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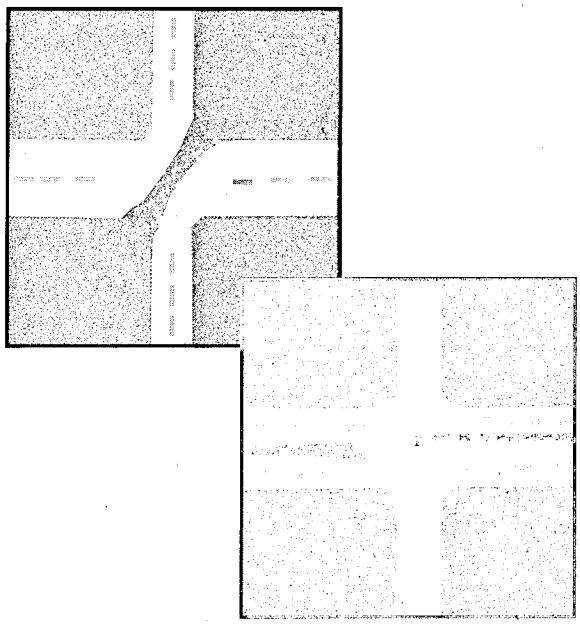

Effective Traffic Calming Applications and Implementation

Minnesota Local Road Research Board

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Traffic calming alters the appearance or geometry of a roadway in an attempt to reduce traffic volumes and speeds. This report will assist engineers with the evaluation, implementation, and application processes as they relate to traffic calming. It provided a "toolbox" containing purpose, cost, pros and cons, and effectiveness of various applications, as well as specific examples of projects in Minnesota.

The success of traffic calming often hinges on the approval of residents and business who will be directly affected. To ensure success, engineers must work with the public to first define the problem, explore options, and then work with the residents and any service providers to decide the best solution. Temporary devices should be installed whenever possible. It also is crucial that engineers consider the overall design plan, since traffic calming is often retrofitted to existing roadways. Engineers must also be sure to collect any before/after data, Average Daily Traffic (ADT), 85th percentile speed, and related information to better document the outcome of installing a traffic calming device.

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EXECUTIVE SUMMARY

In recent years traffic calming has become a subject of great interest to many city and county engineers throughout the State of Minnesota. Increasing traffic volumes on the arterial street network are shifting drivers onto the local street networks, resulting in a general decline in the quality of life for residents who live on the local roadways. This has led to an increasing number of requests made by citizens to "calm" the traffic in their communities.

One of the ways traffic is being calmed is through the incorporation of devices which alter the appearance or actual geometry of the roadway. It is the intent that these devices will either make drivers seek alternate routes or, by creating a sense of shared space between the driver and resident, make them want to slow down on the local roads. What is causing confusion for many engineers who are being asked to install traffic calming devices is how to actually go about implementing the device to ensure that it will be successful. What makes matters worse is that there is little documented data available for reference. This has resulted in the installation of many traffic calming projects being motivated more so by politics rather than justifiable need.

A successful traffic calming project will not only depend on whether or not traffic speeds or volumes are reduced, but also on whether or not the residents and businesses who are directly affected approve of the device. Since the public is often the one to initiate the desire to have the traffic calmed in their community, it is crucial that they be involved in the decision-making process. Engineers and city officials must work with the public to first define the actual problem, develop options, and then work with residents and service providers, including fire, emergency, and maintenance crews, and school and transit officials, to determine what the best solution may be. Funding should also be addressed early on in the decision-making process so as to avoid any problems in the future. Residents may object strongly to the installation of a traffic calming device if they are misled or did not receive fair warning that they would be assessed for the improvements.

In addition to community involvement, designers must give careful consideration to the overall design plan. Traffic calming projects which not only solve the problem at hand, but also add to the residents' general quality of life will be perceived as more successful. Success becomes heightened when amenities such as environmental enhancements, including additional greenery, are incorporated into the design plan. It is also important for designers to incorporate the needs of all members of the community. Pedestrians, bikers, and

people with disabilities may experience a decline in quality of life if the device makes it difficult for them to move about in their community. For this reason, sidewalks, bike paths, and wheelchair access ramps should be provided wherever possible, along with proper lighting, to ensure residents' safety.

A good design plan also pays careful attention to the architecture of the community. Traffic calming devices which match existing structures in the community and are aesthetically appealing will generate much more positive reactions. Temporary devices should be installed whenever possible and residents should be forewarned that the device is only temporary and, if installed permanently, will be much more aesthetically pleasing.

Since traffic calming devices often are installed at the request of citizens, devices will often be retrofitted to existing roadways. To minimize the intrusion into the lives of the community, construction should be carefully scheduled and monitored to assure quality workmanship. Residents may view the device negatively if contractors have to come back to make changes or repairs or if the project goes beyond the proposed finish date. Therefore, engineers and city officials should take any measures necessary to ensure that projects go smoothly, disruption is held to a minimum, and deadlines are met.

Not only is the implementation process important, but it is also crucial that the most appropriate traffic calming device be installed and that it be effective. Success will depend on the intended purpose of the device, estimated cost, pros and cons, service provider impacts, residents' reactions, and overall effectiveness. Shown on the following page is a list of the most common traffic calming devices reported in Minnesota, which can be grouped into the five categories shown.

Street width adjustments:

- ⇒ Street narrowing
- ⇒ Choker
- ⇒ Median island
- ⇒ On-street angled parking
- ⇒ Protected parking bays

Traditional traffic control techniques:

- ⇒ Vehicle restrictions
- ⇒ Turn restrictions
- ⇒ One-way streets
- ⇒ Variable-speed display board
- ⇒ Trumpet island
- ⇒ Marked crosswalks
- ⇒ Stop signs
- ⇒ Basket-weave stop signs

Vertical or horizontal realignments:

- ⇒ Speed hump
- ⇒ Speed bump
- ⇒ Speed table
- ⇒ Traffic circle
- ⇒ Roundabout
- ⇒ Chicane

Route modifications:

- ⇒ Street closure (cul-de-sac)
- ⇒ Diagonal diverter
- ⇒ Semi-diverter

Perceptual enhancements:

- ⇒ Streetscape material or landscape plantings
- ⇒ Change in surface material or color

It should be noted that although traditional traffic control devices alleviate the negative effects of the motor vehicle by controlling the flow of traffic rather than making drivers want to slow down as traffic calming devices do, many refer to them as traffic calming devices since they do in effect calm traffic.

Engineers must remember that although traffic calming devices are installed locally to reduce traffic volumes and speeds, traffic calming should not be done in isolation. The traffic calming concept of shared space between driver and resident must be applied globally. This begins with good overall traffic management and planning to ensure that the appropriate trip be placed on the appropriate road. If traffic calming is to be successful at making the local street network function better, then the arterial network must function just as well.

Most importantly, the future of traffic calming will depend on those who are implementing it today. Before and after data including ADT, 85th percentile speed, accident experience, residents' reactions, roadway classification, funding resources, and service provider impacts, to name just a few, must be collected and documented. This information may then be used by others to better determine which device is most appropriate at achieving certain outcomes. It is the hope that increased knowledge will make traffic calming an easier, more effective way to make our neighborhoods an enjoyable place to live.

INTRODUCTION

As traffic volumes continue to increase, the arterial road system continues to become more and more congested. As a result, motorists are seeking alternative routes on the local street network. Additionally, as drivers become less tolerant with the congested arterial, they seem to be developing an increasing disregard for traditional traffic control devices, such as stop signs and turn prohibitions, on local roadways. Consequently, once typically quiet neighborhood roads are now becoming high-volume roadways.

Perhaps the most significant effect of this is being felt by the residential community. An increasing number of citizens are complaining of the general decline in their quality of life, with regard to pedestrian safety and noise pollution, due to the dominance of the motor vehicle. For that reason, engineers and citizens have found themselves searching for alternative solutions to deal with the traffic in their communities. The answer many municipalities are considering is the installation of treatments to the roadway, aimed at reducing traffic volumes and speeds, referred to as "traffic calming."

This synthesis presents information on current traffic calming practices in Minnesota. It will be of interest to city and county engineers, as well as planners, designers and residents concerned with roadway safety. Since there are no guidelines available which "warrant" the installation of traffic calming devices, installation, to date, has often been motivated by politics. For many, this approach has been both confusing and inconsistent. It is the intent of this synthesis to assist engineers and city officials with the evaluation, application, and implementation processes as they relate to traffic calming. It should be noted that the recommendations provided in this synthesis are to be used only as a tool and are in no way intended to serve as a substitute for good engineering practice.

The applications presented in this synthesis include traffic calming devices, as well as traditional traffic control devices. Traffic calming devices try to minimize the adverse effects of the motor vehicle by either changing the behavior of drivers or influencing access. The concept of traffic calming, often achieved by altering the appearance or actual geometry of the roadway, is to create a sense of shared space between the driver and resident so that the driver will actually want to slow down. The concept of traditional traffic control devices, such as stop signs and one-way streets, is to alleviate the negative effects of the motor vehicle by controlling the flow of traffic. Despite the different philosophies, both are included since many feel that traditional traffic control devices do in effect calm traffic.

As requested by the Local Road Research Board (LRRB), this synthesis also includes an executive summary of a report written by SRF Consulting Group, Inc. The report, entitled "Traffic Calming Activity in Minnesota," was published in December of 1997 by the LRRB. Information for the report was obtained through a survey which was funded by the LRRB and the Minnesota Department of Transportation (Mn/DOT). The survey, which examined the extent of traffic calming activity in Minnesota and the degree of actual and perceived success of those projects, was conducted in January and February of 1997 by Hennepin County, along with the cities of St. Paul and Eagan. The included summary of that report was taken directly from "Traffic Calming Activity in Minnesota" and is intended to serve as an overview of traffic calming practices in Minnesota. For more details, please reference the entire report.

