Report

Traffic Impact Analysis Guidelines

City of

Middleton, WI

March 2005

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City of Middleton, Wisconsin

Traffic Impact Analysis Guidelines

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SECTION 1
GENERAL

1.01 PURPOSE

A Traffic Impact Analysis (TIA) evaluates the adequacy of the existing and planned transportation system to serve future traffic growth and new development. A TIA should address all elements of the transportation system as it relates to pedestrians, bicyclists, transit, vehicular traffic, and adjacent land development. Throughout the TIA process, cooperation between City staff and the applicant is encouraged to provide safe and efficient conditions for public travel.

Prior to the commencement of a TIA, an initial development meeting should be conducted with City engineering and planning staff to establish a communication base between the City and the development applicant. This meeting will provide the City an understanding of the proposed development concept and needs, identify City site development requirements, and define the TIA requirements for the proposed development. It is noted that the Wisconsin Department of Transportation (WisDOT) has TIA requirements that must be followed if a development project has direct access to the State Trunk Highway System. In such cases the initial project meeting should include both state and City officials. The following City TIA Guidelines are generally consistent in analysis procedures to those of the WisDOT with the exception of study analysis type thresholds, multi-modal analysis requirements, and transportation system adequacy credits.

The TIA should be conducted by a licensed professional engineer with experience in traffic engineering studies. For Level 3 and 4 TIAs (see Section 2), preparation by a Professional Traffic Operations Engineer (PTOE) is preferred. The City Engineer will determine when the analysis has satisfied the needs of the City’s TIA requirements.

1.02 REVIEW

Review of TIAs submitted to the City will be undertaken jointly by the City planning and engineering staffs. TIAs for some small developments, and for all medium and large developments, will be reviewed by a PTOE at a consulting firm to be hired by the City. Consulting firms selected by the City for TIA reviews will be identified by City staff based on their experience and cost proposals. TIA review consultants may not have an existing relationship with the developer for which they are conducting the review. The costs for TIA reviews will be based on review proposal costs requested by City staff of qualified engineering firms charged on an estimated hourly basis determined by City staff. The developer will deposit the TIA review fee prior to the start of the City’s review. If in the review process additional study revision reviews or meetings are required, a supplemental deposit will be required by the City.

The development of the TIA requirements for a specific development request is an iterative process starting with the initial staff meeting through the final review. City staff must give final approval before recommendations will be made to the City Plan Commission and/or Common Council. The City reviews will be completed within 20 working days after the City has a review engineer under contract. For roadways under state or county jurisdiction, the City staff review will be completed within 30 working days after the City has a review engineer under contract, unless delayed by state/county review schedules.

SECTION 2
TIA PROCESS

2.01 TIA PROCESS

This section of the City TIA guidelines identifies study analysis requirements, format, and transportation operation requirements.

A. Initial Development Meeting

All proposed developments will be required to prepare a TIA. All TIAs for future developments shall begin with an initial meeting between the developer and City planning and engineering staff. This initial meeting should be requested by the developer as soon as a project concept is under consideration. The developer should not wait until the project has undergone a detailed design before requesting a meeting. Failure to do so could require changes to site access locations and site circulation based upon initial City review comments. The purpose of this meeting is to provide developers with information on City site design, access, and traffic study analysis requirements. Site plans should be of a conceptual nature for this meeting to minimize developer efforts in the preparation of final plans for submittal to the City approval processes. A checklist to be used by a developer for this initial project meeting is located in Appendix A of these guidelines.

B. Study Analysis Types

The content and level of analysis for each of the study types will increase as the potential impact of the development increases. The following trip generation warrants shall be used to determine the level of analysis required for a TIA.

Study Type	Peak-Hour Trips
1. Access Location and Design Review	Less than 50
2. Small Development	50 to 99
3. Medium Development	100 to 499
4. Large Development	Greater than 500

(Subsection E specifies the basis for these trip generation estimates.)

Each of the study types should include the following details:

1. Access Location and Design Review (for developments that generate less than 50 peak-hour trips)

   a. Existing Roadway Geometrics, Traffic Controls, and Traffic Volumes

      The TIA should provide a sketch that shows the roadway and intersection geometry of all roadways and intersections that are adjacent to the development. This sketch should also note the existing traffic controls (stop signs, signals, etc.) for the intersections being depicted. The developer should also provide a schematic of the roadway system that lies directly adjacent to the development along with the estimated daily volumes on those

roadways. The daily volumes for many area roadways are available on the following WisDOT web site:
http://www.dot.wisconsin.gov/travel/counts/maps.htm

b. Planning Level Capacity Analysis of Fronting Roadway

The TIA should contain an estimated daily Level of Service of the roadway adjacent to the development by using the chart contained in Appendix D.

c. Sight Distance Evaluation

The TIA should contain an evaluation of the sight distance available for the development entrance/exit using the methodology described in AASHTO's *A Policy on Geometric Design of Highways and Streets*. The stop-controlled Type B1 and B2 situations should be used. A summary of this methodology is shown in Appendix E. The evaluation should be performed for development street connections with the existing street system. The evaluation should also be performed for internal street intersections if they exist.

d. Access Evaluation: Number and Spacing

The TIA shall show the proposed driveway location and its relationship to other adjacent driveways. Driveways on both sides of the roadway should be shown. This shall be in graphic form and show distances and widths of driveways.

e. Trip Generation

The TIA should provide a general trip generation for the weekday morning and evening peak hour. This trip generation should be based on the most recent edition of the Institute of Transportation Engineers Trip Generation Manual. Appendix C provides some example rates for common land uses as taken from the Trip Generation Manual 7th Edition.

f. Site Circulation Evaluation

The TIA shall contain a site circulation map with arrows that clearly define how entering and exiting traffic and service/delivery vehicles will travel through the site.

2. Small Development (for developments that generate from 50 to 99 peak-hour trips)

   a. All required elements of Access Location and Design Review (above).

   b. Nearby Intersection Ped/Bike LOS Analysis

      The TIA shall determine the Ped/Bike Level of Service at signalized intersections within the influence area of the development. For bicycles and pedestrians, the influence area is generally 600 feet from the development (which is smaller than the motor vehicle influence area.) The methodology for this analysis is described in Appendix G.

   c. Crash History and Analysis

      If the development is adjacent to a roadway or intersection with a high frequency of crashes, as identified by the City Engineer or Police Chief, the TIA shall contain a crash history and analysis. The need for this shall be discussed at the initial development meeting. If a crash analysis is needed, City Engineering will provide a list of crash reports for the study area. The TIA shall diagram the crashes and list possible causes for the crashes. The TIA shall then discuss how the proposed development access will may affect and address the crash potential at this location.

   d. Trip Distribution and Assignment

      The TIA shall schematically show how trips from the development were distributed throughout the study area network. (This is typically shown with arrows and percentages.) The TIA shall also have a diagram that shows the resulting trip assignments (actual trip numbers).

   e. Intersection Operation Analysis

      The TIA shall perform an operations analysis for both the development entrance(s)/exit(s) as well as all intersections within the influence area of the development. The operations analysis shall include delay values for all movements, as well as 95 percentile queues. Highway Capacity Software, Synchro/SimTraffic, Signal2000, or other software approved by the City, shall be used. Two operations analysis shall be performed:

      - Opening year without development
      - Opening year with development

      The two operations analyses shall then be compared to determine the effect of development on traffic operations.

f. Mitigation Analysis for Movements Experiencing LOS D or below

The TIA shall investigate improvement measures for all traffic movements that experience an LOS D or below as a result of the development. The analysis shall be performed using traffic operations software. For movements that experience LOS D prior to the addition of development traffic, the TIA shall investigate improvement measures that maintain traffic operation levels.

3. Medium Development (for developments that generate from 100 to 499 peak-hour trips)

a. All required elements of Small Development Study (above)

b. Future Road Improvements

The TIA shall identify all improvements planned by the City, county, or state for roadways within the study area of the development. The nature of the improvements should be described and considered in the horizon year analyses.

c. Trip Generation of Adjacent Developments that Are Currently Proposed or Reasonably Anticipated

In the operations analysis, the TIA must consider trips from other adjacent planned development. In areas where the adjacent properties are vacant and do not have development planned, the TIA should assume a probable land use based on existing zoning and provide a trip generation for the assumed land uses. These trips shall be added to the background traffic growth.

d. Background Traffic Growth

For the horizon year analysis, the TIA shall account for normal traffic growth on study area roadways. The background growth increase shall be discussed with City staff. A linear regression of historic traffic growth can be used as a basis for the increase; however, area development potential may justify a higher or lower growth increase than what has been observed historically.

e. Future Conditions Operation Analysis of Nearby Intersections

In addition to the two opening year analyses (with and without development), the TIA shall consider traffic operations in the future horizon year. Two horizon year analyses shall be performed:

- Horizon year *without* development, with background and adjacent anticipated development.

- Horizon year *with* development, with background and adjacent anticipated development

The two operations analyses shall then be compared to determine the effect of development on traffic operations. As with the previous TIA level, an improvement (or mitigation) analysis will then need to be performed for traffic movements that fall at or below an LOS D.

f. Effect on Signal Progression

When the study area contains multiple signals that are coordinated, the operations analysis shall use software capable of analyzing progression between the signals. Examples of software include Synchro/Simtraffic, Transyt7f, and Passer.

