Wisconsin
Statewide Speed Management Guidelines

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Developed by the Wisconsin Department of Transportation
Bureau of Highway Operations, Traffic Engineering Section
4802 Sheboygan Ave., Room 501
P.O. Box 7910
Madison, WI 53707-7910

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Introduction

The purpose of this document is to provide uniform guidelines for the establishment or adjustment of speed zones on Wisconsin's state highways and local roads. The application of uniform guidelines will move the Wisconsin Department of Transportation (WisDOT) toward its goal of setting rational speed limits throughout the state based on sound traffic engineering principles as recommended in the Wisconsin Strategic Highway Safety Plan 2006–2008. The guidelines will also promote a consistent study methodology and provide a uniform speed study reporting format, allowing for efficient review of speed studies by state or local authorities. Numerous transportation professionals throughout the state are charged with providing and operating a safe and efficient roadway system. The consistent application of rational speed management procedures is vital in maintaining motorist safety and efficiency on the system.

Background on Speed Limits

Policy makers, transportation professionals, and law enforcement agencies use speed limits to convey the maximum permitted travel speed for a roadway under ideal conditions to motorists. Setting reasonable travel speeds, also called *rational* speed limits, has the greatest effect on achieving voluntary driver compliance. High rates of speed limit compliance promote mobility, because traffic flows more efficiently when vehicles move uniformly at the highest reasonable speed. High rates of compliance also promote safety by increasing the number of motorists traveling at or near the same speed. When the speed differential is high, it is more likely that crashes will be more severe, cause more property damage, and result in more injuries.

Wisconsin State Statutes Section 346.57(4) defines speed limits for all public roadways based on factors that include surrounding land use, roadway jurisdiction, and roadway type. These speed limits, referred to as *statutory* speed limits, are summarized in Table 1.

Speed Zones

While state statute establishes speed limits for roadways, Section 349.11 also gives state and local governments administrative authority to change the speed limit on a roadway. The statute vests WisDOT with authority to modify speed limits on the state trunk highway (STH) system and local governments with authority to modify speed limits on the local road system within constraints.[1] The changed speed limit is called a *modified* speed limit, and the segment of roadway that exhibits the modified speed limit is called a *speed zone*. Speed zones may be appropriate where land use, access, traffic volumes, or crash history call for a change from the statutory speed limit. Table 1 summarizes state and local government authority to establish speed zones.

[1] The statute vests WisDOT with approval authority over proposed changes to speed limits on the local road system that are outside the constraints identified in Table 1.

Table 1
Speed Limits and Authority to Change

Fixed Limits – Statute 346.57(4)[a]	**Local Government Authority[b] – Statute 349.11(3) and (7)[a]**
65 mph – Freeway / Expressway	WisDOT only.
55 mph – State Trunk Highways (STHs)	WisDOT only.
55 mph – County Trunk Highways (CTHs), town roads	Lower the speed limit by 10 MPH or less.
45 mph – Rustic roads	Lower the speed limit by 15 MPH or less.
35 mph – Town road (1,000’ min) with 150’ driveway spacing	Lower the speed limit by 10 MPH or less.
25 mph – Inside corporate limits of a city or village (other than outlying district)	Raise the speed limit to 55 mph or less. Lower the speed limit by 10 mph or less.
35 mph – Outlying district[c] within city or village limits	Raise the speed limit to 55 mph or less. Lower the speed limit by 10 mph or less
35 mph – Semi-urban district[d] outside corporate limits of a city or village	Raise the speed limit to 55 mph or less. Lower the speed limit by 10 mph or less.
15 mph – School zone, when conditions are met	Raise the speed limit to that of the roadway. Lower the speed limit by 10 MPH or less.
15 mph – School crossing, when conditions are met	Raise the speed limit to that of the adjacent street. Lower the speed limit by 10 MPH or less.
15 mph – Pedestrian safety zone with public transit vehicle stopped	No changes permitted.
15 mph – Alley	Lower by 10 MPH or less.
15 mph – Street or town road adjacent to a public park	Lower by 10 MPH or less.
Construction or maintenance zones, as appropriate[e]	State and local agencies have authority to establish.

Notes:

(a) Source: Updated 2007-2008 Wisconsin Statutes Database

(b) All speed limit changes **shall** be based on a traffic engineering study, including modifications allowed under State Statute. Local governments can implement speed limit changes on the local road system without WisDOT approval when proposals are within the constraints identified above.

(c) Per Statute 346.57(1)(ar) “outlying district” is an area contiguous to any highway within the corporate limits of a city of village where on each side of the highway within any 1,000 feet buildings are spaced on average more than 200 feet apart.

(d) Per Statute 346.57(1)(b) “semiurban district” is an area contiguous to any highway where on either or both sides of the highway within any 1,000 feet buildings are spaced on average less than 200 feet apart.

(e) Guidance on establishing speed limits in work zones is available in TGM 13-5-6.

Modified from original found in WisDOT Traffic Guidelines Manual, Chapter 13-5-1, Figure 1, June 2009.

Standard Language

In this guidance, the verbs **shall** and *should* are used consistent with national and WisDOT guidelines, including the Federal Highway Administration (FHWA) Manual on Uniform Highway Control Devices (MUTCD), WisDOT Facilities Development Manual (FDM), and WisDOT Traffic Guidelines Manual (TGM). Use of the verbs is characterized as follows:

1. **Shall** - a statement of required, mandatory, or specifically prohibitive practice regarding performing a speed study or modifying a speed limit. The verb shall consistently appears in bold type.
2. *Should* - a statement of recommended, but not mandatory, practice in typical situations, with deviations allowed if engineering judgment or engineering study indicates the deviation to be appropriate. The verb should consistently appears in unbold, italicized type.

Context of Potential Speed Zones

Effective speed zones are established relative to their surroundings. A number of factors contribute to a roadway's context, including physical, geographic, and political conditions. Physical conditions form the driving environment, which is the main influence on motorist speed. The physical attributes of a roadway that significantly influence vehicle speeds include:

- Traffic characteristics such as total traffic volume, truck percentage, turn movement volumes, and local versus regional traffic
- Characteristics of roadside development such as type of land use, density, and development's lateral offset from the roadway
- Roadway design elements including number of lanes, shoulder, clear zone widths, and presence of horizontal and vertical curves
- Roadway pavement condition
- Access characteristics including number, type, and design of roadway and driveway intersections
- Presence of on-street parking adjacent to travel lanes
- Presence of bicycles or pedestrians on, along, or crossing the roadway
- Level of maintenance such as snow and ice removal

A roadway's posted speed limit and its physical attributes communicate to a great extent the driving experience that motorists should expect. But geography also contributes to this perception, including the location of the roadway within rural or urban settings. For example, the statutory speed limit on freeways is 65 mph. But on some freeways passing through urban areas, WisDOT has established speed zones with 55 mph speed limits to account for more lanes, narrower shoulders and clear zones, more closely spaced interchanges, and higher traffic volumes when compared to typical freeways in rural areas. Urban settings vary from dense urban core; urban fringe; suburban area; or small, isolated urban land development (less than 1/4- to 1/2-mile long) located within an otherwise rural setting. Together, the physical attributes and the geographic location of a roadway (urban or rural) support a driver's expectation of a reasonable speed limit.