EXECUTIVE SUMMARY FROM "TRAFFIC CALMING ACTIVITY IN MINNESOTA" REPORT

This research examines the extent of traffic calming activity in Minnesota and the degree of actual and perceived success of such projects. In particular, the research focuses on traffic calming activity on streets classified as major collectors and minor arterials. The study discusses the compatibility between design changes proposed in support of traffic calming activities and the State Aid design standards that govern the facilities being calmed.

The research consisted of the following tasks:

- A brief literature review
- A survey of traffic calming activity within the State of Minnesota
- An assessment of the effectiveness of various traffic calming actions
- A review of State Aid Rules
- An attempt to collect before/after data on several projects located on streets classified as major collectors and minor arterials that were scheduled to be constructed during the summer of 1997. (Due to unforeseen data collection problems, a decision was made to terminate this data collection effort).

The survey responses indicated that:

- Fifty-three percent of the respondents had implemented or planned to implement traffic calming projects. Eighty-one percent of the traffic calming projects reported have been implemented on local streets and minor collectors. Fifteen percent of the reported projects have been implemented on major collectors and minor arterials.
- The most frequent reasons that initiated a project include: negative street environment, high traffic volumes, and high speeds.
- Twenty-one distinct traffic calming methods were reported. The most frequently used devices fall under the following groupings: street width adjustments and traditional traffic control techniques.
- The most frequent project outcomes reported were enhanced street environment, improved street safety, and improved traffic conditions.
- In 61 percent of the projects, residents fronting the projects are reported to have reacted positively to the project.
- Only 37 percent of the reported projects had collected some form of before/after data to verify their effectiveness. In most cases, the amount of data collected was very limited.
- For traffic calming projects in which before/after ADT and 85-percentile speed data had been collected, all except one, reported reductions in both ADT and 85-percentile speed.

It appears that the reported success of traffic calming activities lies not only in the perceived "calming" of traffic on residential streets, but in the perception of what we have called the "enhanced street environment," which includes the sense that not only has street safety improved, but that street "livability" and overall quality have also improved.

Numerous devices and actions are being employed to "calm" traffic, with generally positive results, but with some unintended negative consequences as well. Unintended consequences include snow removal problems, emergency vehicles response delays, and, in some cases, increased noise.

One implication of the speed/width relationships in the State Aid Rules is that if the driving lanes on an urban 35-plus mph design-speed roadway are reduced from 12 to 11 feet, and the parking lanes from 10 to 8 feet, the design speed is also affected; that is, the corresponding design speed may become 30-35 mph. Since the design speed must equal or exceed the posted speed limit, it follows that the speed limit can be as low as 30 mph but no higher than 35 mph. However, other speed-related design factors such as stopping sight distance, horizontal and vertical curves, and rate of superelevation, which affect the "feel" of the road, influence the speed that drivers feel comfortable driving. It follows that if the lane width changes do not result in a speed reduction, as revealed by speed studies, it may not be possible to justify reducing the posted speed limit. Considerations regarding design changes may be more appropriate for roads in residential neighborhoods, where speed and safety are the major concerns.

Municipal and county engineers and planners, urban designers and neighborhood residents hear about traffic calming concepts and are eager to see more data on the actual effectiveness of these devices. Numerous studies are being performed statewide and throughout the country, yet most of the data is in the form of specific case studies and most of the case studies are located on local residential streets. There are few standards that designers can reference when trying to select the most appropriate traffic calming device or when trying to determine appropriate geometric standards to follow when designing these devices.

It is important that additional research be performed on traffic calming, especially as it relates to projects that are proposed for streets classified as major collectors and minor arterials. This research should be performed under controlled conditions to better understand how driving behavior is affected by different devices, and the degree of driver behavior change. Future research should also examine long-term versus short-term effects of various traffic calming actions and devices. (10)

TRAFFIC CALMING IMPLEMENTATION

Since the writing of the "Traffic Calming Activity in Minnesota" report, traffic calming has become a subject of even greater interest to many municipalities throughout Minnesota. More and more residents are realizing that their quality of life is being diminished by increasing traffic volumes, speeding, noise, and unsafe conditions for children, pedestrians, and bikers. The "old way" of traffic planning with wide, straight streets no longer seems to be suitable for maintaining a liveable neighborhood.

Due in large part to the many requests made by residents to "calm" traffic in their communities, engineers are being forced to explore a new concept, one which discourages speeding and added capacity. That concept is traffic calming, and despite the increasing number of traffic calming projects in Minnesota, there is still little documented data available for reference. And what is worse, the problem only seems to be magnified by the fact that there are no set guidelines which apply to every situation. Therefore, to ensure the success and effectiveness of traffic calming, it is crucial that the community be involved in the decision-making process and that the most appropriate device be implemented for the given situation.

COMMUNITY INVOLVEMENT

Since it is often the community who initiates the need for traffic calming, implementing a successful traffic calming device hinges on the approval of the residents and businesses who will be directly affected. (5) Residents may approve of a traffic circle or speed hump on someone else's street, but not their own. And the device implemented may not solve the perceived problem. Installing speed humps to reduce cut-through traffic in just one area of a neighborhood may in effect displace the traffic into adjacent areas. It is therefore important for engineers to focus on overall traffic management. The entire community, including neighboring areas that will just as likely to be affected, need to be involved in the decision-making process and made aware of their options.

Community involvement plays an intricate part in two areas, the first of which is defining the actual problem. Engineers and planners need to be sure they have a good understanding of what the public perceives to be the problem and what exactly they are trying to solve. If the problem is properly addressed from the onset, the most effective traffic calming device can be implemented. Meetings, questionnaires, flyers, and/or public events all serve as an excellent means of communication between the engineer and the public as a way to work together in identifying the problem. (2)

Once the problem has been properly identified, the community should then be allowed to participate in the actual decision-making process. Since the goal of traffic calming is to enhance the quality of life for the residents, it makes sense that they have a say in how the problem should be solved. After all, it is the resident who knows the street the best. It used to be that engineers would define the problem, devise a plan, and then present the solution to the citizens, in effect "selling" the plan to the residents. This approach creates a vertical line of communication and can often lead to serious objections, especially if the two have different perceptions about what the problem is and how it should be solved.

A more effective approach may be to create a horizontal line of communication between the engineer and the residents by welcoming the public's involvement. If engineers express their views, provide residents with options, and then step aside and turn the decision making over to the residents, residents will be more apt to accept the solution. It is important that engineers make themselves available to help guide the public along and answer any questions that the public may have. (2) It would also be helpful for city officials to provide residents with examples of what other cities are implementing in terms of traffic calming. If residents actually visit neighboring traffic calming projects, they will be better able to visualize their options and decide what the best alternative may be.

During the decision-making process, it is important for engineers to present the public with several options from which to choose and to apply temporary devices on an experimental basis, which are usually less costly, whenever possible. That way, if strong opposition to a device is encountered after it is implemented, it can easily, and cheaply, be removed and a second option can be further explored. It is also important to collect and document the public's reactions to the traffic calming devices both before and after implementation. This will not only assist in selecting alternative measures to solve the current problem, but will help to solve similar problems in the future. Before/after data including ADT, 85th percentile speed, accident experience, residents' reactions, roadway classification, funding sources, and service provider impacts should also be collected to gain a better understanding of how the devices are affecting driver behavior.

Although they may not be referred to as the general public, it is crucial to project success to involve any service providers in the decision making and planning processes. (4) Service providers may include police, fire, emergency, school, maintenance, public transit, and delivery services. Any unforeseen adverse effects can be avoided by consulting these service providers prior to installing a particular traffic calming device.

Service providers should be supplied with maps indicating the exact location of the proposed devices so that they can determine alternate routes wherever and whenever possible. If alternate routes are not possible, alternative traffic calming devices should be sought. Maps should include specific dimensions of the traffic calming device so that emergency vehicles and delivery trucks can ensure that they will be able to maneuver around or over the traffic calming device in a timely and efficient manner.

It is also important for municipalities to address funding as it relates to traffic calming. Funding sources such as grants, developers, or specific budget provisions need to be defined in the early stages of the decision making and planning process so as to avoid any future problems. Most property owners will give strong objection to a traffic calming project if they are misled or do not receive fair warning that they will be assessed for the improvements.

OTTAWA, ONTARIO COMMUNITY INVOLVEMENT PROCESS

A decision-making process which has produced over 20 excellent traffic calming design plans is that used in Ottawa, Ontario. Success of the process is attributed to shifting the emphasis from city-based planning to community-based planning. In community-based planning, the public's participation becomes an essential part of the decision-making process. Ottawa considers the public, including residents and business people, to be the experts when it comes to voicing their concerns, needs, and solutions. In turn, the engineering professionals act only as the facilitator, who gather, input, analyze, and guide the planning process. (1)

The Ottawa process begins by uniting citizens of the community with city staff and politicians into what is called a Working Group. The initial tasks of the Working Group are to solicit funds for studies, help city staff prepare terms of reference, and document the public's issues and concerns. The issues and concerns are acquired by the Working Group meeting with the people who actually live and work in the study area. This information can be gathered via questionnaires, interviews, and/or walk-abouts. Walk-abouts involve the public, city staff, and Working Group members actually walking the study area. This gives the public a chance to point out first hand their problems and concerns. The Working Group then meets on a monthly basis to guide the project, act as a liaison to the public, and help make decisions.

The next step is to hold a Public Information Session which can be either a formal public meeting or a special meeting of the Working Group. The purpose of the session is to solicit public comments, confirm an understanding of the public's issues and concerns, verify any data which was collected, and to gauge the level of community support for traffic calming. If there is a respectable amount of support for traffic calming, the Working Group goes on to prepare what they call a Traffic Calming Vision.

