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Operational Design Guidelines for High Occupancy Vehicle Lanes on Arterial Roadways

November 1994

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OPERATIONAL DESIGN GUIDELINES FOR

HOV LANES ON ARTERIAL ROADWAYS

INCLUDING PLANNING STRATEGIES AND SUPPORTING MEASURES

MUNICIPAL/PROVINCIAL HOV/TDM COMMITTEE

DEMAND MANAGEMENT AND FORECASTING OFFICE

MINISTRY OF TRANSPORTATION OF ONTARIO

McCormick Rankin
November 1994

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PREFACE

The purpose of this document is to summarize relevant information and proven guidelines in the areas of planning, design and operation of High Occupancy Vehicle (HOV) lanes on arterial roadways in Ontario Municipalities. It is intended for reference by planners, designers and decision-makers involved in developing municipal transportation programs and facilities.

This document presents a set of experience-based HOV guidelines, but does not purport to define design standards for all Ontario applications. Some standards may evolve over time, while many HOV applications will be tailored to site-specific needs and conditions. Nevertheless, it is intended that this report form a common basis for municipal HOV activity in the province, so that the HOV concept does not have to be researched and "re-invented" with every new project.

This report is a companion to the 1993 Ministry of Transportation of Ontario document, *"Operation & Design Guidelines for HOV Lanes on Provincial Freeways"*. Since that document deals exclusively and comprehensively with freeway HOV applications, the current report will restrict its scope to arterial roadway applications. Another related MTO booklet, *"High Occupancy Vehicle Opportunities, Incentives and Examples - a Handbook for Ontario Municipalities"*, in 1993, provides an overview of HOV strategies suited to Ontario and may be read as a supplement to the current report.

This report is based on the guidelines developed as part of the Metro Toronto HOV Network Study (1992, Metropolitan Toronto Transportation Department), augmented by recent operational experience and research in Ontario and elsewhere, and modified to reflect the needs of the broader community.

The preparation of this document was funded by the Ministry of Transportation of Ontario and was carried out by McCormick Rankin under the direction of the HOV Design and Operations Working Group, a subcommittee of the Greater Toronto Area Municipal / Provincial HOV / TDM Committee.

For additional copies of this report, other MTO HOV reports, or for provincial HOV information, contact Mr. Brian Ogden, Demand Management and Forecasting Office, Ministry of Transportation of Ontario, 3rd Floor, West Tower, 1201 Wilson Avenue, Downsview, Ontario, CANADA, M3M 138 [ph. 416-235-3969, fax 416-235-5224).

For planning and operational experience with HOV and Reserved Bus Lane applications on arterial roads, the following are key contacts: Mr. Tom Mulligan, Transportation Department, Metro Toronto, 17th Floor, Metro Hall, 55 John Street, Toronto, Ontario M5V 3C6 fph 416-392-8329, fax 416-392-4426); Mr. Kees Schipper, Transportation and Works Department, City of Mississauga, 3484 Semenyk Court, Mississauga, Ontario L5C 4R1 fph 905-896-5787, fax 905-615-3173); and Mr. Rajan Philips, Transportation Department, Regional Municipality of Ottawa-Carleton, Ottawa-Carleton Centre, Cartier Square, 111 Lisgar Street, Ottawa, Ontario K2P 2L7 (ph 613-560-2064, fax 613-560-6068).

DEFINITIONS

Throughout this report, "HOV" and "HOV Lane" are terms which refer to Carpools, Vanpools and buses together; a bus-only facility (Reserved Bus Lane, or RBL) will be referred to specifically as appropriate. If the eligibility criteria (vehicles (including buses) with two or more occupants = HOV 2 +; vehicles with three or more = HOV 3 +) are relevant to a particular discussion, they will be noted. Vehicles which are not HOVs or which do not use HOV lanes will, for convenience, be referred to as LOVs (Low Occupancy Vehicles) or General Purpose traffic. Mixed Flow refers to undifferentiated traffic flow, including HOVs and LOVs. Bus-only Transitways (e.g. Ottawa Transitway System) are not considered within the scope of this report.

SECTION I: HOVs AS PART OF THE MUNICIPAL TRANSPORTATION PLANNING STRATEGY

I-1 INTRODUCTION

The transportation system of each Ontario municipality is a critical component of the economic and social well-being of those who live and work in the province's urban areas. Transportation systems face increasing demands and constraints in terms of usage, operation, safety, funding, and environmental impact. As an era of change sweeps through our urban centres, transportation systems must change as well. Key aspects of that change are a new emphasis on management of travel demand, more efficient use of existing and new infrastructure, and a shift towards a more environmentally sustainable transportation strategy.

In this context, High Occupancy Vehicle (HOV) programs have great potential to contribute to more efficient and effective transportation systems. In providing incentives and priority measures to encourage the use of transit, Carpools, and Vanpools rather than the single-occupant car, HOV programs can play a key role in maximizing the efficiency of our roads in terms of carrying people and goods (not just vehicles). If problems such as congestion, air pollution, environmental impact, and the cost of new infrastructure in our transportation system are to be effectively addressed, HOV programs are sure to play a significant part.

I-2 WHY HOV? COSTS, BENEFITS AND EXPERIENCE

High Occupancy Vehicle priority measures are a response to urban transportation problems. The problems are legion: congestion, unreliability, land requirements, energy waste, air pollution, inability to accommodate growth in demand, and the negative impact of all of the aforementioned on quality of life and economic competitiveness. HOV-based responses are of particular value because of their flexibility, functionality, cost-effectiveness, ready implementation, use of conventional transportation system elements, and ability to touch on all aspects of an individual's trip.

In this context, it is understood that HOV lanes are but one component in an effective HOV strategy, just as a subway may be one component in an area's transit strategy. In the same way that fare decisions, park and ride lots, marketing, service scheduling, and so on will affect the utilization of the subway, a complete package of ridematching programs, employer incentives, enforcement measures, express bus services, priority parking measures and other initiatives should be considered "part and parcel" of the HOV plan.

Amidst this broad spectrum of HOV applications and effects, several items stand out:

- HOV lanes allow faster, more reliable transit service than do the equivalent mixed flow lanes; this in turn is significant in attracting new transit riders and inducing a shift from auto use to transit ridership.

Dundas Street, Mississauga / Etobicoke - transit ridership up 15 percent in first year of HOV lane operation'.

- any measure which leads to more efficient bus operation during peak periods can produce considerable savings in transit agency operating cost without penalizing service levels

Ottawa Transitway System - exclusive bus-only roadway network requires 140 fewer buses to move the same number of people as a mixed-flow system[2]; an HOV lane-based system would lie somewhere between the two

- using an HOV can mean considerable savings to each individual, including not having to buy a car for commuting in the first place

Average daily commuting cost - Vanpool $ 0.80 U.S.; Carpool $ 2.18; bus $ 2.38; single occupant auto $ 5.46[3] (U.S. study; proportionally higher in Ontario)

- HOVs are considerably less polluting than single occupant vehicles; this has been a major impetus in the U.S. policy-based emphasis on HOV systems

Average single occupant auto emissions - 3 to 10 times as many Hydrocarbons, 3 to 6 times as much Carbon Monoxide, and 1 1/2 to 5 times as many Nitrogen Oxides as a bus, Carpool, or vanpool[4].

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1 Report to General Committee of Council, Commissioner of Transportation and Works, June 2, 1993

2 "Transitways - the Ottawa-Carleton Experience", J. Bonsall, OC Transpo, June 1989

3 "Implementing Effective Travel Demand Management Measures", Institute of Transportation Engineers, June, 1993

4 "Mass Transit - the Clean Air Alternative", American Public Transit Association

- HOV lanes are often low cost, easy to implement, and can be used for other activities (parking, deliveries, general purpose traffic) during off-peak periods

> Dundas Street, Etobicoke - cost of HOV lane signage and markings for peak period HOV use $ 64,000 or $ 13,000 per lane kilometre, compared to typical arterial widening cost of in the order of $ 1 M per lane km[5].

- in the right setting, HOV lanes are enthusiastically received by the public as a visible response to concerns about congestion, the environment, and as a readily-implemented alternative to high-cost, high-impact facilities

> Bay Street, Toronto - 91 per cent of Clearway users satisfied with operation four months after opening'.
>
> Seattle, Washington - 2000-name petition saying "give us HOV lanes - NOW!" resulted in advancing HOV lane construction on I-5 South by four years[7].

- employers and businesses can benefit from increased HOV use, and many North American employers are among the most effective promoters of transit and carpooling

> Sunnybrook Health Science Centre, Toronto - marketing and incentive program to reduce single occupancy auto use by employees avoided need to construct 100 new parking spaces[8].

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5 Metro Toronto, 1991

6 Bay Street Clearway Additional Survey, Toronto Transit Commission, February 28, 1991

7 I-5 South High Occupancy Vehicle Study Bulletin, Washington State Department of Transportation, March 1991

8 pers. corresp., Kathy Webster, DNL Group, Sept. 1994

- a reversal of trends towards lower auto occupancy rates and lower transit modal share is required simply to return to the level of efficiency (congestion) of the mid-l 980s, let alone address future growth needs

Metro Toronto / York Region Cordon Counts[9]

Screenline		South York		Metro Boundary		Suburban		Central Area	
Indicator		Transit Share	Auto Occ.	Transit Share	Auto Occ.	Transit Share	Auto Occ.	Transit Share	Auto Occ.
Year	1983	7.3%	1.43	11.1%	1.28	27.6%	1.27	54.0%	1.30
	1993	N/A	1.19	9.9%	1.23	25.9%	1.25	49.7%	1.31

I-3 HOV INITIATIVES IN ONTARIO TO DATE

I-3.1 Reserved Bus Lanes

Ontario's first Reserved Bus Lanes were implemented in Metropolitan Toronto in 1972, on Eglinton Avenue. This originated as a recommendation from the Toronto Transit Commission for a six month trial improvement in operating conditions on a busy bus route serving a major subway station. The initial operation resulted in a minor time savings for buses, while passengers surveyed perceived a much greater savings. The lane has operated successfully ever since, leading to the provision of additional segments of bus-only and HOV 3+ lanes on Eglinton Avenue.

Following the success of the Eglinton Avenue experiment a more extensive program of bus priority lanes in Metro was put forward in 1974. The reservation of curb lanes on four lane roadways in peak periods for buses was implemented on St. Clair Avenue East, York Mills Road, Pape Avenue, Wilson Avenue, and Lansdowne Avenue. The Pape and Lansdowne applications continue in operation today, while the other three were all terminated in 1975, mainly due to the congestion that resulted for mixed flow traffic in the remaining lanes.

In Ottawa, the National Capital Commission's Ottawa River Parkway was the site of peak period Reserved Bus Lanes from 1974 to 1987, whereby the two off-peak direction lanes of the four lane roadway were set aside for two-way bus-only operation. The opening of the West Transitway in 1987 allowed the Parkway to revert to normal mixed flow in both directions, although an uncongested 3 km segment remains in use by buses in mixed flow as a vital link in the Transitway system.

The next Reserved Bus Lane in Metro Toronto emerged on Allen Road south of Finch Avenue in North York in 1982, utilizing the newly-constructed curb lanes of a 6 lane arterial road during peak periods. This continues to operate successfully,

[9] 12 hour counts from Metro Transportation Planning Bulletin 94-01, 7/94; York Region Cordon Counts 1983, 1993.

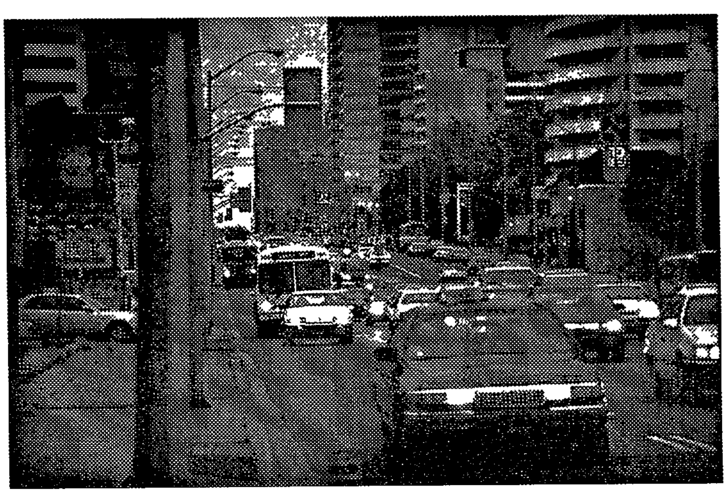
yielding significant time savings to more than 2,000 bus passengers per hour. It was converted to HOV 3 + operation in 1993 as part of the Metro HOV Network.

Reserved Bus Lanes have been in place on several Ottawa streets since the mid 1980s. The most significant are on Albert and Slater Streets in the downtown core, where bus lanes on the one-way pair serve more than 200 buses per hour per direction and provide an essential link between the east and west segments of the bus-only Transitway system. To the east, Montreal Road features a brief segment of Bus Lane leading to the Rideau Street retail core. Both Rideau Street (1980 - 1992) and Bank Street (1980) in central Ottawa operated as transit malls but were ultimately unsuccessful in meeting the commercial needs of the respective corridors and reverted to mixed flow.

In 1990, the City of Toronto introduced the Bay Street Urban Clearway, two lanes in the downtown core reserved for buses, taxis, and bicycles throughout the day.

I-3.2 HOV Lanes

The concept of permanent High Occupancy Vehicle Lanes open to Carpools and Vanpools as well as buses was introduced to Ontario in 1990 by the Ministry of Transportation following observation of experience elsewhere and in response to several proposed municipal transit priority programs. Priority lane applications prior to this had been for buses only. With provincial support, the first HOV 3+ lane in the province was implemented by Mississauga and Metro Toronto on Dundas Street West between Dixie Road in Mississauga and the Kipling Subway Station in Etobicoke in January 1992. Simultaneously, Metro Toronto carried out a comprehensive HOV Network Study, which provided the basis for a recommended 300 kilometre system of HOV 3+ lanes. This Network is being implemented in stages, incorporating new construction as well as lane conversions (including most of the pre-existing Reserved Bus Lanes in Metro); approximately 65 km of lanes are now in operation (see box next page), on parts of seven different roadways. Some RBLs remain in operation and will not be converted to



HOV 3+ lane in dense, transit - oriented setting
(Yonge Street, North York)

Metropolitan Toronto HOV 3+ "Diamond Lanes"					
Road	Section	Length (km)	Date Opened	Type	No. of Lanes
Dundas St. W.	Kipling Ave. - Etobicoke Creek	2.5*	Jan 6/92	Conversion (General)	7
Yonge St.	Steeles Ave. - Bishop Ave.	1.8	Aug 16/93	Conversion (General)	6
Allan Rd. / Dufferin St.	Finch Ave. - Transit Rd.	3.3	Aug 16/93	Conversion (RBL)	6
Eglinton Ave. E.	Leslie St. - Victoria Park Ave.	4.0	Nov 8/93	Conversion (General)	6
Don Mills Rd.	Lawrence Ave. - Overlea Blvd.	3.1	Nov 8/93	Widening	6
Pape Ave.	Millwood Rd. - Danforth Ave.	2.1	Nov 8/93	Conversion (RBL)	4
Overlea Blvd.	Don Mills Rd. - Milwood Rd.	1.8	Nov 8/93	Conversion (General)	6
Eglinton Ave. E.	Victoria Park Ave. - Markham Rd.	7.3	Dec 6/93	Conversion (General)	6
Don Mills Rd.	York Mills Rd. - Lawrence Ave.	2.1	Dec 6/93	Widening	6
Don Mills Rd.	Finch Ave. - York Mills Rd.	4.5	Oct 3/94	Widening	6
Total	32.5 km (65 lane-km)				

* Lanes continue to Dixie Road in Mississauga, for a total length of 5.0 km; the Mississauga portion was a widening from 5 to 7 lanes.

HOV 3 + use. All Regions and several local municipalities in the Greater Toronto Area are now actively pursuing the HOV Lane concept as part of their transportation strategies.

In the National Capital area, the first experience with HOV lanes occurred during the late 1980s with the conversion of one lane in the peak direction on Innes Road and Industrial Road as a temporary measure to maintain transit service during the reconstruction of the Queensway. A promotion campaign ("Jump the Jam") was used. In light of public opposition to the "loss" of a lane in such a congested situation, the route was converted to HOV 3+ operation but to little additional effect. Peak hour usage was in the order of 50 buses, 20 - 30 Carpools, and 80 - 100 violators.

A similar temporary HOV 3 + lane was implemented on the Portage Bridge across the Ottawa River in 1992 in conjunction with the reconstruction of the adjacent Chaudiere crossing; this acted as an extension of the permanent 1.2 km long HOV 3+ lanes on Boulevard Maisonneuve leading to the bridge in Hull, Quebec.

I-3.3 HOV Priority Programs and Initiatives

With the recent introduction of HOV lanes to Ontario there have been two associated efforts underway - the planning of HOV facilities and the development of programs intended to support HOV use as part of the broader Travel Demand Management picture. These build on the experience of previous MTO initiatives dating from the "energy crisis" era of the mid-1970s.

Following is a listing (with contacts) of the most relevant recent Ontario initiatives in this field, independent of the substantial ongoing effort in transit-specific projects and marketing. Of course, there has been a great deal of research and application of HOV / TDM programs outside Ontario, as documented through TRB, ITE and other publications.

MTO - HOV Facilities

- HOV Policy Development (Brian Ogden, MTO Urban and Regional Planning Office)
- Highway 403 HOV / RBL Functional Planning Study (MTO Central Region Planning Section)
- GTA Freeway Corridor HOV Overview (400, 403, 404, 427) (Bob Stephenson, MTO Central Region)

Municipal - HOV Facilities

- Metro Toronto HOV Network Study (Tom Mulligan, Metro Transportation Department)
- Peel Region HOV Strategy Study (Doug Billett, Peel Transportation Department)
- Halton Transit Opportunities Study (Dave McCleary, Halton Planning Department)
- York Region Rapid Transit / HOV Network Study (Jeff Mark, York Transportation Department)
- various individual Lane Feasibility Studies and Environmental Study Reports (including Don Mills, Metro Toronto: Hurontario Street, Mississauga; Dundas Street, Mississauga; and others)

Demand Management / Support Programs

- Ontario Government "Green Workplace" Program Share-a-Ride System (ph I-800-56-SHARE)
- Metropolitan Toronto Travel Demand Management Overview Study (Rob Pringle, Metro Planning Department)
- Metropolitan Toronto Ridesharing Strategy Study (Tom Mulligan, Metro Toronto Transportation Department)
- Development of a Strategy for a Ridesharing Centre (Vello Soots, MTO Transportation and Energy Productivity Office)

- Travel Demand Management for Interprovincial Travel in the National Capital Region (Don Stephens, Regional Municipality of Ottawa-Carleton Transportation Department)

- GO Transit Priority Parking for Carpools (Ian Caie, GO Transit Project Development)

- Metro Toronto Carpool lots at "end of line" TTC Subway Stations - Kipling, Finch, Wilson

- various private sector Vanpool initiatives (Vello Soots, MTO Transportation and Energy Productivity Office)

I-3.4 Provincial Policy

The Ministry of Transportation of Ontario has only recently entered the HOV lane field, with an initial policy development study having been carried out in 1989-90. Earlier MTO work had focused on the ridesharing and energy efficiency aspects of HOV use. In the absence of any operational experience with HOV lanes on provincial freeways, a cautious approach is being taken with regard to the introduction of HOV priority measures.

The MTO's current HOV policy position may be summarized as follows:

> *"The Province recognizes the importance of improving road utilization through High Occupancy Vehicle systems in addressing future transportation, environmental, social and economic needs. The province will work with other levels of government, transit operators and the private sector to establish a coordinated network of HOV facilities and approptiate support programs.*

The provincial HOV policy has the following objectives:

- *to increase the travel capacity of congested road and highway corridors by increasing the number of persons per vehicle*

- *to provide travel time savings and a more reliable trip time to high occupancy vehicles*

- *to increase the capacity of the existing road network without compromising safety*

- *to reduce the need for new road construction*

- *to reduce energy consumption and air pollution caused by passenger vehicles*

- *to improve the attractiveness of bus transit by increasing its operational efJiciency*

- *to promote transit ridership by feeding existing rapid transit facilities*

- *to develop ridership in future transit corridors*

- *to facilitate more intensified land use in urban areas*

MTO's HOV strategy is more fully explained in Appendix A.

This approach is being applied to provincial highways and programs as well as to funding and support of municipal HOV initiatives. A Greater Toronto Area Municipal /Provincial HOV / TDM Committee has been set, and has as its mandate to provide leadership and co-ordination for development and implementation of Municipal and Provincial HOV facilities and programs. The current document is a product of the Committee.

I-3.5 Municipal Policy

Several Ontario municipalities have gone through Official Plan updating exercises since the late 1980s when HOV and transit priority began to emerge as an accepted transportation strategy. Most of the policy statements which have consequently been incorporated into revised or Draft Official Plans have placed a significantly increased emphasis on the need to move people (and goods) efficiently on the municipal transportation system and with less environmental impact. This policy approach has translated into thrusts towards the provision of HOV lanes as a fundamental part of the transportation system, when and where they make sense.

The following statement from the Metropolitan Toronto Draft Official Plan (September 1992) captures this change in thinking: *"An effective transportation system is one that provides choice in meeting transportation needs in a convenient, quick, and reliable manner. Integration of the different modes of travel provides the widest possible range of travel options. In the past, the primary emphasis in achieving system efficiency has been on moving the greatest number of vehicles along streets and through intersections. In view of the physical, financial, and environmental constraints on the transportation system, it has become necessary to emphasize the effcient movement of people and goods rather than of vehicles; this emphasis includes measures to promote and facilitate the use of High Occupancy Vehicles, including public transit.*

Building on this philosophy, Metro Toronto sets out the following policy regarding HOV facilities: *"It is the policy of Council...to pursue improvements to the Metropolitan Toronto street system that will enhance the movement of people and goods rather than the movement of vehicles through:*

a) *phased implementation, as is practical and beneficial, of a network of High Occupancy Vehicle lanes on Metropolitan Toronto streets;*

b) *consideration of all future additional lanes on Metropolitan Toronto streets for the use of High Occupancy Vehicles in the context of the network mentioned above;*

c) *promotion and support of High Occupancy Vehicle lanes on area municipal streets to complement those on Metropolitan Toronto streets:*

d) *providing and supporting the provision by others of ancillary facilities and services (such as lots for Carpool and Vanpool formation, reserved parking spaces, and ride-share coordination services) to facilitate and promote the use of High Occupancy Vehicles;*

e) *implementation of operational improvements that would enhance the movement of High Occupancy Vehicles (such as traffic signal priority or pre-emption and reserved-use lanes) where practical and where the safety of other street users would not be decreased.*

It is important to note point (d), which recognizes that an effective HOV priority strategy consists of more than a network of HOV lanes, and that an equivalent effort must be put into supporting and complementary HOV and Travel Demand Management programs. This is borne out in the Metro plan by statements such as *"parking policies and standards...shall provide for preferential treatment of High Occupancy Vehicles* ".

Not all Ontario municipalities face the issues that Metro Toronto has to deal with, but the planning approach behind the strategies applied there is relevant to all urban areas. The Regional Municipality of Ottawa-Carleton, for example, has a different approach to transportation with its "transit-first" philosophy and the resulting emphasis on the bus-only Transitway system to move people efficiently. Whether non-transit HOVs compete with or complement the transit strategy is a key issue in that context.

The Regional Municipality of Halton, meanwhile, is studying the Trafalgar Road corridor with a view to creating "a more balanced approach to meeting transportation needs through the use, where feasible, of exclusive transit lanes or busways, high occupancy vehicle lanes, pedestrian and bicycle path systems, while creating opportunities to delay or limit infrastructure investments, or secure more cost effective capacity and operational solutions"[10].

Whatever the situation, if congestion exists, if single occupant vehicles cause a disproportionate amount of air pollution and energy waste, and if the public investment in transportation infrastructure is being used at less than its capabilities, there is a strong argument at the municipal policy level to look to HOV priority as part of a sustainable and efficient transportation system.

10 Report to Planning and Public Works Committee, R. Mohammed, Commissioner of Planning and Development, January 25, 1994

I-3.6 Funding Practice

I-3.6.1 HOV Lane Construction

The provision of transportation service in Ontario municipalities is a jointly-funded undertaking of the provincial and municipal governments, traditionally with relatively minor private involvement.

Physically, arterial HOV lanes are either existing or additional lanes on a municipal road with little except signage to distinguish them from general use lanes. HOV lanes are commonly created through the widening of an existing roadway (usually from 4 or 5 lanes to 6 or 7 lanes) and frequently involve either the reconstruction or repaving of the existing road at that time. If the additional lanes are to be used as Reserved Bus Lanes (exclusive use by buses for 6 or more hours in the daily peak periods) funding for the widening portion of the project only is eligible for 75% subsidy from the Municipal Transit Program. If the additional lanes are to be used as HOV lanes, the cost of widening is eligible for 50% subsidy also from the Ministry's Municipal Transit Program. The cost of rebuilding the existing roadway is eligible for 50% subsidy from the Ministry's Municipal Road Program.

The project must be fully justified and application must be made to the Ministry for subsidy in advance of project initiation. Costs of the work including design costs are split using several methods to identify the share eligible from Roads and Transit. The result to the municipality is that 50% of the cost is eligible for provincial subsidy for an HOV lane and for an RBL the split is 75% for the widening portion of the project and 50% for the associated reconstruction of the existing roadway.

I-3.6.2 Operational and Supporting Measures

The Ministry of Transportation and several of Ontario's larger municipalities have been active in recent years (and in the MTO's case, since the energy crisis of the early 1970s) in developing and implementing various Travel Demand Management and HOV-supportive measures. Another key area has been enforcement, where those agencies charged with ensuring safe and effective lane operation have had to shift resources accordingly.

Funding and cost-sharing has been on a case-by-case basis to date, with the MTO participating financially in most municipal initiatives as well as carrying out their extensive internal effort under the Transportation Technology and Energy Branch.

It is recognized that TDM / HOV measures hold little potential to generate direct revenue. The one area where fiscal benefits may accrue is in transit operation, where increased efficiency on HOV routes can help counteract the transit operator's trend towards increasing costs due to congestion. The Ottawa - Carleton Transitway system is a large-scale example of this, whereby the efficiency of transit operation with the priority measures in place is such that over one hundred buses and operators are saved compared to the case if buses were to remain on the street system. On a smaller scale, several bus routes in Metropolitan Toronto could require one less bus while maintaining the same headway if a five minute time savings could be found on each trip; the HOV lane network now being implemented in Metro is intended to provide that time savings.

In recognition of the key role transit service can play in supporting and generating development, frequent express bus operation (over and above that which could be supported by initial demand) was supported by the Province on the Ottawa-Carleton Transitway system through a special funding agreement. The subsidy support paid off in tremendous ridership success, upon which the achievement of almost all other transportation goals hinges.

The potential role of private interests in supporting HOV use has not been explored to any great extent in Ontario to date. It would be more likely that such support would come through the provision of facilities and programs oriented towards parking, employer incentives, and so on rather than funding HOV lane segments. Some TDM initiatives such as Vanpool programs have been undertaken by individual companies throughout southern Ontario, but apart from monitoring by MTO there has been little coordination or external support for these activities.

The ability of a high level of transit service operating on an HOV route to provide an interim stage of service prior to rapid transit construction, may have the potential to defer major capital expenditures on new fixed rapid transit facilities. Although a bus-only application, this principle is illustrated by Ottawa's "outside in" approach to Transitway construction, whereby surface priority measures on downtown streets ensure adequate transit operation, allowing capital funds to be oriented first towards building the areawide feeder network instead of the relatively short but extremely costly central area tunnel.

The emerging development of "congestion pricing" and electronic road use monitoring technologies may lead to some direct application of the principle of user fees; HOV lanes are well-situated to benefit from preferential treatment in this area, but it would be the non-HOV traffic which would likely bear the brunt of the fee if HOV priority (in cost, as well as travel time) remained a guiding principle.

1-3.7 Documentation and Resources

The recent burst of activity on the HOV front in Ontario has produced several useful reports which go alongside those documenting the past two decades' experience in the U.S. Among all the studies and applications, however, there has been a skew towards freeway HOV lanes and there is relatively poor documentation of arterial applications. A great deal of research remains to be carried out on the arterial front, and all current documentation is regarded as "interim" or guidelines rather than as definitive standards. It is worthy of note that the Metro Toronto HOV Network Plan and study constitutes the most comprehensive and extensive arterial HOV strategy in North America to date. Also of interest is that the most recent trend is towards a broader approach to Travel Demand Management measures, incorporating and expanding on HOV strategies. Thus the literature relevant to HOV priority has expanded to include the whole field of TDM.

The most relevant documents for HOV application in Ontario are readily available (see box), while Appendix C provides a more thorough bibliography of published material on the topic.

Additional relevant documents include those produced by the City of Toronto, the City of Mississauga, and Metropolitan Toronto regarding individual HOV and Reserved Bus Lane projects, including planning studies, reports to Council, and monitoring reports.

Both the Institute of Transportation Engineers and the Transportation Research Board are active in the HOV field by sponsoring research, hosting conferences, and publishing reports and guidelines.

HOV SOURCES

Metropolitan Toronto HOV Network Study McCormick Rankin for the Metropolitan Toronto Transportation Department, Toronto, 1992

Operational Design Guidelines for High Occupancy Vehicle Lanes on Ontario Freeways, McCormick Rankin for the Surveys and Design Office, Ministry of Transportation of Ontario, Downsview, 1993

High Occupancy Vehicle Oppotunities, Incentives and Examples - A Handbook for Ontario Municipalities, McCormick Rankin for the Transportation Technology and Energy Branch, Ministry of Transportation of Ontario, Downsview, 1993

High Occupancy Vehicles - A Planning Design and Operation Manual, C. Fuhs, Parsons Brinckerhoff Quade and Douglas, Orange, California, 1990

Guide for the Design of High Occupancy Veh icle Facilities, American Association of State Highway and Transportation Officials {AASHTO), Washington, D.C., 1992

Implementing Effective Travel Demand Management Measures, Institute of Transportation Engineers (ITE), Washington, D.C., 1993

I-4 HOV NETWORKS AND STRATEGIC PLANNING

I-4.1 The Transportation - Land Use Link

Urban planning and transportation experts concur that the generation of trips and the subsequent potential congestion is directly related to decisions made regarding the location, scope and type of land use in an urban area. In fact this linkage lies at the heart of the congestion issue which has resulted in the need for initiatives such as HOV priority and Travel Demand Management programs.

Higher capacity transportation elements such as transit and HOV programs stand to gain the most by recent urban trends towards infill, densification, proximity of work to homes, and related land use policies. However, it is recommended that HOV opportunities be specifically considered in the future to a greater extent than has normally been the case in past land use exercises.

An example which may be cited regarding the current lack of HOV status in land use analysis is the difference that may exist in terms of vehicle trip generation between a development with a strong Transportation Demand Management / Carpool / transit program and a "normal" development; these differences are not accounted for to date in major reference documents such as the Institute of Transportation Engineers' Trip Generation Manual, upon which many density, traffic impact, and land use decisions may be based. The risk of "overlooking" HOV's potential role in lane use planning may be minimized through traffic surveys or calculations which are structured to account for HOV use being used in the development review process.

Another situation which has acted as a great inhibitor of transit and carpooling market share is the practice of monolithic segregated zoning by land use type, whereby vast industrial parks provide thousands of jobs without so much as a convenience store, restaurant or bus service present. This virtually requires workers to drive to work and, because the car is needed to run the simplest of errands or go out to lunch, the need is to drive to work alone. Similarly, the placement of major travel generators (e.g. shopping centre, school, office node, residential area, entertainment complex, civic centre) all beyond walking distance (400 m ±) from any other generator is a major factor in creating an auto-dependent community.

The definition of HOV's role in land use can be achieved through the municipal planning and zoning process to a great extent; one recent example in Metro (October 1991) is North York's proposed "Business Park Secondary Plan" which covers four major office / industrial zones with a new zoning by-law which, among other items, establishes target auto occupancies and transit modal splits for the areas, encourages parking supply related to target modal splits, and encourages the formation of Transportation Management Associations.

I-4.2 Managing the Transportation System

Any HOV initiative should be considered a subset of a Transportation Demand Management strategy, which is in turn one aspect of the municipal transportation system. Accordingly the goals and objectives of an HOV incentive program (and its components such as HOV lanes) should be considered in the context of the overall goals of the municipality.

In the broadest sense, the goals of the HOV network and its components are identical to the goals of the transportation system as a whole, and may be summarized as the improvement, in a cost effective and environmentally responsible manner, of personal mobility throughout the urbanized area.

AN EXAMPLE OF OFFICIAL PLAN TRANSPORTATION GOALS

As an example of a typical major urban municipality's approach to transportation, the transportation goals of Metropolitan Toronto, as defined in Section 6 of the current Official Plan may be considered:

- **to improve transit accessibility and mobility throughout Metropolitan Toronto;**
- **to provide adequate transportation services to support the employment growth of the Central Area;**
- **to emphasize transit and arterial road accessibility to each designated Centre, both from the surrounding district and from the Planning Area as a whole;**
- **to complete the Metropolitan arterial road network;**
- **to incorporate facilities to allow interchange between automobile and transit modes of travel, and interchange between GO Transit commuter services and Toronto Transit Commission services;**
- **to base all expansion or improvements to roads and transit facilities on environmentally sound principles, in order that the Metropolitan transportation system will have minimal impact on the environment,**

In order to achieve such goals, the main thrust of a typical HOV network would be to provide a system which makes the most efficient use possible of the affected area's existing and future transportation infrastructure. To a great extent, this requires the use of as few vehicles as possible to accommodate the demand for travel, thereby reducing the need for additional infrastructure.

BUSES AND CARPOOLS - MODES OF CHOICE

Individuals make dozens of travel decisions every day and each decisions is based on the needs of the traveller and on the ability of the free market to provide for those needs. To succeed in achieving the goals of an HOV program, HOVs must be positioned in the transportation marketplace as the mode of choice for a significant number of those trip makers. For the most part, the competition is the singfe occupant automobile. In that respect, any HOV strategy is as much a marketing program as it is a transportation service or facility; an HOV lane is essentially a marketing tool meant to demonstrate the benefits of using (and shifting to) HOVs. The fact that an HOV lane may operate more efficiently and move more people than an equivatent general purpose lane is important to its justification and cost-effectiveness, but it forms only part of an HOV program which must produce demonstrably superior results in travel time and cost to overcome the factors (such as door-to-door convenience, personal comfort, flexibility) on which it is fess able to compete with the single occupant auto.

I-4.3 HOV Strategic Planning at the Municipal Level

I-4.3.1 Municipal HOV Strategy

A municipal HOV strategy will stem from the planning and transportation goals of the community as expressed in the Official Plan, the basic thrust being the achievement of the most efficient movement of people and goods within and around the municipality. Whether this means an emphasis on roadway expansion, transit service, shared-ride promotion, land use planning to reduce demand, demand management, or any combination of strategies will depend on the local municipal situation and philosophy.

If it is determined that there is a significant role for HOV priority measures to play in the municipal transportation scene, a strategy for HOV promotion will need to be laid out. While HOV lanes are obvious initial candidates for inclusion in the HOV strategy, there is little point to proceeding in that direction without a commitment to a broad range of related and supporting measures, most of which are drawn from the Demand Management toolbox. It is entirely possible to have an effective HOV program - one which induces people to shift from single occupant vehicle use to transit and HOV use - without a single kilometre of HOV lane in place. Parking priority measures, employer-based financial incentive programs, convenient rapid transit service, land use planning to reduce auto travel needs, and many other measures can be put in place and together can influence, if not control, individuals' modal choices.

The above comments notwithstanding, in all likelihood the most visible, effective, and important element in a municipal HOV strategy is the provision of on-street priority for buses and other shared-ride vehicles: HOV lanes. This importance comes not only from the direct benefits in travel time and reliability that lane users enjoy but also from the ability to link the lane benefits with the other programs so that the whole is much greater than the sum of the parts.

A three minute savings over several blocks of an HOV lane will not induce anyone to change modes, but if it can be combined with an employer-subsidized transit pass to the value of the parking space the driver would otherwise occupy, if there is a ridematch program in place, if there is a shuttle bus service in the office park to allow lunchtime errands to be run, and if there is an express bus route to take advantage of the HOV lane, the HOV mode would be in a much more competitive position relative to driving alone. None of the HOV incentives just described are "pie in the sky" - completely traditional technology is all that is needed - and most measures are either already part of operational programs or cost little to initiate. All that is needed is a commitment, an organizational strategy, and some innovation to position HOVs as the mode of choice in the community.

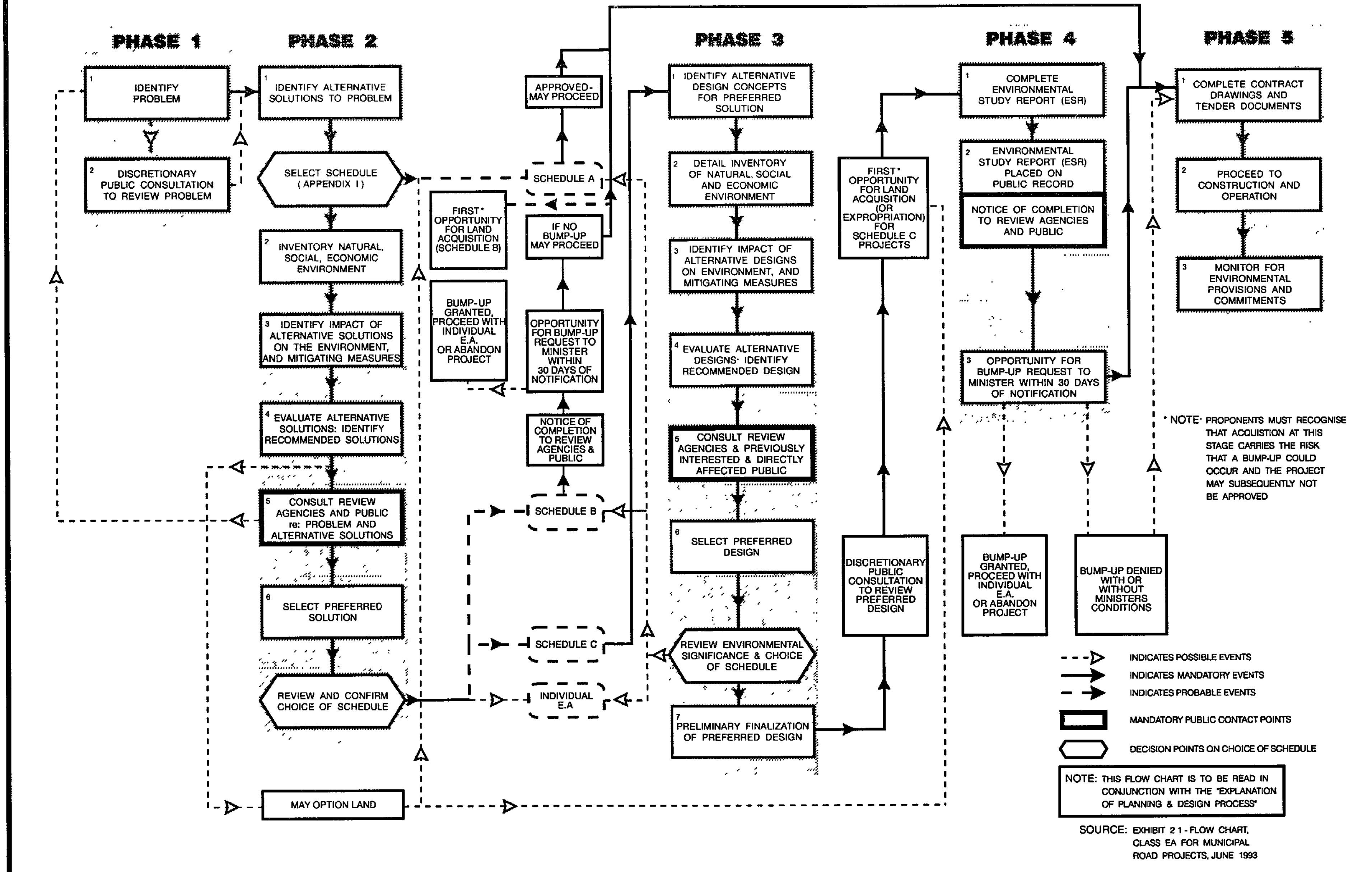
The possible strategies to encourage HOV use suited to different types and sizes of communities in Ontario are outlined in the report *High Occupancy Vehicle Opportunities, Incentives, and Examples - A Handbook for Ontario Municipalities* (MTO, 1993). Essentially, smaller municipalities would be most effective at focusing on employer-based and parking-related demand management strategies, while HOV lanes play a greater part in the strategies suited to larger urban areas. At the upper extreme, the comprehensive network of HOV lanes now being implemented in Metro Toronto will provide the building block for the HOV program of the entire Greater Toronto Area.

I-4.3.2 Planning Steps

The planning process for municipal road projects such as the provision of HOV lanes is well laid out in the *Class Environmental Assessment for Municipal Road Projects* (Municipal Engineers' Association, June 1993).

Exhibit I-1, excerpted from that report, provides a "generic" planning process suited to work on a particular roadway. A study following such steps will be carried out in accordance with the requirements of the Environmental Assessment Act of Ontario.

The steps to be taken for an HOV-oriented project should follow the Class process but are likely to be somewhat more complex. This is because of the importance placed on developing an HOV operating strategy and its interrelationship with any physical requirements for road widening or modification. In order words, instead of a simple road widening project, an HOV lane study must consider lane conversion, vehicle eligibility, operating rules, community response, and a myriad of other HOV-specific issues. These may not necessarily end up affecting the physical layout of the roadway, but they will play a key role in the project's need and justification.



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES

OPERATIONAL PLANNING & DESIGN GUIDELINES

EXHIBIT I - 1

PLANNING AND DESIGN PROCESS FOR MUNICIPAL ROAD PROJECTS

Exhibit l-2 is a flow chart which illustrates how HOV-related decisions have to be made in conjunction with the "normal" analysis process. The exhibit also demonstrates the role that an areawide HOV network study can play, in providing a consistent set of planning principles and a strategic plan as the context for the subsequent study of any particular corridor.

I-4.3.3 HOV Facility Principles and Preconditions

There are several principles which underlie all HOV applications, be they in a network setting or as standalone programs. These principles should either be in place or be acted on as part of the HOV planning process in order for the facility to have a good chance of success.

1. Network Role

   A network is made up of elements, some of which may be crucial to the viability of the network as a whole. Although some HOV facilities may be justifiable on a standalone usage basis, others will be considered to be key network elements or have objectives distinct from those of the rest of the network. The objectives of each HOV facility must therefore be considered in both the facility-specific and systemwide contexts.

2. Transit Priority

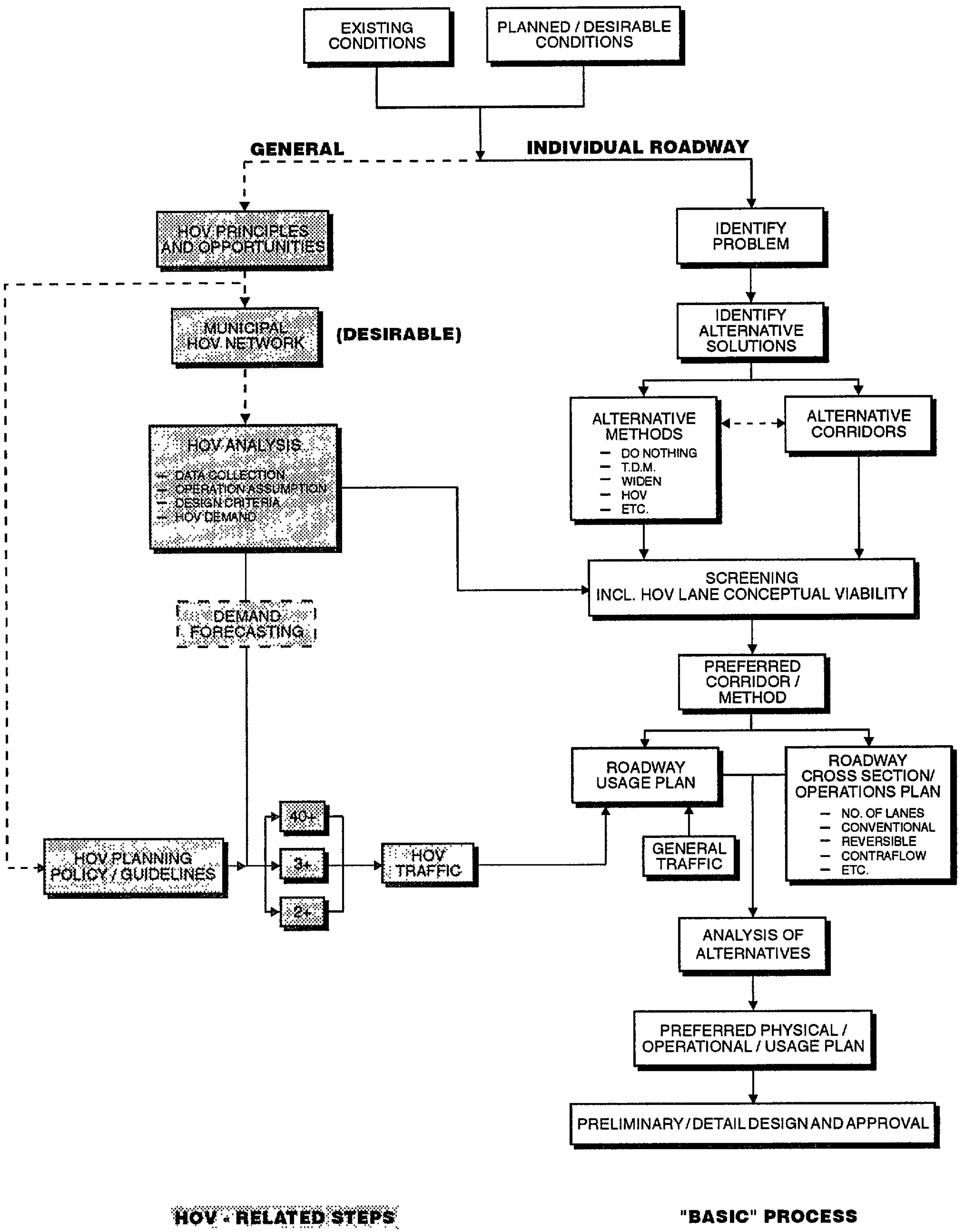
   In municipalities or corridors which are heavily transit-dependent or which place a high priority on transit usage, a basic HOV principle is generally that transit vehicles are the highest priority HOVs, and other HOVs (carpools, vanpools) should be considered only insofar as they do not interfere to an unacceptable degree with transit HOVs.

3. Level of Service

   A key objective of an HOV lane is to give HOV users a faster trip compared to LOV users on the same road. This improvement should not, however, cause an unacceptable delay to the pre-existing mixed flow's Level of Service. A before-and-after Level of Service analysis of the entire affected portion of the transportation network should be made to assess whether sufficient capacity would remain after HOV implementation to accommodate LOV traffic at an acceptable Level of Service.

4. Enforcement

   Commitment from the appropriate enforcement agencies to provision of an adequate level of enforcement of the HOV facility is a prerequisite. Enforcement agencies must also be aware of the additional responsibilities for monitoring turning moves and intersection operations that are unique to the HOV network. The enforcement of parking and stopping regulations is critical



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT I - 1	HOV DECISION - MAKING FLOW CHART

to the operation of an HOV lane. In recognition that in most Ontario municipalities it is unrealistic to expect ongoing active enforcement, attention must be given to innovative design, education, signage, and "passive" techniques to enhance the self-enforcement of the HOV facility.

5. Safety

Implementation of an HOV lane should not result in a decrease in safety to a level worse than that of the equivalent mixed flow roadway (considering measurements of both frequency and severity of accidents). Pedestrians, transit passengers, and LOVs all have their environments changed with the introduction of HOV facilities; this change should not make the situation less safe than normal.

6. Physical Characteristics

The roadway or facility under consideration must have, or be capable of reconstruction so as to have, acceptable geometric design and operating characteristics for HOV use. Substandard HOV facilities are similar to substandard roadways anywhere: safety is reduced and operational efficiency is constrained. The effects on a HOV lane, however, are magnified due to its unique demand sensitivity.

7. Support Programs

At all stages of HOV lane planning, design, opening and ongoing operation, relevant and targeted HOV support programs should be a full partner in the project. Commitment and funding for marketing, transit operational improvements, education, employer programs, and other appropriate TDM measures are essential to the success of the HOV lane.

8. Evaluation Period

All HOV applications should be assessed after at least one year of operation as to whether these are successful in meeting their objectives. A review of whether the treatment can / should be enhanced in any way or whether it should switch to mixed flow should occur at that time. This review should take into account the HOV facility's role in the network, its dependence on other, complementary HOV facilities being in place, the effectiveness of the support measures in place, and the rate of change of HOV-related travel patterns.

I-4.3.4 Justification Criteria for HOV Facilities

The criteria against which an HOV network or HOV lane may be measured to assess whether the facilities contribute significantly to the achievement of typical HOV network objectives follow:

TYPICAL HOV NETWORK OBJECTIVES

OBJECTIVE	CRITERIA
To increase the person movement capability of road links	The total usage of an HOV lane measured in person trips in eligible vehicles, should be greater than that which would occur if the lane were to be used by mixed traffic.
To improve the operation of surface transit routes	An improvement in running time of five per cent or more over the length of the designated lane for transit compared to that available if there were no HOV facility represents a significant improvement.
To increase the overall vehicle occupancy rate for travel	This objective indicates some minimum structure or length of HOV network great enough to induce carpooling and greater transit use. The minimum will vary depending on the nature of the network, but experience elsewhere indicates that a significant shift to carpooling from LOV use does not normally occur until a minimum time savings of 8 to 10 minutes is available for HOVs compared to ineligible vehicles. Even though many trips will not be long enough to achieve such a savings, as long as some trips could achieve an 8 minute time savings the objective would likely be reached. If it is determined that other factors such as transit service materially affect the overall vehicle occupancy rate the justification criteria may be adjusted accordingly.
To contribute to a net improvement in air quality	HOV application should contribute to a net systemwide improvement in air quality, compared to the "do nothing" alternative. This would include reduced vehicle emissions for HOVs and any change in emissions from other vehicles affected by the HOV network.
To contribute to a net reduction in energy use	Transportation energy use following the HOV application should be less, on a systemwide basis, than that which existed before. One of the main goals of sharing vehicles is the more efficient use, not only of the facilities those vehicles travel on, but of the fuel which they use. An application which increases the amount of fuel used over that of the "do nothing" alternative is inconsistent with its goal. The balance of increased HOV efficiency must be weighed against any negative impacts which may occur on LOV traffic.

I-4.4 HOV Networks

I-4.4.1 HOV Network Planning

A key element in an areawide HOV strategy is the determination of the size, scope, and type of network of HOV lanes appropriate to the area. Such a network may involve only a couple of key roadways or it may utilize most of the available corridors; it may focus on downtown-oriented commuters or deal with suburb-to-suburb travel; it may have a radial pattern with the Central Business District at its core or it may form a grid such as Metro Toronto's plan - all of these decisions will involve a marriage of HOV market needs with available opportunities and constraints. The importance of thinking in terms of a network rather than at the individual corridor level is that the time savings and benefits of any particular HOV segment in many cases will not reach the threshold at which modal choice decisions can be influenced, whereas the impacts are multiplied severalfold when a set of linked HOV measures are available.

The most significant input to HOV network planning is the shape of the existing road network, be it a grid, a radial system, or an irregular collection of roads. This will have defined how traffic flows within the urban area and where regular recurring congestion is a problem. The place to start is to consider the application of HOV lanes to those areas of congestion and to look at the pattern which forms as a result: if the HOV priority corridors are, or can reasonably be, readily linked to one another to form a continuous initial network, there is a sound basis for pursuing the network concept; if on the other hand the congested corridors are relatively few or are not related to one another (for example, two radial arterials approaching the downtown from different directions) the HOV system will be more appropriately treated as a series of discrete links.

An HOV network must be firmly rooted in the current situation, while being shaped and guided in its evolution so that it occupies its appropriate place in the planned ultimate transportation and development system. The three points of reference in network development are therefore:

- understanding the existing conditions
- understanding the planned / ultimate / desirable future conditions
- applying HOV pfanning principles and criteria, and utilizing available opportunities to bridge between existing and future.

In terms of the existing conditions, key factors are knowledge of the location and extent of roadway congestion, determining the level of HOV use (including Carpools and public / private transit), and placing the appropriate level of importance on major transit nodes or centres of demand. A plan illustrating all of these conditions is likely to clearly demonstrate both the potential for, and conceptual layout of, an initial HOV network.

Looking forward to the ultimate goals of the network, the focus would then shift to locating major growth areas or nodes, on identifying the long term major transit corridors, and on potential linkages with adjacent or outlying urban centres. The future demand picture is of considerable importance because "new" travellers are far more likely to choose HOV modes (assuming a program is in place) than are existing travellers who have already made their modal choice. In the transportation marketplace, it is easier to choose than it is to switch.

The third angle to consider is the application of the HOV planning and design principles outlined in this document to the existing /future situation, in which case the physical feasibility of the various alternative measures, the opportunities which may be present, the ability to develop an effective HOV / TDM support program, and the willingness of the community to support an HOV priority strategy are the most significant factors to consider.

HOV planning should be integrated with ongoing road improvement plans. Dedication of lanes to HOV use can be used to support the need and justification for road widenings and improvements; caution must be exercised in this respect, however, lest HOV lanes be perceived as "an excuse to widen roads".

Opportunism is an aspect of HOV strategy which is worth emphasizing -there are many examples of successful HOV lanes which resulted not from in-depth technical analysis in the context of an areawide strategic plan, but which came from simply seizing brief or unique opportunities as they presented themselves. One case is Metro Toronto Council's decision, upon completion of construction, to not open added lanes on Don Mills Road to general purpose traffic as originally planned but to open them only to buses and later to Carpools. Another example is the "piggybacking" of the widening for Reserved Bus Lanes on Highway 403 in Mississauga onto a pavement rehabilitation and shoulder improvement project already underway. Transportation planners should be alert to all such opportunities which may emerge over the course of HOV network development. This approach may be formalized with approval of a policy to the effect that "all new road construction in the municipality of ___________ shall consider HOV applications".

I-4.4.2 HOV Network Implementation

Once a general network shape has been decided on, the next important step is the determination of an implementation / staging strategy. Particularly if new construction is involved, the provision of an HOV network is not likely to be an overnight achievement - Metro Toronto's network plan, for example, is projected to evolve over the course of two decades.

Implementation strategy is once again a function of the local situation and the commitment at the governmental level to bring the plan to fruition. While recognizing constraints on funding, it is important that an initial stage of the network be substantial enough and be brought on board in a short enough time frame that some momentum can be generated. If short, unconnected, "easy" HOV lane segments are all that are achieved over the first several years of the plan, there is considerable risk that the more costly but more effective elements will never be built, particularly since there will likely be little evidence that the initial phases have achieved any of the HOV program goals. Furthermore, there is now adequate documentation and knowledge in the HOV field that a "pilot project" approach should be unnecessary; flexibility should certainly be maintained, but a definitive network plan and approved staging sequence should be in place so that the assessment of any particular network link can take place in the larger context.

An example of how an implementation strategy can be tailored to the local situation while at the same time ensuring that initial momentum is strong enough to carry the program to completion is provided by Metro Toronto. Metro's strategy called for the immediate conversion to HOV designation of most of the existing Bus lanes, as well as the redesignation of general purpose lanes to HOV on key six lane suburban roadways. Adding in the conversion of road widenings already scheduled in the near term and restriping to create HOV lanes on selected other links brought the HOV network to a substantial presence within a short time after the HOV Network Plan was conceived and approved. With HOV lanes now an established fact of life in Metro, future widenings and conversions leading to network completion can be carried out as a regular part of the transportation improvement program in the coming years.

Although a network of HOV lanes may be phased in over a number of years, it is extremely important that the initial stage consist of a significant proportion of the entire network. If not, it will be incapable of generating the trip time savings which act as an incentive to change modes from single occupant vehicle use. While not downplaying the advantages for transit operation and potential incentives for increased transit use, such a scenario would fail to achieve all of the HOV network objectives (notably the increase in average auto occupancy rate).

Based on a minimum time savings to induce mode shifting of 5 minutes per trip (as experienced in other HOV systems), the table below indicates that a minimum continuous linked network length of approximately 10 kilometres would be required to be in place before noticeable shifts in auto occupancy would be anticipated to begin occurring on a particular commuter route. Obviously, the greater the extent of the network, the larger the potential market for HOV use and the greater the overall benefits to the transportation system and the community at large.

MINIMUM LENGTH OF ROADWAY TO SAVE 5 MINUTES BY HOV

Average Speed in HOV Lane (km/h)	Average Speed in Non-HOV Lane(s) (km/h)				
	10	20	30	40	50
30	2.5 km	10			
40	1.67	5	15		
50	1.25	3.33	7.5	20	
60	1	2.5	5	10	25

I-4.4.3 Network Consistency

One of the goals (and virtues) of any transportation system is consistency in function, operation and design. HOV lanes are confusing enough to the public without having the rules vary by time or location. Accordingly, it is desirable in principle that there be a single set of HOV rules across an area.

However, there must be flexibility in those rules to allow the facilities to reflect the needs of their respective users and to reflect their context. It is clear that both user needs and corridor context may vary tremendously across an area, from downtown to suburb, from freeway to arterial, from transit spine to rural commuter route, and from industrial park to retail core. Furthermore, the staged development of an areawide HOV network will result in different HOV corridors maturing at different times over the course of many years.

Within one area, this may result in a long distance commuter corridor (or portions of it) being most appropriately designated as HOV 2+ while another roadway serving high transit volumes operates at HOV 3+, or in one applying HOV restrictions during rush hours only while a nearby freeway has a 24 hour HOV lane designation.

Given the fluidity of travel demand and traffic operations, in reality there may be relatively little effect on HOV usage of such variations. Just in the way that auto traffic now reflects road closures, parking restrictions, congested locations, dynamic traffic information, and the hierarchy of road types available, it is likely that HOVs would do the same. Furthermore, if each individual corridor has an HOV facility that reflects the needs of that corridor (e.g. operating at a good Level of Service when adjacent lanes are congested and not being in operation when mixed traffic is flowing freely), no HOV would suffer as a result. In this respect consistency in time of operation between lanes is not necessarily a requirement.

The key problems are those of public understanding and of the transition from a less-restricted lane to a more-restricted route (i.e. from HOV 2 + to HOV 3 +). Both issues can be addressed by defining as a basic unit an HOV of two or more occupants, and then stating that where necessary the use of a facility or program may be restricted to HOV 3+ or buses only in order to ensure efficient and effective operation. The more-restricted lanes are freely available to those who wish to make use of them, but it is understood that the function of an HOV 3+ lane cannot be subverted by flooding it with two person Carpools in order to maintain “consistency” (of course, HOV lanes are self-balancing in this respect, in that eligible vehicles will simply not use one if it is congested with buses and other carpools). Alternatively, a “basic” HOV can be defined as a bus, with lanes opened to Carpools only to the extent that bus operations are not compromised (although this approach is less suited to working within a demand management framework which features Carpool-oriented support programs). The key is that an areawide baseline has been established and understood.

CONSISTENCY AND FLEXIBILITY THE GTA CHALLENGE

A conceptual example of a large-scale network in which some variation in HOV priority is present may be envisioned in the Greater Toronto Area, working from downtown Toronto outwards:

- transit priority lanes (Bay Street Clearway, streetcar lanes) in the congested downtown core, with carpool incentives limited to parking and employer-based measures

- surrounding the core, and extending out to the contiguous limits of frequent bus service (> 20 buses / hour) a network of HOV 3 + lanes to complement but not delay bus operations

- in the outer suburban ring (e.g. most of Peel, York, Durham, and Halton) where transit presence is limited, continuing the network at a 2 + designation to reflect the market characteristics and user needs

- beyond that ring, congestion and transit use are not such that HOV fanes are warranted but selected support measures (carpool parking lots, for example) may be appfopriafe

In this system, a traveller would achieve the greatest benefit by using the highest-level mode suited to the entire trip - e.g. to go from the suburbs to downtown Toronto, transit use would guarantee a priority trip along the entire commute, whereas to go from suburb to suburb that same traveller would have priority treatment by using any HOV 2 + mode (carpool, Vanpool, bus), Potential HOV users can make their travel decisions on that basis.

