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"Efficiency - Equity - Clarity"

Traffic Calming
Benefits, Costs and Equity Impacts

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Abstract

This paper describes a framework for evaluating traffic calming programs. Potential benefits include road safety, increased comfort and mobility for non-motorized travel, reduced environmental impacts, increased neighborhood interaction, and increased property values. Traffic calming can help create more livable communities and reduce suburban sprawl. Traffic calming costs can include project expenses, liability claims, vehicle delay, traffic spillover, problems for emergency and service vehicles, driver frustration, and problems for bicyclists and visually impaired pedestrians.

Traffic calming tends to provide the greatest benefits to pedestrians, bicyclists and local residents, while imposing the greatest costs on motorists who drive intensively (i.e., as fast as possible). Traffic calming tends to increase horizontal equity by reducing the external costs imposed by motor vehicles and improving the balance between different uses of public streets. Traffic calming tends to increase vertical equity because it benefits people who are physically, economically and socially disadvantaged, while imposing the greatest disbenefits on relatively wealthy, higher mileage drivers.

Each traffic calming project is unique, so each project should be evaluated individually. It is important to avoid double counting. Sensitivity analysis can be used to test whether conclusions are reliable under a range of possible scenarios.

Introduction

During the last century roads have been widened and straightened to accommodate more and faster vehicle traffic. These changes facilitate driving but often degrade conditions for walking, cycling, and for nearby residents. Even during the early years of motor vehicle use some neighborhoods resisted increased traffic,[1] and this opposition has increased in recent years.[2]

Traffic calming is the name for road design strategies to reduce vehicle speeds and volumes.[3] There are many potential traffic calming strategies, as indicated in Table 1. Traffic calming projects can range from a few minor changes to neighborhood streets to major rebuilding of a street network. Impacts range from moderate speed reductions on residential streets, to arterial design changes,[4] and woonerfs (residential streets with minimal traffic speeds).[5] Traffic calming is becoming well accepted by transportation professional organizations and urban planners.[6]

Some people love traffic calming, some hate it, and others have mixed feelings. Advocates argue that traffic calming protects residents, pedestrians and bicyclists from externalities imposed by motor vehicle traffic, and allows residential and commercial streets to better balance their multiple uses. Critics argue that it wastes resources, that it imposes an unfair burden on drivers, that it simply shifts traffic impacts from one street to another, and that it does more harm than good.[7]

Many of the concerns about traffic calming relate to specific devices, such as speed humps or chokers, rather than the general concept of changing street designs to reduce traffic speeds. These can often be addressed by expanding the range of strategies considered and using the most appropriate strategy in each particular situation.

This paper provides a comprehensive framework for evaluating the benefits and costs of traffic calming programs. This can help determine whether traffic calming is justified, improve project designs, and identify who should bear project costs.

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[1] Stephen Goddard, *Getting There*, Basic Books (New York), 1994.
[2] David Engwicht, *Reclaiming our Cities and Towns; Better Living with Less Traffic*, New Society Publishing (Philadelphia; www.slonet.org/~canderso/dec.html), 1993.
[3] Ian Lockwood, "ITE Traffic Calming Definition," *ITE Journal*, July 1997, pp. 22-25.
[4] Dan Burden and Peter Lagerwey, *Road Diets; Fixing the Big Roads*, Walkable Communities (www.walkable.org), 1999; Ian Lockwood, "A Traffic Calming Plan for Route 50," *Transportation Planning*, American Planning Association, Vol. 23, No. 3, Fall 1997, pp. 1-8.
[5] Eran Ben-Joseph, "Changing the Residential Street Scene: Adapting the Shared Street Concept to the Suburban Environment," *Journal of the Am. Planning Asso.*, Vol. 61, No. 4, Autumn 1995, pp. 504-515.
[6] Wolfgang Homburger, et al., *Residential Street Design and Traffic Control*, ITE (Washington DC; www.ite.org), 1989; *Residential Streets*, American Society of Civil Engineers and National Association of Home Builders (Washington DC), 1990; *Canadian Guide To Traffic Calming*, TAC (Ottawa; www.tac-atc.ca), 1999.
[7] *Say "NO" to Traffic Obstruction!*, National Motorists Association (www.motorists.com); Americans Against Traffic Calming (www.io.com/~bumper/ada.htm).

Table 1 Menu of Traffic Calming Strategies and Devices[8]

Type	Description	Applications		Impacts	
		Arterials	Local	Volumes	Speeds
Speed limits	Reduced speed limits.	✓	✓	Yes	Yes
Speed alert, enforcement	Radar-clocked traffic speeds displayed to drivers. Strong speed limit enforcement.	✓	✓	No	Yes
Vehicle restrictions	Limiting vehicle types (trucks) or users (residents only) on specific roads.	✓	✓	Yes	No
Warning signs and gateways	Signs & gateways indicating changing road conditions, traffic calming, residential or commercial districts.	✓	✓	No	Yes
Speed tables, raised crosswalks	Ramped surface above roadway, 7-10 cm high, 3-6 m long.	With caution	✓	Possible	Yes
Median island	Raised island in the road center (median) narrows lanes and provides pedestrian with a safe place to stop.	✓	✓	No	Yes
Channelization islands	A raised island that forces traffic in a particular direction, such as right-turn-only.	✓	✓	Possible	Yes
Speed humps	Curved 7-10 cm high, 3-4 m long hump.	✓	✓	Possible	Yes
Rumble Strips	Low bumps across road make noise when driven over.	✓	✓	No	Yes
Mini-circles	Small traffic circles at intersections.		✓	Possible	Yes
Roundabouts	Medium to large circles at intersections.	✓			Yes
Pavement treatments	Special pavement textures (cobbles, bricks, etc.) and markings to designate special areas.	✓	✓	Not Likely	Yes
Bike lanes	Marking bikelanes narrows traffic lanes.	✓	✓	No	Possible
Curb extensions (bulbs, chokers).	Extending curb a half-lane into the street to control traffic and reduce pedestrian crossing distances.	✓	✓	Possible	Yes
"Road diets"	Reducing the number of traffic lanes.	✓		Yes	Yes
Lane narrowings, "pinch points"	Curb extensions, planters, or centerline traffic islands that narrow traffic lanes. Also called "chokers."	✓	✓	Not Likely	Yes
Horizontal shifts	Lane centerline that curves or shifts.	✓	✓	No	Yes
Chicanes	Curb bulges or planters (usually 3) on alternating sides, forcing motorists to slow down.		✓	Possible	Yes
2-lanes narrow to 1-lane	Curb bulge or center island narrows 2-lane road down to 1-lane, forcing traffic for each direction to take turns.		✓	Possible	Yes
Semi-diverters, partial closures	Restrict entry/exit to/from neighborhood. Limit traffic flow at intersections.	✓	✓	Yes	Possible
Street closures	Closing off streets to through vehicle traffic at intersections or midblock		✓	Yes	Yes
Stop signs	Additional stop signs, such as 4-way-stop intersections.		✓	Possible	Yes
"Neotraditional" street design	Streets with narrower lanes, shorter blocks, T-intersections, and other design features to control traffic speed and volumes.	✓	✓	Yes	Yes
TDM	Various strategies to reduce total motor vehicle use.	✓	✓	Yes	No
Woonerf	Very low-speed residential streets with mixed vehicle and pedestrian traffic.		✓	Yes	Yes

This table summarizes common traffic calming strategies and devices, indicating suitable applications and impacts. Traffic calming projects often involve several measures.

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[8] Based on Carman Hass-Klau, et al, *Civilised Streets; A Guide to Traffic Calming*, Environmental and Transport Planning (Brighton, UK), 1992; Joseph Savage, R. David MacDonald and John Ewell, *A Guidebook for Residential Traffic Management*, WSDOT (Olympia; www.wsdot.wa.gov), 1994; *Making Streets that Work*, City of Seattle (www.ci.seattle.wa.us/npo/tblis.htm), 1996; Pat Noyes, *Traffic Calming Primer*, Pat Noyes & Associates (Boulder; pat@pdprog.com), 1998.

Traffic calming design is an art and science. Some strategies, such as four-way stopsigns, quickly lose their effectiveness without strict enforcement. Vehicle restrictions (such as prohibiting trucks on a particular road) may raise legal and logistical issues. Because of possible spillover effects (discussed later in this paper) it may be important to implement an overall traffic management plan, which includes traffic calming.

Roundabouts & Traffic Circles
There are three types of roundabouts (also called "traffic circles"):

1. *Big old ones*, such as Picadilly Circus in London and Dupont Circle in Washington DC, which have lots of traffic lanes, lots of confusion, and lots of problems for drivers, cyclists and pedestrians. They exist primarily to provide a dramatic site for a large monument.

2. *Modern Roundabouts*, are modest in size, are limited to a single circular traffic lane, and require vehicles entering that lane to slow to about 15 mph maximum and yield. They are widely promoted by traffic engineers as an efficient and safer alternative to signaled intersections.

3. *Mini Roundabouts*, are small (usually 10-25 feet in diameter) traffic circles placed in existing low-volume intersections as traffic calming devices. They reduce traffic speeds and crashes.

Traffic calming can be incorporated into new developments using "neotraditional" neighborhood street design. This uses a network of trough streets (as opposed to a hierarchical road system with many dead end streets and cul de sacs) with narrow street widths, shorter block lengths, "tee" intersections, and other design features to control vehicle speeds and volumes.[9] Table 2 summarizes typical street dimensions for neotraditional neighborhoods, which are much narrower than has been used in most new developments during the last half century.

Table 2 **Narrow Residential Street Standards From Selected Communities**[10]

City	Street Type	ROW	Width	Parking	Direction
Portland, OR	a) Dead End Streets <300' long	35'	18'	None	2-way
	b) < 9 units per acre	35'	20'	1-side	2-way
	c) Standard Residential	40'*	24'	2-sides	2-way
Madison, WI	a) <3 units per acre	40'	27'	2-sides	2-way
	b) 3-10 units per acre	56'	28'	2-sides	2-way
Novato, CA	a) Serves 2-4 dwellings	25'	20'	2-sides	2-way
	b) Serves 5-15 dwellings	40'	28'	2-sides	2-way
San Jose, CA	Unspecified	50'	24'-36' **	2-sides	2-way
Dublin, CA	Unspecified	50'	26'-36'***	2-sides	2-way

56' with sidewalks ** Narrows to 24' at tree planters forming parking bays.
*** Two opposing five foot wide tree planters located every 100' reduce the effective street width by 10'.