Preparing a Traffic Calming Vision includes analyzing the issues and concerns, finalizing goals and objectives, identifying any technical constraints, establishing planning principles, preparing a newsletter, and assigning traffic calming designations to the streets. Assigning traffic calming designations becomes the core of the vision. Each street is no longer referred to as being a local, collector, or arterial roadway, but rather a living, mixed, or traffic-purpose street. These traffic calming designations classify streets based on their intended purpose, which in turn dictates the most appropriate traffic calming devices to implement. A living-purpose street is one designed primarily for living functions such as walking, socializing, and providing vehicular access for residents. Mixed-purpose streets share the living function with traveling along the street. These streets will have some through traffic and some traffic related to non-residential uses, such as providing access to local shopping areas. Streets which are designed strictly for through traffic and access are referred to as traffic purpose streets.

A second Public Information Session is held to achieve a consensus on the Vision and to recruit participants for workshops. The Workshop is essential to the community-based plan since this is where the public will actually have the opportunity to redesign their own streets. Workshops are generally restricted to 15 to 20 people and usually last about three hours. Depending on the size and complexity of the study area, several workshops may be held. Time at the workshops is allotted to discussing goals and objectives, presenting possible solutions, and actual planning of the streets.

Results from the workshops are then merged into the larger study area and are checked for technical feasibility. This first draft, along with alternatives, is presented to the Working Group who will refine the draft and rank the alternatives. This becomes the "preferred solution" which the public will have a chance to comment on at a third Public Information Session. This session is especially important since it is the public's first opportunity to see the complete draft plan.

Once all of the comments given by the public at the third Public Information Session are received, the Group meets again to discuss any additional alternatives, refinements, or implementation strategies. A second technical analysis is performed, after which the public is given a chance to comment one last time. The plan is then finalized, followed by a summary report which will be used to assist the council members in the final decision-making process.

DESIGN PLAN

In addition to the importance of community involvement, what is incorporated into the actual design plan will affect the perceived success of traffic calming projects. Traffic calming projects which not only attempt to solve the problem at hand, but do so by adding to the general quality of life will be viewed by the residents as much more successful. Project success can become heightened when amenities such as environmental enhancements, including additional trees and greenery, are incorporated into the design plan. These projects are often the most popular among residents, and therefore the most successful, since they are designed to enhance the overall appearance of the street, thus adding to their perceived quality of life.

Those designing the traffic calming plan should not only incorporate environmental enhancements whenever possible, but should also incorporate the needs of all members of the community. (2) Pedestrians, bikers, and people with disabilities may experience a decline in their quality of life if the traffic calming device makes it difficult for them to move about in their community. Sidewalks, bike paths, and wheelchair access ramps should be provided wherever possible, along with park benches and trash receptacles. Security should also be provided through the use of proper lighting and protected walk areas. (2) Residents will appreciate the changes generated by traffic calming if it makes it more enjoyable to be out in their neighborhood.

The architecture of the community also deserves special consideration in terms of the design plan. (2) Traffic calming devices which are regarded as aesthetically appealing will generate much more positive reactions from the community. City officials may receive strong opposition from the public if the traffic calming device is unsightly or does not complement the style and characteristics of the community. This can be avoided by ensuring that the traffic calming device matches the existing structures in the community. If temporary devices are installed, residents need to be forewarned that the device is only temporary and, if installed permanently, will be much more aesthetically pleasing. (3)

Since traffic calming design plans are generally in response to increasing traffic volumes and speeds in existing communities, implementation will often involve retrofitting a traffic calming device to an existing roadway. Retrofitting will involve construction which can be an inconvenience to the residents and businesses of the community. Although it is often unavoidable, the community may experience a temporary decline in their quality of life throughout the construction phase. Any construction should therefore be carefully planned and managed and thought should be given to any community events, shopping, or tourist areas so as to minimize the intrusion into the lives of the community. (2) Any new community developments, either residential or commercial, can avoid retrofitting altogether by introducing the concept of traffic calming early on in the preliminary design stages.

As traffic calming projects are under construction, it is crucial that they be carefully monitored. Contractors should use quality workmanship and pay close attention to detail. Residents may view the traffic calming device negatively if contractors have to come back to make changes or repairs or if projects go beyond the proposed finish date. Therefore, city officials should take any measures necessary to ensure that projects go smoothly, disruption is held to a minimum, and deadlines are met. (2)

TRAFFIC CALMING APPLICATIONS

Not only should it be important to the engineer that residents perceive traffic calming devices to be successful, but also that the device be effective. To be effective means that the most appropriate device must be applied. The following list contains the 21 distinct traffic calming applications which were reported in the survey by SRF Consulting Group, Inc., (10) as well as some additional devices. Information on each device, such as purpose, cost, pros and cons, and effectiveness, is provided and will serve as a "toolbox" to assist engineers in choosing the most effective device.

Street width adjustments:

- ⇒ Street narrowing
- ⇒ Choker
- ⇒ Median island
- ⇒ On-street angled parking
- ⇒ Protected parking bays

Traditional traffic control techniques:

- ⇒ Vehicle restrictions
- ⇒ Turn restrictions
- ⇒ One-way streets
- ⇒ Variable-speed display board
- ⇒ Trumpet island
- ⇒ Marked crosswalks
- ⇒ Stop signs
- ⇒ Basket-weave stop signs

Vertical or horizontal realignments:

- ⇒ Speed hump
- ⇒ Speed bump
- ⇒ Speed table
- ⇒ Traffic circle
- ⇒ Roundabout
- ⇒ Chicane

Route modifications:

- ⇒ Street closure (cul-de-sac)
- ⇒ Diagonal diverter
- ⇒ Semi-diverter

Perceptual enhancements:

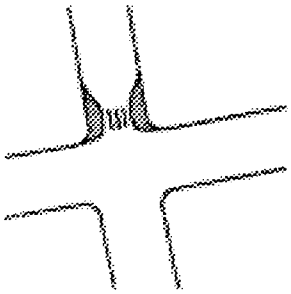
- ⇒ Streetscape material or landscape plantings
- ⇒ Change in road surface material or color

STREET WIDTH ADJUSTMENTS

Street Narrowing

Narrowing of the roadway can be done in one of two ways. Street narrowing can be done by either moving the actual curb line physically inward or by simply altering the appearance of the roadway width through the use of pavement markings. (8)

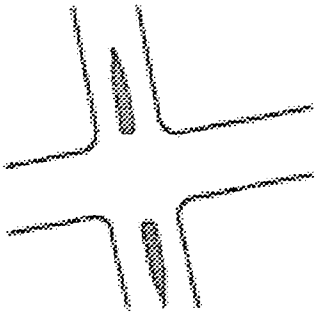
Purpose	The intention of street narrowing is that the loss of pavement width on which drivers are able to drive will cause drivers to slow down.
Cost	$150 per meter ($50.00 per foot) if narrowed physically, may be more depending on drainage structures. $0.60 per meter ($0.20 per foot) if narrowed using pavement markings.
Pros	Can be fairly inexpensive if the roadway is narrowed using pavement markings. Can be accompanied with additional landscaping. Does not increase traffic noise
Cons	May require some parking removal.
Service Provider Impacts	Enough width should be provided to allow for the easy flow of all service providers, especially emergency vehicles.
Effectiveness	Street narrowing has little to no effect on traffic volume and vehicle speed changes are not significant. Street narrowing also has minimal effect on the number of overall traffic accidents.
Other Considerations	By physically taking away part of the pavement structure, there is less room available for bicyclists and pedestrians. Therefore, sidewalks may need to be added to provide protection from moving traffic.



Chokers

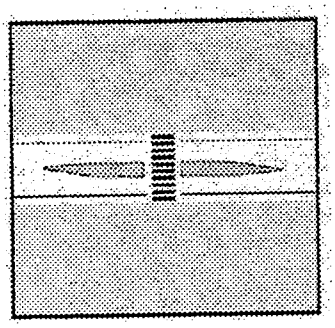
Chokers, also referred to as bump-outs or curb-extensions, narrow the space through which vehicles must travel. Narrowing can be done either midblock or at intersections, as shown in the diagram to the left. (9)

Purpose	Chokers are employed to narrow the roadway width through which drivers must travel, causing drivers to slow down in order to pass through them. Chokers can also be used to facilitate pedestrian crossings.
Cost	$5,600 each, depending on drainage facilities, sidewalk or boulevard material, and landscaping.
Pros	Reduce pedestrian crossing distance and time. Make pedestrian crossing points more visible to drivers. Prevent vehicles from passing other vehicles that are turning. May be used to visually enhance the street through landscaping.
Cons	May require some curbside parking removal. Difficult to accommodate space for both vehicle and bicycle lanes.
Service Provider Impacts	May obstruct snow plow and emergency vehicle movement. Chokers can enhance transit service by moving the curb so riders can step directly between the sidewalk and bus door.
Effectiveness	Traffic volumes may be reduced if the street narrowing limits traffic to one direction at a time. Chokers have little effect on vehicle speed, but effectively improve pedestrian safety by reducing the street crossing distance and improving sight distance. They may also slightly influence driver behavior by changing the appearance of the street.
Other Considerations	Where the crowns of the street are steep, curb extensions may actually go "uphill" because the new curb is higher than the original curb. If poorly designed, this can result in drainage problems both at the curb and on the sidewalk.

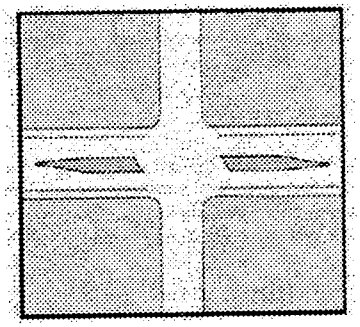


Median Islands

Median islands are small islands in the middle of the street which narrow the vehicle travel lanes. Also referred to as slow points or pedestrian refuges, they can be installed at intersections or midblock. Median islands can be used to enhance pedestrian crossing points and provide a visual narrowing along the roadway. (9)



Midblock



Intersection

Purpose	Median islands reduce the roadway width available to a driver, provide a visual cue to drivers that they are in a pedestrianized area, and provide a refuge for pedestrians
Cost	$8,000 - $15,000
Pros	Allow pedestrians to cross half of the street, stop in the median island for refuge, and then cross the other half of the street. Make pedestrian crossing points more visible to drivers. Prevent vehicles from passing other vehicles that are turning. May reduce vehicle speeds.
Cons	May restrict access to property drives. Mid-block islands may require some parking removal on both sides of the street.
Service Provider Impacts	May restrict emergency vehicle access. Important to leave enough space for maintenance, transit, and other service providers to pass through.
Effectiveness	Median islands are effective pedestrian amenities but have minimal influence on a driver's behavior. Depending on their location, they may result in small to moderate traffic speed reductions.
Other Considerations	Median islands have usually been used to supplement a pre-existing crosswalk, as compared to creating a new crosswalk location.