If a hierarchy of HOV lanes such as that envisioned for the GTA (see box above) is clearly spelled out and is consistent across the entire commutershed, all users can adapt to it and the greatest efficiency can be maintained. What is not desirable is a route which changes from 2+ to 3+ to bus-only and back to 2+ over the course of a trip. By starting from the core (worst case) and working outwards in bands to the limits of the network this can be avoided. Special attention must be taken in the case of the Greater Toronto Area, where multiple nodes exist and overlapping of bands could occur: considering the entire commutershed as a whole rather than being constrained by municipal boundaries is essential in such a case.

It is evident from the above discussion that consideration of an individual HOV lane or corridor should not be done in isolation from the broader context, and that the development of an areawide HOV strategy is desirable <u>before</u> addressing individual routes.

I-4.5 Individual HOV Lanes

I-4.5.1 Indicators of Suitable Corridors

There have been several attempts over the years to identify "warrants" for HOV lane treatment, but the complexity of the situation has meant that guidelines or indicators are more suitable in most cases. While some aspects of HOV lane use and potential may be readily quantified and measured, technical warrants are incapable of capturing the interplay between transit needs, market characteristics, the presence and effectiveness of HOV incentive programs, local community / political climate, and funding / network development strategies. This is often of vital importance at the start of an HOV lane project, when "opening day" HOV demand may not meet technical warrants yet opening the lane to mixed flow would lose the ability to protect for long term HOV needs. For this reason each HOV application must be considered carefully and an understanding must be gained of the balances and compromises required.

The above comments notwithstanding, the following points may be referred to as indicators of corridors where HOV lanes are most likely to be applicable and effective:

1. The roadway must be congested. The main direct benefit to the HOV lane user is time savings compared to the non-HOV alternative; the greater the time savings the greater the likelihood that travellers will use and shift to HOVs.

2. The HOV lane must be seen to be well-utilized. The effectiveness and viability of an HOV lane depends on public support; to have a publicly-funded lane sitting empty amidst a congested urban arterial invites violation, protest, and contempt (and ultimately the reversion of the lane to mixed flow). The minimum number of vehicles constituting a "well-utilized" HOV lane may vary considerably, depending on the mix of buses and Carpools, the congestion in the general purpose lanes, the visible effectiveness of the HOV lane, marketing and enforcement efforts in the corridor, and community attitudes towards transit. The number of buses in the lane plays a significant role in this situation, as the public is more knowledgeable and accepting of transit priority policies than of the role of carpooling in most Ontario municipalities. Where a lane is dedicated to bus use, Toronto experience shows acceptance of a 15-20 bus per hour level of usage; at that level, any Carpools which are added in make little difference to public acceptance. Where there are ten or fewer buses per hour, the importance of the lane being visibly well-utilized by Carpools becomes more important. At a minimum, ensuring that an eligible vehicle is always within sight on the HOV lane is a starting point (corresponding to at least 250 vehicles per hour, or one every 15 seconds on average). The above points imply that, in areas where there are 15 - 20 buses per hour or more, HOV 2 + or HOV 3+ vehicles can be added according to the physical and operational capability of the corridor; where there are 10 buses per hour or less, an HOV 3 + criterion is unlikely to generate the level of usage acceptable to the public and an HOV 2+ eligibility would be more appropriate.

3. **The roadway must retain an acceptable overall level of service. To create a "win - win" situation for all traffic the addition of lanes for HOV use is desired. The conversion of a pre-existing mixed flow lane to HOV-only use poses a greater risk of increasing congestion for the remaining LOVs, potentially to the degree that any benefits gained by HOV users would be more than cancelled by increased delay to others. In the right situation, however, the conversion of a lane is reasonable and beneficial to all, and in some cases is essential to the effectiveness of the HOV network.**

4. **The HOV lane must be physically and operationally feasible. In physically constrained areas, innovative operational strategies may be used, but basic lane width must be available. HOV-related features such as bus bays, signage, and enforcement areas must be factored into the design, and their relative importance (essential, desirable, or unnecessary) to the success of the facility should be considered.**

5. **An administrative, enforcement, and marketing framework must be in place. An HOV lane in itself is generally a relatively weak inducement for single occupant motorists to change modes; complementary Travel Demand Management initiatives are a prerequisite for a successful HOV program. A commitment and the ability to enforce the HOV facility is also essential to its success. Finally, the complex issues raised by HOV initiatives (funding, interjurisdictional network development, proponency, transit role, marketing, etc.) put it beyond the mandate of most existing organizations; clearly defined roles for all involved parties within a multi-agency framework need to be in place lest the HOV program "slip between the cracks".**

An HOV 3+ lane in operation (Dufferin St., North York at 9 :30 a.m.)

Ease Study: HOV Lanes on Dundas Street, Mississauga / Etobicoke

Based on a city transportation and transit strategy, and taking advantage of a road widening project, peak period HOV 3 + lanes were implemented on a 5 km long stretch of Dundas Street between Dixie Road in Mississauga and the Kipling Subway Station in Etobicoke in January, 1992. Dundas Street is 7 lanes wide; the Mississauga portion was widened from 5 lanes in order to provide HOV lanes in each dkection. The setting is a high-volume suburban retail strip with heavy peak period transit usage oriented to the subway.

The results of monitoring by the City of Mississauga over the first year of operation include:

- Transit Travel Time - average trip savings 2.5 minutes (range 0.5 - 6.0) or 3 6% of travel time over affected section. Transit service reliability cited as key improvement by operators.

- Transit Ridership - shift of bus routes to HOV corridor and emphasis on express bus service produced a 15% increase in transit ridership (compared to a systemwide decrease of 3.5% over the same period).

- Auto Travel Time: - travel in HOV lanes was 1 minute faster and travel in non-HOV lanes 1 minute slower than travel in general purpose lanes before implementation.

- Lane Usage - the HOV lanes carry 36 - 42% of parson trips carried on the roadway in 3 - 4% of all vehicles (not including violators).

- Enforcement - 50% of HOV lane vehicles are not HOVs: low levels of enforcement, low penalties, and poor public awareness were cited as concerns and efforts are being made to address this issue. The HOV lanes have had no effect on accident rates.

- Public Awareness - understanding of Carpool eligibility appears to remain poor: 52% of eligible Carpools remain in general purpose lanes.

- Conclusions - HOV lanes on the Mississauga Portion of Dundas Street are effective and beneficial for transit, not as standalone facilities, but as essential elements of a package of initiatives (express buses, marketing, route shifts, etc.). The public has accepted the HOV lanes tboth the widened and the “take away” segments), but increased effort in the areas of enforcement, education and marketing are required.

(Source: Commissioner of Transportation and Works’ report to General Committee of Council, City of Mississauga, June 2, 1993)

I-4.5.2 Vehicle Eligibility and Related Issues

I-4.5.2.1 Vehicle Occupancy Criteria

Setting the appropriate vehicle occupancy criterion is the key aspect to successful operation of an HOV lane. Whatever the criterion, be it 2+, 3 +, or 40 + (i.e. buses only), the decision should be set in an areawide context and then tested for viability on the particular corridor under study. For linked corridors, consistency is highly desirable, while it may be a lesser concern for those HOV facilities which can operate relatively independently, or with trip patterns that do not use the rest of the HOV network. What is not desirable is a patchwork system of HOV lanes with differing eligibility criteria, different operating times, and discontinuous routes. This issue is explored in Section I-4.4.3.

The long term goal of an HOV strategy would generally be to get as many people as possible moving in as few vehicles as possible. This points to a strategy which promotes bus and HOV 3+ use. It must be recognized, however, that an HOV 2+ strategy may be far more practical and effective in the earlier stages or in certain markets, with greater HOV use developing over time.

Each approach has its pros and cons, tradeoffs and benefits. The argument here is that the overriding goal is the efficient movement of people in urban areas, regardless of the mode they use. If every trip could be made in a personal vehicle at a reasonable cost with no congestion, accidents, environmental degradation, and with comfort, speed and convenience, there would be no need for an HOV program, or transit for that matter. This not being the case, we are obliged to search for the "next best thing", which is a multimodal system where the diversity of the market's needs are matched by the variety of available transportation services. Shared-ride vehicles directly address many of the problems present in the system, as do buses and single occupant vehicles; no mode, however, addresses all of the problems and needs and a place must be made for each in the system.

In this context, if setting aside some portion of the arterial road network for HOVs helps achieve the efficient movement of people, there should be little argument against introducing it to the system. Alternatively, if a bus-only lane is the most efficient use of that portion of infrastructure, it should be implemented as such.

The key strategy is to establish "ownership" of the HOV lane; once it is established as a priority route the operating rules which apply to it (eligibility, time of day) may be modified as needed, but if it is left to mixed flow it will be far more difficult to achieve such changes.

I-4.5.2.2 HOV or RBL?

Should Carpools be permitted to use HOV lanes, or should the lanes be dedicated exclusively to transit use? The reason for asking the question is the uncertainty in some situations as to what extent (a) the presence of Carpools in the HOV lanes would interfere significantly with transit operations and (b) the promotion of

Carpool usage will be at the expense of transit ridership, thereby producing a net disbenefit to the transportation system.

(a) Operational Issues

Regarding the issue of operational interference between buses and cars, a typical urban arterial is capable of moving 600 to 900 vehicles per hour per lane; transit use varies, but may be assumed to be between 5 and 20 buses per hour for most of the roadways under consideration for HOV lanes. On average, this produces a headway of 3 to 12 minutes per bus. Clearly, restriction of the HOV lane to bus use does not result in the lane being utilized to its optimum potential, even if transit trips are double or triple in frequency (as is the case on a few Toronto-area roads). It is also evident that ample scope exists, on a link basis, for use of such a lane by additional vehicles. In the context of current and future demands for road use in and the limited amount of pavement available to accommodate such demand, it would be inappropriate to not make the best use of this potential as long as the operational needs of the various users do not unduly compromise each other.

The use of HOV lanes by right turning non-HOV traffic does in some cases hold the potential to delay travellers in the HOV lanes, and close study of the phenomenon is required during initial HOV lane operation. This, however, is independent of the issue of whether Carpools using HOV lanes interfere with transit operations, since the same number of right turns would be made no matter what the HOV eligibility criteria are. On a four lane roadway without left turn lanes, conversion of one lane to HOV use may require corresponding restrictions on left turns lest through traffic in the non-HOV lane be completely blocked. The effects of such restrictions need to be considered on a network-wide basis (i.e. are alternative locations available to make the turns, or if not, is the HOV lane concept still viable).

If transit operational needs are such that only a limited number of other vehicles can share the lane without its Level of Service being compromised, there are several ways of managing the non-transit usage, chief among them the definition of eligible HOVs (i.e. HOV 2 + vs. HOV 3 +). Enforcement of the lane to ensure its use only by eligible vehicles would also go a long way, in most cases, to addressing such operational concerns.

In cases where the combination of Carpools, buses and right turning vehicles approach volumes that would begin to reduce the potential transit benefits, the following options to reduce or eliminate this impact may include:

- provision of right turn bays on the HOV street
- channelizing the intersection
- location of bus bays on the far side of intersections
- shifting bus stop location in advance of intersection to reflect right turn queue length
- banning or relocating right turns
- introduction of an HOV-only signal phase
- restriction of pedestrian crossing to alternative intersection legs

- provision of grade-separated pedestrian crossings
- provision of a physical barrier between the HOV lane and LOV lane
- an increase in the minimum Carpool occupancy level from 2 + to 3 + or 4 +
- a change in the time of HOV lane eligibility (e.g. ban HOV 2+ during rush hour)
- shorter signal cycle length
- grade separation
- increased communications and marketing effort
- enhancement of transit service to induce a shift to bus mode

These measures could affect HOV traffic, non-HOV traffic, pedestrians, trucks, and bicyclists, since each intersection has to accommodate the diverse needs of each user group. The variety of options and the different circumstances in which they could apply are factors which support an intersection-by-intersection review of the potential HOV-related improvements rather than a universal standard approach.

Generally, however, the presence of Carpools in HOV lanes would not be expected to interfere with the efficient operation of transit in the lanes, and means exist with which to resolve virtually all point-specific potential problems.

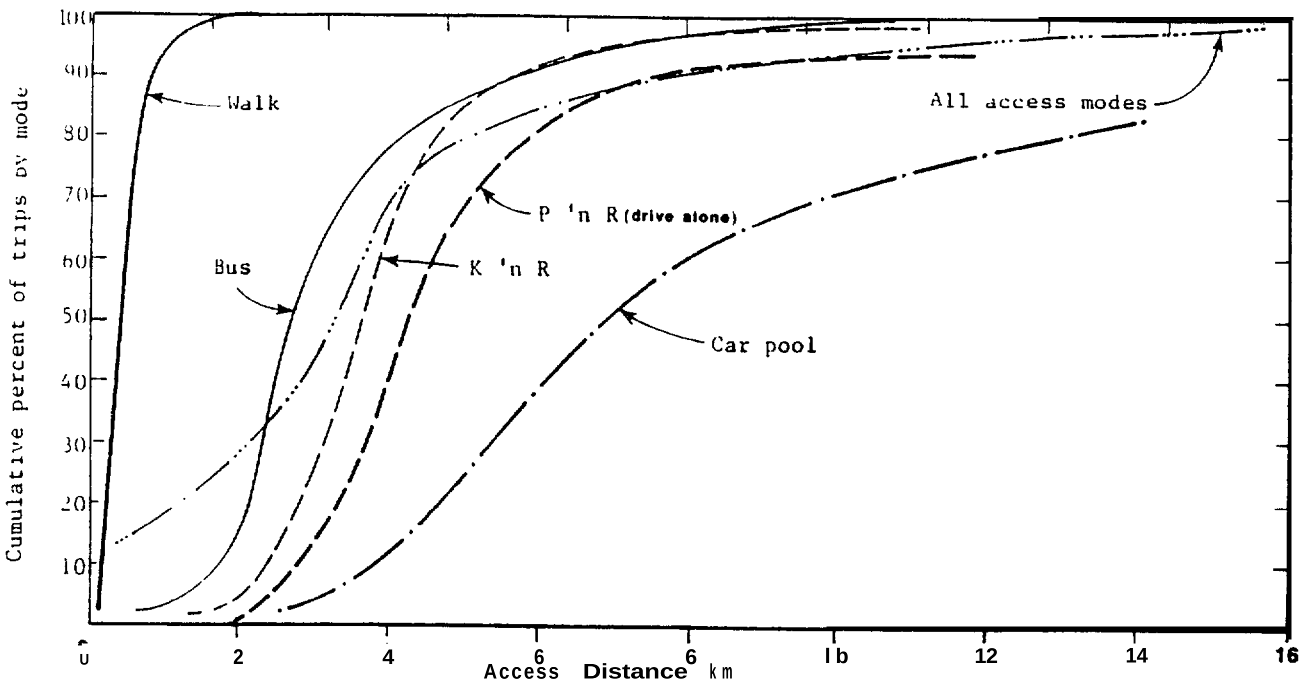
(b) Marketing / Usage Issues

The urban transportation marketplace is a competitive one, in which the attributes of each available mode are positioned so as to influence the individual's choice at the start of each trip he or she makes. Auto usage dominates Ontario residents' choice because of its many positive attributes and because a vast infrastructure has been put in place to support it. Transit operators, in recent decades, have as a consequence had to target two niches in the marketplace - "captive" riders (those who are unable physically or legally to drive, and those who do not have access to a car) and "choice" riders (who for speed, comfort, convenience, and cost reasons - usually in a severely congested urban situation - prefer transit to private car use). The concern is that Carpool-oriented HOV programs may siphon off "choice" transit passengers while doing little to affect the mode choice of solo drivers.

In this context, it must be recognized that the Carpool market is already, in many areas, significantly larger than the existing transit market (typically 15 - 20 per cent of road users in Ontario cities are in 2 + Carpools throughout the day, whereas many transit agencies don't achieve that modal share even during peak periods). The fact that two- and three-person Carpools today form regularly under conditions of congested roads, reasonably good transit service, and no particular HOV incentives, indicates that this market niche is extremely strong and virtually untapped.

Experience with HOV lane implementation elsewhere, and research into the travel habits and desires of transit passengers indicates that the Carpool and transit markets are in fact two distinct niches of the greater urban travel market. The following Exhibit I-3 demonstrates the fact that carpoolers tend

THE RELATIONSHIP BETWEEN THE CUMULATIVE PERCENT OF TRIPS BY MODE FOR AND ACCESS DISTANCE FOR 8 BAY AREA RAPID TRANSIT STATIONS



CONCLUSION : CARPOOLERS TEND TO DRIVE MUCH FARTHER THAN OTHER MODE USERS TO ACCESS PARK & RIDE LOTS AT RT STATIONS (LONGER THAN SINGLE DRIVERS)

SOURCE BAY AREA RAPID TRANSIT PASSENGER FROFILE SURVEY, 1972, AS REPORTED IN RAPID TRANSIT ACCESS MODE CHOICE ANALYSIS, KORK & DEMETSKY VIRGINIA HIGHWAY AND TRANSPORTATION RESEARCH COUNCIL, DEC. 1980

HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES ***OPERATIONAL PLANNING & DESIGN GUIDELINES***	**EXHIBIT** I-3	**RAPID TRANSIT ACCESS PATTERNS BY MODE**

to have longer trips than any other urban travellers, for instance. This means that many Carpools are used as surrogate transit services from rural or low-density suburban areas where fixed transit routes are infrequent or unavailable. Furthermore, the time and effort involved in forming and using a Carpool (including additional travel time to pick up a passenger) make it worthwhile mainly for longer trips.

In freeway corridors outside Ontario where HOV lanes have been introduced, a generalization is that less than ten per cent of the carpoolers previously used transit, forty to sixty per cent previously drove alone, and the remainder were either already in Carpools or were making new trips in the corridor. Together with the changes in Carpool usage, the improvement in transit service corresponding to the introduction of the HOV facilities generally resulted in a significant transit ridership increase (itself drawn from drive-alone, Carpool, and transit market sectors). There are no examples in the literature of transit operators having a net loss of ridership to Carpools upon the introduction of an arterial HOV lane. It should be recognized, however, that little information is available on arterial HOV lane user characteristics, and considerable research remains to be done to understand the influence of various HOV lane scenarios on patterns of inter-modal shifting.

In terms of market growth, it is the transit mode which exhibits the greatest growth potential whereas the shared-ride auto market has some potential but faces inherent limitations on its use. If transit operators can respond to the market needs in a setting in which land use and transportation priorities are geared towards transit, the mode is entirely capable of attracting 30 to 60 per cent of the peak hour peak direction commuter travel in an urbanized area. On the other hand, if carpooling were somehow to reach the 30 - 40 per cent modal split level it would clearly indicate a commonality of trip patterns among users that could in fact be readily tapped by transit. Furthermore, the long-trip patterns of carpoolers naturally produce a highway orientation rather than reliance on arterial use. Municipal roads are more likely to be used by short-trip carpoolers on family errands, shopping, school / spouse drop off, recreation, etc.

In discussing modal choices made by individuals, it should be kept in mind that, in the context of various transit operational initiatives, shifting land use / population / employment patterns, relatively low fuel prices, provincial and municipal transit funding policies, and significant growth in auto-dependent suburban and urban communities, it may be difficult to assign a particular weight to the importance of HOV lanes or priority measures in actually affecting personal transportation habits. For example, if fuel prices or parking costs were to plummet, transit mode share would also likely fall and auto share increase virtually independent of whether or not an HOV network existed (even though HOV lanes could have the effect of cushioning the blow to transit mode share compared to the condition of there being no HOV lanes). Conversely, if overall conditions act to increase transit modal share, the presence of HOV lanes would act to multiply the benefits.

It is also important to consider the relationship between trip purpose and modal choice. It varies considerably as the following table illustrates.

MODAL CHARACTERISTICS BY TRIP PURPOSE

Trip Purpose	Transit %	Auto			
		Driver %	Passenger %	Total %	Avg. Occ. Rate
Work	33.3	57.2	9.5	66.7	1.17
School	68.2	15.0	16.8	31.8	2.08
Shopping / Personal Business	20.9	55.2	23.9	79.1	1.42
Social / Other Home Based	26.1	61.7	12.2	73.9	1.42
Non-home Based	16.4	63.9	19.7	83.6	1.29
Average	27.4	53.4	19.1	72.5	1.30

Note: Walking, cycling, and other modes not included.

Source: 1979 Metro Toronto Home Interview Data, as reported in Canadian Transit Handbook, 2nd Ed., Canadian Urban Transit Association and Roads and Transportation Association of Canada, 1985

In the a.m. peak period, work trips (for which the auto occupancy rate is low) dominate: consequently, congestion is often most severe at that time. Since carpooling is more popular than transit for some major trip purposes (e.g. shopping) even with the considerable expenditure to date on transit infrastructure and service, it is evident that there is in fact a considerable difference between the transit and Carpool markets.

(c) Conclusions

In summary, the transit and Carpool sectors of the urban transportation market are distinct and largely complementary rather than competitive. In a balanced transportation system which offers choices to users which cumulatively lead to optimal efficiency, convenience, and cost-effectiveness, there is a place for both buses and Carpools. The use of a single lane for both modes remains an operational planning issue, dealt with most appropriately at the corridor and network planning stages. Unless it is operationally imperative that a lane operate as bus-only, it would be recommended that Carpools be included as eligible HOV lane users. Maintenance of the number of Carpools below the level at which operational interference becomes a significant concern should be the guiding principle.

The risk of transit operators losing significant ridership to private shared-ride modes is minor: with concurrent improvement to transit service provided by HOV lanes it is even less likely that people who have previously made the choice to use transit (without priority treatment) would subsequently switch to car use.

Carpools and Buses in HOV 3+ lane (Yonge St., North York)

I-4.5.2.3 HOV 2+ or HOV 3 + ?

There are significant operational and marketing differences between HOV 2 + and 3 + lanes, even though they may be physically identical. Because a single HOV lane performs multiple functions, has several objectives, and suffers from a variety of constraints, the decision as to eligibility criteria is not necessarily straightforward or easy. Extreme care must be taken at this stage of the planning process to ensure that decision-makers have an adequate understanding of the lane usage, operational needs, and implications of the choice. If an error is made, the viability of the lane may be jeopardized with potentially significant consequences to the areawide HOV / TDM strategy.

It should be recognized that there may be a place for HOV 2+, HOV 3+, and Reserved Bus Lanes within a single region, depending on the function and market served by each route.

(a) HOV 2 +

The most effective way of reaching out to the transportation market with a new initiative is to make it accessible and beneficial to as large a group as possible on "day one". Once the market has been identified and has "bought in" to the concept, it becomes easier to manage the HOV program to reflect the market's needs and to optimize its performance. In this light an initial HOV program incorporating HOV 2+ has considerable merit.

Furthermore, with 15 - 20% of vehicles already typically 2+, there is an "instant" base of HOV lane users upon which to build an HOV lane strategy. Such a user base could be effective in a lane conversion situation in order to minimize concerns about the impact to non-HOV traffic. Along with the higher volume, however, comes the risk of there being too many Carpools in the HOV lane and transit operations being compromised as a result. Thus a 2 + designation is more likely to be appropriate in a suburban area where bus volumes are relatively low.

It may be kept in mind, however, that if there are so many HOVs that congestion occurs in the HOV lanes, that is a clear sign that there are a great many trips in the corridor with common origins and destinations and that transit is failing to capture that market; adjustments to improve transit's competitiveness (e.g. express services, shuttle bus, routing changes, park and ride lots) may be a more effective way of dealing with the congestion problem than to cast out the two person Carpools into the congested LOV lanes.

It is more likely that any problem which results from excess HOV lane usage will be site-specific (e.g. right turn to a major generator, or a bus stop without a bay) and can be addressed on that basis. A concern, though, is that areawide consistency may not be achievable if selected HOV links are congested at the 2+ level even if most lanes operate smoothly.

A 2+ designation is far more likely than 3+ to leave an impression with the public that the lane is being adequately utilized. As well, the potential scope and effectiveness of HOV / TDM support programs is considerably enlarged, as it would be difficult to promote HOV 2 + use at the workplace if the lanes served only 3 + users. Finally, there is nothing preventing an HOV 2 + facility from serving every 3 + vehicle which the HOV program produces; the reverse is not the case.

Where to Apply HOV 2 + Designation

- an initial project
- a lane conversion from mixed flow
- where required due to network consistency
- a suburban roadway with few / no alternative routes
- where lane usage would not otherwise reach "minimum" public acceptance levels (see Section II-4.2)
- transit use is low (less than 20 buses / hour)
- transit provisions (e.g, bus bays) are adequate to ensure a good level of service for all lane users
- lane congestion does not result nor is projected in near future
- a corridor / area with support programs oriented to 2 + use

(b) HOV 3+

An HOV 3 + designation virtually guarantees problem-free HOV lane operation and transit priority. The difference in Level of Service between the HOV lane and the mixed-flow alternative will be clear and the rideshare incentive maximized due to the relatively low volumes (probably 50 - 20 veh/hr at most) of HOV 3 + lane users.

It is a dramatic leap, however, from current auto usage patterns to substantial HOV 3 + numbers, and one that should be accompanied by significant transit usage or improvements if it is to work. For roadways carrying less than ten or twenty buses per hour, it is questionable that limiting Carpools to 3+ is required for operational purposes; if bus bays are provided and some buses operate in express mode, it would be even less necessary. In Metro Toronto, however, several streets carry 50 buses / hour or more and are therefore suited to 3 + designation; applying the principle of areawide consistency then produced a comprehensive HOV 3+ network.

Enforcement of a 3 + lane is, on balance, not significantly more onerous than for a 2+ operation; while there are far fewer vehicles to observe the greater "availability" of the lane is likely to induce more violation by ineligible users.

It is generally recognized that, due to inherently better efficiency of space, fuel, cost and person-carrying capacity, 3+ Carpools are preferred over 2+ vehicles in terms of meeting HOV goals and objectives. In that sense, a lane

HOV 3+ lane in operation, showing (a) public acceptance and self - enforcement, (b) HOV travel time advantage and transit reliability benefits, and (c) possible under - utilization (Dufferin St., North York)

full of 3+ users remains the ultimate achievement. However, limitations inherent in the marketplace are such that it would be an extraordinary feat for the number of 3 + Carpools to even reach the level currently enjoyed by 2 + vehicles.

Experience with freeway HOV lanes has been that a 3+ designation can be readily changed to 2 + if more users are needed, while raising eligibility criteria is more difficult to achieve; this flexibility may be of use in certain situations.

However, if an initial 3 + designation produces only an underutilized lane and a high violation rate, it is a less than desirable situation from which to build a publicly supported HOV strategy; a 2 + designation may be more appropriate in that case, with provision for reassessing the 3 + situation at some future point.

Where to AmIv. HOV 3 + Designation

- conversion from a Reserved Bus Lane
- where transit provisions (e.g. bus bays) are limited or non-existent
- transit use is heavy (more than 50 buses / hour} and operational problems are a concern
- where required due to network consistency
- a corridor / area with effective and comprehensive support programs
- a corridor which is anticipated to have a significant increase in demand
- a downtown roadway with available route alternatives
- where right turning vehicles and pedestrians create intersection delays

I-4.5.3 Changing the Rules

As the transportation market evolves, so must the system which serves it. In the case of an HOV lane, there are several circumstances which may arise where the rules by which the lane operates need to be changed. Most such changes can be readily implemented, but care has to be taken to ensure that the transition is as smooth and beneficial as possible.

I-4.5.3.1 Modifying Use of an Existing HOV Lane

Having established "ownership" or stewardship of the HOV lane by virtue of its designation and signage, the municipality is then capable of adjusting the rules of eligibility and operation as needed to ensure the continuing safe and effective operation of the facility. The need to change the rules may arise in response to concerns about lane underutilization or congestion in the lane, or as a consequence of changes in the characteristics of the corridor.

The basic thrust would normally be to either increase or decrease the number of vehicles using the HOV lane. The most direct way to achieve this is to change the vehicle eligibility criteria to cover a larger or smaller portion of the transportation market, most simply by raising or lowering the Carpool criteria between 2 +, 3 + , and even 4+ (or 40 +, for a Reserved Bus Lane). Apart from such a "broad brush" approach, however, the eligibility can be fine tuned to match peaking characteristics throughout the day by, for example, raising a 2 + lane to 3 + only during the peak hour in the peak direction. Spreading the HOV lane operation from peak periods to twelve hour (7 - 7) or all day operation can resolve midday congestion problems, while lowering the criterion from 3+ to 2+ can instantly resolve underutilization concerns.

With each change, HOV lane users and other travellers will adapt to the new rules in their own way, with the collective net result hopefully an improvement on the previous situation. The complex interplay between the transit, Carpool, and single occupant vehicle sectors of the market will produce varying results as individuals change patterns to achieve their own "most efficient" trip. A peak period increase from 2 + to 3 + eligibility, for example, will affect all 2 occupant carpoolers; many will shift to off-peak travel, others will try an alternate route, some will revert to single occupant vehicle use, some will add a person to the Carpool or change to transit to keep on using the HOV lane, while most will simply shift over to the LOV lanes. At the same time, the improvement in HOV lane flow due to the elimination of the two occupant cars may cause greater congestion in the adjacent LOV lanes, the net difference being great enough to induce single occupant motorists to finally shift to transit or a work-based Carpool.

While the market response to a change in the rules for HOV lane use is difficult to predict and inherently a corridor-specific concern, it is vitally important that two aspects of the HOV program be in place if a change is to be attempted: an effective communications strategy; and supporting measures to take advantage of the changes. In the first instance, HOV lane users as well as non-users and the general public must be made aware of the fact that a change will occur, the reasons for it, and the benefits that will result; this reflects the need for both an orderly transition to the new lane operation and for the generation of public support and understanding for such a change. Complementary measures to assist any party potentially negatively affected by a change (for example, two occupant carpoolers in the situation described above) should focus on inducing a shift in habit towards HOV 3 + or transit use: if they are going to change their commuting pattern anyways, the availability of a ridematching service (to find that third rider), the introduction of an express bus (to take advantage of the free-flowing lane and make the travel time savings irresistible), a change in parking priority measures among major employers in the corridor (to match the new rules), and so on can cumulatively act as significant factors in each trip-making decision. Consultation, education and communication with lane users is a vital part of this sensitive process.

The impact of an operational change on the lane itself is likely to be minor; particular attention, however, must be paid to any signage changes that are required to communicate the new rules to the users. If there are variations in eligibility at different times of the day, or if the hours of operation vary (between weekdays and weekends for example), electronic changeable signs are likely to be required to communicate the rules to motorists (see Section III-4).

I-4.5.3.2 Conversion of a General Purpose Lane to HOV Use

The conversion of an existing road lane to HOV use (i.e. "banning" non-HOV use of the lane) has been a controversial topic since the introduction of the HOV lane concept. A couple of early freeway applications in the U.S. ran into problems and opposition and the approach has never been attempted on freeways since. On the arterial front, however, there is a long and generally successful history of such lane conversions, including the creation of several bus-only lanes in Toronto and Ottawa. The considerable cost difference between a lane conversion and the construction of a new lane, along with physical, environmental, and social constraints on new lane construction, lead to the conclusion that conversion of general purpose lanes to HOV use will in all likelihood be an essential component of any municipal HOV lane strategy. An argument is also being made in some circles that the only effective HOV lane strategy is one which removes lanes from general purpose traffic through conversion to HOV or bus use.

The lessons which may be drawn from the experience to date are that in the suitable circumstances, lane conversion can be an effective and publicly-supported strategy, but that particular care must be taken to ensure that LOV traffic problems do not consequently overwhelm the benefits of HOV priority. Lane conversion is more readily accomplished in short-block "traditional" urban areas, where there are many parallel alternative routes for LOV use, or where on-street parking occupies the lane otherwise (although removal of on-street parking is another sensitive issue). Evidence of strong HOV lane usage, particularly by frequent transit vehicles, is a key element in generating public support (at 40 buses per hour or more, the curb lane effectively already acts as a priority lane, as auto traffic avoids travelling in the lane). The introduction of turn restrictions along with the HOV lane (as in the Bay Street example in Toronto) can act to ensure that both HOVs and LOVs in the corridor get an improved trip. In suburban areas with long-block or "supergrid" arterials, the elimination of a mixed flow lane can create problems, particularly at major intersections where longer queues and neighbourhood infiltration by cut-through traffic can result. This is mainly because there are not enough alternatives to accommodate the affected LOV traffic. In this situation, optimization of the traffic signal system can offset some of the impact to non-HOV traffic, through techniques such as lengthening cycles, improving progression, and expanding protected phases.

It is important to note that lane conversions have occurred on both four lane and six lane arterials in Ontario, and that the only significant problems in twenty years of experience have occurred in the case of four lane roadways in suburban settings. The conversion of lanes to HOV use on Dundas Street, Yonge Street, Eglinton Avenue, and other arterials in Metro Toronto has occurred in recent years with virtually no public concern.

I-4.5.3.3 Dealing with HOV Lane Underutilization

If an HOV lane is underutilized yet remains a desirable element in an areawide network, the fate of the lane must be considered carefully. If there is public support for the lane (or at least an absence of complaint) there may be little problem apart from enforcement in keeping it in operation. All reasonable efforts should be made to increase its utilization - the key step in this regard would be expanding its eligibility (from 3 + to 2+, for example). Targeted promotion of transit use and ridesharing among major employers in the corridor and the development of complementary parking / marketing programs will also help. Another effective strategy is the rationalization and rerouting of buses so as to make more use of the facility. Alternatively, minimizing the impact of the lane by limiting it to peak hour and / or peak direction only operation can be tested. Use of the curb lane for parallel parking during off-peak periods is one approach to "preserve" the lane from assumption by mixed-flow traffic.

Whatever the strategy, the most important thing is to not lose "ownership" of the lane, for once it reverts to mixed flow it will be significantly more difficult to convert it back to HOV use (particularly if it is thus stigmatized by previous "failure").

The presence of future opportunities may be a factor in "recapturing" a lane - if a future road widening is planned, or a major reconstruction that would eliminate use of one of the lanes for an extended period of time is scheduled, the HOV lane can perhaps wait until that time rather than put into immediate operation (keeping in mind that if it were implemented with little usage and construction subsequently occurred that required temporary loss of a lane, the HOV lane would be the likely candidate for closure anyway). If a roadway is built or widened with the ultimate intent of there being HOV lanes on it, the placement of roadside signage to that effect may be considered (as the City of Mississauga is currently doing with newly-opened Centre View Drive).

Throughout this process, consultation and cooperation amongst planners, engineers, transit operators, enforcement agency staff, and elected officials is essential with the intent being that all concerned have an understanding of the role of the HOV facility and of the implications of either maintaining it or closing it, as well as the various strategic options available to ensure its efficient operation. If possible, bringing interest groups, employers, and lane users into this process will be beneficial.

I-4.5.4 HOV Lane Implementation: Leading up to Opening Day

HOV lanes vary from the norm of urban transportation facilities to a sufficient degree that particular care must be taken with the development and opening of each lane. More HOV lanes have "failed" or been removed in the first few months of existence than at any other time. Following are some lessons which have been learned in this respect:

- stage lane construction so that the HOV lane can open as it is built: avoid opening one HOV segment to general traffic while waiting for another segment to be completed

- if only one HOV lane direction is possible initially, apply it in the a.m. peak direction; the home-to-work trip is the critical HOV market, and once a carpooler is at work the return trip is likely to be by HOV whether or not an HOV lane exists in that direction

- communicate the plans to the public, potential users, and neighbours

- involve directly involved agencies (police, transit, public affairs) in lane planning

- highlight HOV lane plans in construction site signage and notices

- ensure that there is an effective enforcement commitment in place for at least the first month of HOV lane operation

- open lanes (particularly conversions) during periods of good weather and low volume; August is preferable to December in this respect (an opening-day blizzard that results in chaotic traffic conditions on a new HOV route will not contribute much to public support for the initiative)

I-4.5.5 Environmental Assessment Requirements for HOV Lanes

Most roadwork in Ontario is covered by either the *MTO Provincial Highway Class EA* or the *Municipal Engineers' Association (MEA)'s Class EA for Municipal Road Projects* and as such the planning of any HOV facility should be in keeping with the requirements of these Class EAs.

The practice to date for arterials has been that the conversion of an existing lane or shoulder into an HOV lane is considered as approved (per Schedule A of the MEA Class EA). This also applies to changes in operating hours, vehicle eligibility, and so on for an existing HOV lane.

Any HOV facility requiring the construction of a new lane would have to meet the specific requirements of the appropriate Class EA to be considered approved.

I-4.6 HOV Priority and Support Programs

The measures, other than an HOV lane itself, which are related to or support the goals of the HOV strategy are vital to its success; while the HOV lane may form an essential framework upon which to build the program, any induced changes in personal travel habits are more likely to stem from the related support measures.

These programs and strategies are dealt with in detail in Section IV of this report.

I-4.7 Demand Modelling for HOVs

I-4.7.1 Modelling Techniques

It must be said that, at this point, the ability to model or forecast operational and demand characteristics on arterials with HOV priority measures is extremely limited, and that research and development continues in this area. In that an HOV lane operates much the same as any arterial lane, the analysis of traffic flow using current conditions is readily undertaken, using proven methods. By assigning all current HOVs using the roadway and adjusting for turning moves, transit presence, violation, shifts from other corridors and time periods, and the fact that not all eligible vehicles use the lane, the range of potential flow in the HOV lane and in the remaining lanes may be calculated and Level of Service characteristics determined.

In forecasting demand, it is important to consider the potential shift of demand to the peak hour by HOV users currently travelling in the shoulder period. Since HOV lanes offer relief to the phenomenon of peak period spreading by providing guaranteed capacity and reliability for Carpools, it is common for such vehicles to shift back into the peak hour, having been forced out of it by congestion, This phenomenon is illustrated by the GO train Carpool parking lot pilot project, where

60% of participants used the opportunity provided by guaranteed peak period parking to shift to a later train. The extent of such a shift in the arterial HOV lane case would depend on its length, time savings, location, support program context, and several other factors.

What has proven to be difficult to model has been the prediction of modal shifts to and from Carpools and transit resulting from the presence of the lane. It has been shown that little shift is likely to occur on freeway HOV lanes until a 5 - 10 minute time savings per trip is provided, but the arterial picture is more complex, with shorter trips and a different transit situation. The presence or absence of supporting programs and TDM measures is undoubtedly a factor, as is the extent of HOV priority on a network wide basis. The travel patterns (origins, destinations, and trip purpose) in a corridor are important inputs, as is the proportion of the total trip taken on the route in question (is it a small segment of a long highway commute, or is it a cross-town journey to work?). If a trip to work is only twenty minutes long, it is unlikely that a ten minute savings can be generated. Finally, since travel time savings play such a large role in HOV usage inducement, the level of congestion which the LOV alternative experiences is a driving force.

The subtle interaction between two occupant Carpools, 3+ vehicles, and the transit market in light of various possible HOV eligibility regulations is difficult to assess, let alone to quantify and model.

All of these problems may be of only academic interest in many situations, however, since it is the “day one” situation which will make or break the viability and public acceptance of the lane, and the existing corridor information should be able to provide a sound basis for decisions regarding initial operation. The approach taken thus far in Ontario has therefore been to establish a sound understanding of existing conditions, to note the future travel demand growth prospects of the corridor along with the ability to accommodate such demand increases in traditional ways (e.g. widening for general purpose traffic, accept increased congestion, or rely on increased transit service), and to assess whether an HOV lane represents both an appropriate long term strategy and a viable short term solution. If the need and justification of the HOV lane is accepted on that basis there is little need for complex computer modelling of demand and flow. It may be kept in mind that, once initial support is established and the lane is implemented, there are many techniques available to “manage” the lane to ensure its efficient and effective operation: the key is to establish initial credibility and to take it from there.

I-4.7.2 Information Requirements

The ability to understand or to model any transportation phenomenon relies on the availability of relevant information. The intent of an HOV program is to change things - travel habits, congestion, transit use, pollution levels, and more. If there is to be a chance of properly assessing the program’s effectiveness in achieving change, “before” and “after” data must be available. This implies that a comprehensive listing of the required data should be generated and field measurements undertaken in the short term in order to provide a base line from which HOV measures can be considered. Also required is the monitoring and understanding of public HOV attitudes over time.

User information of specific relevance to the HOV program includes:

- existing vehicle use of corridor
- existing person movement in corridor by mode, including one-, two-, and three or more-occupant autos and by buses
- Origin - destination patterns of corridor travellers
- time of day variations in flow
- transit travel time in corridor
- travel delays in corridor
- HOV use in adjacent parallel corridors
- planned / projected change (growth) in demand characteristics

A particular need is the monitoring and analysis of HOV lanes in different contexts to understand the bus / Carpool / non-HOV interrelationship and the physical and operational means of resolving conflicts between the different road users. One such research need relates to the impact of bus bay provision on HOV lane traffic flow, safety and transit operation. Knowledge of the relationship between HOV lane volume, vehicular type mix, and bus stop types would, if established, be of assistance in setting policies and designs for future HOV lanes. On-street stops could be a significant inhibitor to Carpool use of HOV lanes and to express transit opportunities.

It is recommended that a focus on HOV-related information be maintained amongst all public data-gathering agencies and that categories such as vehicle occupancy become standard manual traffic counting elements in urban municipalities in Ontario. Without relevant information, the ability to justify a particular lane implementation project, to assign funding priority to the HOV program, and to learn from pilot project experience wilt be severely constrained. Furthermore, Ontario HOV experience can add to the relatively sparse international research literature on arterial HOV measures.

If actual HOV lane operational issues arise or become a critical issue it might be suggested that pilot HOV lane projects be implemented and monitored closely and analyzed as to the interaction of buses, taxis, Carpools and non-HOVs, and that if unreasonable operational conflicts occur on some segments of the ultimate HOV network consideration be given to identifying them as “bus only” lanes. The experiencegained to date by OC Transpo, Mississauga Transit, the Metro Toronto Transportation Department and the Toronto Transit Commission may be drawn on in this regard.

I-4.8 Costs and Benefits

I-4.8.1 Capital Cost

The capital cost of implementing HOV lanes on an urban arterial, based on recent Ontario experience, is in the range of $ 10 - 20,000 per lane kilometre. This covers signage and lane marking costs only, and will vary depending on the presence (or absence) of suitable hydro poles, light standards, sign supports, etc. to attach the overhead signage to.

COST OF IMPLEMENTING HOV LANES ON ARTERIAL ROADWAYS
(not including cost of roadway widening: signage and markings only)

Municipality	Roadway	No. of Lanes		HOV Lane Length (lane-km)	Year	Capital Cost for HOV Designation	Cost per km
		Before HOV	With HOV				
Metro Toronto	Don Mills Road	4	6	4.0	1991	75,800	19,600
	Dundas St. West	7	7	5.0	1991	63,800	12,800
	Eglinton Avenue	5	5	9.4	1991	91,200	9,700
Hull, Quebec	Blvd. Maisonneuve	6	6	2.25	1991	50,000	22,200
Mississauga	Dundas Street West	5	7	5.0	1991	37,300	7,500

If a road requires significant alteration or widening to accommodate HOV needs, significant capital costs can arise. In most situations, congestion is such that the widening would have been programmed for mixed flow purposes in any case, and it may not be entirely accurate to assign the cost to the HOV program, but at costs of up to $ 1.5 million per lane kilometre for widening an urban arterial it is an important and often dominant, aspect of the project cost.

To keep HOV costs in perspective, it may be noted that the HOV-related features of the Dundas Street West widening project in Mississauga amounted to 1 percent of the total $ 3.5 m construction cost.

I-4.8.2 Related Costs

The cost of HOV-related enforcement is difficult to calculate, as it most often requires an internal shift in resources and priority from another enforcement area. Consultation with the police agency involved is required to estimate that cost.

Several recent projects have had “opening day” publicity efforts attached to them to ensure that the transition from mixed flow to the HOV operation proceeds smoothly and with public understanding; these have been limited in scope with a $ 10 - 20,000 one-time cost. Inclusion of such marketing costs in the project capital budget should not be overlooked.

Associated with any HOV project are planning and design studies, which may be more extensive than other roadway projects due to the special considerations involved (need and justification, market assessment, special signage, etc.) The associated costs range from minimal for in-house design of a lane conversion project to $ 250,000 or more for an environmental assessment study of a major arterial roadway widening.

A final HOV lane cost stems from its special monitoring requirements, involving significant manpower for observing vehicle occupancy rates, lane usage, and speed / delay characteristics.

The costs associated with other Transportation Demand Management strategies are dealt with separately in Section IV. It may also be noted that costs or benefits may accrue to the public transit authority which utilizes the HOV lane, reflecting the routing and operational changes which may occur in response to the presence of the priority facility.

A summary of the financial costs and benefits associated with HOV priority measures follows:

COSTS AND BENEFITS OF HOV FACILITIES

POTENTIAL EXPENSES	POTENTIAL BENEFITS
<u>TO HOV USER</u> - costs of HOV mode - transit pass - Vanpool fee <u>TO LOV USER</u> - time delay - value of private and commercial time if congestion increased for non-HOVs - slower travel by transit than by car in off-peak - vehicle operation . increased operating cost (fuel) if congestion increased for non-HOVs	<u>TO HOV USER</u> · time savings · value of private and commercial time · vehicle operation · need for a vehicle reduced · maintenance / operating cost (fuel, insurance) shared for Carpool use; eliminated if park and ride use. · safety • (vehicle kilometres of travel) x (change in accident severity) x (average cost per accident) = net value of safety change. – parking priority (availability, location, cost)
<u>TO TRANSIT OPERATOR</u> . possible loss of passenger revenue to other HOVs • operation of express buses, construction of bus bays, marketing cost	<u>TO TRANSIT OPERATOR</u> • reduced / deferred vehicle requirements · reduced maintenance requirements • increased farebox revenue · increased efficiency (fuel and staff)
<u>TO MUNICIPALITY / PUBLIC</u> • increased police / enforcement budget • marketing • publicity • ridematching service - facility maintenance • capital construction cost - reduced parking meter / toll revenues • monitoring / analysis	<u>TO MUNICIPALITY / PUBLIC</u> • transit operator subsidy reduced • parking fines / towing fees · net decrease in air pollution · net reduction in energy use · reduction in need for / cost of road widening

I-4.9 An Administrative Challenge

When considering the scope and scale of the measures required to make the HOV principle a success in reality - road construction, parking regulations, community involvement, advertising, transit operational changes, taxincentives, enforcement, ridematching services, route planning, highway HOV policies, and more - it becomes clear that a significant challenge exists in simply putting the administrative framework in place that will make the components work together.

It will require close cooperation between government jurisdictions in order to bring an areawide HOV strategy to fruition and effective use. A number of HOV issues, like the users of the lanes themselves, cross municipal boundaries, while there is the potential for the involvement of some or all of the Federal, Provincial, Regional and Local levels of government. Furthermore, while some HOV aspects such as transit use are well-organized and regulated, carpooling and vanpooling is personal, unregulated, and subject to the forces of the free market.

Because the HOV approach to moving people is such a new, flexible, market-driven approach to mobility, bridging traditional road and transit programs while introducing marketing aspects to infrastructure use, there are virtually no established public bodies in Ontario dedicated to HOV principles. The majority of the elements of the HOV program are, however, already in existence as parts of the mandates of virtually every transportation agency. What is necessary is coordination, cooperation, and a shift in attitudes and mandates. Municipalities have not often been in the position of trying to convince people to use particular roadway lanes!

Public Transit authorities, meanwhile, are dedicated to a particular form of people moving and have the marketing and operational expertise to take the lead in HOV proponency, but it requires a significant change in corporate position for such agencies to become comfortable in promoting Carpool and Vanpool usage since the car has been treated as the "competitor" for so long. While this has occurred in Portland, Oregon for example (where the transit authority runs the ridematching program, promotes carpooling, and operates Vanpools as well as buses), it has been a difficult transition for many operators to make - so much so that the tendency has been to add an HOV agency rather than attempt to adapt existing ones.

At the provincial level, the Ministry of Transportation has taken the lead in HOV policy and operates through an interdepartmental executive committee to coordinate the infrastructure, funding, road, and transit aspects of the work. The Energy branch of the Ministry of Environment and Energy has traditionally been involved in the support of initiatives to reduce the transportation sector's energy use, and has therefore been involved in several HOV, ridesharing, and Vanpool projects in the past, in conjunction with the Ministry of Transportation's own Energy group.

In the interests of efficiency and effectiveness, the concept of a single unified areawide approach to moving people, no matter what mode they happen to be in, has considerable merit. The identification of a "Lead Agency" in this respect in

each urban area would help in this respect. Keeping in mind that HOV is a market-driven strategy and that the market consists of all travellers to and within an urban area, the responsibility of such a body should extend over the entire commutershed rather than be prescribed by municipal boundaries.

Even in the absence of a single Lead Agency, with so many interjurisdictional issues involved it is essential that a mechanism for regular liaison and formal involvement of interested parties be in place; the method of coordination, the mandate of each responsible agency, and the commitment of all involved parties to furthering the HOV approach should be subject to multilateral discussions between the interested parties during the earliest stages of HOV strategy development and implementation. The GTA Municipal / Provincial HOV / TDM Committee may serve as a model in this report.

Twin Cities' 'Team Transit' Speeds Buses through Traffic Congestion

MINNEAPOLIS, MINN.-Got a bus bottleneck? If you're in the Minneapolis area, call Team Transit! According to Aaron Isaacs, director of the Team Transit Division of the Metropolitan Transit Commission, "We're always looking for bus bottlenecks. Tell us where they are and we'll find a way to fix them."

Team Transit, a unique cooperative alliance of several government agencies working to speed bus customers through traffic congestion in the seven-county Minneapolis metropolitan area, was founded in 1991.

To date, the team has completed 30 miles of shoulder bus lanes on local highways, plus two miles in downtown St. Paul. Shoulder bus lanes allow buses to travel through congested areas as much as 10 minutes faster than cars.

During the past two years, Team Transit also has developed seven HOV ramp meter by-passes. By using these by-passes, buses and carpools pass waiting cars and enter the freeway faster.

Team Transit has also shortened downtown bus travel times using a new traffic signal timing measure, called "green time." Here's how it works: The city of Minneapolis assigns "green time" according to the number of people, not vehicles, moving through an intersection. For example, a bus with 40 passengers represents the same level of traffic as 40 cars. This new timing device began operation in October, allowing buses to travel more quickly through the downtown area.

A busy 1994 is planned by Team Transit, including plans to add bus-only shoulder lanes at six locations, and install ramp meter by-passes for buses and car/van pools at 10 sites. In addition. Team Transit is planning to improve the future of bus transit along the I-35W corridor between downtown Minneapolis and Bumsville.

"Team Transit projects are typically not large or expensive, are quickly approved, and easily implemented," Isaacs said. Active participants in Team Transit include the MTC, Minnesota DOT, Metropolitan Council, Regional Transit Board, Center for Transportation Studies, and several cities, counties, and suburban transit authorities.

from Public Transport. (APTA), Feb. 7, 1994

SECTION II: HOV LANE OPERATIONAL PLANNING GUIDELINES

In this section, the principles, strategies, and planning criteria outlined in Section I are applied to the most significant design element of the HOV program - an HOV lane on a municipal arterial roadway. The guidelines in this Section are based on the cumulative experience of HOV planners and operators throughout North America, with particular reference to recent Metro Toronto, Mississauga, and Ottawa-Carleton experience and modified as appropriate to reflect the full range of potential Ontario municipal situations.

II-1 ELIGIBLE VEHICLES

There are innumerable demands placed on a roadway lane, and the restriction of its use to narrowly-defined HOVs may unnecessarily penalize other vehicles that could use the lane with little or no impact on the primary transit and Carpool users.

II-I.1 Buses

It is appropriate that all buses (I0 passenger capacity or more) be allowed to use the HOV lane, as they all perform a mass transit role. Therefore, the minimum bus demand figures should include public transit buses, intercity buses (private or public), chartered buses, school buses, and paratransit buses. The passenger demand figures will have to consider the mix of vehicle types, carrying capacities, and load factors for all the buses in a particular corridor. In the cases of school and chartered buses, seasonal variations should be considered, and the variability of routes for chartered and paratransit buses is also a factor. To maximize transit efficiency and flexibility, deadheading (empty) buses should also be allowed to operate in a HOV lane.

II-1.2 Taxis

There has been a longstanding practice in some areas (e.g. Metropolitan Toronto) of allowing taxis to use bus-only lanes. Since taxi volumes are relatively low and drivers are professionals, there has been little operational concern with this practice. Furthermore, taxis are readily distinguishable from other traffic and public acceptance and enforcement of taxi use of the lanes have not been major issues.

It may be noted that measures to increase the efficiency of taxis are likely to reduce the usage of single occupant private autos. There has been some concern expressed, however, (publicly and technically) that use of HOV facilities by taxis <u>without</u> passengers is inconsistent with the HOV principle and should therefore be banned. This approach would see taxis treated the same as any other vehicle in terms of eligibility.

Banning taxis from bus-only lanes (e.g. Ottawa), may be appropriate on a high bus volume bus-only roadway (such as a transit mall) or a dedicated transit-designed facility (Transitway) but in an arterial HOV lane context with limited bus volumes, taxi use in fact helps justify setting aside the lane by making it perceivably better utilized.

In consideration of the above, it would be suggested that taxis, either with or without passengers, should generally be allowed to use the HOV lane in all cases except a specified bus-only facility.

II-1.3 Carpools, Vanpools and Motorcycles

Carpools and Vanpools with a specified minimum number of occupants should be allowed to use the HOV facility only to the extent that the level of service on the facility is not reduced to an unacceptable level. Motorcycles should be treated the same as cars in this respect (i.e. a motorcycle carrying two people would be allowed to use an HOV 2+ lane but would not be eligible for a 3+ facility).

II-1.4 Trucks

Trucks and commercial vehicles may be considered as possible users in the examination of a specific lane, but as a general principle should not be considered valid HOVs for the purposes of assessing demand and viability of the proposed lane. Significant other concerns arise with the operation of these vehicle types concurrently with HOV lane use: these may be dealt with as design issues on an individual basis. Since the concerns related to truck usage are independent of the number of occupants in the vehicle, it would be reasonable to exclude trucks from HOV lanes even if they carried an adequate number of occupants. In this regard, a semi-trailer unit with two cab occupants would not be eligible to use an HOV 2+ lane.

II-1.5 Bicycles

There is an increasing call for improved facilities for bicycles in the transportation network of several Ontario municipalities. In this context, the introduction of HOV lanes represents a significant opportunity to support bicycle use, while raising concerns in a few areas.

An HOV Lane, consisting of a curb lane on a major arterial roadway, would normally represent a potentially major improvement in bicycling conditions on those roads, as most car use of the lanes would be eliminated. Furthermore, as a major transportation initiative which firmly places transit and carpooling as priority modes of travel as opposed to single-occupant car use, the HOV strategy shares much of the urban vision held by bicyclists. In reducing air pollution and energy use while freeing pavement from single-occupant car use, the HOV initiative benefits cyclists. As well, an efficient surface transit system, enhanced through HOV lane use, is essential to cyclists during periods of inclement weather and in the winter months (altogether, a significant portion of the year) as it may be assumed that the majority of peak period (commuting) cyclists would not seek single-occupant car use as a preferred alternative during those times. Nevertheless, HOV program goals typically do not specifically include the encouragement of bicycle use: bicycles can be absorbed into the HOV network as allowable vehicles but do not contribute to the rationale for, or justification of, the HOV strategy.

Regarding the designation and use of the HOV lanes, bicycles should be allowed to use arterial HOV lane facilities at all times. It should be carefully considered whether HOV lane signage must be explicit in this regard (as per the current Bay Street signage in Toronto); given the relatively low volumes of bicycles on most arterial roads year-round, general public acceptance of bicycle use of roadways, and the many other instances where bicycle operation is not explicitly signed, it is not recommended that all HOV lane signage refer to bicycles. By the same token, HOV lane signage should not preclude bicycle use (i.e. avoid signage stating "buses and carpools only" unless bicycles are in fact excluded). It is imperative, however, that public awareness regarding authorized bicycle use of HOV lanes be raised. In key bicycle corridors an appropriate approach, should signage become an issue, would be to have separate "tags", either in conjunction with the standard HOV signage or on standalone sidewalk posts, stating a message such as "Bicycles OK" or "Bicycles ↘".

Realistically, it would be inappropriate to require that bicycles <u>not</u> use right curb HOV lanes, given that Section 126 of the Highway Traffic Act requires that "any vehicle travelling upon a roadway at less than the normal speed of traffic at that time and place shall, where practicable, be driven in the right hand lane then available for traffic or as close as practicable to the right hand curb or edge of the roadway". This provision would apply to bicycles.

The joint use of curb lanes by bicycles, buses and carpools represents some potential safety concerns, either from buses edging into adjacent lanes to avoid cyclists or from close proximity of fast-moving vehicles (especially buses) and bicycles. In this regard, allocating an extra metre in width to the curb lane where possible is current Metro Toronto practice. In retrofit areas or where this is not physically attainable, consideration can be given at the design stage to restriping all the roadway to possibly narrow the inner lanes and transfer additional width to the curb HOV lane. The widening of curb lanes beyond 4.3 m would lead to concerns regarding the inducement to park in the widened lane, and is not recommended. Similarly, the provision of dedicated bicycle lanes immediately adjacent to the curb (i.e. between the HOV lane and the curb) is not appropriate where the HOV lane serves curbside bus stops or bays, due to safety concerns. Consideration of separate off-street bicycle paths, bike lanes on parallel streets, or mixed flow operation may be required if bicycle use remains an issue.

It may be noted that the initial response by cycling groups to the Metro Toronto HOV Network plan was disappointment that bicycles would have to continue to share the curb lane with bus and car traffic, and general disagreement with the principle of widening roadways for some of the HOV lanes. Based on this experience, the assumption of support for HOV lanes by the cycling public should not be treated as unqualified or automatic.

II-2 <u>VEHICLE OCCUPANCY</u>

One of the fundamental decisions to be made in the planning of an HOV facility is the definition of an "HOV". This requires a balancing of corridor-specific needs and circumstances, the desire for areawide consistency, and elements of strategic operational planning. This is discussed in some detail in Section I-4.5.

Once the decision on eligibility has been made, there is little effect on the design of the lane: only signage and the presence or lack of bus bays are likely to be dependent on the occupancy designation.

It must be kept in mind that the HOV lane operates as such for as little as 20 out of the 168 hours per week; during the other 148 hours it is used by all traffic and the design criteria relating to that situation must also be considered.