Although physical and geographic attributes provide elements of speed zone context, political conditions can also significantly contribute to speed limit determination. Political conditions are largely set by interested stakeholders. It is important for analysts to inform stakeholders and seek their support throughout the speed study process. For freeways, which carry Interstate highway and state trunk highway (STH) designations, WisDOT, including the State Patrol, and the Federal Highway Administration (FHWA) are generally the primary stakeholders as local governments do not have direct access to the freeway. For non-freeways, which carry STH, county trunk highway (CTH), local road, and urban street designations, WisDOT, local governments, traffic safety commissions, and local law enforcement are generally the primary stakeholders.

Assessing Need for a Speed Zone or for Modification

In order for a state or local authority to establish or modify a speed zone along a roadway, a speed study **shall** be performed that evaluates need for a speed zone or for modification of an existing speed zone. The process for completing a speed study **shall** be the same for both state and local authorities; however, it is acknowledged that specific details of the process may occasionally differ by jurisdiction, depending on factors such as time constraints, resources at-hand, and budget limitations.

The following text presents the process by which a speed study **shall** be performed and recommends data collection procedures and required documentation. Essentially, the speed study process consists of applying the six steps listed below:

1. Identify and inform stakeholders.
2. Collect location-specific data.
3. Analyze data and develop study conclusions.
4. Develop speed zone recommendations.
5. Report draft results, conclusions, and recommendations.
6. Seek stakeholder support.

Step 1: Identify and Inform Stakeholders

Requests for speed studies originating outside of WisDOT for STHs or the local authority for local roads *should* come through a mayor or other elected executive, appointed official, government body[2], or a Traffic Safety Commission and be submitted in writing. WisDOT or the local authority **shall** evaluate the request and use it in identifying primary

[2] WisDOT regions contacted directly by state or national legislators *should* notify and coordinate with the WisDOT Bureau of Highway Operations, Traffic Engineering Section.

stakeholders. If study is not warranted, WisDOT or the local authority **shall** inform primary stakeholders in writing of this finding and provide supporting rationale.

If study is warranted, WisDOT or the local authority **shall** inform primary stakeholders before the speed study is initiated, but **shall** minimize bias in the data collection effort by avoiding disclosure of specific study dates or times. WisDOT or the local authority *should* take the opportunity to brief decision-makers early in the speed study process, especially when the study area includes local roads or driveway access and passes through local jurisdictions. Briefings *should* include how recommendations are developed and how they will be communicated as the study concludes. WisDOT or the local authority *should* coordinate with municipal and county officials, such as engineers, public works directors, and law enforcement, to access their local knowledge and identify vital information, especially in crash analysis, as the information may affect recommendations resulting from the speed study.

Step 2: Collect Location-Specific Data

The objective of a speed study is to assess whether the speeds at which motorists travel along a stretch of roadway appropriately relate to the existing physical and geographic environment. State and local speed zone studies **shall** collect the following location-specific data:

- Vehicle speeds
- Crash data for the preceding three to five years including crash location, light/weather/pavement conditions, type of crash, and contributing factors such as speed
- Roadway geometrics including lane width and pavement condition, shoulder width and condition, and sight distances
- Traffic control and posted speed limits in, and in close proximity to, the study area
- Land uses including type of development and intensity and access points from adjoining parcels, lots, or fields onto the roadway
- Official functional classification of the roadway, which indicates how the road is intended to function in the overall state and local highway system. Classifications include principal arterial, minor arterial, collector and local road. Interstates and most routes in the Wisconsin STH system are designated principal arterials. Major local roadways and some routes in the STH system are designated minor arterials, with other important local roads and a few STH routes designated collectors. Other local roads are classified as local roads. [3]
- Practical function of the roadway, which indicates the analyst's perception of the actual function of the roadway within the state and local highway system

[3] Additional information on functional classification is available in the FHWA Functional Classification Guidelines (http://www.fhwa.dot.gov/planning/fcsec1_1.htm) or by contacting WisDOT Regional offices.

The above-mentioned data is required for all speed studies. Supplemental observations may also help in establishing a fuller understanding of current traveling conditions in the study area. Therefore, the speed study *should* also include, but is not limited to, the following information if pertinent:

- Presence of conflicts with parked vehicles, pedestrians, and bicycles in the study area
- Proximity to schools
- Current level of speed enforcement in the study area

Data Collection Guidelines and Considerations

The data collection process is the foundation of the speed study. Speed observations collected properly with minimal motorist detection will provide a better representation of vehicle speeds in the study area and will lead to more valid study conclusions and recommendations. For this reason, an unmarked car is recommended, and the speed data collection device should be located as inconspicuously as possible. Several issues regarding the physical and environmental conditions of the speed zone study area *should* be taken into account before collecting speed data. These considerations include:

- Day and time to perform the speed study
- Study location
- Observer location and position
- Data sample characteristics

When a speed study is performed, regardless of the data collection method applied, a standard operating procedure *should* be followed to ensure that the sample set of data collected represent vehicles traveling at uninterrupted, free-flow speeds. In doing so, an accurate representation of vehicle speeds within the speed zone study area will be depicted. The following outlines the recommended procedure that *should* be followed when performing a speed study:

- The speed study *should* be performed during non-peak traffic conditions on a typical weekday (usually a Tuesday, Wednesday, or Thursday), when motorists are likely to be traveling at uninterrupted speeds. Speed studies conducted during peak commuter times, unique events, weekends, or holidays may unintentionally capture more variable travel characteristics. These variable traffic conditions may impede vehicles from operating at their typical free-flow speeds due to congestion or platooning. In addition, the speed data *should* be collected during daylight hours and favorable weather conditions to reflect typical driving behavior.