4. Large Development (for developments that generate more than 500 peak-hour trips)

a. All required elements of Medium Development Study (above)

b. Transportation System Management/Transportation Demand Management Mitigation Measures

The TIA shall contain a section that describes Transportation System Management and/or Transportation Demand Management (TDM) measures that the development will implement to reduce its effect on the transportation system. Examples of TDM measures include staggered work hours, transit subsidies, and carpooling initiatives.

In addition to projected peak-hour trips, other considerations may require a study to be conducted or increase the level of detail required. These considerations will be based on recommendations of the City Engineer and may include:

1. Crash rates: Locations identified by the City Engineer or Police Chief as being high crash intersections or locations.

2. Neighborhood sensitivity to traffic impacts: Areas where the potential exists to increase average daily traffic volumes on neighborhood streets by 15 percent or more.

3. Congestion: Areas of high traffic congestion that are currently operating with peak-period LOS D conditions.

These considerations will be identified by the City Engineer.

C. Impact Analysis Area

The analysis area for each study type varies to reflect the potential geographic area affected by the volume of traffic generated by a development. Smaller developments generally draw local trips, potentially affecting adjacent intersections. Conversely, larger size developments generally draw from regional areas, potentially affecting major arterials, freeway interchanges, and most minor roadways. Study areas for motor vehicle analysis can generally be defined for each study type as follows:

1. Access Location and Design Review

   Adjacent street intersections within 600 feet of site driveway(s) (access points).

2. Small Development

   All major signalized and unsignalized intersections within 2,500 feet of site driveway(s).

3. Medium Development

   All signalized intersections within 1 mile and major unsignalized street intersections within 2,500 feet of site driveway(s).

4. Large Development

   All signalized intersections and freeway ramps and all unsignalized streets within 1 mile of site driveways. The analysis shall also include signalized intersections greater than one mile from the development if the signal is in a coordinated system with other signals in the study area, or if the signal is in a special travel corridor identified by the city.

The study area/influence area for pedestrian/bicycle analyses is smaller and is generally about 600 feet from the development.

D. TIA Horizons

Based on the level of detail required for each TIA study type, it is necessary to define future traffic analysis horizon years. The following horizon years are required for the different study types:

1. Access Location and Design Review

   No detailed operations analysis required.

2. Small Development

   Opening year with full buildout/occupancy.

3. Medium Development

    a. Same as above.
    b. Ten years after full buildout/occupancy, if single-phase project, or five years after last phase is completed, whichever is the longer time period.

4. Large Development

    a. Opening year, plus:
    b. Madison Area MPO traffic forecast long-range plan year.

E. <u>Trip Generation</u>

The major factors determining the amount of traffic that will be generated by a development are its size and land uses. In particular, the type of land use (residential, retail, industrial, office, etc.) will have a significant effect on the amount of new traffic that will be added to the area roadway network and the time(s) of day when it will occur.

The developer should use the Institute of Transportation Engineers (ITE) *Trip Generation Manual*. Trip generation rates or equations published in the latest edition of the ITE *Trip Generation Manual* should be used to estimate site traffic unless individual special studies have been conducted specific to the proposed development or individual company data exists. All sources used shall be referenced. If the source is not from the ITE *Trip Generation Manual*, evidence shall be provided as to their suitability for this particular application. The outcome of the entire traffic analysis can often depend on appropriate trip generation rates. Use of non-ITE rates must be reasonable and defensible.

The trip generation table should be organized in a manner that will be clearly understandable by the author of the report and its readers. The table should identify the following:

- Land use
- ITE code
- Size of development
- Trip rates (in, out, total for peak hours) (two-way–daily)
- Number of vehicle trips generated (in, out, total for peak hours) (two-way–daily)

F. <u>Pass-By and Multi (Linked)-Trip Traffic</u>

When dealing with land uses such as residential projects, office buildings, hotels, and industrial parks, projected site access volumes usually represent the amount of new traffic being added to the area roadway network by those particular uses. However, other land uses–most notably service stations, fast-food restaurants, and smaller shopping centers–attract a large percentage of their traffic from pass-by traffic (traffic already on the adjacent streets), particularly during peak travel periods.

The amount of pass-by traffic does not affect the estimates of the number of trips that will enter and exit a proposed development (site access), which are derived from trip generation rates or equations. However, it does affect the amount of traffic that will be added to the adjacent street system by the new development.

Any assumptions regarding the amount of pass-by traffic attracted to the new development should be clearly stated in the traffic study and accompanied by documentation supporting the percentage of pass-by traffic used in the analysis. The amount of pass-by traffic reduction being used for the analysis should be discussed with City staff at the initial development meeting.

Similarly, not all trips to the development will be for one purpose. Multi (linked)-trips include vehicles that stop at a drugstore, fast-food restaurant, and a service station within the development. Multi (linked)-trips do affect the estimates of the number of trips entering and exiting the proposed development. One entrance and exit may serve two or more trips. Multi (linked)-trips also affect the amount of traffic that will be added to the adjacent street system by the new development.

Any assumptions regarding the amount of multi (linked)-trip traffic attracted to the new development should be stated in the report and accompanied by documentation supporting the percentage of multi (linked)-trip traffic used in the analysis. The amount of linked-trip traffic reduction being used for the analysis should be discussed with City staff at the initial development meeting.

G. Trip Distribution

The developer should discuss proposed trip distribution with City staff at the initial development meeting. Reasons for the proposed trip distribution should also be discussed with staff. Within the TIA, site traffic distributions should be depicted graphically as percentages for each direction of travel. Displaying this information on a map provides the best method of showing the directional distribution of traffic for the development.

2.02 STUDY FORMAT

Each TIA needs to be prepared in a consistent manner to assure that all study requirements are addressed and that elected officials and City staff are familiar with study assumptions, procedures, and conclusions. The content of each TIA will vary based on which of the four study types is being required for the development.

The following general TIA format should be followed. For TIA study types that do not require a certain analysis, such as Future Traffic analysis for Type 1 TIA, that portion of the outline should be omitted.

1. Introduction and Executive Summary
2. Proposed Development Description and Site Plan
3. Existing Area Conditions
    a. Roadway and Transportation System
    b. Area Land Uses
    c. Site Access

4. Development Traffic
    a. Trip Generation and Distribution
    b. Mode Split
    c. Assignment
5. Future Traffic
    a. Background Traffic Growth
    b. Proposed Off-site Development Traffic
    c. Total Traffic
6. Analysis (without proposed roadway improvements)
    a. Existing Conditions
    b. Opening Year Traffic Conditions without Development
    c. Opening Year Traffic Conditions with Development
    d. Future Horizon Year Traffic Conditions without Development
    e. Future Horizon Year Traffic Conditions with Development
7. Improvement Analysis (with proposed roadway improvements)
    a. Existing Conditions
    b. Opening Year Traffic Conditions without Development
    c. Opening Year Traffic Conditions with Development
    d. Future Horizon Year Traffic Conditions without Development
    e. Future Horizon Year Traffic Conditions with Development
8. Bicycle and Pedestrian Levels of Service
9. Findings
    a. Motor Vehicle
    b. Bicycle/Pedestrian
10. Recommendations
11. Technical Appendix
    a. Hourly Traffic County Data
    b. Trip Generation/Assignment Calculations
    c. Printouts of Operational Level of Service Analysis
    d. Pedestrian and Bicycle Level of Service Calculations

For a development that is adjacent to a state highway, the DOT TIA format may be substituted for the outline listed above.

2.03 SITE PLAN

A TIA submittal shall include a development site plan with the following information:

a. Location of site.
b. Layout of development on-site.
c. Driveways and median openings on both sides of streets fronting development.
d. Parking space number and layout.
e. Internal circulation patterns for customers, employees and delivery vehicles.
f. Sidewalks, bicycle facilities, transit stops, traffic controls, speed limits.
g. Site access vision requirements.

2.04 OPERATION REQUIREMENTS

System operation is defined to include motor vehicles, pedestrians, and bicycles. Typically, operation is cited in Levels of Service (LOS) that range from A to F. An LOS A represents excellent operating conditions while an LOS F represents very poor operating conditions. The methodology to determine motor vehicle operation is set forth in the *Highway Capacity Manual* published by the Transportation Research Board. The pedestrian and bicycle Level of Service operation is based on methodologies developed by the City of Charlotte, North Carolina, and is included in Appendix G.

The following paragraphs describe the operational requirements for the City of Middleton.

A. Motor Vehicle Level of Service

In order for the City transportation system to continue to operate safely and efficiently, it is the responsibility of new developments to minimize their traffic impacts on the system. The City goal is to have its transportation system operate at a minimum Level of Service (LOS) C. However, the City recognizes that at some locations on the major arterial roadway system, it may only be economically feasible to achieve Level of Service D. Therefore, the desirable intersection operation for the City's major arterial system is LOS C and the minimum is LOS D. For analysis purposes, this LOS requirement includes each intersection movement, not just the overall average intersection operation. Time periods to be analyzed depend upon the development type and can include existing street morning and evening peak-traffic periods in addition to the peak hour of the generator such as movie theaters and Saturday midday time periods for commercial shopping corridors. The analysis periods should be discussed with City staff at the Initial Development Meeting.