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[9] Dan Burden, *Street Design Guidelines for Healthy Neighborhoods*, Center for Livable Communities, Local Government Commission (Sacramento; www.lgc.org/clc), 1999.; *Traditional Neighborhood Development Street Design Guidelines*, Institute of Transportation Engineers, Publ. No. RP-027 (Washington DC; www.ite.org), 1998.
[10] J. Kevin Keck, *Caught in the Middle: The Fight for Narrow Residential Streets*, Proceedings of the ITE 14th International Conference, 1998.

Estimating Travel Impacts

An important factor in evaluating traffic calming projects is the number of trips that are affected. The number of automobile trips affected is usually easy to determine since most communities have good motor vehicle traffic data. It may be more difficult to determine the number of non-motorized trips affected because they are usually undercounted.

Some travel surveys exclude non-motorized trips altogether, and when included they are undercounted because walking and cycling trips are often short, non-work, recreational trips, or involve children. Automatic traffic counters do not record non-motorized travel, and manual counts usually focus on arterial streets, ignoring popular walking and cycling routes on minor streets. Walking and cycling links of trips involving a motor vehicle are also ignored. For example, “walk-auto-walk,” or “walk-transit-walk” trips are usually classified simply as “auto” or “transit,” even if walking takes place on a roadway. Extra effort is needed to gather accurate data on non-motorized travel.

There is considerable latent demand for non-motorized travel. That is, people would walk and bicycle more if they had suitable conditions. One market survey found that 80% of Canadians would like to walk more, and 66% would like to cycle more than they currently do.[11] A Harris poll found that 70% of U.S. adults want better facilities for non-motorized transport.[12] Communities and shopping districts that accommodate non-motorized transportation are popular with residents and customers.

Improving pedestrian security (protection from accidents and crimes) is important for increasing travel choices.[13] Traffic calming can be an important part of Transportation Demand Management (TDM) programs by creating streets that are more suitable for walking, bicycling and public transit.[14] Transit and rideshare passengers rely on walking or cycling for mobility at their destinations.

A grid-street network reduces trip distances and congestion by providing more direct routes then a branched street network that concentrates all traffic on a few routes.[15] But many people prefer living on a cul de sac rather than a through street to avoid traffic impacts. Traffic calming allows communities to have the best of both worlds: a grid street network with limited traffic speeds and volumes. This allows older urban neighborhoods to have attractive street environments that are otherwise only be available in more automobile-dependent suburban locations. Traffic calming is therefore key to creating grid street patterns and encouraging urban infill, both of which reduce automobile use.

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[11] Environics, *National Survey on Active Transportation*, Go for Green, (www.goforgreen.ca), 1998.
[12] Cited in *Trails for Transportation*, National Bicycle and Pedestrian Clearinghouse Technical Assistance Series, Number 3 (www.bikeped.org), 1995.
[13] Social Research Associates, *Personal Security Issues in Pedestrian Journeys*, UK Department of the Environment, Transport and the Regions (London; www.mobility-unit.detr.gov.uk/psi), 1999.
[14] Todd Litman, *Potential TDM Strategies*, VTPI (www.vtpi.org), 1999.
[15] Reid Ewing, *Best Development Practices*, Planners Press (www.planning.org), 1996.

Table 3 Daily Trips Per Household[16]

	Rural	Suburban	Urban	Average
Walk	0.4	0.4	1.8	0.6
Bicycle	0.1	0.1	0.1	0.1
Total Non-Motorized	*0.5*	*0.5*	*1.9*	*0.7*
Transit	0.3	0.3	1.1	0.4
Auto Passenger	3.5	2.7	2.8	2.7
Auto Driver	7.8	6.6	6.3	6.4
Total, All Modes	*12.2*	*10.1*	*12.1*	*10.1*

Residents in neighborhoods with suitable street environments tend to walk and bicycle more,[17] ride transit more,[18] and drive less than comparable households in other areas.[19] One study found that residents in a pedestrian friendly community walked, bicycled, or rode transit for 49% of work trips and 15% of their non-work trips, 18- and 11-percentage points more than residents of a comparable automobile oriented community.[20] Another study found that walking is three times more common in a community with pedestrian friendly streets than in otherwise comparable communities that are less conducive to foot travel.[21] U.S. Households average 0.7 non-motorized trips per day overall, but more than twice this amount in urban neighborhoods, which tend to be more suitable to walking, as indicated in Table 3, and Figure 1.

In recent years various techniques have been developed to help evaluate pedestrian and cycling conditions and predict the effect of changes on non-motorized travel.[22] For example, the *Bicycle Compatibility Index* developed for the Federal Highway Administration can be used to evaluate the benefits to cycling that result from changes in road and traffic conditions.[23] Similarly, the Pedestrian Environmental Factor (PEF) can be used to assess conditions for pedestrians.[24]

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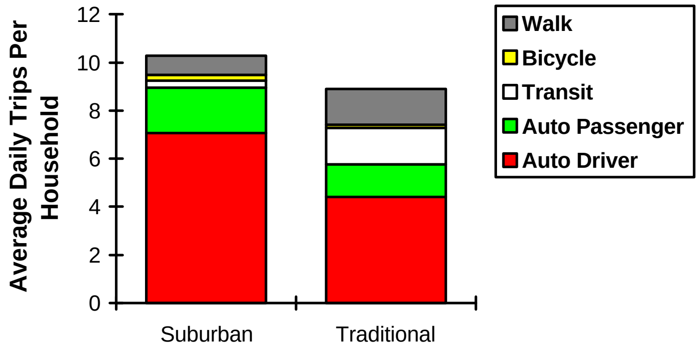
[16] *1995 National Personal Transportation Survey*, USDOT (www-cta.ornl.gov/cgi/npts).
[17] Rhys Roth, *Getting People Walking: Municipal Strategies to Increase Pedestrian Travel*, WSDOT (Olympia; www.wsdot.wa.gov/ta/t2/t2pubs.htm), 1994.
[18] Project for Public Spaces, *Transit-Friendly Streets: Design and Traffic Management Strategies to Support Livable Communities*, TCRP Report 33, TRB (Washington DC; www.nas.edu/trb), 1998.
[19] Parsons Brinckerhoff, *The Pedestrian Environment*, 1000 Friends of Oregon (Portland; www.teleport.com/~friends), 1993; Andrew Clarke, *Traffic Calming, Auto-Restricted Zones and Other Traffic Management Techniques: Their Effects on Bicycling and Pedestrians*, National Bicycling and Walking Study, #19, FHWA (Washington DC; www.bikefed.org), 1994.
[20] Robert Cervero and Carolyn Radisch, *Travel Choices in Pedestrian Versus Automobile Oriented Neighborhoods*, UC Transportation Center, UCTC 281 (http://socrates.berkeley.edu/~uctc), 1995.
[21] Anne Vernez Moudon, *et al.*, *Effects of Site Design on Pedestrian Travel in Mixed Use, Medium-Density Environments*, Washington State Transportation Center (Seattle), 1996.
[22] *Bicycle/Pedestrian Trip Generation Workshop: Summary*, FHWA (www.tfhrc.gov), 1996.
[23] David L. Harkey, Donald W. Reinfurt, J. Richard Stewart, Matthew Knuiman and Alex Sorton, *The Bicycle Compatibility Index: A Level of Service Concept*, Federal Highway Administration (www.hsrc.unc.edu/research/pedbike/bci), 1998.
[24] PBQD, *The Pedestrian Environment*, 1000 Friends of Oregon (www.teleport.com/~friends) 1993.

Figure 1 **Average Daily Trips Per Household by Neighborhood Type**[25]



Vehicle trips per household are significantly higher in suburban communities due to lower densities and fewer travel choices.

If more precise modeling is not feasible, a reasonable assumption is that traffic calming which significantly improves walking and cycling conditions can increase non-motorized trips in an area by 10-20% from what would otherwise occur, and that half of these trips substitute for motor vehicle trips. Thus, if per household non-motorized trips currently average 1.8 per day (typical in urban neighborhoods), comprehensive traffic calming could increase this to 2.0-2.2, and reduce 0.1-0.2 motor vehicle trips per day.

The following factors influence how much a traffic calming project will affect travel:

- *Magnitude of change.* The more traffic calming improves pedestrian and cycling conditions, the more it will affect travel. Traffic calming that significantly reduces a barrier to non-motorized travel (for example, by making it easier to walk across an arterial from one major commercial center to another or creating a pleasant bicycle travel corridor where none otherwise exists) may have significant travel impacts in an area.
- *Demand.* A greater effect is likely to occur where traffic calming is implemented near major pedestrian and cycling generators: residential neighborhoods, commercial centers, schools, and recreation centers.
- *Integration with other improvements.* Traffic calming can have synergetic impacts with other Transportation Demand Management (TDM) and land use changes that support walking, cycling and transit. For example if traffic calming is implemented with sidewalk and bikepath improvements, parking management, and improved public transit service, the effects are often greater than the sum of what individual strategies could achieve.
- *Land use effects.* Over the long term, traffic calming can support land use patterns that further reduce automobile use and automobile dependency, such as more neighborhood shops and activity centers.

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[25] Bruce Friedman, Stephen Gordon, John Peers, “Effect of Neotraditional Neighborhood Design on Travel Characteristics,” *Transportation Research Record, #1466*, 1995, pp. 63-70.

Benefits and Costs

This section explores benefits and costs that frequently result from traffic calming.

