City of Stockton

Traffic Calming Guidelines

Revised April 2008

City of Stockton
Public Works Department

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I. INTRODUCTION

Purpose

The City of Stockton developed a Neighborhood Traffic Management Program (NTMP) to address concerns about safety, noise and quality of life issues related to vehicle traffic on neighborhood streets. The NTMP includes a formal process for the implementation of traffic calming measures in Stockton neighborhoods and a toolbox of potential traffic calming measures. This document outlines the traffic calming program and is supported by two related documents:

- Street Design Guidelines, which include revisions to Stockton's street development standards to include narrower street widths, landscape strips separating the curb from the sidewalk, and requirements for roundabouts and traffic circles in lieu of traffic signals or stop signs at many new intersections as development occurs in Stockton

- Pedestrian Safety and Crosswalk Installation Guidelines, which provide guidance for improving pedestrian safety, circulation, and specific guidelines for the installation of crosswalks

The traffic Calming Guidelines provide a framework for the selection, application, and design of traffic calming measures in the City of Stockton. This document is primarily intended for use by City staff and neighborhood residents when developing traffic calming plans as part of the NTMP. The NTMP is the formal process by which City staff identifies neighborhoods in need of traffic calming and implements a neighborhood specific traffic calming plan to reduce the severity of the problem at hand. This document also assists City staff and developers concerned with avoiding traffic problems in new neighborhoods and members of the general public who are interested in finding out how the City of Stockton implements traffic calming plans.

Being guidelines, the contents are not intended as rigid requirements; rather, they are a tool for use by City staff, citizens, and other interested parties to help develop effective traffic calming plans that adequately accommodate motor vehicles, pedestrians, and bicyclists, while enhancing the neighborhood environment.

The guidelines provide a process for City staff and community members to identify various traffic calming problems experienced in existing neighborhoods (i.e. high speeds, volumes, and cut-through traffic) and to develop effective solutions. A "toolbox" of traffic calming measures describes each device and the type of problem that it is effective at treating. The toolbox also contains pictures of past installations, design considerations that may apply to your preferred traffic calming solutions, and design standards.

City Staff and developers can reduce the need for future traffic calming by designing new streets that discourage speeding and cut-through traffic. Streets should be designed to provide adequate travel lanes and parking yet avoid excessive widths. Shorter blocks reduce the ability of drivers to reach and maintain high speeds. To supplement these good design practices, traffic calming measures can also be installed as part of the initial development.

Goals

The goal and objectives of this document are patterned after the NTMP. The driving goal of the NTMP is:

> To improve safety and the quality-of-life for residents by reducing the impacts from speeding vehicles, cut-thru traffic, and careless drivers.

The NTMP strives to meet this goal through the implementation of self-enforcing mechanisms that result in:

- Reduced speeding
- Reduced numbers and/or reduced severity of reported collisions
- Reduced cut-through traffic where existing levels are significant and where the remedy will not create a problem on other streets
- A better environment for residents and business owners as indicated by their sense of safety, property values, comfort in using the street, and reduced traffic-related complaints

These objectives will be met through effective engineering principles applied to the development of traffic calming strategies that address

community-identified traffic issues. Residents will be educated with information and tools necessary to become active participants in addressing their neighborhood traffic concerns. Targeted police enforcement will support the traffic calming plan developed by residents and the City Traffic Engineer.

The traffic calming measures proposed in this document are intended for use on two-lane local residential, local commercial, and minor collector streets to "calm" traffic in and around neighborhoods. Speed management on arterials and major collectors can be accomplished through non-physical measures (such as signal timing) rather than physical devices that reduce roadway capacity.

The role of the guidelines in supporting the goal and objectives above is to articulate the method by which tools and strategies are considered and selected for use in meeting those goals and objectives.

ADVISORY PANEL MEMBERS:

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- Tom Wells, City of Stockton Police Department
- Kari Wilson, San Joaquin Regional Transit District

How the Guidelines Were Developed

The contents of the guidelines were developed with the assistance of an advisory panel, composed of City staff and other local agencies. The advisory panel was convened on January 24, 2003, for a workshop designed to gather input on the traffic calming guidelines.

The workshop also included a tutorial on traffic calming, focusing on the types of measures available including engineering and aesthetic issues. The panel actively discussed traffic calming measures and aesthetic options. Through this discussion, the panel reached a consensus that defined the range of acceptable roadway characteristics on which selected measures, designs, and aesthetics would be applicable.

In June 2006, these guidelines were revised to reflect changes approved by the City Council such as the way neighborhoods are

organized on the waiting list and the inclusion at vertical traffic calming measures in the "toolbox."

These guidelines where revised again in April 2008 to simplify the overall process in order to shorten its timeline and reduce administrative costs. Part of this revision included creating a Humps/Lumps Program that allowed only a few choices from the "toolbox" but provided an expedited process.

For More Information

The guidelines draw extensively from the approved *City of Sacramento Traffic Calming Guidelines*, 2002 and two documents written by Reid Ewing: *Traffic Calming: State of the Practice* (Reid Ewing, FHWA, 1999) and *Delaware Traffic Calming Design Manual* (Reid Ewing, Delaware Department of Transportation, 2000). For more detailed information on the topics addressed in this document, please refer to these reports. A more comprehensive list of resources is listed in Chapter VII.

II. NEIGHBORHOOD TRAFFIC MANAGEMENT PROGRAM (FOR EXISTING NEIGHBORHOODS)

Process for Selecting a Neighborhood

For a neighborhood to be included in the NTMP, a resident must complete the NTMP Request Form which includes questions about the neighborhood boundaries, traffic issues that concern residents in the neighborhood, and a petition. Ten residents at least 18 years of age and from separate households within the neighborhood boundaries described in the NTMP Request Form must sign the petition. The completed form/petition must be submitted to the Public Works Department, Traffic Engineering/NTMP.

The process began with an initial sixty-day filing period to provide an equal opportunity for all interested residents to submit their completed form. At the close of the filing period, a lottery was held to determine the order of participation and establish a waiting list. Public Works continuously accepts NTMP Request Forms and ranks on the waiting list in the order received. The goal is to select the highest ranking neighborhood in each of four geographical areas to participate in the program each year. The Calaveras River divides the north and south areas, and Lower Sacramento Road, Pacific Avenue, Harding Way, and El Dorado Street divide the east and west areas.

Neighborhood boundaries will be established based on information from the NTMP Request Form, a review by Public Works staff to ensure that all affected areas are included, and input from the City Council if necessary. Requests with overlapping boundaries may be consolidated if appropriate. The NTMP process is summarized by the flowchart in Figures A-1. The process includes two program options – the Humps/Lumps Program and the Full Program. The Humps/Lumps Program is an expedited process that includes the use of only humps, lumps, striping, and signing while the Full Program allows the use of all the traffic calming options in the "toolbox". At the beginning of the process, the neighborhood will need to decide which program they want to pursue. However, nothing precludes a neighborhood from changing programs during the process if they so chose.

Getting the Process Started

Public Works kicks off the NTMP in each selected area by inviting all residents to learn more about the program at a community meeting. At this meeting, interested residents can volunteer to participate on the Traffic Calming Committee (TCC) for their neighborhood. Although all residents provide input and receive updates as the plan develops, the TCC is more actively involved, committing the time and effort necessary to develop a comprehensive plan.

Timeframe

The approximate timeline for each program is shown in Figure A-1. The timelines for each program are approximate and depend on the number of meetings that the neighborhood needs to develop and approve a traffic calming plan.

Traffic Calming Plan:

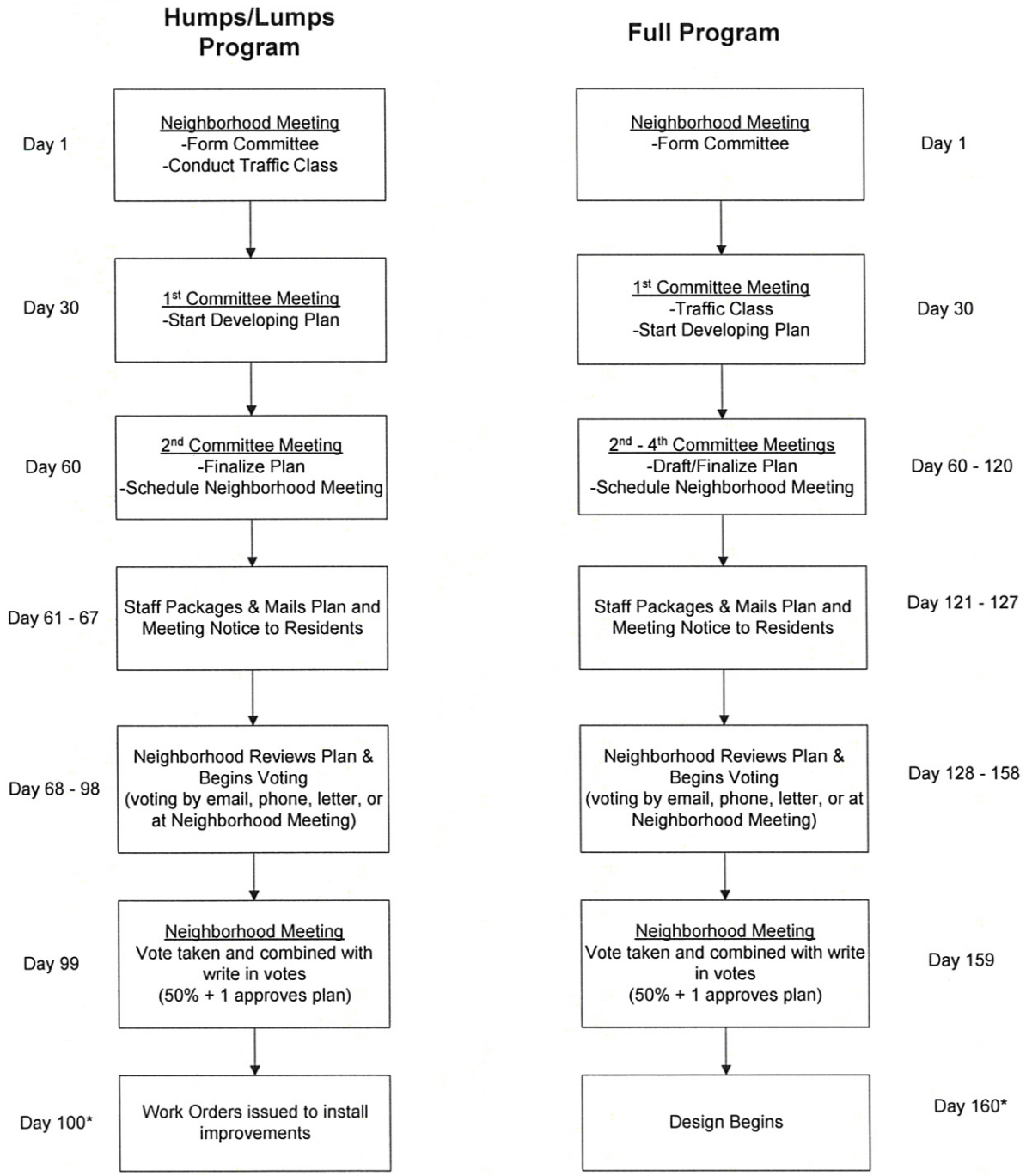
All neighborhoods begin by developing a traffic calming plan aimed at changing driver behavior. Under the Humps/Lumps Program the traffic calming plan will use non-physical measures, humps and lumps. The Full Program will have the option of choosing from all five types of traffic calming measures as follows:

- Non-physical measures – include reducing obstructions that limit driver visibility, signage, and striping improvements
- Narrowing measures – include bulbouts, chokers, and center island narrowing
- Horizontal measures - include traffic circles, roundabouts, and chicanes
- Vertical measures – include speed humps and speed lumps
- Diversion Devices – includes partial and full street closures

These measures are coupled with police enforcement and educational outreach for a comprehensive approach to traffic calming.

Non-Physical Measures (i.e. visibility, signage and striping improvements, etc.) do not require the same level of community consensus as the implementation of physical measures. Therefore, Non-Physical Measures (see Table 1) may be installed with a request from the TCC and approval by the City Traffic Engineer.

REVISED TRAFFIC CALMING PROCESS



***Schedule dependent on number of Committee Meetings**

Figure A-1. NTMP Process Flowchart

Developing the Plan

The TCC and Public Works hold regular meetings to

- Organize neighborhood outreach
- Identify specific traffic concerns
- Target potential measures
- Consider transit needs and public safety , if applicable
- Develop a traffic calming plan
- Present the plan to the neighborhood at a community meeting
- Refine the plan based upon community input

Voting Process

All neighborhood households and businesses have the opportunity to participate in a vote to approve the traffic calming plan that is developed. A simple majority of those that chose to vote is needed to approve the plan. Every household and business is allowed one vote.

For a neighborhood approved plan developed through the Full Program process, plans, specifications, and estimates will be prepared and the project advertised for bids. The plan is then presented to the City Council for final approval, funding, and award of a construction contract.

For a neighborhood approved plan developed through the Humps/Lumps Program process, no design work will be needed. Once this type of plan is approved by a neighborhood vote, City staff will proceed straight to construction and notify the City Council through "*The Week in Review*" or other suitable written method.

III. EXISTING NEIGHBORHOOD IMPLEMENTATION

This chapter addresses how to select a traffic calming device in an existing neighborhood. Typically, this process will occur as a part of the larger NTMP. By clearly identifying traffic problems, setting goals and selecting appropriate traffic calming measures to meet those goals, a TCC can develop a traffic calming plan that has a greater likelihood of being approved and of meeting its goals. Figure 1 summarizes the steps that should be taken in the plan development process.

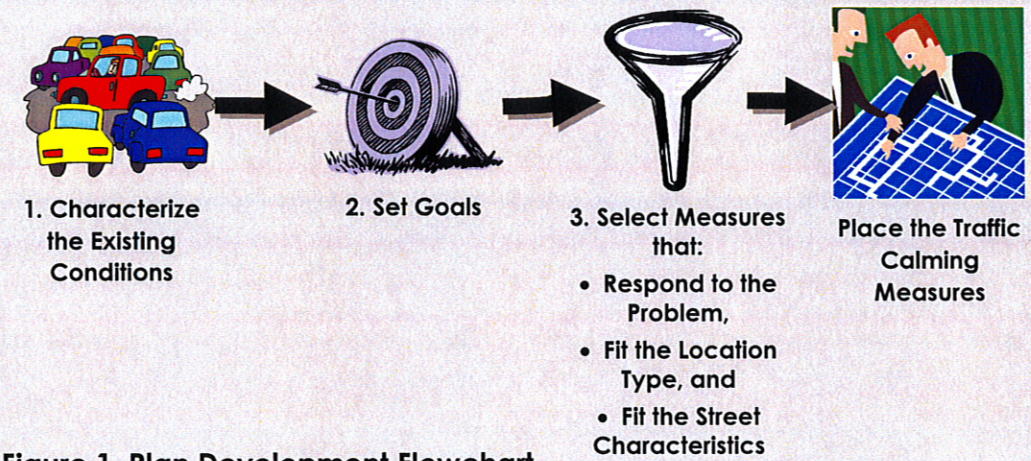


Figure 1. Plan Development Flowchart

1. Characterizing the Problem and Its Environment

The first step in developing a traffic calming plan is to characterize the problem type and to gather information about other conditions present at the problem location. This is accomplished through two tasks:

- Gathering neighborhood input on problems and priorities
- Characterizing problem details

Neighborhood Input

Resident input must be used to determine whether the primary concern is one of vehicle safety, pedestrian safety, congestion, noise, inconvenience, or something else entirely. If speeding is raised as the main issue, it is important to determine whether the noise factor, the safety factor, or some other concern is paramount. If cut-through traffic is a concern, it is important to know why the traffic is problematic: does it travel too fast, or is there simply such a high volume that it bogs down traffic flow through the neighborhood? If safety is the main concern, then what seems to be the cause: high speeds, cut-corners, or a particularly dangerous conflict location? In many cases, a problem that initially looks like a speeding problem may be a safety problem, or one that initially looks like a volume problem may be a speeding problem.

Characterizing Problem Details

When the primary problem type is determined, the details of the problem need to be characterized: exactly where does it occur, and at what times of day and days of week? Is there a traffic control device (such as all-way stop control at an intersection) that does not seem to work?

Collecting Data

Knowing the exact nature of the problem, the next step is to collect relevant information about the problem and its environment. See the sidebar "Types of Traffic Data" for some examples. For the Humps/Lumps Program, data collection will be minimal.

TYPES OF TRAFFIC DATA:

- **Roadway Geometry:** Street widths, block lengths, and locations of stop signs and traffic signals.
- **Roadway Users:** Traffic volumes during peak hours, the entire day, and any particular periods when the problem occurs; pedestrian and bicycle volumes; truck volumes; bus routes; designation as a primary emergency response route; and origin-destination studies.
- **Vehicle Performance Data:** travel speeds, stop sign violations, rates of unsafe driving practices (e.g. cutting corners or crossing the centerline), and collision records.

2. Setting Goals

Before selecting between the Full Program or the Humps/Lumps Program, the neighborhood should have some idea of their desired outcome. Goals should be stated to express the results that the neighborhood would like to achieve with a Traffic Calming Plan.

3. Choosing the Process (Full Program or Humps/Lumps Program) and the Traffic Calming Committee

At the first Neighborhood meeting, a decision must be made as to which program will be selected – Full Program or the Humps/Lumps Program. This choice will have an affect on the types of devices that may be used in a Traffic Calming Plan and the speed at which these devices are in place.

As noted previously, the Humps/Lumps Program is a much faster process, however, the types of traffic control devices are limited to humps, lumps, signing, and striping.

The Full Program has the advantage of allowing a much broader range of control devices but will take longer to work through and, ultimately, to construct.

The program selection is not final and irrevocable. A neighborhood can chose to change the program selected during the process.

Once the neighborhood selects the program, a Traffic Calming Committee (TCC) must be formed with approximately six to ten volunteers from the neighborhood that can be actively involved and commit the time needed to develop a draft Traffic Calming Plan. This draft Plan must then be approved by the neighborhood via a vote before it is implemented.

4. Selecting Measures

<u>In either program, the next step is to determine which control devices will be used at what location.</u>

<u>Selecting Measures for the Problem Type</u>

The major types of problems that result in a desire for traffic calming are:

- **Speeding** – motor vehicle speeds are too high
- **Traffic Volumes** – motor vehicle usage levels (all trips or non-local trips only) are too high
- **Vehicle Safety** – motor vehicles have an inordinate level of risk

- **Pedestrian Safety** – motor vehicles cause an unnecessary risk to pedestrians

- **Noise/Vibration/Air Pollution** – motor vehicles cause excessive levels of these environmental effects

Each device in the toolbox is appropriate to a different subset of the above problem types. The appropriateness of each device is summarized in Table 1 (page 14).

Selecting Measures for the Location Type

Identification of appropriate traffic calming measures should start by determining which measures are applicable to the location of the problem. If the traffic problem is confined to a specific roadway segment, then only measures applicable to roadway segments can be considered. Some other measures can be considered at intersections. Furthermore, certain types of devices are appropriate in residential areas but not in non-residential areas. Table 2 (page 155) indicates the location(s) where each traffic calming measure is applicable.

Selecting Measures for the Street Environment

The last step in narrowing the field of devices requires finding which devices are compatible with the traffic volumes, posted speeds, and special roadway users at the proposed location. For example, many devices have an upper boundary of traffic volumes beyond which any greater volume could result in traffic congestion that might be perceived as worse than the original traffic problem.

Also, since most devices cause some delay for emergency vehicles and transit buses, only certain devices can be used on primary emergency response routes and transit routes. Some measures have additional restrictions, such as hills, curves and bicycle routes that must be considered.

Table 3 (pages 17 & 18) summarizes the constraints on the use of traffic calming devices in these various environments.