For developments, there are two basic conditions typically encountered that affect transportation operation. The first condition affects intersections that currently, or which will in the future horizon year, operate without development traffic at LOS C or better. Under this condition, new developments are required to prevent degradation of LOS to a lower level. It is the City Engineer's responsibility to determine if LOS C is a feasible goal to maintain or if LOS D is a more appropriate operational goal. The City Engineer shall then make a recommendation to the Board of Public Works for a variance from these LOS requirements for their decision. These variances shall be treated on a case by case basis.

The second condition affects intersections that currently, or which will in the horizon year, operate without development traffic at or below LOS D. Under this condition, the developer is responsible to prevent operational degradation to a lower LOS than currently exists. The developer is responsible for improvements to intersection and site access geometry or control to maintain the stated LOS operation for all motor vehicle movements. Levels of Service descriptions are contained in Appendix F of these guidelines.

B. Pedestrian Level of Service

Pedestrian Level of Service consistency with motor vehicle Level of Service is important. Intersection pedestrian Level of Service follows a similar grading system as used for motor vehicles, ranging from A through F. These service levels relate to the ability of a pedestrian to cross a signalized intersection. Principal pedestrian considerations include number of lanes to be crossed, crosswalk amenities, and traffic control operation. It is noted that conflicts may exist between motor vehicle and pedestrian Level of Service, with priorities to be established by the City engineering and planning staff. The pedestrian Level of Service goals required for different roadways or sections of roadway can vary depending on the adjacent land use context. The following table describes the pedestrian Level of Service requirement based on adjacent land use development.

Land Use	Level of Service
Residential	A
Neighborhood Commercial	A
Business/Office	B
Other	C

Table 2.04-1 Pedestrian Intersection Levels of Service Thresholds

Level of Service descriptions and methodology are contained in Appendix G of these guidelines. Pedestrian Levels of Service shall be calculated at signalized intersections where motor vehicle operation levels are being calculated.

C. Bicycle Level of Service

Bicycle Level of Service consistency with motor vehicle and pedestrian Level of Service is important. Intersection bicyclist Level of Service follows a similar grading system as used for motor vehicles, ranging from A through F. The Level of Service criteria relate to the ability of a bicyclist to cross a signalized intersection. Principal bicycle considerations include number of lanes to be crossed, bicycle lane design, and traffic control operation. Similar to pedestrian Level of Service, the operational goals required for different roadways can vary depending on the context of adjacent land use and consideration of the City’s bike route plan. It is noted that conflicts may exist between motor vehicle and bicycle Level of Service with priorities to be established by the City engineering and planning staff. The following table describes the bicycle Level of Service requirement based on adjacent land use development.

Land Use	Level of Service
Residential	A
Neighborhood Commercial	A
Bike Route	B
Business/Office	B
Other	C

Table 2.04-2 Bicycle Intersection Levels of Service Thresholds

Level of Service descriptions and methodology are contained in Appendix G of these guidelines. Bicycle Levels of Service shall be calculated at signalized intersections where motor vehicle operation levels are being calculated.

SECTION 3
NEIGHBORHOOD TRAFFIC MANAGEMENT

3.01 NEIGHBORHOOD TRAFFIC MANAGEMENT–EXISTING NEIGHBORHOODS

The City of Middleton desires to promote livable neighborhoods that are safe for pedestrians, bicyclists, and motorists. When a TIA indicates that traffic in an existing neighborhood will increase as a result of a new development, the developer will be required to prepare a neighborhood traffic management plan to minimize the effects of neighborhood cut-through traffic.

Most existing neighborhood streets were not designed with traffic management principles. Typical neighborhood traffic complaints relate to speeding traffic and high volumes of cut-through traffic. These complaints occur when there is a perceived increase in traffic volume or speed to an adjacent neighborhood street system. For residential neighborhoods, there are two basic functional street categories. These categories are local and neighborhood collector streets. Local streets provide access to adjacent dwelling units and experience traffic volumes below 800 vehicles per day. Neighborhood collector streets, in addition to providing access to adjacent dwelling units, also serve to collect and feed other neighborhood street network traffic to the community arterial street system. Neighborhood collector streets experience traffic volumes from 3,000 to 5,000 vehicles per day.

The use of traffic0calming devices can reduce neighborhood traffic speeds and cut-through traffic volumes. The retrofitting of neighborhood traffic-calming controls to local and neighborhood collector streets should require neighborhood agreement that a traffic-calming program is an acceptable solution. This consensus is required because traffic calming devices also affect neighborhood resident travel speeds and convenience. A formal procedure for implementing traffic-calming devices in existing neighborhoods is documented in the City of Middleton *Traffic Calming Guidelines*. This procedure must be followed by developers of new residential and/or commercial developments that are expected to increase daily traffic volumes above the local and neighborhood collector street thresholds.

The TIA shall document proposed traffic calming measures and locations. The developer and City staff shall then interact with neighborhood residents to determine if the measures will be implemented. If the neighborhood consensus supports implementation of traffic calming devices, the cost of their implementation will be the responsibility of the developer.

3.02 NEIGHBORHOOD TRAFFIC MANAGEMENT–PROPOSED DEVELOPMENT

One component of neighborhood traffic management is discouraging the overdependence on a few specific streets for neighborhood access. Therefore, connectivity and street continuity are desired in the street layout of new subdivisions. The subdivision layout should minimize the use of cul-de-sacs or discontinuous street layouts. The subdivision layout should provide connections to existing roadways or adjacent developments to the extent possible. Where adjacent properties are undeveloped condition, street stubs for future connections should be constructed. The location of these connections should be discussed with City engineering and planning staff.

Another component of neighborhood traffic management is ensuring that motorists travel at reasonable speeds through neighborhoods. Traffic calming measures should be implemented on new subdivision neighborhood streets that are projected to carry more than 800 vehicles per day (vpd) and may be implemented on other streets. The 800 vpd threshold should account for both the traffic generated from the proposed development along with potential traffic from adjacent developments. Traffic calming measures that horizontally affect vehicle travel, such as road narrowing and traffic circles, are preferred over traffic calming measures that vertically affect vehicles, such as speed tables. Some vertical traffic calming measures may have undesirable noise impacts associated with them, along with introducing potential operational problems for street sweepers, snow plows, and emergency response vehicles. Traffic calming measures to be considered in design can include but are not limited to:

Horizontal Treatments:

- Perimeter (gateway) treatments
- Intermittent road narrowing
- Two-lane angle slow points
- Traffic circles
- Midblock islands
- Overall roadway width

Vertical Treatments:

- Speed tables and raised crosswalks
- Speed humps
- Speed cushions
- Pavement treatments

Figure 3.02-1 illustrates some of these measures.

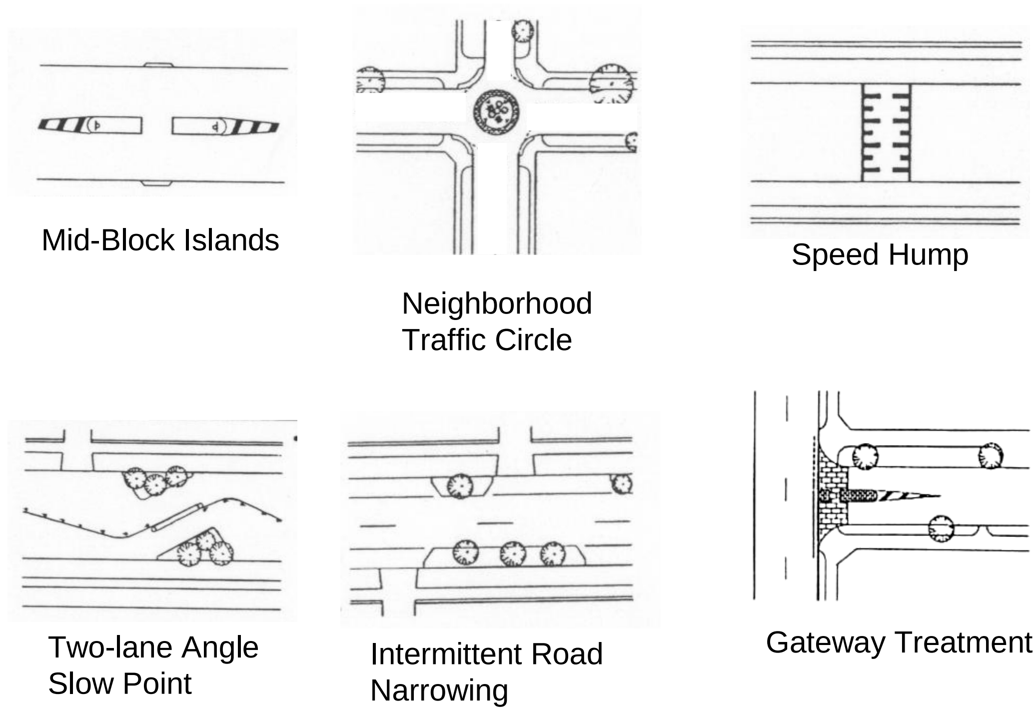


Figure 3.02-1 Traffic Calming Measures

Detailed information on neighborhood traffic calming procedures and tools are contained in the City of Middleton *Traffic Calming Guidelines* and the *Traffic Calming State of the Practice* report published by the Institute of Transportation Engineers.

