lanes for two-way traffic, or one 12 feet lane for one-way traffic
Bicycle lanes	Two 6 feet lanes combined with parking lanes	4 feet lanes with no parking, or 6 feet lanes combined with parking lanes	None	None
Parking	Both sides, 8feet	None, one, or both sides, 8 feet	None or one side, 8feet	None (access to individual drives & garages outside Right-of-way)
Curb and gutter	Required	Required	Not required	
Planting strips	Minimum 6 feet	Minimum 6 feet	Minimum 6 feet	None
Sidewalks	Both sides, 5 feet minimum	Both sides, 3-5 feet	Both sides, 3-5 feet	None

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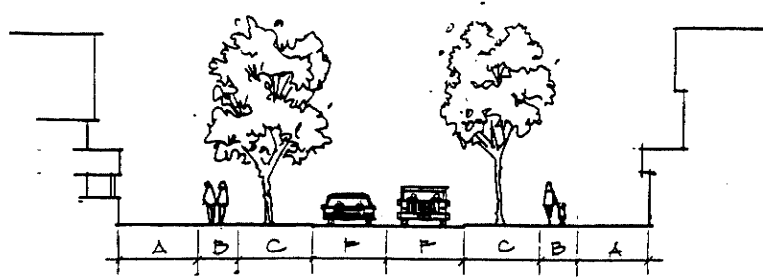


Figure 7a. Schematic sketch of a typical local street cross-section. Table 1 lists the recommended dimensions of each component: A) building setback from street right-of-way; B) walkway; C) planting area; F) travel lane.

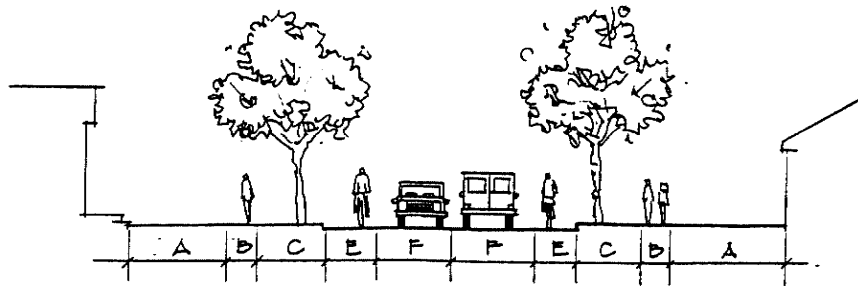
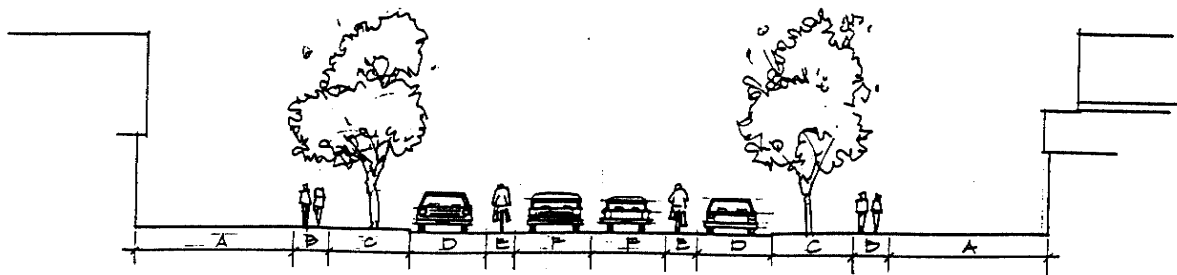


Figure 7b. Schematic sketch of a typical sub-collector street cross-section. Table 1 lists the recommended dimensions of each component: A) building setback from street right-of-way; B) walkway; C) planting area; E) bicycle lane; F) travel lane.



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Figure 7c. Schematic sketch of a typical collector street cross-section. Table 1 lists the recommended dimensions of each component: A) building setback from street right-of-way; B) walkway; C) planting area; D) parking lane; E) bicycle lane; F) travel lane.

- b. Street Layout. The traditional neighborhood development should maintain the existing street grid, where present, and restore any disrupted street grid where feasible. In addition:
 - i. Intersections shall be at right angles whenever possible, but in no case less than 75 degrees. Low volume streets may form three-way intersections creating an inherent right-of-way assignment (the through street receives precedence) which significantly reduces accidents without the use of traffic controls.
 - ii. Corner radii. The roadway edge at street intersections shall be rounded by a tangential arc with a maximum radius of [15 feet] for local streets and [20 feet] for intersections involving collector or arterial streets. The intersection of a local street and an access lane or alley shall be rounded by a tangential arc with a maximum radius of 10 feet.