Table 1 – Traffic Calming Measures and Problem Types

Types of Measures		Type of Problem				
		Speeding	Traffic Volume	Vehicle Accidents	Pedestrian Safety	Noise
Non-Physical Measures						
	Targeted Speed Enforcement	●	○	◒	◒	◒
	Radar Trailer	●	○	○	○	◒
	Speed Feedback Signs	●	○	○	○	◒
	Edgeline/Centerline Striping	●	○	○	○	○
	Optical Speed Bars	◒	○	○	○	○
	Speed Limit Signage	●	○	○	○	○
	Speed Legends	●	○	○	○	○
	Truck Restriction Signs	○	◒	○	○	●
	"Cross Traffic Does Not Stop" Signage	○	○	●	◒	○
	Botts Dots/Raised Reflectors	○	○	●	◒	○
	High-Visibility Crosswalks	◒	○	○	●	○
	Angled Parking	●	◒	○	○	○
Narrowing Measures						
	Bulbouts	●	◒	○	●	○
	Two-Lane Chokers	●	◒	○	○	○
	Center Island Narrowing/ Pedestrian Refuges	●	◒	◒	●	○
Horizontal Measures						
	Traffic Circles	●	◒	●	◒	○
	Roundabouts (Single-Lane)	◒	◒	●	○	●
	Lateral Shifts	◒	◒	○	○	○
	Chicanes	●	◒	○	○	○
Vertical Measures						
	Speed Humps	●	●	◒	◒	×
	Speed Lumps	●	●	◒	◒	×
	Speed Cushion	●	●	◒	◒	×
	Split Speed Hump	●	●	◒	◒	×
	Speed Tables	●	◒	◒	◒	×
	Raised Crosswalks	●	◒	◒	●	×
	Raised Intersections	●	◒	◒	●	×
	Textured Pavement	◒	○	○	◒	×
Diversion Devices						
	Full Closures	●	●	○	○	○
	Half Closures	●	●	○	○	○
	Diagonal Diverters	●	●	○	○	○
	Median Barriers	○	●	◒	○	○
	Forced Turn Islands	○	●	◒	○	○

Key: ● = Strongly Appropriate; ◒ = Moderately Appropriate; × = Inappropriate/Counterproductive; ○ = Indifferent

Table 2 – Traffic Calming Measures and Location Types

Types of Measures	Residential			Non-Residential	
	Midblock	Intersection	Boundary of Area	Midblock	Intersection
Non-Physical Measures					
Targeted Speed Enforcement	●	●	●	●	●
Radar Trailer					
Speed Feedback Signs					
Edgeline/Centerline Striping	●	×	×	●	×
Optical Speed Bars	●	×	×	●	×
Speed Limit Signage	●	●	●	●	●
Speed Legends					
Truck Restriction Signs	×	×	●	×	●
"Cross Traffic Does Not Stop" Signage	×	○	●	×	○
Botts Dots/Raised Reflectors	**On Curves**	×	×	●	×
High-Visibility Crosswalks	●	**Unsignalized Intersections**	**Unsignalized Intersections**	●	**Unsignalized Intersections**
Angled Parking	●	×	×	●	×
Narrowing Measures					
Bulbouts	×	●	●	×	●
Two-Lane Chokers	●	×	×	●	×
Center Island Narrowing/ Pedestrian Refuges	●	●	●	●	●
Horizontal Measures					
Traffic Circles	×	●	○	×	○
Roundabouts (Single-Lane)	×	○	○	×	●
Lateral Shifts	●	×	×	●	×
Chicanes					
Vertical Measures					
Speed Humps	●	×	×	×	×
Speed Lumps					
Speed Cushions					
Split Speed Humps					
Speed Tables	●	×	×	○	×
Raised Crosswalks	●	○	○	○	×
Raised Intersections	×	●	●	×	●
Textured Pavement	●	●	●	●	●
Diversion Devices					
Full Closures	×	●	●	×	×
Half Closures	×	●	●	×	×
Diagonal Diverters	×	●	×	×	×
Median Barriers	×	○	●	×	×
Forced Turn Islands	×	○	●	×	●
Key: × = Seldom or never applicable.		● = Generally applicable.			
○ = Not applicable except in some cases.					

Non-Physical Measures – The first solutions to consider should always be the Non-Physical Measures, such as signs and markings, since these can be most easily removed if unanticipated problems occur.

Narrowing Devices – The next type of traffic calming measure to consider should be Narrowing Measures, such as bulbouts or center island medians, which are less obtrusive and more aesthetically appealing than some other devices since they can be combined with landscaping.

Horizontal Deflection Devices – Narrowing Devices are followed by Horizontal Deflection Devices, such as chicanes and traffic circles, which are more intrusive but also more effective because they force vehicles to navigate horizontally around physical objects. These can also be combined with landscaping.

Vertical Deflection Devices – Vertical deflection devices such as a speed humps or speed lumps are generally the most effective at reducing travel speeds, but they can also be controversial because of driver discomfort, noise, and aesthetics.

Diversion Devices – Diversion devices include half or full road closures and forced turn islands. Installation of these devices is not appropriate if they simply move the traffic issue to an adjacent street.

Table 3 – Traffic Calming Measures and Traffic Constraints

Types of Measures		Roadway Classification			Bus or Emergency Response Route	Other Considerations
		Local Streets	Non-Residential Collectors	Residential Collectors		
Non-Physical Measures[1]						
	Targeted Speed Enforcement	ADT < 10,000; Speed Limit ≤ 35 mph			OK	(None)
	Radar Trailers					
	Speed Feedback Signs					
	Edgeline/Centerline Striping					
	Optical Speed Bars					
	Signage					
	Speed Legend					
	Center Line or Edge Line Botts Dots					
	High Visibility Crosswalk					
	Angled Parking	ADT < 4,000; Width ≥ 48 feet; Speed Limit ≤ 30 mph			NO	Not used with bike lanes
Narrowing Measures[1]						
	Bulbouts	ADT < 20,000; Speed Limit ≤ 35 mph			OK	On bike routes, design with clear bike accommodations
	Two-Lane Chokers	ADT < 20,000; Speed Limit ≤ 35 mph			OK	
	Center Island Narrowings/ Pedestrian Refuges	ADT < 20,000; Speed Limit ≤ 35 mph			OK	
Horizontal Measures[1]						
	Traffic Circles	Daily Entering Volume < 7,500; Speed Limit ≤ 35 mph	May be required at intersections where residential collector streets intersect with local streets		OK	Grade ≤ 10%
	Roundabouts (Single-Lane)	Daily Entering Volume < 20,000; Speed Limit ≤ 45 mph			Must design inscribed radius to be 100+ feet	Grade ≤ 6%; On bike routes, design with clear bike accommodations
	Lateral Shifts	ADT < 10,000; Speed Limit ≤ 35 mph			OK	Grade ≤ 10%
	Chicanes	ADT < 5,000; Speed Limit ≤ 35 mph				Grade ≤ 8%
Vertical Measures[1]						
	Speed Humps	ADT <4,000; Speed Limit ≤ 30 mph			NO	Grade ≤ 8%
	Speed Lumps				OK	
	Speed Cushions				OK	
	Split Speed Humps				OK	
	Speed Tables	ADT <7,500; Speed Limit ≤ 35 mph			OK	
	Raised Crosswalks				OK	
	Raised Intersections				OK	
	Textured Pavement	Yes			OK	None
Note:	[1] Traffic calming devices are suitable for existing and new streets.					

Table 3 (continued) – Traffic Calming Measures and Traffic Constraints

Types of Measures		Roadway Classification		Bus Route	Other Considerations
		Local Streets	Collectors		
Diversion Devices [2]					
	Full Closures	ADT < 5,000; > 25% Non-Local Traffic	No	No	(None)
	Half Closures		No	Public Works & SJRTD[3] must review	
	Diagonal Diverters			No	
	Median Barriers	ADT < 5,000; > 25% Non-Local Traffic			
	Forced Turn Islands				
Combined Measures		Subject to Constraints of Component Measures			
Notes:	[2] Not to be used on new streets. [3] San Joaquin Regional Transit District.				

4. Placing the Traffic Calming Measures

The last task in laying out a traffic calming plan is to identify the actual locations where devices should be placed. Strategies for location devices differ depending on whether the major issue is speed-control, volume-control, or safety. Refer to Tables 1, 2, and 3 for guidance.

IV. NEW NEIGHBORHOOD IMPLEMENTATION

In addition to existing neighborhoods, new neighborhoods in the planning stage can benefit from neighborhood traffic management. As part of the NTMP, the City has recently developed *Draft Street Design Guidelines* that include revisions to the City's design standards for new streets. A key element of the revisions is the development of narrower local and collector street standards, and shorter block lengths, to slow and disperse traffic.

Traffic problems can often be anticipated and prevented by properly reviewing street and lot plans for a neighborhood and prescribing refinements to the plan or identifying traffic calming measures that can be constructed concurrent with street construction. The process for reviewing new residential subdivisions is as follows:

1. ***Development Services Review –*** Prior to final approval of a street and lot plan, the plan will be reviewed by the City's Development Review Committee (DRC). In this review, staff will identify proposed roadway layout features that are likely to cause traffic problems, such as inducing speeding or cut-through traffic or presenting an unnecessary risk of collisions.

2. ***Traffic Engineering Review –*** The City's Traffic Engineering Section will review the above recommendations. Any discrepancies will be discussed and resolved.

3. ***Plan Revisions –*** Development Services staff will submit the final comments on the street layout to the developer. If the indicated roadway changes are infeasible due to other constraints, then City Development Services will prescribe traffic calming measures based on the guidelines contained in this document. The cost of the traffic calming measures will be borne by the developer.

4. ***SJRTD Review –*** SJRTD will review the plans to determine the need for future bus routes in the new development and placement of bus stops and associated transit amenities (benches or shelters). The cost of bus stop installation and transit amenities will be borne by the developer.

Designing Street Networks

The guidelines below describe some common street design features and their propensity to lead to traffic calming problems such as speeding and cut-through traffic. These guidelines are intended to complement the *Street Design Guidelines*. They should also assist developers in laying out streets in new residential developments and City staff in reviewing them pursuant to the process described above. This chapter is by no means comprehensive on the layout of new residential streets. For detailed information, the following documents are recommended:

- City of Stockton Street Design Guidelines, City of Stockton, 2003
- Residential Street Design and Traffic Control, Homburger, Deakin, Bosselmann, Smith, and Beukers (Institute of Transportation Engineers), 1989
- Residential Streets, American Society of Civil Engineers, National Association of Home Builders, and the Urban Land Institute, 1990
- Traditional Neighborhood Development: Street Design Guidelines, Institute of Transportation Engineers, 1999

Designing for Appropriate Speeds

The following paragraph from *Residential Streets* (ASCE/NAHB/ULI, 1990) provides a useful summary of the task of designing residential streets to minimize speeding problems:

> "The selection of appropriate pavement widths must account for probable peak traffic volume, parking needs and controls, likely vehicle speeds, and limitations imposed by sight distances, climate, terrain, and maintenance requirements. Designers should select the *minimum* width that will reasonably satisfy all realistic needs, thereby minimizing construction and average annual maintenance costs. The tendency of many communities to equate wider streets with better streets and to design traffic and parking lanes as though the street were a "microfreeway" is a highly questionable practice. Certainly the provision of 11- or 12-

foot clear traffic lanes is an open invitation to increased traffic speeds."

Residential Streets goes on to recommend pavement widths for access streets, subcollectors, and collector streets. In addition to wide streets, long, straight, and uninterrupted stretches of residential roadways can also induce drivers to accelerate to unsafe speeds, increasing noise and risk of accidents with pedestrians and other vehicles. The following attributes should be considered when designing residential streets.

- ***Travel Lane Width*** – Travel lanes are often designed with excessive widths. To minimize drivers' propensity to speed, residential travel lanes on local streets should be designed to be no more than 10 feet wide. Wide shoulders should not be included unless they are needed to accommodate demand for parking or are striped as bicycle lanes. If excess width is provided in anticipation of a future need for traffic capacity, then in the short-term this width should be occupied by appropriately spaced chokers or other traffic calming measures (see Chapter II).

- ***Parking Lanes*** – Excessive width is sometimes provided for on-street parking in places where adjacent land uses generate little parking demand, leaving long gaps of unused space adjacent to the travel lane. This can often be the case along residential collector streets with few front-on houses. If the parking demand can be accommodated elsewhere, the parking lanes should be eliminated and the street width reduced accordingly.

- ***Block Length*** – Some street networks leave excessively long blocks without interrupting intersections. Drivers that travel a long distance (600 feet or greater) without being required to slow or stop by traffic control or traffic calming devices tend to travel at speeds higher than the limit. To minimize this effect, the street network can be designed such that street blocks are interrupted by streets of sufficient traffic volumes to warrant a traffic control device (e.g. a traffic circle or stop sign) on the street of concern. Shorter block lengths also facilitate pedestrian movement throughout the neighborhood. Acceptable block lengths for low and medium volume residential streets should not

exceed 600 and 800 feet respectively, while collector street block lengths should not exceed 1,000 feet[1].

Designing for Local Traffic

If designed improperly, some residential collector streets can become cut-through routes, or routes used by non-local motorists as a means of bypassing congested or circuitous arterial roads. In these cases, the residential collector should be modified in one of two ways.

- The collector can be designed with a deviating path so that the overall distance by collector is greater than the distance by arterial.
- The residential roadway network can be designed such that traffic-controlled intersections interrupt the parallel collector route sufficiently that the travel time by collector is greater than the travel time by arterial.

Pedestrian/Vehicle Conflict Areas

Some elements of residential areas, such as schools and parks, have particularly high potential for vehicle and pedestrian conflicts because of the pedestrian activity they generate. The major pedestrian routes to school should be identified and traffic controls should be structured so that the number of crossings at uncontrolled cross-streets is minimized. For both schools and parks, entrances tend to focus pedestrian street crossings at particular locations. These entrances can be made safer by combining them with roadway intersections, so that the intersection's traffic control can also allocate right-of-way to pedestrians.

If a pedestrian-oriented land use is located in an area where speeding or high traffic volumes are unavoidable, then traffic calming measures should be selected that incorporate pedestrian accommodations. For example, at an intersection, bulbouts or center island narrowing should be given some preference over other measures, such as intersection

[1] City of Stockton Street Design Manual, 2003.

realignment. Midblock locations can benefit from such treatments as chokers or chicanes.

Developing a Traffic Calming Plan

When a proposed street layout cannot be modified in such a way that will eliminate all potential traffic problems, a traffic calming plan should be developed. The procedure for developing a traffic calming plan should be the one described in Chapter II, with the following exceptions:

- For volume-related problems, traffic volume data will only be available in the form of traffic forecasts, and these will typically be limited to the major roads. Some manual traffic volume estimates may be required using land use quantities and trip generation rates for the proposed development.

- For speed-related problems, existing travel speed data will not be available. Consequently, a response to anticipated speeding problems would need to rely on roadway geometry. For example, if a block length is greater than 600 feet, then traffic calming measures could be used to break up the block into segments that are each shorter than 600 feet.

- Anticipated safety problems will likely revolve around land uses that generate pedestrian activity, such as schools, parks, and community centers. The placement of traffic calming devices that include pedestrian crossings should take into consideration the planned locations of walkways, gates, and building entrances for these land uses.

- For some traffic calming measures, particularly those involving modified roadway curbs, significant cost-savings can be achieved by constructing them concurrent with roadway construction. Consequently, when selecting a type of traffic calming measure, some additional preference should be given to measures that take advantage of these cost-savings.

V. TOOLBOX OF TRAFFIC CALMING MEASURES

The following traffic calming measures constitute the standard "toolbox" of devices available to citizens and Public Works staff when developing neighborhood traffic management plans:

- Non-Physical Measures
- Narrowing Measures
- Horizontal Deflection Measures
- Vertical Deflection Measures
- Diversion Measures

For each non-physical and physical measure in the toolbox, a description, photograph, list of advantages and disadvantages, and approximate cost are provided. In addition, all physical traffic calming measure include an overhead schematic and detailed standard designs which are located in Appendix A.

Non-Physical Measures

Description

Non-physical measures include any measures that do not require the construction of physical modifications to the roadway. This category includes signing and striping modifications, as well as temporary use of certain enforcement strategies.

- **Targeted Speed Enforcement**
- **Radar Trailers**
- **Speed Feedback Signs**
- **Lane Striping**
- **Optical Bars**
- **Signage**
- **Speed Legend**
- **Centerline or Edgeline Botts Dots**
- **High Visibility Crosswalk**
- **Angled Parking**

TARGETED SPEED ENFORCEMENT

The TCC identifies locations for temporary targeted enforcement enhancements, based on personal observations and survey comments. A request is then submitted to the Police Department for the desired enforcement. Because of limited citywide resources, the targeted enforcement will not be continued indefinitely. Targeted enforcement may also be used in conjunction with new traffic calming devices to help drivers become aware of the new restrictions.

Approximate Cost: Varies.

Advantages

- Inexpensive if used temporarily
- Does not require time for design
- Does not slow trucks, buses, and emergency vehicles
- Effective in reducing speeds in a short time frame

Disadvantages

- Expensive to maintain an increased level of enforcement
- Effectiveness may be temporary

RADAR TRAILER

A radar trailer is a device that measures each approaching vehicle's speed and displays it next to the legal speed limit in clear view of the driver, reminding speeding drivers to slow to the speed limit. They can be easily placed on a street for a limited amount of time then relocated to another street, allowing a single device to be effective in many locations.

Approximate Cost: Varies

Advantages

- Inexpensive if used temporarily
- Does not require time for design
- Does not slow emergency vehicles
- Effective in reducing speeds in the short-run

Disadvantages

- Effectiveness may be temporary
- Aesthetics
- Only effective for one direction of travel
- Subject to vandalism

SPEED FEEDBACK SIGNS

Speed feedback signs perform the same functions as radar trailers but are permanent. Real-time speeds are relayed to drivers and flash when speeds exceed the limit. Speed feedback signs are typically mounted on or near speed limit signs and can also be mobile units.

Approximate Cost: $7,500 - $9,000

Advantages

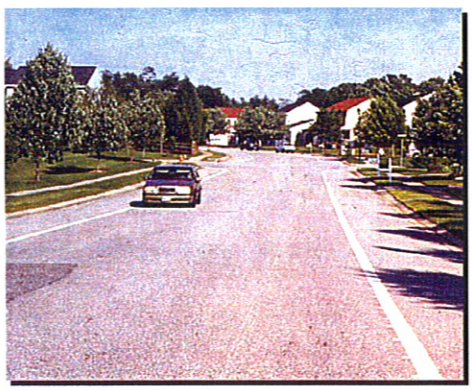
- Inexpensive
- Does not require time for design
- Does not slow emergency vehicles
- Effective in reducing speeds in a short time frame

Disadvantages

- Requires power source
- Only effective for one direction of travel
- Long-term effectiveness uncertain
- Subject to vandalism

LANE STRIPING

Lane striping can be used to create formal bicycle lanes, parking lanes, or simple edge lines. As a traffic calming measure, they are used to narrow the travel lanes for vehicles to encourage drivers to lower their speeds. The past evidence on speed reductions is, however, inconclusive.



Approximate Cost:
$2 per linear foot

Advantages

- Inexpensive
- Can be used to create bicycle lanes or delineate on-street parking
- Does not require time for design
- Does not slow emergency vehicles

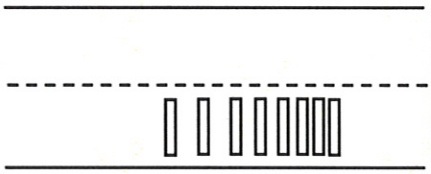
Disadvantages

- Has not been shown to significantly reduce travel speeds
- Increases regular maintenance

OPTICAL SPEED BARS

Optical speed bars are a series of pavement markings spaced at decreasing distances. They have typically been used in construction areas to provide drivers with the impression of increased speed.