3.03 TRANSPORTATION SYSTEM ADEQUACY

Transportation system adequacy refers to a combination of transportation and land uses that reduce the need to drive and provide better pedestrian and bicycle accessibility. Convenient transit stops on major streets, interconnected street networks, sidewalks, and connections to bike lanes are considered essential to minimizing dependence on vehicular trip making. Proposed developments may receive trip reduction credits for providing transportation system adequacy improvements for sidewalk connections to specific destinations. These destinations include parks, public institutions such as schools, libraries, transit stops, and other uses identified by the City. Trip reduction credits can also be obtained for street system continuity improvements that reduce circuitous travel within the City.

Studies have shown that interconnected street systems within one-quarter mile of certain destinations can reduce automobile dependence by up to 10 percent. For residential developments, good connectivity is defined by short block lengths of less than 600 feet, sidewalks on both sides of neighborhood streets, multiple street connections between subdivisions, sidewalk connections between cul-de-sacs, and convenient transit stops. When the ratio of the number of street intersections to street segments is greater than 1.4, it reflects that the neighborhood street system is well connected and the developer may use the trip reduction credit.

For commercial developments, good connectivity is defined by parking lot designs that include internal pedestrian pathways and direct connections to neighborhood streets. It is also defined by sidewalks on both sides of the street, convenient transit stops, and the inclusion of bike rack facilities.

A walking credit (2 percent) is obtained if the development has sidewalks on both sides of the street and the sidewalks are constructed according to Middleton ordinances. Also, an extra credit (1 percent) can be obtained if cul-de-sacs are connected with trans-parcel sidewalk connections.

A biking credit is obtained if the development is adjacent to a designated (on or off-street) bike route and the development provides bike racks. For commercial properties, bike racks should be located close to entrances. A bicycle credit can also be obtained by residential developments that have path (off-street) connections to adjacent land uses.

A transit credit is obtained if the development is within one-quarter mile of a transit stop that has a service level of 20 buses per day or more. (Note, the service level applies to one transit stop only and is not additive.)

Table 3.03-1 identifies trip generation rate reductions for developments with good transportation system connectivity.

These trip reductions may be deducted directly from the trip generation in the TIA. The reduction being used should be discussed with City of Middleton staff prior to the submittal of the TIA.

Connectivity	Percent Trip Reduction
Transit	7
Walking	2-3
Biking	2
Street System	5

Table 3.03-1 Transportation System Adequacy Trip Reduction Credits

SECTION 4
GLOSSARY

4.01 DEFINITIONS

Access Management–The control and spacing of access points and median openings to minimize traffic conflicts and reduce crashes.

Background Traffic Growth Rate–The annual rate of change in through traffic on principal off-site streets as determined from historical 24-hour average daily traffic volumes or from MPO transportation/land use projection models.

Crash Analysis–A summary of the three-year crash history at street intersections and along roadway segments. Such analysis typically includes measures to mitigate the impact of site traffic based on safety and crash history.

ITE–Institute of Transportation Engineers.

Level of Service (Motor Vehicles)–A quantitative measure of motor vehicle operating conditions based on such factors as delay, speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

Level of Service (Pedestrians–Bicyclist)–A qualitative measure of perceived comfort and safety based on such factors as traffic conflicts and intersection enhancements.

MPO–Metropolitan planning organization responsible for regional planning functions as it relates to transportation and land use.

Mode Split–The percentage of site-generated trips that utilize various modes of travel to access a site, such as auto, bus, walk, and bike.

Off-Site Development–Development proposals that have been submitted for the City approval process that are within the TIA study area that may increase traffic volumes on the study area roadway network.

Peak Hour–The single hour of a representative day when the traffic volume on a highway represents the most critical period for operation and the highest typical capacity requirements. Usually considered as the hour with the highest volumes of adjacent street traffic or site-generated traffic.

Planning Capacity–General daily capacity of a street segment based on the typical relationship of daily volume to average system peak-hour volume and traffic composition characteristics.

PTOE–Professional Traffic Operations Engineer as certified by ITE.

Queuing Analysis–An analysis of vehicle stacking and required lane storage lengths.

Study Area–The street network and land use area that encompasses the principal intersections, street segments, and new developments of primary concern in traffic impact analysis.

Traffic Control Device–Any sign, signal, marking, or other device placed or erected for the purpose of regulating, warning, or guiding traffic, pedestrians and/or bicyclists.

TIA–Traffic Impact Analysis

Trip Assignment–The assignment of site plus nonsite traffic to specific streets and highways.

Trip Distribution–The allocation of site-generated traffic among all possible arrival and departure routes.

Trip Generation–The number of one-way traffic movements associated with land uses. Factors determining trip generation include use, building size, type of dwelling unit, employees, and land area.

Vehicle Trip–A one-way movement of a vehicle between two points.

APPENDIX A
INITIAL DEVELOPMENT MEETING CHECKLIST

INITIAL DEVELOPMENT MEETING CHECKLIST

1. Area Roadway Map
2. Preliminary Site Plan
3. Development Description
    a. Type of Use
    b. Square Footage or Number of Dwelling Units
    c. Buildout Schedule for Single or Phased Developments
    d. Estimate of Daily and Peak-Hour Trip Generation
    e. Conceptual Site Plan with Site Access Location(s)
    f. Adjacent Development Driveway Locations
    g. Median Opening Locations for Divided Streets
4. Initial Trip Distribution

INITIAL DEVELOPMENT MEETING DISCUSSION TOPICS

1. Type of TIA to be required
2. Analysis periods (AM?, PM?, Weekend Noon?)
3. Intersections to include in analysis
4. Horizon year, background growth factors
5. Pass-by reduction/Linked trip reduction factors and justification
6. System adequacy reduction credits
7. Distribution
8. Acceptable LOS thresholds for intersections studied. (Motor Vehicle, Pedestrian, Bicycle)

APPENDIX B
TYPICAL DEVELOPMENT PEAK-HOUR TRIP GENERATION

TYPICAL PEAK-HOUR TRIP GENERATION

		Size/Number of Land Use Needed to Generate		
Land Use	Units	50 Pk-Hr Trips	100 Pk-Hr Trips	500 Pk-Hr Trips
Residential				
Single-Family	DU	50	100	500
Apartments	DU	80	161	806
Condo/Townhouse	DU	96	192	961
Shopping Center	GSF	13,000	26,000	133,000
Fast Food with Drive Thru	GSF	900	1,800	NA
Gas with Convenience	FP	4	8	NA
Bank with Drive Thru	GSF	1,000	2,100	NA
General Office	GSF	32,000	65,000	322,000
Medical/Dental	GSF	13,200	27,000	NA
Research/Development	GSF	40,000	80,000	403,000
Light Industrial	GSF	51,000	102,000	510,000
Manufacturing	GSF	67,000	135,000	675,000
Home Building Supplies	GSF	NA	40,000	204,000

DU–Dwelling Unit
FP–Fueling Positions
GSF–Gross Square Footage
GFA–Gross Floor Area

Source: Institute of Transportation Engineers Trip Generation Manual, 7th Edition

APPENDIX C
TYPICAL TRIP GENERATION RATES

Land Use	ITE Code	Unit	Wkdy AM Pk Hr Trip Gen Rate	Wkdy PM Pk Hr Trip Gen Rate
General Light Industrial	110	1,000 SF GFA	0.92	0.98
Manufacturing	140	1,000 SF GFA	0.73	0.74
Single Family Detached	210	Dwelling Unit	0.75	1.01
Apartment	220	Dwelling Unit	0.51	0.62
Residential/Condo	230	Dwelling Unit	0.44	0.52
Senior Adult Housing–Attached	252	Dwelling Unit	0.08	0.11
Hotel	310	Rooms	0.56	0.59
Movie Theater	443	Seats		0.07
General Office Building	710	1,000 SF GFA	1.55	1.49
Single Tenant Office Bldg	715	1,000 SF GFA	1.80	1.73
Medical Dental	720	1,000 SF GFA	2.48	3.72
Research and Development	760	1,000 SF GFA	1.24	1.08
Shopping Center	820	1,000 SF GFA	1.03	3.75
Convenience Market	851	1,000 SF GFA	67.03	52.41
Convenience Market with Gas	853	1,000 SF GFA	45.58	60.61
Drive-in Bank	912	Drive-In lanes	19.38	51.08
Bank with Drive Thru	912	1,000 SF GFA	12.34	45.74
Quality Restaurant	931	Seats	0.16	0.30
High-Turnover Sit-Down Restaurant	932	1,000 SF GFA	11.52	10.92
Fast Food with Drive-Thru	934	1,000 SF GFA	53.11	34.64
Gas with Convenience Store	945	Pump	10.06	13.38
Home Improvement Superstore		1,000 SF GFA	1.20	2.45

DU–Dwelling Unit
FP–Fueling Positions
GSF–Gross Square Footage
GFA–Gross Floor Area

Source: Institute of Transportation Engineers Trip Generation Manual, 7th Edition

Note: These planning level trip generation rates are for use with Type 1 or Type 2 (small development) traffic impact studies.