II-3 TIME OF HOV DESIGNATION

II-3.1 Time of Day

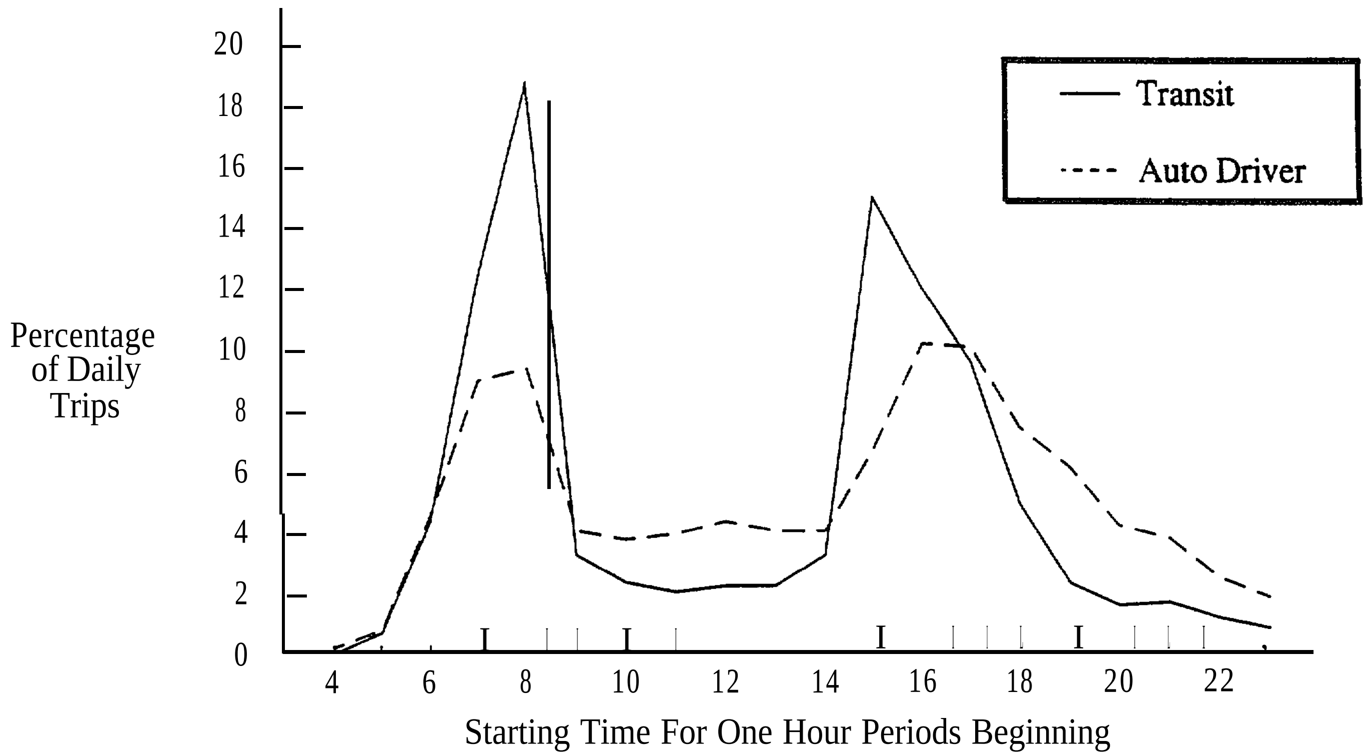
The problems of traffic congestion and inefficient use of the transportation system are essentially peak period problems, occurring morning and evening on weekdays (see Exhibit II-11. In some cases, congestion may occur at other times due to an accident, commercial activity, special events or road work. Also, some severely congested corridors experience travel delays throughout the day. It is important to note that transit use tends to peak much more sharply in the "rush hours" than auto use.

HOV lanes are variable in their timing, in that they need not be restricted to HOV use 24 hours a day. The optimum situation would be the designation of HOV lane restrictions only when congestion is occurring on the roadway. In designated periods, HOVs would receive the benefit of preferential treatment, while at non-congested times there would be no need to segregate HOVs from the rest of the traffic flow. Although the use of variable message signs and road sensors would be capable of achieving this type of system today, the ability to use and implement an areawide system would appear to be a number of years off.

In the absence of the ability to continuously monitor traffic and to make such changes, there are three possibilities:

- designation during peak periods only
- daytime (12 hour) designation
- 24 hour per day designation

A trip using an HOV can occur in any location at any time; the desire for consistency (in order to minimize confusion) and flexibility (to maximize HOV use) would lead to a preference for 24 hour per day HOV lane designation. On the other hand, the need for HOV lanes, as tied to the congestion level of adjacent roads, and competition for use of the roadway for other purposes (loading, parking, mixed flow) indicate that HOV designation during peak periods only should be considered. A compromise between these two alternatives yields the 12 hour per day designation.



SOURCE: TRANSPORTATION TOMORROW SURVEY, 1986
GREATER TORONTO AREA RESIDENTS

HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES *OPERATIONAL PLANNING &; DESIGN GUIDELINES*	**EXHIBIT** II - 1	**TIME OF TRIPMAKING BY MODE**

Of the factors restricting the ability to designate 24 hour HOV lanes, the most serious is the desire (or need) to use the lane for other purposes at times when HOVs do not fully utilize it. This competition is mainly in high density commercial land use areas, where curbside loading (in the Central Area), stopped vehicles (e.g. couriers) and parking also lay claim to the curb lane. This is an issue even when HOVs do not use the curb lane; at least one lane must be kept open for LOVs. This implies the banning of parking, stopping, turning, and loading in the curb lane at all times the HOV lane is in operation, unless at least one lane each for HOVs, LOVs and curb users is available.

Both in design and operation, numerous options exist, and the one which allows the greatest period of designation with the least impact on frontage users should be preferred. In a "worst case" situation, the following options illustrate the combination of physical and operation flexibility which may be available:

- peak period only curb HOV lanes
- one way HOV lane in the peak direction in each peak period
- single interior reversible HOV lane, designated in peak direction only
- 12/24 hour HOV lane with midday permit-only loading
- reconstruction to provide loading bays
- designation of block for HOVs and deliveries only
- interior HOV lane on one way street

In dealing with the issue, the keynote is flexibility. In order to simplify the system to the user, decisions on the time designation for an individual facility should be made in the context of the need for as great an extent of systemwide consistency as possible.

For HOV preferential treatment at parking garages or other ancillary facilities, all-day HOV designation is desirable: at a minimum, reservation of preferred spaces for HOV use should be made until after the incoming peak period.

The use of variable message signs (e.g. "HOVs Only When Light Flashing") may be considered on key recreational routes, to allow HOV lane designation during special events at times outside the recommended core period. Examples would be HOV lanes on roads leading to sports stadiums, fairgrounds, shopping malls (i.e. at Christmas), or other high volume occasional generators.

All of the above criteria referring to maximum and minimum facility usage are for peak hour conditions. Since transit usage normally peaks far more sharply in the morning and afternoon peak periods than does usage of other vehicles, HOV lane usage in off-peak periods may drop below the identified threshold even if peak period usage is very high. It is during these periods that other uses may be considered for the lanes, ranging from service / delivery vehicles to mixed flow traffic. There is also a strong argument to be made for continuing with an HOV lane designation from the start of the morning peak period to the end of the afternoon peak period, irrespective of the volume of off-peak lane usage. This reflects the fact that mixed-flow demand decreases in off-peak periods, thereby eliminating the need to provide any more lanes for it than in the peak period, as well as the strategic desire for systemwide consistency of transit operation.

II-3.2 Day of Week

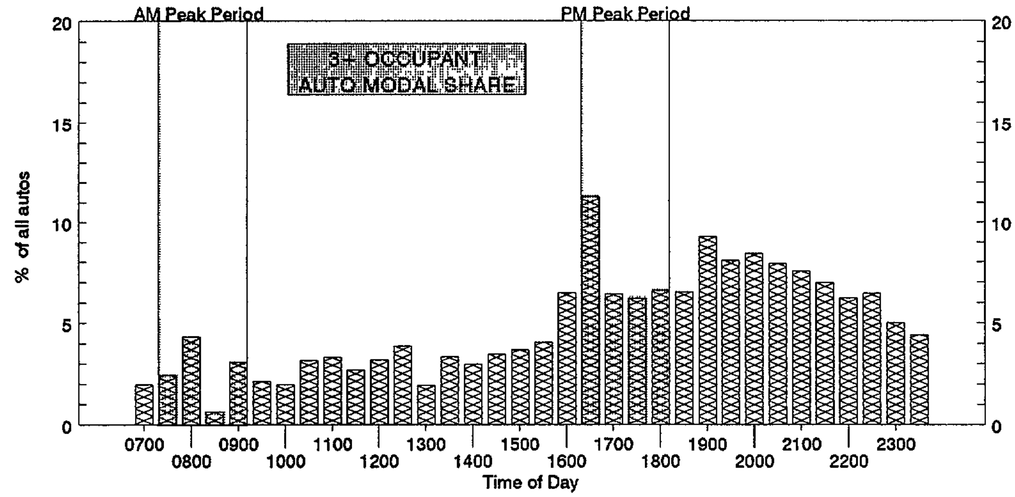
It is a given that HOV lanes be designated as such at least during the Monday - Friday peak periods. The extension of the practice to Saturday and Sunday is less clear. In the absence of typical a.m. and p.m. "rush hours" and the generally reduced level of transit use (and service) on weekends, the need for HOV priority is less apparent. However, Carpools make up a significantly greater proportion of the market on weekends, and many commercial and recreational arteries experience their greatest congestion on Saturdays. Furthermore, situations such as Christmas shopping, regional shopping centres, or a major sporting or entertainment event can generate huge traffic volumes and significant queues on approach roads.

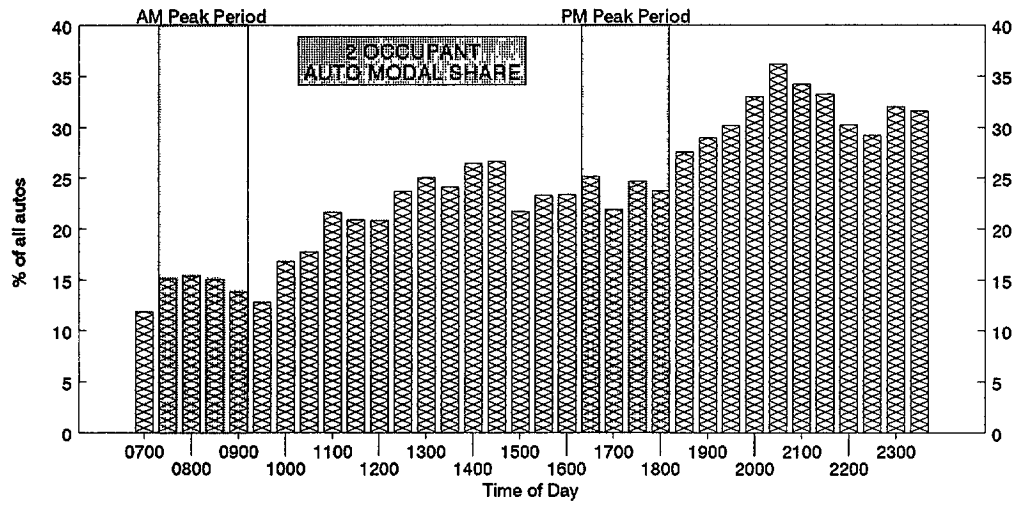
For municipalities which must deal with these situations, consideration of 7 day HOV lane designation is worthwhile. Since weekend peaks do not generally coincide with weekday peak periods, signage and enforcement become key issues. A blanket 6:30 - 9:00 a.m. and 3:30 - 6:30 p.m. designation will not work because those times, although entirely appropriate for Monday - Friday, are mismatched with Saturday needs. There are two approaches available: designate the lane on a 24 hour a day (or at least a 12 hour 6:30 - 6:30) basis; or use variable electronic overhead signs (e.g. "HOVs Only When Flashing") to provide flexibility in communicating the regulations.

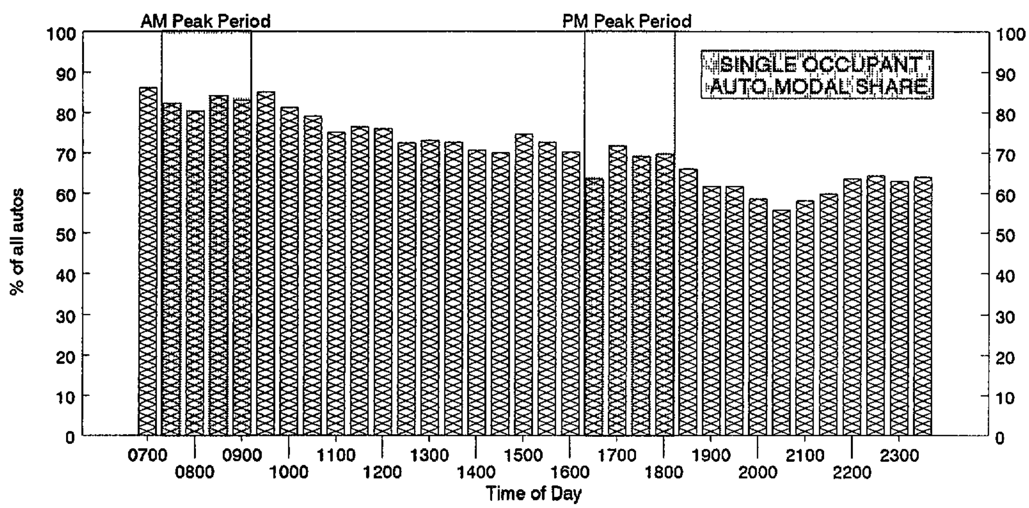
II-4 HOV LANE USAGE CRITERIA

The use of an HOV lane must strike a balance between the maximum number of vehicles per hour which allow it to operate at a desirable Level of Service (i.e. better than the mixed flow alternative) and the minimum number of vehicles which will not only move as many people as the adjacent single occupant auto lane but will be seen by the public to be an effective use of infrastructure. The key to the latter is avoiding the "empty lane syndrome". The upper limit of HOV lane usage is therefore based on vehicular capacity while the lower limit is a mix of vehicular, person-movement, and public perception factors. It is in this respect that HOV lanes are different from, and more complex than, any other arterial road situations.

Carpooling characteristics also tend to vary considerably throughout the day, as illustrated by the "typical" arterial figures for Bathurst Street in York Region (Exhibit II-2). This is significant because of the weight placed on the need to maintain lane usage within a defined range (i.e. not underutilized but not congested). Clearly, both a.m. peak period and p.m. period characteristics need to be considered when minimum or maximum usage is an issue.







data source. Bathurst Street north of Steeles Avenue
Metro Toronto Cordon Count Program, 1991

HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES ***OPERATIONAL PLANNING & DESIGN GUIDELINES***	**EXHIBIT** II - 2	**HOURLY VARIATION OF AUTO OCCUPANCY CHARACTERISTICS**

II-4.1 Maximum Vehicular Capacity

The capacity limit of a lane is based on the maximum number of vehicles that can be accommodated over a set time period. An arterial HOV lane will normally be used by buses and cars, but since buses have different operating characteristics than cars (slower acceleration; possible stops) they affect traffic flow in a lane to a greater extent than their numeric proportion would indicate. In uninterrupted free flow conditions, a bus is the equivalent of 1.5 to 1.6 cars in terms of its effect on vehicular capacity, while on urban streets with frequent on-street bus stops the equivalency factor can range up to 11 or more. (As shown in the following table, adapted from Table 12-8, Highway Capacity Manual, TRB Special Report 209, 1985).

PASSENGER CAR EQUIVALENCY OF URBAN BUSES AT SIGNALIZED INTERSECTIONS (APPLIES WHERE BUSES BLOCK CARS)

Duration of Stop (Sec)	Percentage Green Time on Street with Buses			
	30%	40%	50%	60%
5	2	2	3	3
10	2	3	4	5
15	3	4	5	6
20	4	5	7	8
25	5	6	8	9
30	5	7	9	11
45	8	10	13	15
60	10	13	19	20

NOTE: Computations are based on the following relationship:
Pass. car equivalent per bus =

$$\frac{g}{C} \times \frac{(D+6)}{h}$$

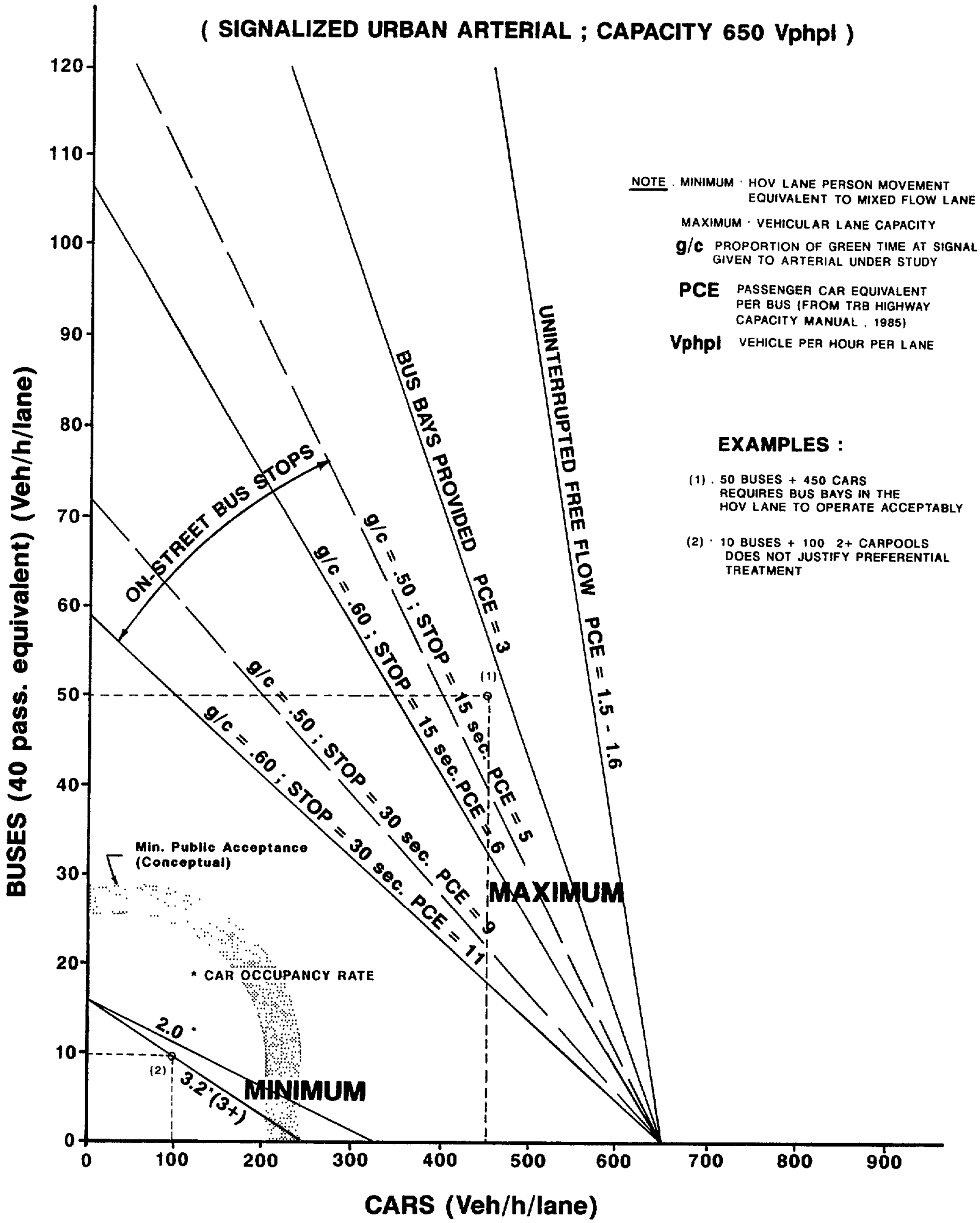
where:

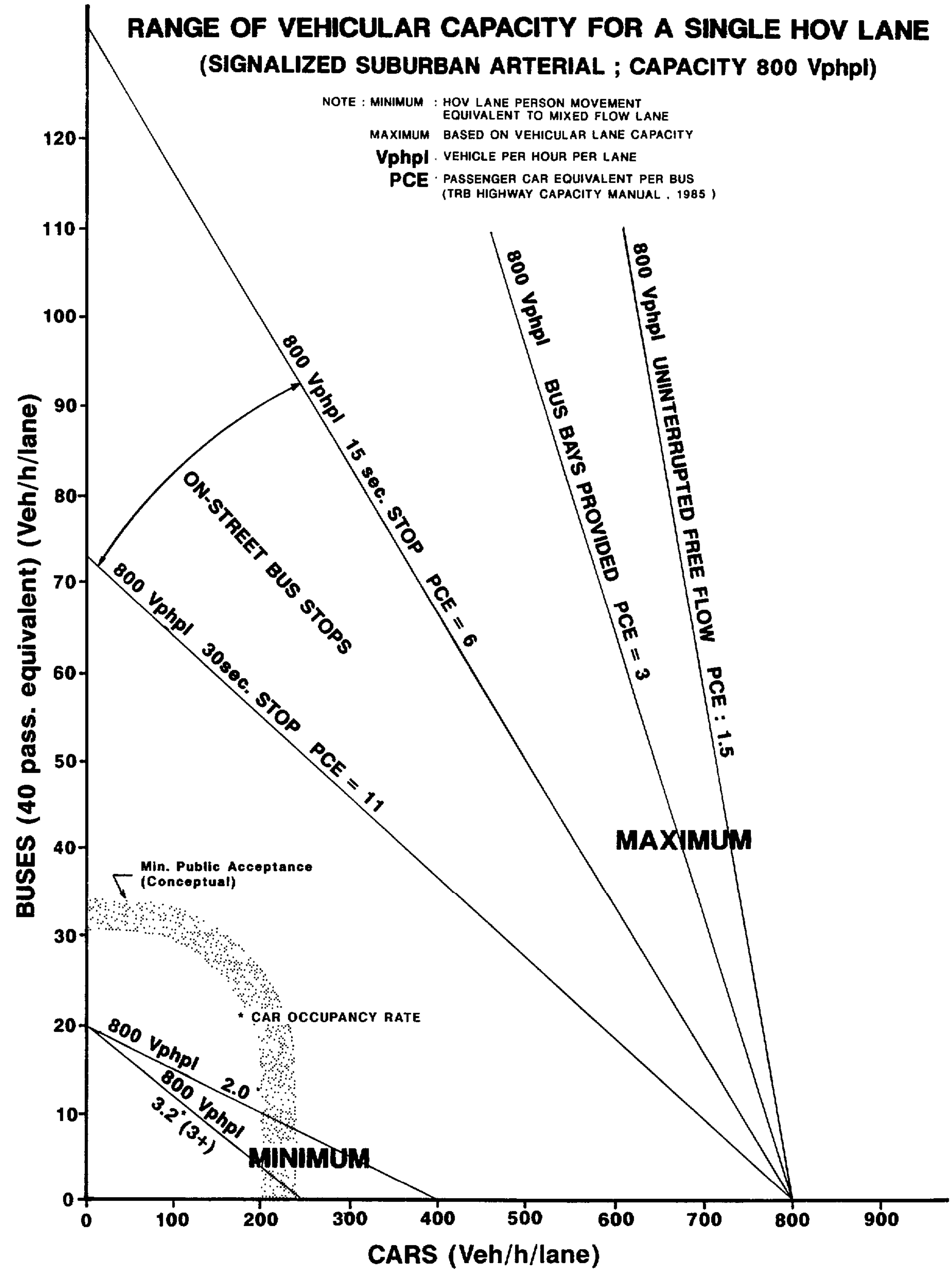
- h = 2 sec per car;
- g/C = green time/cycle ratio;
- 6 = additional time loss due to starting, stopping, and queuing, sec; and
- D = dwell time per bus, sec.

The net result of the capacity analysis for various arterial street types (capacities of 650, 800 and 900 vehicles per hour per lane) are summarized in Exhibits II-3, II-4 and II-5 respectively.

RANGE OF VEHICULAR CAPACITY FOR A SINGLE HOV LANE

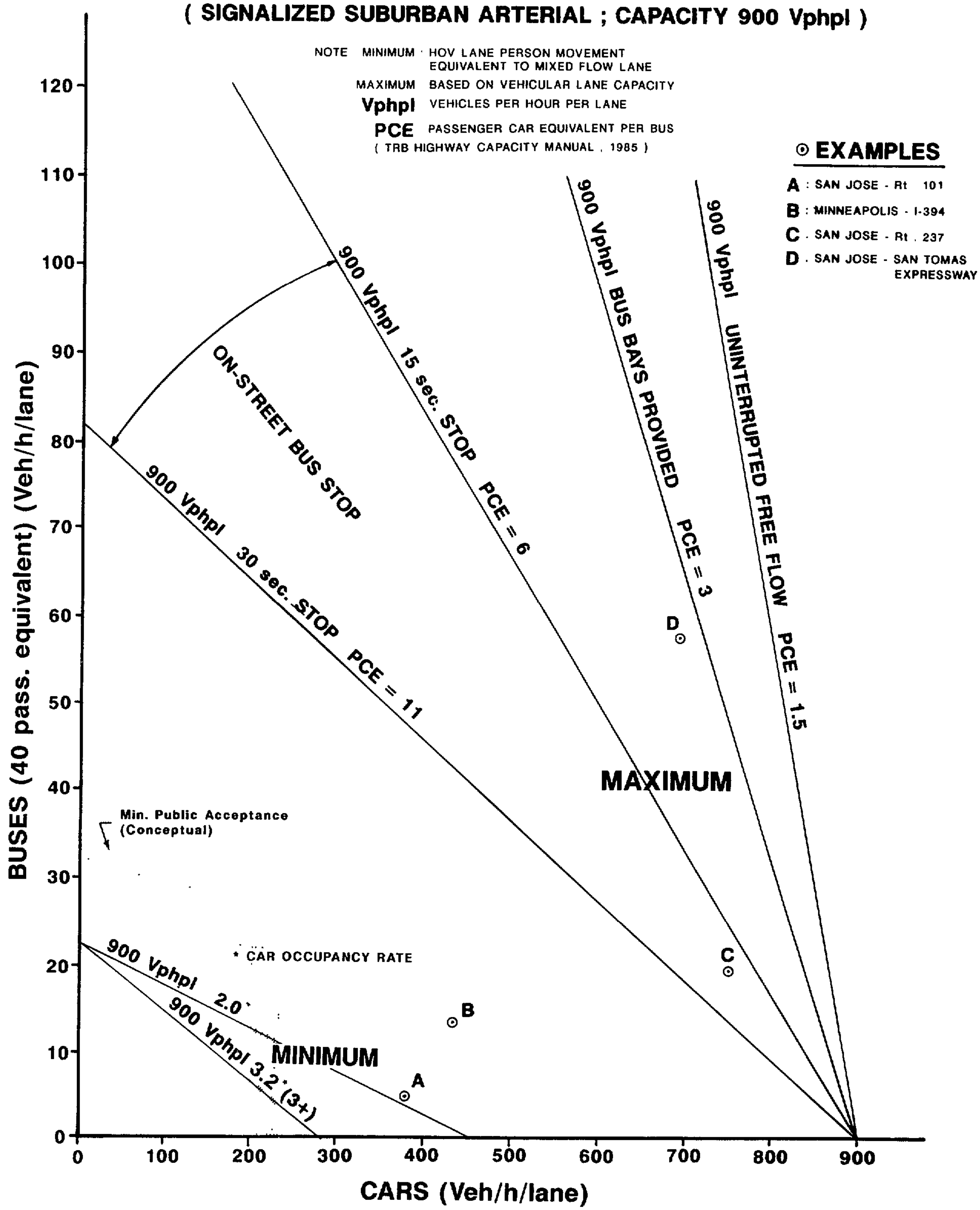
(SIGNALIZED URBAN ARTERIAL ; CAPACITY 650 Vphpl)





HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT II - 4	HOV LANE CAPACITY (II) (800 veh / lane / h arterial)

RANGE OF VEHICULAR CAPACITY FOR A SINGLE HOV LANE
(SIGNALIZED SUBURBAN ARTERIAL ; CAPACITY 900 Vphpl)



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT II - 5	HOV LANE CAPACITY (III) (900 veh / lane / h arterial)

The computed volumes in this section assume an equivalent bus occupancy rate of 40 passengers. This accounts for the potential variety of buses, from paratransit to intercity to articulated types, and an average load factor. If, in considering a particular HOV lane, average bus occupancy rates significantly different than 40 occur, this should be taken into account in assessing usage.

The capacity of an HOV lane will be affected by all of the operational issues which affect flow on any roadway lane, but with particular emphasis on right turning vehicles and bus stops.

II-4.2 Minimum Volume for Viability

A key question that arises in every HOV lane study is that of the definition of the minimum number of vehicles that justifies setting aside an HOV lane. The principle involved is one of making the most efficient use of the available infrastructure - if the HOV lane is going to be carrying only a few people while the adjacent lanes are congested, it can not be considered an effective improvement to the transportation system.

At the one extreme, that of a bus-only lane on an arterial, at least 20 to 24, 40 - passenger equivalent buses would be required to accommodate the trips moved by the 650 (urban) - 800 (suburban) vehicle per hour per lane capacity of a typical arterial roadway. This assumes typical auto occupancy rates of in the order of 1.2 and an average bus ridership of 40 passengers.

On the other hand, an HOV lane could be technically justified to an equivalent degree if there were 400 - 500 two-person Carpools, or 250 - 350 three occupant Carpools in the lane. Exhibits 11-3, 11-4, and II-5 show that there is a line linking the bus-only and Carpool-only situations, above which any combination of the two would be effective. It is important to note that there is no minimum number of buses which is a prerequisite of an effective HOV lane: the lane can be an efficient people-moving facility even when there are 5 or 10 buses per hour, as long as the corresponding car /vanpool volumes are available. Similarly, there is no minimum number of Carpools required if transit vehicles are moving an adequate number of people in the lane.

The role of the community (public, residents, merchants, elected officials, motorists) in setting the “minimum” criteria is very important, for a technically viable solution may not visibly appear to be the most effective use of public funds. There have been cases where HOV lanes have been removed because of a lack of public support, based on there not appearing to be enough users of the lane while adjacent lanes suffered from severe congestion. The minimum usage of an HOV lane which will be supported will vary from corridor to corridor, area to area, and situation to situation. Close consultation with local elected representatives, planners, and community groups should therefore be part of the HOV lane planning effort.

Stemming from general support in Ontario’s urban areas for transit priority measures, the “weight” of bus presence in public perception of HOV lane usage is more significant than its numerical presence: forty buses per hour would likely be accepted as a reasonable level of lane usage whereas one hundred Carpools may not be.

As an approximation of this "public" (non-technical) minimum HOV lane usage criterion, a line has been drawn on Exhibits II-3, II-4 and II-5 based on there being about 200 - 250 vehicles in the lane (i.e. one every 15 - 20 seconds on average, which would ensure that an HOV was always in sight on the lane) for a carpool-oriented facility with few buses, up to a 30 - 40 bus point where the presence of buses is visually compelling and additional Carpools are of little consequence. This line overlaps the "technical" minimum line, and highlights the fact that an HOV lane with 15 buses and 50 Carpools per hour may be technically viable but will likely not be supported by the public.

It is worthwhile noting that the public has been very accommodating of the HOV lane initiatives in and around Metro Toronto to date, and support by elected officials has remained high. The affected lanes, however, carry some of the highest transit vehicular volumes in the province.

It should also be noted that any "minimum" usage criteria may be overridden for strategic reasons (for example, an HOV link in a network that is essential to efficient bus service but relatively unattractive to other HOVs) or if a lane is implemented in anticipation of, or in an effort to shape, future demand or modal split. As discussed in Section I - 4.5.2, this requires acute sensitivity to public and political perception, however, and should only be done in the context of there being an effective Travel Demand Management strategy in place.

Good Utilization of HOV 3+ lane (Yonge Street, North York)

II-4.3 Non-Users, Turning Vehicles, and Violators

HOV lanes do not automatically attract all eligible users: on arterial applications, between 20 and 50% of eligible Carpools typically remain in the adjacent general purpose lanes. Some reasons are:

- drivers are not aware of the HOV lane (not paying attention to signs or signage is inadequate)
- drivers do not understand the HOV lane concept (assume they are bus lanes; novice drivers)
- drivers are unsure of their eligibility (is it the right time of day? are vehicles other than buses eligible?)
- signage is inappropriate (buses and taxis clearly identified while Carpools unclear; intensity / visibility of signs inadequate: pavement markings unclear at night / in rain / snow)
- general purpose lanes are uncongested (the greater the apparent benefit of the HOV lane the greater the likelihood that all eligible vehicles will use it)
- buses slow the HOV lane flow (if no bus bays, the risk of being stopped behind a bus may be greater than moving slowly in the general purpose lane; buses tend to operate at a slower speed than cars)
- Carpools need to make a left turn, or are unsure of where / what direction their upcoming turn is (study in the middle lane for flexibility)
- the lane has a risk of obstruction (parked vehicles, right turn queues, heavy pedestrian volumes, enforcement activities, stopped vehicles (garbage, courier), bus stops, bicycle use, snowbanks, road maintenance work

Nearly all of these issues can and should be dealt with through design, operation, and marketing / education efforts; monitoring and user surveys may help pinpoint particular problems.

On an arterial HOV lane, non-HOVs will in many instances legally use the lane in advance of a right or left turn; this is more an operational and enforcement issue than one of lane utilization.

The final group of HOV lane users is one which should not be there: ineligible vehicles such as single-occupant autos. It is generally understood that the violation rate is to be minimized, just as it is recognized that absolute adherence to the eligibility rules is unrealistic to expect. Violation rates have been quite high on many arterial HOV lane applications in Ontario and elsewhere, but there has been little research done regarding the effect of violation rate on public acceptance and lane viability. To some extent, increased usage of the lane may help counter the “empty lane syndrome” but it is clear that there is a limit to the public’s tolerance of lane misuse. On concurrent flow freeway HOV lanes, US. experience has indicated that a violation rate of in the order of 4 to 10% is that threshold level, and it may be considered that the arterial figure is likely to be somewhat higher due to the acknowledged multitude of uses of the roadway. Therefore, while it has not been the practice to date, it is reasonable to build a 10 to 15% "violation premium" into usage forecasts for arterial HOV lanes to account for the additional (ineligible) non-HOV vehicles which will be using the facility.

II-4.4 Net HOV Lane Usage

When considering the addition of Carpools and Vanpools to the list of HOV-eligible vehicles, the potential HOV lane usage should be the cumulative total determined as follows:

- measurement of eligible HOVs amongst the existing traffic using the facility,
- reduced by a percentage of eligible vehicles that will not use the lane (as discussed in Section 11-4.3)
- increased by HOVs diverted to the preferential lane from adjacent corridors (dependent on the area of influence of the lane and travel patterns),
- increased by the number of new Carpools formed from existing trips (including groups of single-occupant users and those possibly diverted from transit),
- background growth in travel demand, or growth associated with local redevelopment,
- and any increase in transit passenger trips resulting from diverted or more efficient transit operation (such as revised transit routes).

A typical net result would see actual initial HOV usage be 120-140 per cent of the existing HOV's on the roadway, although a much wider variation is possible. As noted in the previous Section, a "violation premium" of IO to 15% could realistically be added to the number of eligible users.

Since these factors depend on the definition of eligible HOVs (i.e. whether two person, three person, or transit only), each possible scenario must be considered. If the usage that results for any particular scenario is in accordance with the HOV application criteria, the scenario which utilizes the lane to the greatest extent should be used.

It is inappropriate to specify a universal minimum demand volume for HOV lane justification. Total volume in a specific lane will depend on both technical and perceptual criteria, on the length of the lane and its role in the transportation system, and on the mix of vehicles using the lane.

The combination of buses and Carpools in the HOV lane that lies between the "minimum" and "maximum" for the particular lane type under review will operate at an acceptable Level of Service and will be effective in moving people. Should the condition arise, considerable flexibility exists in managing demand at both boundaries; some strategies are outlined in Section I-4.5.3.

II-5 ENFORCEMENT

The ability of an HOV lane to function effectively and to achieve its goals depends to a significant extent on the consistent limitation of use of the lane to authorized HOVs only, and on the elimination of interference with lane operation by illegally parked or stopped vehicles. In addition to self-enforcing techniques such as signage, some direct enforcement of this use will be required. Of course, the ability to enforce other "normal" traffic violations (e.g. speeding) on the HOV facility is also required.

It is desirable that violation and enforcement activities do not interfere with HOV operation. These deal with the use of the HOV lane by ineligible vehicles (non-HOVs).

II-5.1 Legislation

A legal basis for the restriction of the facility to HOVs and for penalizing violators must be defined. General practice is to do this under a municipal by-law to establish reserved lanes and control their use. The City of Mississauga's Bylaws 490 - 91 and 14 - 92 covering the Dundas Street West HOV lanes are typical - they establish (a) eligible vehicles (specifying transit, school buses, and private motor vehicles carrying a minimum of three persons), (b) location and times of operation, (c) provision for any entering / exiting vehicle to use the lane within 45 m of the entry / exit point, (d) a ban on stopping vehicles (other than public transit) in the lane during HOV lane operation, and (e) signage.

Some degree of flexibility is appropriate in a by-law establishing an HOV lane, especially regarding the time of operation and the eligibility of different vehicle types, so that operational rules can change in response to traffic needs without going back to change the enabling by-law every time. One example is the Bay Street Urban Clearway in the City of Toronto, in which the pre-existing by-law under which the reserved lanes were designated prohibited non-municipal transit buses from the lane even though the main intercity bus terminal was located on the route. Although no intercity bus was ever charged with illegal use of the lane, the by-law subsequently had to be changed to allow such vehicles.

The establishment of a schedule of penalties for violation of the HOV lane eligibility is also very important. The level of any fines should be high enough to act as a strong deterrent - in California a noticeable drop in the violation rate occurred upon raising the fine from $50 to $250. On Mississauga's Dundas Street HOV lanes-, the $13.75 fine initially levied on violators was viewed as the "cost of business" for many, particularly since there was a relatively low level of enforcement activity. Some benefit may be gained from the posting of the fine amount on the HOV eligibility signage (but only if the fine is large enough that it serves as a deterrent). The loss of points on the provincial drivers' licence for recurrent violation should also be considered. Consideration of developing province-wide or at least areawide consistency in the level and application of fines for ineligible HOV lane users is warranted.

II-5.2 Stationary Violations

Of great importance to the integrity of a curb lane arterial HOV route is the imposition and enforcement of parking and stopping restrictions. The advantages of HOV use are lost and safety problems arise if the HOV lane is blocked by a parked or stopped vehicle and HOVs must merge with LOV traffic to get around the obstacle. In many cases, a stopped or parked vehicle in the HOV lane will cause far greater disruption to lane operation and effectiveness than use of the lane by an ineligible vehicle, and enforcement priorities should reflect this fact.

A policy of immediate towing of parked or stopped vehicles from the HOV lane, and signage to that effect, is required to ensure the lane's operational integrity. Ticketing of illegally parked vehicles alone is insufficient to protect HOV lane operation. In order to accomplish this, additional towing contracts, vehicle impoundment areas close to the affected area, and enforcement manpower would be required.

II-5.3 Moving Violations

Enforcement of moving violations such as speeding, illegal or unsafe turning movements, and other "normal" traffic violations is the responsibility of the local police authority, with the potential for some participation by transit authorities (an example being the Metro Toronto situation, whereby designated TTC staff are capable of ticketing and calling for the removal of illegally parked vehicles in Reserved Bus lanes).

II-5.4 Occupancy Rate Violations

It is impractical on even a physically separated bus-only facility to expect a 100 per cent compliance rate with the HOV regulations. The illegal use of the lane by non-HOVs should be kept to a minimum, and periodic enforcement sweeps may be required in addition to regular patrols to keep the violation rate to a level that does not interfere with HOV operations and is publicly acceptable. Since HOV lanes are normally adjacent to congested unrestricted lanes, the public is generally intolerant of perceived lane misuse, particularly by single-occupant vehicles.

Some potential problems in enforcement of occupancy restrictions include:

- monitoring vehicle occupancy in darkness
- observation of vehicles travelling at high speed
- use of tinted windows in vehicles
- difficulty of detecting small passengers / children
- licensing of HOVs
- use of "dummies" or false passengers
- lack of enforcement facilities
- lack of enforcement effort
- inappropriate fine structure

In the absence of the technological and legal ability to adequately monitor usage electronically, reliance on direct visual enforcement will be required. This places greater emphasis on public acceptance, good lane design, effective signage and lane markings, peer pressure, marketing and disincentives to minimize the number of HOV violators, thereby minimizing the extent of enforcement concerns. In reality, the number of HOV violators with heavily tinted windows or false passengers will be a very small percentage of lane users; the publicity associated with apprehending a violator using inflatable dolls as passengers is likely to be of far greater value to the HOV program than the traffic impact of one or two such vehicles. The tinted window issue, in particular, is of concern in more than HOV circumstances, and should be addressed as a province-wide basis.

In order to overcome problems of darkness, particularly during early or late winter rush hours, strategic well-lit spots for enforcement may be chosen, and intersections where HOVs are stationary for brief periods may also be used.

The licensing of HOVs cannot be effective in monitoring or controlling occupancy for moving HOVs, as a licensed HOV could readily carry fewer than the required number of occupants. If such a vehicle were to be seen using the HOV lane the credibility and public perception of the lane's effectiveness would be significantly affected. Application is limited to HOV parking facilities or barrier-separated controlled-entry facilities, where actual usage may be observed and controlled.

The ability to make a distinction between a licensed vehicle owner and a vehicle operator is a particular concern due to the high number of leased, rented and fleet vehicles. If HOVs are registered and electronically monitored on that basis, potential exists for a registered vehicle driven by a lone occupant to use the HOV lane undetected.

Experiments elsewhere with video monitoring of vehicle occupancy (with citations to be mailed to the registered owner of the vehicle based on the licence plate) hold the promise of catching violators without disrupting traffic flow but satisfactory results have not yet been obtained in prototype application; remote observation of vehicle interiors has not been able to account for reclining persons, children, panel vans, tinted windows, etc. In addition, the privacy issues associated with remote video monitoring have been the subject of public concern whenever the idea is discussed or tried; this would have to be satisfactorily resolved before an extensive monitoring project is launched.

One of the most common violation situations is the use of the HOV lane by an ineligible vehicle to approach a right turn. While the municipal by-law designating the lane for HOV use will normally specify that right turning vehicles may enter the lane immediately upstream of the turn (in Metro Toronto's case, the by-law prohibits use of a regulated lane for more than 46 m (150 feet) by a right turning vehicle) violators may attempt to travel several blocks in the lane with the right turn signal on. This is especially common on the approaches to a major congested intersection. The resulting delay to transit vehicles due to queues of unauthorized turning cars (particularly if there are heavy pedestrian moves across the intersection) can negate many of the benefits of an HOV lane's person-moving capacity and cause safety concerns as well. Of note, however, is that this limit or restriction has not traditionally been communicated to the public, and it is common to see motorists turning at the last minute from the centre (LOV) lane in order to avoid using the right curb HOV lane. This situation is not satisfactory, and although the 46 m distance is appropriate, it is recommended that either one or both of the following be considered:

- a differentiation in the lane marking on the approach to an intersection such as using a single white dashed line rather than the basic double dash lane separator (in much the same way as the Ministry of Transportation changes the dashed line width on the approaches and exits at freeway interchanges);
- signage to the effect of “right turns only - HOVs excepted” in advance of intersections.

On a roadway with numerous driveways or mid-block commercial entrances, the ability to use lane marking differentiation is lost, and concentration instead of a communications strategy targeting all motorists, including information signage on the HOV route and highlighting the issue in marketing materials, may be required.

II-5.5 Enforcement Facilities

It is extremely important that the enforcement of HOV lane regulations does not itself result in disruption to HOV operation. On roadways where there are limited opportunities to stop vehicles out of the travelled way, the provision of setback or designated enforcement areas is required. The maximum enforcement impact occurs if the enforcement is visible to roadway users. This benefit outweighs the potential disruption to traffic flow caused by “rubber neckers”; the enforcement facility should be linked to the HOV lane where possible.

On a downtown short-block urban street HOV violators should be pulled over to a side street. Provision of enforcement zones (for example, removal of the parking spot nearest the HOV lane) on side streets may be considered. In long-block suburban arterials, enforcement bays should be provided if there are not cross street opportunities within one kilometre. An extended bus bay could function as an enforcement facility, but the areas should not, however, occupy a scheduled transit bay, as this would force buses to stop in the lane, creating safety and operations problems. Since they are private property, retail plaza parking lots should not be considered for use in pulling aside violators.

These enforcement areas can also be utilized for violators in the mixed-flow lanes, if the HOV lane is accessible from the mixed flow lanes. Another potential role of HOV enforcement areas (and one which could play a part in their location) is in “RIDE” program use for impaired driving checkpoints.

Vehicles involved in a minor accident in or affecting the HOV lane should be removed immediately to the nearest enforcement area. Increased enforcement of towaway conditions to clear HOV lanes of parked cars implies the provision of adequate impoundment areas for towed cars. Consultation with enforcement agencies and towing operators should establish the extent of the need for pounds.

Design features which act to reduce the likelihood of inadvertent (as opposed to intentional) violation occurring in the HOV lane include the provision of right turn lanes or elimination of right turns at major intersections, effective signage and pavement markings, elimination of curbside parking, and separation of the lane from adjacent lanes by a barrier or buffer strip.

II-5.6 Other Enforcement Techniques

Advances in enforcement technology and practice offer the potential for less disruptive and more effective targeting of moving violations. Removal of parked and stopped vehicles blocking arterial lanes will continue to rely on towing, but use of HOV lane by ineligible vehicles may be deterred by:

- ticketing by mail of vehicle owners through observation of licence plates:
- remote photography / video of vehicles and licence plates:
- roadside posting of fines for ineligible vehicles;
- electronic monitoring of vehicle eligibility through in-road sensing of registered HOVs; and
- Public violation report "HERO" telephone line (capable of warnings only).

Use of these techniques may significantly reduce the need for enforcement areas on roadways: the corollary is that, if an enforcement area can not be provided, use of these techniques may be required for the HOV lane to be enforceable.

It should be noted that the use of photo - radar is being initiated by the Ontario Provincial Police on provincial highways for speed enforcement: further application of the principle may depend on the results of the pilot project. Potential difficulties arise in applying remote enforcement techniques to HOV situations, including the overlooking of small children in a car, the difficulty in discerning vehicle occupancy in darkness, observing panel vans and cars with heavily tinted windows, and making the distinction between a vehicle owner and a vehicle operator. This latter factor is a particular concern due to the high number of leased, rented, and fleet vehicles, although a shift towards making the owner responsible for paying fines has been made.

Regarding video enforcement of vehicle occupancy, this had been a subject of much research and no effective system has been developed to date. However, peer enforcement through phoning in the licence plate number of violators has been demonstrated to be effective elsewhere, and has some merit in supplementing the active police enforcement program, and in involving all motorists in ensuring that the rules of the road are followed.

One hybrid approach used in certain U.S. jurisdictions is the observation of a lane by an enforcement officer, with ineligible vehicles noted either in writing or by tape recording: a citation is then mailed to the vehicle owner, whose name can be traced through a licence plate search.

Special funding (as part of the HOV lane project budget) to allow a concentrated enforcement effort to occur for the first several months of operation of each new HOV lane should be set aside. Subsequent enforcement effort can focus on occasional "sweeps" as part of the ongoing traffic police work.

In reality, the most effective enforcement technique is public awareness, acceptance, and support for HOV lanes as generated through advertising, visibly successful HOV operation, high-profile enforcement, and peer pressure. The ultimate goal is to have the HOV facility become a self-enforcing component of the transportation system.

II-5.7 Public Involvement in HOV Lane Enforcement ("HERO" Program)

Public awareness of the impact of HOV lane violation should be fostered through the HOV marketing and education strategy; one approach that may be suggested is to refer, not to a "violation rate" (of perhaps 1 O%), but to a "compliance rate" - i.e. the percentage of people of the roadway who are complying with the HOV designations, including non-HOV traffic which uses the non-HOV lanes; the "compliance rate" is likely to be closer to 98%, which presents HOV in a much more positive light.

Perhaps the most successful supplementary method of occupancy monitoring and enforcement (and by extension public involvement and awareness) to date has been Seattle's HERO program. A telephone hotline (XXX-HERO) is advertised on HOV routes, with motorists advised to phone in the licence plate number of any vehicle observed to be violating the HOV lane occupancy restrictions. Although incapable of producing a citation, there is a strong follow-up procedure which has been effective in reducing HOV violations. A first incident results in a brochure and note explaining the HOV system being mailed to the violator; a second observation generates a personal letter from the Transportation Department; a third incident results in a letter from the State Police noting that the violator's licence plate is on a list of habitual violators who will be targeted for observation (since most violators are recurring incidents by commuters who travel constant routes). Apart from violation rates being reduced by one-third, of significant value is the program's generation of public support for compliance and the ability of non-HOV users to contribute to HOV enforcement; the hotline handles over 1,000 reports per month in Seattle. The program is now being duplicated elsewhere (and is being considered for Metro Toronto), but would require additional funding and manpower for any existing agency to operate effectively.

The introduction of such a non-traditional enforcement program may face limited initial public. / political support: however, its proven success elsewhere and the potential benefits of expanding the enforcement ability of a concurrent flow arterial lane HOV network (which is inherently difficult to enforce) indicates that serious consideration of the method is warranted. Limited application in a pilot project form would be an appropriate means of assessing the viability of a phone-in enforcement program.

SECTION III: OPERATIONAL DESIGN GUIDELINES FOR ARTERIAL HOV LANES

This section of the document deals with the preliminary design features of HOV lanes on urban arterial roadways in Ontario municipalities. The design of related facilities such as Carpool parking lots is dealt with in other reports (AASHTO Design Manual, various municipal standards), while the possible treatments for HOVs at interchanges between freeways and arterial roads are dealt with in the Ministry of Transportation of Ontario report, "Operational Design Guidelines for HOV Lanes on Ontario Provincial Freeways" (Surveys and Design Office, May 1993).

III-I ROADWAY TYPES

For the purposes of the current document, "Urban Arterials" are referred to as major multi-lane streets where the adjacent land use is predominately business and commercial. Development is normally carried to the edge of the road allowance. Signalized intersection at an average spacing of more than 3 per kilometre, and short block lengths of less than 350 m characterize "Urban Arterials".

Also, traffic volumes are high and the transit modal split typically ranges up to 70 percent of all person trips on this type of roadway.

Suburban arterials are defined, for the purpose of the current study, as major multi-lane roadways which access predominantly residential and industrial land. Buildings are normally set back from the road allowance. Signalized intersection spacing is greater than that of "Urban Arterials". In most cases, access points are limited. Traffic volumes are generally high at peak hours, and the 24 hour transit modal split is generally in the IO to 30 per cent range.

III-2 HOV LANES ON ROADWAY SEGMENTS

Roadways used in whole or in part by HOVs can have many combinations of physical and operating characteristics. They may be one way, two way, with median, without median, and have any number of lanes. Where specific lanes are reserved for HOV use, they may be curb, interior, or inside lanes.

HOV lanes may operate as single or as twin lanes flowing in opposite directions. They can be concurrent, contraflow, or reversible. The HOV designation can be on a 24 hour, 12 hour, or peak period basis.

There are several HOV design guidelines which are applicable to all HOV treatments. These are:

1. **Constructing a new lane for HOV use is more expensive than pre-empting an existing one from mixed traffic use.**

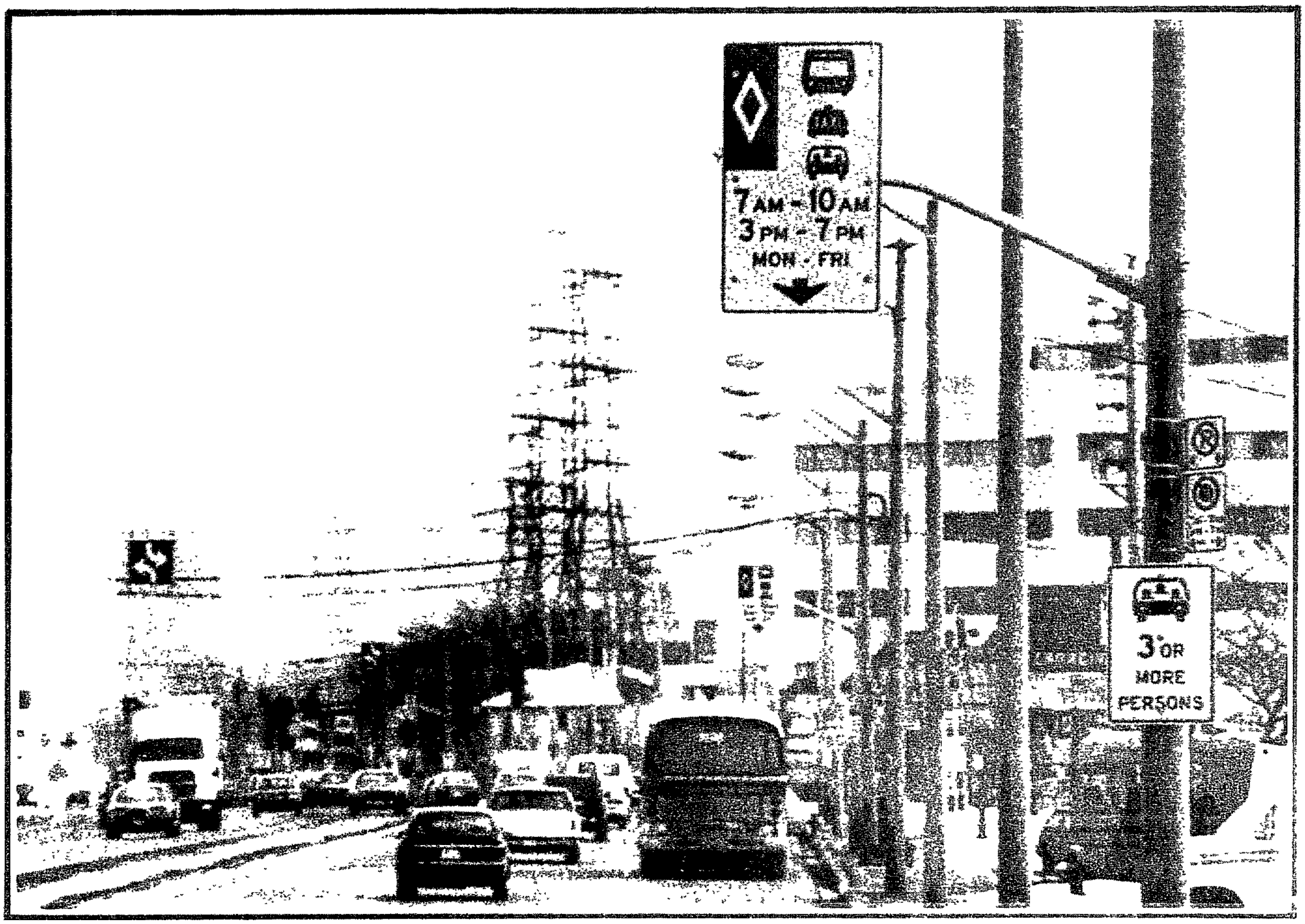
2. **Restriping can be used to add an additional lane if it does not decrease the widths of the existing lanes to less than acceptable standards.**

3. An HOV lane should be no narrower than the adjacent mixed flow lanes, with a desired standard width of 3.75 m. Due to the use of HOV lanes by buses, a lane width of less than 3.5 m is unacceptable. If the lane is to be used as a bicycle facility as well, it should be at least 4 m wide.

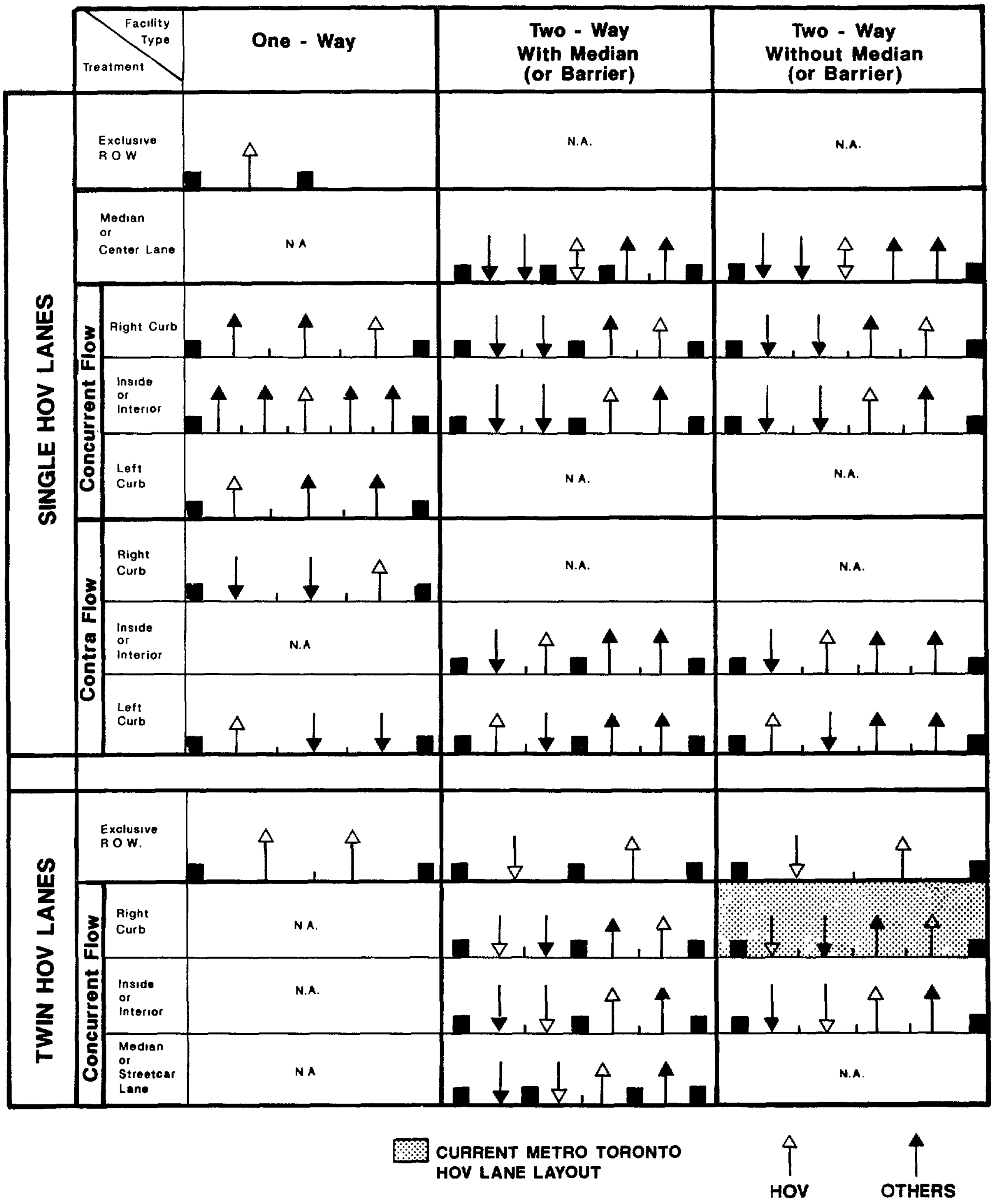
4. Reversible lanes are applicable to corridors who have a peak directional split greater than 65 peak / 35 non-peak.

The many possible lane configurations are illustrated in matrix form in Exhibit III-l, while the following Exhibit III-2 summarizes key specific guidelines pertaining to individual HOV combinations.

The guidelines in the table deal only with cross-sectional design issues on isolated segments. Other design issues such as intersection treatments, access / egress points and signage will be dealt with in subsequent sections.