Approximate Cost: $2 per linear foot



Advantages

- Inexpensive
- Reduction in 85th percentile speed
- Does not slow bus and emergency vehicles
- Does not require time for design

Disadvantages

- Effectiveness diminishes after repeated use
- Aesthetics

SIGNAGE

Signage that can be used as traffic calming measures include:

- Speed Limit Signs
- Truck Restriction Signs
- "Cross Traffic Does Not Stop" Signs

For speed limit signs to be eligible for radar enforcement, they must be set using an appropriate engineering and speed study.

Approximate Cost: $200 per sign

Advantages

- Inexpensive
- Does not require time for design
- Turn restrictions can reduce cut-through traffic
- Does not significantly slow emergency vehicles

Disadvantages

- Speed limit signs are ineffective if unaccompanied by increased police enforcement
- If speed limit is set unreasonably low, drivers are more likely to exceed it

SPEED LEGENDS

Speed legends are numerals painted on the roadway indicating the current speed limit in miles per hour. They are usually placed near speed limit signposts. Speed legends can be useful in reinforcing a reduction in speed limit between one segment of a roadway and another segment. They may also be placed at major entry points into a residential area.

Advantages

- Inexpensive
- Helps reinforce a change in speed limit
- Does not require time for design
- Does not slow emergency vehicles

Disadvantages

- Has not been shown to significantly reduce travel speeds

Approximate Cost: $150 each

BOTTS DOTS AND RAISED REFLECTORS

Botts dots and raised reflectors, or "raised pavement markers," are small bumps lining the centerline or edgeline of a roadway. They are often used on curves where vehicles have a tendency to deviate outside of the proper lane, risking collision. Raised reflectors improve the nighttime visibility of the roadway edges.

Advantages

- Inexpensive
- Does not slow trucks, buses, and emergency vehicles
- Can help keep drivers in the appropriate travel lane on curves and under low-visibility conditions

Disadvantages

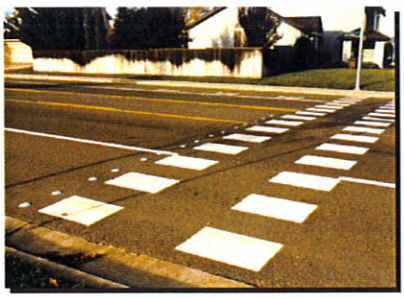
- Noise caused by rumble strips may bother neighborhood residents

Botts dots can be arranged into a rectangular array across the roadway, creating a *rumble strip*, which causes a rumbling sensation to drivers as they cross. These can reduce travel speeds but also increase roadway noise considerably. Consequently, rumble strips are only placed in very low-density areas because of the noise factor.

Approximate Cost: $4.50 per marker

HIGH-VISIBILITY CROSSWALK

High-visibility crosswalks use special marking patterns and raised reflectors to increase the visibility of a crosswalk at night. A "triple-four" marking pattern is created by painting two rows of four-foot wide rectangles, separated by four feet of unpainted space across the roadway. Raised reflectors are placed at the approach edges of these rectangles. The unpainted space along the center of the crosswalk allows wheelchairs and foot traffic to cross in the rain without sliding problems across the paint.



Approximate Cost: $2,000

Advantages

- Increase visibility under low-visibility conditions
- Focus crossing pedestrians at a single location
- Motorists may not "tune out" IPFs as typical overhead beacons

Disadvantages

- May give pedestrians a false sense of security
- Requires more maintenance than normal crosswalks
- Can decrease effectiveness of coordinated traffic signals

In-Pavement Flashers (IPF) are another type of High-visibility crosswalk. They are typically installed at mid-block pedestrian crossings and feature a series of flashing lights flanking the outer edge of the crosswalk. The flashing lights are activated through a push button detector. IPFs are most effective on multi-lane undivided roadways near pedestrian trip generators such as schools, commercial areas, downtown areas, etc.

Approximate Cost: $40,000-$50,000

Advantages

- Increase visibility under low-visibility conditions
- Focus crossing pedestrians at a single location

Disadvantages

- May give pedestrians a false sense of security, causing them to pay less attention to traffic
- Require more maintenance than normal crosswalks

ANGLED PARKING

Angled parking reorients on-street parking spaces to a 45-degree angle, increasing the number of parking spaces and reducing the width of the roadway available for travel lanes. Angled parking is also easier for vehicles to maneuver into and out of than parallel parking. Consequently, it works well in locations with high parking demand, such as multi-family residences, and high turnover rates, such as commercial and mixed-use areas.

Approximate Cost: $250- $300 per stall

Advantages

- Reduces speeds by narrowing the travel lanes
- Increases the number of parking spaces
- Makes parking maneuvers easier and takes less time than with parallel parking
- Favored by businesses and multi-family residences

Disadvantages

- Precludes the use of bike lanes (unless roadway is wider than 58 feet)
- Ineffective on streets with frequent driveways
- May be incompatible with one-way streets approaching a two-way segment

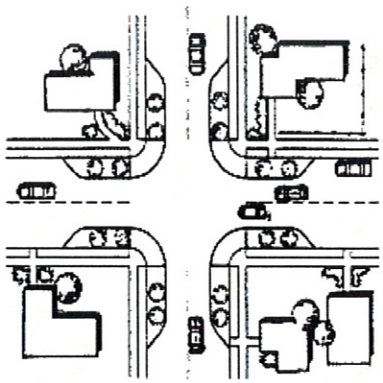
Narrowing Devices

Description

Narrowing devices use raised islands and curb extensions to narrow the travel lane for motorists. The narrowing devices in the toolbox include:

- **Bulbouts**
- **Two-Lane Chokers**
- **Center Island Narrowings/Pedestrian Refuge Islands**

BULBOUTS



Bulbouts (neckdowns, intersection narrowing, safe crosses, etc.) are curb extensions that reduce roadway width curb to curb at either midblock or intersection locations. Midblock treatments narrow the travel lane but do not provide additional sidewalk width. Intersection treatments actually "pedestrianize" intersections by shortening crossing distances for pedestrians by tightening curb radii thereby reducing the speeds of turning vehicles. Intersection treatments can be retrofit into existing intersections without modifying the existing drainage or they can be designed to provide additional sidewalk width for increased pedestrian use or street furniture. The effects are increased pedestrian comfort and safety at the intersection.

Approximate Cost: $2,000 - $5,000 for four corners (without drainage modifications) or $25,000 per corner with full drainage modifications

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**-7%**
Volume Impacts	**Reduction in Vehicles per Day**	**-10%**
Source: Traffic Calming: State of the Practice, 2000.		

Advantages

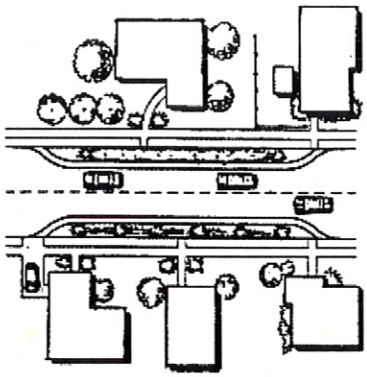
- Improves pedestrian circulation and standing space on sidewalk area
- Through and left-turn movements are easily negotiable by large vehicles
- Creates protected on-street parking bays
- Reduces speeds (especially right-turning vehicles) and traffic volumes
- Provides opportunity for landscaping and street furniture

Disadvantages

- Effectiveness is limited by the absence of vertical or horizontal deflection
- May slow right-turning emergency vehicles
- Potential loss of on-street parking
- May require bicyclists to briefly merge with vehicular traffic

TWO-LANE CHOKER

Chokers are curb extensions at mid-block that narrow a street by widening the sidewalk or planting strip. If marked as crosswalks, they are also called safe crosses. Chokers leave the street cross section with two lanes that are narrower than the normal cross section.



Approximate Cost: $5,000-10,000

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**-7%**
Volume Impacts	**Reduction in Vehicles per Day**	**-10%**

Source: Traffic Calming: State of the Practice, 2000.

Advantages

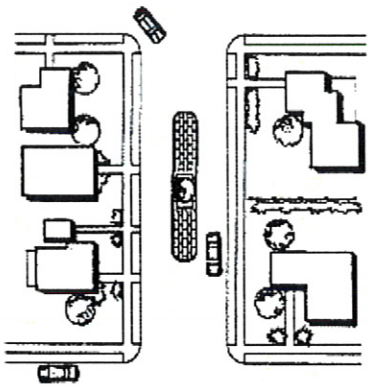
- Easily negotiable by large vehicles (such as fire trucks)
- If designed well, can have positive aesthetic value
- Reduces both speeds and volumes
- Opportunity for landscaping

Disadvantages

- Effect on vehicle speeds is limited by the absence of any horizontal deflection
- May require bicyclists to briefly merge with vehicular traffic
- Potential loss of on-street parking
- Maintenance of landscaping (City vs. residents)

CENTER ISLAND NARROWING/PEDESTRIAN REFUGE ISLAND

Center island narrowing are raised islands located along the centerline of a street that narrow the travel lanes at that location. They are often landscaped to provide visual amenity. Placed at the entrance to a neighborhood and often combined with textured pavement, they are sometimes called "gateways." Fitted with a gap to allow pedestrians to walk through at a crosswalk, they are often called "pedestrian refuges".



Approximate Cost: $6,000-9,000

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**-7%**
Volume Impacts	**Reduction in Vehicles per Day**	**-10%**
Source: Traffic Calming: State of the Practice, 2000.		

Advantages

- Increases pedestrian safety
- If designed well, can have positive aesthetic value
- Reduces traffic volumes
- Opportunity for landscaping

Disadvantages

- Effect on vehicle speeds is limited by the absence of any vertical or horizontal deflection
- Potential loss of on-street parking
- Maintenance of landscaping (City vs. residents)

Horizontal Deflection Devices

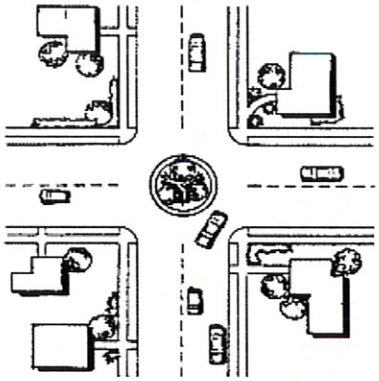
Description

Horizontal deflection devices use raised islands and curb extensions to eliminate straight-line paths along roadways and through intersections. The horizontal deflection devices in the toolbox include:

- **Traffic Circles**
- **Roundabouts**
- **Lateral Shifts**
- **Chicanes**

TRAFFIC CIRCLE

Traffic circles are raised islands, placed in intersections, around which traffic circulates. They are usually circular in shape and landscaped in their center islands, though not always. Traffic controls at the approaches vary by location. Circles prevent drivers from speeding through intersections by impeding the straight-through movement and forcing drivers to slow down to yield. Drivers must first turn to the right, then to the left as they pass the circle, and then back to the right again after clearing the circle.



Approximate Cost: $15,000

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**-11%**
Volume Impacts	**Reduction in Vehicles per Day**	**-5%**
Safety Impacts	**Reduction in Average Annual Number of Collisions**	**-71%**
Source: Traffic Calming: State of the Practice, 2000.		

Advantages

- If designed well, can have positive aesthetic value
- Very effective in moderating speeds and improving safety
- Opportunity for landscaping

Disadvantages

- Difficult for large vehicles (such as fire trucks) to circumnavigate
- Must be designed so that the circulating lane does not encroach on crosswalks
- Potential loss of on-street parking
- Maintenance of landscaping (City vs. residents)

ROUNDABOUT

Like traffic circles, roundabouts require traffic to circulate counterclockwise around a center island. But unlike circles, roundabouts are used on higher volume streets to allocate rights-of-way among competing movements. They are found primarily on arterial and collector streets, often substituting for traffic signals or all-way STOP signs. They are larger than neighborhood traffic circles and typically have raised splitter islands to channel approaching traffic to the right.

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**I/D**
Volume Impacts	**Reduction in Vehicles per Day**	**I/D**
Safety Impacts	**Reduction in Average Annual Number of Collisions**	**-1.5% to 33%**

Notes: I/D = Insufficient Data
Source: Traffic Calming: State of the Practice, 2000.

Approximate Cost: $100,000-$200,000 for retrofits; $100,000 for a single-lane and $150,000 for two-lane in new developments.

Advantages

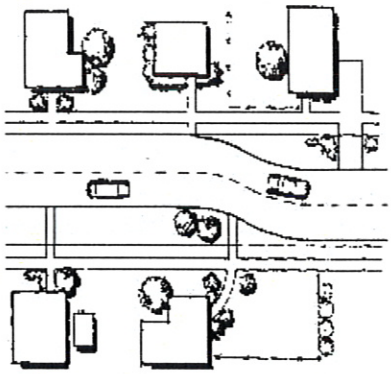
- Moderates traffic speed on an arterial
- Enhanced safety compared to a traffic signal
- Minimizes queuing at approaches to the intersection
- Less expensive to operate than traffic signals
- Provides opportunity for landscaping and street furniture

Disadvantages

- May require major reconstruction of an existing intersection
- Loss of on-street parking
- Increases pedestrian distance from one crosswalk to the next
- Difficult for visually impaired pedestrian to navigate
- Maintenance of landscaping (City vs. residents)

LATERAL SHIFT

Lateral shifts are curb extensions on otherwise straight streets that cause travel lanes to bend one way and then bend back the other way to the original direction of travel. Lateral shifts, with just the right degree of deflection, are one of the few measures that have been used on collectors or even arterials, where high traffic volumes and high posted speeds preclude more abrupt measures.



Approximate Cost: Varies by size of offset and length of transition.

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**I/D**
Volume Impacts	**Reduction in Vehicles per Day**	**I/D**
Safety Impacts	**Reduction in Average Annual Number of Collisions**	**I/D**

Notes: I/D = Insufficient Data
Source: Traffic Calming: State of the Practice, 2000.

Advantages

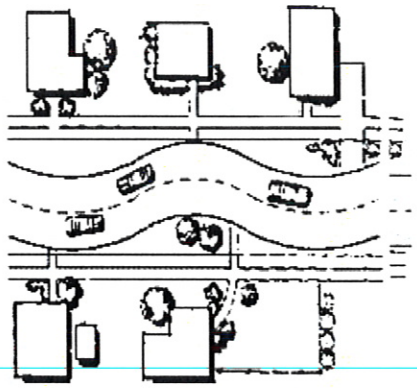
- Can accommodate higher traffic volumes than many other traffic calming measures
- Easily negotiable by large vehicles (such as fire trucks)
- Opportunity for landscaping and street furniture

Disadvantages

- Not as effective reducing speeds as other traffic calming measures
- Potential loss of on-street parking
- Must be designed carefully to discourage drivers from deviating out of the appropriate lane
- Maintenance of Landscaping (City vs. residents)

CHICANE

Chicanes are curb extensions that alternate from one side of the street to the other, forming S-shaped curves. Chicanes can also be created by alternating on-street parking, either diagonal or parallel, between one side of the road and the other. Each parking bay can be created either by restriping the roadway or by installing raised landscaped islands at each end, creating a protected parking area.



Approximate Cost: $8,000-14,000

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**I/D**
Volume Impacts	**Reduction in Vehicles per Day**	**I/D**
Safety Impacts	**Reduction in Average Annual Number of Collisions**	**I/D**

Notes: I/D = Insufficient Data
Source: Traffic Calming: State of the Practice, 2000.

Advantages

- Discourages high speeds by forcing horizontal deflection
- Easily negotiable by large vehicles (such as fire trucks) except under heavy traffic conditions
- Provides opportunity for landscaping and street furniture

Disadvantages

- Must be designed carefully to discourage drivers from deviating out of the appropriate lane
- Curb realignment and landscaping can be costly, especially if there are drainage issues
- Potential loss of on-street parking
- Maintenance of landscaping (City vs. residents)

Vertical Deflection Devices

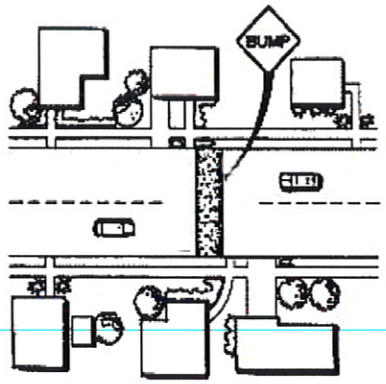
Description

Vertical deflection devices use variations in pavement height and alternative paving materials to cause drivers discomfort at high travel speeds. The vertical deflection devices in the toolbox include:

- **Speed Humps**
- **Speed Lumps**
- **Speed Cushions**
- **Split Devices**
- **Speed Tables**
- **Raised Crosswalks**
- **Raised Intersections**
- **Textured Pavement**

SPEED HUMP

Speed Humps are rounded raised areas placed across the road. They are generally 12 feet long (in the direction of travel), 3 ¼ to 3 ¾ inches high, and parabolic in shape, and have a design speed of 15 to 20 mph. They are usually constructed with AC and have a taper on each side to allow unimpeded drainage between the hump and curb. When placed on a street with rolled curbs or no curbs, bollards are placed at the ends of the speed hump to discourage vehicles from veering outside of the travel lane to avoid the device. Speed humps are not installed on emergency response or SJRTD routes.



Approximate Cost: $2,000

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**-18%**
Safety Impacts	**Reduction in Average Annual Number of Collisions**	**-13%**
Source: Traffic Calming: State of the Practice, 2000.		

Advantages

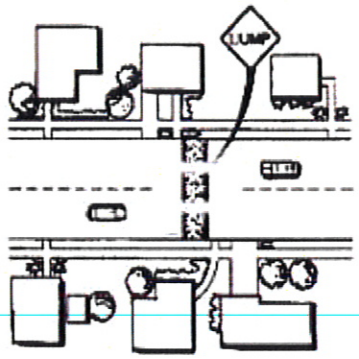
- Relatively inexpensive
- Relatively easy for bicyclists to cross if taper is designed appropriately
- No loss of on-street parking
- Very effective in slowing travel speeds

Disadvantages

- Causes a "rough ride" for all drivers, and can cause severe pain for people with certain skeletal disabilities
- Emergency vehicles forced to travel at slower speeds
- Increased noise to adjacent residences
- Aesthetics

SPEED LUMP

The speed lump is a variation on the speed hump with two wheel cut-outs. The center mound or lump, has a width of 5 ½ feet to accommodate the wheelbase of fire trucks and buses so they can pass through without slowing. The lumps adjacent to the center lump vary in width to accommodate the street width. For standard size vehicles to pass, at least one set of wheels must travel over the lump. Speed lumps are installed on emergency response and SJRTD routes.



Approximate Cost: $2,500

Measured Impacts		
Speed Impacts Safety Impacts	**Reduction in 85th Percentile Speeds between Slow Points** **Reduction in Average Annual Number of Collisions**	**Comparable to speed humps but I/D**
Source: Traffic Calming: State of the Practice, 2000.		

Advantages

- Relatively inexpensive
- Relatively easy for bicyclists to cross if taper is designed appropriately
- No loss of on-street parking
- Effective in slowing travel speeds

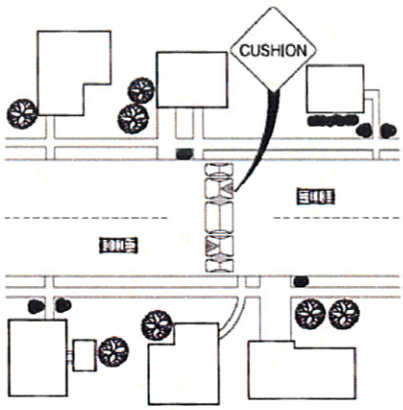
Disadvantages

- Large (non-standard) vehicles can avoid the lump by passing through the cut-outs
- Increased noise to adjacent residences
- Aesthetics

SPEED CUSHION

The speed cushion is a speed lump that is constructed out of durable recycled rubber. These prefabricated devices consistently have a uniform shape unlike AC humps. The devices can be constructed without or with tapers or inlaid markings.