APPENDIX D
APPROXIMATE STREET SYSTEM PLANNING CAPACITIES

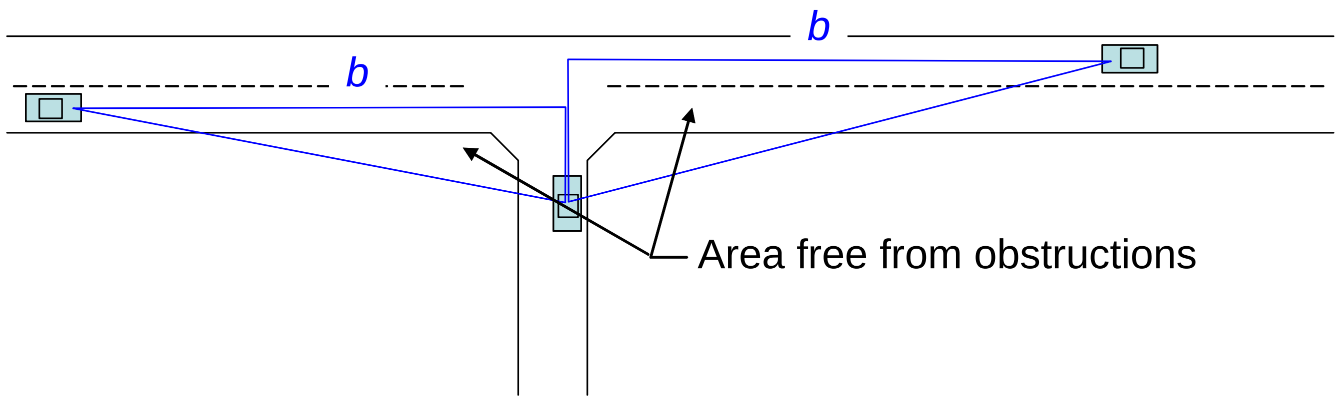
APPROXIMATE STREET SYSTEM PLANNING CAPACITIES

	Level of Service Volume (vpd)	
Roadway Cross-Section	LOS C	LOS D
2-Lane Undivided without Turn Lanes	13,000	15,000
2-Lane Undivided with Turn Lanes	15,000	17,000
4-Lane Undivided without Turn Lanes	17,000	19,500
4-Lane Undivided with Turn lanes	21,000	24,000
4-Lane Divided with Turn Lanes	25,000	29,000
5-Lane with Two-Way Left Turn Lanes	30,000	35,000
6-Lane Divided with Turn lanes	35,000	40,500

Notes: All street cross-sections include on-street parking on both sides.

Table is based on former WisDOT FDM planning values and supplemented by iterative HCS calculations.

APPENDIX E
INTERSECTION SIGHT DISTANCE EVALUATION CRITERIA



Design Speed of Roadway	Intersection Sight Distance for a Passenger Car (Lt Trn)	Intersection Sight Distance for a Passenger Car (Rt Trn)
15	170	145
20	225	195
25	280	240
30	335	290
35	390	335
40	445	385
45	500	430
50	555	480

Intersection Sight Distance, Case B1 and B2, taken from AASHTO Policy on Geometric Design of Highways and Streets 2001

APPENDIX F
MOTOR VEHICLE LEVEL OF SERVICE DESCRIPTION

The *2000 Highway Capacity Manual* (HCM) defines Level of Service (LOS) operating characteristic of roadways and intersections.

LOS describes the operational effectiveness of a roadway. The LOS rating system ranges from LOS A (near ideal with no congestion) to LOS F (oversaturated with substantial congestion).

Intersection LOS is generally used to describe urban roadway operations. It relates to the average delay (in seconds) of all vehicles entering the intersection. Average delay is based on the peak 15-minute period of the peak travel hour. Since this delay is an average value, some vehicles experience substantially greater delay while others experience less delay. Intersections with short average delays have high LOS, while intersections with long average delays have low LOS.

LOS thresholds are different for signalized and unsignalized intersections. Because of driver expectancy and behavior, longer delays are more acceptable at signalized than at unsignalized intersections. For example, drivers at signalized intersections are able to relax during the red interval, while drivers on the minor approaches to an unsignalized intersection must remain attentive to identify acceptable gaps for entry.

The following table describes LOS characteristics for signalized and unsignalized intersections.

LOS	Signalized Intersections	Unsignalized Intersections
A	Describes intersections with very low levels of delay that average less than 10 seconds per vehicle. This condition occurs with extremely favorable signal progression and most vehicles arrive on the green phase of the signal.	Describes intersections with very low levels of delay that average less than 10 seconds per vehicle.
B	Describes intersections with low levels of delay that are more than 10 seconds yet less than 20 seconds per vehicle. This condition generally occurs with short-cycle lengths and/or good signal progression.	Describes intersections with low levels of delay that are more than 10 seconds yet less than 15 seconds per vehicle.
C	Describes intersections with average delays ranging from 20 to 35 seconds per vehicle. Individual cycle failures (waiting through more than one cycle) may appear at this Level of Service. The number of vehicles stopping is also substantial at this Level of Service.	Describes intersections with average delays ranging from 15 to 25 seconds per vehicle.
D	Describes intersections with average delays ranging from 35 to 55 seconds per vehicle. The influence of congestion becomes more noticeable. This Level of Service may result from long-cycle lengths, unfavorable progression and/or high vehicle-to-capacity ratios. Many vehicles stop and the proportion of nonstopping vehicles declines. Individual cycle failures are noticeable.	Describes intersections with average delays ranging from 25 to 35 seconds per vehicle. The influence of congestion becomes more noticeable.
E	Describes intersections with average delays ranging from 55 to 80 seconds per vehicle. Individual cycle failures are frequent occurrences. This Level of Service is considered by most agencies to be the limit of acceptable delay.	Describes intersections with average delays ranging from 35 to 50 seconds per vehicle.
F	Describes intersections with average delays that are more than 80 seconds per vehicle. This Level of Service, considered to be unacceptable by most drivers, often occurs with oversaturation. The number of vehicles entering the intersection exceeds the intersection's capacity.	Describes intersections with average delays that are more than 50 seconds per vehicle. LOS F exists where there are insufficient gaps of suitable size to allow side-street traffic to cross safely through a major street traffic stream. This LOS is usually evident from extremely long total delays experienced by side-street traffic and queuing on the minor approaches.

Source: Highway Capacity Manual 2000

Intersection Level of Service (LOS) Characteristics

APPENDIX G
PEDESTRIAN AND BICYCLE LEVEL OF SERVICE METHODOLOGY

G.01 INTRODUCTION

The following Level of Service (LOS) methodology was developed by the City of Charlotte, North Carolina to assess pedestrian and bicyclist comfort and safety while crossing signalized street intersections. The results can be weighed against motor vehicle LOS to balance user needs and priorities at an intersection. Pedestrian and bicyclist LOS is based on crossing comfort and safety compared to motor vehicle LOS, which is based on driver delay. While delay is a factor to pedestrians and bicyclists, crossings that appear unsafe or imposing result in people avoiding those intersection crossings. Efforts to improve motor vehicle LOS typically include the addition of extra lanes or signal timing enhancements that are generally perceived to negatively affect pedestrians and bicyclists. Resources used to prepare this methodology include FHWA's *Pedestrian Facilities Users Guide*, ITE's *Traffic Control Devices Handbook*, FDOT's *Point Level of Service Report* dated August 2001 and Portland's *Pedestrian Design Guide*. The LOS methodologies for pedestrians and bicyclists are presented as separate analysis techniques since major impediments are different for pedestrians and bicyclists.

G.02 PEDESTRIAN INTERSECTION LOS

A. Signalized Intersection Parameters and Their Relative Importance

The primary impediments to comfort and safety for pedestrians at signalized intersections are crossing distance and conflicts with turning vehicles. Vehicle volumes and speeds are factors as well, but these are tempered by the presence of the traffic signal, its phasing and/or physical characteristics of the intersection. For example, tight corner radii can slow the speed of right-turning vehicles, and right and left turn volume conflicts can be reduced or eliminated by signal phasing. These design factors affect pedestrian's perceived comfort and safety.

This methodology identifies those key elements or features that enhance or reduce pedestrian perceptions of comfort and safety and then weighs them relative to one another by a point system.

B. Key Intersection Parameters

1. Pedestrian Crossing Distance

Crossing distance is the primary crossing obstacle for pedestrians and therefore receives the greatest weight in this methodology–accounting for more than half of all possible points. The shorter distance a pedestrian has to walk to cross a street, the easier and more comfortable it is perceived to be. For example, a crossing distance equivalent to two or three lanes rates a minimum LOS C, exclusive of any other features. By contrast, a crossing of six to seven lanes generally falls in the LOS E to F range, exclusive of any other features. For wide crossings, where there is a greater probability that pedestrians might fail to make it across the entire roadway in the signal time provided, LOS can be improved noticeably if there is a median wide enough to serve as refuge. Crossing distance should be measured along the marked crosswalk, or if unmarked, the assumed path one would take to cross the street. The crossing distance for streets with medians is the total distance to cross the street, including the median width. For streets with right-turn porkchop islands, the crossing distance is that required to reach the far intersection corner minus the distance within the porkchop island.

2. Signal Phasing and Timing

This is the most intricate of the categories and accounts for nearly 20 percent of the total points. It is rated according to the type and level of crossing information provided to the pedestrian and whether the signal phasing minimizes or eliminates conflicts between pedestrians and turning vehicles.

