U.S. Department of Transportation

High Occupancy Vehicle (HOV) Guidelines for Planning, Design, and Operations

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for

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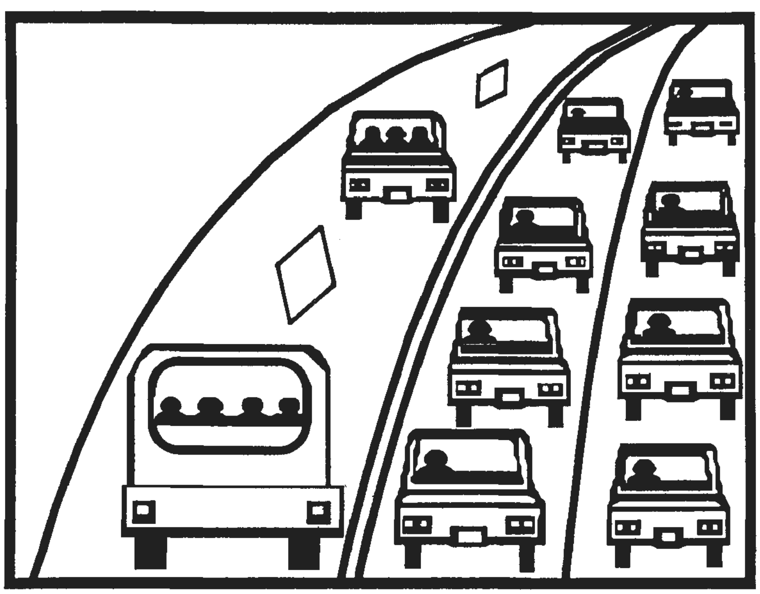

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Business, Transportation and Housing Agency

Caltrans

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Department of Transportation
Division of Traffic Operations

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LIST OF ABBREVIATIONS

AASHTO	----	American Association of State Highway and Transportation Officials
AC	----	Asphalt Concrete
AQMP	----	Air Quality Management Plan
AQP	----	Air Quality Plan
AVR	----	Average Vehicle Ridership
CARB	----	California Air Resources Board
CCAA	----	California Clean Air Act of 1988
CHP	----	California Highway Patrol
CIP	----	Capital Improvement Program
CMA	----	Congestion Management Agency
CMP	----	Congestion Management Program
COG	----	Council of Government
CTC	----	California Transportation Commission
CVC	----	California Vehicle Code
DSMP	----	District System Management Plan
EPA	----	Environmental Protection Agency
FCAAA	----	Federal Clean Air Act of 1990, as amended
FCR	----	Flexible Congestion Relief
FHWA	----	Federal Highway Administration
HDM	----	Highway Design Manual
HOV	----	High-Occupancy Vehicle
LOS	----	Level of Service
LTC	----	Local Transportation Commission
MTC	----	Metropolitan Transportation Commission

OCTC	----	Orange County Transportation Commission
PCC	----	Portland Cement Concrete
PMS	----	Pavement Management System
PPH	----	Persons Per Hour
PS&E	----	Plans, Specifications & Engineer's Estimate
PSR	----	Project Study Report
PSTIP	----	Proposed State Transportation Improvement Plans
RTIP	----	Regional Transportation Improvement Plan
RTP	----	Regional Transportation Plan
RTPA	----	Regional Transportation Planning Agency
SCAG	----	Southern California Association of Governments
SIP	----	State Implementation Plan (for federal air quality)
SSD	----	Stopping Sight Distance
STIP	----	State Transportation Improvement Program
TCM	----	Transportation Control Measure
TCR	----	Transportation Concept Report
TDM	----	Transportation Demand Management
TDP	----	Transportation Development Plan
TMP	----	Traffic Management Plan
TOS	----	Traffic Operations System
TSM	----	Traffic Systems Management Program (created by AB 471)
VMT	----	Vehicle Miles of Travel
VPH	----	Vehicles Per Hour
VPHPL	----	Vehicles Per Hour Per Lane

July 1, 1991

FOREWORD

High-occupancy vehicle (HOV) operation in California began in April of 1970 with the HOV bypass lane at the San Francisco-Oakland Bay Bridge toll plaza. The El Monte Busway (LA-10), which opened as a buses-only facility, was added in January 1973. In 1976, the Department converted two mixed-flow lanes to HOV operation on the Santa Monica Freeway. Although technically feasible, the conversion aroused intense public and political opposition. Legal action was brought against the Department which resulted in returning the lanes to mixed-flow operation. The conversion was short lived. However, the resulting anti-HOV sentiment was instrumental in delaying development of the State's HOV program, which did not gain momentum until the mid-1980's. By 1985, only 35 directional miles of HOV lanes were operational.