Approximate Cost: $2,000



Measured Impacts		
Speed Impacts Safety Impacts	**Reduction in 85th Percentile Speeds between Slow Points** **Reduction in Average Annual Number of Collisions**	**Comparable to speed humps, but I/D**
Source: Traffic Calming: State of the Practice, 2000.		

Advantages

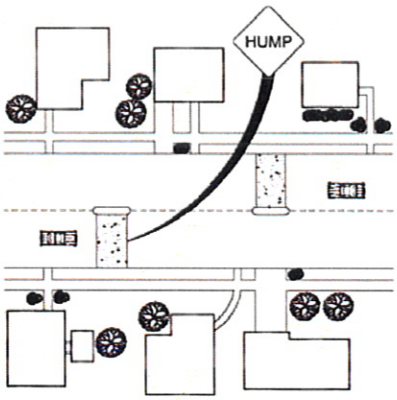
- Relatively inexpensive
- Softer ride than asphalt humps
- No loss of on-street parking
- Effective in slowing travel speeds
- Can be used as a temporary device

Disadvantages

- Large (non-standard) vehicles can avoid the lump by passing through the cut-outs
- Increased noise to adjacent residences
- Aesthetics

SPLIT SPEED HUMP

The split speed hump consists of one speed hump in each direction of travel with approximately 28-50 feet separating the humps. An approach island at each lump discourages drivers from maneuvering around the humps while the distance between the two humps is adequate for emergency response vehicles to maneuver around without traversing



Approximate Cost: $5,000

Advantages

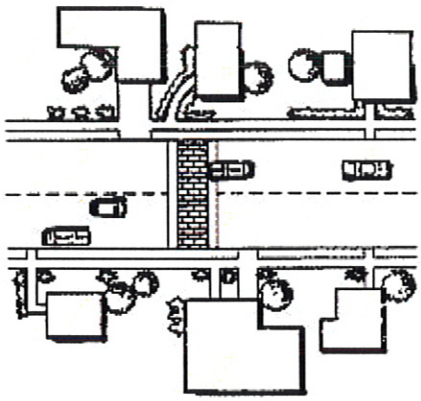
- Effective at reducing speeds
- Less of an impedance on emergency response vehicles compared to speed lumps

Disadvantages

- May require removal of on-street parking within limits of the device
- Increased noise to adjacent residences
- Aesthetics

SPEED TABLE

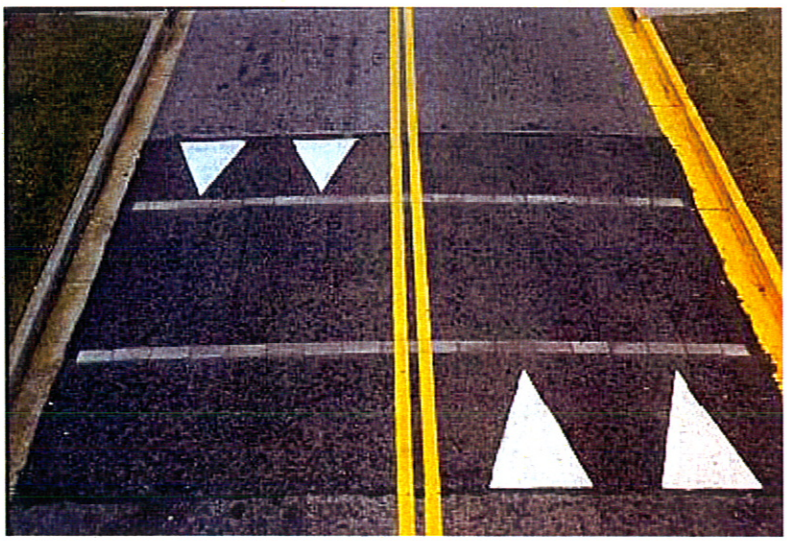
Speed tables are flat-topped speed humps often constructed with a brick or other textured materials on the flat section. Speed tables are typically long enough for the entire wheelbase of a passenger car to rest on top. Their long flat fields, plus ramps that are sometimes more gently sloped than speed humps, give speed tables higher design speeds than humps. The brick or other textured materials improve the apperance of speed tables, draw attention to them, and may enhance safety and speed reduction.



Approximate Cost: $4,500

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**-18%**
Volume Impacts	**Reduction in Vehicles per Day**	**-12%**
Safety Impacts	**Reduction in Average Annual Number of Collisions**	**-45%**

Source: Traffic Calming: State of the Practice, 2000.



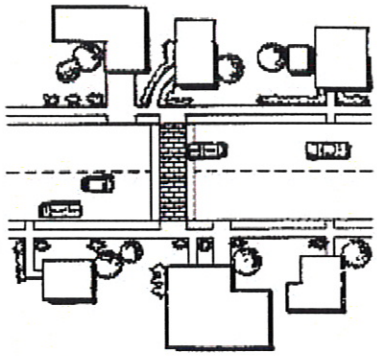
Advantages

- Smoother on large vehicles such as fire trucks than speed humps
- Effective in slowing travel speeds, though not to the extent of speed humps

Disadvantages

- Textured materials can be expensive
- Aesthetics is not textured
- Causes a rough ride

RAISED CROSSWALK



Raised crosswalks are speed tables outfitted with crosswalk markings and signage to channelize pedestrian crossings providing pedestrians with a level street crossing. Also, by raising the level of the crossing, pedestrians are more visible to approaching motorists.

Approximate Cost: $5,000

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**-18%**
Volume Impacts	**Reduction in Vehicles per Day**	**-12%**
Safety Impacts	**Reduction in Average Annual Number of Collisions**	**-45%**
Source: Traffic Calming: State of the Practice, 2000.		

Advantages

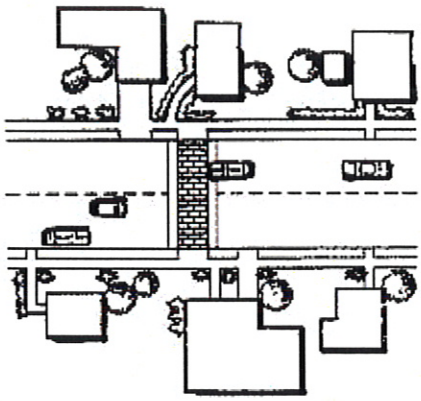
- Improves safety for both vehicle and pedestrians
- If designed well, can have positive aesthetic value
- Effective in reducing speeds, though not to the extent of speed humps

Disadvantages

- Textured materials can be expensive
- Increased noise to adjacent residences
- Impact to drainage needs to be considered

RAISED INTERSECTION

Raised intersections are flat raised areas covering entire intersections, with ramps on all approaches and often with brick or other textured materials on the flat section. They usually rise to sidewalk level, or slightly below to provide a "lip" for the visually impaired. By modifying the level of the intersection, the crosswalks are more readily perceived by motorist to be pedestrian territory. They are particularly useful in dense urban areas, where the loss of on-street parking associated with other traffic calming measures is considered unacceptable.



Approximate Cost: $70,000

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**-1%**
Source: Traffic Calming: State of the Practice, 2000.		

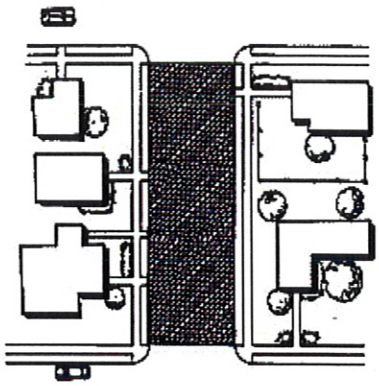
Advantages

- Improves safety for both pedestrians and automobiles
- Can have positive aesthetic value
- Can calm two streets at once

Disadvantages

- Less effective in reducing vehicle speeds than speed humps or speed tables
- Expensive, varying by materials used

TEXTURED PAVEMENT



Textured colored pavement includes the use of stamped pavement (asphalt) or alternate paving materials to create an uneven surface for vehicles to traverse. They may be used to emphasize either an intersection or a pedestrian crossing.

Approximate Cost: Varies

Advantages

- Can reduce vehicle speeds over an extended length
- Can have positive aesthetic value
- Placed at an intersection, it can calm two streets at once

Disadvantages

- Expensive, varying by materials used
- If used on a crosswalk, can make crossing difficult for wheelchair users or the visually impaired

Diversion Devices

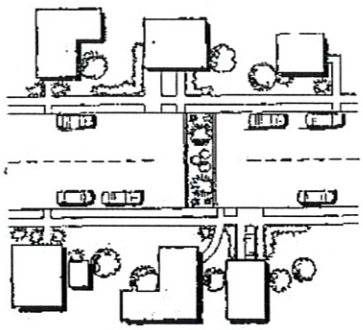
Description

Diversion devices use raised islands and curb extensions to preclude particular vehicle movements, such as left-turn or through movements, usually at an intersection. These devices can only be considered after Phase I devices have been attempted and fail to resolve the traffic problem. The diversion devices in the toolbox include:

- **Full Closures**
- **Half Closures**
- **Diagonal Diverters**
- **Median Barriers**
- **Forced Turn Islands**

FULL CLOSURE

Full street closures are barriers placed across a street to close the street completely to through traffic, usually leaving only sidewalks or bicycle paths open. The barriers may consist of landscaped islands, walls, gates, side-by-side bollards, or any other obstructions that leave an opening smaller than the width of a passenger car.



Approximate Cost: $30,000-100,000

Measured Impacts		
Volume Impacts	**Reduction in Vehicles per Day**	**-44%**
Source: Traffic Calming: State of the Practice, 2000.		

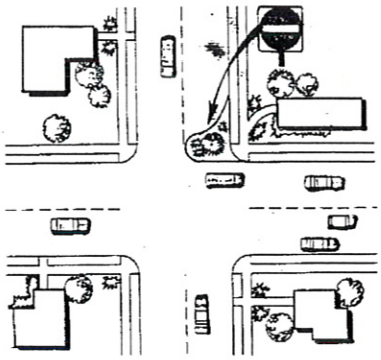
Advantages

- Able to maintain pedestrian and bicycle access
- Very effective in reducing traffic volumes
- Opportunity for landscaping

Disadvantages

- Requires legal procedures for public street closures
- Causes circuitous routes for local residents and emergency services
- May be expensive
- May limit access to businesses
- Maintenance of landscaping (City vs. residents

HALF CLOSURE



Half street closures are barriers that block travel in one direction for a short distance on otherwise two-way streets. Half closures are the most common volume control measure after full street closures. Half closures are often used in sets to make travel through neighborhoods with gridded streets circuitous rather than direct. That is, half closures are not lined up along a border, which would preclude through movement, but instead are staggered, which leaves through movement possible but less attractive than alternative routes.

Approximate Cost: $6,500

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**-19%**
Volume Impacts	**Reduction in Vehicles per Day**	**-42%**
Source: Traffic Calming: State of the Practice, 2000.		

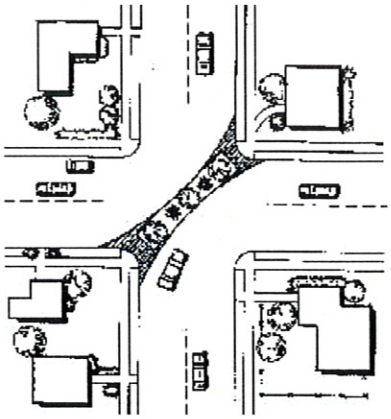
Advantages

- Able to maintain two-way bicycle access
- Effective in reducing traffic volumes

Disadvantages

- Causes circuitous routes for local residents and emergency services
- May limit access to businesses
- Drivers can circumvent the barrier

DIAGONAL DIVERTER



Diagonal diverters are barriers placed diagonally across an intersection, blocking through movement. Like half closures, diagonal diverters are usually staggered to create circuitous routes through neighborhoods.

Approximate Cost: $15,000-35,000

Measured Impacts		
Speed Impacts	**Reduction in 85th Percentile Speeds between Slow Points**	**-4%**
Volume Impacts	**Reduction in Vehicles per Day**	**-35%**

Source: Traffic Calming: State of the Practice, 2000.

Advantages

- Does not require a closure per se, only a redirection of existing streets
- Able to maintain full pedestrian and bicycle access
- Reduces traffic volumes

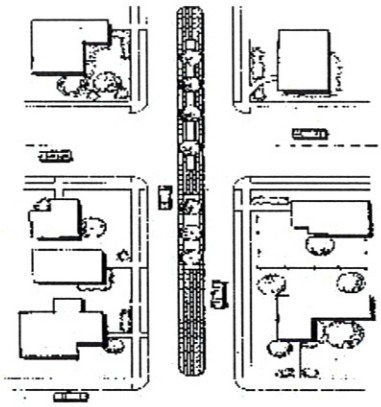
Disadvantages

- Causes circuitous routes for local residents and emergency services
- May be expensive
- May require reconstruction of corner curbs

MEDIAN BARRIER

Median barriers are raised islands that are located along the centerline of a street and continue through an intersection so as to block through movement at a cross street.

Approximate Cost: $15,000-20,000 per 100 feet



Measured Impacts		
Volume Impacts	**Reduction in Vehicles per Day**	**-31%**
Source: Traffic Calming: State of the Practice, 2000.		

Advantages

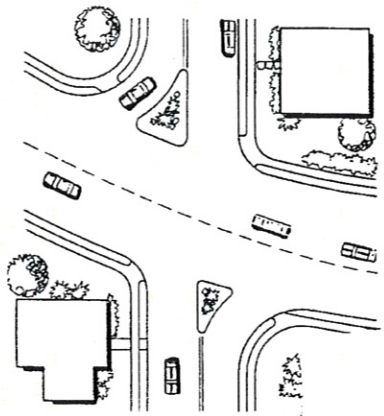
- Can improve safety at an intersection of a local street and a major street by prohibiting dangerous turning movements
- Can reduce traffic volumes on a cut-through route that crosses a major street

Disadvantages

- Requires available street width on the major street
- Limits turns to and from the side street for local residents and emergency services

FORCED-TURN ISLAND

Forced turn islands are raised islands that block certain movements on approaches to an intersection.



Approximate Cost: $3,000-5,000

Measured Impacts		
Volume Impacts	**Reduction in Vehicles per Day**	**-31%**
Source: Traffic Calming: State of the Practice, 2000.		

Advantages

- Can improve safety at an intersection of a local street and a major street by prohibiting dangerous turning movements
- Reduces traffic volumes

Disadvantages

- If designed improperly, drivers can maneuver around the island to make an illegal movement
- May simply divert a traffic problem to a different street

EFFECTIVENESS COMPARISON

Table 4 summarizes the effectiveness data that has been compiled for each of the traffic calming measures in the toolbox. Note that these data are averages. Actual effectiveness can vary based on site-specific circumstances, such as proximity to major roads and the availability of alternate routes.

Table 4 – Quantitative Impacts of Traffic Calming Measures

Types of Measures	Effectiveness									
	85th Percentile Speeds				Vehicles per Day		Average Annual Collisions			
	Before	After	Change	Percent Change	Change	Percent Change	Before	After	Change	Percent Change
Non-Physical Measures	I/D									
Narrowing Measures										
Bulbouts	34.9	32.3	-2.6	-7%	-293	-10%	I/D			
Two-Lane Chokers										
Center Island Narrowing/ Pedestrian Refuges										
Horizontal Measures										
Traffic Circles	34.2	30.3	-3.9	-11%	-293	-5%	2.19	0.64	-1.55	-71%
Roundabouts (Single-Lane)	Insignificant Speed Effects				Insignificant Volume Effects		Not Recorded			-15% to –33%
Lateral Shifts	I/D				I/D		I/D			
Chicanes	I/D				I/D		I/D			
Vertical Measures										
Speed Hump	35.0	27.4	-7.6	-22%	-335	-18%	2.62	2.29	-0.33	-13%
Speed Lump	Comparable to Speed Hump but I/D									
Speed Cushion										
Split Speed Hump	37	32	-5	-14%	Comparable to Speed Hump but I/D					
Speed Table	36.7	30.1	-6.6	-18%	-415	-12%	6.71	3.66	-3.05	-45%
Raised Crosswalk										
Raised Intersection	34.6	34.3	-0.3	-1%	I/D		I/D			
Raised Intersection	34.6	34.3	-0.3	-1%	I/D		I/D			
Textured Pavement	I/D				I/D		I/D			
Diversion Measures										
Full Closures	I/D	I/D	I/D	I/D	-671	-44%	I/D			
Half Closures	32.3	26.3	-6.0	-19%	-1,611	-42%	I/D			
Diagonal Diverters	29.3	27.9	-1.4	-4%	-501	-35%	I/D			
Median Barriers	I/D	I/D	I/D	I/D	-1,167	-31%	I/D			
Forced Turn Islands										

Notes: I/D = Insufficient Data
Source: *Traffic Calming: State of the Practice* (Ewing, 1999)

VI. DESIGN GUIDELINES

This chapter identifies some physical design considerations and constraints associated with the traffic calming measures in the toolbox in the previous chapter. Engineering designs for the standard traffic calming measures in Stockton's NTMP toolbox are contained in Appendix A.

Emergency Response Routes

Because every situation is different, variations on the standard traffic calming devices may be appropriate in some cases. The NTMP promotes the consideration of these existing experimental measures and the exploration of new measures through continuous dialogue between Public Works, emergency services staff, and citizens of the community. The development of an official "Emergency Response Route" may aid City staff and TCC members in selecting devices that would least likely impact emergency response times.

Horizontal Deflection Measures

Traffic Circle Placement

Traffic circles are very effective in moderating speeds in existing neighborhoods. Placement of traffic circles in existing neighborhoods is determined on a case by case basis and should meet the following criteria:

- At the intersection of two local streets or a local and collector street with ADT >1,000

Traffic Circles can also be incorporated into new developments as seen fit by Development Services Review. The above installation criterion also applies.

Traffic Circle Center Island Profile

Traffic circles should be designed with both a square inner curb and a mountable apron. The apron is a shallow-sloped curb extending out from the bottom of a square curb; the apron has a low lip at its pavement-side edge. This apron effectively reduces the diameter of the center island for large vehicles, facilitating easier turns. The low lip at the apron's edge discourages vehicles from using it unless it is necessary.

Traffic Circle Turn Operations

All vehicles should circulate around the center island on left-turns.

Traffic Circles at T-Intersections

Traffic circles should have deflection on all approaches if implemented at a T-intersection. This can be implemented using one of two methods. First, a raised island can be placed at the right side of the un-deflected approach to the traffic circle to artificially introduce deflection, as shown in Figure 2 (a). Alternatively, the street curbs can be modified to allow the center island to be located at the center of the intersection, as shown in figure (b). This method may require the acquisition of additional right-of-way.

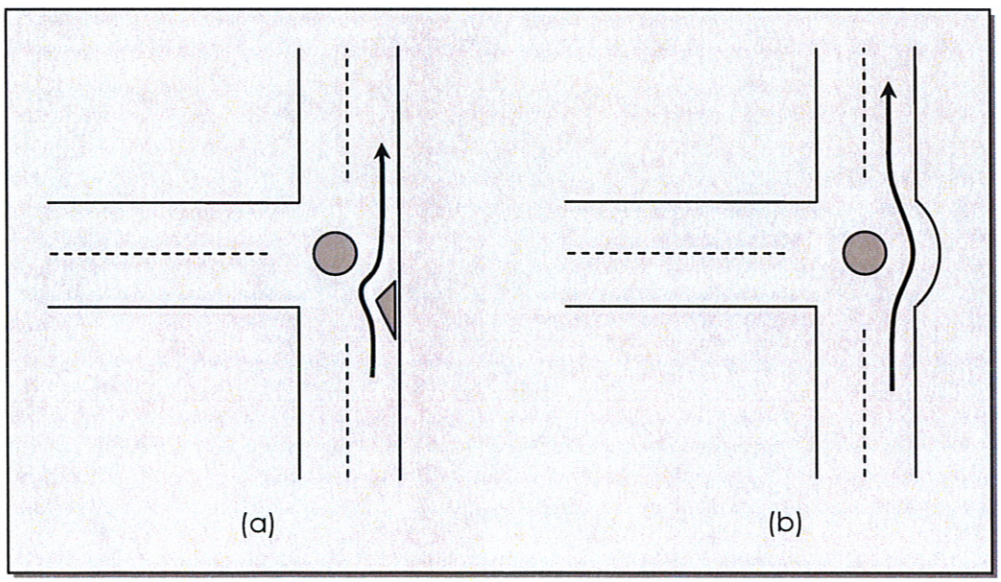


Figure 2. Roundabouts at T-Intersections

Landscaping

Landscaping on traffic calming devices serves two primary purposes. First, it increases the visibility of a device, such as a raised center island, by extending the device's vertical size and introducing more varied colors. Second, landscaping generally improves the aesthetic quality of traffic calming devices, making them more acceptable to nearby residents. Landscaping should be included on all raised islands unless it is physically infeasible to do so. In those cases, hardscape (e.g. grouted cobble) should be used instead. Trees planted on center islands must allow adequate sight distances for motorists.