  In certain cases, though, speed concerns on a particular roadway do involve adverse weather or peak traffic volume conditions (e.g., school startup and release times, shift changes at major employment centers, or corridors with numerous points of commercial access). In these cases, it would be appropriate to conduct a speed study under these conditions to observe vehicle speeds during these unique situations.

- Speed data *should* be collected away from factors that might influence vehicle speeds, such as railroad crossings, intersections, horizontal and vertical curves, and work zones. The location of the speed study *should* avoid speed limit transition areas and active pedestrian and on-street parking areas as motorist awareness is heightened, which may influence their free-flow speeds.

- Regardless of the data collection device being used, safety **shall** be the first priority when the observer or technician is performing this task. Although the amount of human interaction in collecting speed data varies by device, the observer or technician **shall** not be placed in a situation where their safety or that of passing motorists is in question.

- Speed data for the speed study is typically collected by recording the speeds of free-flowing vehicles using a speed-measuring device. A representative sample of speeds is recorded, which include local residents, commuters, and regional traffic. To assist in obtaining accurate speed measurements, the observer or speed-measuring device *should* be inconspicuous to the observed traffic so unusual driver behavior does not skew data.

- Whenever possible, a minimum sample size (number of observations) for a speed study *should* not be less than 100 vehicles per lane per direction to provide an accurate representation of vehicle speeds within the study area[4] (e.g., a total of 200 vehicles for a roadway with one lane in each direction, or 400 vehicles total for a roadway with two lanes in each direction). For roadways classified as "Very-Low Volume Local Roads",[5] the minimum sample size *should* not be less than 30 vehicles (e.g., 15 vehicles per direction on a two-lane roadway). If the analyst anticipates that a sample of 30 vehicles cannot be collected within a reasonable amount of time, the submitting party **shall** request approval to use a smaller sample size from the agency with jurisdiction over the roadway. Data can be collected over multiple weekdays (typically a Tuesday, Wednesday, or Thursday), as discussed previously.

- When an observer is gathering speed data, vehicle headway (the time between successive vehicles) of four to six seconds *should* be present for reliable speed observations. Measurements collected with smaller headways may not reflect free-flow conditions, as the lead vehicle may influence the speed of the vehicle(s) behind it.

- A minimum of one hour **shall** be the minimum amount of time to perform a speed study.

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[4] Wolfgang Homburger, Jerome Hall, William Reilly, and Edward Sullivan. *Fundamentals of Traffic Engineering, 15th Edition.* Institute of Transportation Studies, University of California-Berkeley, 2001.

[5] ADT of less than 400, as defined in AASHTO *Guidelines for Geometric Design of Very-Low Volume Local Roads,* 1st Edition, 2001.

Avoiding Bias in Sampled Data

When an observer collects speed measurements using a hand-held speed-measuring device, the observer *should* collect speed data by randomly selecting vehicles to measure, without bias toward certain vehicles that may be encountered. The following are examples of situations that *should* be avoided so as to not skew the study results:

- *Fast or slow vehicles.* Avoid favoring vehicles that are perceived by the observer to be going fast or slow relative to the rest of the vehicle stream.
- *Platoon leaders or followers.* Avoid favoring vehicles that are the lead car in a platoon, also called platoon leaders, or vehicles that are immediately behind the lead car in a platoon, known as platoon followers.
- *Trucks and buses.* Avoid favoring observation of trucks and buses. Because of their prominent size, trucks and buses may be favored for observation and may operate at speeds which are different than passenger cars.

In each of these situations, collecting a disproportionate number of these vehicles may create a bias toward higher or lower speeds in the sample. To avoid these biases, the observer *should* consider randomly selecting vehicles to measure, or measure every '*n*th' vehicle when traffic volumes allow. Speed data collected from trucks and buses *should* be analyzed separately from passenger vehicle data.

Data Collection Methods

An analyst or agency can use a variety of data collection devices. These devices can be grouped into three categories, which for these purposes, are based on the location that the speed data collection device is installed:

- Manually-operated, handheld devices that are portable and can be used in most places (e.g., stopwatch, radar gun, and laser gun).
- In-road devices that are installed into or on top of the roadway surface (e.g., pneumatic road tube).
- Out-of-road devices that are installed overhead or to the side of the roadway surface (e.g. radar recorders).

Each device has distinct advantages and disadvantages for collecting and analyzing data that may factor in determining the appropriate device to use for a particular location. The analyst or agency *should* make a concerted effort to use devices that incorporate the most advanced data collection technologies available to them. In doing so, a more accurate representation of vehicle speeds can be obtained while minimizing observer-related biases. Table 2 summarizes several common speed data collection techniques and the following section describes the methodologies and processes for each one.

Table 2
Comparison of Data Collection Methods

Method	Data Collected	Labor Involvement	Equipment Costs [1]	Advantages	Disadvantages
Radar Recorders	Instantaneous speed, traffic volumes, vehicle class, traffic flow gaps [3]	Low	High	Little labor required to collect and tabulate data: Can collect data for long periods of time; Other traffic-related data may be collected at the same time; Can be used when snowplows may be present without risk of damage; Less visible to traveling public than road tubes	User cannot randomly select vehicles for data set; Some devices may not accurately collect data for multi-lane roadways and/or determine directionality of observed vehicles; Equipment-intensive method; Maintenance/calibration required
Pneumatic Road Tube	Instantaneous speed, traffic volumes, vehicle class, traffic flow gaps [3]	Low	Medium	Little labor required to collect and tabulate data; Can collect data for long periods of time; Other traffic-related data may be collected at the same time	Visible to traveling public which may change driver behavior; User cannot randomly select vehicles for data set; Use discouraged when snowplows may be present; Most equipment-intensive method; Maintenance/calibration required
Laser Gun	Instantaneous speed	Medium	High	Equipment is easily portable; User controls vehicles sampled as a more focused laser beam limits the number of readings for non-target vehicles as compared to radar	Cosine error limits horizontal/vertical deployment; Scopes and sights may not be user-friendly; Laser beams more sensitive to environmental variances than radar; Maintenance/calibration required
Radar Gun	Instantaneous speed	Medium	Medium	Equipment is easily portable; User controls vehicles sampled; Accurate data collection method; Widespread equipment availability has lowered its cost	Cosine error limits horizontal/vertical deployment; Closely-spaced and larger vehicles may create readings for non-targeted vehicles; Maintenance/calibration required
Stopwatch [2]	Travel time over a distance	High	Low	Little equipment to purchase and maintain; Easy to perform data collection process	Labor-intensive; Collects time data that needs to be converted to speed data; Typically low accuracy

1 Equipment costs reflect the initial purchasing costs of the equipment and not future maintenance and calibration costs
2 The stopwatch method **shall not** be utilized in State-sponsored studies or studies that involve roadways under the jurisdiction of WisDOT.
3 The amount of additional data collected varies for each device, please consult the device's user manual for a better understanding of its capabilities.