HOV 3+ Lane, Dundas Street West, Etobicoke, Ontario



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 1	ARTERIAL STREET HOV LANE CROSS SECTION ALTERNATIVES

<table>
<tr><th colspan="3">FACILITY TYPE / TREATMENT</th><th>One-Way</th><th>Two-Way
With Median
(or Barrier)</th><th>Two-Way
Without Median
(or Barrier)</th></tr>
<tr><td rowspan="9">SINGLE HOV LANES</td><td colspan="2">Exclusive R.O.W.</td><td>AN ADJACENT SHOULDER MUST BE PROVIDED
BUS BAYS MUST BE PROVIDED IF USED BY LOCAL TRANSIT
MINIMUM NUMBER OF LANES REQUIRED 1</td><td>N.A</td><td>N.A</td></tr>
<tr><td colspan="2">Median or Centre Lane</td><td>N.A</td><td>*NOTE APPLICABLE ONLY TO SUBURBAN ARTERIALS
AN ADJACENT SHOULDER MUST BE PROVIDED
BUS BAYS MUST BE PROVIDED
IF USED BY LOCAL TRANSIT
MINIMUM NUMBER OF LANES REQUIRED 3</td><td>LANE SEPARATION
a) WITH FLOW TRAFFIC DESIRABLE 0 6m BUFFER
MINIMUM - S W S
b) AGAINST FLOW TRAFFIC DESIRABLE 0 6m BUFFER
MINIMUM O S Y S
PASSENGER LOADING PLATFORMS MUST BE PROVIDED
AT BUS STOPS IF USED BY LOCAL TRANSIT
MINIMUM NUMBER OF LANES REQUIRED 3</td></tr>
<tr><td rowspan="3">Concurrent Flow</td><td>Right Curb</td><td>LANE SEPARATION DESIRABLE 0 6m BUFFER
MINIMUM - B W L
BUS BAYS MUST BE PROVIDED IF USED BY LOCAL TRANSIT
PARKING & LOADING ARE PROHIBITED
IN RIGHT CURB LANE
RIGHT TURNS ARE PROHIBITED
IN THE RIGHT CURB LANE
MINIMUM NUMBER OF LANES REQUIRED 2</td><td colspan="2">LANE SEPARATION DESIRABLE - 0 6m BUFFER
MINIMUM B W L
BUS BAYS MUST BE PROVIDED IF USED BY LOCAL TRANSIT
PARKING & LOADING ARE PROHIBITED IN RIGHT CURB LANE
RIGHT & LEFT TURNS ARE PROHIBITED IN THE RIGHT LANES
WITH THE PROVISION OF AN INTERIOR RIGHT LOV LANE LEFT TURNS ARE PERMITTED
MINIMUM NUMBER OF LANES REQUIRED 3</td></tr>
<tr><td>Inside or Interior</td><td>LANE SEPARATION DESIRABLE - 0 6m BUFFER
MINIMUM B W L
PASSENGER LOADING PLATFORMS MUST BE PROVIDED
AT BUS STOPS IF USED BY LOCAL TRANSIT
MINIMUM NUMBER OF LANES REQUIRED 2</td><td colspan="2">LANE SEPARATION DESIRABLE 0 6m BUFFER
MINIMUM B W L
PASSENGER LOADING PLATFORMS MUST BE PROVIDED AT BUS STOPS IF USED BY LOCAL TRAFFIC
PARKING & LOADING ARE PROHIBITED IN RIGHT CURB LANE
- RIGHT & LEFT TURNS ARE PROHIBITED IN RIGHT CURB LANE
WITH THE PROVISION OF AN INTERIOR RIGHT LOV LANE RIGHT TURNS ARE PERMITTED
MINIMUM NUMBER OF LANES REQUIRED 3</td></tr>
<tr><td>Left Curb</td><td>LANE SEPARATION DESIRABLE 0 6m BUFFER
MINIMUM B W L
PASSENGER LOADING PLATFORMS MUST BE PROVIDED
AT BUS STOPS IF USED BY LOCAL TRANSIT
PARKING & LOADING ARE PROHIBITED
IN LEFT CURB LANE
- LEFT TURNS ARE PROHIBITED
IN THE LEFT CURB LANE
MINIMUM NUMBER OF LANES REQUIRED 2</td><td>N.A</td><td>N.A</td></tr>
<tr><td rowspan="3">Contra Flow</td><td>Right Curb</td><td>LANE SEPARATION DESIRABLE - BARRIER
MINIMUM - 0 6m BUFFER
BUS BAYS MUST BE PROVIDED IF USED BY LOCAL TRANSIT
PARKING & LOADING ARE PROHIBITED
IN RIGHT CURB LANE
MAY INCREASE PEDESTRIAN ACCIDENT RATE
RIGHT & LEFT TURNS ARE PROHIBITED
IN THE RIGHT CURB LANE
SPECIALIZED TREATMENT OF ENTRY/EXIT POINTS
MINIMUM NUMBER OF LANES REQUIRED 2</td><td>N.A</td><td>N.A</td></tr>
<tr><td>Inside or Interior</td><td>N.A</td><td colspan="2">LANE SEPARATION DESIRABLE - BARRIER
MINIMUM - 0 6m BUFFER
PASSENGER LOADING PLATFORMS MUST BE PROVIDED AT BUS STOPS IF USED BY LOCAL TRANSIT
PARKING & LOADING ARE PROHIBITED IN LEFT LANES
LEFT TURNS ARE PROHIBITED IN RIGHT LANES
MAY INCREASE PEDESTRIAN ACCIDENT RATE
RIGHT & LEFT TURNS ARE PROHIBITED IN LEFT LANES
WITH THE PROVISION OF A SECOND SAME DIRECTION LOV LANE LEFT & RIGHT LOV TURNS MAY BE PERMITTED
IN LEFT LANES
MINIMUM NUMBER OF LANES REQUIRED 3</td></tr>
<tr><td>Left Curb</td><td>LANE SEPARATION DESIRABLE BARRIER
MINIMUM - 0 6m BUFFER
PASSENGER LOADING PLATFORMS MUST BE PROVIDED
AT BUS STOPS IF USED BY LOCAL TRANSIT
PARKING & LOADING ARE PROHIBITED
IN LEFT CURB LANE
MAY INCREASE PEDESTRIAN ACCIDENT RATE
RIGHT & LEFT TURNS ARE PROHIBITED
IN THE LEFT CURB LANE
SPECIALIZED TREATMENT ENTRY/EXIT POINTS
MINIMUM NUMBER OF LANES REQUIRED 2</td><td colspan="2">LANE SEPARATION DESIRABLE BARRIER
MINIMUM - 0 6m BUFFER
PASSENGER LOADING PLATFORMS MUST BE PROVIDED AT BUS STOPS IF USED BY LOCAL TRANSIT
PARKING & LOADING ARE PROHIBITED IN LEFT LANES
LEFT TURNS ARE PROHIBITED IN RIGHT LANES
RIGHT & LEFT TURNS ARE PROHIBITED IN LEFT LANES
WITH THE PROVISION OF A SECOND SAME DIRECTION LOV LANE LEFT & RIGHT LOV TURNS MAY BE PERMITTED
IN LEFT LANES
- MAY INCREASE PEDESTRIAN ACCIDENT RATE
- SPECIALIZED TREATMENT ENTRY/EXIT POINTS
MINIMUM NUMBER OF LANES REQUIRED 3</td></tr>
<tr><td rowspan="4">TWIN HOV LANES</td><td colspan="2">Exclusive R.O.W.</td><td>LANE SEPARATION DESIRABLE 0 6m BUFFER
MINIMUM D S Y S
PARKING & LOADING ARE PROHIBITED
IN BOTH LANES
MINIMUM NUMBER OF LANES REQUIRED 2</td><td>A SHOULDER MUST BE PROVIDED FOR EACH LANE
BUS BAYS MUST BE PROVIDED IF USED BY LOCAL TRANSIT
PARKING & LOADING ARE PROHIBITED
IN BOTH LANES
RIGHT & LEFT TURNS ARE PROHIBITED
IN EACH LANE
MINIMUM NUMBER OF LANES REQUIRED 2</td><td>LANE SEPARATION DESIRABLE - 0 6m BUFFER
MINIMUM - D S Y S
BUS BAYS MUST BE PROVIDED IF USED BY LOCAL TRANSIT
A SHOULDER MUST BE PROVIDED FOR EACH LANE
RIGHT & LEFT TURNS ARE PROHIBITED
IN BOTH LANES
MINIMUM NUMBER OF LANES REQUIRED 2</td></tr>
<tr><td rowspan="3">Concurrent Flow</td><td>Right Curb</td><td>N.A</td><td colspan="2">LANE SEPARATION DESIRABLE - 0 6m BUFFER
MINIMUM - B W L
BUS BAYS MUST BE PROVIDED IF USED BY LOCAL TRANSIT
PARKING & LOADING ARE PROHIBITED IN BOTH CURB LANES
RIGHT & LEFT TURNS ARE PROHIBITED IN ALL LANES
WITH THE PROVISION OF ANOTHER SAME DIRECTION LOV LANE LEFT TURNS MAY BE PERMITTED IN
RIGHT & LEFT INSIDE LANES
MINIMUM NUMBER OF LANES REQUIRED 4</td></tr>
<tr><td>Inside or Interior</td><td>N.A</td><td colspan="2">LANE SEPARATION DESIRABLE - 0 6m BUFFER
MINIMUM - B W L
PASSENGER LOADING PLATFORMS MUST BE PROVIDED AT BUS STOPS IF USED BY LOCAL TRANSIT
PARKING & LOADING ARE PROHIBITED IN BOTH CURB LANES
RIGHT & LEFT TURNS ARE PROHIBITED IN ALL LANES
WITH THE PROVISION OF A SECOND SAME DIRECTION LOV LANE RIGHT TURNS MAY BE PERMITTED
IN RIGHT & LEFT CURB LANES
MINIMUM NUMBER OF LANES REQUIRED 4</td></tr>
<tr><td>Median or Streetcar Lane</td><td>N.A</td><td>LANE SEPARATION DESIRABLE 0 6m BUFFER
MINIMUM O S Y S
PASSENGER LOADING PLATFORMS MUST BE PROVIDED
AT BUS STOPS IF USED BY LOCAL TRANSIT
PARKING & LOADING ARE PROHIBITED
IN BOTH CURB LANES
RIGHT & LEFT TURNS ARE PROHIBITED IN ALL LANES
WITH PROVISION OF ANOTHER SAME DIRECTION
LOV LANE RIGHT TURNS MAY BE PERMITTED
IN THE RIGHT CURB LANES
MINIMUM NUMBER OF LANES REQUIRED 4</td><td>N.A</td></tr>
</table>

NOTE B W L BROKEN WHITE LINE
O S Y S DOUBLE SOLID YELLOW STRIPE
N A - NOT APPLICABLE

HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 2	DESIGN ISSUES FOR ARTERIAL HOV LANE ALTERNATIVES

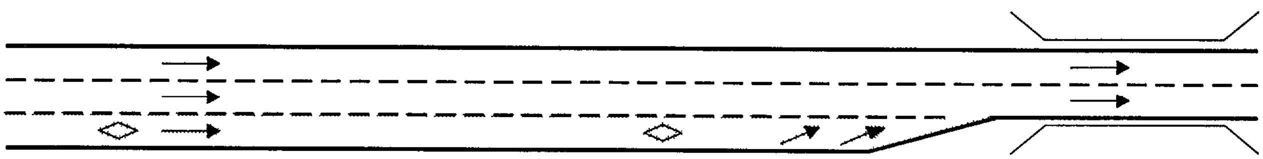
III-3 QUEUE BYPASSES

Recurring congestion in many urban areas is limited to isolated or unique locations such as a narrow bridge or tunnel approach, a freeway entry ramp, the approach to a toll plaza, an awkward intersection, or a lane drop. In addition, there may be many cases where provision of an HOV lane running the length of a major arterial is not physically or operationally feasible.

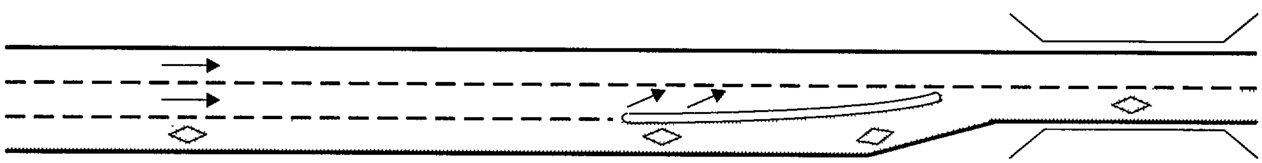
Short HOV "queue bypass" lanes can be very effective in these situations and can play an important role in easing HOV movement and (in combination with other HOV priority measures) contributing to overall HOV travel time savings.

The Ministry of Transportation of Ontario is planning to implement HOV bypass lanes at its future metered freeway entry ramps; designs for this type of queue bypass are detailed in the report *"Operational Design Guidelines for HOV Lanes on Ontario Freeways"*, (MTO, 1993).

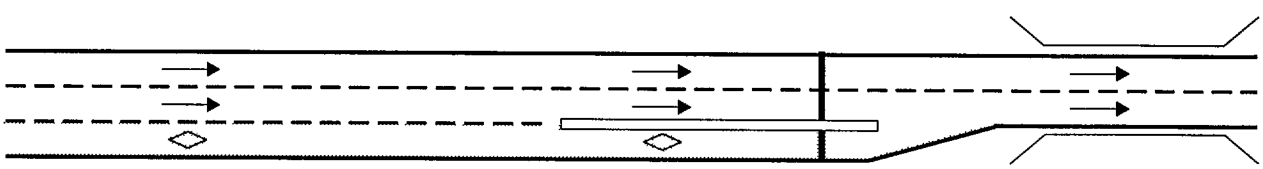
Queue bypasses on arterial roads can take the form of priority treatment at signalized intersections (see Section III-4) or the physical provision of a lane of adequate length to allow HOVs to flow past a regular, recurring queue.



LANE DROP - HOV LANE



LANE DROP - MIXED FLOW LANE



LANE DROP - HOV SIGNAL PRIORITY or METERED FLOW

III-4 INTERSECTION TREATMENTS

Depending on the type of HOV lane (right curb, median, reversible, etc.) the treatment of turning moves at intersections can be critical to the successful operation (or even feasibility) of the lane; the queuing which occurs at signalized intersections is also the location of greatest potential HOV time savings. Applying the principle of HOV priority corresponds in most cases to placing restrictions on non-HOV turning moves. Those restrictions range from the outright banning of turns to the joint use of a lane by HOVs and turning vehicles (both HOVs and LOVs). If an operationally feasible solution cannot be found, grade separation of the through move or of the HOV lane(s) is not out of the question.

Intersection operations involving HOV lanes are discussed first in the more constrained four lane context, then in the flexible six (or more) lane setting. Most of the following comments would also apply to a mid-block entrance or minor tee intersection, with appropriate site-specific considerations.

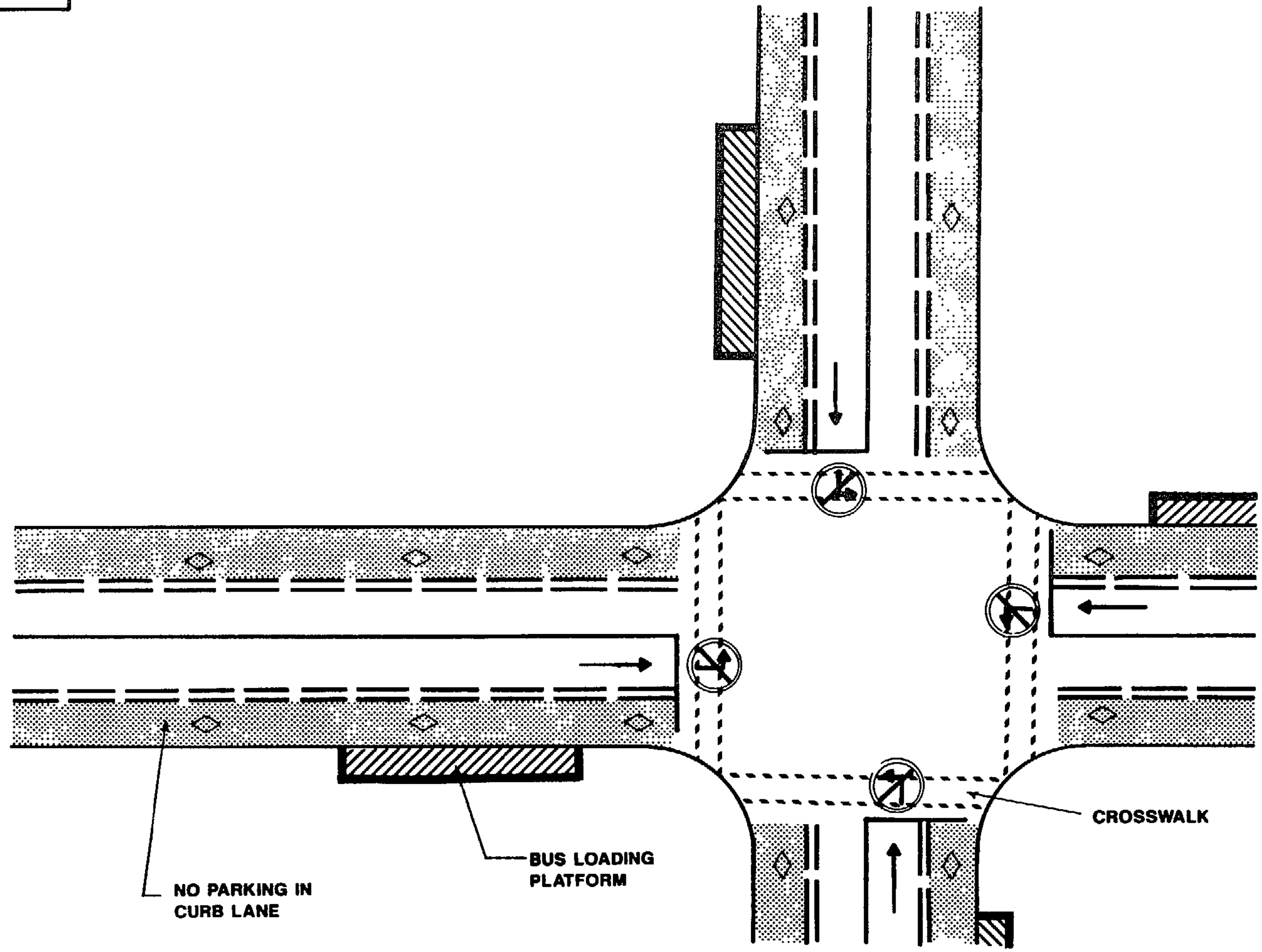
III-4.1 Four Lane Approach

The application of HOV or Reserved Bus Lanes to a four lane street will have significant implications for intersection operations. For example, in the case of curb HOV lanes on a 4 lane two-way street with or without median, only one lane in each direction remains for mixed flow, from which neither right nor left turns may be allowed during times of HOV lane operation. The addition of exclusive left turning lanes / bays would allow left turns to occur, but detailed operational review would be required to determine whether right turns could occur from the HOV lane or from a separate right turn lane without significant impact on HOV lane users. If a left turn lane / bay is not physically feasible, the ability to implement an HOV lane on a four lane roadway without compromising the effectiveness of the whole road network may be in question. Exhibits III-3 and III-4 illustrate such a case, with Exhibit III-3 showing a “most restricted” situation whereby a left turning vehicle and a stopped bus could completely block the traffic flow if turns were not banned. If right turns are problematic due to pedestrian movement, the provision of a right turn bay and / or a far side bus stop (per Exhibit III-4) may help accommodate bus needs. The restriction of the HOV lane’s use to buses or HOV 3 + vehicles only can also help reduce the risk of HOV lane blockage by right turning vehicles (short of an outright ban on right turns).

A “tidal flow” lane arrangement is one way of dealing with such a situation, whereby an HOV lane, a through lane, and a combined through / left turn lane is provided in the peak direction, with a single through / right turn lane only in the non-peak direction. This, however, poses its own operational concerns.

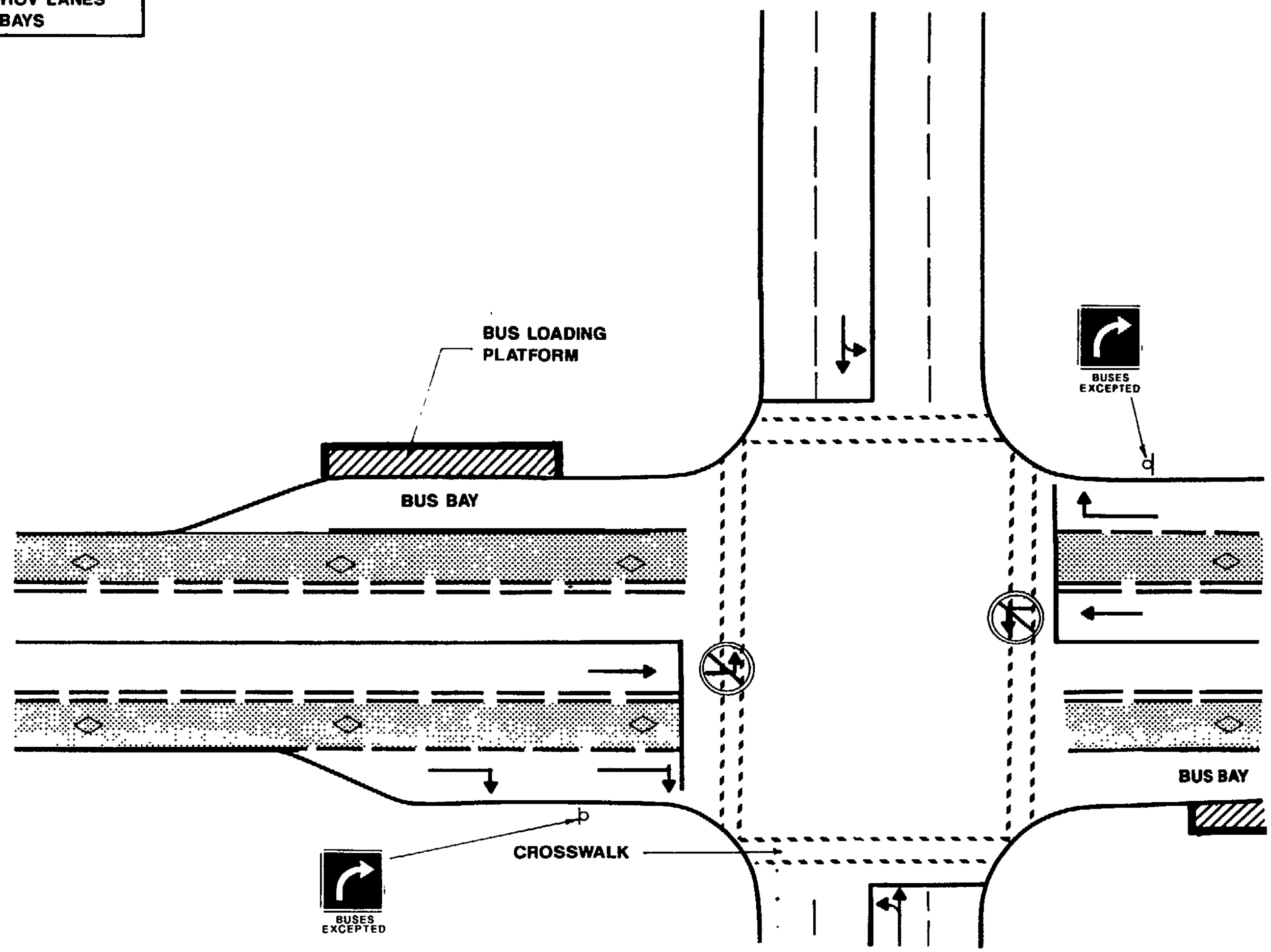
If the left lane is designated as the HOV lane or if a reversible median HOV lane is applied, it is again the left turns which are problematic in a four lane roadway. As shown in Exhibit III-5, left turns would need to be banned outright unless a turning bay were to be provided. The option exists in such a case for a streetcar-style island loading platform for buses, although such an unusual and permanent facility would only be applicable for a 24-hour reserved lane with a major bus orientation (and preferably in a city such as Toronto where motorists are already familiar with in-road loading platforms).

URBAN ARTERIAL CONCURRENT RIGHT CURB HOV LANES



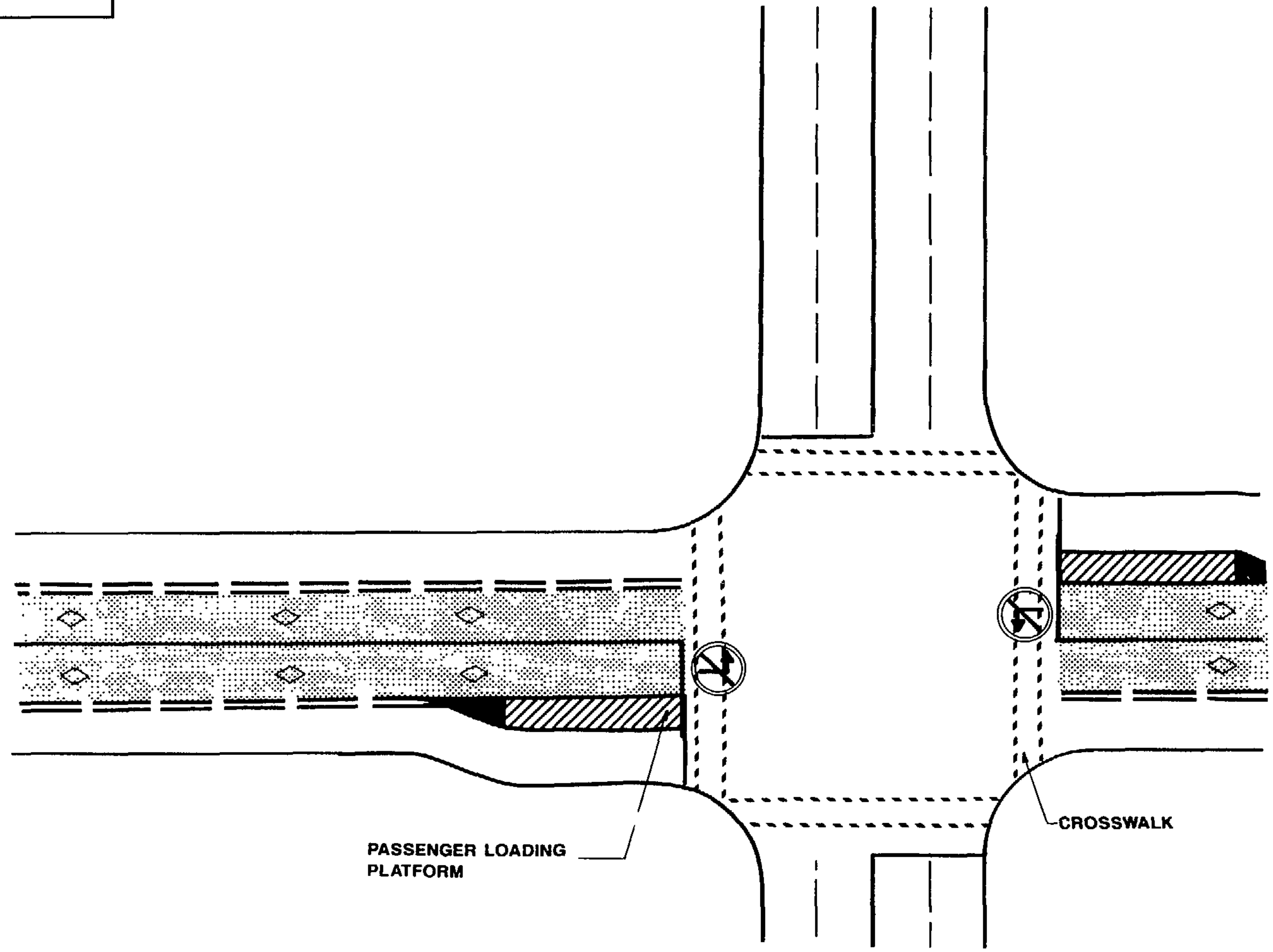
HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 3 SCHEMATIC : NOT TO SCALE	URBAN INTERSECTION TREATMENT (1)

URBAN ARTERIAL CONCURRENT RIGHT CURB HOV LANES
WITH RIGHT TURN LANES AND FAR SIDE BUS BAYS



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 4 SCHEMATIC . NOT TO SCALE	URBAN INTERSECTION TREATMENT (2)

URBAN ARTERIAL CONCURRENT CENTRE HOV LANES
WITH LOADING PLATFORMS



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 5 SCHEMATIC : NOT TO SCALE	URBAN INTERSECTION TREATMENT (3)

In any four lane situation, the ability to operate express buses or to have large numbers of Carpools (i.e. HOV 2 +) use the priority lane may be limited by the presence or absence of bus bays: consideration of the use of right turn bays for bus stops (either near side or far side per Exhibit III-4) is worthwhile. If right turns from the HOV roadway are prohibited, it may be considered that right turns to the roadway from crossing streets should be prohibited as well.

It may be noted that the introduction of HOV lanes on a four lane road along with the turning restrictions necessary to make it operate effectively may in fact result in faster travel for both HOVs and non-HOVs (as was experienced upon implementing the Bay Street Clearway in Toronto). The benefits stem mainly from the turn restrictions: the planner should thus be aware that the HOV lane savings relative to the non-HOV lane travel time may be negligible (or even negative) despite being significantly better than the "before HOV lane" case. This has the potential to be a sensitive public issue.

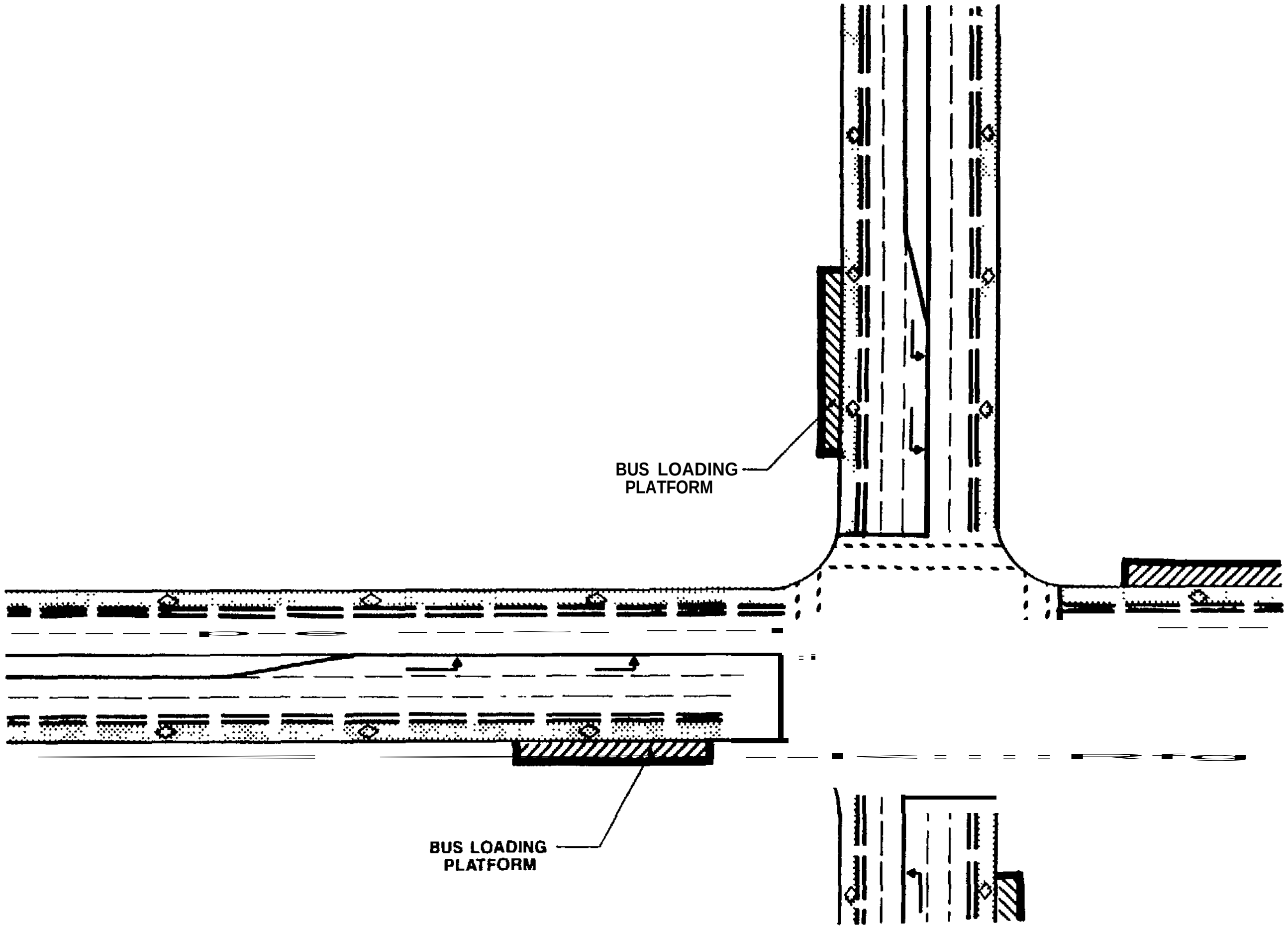
III-4.2 Six Lane Approach

A six lane roadway, with or without turning lanes, offers considerably more operational flexibility for non-HOV traffic than does a four lane facility. The key point is that there will always be an open through lane even if a bus is stopped in the right lane and a left turning vehicle blocks the left lane. The need for turn restrictions is thus reduced and the main problem becomes an operational one - the joint use of the HOV lane (in either the right lane or left lane) by through HOVs and turning vehicles. As noted previously, turns by non-HOVs or by all vehicles across or from the HOV Lane may need to be banned during periods of HOV operation in order to preserve person throughput. Alternatively, the provision of bus bays, turning lanes / bays and / or HOV lane usage restrictions may be sufficient to allow the smooth and efficient operation of the HOV lane with turns permitted.

Exhibit III-6 illustrates a basic six lane situation, in which the lack of bus bay or right turn lane would likely cause the planner to consider banning right turns from the HOV lane, particularly if there were heavy pedestrian movement on the crossing street. It may be impossible to ban right turns, however, if this were in a large-block suburban area where there are no reasonable alternative routes for turning vehicles. The provision of a separate right turn lane (with either near-side or far-side bus bay) as shown in Exhibit III-7 would be the recommended strategy in such a case. Alternatively, if there is on-street parking, curbside loading, or very frequent driveways, entrances, and cross streets on a six lane roadway, locating the HOV lane in the middle lane (as shown in Exhibit III-8) can be a way or preserving the function and flexibility of the route for all users. If an intersection is channelized, the island may be expanded so as to service as a bus stop.

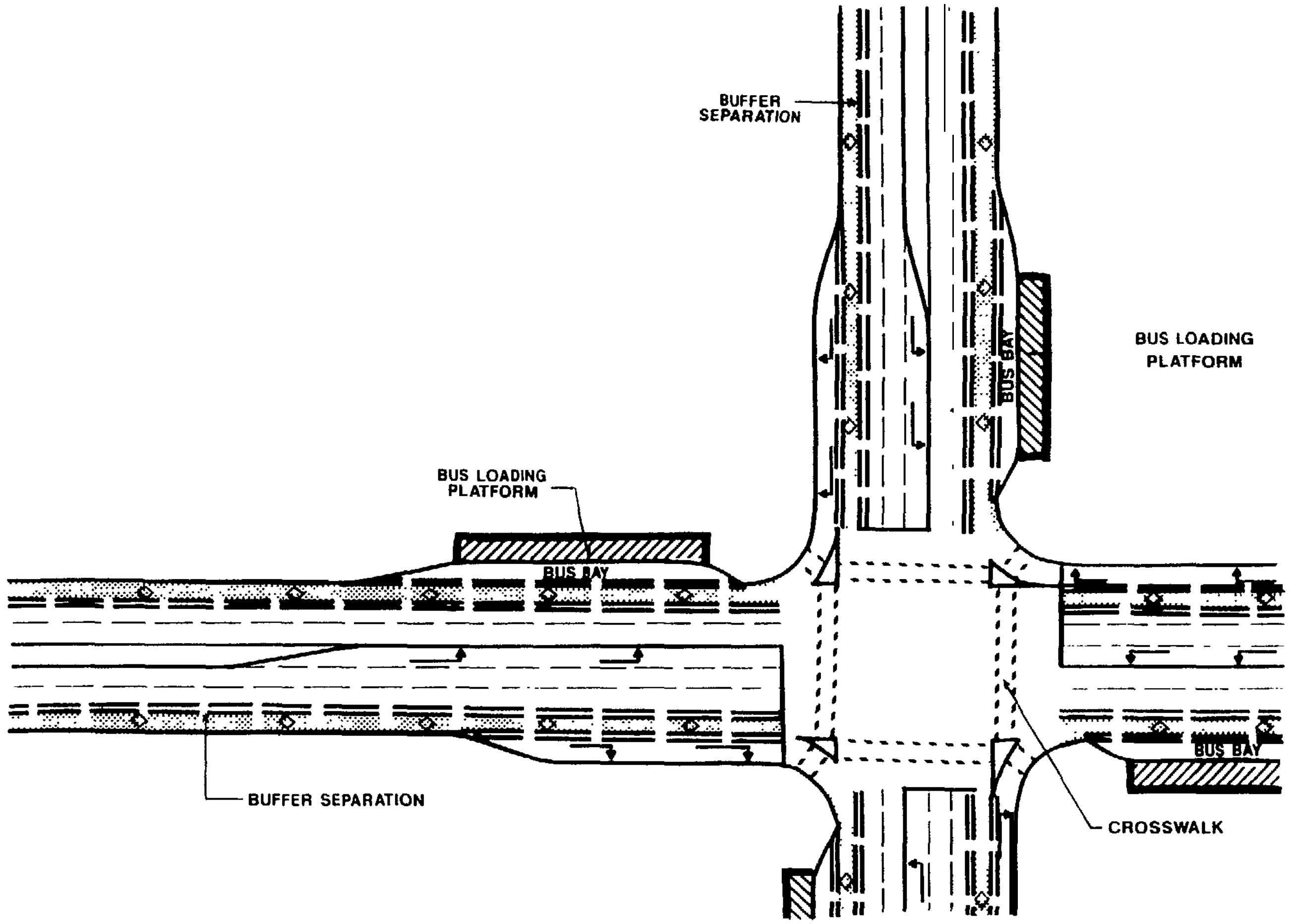
Potential disruption to transit by right turn queues is a key issue. Of note is that transit operator's regulations in some areas do not permit a bus to open its doors when not at or very close to a posted stop. In order to reduce the risk of a bus being delayed through one or two signal cycles while waiting for a right turn queue to dissipate to allow the bus to approach a near-side stop, consideration could be

SUBURBAN ARTERIAL CONCURRENT RIGHT CURB HOV LANES



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES OPERATIONAL PLANNING & *DESIGN GUIDELINES*	**EXHIBIT** III - 6 SCHEMATIC NOT TO SCALE	**SUBURBAN INTERSECTION TREATMENT (1)**

SUBURBAN ARTERIAL CONCURRENT RIGHT CURB HOV LANES
WITH RIGHT TURN LANE AND FAR SIDE BUS BAYS



HOV FACILITIES & PROGRAMS
FOR ONTARIO MUNICIPALITES

*OPERATIONAL PLANNING &
DESIGN GUIDELINES*

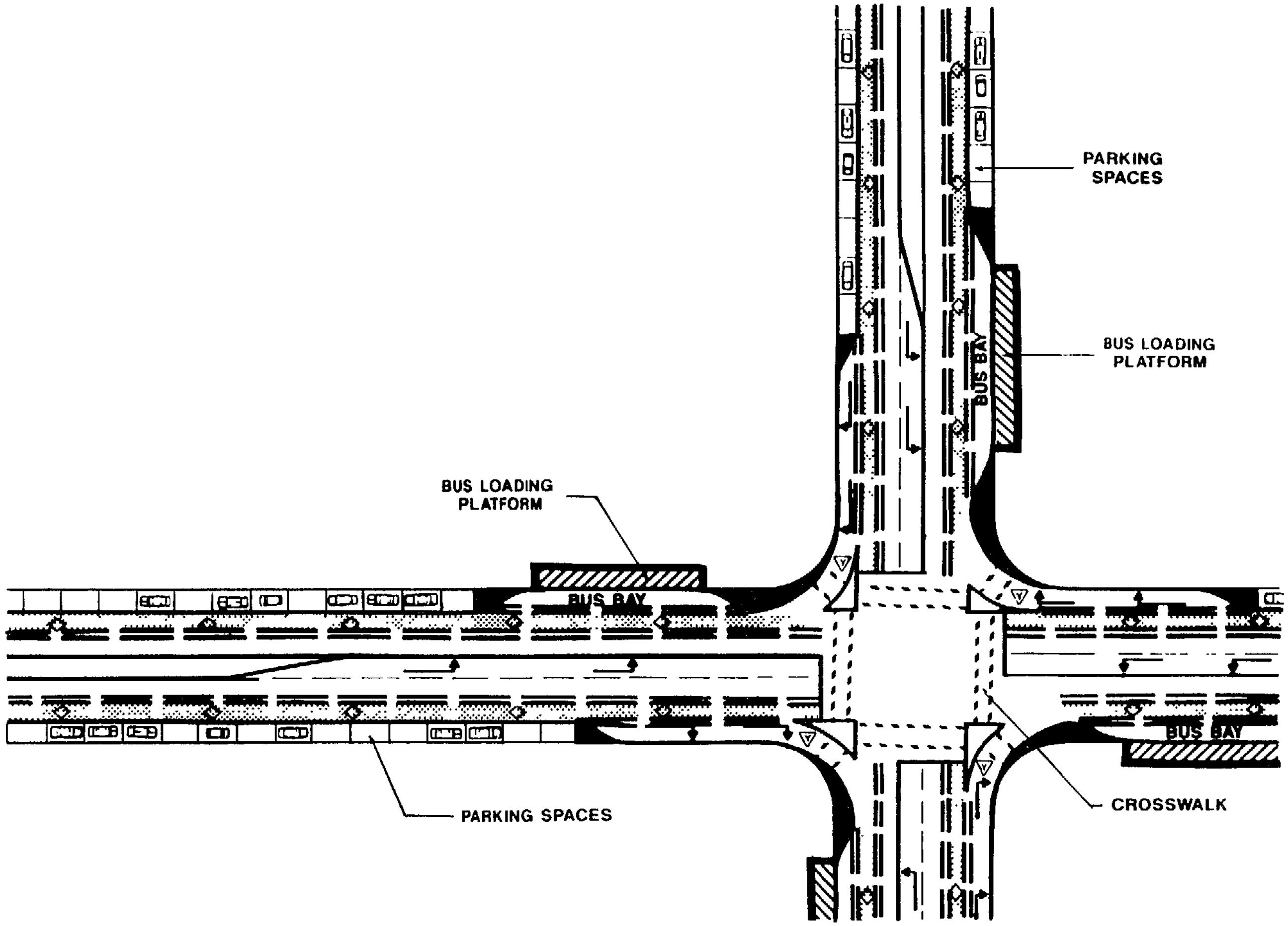
EXHIBIT

III - 7

SCHEMATIC : NOT TO SCALE

SUBURBAN INTERSECTION TREATMENT (2)

SUBURBAN ARTERIAL CONCURRENT RIGHT INSIDE HOV LANES
WITH CURB-SIDE PARKING RIGHT TURN LANES AND BUS BAYS



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 8 SCHEMATIC : NOT TO SCALE	SUBURBAN INTERSECTION TREATMENT (3)

given to drawing the stop (preferably a bus bay) back from the intersection as shown in Exhibit III-9 At major intersections with a significant number of transferring passengers, walking distance between stops would be a factor, but any extra time spent walking between stops could be less than that otherwise spent in a queue approaching a near-side stop. Control of jaywalking would be an issue if the stop were to be a significant distance from the intersection crosswalk.

If the HOV lane is in the left lane of a six lane roadway, the same considerations apply (see Exhibits Ill-l 0, Ill-1 1). Because left turn queues often stand through an entire signal cycle, it is important to design the storage lane length and signal phasing so that queued HOVs do not block access to the left turn bay and that the left turn queue does not extend into the HOV lane. As with any median lane HOV application, the ability to serve local transit passengers is problematic: either a local bus route operates in the right curb lane (per Exhibit Ill-l 1) or bus loading platforms are provided in the median (Exhibit Ill-l 2). As noted previously, the latter case is more suited to 24 hour transit-oriented HOV lane application.

III-4.3 Signal Phasing

HOV signal phasing treatments consist of allocating a portion of the signal time at intersections or queue by-passes for HOV applications. The signal systems of each potential HOV corridor in this study should be reviewed. If deemed necessary, improvements such as providing the HOV traffic with more green time or signal phases which allow for preferential turning movements should be considered. At locations where the number of lanes are reduced or the traffic flow is impaired such as bridge underpasses and narrow rights-or-way, HOV queue by-passing signals should be provided.

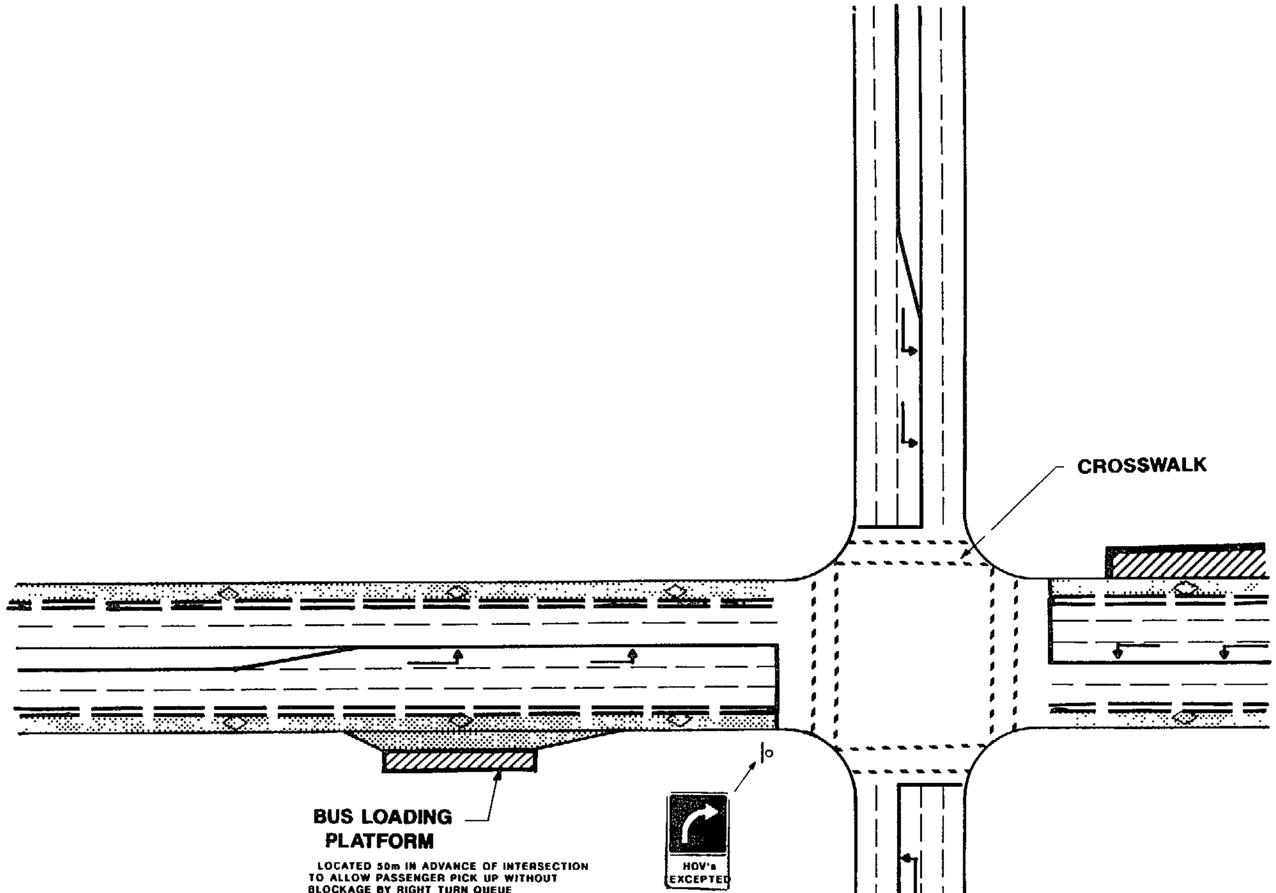
Special signal phasing may not be effective for every HOV application, but nevertheless its potential should be fully explored. The traditional technique of distributing signal green time on the basis of vehicle delay at intersection approaches should be revised to reflect person delay; this would maintain an inherent priority for HOV traffic.

Exhibit Ill-1 2 illustrates several options for preferential signal phasing for HOVs.

III-4.4 Signal Priority

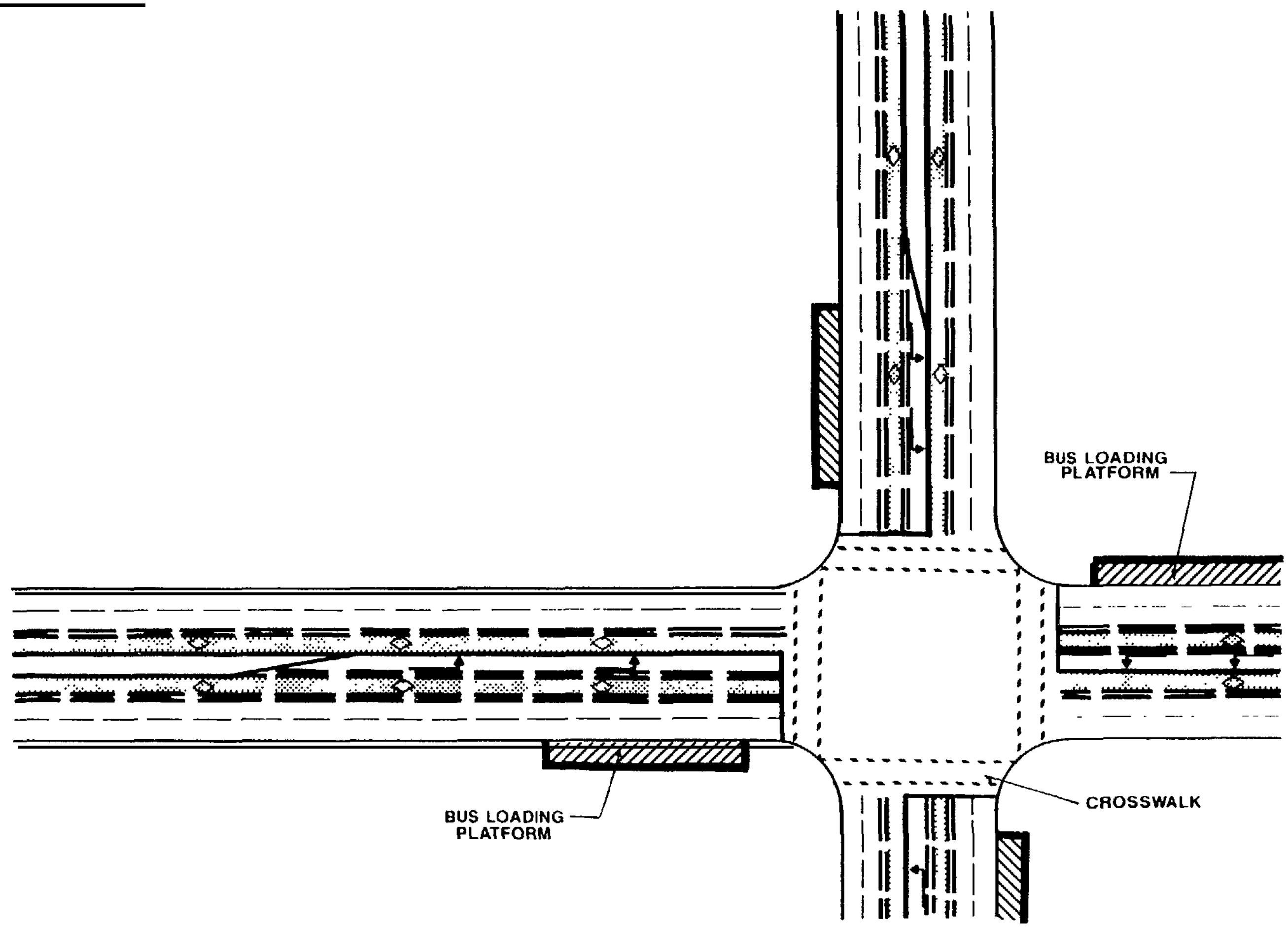
A vehicle’s ability to pre-empt traffic signals may offer it significant operational advantages over regular traffic. Signals may be pre-empted by an on board laser or radiowave emitting device, or by the use of on board magnetic transmitters and detector loops in the asphalt. Due to the operational requirements of these types of systems, this priority treatment is currently limited to transit and emergency vehicles only (for example, on the Ottawa Transitway system and on some Toronto streetcar lines). Future technical advances may extend signal pre-emption capability to other vehicles.

SUBURBAN ARTERIAL CONCURRENT RIGHT CURB HOV LANE



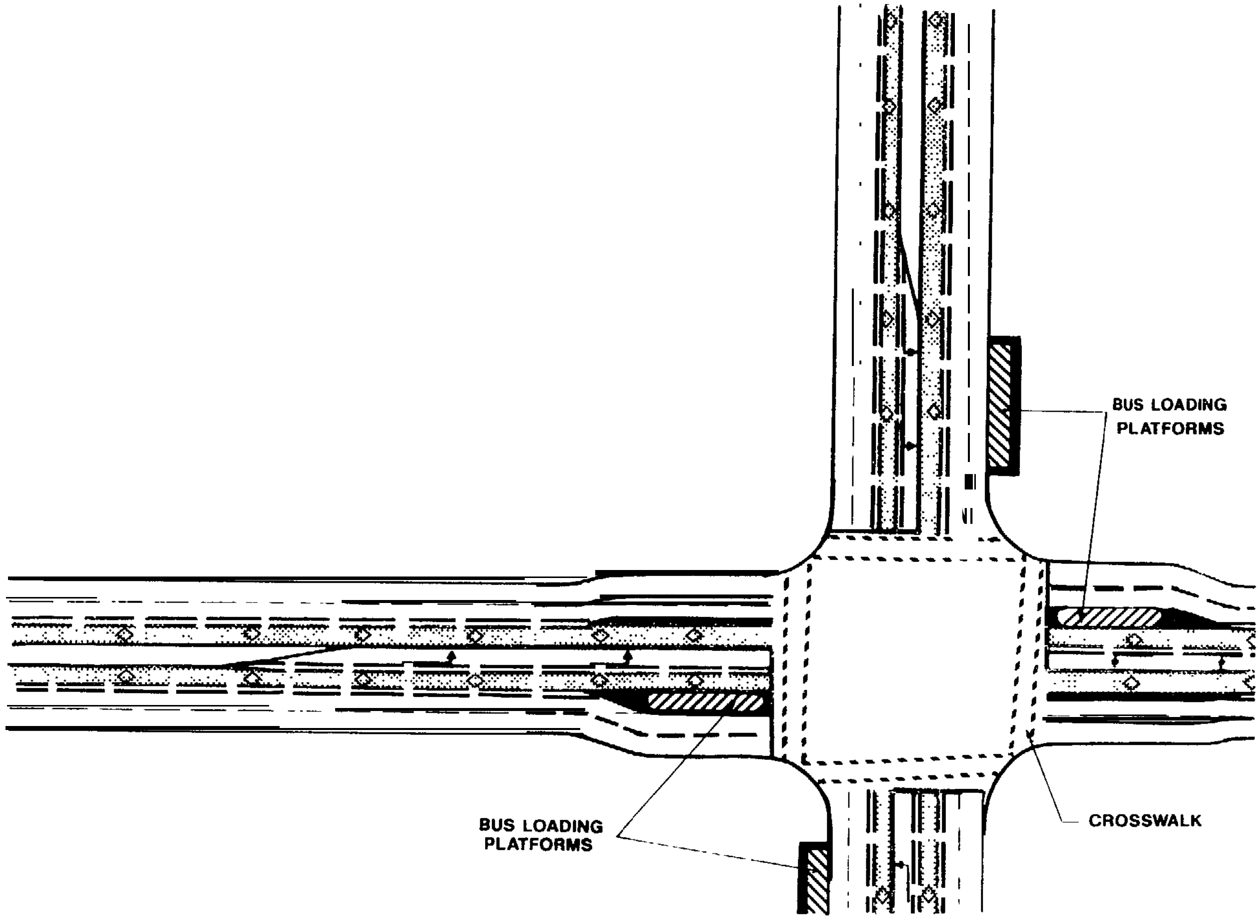
HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 9 SCHEMATIC : NOT TO SCALE	SUBURBAN INTERSECTION TREATMENT (4)

SUBURBAN ARTERIAL CONCURRENT INSIDE HOV LANES

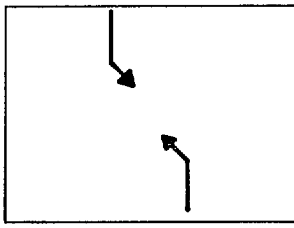
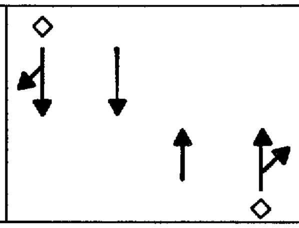
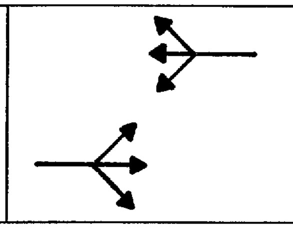
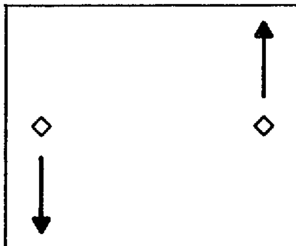
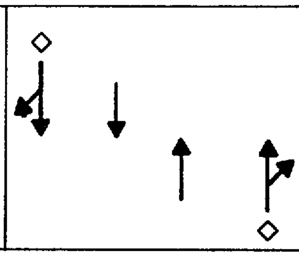
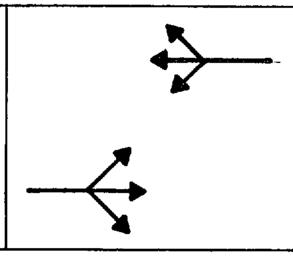
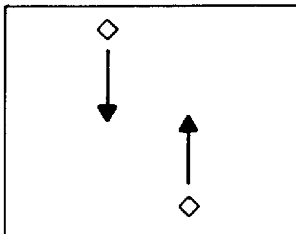
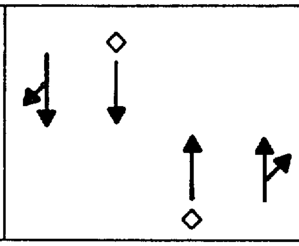
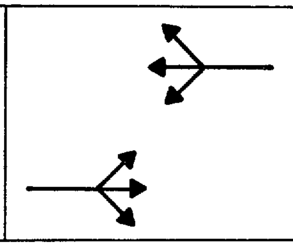
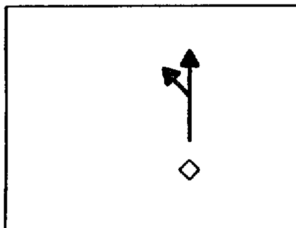
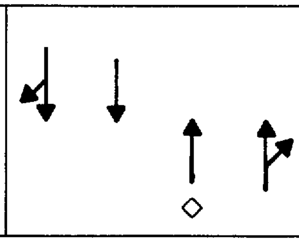
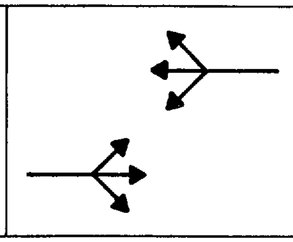
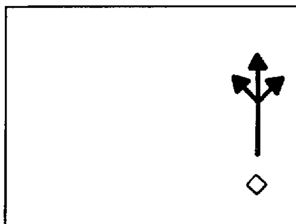
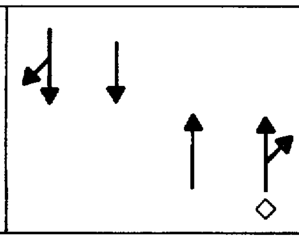
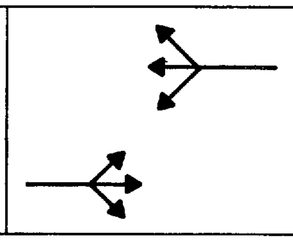
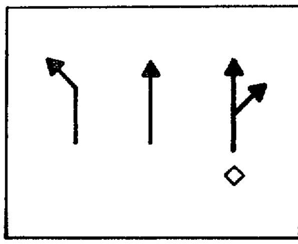
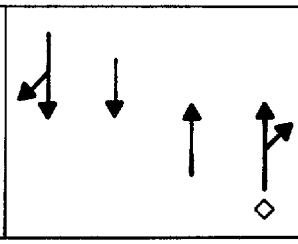
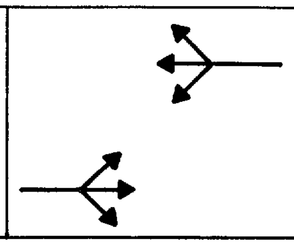


HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 10 SCHEMATIC · NOT TO SCALE	SUBURBAN INTERSECTION TREATMENT (3)

SUBURBAN ARTERIAL CONCURRENT INSIDE HOV LANES
WITH LOADING PLATFORMS



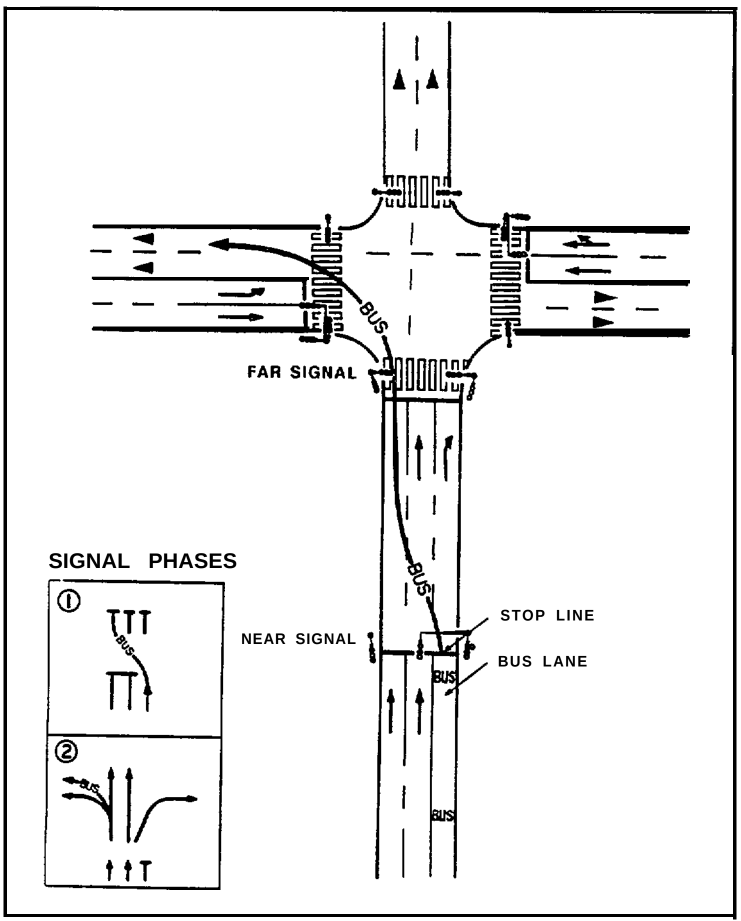
HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 11 SCHEMATIC NOT TO SCALE	SUBURBAN INTERSECTION TREATMENT (2)

PHASE : A	PHASE : B	PHASE : C	HOV LANE TYPE
			TWIN HOV LANES CURB LANE NO HOV LEFT TURN
			TWIN HOV LANES CURB LANE QUEUE BYPASS
			TWIN HOV LANES INSIDE LANE QUEUE BYPASS NO NON-HOV LEFT TURN
			ONE WAY HOV LANE MEDIAN NO NON-HOV LEFT TURN
			ONE WAY HOV LANE CURB LANE QUEUE BYPASS HOV LEFT TURNS ALLOWED
			ONE WAY HOV LANE CURB LANE QUEUE BYPASS HOV LEFT TURNS NOT ALLOWED

HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 12	SIGNAL PHASING FOR HOV LANES

One of the advantages of signal pre-emption is that it can be applied selectively, in locations and at times when congestion is present and a bus needs to "catch up" to schedule. By contributing to the ability to maintain scheduled headways, signal pre-emption systems exhibit considerable potential benefit for transit operators. Combining signal pre-emption with an HOV lane would have a synergistic effect on transit operating efficiency.