Signing & Marking

Concurrent with the installation of traffic calming devices, device-specific symbol-based signs will be installed (Appendix A). At the discretion of Public Works staff, advanced warning signs may also be installed. Traffic circle center islands will include signage symbolically indicating the permitted travel paths around the center island (Appendix A).

Special signing for bicyclists should be provided on designated bikeways. For example, the approaches to narrowing devices that do not include a bypass lane for bicyclists will include signage warning motorists to watch for merging bicyclists.

Combined Measures

Some measures from the toolbox can be combined to increase the combined effect on traffic volumes and speeds. For example, a center island narrowing may be combined with bulbouts, with the effect of a much shorter walking distance. Motorists must also react to the narrower lane and object on either side. In assessing the suitability of a proposed combined measure, the guidelines in Table 1 for both of the component devices should be applied.

Roundabouts

Roundabouts are a unique traffic control device that may be useful in a variety of situations. They are often used in lieu of all-way stop control or traffic signals as a means of increasing the capacity of the intersection and improving its operations. Roundabout treatments should be considered when a local street and collector or two collector streets meet with an ADT greater than 2,000. Roundabouts can also be designed into new developments based on the same criteria.

Roundabouts require a considerably more rigorous design process than the other traffic calming devices in the toolbox. Because of their complex design features, no generic design is included in this document. However, roundabouts should generally have the following characteristics:

- A circular travel lane operating counter-clockwise for collecting and distributing traffic
- A raised center island
- Channelized approaches
- Yield control at all approaches
- Tapered approaches to encourage entering vehicles to travel in the correct direction through the circular travel lane

In general, roundabouts in the United States tend to be used on collector streets and on low-volume minor arterial streets. The use of roundabouts is primarily constrained by traffic volumes and by geometrics. The design of every roundabout should be customized using detailed traffic and geometric information and procedures beyond what is presented here. The cursory check found in Appendix B can helpful in determining whether a roundabout is a reasonable option to consider. Also, the following examples illustrate cases where a roundabout may be appropriate:

- ***History of Collisions –*** For example, roundabouts are placed at intersections with a history of accidents, especially head-on collisions and right-angle collisions. A roundabout can help

improve safety by substantially reducing the number of conflict points and by simplifying interactions between vehicles.

- ***Minimizing Queues*** – Another case is a collector/arterial intersection located near an arterial/arterial intersection. A roundabout may be useful here because it can allocate right-of-way between both the arterial and the collector, while minimizing the queues on the approach stemming from the arterial/arterial intersection.

- ***Handling Irregular Approach Geometry*** – An intersection with greater than four approaches or with approaches that meet the intersection at irregular angles may be a candidate for a roundabout.

- ***Inexpensive Traffic Control*** – In some cases, traffic volumes at an intersection may be too high to allow acceptable operations with all-way stop control, a traffic signal is considered inappropriate due to sight distance or other constraints. If ample right-of-way is already available, a roundabout may be considered.

- ***High Proportion of U-Turns*** – If an intersection is situated where U-turns are frequent, a roundabout can facilitate those U-turns without adversely affecting the operations of the intersection as a whole.

- ***Pedestrian Accommodation*** – Roundabouts represent a trade-off for pedestrians. They can be inconvenient for pedestrians because the crosswalks are set back farther from the intersection. Additionally, roundabouts pose as a greater challenge to the visually impaired than typical intersections do. However, they are also superior to signalized intersections because crossing distances are shorter and are broken by a pedestrian refuge, and pedestrians do not need to wait for the pedestrian signal through a long traffic signal cycle.

Vertical Deflection Measures – Humps and Lumps Installation

Speed humps and speed lumps may be installed on City streets in neighborhoods selected to participate in the Neighborhood Traffic

Management Program (NTMP) if the following conditions are met. In addition, Public Works staff will coordinate with the Fire Department and SJRTD during the review process of proposed traffic calming plans that include speed humps or speed lumps.

1. The street must be two lanes and primarily function as a local residential or minor collector street.
2. The speed limit must be 30 mph or less.
3. The street frontage of subject segment must consist of at least 75% residential development except when fronted by a school or park.
4. The street segment must be at least 500 feet in length between traffic controls, four-way intersections, and/or curves with less than a 250-foot radius.

Selection of Precise Installation Locations

In selecting precise locations for the speed hump/lumps, the following guidelines shall be followed. For simplicity, the term speed hump refers to both the speed hump and speed lump.

1. Speed humps shall not be located over manholes, water valves, or street monuments, or whenever possible, within twenty-five feet of fire hydrants, as they prevent/impede access to these facilities.
2. Speed humps should be located five to ten feet away from driveways, whenever possible, to minimize their effect on driveway access.
3. Speed humps should be located on or near property lines, whenever possible, to minimize the impact on individual properties.
4. Speed humps should be located near streetlights, whenever possible, in order to enhance their visibility at night.
5. Speed humps should be located a minimum distance of 200 feet from corners, whenever possible, and shall never be located within a corner radius.
6. Speed humps shall be placed no closer than 200 feet from traffic control devices or four-way intersections.
7. Where speed humps are constructed on streets having curves with greater than a 250-foot radius, no speed hump shall be located on the horizontal curve(s).

8. Speed humps shall be spaced at a minimum interval of 250 feet and a maximum interval of 600 feet.

9. To deter motorists from driving around speed humps where no vertical curb exists, a two-inch pipe should be set in the sidewalk, centered on the speed hump. The pipes shall be placed at a maximum of six inches from the back of curb.

Signs and Markings

1. Advance warning signs and supplemental speed advisory signs shall be installed per the MUTCD.

2. Pavement markings for speed humps shall be installed per the MUTCD.

3. Pavement marking for speed lumps should include diamond striping on the center lump(s) and arrow markings on the side lumps.

VII. REFERENCES

To find out more about Traffic Calming and Neighborhood Traffic Management, please see the web sites and documents listed below:

Local Traffic Calming Programs

- City of Sacramento. (2002b). Neighborhood Traffic Management Program (Web Site: http://pw.sacto.org/traffic/ntmp.html). Sacramento, CA: City of Sacramento, Department of Public Works.
- City of Austin (2002). Neighborhood Traffic Management Program (Web Site: http://www.ci.austin.tx.us/roadworks/tc.htm). Austin, TX: City of Austin Department of Public Works and Transportation.
- City of Portland (2002). Portland Traffic Calming Program (Web Site: http://www.trans.ci.portland.or.us/trafficcalming/default.htm). Portland, OR: City of Portland Neighborhood Traffic Management.
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- Ewing, R. (2000). *Delaware Traffic Calming Design Manual*. Wilmington, DE: Delaware Department of Transportation.

General Information on Traffic Calming

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- Fehr & Peers. (1999). Traffic Calming .Org (Web Site: http://www.trafficcalming.org). Lafayette, CA: Fehr & Peers Associates, Inc.

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- Hass-Klau, C. et al. (1992). *Civilised Streets: A Guide to Traffic Calming.* Brighton, U.K.: Environment & Transport Planning.

- Hehrstedt, L. et al. (1993). *An Improved Traffic Environment: A Catalogue of Ideas.* Copenhagen, Denmark: Danish Road Directorate.

- Litman, T. (2001). Online TDM Encyclopedia (Web Site: http://www.vtpi.org/tdm/). Victoria, BC: Victoria Transport Policy Institute.

- Smith, D. T. Jr. and D. Appleyard. (1980). *State of the Art: Residential Traffic Management.* Washington, DC: Federal Highway Administration.

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- Tolley, R. (1990). *Traffic in Residential Areas.* Brefi, U.K.: Brefi Press.

Roundabouts

- Robinson, B. W. et al (2000). *Roundabouts: An Informational Guide.* Washington, DC: Federal Highway Administration.

- Wallwork, M. (2002). *Modern Roundabouts (Web Site: http://www.roundabouts.net)*. Orange Park, FL: Alternate Street Design, P.A.

Appendix A
Standard Traffic Calming Device Designs

Triple 4 Crosswalk A-1

Traffic Circle A-2

Chicane A-3

Bulbout (Midblock treatment) A-4

Bulbout (Intersection treatment) A-5

Center Island Narrowing A-6

Choker A-7

Speed Hump A-8

Speed Lump or Speed Cushion A-9

Split Speed Hump A-10

Speed Table A-11

Raised Crosswalk A-12

Raised Intersection A-13

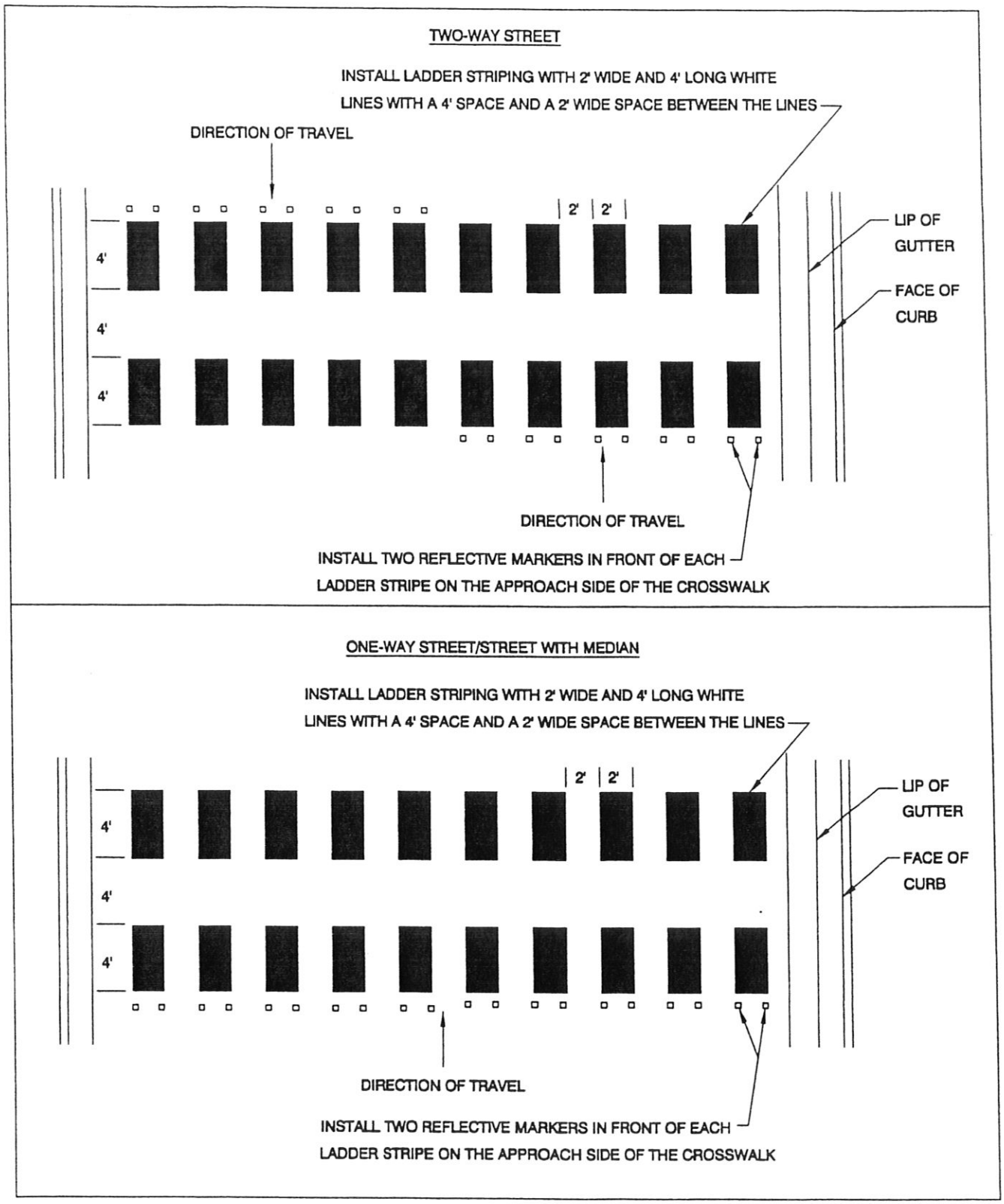
Half Closure A-14

Diagonal Diverter A-15

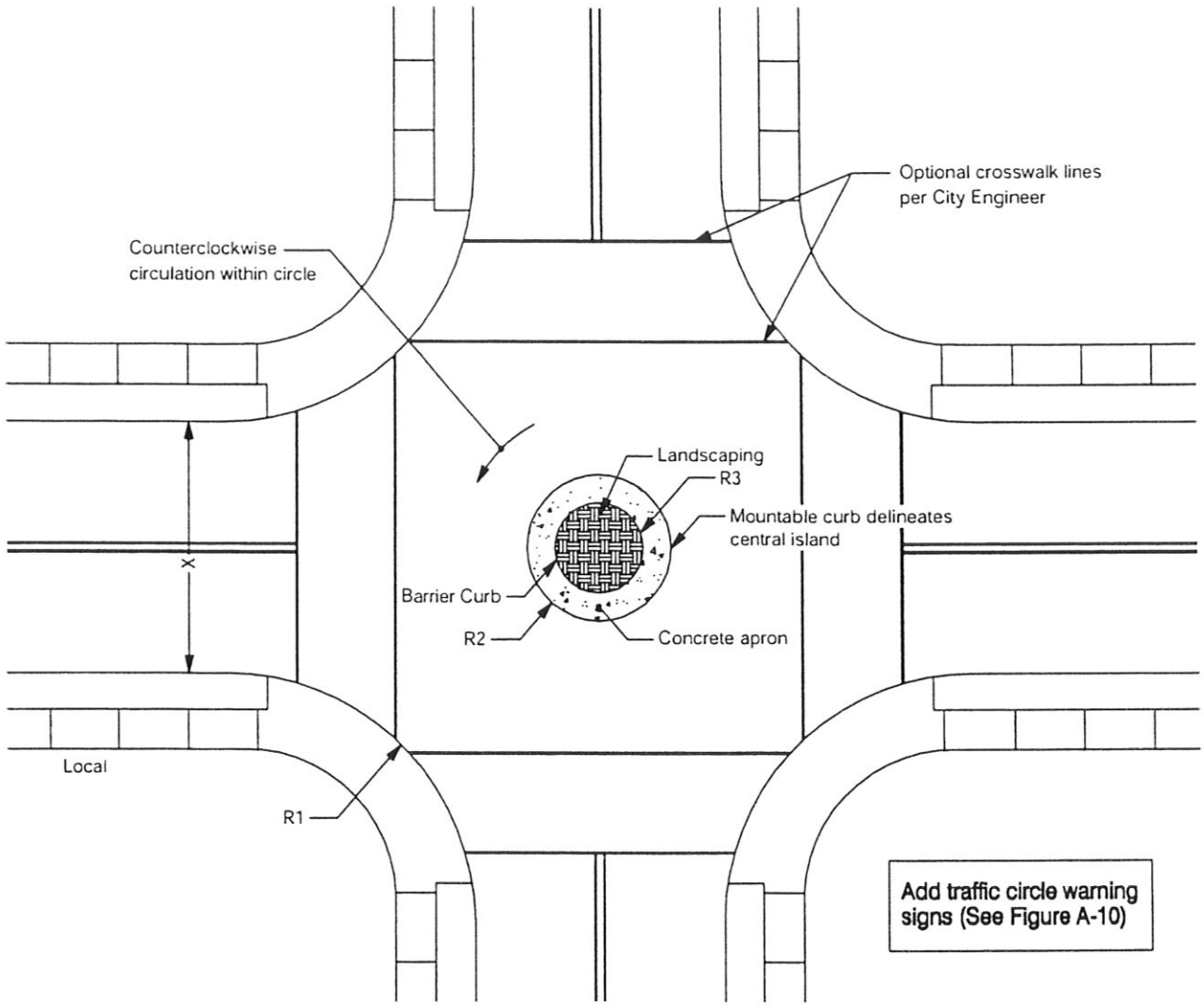
Median Barrier A-16

Forced Turn Island A-17

Warning Signs A-18



TRIPLE 4 CROSSWALK
FIGURE A-1

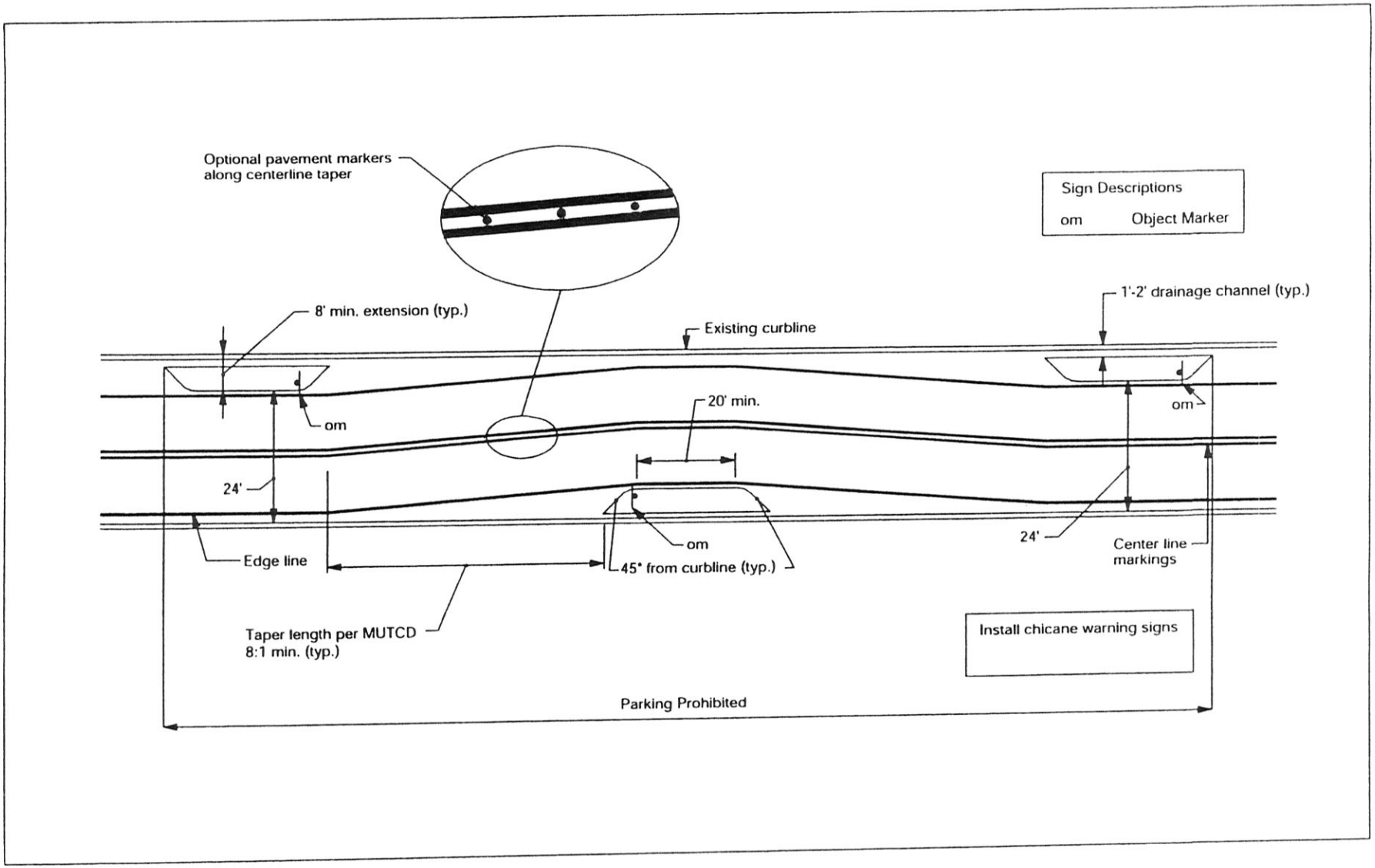


For This Street Width[2]:	Use These Curb Radii:		
X	R1	R2	R3
34'	20'	20'	8'
	25'	24'	8'
32'	15'	12'	7'
	20'	18'	7'
	25'	20'	7'
30'	15'	11'	6'
	20'	15'	6'
	25'	16'	6'

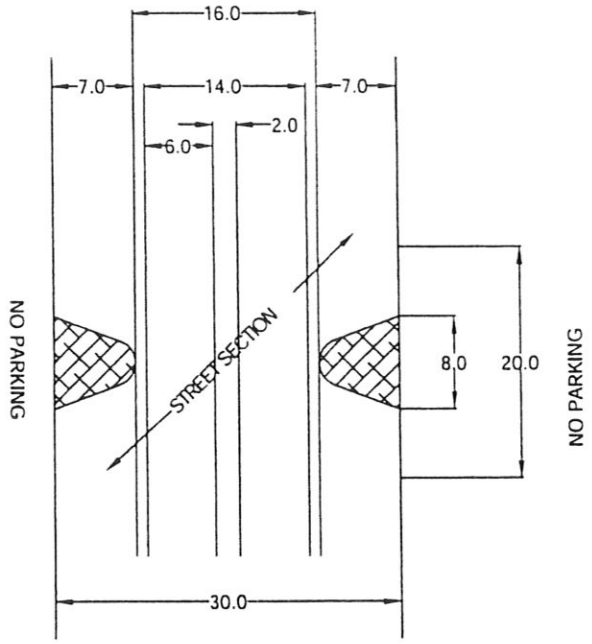
NOTE: 1. Assumes equal street widths; For unequal street widths, use Autoturn to ensure adequate turning radii for the desired design vehicle.