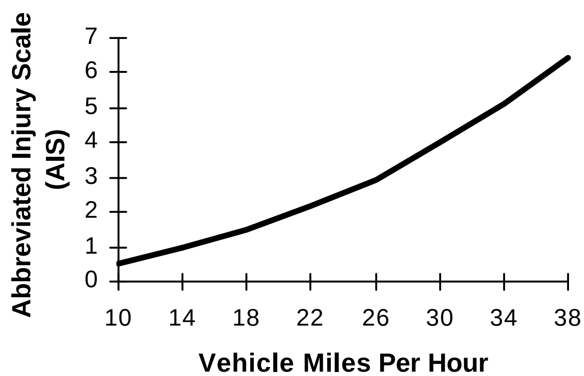
Benefits

1. Increased Road Safety

Reducing traffic speeds and volumes can reduce the severity and severity of vehicle crashes, particularly those involving pedestrians and bicyclists.[26] Each 1-mph traffic speed reduction typically reduces vehicle collisions by 5%, and fatalities by an even greater amount.[27] Travelling at 40 mph, the average driver who sights a pedestrian in the road 100 feet ahead will still be travelling 38 mph on impact: driving at 25 mph, the driver will have stopped before the pedestrian is struck.[28]

Pedestrian injury severity increases with the square of vehicle speed, as indicated in Figure 1. The probability of pedestrians receiving fatal injuries when hit by a motor vehicle is 3.5% at 15 mph, 37% at 31 mph and 83% at 44 mph.[29] Researcher Gary Davis developed a method for predicting pedestrian accident and injury risk.[30]

Figure 1 **Impact Speed Versus Pedestrian Injury**[31]



Risk to pedestrians and cyclists increases with traffic speed.

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[26] C.N. Kloeden, A.J. McLean, V.M. Moore and G. Ponte, *Travelling Speed and the Risk of Crash Involvement*, NHMRC (Adelaide; http://plato.raru.adelaide.edu.au/speed/index.html), 1998; Jack Stuster and Zail Coffman, *Synthesis Of Safety Research Related To Speed And Speed Limits,* FHWA No. FHWA-RD-98-154 (www.tfhrc.gov/safety/speed/speed.htm), 1998; "Pedestrian Safety," *Oregon Bicycle and Pedestrian Plan,* Oregon DOT (www.odot.state.or.us/techserv/bikewalk/planimag/pedestrn.htm).

[27] D.J. Finch, P. Kompfner, C.R. Lockwood and G. Maycock, *Speed, Speed Limits and Accidents*, Transport Research Laboratory (www.trl.co.uk), Report 58, 1994.

[28] A.J. McLean, RWG Anderson, MJB Farmer, BH Lee and CG Brooks, *Vehicle Speeds and the Incidence of Fatal Pedestrian Collisions - Volume 1*. Federal Office of Road Safety, Australia.

[29] Rudolph Limpert, *Motor Vehicle Accident Reconstruction and Cause Analysis*, Fourth Edition, Michie Company, Charlottesville, 1994, p. 663.

[30] Gary Davis, "Method for Estimating Effect of Traffic Volume and Speed on Pedestrian Safety for Residential Streets," *Transportation Research Record 1636*, 1998, pp. 110-115.

[31] *Traditional Neighborhood Development Street Design Guidelines*, Institute of Transportation Engineers (Washington DC; www.ite.org), June 1997, p. 18.

How Quickly A Motorist Can Stop[32]
Take speed in MPH and multiply by 1.5 to get the approximate feet traveled per second. Drivers typically require about 2.5 seconds to react to a hazard. At 40 MPH, that's 60 feet per second travel speed, which requires about 150 feet of travel before the driver even steps on the brakes. The faster a vehicle travels the longer its stopping distance and the greater its potential for causing damage and injuries if it hits another road user.

Other researchers conclude that, "small reductions in traveling speed translate into large reductions in impact speed in pedestrian collisions, often to the extent of preventing the collisions altogether."[33] They predict that a 5 km/h reduction in urban traffic speeds could reduce pedestrian fatalities by 30%. In 10% of cases the collisions would be avoided and in 20% an otherwise fatal collision would become non-fatal, with comparable reductions in severity for non-fatal accidents. The researchers find that limiting speed reductions to residential areas would have a much smaller benefit, since more than 85% of fatal pedestrian collisions occur on non-local roads such as arterials. Eliminating driving above the posted speed limits would reduce an estimated 13% of pedestrian fatalities.

Another study using a database of 20,000 residential-area automobile accidents found that crash rates (annual crashes per mile) increased as street width increased beyond 24-feet between curbs, particularly on straighter streets with lower traffic volumes, where average traffic speeds tend to be highest.[34] The analysis indicates that accident rates are approximately 18 times higher on a 48-foot width street compared with a 24-foot street.

With any traffic safety program it is important to consider the possibility of "offsetting behavior." If drivers, bicyclists or pedestrians feel safer they may become less cautious and "offset" a portion of crash reduction benefits.[35] It is therefore important to use empirical as well as theoretical evidence to determine traffic safety effectiveness.

Experience indicates that traffic calming programs do significantly reduce traffic crash frequency and severity.[36] Studies show long-term crash and injury reductions of 15-40%,

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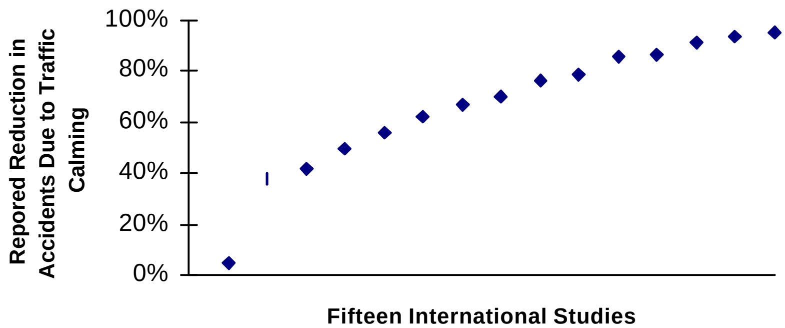
[32] Michael Ronkin, Bicycle and Pedestrian Program Manager, Oregon Department of Transportation.
[33] A.J. McLean, et al., "Vehicle Travel Speeds and the Incidence of Fatal Pedestrian Collisions," *Accident Analysis and Prevention*, Vol. 29, No. 5, 1997, pp. 667-674.
[34] Peter Swift, *Residential Street Typology and Injury Accident Frequency*, Swift and Associates (Longmont), 31 March 1998.
[35] Gerald Wilde, *Target Risk*, PDE Publications (Toronto; http://psyc.queensu.ca/target), 1994; Robert Chirinko and Edward Harper, Jr., "Buckle Up or Slow Down? New Estimates of Offsetting Behavior and their Implications for Automobile Safety Regulation," *Journal of Policy Analysis and Management*, Vol. 12, No. 2, 1993, pp. 270-296.
[36] Andrew Clarke, *Traffic Calming, Auto-Restricted Zones and Other Traffic Management Techniques: Their Effects on Bicycling and Pedestrians*, National Bicycling and Walking Study, #19, FHWA (Washington DC; www.bikefed.org), 1994.

and even greater reductions in pedestrian injuries.[37] One recent before-and-after study found that traffic calming reduced collision frequency by 40%, vehicle insurance claims by 38%, and fatalities from one to zero.[38] This provided a very favorable six-month payback on project expenses from insurance claim savings alone.

Similarly, a study of 119 residential traffic circles installed in the city of Seattle between 1991 and 1994 found that reported accidents in those areas declined from 187 before installation to 11 after installation, and injuries declined from 153 to one.[39] Portland, Oregon found similar safety benefits.[40] A review of 600 Danish traffic calming projects found an average 43% reduction in traffic crash casualties.[41] Similar reductions in accidents are reported in other studies, as indicated in Figure 2.

Figure 2 **Reported Traffic Calming Accident Reductions**[42]



This figure illustrates changes in vehicle accident rates from traffic calming programs reported in fifteen international studies, indicating that most show significant reductions.

Quantifying Safety Benefits

Studies described above indicate that traffic calming which significantly reduces traffic speeds typically reduces crashes by 40%, although impacts vary depending on other factors. Historical accident data can be used to determine the frequency of crashes on the roads to be calmed, keeping in mind that many crashes (particularly those involving pedestrians and cyclists) are not reported to police.[43] An alternative approach is to use national crash rate data for urban streets in Table 4.

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37 Steve Proctor, "Accident Reduction Through Area-Wide Traffic Schemes," *Traffic Engineering & Control*, Vol. 32, No. 12, Dec. 1991, pp. 566-572.

38 Sany R. Zein, Erica Geddes, Suzanne Hemsing and Mavis Johnson "Safety Benefits of Traffic Calming," *Transportation Research Record 1578*, 1997, pp. 3-10.

39 James Mundell, "Neighborhood Traffic Calming: Seattle's Traffic Circle Program," *Road Management & Engineering Journal* (www.usroads.com/journals/rmej/9801/rm980102.htm), January 1998.

40 See www.trans.ci.portland.or.us/Traffic_Management/trafficcalming/reports/accidents.htm.

41 T. Harvey, *A Review of Current Traffic Calming Techniques*, Institute of Transport Studies (Leeds, www.its.leeds.ac.uk/primavera/p_calming.html#a41), 1991.

42 Hamilton Associates, *Safety Benefits of Traffic Calming*, Insurance Corporation of British Columbia, (Vancouver), available from the Road Safety Group (www.roadsafety.com), 1996, Figure 3.2.

43 Helen James, "Under-reporting of Road Traffic Accidents," *Traffic Eng+Con*, Dec. 1991, pp. 574-583.

Table 4 **Crash Rate on Lower-Speed Urban Streets** (Per 100 Million Vehicle Miles)[44]

	Fatalities	**Persons Injured**	**Serious Injuries**	**Pedestrian Fatalities**	**Pedestrian Injuries**	**PDOs** (estimate)
Minor Arterials	1.08	191	16.8	0.28	6.3	1,910
Collectors	1.48	161	19.5	0.21	8.9	1,610
Local	1.17	311	32.9	0.37	18.6	3,110

As an analytic tool, accident costs are often monetized (measured in monetary units).[45] Although human life is not a commodity, many financial decisions involve marginal changes in the risk of injury and death. For example, consumers must decide whether to purchase optional safety equipment such as vehicle air bags, and society must decide whether to mandate such equipment. These tradeoffs are used to identify the value society places on risk reduction.[46] Table 5 shows values used by the U.S. Federal Highway Administration. Some state and provincial transportation agencies have developed their own values. Table 6 illustrates typical monetized traffic calming road safety benefits. This analysis indicates that traffic calming can provide road safety benefits typically worth 6-12¢ per vehicle mile if it reduces crash damages by 40%.