Another example of a suitable application of signal priority for HOVs is the case of a right curb HOV lane approaching a major intersection at which a significant number of HOVs (particularly buses) wish to turn left. The ability of buses to manoeuvre across congested mixed flow lanes while still serving right curb bus stops may depend on some form of priority treatment. This could take the form of an additional stop bar and traffic signal for all traffic a suitable distance upstream of the intersection: upon the approach of a bus in the HOV lane a red light could be actuated for the mixed flow lanes and the bus (and following HOVs) could weave freely across to the left turn lanes (see Swiss example below). Alternatively, after registering the presence of a bus in the HOV lane, the lane could be given a brief advance green phase at the next upstream intersection. In such a case, the bus stop would be located on the cross street, accessed after the left turn.



Signal Priority for Left Turn from Right Curb Bus Lane

"Source: Criteres pour I'establissement de voies reservees aux bus.
Association S uisse des Ingenieures de la Circulation, July 1978"

III-5 SIGNAGE

III-5.1 Experience

Standardization of symbols, materials, and design standards for signage related to HOV facilities is essential to public awareness, acceptance, and enforcement. There are factors such as multiculturalism and illiteracy which prompt the need for signage which is as graphic as possible instead of signage which consists mostly of written text.

The "Manual of Urban Traffic Control Devices" should be referred to in developing signage standards (relevant excerpts are included as Appendix B). As a general principle the elongated diamond symbol internationally recognized for HOV designation should be used. Coordination with adjacent municipalities and other levels of government is also required to ensure consistency for the user.

The experience in Ontario to date has been that HOV lanes on arterials are generally not adequately distinguished from the remaining mixed flow lanes. This has contributed to a high level of misuse of the lane by ineligible vehicles, increased enforcement needs, created confusion among both HOV and non-HOV motorists as to eligibility requirements, and induced unsafe turning moves. If left unchecked this could play a significant role in the public losing respect for, and understanding of, the HOV lane principle and the potential benefits associated with it, as well as to ongoing violation / enforcement problems. The demarcation issue appears to be somewhat greater for HOV lanes than for Reserved Bus Lanes, due to the added question of whether or not a particular vehicle is eligible to use the lane.

For these reasons a more substantial approach to lane designation and demarcation is recommended than has been the practice to date. In addition to the need for greater marketing efforts to raise public awareness and educate motorists about the HOV approach, there are two "on line" elements available: pavement markings and overhead / roadside signage. Both are essential to use, as motorists gain most of their visual information from the road surface while many messages can only be communicated through signage. Overhead signs become the major source of information in severe congestion or poor weather (snow, rain) conditions.

III-5.2 Pavement Markings

It has been common practice to delineate the arterial HOV lane with a double parallel white dashed stripe, reflecting the compromise required between making its presence noticeable, allowing vehicles to merge into and out of the lane, and operating in normal mixed flow mode most of the time.

In addition to distinctive striping, the HOV diamond symbol is normally marked on the pavement in the lane (see Exhibit III-l 3) and additional wording re: eligible vehicles and / or time of operation may also be marked on the road. Due to high volumes, snowplowing, and limited durability of the thermoplastic materials used, pavement markings cannot be relied upon exclusively to provide the necessary information.

There are three approaches available to emphasize the HOV message: pavement markings can be made larger and bolder (e.g. use of colour); additional distinctive markings can be applied; or the entire lane can be made of a distinct material or colour. In light of the impracticality of the latter (particularly on an areawide bases), some combination of the first two is recommended. "Filling in" the double dash to form a triple width single dashed stripe would make it stand out more and provide the opportunity to downsize to a single width line at intersection approaches, thereby resolving the right turn violation problem discussed in Section II-5.3. Supplementing the lane marking with a single coloured stripe located in the middle or to the traffic side of the HOV lane, running longitudinally can be an effective constant reminder to both lane users and LOVs that "this lane is different". This is practised in Quebec City (and similarly in New York City) to designate reserved bus lanes on selected arterials, and would be a very low-cost, easily-implemented and effective measure.

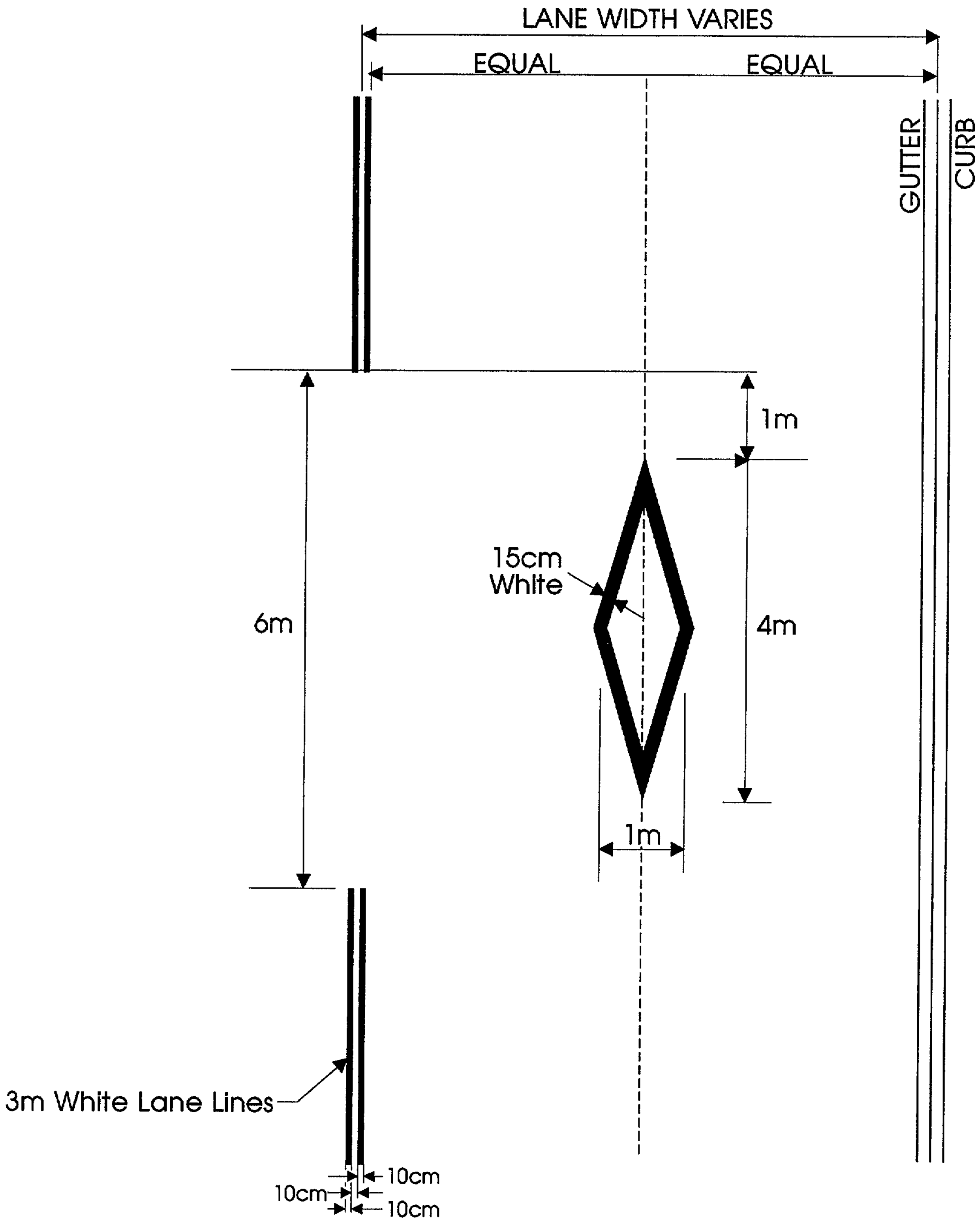
Typical existing practice are shown in Exhibits III-l 3 and III-l 4. Relevant excerpts from the MUTCD are included as Appendix 'B'.

In a community with a limited length of HOV lane, consideration could be given to using a distinctive pavement colour or material for the HOV lane: the additional expense could result in a more effective, more easily enforced facility and could be an effective marketing / educational tool as well ("ride the blue lane").

It should be noted that in Section C2.44 of the MUTCD (Appendix 'B'), the principle of using pavement markings such as the diamond symbol and double striping only for permanent (24 hour) reserved lanes is put forward. Based on the experience to date in Ontario, such a restrictive policy is not recommended and use of both pavement markings together with appropriate overhead signageshould be applied. While the principle of applying permanent markings only to permanent operations is valid in theory, there is an overriding need to ensure public awareness that the lane is a "special" lane and both pavement markings and signage contribute significantly to that effort.

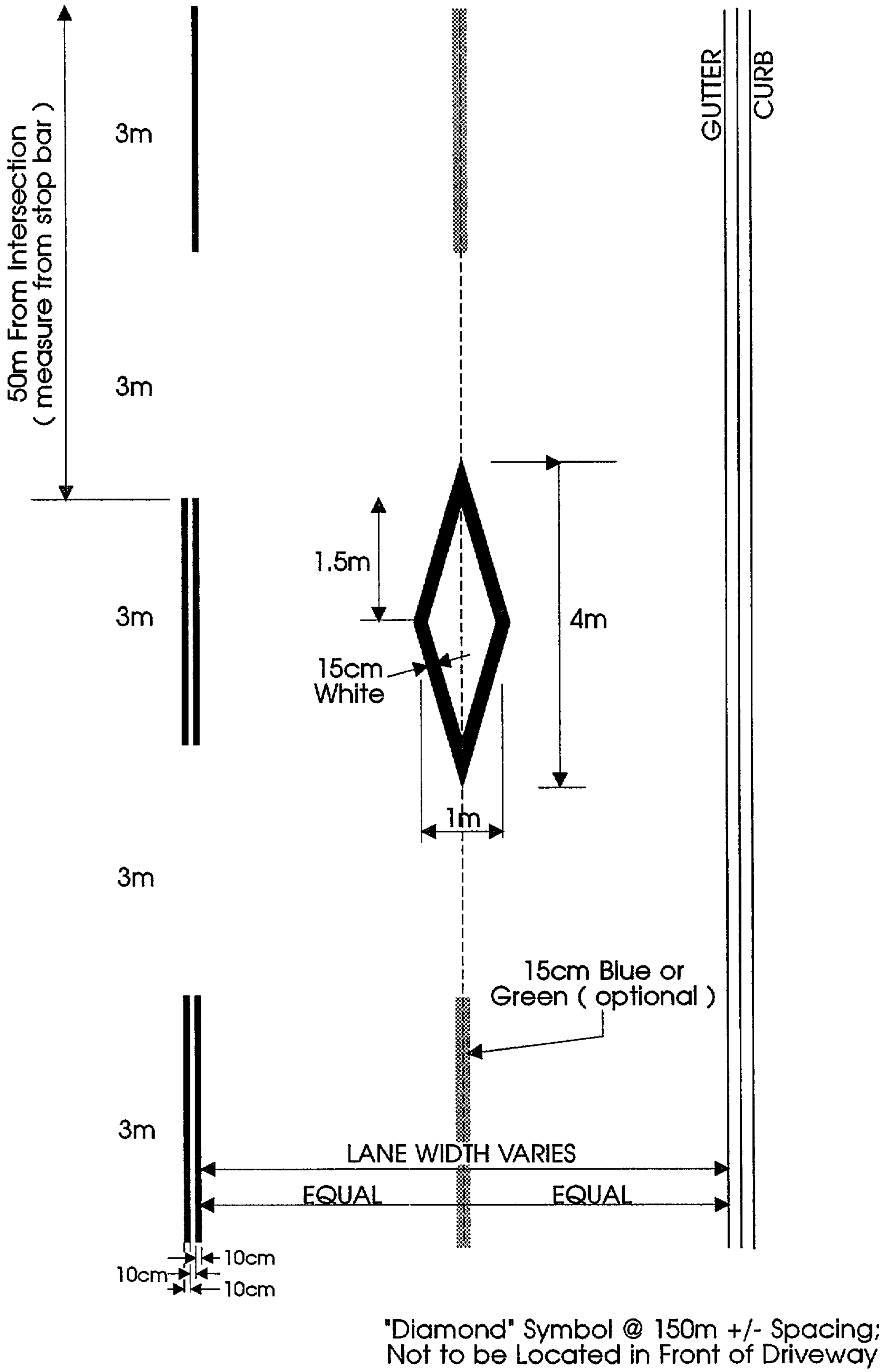
III-5.3 Overhead / Roadside Signage

Exhibits III-15 and III-l 6 illustrate the signage used in Mississauga and Metro Toronto on HOV routes; on suburban arterial roads a sign is placed above the HOV lane every 120 - 150 m, usually utilizing an adjacent hydro pole. Due to the limits on information on the overhead sign, a "Carpool definition" sign (i.e. 3 or more occupants) is placed on the same pole as the overhead sign, at the roadside.

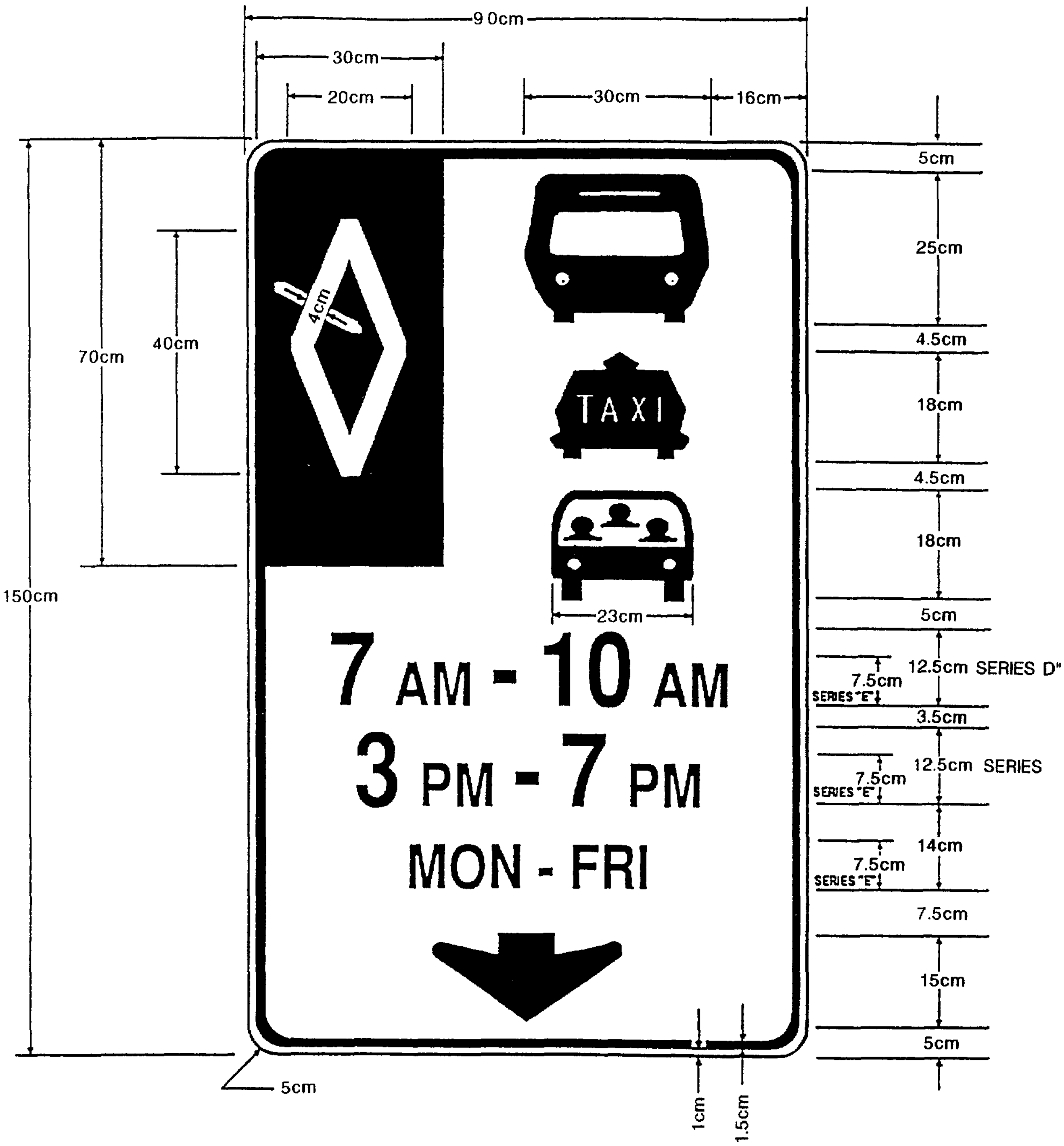


SOURCE : MUNICIPALITY OF METROPOLITAN TORONTO STANDARD E - 1006

HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES ***OPERATIONAL PLANNING & DESIGN GUIDELINES***	**EXHIBIT** III - 13	**CURRENT HOV LANE MARKING PRACTICE**

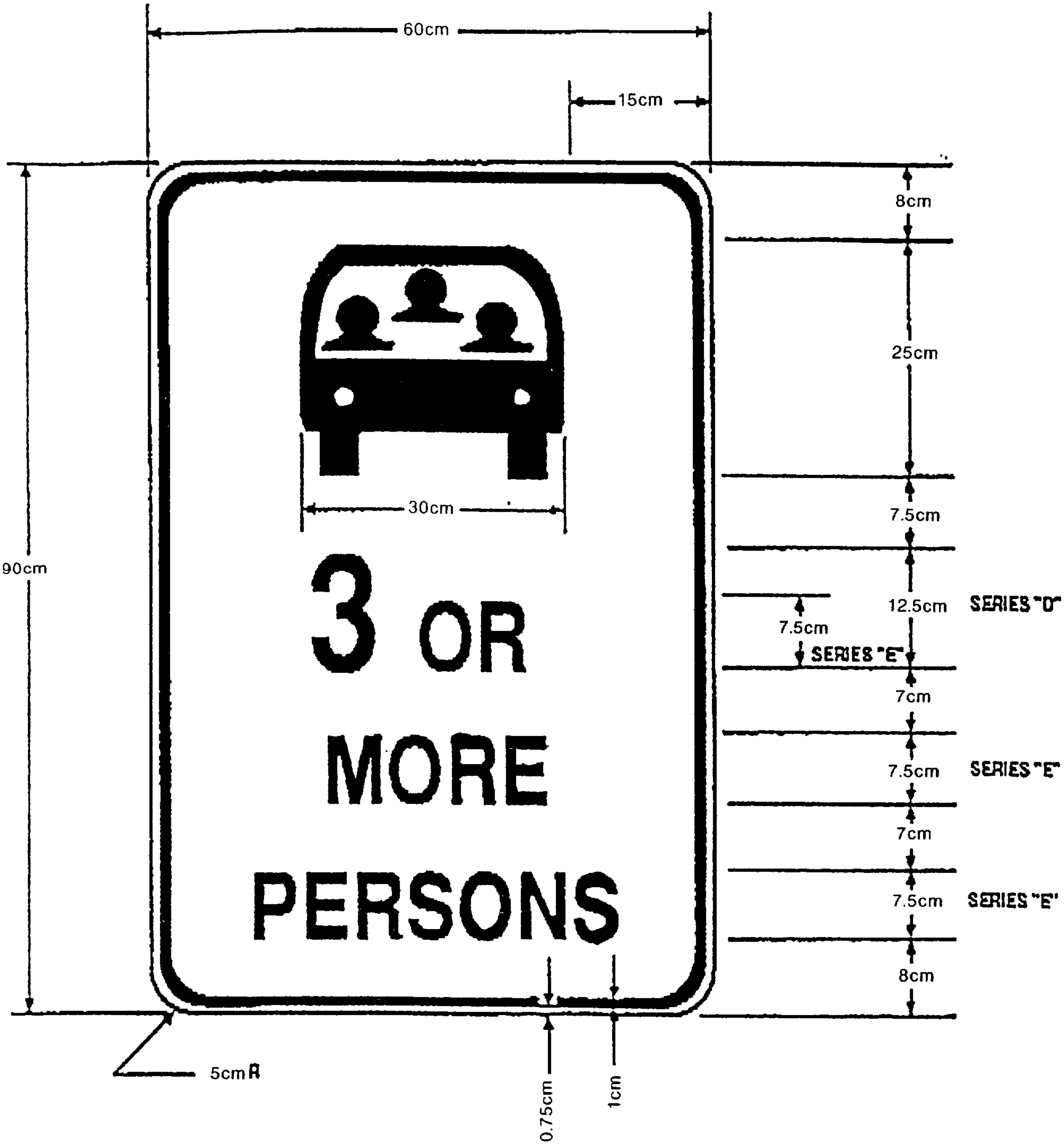


HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES ***OPERATIONAL PLANNING & DESIGN GUIDELINES***	**EXHIBIT** III - 14	**HOV LANE MARKING - IMPROVED PRACTICE**



SOURCE : 110 - 180m SPACING (3-4 HYDRO POLES)
DIAMOND MARKING ON PAVEMENT BELOW
"3 OR MORE PERSONS" SIGN (SEE Ex. III - 16) MOUNTED ON SAME POLE AS USED ON DUNDAS STREET WEST, MISSISSAUGA

HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 15	OVERHEAD SIGN FOR HOV 3+ LANES



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 16	CARPOOL DEFINITION SIGN

To improve its effectiveness, static signage can be made larger (more visible), use a different background colour than white (more distinctive), and / or present a message of greater clarity (better information). Using Exhibit Ill-l 5 as an example, it might be considered whether:

a) most motorists understand what the diamond symbol means;

b) the pictographs (especially the bus) clearly communicate the intended message

c) it is clear that only the curb lane is affected.

In the case of (a), a "tag" above or on the sign stating "Diamond Lane" (Metro Toronto's nomenclature), "Priority Lane", or some equivalent may be worth considering. For (b), writing BUS on the pictogram similar to the way TAXI is written on the one below it would be an improvement, as the pictogram is so stylized as to be indistinguishable from a truck, van, or commercial vehicle. Alternatively, simply writing BUS /TAXI / CARPOOL on some of the signs instead of using the symbols would effectively convey the information to motorists. Finally, the fact that only the curb lane is affected would be greatly clarified by improved pavement markings (per Section III-4.2), tagging the sign (per above) with a "Diamond Lane" or equivalent note, specifying THIS LANE on the sign, or introducing signage over the entire road width which specifies the peak period designation of all lanes.

Unfortunately, the French term for Carpool (covoiturage) is so long as to effectively preclude such written signage in bilingual areas of the province.

One issue which has arisen is the effective communication of time of HOV lane operation, and changes to signage practice may be proposed in this area as well.

As noted previously, many potential HOV lane users are unsure of whether the lane is in operation, particularly around the transition periods. Without a watch or a dashboard clock it can be virtually impossible to tell whether or not the lane is restricted to HOVs or open to general traffic. This creates enforcement problems, to the extent that in Denver's case driver citations were being thrown out in court on the basis that drivers were not legally required to know what time of day it was. Furthermore, the need for flexibility in lane operating times in response to individual corridor needs, the inappropriateness of complete areawide consistency (e.g. peak periods in outlying parts of the Toronto area may be somewhat different from the peaks within Metro Toronto), and the potential to operate HOV lanes on Saturdays as well as on weekdays all point to the need for flexibility and effectiveness in signage.

The most straightforward solution, and one which is recommended for Ontario practice, is to shift towards "active" signage, for example with the addition of lights and a message to the effect of "HOVs only when flashing" over the lane, with the lights timed to flash or operate continuously throughout the period of operation. This would allow the information regarding time of operation (e.g. "7 - I0 a.m., 3 -7 p.m., Mon-Fri; 10 a.m. - 6 p.m., Sat) to be removed from the overhead sign and posted at the roadside. Space would be freed up on the overhead to clearly illustrate the eligible vehicles with words and / or larger pictograms. Such a sign may not be required to replace all existing overhead signs; it could be located in place of every fourth or fifth static sign, or at key intersections. If it were to be used exclusively the spacing between signs could be considerably greater than the 120 - 150 m currently in use (thereby producing savings to balance the greater cost of each sign). Some U.S. jurisdictions can provide examples: the photos from Santa Clara County (California) in Exhibit III-l 7 illustrate one approach to active HOV signage.

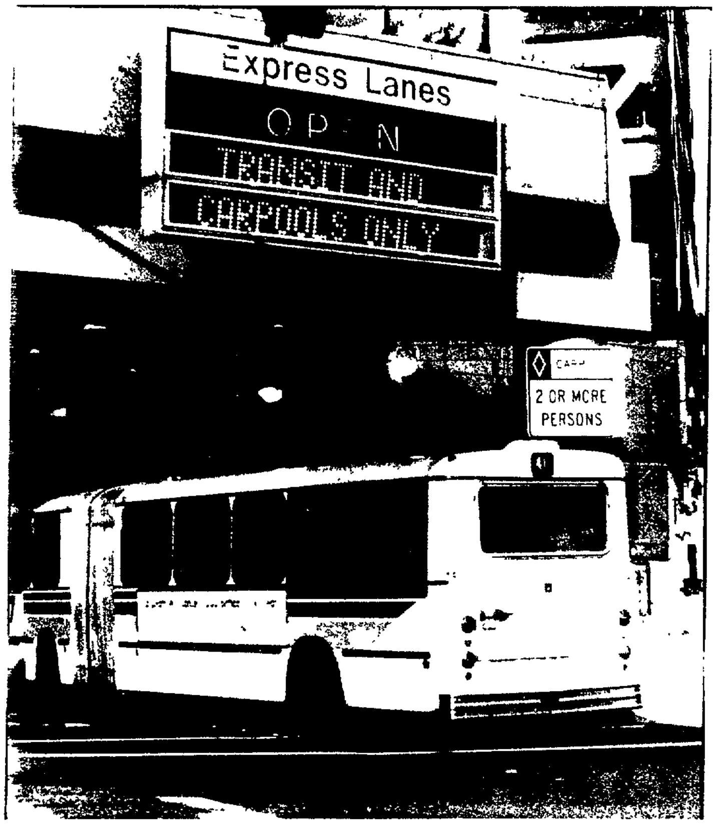
An alternative design such as a completely electronic "message board" LED sign could be considered, but at a considerable cost premium. As the example for Seattle in Exhibit III-l 7 illustrates, the concept is well suited to certain situations.

Issues to be addressed would include the sign design, colours of flashing lights, sign spacing visibility and impact with respect to visual "clutter" and supplementary signage needs. There being no prototype in Ontario, a period of research, including application of pilot projects on existing / new HOV lanes, is likely required; this activity should get underway as soon as possible so that results can be incorporated into subsequent HOV lane design with a minimum of retrofitting.

III-6 TRANSITIONS

An HOV access transition is defined as a point on an HOV facility where either the HOV designation or a separate HOV facility begins. An intermediate point where the HOV lane is accessed via a lateral movement from a parallel LOV lane is also considered a transition. Egress transitions are the converse of those listed above. The design of such transitions will depend on several factors such as the type of HOV treatment, type of roadway (one-way, two-way), traffic volume, and the number of lanes. In general, transitions must be designed using established geometric design standards to provide smooth and safe access to and from the HOV facility.

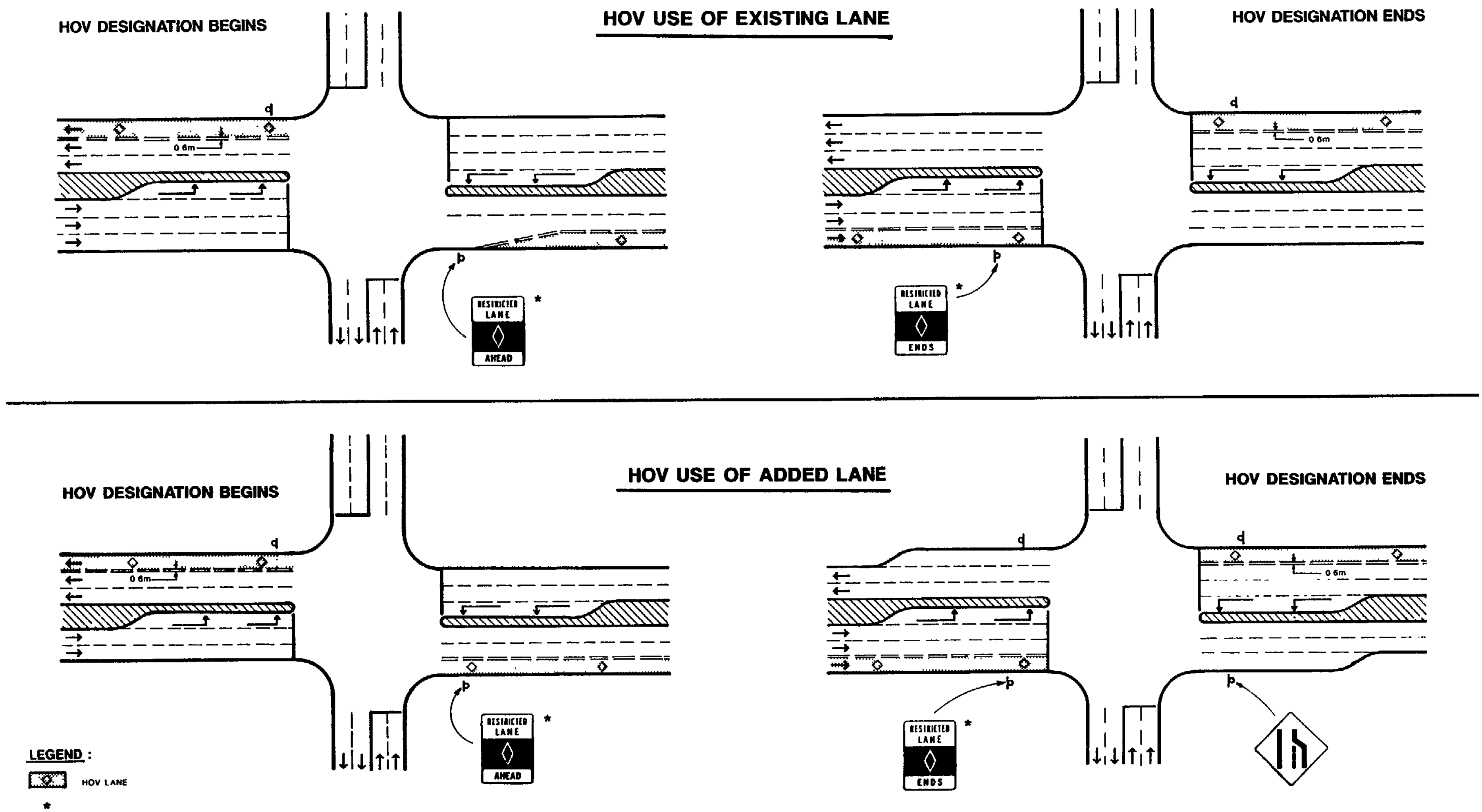
Concurrent and contraflow lane transitions can occur at intersections as well as at mid-block locations. Other than conventional HOV lane signing and marking, concurrent lanes on arterials do not require any special transition treatments. Typical concurrent lane transitions are shown in Exhibits iII-1 8, III-l 9 and III-20. Contraflow transitions on the other hand require specialized signage and engineering treatments. Conventional turn prohibitions such as "Do Not Enter" and "Wrong Way" signs should be used at the beginning and end points. Also, appropriate barriers and signage should be used at the terminal points to channel opposing traffic to the right or to the left. Vehicle movements either to or from an HOV lane should be allowed only where a broken line buffer is present. For an example of a broken line buffer see Exhibit III-l 6. Examples of contraflow lane transitions are illustrated in Exhibits III-18 to III-22.



CHANGEABLE MESSAGE SIGN
SEATTKE, WA

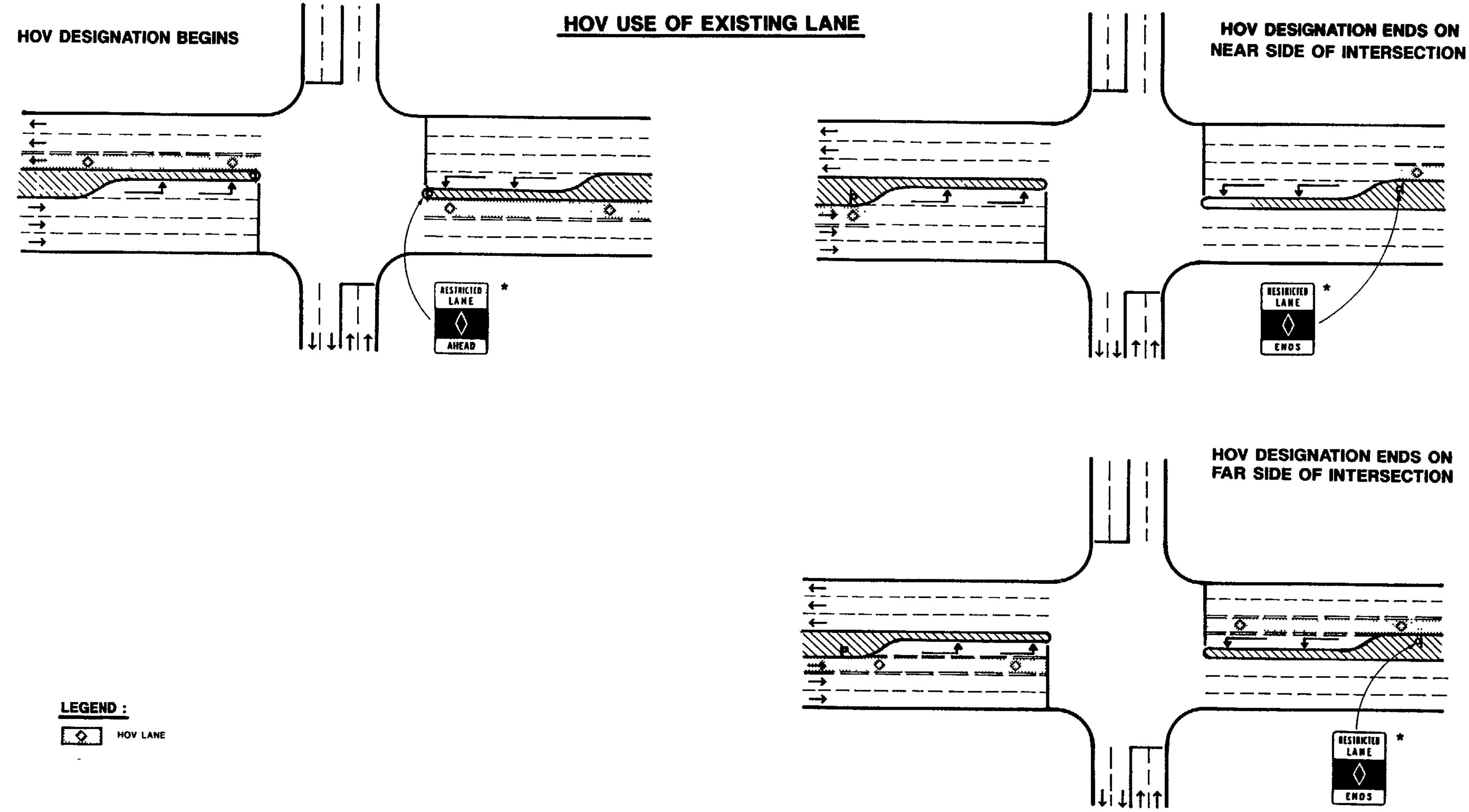
COMBINATION OF DYNAMIC OVERHEAD
SIGN AND STATIC ROADSIIE INFORMATION SIGN.
SANTA CLARA COUNTY CALIF.

HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	**EXHIBIT** III - 17 SCHEMATIC · NOT TO SCALE	**DYNAMIC HOV LANE SIGNAGE**



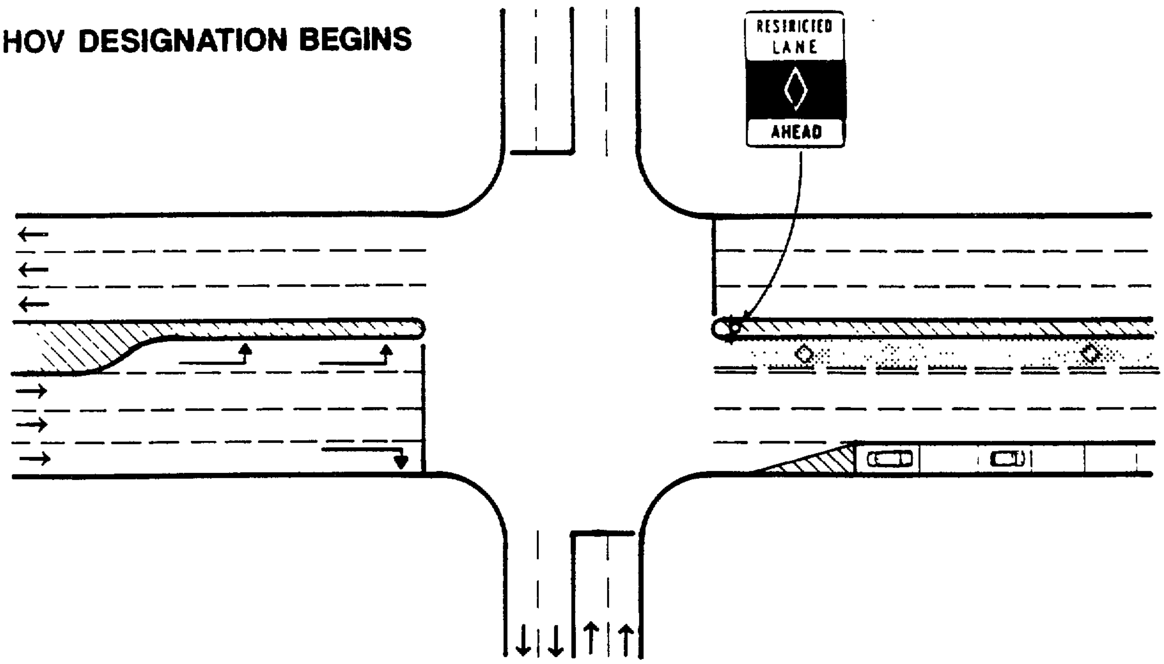
HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING &* *DESIGN GUIDELINES*	EXHIBIT III - 18 SCHEMATIC . NOT TO SCALE	SIGNAGE FOR HOV LANE START / END (I) (Curb Lane)

HOV USE OF EXISTING LANE

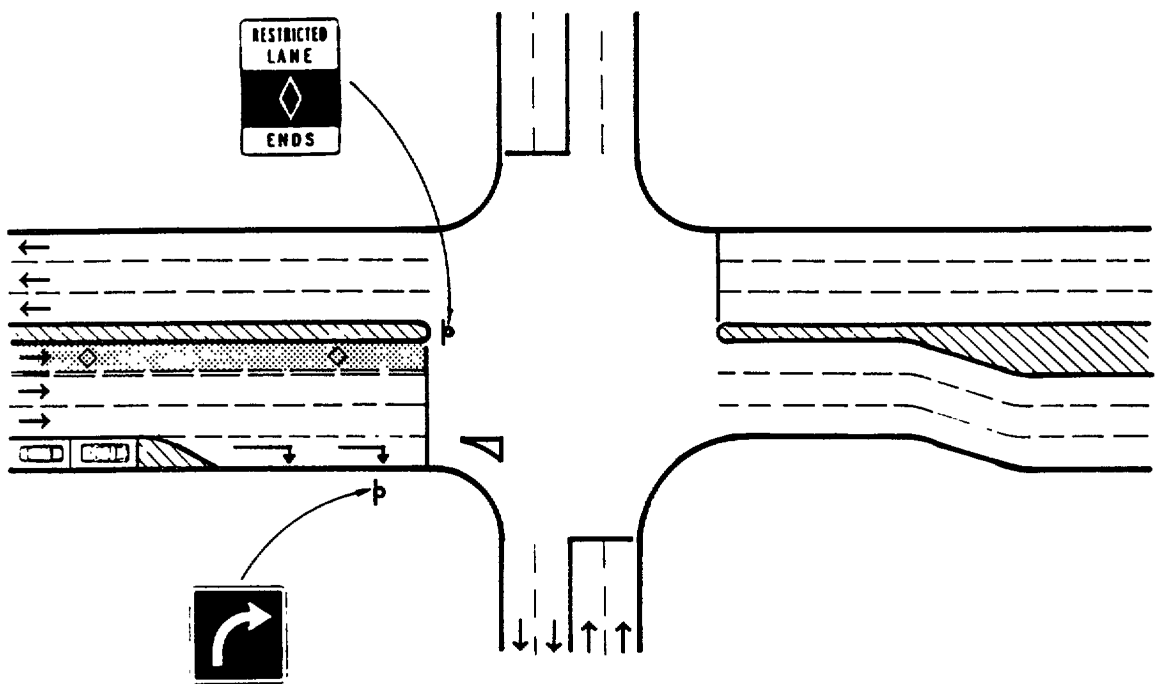


HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 19 SCHEMATIC : NOT TO SCALE	SIGNAGE FOR HOV LANE START / END (2) (Inside Lane)

HOV DESIGNATION BEGINS



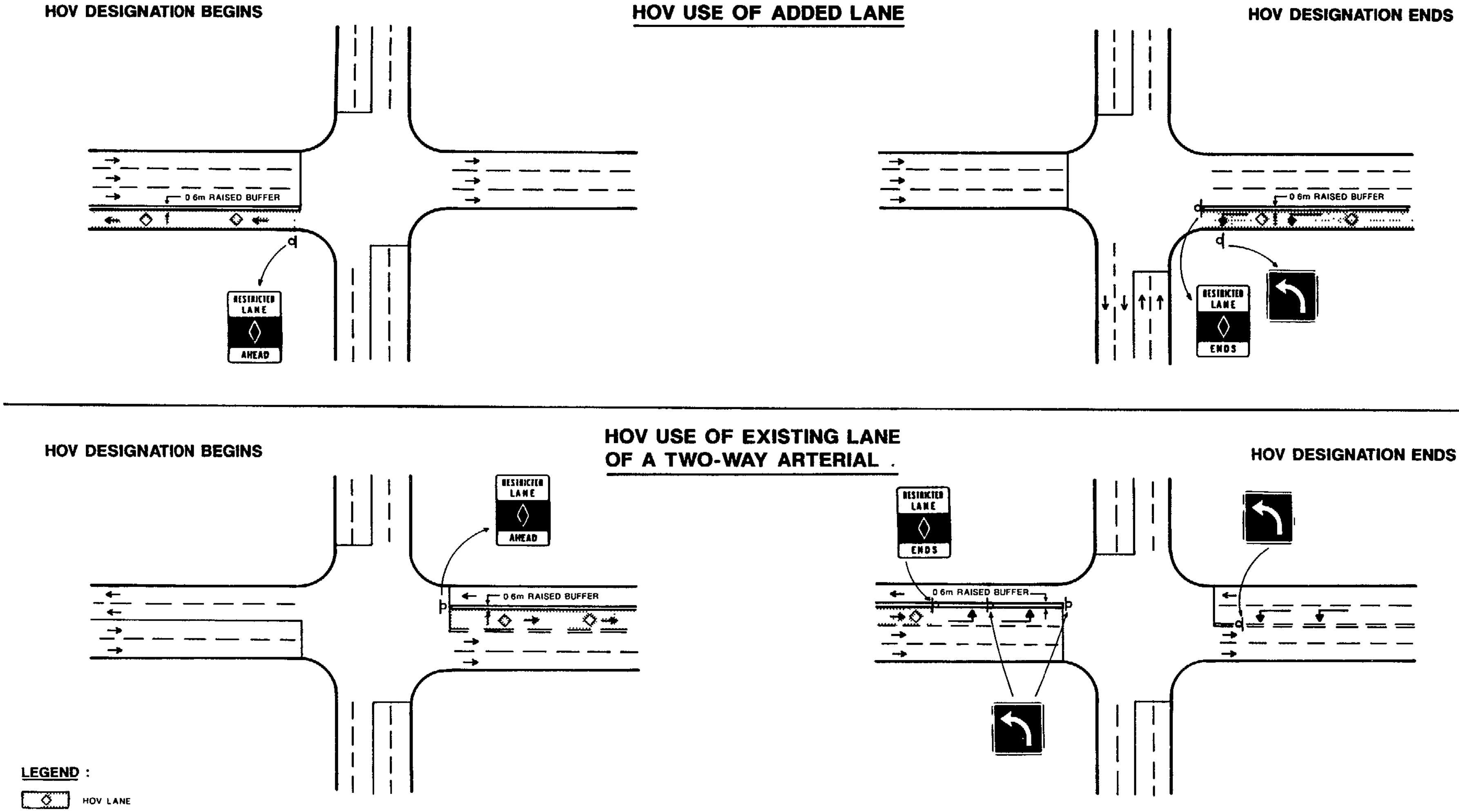
HOV DESIGNATION ENDS , FACILITY CONTINUES



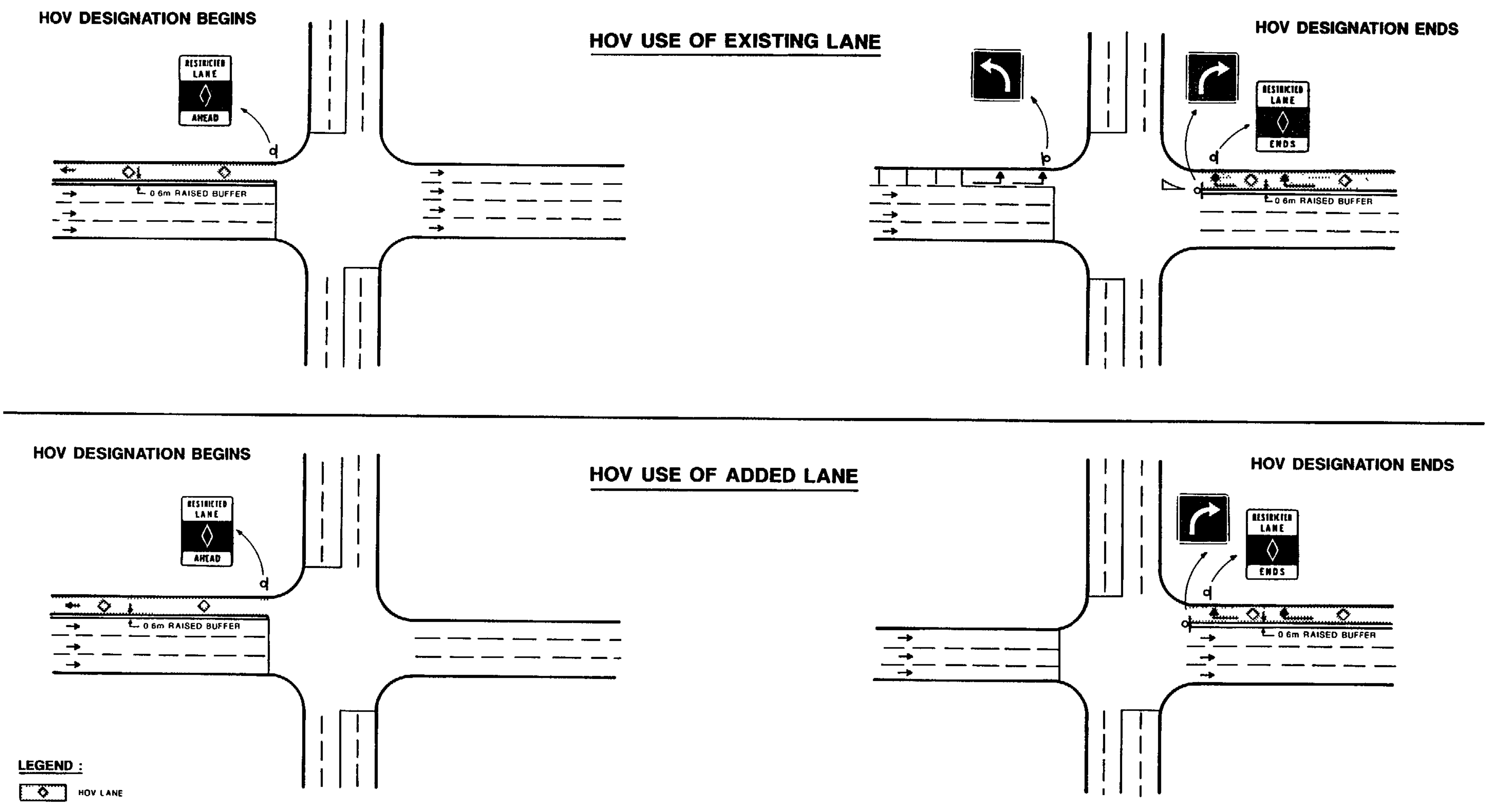
LEGEND:

 HOV LANE

HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITIES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 20	SIGNAGE FOR HOV LANE START / END (3) (Median Conversion)



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 21 SCHEMATIC . NOT TO SCALE	START / END CONTRAFLOW HOV LANE ON TWO - WAY ROADWAY



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 22 SCHEMATIC : NOT TO SCALE	START / END CONTRAFLOW HOV LANE ON ONE - WAY ROADWAY

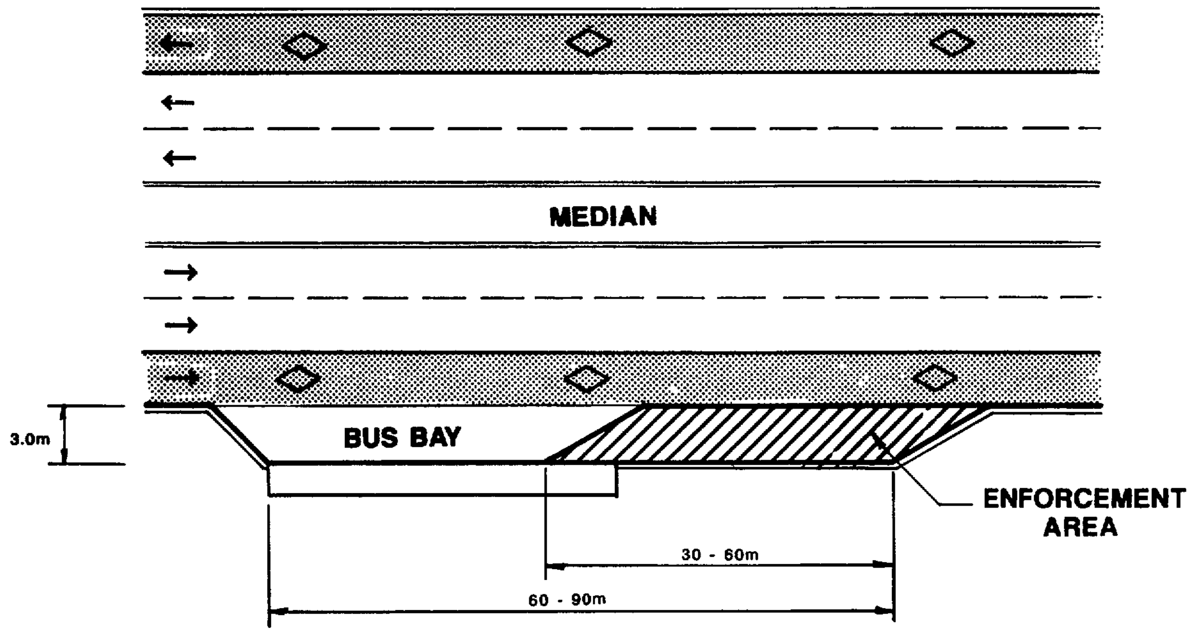
III-7 ENFORCEMENT FACILITIES

Enforcement is a necessary component of any HOV facility. In order to actively enforce an HOV facility, areas must be provided where authorities can apprehend and fine moving violators without greatly affecting the facility's operation. These specially designated areas can be located in the median, on the shoulder, set back from the right curb lane, or in the right curb lane of an intersecting roadway. To maximize deterrence, the enforcement activities should be visible from the HOV facility, yet not interfere with its operation.

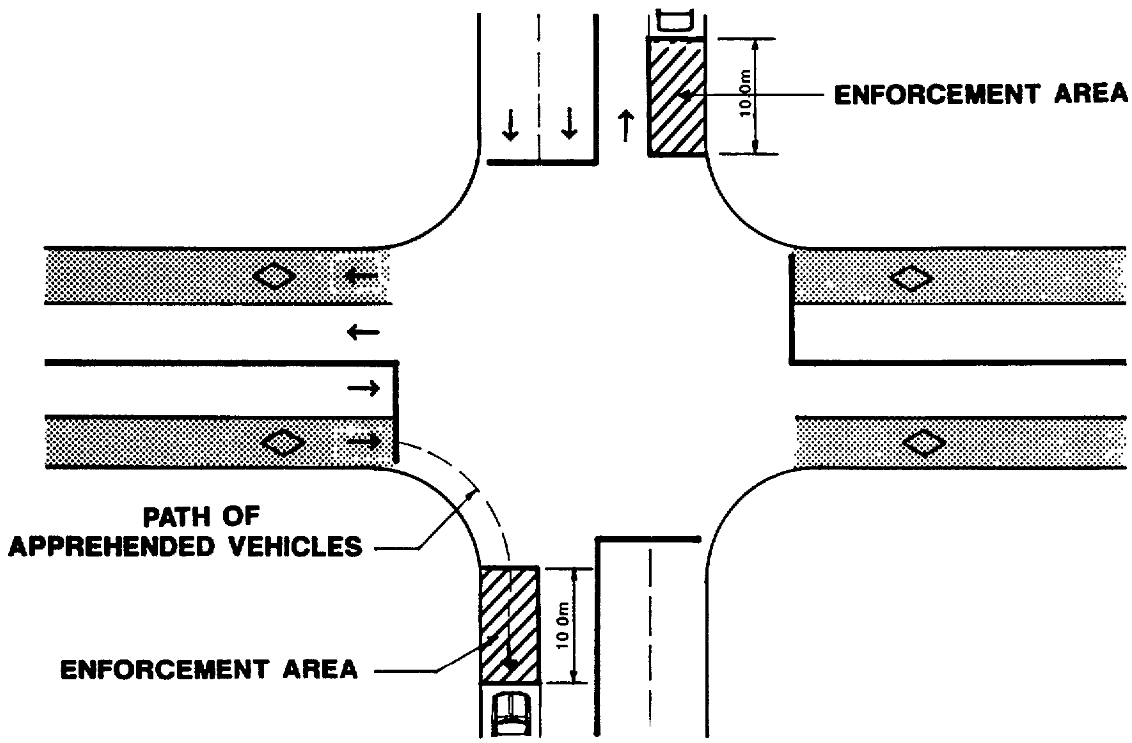
Low speed enforcement areas are typically used at queue by-passes, metered on-ramps, as well as an suburban arterial roadways. They can be located adjacent to a curb lane and can be combined into an extended bus bay where the enforcement area is located downstream of the bus loading area. Some enforcement area types are shown on Exhibit III-23.

Urban arterials typically do not allow for the provision of enforcement areas adjacent to the HOV facility due to space restrictions. However, the first few parking spaces in the right curb lane of a local crossing road which allows for curb-side parking can be designated for enforcement use during peak periods. With this arrangement a violator can be escorted by the authorities into the enforcement facility to be stopped and fined without degrading the flow of both HOV and LOV traffic. An example of this type of enforcement area is also shown in Exhibit III-23.

COMBINATION BUS BAY / ENFORCEMENT AREA FOR A RIGHT CURB SUBURBAN HOV FACILITY



ENFORCEMENT AREA FOR A RIGHT CURB URBAN HOV FACILITY



III-8 TRANSIT PROVISIONS

The following discussion focuses on bus transit operation: provisions related to streetcars or on-street rail operation are exclusive to Toronto and are dealt with in the context of the Metro Toronto HOV Network Study.

III-8.1 Bus Bays

The provision of bus bays on a curb lane serving HOVs is highly desirable, as it allows buses to pick up and discharge passengers out of the travelled lane. In the case of an HOV network, where priority treatment is given to traffic in the HOV curb lane, the presence of stopped buses in the HOV lane conflicts with both the principle of HOV incentives and with safety and capacity requirements. Bus bays allow the operation of express bus service on an HOV curb lane, and they maintain the continuity and attractiveness of the lane for Carpools. Although physically impractical in some retrofit locations, the provision of bus bays is highly recommended where feasible. It is important to ensure that adequate property for bus bay provision is available through the planning and design process.

In the *Canadian Transit Handbook* (2nd ed., Canadian Urban Transit Association and Transportation Association of Canada, 1985), the following guidelines for bus bay application are given:

- no parking in curb lane
- 500 vehicles per hour or less in the curb lane during peak periods
- low bus volumes of 10 to 15 in the peak hour
- dwell times of 10 seconds or more per stop
- adequate rights-of-way for the bay and sidewalk
- locations of bus transfers or overtaking lanes

On a congested urban roadway, it is likely that all of the criteria can be readily met except that of less than 500 veh/h in the lane; with the ability to manage usage of an HOV lane so as to be well below that figure the problems associated with such high volumes (particularly merging back into the lane from the bay) can be removed. Together with making it a legal requirement for cars to yield to buses in a merge situation (as in Quebec), efficient transit operation can be readily maintained.