TRAFFIC CIRCLE

FIGURE A-2



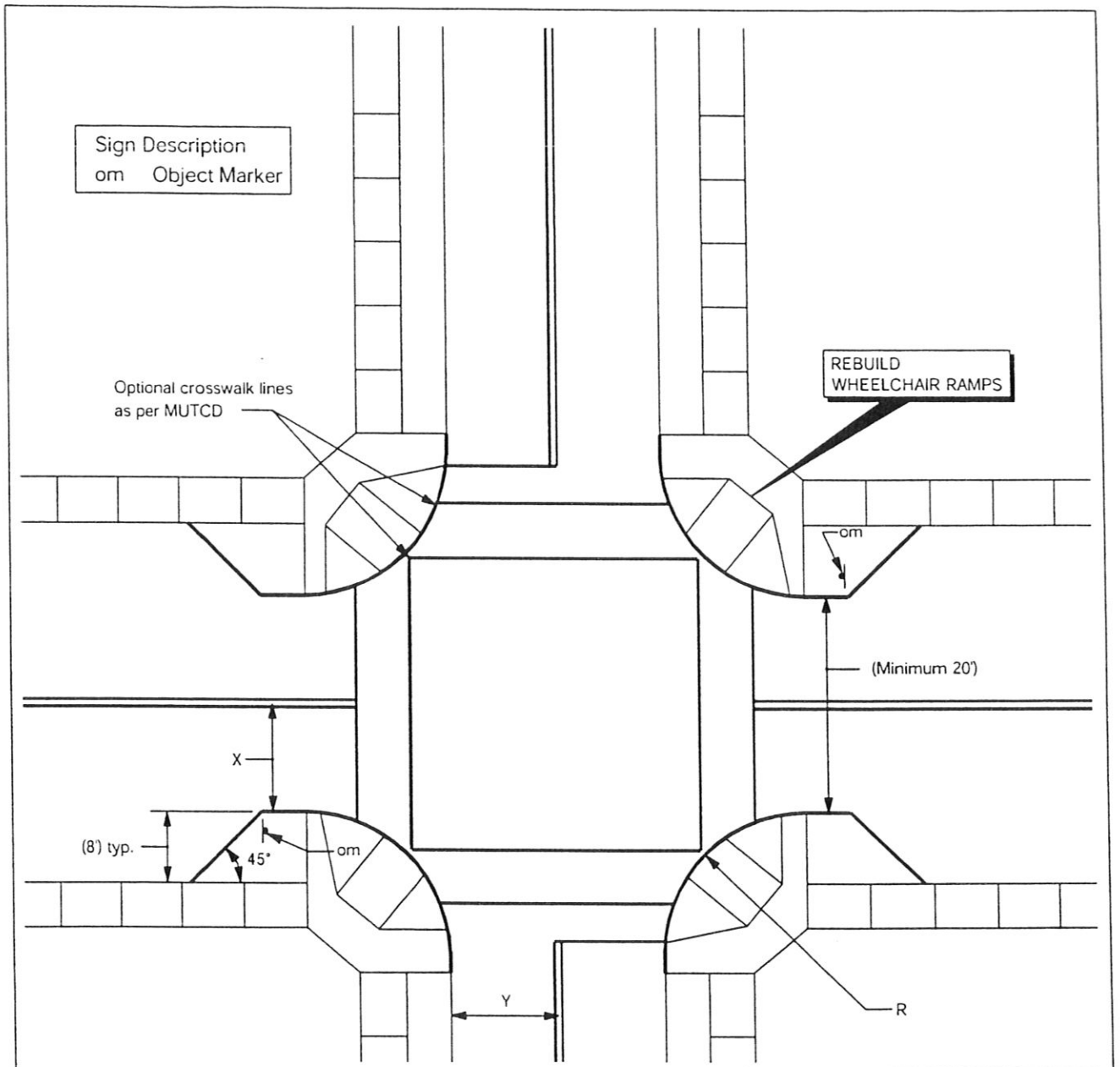
CHICANE
FIGURE A-3



MIN. 30' WIDE STREET
FOR WIDER STREETS
MAKE BULB DEEPER

THE BULB-OUT DRAWING SHOWN IS FOR A 30 FOOT WIDE STREET. IF A STREET IS WIDER, THE BULB WOULD BE DEEPER; EACH BULB SHOWN IS SEVEN FEET DEEP. THE WIDTH BETWEEN BULBS SHOULD BE 16 FEET, WHICH ALLOWS FOR ONE FOOT BETWEEN BULB AND CAR, SIX FEET PER CAR AND TWO FEET BETWEEN CARS. THIS WOULD REQUIRE CARS TO SLOW DOWN SUBSTANTIALLY IN ORDER TO PASS. THE BULB WOULD RESTRICT PARKING FOR APPROXIMATELY 20 FEET (ONE CAR LENGTH FOR PARKING PURPOSES) IN ORDER FOR THE BULB TO BE VISIBLE, ALLOW WIDER VEHICLES TO PULL TO THE RIGHT AND ALLOW AN OPPOSING VEHICLE TO PASS. IT MAY BE POSSIBLE TO PLANT A TREE IN EACH BULB.

BULBOUT (MIDBLOCK TREATMENT)
FIGURE A-4

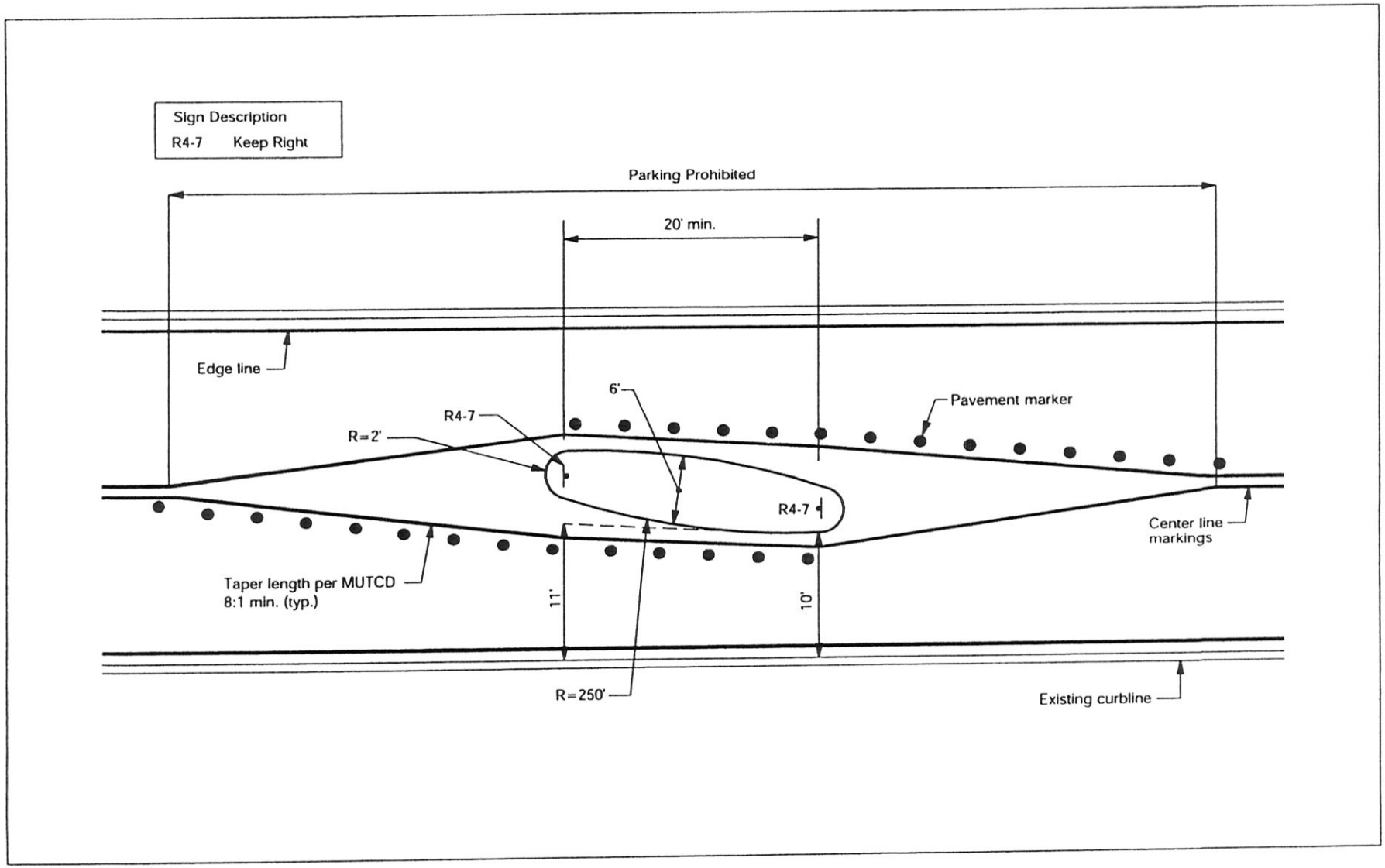


For The Street Widths:		Use This Curb Radius:
X	Y	R
12'	12'	40'
12'	14'	32'
12'	16'	26'
14'	12'	37'
14'	14'	35'
14'	16'	24'

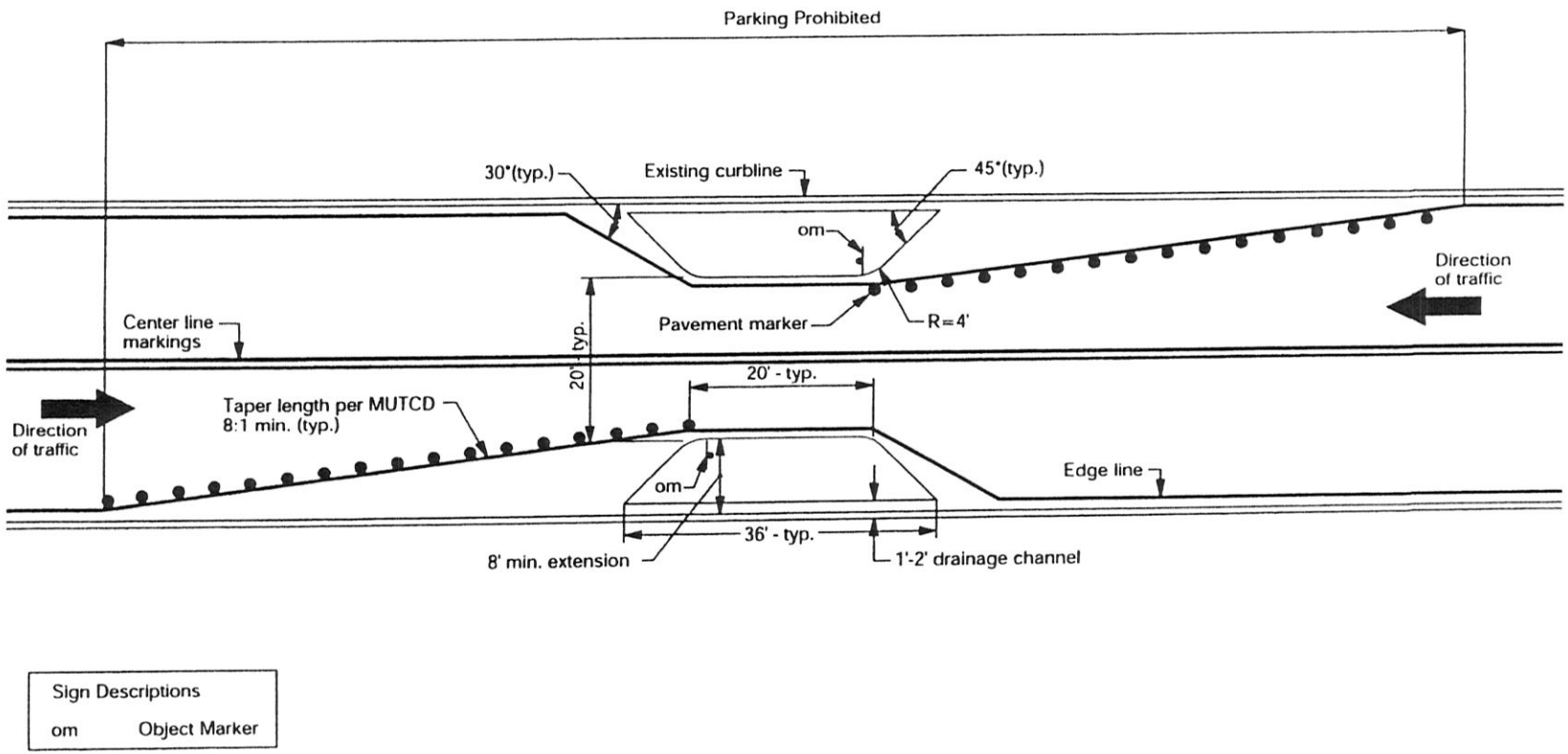
NOTES: 1. Distance X is referenced from the center of the roadway to the lip of gutter.

BULBOUT
(INTERSECTION TREATMENT)