On-Street Angled Parking and Protected Parking Bays

In order to reduce roadway width, parallel, end-to-end vehicle parking can be protected through the use of protected parking bays or, parking can be converted to on-street angled parking. These types of parking changes reduce roadway width, making it more difficult for drivers to maneuver along the roadway, causing them to reduce their speeds. On-street angled parking allows drivers to enter and exit parking stalls more easily than right-angled parking and, like protected parking bays, can be easily incorporated with landscaped chicanes or chokers to enhance the appearance of the street while narrowing its width.

Purpose	On-street angled parking or protected parking bays reduce roadway widths, causing reduced vehicle speeds.
Cost	Minimal, if the only changes are to existing parking; more costly if incorporated with a chicane or choker.
Pros	Effectively reduce vehicle speeds by reducing the roadway width. May provide additional parking space. Can be incorporated with environmental enhancements.
Cons	Safety of pedestrians and bikers may be reduced by the opening of car doors. Children between parked cars are also very difficult for drivers to see. May reduce the number of parking stalls if there is only enough room to have angled or protected parking on one side of the street. Added parking reduces the space available for pedestrians and bikers.
Service Provider Impacts	May make snow plowing more difficult, if used with chicanes or chokers. Should be installed only where enough space would still be available for the easy flow of emergency vehicles.
Effectiveness	Effective at reducing vehicle speeds.
Other Considerations	Very important to ensure that a sufficient number of parking spaces are made available. If not enough parking is provided, the level of illegal car parking may be increased.

TRADITIONAL TRAFFIC CONTROL TECHNIQUES

Vehicle Restrictions

Vehicle restrictions can be used to reduce the effects of cut-through traffic. Access may be restricted through the use of DO NOT ENTER signs. (8)

Purpose	Vehicle restrictions are intended to prohibit vehicles from entering a roadway.
Cost	Minimal.
Pros	Effectively reduce vehicle volumes by diverting traffic to adjacent streets. Can restrict vehicle access while retaining bicycle and pedestrian access. Noise and environmental pollution is reduced on streets which have prohibited access. Safety may be increased on streets which have prohibited access.
Cons	Prohibit or limit access and movement. Noise and environmental pollution is increased on streets which serve as alternate routes. Safety may be reduced on alternate routes due to the additional traffic. May be difficult to enforce.
Service Provider Impacts	Emergency vehicle access may be allowed despite the sign restrictions, although significant thought should be given as to how this can be done effectively and safely.
Effectiveness	Traffic volumes may be reduced dramatically on streets which have prohibited access, if sign is enforced.
Other Considerations	Signs may be ignored if congestion on alternate routes is too significant. This may result in the need for additional law enforcement.

Turn Restrictions

Regulatory signs, such as "No Right Turn" and "No Left Turn," can be used to restrict turning movements, typically from a high-volume street onto a low-volume street.

Purpose	Turn restrictions are intended to prohibit vehicles from entering a roadway, either all of the time or only during certain specified times.
Cost	Minimal.
Pros	Turn restrictions can be effective in reducing cut-through traffic. Noise and environmental pollution are decreased and safety is increased on the local streets. Traffic volumes are reduced on local streets. Speeds may be reduced on local streets.
Cons	Prohibit or limit access and movement. Noise and environmental pollution is increased and safety is decreased on streets which serve as alternate routes. May be difficult to enforce. Alternate routes will experience increased traffic volumes.
Service Provider Impacts	Service provider access to local streets which are restricted will be limited or altered.
Effectiveness	Turn restrictions may be extremely effective where cut-through traffic is a problem. Traffic volumes on streets which have prohibited access will be reduced; however, volume on streets where traffic is diverted to will increase.
Other Considerations	Turn restrictions should be used on the neighborhood boundaries rather than inside the neighborhood. Signs may be ignored if congestion on alternate routes is too significant which may result in the need for additional law enforcement.

One-Way Streets

One-way streets can be used to prevent cut-through traffic in residential areas. One-way streets can either diverge and converge at the main thoroughfare, alternate north/south or east/west from one block to the next, or form a one-way pair. A one-way pair couples a residential street with a main thoroughfare to create a passageway for through traffic while diverting traffic from adjacent residential streets. (8)

Purpose	One-way streets are used to control traffic in residential neighborhoods.
Cost	$400 per block.
Pros	Safety is improved since one-ways result in fewer conflicting movements. Parking is increased.
Cons	One-way streets often result in increased speeds. Residents often feel safety is reduced due to the increased speeds. One-way pairing has a negative impact on livability and property value on the upgraded residential street.
Service Provider Impacts	Since one-way streets do not involve any physical barrier to be applied to the street, emergency vehicle access is not obstructed.
Effectiveness	Diverging/converging one-way streets are very effective at reducing traffic volumes of cut-through traffic. Alternating one-way streets have no effect on volume. One-way pairing increases volume on one street and decreases volume on adjacent streets.
Other Considerations	One-way streets may be used in combination with other measures which reduce vehicle speed. Accommodations may be made on one-way streets for bicycle traffic. Residents may object to the limited access created by one-way streets.

Variable-Speed Display Board

A variable-speed display board is a temporary device used to educate drivers about speeding. Radar aimed at passing motorists allows drivers to see their actual speed as well as the street's posted speed limit. The display board not only alerts drivers of their speed, but can also be used to record data on traffic volumes and speeds which can be used to determine if a speeding problem actually exists. If so, a permanent traffic-calming device can be installed. Display boards can be designed to stand alone or may be mounted on a trailer, referred to as speed wagons, and can be "run" by the residents, police department, or engineering department. (8)

Purpose	Display boards are intended to influence driver behavior by alerting drivers of their actual speed verses the posted speed limit.
Cost	$2,000 - $11,500 per unit, depending on sophistication.
Pros	Display boards serve as a good educational tool to inform the public of their driving behaviors. Data collected can be used to target times of the day when additional police enforcement may be needed. Display boards allow police, traffic engineers, and the neighborhoods to work together to reduce vehicle speeds on residential streets.
Cons	There is a potential for sudden braking by motorists when they see the display board, which results in biased data. Has no effect on speed when the display board is not present.
Service Provider Impacts	None.
Effectiveness	Speeds are reduced only when the display board is present. Display boards have little effect on traffic volumes.
Other Considerations	Residents may oppose the use of display boards if they feel it is a form of "vigilantism."

Marked Crosswalks

Marked crosswalks are a portion of the roadway designated as pedestrian crossings, located by painted lines. By law, vehicles are required to stop for any pedestrians using a marked crosswalk. The markings can be created fairly inexpensively and run the entire width of the roadway. Since motorists generally expect crosswalks to be at intersections, it is recommended that they not be installed mid-block. Crosswalk signage should be in accordance with the Manual on Uniform Traffic Control Devices (MUTCD) and lighting should be incorporated into the design plan to enhance the visibility and safety of those using the crosswalk.

Purpose	Provide a protected area for pedestrians to cross a busy street, while alerting drivers that the area is pedestrianized and they should slow down.
Cost	Minimal.
Pros	Provides pedestrians with a protected area in which to cross the street. Do not affect bicycle traffic.
Cons	Pedestrians seem to develop a false sense of security from a marked crosswalk, assuming that traffic will see the crosswalk and will stop.
Service Provider Impacts	Do not affect the movement of transit or emergency vehicles.
Effectiveness	Very unlikely that marked crosswalks will actually reduce vehicle speeds. Marked crosswalks can be more effective at reducing vehicle speeds if used in combination with chokers or pinch points.
Other Considerations	It is important to remember that a driver's view of the crosswalk will be affected by road alignment, irregularities in the pavement, weather, and adverse lighting. Pedestrian safety can be increased by incorporating raised medians or signal timing with the marked crosswalks.

Stop Signs

Stop signs can be a very effective way to control traffic if used properly. As indicated by various traffic studies, they should not be used to control speeding. An excessive use of stop signs may cause drivers to speed up in between the stop signs as they try to compensate for the time they lost having to come to a stop at each stop sign. Reductions in speed may only occur in the immediate vicinity of the stop sign since some drivers may accelerate rapidly after stopping, creating an even more dangerous situation. And if there are too many stop signs, drivers may choose to ignore them.

Stop signs can also create a false sense of security in pedestrians who assume vehicles will stop. For that reason, it is recommended that stop signs be used to help drivers determine who has the right-of-way and should be installed only where justified or "warranted."

According to the set of warrants given in the Manual on Uniform Traffic Control Devices (MUTCD), stop signs may be warranted at an intersection where one or more of the following conditions exist:

1. Intersection of a less important road with a main road where application of the normal right-of-way rule is unduly hazardous.
2. Street entering a through highway or street.
3. Unsignalized intersection in a signalized area.
4. Other intersections where a combination of high speed, restricted view, and serious accident records indicates a need for control by the STOP sign.

The MUTCD should be referenced for further important details and conditions. Also found in the manual are additional warrants for installing all-way or 4-way stops. The installation of an all-way stop is based upon interim use pending signal installation, accident history, or traffic volumes.