Current Data Collection Methods

The following describes data collection methods that use current technologies to accurately collect speed data while minimizing driver awareness of the device and associated observer-related biases. When performing a speed study, it is recommended that the high-technology devices be considered first for deployment to capture vehicle speed data.

Radar Recorders

Methodology. Radar recorders use the Doppler principle to obtain vehicle speeds. This is performed by a module that emits radar or microwave energy that reflect off of moving vehicles. The device collects the returning waves and uses them to generate an instantaneous measurement of speed.

Equipment. Radar recorders typically are constructed as pole-mounted modules that are affixed to a signpost, utility pole, or overhead sign. In addition, law enforcement speed boards also use radar technology that can function as data collection devices; however, the speed limit visual display **shall** be turned off so motorists do not alter their speeds because of the speed board.

Process. The analyst secures the radar recorder to a fixed object outside the traveled way based on the device's user manual (for speed boards, it should be parked well off the traveled way to avoid motorist collision). The radar recorder is left to collect data for a predetermined period of time and then is collected from the field. Data collected by the recorder is downloaded to a computer for further analysis.

Advantages/disadvantages: Radar recorders provide the least labor-intensive method, only requiring a technician to install and remove the module or speed board. Because of this, many of the observer-related errors that may occur with other methods are eliminated. Radar recorders can collect data for long periods of time, and some recorders also include software that can tabulate traffic volumes and distinguish vehicle classes. Because radar recorders are installed outside of the traveled way, they are not readily noticeable to the traveling public (as previously mentioned, it is recommended that the visual display of a radar speed board be turned off to increase its inconspicuousness). Radar recorders measure speed data for all vehicles that pass through the capture zone, which may include vehicles that are not traveling at free-flow speeds. Dependent on the device, some radar recording devices cannot accurately collect speed data along multi-lane roadways due to device limitations. Furthermore, some radar recorders are unable to distinguish directionality of observed vehicles. Because radar recorders rely on equipment to perform the data collection task, they require more maintenance and calibration to uphold its accuracy.

Pneumatic Road Tube Method

Methodology. The pneumatic road tube method uses a set of pneumatic road tubes that are attached to an electronic counter with air-sensitive switches. When a vehicle passes over a road tube, the pressure created in the tube actuates a switch in the counter. The amount of time it takes to receive actuations from the two tubes is then converted into an instantaneous speed measurement.

Equipment. The pneumatic road tube method is performed using two road tubes and a recorder, devices to attach and secure the road tubes to the roadway and the counter to a fixed object for security, and a measuring tape.

Process. The analyst installs the road tubes on the roadway surface, spaced at a specified length based on the counter's user manual. The road tubes are then attached to the counter and the counter is secured to a fixed object (e.g. tree, sign post, or light pole) so it will not be tampered with or stolen. The counter and road tubes are left to collect data for a predetermined period of time and then are collected from the field. Data collected by the counter is downloaded to a computer for further analysis.

Advantages/disadvantages: The pneumatic road tube method possesses many of the same advantages and disadvantages that can be found by using radar recorder devices. Pneumatic road tubes require little labor to collect speed data, eliminating observer-related errors. Pneumatic road tubes can collect data for long periods of time, and some traffic counters also include software that can tabulate traffic volumes and distinguish vehicle classes. Pneumatic road tubes measure speed data for all vehicles that pass over them, which may include vehicles that are not traveling at free-flow speeds. This method also relies on equipment to perform the data collection task and, therefore, requires more maintenance and calibration to uphold its accuracy.

Unlike radar recorders, though, some pneumatic road tube traffic counters can be configured to collect the directionality of observed vehicles with only one device, provided a median is present to store the traffic counter. In addition, some traffic counters can be configured to collect data along multi-lane roadways. However, pneumatic road tubes are more visible to the traveling public, which could influence driver behavior as they cross them. Pneumatic road tubes are also discouraged for winter-time use due to the affect of cold weather on counter performance and the potential for snow plows to damage the road tubes and/or counter. Installation and removal of the pneumatic road tubes requires the analyst to work within the traveled way, raising safety concerns and potentially conflicting with the traveling public.

Other Data Collection Methods

Other data collection methods are also available for use in collecting vehicle speeds. These methods range from labor-intensive because they require an observer to collect the data (i.e., Laser Gun, Radar Gun, or Stopwatch) to more technologically advanced (e.g., devices that emit microwave or infrared beams). The labor-intensive methods may be more viable for agencies with limited resources to purchase or borrow radar recorder or pneumatic tube technologies, or with limited resources to hire outside data collection services.

Laser Gun Method

Methodology. The laser gun technology uses laser beams to obtain vehicle speeds. Similar to the radar gun, a handheld device (or 'gun') emits a laser beam that reflects off of moving vehicles. The device collects the returning beams and converts the amount of time for the beam to emit and return into an instantaneous speed measurement.

Equipment. The laser gun method is performed using a laser gun, a mounting device (if applicable), and data collection forms.

Process. An observer 'shoots' the laser gun at approaching vehicles and records the speed data transmitted by the laser gun on the data collection form. The speed data is then processed for further analysis.

Advantages/disadvantages. The laser gun possesses many of the advantages for use like the radar gun; however, unlike the radar gun, the laser gun emits a concentrated beam of light, which enables the observer to target exactly those vehicles he/she wishes to collect speed data and not inadvertently receiving speed data from non-targeted vehicles. The laser gun also possesses many of the limitations of the radar gun, such as tolerance, maintenance, and calibration.

Because the laser gun uses laser beams to collect data, the observer must target vehicles using a scope and sights attached to the device, which may not be as user-friendly as radar guns. Furthermore, laser-light beams are more sensitive to climate conditions, such as precipitation and humidity, which may interfere with readings.

Radar Gun Method

Methodology. The radar gun method uses the Doppler principle to obtain vehicle speeds. This is performed by a handheld device (typically called a 'gun') that emits radar or microwave energy that reflect off of moving vehicles. The device collects the returning waves and uses them to generate an instantaneous measurement of speed.

Equipment. The radar gun method is performed using a radar gun, a mounting device (if applicable), and data collection forms.