Far side placement of bays at intersections can help ensure a gap in traffic, and public cooperation in providing gaps in the traffic stream can be the focus of a marketing campaign. Due to the higher operational speed of traffic in the curb HOV lane, consideration may be given to lengthening the bus bay exit taper to allow for a more flexible, higher speed merge. Lengthened bus bays may be utilized as enforcement pullovers, as noted in Exhibit III-24.

III-8.1.1 Intersections

There are several bus bay designs that can be used at intersections. The stop can be in the form of a bus bay or combination bus bay / enforcement area. Furthermore, these bus bays can be located either on the near side, or on the far side of an intersection.

Near side bus bays are preferred when transit flows are heavy but traffic and parking conditions are not critical. A disadvantage of near side stops is that buses often obstruct stop signs, traffic signals, as well as pedestrians crossing in front of the bus. Shifting near side stops several meters back from the intersection may allow a bus to serve passengers without having to wait in a right turn / carpool queue (refer to Exhibit III-9).

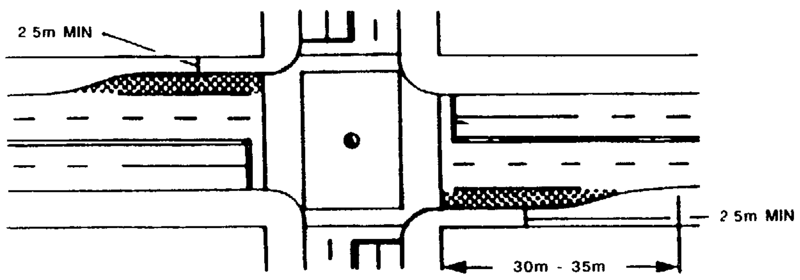
Far side bus bays should be encouraged whenever conditions permit. Far side bays are preferred where signal capacity problems exist, and when buses have use of the curb lane. Conflicts between buses and right turning vehicles, and sight distance deficiencies on approaches to intersections are eliminated when bus bays are located on the far side of the intersection. Also, pedestrians are able to cross at the rear of the buses while being clearly visibly to the oncoming traffic. A disadvantage of a far side stop is where the stopping area is not long enough to accommodate heavy demands and the overflow obstructs the cross streets. Exhibit III-24 illustrates these two bus bay designs; signal pre-emption by transit vehicles can optimize the use of either bus bay type.

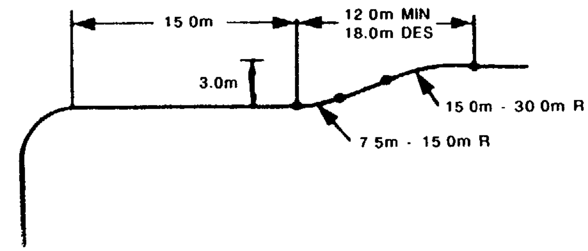
III-8.1.2 Mid-block

Mid-block bus bays should be provided whenever an HOV facility is used by local buses. Express buses can access mid-block locations in areas where large generators of passengers exist. Enforcement facilities may also be incorporated into the design of a mid-block bus bay. Mid-block bus stops improve the bus drivers' sight distance and thereby reduces potential conflicts with both vehicles and pedestrians. Also, passengers waiting to board at mid-block locations assemble at less crowded sections of the sidewalk. An example of a mid-block bus bay is also shown in Exhibit III-24. However, mid-block connections are unsuitable for transferring passengers from a crossing bus or rapid transit route, due to the walking distance and indirect connection.

III-8.2 Platforms / Shelters

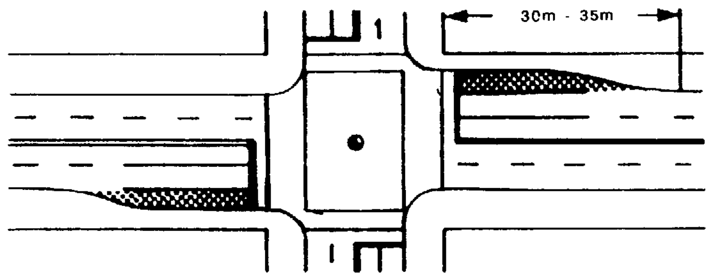
Proper passenger loading facilities should be used at all passenger /transit access points. These platforms should be large enough to accommodate the number of passengers using the facility as well as be capable of providing an adequate shelter. Passenger loading platforms should be designed in conjunction with HOV facilities as well as off line HOV transfer faculties. A premium should be put on safety and visibility.

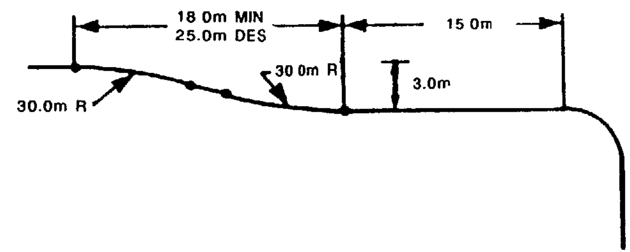




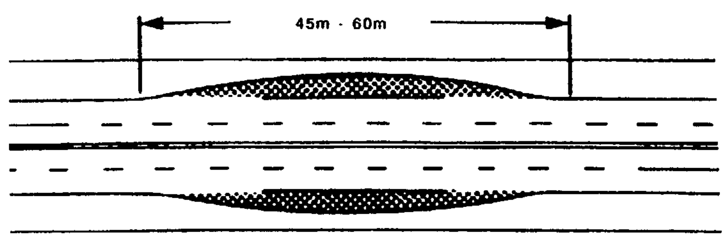
FAR SIDE BUS BAY

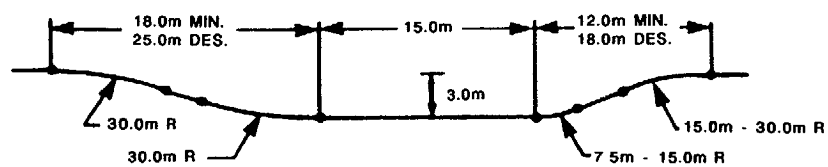
NOTE : DESIGNS BASED ON STANDARD 12.0m BUS
ADD 14.0m FOR EACH ADDITIONAL BERTH





NEAR SIDE BUS BAY





MID - BLOCK BUS BAYS

SOURCE : ADAPTED FROM THE GUIDE FOR THE DESIGN OF HIGH OCCUPANCY VEHICLE AND PUBLIC TRANSFER FACILITIES (AASHTO 1983)

HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 24 SCHEMATIC : NOT TO SCALE	BUS BAY DESIGN

Interior lane HOV routes which are used by local transit must have passenger loading areas located adjacent to the lane in order to minimize passenger / LOV traffic conflicts. Right curb HOV facilities with or without bus bays must have passenger loading platforms either adjacent to the lane or the bus bay, respectively. Passenger loading areas located in a median or adjacent to an inside lane must be carefully designed for pedestrian safety. The length of such areas will depend upon the number of buses expected to use the facility at any one time but should not be less than 15 m. The width should be adequate enough to provide for pedestrian storage and movement and should not be less than 1.5 m. Loading platforms should be raised to allow passengers to board and exit from transit vehicles easily. Also, it may be desirable to provide splash plates or mesh fencing to reduce the risk of pedestrian-auto conflict.

III-9 NON-HOV CONSIDERATIONS

III-9.1 On-Street Parking

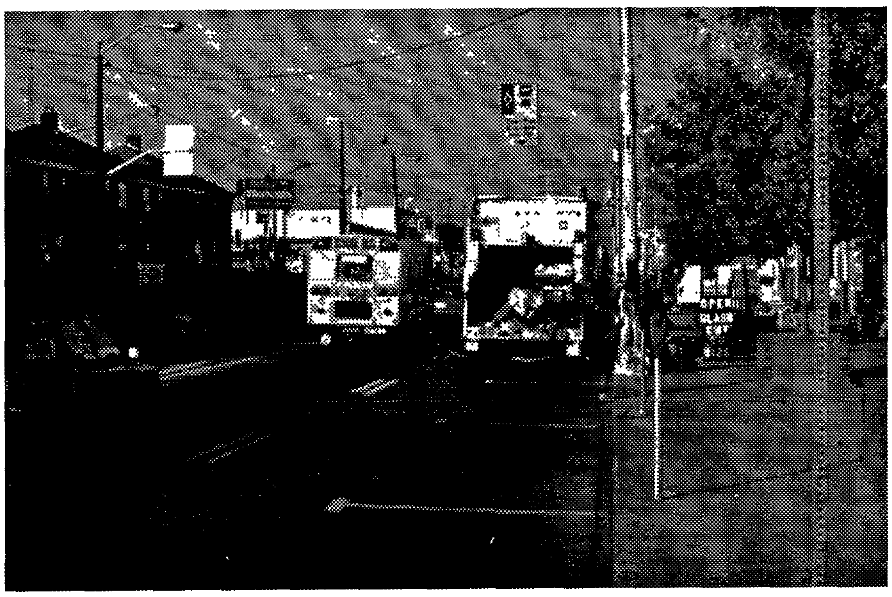
On-street parking must be prohibited at times when the right curb of a roadway is designated as an HOV facility. If the designation is for peak periods only, parking (strictly enforced) may be allowed in the off-peak hours; all vehicles must be removed by the time the lane begins operation, though, implying the need for an active "tag and tow" policy. In the case of an interior HOV lane, parking may be allowed in the curb lane only if at least one lane remains for through LOV traffic (implying at least three lanes of pavement in the affected direction - a six lane arterial or a three or four lane one way street would be required). Both Quebec City and Ottawa operate bus lanes in the second lane on key arterial segments where on-street parking must be preserved; due to the higher volumes normally present in an HOV 2 + lane, this strategy may be less suited to non-RBL situations if parked

On-street Parking with Reserved Bus Lane (5 lane roadway) - Boulevard Rene-Levesque, Quebec City (CUTA Forum, July 1993) vehicle turnover is significant. If it is desired to "preserve" an HOV lane under conditions of underutilization, one strategy to minimize public concern is to allow parking in the curb (HOV) off-peak periods; this ensures that the lane is visibly well-utilized most of the time, and builds local support for the preservation of the lane's special status.

III-9.2 Delivery Zones

As with on-street parking, deliveries must also be prohibited from right curb HOV applications. In the case of interior HOV lanes, specific segments along the right curb lane may be designated as loading and delivery zones during non peak hours, as long as at least one lane remains for through LOV traffic.

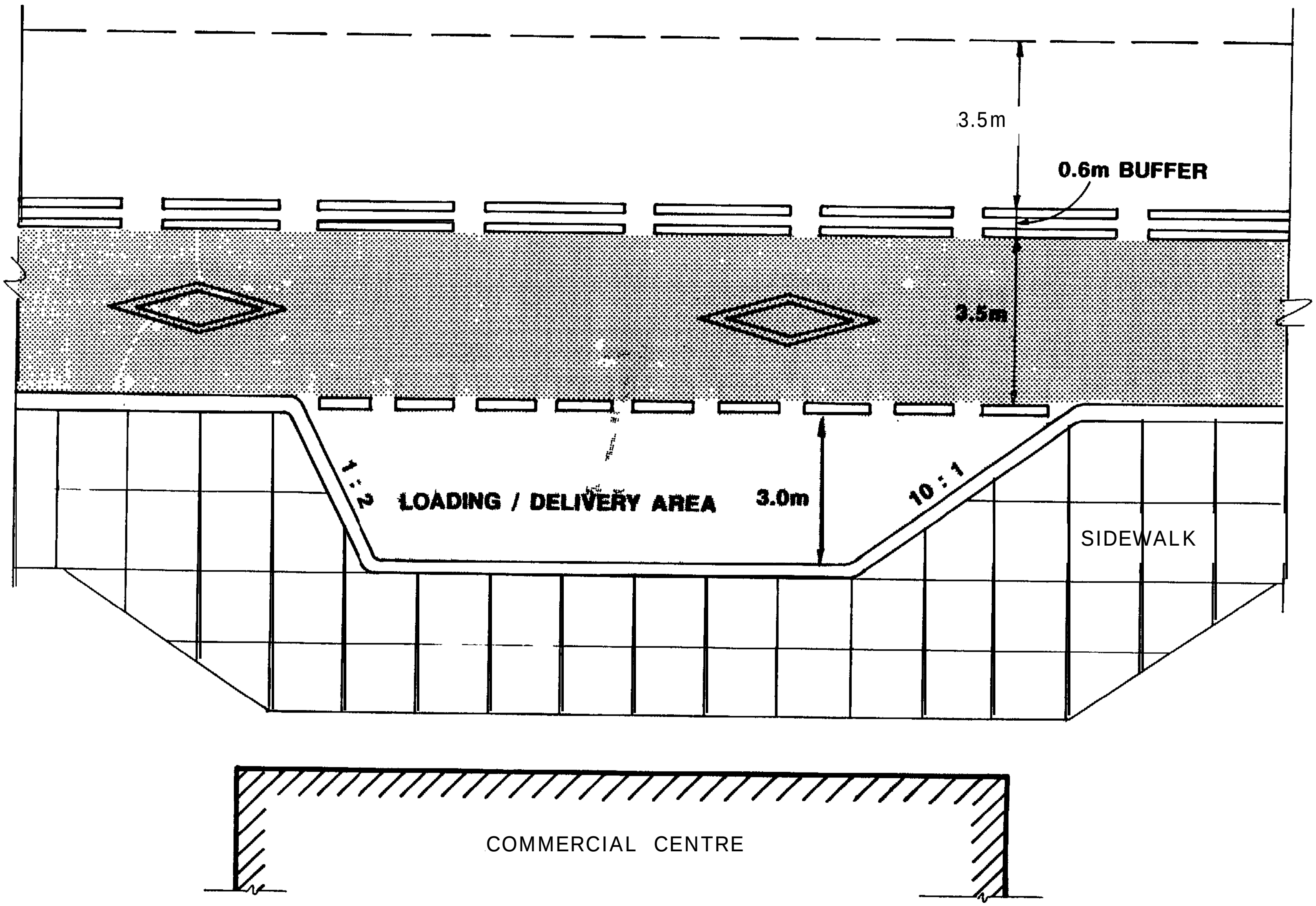
If the need is great enough and right-of-way is available, set back delivery areas can be constructed at required locations along arterials in commercial areas. An example is shown in Exhibit III-25. The most effective solution, however, is to have deliveries made from a rear access, a side street, or from off-street parking. In a related issue, every effort should be made to schedule curbside garbage pickup at times other than during HOV lane operation (see photo).



To be avoided : garbage pickup during reserved bus lane operation (Eglinton Avenue, North York)

III-9.3 Snow Removal

All roadways which have HOV lanes should be designated as "snow routes" and should be given first priority for snow removal.



HOV FACILITIES & PROGRAMS FOR ONTARIO MUNICIPALITES *OPERATIONAL PLANNING & DESIGN GUIDELINES*	EXHIBIT III - 25 SCHEMATIC : NOT TO SCALE	DELIVERY BAY DESIGN

III-9.4 Construction / Maintenance

Whenever a roadway is being planned for construction, designating one of its lanes for HOV use should be given prime consideration. If an existing facility is planned for widening, designating the new or existing lanes for HOV use should also be given consideration.

Also, designating a lane for HOV use on a roadway under construction as a temporary means of maximizing the available capacity may provide another HOV opportunity. If proven successful the lane can be implemented on a full time basis, and if not, the HOV designation can be terminated upon completion of the project.

SECTION IV: HOV PRIORITY PROGRAMS - AN ESSENTIAL PART OF THE PACKAGE

IV-I INTRODUCTION

HOV lanes are intended to move people as efficiently as possibly and in doing so to provide a significant incentive for those who now drive to switch to HOV use. However, the time saved while travelling in an HOV lane is but one factor in the series of decisions which are made by each traveller regarding the need for and mode of each trip.

If a system of HOV lanes is to be as effective as possible in improving mobility and achieving its other goals, it is imperative that HOV - related incentives be established which address the entire trip decision making process. This section outlines the key programs, and facilities, and operational techniques which act together with the HOV lanes themselves to produce the greatest benefit (see Exhibit IV-I). It may be noted that many of the programs and policies outlined below are capable of acting independently of the presence of HOV lanes and stand alone as significant inducements to change travel habits. Several examples of priority programs can be found in the MTO publication *"Highway Vehicle Opportunities, Incentives and Examples - A Handbook for Ontario Municipalities "*. It may also be noted that targeted, relevant support measures are <u>very important</u> in ensuring that HOV lanes are effective and well-used,

> It is recommended that, in each urban area where HOV initiatives are being cunsidered, a mechanism be put in place to bring together all providers and planners of such services and facilities, and that a coordinated, concerted effort be made through joint actions and defined responsibilities of all involved. It is further recommended that each HOV lane project be accompanied by a parallel and related HOV support program effort and commitment.

IV-2 TRAVEL DEMAND MANAGEMENT

The term, "Travel Demand Management", or TDM has grown in usage to refer to the entire spectrum of initiatives aimed at reducing peak period congestion in urban areas. This includes everything from physical facilities such as HOV lanes to marketing programs and express buses, and reflects the fact that, rather than build more infrastructure (supply), gains can be made through management of demand. In this respect TDM is a broader (and different) term than TSM, or Transportation System Management. TSM refers to the various engineering approaches taken to maximize the capacity and efficiency of the physical system, such as electronic traffic management initiatives.

Exhibit IV-1 : HOV INCENTIVE POLICIES/PROGRAMS/FACILITIES

	INITIATIVES	EXAMPLES	MARKET					COSTS		BENEFITS			IMPLEMENTATION						
			GENERAL PUBLIC	CARPOOLERS		BUS USERS		START UP COST	ONGOING COST	NEW CARPOOL USERS	NEW BUS USERS	BETTER USE OF LANE	ESSENTIAL	AREAWIDE	CORRIDOR SPECIFIC	PILOT PROJECT POTENTIAL	DEPENDENT ON HOV/RRL PRESENCE	ORGANIZATIONAL NEEDS	
				EXISTING	POTENTIAL	EXISTING	POTENTIAL											EXISTING	NEW
SHORT TERM	SPECIAL PUBLIC TRANSIT PLANS	EXPRESS BUSES NEW STOPS, NEW ROUTES, CO-ORDINATED FARES AND SERVICES				✓	✓	HIGH	HIGH		✓		✓	✓	✓	✓		✓	
	PARK AND RIDE LOTS CARPOOL LOTS	PARKING AREAS TO FORM CARPOOLS OR TO TAKE A BUS		✓	✓	✓	✓	MEDIUM	LOW	✓	✓		✓		✓			✓	
	ENFORCEMENT REQUIREMENTS	*PULLOVER AREAS, SURVEILLANCE AREAS,* FUNDING, LEGAL STATURE SIGNAGE, PHONE IN VIOLATION REPORTS	✓					HIGH	HIGH			✓	✓		✓	PHONE-IN PROGRAM	✓	✓	
	PUBLIC INFORMATION, EDUCATION AND MARKETING	MARKET SURVEYS, ADVERTISING, ENVIRONMENTAL ADVOCACY INFORMATION KITS	✓		✓		✓	HIGH	MEDIUM	✓	✓		✓	✓	✓				✓
INCENTIVE PROGRAMS	PRIVATE BUS AND VANPOOL OPERATION	AIRPORT SHUTTLE BUSES, CORPORATE VANPOOLS, INTERCITY BUSES				✓	✓	LOW	LOW		✓				✓	✓		✓	
	PREFERENTIAL HOV PARKING	RESERVE BEST SPACES AND/OR LOWEST FEES FOR CARPOOLS		✓	✓			LOW	LOW	✓				✓	✓	✓		✓	
	EMPLOYER INCENTIVES	SUBSIDIZE TRANSIT PASSES, IMPLEMENT RIDESHARE PROGRAM, REDUCE USE OF SINGLE OCCUPANT VEHICLES		✓	✓	✓	✓	LOW	LOW	✓	✓			✓		✓		✓	
	HOV BYPASS LANES AT METERED RAMPS	*QUEUE BYPASS FOR HOVS*		✓	✓	✓	✓	MEDIUM	LOW	✓	✓				✓			✓	
	RIDEMATCHING SERVICE	AREAWIDE PROGRAM TO HELP *PEOPLE FORM OR USE CARPOOLS*		✓	✓			MEDIUM	MEDIUM	✓				✓		✓			✓
	RIDE BACKUP SYSTEM	"GUARANTEED RIDE HOME" BY TAXI OR BUS IF CARPOOL IS UNAVAILABLE ON SOME DAYS		✓	✓			LOW	LOW	✓				✓	✓	✓			✓
BROAD POLICIES	MUNICIPAL INCENTIVES	REDUCED PARKING REQUIREMENTS FOR HOV - SUPPORTIVE DEVELOPMENT, TRANSPORTATION MANAGEMENT ASSOCIATIONS, HIGHER DENSITY ZONING TO CREATE TRANSIT AND RIDESHARING OPPORTUNITIES	✓		✓		✓	LOW	LOW	✓	✓			✓		✓		✓	
	PREFERENTIAL HOV INSURANCE RATES	LOWER RATES FOR CAR/VANPOOLS			✓			LOW	LOW	✓				✓		✓		✓	
	TRANSPORTATION HUBS	IMPROVED INTERMODAL CONNECTIONS TO REDUCE NEED FOR CAR USE	✓					HIGH	LOW	✓	✓			✓				✓	

Since their goals are essentially identical, HOV priority measures have become a cornerstone of TDM efforts. An HOV lane would in fact be a subset of an area-wide TDM program. In most cases to date, however, TDM has been applied on a site-specific basis, in situations ranging from several-thousand-employee office parks to individual traffic generators to emerging urban centres. The nature of TDM measures in this context requires that some or all of the key players (major employers) in an area voluntarily associate to coordinate and implement them, usually acting in self-interest in response to parking restrictions, peak period accessibility problems, municipal direction, or land use intensification desires: TDM application on a community - wide basis is rare, but most TDM components can readily act across a large area. It may be assumed that private-sector-initiated TDM programs are unlikely to be prevalent, and that government agencies would be required to play a coordinating / initiating role.

Examples of TDM applications are most common in the U.S., and in many cases very significant achievements have been made in reducing the peak period load on the road system. In a number of areas, TDM programs have been initiated to help resolve air quality or energy use problems through transportation measures. These are well documented in the Institute of Transportation Engineers' 1993 report, *"Implementing Effective Travel Demand Management Measures:.*

A brief list of typical TDM measures includes:

<u>Facilities</u>

- HOV Facilities
- Parking Management - priority parking location
- priority pricing

<u>Services</u>

- Express Buses
- Shuttle Buses
- Carpools
- Vanpools
- Public Transit
- Employee Transportation Coordination
- Workplace Amenities / Services

<u>Programs</u>

- Employer Sponsored Programs
- Employee Programs
- Alternative Work Hours / Flex Time
- Transit Pass Programs
- Ride Matching Services
- Guaranteed Ride Programs
- Marketing

The variety of TDM measures available emphasizes the fact that, due to the personal, relatively informal, non-financial nature of carpooling, it is difficult for a particular agency to take responsibility for it in the same way that, say, public transit is organized. What must be provided are the facilities and programs which encourage and facilitate Carpool formation and transit use, through coordinated efforts of all of the various organizations with responsibilities in the transportation area.

Achieving significant results on an areawide basis with anything less than an overwhelming mandatory TDM approach has proven to be extremely difficult. In large part, this is due to factors beyond the control of the TDM proponent, such as low fuel prices, unemployment, and past land use planning practices. When combined with the inherent functional and organizational difficulties of a broad-based TDM program the ability to independently affect travellers' mode choice is relatively limited.

AREAWDE TDM - AN UPHILL BATTLE

A recent assessment of Massachusetts' TDM program holds some usefut lessons:

- TDM program has been run since 1979 by a non-profit organization {CARAVAN) under contract to the State Highway Department; $ 800,000 annual budget supports 10 professional and several administrative staff
- Vanpool program put 140 vanpools on the road in 1930 (vs peak of 216 in 1988); users satisfied but problems occur in finding replacements for riders / drivers
- support for 200 employers has not produced noticeable, lasting increases in carpooi use
- areawide vehicle occupancy rates declined continually since 1979 despite TDM efforts
- public ridematch program diverts only about 300 divers / year to HOV modes
- TDM publicity only reached 1 % of commuters
- outreach program utilzing public libraries was not followed up by library staff
- work with two Transportation Management Associations exhibits some potential

The study recommended refocusing the TDM organization's activities - "Rather than try to communicate and work directly with dozens of cities and towns, hundreds of private firms, and hundreds of thousands of individual commuters, it is suggested that CARAVAN attempt to work more closely with a selected number of major employers to develop site-specific, employer ride-sharing programs. Wherever possible and appropriate, CARAVAN should use the assistance of Transportation Management Associations".

("Evaluating Ride-Sharing Programs: Massachusetts' Experience", J. Collura, Journal of Urban Planning and Development, American Society of Civil Engineers, March 1994)

A successful TDM initiative requires a clearly defined mandate, an experienced, skilled and committed lead agency, inter-agency cooperation, a defined funding source, and support from potential users. A formal mechanism which involves all HOV practitioners is recommended for each urban area considering any such initiatives.

The key TDM measures relevant to Ontario (with the exception of HOV lanes themselves), are outlined in the following sections.

IV-3 HOV-SUPPORTIVE PROGRAMS AND ACTIVITIES

IV-3.1 Transportation Management Associations

As noted above, TDM initiatives in a particular area require the involvement and commitment of, in particular, the major employers affected. The most popular method is through the implementation of a Transportation Management Association, or TMA, consisting of property owners, employers, transportation providers, and workers in a defined high-activity area. A TMA may emerge in response to specific issues, or it may be guided by government initiative; as each area is unique, so is the purpose, funding arrangement, and scope of activity of each TMA. The key benefit is that a TMA provides a forum for results-oriented grassroots responses to a local problem; however, it can be difficult to maintain involvement once the specific immediate goal (e.g. reducing parking demand) has been met, and turnover in businesses and employees may create the problem again while the program is cut off well short of the maximum potentially achievable benefit. There is often a key role to be played by government agencies in initiating and ensuring the continuity of TMAs, however, a clear mandate is required if the TMA in question is not to become one of the many examples of TDM programs struggling due to inter-agency competition or lack of direction.

IV-3.2 Ride Matching Service

One of the fundamental marketing elements of any effective HOV system is some form of ridematching service, whereby assistance is given to potential carpoolers in forming eligible Carpools. This basically consists of a computer listing of people wishing to Carpool, their travel patterns, and contact information. Registrants are screened and given a list of potential riders with similar characteristics. Ridesharing centres can operate privately (e.g. “Commuter Computer” in Los Angeles) or publicly, or can be operated by the municipal transit authority (e.g. Portland, Oregon). In view of their common people-moving mandate and marketing and public response mechanisms, closecooperation between ridesharing agencies and transit operators is essential.

It is important to recognize that Carpool / ridesharing programs complement, rather than compete with, transit services, and that both aspects of the HOV program are important to the achievement of the HOV network objectives. In any case, the auto component, accounting for the majority of person trips in most Ontario centres (and virtually all of their congestion) must be addressed effectively by the HOV program.

Surveys of carpoolers show that the majority of Carpools are formed either at home or amongst co-workers. The higher the minimum occupancy requirement, the greater the emphasis on work-based carpools. For example, a 3 + requirement would generate more work-based Carpools while a 2 + designation would be more oriented towards home-based Carpools. Other research and experience has indicated that area-wide rideshare programs are less likely to realize their potential to generate Carpools than are home- or work-based initiatives.

Ridematching services within employers or office complexes should be a high priority; the mandate of the rideshare office should include working directly with companies or agencies to create ridesharing programs tailored to individual needs. One mechanism commonly used is to designate an "Employee Rideshare Coordinator" within an organization and provide them with adequate support material to do the job.

Kathy Webster, former employee transportation co-ordinator at Toronto's Sunnybrook Health Science Centre (now with DNL Group, Inc.), provides this example of an effective employer-initiated ridesharing effort:

"Sunnybrook Health Science Centre initiated an employee ride sharing program in 1992 in response to rapidly growing parking demands, municipal zoning requirements for a new capital construction project, tra&fic congestion on the campus and a sincere concern for environmental issues.

The program was implemented using a strong marketing and incentive plan over a 12 month period. Its success was partially due to a drastic increase in overall parking fees, with reduced fees for ride share participants. Unique aspects of each employee group, and the geographic home location and travel route of each participant were integrated into a customized database management system.

This approach resulted in an interest group of over 600 people with 100 plus active car pools. Along with the promotion of bicycling, the TTC the use ofprovincial Car Pool Lots, and GO Transit, ride sharing has produced a saving of over 100 parking spaces and has been a major contribution to Sunnybrook's efforts in Transportation Demand Management."

The Ontario Ministry of Transportation / Ministry of Energy recent joint initiative to establish a ridesharing centre should be monitored closely. Also of note is the Ministry's experience in the early 1980's with a pilot ridematch project; the ridematch software and procedures are still in use for Ministry employees, and a free start-up kit is available to those wishing to initiate a Carpool / Vanpool program. The most recent provincial ridesharing initiative has been the promotion of the system under the "Green Workplace" environment-related program (see below).

2 Feb. 18, 1994 topical

It must be recognized that initiating, advertising and operating a rideshare centre is not free; salaries of one or two full time staff, phone lines, computer materials, and office space would entail an expenditure of upwards of $100,000 per year plus advertising (which can easily double the figure). There are limited means of direct recovery of costs apart from TDM-related development contributions. However, a public access ride match program of some sort is virtually a prerequisite if the optimum benefits of an HOV facility are to be achieved.

One carpool matching opportunity which exists in major urban centres in Ontario (and has not been subject to study) is at transit terminals (e.g. subway stations, shopping centre transit hubs, and GO train stations). Since rapid transit services act as a funnel for multi-origin / multi-destination trips, their terminals are in fact among the points of greatest commonality for trip making. The number of potential ridesharers involved is much higher than in any household or office, and interregional park and ride type car trips would appear to be particularly amenable to a transit terminal-based ridematching program. It is of note that a survey of GO Transit's parking lots where carpool priority measures are in place revealed that 70% of carpoolers and 74% of single occupant drivers expressed an interest in a ride-matching service. Such a service is not currently available.

In this context, it is also of interest that carpoolers tend to drive the greatest distance on average to a transit terminal, compared to bus passengers, kiss & ride users, and solo drivers (see Section I-4.4.2.2). While the latter modes all have cumulative access distance patterns similar to bus, and are therefore potentially amenable to shifting to that mode, carpoolers have a distinct pattern and are thus more appropriately addressed through targeted actions. Among these are enhanced rideshare programs and preferential parking spaces for Carpools. Both GO Transit (on the Lakeshore rail line west of Toronto) and BC Transit (in Burnaby, B.C.) have initiated pilot projects for preferential Carpool parking spaces.

PRIVATE RIDESHARING SERVICES

In Ontario, most if not all organized ridesharing services are run either by large employers or government agencies. As the interest in ridesharing increases, several private enterprises have begun operations that provide carpool matching services to the public. This service is not government sponsored. Each company requires a fee for its matching services.

The following companies offer carpool matching services in the Greater Toronto Area.

Carpool Organizer Inc,	1-800-481-8967
Ontario Carpool Inc.	1-416-454-9080
Poolit	1-416-515-9000
Rideshare Canada Inc.	1-416-777-1210

For further information on these services please contact the companies directly.

reprinted from Fuel $aver and MTEEAC News, MTO, July 1993

IV-3.3 Vanpools

Vanpooling programs may be offered by private firms, major employers, transit agencies, governments, or other organizations. Several large companies in the Toronto area, already include vanpooling in their ridesharing strategies, and they have been proven successful for many large-scale suburban employers. In the Seattle area, for example, transit agencies operate about 250 Vanpools while 100 more are privately run. This serves 4000 or more commuters and removes more than 3000 vehicles from the road.

Normally, the agency owns a passenger van which it offers to a group of riders who share the operating expenses amongst themselves. The driver must be licensed for passenger van operation, typically pays no operating expenses and has use of the vehicle outside commuting periods, while he / she is responsible for maintaining a regular daily schedule and organizing the pool. Alternatively, the sponsoring agency could subsidize an operator's own van purchase or lease. Often, the van is used for business purposes (meetings, deliveries, and so on) during the workday as well, helping to rationalize its purchase or lease.

Milwaukee Purchases 20 Vans For Regional Vanpool Service

Milwaukee, Wis.—Over the past 134 years, Milwaukee County Transit System and its predecessors have provided public transportation in a variety of forms. Now, for the first time, MCTS will have 20 vans available for regional vanpool service.

The vans were purchased with $400,000 in federal funds and $100,000 in state grant monies. The fleet includes 12 eight-passenger vans, seven 12-passenger vans, and one wheelchair-equipped, 1 O-passenger van.

"Because of the Clean Air Act, many area employers are looking for ways to reduce the number of employees driving alone to work. The VanPool program is a way for MCTS to help out employers by offering their employees another transit option," explained MCI'S Managing Director Thomas Kujawa.

Either the origin or destination of each VanPool work commute must be beyond MCTS and other public transit service areas in Milwaukee, Waukesha, Washington, Ozaukee, Racine, and Kenosha counties, the six-county area designated by the Environmental Protection Agency as having "severe" air quality.

Vanpools are expected to consist of employees from one comnany or a number of companies located near each other. Employers can assist employees with the VanPool costs or simply help employees who want to form Vanpools through internal communications and promotions. Vanpool fees cover fuel costs, van maintenance and insurance, and administrative costs.

Monthly VanPool fees are set by MCTS, based on the average work commute distance. For example, the seven Vanpool riders in an eight-passenger van will pay $64.29 per person per month for a work commute averaging between 3 1 and 40 miles roundtrip.

Only the VanPool riders pay monthly fees, The driver rides free and keeps the van for personal use, getting a free monthly personal mileage allowance of 150 miles. In exchange for these benefits, the driver submits monthly reports to MCTS, collects the monthly VanPool fees from riders for payment to MCTS, and cares for the van's fuel and maintenance needs.

Vanpool users are automatically eligible for the MCTS Guarantee Ride Home program through which transportation is provided for VanPool riders in case of personal emergencies.

from Public Transport (APTA), Sept 12, 1994

This strategy can fill the gap between Carpool and transit use, reduce parking requirements, and is particularly suited to customized commuting trips for large employers. For example, if a large employer shifted from an established location where many employees lived nearby to a suburban site not well linked by transit to the former spot, a Vanpool program could directly address the needs of the people affected without causing new car trips or long bus rides. Of course, linked with an HOV lane system, there is a stronger attraction to ridesharing in this manner. Another situation could involve a corporate van or bus shuttle between a major Rapid Transit / GO / Subway terminal and the office / factory / employment centre. This is essentially the principle used by many hotels in serving airport-based and downtown passengers.

Such services can be cost-effective, convenient, attractive, and directly targeted to specific interested people. In this manner vanpooling is a welcome option in a balanced, HOV-oriented transportation system and should be considered seriously as a potentially valuable element in the broader TDM package.

IV-3.4 Guaranteed Ride Home

An innovative HOV program in Bellevue, Washington (an urban centre in the Seattle urban area) is called "Guaranteed Ride Home". It was found that a number of potential carpoolers and vanpoolers were being dissuaded from switching from driving alone because of the difficulty in establishing a regular Carpool. If a Carpool driver, one or two nights a week, wanted to work late, leave early, go shopping, etc. it became difficult to rely on a Carpool. Meanwhile, many carpoolers may come from distant suburban rural communities, or other areas where transit service is unattractive or unavailable. Others cited safety concerns about travelling alone, while many felt the need for a car during the day for business or shopping needs. This issue becomes more important the higher the minimum vehicle occupancy rate for HOV priority; it is more difficult to keep three commuters together than two persons.

In response, a program whereby a registered carpooler was provided with a voucher good for a fixed value of taxi service per month was begun, and has been a factor in generating several hundred additional Carpools. In easing the risk and cost of being "stranded" this has proven a popular program; its cost-effectiveness stems from the reduction in structured parking required in downtown Bellevue, the energy and environmental benefits of HOV versus non-HOV use, and the stronger marketing position in which employers (taxpayers) in downtown Bellevue are put. Interestingly, relatively little use is made of the vouchers, but they are effective as an insurance policy.

The Guaranteed Ride Home Concept has since extended to dozens of TDM projects across the U.S. and is received as a very popular and low-cost insurance policy; its effectiveness in contributing to inducing modal shift is far out of proportion to its cost, and the program is recommended as a basic element in most TDM programs.

IV-3.5 Fuel Pricing and Road Tolls

An HOV incentive that has not been tried but which could be tested as a matter of provincial or federal government policy is the provision of lower fuel prices (or price rebates) for registered HOVs. Given the difficulties with monitoring car usage (a car could be registered as an HOV yet not used as such) the most practical test ground would be in the area of corporate vanpooling and municipal transit services.

If considering a broader "public" application, it may be more appropriate to instead raise the tax for single-occupant vehicles than to lower it for carpools. Given the extent of gas use, a nominal "Low Occupancy Vehicle tax" of less than a cent per litre would raise significant revenue which could then be applied to the HOV program. However, this would function more as a source of funding than as a significant deterrent to non-HOV use, while an increase large enough to have some effect on single occupant auto use would require careful consideration as to its net impact.

Another potential congestion management / funding strategy is the introduction of tolls. This action has the potential to be utilized very effectively to induce modal shifts; since the key determinants of model choice are time and cost, the provision of HOV queue bypass lanes at toll stations and preferential toll rates relative to single occupant vehicles are directly targeted opportunities. In areas such as San Francisco - Oakland and New York City, preferential treatment of HOVs in toll corridors forms the basis of the areawide HOV strategy. Monitoring of vehicle occupancy would require direct observation or video monitoring /ticket by mail capabilities in order to distinguish and enforce differences between HOVs and non-HOVs.

IV-4 PARKING PRIORITY

The time, cost, and convenience of parking plays a major role in any urban transportation system; parking conditions are simultaneously a major incentive in some areas to use cars and in other areas (e.g. downtown) to use transit. The ability of parking related initiatives to support the HOV network in achieving its goals should not be underestimated; it has consistently been cited as the single most effective tool available to achieve the goals of any TDM program. In many cases, parking management is, or can be, more influential than the presence of HOV lanes or even transit service in inducing single occupant vehicle users to change their travel habits.

IV-4.1 Policy

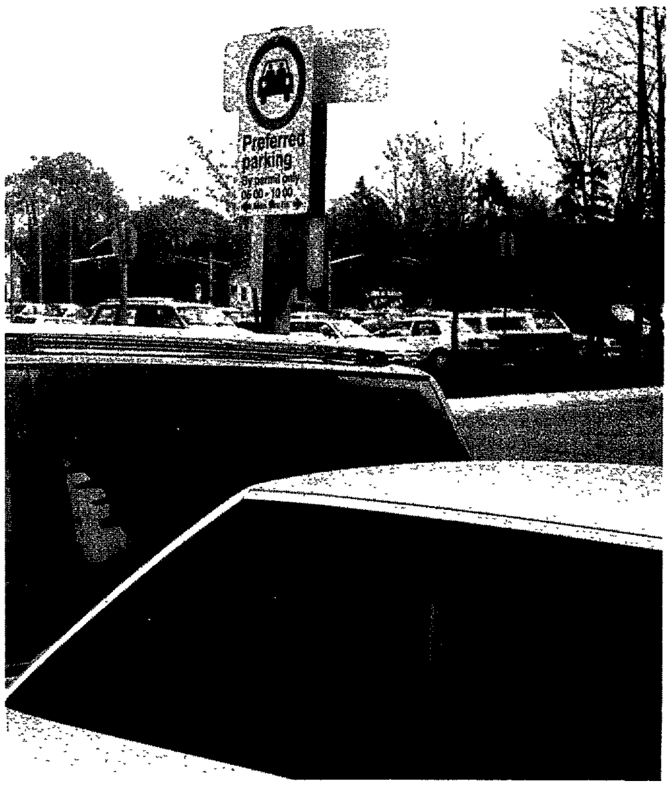
Just as the provision of ample free parking can negate an effort to shift car users to transit, so can a properly-focused HOV priority parking initiative support the achievement of HOV objectives. As an integral part of the entire car trip, it is a basic recommended policy that preferential parking treatment should be accorded Carpools over one-occupant cars. This can take many forms, as outlined in the following sections, and it is recommended that carpool parking priority become a standard element of municipal development and transportation systems as soon, and as extensively, as possible. It is of particular note that HOV parking policy can proceed and play some role in generating carpool use completely independent of HOV lane provision (although there are obvious benefits to linking the two).

It is of note that all of the factors which affect carpool parking - fees, location, extent, timing, availability, degree of preference over non-HOVs - are readily controlled; this ensures that the policy can be implemented and operated in an effective manner.

IV-4.2 Park and Ride Lots

Park and Ride lots form a major component of an HOV parking strategy. These are facilities intended to encourage transit use by providing large, low-cost parking areas where transit passengers can be concentrated, thereby providing enough demand for express transit service to operate efficiently and cost-effectively between the lot and major employment or entertainment centres. Park and Pool lots, on the other hand, are less oriented towards transit use, and simply provide a convenient staging area for assembling carpool patrons (see Section IV-4.3).

Where appropriate, HOV lanes can "feed" key park and ride lots on existing and future rapid transit systems. The inducement to thus use transit and Carpools on the trip to the park and ride lot (enhanced by express bus service and corridor ridematching) helps address one of the main drawbacks of the park and ride concept; namely, that provision of large low-cost parking areas in an effort to encourage transit use in fact acts as a strong incentive to drive a car (more often than not with a single occupant) to the lot, thus adding to congestion upstream of the transit system. Of course, driving to a park and ride lot offers convenience to the user that has meant tremendous popularity for the program over the years, but the provision of HOV lanes can go some way to make the transit and carpool alternatives more convenient. In fact, the significant concentration of trips at transit terminals offer new opportunities for carpooling (three people on the same block need only go together in a car to the subway, rather than to the same work destination).



Within the lots themselves, the setting aside of preferred areas for use by Carpools is another element in enhancing the total trip HOV incentive. Three or four minutes can easily be cut off a single trip by providing a carpool parking area near the station entrance while non-HOVs fill the rest of the lot; this time advantage is much more easily obtained here than on an HOV lane itself, and can go some way to offset the additional time often required to form a carpool or walk to a bus stop.

There is a more prosaic rationale for the provision of preferential carpool parking -the ever-growing demand for parking combined with limited availability and high cost of property to expand the lot makes it imperative in some locations to reduce or maintain current levels of vehicular demand. Most park and ride lots, in part because they are priced so as to encourage transit use, are full all day. If they are expanded, they still fill up (to the point where there are several 1000 - vehicle lots in operation in the Toronto area, including the 2,934-space lot at the Finch Subway Station). Further expansion of such lots implies more property being required, construction of costly parking structures (which cannot be funded by the user at typical park and ride fees), or unacceptably long walking distances. Safety of such long walks at night (or even during rush hour in the winter) becomes another concern. The heavy peaking characteristic of commuter flow also results in the need for a wide variation in exit vehicle processing capability, as well as in congestion on feeder roads,

SHOULD A COMMUTER TRAIN OPERATOR ENCOURAGE CARPOOLING?
GO TRANSIT'S EXPERIENCE

Go Transit Operates more than 20,000 parking spaces at 30 commuter rail stations in the Greater Toronto Area. Many of the lots operate at ~&pa&y, despite the fact that some can accommodate more -than- 1,500 cars; In an effort to encourage ridesharing at overcrowded parking lots thereby reducing the pressure to expand- lots or build costly parking structures, GO, in October 1990 initiated a preferential parking program for carpools at four of the busiest stations on the Lakeshore line Oakville, Port Credit, Long Branch, and Ajax.

A survey by GO Transit of its parkinglot lot users in May 1 990 indicated thatthe number of carpools using the parking lots could increase two to three times if a preferential carpool parking program were to be put in effect, To that end, a pilot project was implemented at the four lots whereby a number of parking' spaces near the platform were set aside for two-person carpools. To use the spaces an eligible vehicle must be registered with GO as a carpool car and display a sticker to that effect. As the number of car-pools increase, so will be site of the designated parking area.

GO Transit officials enforce the carpool areas by issuing tickets to unregistered vehicles up to 10:00 a.m., after which time any remaining spacies are available for general use. The program has been both successful and were received by users so far, and has demonstrated its ability to cause a mode shift from. SOV to. HOV at locations where parking is limited. 36% of the carpoolers taking advantage of the program previously drove atone, and 60% of users shifted to a later train because of the guaranteed availability of parking. Work is Currently underway to expand the program .

The expansion of this program to all similar park and ride lots is strongly recommended, both as an effective means of encouraging HOV use in urban areas and as a means of reducing site-specific parking demands. A particular focus on peripheral and line terminal stations is appropriate to reduce unnecessary vehicle travel within the urban boundary. It is of value to consider the potential impact on non-HOVs; in fact there may be considerable latitude for a relatively aggressive approach to preferential carpool parking at park and ride lots, because non-HOVs often have little alternative. Park and ride users have established a pattern and are taking transit because use of their car over their entire trip is either too slow, inconvenient, or costly. The risk of significant numbers changing to non-HOV car use over their entire trip when transit and carpooling incentives are becoming stronger would appear to be minimal. Strict enforcement of illegal parking (on side street, in shopping centres, etc.) by non-HOVs may be required in some areas.

IV-4.3 Carpool Lots

At several key freeway interchanges throughout the Southern Ontario, the Ministry of Transportation has provided and signed "carpool parking lots". These provide convenient parking and meeting points for commuters, and minor amenities such as telephones, lighting, and newspaper boxes are usually present. Most are not served by scheduled transit, but are well used by those assembling carpools.

A distinct effort to extend transit service to such lots is recommended (through GO Bus stops, for example), and improvement of lighting, safety, and publicity features should be pursued. In particular, these should be associated with any HOV lane initiatives on provincial highways. This may require changes to Ministry of Transportation interchange design standards (e.g. Highway 7 / Highway 400 carpool lot access). The introduction of convenient, well-lit sheltered pick-up and waiting areas in the lots, with posted transit schedules and rideshare service information would go some way to establishing the lots as a formal part of the HOV strategy serving suburban commuters. This is in recognition that a significant portion of the traffic on provincial highways in or near Ontario's urban areas is normally destined to, rather than through, the area, and that longer commuting trips are among the most likely to generate HOV use.

Within urban areas, the presence of transit service means that such lots would in effect act as park and ride facilities. However there are opportunities on a more limited scale to further encourage carpool formation and transit use through the provision of defined HOV parking facilities. It can be difficult for many people to form regular 3 + carpools yet the use of a car may be required only at the home end of the trip - for example to drop off school children or to do post-work grocery shopping. With park and ride / park and pool lots located throughout the area the ability of transit to expand into this market niche would be enhanced.

In addition, more than half of all carpools could be expected to form outside the home - for example, with co-workers - and although some of those trips would involve organized pickups, others would require the assembly of individuals at a common parking area, where one or two cars would be parked and the ride shared to the destination (work, a sporting event, recreation, etc.).

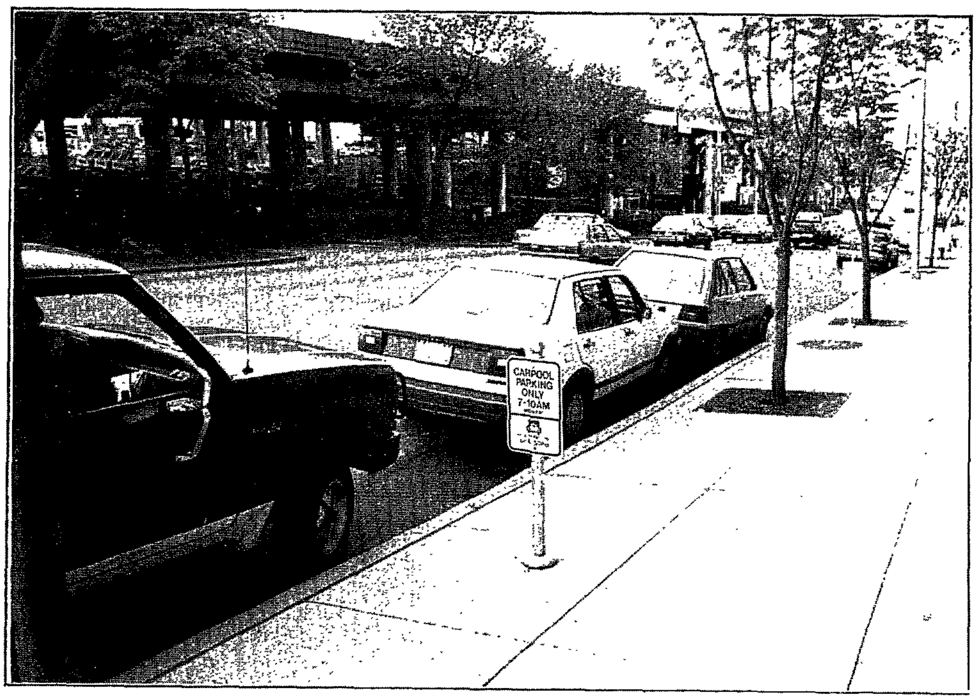
All of these activities now occur in the absence of any formal facilities, but transit and HOV lane use would be enhanced by the focusing of HOV formation on corridors with HOV lanes in place. Given the diversity of trip origins, destinations, and trip patterns in most urban areas, it is appropriate to develop carpool lots on relatively small scales. HOV lots should be located at the urban periphery (in order to intercept external trips and shift their mode within the urban area to HOV use) and in internal HOV corridors where rapid transit park and ride facilities are unavailable. A good level of transit service (preferably 20 buses / hour or more) is a prerequisite for attractive park and ride sites. The provision of bicycle lockers would help encourage use of bikes for the short collector trip rather than cars.

With a network of 50-100 car designated lots scattered throughout an area, a great deal of flexibility would exist as to their implementation and operation. What would be particularly encouraged is the joint use of existing parking facilities, whereby a designated portion of an existing lot is set aside for carpoolers (a registration system such as that now in use by GO Transit could ensure use only by eligible vehicles), and an annual rent could be paid to the lot owner (potentially generated through carpool parking registration fees) by the sponsoring agency. This would obviate the need for parking control and meter installation by the lot owner and would be a flexible mechanism to cut down unnecessary non-HOV travel. Other benefits include the optimization of use of existing facilities and elimination of the need for costly new lot construction. Potential sites are those which typically have low daytime weekday demand or lots which are large enough that a portion can be set aside in off-peak periods: churches, movie theatres, community / recreation centres, sports facilities, shopping centres and nightclubs could all be utilized. Shared use of shopping centre lots would encourage convenience shopping on the way home, thereby generating retail trade while reducing the number of convenience shopping trips taken by car. There need not be a minimum lot size, and ongoing monitoring of the program would be required.

IV-4.4 Trip-End Parking

At the trip destination, preferential parking for carpools is desirable in all municipal and private parking lots and garages, including employee parking lots. This does not require the creation of new parking spaces or facilities, but only the designation of existing spaces to the extent that all eligible vehicles may be accommodated. In reducing the total number of spaces available to non-HOVs, this approach signals the intent to encourage carpooling.

An innovative program in downtown Seattle illustrates other possibilities. In it, a registered carpool (with signed commitments by the participants that they form a carpool and commute together on a regular basis) can “buy” an on-street parking space with a monthly payment significantly less than that for a commercial parking garage. The meter is then removed from the designated space, to be replaced by a sign stating “carpool parking only”, including the carpool registration number. The space is so designated only from 7:00 to 10:00 a.m., thereby allowing commuting carpoolers first choice at the space while ensuring that the space is available later in the day if not in use by the registered vehicle. There are currently 640 spaces in the program. While such a program would constitute a minor part of any area-wide HOV incentive strategy, it is indicative of the broad range of HOV incentives which could be applied to any urban area.



ON-STREET CARPOOL PARKING, SEATTLE

IV-4.5 Parking Fees

In the provision of preferential parking facilities for carpools, a direct comparison to non-HOV treatment is involved (usually in the same lot) and therein lies the incentive to shift to HOV use. In other aspects of parking policy, such as fees, the comparison is blurred and transit policy enters the equation.

There are three ways of looking at this:

- destination-end carpool parking should not be given preferential fee treatment because it encourages car use and makes transit use relatively less attractive;
- the sharing of parking costs amongst carpoolers reduces each participant's parking costs by two-thirds - this is an adequate benefit / incentive on its own; or
- HOVs, be they carpools or transit, should be provided with the strongest possible incentives with which to attract non-HOV users, and low-cost parking for carpools is an effective high-profile way of helping achieve this goal.

It is of note that the issue mainly arises in downtown areas and in other commercial areas where paid parking lots are used.

There is a strong argument to be made for a parking incentive program to be as extensive and effective as possible, and therefore reduced carpool parking fees must be considered. In defense of the charge that it would encourage greater car use it is noted that the supply of parking may be considered to be fixed and therefore it would be impossible to increase the number of parked cars generated. And given the public funds invested in roads and parking facilities, it is appropriate that they be put to their optimum use: a garage full of three-person cars may obviate the need to build two more garages to accommodate the equivalent single-occupant vehicles. This principle is of particular note in areas with existing parking shortages; rather than build a new garage, efforts to replace the demand through transit use and carpool parking could be less costly and disruptive. Also, as noted previously, the preferential treatment accorded carpools can be readily manipulated to manage the demand.

A significant employee benefit, and one which encourages driving, is the provision of parking passes and free parking. Provision of a company car is also part of this issue. There is significant opportunity in this area to move towards encouragement of HOV use; an example comes from that most car-oriented of metropolises, Los Angeles, where Atlantic-Richfield (ARCO) has 1500 downtown employees and a strong successful TDM program. A significant part of its success in reducing non-HOV trips has been attributed to a parking policy which subsidizes employee parking costs on a scale tied to the number of vehicle occupants; also, a "transportation allowance" paid to those employees who do not drive effectively pays for their transit or vanpool use. This example highlights the fact that non-drivers, if they are not given an allowance equal to the parking privilege of drivers, are effectively subsidizing non-HOV use in most cities. The treatment of parking benefits as taxable income is one means which could help address this imbalance.

Another approach is to give each employee a transportation credit, which may be applied against a transit pass, a scaled-fee parking space (at lower cost for carpoolers) or pocketed if the employee walks or cycles.

For most employers, particularly those in central cities or suburban office parks, a major benefit provided employees is “free” parking. Although cars may be needed in some cases for business use, the guaranteed availability of such parking is a significant factor in inducing people to commute to work. Such an unrestricted drive-alone incentive is in direct contradiction with transportation, planning and HOV goals. It would also be worth calculating whether the annual cost of a company fleet car is greater than or less than the cost of a bus pass, guaranteed ride home program, and taxi use for meetings for all employees.

The other approach available is not to reduce carpool fees but rather to increase non-HOV parking rates as a form of pollution /energy /congestion /transit surtax. This would simultaneously encourage both transit and carpool use, while providing additional revenues for other HOV programs and reducing auto trip demand. The benefits and policy attributes of such an action are apparent, but the possible impact on business and public acceptance are significant concerns. One possible approach to balance the concerns is to raise non-HOV rates and lower carpool rates simultaneously rather than independently.

IV-4.6 Private Parking

In parking facilities such as offices and shopping centres where there are no parking fees involved, an immediate recommended action would be to designate preferred carpool parking areas near stairs, elevators, or building entrances. As mentioned previously, this can offer HOV users an incentive of up to several minutes of time savings per trip independent of any other HOV priority measure.

The incorporation of TDM principles into the development review process and encouragement of HOV-related measures to achieve an acceptable net transportation impact is a logical outcome of Official Plan policies promoting reduced transportation demand. Having endorsed such an Official Plan, Metro Toronto is monitoring the effectiveness of such measures in actually reducing demand.

IV-5 TRANSIT OPERATION

The introduction of HOV lanes provides transit operators with a new tool to generate more ridership and to provide more cost-efficient service. One key to success of the HOV network and by extension, the overall transit system, is the willingness and ability of transit operators to capitalize on this opportunity.

IV-5.1 Intermodal Coordination

The integration of transit service and fares across municipal boundaries is an ongoing process, and the linking of HOV routes across boundaries should provide an additional impetus to the program. Another focus is modal integration, whereby buses, subways, commuter rail, and other transit modes are integrated physically, fare-wise, and operationally both with each other and with car access. Thus HOV lanes not only serve transit operators on specific routes, they play a role in improving access to the entire transit system.

IV-5.2 Express Services

One means of making use of the potential is the introduction of express or limited-stop bus service on HOV routes. Since HOV lanes, by design, provide a faster transit route than in mixed traffic in a congested corridor, and one of the greatest hindrances to improving transit modal share is its current relatively low average speed, it is apparent that express routes utilizing HOV lanes could directly address some key transit problems. In considering this proposal, it may be noted that:

- HOV lanes provide a way out of the overall congestion which an express bus would have had to contend with in the past;
- HOV lanes in many instances are intended to support future rapid transit service - an express service provides both a strong intermediate step and helps build demand for transit in the corridor;
- express route initiatives (e.g. in Ottawa and Mississauga) have been well - received and have exceeded systemwide revenue / cost ratios;

- increased efficiency on HOV lane routes may be enough to free up at least a small portion of the existing fleet for express use; and,

- a faster express trip and a deadhead return trip utilizing reliable HOV lanes may allow a transit operator to obtain two or three peak period peak direction trips from a single bus, thereby significantly improving the revenue / cost ratio for the route.

The express route system is well-established in Ottawa, with a premium fare structure (both on an individual ticket and monthly passes) that distinguishes it from a non-express route. The express system allows a single bus to make two or three round trips during the peak period rather than one, thereby significantly improving system efficiency and reducing the fleet size (which is a direct function of the number of buses required during the weekday peak periods). With fewer buses and operators required, per passenger, there are direct financial benefits to the operator and the public who use and subsidize transit services.

For HOV corridors where a mix of local and express services is a possibility, there would be a strong incentive to provide bus bays so that express buses could move freely past stopped local service buses without having to merge into the adjacent mixed-flow lane.

"Dead Heading" buses via HOV lanes can improve fleet utilization during peak periods (Dufferin St., North York)

IV-5.3 Technological Advances

There are other transit initiatives of some benefit to HOV operation, but most fall under the broader area of Transit Priority measures as they also apply elsewhere in the system. Examples include electronic bus monitoring, proof-of-payment fare systems, use of advanced fare media (punch tickets, magnetic cards, etc.), signal preemption, use of Cable television, remote terminals and automatic telephone systems for schedule information, systemwide measures to improve access for mobility impaired passengers, and so on. In reducing loading time, improving convenience, speeding operation, and saving money all of these transit initiatives will enhance transit's ability to compete in the transportation market.

IV-5.4 "People-Moving Companies"

Several transit authorities in the U.S. have, in recent years, expanded their mandates to encompass all forms of public transportation - essentially transforming themselves into "people-moving companies". The integration of vanpooling, ridematching, employer-based HOV programs, paratransit, and "traditional" fixed-route transit service under one roof is intended to provide a more effective focus to all non-drivealone modes. There are considerable synergies to be gained, particularly in marketing, and the roles of carpools and transit can be defined (and any conflicts resolved) internally and consistently.

King County (Seattle), Washington: Portland, Oregon; and Milwaukee, Wisconsin have moved in this direction, while in Vancouver, B.C. Transit is part of the provincial "GO Green" initiative - "GO Transit or Carpool".

IV-6 MARKETING

One of the areas in which HOV lanes differ from "normal" roadway facilities is the need to market their use. Undoubtedly, the provision of an HOV lane would result in improved travel time and reliability for transit and therefore make it more attractive to riders, but it is clear that an extensive, multi-faceted marketing program should be undertaken as an integral part of any HOV initiative if significant gains are to be achieved. This is because the fundamental goal of an HOV system is to change people's travel patterns by inducing them to take buses and carpools more often than they do at present. In this respect, HOV lanes themselves are little more than a marketing tool, in providing a time and convenience incentive for drivers to change to HOV use. In order for change of any sort to occur, the people doing the changing must be made aware of the reasons to change, the benefits of doing so, the consequences of not changing, and the means by which it is most convenient and beneficial to become an HOV user. This is the job of the HOV marketing program.