Table 5 **FHWA Accident Costs Per Injury (1994 dollars)**[47]

KABC Scale			**Abbreviated Injury Scale (AIS)**		
Severity	Descriptor	Cost ($)	Severity	Descriptor	Cost ($)
K	Fatal	2,600,000	AIS 6	Fatal	2,600,000
A	Incapacitating	180,000	AIS 5	Critical	1,980,000
B	Evident	36,000	AIS 4	Severe	490,000
C	Possible	19,000	AIS 3	Serious	150,000
PDO	Property Damage Only	2,000	AIS 2	Moderate	40,000
			AIS 1	Minor	5,000

Table 6 **Monetized Traffic Calming Road Safety Benefits**[48]

	Fatality Rate*	**Cost at $3 million per Fatality**	**Injury Rate***	**Cost at $50,000 Per Injury**	**PDO Rate***	**Cost at $2,500 Per PDO**	**Total Crash Costs**	**Traffic Calming Savings**
Minor Arterials	1.08	3.2¢ /mile	191	9.6¢ /mile	1,910	4.8¢ /mile	17.6¢ /mile	7.0¢ /mile
Collectors	1.48	4.4¢ /mile	161	8.1¢ /mile	1,610	4.0¢ /mile	16.5¢ /mile	6.6¢ /mile
Local	1.17	3.5¢ /mile	311	15.6/mile	3,110	7.8¢ /mile	26.8¢ /mile	10.7¢ /mile

* Per 100 million vehicle miles.

44 *Highway Statistics 1996*, FHWA (www.fhwa.dot/gov/ohim/1996), 1997, Table F1-1). PDO crash rates are estimated based on 10 PDO crashes for each injury crash.
45 Lawrence Blincoe, *Economic Cost of Motor Vehicle Crashes 1994*, NHTSA, USDOT (Washington DC; www.nhtsa.doc.gov/people/economic/ecomvc1994.html), 1995.
46 Ted Miller, *The Costs of Highway Crashes*, FHWA (Washington DC), FHWA-RD-055, 1991.
47 Homberger, et al, *Fundamental of Traffic Engineering*, 14th Edition, Institute of Transportation Studies (Berkeley), UCB-ITS-CN-96-1, 1996, p. 9-13.
48 Crash rate data from Table 2. Assumes traffic calming reduces crashes, injuries and fatalities by 40%.

Arterial Traffic Calming Success Story

Bridgeport Way W. is a principal arterial that carries 25,000 vehicles a day. It has two travel lanes in each direction with a middle two-way-left-turn lane. Before the road improvements, there were over 160 accidents less than a mile long section of this road for a three year period. We improved this roadway by building curb, gutter, sidewalk, bike lanes, street lights, pedestrian crosswalks, landscaped median and planter strips. We eliminated two-way-left turn lane with a landscaped median and provided U-turn capabilities at intersections for passenger vehicles only.

The results of our study show that the both accidents and the speed dropped on this roadway after we built the improvements. We are very pleased to see that we have 70% less accidents on this road now. This is a significant improvement.

When we replaced the two-way-left-turn lane with a landscaped median, the local business owners were very concerned. They did not believe people would drive an extra block to make U-turns to access their businesses. Well, guess what! I just asked our Finance Department to get me a City wide sales tax information. We are collecting 5% more sales tax this year than previous year on a city wide basis. But what is interesting is that we are collecting 7% more sales tax from the businesses around the Bridgeport corridor. We all know that the economy is good now, nation wide. Our general sales tax increase is primarily due to the good economic conditions. We are not claiming that our road project is the primary reason for sales tax increase. But what we are claiming is that, our road project helped.

We, engineers, must think more than cars when we build road projects. We must consider the other factors just as much important as the cars; community vision, pedestrians, economic vitality, bikers, joggers, etc. We all love to talk about vibrant communities. What better way to start building a vibrant community than building a well balanced road projects!

Isn't it where it all starts from? Look around you, you can easily connect a poor road design and construction with the poverty, isolation, community deprivation, frustration, high crime rates, etc. We need to think differently. As someone stated oncec "we can not fix today's problems with the same thinking that the created them in the first place." This is a very difficult concept for us, engineers, to understand and translate into our road designs. Because, we are educated and trained to move cars faster on wider roads.

I hope that your council will look at your road project from a broader perspective of what your community will look like in the future rather than what specific engineering manuals or guidelines to meet today. All design manuals and guidelines have enough flexibility for us to implement the Council's vision. Obviously, some of us are doing it, so should your engineers.

Ben Yazici
Assistant City Manager/Director of Public Works
City of University Place, Washington

2. Improved Conditions for Non-Motorized Modes

Traffic calming tends to improve pedestrian and cycling conditions.[49] Reduced vehicle traffic speeds and volumes tend to make walking[50] and cycling[51] safer, more comfortable and more convenient. Many people place a high value on street design features that improve safety and mobility for non-motorized transportation.[52] A 1995 Harris poll found that 70% of U.S. adults want better local facilities for non-motorized transportation.[53] A market survey found that 80% of Canadians would like to walk more, and 66% would like to cycle more than they currently do.[54] Many homebuyers want residences in neighborhoods with narrow streets that limit vehicle traffic.[55]

> Before Walt Disney Corporation built Celebration, its new town in Florida, they conducted an extensive market study of what homebuyers wanted. Focus groups revealed that one out of every two Americans wanted to live in a village-style or traditional neighborhood. However, since less than one percent of current new development is styled on older, traditional patterns, a major demand for neighborhoods that retain old town living styles goes unfilled.[56]

Better walking and cycling conditions are particularly important for people with disabilities, the elderly, and children, who are more dependent on non-motorized travel, and often have difficulty crossing busy traffic. As the population ages, a greater portion of urban residents are likely to walk and cycle for transportation and recreation.

Quantifying This Benefit

The number of trips that benefit from traffic calming can be estimated based on local travel data, as described earlier. These benefits can be monetized by asking residents how much they value improved walking and cycling conditions. For example, a survey might investigate how much residents would willingly pay for a significant improvement in pedestrian and walking conditions on their street or in their neighborhood. Some transport agencies place a dollar value on the delay and reduced mobility by walking and cycling resulting from heavy vehicle traffic.[57]

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[49] Rhys Roth, *Getting People Walking: Municipal Strategies to Increase Pedestrian Travel*, WSDOT (Olympia; www.wsdot.wa.gov/ta/t2/t2pubs.htm), 1994.
[50] Ellen Vanderslice, *Portland Pedestrian Design Guide*, Pedestrian Transportation Program, City of Portland (503-823-7004; www.trans.ci.portland.or.us), 1998.
[51] David L. Harkey, Donald W. Reinfurt, J. Richard Stewart, Matthew Knuiman and Alex Sorton, *The Bicycle Compatibility Index: A Level of Service Concept*, Federal Highway Administration (www.hsrc.unc.edu/research/pedbike/bci), 1998.
[52] Daniel Carlson, Lisa Wormser and Cy Ulberg, *At Road's End: Transportation and Land Use Choices for Communities*, Island Press (Washington DC; www.islandpress.org), 1995.
[53] Cited in *Trails for Transportation*, National Bicycle and Pedestrian Clearinghouse Technical Assistance Series, Number 3 (www.bikeped.org), 1995.
[54] Environics, *National Survey on Active Transportation*, Go for Green, (www.goforgreen.ca), 1998.
[55] "Neighborhoods Reborn," *Consumer Reports*, May 1996, pp. 24-30.
[56] Dan Burden, *Street Design Guidelines for Healthy Neighborhoods*, Center for Livable Communities, Local Government Commission (Sacramento; www.lgc.org/clc), 1999.
[57] Donald Rintoul, *Social Cost of Transverse Barrier Effects*, Planning Services Branch, B.C. Ministry of Transportation and Highways (Victoria; www.th.gov.bc.ca/bchighways), October 1995.

3. Increased Non-Motorized Travel And Reduced Automobile Travel
As described earlier, traffic calming can increase walking, bicycling and public transit use, and reduce automobile travel. This provides both internal benefits (to people who increase their non-motorized travel and reduce their driving) and external benefits (to others), as summarized in Table 7. These benefits are not limited to the streets being calmed. If traffic calming reduces a bottleneck on a cycling route, or improves access to public transit it can result in mode shifts that reduce vehicle traffic on other roads.

Table 7 **Benefits of Increased Non-Motorized Travel**[58]

User (Internal) Benefits	External Benefits
	Reduced congestion
	Reduced road and parking facility expenses
Financial savings	Reduced accidents
Health benefits	Reduced pollution
Increased mobility for non-drivers	Resource conservation
Enjoyment	Increased travel choices (reduced automobile dependency)

Increased walking and bicycling can improve health through aerobic exercise.[59] A sedentary lifestyle has a cardiovascular risk equal to smoking 20 cigarettes a day.[60] This exercise benefits children's physical and intellectual development, and parents who are otherwise required to chauffeur children.[61] Traffic calming can help reduce automobile dependency (high levels of automobile use, limited travel choice for non-drivers, and automobile oriented land use patterns) and its associated costs.[62]

Although walking and bicycling are often slower than driving, a voluntary shift to non-motorized travel can be assumed to provide net user benefits. In other words, if traffic calming allows people to shift from driving to walking or bicycling, any increase in time does not represent a net cost to users since they would not otherwise make that choice. Many people enjoy time spent walking and cycling, or value it as a form of exercise.

Quantifying These Benefits
Studies described earlier in this report indicate that traffic calming can increase non-motorized travel and reduce automobile travel, although actual impacts will vary depending on many factors. A single traffic calming project is unlikely to have much effect on total travel, but a comprehensive traffic calming programs that supports other transportation demand management efforts may have very significant effects.

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[58] Todd Litman, *Guide to Calculating TDM Benefits*, VTPI (www.vtpi.org), 1997.
[59] Edmund Burke, *Benefits of Bicycling and Walking to Health*, National Bicycling and Walking Study #14, USDOT, FHWA (Washington DC; www.bikeped.org), 1992; Physical Activity Task Force, *More People, More Active, More Often*, UK Department of Health (London), 1995.
[60] Ian Roberts, et al., *Pedalling Health—Health Benefits of a Modal Transport Shift*, Bicycle Institute. of South Australia (www.science.adelaide.edu.au/slate/demos/cyhealth.pdf), 1996.
[61] Mayer Hillman, ed., *Children, Transport and the Quality of Life*, Policy Studies Inst. (London), 1993.
[62] Peter Newman and Jeffery Kenworthy, *Cities and Automobile Dependency*, Gower (Aldershot), 1989; Todd Litman, *Automobile Dependency as a Cost*, VTPI (www.vtpi.org), 1996.