Dedicated left-turn phasing is generally perceived as a benefit to pedestrians if accompanied by pedestrian signals that inform pedestrians when they can cross without a conflict with left-turning vehicles. With a dedicated left-turn signal phase but no pedestrian signal, pedestrians have greater risk exposure because motorists are less likely to yield when they have a green arrow than when they have a solid green ball indication. This situation is viewed negatively.

Right turns are rated according to lane configuration and signal phasing. Points cannot be gained from this subcategory but can be lost if overlap phasing is used and no pedestrian signals are present. Similar to dedicated left-turn phasing, motorists are less likely to yield to pedestrians when they have a green arrow than when they have a solid green ball indication.

Points can be attained by the presence of pedestrian signals, provided vehicle conflicts are reduced and/or information is given by the signals that show pedestrians how much time is available for them to cross the street (countdown signals). Additional points can be obtained by timing the pedestrian phases for slower walk speeds if countdown pedestrian signals are used. Pedestrian phase times based on slower walk speeds without countdown signals are not perceived by pedestrians and therefore do not receive extra points.

3. Corner Radius

A corner radius is rated according to its potential effects on right-turning vehicle speeds and any increased walking distance for the pedestrian. A smaller corner radius will generally lead to slower right-turn speeds and will help minimize the crosswalk distance. Negative points are given for very large corner radii. If the effective radius for right-turning vehicles is significantly larger than the actual radius of the pavement edge (as might be the case where on-street parking is allowed near intersection corners), the effective radius should be considered. For simplicity, no distinction is made between radius distance and its effect on vehicle-turning speeds onto a street with either a single lane or multiple lanes. Also, the effect of intersection angle on vehicle-turning speeds is not directly incorporated into this methodology. Corner radius ranks third for points among the rated intersection features.

4. Right-Turns-On-Red

There are differing views as to the safety benefits of prohibiting right-turns-on-red. Since prohibiting right-turns-on-red eliminates a possible conflict between pedestrians and motorists, its effect is rated. The Right-Turns-On-Red and Crosswalk (below) features each account for 5 percent of the possible points.

5. Crosswalk

The presence and design features of a crosswalk are both rated. Marked crosswalks may help raise awareness to motorists of the possibility of pedestrians crossing the street. Enhanced crosswalks are perceived as being more visible and therefore somewhat more effective than simple transverse markings.

6. Traffic Flow Direction

Points are given to account for situations where there are no left or right turn traffic conflicts, such as for one-way streets or intersections. Note, however, that points are subtracted for the departure leg of a one-way street, if that street intersects with a two-way street. This accounts for the increased risk to pedestrians caused by their exposure to turning traffic for the entire crossing distance of the road, instead of just a portion of the crossing distance (such as is the case for crossing a two-way street).

C. <u>Intersection Features Not Rated</u>

There are several other intersection features which are not rated, that should be considered for pedestrian comfort and safety. Among these features are sight lines, lighting, pavement condition, signing, curb extensions, and ADA features such as accessible ramps and signals. These features are not included in the pedestrian LOS determination in an effort to focus on the major elements previously described.

D. <u>Pedestrian LOS Matrix</u>

The summation of total points for all six intersection pedestrian parameters for a particular intersection approach provides the LOS for that approach. Adding all approach points and dividing by the number of approaches provides the overall intersection LOS. More points equate to a higher LOS.

When applying this methodology, it is important to remember that for a particular intersection approach, the feature being assessed is the one that affects or creates conflicts with the pedestrian crossing. For example, vehicle-turning movements from the street adjacent to the crossing are the turns to be considered. This is true for both right and left turns.

1. Pedestrian Crossing Distance			
Crossing Distance	Typical Number of Travel Lanes	Median Presence	Points
Less than 30 feet	2	None	60
30 feet to 40 feet	3	No median or less than 4 feet	53
41 feet to 52 feet	4	No median or less than 4 feet	42
		Narrow median (4 feet to 6 feet)	45
		Median refuge (6 feet or more)	48
53 feet to 64 feet	5	No median or less than 4 feet	30
		Narrow median (4 feet to 6 feet)	35
		Median refuge (6 feet or more)	43
65 feet to 76 feet	6	No median or less than 4 feet	15
		Narrow median (4 feet to 6 feet)	22
		Median refuge (6 feet or more)	35
77 feet or more	7+	No median or less than 4 feet	0
		Narrow median (4 feet to 6 feet)	10
		Median refuge (6 feet or more)	25

2. Signal Phasing and Timing			
A. Left turn phasing			
A1.	No protected left turn phase	No pedestrian phase	0
A2.	No protected left turn phase	With pedestrian phase	4
A3.	Protected/Permissive phase	No pedestrian phase	-5
A4.	Protected/Permissive phase	With pedestrian phase	6
A5.	Protected/Prohibited phase	No pedestrian phase	-2
A6.	Protected/Prohibited phase	No pedestrian phase w/ dual left turn lanes	-5
A7.	Protected/Prohibited phase	With pedestrian phase	10
A8.	No left-turn conflict	(Tee intersection or one-way)	See Parameter 6
B. Right Turn Traffic (Lane Configuration and Signal Phasing)			
B1.	Shared thru/right lane	No pedestrian phase	0
B2.	Shared thru/right lane	With pedestrian phase	0
B3.	Exclusive right-turn lane No overlap phase	No pedestrian phase	0
B4.	Exclusive right-turn lane No overlap phase	With pedestrian phase	0
B5.	Exclusive right turn lane Overlap phase	No pedestrian phase	-10
B6.	Exclusive right turn lane Overlap phase	With pedestrian phase	0
B7.	Dual right turn lanes No overlap phase	No pedestrian phase	-10

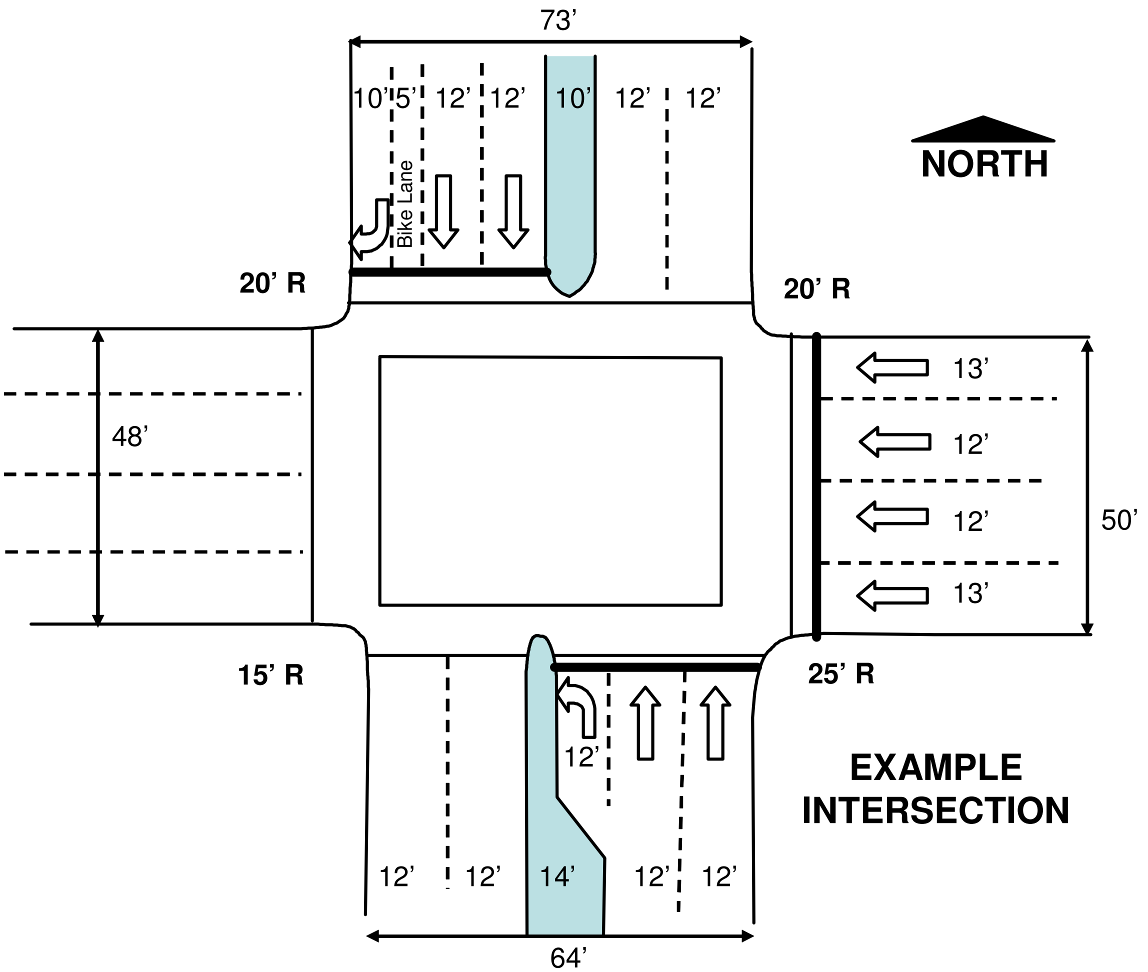
B8.	Dual right turn lanes No overlap phase	With pedestrian phase	0
B9.	Dual right turn lanes Overlap phase	No pedestrian phase	-15
B10.	Dual right turn lanes Overlap phase	With pedestrian phase	0
B11.	No right turn conflict	(Tee intersection or one-way)	See Parameter 6
C. Pedestrian Signal Display			
C1.	Pedestrian phase with conventional style display (walk / flashing don't walk)		0
C2.	Pedestrian phase with countdown display		5
C3.	Leading pedestrian phase (Peds start crossing before vehicles on adjacent street) – Conventional display		4
C4.	Leading pedestrian phase (peds start crossing before vehicles on adjacent street) – Countdown display.		7
C5.	Pedestrian walk speeds 4.0 ft/sec or faster 3.5 ft/sec 3.0 ft/sec		 0 1 2
3. Corner Radius			
A. Radius up to 20’			11
B. Radius of 21’ to 35’			5
C. Radius of 36’ to 50’			0
D. Radius larger than 50’			-5
E. Compound Curve			
E1.	Without Channel Island		-5
E2.	With Channel Island		0
F. Channel Island Slip Lane Design			
F1.	Yield Controlled		2
F2.	Signal Controlled		8
G. No Corner Radius (Tee Intersection)			11
4. Right Turns on Red			
A. Allowed			0
B. Prohibited			5
5. Crosswalk			
A. No Marked Crosswalk			0
B. Marked Crosswalk			
B1.	Transverse markings (perpendicular to traffic flow)		3
B2.	Diagonal/Longitudinal markings (between transverse markings)		5
C. Textured/Colored Crosswalk Surface			5