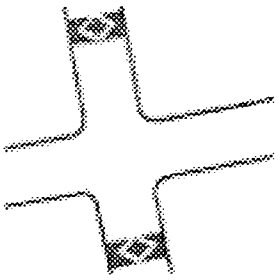
An alternative to stop signs may be to install yield signs, which are also intended to assist drivers with determining who has the right-of-way at intersections. Studies have found that yield signs have little effect on traffic volumes and can reduce vehicle speeds within approximately 50 feet of the intersection. The installation of a yield sign should be carefully analyzed and installed only if warranted by the MUTCD.

Basket-Weave Stop Signs

Basket-weave stop signs, as opposed to lone stop signs, use a neighborhood or system-wide traffic management approach by installing stop signs at every other intersection, allowing traffic to pass through one intersection and then stop at the next. (8)

Purpose	Basket-weave stop signs allow some control to be placed on traffic as it moves through a residential area.
Cost	Cost depends on the area over which the basket-weave pattern is implemented.
Pros	Basket-weave stop signs may have a significant impact on accident reduction by reducing driver questions as to who has the right-of-way. Vehicle speeds within 61 meters (200 feet) of the intersection may be reduced.
Cons	Speed may be increased between stop signs. Noise is increased due to the braking and accelerating of vehicles. Also, is a reduction in air quality due to fumes from automobiles.
Service Provider Impacts	Emergency response times will increase with the installation of basket-weave stop signs, especially on routes which initially had no signage.
Effectiveness	Extremely effective at reducing traffic accidents.
Other Considerations	Due to the northern climate, basket-weave traffic patterns are not recommended at intersections in hilly terrain since they may become icy from the additional starting and stopping of vehicles.

VERTICAL OR HORIZONTAL REALIGNMENTS



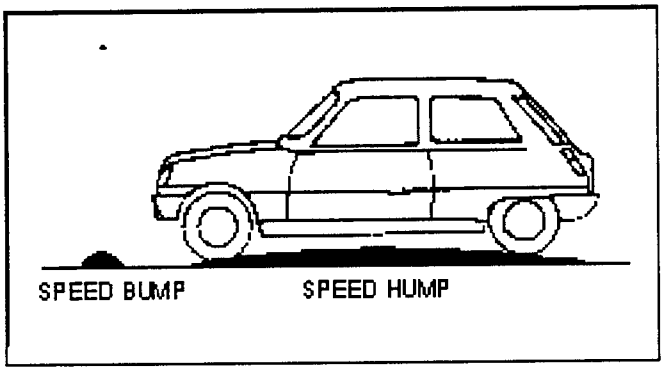
Speed Humps

Speed humps are asphalt mounds of pavement which run the full width of the roadway and are typically 76 to 102 millimeters (3 to 4 inches) in height and 2 meters (8 feet) in length. They should be installed on streets less than 12 meters (40 feet) wide with no more than two travel lanes. A minimum of two speed humps should be installed in a series with approximately 76 meters (250 feet) between humps. No more than two series of speed humps should be installed per 85 meters (one-half mile). Speed humps should only be installed on "local" streets and should not be installed on collector or arterial streets. (6)

Purpose	Speed humps are intended to reduce vehicle speeds.
Cost	$7,000 per pair, may be more depending on drainage.
Pros	Effectively reduce vehicle speeds. Do not require parking removal. Pose no restrictions for bicycles. Do not affect intersection operations. May reduce traffic volumes.
Cons	Can possibly increase traffic noise from braking and acceleration of vehicles, particularly buses and trucks. May interfere with drainage.
Service Provider Impacts	Speed humps should not be installed on transit or truck routes. Emergency vehicles can safely cross properly designed speed humps, although response times may be increased. Slows fire vehicles. Does not affect snow removal.
Effectiveness	Speed humps are very effective at encouraging reduced vehicle speeds.
Other Considerations	Speed humps should not be constructed on grades greater than 5 percent.

Speed Bumps

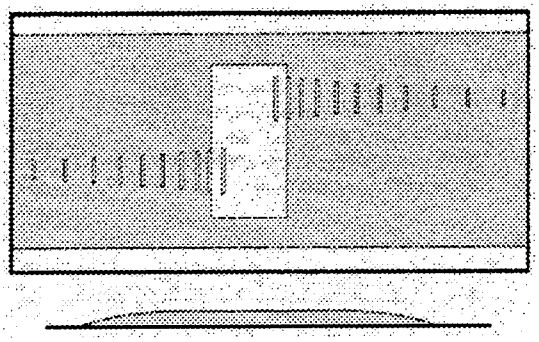
Speed bumps should not be confused with speed humps although they have the same objective of reducing motor vehicle speed. Speed bumps are generally 76 millimeters (3 inches) high and are from 203 to 406 millimeters (8 to 16 inches) in length (in the direction of travel) and have a round top. They are typically installed on private roadways and parking lots. (9) Speed humps are generally round or flat-topped with an approximate height of 76 to 102 millimeters (3 to 4 inches) and an approximate length of 2 meters (8 feet) (in the direction of travel) and are typically installed on local streets.



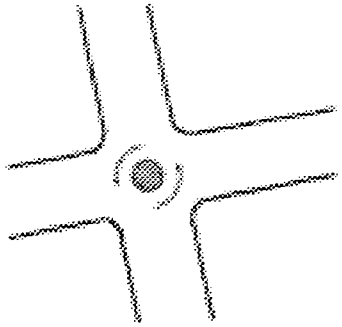
Purpose	Speed bumps are intended to reduce vehicle speeds.
Cost	$500 - $1,000
Pros	Effectively reduce vehicle speed. Do not require parking removal.
Cons	Traffic noise is increased from the braking and acceleration of vehicles, particularly buses and trucks. Speed bumps are hazardous for bicyclists and motorcyclists.
Service Provider Impacts	Slows emergency vehicles. Snow removal and street sweeping are difficult where these devices have been implemented.
Effectiveness	Speed bumps are effective at encouraging reduced vehicle speeds.
Other Considerations	Speed bumps result in an abrupt vertical motion for vehicles and occupants at slow speeds and encourage drivers to keep under 16 kilometers per hour (10 miles per hour). At high speeds, however, speed bumps have less impact on vehicles because suspension systems can absorb the sudden shock.

Speed Tables

Speed tables are raised road surfaces with a flat top which are intended to reduce vehicle speeds. (9) They are longer than the speed hump in the direction of travel, usually about 4 meters (12 feet), so that both the front and back wheels of a vehicle are on the table at the same time. Since speed tables do not run curbline to curbline, they do not interfere with drainage. They can be crossed comfortably at 24 to 40 kilometers per hour (15 to 25 miles per hour) and because they do not run the full width of the roadway, large vehicles can pass over the table without hindrance. Speed tables also allow enough space for bicyclists to pass along side of the speed table without having to cross over the top of the table. They may be implemented on both one-way and two-way streets with two-way streets often having two separate speed tables installed side by side.



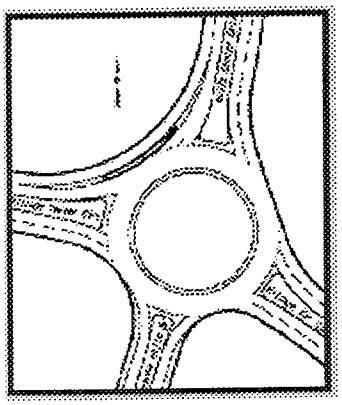
Purpose	Speed tables are intended to reduce vehicle speeds.
Cost	Less than the cost of speed humps since they do not run the full width of the roadway, nor do they affect drainage.
Pros	Effectively reduce vehicle speed. May also reduce traffic volumes. Allow for large vehicles to pass over the table without having to slow down. Improves the safety of pedestrians and bicyclists. Do not interfere with drainage.
Cons	Traffic noise is increased from the braking and acceleration of vehicles. Requires some parking removal.
Service Provider Impacts	Certain emergency vehicles, large trucks, and buses can pass over the speed table easily. Also do not interfere with snow removal.
Effectiveness	Speed tables are effective at reducing vehicle speeds and possibly volumes.
Other Considerations	Speed tables will be more effective if installed in series so as to avoid the speeding up of vehicles between tables. Spacing between tables should be about 76 meters (250 feet).



Traffic Circles

Traffic circles are raised islands placed in the center of an intersection. They can be landscaped with ground cover, flowers, and street trees. Traffic circles require drivers to slow to a speed that allows them to comfortably maneuver around them.

Purpose	The primary benefit of traffic circles is that they reduce the number of angle and turning collisions. An additional benefit is that they slow high-speed traffic.
Cost	$1,500 temporary, $7,000 permanent [4 to 5 meters (12 to 16 feet in diameter)].
Pros	Effectively reduce vehicle speeds. Improve safety conditions (for example, there are fewer left-hand crashes involving other vehicles). Can be visually attractive if accompanied by landscaping.
Cons	Require some parking removal. Can cause bicycle/auto conflicts at intersections because of narrowed travel lanes. Some noise may be generated by the deceleration and acceleration of vehicles as they near the traffic circles.
Service Provider Impacts	Transit buses and fire trucks can maneuver around traffic circles at slow speeds, provided vehicles are not illegally parked near the circles. The installation of traffic circles may interfere with existing utilities in the roadway, such as manholes.
Effectiveness	Traffic circles are very effective at lowering speeds in their immediate vicinity and reducing turning collisions. Traffic circles are most effective when constructed in a series on a local service street.
Other Considerations	If well maintained, traffic circles can be very attractive. However, there are also a lot of traffic control signs and pavement markings associated with circles that are not so attractive. Traffic circles are not effective at T-intersections and difficult to design for offset intersections. A minimum of 9 meters (30 feet) of curbside parking must be prohibited on the through street at each corner of the intersection.



Roundabout

As stated in the National Cooperative Highway Research Program (NCHRP) Synthesis 264, (7) the modern roundabout can be defined by the following operational and design principles:

Yield-at-Entry: Also known as off-side priority or yield-to-left rule, yield-at-entry requires that vehicles in the circulatory roadway have the right-of-way and all entering vehicles on the approaches have to wait for a gap in the circulating flow. To maintain fluidity and high capacity, the entry control is a YIELD sign.