Process. An observer 'shoots' the radar gun at approaching vehicles and records the speed data transmitted by the radar gun on the data collection form. The speed data is then processed for further analysis.

Advantages/disadvantages. Technologically, the radar gun method is one of the most accurate ways to measure vehicle speeds. The radar gun is portable and can be mounted to a vehicle or tripod for use. Radar guns allow the observer to collect and distinguish speed data from vehicles traveling in both directions of the roadway. The observer *should* consult the reference manual of the radar gun before application to determine the device's effective range and tolerance. One particular tolerance, known as cosine error, limits the horizontal and vertical location an observer can be positioned relative to the roadway. Because beams from the gun are emitted in the shape of an inverse funnel, the speeds of non-targeted vehicles may be transmitted due to the distance of non-targeted vehicles and the targeted vehicle as well as the amount of reflective surface each vehicle possesses. As with most data collection devices, the radar gun requires maintenance and calibration to ensure accuracy.

Stopwatch Method

Methodology. The stopwatch method measures the time a vehicles takes to pass between two points of a known distance. From the time data collected, speed can be calculated.

Equipment. The stopwatch method is performed using a stopwatch (or similar time-measuring device, such as certain electronic traffic count boards), a measuring tape or wheel, a data collection form, and posts or other objects to use as starting and ending reference points (if necessary).

Process. The observer first uses the measuring tape or wheel to establish a known length of roadway. The start and end points of this roadway section are then delineated using posts or other objects placed away from the traveled lanes that can be identified by the observer (existing objects in the field such as pavement cracks, utility poles, and trees can suffice as well). The observer then measures the amount of time vehicles take to travel from the start to end points and records it on the data collection form. After a sufficient number of time data records have been collected, the analyst converts the time data into speed data for further analysis.

Advantages/disadvantages: The stopwatch method can usually be performed without purchasing additional equipment, reducing costs for the purchase and maintenance of speed-collecting devices. While the stopwatch method is relatively simple to perform, it is also the most labor-intensive to conduct due to the setup of the study area and conversion of time data into speed data. The stopwatch method includes numerous factors that must be considered to ensure accurate data collection.

Additional Technologies

Speed data collection may be performed using other methods. The "floating car" or "pacing" method relies on an observer physically driving through the study area while following random vehicles, noting speed or time data of the random vehicle. This technique is more commonly used for travel time and delay studies where space-mean speeds are of greater concern. Other methods gaining popularity in larger cities and state transportation agencies involve out-of-road devices that emit microwave or infrared beams to count and measure vehicle speeds. Finally, devices such as inductive loops can be installed under the roadway surface. When vehicles pass through the loop's electrical field, recorders note the speed of vehicles passing over them. This methodology requires extensive installation time and costs and is, therefore, not recommended for use on speed zone modification studies.

As previously mentioned, each device and technique has its distinct advantages and disadvantages for collecting and analyzing speed data, and it is up to the analyst or agency to select the most appropriate data collection method for a particular location. It is recommended that the analyst use the most technologically advanced data collection method available to them to gather an accurate representation of vehicle speeds. For state-sponsored speed studies and speed studies performed on a section of roadway that is part of the state trunk highway (STH) network, devices that use radar, laser, and microwave technology as well as pneumatic road tubes are appropriate data collection methods; the stopwatch method **shall** not be used to collect speed data for these particular studies. The stopwatch method may be used occasionally for speed studies on local roadways and streets by agencies that do not have access to more sophisticated data collection options.

Step 3: Analyze Data and Develop Study Conclusions

After location-specific data has been collected, it *should* be analyzed and serve as the basis for study conclusions and recommendations. A report template is available in Attachment A and electronically on the WisDOT Web site at http://dotnet/dtid_bho/extranet/manuals/index.shtm. Based on the data collected in Step 2 and consistent with the report template, state and local speed studies **shall** analyze the data and report the following study conclusions:

- *85^{th} percentile speed.* The 85^{th} percentile speed is the speed at or below which 85 percent of the observed traffic travels. The 85^{th} percentile speed has been found to best represent the "reasonable" and "proper" speed perceived by motorists and is a key characteristic of traffic conforming to a "safe" and "reasonable" speed limit. While 15 percent of the observed motorists travel above the perceived "reasonable" and "proper" speed, studies have shown that this group of motorists causes many of the vehicle crashes along roadways. This is also the group at which enforcement action is most effectively targeted. Studies have also indicated that the lowest risk of being involved in a crash occurs when motorists travel at approximately the 85^{th} percentile speed[6].

- *Pace speed.* The pace speed is a range of speeds that covers the highest number of observations from the data set. The pace speed **shall** be generated using a ten-mile per hour range.

- *50^{th} percentile speed.* The 50^{th} percentile speed (also known as the median speed) is the speed at which 50 percent of the observed traffic traveled at or below that speed.

- *Design speed of the roadway (if it is known).* The design speed is the speed limit for which engineering elements of the roadway were designed to accommodate (e.g. roadway and shoulder width, curve radii, and superelevation). Often times the design speed of state trunk highways is 5 mph higher than the posted speed limit. When the design speed is not known, it can be estimated based on elements of the horizontal and vertical alignment.[7]

- *Speed distribution.* Two distribution methods are used to analyze speed data: frequency distribution and cumulative frequency distribution. Frequency distribution compares speed versus the number of observed vehicles traveling at a particular speed. A frequency curve presenting this data will illustrate the modal speed (speed most frequently observed) as well as the pace. Cumulative frequency distribution compares speed to the number of vehicles or percentage of the sample traveling at or less than a particular speed. A cumulative frequency curve presenting this data will illustrate percentile speeds.

- *Proportion of vehicles exceeding existing speed limit.* This statistic reports compliance with the existing posted speed limit and current driver expectation in the proposed speed zone. This data may be useful in building an argument for or against a change to the existing posted speed limit.

- *Significance of secondary roadway attributes*. Attributes such as presence of long turning queues, large volumes of trucks, large volumes of regional traffic, driveways and intersections, sight distance, on-street parking, pedestrian and bicycle activity, as well as pavement condition, level of law enforcement, and divergence between functional classification and practical function play a significant role in driver expectancy and vehicle speeds along a roadway. The analyst *should* note when secondary roadway attributes are significant and which attributes are present.

- *Crash data analysis.* The speed study conclusions **shall** also include an analysis of crash data for the past three to five years, indicate if a safety concern exists, and provide the number and percentage of crashes for which speed was a contributing

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[6] *Speed Zoning on Texas Highways*. State Department of Highways and Public Transportation, Austin, Texas, 1990.