6. Traffic Flow Direction		
A. Pedestrian Crossing of Two-way Street		0
B. Pedestrian Crossing of One-way Street (or Tee intersection without left/right-turn conflicts)		
B1.	Approach crossing where the only pedestrian/vehicle conflicts are from right-turning vehicles (no left-turn conflicts)	15
B2.	Approach crossing where the only pedestrian/vehicle conflicts are from left-turning vehicles (no right-turn conflicts)	15
B3.	Approach crossing where there are no pedestrian/vehicle conflicts	30
B4.	Departure leg of a one-way street with three or more lanes that intersects with a two-way street (pedestrian exposed to both left- and right-turn vehicle conflicts for entire crossing distance)	-10
B5.	Departure leg of a one-way street with three or more lanes that intersects with a two-way street (pedestrian exposed to both left- and right-turn vehicle conflicts for entire crossing distance), but the left-turn conflict minimized by Protected/Prohibited left-turn phase on the adjacent street, and pedestrian crossing is controlled by ped signals.	-3

Pedestrian LOS based on total points

LOS	**Total Points**
A	84 or greater
B	68-83
C	52-67
D	35-51
E	18-34
F	less than 18

INTERSECTION PEDESTRIAN LOS WORKSHEET–EXAMPLE



Parameters	Approach Crossing			
	Northbound	**Eastbound**	**Southbound**	**Westbound**
1. Pedestrian Crossing Distance	64 feet 5 lanes (4 TH, 1 LT and a 4 foot median)	48 feet 4 lanes (4 shared/TH, no median)	73 feet 5 lanes (4 TH, 1 RT and a 10 foot median)	50 feet 4 lanes (4 shared/TH, no median)
Score	**35**	**42**	**35**	**42**
2. Signal Features:				
2A. Adjacent LT Traffic	No protected turn phase with ped. phase	Dedicated permitted LT phase with ped.	No LT conflict-intersects with one-way	No LT conflict-intersects with one-way
Score	**4**	**6**	**--**	**--**

2B. Right Turn Traffic	No conflict (one-way Street–see Parameter 6)	No conflict (one-way Street- see Parameter 6)	Rt Trn Ln, No overlap, w/ Ped Phase	Shared Right-Thru, w/ Ped Phase
Score	**--**	**--**	**0**	**0**
2C. Pedestrian Signal Display	Ped. phase with countdown signals	Ped. phase with countdown signals	Ped. phase with countdown signals	Ped. phase with countdown signals
Score	**5**	**5**	**5**	**5**
3. Corner Radius	25 feet	15 feet	20 feet	20 feet
Score	**5**	**11**	**11**	**11**
4. Right Turns On Red	No RTOR – one-way street	No conflict – one-way Street	Allowed	Allowed
Score	**5**	**5**	**0**	**0**
5. Crosswalk	Painted markings perpendicular to traffic flow	Painted markings perpendicular to traffic flow	Painted markings perpendicular to traffic flow	Painted markings perpendicular to traffic flow
Score	**3**	**3**	**3**	**3**
6. Traffic Flow Direction	Intersects with one-way street (No RT conflict)	Departure leg crossing one-way street intersects with two-way street (LT not protected)	Intersects with one-way street (no LT conflict)	Approach leg crossing of one-way street (no LT conflicts)
Score	**15**	**-10**	**15**	**30**
Approach Total	**72**	**62**	**69**	**91**
Approach LOS	**B**	**C**	**B**	**A**
Ave Intersection Score	**73**			
Ave Intersection LOS	**B**			

LOS	**Total Points**	**LOS**	**TOTAL POINTS**
A	84 or greater	D	35-51
B	68-83	E	18-34
C	52-67	F	less than 18

INTERSECTION PEDESTRIAN LOS–BLANK WORKSHEET

Parameters	Approach Crossing			
	Northbound	Eastbound	Southbound	Westbound
1. Pedestrian Crossing Distance				
Score				
2. Signal Features:				
2A. Adjacent LT Traffic				
Score				
2B. Right Turn Traffic				
Score				
2C. Pedestrian Signal Display				
Score				
3. Corner Radius				
Score				
4. RTOR				
Score				
5. Crosswalks				
Score				
6. Traffic Flow Direction				
Score				
Approach Total				
Approach LOS				
Ave Intersection Score				
Ave Intersection LOS				

LOS	Total Points	LOS	TOTAL POINTS
A	84 or greater	D	35-51
B	68-83	E	18-34
C	52-67	F	less than 18

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G.03 BICYCLE INTERSECTION LOS

A. General

The major impediments to the comfort and safety of bicyclists at signalized intersections are somewhat different than those for pedestrians. Traffic signal features, potential conflicts with turning vehicles, and a desire for physical space in the roadway (separation from automobile traffic lanes) are prominent issues for bicyclists, with intersection crossing distance playing a minor role. Since bicyclists share space with, and travel alongside motor vehicles, the speed of traffic is also a factor.

The key parameters of signalized intersections that enhance or reduce the perceived comfort and safety of bicyclists are identified and assigned points according to how well they meet the objectives.

B. Key Intersection Parameters

1. Signal Phasing and Timing–Features that remove potential vehicular left-turn conflicts from the path of bicyclists and features that place bicyclists before motorists (in time and space) are rated as desirable. Signal phasing and timing accounts for 40 percent of the possible points.

2. Roadway Space for Bikes–Bicycle travel space, separated from the outside vehicular travel lane, is viewed as highly desirable. Marked bike lanes are the preferred method of accommodating in-street bike operations. There is a difference of opinion among bicyclists concerning the desirability of wide outside travel lanes (13 to 14 feet) compared to standard width travel lanes (10 to 12 feet). Because wide outside travel lanes provide extra clearance between bicyclists and motorists, this methodology rates wide outside lanes as better than standard lanes. Ratings are assigned according to how space is allocated in advance of the intersection (approach leg) as well as how it is allocated beyond the intersection (departure leg). This feature accounts for 30 percent of the possible points.

3. Right-Turn Conflict Treatment–This parameter addresses the potential conflict involving motorists turning right and bicyclists traveling straight ahead at an intersection approach. The preferred method of resolving this conflict is for bicyclists to use the traffic lane if it is shared with traffic, or if there is a separate right turn lane, motorists should merge right with bicyclists that are traveling straight ahead. Points are awarded if there is no right-turn conflict with motorists. If there is a conflict, either no points are awarded or points are taken away, depending on whether the bicyclist or motorist is required to merge.

4. Approach Speed of Traffic–As previously mentioned, vehicular traffic speeds affect bicyclist's comfort and safety. For simplicity, the posted speed limit is used as a measure.

5. Right-Turns-On-Red–This is another potential source of conflict between bicyclists and motorists. Bicyclists can easily appear to blend into the background when a motorist is looking to turn right on red because motorists are often looking for larger vehicles.

6. Intersection Crossing Width–Crossing distance is a less important factor for bicyclists than for pedestrians, but the risk of exposure in an intersection is worthy of rating.

C. <u>Intersection Features Not Rated</u>

There are several other intersection features which are not rated that should be considered for bicyclist safety and comfort. Among these features are sight lines, roadway lighting, pavement condition, and street signing. To obtain meaningful results, a limited number of primary features are rated. Rating too many features dilutes the results and tends to make features nearly indistinguishable in their relative importance.

D. <u>Bicycle LOS Matrix</u>

Adding the points of all six parameters for a particular intersection approach yields the LOS for that approach. Adding all approach points and dividing by the number of approaches yields the overall intersection LOS. More points equate to higher LOS.