Deflection for Entering Traffic: No tangential entries are permitted, and no traffic stream gets a straight movement through the intersection. Entering traffic points toward the central island, which deflects vehicles to the right, thus causing low entry speeds.

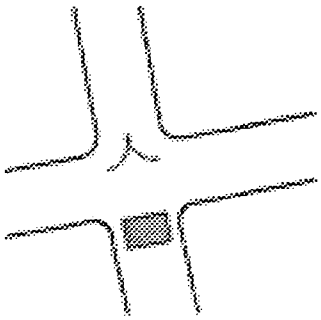
Purpose	Roundabouts are used at intersections where there is either an insufficient amount of queue space available or the intersection has a high accident rate, especially in terms of cross movements or left-turns. In terms of traffic calming, the roundabout can be used to create a change in roadway character prior to entering a community or where a bypass road connects to an arterial.
Cost	$10,000 for an existing intersection, $500,000 (including drainage costs) for a roundabout constructed on a state highway.
Pros	Creates shorter delays. Increased capacity. Improved safety. Can be visually attractive if accompanied by landscaping.
Cons	Low volume streets have the advantage, thus causing undue delays on the major street. Construction costs can be very high. May be difficult for drivers to adjust to the roundabout. Absence of clear right-of-way control for pedestrians. Required parking removal.
Service Provider Impacts	Creates new or unusual maintenance procedures. Snow plowing may require special procedures, particularity if the roundabout is a single-lane design.
Effectiveness	Very effective at reducing the number of accidents, creating shorter delay times, and improving capacity.
Other Considerations	There are no U.S. guidelines currently available for design of the modern roundabout; however, the Federal Highway Administration has started a two-year study to develop guidelines by the end of 1999. Flares are often used at the entries by adding lanes before the yield line in order to increase capacity. The size of roundabouts can range from 15 meters (50 feet) in diameter to 35 meters (115 feet), depending on the number of travel lanes.

Chicane

Chicanes are created by islands along alternating sides of the roadway which narrow the width through which vehicles must travel. Motorists are forced to slow down in order to maneuver along the roadway. Despite an unlimited number of design types, chicanes must be wide enough to allow for the easy passage of emergency vehicles which may result in a loss of effectiveness.

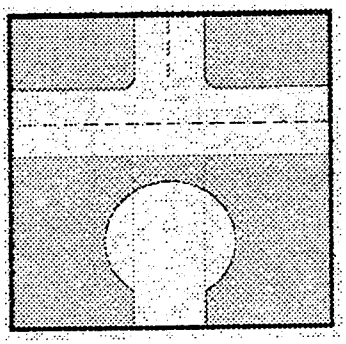
Purpose	Chicanes are used to reduce traffic speeds by creating narrowed sections of roadway which the driver must maneuver around.
Cost	Costs can be very high, depending on drainage structures.
Pros	Additional landscaping space is created by using chicanes. Chicanes serve as a refuge point for pedestrians crossing the road.
Cons	Can make the street look cluttered if not properly designed. Noise levels may be increased.
Service Provider Impacts	Chicanes are difficult for motorists and snow removal operators to see in the winter and may be difficult for emergency vehicles to pass through if not designed wide enough.
Effectiveness	Chicanes are effective at reducing vehicle speed.
Other Considerations	Chicanes are not intended for high-volume roadways. When installed on local streets, it is important to accommodate bicycle traffic into the design.

ROUTE MODIFICATIONS

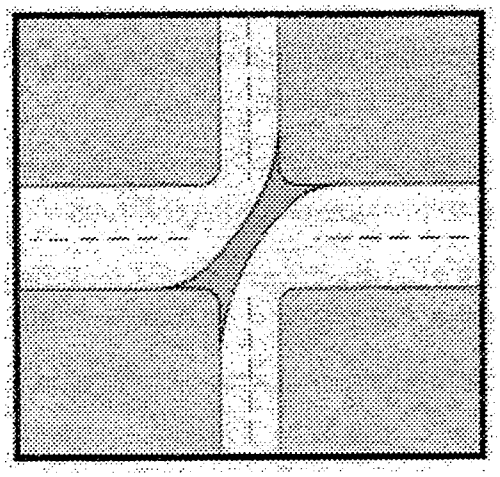


Street Closure (Cul-de-Sac)

Intended to reduce cut-through traffic on residential streets, street closure can either be done at the end of a street or mid-block. There are two types of street closures: a closure near a main thoroughfare which is more effective at reducing traffic volumes; and a second type which allows residents to only have access to the main thoroughfare by having the closure at the far end. (9)



Purpose	Street closures are intended to eliminate cut-through traffic.
Cost	Costs may be very high, depending on added drainage structures and if necessary, right-of-way acquisition.
Pros	Since traffic is limited to that which is generated by residents, traffic volumes, speeds, and noise are greatly reduced. Safety is increased on both the closed street and the main thoroughfare.
Cons	Some residents may view closures as negative since access is limited to only the main thoroughfare. Traffic volumes on neighboring roadways may increase.
Service Provider Impacts	Street closures may affect emergency vehicle and city service routes, although the center of the cul-de-sac can be used for snow storage in the winter. Emergency vehicle access to the closed street should be analyzed prior to the actual closing.
Effectiveness	Very effective at reducing traffic volumes and speeds.
Other Considerations	Street closures should be visible to drivers prior to entering the cul-de-sac to avoid traffic not realizing it is a dead end until they have already entered the cul-de-sac. The capacity of the main thoroughfare should be carefully analyzed prior to any closure.



Diagonal Diverters

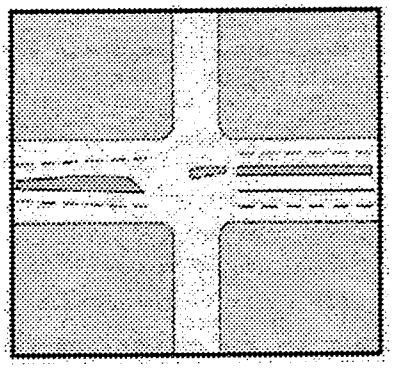
Diagonal diverters place a barrier diagonally across an intersection, disconnecting the legs of the intersection. (9)

Purpose	Strategically located diagonal diverters reduce traffic volumes by preventing through movements at intersections where installed.
Cost	$15,000 - $35,000
Pros	Effectively reduce traffic volumes. Can restrict vehicle access while retaining bicycle and pedestrian access.
Cons	While the purpose of a diversion device is to prohibit or limit access and movement, some drivers consider it a disadvantage.
Service Provider Impacts	Generally, the turn restrictions imposed by a diagonal diverter would apply to emergency vehicles and are typically not used on primary fire response routes. However, diagonal diverters can be designed and installed to provide for emergency vehicle access. Diagonal diverters should not be considered on transit streets.
Effectiveness	Diagonal diverters are very effective at reducing traffic volumes.
Other Considerations	Diagonal diverters apply to all drivers, including local residents. Very special care must be taken to consider the availability, capacity, and appropriateness of the alternative routes drivers might use if a diverter is constructed. Provisions should be made to make diverters passable for pedestrians and bicyclists.

Semi-Diverters

Semi- or partial-diverters eliminate travel in one direction by reducing the roadway width to only one lane. Semi-diverters can be used at intersections to effectively divert traffic onto an alternate route. Traffic is physically prohibited from turning movements onto the side street. The diverter can then be used for additional landscaping space or as a pedestrian refuge. (9)

Purpose	Semi-diverters reduce traffic volumes by allowing only one lane of travel. Traffic is then rerouted onto other roadways.
Cost	$2,500
Pros	Traffic volumes are virtually eliminated at the semi-diverter in the closed direction. Volume beyond the diverter is reduced to that generated by the land use of the adjacent properties. Noise pollution is reduced and safety is increased in the closed direction on the residential streets.
Cons	Traffic volumes on alternate routes are increased.
Service Provider Impacts	Since turning movements onto side streets are physically prohibited, semi-diverters should not be considered on transit or primary fire response routes.
Effectiveness	Extremely effective at reducing traffic volume in the closed direction.
Other Considerations	May be helpful to educate residents on its use since it is not a common traffic device. Semi-diverters should only be used on streets designed as local streets and are not intended to be through routes. Also should not be installed on streets which provide access to schools, parks, etc.



Median Barriers

Median barriers prevent cut-through traffic by prohibiting left turn movements from a major street onto a local street. Median barriers also prevent continuous through travel on the local street. (9)

Purpose	Strategically located median barriers will reduce traffic volumes on the minor street if there are a significant number of left turn movements onto or off of the local street. Traffic volumes of through traffic on the minor street will also be reduced significantly.
Cost	$1,500 - $20,000, depending on the need for road widening.
Pros	Separate opposing vehicle travel lanes. Prevent vehicles from passing other vehicles. Depending on location, may improve safety through access limitations. Can be designed to provide pedestrian refuges. May be used to visually enhance the street through landscaping.
Cons	May require major parking removal. Prohibit or limit access and movement (from driveways).
Service Provider Impacts	May have a negative impact on emergency services because of access limitations. They may also prevent transit service on the blocked street. The turn restrictions imposed by a median barrier would apply to emergency vehicles and are therefore, not typically used on primary fire response routes.
Effectiveness	Median barriers can be very effective in reducing traffic volumes. Vehicle speeds may also be reduced by reducing through traffic.
Other Considerations	Very special care must be taken to consider the availability, capacity, and appropriateness of the alternative routes drivers might use if a median barrier is constructed.

PERCEPTUAL ENHANCEMENTS

Streets with few changes in physical or visual make-up can often create a sense of monotony, resulting in little attention being given to actual driving behavior. Drivers concentration on the roadway can be increased by creating "obstacles" which the driver must adapt to by changing his or her driving behavior. One of the ways this can be done is through perceptual enhancements which alter the actual road surface material or color.