The years between 1985 and 1990 witnessed a surge in HOV activity, both in terms of policy and of projects implemented. In July, 1987, following the success of several HOV projects (including Marin-101, Santa Clara-101, LA-91 and Orange 55), the California Transportation Commission (CTC) passed Resolution G-87-8. The resolution stipulated that bus and carpool lanes must be considered whenever capacity is added to existing metropolitan freeways. In December, 1987, the Federal Highway Administration (FHWA) issued Procedure Memorandum D6103 which also directed that the HOV alternative be given thorough consideration on capacity adding projects in metropolitan areas. In March of 1989, the Department finalized Policy and Procedure Memorandum P89-01. The Memorandum outlined the Department's policy and procedure for the development of HOV facilities and detailed the areas of responsibility for implementation of the policy. District Directors are responsible for implementing the policy. The Chief, Division of Traffic Operations, is responsible for establishing procedures and criteria to: (1) ensure policy implementation, and (2) recommend policy revisions. By late 1990, the Department was operating nearly 220 directional miles of HOV facilities, with another 550 planned or under construction.

For most situations, retrofitting an HOV lane on an existing freeway requires some compromises in design standards. FHWA's Procedure Memorandum D6103 allows, under certain conditions, exceptions to AASHTO design standards. But it offers little guidance on acceptable geometric reductions. This is not surprising considering HOV facilities are still a relatively new development and few design guidelines are available. In 1989, in response to District requests for guidelines to provide statewide consistency and uniformity, the Division of Traffic Operations began preparing these guidelines. The Division staff organized and chaired a committee consisting of representatives from the metropolitan Districts, several Headquarters Divisions, the CHP, FHWA and private consultants. Without exception, the participation and cooperation received from the committee members was outstanding. It is their contribution and dedication that made these guidelines possible.

INTRODUCTION

These guidelines are not intended to supersede Caltrans' Transportation Planning Manual, Project Development Procedures, Highway Design Manual, Traffic Manual, or other established manuals, procedures or practices. They are not, and should not be used as a set of standards. The guidelines are advisory in nature and are to be used only when every effort to conform to established standards has been exhausted. When conformance is not possible, the deviation must be documented by a sound and defensible engineering analysis and an approved design exception fact sheet.

The goal of these guidelines is to provide a "how to" document for planners, designers and operators of mainline HOV facilities.* Since individual site characteristics vary, only typical scenarios can be presented. For situations not discussed, Districts are advised to consult the appropriate District and Headquarters representatives for advice and consent.

Twenty years have passed since the opening of the bypass lanes at the San Francisco-Oakland Bay Bridge toll plaza. But it wasn't until the mid-1980's that operational and research data on HOV facilities started to accumulate. This means that guideline updates and revisions will be necessary as new data becomes available. Since much is yet to be learned on the subject it is recommended that the Districts conduct "before and after" operational studies for HOV projects implemented. Headquarter's Division of Traffic Operations will, simultaneously, be conducting studies to resolve HOV issues which are generic in nature and applicable statewide. The results from District and Headquarter studies, with participation from outside agencies such as the FHWA, the CHP and the ARB, will then be used to update these HOV guidelines. A coordinated and cooperative effort is, therefore, needed to ensure these guidelines reflect the latest experience and operational data for planning, designing and operating HOV facilities.

Further discussion on HOV facilities may be found in other publications such as AASHTO's "Guide for the Design of High-Occupancy Vehicle Facilities", and Charles A. Fuhs' "High-Occupancy Vehicle Facilities - a Planning, Design, and Operation Manual". Should the District use recommendations from other publications which either deviate from or are not contained in this document, it is recommended that the District consult with the appropriate Headquarters and District functional units for concurrence.