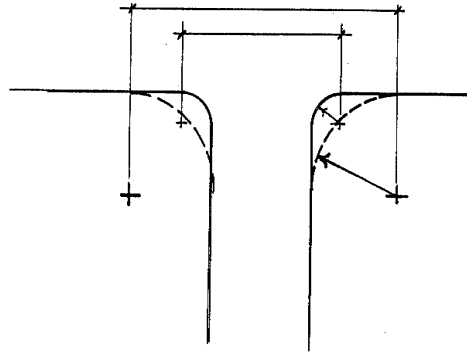


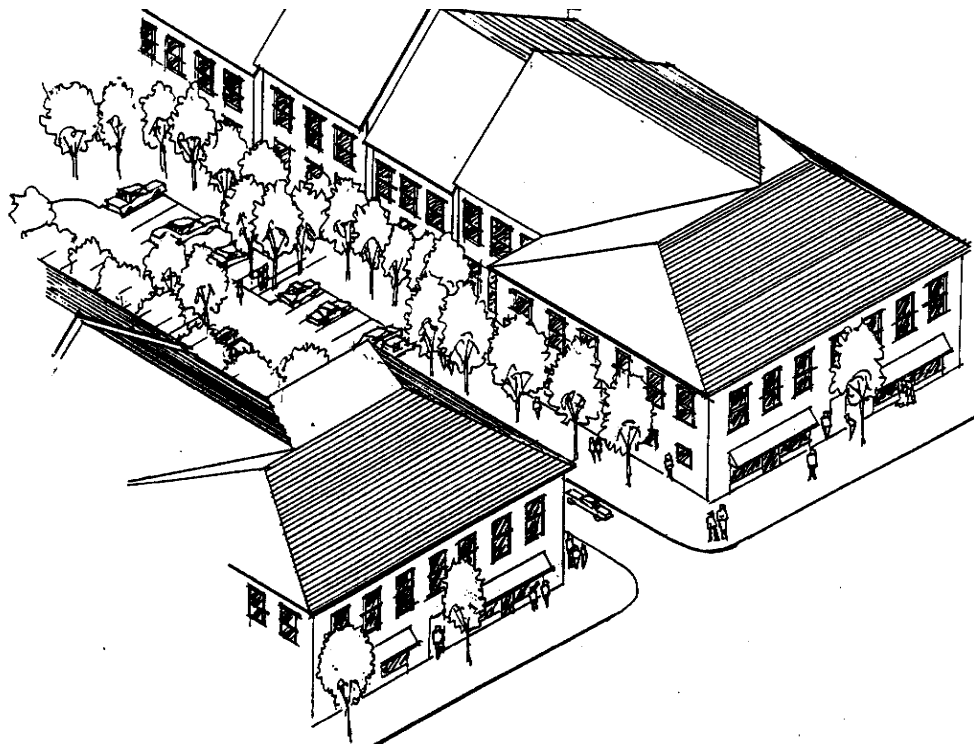
Figure 8. Plan-view diagram of a street intersection. Reducing the radius of street corners slows turning vehicle traffic and shortens pedestrian crosswalks.

- iii. Curb cuts for driveways to individual residential lots shall be prohibited along arterial streets. Curb cuts shall be limited to intersections with other streets or access drives to parking areas for commercial, civic or multifamily residential uses. Clear sight triangles shall be maintained at intersections, as specified below, unless controlled by traffic signal devices:

<u>intersection of:</u>	<u>minimum clear sight distance:</u>
local street and collector	[120 feet]
collector and collector	[130 feet]
collector and arterial	[50 feet]

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- iv. The orientation of streets should enhance the visual impact of common open spaces and prominent buildings, create lots that facilitate passive solar design, and minimize street gradients. All streets shall terminate at other streets or at public land, except local streets may terminate in stub streets when such streets act as connections to future phases of the development. Local streets may terminate other than at other streets or public land when there is a connection to the pedestrian and bicycle path network at the terminus.
- c. Parking requirements. Parking areas for shared or community use should be encouraged. In addition:
 - i. In the mixed use area, any parking lot shall be located at the rear or side of a building. If located at the side, screening shall be provided as specified in section 4.8.
 - ii. A parking lot or garage may not be adjacent to or opposite a street intersection.
 - iii. In the mixed use area, a commercial use must provide one parking space for every [500] square feet of gross building area.
 - iv. Parking lots or garages must provide not less than one bicycle parking space for every [10] motor vehicle parking spaces.
 - v. Adjacent on-street parking may apply toward the minimum parking requirements.
 - vi. In the mixed residential areas, parking may be provided on-site. [One] off-street parking space with unrestricted ingress and egress shall be provided for each secondary dwelling unit.
 - vii. Multi - family uses must provide one parking space for every dwelling unit and [0.5] parking space for each additional bedroom.



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Figure 9. Aerial perspective sketch of a mixed-use area integrating commercial (ground floor) and residential (second story) uses. A relatively narrow gap in the continuous street wall (created by the mixed-use buildings) provides access from the street to a landscaped, pedestrian-friendly parking lot.

- d. Service access. Access for service vehicles should provide a direct route to service and loading dock areas, while avoiding movement through parking areas.
- e. Paving. Reduction of impervious surfaces through the use of interlocking pavers is strongly encouraged for areas such as remote parking lots and parking areas for periodic uses.

4.7 Architectural Standards. A variety of architectural features and building materials is encouraged to give each building or group of buildings a distinct character.

COMMENTARY: A goal of traditional neighborhood development is that it is compact. Compact development in part means the development is designed for the human scale. This emphasis on design includes being sensitive to walking distances, the height of buildings, the design of street lights and signs, sidewalks, and other features.

1. Guidelines for Existing Structures

- a. Existing structures, if determined to be historic or architecturally significant, shall be protected from demolition or encroachment by incompatible structures or landscape development.
- b. The U.S. Secretary of the Interior's Standards for Rehabilitation of Historic Properties shall be used as the criteria for renovating historic or architecturally significant structures.

COMMENTARY: Guidelines for new structures within a Traditional Neighborhood Development must be responsive to the community context. It may be appropriate to conduct an architectural inventory of existing architectural styles in the community and determine which, if any, styles should be replicated.

2. Guidelines for New Structures

- a. Height. New structures within a Traditional Neighborhood Development shall be no more than [3 stories] for single-family residential, or [5 stories] for commercial, multi-family residential, or mixed use.