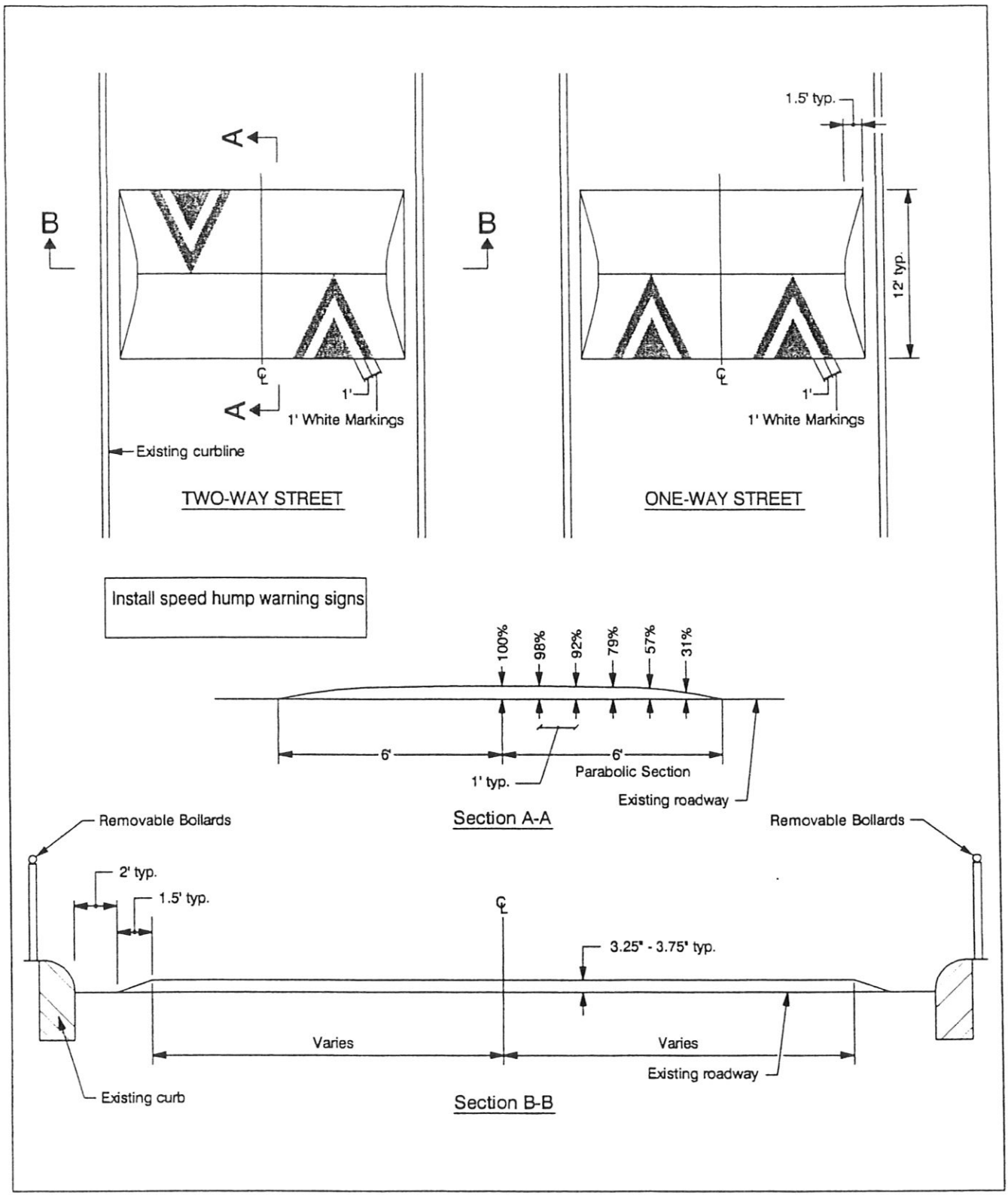
FIGURE A-5



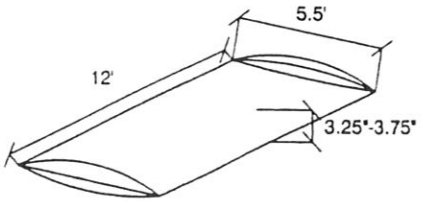
CENTER ISLAND NARROWINGS
FIGURE A-6

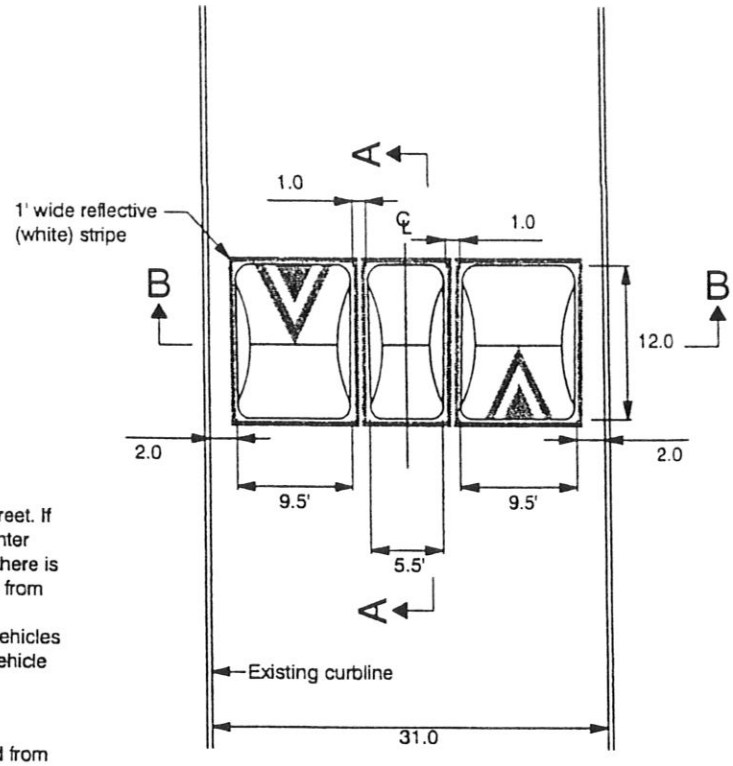


CHOKER
FIGURE A-7



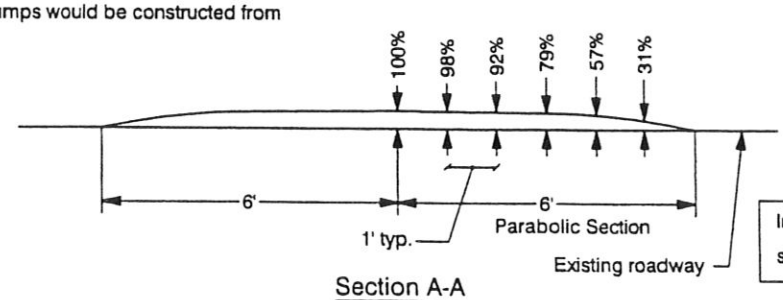
SPEED HUMP
FIGURE A-8





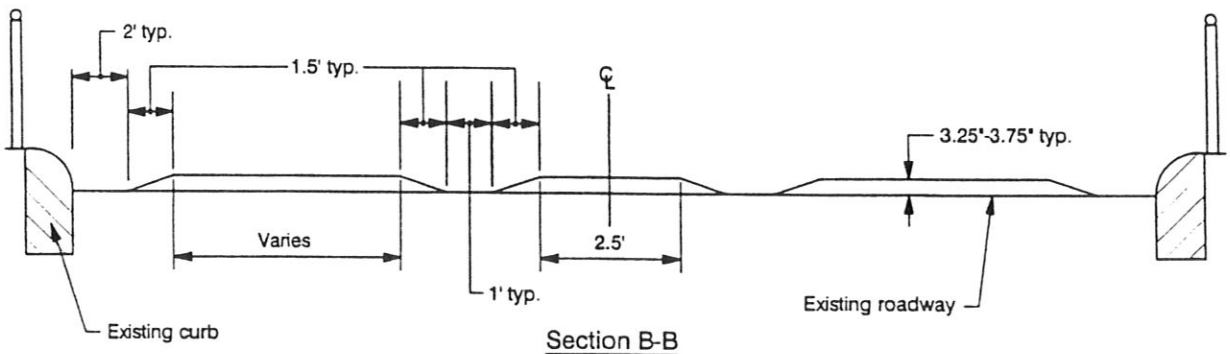
The speed-lump drawing shown is for a 31-foot wide street. If a street is wider, another lump may be added. Each center lump (only one shown) is 12 feet deep, 5 ½ feet wide, there is 1 foot between outer lumps and center lump with 2 feet from curb to drainage. This would require cars to slow down substantially in order to pass. It may be necessary for vehicles to pull to the right and allow an opposing emergency vehicle to pass.

NOTE: Speed cushions would be constructed from pre-manufactured rubberized material (obtained from vendor). Speed lumps would be constructed from asphalt.



Section A-A

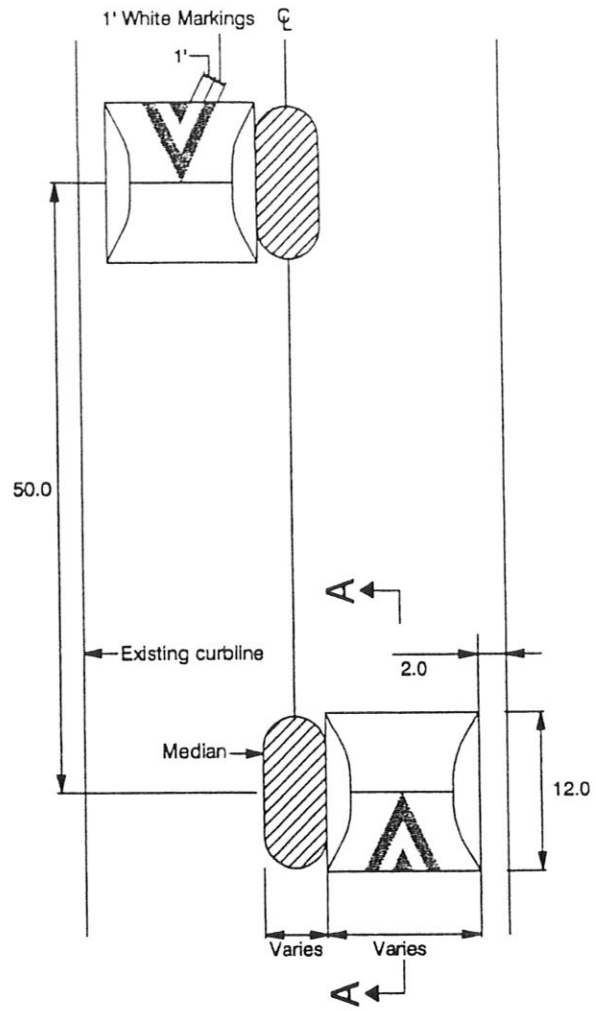
Install speed cushion warning signs

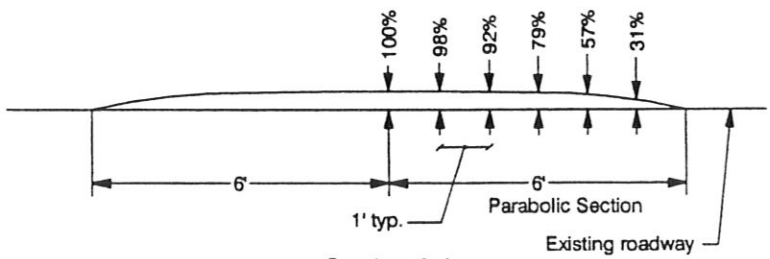


Section B-B

SPEED LUMP OR SPEED CUSHION
FIGURE A-9

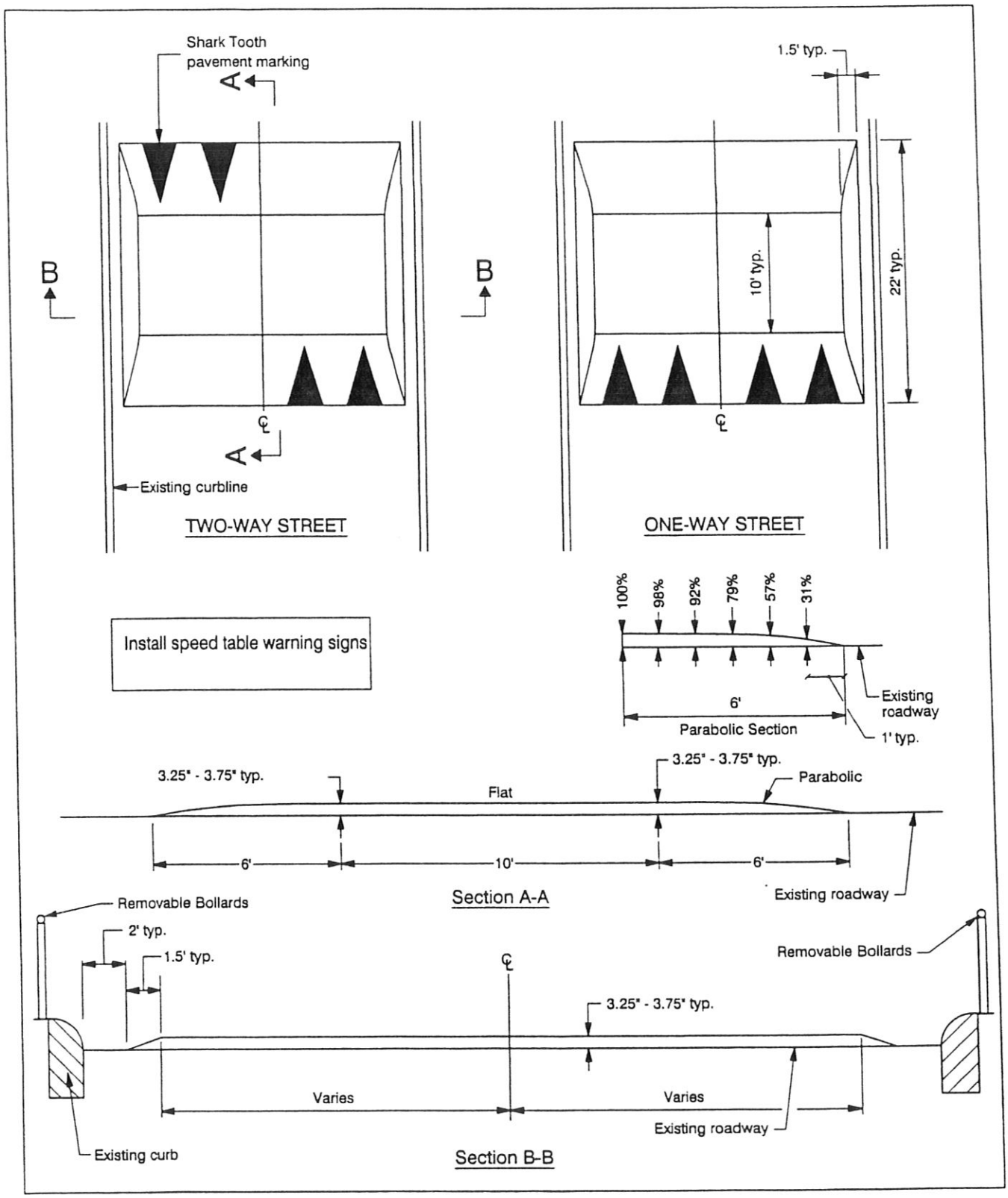
Width of split speed hump varies depending on street width. Humps should occupy travel lane from approximately 1' from curb and drainage and extend to landscaped median. Median should be wide enough to discourage drivers from maneuvering around hump.