* Refer to the Division of Traffic Operation's "Ramp Meter Design Guidelines" for guidance on HOV bypass lanes on ramps.

Chapter One

PLANNING

1.1 GENERAL

The majority of California's HOV facilities were planned and built on a "route" or "corridor" basis where the feasibility of HOV operations was determined without the benefit of a regionwide HOV system plan. In some cases, HOV facilities were designed as "queue-jumpers" to give multiple-occupant vehicles a time advantage over single-occupant vehicles. This is understandable and appropriate considering HOV experience, both state and nationwide, was in a fluid state where operational data were lacking and public acceptance of HOV facilities uncertain. Still, the overall performance of those HOV facilities frequently exceeded expectations and, in some cases, projected HOV demands were met within a year or two of implementation. While a regionwide HOV system is ideal, such a system requires a supporting cast of HOV freeway-to-freeway connectors, direct access ramps to local cross streets, park and ride/transit facilities, and rideshare inducement and promotional programs. The cost of providing these elements requires a high degree of political and public commitment to the HOV philosophy which, during the early years of HOV application, did not exist. However, as congestion has worsened in the metropolitan areas of the State and as existing HOV facilities have proven to be successful, local transportation planning agencies and the Department have responded by jointly drafting HOV system plans for the four metropolitan areas of the state - the Los Angeles Basin, the San Francisco Bay Area, San Diego, and Sacramento. These system plans will be revised periodically as appropriate.

Planning for HOV facilities is integrated into the District's system planning process through the District System Management Plan (DSMP), Transportation Concept Reports (TCR), and Transportation Development Plan (TDP). It also provides a linkage between system planning and the preparation of Project Study Reports (PSRs). The appropriate level of planning, analysis and system development for HOV planning must be incorporated into these documents.

Procedurally, there is no difference between HOV projects and other capital outlay projects as they advance from the planning phase into the project development process. The PSR is one of the critical documents as an HOV proposal advances from the planning phase into the project development phase. During the development of a PSR, consideration should be given to the type of HOV facility which best balances the traffic demands of the corridor with cost, right-of-way and environmental concerns. The next two chapters, "HOV Operations" and "Geometric Design", should also be consulted when preparing the PSR and the project report.

1.2 HOV STATUTES AND POLICIES

Numerous statutes and policy memoranda affect the planning and implementation of HOV facilities. Some of these are summarized below. See Appendix A for complete texts.

A. Policy and Procedures Memorandum P89-01:
The Department will consider an HOV lane alternative for all projects which add capacity to metropolitan freeways or proposed new metropolitan freeways.

The Department will work with regional transportation planning agencies in the conceptual planning phase to develop regional HOV lane system plans in metropolitan areas and to include these systems in the regional transportation plans.

B. California Transportation Commission Resolution G-87-8:
"BE IT RESOLVED, that in the planning of any new freeway facility or freeway capacity addition in and around a metropolitan area, the Department . . . shall examine and report to the California Transportation Commission on the feasibility . . . of designating bus and carpool lane operation . . . ."

"That such examination should consider the possible extension of bus and carpool lane operation into existing adjacent facilities . . . that the Commission shall also give serious consideration to extending such a bus and carpool facility to existing adjacent facilities when it is demonstrated to be feasible and of likely benefit and to contribute to the operation of the bus and carpool facility within the new project."

C. FHWA Procedure Memorandum D 6103:
Regional Transportation Planning Agencies should develop in concert with Caltrans and local agencies, route specific regionwide HOV system plans as a part of the regional transportation plan in metropolitan areas.

An HOV lane shall be an essential alternative for evaluation in the project development process when considering an additional lane by restriping and/or reconstruction or widening on freeways with three or more lanes in one direction.

D. Streets and Highways Code - Section 149:
"The department may construct exclusive or preferential lanes for buses. . . and other high-occupancy vehicles . . . ."

E. Surface Transportation Assistance Act - Section 167:
Motorcycles are permitted in high-occupancy and other exclusive vehicle lanes constructed with federal participation unless such use would create a safety hazard.