Vehicle travel reductions can be estimated using values of the elasticity of vehicle travel with respect to travel time, which ranges from about -0.2 in the short term up to -1.0 over the long term.[63] Thus, if a comprehensive traffic calming program reduces average travel speeds by 10%, it can be estimated that total vehicle travel would decline 2% in the short term and up to 10% over the long term.

Table 8 summarizes estimates of some benefits of a mode shift from driving to non-motorized travel. These benefits tend to be greatest in urban areas where traffic calming projects are most common. A reasonable estimate is that these benefits average about $2.00 per urban trip shifted from driving to non-motorized travel.

Table 8 **Savings Per Trip of Shift From Driving To Non-Motorized Travel**[64]

	Urban Peak	**Urban Off-Peak**	**Rural**
Congestion	$0.40	$0.04	$0.00
Road Costs	0.10	0.05	0.05
Parking	1.50	0.25	0.05
User Costs	0.85	0.55	0.55
Air Pollution	0.25	0.20	0.05
Noise	0.10	0.05	0.02
Road Safety	0.15	0.12	0.10
Additional Environmental & Social	0.23	0.23	0.23
Totals	*$3.58*	*$1.49*	*$1.05*

4. Noise, Air Pollution, and Aesthetics

Traffic calming generally reduces traffic noise.[65] Speed reductions from 50 to 30 kph typically reduce noise levels by 4-5 decibels,[66] or more in some circumstances.[67] Strategies that reduce traffic speeds to about 30 kilometers per hour and smooth traffic flow reduce air pollution, while those that increase stops may increase emissions.

Actual impacts vary depending on specific conditions. Measures that cause more frequent acceleration, and some textured road surfaces, can increase noise and air emissions. One study found that installing six speed humps on a previously 40 km/hr road increased NOx emissions 10 times, CO emissions 3 times, and fuel consumption from 7.9 to 10 liters per 100 km.[68] Strategies resulting in constant, moderate speeds provide the greatest benefits.

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[63] Harry Cohen, “Review of Empirical Studies of Induced Traffic,” *Curbing Gridlock*, Appendix B, National Academy Press (Washington DC; www.nas.edu/trb), 1994, pp. 295-309.
[64] Todd Litman, *Quantifying Bicycling Benefits for Achieving TDM Benefits*, VTPI (www.vtpi.org), 1998.
[65] *Traffic Calming: Traffic and Vehicle Noise*, Department of the Environment, Transport and the Regions (UK; www.roads.detr.gov.uk/roadnetwork/ditm/tal/traffic/06_96/item1.htm), 1996.
[66] Tim Pharoah and John Russell, *Traffic Calming: Policy and Evaluations in Three European Countries*, South Bank Polytechnic (London), February 1989.
[67] *Take Back Your Streets*, Conservation Law Foundation (Boston; www.clf.org), May 1995, p. 27.
[68] Quoted in *Daily Express* (London), October 1995.

Table 9 summarizes air emission and fuel consumption impacts from typical traffic calming speed reductions.

Table 9 **Effects of 50 kph to 30 kph Speed Reduction**[69]

	"Easy" Driver	"Aggressive" Driver
Carbon monoxide	-13%	-17%
VOCs	-22%	-10%
NOx	-48%	-32%
Fuel use	-7%	+7%

Reduced traffic speeds reduces vehicle emissions and fuel consumption in most cases.

Traffic calming can help create more attractive urban environments.[70] Commercial areas along higher-speed streets tend to be unattractive because businesses must "shout" at passing motorists with large signs, because so much land is used for parking, and because settlement patterns have no clear form.[71] Traffic calming projects sometimes reduce the amount of land devoted to streets and parking.[72] This can increase greenspace and reduce impervious surfaces, resulting in environmental and financial benefits (particularly reduced stormwater costs).[73]

Quantifying These Benefits

Traffic noise and air emission models are available,[74] but these are mostly designed for highway conditions and are poorly calibrated for lower-speed travel. A better approach would be to field test the effects of traffic calming. A number of monetized estimates of automobile environmental costs are available, although many use nation-wide values that tend to underestimate costs under higher-density urban conditions.[75]

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[69] Michael Replogle, "Minority Statement," *Expanding Metropolitan Highways*, Transportation Research Board/National Academy Press (Washington DC; www.nas.edu/trb), 1995, p. 369.

[70] Suzanne Crowhurst Lennard and Henry Lennard, *Livable Cities Observed*, Gondolier (Carmel) 1995.

[71] William Shore, "Recentralization; The Single Answer to More Than a Dozen United States Problems and A Major Answer to Poverty," *American Planning Assoc. Journ.*, Vol. 61, No. 4, Summer 1995, 496-503.

[72] Jim West and Allen Lowe, "Integration of Transportation and Land Use Planning through Residential Street Design," *ITE Journal*, August 1997, pp. 47-51.

[73] Chester Arnold and James Gibbons, "Impervious Surface Coverage: The Emergence of a Key Environmental Indicator," *Am. Planning Association Journal*, Vol. 62, No. 2, Spring 1996, pp. 243-258; NEMO project (www.lib.uconn.edu/CANR/ces/nemo/nnps.html).

[74] Such as the EPA MOBILE model for air pollution, and the FHWA STAMINA model for noise.

[75] Dr. Peter Bein, *Monetization of Environmental Impacts of Roads*, Planning Services Branch, B.C. Ministry of Transportation and Highways (Victoria, www.th.gov.bc.ca/bchighways), 1997; Todd Litman, *Transportation Cost Analysis; Techniques, Estimates and Implications*, VTPI (www.vtpi.org), 1998.

5. Increased Neighborhood Interaction and Crime Prevention

Public streets are an important component of the "public realm" where people can meet in a neutral space. Street environment conditions affects how people interact in a community. Traffic calming helps make public streets lively and friendly, encourages community interaction, and attracts customers to commercial areas.[76] As traffic increased on a street, residents tended to have fewer friends and acquaintances among their neighbors, and the area they consider "home territory" declined.[77]

Traffic calming is also used to discourage extreme anti-social behavior.[78] Neighborhoods that are more difficult to drive through (narrow streets, few straight thoroughfares) have significantly less crime than those that are more permeable. After closing off residential streets to through traffic, researchers found that "Without the heavy traffic of the past, internal streets could be 'taken back' and used for play by children and other forms of interaction among neighbors."[79] In a Dayton, Ohio case study, traffic calming reduced neighborhood crime by 25-50% and encouraged residents to get to know their neighbors better and become more involved in community activities.[80] A survey of residents found that many knew their neighbors better and were more involved in community activities after these changes.

It is difficult to measure these benefits, although there are indications that they are highly valued.[81] One indication is the number of people who spend their vacations strolling the pedestrian-friendly streets of pre-automobile cities, or at pedestrian-oriented resorts such as Disneyland. Similarly, homes in "neotraditional" neighborhoods command higher prices in part because buyers expect more neighborhood interaction.[82]

Quantifying These Benefits

Although these benefits appear to be highly valued by many residents, they are difficult to quantify.

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[76] Suzanne Crowhurst Lennard and Henry Lennard, *Livable Cities Observed*, Gondolier (Carmel) 1995.
[77] Donald Appleyard, *Livable Streets*, University of California Press (Berkeley), 1981.
[78] Mark Jones and Kenneth Lowrey, "Street Barriers in American Cities," *Urban Geography*, Vol. 16, No. 2, 1995, pp. 112-122.
[79] Henry Cisneros, *Defensible Space*, HUD (Wash. DC; www.huduser.org), 1995.
[80] Stephen Burrington & Bennet Heart, *City Routes, City Rights*, Conservation Law Foundation (Boston; www.clf.org), 1998.
[81] James Howard Kunstler, *The Geography of Nowhere*, Simon & Schuster (New York), 1993; Philip Langdon, *A Better Place to Live*, HarperPerennial (New York), 1994.
[82] "Neighborhoods Reborn," *Consumer Reports*, May 1996, pp. 24-30.

6. Increased Property Values

Most homebuyers prefer homes on streets with lower traffic volumes and speeds. For this reason homes on cul de sac streets command a price premium and new developments are being built with streets designed to control traffic.[83] Reduced traffic speeds and pedestrian amenities can also make small commercial districts more attractive and accessible to nearby residents. One study found that traffic restraints that reduced traffic volumes on residential streets by several hundred vehicles per day increased house values by an average of 18%.[84] Other studies find similar results.[85].

These higher values partly reflect the safety and environmental benefits experienced by residents, so it is important to avoid double-counting. Safety and environmental benefits to non-residents (non-residents walking or cycling along a street, or playing in a nearby park) are not reflected in residential home prices.

Quantifying This Benefit

Market surveys and consultation with real estate experts can help quantify this benefit in particular locations. A rough estimate is that each reduction of 100 vehicles per day below 2,000 provides a 1% increase in adjacent residential property values.[86] Traffic speed reductions also increase adjacent residential property values by reducing noise. A 5-10 mph reduction can increase adjacent residential property values by about 2%.[87] Similar benefits may occur in commercial areas where traffic calming enhances the street environment.

7. Reduced Suburban Sprawl

Traffic calming can give residents of existing urban neighborhoods the lower-traffic amenity often associated with suburban cul-de-sac locations. By creating a more pleasant urban environment and encouraging the use of non-automotive travel modes, traffic calming can help reduce "suburban sprawl." Sprawl imposes a number of economic, social and environmental costs on society.[88]

Quantifying This Benefit

Although reduced sprawl may provide significant benefits in some regions, these benefits are difficult to quantify.

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[83] Dan Burden, *Street Design Guidelines for Healthy Neighborhoods*, Center for Livable Communities, Local Government Commission (Sacramento; www.lgc.org/clc), 1999.

[84] Gordon Bagby, "Effects of Traffic Flow on Residential Property Values," *Journal of the American Planning Association*, Vol. 46, No. 1, January 1980, pp. 88-94.

[85] William Hughes and C.F. Sirmans, "Traffic Externalities and Single-Family House Prices," *Journal of Regional Science*, Vol. 32, No. 4, 1992, pp. 487-500.

[86] Based on Bagby, 1980. More research is needed to better quantify these values.

[87] M. Modra, *Cost-Benefit Analysis of the Application of Traffic Noise Insulation Measures to Existing Houses*, EPA (Melbourne), 1984.