[7] For example, design speed of the curves (an element of horizontal alignment) and stopping sight distance (an element of vertical alignment) are often suitable estimates for overall design speed.

factor. The conclusion **shall** report a crash rate for the roadway segment being studied, the comparable statewide average[8], and key contributing factors such as speed, the driver's physical condition (e.g. chemical impairment, sleeping, age, and seat belt use), weather, and time-of-day the crash occurred.

Attachment A includes a copy of the WisDOT speed study data analysis and reporting template. The template is available electronically for use in both state and local speed studies on the WisDOT Web site at

http://wisconsindot.gov/Pages/doing-bus/local-gov/traffic-ops/manuals-and-standards/manuals.aspx.

Step 4: Develop Speed Zone Recommendations

After vehicle speed and location-specific data has been analyzed, the analyst **shall** use it to develop and support the speed zone recommendations. It is important for the analyst to note that study conclusions may indicate a speed zone is not needed. A recommendation **shall** be developed for the speed study indicating whether conditions warrant a need to modify the speed limit of the studied section of roadway. For a change in the speed limit to be effective, it *should* accomplish the following:

- Reduce the speed differential of vehicles using the highway.
- Be a reasonable speed so the majority of drivers will comply voluntarily.
- Reflect consistent application of traffic engineering principles and guidelines.

Decisions regarding the potential change in a speed limit *should* be based on the objective findings of the speed study and on conditions that exist at the time of the evaluation. Modified speed limits *should* not be installed to address the following conditions:

- Response to noise complaints
- Accommodation of specialty vehicles that use the roadway
- Future growth anticipated in the area
- Anticipated law enforcement of the roadway
- Future concerns that have not previously occurred
- Correction of spot safety or operational problems.

A recommendation **shall** be made in the speed study that identifies whether the speed limit should change or remain the same. Any recommendation made in the speed study *should* relate to improving motorist and bystander safety along the route, reference findings from the crash data analysis, and suggest additional study if a safety problem is discovered where speed is not a primary contributing factor.

[8] Statewide average crash rates are available in Traffic Operations Manuals Library.

Recommending a Speed Limit Change

When the analyst establishes that a modified speed limit should be proposed, the study recommendations **shall** include two parts: the proposed speed limit and a definition of the proposed speed zone. The process for developing recommendations for each part is outlined below.

Setting the Speed Limit

When a modified speed limit is proposed as a result of a speed study, several factors **shall** be considered in the process of developing the speed limit recommendation.

- The number of speed limit changes along a route *should* be minimized and changes *should* made in significant increments. For speed zones outside of incorporated cities and villages, speed limit changes *should* be made in increments of 10 mph, though increments of 5 mph are permissible when justified. Within incorporated cities and villages, an increment of 5 mph *should* be implemented.
- The proposed speed limit *should* be set within 5 mph of the observed 85th percentile speed of free-flowing traffic.[9] It is widely accepted that speed limits set at unrealistic levels above or below the 85th percentile speed have little impact on a driver's choice of speed.[10] In addition, the lowest risk of being involved in a crash occurs at approximately the 85th percentile speed.[11] [12] [13]
- Highways that serve predominantly regional or statewide traffic, including by-pass highways and roadways on the urban fringe, *should* have higher speed limits in rural or urbanizing areas than in urban commercial or residential-core areas. These highways *should* also have speed limits at or closer to the 85th percentile speed as compared to roadways that serve predominantly local traffic.
- All recommended modifications to posted speed limits **shall** be within the range allowable by Wisconsin statute (see Table 1) or **shall** gain approval from WisDOT.

While the 85th percentile speed is a starting point for the speed limit proposal, the analyst *should* ensure a full range of factors is considered when developing the recommendation. For example, close correlation between design speed, operating speed, and the posted speed limit is desirable. Research also indicates that crash rates go down when posted speed limits are within 10 mph of the mean speed. Determining the pace is another valuable tool when considering a speed limit recommendation. A normal distribution

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[9] *Manual on Uniform Traffic Control Devices.* Federal Highway Administration. Washington, D.C., 2003. Section 2B.13.

[10] *POLICY RESOLUTION PR-5-93, TITLE: The National Statutory Speed Limit*. American Association of State Highway Transportation Officials (AASHTO) Board of Directors. April 19, 1994.

[11] *Speed Zoning on Texas Highways* State Department of Highways and Public Transportation. Austin, Texas, 1990.

[12] *Speed Zoning Information: A Case of "Majority Rule"*. Institute of Transportation Engineers. http://www.ite.org/standards/speed_zoning.pdf.

[13] Publication FHWA-RD-98-154: *Synthesis of Safety Research Related to Speed and Speed Management.* Federal Highway Administration. Washington, D.C., 1998.

curve would include approximately 70 percent of observed vehicles within the pace with approximately 15 percent of observed vehicles below the pace and 15 percent of observed vehicles above the pace. Typically, the 85th percentile speed is at or near the upper limit of the pace.

Several factors other than the posted speed limit influence the 85th percentile free-flow operating speed. These factors include access density, median type, parking along the street, and pedestrian activity level. When the analyst concludes and documents that significant secondary roadway attributes like these exist, the factors may call for a proposed speed limit that is significantly lower (greater than 5 mph) than the 85th percentile speed. The 50th percentile operating speed rounded to the nearest five-mile per hour increment may be a suitable alternate recommendation. However, the analyst *should* acknowledge that speed limit changes based on secondary roadway attributes rather than observed speeds may have several negative effects, including those listed below:

- Higher financial cost due to the need for increased enforcement to ensure driver compliance.
- Potential for increased crashes due to larger variability in vehicle speeds.
- Mistrust of highway and enforcement officials and potential disregard for other speed limits, because motorists do not readily perceive the need for lower speeds.

In this case, the analyst *should* also recommend that changes to the physical environment accompany the speed limit change as well as consideration of public outreach efforts aimed at reducing speeds using educational and enforcement initiatives. Potential changes to the physical environment range from installation of pedestrian zone or other warning signs to installation of engineering countermeasures including those that modify the roadway itself such as adding sidewalks or consolidating access. A comprehensive discussion of traffic calming measures is available from the Institute of Transportation Engineers (ITE);[14] it is generally not recommended to use traffic control devices such as stop signs or traffic signals as tools for controlling speeds.