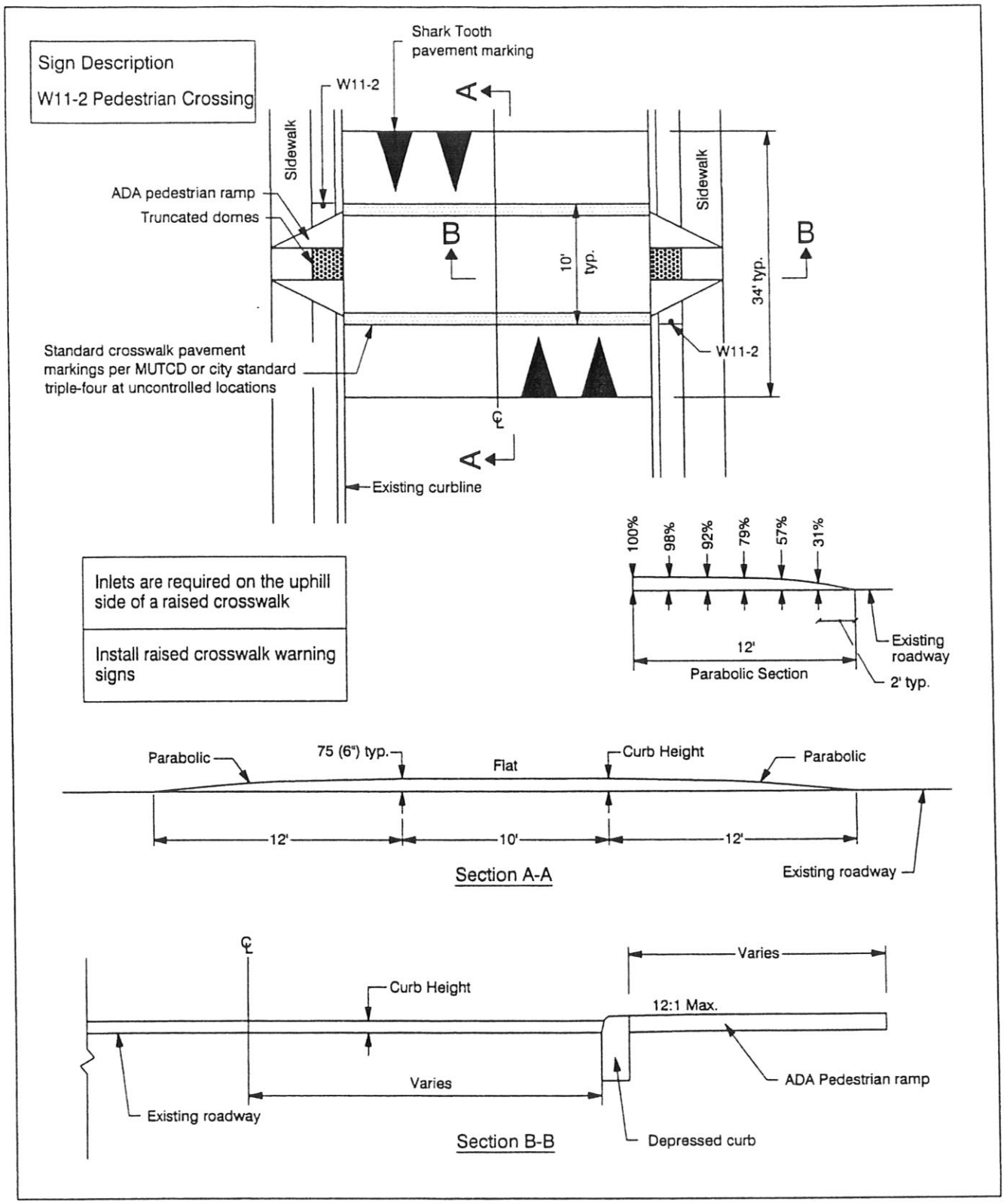


Section A-A

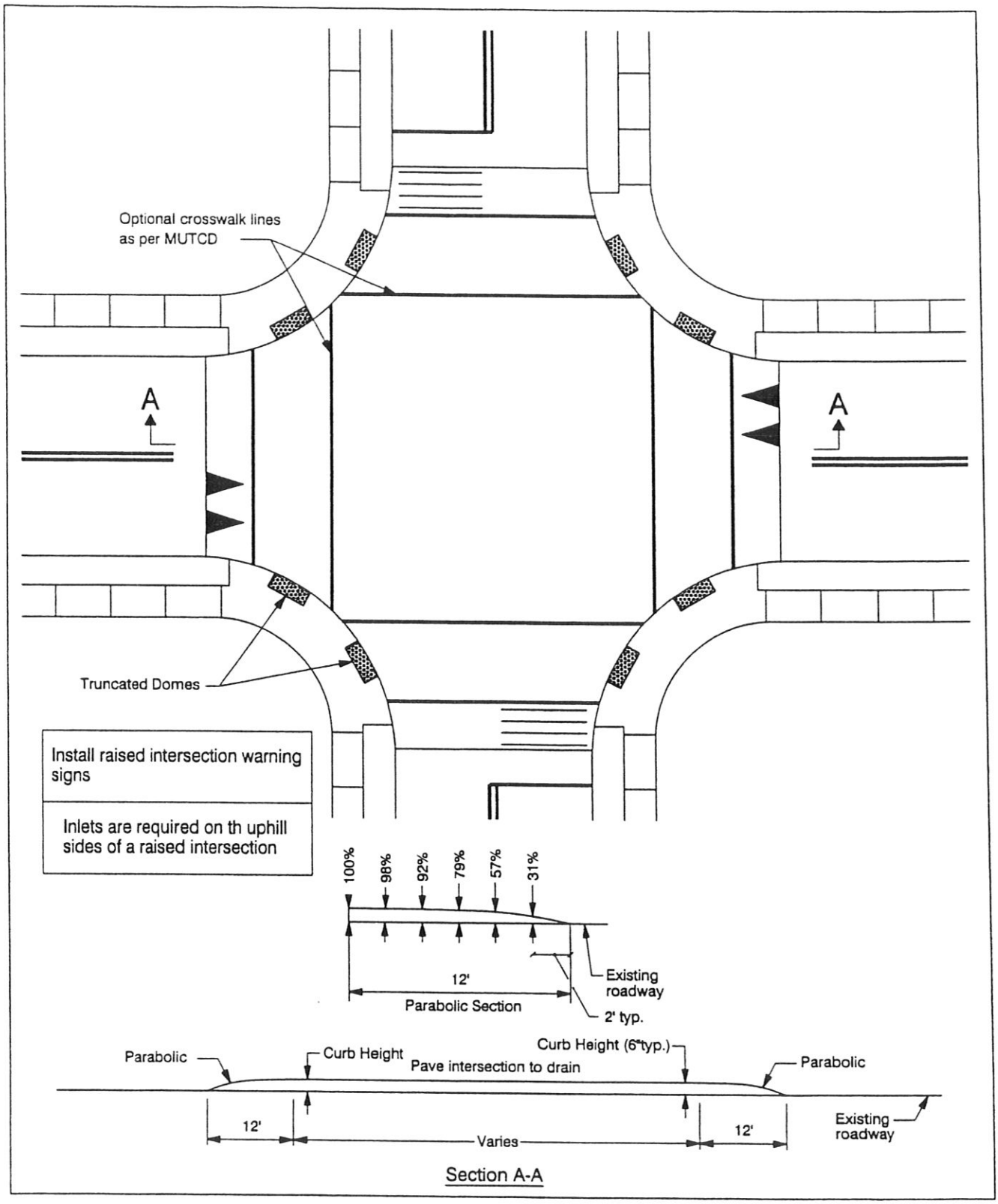
SPLIT SPEED HUMP
FIGURE A-10



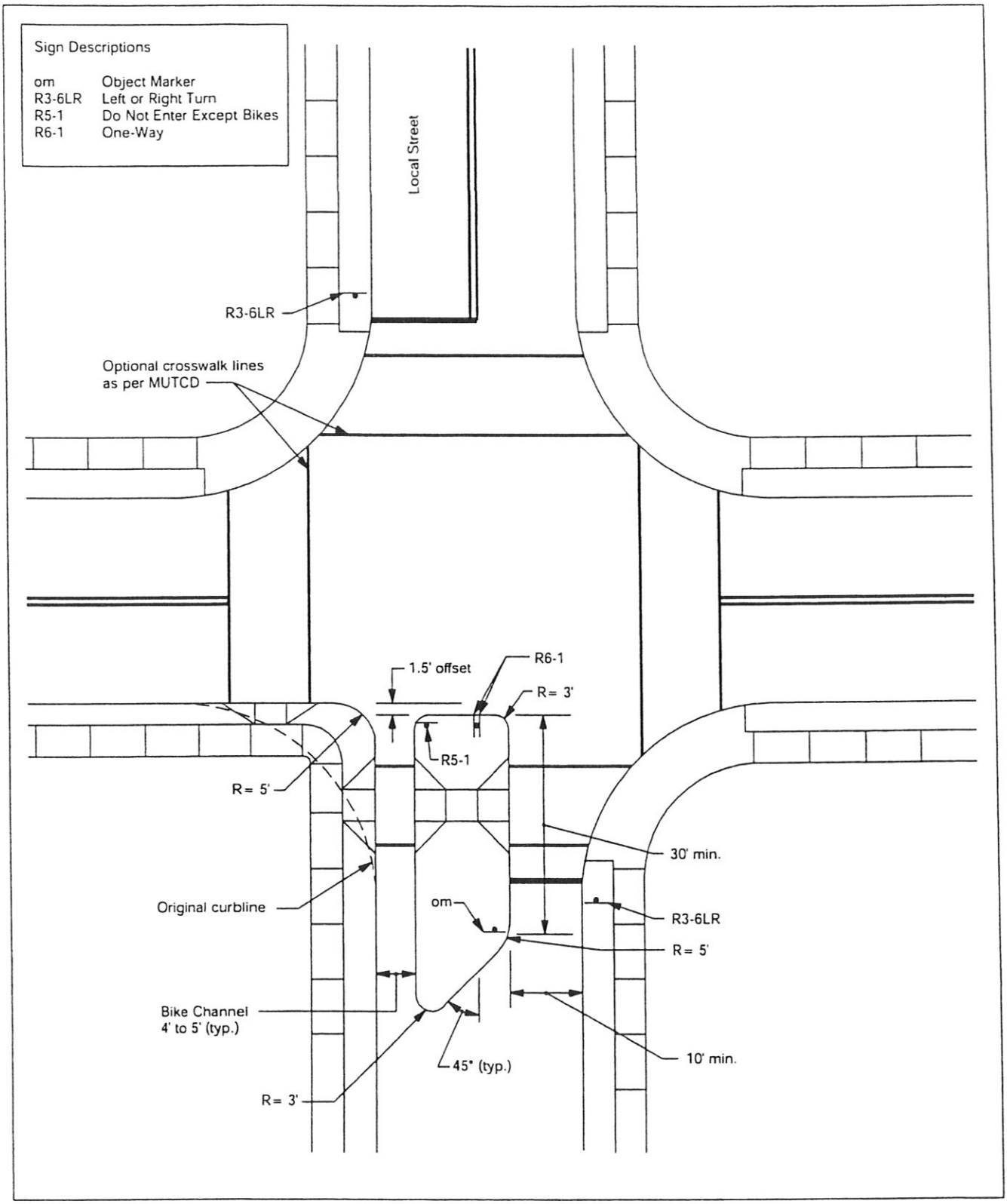
SPEED TABLE
FIGURE A-11



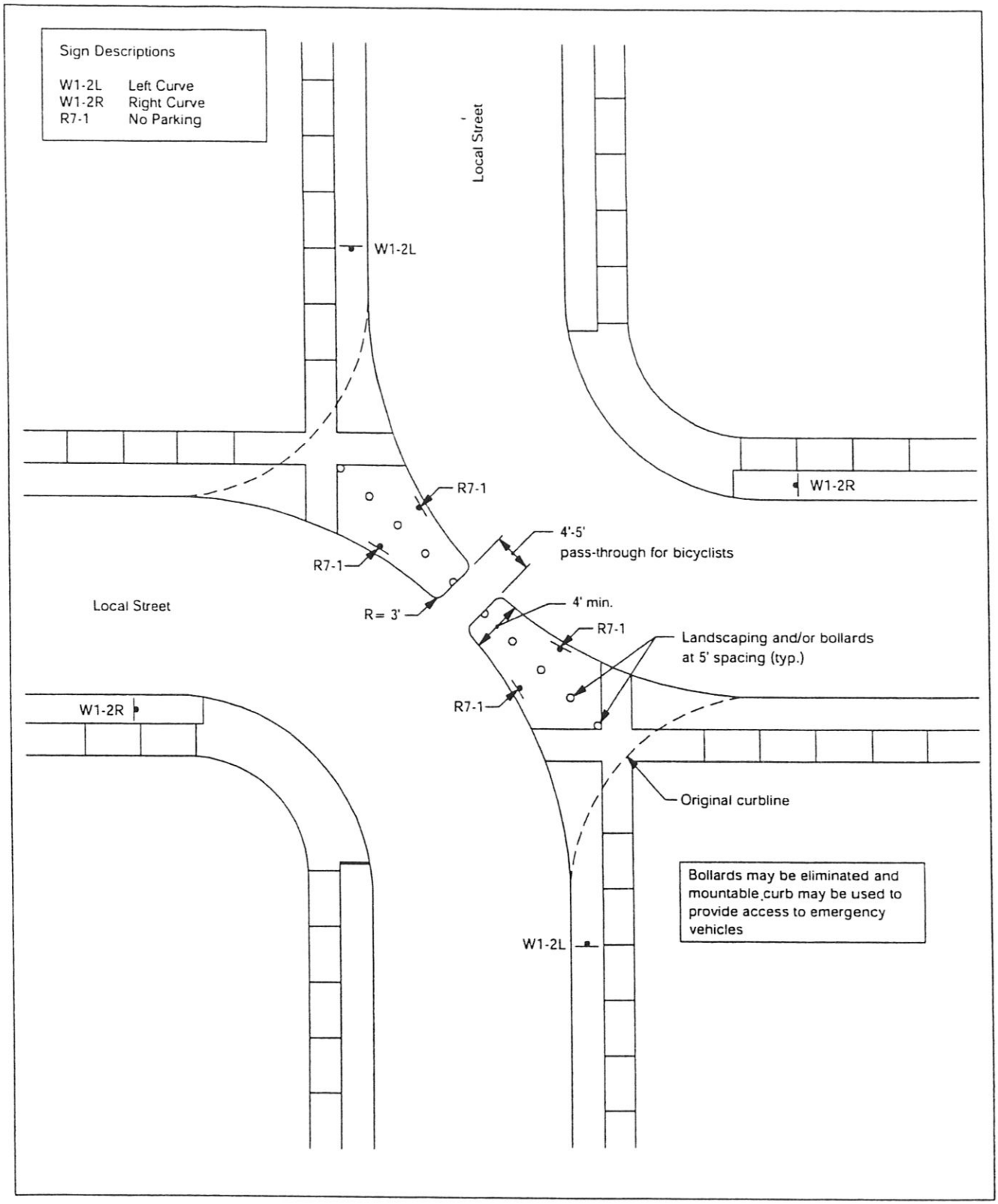
RAISED CROSSWALK
FIGURE A-12



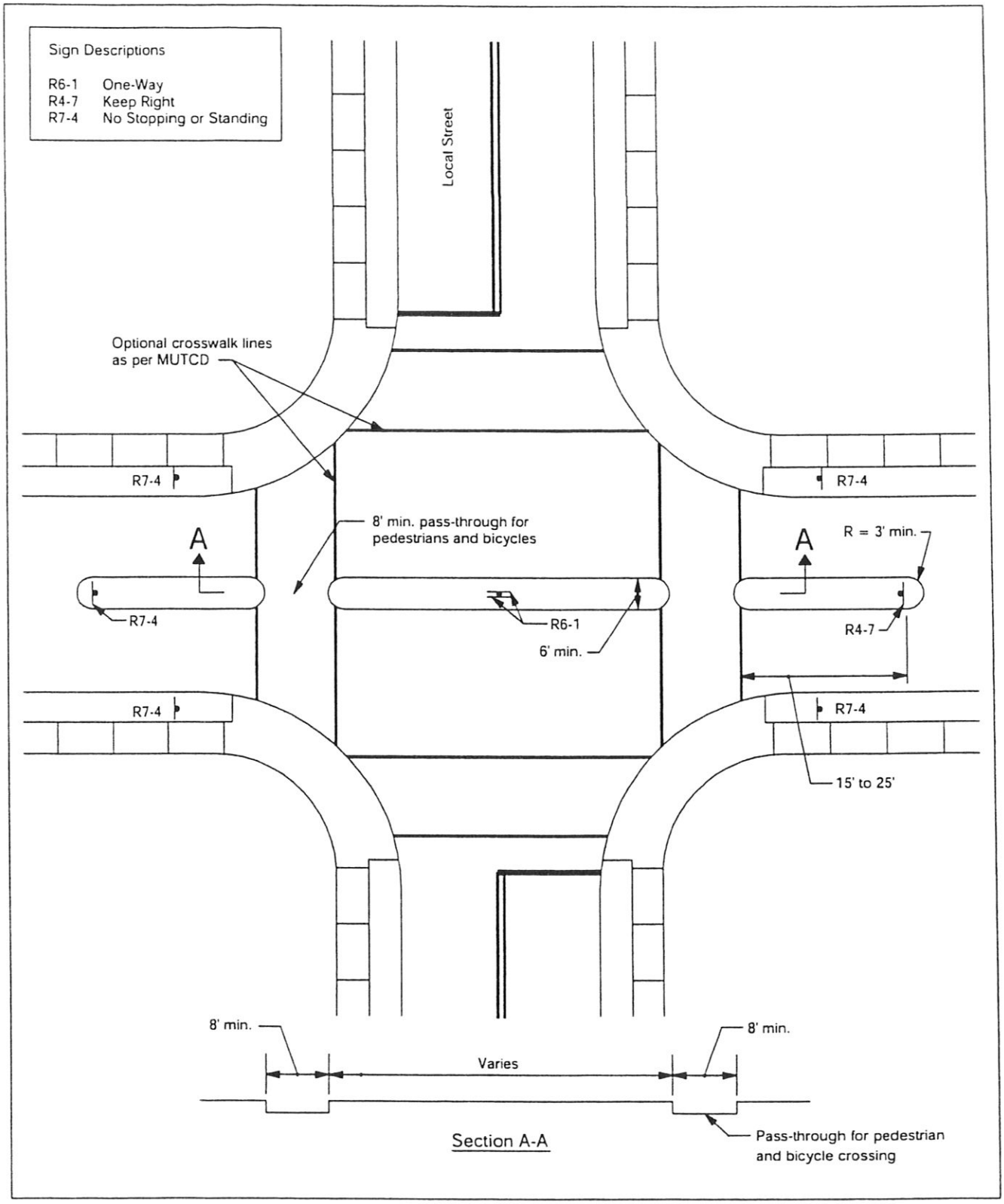
RAISED INTERSECTION
FIGURE A-13



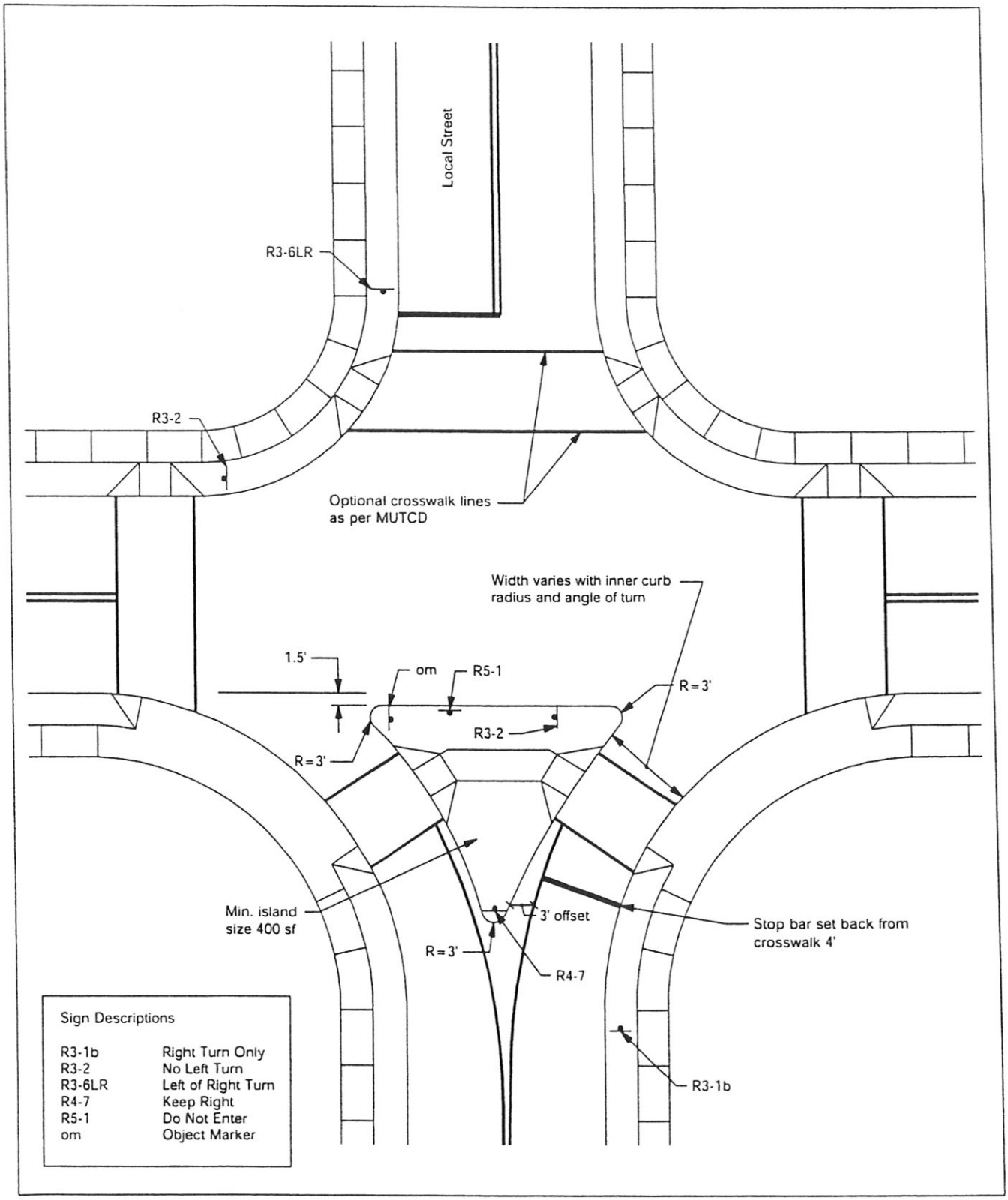
HALF CLOSURE
FIGURE A-14



DIAGONAL DIVERTER
FIGURE A-15



MEDIAN BARRIER
FIGURE A-16



FORCED TURN ISLAND
FIGURE A-17

Sign Dimensions	Color Code		
	Background	Message	Border
30" x 30"	Flourescent Yellow or Yellow-Green	Black	Black

SPEED HUMP

SPEED TABLE

RAISED CROSSWALK

RAISED INTERSECTION

TRAFFIC CIRCLE OR ROUNDABOUT

TWO-LANE CHICANE

WARNING SIGNS
FIGURE A-18

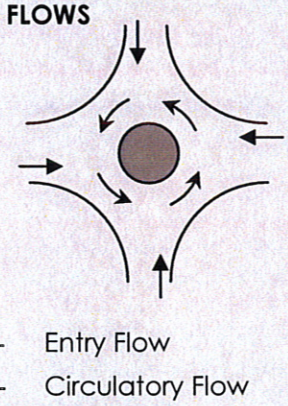
Appendix B
Checking Roundabout Compatibility

When considering a roundabout for a particular intersection, the expected traffic volumes and the available geometry must be taken into consideration, along with several other considerations.

Traffic Volumes

The first check is to determine whether a roundabout could accommodate the traffic volumes at a particular intersection. Two quantities are required: the Maximum Entry Flow and the Maximum Circulatory Flow (see Figure B-1). The Maximum Entry Flow is the traffic volume entering the intersection (including left-turning, through, and right-turning vehicles) at the highest-volume approach. Circulatory Flow is calculated for each quadrant of the circulating lane by adding up the contributing Entry Flows:

FIGURE B-1. TYPES OF ROUNDABOUT TRAFFIC FLOWS



$$V_{EB,circ} = V_{WB,LT} + V_{SB,LT} + V_{SB,TH} + V_{NB,U\text{-}turn} + V_{WB,U\text{-}turn} + V_{SB,U\text{-}turn}$$

$$V_{WB,circ} = V_{EB,LT} + V_{NB,LT} + V_{NB,TH} + V_{SB,U\text{-}turn} + V_{EB,U\text{-}turn} + V_{NB,U\text{-}turn}$$

$$V_{NB,circ} = V_{SB,LT} + V_{EB,LT} + V_{EB,TH} + V_{WB,U\text{-}turn} + V_{SB,U\text{-}turn} + V_{EB,U\text{-}turn}$$

$$V_{SB,circ} = V_{NB,LT} + V_{WB,LT} + V_{WB,TH} + V_{EB,U\text{-}turn} + V_{NB,U\text{-}turn} + V_{WB,U\text{-}turn},$$

where $V_{i,circ}$ = Circulatory flow immediately downstream of approach *i*.

$V_{i,j}$ = Traffic volume at approach *i* taking turning movement *j*;

EB, WB, NB, SB = Eastbound, Westbound, Northbound, and Southbound, respectively; and *LT, TH, U-turn* = Left Turn, Through, and U-Turn, respectively.

After using the above formula to find the circulatory flows, the highest of the four values is used in Figure B-2 in combination with the Maximum Entry Flow to determine whether an Urban Single-Lane Roundabout could accommodate the traffic volume.

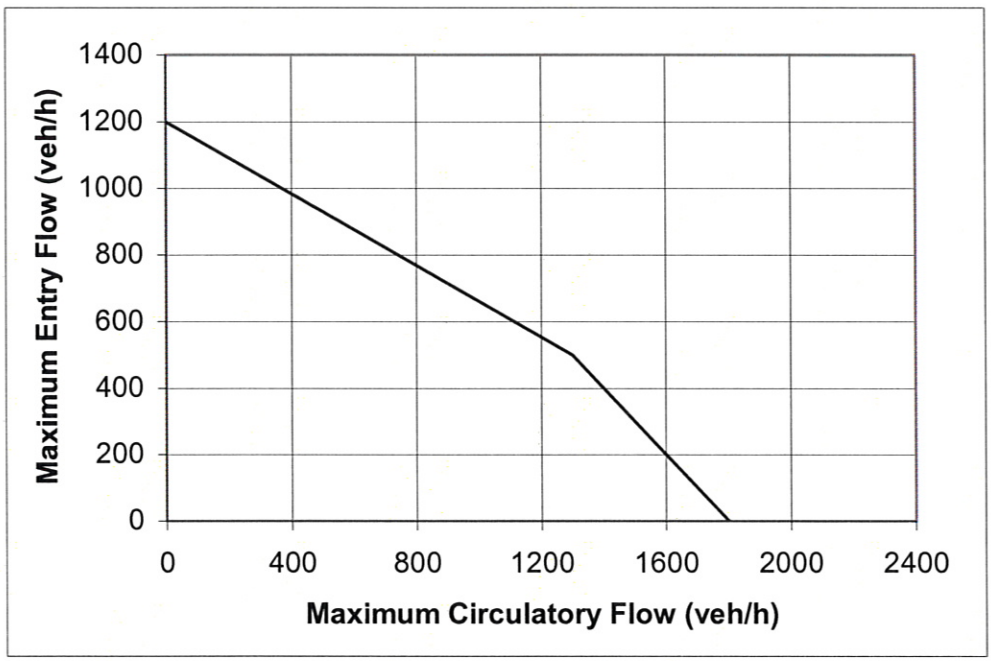


Figure B-2. Approach Capacity of an Urban Single-Lane Roundabout

Geometry

The second check is the available geometry. The width of the approach tapers and the size of the inscribed diameter of a roundabout can vary over a wide range. However, it may be possible to eliminate a roundabout from consideration by comparing the available right-of-way to some minimum geometric values as shown in Drawing 12B of the Standard Plans.