Different road surface materials, such as cobblestone, can be added to the roadway in localized strips to produce a rougher roadway section. This alerts drivers to their surroundings by creating a rumble as they pass over the change in roadway material. Different colors can also be used to create a separate lane of travel for bicycle or pedestrian traffic, indicating to drivers that the area is pedestrianized and they should slow down. It is important to note that extremely rough materials may be very noisy at high speeds, which can be annoying to residents who live nearby.

Surface material changes can also be done to the entire roadway section. This is done primarily in shopping and historic areas. The surface change often results in reduced speeds, particularly for drivers who are unfamiliar with the area.

Landscape plantings may be another effective way to alter the behavior of drivers while improving the overall appearance of the street. Often most effective when combined with modifications in roadway geometry, landscape plantings are thought to cause the average driver to pay closer attention to his or her surroundings. If drivers have more to focus on, they will tend to slow down. Designs should include trees with a certain volume and maturity and a clear stem height of 2.4 meters (8 feet) so that drivers are able to see pedestrians. Bushes and hedges should not be left to grow beyond 0.6 meters (2 feet) so that children are visible to the driver. It is also important to consult a landscape specialist on the type and species of plantings suitable to the climate and to ensure that existing drainage patterns will not be hampered.

TECHNOLOGY

An alternative to installing speed reduction treatments to the roadway, such as those mentioned above, may be through the use of technology. One such technology is the Motion Imaging Recording System (MIRS), which is gaining popularity in over 30 countries throughout the world. Although MIRS is currently not enforceable in Minnesota, it is being employed in 13 states throughout the United States to detect traffic violations. (11) Often used at traffic light controlled intersections to detect red-light running, MIRS uses a camera to photograph the vehicle and license plate once a violation has been detected. The camera is triggered when a driver passes over an inductance loop, which is imbedded into the roadway, after the light has turned red. Once triggered, the camera, which sits atop a pole about 23 meters (75 feet) from the intersection, will take a picture of the vehicle entering the intersection. A second picture is taken approximately one second later as the vehicle leaves the intersection. Drivers are then either issued a warning or a ticket for the violation. With a clear picture of their vehicle license plate and the red traffic light, the offense is hard to dispute.

MIRS can also assist police officers with numerous other traffic violations, such as work zone speeding, railroad crossing gate violations, bus-only shoulder and HOV lane misuse, to name just a few. Attributed results of using the cameras are reductions in traffic violations and accidents. Another outcome of MIRS is that it enables police officers to spend less time issuing traffic violations and more time concentrating on more serious crimes.

Offenders may, however, object to the use of MIRS. Some feel that having their picture taken is an invasion of privacy. Drivers are also not given the luxury of trying to explain themselves and face their accuser immediately. Regardless of the position held, drivers who obey the law may in time become violators if they feel enforcement of the law is being ignored.

EXAMPLES OF TRAFFIC CALMING IN MINNESOTA

Examples of what various cities in Minnesota are implementing in terms of traffic calming are included on the following pages. Located on local, collector, and arterial roadways, these projects are intended to serve as a reference for municipalities who are considering the installation of a traffic calming device. Some of the projects were failures, some successes, but all should prove to be an excellent learning tool. Most of the information was provided by SRF Consulting Group, Inc. and was obtained through the survey conducted in early 1997. These projects were not cited in the "Traffic Calming Activity in Minnesota" report since that report focused mainly on higher functioning roads. Residents' reactions to the traffic calming devices are summarized in the table as positive (+), negative (-), or neutral (N). If the reaction is that of an adjacent business owner, the symbol is followed by an asterisk.

Traffic Calming Summary Data									
City	**Project Location**	**Project Description**	**Date**	**Road Class**	**Reasons for Project**	**Actual/Perceived Outcomes**	**Negative Impacts**	**Resident Reaction**	**Contact Person & Other Comments**
Andover	Narcissus St. between Bunker Lake Blvd. and Round Lake Blvd.	Temporary speed humps; Street closure; Increased police patrols; Extensive neighborhood participation.	Aug, 1996		Cut-through traffic				Scott Erickson: (612) 755-5100 Temporary speed bumps removed after 2 weeks at the request of the neighborhood.
Blaine	129th Ave. between Isanti Rd. and Radisson Rd.	Median island; Street narrowing; One-way streets.	Fall, 1996	Local Street	Proposed development included traffic calming measures.				Chuck Lenthe: (612) 785-6188 Partially funded by developer.
Blaine	Jefferson St. between 120th Lane and Madison St.	Temporary street closure (since removed); Stop signs.	May, 1991	Local Street	Accident experience; Resident dissatisfaction with street environment.	Improved safety for non-motorized users; Change the psychological feel of the street.		N	Chuck Lenthe: (612) 785-6188 Example of unwarranted stop sign installation that seems to have corrected a problem.
Brooklyn Center	Indiana Avenue and 71st Avenue North	Traffic Circle	1983	Local Street	Organize traffic entering and exiting St. Alphonsus Catholic Church Campus on Sundays.				Neighborhood meetings were held to decide what device to implement.
Brooklyn Center	Unity Avenue	Speed humps	1993	Local Street	Reduce speeding and cut-through-traffic in a multi-family residential neighborhood.		Residents felt the additional signage required and painting were "unsightly."		Speed humps were installed according to the ITE template.
Brooklyn Park	West River Rd. and Riverdale Dr. between 73rd Ave. and Brookdale Dr.	Street closures	Aug, 1992	Local Street	Cut-through traffic (diverting from TH252); High vehicular speeds; High traffic volumes.	Reduction of cut-through traffic; Reduction in vehicle speeds; Reduction in traffic volumes.	More difficult access for emergency vehicles and transit.	+	
Burnsville	Knox Dr. between Burnsville Parkway and 136th St.	Speed humps	Aug, 1996	Local Street	Resident dissatisfaction with street environment; Cut-through traffic; Perception of high vehicle speeds or traffic volumes.	Reduction of cut-through traffic; Maintenance of neighborhood character; Reduction in vehicle speeds.	More difficult access for emergency, maintenance, snow removal vehicles; Poor drainage in winter.	+	Chuck Ahl: (612) 895-4544

Traffic Calming Summary Data									
City	**Project Location**	**Project Description**	**Date**	**Road Class**	**Reasons for Project**	**Actual/Perceived Outcomes**	**Negative Impacts**	**Resident Reaction**	**Contact Person & Other Comments**
Duluth	Jefferson St. at 17th Ave. E.	36' diameter traffic circle; Speed hump.	Aug, 1995	Local Street	High vehicular speeds; Cut-through traffic; Resident dissatisfaction with street environment; Perception of high vehicle speeds or traffic volumes.	Reduction in vehicle speeds, traffic volumes, collisions, and cut-through traffic; Additional greenery; Improved safety.	More difficult access for maintenance and snow removal; Snow storage impacts.	+	Bob McCubbin: (218) 723-3347 Community is planting flowers in the circle.
Eagan	Deerwood Drive	Converging chevron pavement markings, "30 mph" pavement message, high visiblility "wind spinners" on existing speed limit signs, and installation of a pedestrian crosswalk using pavement markings.	1997	Minor Collector	Residents petitioned for a stop sign to be installed. in the neighborhood to slow traffic down. Since the stop sign did not meet any warrants for installation in the MUTCD, other methods were used to reduce traffic speeds.	Before/after speed studies indicated that the 85th percentile speed limits were reduced by 5-7 mph. 83% of the residents felt that the pavement markings were the most effective.		+	Pre and post improvement surveys were mailed out to access the residential perception and inform them of the proposed improvements.
Eden Prairie	Homeward Hills Rd. between Sunnybrook Rd and Anderson Lakes Pkwy.	Prohibition of northbound right turns during peak AM hour.		Major Collector	Cut-through traffic; High traffic volumes; Traffic management.	Reduction in cut-through traffic; Reduction in traffic volumes.		+	Alan Gray: (612) 949-8320 Considered an effective means of curtailing cut-through traffic.
Eden Prairie	Dell Rd. at Evener Way	Creation of right-in/right-out situation at intersection using turn restrictions and a trumpet island.		Minor Collector	Cut-through traffic; High traffic volumes; Traffic management.	Reduction of cut-through traffic; Reduction in traffic volumes.	More difficult access for emergency, maintenance, and left turning vehicles.	N	Alan Gray: (612) 949-8320 Recent survey indicates area residents prefer removal.
Farmington	187th St. between Pilot Knob and English Ave.	Median island; Landscaping.		Local Street	Requested by developers of new housing subdivision.	Reduction in vehicle speeds; Additional greenery.	Increased maintenance costs.	+	
Hopkins	Main Street	Choker; Protected parking bays; Streetscape materials.	1991		Business dissatisfaction with street environment; Desire to increase on-street parking.	Additional greenery; Increased parking.		+*	