These situations are unique and **shall** be reviewed by WisDOT Bureau of Highway Operations (BHO) on a case-by-case basis, when WisDOT review is required, to aid in developing consistent, rational speed limit recommendations throughout the state. WisDOT encourages local authorities to review these situations on a case-by-case basis as well and to work toward establishing speed limit consistency for similar circumstances within their jurisdiction. In all cases, speed zoning modifications *should* be coordinated with adjacent jurisdictions.

The process for developing a speed limit recommendation involves many factors and is often complicated. The Federal Highway Administration (FHWA) has developed an expert, Web-based system to aid in the process called USLIMITS[15], with version 2.0

[14] ITE Traffic Calming Web Site: http://www.ite.org/traffic/
[15] FHWA USLIMITS 2.0: http://www2.uslimits.org

available without cost as of publication of this document. The application provides a speed limit recommendation after the user inputs location-specific data pertaining to the physical environment, speed data, and crash history. Analysts *should* consider using the tool as a starting point in the development of any revised speed limit recommendation.

Defining the Speed Zone

The analyst must recommend a physical length for the speed zone in addition to the modified speed limit. It is recommended that the length of the speed zone *should* be at least 0.3 miles to allow for more uniform and realistic speed limits, especially on roadways that carry large traffic volumes through various roadside conditions or numerous communities.

Transitional Speed Zones

Generally, it is not recommended to establish *transitional* or *step-down* speed zones. Transitional speed zones are typically less than 0.3 miles in length and are intended to provide an opportunity for drivers to step down their speed when approaching zones with lower speed limits. Research suggests that drivers may not reduce their speed to the posted transitional speed limit on the basis of signage alone.[16]

A transitional zone *should* be considered if the physical characteristics of the roadway change, such as a rural roadway section with ditches that transitions to a urban section with curb and gutter and minimal driveways and then to an urban section with a significant number of driveways. Transitional zones may also be appropriate in cases where a rural highway enters a community with outlying districts.[17] The analyst or agency *should* consider no more than two transitional zones on a given section of roadway and they *should* be considered only when the 85th percentile speed shows need for them.

Recommending No Speed Limit Change

When study conclusions indicate the posted speed limit should not be changed, the analyst/agency *should* provide alternatives that the responsible jurisdiction can use to respond to the identified issues and concerns, including, but not limited to, noise, specialty vehicles, spot safety problems, or spot operational problems. Alternatives such as traffic calming, roadway design modifications including modifications to roadway cross-section, access control, or other changes to the physical environment may alter vehicle speeds. . A comprehensive discussion of traffic calming measures is available from the Institute of Transportation Engineers (ITE);[18] it is generally not recommended to use traffic control devices such as stop signs or traffic signals as tools for controlling speeds. The analyst may want to recommend the completion of additional study as well as consideration of public outreach efforts aimed at reducing speeds using educational and enforcement initiatives.

[16] Eric D. Hildebrand, Andrew Ross, and Karen Robichaud. "The Effectiveness of Transitional Speed Zones." *ITE Journal.* October 2004.
[17] Refer to Wisconsin State Statute 346.57 (1) for the definition of outlying districts.
[18] ITE Traffic Calming Web Site: http://www.ite.org/traffic/

Step 5: Report Draft Results, Conclusions, and Recommendations

Each speed study **shall** be accompanied by a cover letter and worksheets documenting study data, conclusions, and recommendations. A report template is available in Attachment A and electronically on the WisDOT Website. These documents supply the reviewer with adequate information about the physical and operational characteristics of the roadway and its surroundings and support a comprehensive review of the speed zone request. In addition to the worksheet and cover letter, the following elements *should* be included as part of the speed zone request:

- Discussion of the reason or reasons for a recommended speed change
- A map depicting the limits of the proposed speed zone and the existing speed zone if present
- Crash history when it bears on the recommendation
- Speed study data to illustrate percentile speeds and the pace (Attachment A includes a copy of the tabulation template that is available electronically on the WisDOT Web site).
- Site photographs of each location where speed readings were taken and, whenever possible, an aerial photograph of the proposed speed zone
- Highway photo log files of the proposed speed zone when the change is recommended on a state highway
- Documentation of any support or opposition from local units of government, particularly where existing speeds are to be altered

<u>The submitting party **shall** also provide an explanation whenever requested information is omitted</u>. These processes will support the efficient review of and response to recommendations.

Step 6: Seek Stakeholder Support

After the study's draft results, conclusions, and recommendations have been developed, WisDOT or the local authority **shall** share them with primary stakeholders (e.g., WisDOT, including the State Patrol, FHWA, local governments, traffic safety commissions, and local law enforcement). WisDOT or the local authority *should* take the opportunity to gather feedback and generate support for study findings by presenting results and answering questions from decision-makers about the speed study process. The outreach *should* include study results, conclusions, and recommendations, as well as the process used to develop the recommendation.

Procedure for Roadways in the State Trunk Highway System

The final stages of stakeholder involvement also include gaining required approvals for the recommendations. The approval process for speed limit modifications proposed by WisDOT on the STH system consists of one to three reviews.

1. The region's approval authority may sign the approval portions of the submittal cover letter and declaration if the recommended speed limit falls within 5 mph of the measured 85th percentile speed and no more than 2 mph below the measured 50th percentile speed, or is increased to the statutory speed limit of the roadway.
2. If the recommended speed limit does not meet these criteria, the region **shall** submit the cover letter, accompanying worksheets, and any supplemental information identified in Step 5 above to the State Traffic Safety Engineer within the WisDOT Bureau of Highway Operations (BHO), Traffic Engineering Section. The State Traffic Safety Engineer reviews the submittal, consults with the regions regarding questions or clarifications, and may sign the approval portions of the submittal cover letter and declaration if no sensitive recommendations are made.
3. For submittals containing sensitive recommendations, the State Traffic Safety Engineer reviews the findings with the State Traffic Engineer before approval.

The WisDOT BHO **shall** respond to the region in writing with their decision. If a speed zone request is denied, BHO **shall** provide an explanation of the reasons for denial.

Procedure for Other Roadways

The approval process for speed limit modifications proposed by local authorities on the local system consists of one to four reviews. Changes proposed within the constraints outlined in Table 1 are subject to the local approval process only and do not require review or approval from WisDOT. It is recommended that the local approval process include legal adoption of the speed zone recommendation through passage of an ordinance. Proposed changes that lie outside the constraints presented in Table 1 **shall** be reviewed and approved by WisDOT, as outlined above, before legal adoption by local authorities. It is recommended that the local process conclude with the local authority responding to the submitting party in writing, providing notification of approval or an explanation of the reasons for denial.