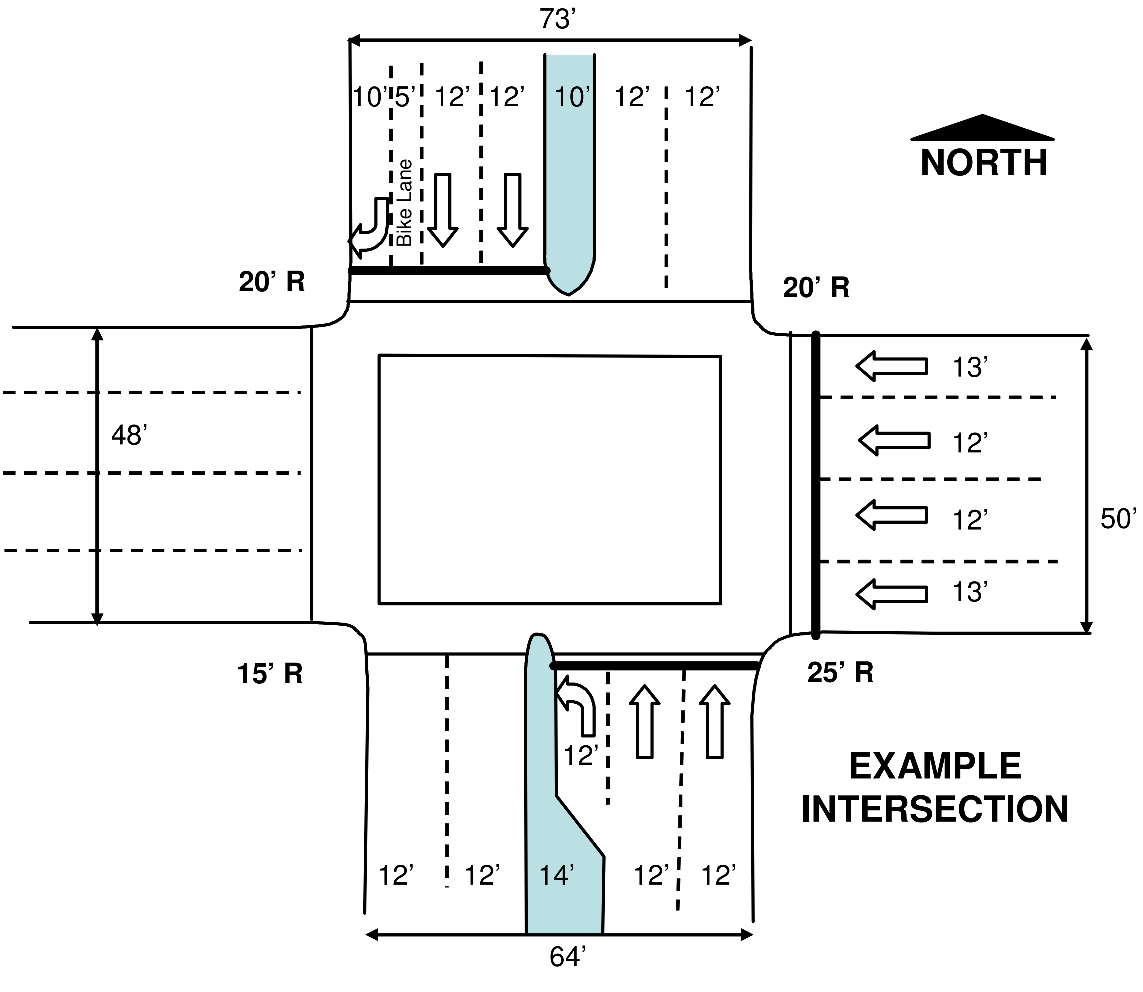
1. Signal Phasing and Timing	**Points**
A. Bicycle Phase	
A1. No leading bicycle phase	0
A2. Leading bicycle phase (cyclists given green seconds before other traffic – requires bike display, bike lane, and bike detection)	12
B. Signal Timing	
B1. Green and yellow clearance time based on vehicular speeds	0
B2. Green and yellow clearance time based on bicycle speeds	6
C. Stop Bar Location	
C1. Shared stop bar (motorists and bikes at common point)	0
C2. Advanced stop bar or bike box (bikes stop closer to intersection than motorists)	10
D. Vehicular Left Turn Phases (opposing cyclists)	
D1. None	0
D2. Leading Protected/Permissive	6
D3. Protected/Prohibited	12
D4. No left turn conflict (Tee intersection or one-way)	15

2. Roadway Space for Bikes		
Approach Leg	**Departure Leg**	
Ride in vehicle travel lane (roadway 12 feet or less in width)	Ride in vehicle travel lane Ride in widened outside lane Ride in bike lane or shoulder (4 feet min)	0 10 15
Ride in widened outside lane (roadway 13 to 14 feet wide)	Ride in vehicle travel lane Ride in widened outside lane Ride in bike lane or shoulder (4 feet min)	10 20 25
Ride in bike lane or shoulder (4 feet min. width)	Ride in vehicle travel lane Ride in widened outside lane Ride in bike lane or shoulder (4 feet min)	15 25 30
3. Right Turn Conflict Treatment		
A. No right turn conflict (Tee intersection or one-way)		15
B. No separate vehicular right turn lane		0
C. Separate vehicular right turn lane		
C1. With bike lane to left of vehicular right turn lane (Figure 9c-3 of 2000 MUTCD)		0
C2. No bike lane		-5
C3. Curb lane drops as vehicular right turn lane with bike lane to left of vehicular right turn lane (Figure 9c-4 of 2000 MUTCD)		-10
C4. Curb lane drops as vehicular right turn lane, no bike lane		-15
C5. Bike lane to right of vehicular right turn lane		-25
4. Approach Speed of Traffic (85th percentile speed if known, otherwise posted speed limit)		
A. High Speed (45 mph or more)		-15
B. Moderate Speed (35-40 mph)		0
C. Low speed (30 mph or less)		15
5. Right Turns On Red		
A. Allowed		0
B. Prohibited		5
6 Intersection Crossing Width		
A. Less than 36 feet (typically up to 3 travel lanes)		10
B. 37 feet to 60 feet (approximately 5 travel lanes)		5
C. Greater than 61 feet (approximately 6+ travel lanes)		0

Bicycle LOS based on total points

LOS	**Total Points**
A	84 or greater
B	68-83
C	52-67
D	35-51
E	18-34
F	less than 18

INTERSECTION BICYCLE LOS–EXAMPLE WORKSHEET



Parameters	Approach Crossing			
	Northbound	**Eastbound**	**Southbound**	**Westbound**
1A. Signal Phasing/Timing Features	No leading bicycle phase	Not applicable (one-way street)	No leading bicycle phase	No leading bicycle phase
Score	**0**	**--**	**0**	**0**
1B. Signal Timing	Based on auto speeds	--	Based on auto speeds	Based on auto speeds
Score	**0**	**--**	**0**	**0**
1C. Stop Bar Location	Vehicles and bikes at same location	--	Vehicles and bikes at same location	Vehicles and bikes at same location
Score	**0**	**--**	**0**	**0**

1D. Opposing Vehicle Left Turn Phases	No left-turn conflict	--	Protected/Permissive	No left-turn conflict
Score	**15**	**--**	**6**	**15**
2. Bike Space on Street (Approach/Departure Leg)	Auto travel lane to auto travel lane: 12 foot outside lane		Bike lane to auto travel lane: 12 foot outside lane	Widened auto travel lane to 12 foot auto travel lane
Score	**0**	**--**	**15**	**10**
3. Right-Turning Traffic Conflict: Shared traffic lane/Separate right-turn lane	No right turn conflict (intersects with one-way street)		Separate right-turn lane that drops, bike lane according MUTCD	Shared TH/right-turn lane- no bike lane
Score	**15**	**--**	**-10**	**-5**
4. Speed of Intersection Approach	35 mph		35 mph	35 mph
Score	**0**	**--**	**0**	**0**
5. Right Turn on Red	Allowed		No right-turn conflict (intersects with one-way street)	Allowed
Score	**0**	**--**	**5**	**0**
6. Intersection Crossing Distance	50 feet		48 feet	73 feet
Score	**5**	**--**	**5**	**0**
Approach Total	**35**	**--**	**21**	**20**
Approach LOS	**D**		**E**	**E**
Ave Intersection Score	**25**			
Ave Intersection LOS	**E**			

LOS	Total Points	LOS	TOTAL POINTS
A	84 or greater	D	35-51
B	68-83	E	18-34
C	52-67	F	less than 18

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INTERSECTION BICYCLE LOS–BLANK WORKSHEET

Parameters	Approach Crossing			
	Northbound	Eastbound	Southbound	Westbound
1A. Signal Phasing/Timing Features				
Score				
1B. Signal Timing				
Score				
1C. Stop Bar Location				
Score				
1D. Opposing Vehicle Left-Turn Phases				
Score				
2. Bike Space on Street (Approach/Departure Leg)				
Score				
3. Right-Turning Traffic Conflict: Shared traffic lane/Separate right-turn lane				
Score				
4. Speed of Intersection Approach				
Score				
5. Right-Turn-on-Red				
Score				
6. Intersection Crossing Distance				
Score				
Approach Total				
Approach LOS				
Ave Intersection Score				
Ave Intersection LOS				

LOS	Total Points	LOS	TOTAL POINTS
A	84 or greater	D	35-51
B	68-83	E	18-34
C	52-67	F	less than 18