F. California Vehicle Code 21655.5:
"The Department . . . and local authorities . . . may authorize or permit exclusive or preferential use of highway lanes for high-occupancy vehicles. Prior to establishing the lanes, competent engineering estimates shall be made of the effect of the lanes on safety, congestion, and highway capacity."

The Department has determined that a separate, detachable report is required to consider the safety and capacity aspects of HOV projects. If the project already has an approved project report, this separate report should be reviewed and concurred with by District Legal and, at a minimum, signed by the chief of the unit preparing the report before the PS&E is sent to Headquarters Office Engineers. For projects without an approved project report, this report should be attached to the project report and be part of the project report approval process. See Appendix B for the recommended format of the report.

G. California Vehicle Code 21655.6:
"Whenever the Department of Transportation authorizes . . . preferential lanes . . . , the department shall obtain the approval of the transportation planning agency or county transportation commission prior to establishing the exclusive use of the highway lanes."

H. Federal Highway Act, Title 23, Chapter 1:
Authority for Department of Transportation to approve HOV facilities on Federal Aid Systems to increase the capacity for the movement of persons.

I. Public Resources Code - Section 25485:
"The Department shall develop programs and undertake any necessary construction to establish, for the use of carpool vehicles carrying at least three persons, preferential lanes on major freeways . . . ."

J. Air Resources Board:
The California Air Resources Board approved guidance documents on May 9, 1991 to assist air quality districts in meeting new requirements of the California Clean Air Act. See Appendix A-9 for the executive summary.

K. Occupancy and Vehicle Type:
Occupancy requirements for and vehicle types allowed on HOV facilities need to be approved by the Director at least one month prior to the opening of the HOV lane to traffic. See Appendix A-10.

Note that the policies and statutes are intended for urban freeways and that FHWA, CTC, and Department policies do not expect rural freeways to have HOV facilities.

1.3 HOV PLANNING

The planning of HOV facilities should focus on the people carrying capacity of the system rather than on vehicle capacity. In accordance with the Department's mission as a multi-modal organization, HOV planning should focus not only on multi-occupant cars and vans but also on buses and other transit vehicles. Therefore, the planning process should consider complementary support elements such as park and ride lots, bus/transit stations, and ingress/egress to them.

1.3.1 HOV Issues

Several specific planning issues are pertinent to HOV system planning. These issues are discussed below.

A. HOV Factors and Criteria

An HOV proposal must be:

1. Consistent with district management strategies as identified in the DSMP and the TCR.

2. Consistent with objectives and strategies of the congestion management program.

3. Supportive of regionally adopted transportation control measures (TCMs) and with the approved air quality management plan (AQMP).

4. Consistent with the short and long-term elements of the Regional Transportation Plan (RTP).

Assuming the above criteria are met, the HOV proposal should be analyzed to respond to the following questions:

1. Will geometric cross-sections conform to the Highway Design Manual? If not, will the design exception be approved?

2. Will the project result in a deterioration of highway safety?

3. Will the project provide at least one minute of time savings per mile for an average commute trip? A total savings of five to ten minutes is desirable.

4. Will the HOV project be cost effective? Factors in benefit/cost analysis should include delay savings (in vehicle-minutes and person-minutes), safety benefits and construction,

right-of-way, maintenance and operation costs. Estimates for delay should consider those incurred by the mixed flow traffic due to HOV operations.

5. Will traffic forecasts for one year from opening indicate that a minimum of 800 vphpl or 1800 persons per hour per lane will be using the HOV facility during the peak hour? FHWA Procedure Memorandum D 6103 stipulates that an additional lane could be a mixed flow lane if 5 years after opening, the HOV option would be carrying fewer person-trips. However, experiences in California indicate that adverse public reaction from perceived underutilization of the HOV facility is a significant factor and that a one-year period may be an appropriate goal.

6. Can HOV violations be enforced easily and safely? See Chapter 6 "HOV Enforcement".

7. Are HOV support facilities such as park and ride lots, transit facilities and public awareness campaigns available to support the HOV proposal? Such support facilities should be considered for all HOV proposals and, if appropriate, be included in the HOV project.