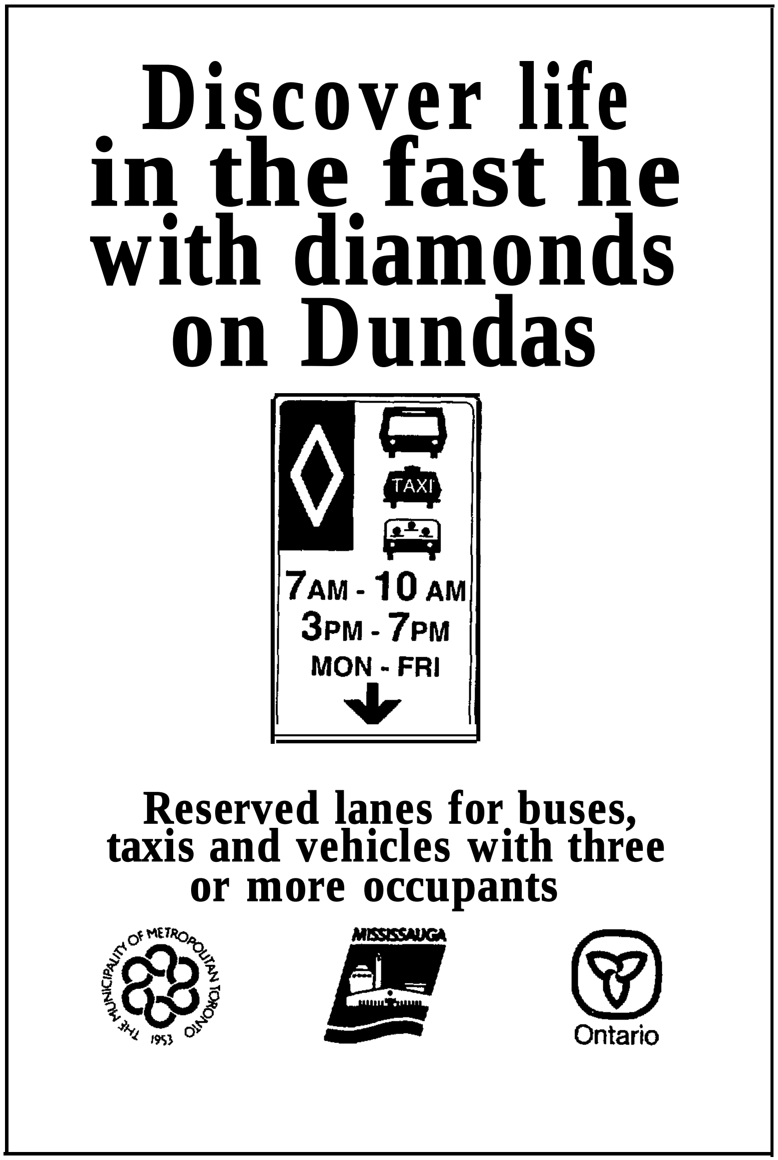
There are countless ways of going about marketing the HOV network, some proven successful elsewhere, some established in Ontario, and others completely untried. Some sustained combination of advocacy advertising, special programs designed to make HOV use as easy as possible, direct incentives and disincentives, and generating positive public opinion will be sought. This will evolve over time until HOV lanes are accepted as an unquestioned part of our urban transportation network.

One of the most significant marketing and promotion opportunities ever available to transit and HOV leaders is the current (and, it may be assumed, future) shift towards public awareness of the environmental and ecological impact of everyday decisions. In shopping, transportation, community planning, and education, the objective of environmental (and economic) sustainability has come to the fore. HOV (particularly transit) use directly and effectively addresses many of the key urban environmental issues of our time. HOV use can clearly be marketed as socially and environmentally preferable to non-HOV use, just as smoking, impaired driving, seat belt use and “participaction” have been in the recent past. This is an important asset, for there may be real or perceived negative effects on mixed flow conditions on some road sections due to HOV lane implementation (particularly when the HOV lane is converted from mixed traffic operation); the ability to cite environmental advantages and objectives in addition to the person-movement and vehicle occupancy benefits will be important in rationalizing / justifying any inconvenience to non-HOVs among both drivers and the general public. It is important to consider, however, that the most effective “advocacy” campaigns have all had a significant mandatory elements and / or various penalties for non-compliance, whereas HOV programs do not yet have the stature which generates support for mandatory or punitive measures for non-HOV use.

HOV marketing in Ontario is essentially starting from scratch, and a commitment to a sustained, strong marketing campaign, particularly in the early years of HOV system development, is a prerequisite of success. One benefit is that a campaign can be designed with few preconditions, and the strong support and concern for transit typical of Ontario’s urban centres provides a valuable base. Nevertheless, it is essential, particularly in the early period, to not only generate HOV use by commuters, but also to raise the awareness of the general public about HOVs, its benefits and implications. It should be considered that non-HOV drivers may hold as much of the key to HOV success as those who actually use the lanes, as the ability to complete and operate a successful HOV facility relies on public (drivers, neighbourhoods, businesses, taxpayers) acceptance of this use of the road infrastructure. If a lane is subject of constant protest, controversy, violation, and underuse, its viability and that of the HOV program will suffer; an HOV marketing program must address the broadest constituency in order to ensure that this does not happen, for it will be the general public, not the HOV users, who will be raising the issues.

Active coordination and cooperation among all HOV proponents - MTO, municipalities, transit agencies, major employers, etc. - is essential, particularly in defining roles, responsibilities, and direction with respect to individual or common HOV marketing exercises..

IV-6.1 Nomenclature



" Diamond Lane"; "Commuter Lane"; "Carpool Lane"; "Bus Lane"; "Urban Clearway"; "Express Lane": these are all terms used in various North American cities to denote an HOV lane, in an effort to get around the fact that "HOV" means different things to different people (and nothing at all to most!). Careful consideration to the public naming of an HOV route should be given, as the entire subsequentmarketing campaign would depend to some extent on ready public identification and understanding of the HOV concept as generated through the name. Metro Toronto has begun to refer to its HOV lanes as "Diamond Lanes", and users of the lanes as "Diamond Riders".

IV-6.2 Public Education

In the marketing of the HOV principle, there are two concurrent responses being sought: among potential HOV users, a change in behaviour resulting in increased HOV use is desired, while those who will not become HOV users need to be brought to accept and support the HOV concept. This broad acceptance is an integral part of the ability to allocate funds to HOV initiatives, to restrict usage of parts of the road by non-HOVs, to minimize violation rates and enforcement needs, and to allow the designation of existing lanes (where required) for HOV use.

To this end, the marketing strategy of the lanes should include an effective public education component. The benefits (congestion, travel time, energy, air pollution, cost-effectiveness, ease of implementation and so on) are all evident, substantial, timely, and relevant to Ontario's urban centres. These should be presented in the overall area context; if the HOV system as a whole is understood and supported, the job of marketing the implementation of individual components will be that much easier.

It is important to be sensitive to the different needs of the various market sectors; an areawide promotion of carpooling that focuses on 3+ formation would not be appropriate if several HOV lanes or other programs revolve around 2+ eligibility. It is also crucial to understand the transit and the carpool market sectors, lest a marketing campaign to promote carpools inadvertently have the effect of draining away transit passengers.

It is essential that municipal elected officials be brought to understand the HOV principle, its role in the transportation system and the unique benefits and implications associated with measures. Generation of this understanding represents a significant element of the marketing strategy.

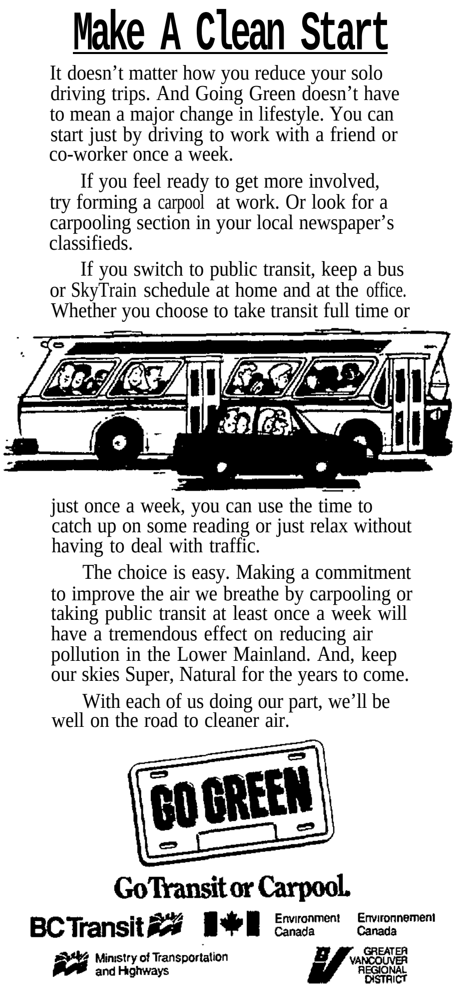
The means of public education in this regard are numerous; the mass media generally plays the largest role in raising public awareness and understanding and support should be pursued there. Other low-cost means of reaching the public include all the occasions on which local, regional, and Provincial correspondence and advertising is used, and the marketing programs of the transit operators affected are both readily accessible and tightly focused on the HOV market. Use of Community Channels on Cable television can provide an excellent opportunity for dialogue, demonstration, and explanation, although it is one medium which is normally underutilized due mainly to lack of publicity. An hour of prime time broadcasting across all of Metro Toronto, for example, can be had for less than $1000 in production cost, and if supported by a marketing effort could be an extremely cost-effective means of reaching the public. A live broadcast can be taped and distributed province-wide as well as replayed locally many times, thereby magnifying the impact at a nominal extra cost.

Cooperation and joint initiatives with employers is another avenue with which to pursue public education amongst those potentially most directly benefitting from the plans. HOV awareness should also be a fundamental part of the driver training, testing and licensing process.

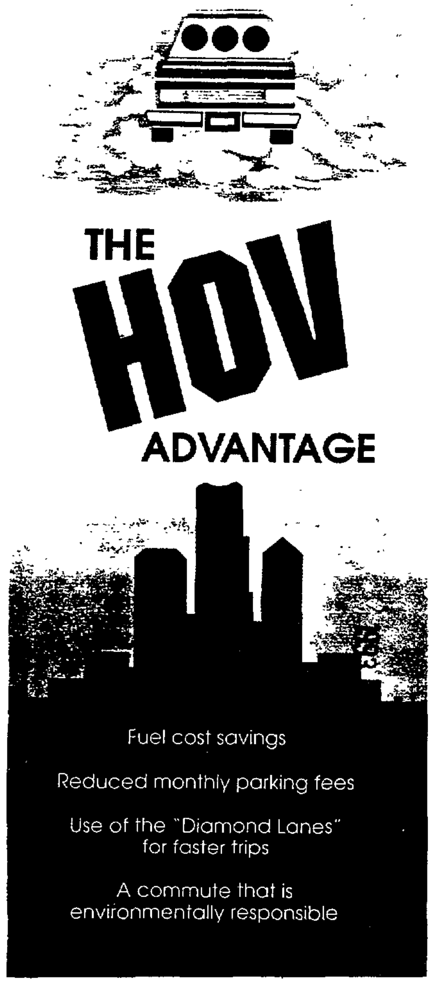
One area of publicity which would be both relatively easy and beneficial would be to show HOV lanes on all public and commercial transit, road and street maps. This would help establish the lanes as distinct parts of the transportation network and would be particularly valuable to visitors to Ontario who may not be familiar with the HOV concept.

On-street signage, billboards, and messages are required to reach the people actually using the road network. And finally, the successful implementation and operation of a significant portion of HOV lane is the greatest lesson in public education of all.

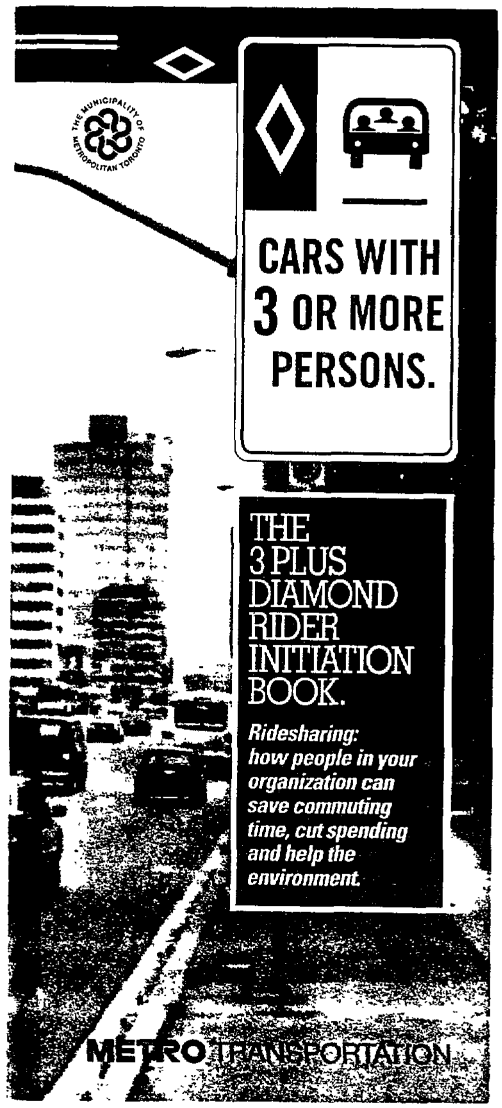
Practice elsewhere provides many examples of extensive and effective education / marketing campaigns. It is of note that target marketing (e.g. focusing on employees of larger firms, highlighting suburban employment centres, etc.) has been found to be more effective than "mass marketing" advertising; there is still a role for the latter to play, however, in generating acceptance of the HOV priority concept' among those who do not benafit yet who (through their taxes) are funding key measures.



Vancouver



Seattle



Metro Toronto

APPENDIX A

MINISTRY OF TRANSPORTATION
HIGH OCCUPANCY VEHICLE AGENDA

HIGH OCCUPANCY VEHICLE AGENDA

Ontario

Ministry of Transportation

September 1994

Preamble

Against the current backdrop of a maturing road network, increasing traffic demand, constraints on funding and increased environmental concern new approaches for maintaining urban mobility are being investigated. Preferred treatment on our road system for high occupancy vehicles (HOV) is one such technique.

This document outlines the ministry's HOV policy, a vision for the future and short term actions. The province and municipalities will both play key roles in the realization of this vision. Within the ministry, various disciplines will be involved, and an HOV Executive Steering Committee has been established to ensure cross-divisional coordination in the development of the HOV program. In the Greater Toronto Area (GTA), provincial and municipal activities are coordinated through a liaison committee.

What is a High Occupancy Vehicle ?

Simply put, HOV's are motor vehicles carrying more than a specified minimum number of people. An HOV can be a car, van, or a bus. The specific definition can vary - "2 or more," "3 or more," or " buses only" depending on the requirements. An HOV lane is a roadway lane dedicated to HOV use for a part of or a whole day.

Policy Statement

The province recognizes the importance of improving road utilization through HOV systems in addressing future transportation, environmental, social and economic needs. The province will work with other levels of government, transit operators and the private sector to establish a coordinated network of HOV **facilities and appropriate support programs.**

Due to fiscal, environmental and physical constraints, there is an increasing need to look at a wider range of options to utilize existing facilities rather than expanding transportation infrastructure. One such option is to provide facilities and programs that give preferential treatment to high occupancy vehicles.

The HOV approach offers many benefits in urban areas facing road congestion. Primarily, it encourages a more efficient use of existing roadways by moving more people in fewer vehicles, and meets one of the ministry's key priorities - ***to maximize use of the existing transportation system.***

Policy Objectives

- **to increase the travel capacity of congested road and highway corridors by increasing the number of persons per vehicle**
- **to provide travel time savings and a more reliable trip time to high occupancy vehicles**
- **to increase the capacity of the existing road network without compromising safety**
- **to reduce the need for new road construction**
- **to reduce energy consumption and air pollution caused by passenger vehicles**
- **to improve the attractiveness of bus transit by increasing its operational efficiency**
- **to promote transit ridership by feeding existing rapid transit facilities**
- **to develop ridership in future transit corridors**
- **to facilitate more intensified land use in urban areas**

The Vision

This look into the future of HOV's applies to the GTA but is adaptable to other urban areas in Ontario.

- An extensive HOV network has been developed. It contains both freeway and arterial facilities and complements other transportation systems; such as, GO Rail and other rapid transit.
- There are HOV lanes in place on most 400 series highways and key Ring's highways.
- A mature municipal HOV system is in place on major arterials.
- The municipal and provincial networks are well coordinated, providing convenience and substantial travel time savings for the users.
- Buses run substantially faster and more reliably, thus attracting many more people to transit.
- HOV lanes feed rapid transit facilities, improving access and encouraging more people to use transit.
- All major population and employment nodes are well served by HOV facilities and/or rapid transit.
- The HOV network is complemented by an extensive ride sharing and matching program.
- An effective HOV enforcement program is in place and the compliance rate is more than 90 per cent.
- A system-wide promotion and marketing program is in place and the public actively support HOV facilities.
- Average auto occupancy has increased 30 per cent from 1.15 to 1.50.

Key Strategies

These are specific measures which are designed to create the conditions to achieve the Vision.

Develop an integrated system of municipal and provincial HOV lanes

- Develop the provincial HOV network plan;
- Assess the feasibility of HOV lanes on all 400 series highways and key King's highways. Priority sections are planned widenings, new roads and areas of repeated congestion;
- Finalize municipal HOV network plans;
- Integrate provincial and municipal network plans to create a coordinated area-wide strategy.

Ensure coordination between HOV and transit operations

- Use HOV lanes to enhance transit service quality and reliability on major transit corridors and thereby increase ridership;
- Build ridership on future rapid transit corridors through interim HOV use;
- Encourage HOV lanes to feed rapid transit stations, eg. GO and subways.

Develop promotion and marketing programs

- Identify potential HOV users and develop appropriate marketing approaches for them;

- Develop integrated and comprehensive promotion and marketing strategies on an area-wide basis.

Ensure enforcement of HOV facilities

- Identify enforcement needs;

- Form partnerships with police forces and other enforcement agencies and develop effective enforcement techniques.

Develop support programs to complement HOV lanes

- In partnership with municipalities and the private sector, identify and develop support programs including ridesharing and parking policies on a corridor specific as well as area-wide basis.

Ensure consistency and coordination of HOV facilities, plans and programs

- Provincial and municipal HOV network plans are well coordinated, thus ensuring maximum efflciency ;

- Develop HOV policies, standards, procedures and guidelines for both provincial and municipal facilities;

- Coordinate planning, design and implementation of municipal and provincial facilities;

- Ensure provincial and municipal coordination of support programs, promotion and marketing strategies and enforcement.

Short Term Actions

The following outlines the short term actions by the province and GTA municipalities that support the Vision and Key Strategies. Some of these actions have already been acted upon or are underway, and others will be initiated shortly.

Network studies

- Studies to identify municipality-wide HOV networks have been completed for Metro Toronto and Halton Region. Similar studies are underway in the Regions qf Peel, York and Durham;

- The ministry will shortly be initiating a study to develop a GTA-wide strategy which will include both provincial and municipal components;

- Areas outside of the GTA which may warrant network studies are being identified.

Provincial facilities

- Reserved bus lanes (RBL) are now in operation on a section of Hwy.17 in Ottawa;

- A pilot project'to investigate the feasibility of HOV lanes on Hwy. 403 in Mississauga was completed and the following recommended:

- Reserved bus lanes on the shoulder between Erin Mills Parkway and Mavis road. These are presently under construction;

- HOV lanes in the median from Winston Churchill Blvd. to Hwy. 401. Preliminary design of these lanes is underway;

- A program to establish the need, justification and feasibility of HOV lanes on all 400 series highways and key King's highways has begun. To date the following actions have been taken:

- Four corridors have been assessed:
  - 403 (within Halton Region)
  - 427 (Hwy. 401 North to Hwy. 7)
  - 400 (401 North to Major Mackenzie)
  - 404 (401 North to Major Mackenzie);

- Detailed studies leading towards implementation are underway on the above sections of Hwys. 403,427 and 404;

- A decision to implement HOV lanes on Hwy. 400 is pending, subject to the resolution of operational issues such as lane mergers at the junction of Hwy. 401;

- Studies on Hwys. 401, 427 (401 south including QEW east to Gardiner Expwy.) and 410 will begin shortly.

Municipal facilities

- HOV lanes have been implemented on a number of roads within Metro Toronto and on Dundas St. in the City of Mississauga;

- Within the GTA a number of municipal HOV studies to determine need, justification and feasibility are underway or planned on major arterial roads,

Support programs

- A computerized ridematching program, developed by the ministry, is available free of charge to companies implementing employee ridesharing;

- The ministry promotes the establishment of ridesharing programs in large companies;

- The ministry is participating in the development and promotion of a government-wide ridesharing program.

Municipal/provincial coordination

- A GTA municipal and provincial committee has been established with representation from the ministry, Metro Toronto and the Regional Municipalities of Durham, Halton, Peel and York to coordinate HOV and Transportation Demand Management (TDM) activities. To date, the committee has addressed the following major issues:
  - Municipal HOV planning, design and operational guidelines have been prepared;
  - A review is underway of marketing, promotion and enforcement strategies in other jurisdictions;
  - Discussions are taking place with Metro, Peel and the Ontario Provincial Police regarding enforcement issues and options.

Recent Ministry Publications

1. High Occupancy Vehicle Lanes on Ontario Freeways - Operational Design Guidelines; May 1993.
2. A Handbook of High Occupancy Vehicle opportunities, Incentives and Examples for Ontario Municipalities: July 1993.
3. Operational Design Guidelines for High Occupancy Vehicle Lanes on Arterial Roadways Including Planning Strategies and Supporting Measures; September 1994.

Further Information

For further information on the ministry's program and/or the activities of the HOV executive steering committee and municipal and provincial HOV/TDM coordinating committee contact:

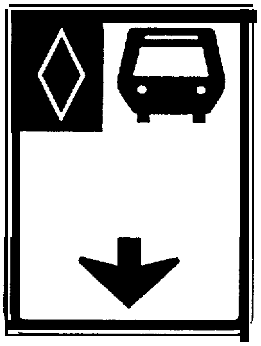
Vello Soots, Manager Transportation Demand Management and Forecasting Office, (416) 235-5036 or Brian Ogden, (416) 235-3969. Fax: (416) 235-5224
Ministry of Transportation
3rd Floor, West Tower
1201 Wilson Avenue, Downsview, Ontario; M3M 1J8.

Cette publication technique n'est disponible qu'en anglais.

APPENDIX B

MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES FOR CANADA (1976) REVISED MARCH 1994

- HOV SIGNAGE



RB-80
9Ox120cm

A2.87

Reserved Lane Signs (RB-80, RB-81, RB-82, RB-83)

The Reserved Lane Signs shall be used where lanes are reserved for specific vehicles, generally high occupancy vehicles. The appropriate symbol or symbols shall be used to indicate whether the lane is reserved for buses, taxis and/or multiple occupant vehicles.

Reserved Lane Signs shall be mounted either directly above or adjacent to the reserved lane. The appropriate sign. either RB-80 or RB-8 1, shall be used.

Reserved Lane Signs for part-time operation shall show the hours of the day and the days of the week when the lane is reserved. The appropriate sign. either RB-82 or RB-83. shall be used.

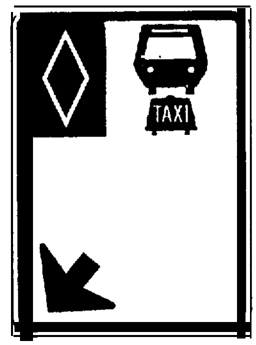
Reserved Lane Signs shall be installed at a minimum of one sign per block with this sign being located at the beginning of the block. Additional signs may be installed on a block where there is public access to the reserved lane. A final sign shall be installed at the end of the reserved lane and shall be accompanied by the supplementary **tab** sign RB-80 S2.

The supplementary tab sign RB-80 Sl may be used to indicate the start of a reserved lane. When used it shall be installed below the first reserved lane sign in a series.

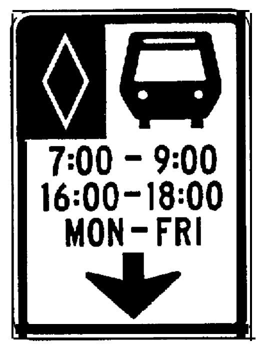
The supplementary tab sign RB-80 S2 shall be used to indicate the end of the reserved lane. It shall be installed below the last reserved lane sign in a series.

Typical applications of reserved lane signs are shown in Figures C.3 1. C.32 and C.33.

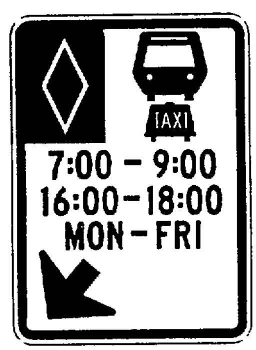
The reserved lane symbol for pavement marking is illustrated in Figure C.36.



RB-81
90xl20cm



RB-82
90xl20cm



RB-83
90xl20cm

RB-80SI
9Ox30cm

RB-80S2
90 x 30 cm

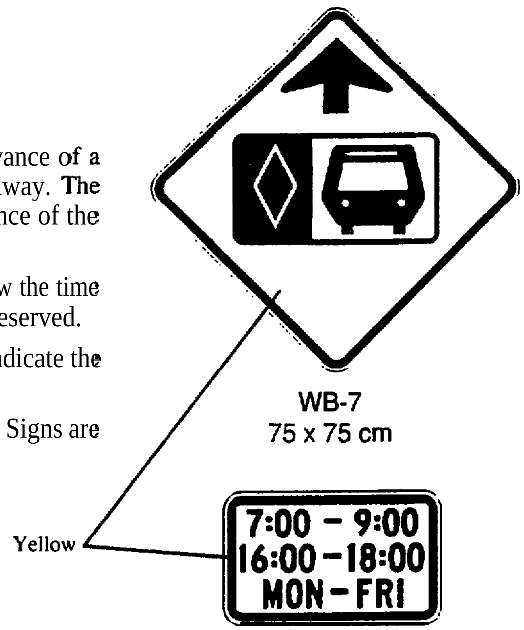
A3.56 **Reserved Lane Ahead Sign (WB-7)**

The Reserved Lane Ahead Sign shall be used in advance of a reserved lane. The signs may be placed above the roadway. The sign shall be located an appropriate distance in advance of the reserved lane.

The supplementary tab WB-7S may be used to show the time of the day and the days of the week when the lane is reserved.

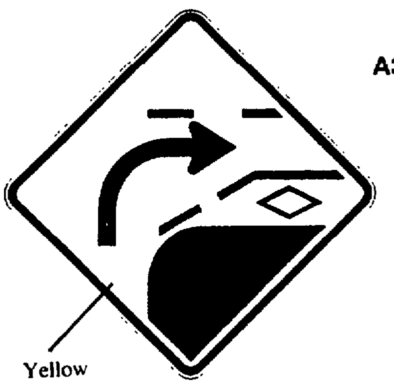
The supplementary tab WB-4T may be used to indicate the distance to the start of the reserved lane.

Typical applications of the Reserved Lane Ahead Signs are shown in Figures C.31 and C.33.



WB-7
75 x 75 cm

WB-7S
60 x 30 cm



WB-8
75x75cm

A3.57 . **Reserved Lane Crossing Sign (WB-8)**

The functions of the Reserved Lane Crossing Sign are to indicate to road users the existence of a near side reserved lane and to indicate that a right turn should be completed in the lane adjacent to the reserved lane.

The sign may be used on the approach to a roadway with a reserved lane if right turns are permitted. It may be utilized for an educational period when the reserved lane is initially installed or in locations where there is a high violation rate for vehicles entering the reserved lane from an intersecting roadway.

A typical application of the Reserved Lane Crossing Sign is shown in Figure C.3 1.

SCHEDULE OF SIGNS (Continued)						
NUMBER	MESSAGE	DIMENSIONS	COLOUR		SECTION REFERENCE	DATE OF REVISION
			BACKGROUND	MESSAGE & BORDER		
RB-80 to RB-83	Reserved Lane	90x 120cm	White	Black	A2.87	March 1994
RB-8OS 1 RB-80S2	Begins Ends	90x30cm 90 x 30 cm	White White	Black Black	A2.87 A2.87	March 1994 March 1994
WB-7	Reserved Lane Ahead	75 x 75 cm	Yellow	Black White	A3.56	March 1994
WB-7S	Hours of Operation	60 x 30 cm	Yellow	Black	A3.56	March 1994
WB-8	Reserved Lane Crossing	75 x 75 cm	Yellow	Black	A3.57	March 1994

C2.43 **Transit Lane and Transit Vehicle Clearance Lines**

Pavement markings to indicate the limits of reserved transit lanes and the clearance of the overhang on turning streetcars or other transit vehicles may be used.

Wide lines may be used for reserved transit lanes.

The clearance lines shall be broken white lines with segments and gaps of equal length not exceeding one metre. They shall be not less than IO or more that 15 cm wide.

On curves of short radius it is necessary to use very short segments and gaps to preserve the appearance of a continuity in a broken line.

C2.44 **Reserved Lane Pavement Markings**

Reserved lane pavement markings shall be used to identify reserved lanes and regulate their operations.

Diamond Symbols for Reserved Lanes

All full-time reserved lanes shall be identified by a white elongated diamond symbol. The white line on the diamond shall be 20cm in width. This symbol is shown in Figure C.36. The diamond symbol is used on the accompanying signing for reserved lanes (RB-80, WB-7. etc.).

On all full-time reserved lanes a diamond symbol shall be centered 1 Om downstream from either the beginning of each block or from each crosswalk. Additional diamond symbols may be used depending on block length and major access points.

On full-time with-flow reserved lanes additional diamond symbols may be used if right turns are not permitted from the reserved lane.

On full-time contra-flow reserved lanes. additional diamond symbols shall be centered 10m upstream from each intersection or crosswalk.

Diamond symbols shall not be placed on part-time reserved lanes.

Typical locations for diamond symbols on reserved lanes are shown in Figures C.37 to C.40.

Lane Lines for With-Flow Reserved Lanes

Lane lines for full-time with-flow reserved lanes shall be single solid white lines 20cm in width. The lane lines shall be solid except where right turns are permitted at the end of the block. In that instance the lane line will be solid for a minimum of 30m from the start of the block and then broken to the end of the block, with a 6m line and 3m gap. Typical installations are shown in Figures C.38 and C.39.

Normal lane lines shall be used for part-time with-flow reserved lanes. (Section C2.20).

Intersection Lines for Right Turns Across With-Flow Reserved Lanes

At an intersection where right turns are allowed from the side street across a full-time with-flow reserved iane. the reserved lane shall be marked with a white line 20cm in width on a 2:l taper from the curb to the lane line. This line shall have a I .5m gap centered on the length of the tapered section. This is shown in Figure C.37. Typical installations are shown in Figures C.38 and C.39.

Intersection lines for reserved lanes shall not be used on part-time reserved lanes.

TABLE C2.44

RESERVED LANE PAVEMENT MARKINGS

TYPE OF RESERVED LANE	DIAMOND SYMBOLS	DIRECTIONAL OR LANE LINES	INTERSECTION LINES FOR RIGHT TURNS
Full-Time With-Flow	Minimum requirement: I centered l0m from the start of each block or after each crosswalk. Additional as required. See Figures: C.36 to C.40.	Lane Lines - White: 20cm solid. Where right turns are permitted. solid for a minimum of 30m and then broken with 6m line and 3m gap. See Figures: C.38 and C.39.	Intersection Line where right turns from side streets are permitted. See Figures C.37. C.38 and C.39.
Part-Time With-Flow	None	Lane Lines - white. standard IO-15 cm broken with 3m line and 6m pap.	None
Full-Time Contra-Flow	Minimum requirements: I centered 10m upstream and I centered 10m downstream from the end of each block or at each crosswalk. Additional as required. See Figures C.36. C.38, C.40.	Directional Lines - yellow 20cm solid. See Figures: C.38 andC-10.	None

TYPICAL SIGNING FOR RESERVED LANES - FULL-TIME WITH-FLOW

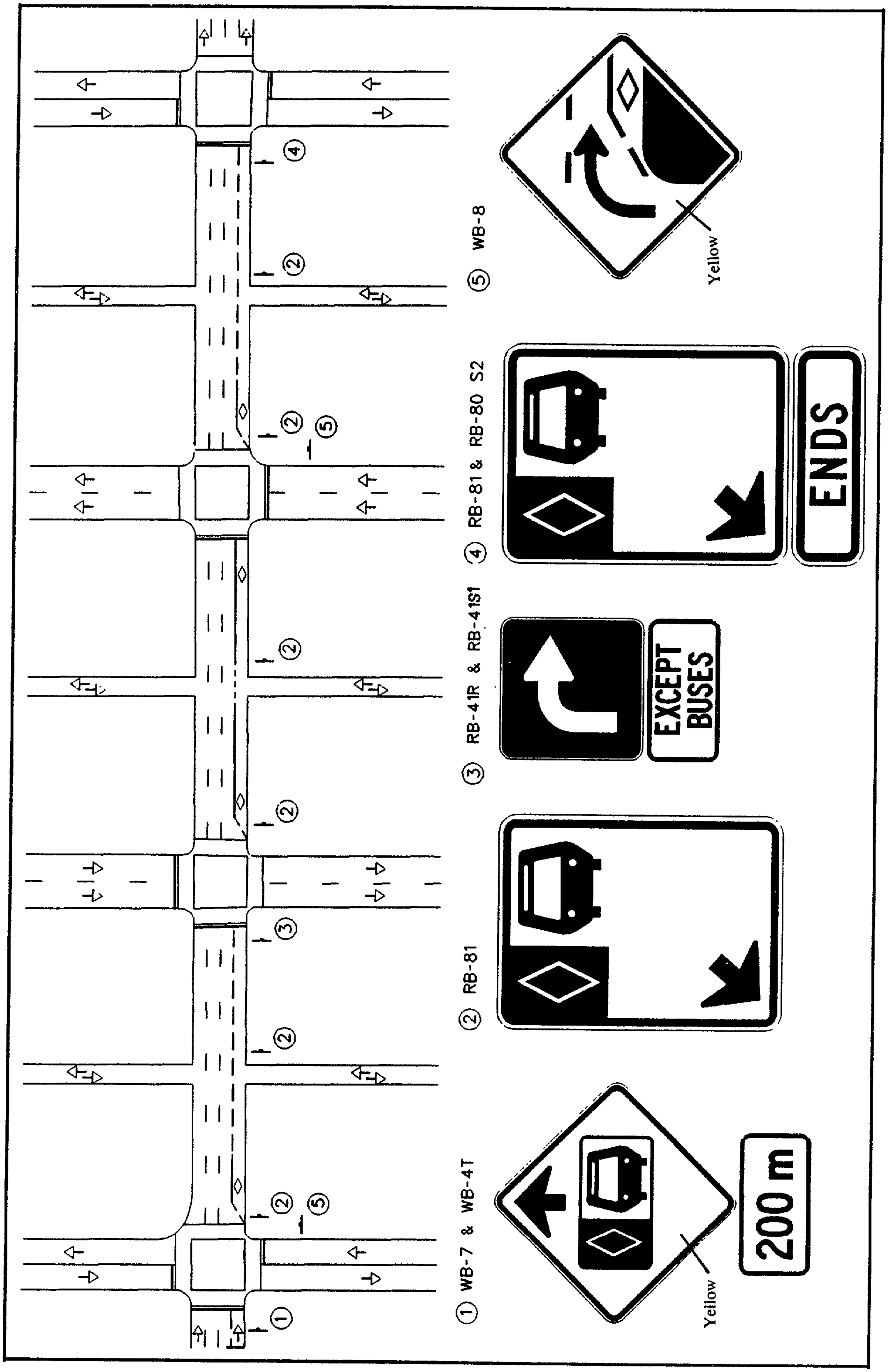


Figure C.31

TYPICAL SIGNING FOR RESERVED LANES - FULL-TIME CONTRA-FLOW

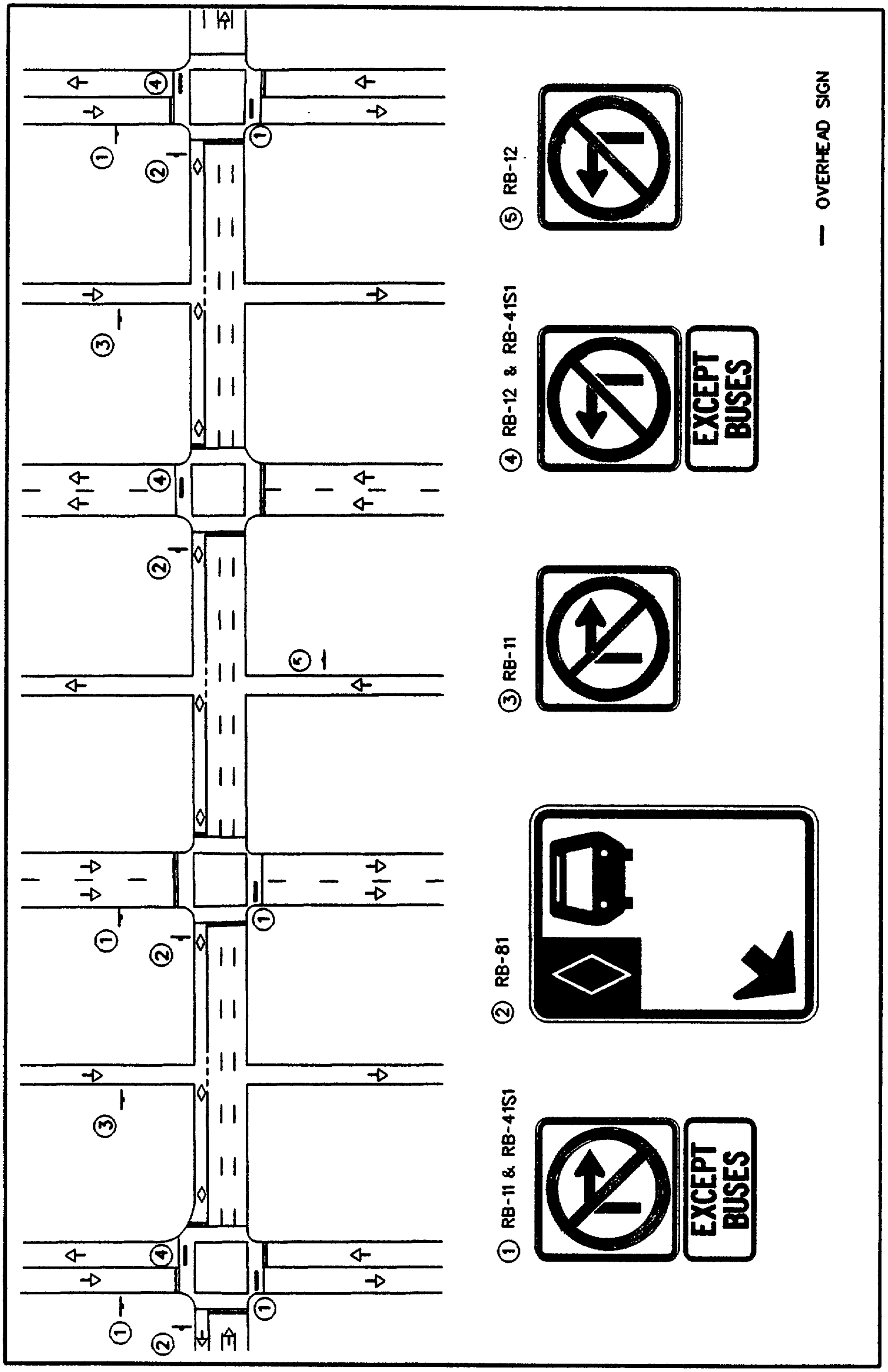


Figure C.32

TYPICAL SIGNING FOR RESERVED LANES - PART-TIME WITH-FLOW

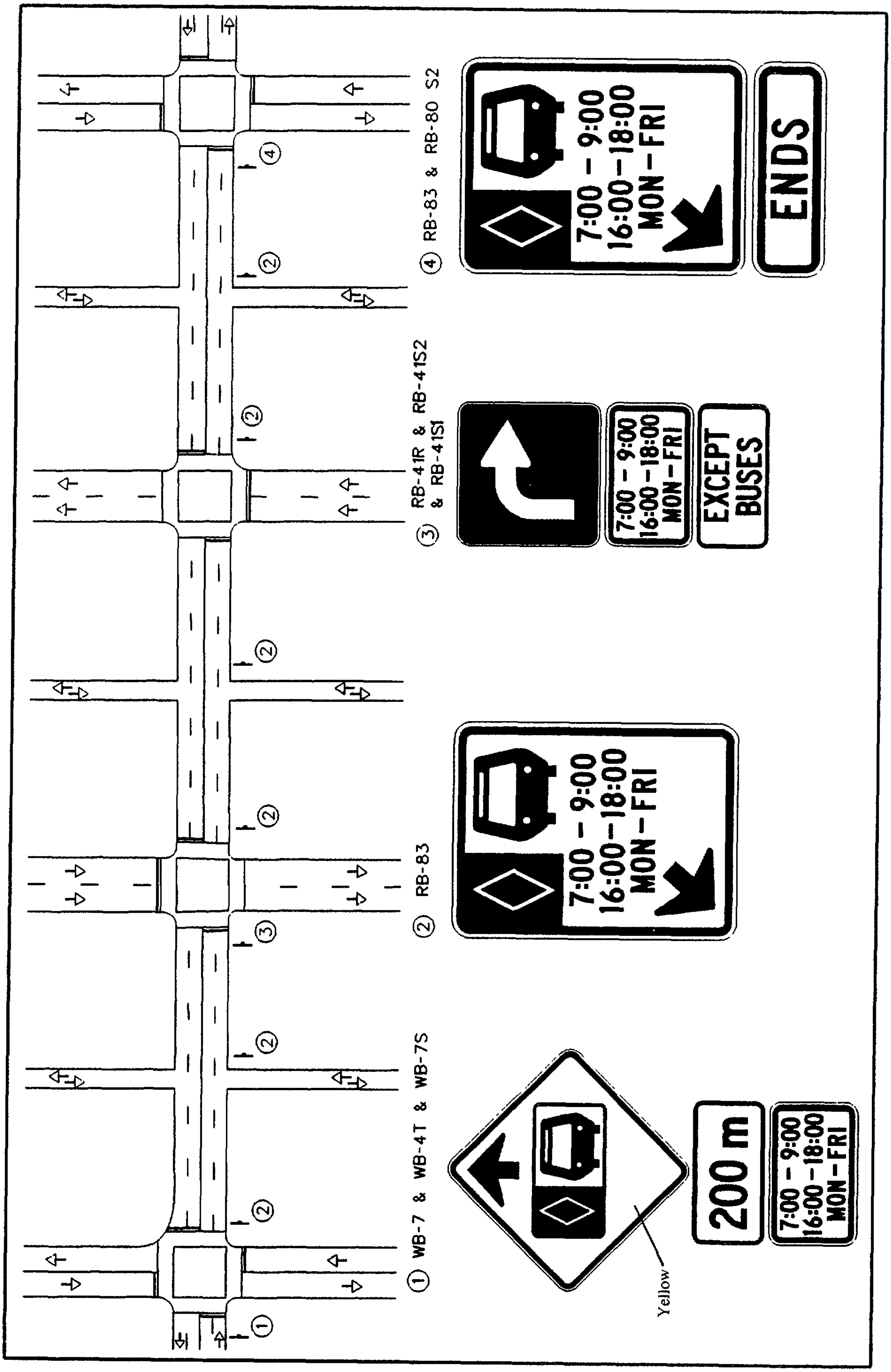


Figure C.33

DIAMOND SYMBOL FOR RESERVED LANES

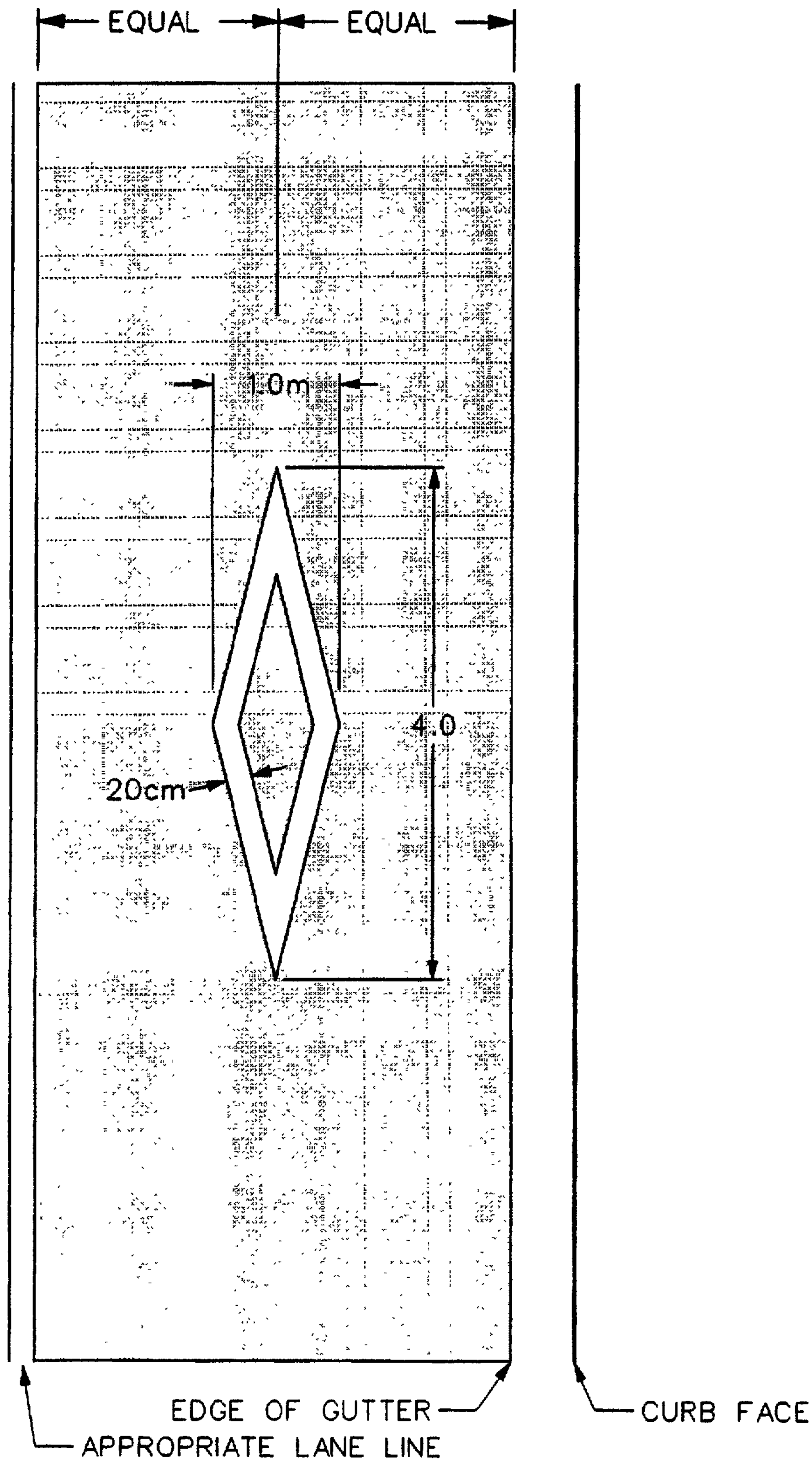


Figure C.36

INTERSECTION LINES FOR WITH-FLOW RESERVED LANES

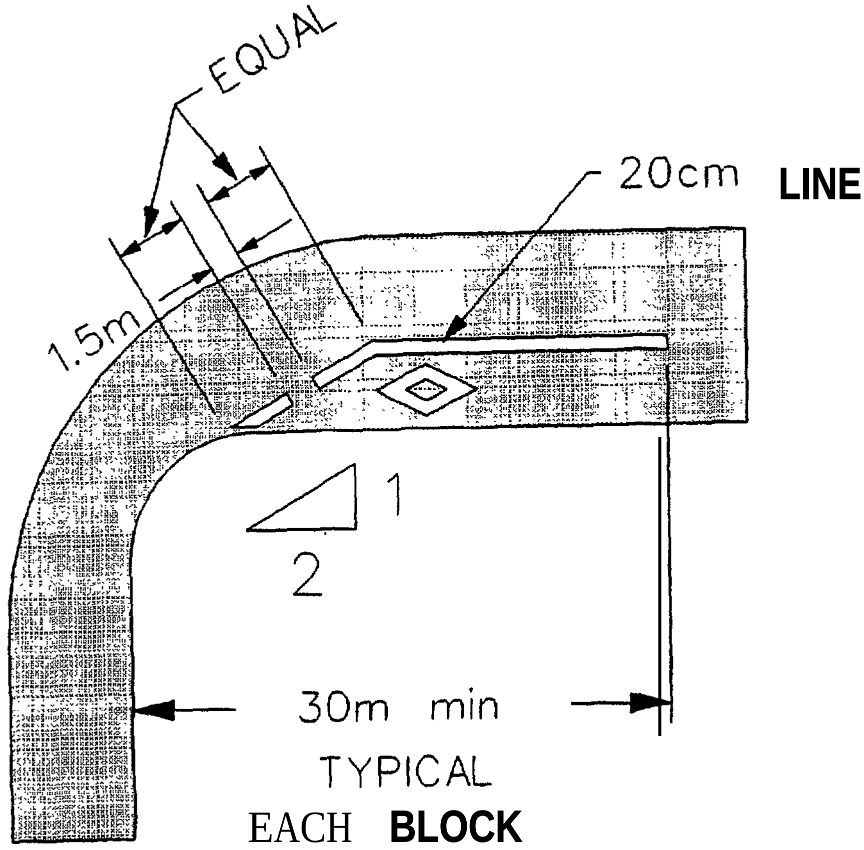


Figure C.37

TYPICAL PAVEMENT MARKINGS FOR FULL-TIME WITH-FLOW AND CONTRA-FLOW RESERVED LANES

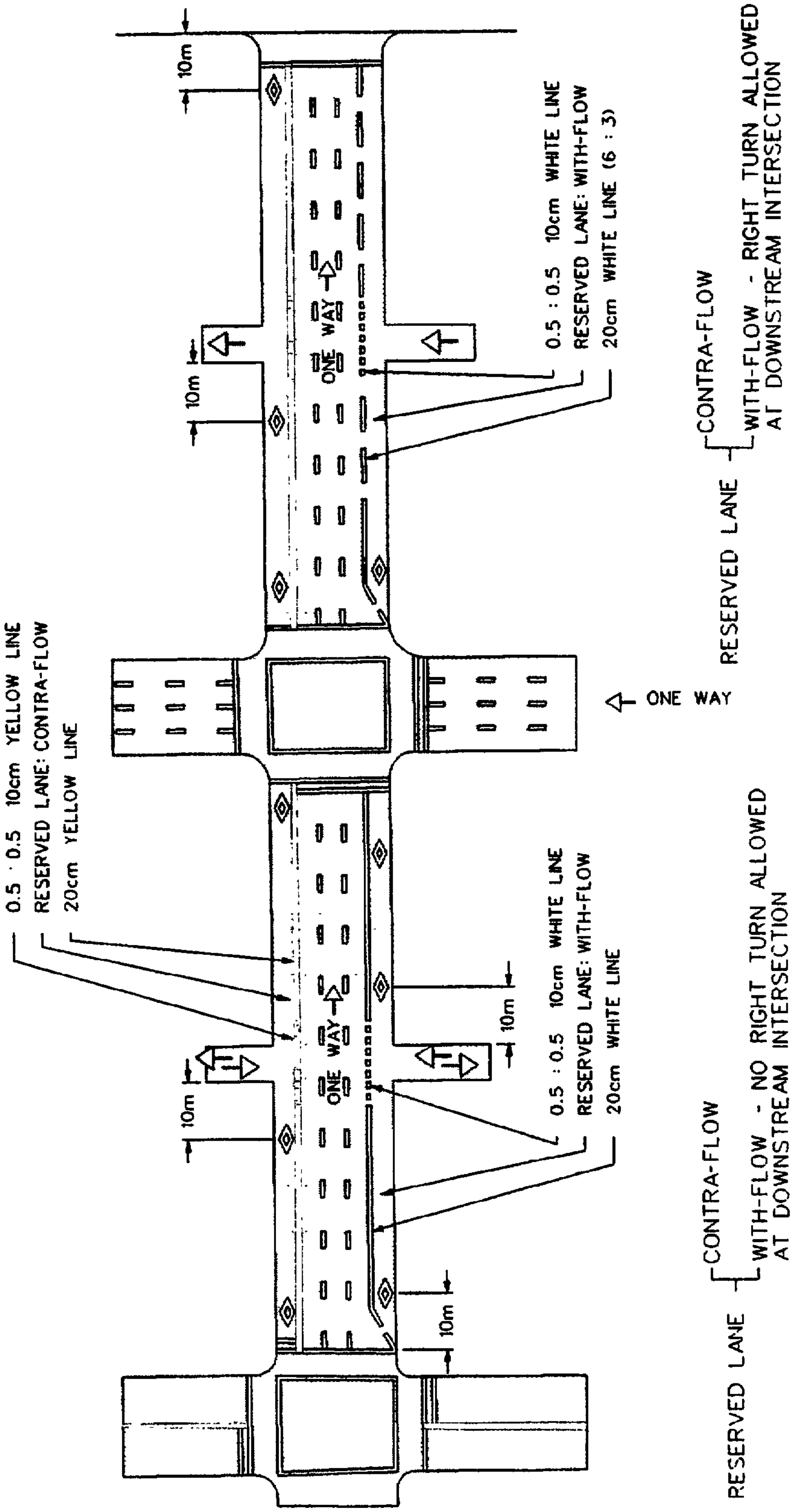


Figure C.38

TYPICAL PAVEMENT MARKINGS FOR FULL-TIME WITH-FLOW RESERVED LANES

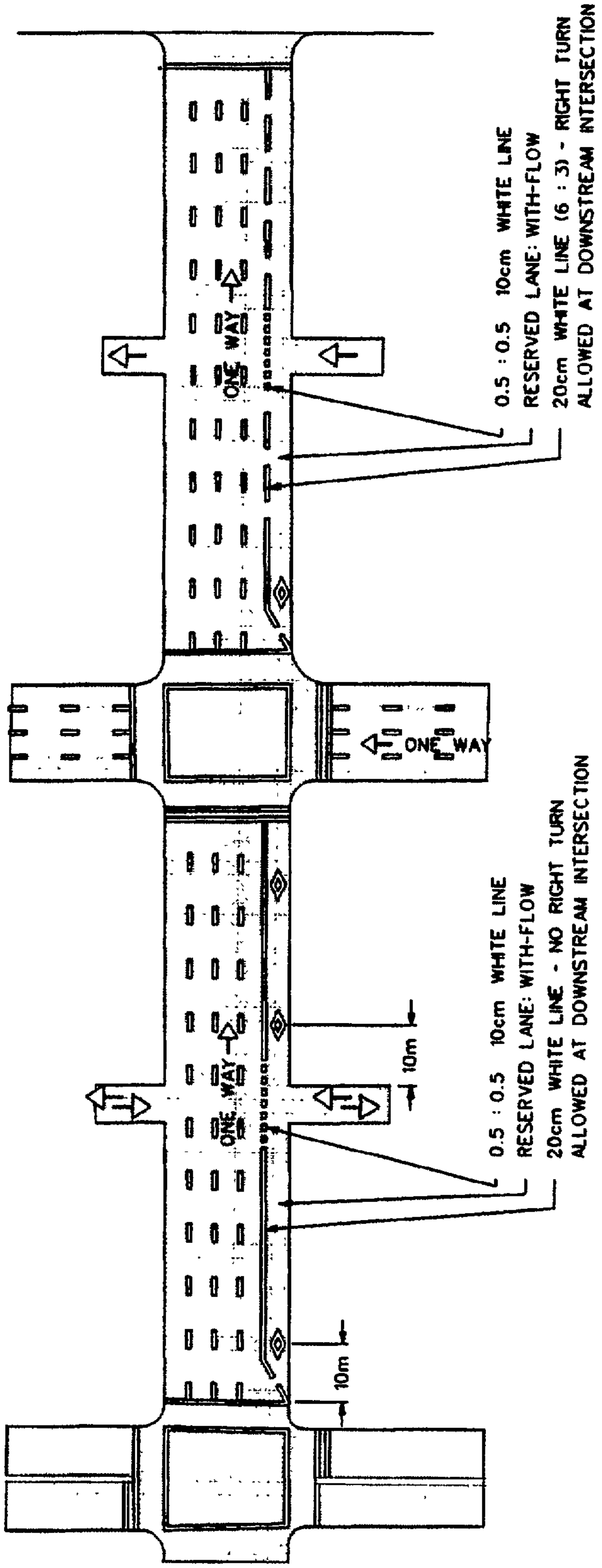


Figure C.39

APPENDIX C

SELECTED BIBLIOGRAPHY

ARTERIAL STREET HOV - RELATED BIBLIOGRAPHICAL REFERENCES

The following annotated bibliography provides a representative (not comprehensive) listing of literature available on the state of the art in HOV research and experience to October, 1994. This listing focuses on arterial HOV facilities and related support programs; freeway HOV lanes and bus-only Transitways are not covered here, except where included in general documents.

Entries are listed chronologically under the following categories:

A: General HOV Reference Texts
B: Area Plans With Arterial HOV Elements
C: Arterial HOV / RBL Case Studies
D: Transportation Demand Management / HOV Support Programs
E: Conference Proceedings
F: Arterial HOV - Related Articles and Research Papers
G: Publications

McCormick Rankin wishes to acknowledge the assistance of Mr. Chuck Fuhs (Parsons Brinckerhoff Quade and Douglas, Orange, California) in contributing to this list. Abstracts prepared by Mr. Fuhs are marked (CF). As well, those abstracts extracted from various Transportation Research Board bibliographies are marked (TRB).

Copies of virtually all of the U .S . publications are available through the National Technical Information Service (NTIS), 5285 Port Royal Road, SpringfIeld, Virginia, 22161, USA (ph. 703-487-4650, fax 703-321-8547).

A: GENERAL HOV REFERENCE TEXTS

A1. Levinson, H. S., et. al., **"Bus Use of Highways: State of the Art."** NCHRP Report 143, Wilbur Smith and Associates, prepared for the Highway Research Board, Washington D.C., 1973.

This report, based on a thorough review of ongoing and completed research, reflects the experiences of more than 200 bus street and freeway priority treatments operated in the U.S. in the early 1970s. This research included a literature search and a survey of transportation agencies involved with priority measures for buses. It describes how bus utilization can be enhanced with the provision of facilities that provide for the mass movement passengers. It identifies signigicant policy implications, contains relevant planning criteria, suggests measures of effectiveness, presents bus design parameters, and sets forth detailed planning and design considerations for each type of bus priority treatment. The report also details basic planning parameters and warrants for various bus priority measures. Various measures of effectiveness are suggested to evaluate the actual performance of a bus system. Vehicle design and performance characteristics are given, together with bus capacity considerations. These include queue behaviour parameters, bus unloading and loading times, and bus capacity ranges. Finally, guidelines present the important planning and design considerations associated with preferential bus treatments related to freeways, arterials, and terminals. (CF)

A2. Levinson, H. S., Adams, C. L., and Hoey, W. F., **"Bus Use of Highways: Planning and Design Guidelines."** NCHRP Report 155, Wilbur Smith and Associates, prepared for the Highway Research Board, Washington D .C., 1975.

This constitutes findings from a second phase of research into preferential bus facilities in the U.S. A first phase, published as NCHRP Report 143, "Bus Use of Highways – State of the Art," contained a literature search and a survey of transportation agencies involved with priority measures. The second phase developed planning and design guidelines for each type of bus priority treatment. The role of bus transport is defined within the framework of various types of preferential treatments. The report then details basic planning parameters and warrants for various priority measures. To aid the designer, vehicle design and performance characteristics are given, together with bus capacity considerations. These include queue behaviour parameters, bus unloading and loading times, and bus capacity ranges. Finally, guidelines present important planning and design considerations associated with preferential treatments on freeways, arterials, and terminals. (CF)

A3. Rothenberg, M. J., and Samdahl, D. R., **"Evaluation of Priority Treatments for High Occupancy Vehicles."** FHWA/RD-80/062, JHK and Associates for the U.S. Department of Transportation, Federal Highway Administration, Alexandria, Virginia, (January 1981).