Traffic Calming Summary Data									
City	**Project Location**	**Project Description**	**Date**	**Road Class**	**Reasons for Project**	**Actual/Perceived Outcomes**	**Negative Impacts**	**Resident Reaction**	**Contact Person & Other Comments**
Minneapolis	Lowry Hill East Neighborhood	Installation of 15 chokers and 6 speed humps as part of neighborhood repaving project.	Oct, 1996	Minor Collector	Resident dissatisfaction with street environment; Traffic management.		None	+	Bill Bruneau: (612) 673-5750
Minneapolis	Intersections of W. 43rd St. and Washburn Ave. S. and W. 43rd St. and Vincent Ave. S.	Traffic circles at both intersections.	Sept, 1996	Local Street	Perception of high vehicle speeds or traffic volumes; Cut-through traffic; Resident dissatisfaction with street environment.	Reduction in vehicle speeds; Reduction in traffic volumes; Reduction of cut-through traffic.	None	+	Jim Daire: (612) 673-3244 Funded by neighborhood.
Plymouth	South Shore Dr. between 10th Ave. and 13th Ave.	5 speed humps	Jun, 1995	Minor Collector	Resident dissatisfaction with street environment; High vehicular speeds; Traffic creates a barrier to pedestrian/bike movement.	Reduction in vehicle speeds; Change the psychological feel of the street; Increased community life and vitality.	Dissatisfied residents routinely honk horns to protest.	+	Fred Moore: (612) 509-5501
Plymouth	Peony Lane and 19th Ave. between CR 6 and 20th Ave.	2 speed humps	Sept, 1996	Minor Collector	Resident dissatisfaction with street environment; High vehicular speeds; Traffic creates a barrier to pedestrian/bike movement.	Reduction in vehicle speeds; Improved safety for non-motorized users; Increased community life and vitality.	Increased noise at one of the speed humps.	+	Fred Moore: (612) 509-5501 Seen as a test project for typical residential minor collector streets.
Prior Lake	Coachman Lane between CSAH 21 and Carriage Hills Parkway	Colored concrete median islands; Street narrowing; Landscaping.	1992-1996	Local Street	New development; Cut-through traffic; Perception of high vehicle speeds or traffic volumes.	Reduction in vehicle speeds; Change the psychological feel of the street; Additional greenery.	Snow storage impacts; Right-in/right-out access to driveways.	N	Jeffery Evens: (612) 447-4230 Funded by developer.
Richfield	W. 70th St. between Penn Ave. and Xerxes Ave.	Strategies to minimize cut-through traffic on W. 70th St.: Stop signs; Yield signs; Left turn arrow at 70th/York signal.	Nov, 1996	Local Street	Cut-through traffic; High traffic volumes; Accident experience.	Reduced collision frequency and severity; Reduction in through traffic.	Unwarranted stop signs and traffic diversion; Opposition from residents on diversion routes.	±	Tom Foley: (612) 861-9791

Traffic Calming Summary Data									
City	**Project Location**	**Project Description**	**Date**	**Road Class**	**Reasons for Project**	**Actual/Perceived Outcomes**	**Negative Impacts**	**Resident Reaction**	**Contact Person & Other Comments**
Rochester	26th St. NE at Viola Heights Dr.	Semi-diverter	Jun, 1996	Local Street	Resident dissatisfaction with street environment; High vehicular speeds; High traffic volumes.	Maintenance of neighborhood character; Reduction of cut-through traffic; Reduction in traffic volumes.	More difficult access for public transit; No alternative route was provided.	+	David Rossman: (507) 281-6194 Partially funded by developer.
Rochester	1st Ave. SE/NE from 1st St. SE to 1st St. NE	On street angle parking	1993	Local Street	Need for increased parking; Business dissatisfaction with street environment; Land use or zoning changes.	Increased parking; Additional greenery.	Snow storage impacts.	+*	David Rossman: (507) 281-6194
St. Cloud	25th Ave. N. (1st St. to 12th St.); 33rd Ave. N. (8th St. to 12th St.)	Delineation of parking lanes with paint	Jul, 1995		Use of parking lanes as driving lanes, thus turning a 2-lane roadway into a 4-lane roadway.				Steve Gaetz: (320) 255-7241
St. Louis Park	Excelsior Blvd. between France Ave. and TH 100	Street narrowing; Choker; Landscaping; Turn restrictions; Median island; Marked crosswalks; Protected parking bays.	Jun, 1994	Minor Arterial	Land use or zoning changes; Resident dissatisfaction with street environment; Traffic creates barrier to pedestrian/bike movement.	Change the psychological feel of the street; Increase in pedestrian, bike, &/or transit use; Additional greenery.		+	Mike Rardin: (612) 924-2555
St. Louis Park	W. 38th St. between France Ave. and Excelsior Blvd.	Strategies to minimize cut-through traffic on W. 38th St.: Diagonal diverter; Stop signs.	Jun, 1993	Minor Collector	Resident dissatisfaction with street environment; Perception of high vehicle speeds or traffic volumes; Cut-through traffic.	Reduction of cut-through traffic; Reduction in traffic volumes; Reduction in vehicle speeds.	Stop sign noncompliance has increased.	+	Mike Rardin: (612) 924-2555
St. Louis Park	31st St. at Louisiana Ave.	Trumpet island; Turn restrictions (only right-in/right-out from 31st to Louisiana Ave.)		Local Street	Accident experience; Traffic management.	Reduction in traffic volumes; Reduced collision frequency and severity.		-	Mike Rardin: (612) 924-2555

Traffic Calming Summary Data

City	Project Location	Project Description	Date	Road Class	Reasons for Project	Actual/Perceived Outcomes	Negative Impacts	Resident Reaction	Contact Person & Other Comments
St. Paul	Summit Ave. at Ramsey Hill	Median island; Elimination of one traffic lane.		Minor Arterial	Perception of high vehicle speeds or traffic volumes; Resident dissatisfaction with street environment; Traffic management.	Increase in pedestrian, bike, &/or transit use; Reduction in traffic volumes; Reduction of cut-through traffic.		+	Tom Stadsklev: (651) 266-6217
St. Paul	Highland Parkway at Woodlawn Ave.	Median islands; Marked crosswalks; Choker.	Aug, 1996	Major Collector	Perception of high vehicle speeds or traffic volumes; Traffic management; Resident dissatisfaction with street environment.	Increase in pedestrian, bike, &/or transit use; Maintenance of neighborhood character; Change the psychological feel of the street.		+	Tom Stadsklev: (651) 266-6217
St. Paul	Wabasha St. between Kellogg Blvd. and 7th St.	Reduction in number of through lanes; Addition of on-street parking; Striped bike lane; Choker (paint); Marked crosswalks.	Jul, 1996	Minor Collector	Business dissatisfaction with street environment; New development; Traffic creates a barrier to pedestrian/bike movement.	Change the psychological feel of the street; Increased community life and vitality; Increase in pedestrian, bike, &/or transit use.	None	+*	Tom Eggum: (651) 266-6099
St. Paul	Victoria at Goodrich Ave. and Fairmount Ave.	Chokers	Aug, 1994	Minor Collector	High vehicular speeds; High traffic volumes; Traffic management.	Reduction in vehicle speeds; Reduction in traffic volumes; Reduction of cut-through traffic.	Complaints of unsightly chevron signs.	+	Tom Stadsklev: (651) 266-6217
St. Paul	Residential streets throughout city	Basket weave stop signs.	1983 - 1993	Local Street	Perception of high vehicle speeds or traffic volumes; Accident experience; High traffic volumes.	Reduced collision severity and frequency; Improved safety for non-motorized users; Reduction in vehicle speeds.		+	Bill Hagland: (651) 266-6206

Traffic Calming Summary Data									
City	**Project Location**	**Project Description**	**Date**	**Road Class**	**Reasons for Project**	**Actual/Perceived Outcomes**	**Negative Impacts**	**Resident Reaction**	**Contact Person & Other Comments**
St. Paul	Shields Ave. and Aldine St.	Chokers	Aug, 1992	Local Street	Perception of high vehicle speeds or traffic volumes; Resident dissatisfaction with street environment; Traffic management.	Improved safety for non-motorized users; Change the psychological feel of the street; Reduction in vehicle speeds.			Tom Stadsklev: (651) 266-6217
St. Paul	Shields Ave. at Fry St.	12' Traffic circle	Aug, 1992	Local Street	High vehicular speeds; High traffic volumes; Resident dissatisfaction with street environment.	Reduction in vehicle speeds; Reduction in traffic volumes; Change the psychological feel of the street.		+	Tom Stadsklev: (651) 266-6217
St. Paul	Hillcrest Ave. between Cleveland Ave. and Kenneth St.	Choker; Street narrowing; One-way street.	Aug, 1995	Local Street	Perception of high vehicle speeds or traffic volumes; Safety concerns due to nearby school and playground; Business dissatisfaction with street environment.	Reduction in vehicle speeds; Increase in pedestrian, bike, &/or transit use; Reduction in traffic volumes.		+*	Tom Stadsklev: (651) 266-6217 Included on-street bus-parking in protected bay.
White Bear Lake	Bald Eagle Ave. and Lincoln Ave. west of TH 96/TH 61 intersection	Street closure of Bald Eagle Ave. and Lincoln Ave., which were close to major TH intersection; Landscaping.	1996	Local Street	Accident experience; Traffic management; High traffic volumes.	Reduced collision frequency and severity; Reduction in traffic volumes; Improved safety for non-motorized users.	More difficult access for emergency vehicles and transit.	+	Mark Burch: (651) 429-8563

CONCLUSION

Although every road authority will approach traffic calming in their own unique way, the manner in which they go about implementing traffic calming will be of utmost importance. The Ottawa process provides an excellent example of how traffic calming can be implemented successfully, but what works for one agency may not work for another. Engineers must consider the uniqueness of their community, along with any past experiences with traffic-related problems. Since residents' reactions will most often be the deciding factor in whether a project is perceived as a success or failure, engineers must involve the community in the decision making process. It will also be crucial to project success that the entire street network be considered to assure that the traffic problem is not simply shifted to another street or neighborhood.

Success also depends on choosing the most appropriate traffic calming application. Despite the increasing number of traffic calming projects, it was concluded in the initial study done by SRF Consulting Group, Inc. that there is little hard data to determine the effectiveness of individual traffic calming devices or techniques. Since the future of traffic calming depends largely on those implementing it today, the manner in which future research is conducted is crucial to the development of these standards. Agencies must be sure to collect and record before and after data such as ADT, 85th percentile speed, accident experience, and residents' reactions, as well as such things as roadway classification, funding resources, and service provider impacts so that others may benefit from what they have learned.

SRF Consulting Group, Inc., along with the Human Factors Research Laboratory at the University of Minnesota, will be using the laboratory's wrap-around driving simulator to evaluate driver response to a select number of traffic calming measures. Before and after data will also be collected on actual projects to evaluate the effectiveness of the implemented devices at achieving their intended purpose. Final results from these studies are expected by the Spring of 2000. It is the hope that with increased knowledge, traffic calming will become an easier, more effective way of making our neighborhoods an enjoyable place to live.

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