B. Multiple HOV Lanes

The planning for HOV facilities should consider the eventuality when the capacity of the HOV lane is reached. To maintain the necessary incentive to use the facility, the level of service (LOS) for the HOV lane should ideally be maintained at LOS-C. The HOV facility should not be allowed to reach unstable flow (LOS-E) and certainly should not experience congestion on a regular basis. Therefore, it is essential that the planning process include options to accommodate additional future HOV traffic. These options include increasing the required occupancy or providing additional HOV lanes.

An additional HOV lane to provide passing opportunities may be appropriate when the facility is in mountainous or rolling terrain, particularly if high bus volumes are anticipated. Tailgating in HOV facilities is a frequent occurrence and vehicles have been observed illegally crossing buffers to avoid being tailgated.

C. Modeling

Standard transportation modeling-based analytical tools have not yet been fully developed to evaluate the effectiveness of HOV facilities. Only general effects of HOV facilities are presently known with certainty, and these are insufficient to drive a model-based assessment. Since experience has not yet been subjected to precise observations, off-model methodologies are being developed by individual metropolitan planning organizations to perform the desired impact assessment. Further research is needed in this area.

In California, the Southern California Association of Governments (SCAG), the Metropolitan Transportation Commission (MTC), and the Orange County Transportation Commission (OCTC) are developing models to forecast travel demand. Each of these are looking at mode split, with emphasis on how many of the potential trips would be carpools, transit, recreational or other special attractor trips. The Department also has several consultant contracts dealing with mode split, air quality and safety issues concerning HOV facilities.

D. Funding and Prioritization of HOV Facilities

Most funding of HOV projects will be through the Flexible Congestion Relief (FCR) Program.* To be eligible for the Regional Transportation Improvement Program (RTIP), the project must be included in the county's Congestion Management Programs (CMPs). Together with projects from the Commuter and Urban Rail Program and the FCR Program, the county prepares a prioritized list of projects for the RTIP. The Department's Proposed State Transportation Improvement Program (PSTIP) and RTIP are used by the California Transportation Commission (CTC) as the basis for the 7-year State Transportation Improvement Program (STIP).

* Current efforts are underway to include restriped HOV projects, which can be quickly implemented, into the TSM funding program.

The prioritization of the HOV project within the FCR is ultimately decided by the regions. However, it is essential that the Districts provide as much input to the regions as necessary to ensure critically needed HOV projects are prioritized accordingly.

E. Evaluation of Existing Facilities

While the operation of a facility normally includes monitoring performance, those results often do not find their way back to the long-range planners of the Department. This feedback loop must be completed to ensure that appropriate models are developed, and the experience of operating mature facilities shapes planning for new facilities.

1.3.2 Caltrans System Planning

System Planning is Caltrans' long-range transportation planning process and is conducted pursuant to Government Code Section 65086(a) and Caltrans policy. The multi-jurisdictional system planning process is multi-modal and considers the entire transportation network, including rail, air, ferries, mass transit, state highways, and local streets and roads. The process produces three interrelated planning documents which provide guidance, evaluate transportation corridors and develop system improvements. The three planning documents are: (1) The District System Management Plan (DSMP), (2) The Transportation Concept Report (TCR), and (3) The Transportation Development Plan (TDP).

The linkage of system planning with development of the HOV System Plan is through consistency in the implementation of system management objectives and strategies, the identification of corridor deficiencies and establishment of transportation solutions, and the recommendations and prioritization of system improvements.

A. District System Management Plan (DSMP)

The DSMP outlines the District's strategies to maintain, manage and develop the transportation system over the next twenty years and beyond. It is a multimodal strategy document describing the Department's goals and policies and the District's objectives and strategies. In the DSMP, modal systems and existing and projected conditions are analyzed, transportation issues are identified and strategies to be implemented to overcome the major issues or problems are established. The DSMP addresses how statutes and policies affect HOV facilities, whether current statutes need revision, the factors that preclude or include HOV facilities from a regional perspective, and the appropriate management techniques to be applied in operating HOV lanes. The degree of detail in which specific HOV facilities are discussed within the DSMP is by a reference to the HOV System Plan. The DSMP may identify specific HOV candidate facility locations (as established within the HOV System Plan) by either a listing, or on a District map. Coordination with other Districts will be necessary when routes cross District boundaries.