This report presents evaluation summaries of 27 priority treatment projects for HOVs. The projects evaluated consist of contraflow; concurrent flow and physically separated HOV lane treatments on both grade separated and surface street facilities. In addition, priority HOV ramps, bus signal preemption, priority parking facilities and toll pricing strategies are covered.

The evaluations include project descriptions, locations and characteristics of each. A detailed bibliography is cross-referenced to each project. These results provide a base from which to evaluate ongoing and future HOV priority treatments.

A3. Rothenberg, M. J., and Samdahl, D. R., **"Evaluation of Prioritv Treatments for Hiih Occupancy Vehicles"**, FHWA RD-80-062, JHK and Associates for the US Department of Transportation, Federal Highway Administration, Washington, D.C., January 1981.

This report provides a project-by-project summary of 27 different HOV priority treatments covering a wide range of applications (freeways, arterials, and support measures). Characteristics and impacts of each project are tabulated and some comments are made as to the effectiveness and problems of each. Overall implications are noted with respect to the key factors in increasing the likelihood of success of a project. A comprehensive bibliography is included (note that the reports cited in the bibliography relating to arterial HOV facilities have been included in Category C of the current listing)

A4. Rothenberg, M. J., and Samdahl, D. R., "High **Occupancy Vehicle Facilitv Development, Operation and Enforcement."** Volume I and II, FHWA IP-82-1, JHK and Associates for the US Department of Transportation, Federal Highway Administration, Alexandria, Virginia, (April 1982).

Priority treatment for HOV projects was a direct result of energy shortages and escalating prices. Numerous HOV projects have been implemented, evaluated, and reported. In order to effectively disseminate this information, this report was developed. It contains guidance on planning, design, operation, and enforcement of HOV facilities. The report was prepared in two volumes, and both volumes are used as textbooks in a two-day training course. Volume I is a stand-alone document that creates an awareness of the need for HOV projects and depicts various HOV treatments. Volume II is a complementary document that provides warrants for selected potential HOV treatments. (CF)

A5. Batz, T. M., **"High Occupancy Vehicle Treatments. Impacts and Parameters (A Synthesis). Volumes I and II"** New Jersey Department of Transportation, Trenton, New Jersey, (August 1986).

This synthesis, comprising two volumes, provides an overview of freeway and arterial HOV treatments, planning and design practice, and parameters used in developing projects across the U.S. The first volume offers a summary of tidings and experiences from a series of surveys which **were** conducted. Conclusions highlight the number and type of projects in existence at the time of the survey, general operating characteristics, and issues influencing these parameters. HOV facilities which had been removed to 1985 and the reasons for their removal are also covered. The second volume presents the survey instruments and procedures, information collected during the survey and a bibliography of available references. (CF)

A6. Institute of Transportation Engineers, **"Guidelines for High-Occunancy-Vehicle (HOVl Lanes. A Recommended Practice"**, Publication No. RP-017, Institute of Transportation Engineers, Washington, D.C., (1986).

The report summarizes the planning ***conditions*** that should be prevalent to consider the application of HOV facilities on separate rights-of-way or shared with freeways or streets. Definitions of typical HOV treatments are defined. Qualitative and specific guidelines are provided to define the role that HOV concept alternatives offer as one solution to urban congestion. (CF)

A7. Institute of Transportation Engineers, **"A Toolbox for Alleviating Traffic Congestion"**, Institute of Transportation Engineers, Washington, D.C., 1989

A comprehensive catalogue of urban traffic problems and potential solutions, written for a non-technical audience (elected officials, public, etc.) A series of actions with benefits, costs, and implementation strategies is outlined within the categories of "Getting the Most out of the Existing System", "Building New Capacity", " Providing Transit Service", "Managing Transportation Demand", and "Funding and Institutional Measures". Topics include Enforcement and HOV Facilities on Arterials, with several examples of downtown bus lanes cited.

A8. Davis, J. E., Nihan, N. L., and Jacobson, L. N., **HOV Improvements on Signalized Arterials: State-of-the-Art Review,"** Presented at the Transportation Research Board 70th Annual Meeting, Washington, D.C., (January 1991).

This report addresses the potential for arterial HOV improvements. Goals and objectives of arterial treatments are presented. various strategies are described along with a listing of successes and failures for each. Planning aspects are raised including types of facilities, safety, enforceability, evaluating impacts, public attitudes, and coordinating these treatments as part of an HOV system. The report groups arterial improvements into three classifications: principal arterial treatments, minor arterial treatments and spot treatments. A literature search is presented in a comprehensivebibliography (see also C27). (CF)

A9. Institute of Transportation Engineers, **<u>"Design Features of High Occupancy-Vehicle Lanes"</u>,** Institute of Transportation Engineers, Washington, D.C., 1991

This report identifies design guidelines and current practice on HOV lanes throughout the U.S. and Canada. Design elements and their function are analyzed for all types of freeway-oriented HOV lanes. A summary of available design guidelines, characteristics, and operating experience from these projects is presented, as well as those proposed and under construction at the time of this writing. It also presents a summary of desirable and reduced widths for various types of HOV facilities. (CF)

A10. American Association of State Highway and Transportation Officials, **<u>"Guide for the Design of High Occupancy Vehicle Facilities"</u>,** Washington, D.C., (1992).

Planning, operation, and design criteria are provided in this overview of HOV facility applications for freeways and streets. Topics addressed include the role of HOV facilities, parameters for measuring effectiveness, determining rules for eligibility, enforcement and incident handling, typical cross sections for each type of facility, signing and markings, and general design criteria related to implementation. A glossary of terms is included. (CF)

A11. Nihan, N. L., Davis, J. E., **<u>"HOVImprovements on Signalized Arterials in the Seattle Area, Final Report, Volume II: State of the Art Review",</u>** Washington University, Seattle, Washington State Department of Transportation, Federal Highway Administration, TransNow, Transportation Northwest WA-RD 301.2, TNW 92-10.2, Feb. 1993, 55p, 2 Tab., 114 Ref. Contract GC8719, Task 17

The primary objectives for this study were to investigate stateof-the-art techniques for providing HOV incentives on arterial routes. The primary goal of making HOV improvements has been to increase the efficiency of transportation systems. Secondary objectives have been to reduce energy consumption, improve air quality, increase modal shift, save travel time, and reduce congestion. Reviews of existing facilities have synthesized operational results into useful generalizations. HOV facility issues include safety, environment, planning f design guidelines, classification schemes, and performance measures. Arterial HOV improvements have had mixed success, though the lack of good beforeand-after studies is significant. HOV facilities have been studied with a variety of computer models. In systems analysis, HOV lanes may be better justified as people movers when they are compared with other fixed-transit alternatives than when they are compared with automobile traffic in adjacent, nonrestricted lanes. (TRB)

A12. McCormick Rankin, **<u>"HOV Opportunities, Incentives, and Examples - a Handbook for Ontario Municipalities",</u>** Transportation Technology and Energy Branch, Ministry of Transportation of Ontario, Downsview, Ontario, July 1993

This report is in three parts: Introduction; Municipal HOV Strategies; and Municipal HOV Actions. A discussion of the different HOV strategies relevant to small, medium and large cities is intended to provide guidance to non-technical readers. Following is an illustration of each potential HOV-supportive measure, including action required for implementation, applications, design guidelines, and several current examples of the measure in action. The measures are grouped under "Convenience Encouragement", "Parking", "Operations and Services", and "On-line Physical Facilities". Appended is an annotated list of key resources in the HOV field.

A13. Transportation Association of Canada, **<u>"Manual on Uniform Traffic Control Devices for Streets and Highways"</u>,** Transportation Association of Canada, Ottawa, Ontario, March 1994

This manual provides a comprehensive listing of the application of traffic control devices for streets and highways, bicycle and pedestrian movements. Generic signing and marking guidelines are provided for HOV facilities and park-and-ride lots.

B: AREA PLANS WITH ARTERIAL HOV ELEMENTS

B1. Read, Voorhees & Associates, Ltd., **"Preferential Treatment for High Occupancy Vehicles - Cycle 1 Analysis"**, for Ministry of Transportation of Ontario, Downsview, Ontario, November 1980

A set of goals, objectives, and guidelines by which candidate HOV treatment opportunities across Ontario were to be identified were defined. The objectives reflected those of the Ministry's Transportation Energy Management Program to reduce the demand for energy by the transportation system. The twelve largest urban areas in the province were reviewed with respect to roadways experienoing congestion, bottlenecks, and / or transit volumes of more than ten buses per hour. A list of 83 locations suitable for consideration of HOV treatment was produced, and after a screening exercise 24 were identified as being feasible.

B2. **Crain and Associates, Inc., "HOV Lanes in St. Louis. Missouri"**, for U.S. Department of Transportation, Washington, D.C., May 1985

This report provides an evaluation of a pilot program involving the designation of reserved bus lanes during the 4 - 6 p.m. period on three streets in downtown St. Louis. The impact of extensive bus rerouting to take advantage of the lanes is assessed, and level of service issues such as bus service reliability and travel time are studied. The need for effective enforcement of no-stopping regulations is highlighted. No significant impact due to the reserved bus lanes on bus ridership, auto speeds, and bus speeds and reliability was found. Bus passengers and operating staff were satisfied with the performance and effectiveness of the lanes.

B3. Transit / Highways Task Force of the Chicago Area Transportation Study, **"HOV Lanes / Special Access"**, Chicago Area Transportation Study, Chicago, Illinois, December 1989

As part of an effort to identify specific projects to enhance transit's ability to reduce traffic congestion and to improve regional transit system operations in congested locations, this report includes a review of local and U.S. experience with HOV facilities, an identification of key issues, a list of policy and design objectives f guidelines for HOV demonstration projects, and a list of recommended demonstration projects. The projects include HOV lanes on a new freeway, a freeway-to-rapid transit HOV link, five major arterials, several special access concepts, and a variety of circulation links in and around the downtown area.

B4. Systan, Inc., **"Final Report: HOV System Planning Study for the Sacramento Metro Area"** for Sacramento Area Council of Governments, May, 1990

An areawide network study of HOV facilities came up with a set of priorities for individual projects within a phased implementation program covering 93 miles of HOV lanes. The recommended network consists exclusively of 2 + lanes on freeways; the benefits of readily-constructed HOV lanes on surface arterial streets were noted, but concerns for their operational feasibility and public acceptability Ied to their exclusion from the network. Reference is made to HOV lanes currently operating on arterials in Santa Clara County, California and Sydney, Australia.

B5. Parsons Brinckerhoff Quade & Douglas, Orange County **"Arterial High-Occupancy Vehicle Study. Final Report"** for Southern California Association of Governments, Grange, California, May 1991

The Los Angeles area is experiencing congestion problems on its freeway and arterial system. HOV lanes have been found to offer substantial relief on much of the freeway system, and the premise follows that similar improvements are also possible on arterials in areas like downtown Los Angeles as a way of improving bus operations and reducing the number of automobiles converging in the downtown area. The purpose of this study was to 1) investigate the design and operations of previously implemented HOV facilities throughout the U.S., 2) create local arterial guidelines based on this investigation, and 3) apply these guidelines to candidate corridor opportunities within Los Angeles. Major sections of this report include a literature search, arterial HOV development guidelines, and identification of local arterial corridor opportunities. Part (1) provides an overview of downtown bus lanes in several U.S. cities, while the recommendations in (3) focus on contraflow bus-only lanes on selected downtown Los Angeles streets. (CF)

B6. **"Planning Strategically for HOV Facilities and Programs in the Twin Cities Metropolitan Area"**, Metropolitan Council, St. Paul, Minnesota, December 1991

A general review of HOV principles and experience both locally and elsewhere is provided as a basis for the specific recommendations of the study. Several freeway HOV lanes are recommended, along with various demand management / support program initiatives. Arterial

HOV lanes are not discussed, with the exception of existing downtown bus lanes. The I-394 "Sane Lane" HOV project is outlined - it included some signalized intersections during its reconstruction to freeway standards. Several significant local initiatives in the areas of HOV parking, vanpool staging areas, ramp metering with HOV bypass lanes, HOV -only freeway access ramps, enforcement, ridematching, Transportation Management Organizations, and employer-based demand management programs are discussed.

B7. McCormick Rankin, **"Metropolitan Toronto HOV Network Study - Final Report"** for Transportation Department, Municipality of Metropolitan Toronto, Toronto, Ontario, March 1992

A comprehensive study to develop a 300 km long HOV 3+ network on major arterial streets is documented in this report. The final report includes a Summary Report, Planning and Design Guidelines for HOV Lanes on Arterials, HOV Experience and Opportunities, Development of an HOV Plan for Metro, and HOV Issues and Priority Programs. All major roads in Metro were assessed with respect to their potential HOV roles, and a recommended grid-based network is identified, along with a multi-year implementation strategy incorporating road widenings as well as lane conversions. The role of support measures and programs is highlighted, and operational issues are analyzed. (note: the initial stages of the network are now in operation)

B8. Planning Department, Municipality of Metropolitan Toronto, **"East Metro Waterfront Corridor Transportation Study?"**, Metropolitan Toronto Planning Department, Toronto, Ontario, April 1994

As part of preparing a new Official Plan, a study was carried out to examine transportation needs and opportunities and to develop a long range transportation plan for the subject area. A multidisciplinary approach to combine planning goals with respect to land use and reurbanization, transportation needs, and waterfront access improvement was applied. The deletion of the Scarborough Expressway corridor from the Official Plan and the corresponding focus on a "transit-friendly" environment for the main arterial streets in the study area led to the recommendation, in key corridors, to provide HOV lanes. Five arterials are included as well as Highway 401. On some roads, HOV lanes are intended as a precursor to the potential long term implementation of Light Rail, while HOV lanes on other roads will support bus operation and accessibility to Rapid Transit stations.

B9. Mulligan, T. W., **"Arterial HOV Lanes in Metropolitan Toronto",** Metro Toronto Transportation Dept., Toronto, June 1994.

Toronto established a 100+ km network of arterial HOV lanes on a plan in 1992, and by the end of 1993, 56 km (37 miles) were in operation. These lanes were implemented by converting existing bus-only lanes, by taking away mixed traffic curb lanes, and by adding new lanes. This paper briefly discusses the development of the HOV lane network in Metro Toronto, outlines the implementation process used, and provides some prehminary findings from monitoring the performance of the lanes after they were opened to the public. (CF)

B10. Samdahl, D., **"Policy Guidelines for HOV Facilities",** JHK Associates, Bellevue, Washington, and Peter Lima, Lima & Associates, Phoenix, Arizona, June 1994.

The purpose of this paper is to describe the development of HOV policy guidelines for use by state, regional and local agencies in the Phoenix metropolitan area. The study, performed for the Maricopa County Association of Governments in late 1993, included a comprehensive evaluation of existing HOV policies, plans and programs, a review of applicable legal requirements, the development of HOV system goals, and finally the development of specific HOV policies. The policies covered a wide range of planning, programming, monitoring, design and operational guidelines for HOV lanes, ramps park & ride facilities and freeway bus stations. The paper describes the evolution of this process, including the development of a statement of HOV commitment by the affected agencies, and the consensus building process used to reach agreement on regional HOV policies. (CF)

C: ARTERIAL HOV / RBL CASE STUDIES

C1. Willis, C. O., Jr., **"High occupancy Vehicle Considerations on an Arterial Corridor in Pensacola. Florida"** Tipton Associates, Inc., Orlando, Florida, in Transportation Research Record, Transportation Research Board, Washington, DC.

Because of the nature of the traffic using arterial corridors and the complexities of adjacent land uses, most high-occupancy vehicle (HOV) priority techniques impose restrictions on general traffic to such a degree that their implementation has met with limited success. In Pensacola, Florida, an arterial corridor was studied to determine the feasibility of implementing HOV priority techniques. The decisions made as to data collection, analysis, alternative selection, and the elimination of parts of the corridor from further consideration will be of general interest to others considering implementing similar projects. The final result of the study was a recommendation to widen part of the roadway to a consistent 6 lanes, and on the 6 lane portion to provide an HOV 2+ lane by using a lane control system to designate three lanes in the peak direction during peak periods with one lane of the three being reserved for HOVs. There would remain two lanes in the off-peak direction as well as a two way left turn lane. This system permits the implementation of an HOV priority system without loss of access to the corridor has the advantage of maintaining left turn movements off the corridor. (note: the project was never implemented.)

C2. Ratulowski, Edward K., **"Report on College Avenue Exclusive Bus Lane",** Federal Highway Administration (Indiana Division), Indianapolis, IN, January 1971.

C3. Commonwealth of Puerto Rico, Department of Public Works, **"Carril Exclusive Para Guaguas",** San Juan, Puerto Rico, March 1971 (Accident Update November 1971).

C4. Commonwealth of Puerto Rico, Department of Public Works, **"Exclusive Bus Lane - A Demonstration Project", San** Juan, Puerto Rico, July 1971.

C5. Transportation Committee, Municipality of Metropolitan Toronto, **"Provision of Reserved Bus Lanes on Eelinton Avenue",** Report No. 19 to Council of the Municipality of Metropolitan Toronto, December 14, 1971.

Based on the warrants developed by the Institute. of Transportation Engineers for the establishment of Reserved Bus Lanes, a request by the Toronto Transit Commission for an eastbound peak period reserved bus lane on Eglinton Avenue between Bathurst Street and Yonge Street (a.m.) and between Yonge Street and Brentcliffe Road (p.m.) was considered. The lane was found to be justified, even under the high ITE standards (60 buses per hour, bus passenger volumes 1.5 times auto person volumes, etc.). Anticipated operational difficulties and an overall reduction in the vehicular level of service were concerns that could only be resolved with a test application. The proposal was approved (and has operated successfully ever since),

C6. Commonwealth of Puerto Rico, Department of Public Works, **"Establishment of Second Phase of Exclusive Bus Lanes On site Traffic Flow on North-South Central Corridor of the San Juan Metropolitan Area", San** Juan, Puerto Rico, September 1972.

C7. Transportation Committee, Municipality of Metropolitan Toronto, **"Reserved Transit Lanes",** Report No. 7 to Council of the Municipality of Metropolitan Toronto, April 23, 1974

Baaed on the analysis of the Eglinton Avenue bus lanes, an expanded program of reserved bus lanes was proposed by the Toronto Transit Commission. Eleven arterial streets with significant transit volumes or operational problems were assessed under a set of criteria modified from that used in the Eglinton Avenue situation. An 18 month trial program for two way peak period reserved bus lanes on six of the arterials (St. CIair Avenue, Pape Avenue, Wilson Avenue, York Mills Road, Lansdowne Avenue, and Ossington Avenue) was recommended. (Note: reserved lanes on Pape, Lansdowne, and Ossington survived the trial period and continue to operate today, Pape as part of the Metro HOV 3 + network and the other two as RBLs.)

C8. Alan M. Voorhees & Associates, Inc., **"Denver Bus & Carpool Lanes Before and After Study",** Denver, CO, February 1975.

C9. Department of Transit and Traffic and Mass Transit Administration, **"Exclusive Bus Lane Study",** Joint Report, Baltimore, MD, April 1975.

C10. Dade County Office of Transportation Coordinator, **"U.S. 1/South Dixie Highway Transportation Demonstration Project-Evaluation Report",** Dade County, FL, November 1975 (Updates December 1975, September 1976).

Cll. **Centennial Engineering, Inc., "'Before and After' Evaluation Exclusive Peak Hour Bus Lane**

Demonstration Program, Broadway and Lincoln Street, Denver, Colorado", Wheatridge, CO, June 1976.

C12. Erdman, John W., and Edward J. Panuska, Jr., **"Exclusive Bus Lane Experiment, Traffic Engineering,** July 1976.

C13. Lubke, Roger A. and D. George Putnam, **"Vehicle Detection Phase III: Passive Bus Detector / Intersection Priority System Development",** (2 Vols., Options 1 and 2), Minneapolis, MN, Honeywell, Inc., August 1976 (option 2, October 1977), 2 Vols.

C14. Rose, Harry S. and David H. Hinds, **"South Dixie Highway Contraflow Bus and Car-Pool Lane Demonstration Project",** Transportation Research Record 606, 1976.

C15. Northern Virginia Transportation Commission, **"Analysis of Preferential Bus Treatment on Arlington Boulevard and Columbia Pike", Arlington,** VA, April 1977.

C16. Department of City Planning, **"A Project on the Status of the Transit Preferential Street Program as of July 1, 1977", San Francisco,** CA, prepared for Transportation Policy Group, July 1977.

C17. Delaware Valley Regional Planning Commission, **"Auto Restricted Zones in the Delaware Valley Region An Evaluation of Trenton Commons and Chestnut Street Transitway",** Philadelphia, PA, August 1977.

Cl8. Kaku, D., W. Yamamoto, F. Wagner, and M. Rothenberg, **"Evaluation of the Kalanianaole Highway Carpool / Bus Lane",** JHK & Associates and AMV & Associates, Alexandria, VA, August 1977.

C19. **Carson, Cindy, et al., "Bus Signal Priority System Evaluation (for the City of Concord, California)",** TJKM, Walnut Creek, CA, July 1978

C20. Wattleworth, Joseph A., et al., **"I-95/NW 7th Avenue Bus / Car Pool Systems Demonstration Project: UMTA Project Evaluation Series I-l to I-9"** 9 Volumes, Transportation Research Centre, University of Florida, Gainesville, FL, September 1978.

C21. Systan, Inc., **"Evaluation Plan for the San Francisco Priority Street Treatment Demonstration",** Los Altos, CA, March 1979.

C22. Regional Transportation District, **"Broadway/ Lincoln Bus Lane Operational Analysis"**, TSM Division, Denver, CO, March 1980.

C23. Transportation Committee, Municipality of **"Metropolitan Reserved Transit Lanes on Dufferin Street",** Report No. 10 to Council of the Municipality of Metropolitan Toronto, June 24, 1980

The construction of Dufferin Street north through the Downsview Airport provides the opportunity to build in reserved bus lanes to serve the concentration of bus routes feeding the northern terminus of the Spadina Subway at Wilson Avenue. It was recommended to provide an extra two lanes of pavement (for a total of six lanes) on the new road and that the portion between Clanton Park Road and Finch Avenue be widened to six lanes in order to provided the reserved bus lane. Buses would use a new direct connection to the Wilson Station. Initial operation of 20 buses per hour, increasing with route reorganization to 60 buses per hour, was foreseen. (note: the bus lanes were built and continue to operate today, although they are now HOV 3 + lanes as part of the Metro Toronto HOV Network).

C24. Cass, S., Bower, R.J., Warren, R.M., **"Reserved Bus Lane Proposal: Victoria Park Avenue - O'Connor Drive to Denton Avenue",** Report to the Metropolitan Transportation Committee, Toronto, Ontario, July 11, 1980

A joint report by the heads of Metro Roads and Traffic Planning, and Transit respectively, proposing the introduction of a Reserved Bus Lane for peak period peak direction buses only on a 1.8 km long stretch of Victoria Park Avenue. The Bus Lane would be created in three parts: one section would involve the conversion of an existing mixed flow lane on a four lane segment, another section would be widened from two to three lanes with the centre lane being reversible, and a third section would be widened from two to four lanes. The cost-effectiveness of the proposed plan relies considerably on the ability to save three minutes in travel time in order to eliminate one bus from the Victoria Park route. In light of concerns over impact to local residents (particularly in the widened portions) and lack of proof that a bus could be saved, local municipalities did not endorse the plan and it was not implemented.

C25. Strgar-Roscoe-Fausch, Inc., **"I-394 Interim HOV Lane: A Case Study - Phase I Report"** Minnesota Department of Transportation, Minneapolis, Minnesota, October 1987

A single reversible HOV 2 + lane in the median of a four lane signalized highway was opened in

November, 1985, in order to provide additional people carrying capacity during the reconstruction of the highway to interstate freeway standards, and to introduce the HOV lane concept in advance of permanent HOV lanes on the freeway facility. This report documents the history, operations, design features, support programs, usage, and cost-effectiveness of the facility after one year of operation.

C26. Levinson, H., **"Bus Priority Proposals for New York City",** October, 1988

This paper focuses on various on-street ways to maintain bus priority amidst New York City traffic. Building on the 20 bus priority lanes or streets already in place and utilizing City Transportation Department policy to give buses priority wherever feasible, some guiding criteria were developed and several specific bus priority actions were recommended. Four city-wide recommendations were also made: provide truck loading zones, eliminated curb parking in peak periods, provided curb bus lanes where bus volumes warrant, and ensure effective enforcement of bus lanes. An appendix covers in detail New York City's existing bus lanes and HOV lanes in adjacent New Jersey

C27. Lightbody, James, et. al., **"An Evaluation of Santa ClaraCounty' s Commuter Lanes."** Santa Clara County Transportation Authority, Systan and Communications Technologies, San Jose, California, (August 2, 1989).

An overview of the Santa Clara HOV lanes is presented in this analysis of public attitudes and usage. Data includes the hours of operation, number of peak users, violations, and program plans for the region. Both freeway and signalized expressways are included. (CF)

C28. Davis, J.E., **"A Study of the Planned NE Pacific Street HOV Facility",** Masters Thesis, Department of Civil Engineering, University of Washington, Seattle, Washington, July 20, 1990

An in-depth analysis of a proposed 1000 foot long queue bypass HOV lane is documented, including the application of a TRAF-NETSIM model to predict its impacts. Design features such as an advance HOV-activated traffic signal and transit service improvements to enhance the modal shift potential are discussed. The unique constraints, opportunities, and demands in the NE Pacific Street corridor are recognized as limiting the transfer of knowledge to other situations. The report includes the results of an in-depth literature review on the topic of arterial priority lanes (also published separately, with Nihan, N. L., as **"HOV Improvements on SignalizedArterials: State-of-The-Art Review"**, Washington State Department of Transportation, May 1990)

C29. UMA Engineering Ltd., **"Don Mills Road Widening HOV Lane Implementation Study"**, for Metropolitan Toronto Transportation Department, Toronto, Ontario, October 1990

In response to Council's resolution that the planned widening of Don Mills Road from 4 to 6 lanes between York Mills Road and Overlea Boulevard be on the condition that the new lanes be for HOV use only, a study of implementation, operational, and functional plan modifications was undertaken. Study recommendations were to maximize the lane's effectiveness by providing bus bays (thereby allowing express bus services to use the lane) and to open the lane to buses and taxis only pending the completion of a broader HOV network study. The lane could be opened to carpools if found to be appropriate within the network context. (note: Don Mills Road was subsequently included in the recommended HOV network for Metro Toronto, and the lanes currently operate as HOV 3 +)

C30. Marshall Macklin Monaghan Ltd., **"High Occupancy Vehicle Lanes on Dundas Street Environmental Studv Report"**, for City of Mississauga Public Works Department, Mississauga, Ontario, March 1991

This report documents the Environmental Assessment Study carried out for the widening of Dundas Street between Dixie Road and Etobicoke Creek in Mississauga and the implementation of HOV lanes on Dundas Street from Dixie Road to the Kipling Subway Terminal (a distance of 5 km). The need for widening, operational alternatives, the impact of a reserved lane on traffic and transit, and the rationale for HOV 3+ operation are documented. (note: the HOV 3+ lanes were subsequently implemented and continue to operate as planned)

C31. Untermann, R. K., **"Linking Land Use and Transportation: Design Strategies to Serve HOVs and Pedestrians. Final Report"** Washington University, Seattle, Washington State Department of Transportation, Federal Highway Administration WA-RD 278.1, June 1991.

This study focuses on the relationship between land uses and transportation along a major arterial, exploring ways to encourage pedestrian use of and access to arterials. It explores in detail the possibility of using high occupancy vehicle (HOV) lanes along arterials for short-distance ridesharing. With emphasis on improving pedestrian and bicycle safety and creating a sense of "community" along the arterial, the study examines problems of street design and potential land use profiles. The study area is a 9-mile stretch of Highway 99 in north Seattle, from Seattle's city limits (at 145th Street) to the Mukilteo Speedway. This section of SR 99 has been chosen for HOV development. (TRB)

C32. Nihan, N. L., **"HOV Improvements on Signalized Arterials in the Seattle Area. Final Report. Volume I: 2 Case Studies",** Washington University, Seattle, Washington State Department of Transportation, Federal Highway Administration, Feb. 1993.

This report represents an analysis of HOV improvements for two signalized arterials in the Seattle metropolitan area. The first involves a planned, 1000 ft (300 m) queue jumper lane on NE Pacific Street in the University District of Seattle. This planned improvement was studied prior to its implementation in Spring of 1990. As part of this study, an extensive beforedata set was developed. The planned improvement is now in place, and an extensive after-study is now in progress as part of a follow-up project. The second study was more of a feasibility analysis of possible HOV improvements for a suburban arterial. Specifically, NE 85th / Redmond Way, an arterial that stretches 2.5 miles (4 km), from Interstate 405 in Kirkland to Willows Road in Redmond, was identified as one of the highest priority candidates for arterial HOV improvements. Because of limited arterial HOV experience in Seattle and nationwide, the study of these two very different types of HOV arterial improvements provided important information for future arterial plans. This project investigated HOV improvements for arterials in the Seattle area, simulated the operation of those improvements for the two case studies, developed a data set for evaluating the impacts of the improvements, and carried out some preliminary evaluations. The preliminary findings of these two case studies suggested favorable outcomes for the planned HOV improvements. Keeping in mind that these analyses must be evaluated in the context of the surrounding network, the results of these two case studies are optimistic.(TRB)

c33. Nihan, N. L., L. 0. Rubstello, **"HOV Improvements on Signalized Arterials in the Seattle Area. Final Report. Volume III: N.E. 85th HOV Study",** Washington University, Washington State Department of Transportation, Federal Highway Administration, TransNow, Transportation Northwest

This paper discusses the problems that are inherent with adding a higher speed HOV lane to an arterial with its unlimited access points. Investigation of current literature shows that although freeway HOV applications have been researched and understood to an adequate degree, almost no data of any kind are available to predict the effectiveness of an arterial HOV project. Further, it is proposed that not only does the research not exist, but that the "measures of effectiveness" to evaluate existing arterial HOV lanes are severely lacking. In addition to the literature search, a motorist survey was handed out to collect data describing commute trip behaviour. Questions about trip origin, destination, and purpose were asked to determine what residential and commercial zones were being served by NE 85th / Redmond Way, and for what purpose. The questionnaire also requested information on the duration of the trip and the occupancy of the vehicle. These data were used as input for a mathematical model to predict the volumes on the facility one year after the implementation of an HOV lane. Since the model was based on past freeway applications across the nation, the threats to validity which that causes were also presented. The final questions on the survey concerned the motorists" own predictions about how likely they were to carp001 and what they thought were some of the problems preventing them. These views were compared with the results from the model. The predicted and resulting effectiveness of the project were evaluated versus the objectives of the Eastside Transportation Program (ETP) policy statements. (TRB)

c34. Auslam, M., **"HOV Lane Conversions in California (1989-1994),** California Dept. of Transportation, Sacramento, CA, June 1994.

Four recent examples of lane conversion in California are highlighted in the paper, including the Routes 91 and 85 cases where short distance segments were converted, and as emergency bypasses following recent earthquakes in the Bay Area and LA. (CF)

c35. Fisher, J., **"Arterial HOV Treatment in the City of Los Angeles"** City of Los Angeles Traffic Dept., Los Angeles, June 1994.

A variety of HOV preferential treatments applied on a number of arterials are presented in this paper, including the temporary detour used on the Santa Monica Freeway during recent earthquake repairs. (CF)

C36. Oliver, Robert and Ottavio Galella, **"Safety Experience of the Pie IX Boulevard Contraflow Bus Lanes and Other Corridors in Montreal",** STCUM, Montreal, June 1994.

This report provides a summary of the evaluation of a contraflow bus arterial lane applied in for buses in the greater Montreal area. The report shows accident data for bus / vehicle and bus / pedestrian conflicts and shows how signing and markings are applied to reduce these conflicts. (CF)

c37. McCormick Rankin, **"Planning Study for tbe Widening of Hurontario Street between North Service Road and Matthews Gate for HOV Lane Purposes - Environmental Study Report"** for City of Mississauga Transportation and Works Department, Mississauga, Ontario, October 1994

This report documents the Environmental Assessment Study carried out for the widening of Hurontario Street from 4/5 to 6/7 lanes. Existing conditions, alternatives considered, public involvement, and preliminary design of the recommended plan are documented. The rationale and benefits of peak period right curb HOV 2+ operation are presented, and various urban design and planning issues associated with the widening are dealt with. (note: the project is scheduled for construction in the 1996 - 97 tune frame)

D: TRANSPORTATION DEMAND MANAGEMENT / HOV SUPPORT PROGRAMS

Dl. Share-A-Ride, **various publications,** Transportation Technology and Energy Branch, Ministry of Transportation of Ontario, Downsview, Ontario, various dates.

Beginning with the "energy crisis" of the 197Os, the Share-A-Ride program has been the focus of much of the provincial effort to reduce transportation energy use through the promotion of ridesharing, vanpooling, caIpooling, fleet management, and employer-based incentives. A wide variety of practical publications and newsletters in all of these areas aimed at helping interested parties to develop and use HOV-oriented measures is available. The program has also developed a computerized ridematching program which is available to public and private users.

D2. California Department of Transportation, **"Evaluation of the Development. Establishment, and Results of the Commuter Carpool Parking Lots Located in Urban Downtown San Francisco",** San Francisco, CA, March 1977.

D3. Aarts, J., J. Hamm **"Effect of Ridesharing Programs on Suburban Employment Centre Parking- Demand",** Transportation Research Record 980, Transportation Research Board, Washington, DC., 1984

To gather information about the effects of a ridesharing program, Seattle I King County Commuter Pool initiated a parking use study in the winter of 1983 that involved 14 office sites in suburban Ring County. Suburban sites were selected because they tend to minimize the number of extraneous variables that can complicate a parking use analysis. The 14 sites selected were similar in terms of (a) surrounding land use, (b) employee density, (c) employee activity, (d) site configuration, and (e) level of available transit service. The only notable difference among the sites was that 7 of the 14 operated organized ridesharing programs for their site employees. Average parking use rates for these two groups were compared to determine if a measurable difference in parking demand, which was due solely to the presence of the organized ridesharing programs, could be detected. The study's objectives, research methodology, and basic findings are discussed and some key factors that emerged in association with the ridesharing programs and the different levels of parking demand are analyzed. (TRB)

D4. Booth, R. and Waksman, R, "**National Ridesharine Demonstration Program: Comparative Evaluation Report",** Urban Mass Transit Administration, Department of Transportation, Washington, D.C., August 1985

The report has an evaluation of 17 ridesharing demonstration projects across the U.S., with detailed analysis of five sites. An understanding of the rideshare market and the effectiveness of various HOV incentives in inducing ridesharing is documented. The relationship between ridesharing and parking costs, transit service, information dissemination, company size, trip length is reviewed. Employer-based rideshare promotion was found to be more effective than neighbourhood-based efforts, and the overall impact of the programs was found to be small. (TRB)

D5. Federal Highway Administration, Office of Planning, **"Transportation Management for Corridors and Activity Centers: Opportunities and Experiences",** Final Report, U.S. Department of Transportation, (May 1986).

This report looks at the role of transportation management in applying cost-effective measures to address supply / demand problems in urban corridors and activity centers. The report consists of separate sections addressing corridors and activity centers, describing transportation management experiences for each in the U.S.

Case studies are the focus for each section. The case studies selected for presentation represent projects considered by the staff of the Federal

Highway Administration as being practical as well as creative in improving efficiency. Many projects described were funded through comprehensive transportation system management and national rideshare discretionary programs initiated in 1979. (CF)

D6. COMSIS Corporation, **"Evaluation of Travel Demand Management Measures to Relieve Congestion. Final Report"** U.S. Department of Transportation Report No. PHWA-SA-90-005, (February 1990).

This report summarizes the results of a research study, sponsored by the Federal Highway Administration, to investigate the effectiveness of existing Travel Demand Management (TDM) programs. This investigation consisted of the evaluation of a number of existing TDM programs located within the United States. The programs, many of which are well known, are varied in size, setting, motivation and accomplishments. Together, they comprise a fairly representative cross section of contemporary experience with TDM.

The study directly measured the quantitative impact of the TDM programs on reducing low-occupancy vehicle trips. The approach was to evaluate each program as a separate case study, using the same set of evaluation tools and guidelines. Vehicle volumes and mode choice evaluations of the programs were prepared whenever data was available. Comparisons were made and inferences drawn between sites that. do have a TDM program and sites that do not. The reportpresents these case studies as well as overall conclusions on the impact that TDM has on reducing the number of low-occupancy vehicle trips. (CF)

D7. Brownstone, D., Golob, T.F., **"The Effectiveness of Ridesharing Incentives. Discrete-Choice Models of Commuting in Southern California,** California University, Berkeley, 1991

Ridesharing incentives are evaluated wit h simulations based on 1989 - 1990 data of 2,200 full-time commuters in the South Coast Air Basin of California. A new developed ordered probit model is used, distinguishing three discrete alternatives: always rideshare, sometimes rideshare, and always drive alone. Drive alone can be reduced by guaranteed ride back home (8%), reserved parking place (7%) and cost subsidy (4 W). HOV lanes can reduce drivealone commuting with only 2%. Predictions on all incentives together give an estimate of 23% (standard error 4.3%) reduction in drivealone commuting.(TRB)

D8. Beroldo, Steve, **"Rideshare System Effectiveness: A Coast to Coast Perspective"** RIDES for Bay Area Commuters, Inc., Presented at the Transportation Research Board 70th Annual Meeting, Washington, D.C., (January 1991).

Although ridematching is one of the most widely employed TDM strategies, little information has been gathered about the characteristics and effectiveness of the systems used to provide the service. A nationwide survey of 84 ridematching systems was conducted in the Spring of 1990. The systems are described with respect to five components: information storage, matching techniques, information dissemination, database maintenance, and evaluation. These components are compared with the effectiveness of the systems in an attempt to identify cause and effect relationships.

Program effectiveness is measured by the percentage of commuters using the service who successfully find alternative commuting arrangements through the program. A surprisingly small number of organizations, 27 of 84, monitor placement. Seven program characteristics are compared with placement. Positive but weak relationships were identified between placement and database size, level of automation, matchlist delivery, and follow-up activities. However, these relationships are somewhat tenuous. It appears that parking supply, commute distance, and other elements of the commute environment may have a stronger effect on placement than ridematching system characteristics. (CF)

D9. Black, K., Bellomo, S., Spillenkothen, R., Berman, W., Chimini, L., **"Developing Transportation Demand Management Packages Using Transportation Surveys: Case Study",** Transportation Research Record No. 1346, Transportation Research Board 1992.

The goal of most transportation demand management (TDM) programs is the reduction of single-occupant-vehicle (SOV) use. The selection and packaging of TDM measures are critical in devising and implementing an effective program. The basis for the selection process can come from specialized transportation surveys. One such survey administered at the U.S. Department of Transportation(DOT) headquarter& Washington, D.C., is reported. The survey was distributed to 11,568 DOT employees with a response rate of 41%. Only 16% of respondents commute by SOV. The Washington, D.C. core average is nearly 31%. DOT has excellent rideshare participation, with an overall occupancy of 1.89 employees per automobile. Several attitudinal questions were asked to investigate possible mode shifts if the headquarters were relocated near Union Station. DOT employees consider discounted transit passes and increased parking costs strong incentives to change modes of travel. It is anticipated that a combination of transit subsidies, rideshare programs, and flexible work schedules will be considered for the possible consolidation of DOT.(TRB)

D10. Giuliano, G., K. Hwang, M. Wachs, **"Employee Trip Reduction in Southern California: First Year Results"**, Transportation Research. Part A: General, Pergamon Press plc Vol. 2i7 No. 2, March 1993.

Trip reduction policies are increasingly utilized in U.S. metropolitan areas to address congestion and an quahty problems. These policies typically focus on the journey to work and are aimed at reducing the amount of drive-alone commuting by providing transit and ride-sharing incentives. Severe air quality problems in Southern California have prompted the air pollution control agency for the Los Angeles metropolitan area to enact Regulation XV. The regulation requires employers to develop and implement a trip reduction program to achieve specified ride sharing goals. It is the most ambitious and far-reaching program of its kind implemented to date, and offers a unique opportunity to determine whether such problems can significantly affect travel behaviour. This paper presents results from the first year of Regulation XV's implementation.

D11. Transportation Division, Metropolitan Toronto Planning Department, **"Travel Demand Management Overview Study and Action Plan Proposals"**, Municipality of Metropolitan Toronto, Toronto, Ontario, June 1993

This report includes a "Technical Overview", "Executive Summary and Action Plan Proposals", and a report from the Commissioner of Planning to Metro Council (June 18, 1993). The study was undertaken in order to formulate a coordinated municipal strategy in the area of Travel Demand Management, as one element in an overall strategy to address transportation supply and demand in Metro Toronto. The recommended TDM plan has 17 elements, and a continuous phased three-year work plan for their implementation is presented.

E: CONFERENCE PROCEEDINGS

El. Conference Proceedings, Second National Conferenceon High-Occupancy Vehicle Lanes and Transitways, Houston, Texas, (October 25-28, 1987).

Presentations and highlights from technical workshops are summarized in this compilation of topics covered at the second national conference on HOV facilities. Topics include planning, operation, enforcement, design, and project implementation issues. A summary of major findings and recommendations is included. Specific project data accompanies presentations made of several case study areas, including Houston, Seattle, Ottawa, Pittsburgh, Minneapolis, Los Angeles, and Orange County, California. Experiences from freeway and arterial applications are included. (CF)

E2. Conference Proceedings, 1988 National HOV Facilities Conference, Minneapolis, Minnesota, (October 17-19, 1988).

Presentations and findings from workshop sessions are summarized in this compilation of topics covered at the third national conference on HOV facilities. Topics include planning, operation, enforcement, design, marketing, policy, and project implementation issues. Highlights of separate workshops on planning, design and evaluation; HOV system elements; operational issues; and public policy and support are provided. A summary of major findings and recommendations is included, along with a panel discussion of what the future holds for HOV facilities. (CF)

E3. Conference Proceedings, 1990 HOV Facilities Conference, April 10-12, 1990, Transportation Research Circular Number 366, Transportation Research Board, Washington, D.C., (December 1990).

This publication includes proceedings to the fourth national HOV conference held in Washington, D.C. It includes keynote speeches and findings from functional working sessions. Presentations included an update on national HOV developments, public-private initiatives; legislative and policy development perspectives from the Urban Mass Transportation Administration, Federal Highway Administration, a Congressional representative, and a state representative; Washington, D .C. regionalpresentationsregarding the northern Virginia sub-regional plan, Maryland commuter assistance study, enforcement activities in northern Virginia, and vanpool operations on area HOV lanes; and an overview of future trends in urban commuting and HOV facility development. (CF)

E4. Conference Proceedings HOV Facilities - Coming of Age, April 28 - May 1, 1991, Transportation Research Board, Washington, D.C. (January 1992).

This publication includes proceedings from the fifth national HOV conference held in Seattle, Washington. In addition to keynote speeches and summaries on functional working sessions, it includes a compilation of six white papers on various subjects drafted at the request of the HOV Systems Committee for presentations. Each paper highlights an emerging area of need in the profession that the Committee felt needed research and dissemination of current experiences. Paper topics include: Travel Demand Management and HOV Systems; Parking, Policy, Transportation Demand Management and HOV Facilities Support, Marketing as Part of the HOV Planning Process; Enforcement Issues Associated with HOV Facilities; Design Features of High-Occupancy Vehicle Lanes; and The Application of Intelligent Vehicle Highway Systems Technology to High-Occupancy Vehicle Facilities. (CF)

E5. Conference Proceedings, Sixth National Conference on HOV Systems, October 25 - 28, 1992, Transportation Research Circular Number 409, Transportation Research Board, Washington, D.C., (June 1993).

This publication includes proceedings from the sixth national HOV conference held in Ottawa, Ontario. Keynote speeches focused on ISTEA's effects in the HOV field, HOV facilities in Canada, moving HOV facilities into the 21st century, and TRB HOV Systems Committee activities. Summaries of the presentations and discussions in twelve working sessions are included. One working session, entitled "Arterial Street HOV Applications", covers experience to date in Seattle, Toronto, Los Angeles and Hartford.

F: ARTERIAL HOV-RELATED ARTICLES AND RESEARCH PAPERS

Fl. Topp, R. M., **"Reserved Transit Lanes"** presentations to the annual meeting of Canadian Transit Association, Ottawa, Ontario, June 17 - 20 1973, with addendum presented in Calgary, Alberta, June 23 - 26, 1974

The experience in Toronto with the Eglinton Avenue reserved bus lane to date, and the principles by which the concept was proposed to be extended to several other arterials in the city were highlighted. The principles are: "Reserved bus lanes should be considered in relation to their effect on the total person movement on the street"; "There should be a reasonable balance between transit passengers and other road users on routes selected for reserved bus lane operation"; and "Reserved bus lane operation should permit reasonable use of the street by other road users." Based on experience, these principles are less definitive than the technical warrants which were used in creating the initial Eglinton Avenue bus lane.

F2. Delaware Valley Regional Planning Commission, **"Modal Choice Analysis of an Exclusive Bus/Carpool Lane on U.S. Route 30. New Jersey"**, Delaware Valley Regional Planning Commission, Philadelphia, Pennsylvania, April 1975

A four mile long highway corridor linking New Jersey with downtown Philadelphia was the subject of a proposal to implement an HOV lane. Prior to implementation, a mathematical modal choice analysis and market definition was undertaken in order to assess the probable shifts between passenger autos, carpools, bus, and high-speed commuter rail modes in the corridor. An operational analysis of the route was also carried out, considering various configurations within a complex traffic circle - arterial - toll bridge context. The model indicated that an HOV lane would induce a shift of 2 - 3 per cent of auto demand and 1 - 2 per cent of rail demand to HOVs. Most of the shifted demand would go to the bus mode, with little impact on carpooling. The greater the restriction on passenger car travel, the greater the attraction of HOVs.

F3. Miller, **C.,** et. **al., "Enforcement Requirements for High-Occupancy Vehicle Facilities."** FHWA-RD-79-15, Beiswanger, Hoch and Associates for the U.S. Department of

Transportation, Federal Highway Administration, North Miami Beach, Florida, (December 1978).

This research report reviews enforcement on HOV facilities, identifies effective HOV enforcement techniques, develops model legislation for effective enforcement and provides HOV enforcement guidelines. Sixteen projects in the US encompassing each type of freeway and arterial treatment were visited to gain operational and enforcement data. These projects exhibited varying enforcement programs, deficiencies and performance levels. Enforcement guidelines have been prepared for each type of freeway and arterial HOV treatment. In order to improve the enforcement of HOV facilities, innovative techniques -- involving photographic instrumentation, mailing of citations, tandem (team) patrols, and para-professional officers -- have been identified within the context of this research. For innovative enforcement techniques to be effective, legislation is often necessary. This report incorporates model legislation examples for this purpose. (CF)

F4. Miller, C., et al., **"Safety Evaluation of Priority Techniques for High-Occupancy Vehicles,"** Final Report, Report No. FHWA-RD-79-59, Beiswanger, Hoch and Associates for the U.S. Department of Transportation, Federal Highway Administration, North Miami Beach, Florida, (February 1979).

Priority treatments for HOVs can introduce new safety problems due to operational and geometric modifications. At the same time, they can reduce the accident potential by improving overall traffic operations. The research in this report focused on five major aspects of HOV projects: 1) an examination of the pertinent accident rates, 2) an analysis of causative factors influencing safety, 3) an identification of difficult manoeuvres and potential safety problems, 4) the development of recommendations to improve safety, and 5) a review of the legal authority and legal liability issues faced by HOV projects.

Twenty-two HOV projects on 16 highway facilities were visited by the research team. These projects encompass virtually every type of preferential strategy currently deployed in the US on freeways and arterial facilities. For each HOV project, data on safety, operations, and geometrics were collected and analyzed. These data and qualitative information can be used to describe the current experience related to the HOV safety issue. (CF)

F5. Erikson, G., W. E. Hurrell, B. W. Nelson, **"Transit Lane Enforcement in the Central City"**, Transportation Research Board, Washington, D. C., 1981.

Transit lanes in crowded urban core streets are potentially effective for improving transit operations when they are available to transit vehicles. Concurrent-flow transit lanes are susceptible to violation by motorists. Police enforcement is often costly and inconsistent. A 2-year demonstration grant, from the Urban Mass Transportation Administration to San Francisco, tested the concept of self-enforcing lanes by using improved lane markings to heighten motorist's awareness and, hence, voluntary compliance. A separate study of nontraditional enforcement techniques was included within the grant finding. The results of the test showed negligible change in motorist's behaviour, but the research uncovered valuable information about more signifant contributors to transit delay, namely, double parked vehicles and a spotty parking enforcement program. Subsequent implementation of new transit lanes on a downtown San Francisco street reflected the lessons learned on design techniques and enforcement priorities.(TRB)

F6. Billheimer, J. W., McNally, J., and Trexler, R., **"TSM Project Violation Rates, Final Report."** Report No. DOT-I-82-10, Systan, Inc., for the California Department of Transportation and the California Highway Patrol, Los Altos, California, (October 1981).

This report presents findings of enforcement activities for three forms of Transportation System Management treatments in California: ramp metering, preferential HOV lanes on freeways, and bypass lanes for HOVs. The purpose of this study was to provide a detailed, quantitative, and objective assessment of the effect of different enforcement options, engineering feature and educational programs on violation rates; and to trace the resulting impact of these violation rates on safety, freeway performance, and public attitudes. Considerable data is arrayed from the various surveys conducted on each candidate treatment. (CF)

F7. Eder, E. S., **"Cost Effectiveness of Priority Treatment for High-Occupancy Vehicles",** Cambridge Systematics, Inc., for the Office of Transportation and Land Use Policy, US Environmental Protection Agency, Washington, D.C., (November 1981).

This report is one of a series of memorandums which examines the cost-effectiveness of implementing various transportation measures for the purpose of reducing vehicle emissions. Because emission reduction is not typically the sole purpose of implementing air quality transportation measures, this analysis quantifies, where possible, all other costs and benefits which result from the measure. The net cost of the

measures is then compared to the amount of hydrocarbons and carbon monoxide which have been eliminated, and the net dollar costs of emissions reduced are determined. (CF)

F8. Hamm, J. T., and Lewis, R. J., **"HOV Enforcement Project Final Report",** TWA-1006(001), Municipality of Metropolitan Seattle, Seattle, Washington, (August 1985).

A demonstration project in Seattle, Washington tested the use of a public telephone hotline to reduce the transit/carpool lane violations and also introduced the use of a variable carp001 definition in order to maximize transit/carpool lane effectiveness. The variable carp001 definition was tested by lowering the occupancy requirements from three to two persons per vehicle at selected locations in an Interstate corridor. Project data from these operational and enforcement changes were documented, and results showed a substantial reduction in violators and improvement in lane use. (CF)

F9. Rowbottom, H. M., **"Contra-Flow Bus Lanes: An Operator's Point of View", in** ITE 1989 Compendium of Technical Papers, Institute of Transportation Engineers, Washington, D. C., 1989.

The experience in the mid-1970s with the implementation and abandonment of contra-flow bus lanes on four streets in Chicago's CBD is recounted. Problems cited include rerouting of buses to the designated streets in order to justify exclusive bus lanes inconvenienced passengers; taxi drivers were upset at losing access to curbside pickups; pedestrian activity was heedless of the lanes, creating dangerous operations; building construction sites had narrow sidewalks, forcing pedestrians into the lane; most lanes had numerous utility manholes in regular use; the lane width was only 11 feet (with a 2 foot wide safety strip); and pedestrian control measures were difficult to implement and enforce. A "with-flow" median reserved bus lane utilizing in-street passenger loading platforms is cited as a more suitable operational concept, per the example of one Chicago street which operated in that mode from the mid 1950s to the late 1970s.

FlO. Billheimer, J. W., **"High Occunancy Vehicle Lane Violation Study. Final Report."** System, Inc., for the California Department of Transportation, Los Altos, California, (January 1990).

This report summarizes an extensive study of the engineering features, enforcement procedures, and public attitudes associated with HOV lane violations, identifying those factors which contribute to violation rates and developing countermeasures to reduce these rates. All mainline HOV lanes operating during 1988 in the state of California were included in the evaluation. Violation rates, design characteristics and other pertinent data are presented on each project. Findings from several types of enforcement strategies are included. Enforcement issues and problems are identified, design options are presented, and the role of public awareness is addressed. (CF)

Fll. Kinchen R., **et al., "HOV Compliance Monitoring and the Evaluation of the HERO Hotline Program** Report No. WA-RD205.1, Seattle, Washington, (February 1990).

An evaluation of enforcement-related issues on the Seattle HOV system focuses on compliance statistics among various facilities. occupancy violations are compared to total vehicle flow on each project. A self-enforcement program, locally termed "HERO" is assessed, including a determination of how effective the program is in discouraging violators without the necessity of on-site apprehension. (CF)

F12. Rutherford, G. S., Kinchen, R. K., and Jacobson, L. **N., "Agencv Practice for Monitoring Violations of High-Occupancy Vehicle Facilities."** Transportation Research Record Number 1280, Transportation Research Board, National Research Council, Washington, D.C., (1990).

Various states monitor their HOV facilities for violations of passenger occupancy requirements. Few states have long term programs to monitor violations. Most current monitoring activities involve human observers; however, new photographic techniques may soon offer improvement. This report overviews monitoring activities across the U.S., focusing on experience and available data from California, Texas, Oregon, New Jersey, Washington, Colorado, Florida, Hawaii, Massachusetts, and Minnesota. Distinctions between short term and long term monitoring approaches are discussed. Photographic monitoring methods are also addressed. (CF)

F13. Jacobson, L. N., Rutherford, G. N., and Kinchen R. K., **"Public Attitude Toward the Seattle Area HOV Svstem and Effectiveness of HERO Hotline Program** Presented at the Transportation Research Board 70th Annual Meeting, Washington, D.C., (January 1991).

The development and use of HOV facilities in the Seattle area has provided a cost effective way to increase the efficiency of the existing

transportation network, and positive public attitudes toward these facilities has been critical. In 1988 a research project was undertaken to determine public attitudes toward a HERO hotline (for motorists to report HOV violations) and the HOV system through a survey, and analyze the effectiveness of the HERO program. This paper describes the public attitude survey results, the implications the survey results have on the effectiveness of the HERO program, and presents conclusions and recommendations from this effort that may be applicable elsewhere. (CF)

F14. Tumbull, K. F., **"International High-Occupancv Vehicle Facilities",** Transportation Research Record 1360, Transportation Research Board, Washington, D.C., 1992.

This report provides an overview and description of HOV lanes in operation in non-North American countries. The results of initial review indicate that HOV facilities are being used extensively in many parts of the world. Exclusive HOV lanes, on either separate rights-of-way or freeways and arterial streets, are in operation in 16 metropolitan areas around the world. The largest number of international HOV projects fall into the general category of non-exclusive HOV lanes on arterial streets. These types of projects have been identified in at least 75 cities. A general description of these facilities is provided. The similarities and differences between HOV projects in North America and other parts of the world are highlighted. Finally, mechanisms for improving the future exchange of information on international HOV projects are presented.

F15. Jacobson, K. L., L. Ingalls, E. H. Melone, **"Alternatives for Providing Priority to High-Occupancy Vehicles in the Suburban Arterial Environment",** Transportation Research Record No. 1394, Transportation Research Board, 1993.

HOV facilities remain rare in the suburban arterial environment. Suburban arterials are complex in their function and design, making the simple application of the basic freeway HOV lane concept difficult. The alternatives for providing HOV priority in the arterial environment studied in Snohomish County, Washington, a suburban county in the Seattle metropolitan area, are discussed. AU of the treatment options that have been used to provide priority to HOVs were considered. The advantages and disadvantages of treatments that show some potential for success are discussed. An important finding is that suburban arterial HOV treatments must be focused on reducing delay for HOVs at signalized intersections since congestion emanates from the signalized intersection in this environment.(TRB)

F16. Nihan, N. L., H. C. Chen **"HOV movements on Signalized Arterial.9 , in the Arctie Area. Final Rewrt. Volume IV: Siiul Planning and Evaluation",** Washington Uni v, SeattIe, Washington State Department of portation, Federal Highway Administration, 1993.

The main research objective of this study is to improve the Iimitation arterial traffic simulation models TRAF-NETSIM and TRANSYT-7F that they can be used to overcome HOV lane planning deficiencies. For instance, after integrating the improved traffic operation models, the evaluation methods can be more adequate for consideration of complex variables associated with arterial HOV lanes. The traffic impacts of HOV lanes can be analyzed from these improved traffic models; therefore, the relationship between traffic impacts and mode shift behaviour can be modeled more accurately. Finally, the guidelines to install a successfuI HOV lane can be derived according to the results of HOV lane evaluation. In brief, the objectives of this study are to: (1) Modify the logic of TRAF-NETSIM turning movements for simulating arterial HOV lanes realistically; (2) Modify the calculation algorithms of TRAF-NETSIM link statistics to provide the travel time of each vehicle type for HOV lane evaluation; (3) Develop the smoothing factor analytical method for TRANSYT traffic platoon dispersion model so that this model can be enhanced and applied appropriately in mixed-flow and priority lane traffic analysis; and (4) Develop two iteration algorithms for TRANSYT traffic platoon prediction so that this model can simulate congested flow accurately. The scope of this study is limited to focus on the planning process of arterial concurrent flow HOV lanes using traffic simulation models TRAF-NETSIM and TRANSYT-7F.(TRB)

F17. Boie, P., **"HOV Detection",** Public Works Financing, Public Works Financing Vol. 65, Aug. 1993, p 19.

Advanced electronic systems to accurately detect and bilI vehicles, sonar and lasers to confirm the types of vehicles, and other sophisticated equipment that will be used on the SR 91 in California are briefly described. Automatic vehicle detection identification systems, and roads and bridges equipped with radio frequency toll collection technology is also discussed. An AVI tag and a high-tech system will identify and ensure that high occupancy vehicles (HOVs) are using the designated lanes. It is expected that videotapes of alleged HOV violators will be used to help the California Highway Patrol enforce the toll traffic laws. The question of billing accuracy is discussed, as well as the possibility of using electronic driver" licenses.(TRB)

F18. Bevington, E. and K. Jacobson, **"AVI for Bus Priority at Traffic Signals in the Puget Sound Region",** Metro Transit and Parsons Brinckerhoff, Seattle, June 1994.

The focus of this paper is on giving buses at signalized intersections preferential travel by altering the timing of traffic signals to favour such vehicles. The guiding philosophy for this application is that signal timing should be operated to minimize total person delay. This is a natural evolution from current signal control strategies, which strive to minimize total vehicle delay. The Puget Sound approach requires two functions: identification of the vehicle using AVI technology and the modification of signal timing in response to these vehicles. This is being considered on a systemwide basis. Specific strategies to perform these functions are discussed in the paper. (CF)

G: PUBLICATIONS

The following publications regularly feature articles and news items of relevance to HOV and bus use of arterials.

Gl. **"Passenger Transport",** 1201 New York Avenue, N.W., Washington, D.C., 20005, USA (ph (202) 898-4000 50 issues/year.

G2. **"Urban Transportation Monitor",** P. 0. Box 12300, Burke, Virginia, 22009-2300, USA, (ph. (703) 764-0512), fax (703) 764, 0516), 24 issues/year.

G3. **Forum Canadian Urban Transit Association/** Association Canadienne due Transport Urbain, Suite 901, 55 York Street, Toronto, Ontario, CANADA, M5J lR7, (ph (416) 3659800, fax (416) 365-1295), 12 issues/year.

G4. **"Transit Connections", Simmons-Boardman** Publishing Corp., 345 Hudson Street, New York, NY, 10014, USA, (ph (212) 620-7200, fax (212) 633-l 165), 4 issues/year.

"Highway Research Abstracts", Transportation Research Board, National Research Council, 2101 Constitution Avenue, N.W., Washington, DC, 20418, USA (ph (202) 334-3214), 4 issues/year.

G6. **"HOV System Notes",** Transportation Research Board, National Research Council, 2101 Constitution Avenue, N.W., Washington, DC, 20418, USA, 1 or 2 issues/year.

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