[88] Robert Burchell, et al., *The Costs of Sprawl – Revisited*, TCRP Report 39, Transportation Research Board (www.nas.edu/trb), 1998.

Costs

1. Project Expenses

Project expenses include both capital expenses of implementing traffic calming and any incremental maintenance costs. Because there are many different traffic calming techniques, devices and conditions, these costs vary widely. Costs also vary depending on whether traffic calming projects are implemented alone or in conjunction with other road construction projects. Traffic calming projects often involve a variety of objectives, such as community beautification, so a portion of project costs may be charged to other budgets. Table 10 provides generic cost estimates for typical traffic calming measures. A variety of sources are used to fund traffic calming projects, including federal and state grants, local general funds, development impact fees, and property assessments.[89]

Table 10 **Typical Costs of Traffic Calming Measures**[90]

Measure	Typical Costs
Asphalt walkway	$30-40 per linear foot for 5-foot wide walkway.
Curb ramps	$1,500 per ramp.
Bike lanes	$10,000-50,000 per mile to modify existing roadway (no new construction).
Chokers	$7,000 for landscaped choker on asphalt street, $13,000 on concrete street.
Curb bulbs	$10,000-20,000 per bulb.
Traffic circles	$4,000 for landscaped circle on asphalt street, $6,000 on concrete street.
Chicanes	$8,000 for landscaped chicanes on asphalt streets, $14,000 on concrete streets.
Street closures	$6,500 for landscaped partial closure, $30,000-100,000 for full closure.
Marked crosswalk	$100-300 for painted crosswalks, $3,000 for patterned concrete.
Pedestrian refuge island	$6,000-9,000, depending on materials and conditions.
Center medians	$15,000-20,000 per 100 feet.
Traffic signals	$15,000-60,000 for a new signal.
Raised intersection	$70,000+ per intersection
Traffic signs	$75-100 per sign.
Speed humps	$2,000 per hump

2. Liability Claims

Current experience indicates that traffic calming projects do not cause significant liability claims. A 1997 survey found that out of more than 1,500 total lawsuits brought against traffic engineers in 68 jurisdictions, only 6 involved traffic calming devices, and only two were successful.[91] Vehicle damage during construction, and inadequately signed speed humps appear to be the most common cause of claims. Monetary awards tend to be relatively small. As designers and motorists become more familiar with traffic calming, and as specific strategies become widely accepted practices, the risk of claims is likely to decline. Liability can be minimized by using standard strategies and designs published by organizations such as ITE or TAC, and by using appropriate signage to warn drivers.

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[89] Asha Weinstein and Elizabeth Deakin, "How Local Jurisdictions Finance Traffic Calming Projects," *Transportation Quarterly*, Vol. 53, No. 3, Summer 1999, pp. 75-87.
[90] *Making Streets that Work*, City of Seattle (www.ci.seattle.wa.us/npo/tblis.htm), 1996.
[91] Ransford S. McCourt, *Survey of Safety Programs*, ITE Traffic Engineering Council (www.westernite.com/technical/signalsurvey/ntm), 1997.

3. Vehicle Delay

Traffic calming reduces average motor vehicle speeds, and sometimes increases the distances required to drive to destinations. This increases automobile users' travel time. On the other hand, traffic calming that reduces excess speeds and smoothes traffic flow (such as calming an arterial, or replacing a conventional intersection with a roundabout[92]) can increase total roadway capacity and reduce congestion delays, since roadway capacity is maximized at 30-40 mph, and less on typical streets with stoplight intersections.[93]

Quantifying This Cost

Conventional assessment techniques can be used to value incremental travel time costs.[94] For example, a traffic calming project may reduce average traffic speeds from 30 to 20 mph, which adds 30 seconds to an average trip, assuming 0.5 mile per trip is traffic calmed. Personal travel time is usually valued at 50% of average wage rates. A 30 second travel time increase is therefore considered worth 5¢, at $12 per hour average wages. This represents a maximum cost. Increased travel time that results when vehicle speeds are reduced to the posted speed limit are not generally considered a "cost." If the posted speed limit on the route is 25 mph, only half the 30 second increase in travel time would be considered a cost, the rest is simply compliance with traffic law.

Motorists respond in various ways to reduced traffic speeds. Some trips are rerouted, consolidated or eliminated entirely, particularly over the long term as transport and land use patterns achieve a new equilibrium.[95] As a result, delay costs decline over time as area motorists adjust their travel and land use patterns to account for changes in trip speeds. Eventually (over 5-10 years), a new land use equilibrium will develop based on lower traffic speeds, so no time is lost. This indicates that net travel time costs are 80% in the short-term, and decline to 0% over the long-term. For example, if 1,000 vehicles per day currently use a roadway, and a traffic calming project increases average travel time by 1 minute per mile, an estimate of total travel delay ignoring travel elasticities is:

1,000 x 1-minute = 16.6 hours per day.

A more accurate estimate that incorporates elasticity values is:

1,000 x 1-minute x (1 + E)

where **E** is an elasticity value that changes from –0.2 in the short-term, to -1.0 over the long term. This represents traffic that changes routes, destinations or modes to avoid delay. Thus, the actual total delay starts at 13:28 and declines over time. A new land use equilibrium eventually develops based on traffic calmed travel speeds, so no time is lost.

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[92] George Jacquesmart, *Modern Roundabout Practice in the United States*, NCHRP Synthesis 264 (TRB, www.nas.edu/trb), 1998; Modern Roundabout website (www.roundabouts.com).
[93] W. Homburger, et al., *Fundamentals of Traffic Engineering*, 14th Edition, Institute of Transportation Studies (Berkeley), 1996, Chapter 4.
[94] William Waters, *The Value of Time Savings for The Economic Evaluation of Highway Investments in British Columbia*, BC Ministry of Transportation and Highways (www.th.gov.bc.ca/bchighways), 1992.
[95] Cairns, Hass-Klau and Goodwin, *Traffic Impacts of Highway Capacity Reductions: Assessment of the Evidence*, London Transport Planning (London; www.ucl.ac.uk/transport-studies/sc1.htm), 1998.

4. Traffic Spillover Onto Other Roads

Traffic calming on one road may cause some vehicle trips to shift to other roads. Net impacts depend on whether the roads experiencing additional traffic are equally sensitive as the road with reduced traffic. Shifting traffic from low-volume residential streets to high-volume arterial roads reduces most external impacts, providing net benefits, although it may increase arterial traffic congestion.

Spillover traffic may be predicted using traffic models. However, most models tend to overestimate spillover impacts because they use fixed trip tables (they assume that the same number of trips will occur between zones regardless of travel conditions). Fixed trip table traffic models tend to overestimate traffic spillover costs.

Quantifying This Cost
Spillover costs can be calculated by determining the number of vehicle trips shifted to other streets and calculating the increased cost these trips impose.

5. Problems for Emergency and Service Vehicles

Some traffic calming techniques can cause delay and other problems for fire trucks and heavy service vehicles (buses, garbage trucks and snowplows). One study found that speed humps and traffic circles can delay fire trucks up to 10.7 seconds per device, depending on vehicle type and conditions.[96] In one city, traffic calming increased average emergency vehicle response time by two seconds, from 3:23 to 3:25 minutes.[97] This increase is much smaller than differences in response times between residential areas.[98] Incremental risk to residents from fire truck delays are usually much smaller than increased road safety from traffic calming accident reductions.

These problems can be minimized if they are considered in project planning. Some street closures include short-cuts for emergency and service vehicles. Communities may purchase smaller fire and garbage trucks for use in traffic calmed areas, or develop more dispersed fire stations. Here are other ways to minimize these problems:

1. Establish extra large no-parking zones adjacent to fire hydrants to help fire trucks maneuver.
2. Limit the use of skinny streets to low- and medium-density residential neighborhoods.
3. Limit the use of skinny streets to streets which are part of an interconnected network of streets (i.e., connected on both sides to other public streets, no cul-de-sacs).
4. Avoid skinny streets on primary emergency vehicle routes.
5. Prohibiting parking within 50' of an intersection (to allow fire trucks to make the turn).

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[96] Crysttal Atkins and Michael Coleman, "Influence of Traffic Calming on Emergency Response Times," *ITE Journal*, August 1997, pp. 42-47; www.trans.ci.portland.or.us/Traffic_Management/trafficcalming.
[97] "First Phase of Traffic Calming Project in Sacramento Yields Positive Effects," *Urban Transportation Monitor*, Vol. 13, No. 6, April 2, 1999, p. 4.
[98] A. Ann Sorensen and J. Dixon Esseks, *Living on the Edge; The Costs and Risks of Scatter Development*, American Farmland Trust (Washington DC; http://farm.fic.niu.edu/cae/catter/index.htm), March 1998.

6. Driver Frustration

Some drivers may be frustrated if confused by unfamiliar traffic calming devices or because they want to go faster than traffic calming allows. This is usually a temporary problem as drivers become familiar with traffic calming and accustomed to the new road conditions. On the other hand, some drivers may experience reduced stress from lower traffic speeds.

Quantifying This Cost
This is generally a minor and temporary cost.

6. Problems For Bicyclists And Visually Impaired Pedestrians

Some traffic calming measures can create problems for bicyclists, particularly if they reduce lane widths, create confusion at intersections, or include bumpy or slippery surfaces.[99] These impacts depend on specific conditions. For example, road narrowing may be a problem where traffic speeds are relatively fast, but may not be a problem if vehicle traffic slows so bicyclists can ride comfortably in the traffic flow.

Some traffic calming techniques can cause problems for visually impaired pedestrians, particularly if they eliminate curbs and edges that blind pedestrians use as references, or if they create unusual sidewalk or traffic configurations.[100] Specific concerns include:

- Where crosswalks are raised to curb level and there is no detectable warning (such as textured pavement), blind pedestrians may have no way to know when they enter the street, and accidentally walk into traffic.[101]
- Blind pedestrians may be confused when they first encounter street crossings with projected intersections (neckdowns).
- Roundabout intersections may be more difficult for blind pedestrians to because they do not have straight traffic or regular breaks in traffic flow.

These problems are likely to decline as planners incorporate these concerns into traffic calming designs, and as cyclists and visually impaired pedestrians become more familiar with various traffic calming devices.