The HOV System Plan must be consistent with the system management strategies identified in the DSMP.

B. Transportation Concept Report (TCR)

The Transportation Concept Report identifies multimodal transportation deficiencies and the improvements necessary to achieve the twenty-year planning concept. The concept considers three modal elements: (1) facility type, (2) level of service, and (3) vehicle occupancy. The TCR is prepared for one of three transportation service areas: the route, corridor or area. Each corridor is evaluated as to how it can be expected to perform over the next twenty years considering funding, environmental and political feasibility. Operating conditions in each route, corridor or area are projected for the twenty-year planning period. Beyond the twenty-year planning horizon the report identifies the ultimate transportation corridor, corridor preservation opportunities and the potential application of new technologies. The development of the route concept is guided by the management strategies and objectives established in DSMP. The TCR considers HOV proposals identified in the HOV system plan in its analysis for specific alternatives for resolving deficiencies. The HOV system plan must be consistent with the planning concepts identified in the TCRs.

C. Transportation Development Plan (TDP)

The Transportation Development Plan identifies system improvements necessary to overcome transportation deficiencies identified in the DSMP, TCR and regional studies. In recommending system improvements in the TDP, considerations must be made regarding corridor development, funding, local, regional and state priorities, interregional travel and system continuity. The TDP is developed using two alternative funding scenarios to bracket low and high estimated funding projections. The TDP covers the five-year planning period following the seven-year STIP. Together, the seven-year STIP and the five-year TDP cover the first twelve years toward attainment of the twenty year planning concept. The TDP includes improvement alternatives identified in the TCR, which are consistent with the strategies of the DSMP and regional studies. The TDP considers the HOV System Plan in recommending and prioritizing system improvements.

The HOV System Plan identifies HOV facilities for consideration and prioritization in the TDP.

1.3.3 Regional Planning

The link between HOV system planning and regional planning is expressed through several regional plans and programs, including the Regional Transportation Plan (RTP), the Congestion Management Program (CMP) and Air Quality Plan (AQP). To be included in the State Transportation Improvement Program (STIP) and receive funding from the Flexible Congestion Relief (FCR) program, an HOV project must be included in the Capital Improvement Program (CIP) of the CMP and be submitted through the Regional Transportation Improvement Program (RTIP). CMPs are required to be consistent with the RTP, which in turn must conform to Federally required AQPs.

A. Regional Transportation Plan (RTP)

The RTP is the document which the Regional Transportation Planning Agency (RTPA) uses to describe the existing system, discuss current trends, and express their intentions and needs for the transportation system within the region. It is prepared by the regional Council of Governments (COG), Local Transportation Commission (LTC), or statutorily created RTPA. Updated every two years, the RTP is a twenty-year plan containing maps, policies, and short-term (5 to 10 year) and long-term projects for each mode of transportation. For metropolitan areas, HOV facilities should be consistent for both the short and long-term elements of the RTP. Short-term projects should consider the easily implemented re-striped HOV lanes which are normally retrofitted within the existing right-of-way. Long-term HOV applications should include considerations for full standard HOV facility and multiple HOV lanes.

B. Congestion Management Program (CMP)

Urbanized counties over 50,000 in population are required to develop CMPs. Two of the five elements of the CMP have linkage to the HOV program. These are: (1) the transportation demand management and trip reduction (TDM) element, and (2) the Capital Improvement Program (CIP). The TDM element involves HOV facilities in that its purpose includes improving system efficiency by increasing person through-put and reducing vehicle demand. In addition, the HOV project must be included in the Capital Improvement Program of the Congestion Management Program before it can be considered for the RTIP.

HOV projects may also be included as a part of a deficiency plan that is developed by the local governments to ensure conformance with the CMP. Deficiency plans are developed to either mitigate a specific instance of nonconformance or, if the instance cannot be mitigated, to measurably improve the overall performance of the system and contribute to significant improvements in air quality.