Establishing or Modifying a Speed Zone

When results from a speed study show a need for a speed zone or for modification of an existing speed zone and primary stakeholders support and legally adopt the findings, WisDOT or the local authority **shall** implement the study recommendations.

Procedure for Roadways in the State Trunk Highway System

When a speed zone request is adopted for an STH, the WisDOT region **shall** update official records and number the declaration in the following manner:

SZ-ww-xxx-yyyy-zz,

where *ww* is the county number that the roadway resides (e.g., Dane County would be entered 13, Milwaukee County would be entered 40, as illustrated in the example numbering system shown in Attachment B), *xxx* is the numeric designation of the highway involved in the declaration, *yyyy* is the four digit year the request was submitted (e.g., 2009), and *zz* is a number in sequence denoting chronological declarations for the roadway throughout the year, beginning with 01.

Procedure for Other Roadways

When a speed zone request is adopted for a local road, the local authority *should* consider cataloging the change and may consider doing so by numbering the approvals in the following manner:

SZC-ww-xxxxx-yyyy-zz,

where *ww* is the county number that the roadway resides (e.g., Dane County would be entered 13, Milwaukee County would be entered 40, as illustrated in the example numbering system shown in Attachment B), *xxxxx* is the letter designation or abbreviated name of the highway/street involved in the declaration,, *yyyy* is the four digit year the request was submitted (e.g., 2009), and *zz* is a number in sequence denoting chronological declarations for the roadway throughout the year, beginning with 01.

Post Speed Limit Signs

Following adoption of recommendations from a traffic engineering-based speed study that includes stakeholder involvement, WisDOT or the local authority *should* post signs with the modified speed limit as soon as possible. Advance warning features such as fluorescent pink flags or portable changeable message signs may be appropriate to notify motorists of the speed limit change.

Monitoring Performance

Implementing speed limits on roadways aims to strike a balance between safety and mobility for the traveling public. However, maintaining this relationship requires state and local officials to monitor performance trends within the study area and make changes when appropriate. WisDOT and local authorities *should* collect data periodically within its speed zones to evaluate whether safety and mobility are being upheld within it. Several performance measures *should* be considered for comparing before-and-after conditions as well as evaluating trends in the behavior of the traveling public. These measures are summarized below. Performance monitoring is valuable for local speed zones to the maximum extent resources will allow.

> *Compliance.* Compliance is the percent of sampled traffic that complies with the posted speed limit. Experts commonly conclude that a speed limit is ‘reasonable’ when 85 percent of sampled traffic travel at or below the posted speed limit. Compliance is a valuable performance measure in before-and-after studies of speed zone implementations.

> *Speed variance.* Speed variance is the frequency distribution of sampled speeds. Experts also conclude that more uniform vehicle speeds reduce the potential for conflict and resulting crashes. Speed variance may also be a significant performance measure in before-and-after studies of speed zone implementations.

Crashes by severity. Crashes by severity is the frequency distribution of crashes by their severity. Severity ranges from fatal to injury to property damage only and *should* be classified as follows:

- Fatal – Crashes involving one or more fatalities, or injuries resulting in death within 30 days of the crash.
- Injury – Crashes involving or potentially involving injuries, grouped into the following three classes:
  - Type A – Incapacitating Injury. Crashes where the most severe injuries prevent the injured from walking, driving, or from performing other activities that were common before the crash.
  - Type B – Non-incapacitating Injury. Crashes where the most severe injuries are not fatal or incapacitating, but are confirmed, or symptoms of the injury confirmed, at the scene.
  - Type C – Possible Injury. Crashes where injury is claimed by a motorist or suspected by the law enforcement officer, but is not obvious or confirmed at the crash site.
- Property Damage Only – Crashes where property damage is the most significant effect.

Crash Rate. Crash rate is the number of crashes along a section of roadway per million vehicle miles traveled. Crash rates indicate safety problems by evaluating roadways based on crash frequency, traffic volumes, length of roadway evaluated, and an amount of time the crashes occurred. By using these variables, roadways with different volumes can be compared. However, comparisons must be made carefully as traffic volumes are not the only factor that affects the frequency of crashes on roadways. Crash rate would be useful in monitoring trends following speed zone implementations.

Severity Rate.[19] Severity rate is an adjusted crash rate that accounts for the severity of a crash. Severity rates present the magnitude of potential safety issues occurring along a stretch of roadway by weighting more severe crashes in the severity rate equation. Like crash rates, though, consideration must be taken when using severity rates as the weighting system of crash severity is subjective and traffic volumes are not the only factor that affects crash frequency along roadways. Severity rate would also be useful in monitoring trends following speed zone implementations.

[19] Wisconsin crash severity rate calculation methodology is available on WisDOT website.

Attachment A

Speed Study Report Template and Worksheet

These documents are available electronically on the WisDOT Web site:

http://wisconsindot.gov/dtsdManuals/traffic-ops/manuals-and-standards/speed/speed-study-template.doc

http://wisconsindot.gov/dtsdManuals/traffic-ops/manuals-and-standards/speed/speed-zone-study.xls

Attachment B

Example Wisconsin County Numbering System

Example Wisconsin County Numbering System for Tracking Speed Zone Requests

County	Number		County	Number
Adams	1		Marathon	37
Ashland	2		Marinette	38
Barron	3		Marquette	39
Bayfield	4		Menominee	73
Brown	5		Milwaukee	40
Buffalo	6		Monroe	41
Burnett	7		Oconto	42
Calumet	8		Oneida	43
Chippewa	9		Outagamie	44
Clark	10		Ozaukee	45
Columbia	11		Pepin	46
Crawford	12		Pierce	47
Dane	13		Polk	48
Dodge	14		Portage	49
Door	15		Price	50
Douglas	16		Racine	51
Dunn	17		Richland	52
Eau Claire	18		Rock	53
Florence	19		Rusk	54
Fond du Lac	20		Sauk	55
Forest	21		Sawyer	56
Grant	22		Shawano	57
Green	23		Sheboygan	58
Green Lake	24		St. Croix	59
Iowa	25		Taylor	60
Iron	26		Trempealeau	61
Jackson	27		Vernon	62
Jefferson	28		Vilas	63
Juneau	29		Walworth	64
Kenosha	30		Washburn	65
Kewaunee	31		Washington	66
La Crosse	32		Waukesha	67
Lafayette	33		Waupaca	68
Langlade	34		Waushara	69
Lincoln	35		Winnebago	70
Manitiwoc	36		Wood	71