[99] *Bicyclists: Caught in the Middle*, PTI, (http://pti.nw.dc.us/task_forces/transportation/docs/trafcalm)
[100] B.L. Bentzen and J.M. Barlow, "Impact of Curb Ramps on the Safety of Persons Who Are Blind," *Journal of Visual Impairment and Blindness*, Vol. 89, 1995, pp. 319-328.
[101] J.S. Hauger, et al., "Detectable Warning Surfaces at Curb Ramps," *Journal of Visual Impairment and Blindness*, Vol. 90, 1996, pp. 512-525.

Equity Impacts

Equity is concerned with the fair distribution of costs and benefits.[102] There are two major categories of equity. *Horizontal equity* refers to the distribution of impacts among people or groups considered to be equal in wealth and ability. *Vertical equity* refers to the distribution of impacts between people or groups that differ in wealth and ability, with the assumption that people who are disadvantaged may require greater public resources.

Horizontal Equity
Motor vehicles, by their nature, impose external costs on non-motorized travel. Pedestrians and cyclists are far more likely to be killed or injured in a traffic accident than are vehicle occupants. Motor vehicles also impose pollution externalities. Such impacts are inequitable, unless they are fully compensated. It could therefore be considered equitable to charge motorists for the costs of implementing traffic calming projects to reduce such impacts.

Public expenditures are sometimes evaluated in terms of whether different groups receive fair value for their tax payments. Many people assume vehicle user fees pay for public roads, so motor vehicles should have first priority in roadway use. In fact, vehicle user taxes cover only a small portion of local road costs, which are mostly funded by local taxes.[103] As a result, residents, pedestrians and cyclists have a claim equal or greater than that of motorists to have roads that meet their needs, even based on the narrow criteria of who funds the facilities.

If motorists, pedestrians, cyclists and residents are all considered to have equal rights to safety, mobility, comfort and property, traffic calming can increase horizontal equity by better balancing different uses of a street. Traffic calming can reduce the uncompensated accident risks and the delays motor vehicles impose on pedestrians and cyclists, give residents more control over their neighborhood environments, and increases property values degraded by higher traffic speeds and volumes.

Vertical equity
In most cases, traffic calming increases vertical equity. Traffic calming often increases vertical equity. People who are economically, physically and socially disadvantaged tend to drive less than average, walk and bicycle more than average, and live in urban neighborhoods that are most impacted by through traffic.

[102] Todd Litman, *Evaluating Transportation Equity*, VTPI (www.vtpi.org), 1999.
[103] *1997 Federal Highway Cost Allocation Study*, USDOT (www.ota.fhwa.dot.gov/hcas/final); Todd Litman, *Whose Roads?*, VTPI (www.vtpi.org), 1998.

Public Support

The public must be involved in planning traffic calming projects in order to develop broad support.[104] Community acceptance can be significantly influenced by details such as aesthetics, neighborhood security, and impacts on parking.

The first few traffic calming projects implemented in a community tend to be the most controversial. Public support generally increases as residents become more familiar with traffic calming and its impacts. For example, the cities of Seattle and Portland, which have implemented many traffic calming projects, now receive hundreds of annual requests for more projects, far more than can be funded each year.

Some public works departments have a specific process for selecting traffic calming projects, which may involve developing a neighborhood traffic management plan in consultation with area residents, or simply a petition signed by a certain portion of residents on a street to be calmed. The City of Seattle guarantees that a traffic calming device can later be removed if residents request. Although this has only occurred once out of more than 800 projects, it gives residents more confidence knowing that they can change their mind if they don't consider the project beneficial overall.

Evaluating Traffic Calming Projects

A project evaluation should describe each impact, quantify and monetize (measured in dollar units) impacts where possible, and indicate how impacts are distributed. Although monetizing impacts can be helpful, it is important to avoid focusing on impacts just because they are easy to measure. If monetary units are used for benefit/cost analysis, it is often useful to perform sensitivity analysis (using high and low range estimates) to test whether conclusions are reliable under different assumptions.

To avoid double counting, the relationships between these impacts should be carefully considered. If benefits and costs are monetized and totaled for benefit/cost analysis, it may be necessary to exclude some impacts that are incorporated in other categories. In particular, increased property values along traffic calmed streets may reflect increased road safety and enhanced local environmental quality, rather than being a benefit in itself. If safety, environmental and social impacts are correctly monetized it may be appropriate to exclude increased property values as a monetized benefit from the benefit total.

Equity analysis requires identifying how benefits and costs are distributed. A policy decision may be made to give greater weight to impacts on certain groups. For example, impacts on residents may be given greater weight than impacts on non-residents, or impacts on disadvantaged groups (disabled, elderly, low income) may be given greater weight for the sake of vertical equity.

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[104] *Canadian Guide To Traffic Calming*, Transportation Association of Canada (Ottawa; www.tac-atc.ca/programs/calming/calming.htm), 1999.

Traffic Calming Evaluation Example

This example illustrates the evaluation of a major traffic calming program in an urban neighborhood with 5,000 residents living in 2,000 households.

Road Safety Benefits
Historical data indicates that there are an average of 50 PDO crashes, 10 injury crashes, and 0.02 fatal crashes (i.e., one fatality every 50 years) on the roads to be traffic calmed. The state transportation agency values traffic safety improvements at $3,000,000 per fatality, $50,000 per injury accident, and $2,500 per PDO avoided. The traffic calming program is predicted to reduce crashes by 40%. The results, summarized in Table 11, indicate safety benefits are valued at $274,000 per year.

Table 11 **Crash Cost Savings From Traffic Calming**

Description	Current Annual Crashes	40% Annual Crash Reduction	Cost Per Crash	Cost Savings
Fatal	0.02	0.008	$3,000,000	$24,000
Injury	10	4	$50,000	$200,000
Property Damage Only	50	20	$2,500	$50,000
Total				*$274,000*

Increased Pedestrian and Cyclist Mobility
Area households currently generate an average of 1.9 non-motorized trips per day. Traffic calming is predicted to increase this by 10% or more, to 2.1+ trips per day. At least 1.5 million annual non-motorized trips (2.1 trips per day x 2,000 households x 365 days) representing 17% of household trips could benefit.

Reduced Automobile Impacts
In this example, half of the additional walking and bicycling trips are assumed to replace an automobile trip, a reduction of 0.1+ motor vehicle trips per household per day. This represents at least 73,000 fewer automobile trips. Reduced vehicle use is estimated to provide net benefits totaling about $146,000 per year, assuming $2.00 savings per trip.

Local Environmental Benefits
Traffic noise is predicted to decline on 15 residential streets with 750 residences and 10 businesses. Air pollution impacts are considered uncertain and too small to measure.

Increased Neighborhood Interaction and Crime Prevention
A survey of residents indicates that they value opportunities to increase neighborhood interaction, particularly because it may reduce crime. This impact is not quantified.

Property Values
Five residential streets are predicted to have an average of 200 fewer vehicles per day, resulting in a 2% increase in property values. Another ten streets will have average traffic speeds reduced by 5 mph, resulting in a 1% increase in property values. This benefit totals $1 million, with an annualized value of about $53,000, as indicated in Table 12.

Table 12 **Increased Property Values from Reduced Traffic Volumes and Speeds**

	Impacts	**Number of Streets**	**Total Houses**[105]	**Total Property Value**[106]	**Increased Property Value**	**Annualized Value**[107]
200 Daily Vehicle Trips Reduced	1% increase per 100 vehicles reduced	5	250	$25 million	$500,000	$26,600
5 mph Speed Reduction	1% increase per 5 mph reduction	10	500	$50 million	$500,000	$26,600
Totals		*15*	*750*	*$75 million*	*$1,000,000*	*$53,200*

Reduced Suburban Sprawl
This project is likely to help reduce suburban sprawl.

Project Expenses.
The project has capital costs of $800,000 and $5,000 annual increased maintenance costs.

Liability Claims
By using standard traffic calming strategies, liability claims are not expected to increase.

Vehicle Delay.
Traffic surveys indicate that the roads being calmed in this project carry 4,600,000 motor vehicle trips annually. Average speeds are predicted to decline from 25 mph (2:24 minutes per mile) to 20 mph (3:00 minutes per mile) for 0.5 miles, adding 18 seconds to an average trip. This increases travel time by 23,000 hours per year, a cost of $138,000 per year at $6 per vehicle hour, if motorists do not change routes or destinations. As described earlier, delays actually tend to decline over time as travel and land use patterns achieve a new equilibrium. The actual delay cost is estimated to start at $110,000 (80% of $138,000) when the project is implemented, and decline to zero over a ten-year period.

Traffic Spillover On Other Streets
In this example, spillover traffic onto other residential streets is expected to be minimal, since the program is comprehensive. Traffic increases on arterials are proportionally small (400-800 additional vehicles per day on roads carrying 20,000 vehicles per day). This may slightly increase arterial traffic congestion.

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[105] Assuming 50 homes per street.
[106] Assuming $100,000 average value per home.
[107] 20 year with a 7% discount rate.

Problems For Emergency Vehicles, Service Vehicles And Snow Removal
Traffic calming strategies selected for this project are designed to accommodate service vehicles. Average fire truck emergency response time is predicted to increase by 2 seconds in the traffic calmed area. This impact is considered too small to quantify.

Increased Drivers' Effort And Frustration
Some drivers who are unfamiliar with traffic calming devices are expected to be confused, and drivers who currently exceed the speed limit are expected to be frustrated by the traffic calming project. These are both considered short-term effects that should soon disappear.

Problems for Bicyclists and Visually Impaired Pedestrians
Traffic calming devices are designed to minimize problems for cyclists. For example, chokers used on busier streets incorporate bike lanes. Some bicyclists who are unfamiliar with traffic calming devices are expected to be confused in the short term. By using standard traffic calming designs that incorporate textured surfaces where crosswalks enter the street without a curb, problems for visually impaired pedestrians are avoided.