C. Air Quality Plans (AQP)

The California Clean Air Act requires that AQPs be prepared for non-attainments areas of the state that have not met state air quality standards for ozone, carbon monoxide, nitrogen oxide and sulfur dioxide. These plans must include a wide range of control measures which, for most areas, include Transportation Control Measures (TCMs). HOV systems plans support and conform to these TCMs, which include the following:

1. Regulatory Measures
    a. Employer based trip reduction rules

    b. Trip reductions rules for other sources that attract vehicle trips

    c. Management of parking supply and pricing

2. Transportation System Improvements
    a. HOV system plans and implementation programs

    b. Comprehensive transit improvement programs for bus and rail

    c. Land development policies for motor vehicle trip reduction

    d. Development policies to strengthen on-site transit access for new and existing land developments

Since regional transportation plans and congestion management programs must conform to the Federally required AQPs, which are focused on trip reductions, it is expected that HOV facilities could be a preferred alternative for most capacity-adding freeway projects in the urban areas. Since the CTC-adopted guidelines for the Flexible Congestion Relief (FCR) guidelines include funding eligibility for rail systems, it may be that HOV projects will not compete well for funding priority in the RTIP. Therefore, the possibility exists that HOV projects will not be fundable in a timely fashion within the Flexible Congestion Relief (FCR) Program. Restriped HOV projects can be implemented within a year and require no right-of-way. In the future such projects may be eligible for the Traffic System Management (TSM) program. However, current eligibility guidelines for the TSM program do not include restriped mainline HOV facilities since such projects create a through lane.

In November, 1990, Congress adopted the Federal Clean Air Act Amendments (CAAA) of 1990. The CAAA requires states that are not meeting federal standards for CO and ozone to develop State implementation Plans (SIPs). SIPs are required to be able to reduce emissions to federal standards and are closely linked to vehicle miles of travel (VMT). All RTPs must conform to the SIP (The CMP will conform to the SIP because it must be consistent with the RTP). The Federal Government may impose sanctions for failure to comply with CAAA SIP requirements. These sanctions include withholding of approval of federal highway projects. However, HOV lanes may be exempt from such sanctions.

Chapter Two

HOV OPERATIONS

2.1 GENERAL

The operation of a high-occupancy vehicle (HOV) facility is closely linked to its design features and the traffic demands on the freeway corridor. Therefore, operational characteristics must be considered not only during the design process, but also for HOV system planning. As recommended for design features, operational characteristics should also be uniform and consistent within a region.

In areas where the central business district is less identifiable and consists of pockets of intensive business activity distributed over a wide area, sometimes called a "suburban" geographical area, the commute pattern is less definitive and the directional traffic split is more equal than that of the "radial" geographical area. For the suburban geographical area, a two way flow is preferable and reversible HOV operation would not be appropriate.

When a metropolitan area largely consists of a central business district with weekday commuter traffic from outlying areas, often referred to as a "radial" geographical area, the traffic demands on each corridor normally would indicate definite directional peaks during the morning and afternoon commute periods. If traffic in the "off-peak" direction is light (35% or less of the total freeway traffic during the peak periods) and is forecast to remain light during the design life of the project, then a reversible HOV operation may be appropriate. Since barrier separated facilities offer features suitable for a reversible operation, it would be one of the logical candidates for initial consideration.

As discussed in Chapter 3, "Geometric Design", HOV facilities can be barrier-separated, buffer-separated or contiguous. Each of these can be operated in different operational modes. The different modes of operation and their applicability with each type of geometric configuration will be addressed below.

2.2 MODES OF OPERATION

HOV facilities can be operated with two way flow, reversible flow, or contraflow.

2.2.1 Two Way Flow

A two way flow HOV operation is appropriate when the existing peak period directional traffic is 35/65 or more evenly split and is expected to remain so during the design life of the project. It is the predominant mode of operation for the Department's HOV facilities.