Example Summary

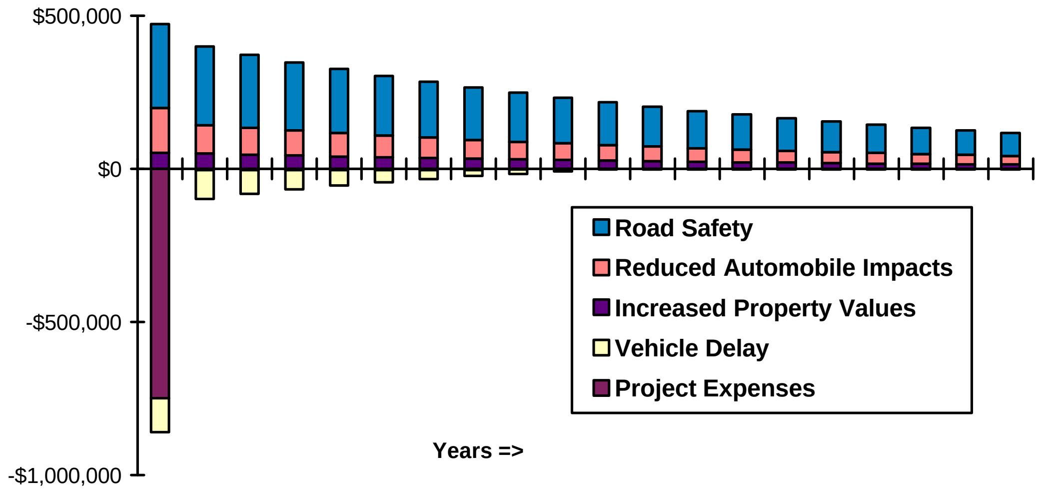
Table 13 summarizes costs and benefits associated with the traffic calming project in this example.

Table 13 **Traffic Calming Impacts**

	Description	**Distribution**	**Quantified Values**
Benefits			
Increased road safety.	Reduced traffic accident frequency and severity, particularly for crashes involving pedestrians and cyclists.	Road users (especially pedestrians and cyclists), and society, due to reduced accident costs.	$274,000 per year
Increased comfort and mobility for non-motorized travel.	Increased comfort and mobility for pedestrians and cyclists.	Pedestrians and cyclists.	1.5+ million annual trips benefit.
Reduced automobile impacts.	Increased non-motorized travel substitutes for automobile trips, reducing congestion, expenses and pollution.	Consumers, who enjoy more travel choices, and society, due to various cost savings.	$146,000 per year
Local environmental benefits.	Reduced noise and air pollution, and improved aesthetics.	Residents, visitors, and some businesses (such as restaurants).	Reduced noise at 760 residences and businesses.
Increased neighborhood interaction.	More hospitable streets encourage street activities and community interaction.	Residents.	Many residents benefit.
Increased property values.	Reduced traffic speed and volumes increase residential property values.	Residents and property owners.	$53,000 per year.
Reduced suburban sprawl.	Improved urban environment encourages urban infill that reduces sprawl.	Individuals and society.	Possible benefit to the region.
Costs			
Project expenses.	Financial costs associated with implementing and maintaining traffic calming facilities.	Local governments or a local improvement district.	$1,000,000, plus $5,000 per year.
Liability claims	Increased liability claims caused by traffic calming.	Municipal governments.	No change
Vehicle delay.	Reduced traffic speeds. Motorists either increase their travel time or reduce travel distance.	Motorists and businesses.	$110,000 the first year, declining to zero after 10 years.
Traffic spillover on other streets.	Traffic calming on one street can shift traffic to other streets.	Residents and travelers on other streets.	Considered minimal in this case.
Problems for emergency and service vehicles.	Delay to fire trucks, and problems for buses, garbage trucks and snow plows.	People needing emergency services, public agencies.	Minimal in this case.
Increased drivers' effort and frustration.	Increased effort required for driving on traffic calmed roads and the resulting frustration.	Drivers.	Considered a minor, short-term impact.
Problems for bicyclists and visually impaired pedestrians.	Some traffic calming strategies cause problems to bicyclists or visually impaired pedestrians.	Bicyclists and visually impaired pedestrians.	Minimal impact due to good design.

The figure below illustrates the monetized benefits and costs projected 15 years into the future. Benefits are illustrated by bars going up and costs are illustrated by bars going down. A 7% discount rate is used, resulting in declining magnitude of impacts over time. In this case, the net present value of the monetized impacts are estimated to total more than $3.5 million, indicating that the traffic calming project is a worthwhile investment.

Figure 4 **Illustration of Traffic Calming Benefit/Cost Analysis**



This figure illustrates how benefit/cost analysis results can be presented.

Of course, this analysis only incorporates monetized values. Decision makers must use their judgment to determine whether impacts that are not monetized may be significant enough to change the results. In this case, the costs that are not monetized (spillover onto other streets, driver frustration, fire truck delay and problems for cyclists and visually impaired pedestrians) are minimized through consideration in the design, and are considered minor compared with other impacts. On the other hand, some benefits that were not monetized (increased mobility and comfort for walking and cycling, increased neighborhood interaction, reduced sprawl, and increased equity) appear to be significant and so may increase the project's net benefits. As a result, the conclusion that the project is a worthwhile investment can be considered robust.

Conclusions

This paper describes a comprehensive framework for evaluating traffic calming benefits, costs and equity impacts. Benefits include increased road safety, increased comfort and mobility for non-motorized travel, reduced motor vehicle travel, reduced noise and air pollution, increased neighborhood interactions, increased property values, and a more attractive streetscape. Traffic calming can help create more livable communities, reduce automobile dependency, and discourage suburban sprawl. Since pedestrian mobility is essential for transit use, traffic calming supports transit.

Traffic calming costs may include project expenses, motor vehicle delay, traffic spillover onto other streets, problems for emergency and service vehicles, driver frustration, and problems for bicyclists and visually impaired pedestrians. Many objections to traffic calming relate to specific devices or measures rather than to traffic calming in general. These concerns may be addressed by considering a broader range of options, and careful selection of specific techniques that are most appropriate to a particular application.

Traffic calming can increase horizontal equity by reducing motor vehicle external impacts, and by creating a more balanced transportation system that increases travel choices for disadvantaged people. It can be argued that local residents' interests should take precedence over the interests of non-resident motor vehicle users, since vehicle users impose unreciprocated impacts on residents, and because residents pay most of the costs of local streets through local taxes. Traffic calming can also increase vertical equity, since the people who benefit most tend to be economically, physically and socially disadvantaged relative to those who experience the most disbenefits from traffic calming (high mileage, suburban drivers).

The impacts of each traffic calming project are unique. There are many different traffic calming devices and measures, and their impacts vary depending on the application. It is therefore not possible to provide "generic" estimates of traffic calming benefits and costs. Each project should be evaluated individually. There are various ways to evaluate benefits and costs, and provide this information to decision makers. Some traffic calming benefits and costs can be quantified using accepted economic techniques. Others, such as increased neighborhood interaction, may be significant but difficult to measure with available information.

Impacts should be described qualitatively, and quantified as much as possible. It is important to avoid skewing analysis results by focusing too much on some impacts just because they are most easily quantified. Tables and graphs can be used to indicate the magnitude and distribution of impacts, and to compare total benefits and costs. It is important to avoid double counting. Sensitivity analysis can be used to test whether conclusions are reliable under a range of possible scenarios.

Resources

Bicycle Federation (www.bikefed.org) provides pedestrian and bicycle planning resources.

Dan Burden, *Street Design Guidelines for Healthy Neighborhoods*, Center for Livable Communities, Local Government Commission (Sacramento; www.lgc.org/clc), 1999.

Dan Burden and Peter Lagerway, *Road Diets Free Millions for New Investment*, Walkable Communities (www.walkable.org), 1999.

Stephen Burrington & Veronika Thiebach, *Take Back Your Streets; How to Protect Communities from Asphalt and Traffic*, Conservation Law Foundation (Boston; www.clf.org), 1995.

Congress for the New Urbanism Narrow Streets database (www.sonic.net/abcaia/narrow.htm).

David Engwicht, *Street Reclaiming; Creating Livable Streets and Vibrant Communities*, New Society Publishers (www.newsociety.com), 1999.

Reid Ewing, *Transportation and Land Use Innovations; When You Can't Build Your Way Out of Congestion*, Planners Press (Chicago; www.planning.com), 1997.

Institute of Transportation Engineers (Washington DC; www.ite.org) publishes several traffic calming and pedestrian planning documents.

Local Government Commission (www.lgc.org/clc/pubinfo) provides a variety of useful material.

Modern Roundabouts: www.roundabouts.com and www-uftrc.ce.ufl.edu/wwwround/rnd-home.htm.

National Highway Traffic Safety Administration (www.nhtsa.dot.gov) provides information on U.S. accidents and safety programs.

National Transportation Week Pedestrian Website (www.ota.fhwa.dot.gov/ntw/bikeped.htm) provides links to a number of other pedestrian planning websites.

Oregon Bike and Pedestrian Planning (www.odot.state.or.us/techserv/bikewalk/obpplan.htm) is an example of bicycle and pedestrian planning at its best.

Partnership for a Walkable America (http://nsc.org/walk/wkabout.htm) promotes the benefits of walking and supports efforts to make communities more pedestrian friendly.

Slow Down You're Going Too Fast, PTI (http://pti.nw.dc.us/task_forces/transportation/pubs.html).

City of **Portland** (www.trans.ci.portland.or.us/Traffic_Management/trafficcalming) provides excellent information and materials on traffic calming and pedestrian planning.

City of **Seattle** (www.ci.seattle.wa.us/npo/tblis.htm) has planning and traffic calming resources.

TAC, *Canadian Guide To Traffic Calming*, Transportation Association of Canada (Ottawa; www.tac-atc.ca/programs/calming/calming.htm), 1999.

UK **Dept. Environment, Transport and Regions** (www.roads.detr.gov.uk) provides resources for creating a safer pedestrian environment, and descriptions of traffic management strategies.

The U.S. **Federal Highway Administration**'s pedestrian program (www.ota.fhwa.dot.gov/walk) provides pedestrian safety information and resources.

Walkable Communities (www.walkable.org) helps create people-oriented environments.

The **WSDOT Pedestrian Website** (www.wsdot.wa.gov/hlrd/Sub-defaults/Pedestrian-default.htm) provides extensive reference information and examples of outstanding programs.

Here are related reports available from VTPI:

Land Use Impact Costs of Transportation

Pavement Buster's Guide

Quantifying Nonmotorized Transport Benefits for Achieving TDM Objectives

Transportation Cost Analysis; Techniques, Estimates and Implications

Whose Roads? Defining Bicyclist's and Pedestrian's Right to Use Public Roads

Win-Win Transportation Management Strategies

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- Additional information, ideas or references that could be added to improve the report.

Thank you very much for your help.

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