When right-of-way and cost constraints allow, a two way barrier-separated HOV facility with a physical barrier separating the HOV lanes from the mixed-flow lanes generally offers a higher level of service than other geometric configurations. See exhibit on page 3-6 in Chapter 3. A portion of the El Monte Busway (LA-10) near Los Angeles is one example of this type of facility. Although the busway is currently only averaging about 1000 VPHPL during the peak hour, the number in term of persons moved approaches 6000 persons per hour, or an average vehicle ridership (AVR) of approximately 6. Since operating data indicate that busways experience congestion at about 1500 vehicles per hour, consideration should be given to using a 3+ occupancy requirement or to having more than one HOV lane in each direction when traffic exceeds this number. Because of potential visibility problems between buses and motorcycles, exclusion of motorcycles on HOV facilities with high bus volumes may be appropriate. However, such exclusions are only allowed if a documented study for that specific HOV facility indicates that motorcycle use constitutes a safety hazard and the exclusion is approved by the Federal Highway Administration.

2.2.2 Reversible Flow

Reversible flow is an operational mode where the HOV lanes operate in one direction during the AM peak period and change to the opposite direction during the PM peak period. This type of operation is feasible only if the existing and forecast peak period directional traffic split is 35% or less in one direction during the design life of the project. Other factors which could support the use of a reversible flow operation are right-of-way constraints and physical constraints, such as bridge columns, in retrofitting a reversible flow operation into the median.

Reversible flow operation should only be used on barrier separated HOV facilities with limited ingress/egress to the HOV lanes. See exhibit on page 3-8 in Chapter 3. Its operation can be expensive in terms of equipment and manpower. Also, a reversible facility is functional only during peak periods due to required preparations for each directional change.

2.2.3 Contraflow

A contraflow HOV facility uses the excess freeway capacity in the off-peak direction to relieve congestion in the direction of peak flow. With median cross-overs, traffic is guided across the median to the inside lane in the opposite direction. Typically, removable pylons, moveable barriers or an additional lane is used to separate the contraflow lane from the adjacent mixed-flow lanes. If neither moveable concrete barriers nor a buffered lane is available and pylons are used instead, the contraflow facility should only be used by vehicles with trained, experienced drivers such as bus drivers. It should only be considered: (1) if the peak period directional traffic split is 35% or less during the design life of the project, and (2) if the speed of the opposing mixed-flow traffic is not reduced by implementation of the contraflow lane.

Between 1974 and 1986, Caltrans operated a bus-only contraflow facility on 4 miles of Route 101 in Marin County, north of San Francisco. The facility, which allowed buses with permits to bypass congestion and go directly into a contiguous HOV lane, used two lanes from the southbound (off-peak) direction with one of the lanes acting as a buffer. The contraflow lane was discontinued after freeway improvements reduced congestion and speeds in the mixed-flow lanes increased to match that of the contraflow lane.

It is unlikely that the contraflow operational mode will be used extensively in California. In most of the State's metropolitan areas, taking an additional lane for a buffer creates an unacceptable level of service for the opposing traffic. Moveable barriers or pylons eliminate the need for a buffer lane but their use requires a set-up and take-down process which is costly and which causes potential conflicts between motorists and the placement crew.

2.3 QUEUE BYPASSES

HOV queue bypasses are relatively short sections of HOV lanes which bypass congestion and provide significant time savings for carpools, vanpools and buses. Examples of queue bypasses in California are bridge toll plaza bypass lanes and ramp meter bypass lanes. They are not associated with any particular geometric configuration and need to be designed for specific sites. For ramp meter bypass lanes, refer to the Department's "Ramp Meter Design Guidelines" prepared by Headquarters Division of Traffic Operations.

2.4 HOURS OF OPERATION

Whether continuous or peak periods only, the operating hours of an HOV facility should be consistent throughout a region. While operational data are still insufficient to definitively support the choice of one mode over the other, each has its' unique characteristics and advantages, as discussed below.

2.4.1 Peak Period Operation

Peak period operation has the following benefits:

A. Avoid the public perception that the HOV lane is underutilized (the "empty lane syndrome") during off-peak periods, particularly if public sentiment is not totally receptive to the HOV project.

B. Freeway lane densities are lower during off-peak periods, thus providing a higher LOS.

C. Lane closures during the off-peak for maintenance create less congestion due to the availability of the additional lane.

Peak period operation is normally associated with contiguous facilities like those in the San Francisco Bay Area or barrier separated HOV facilities like the I-15 reversible lanes in San Diego with the exclusive hours covering the entire peak period. The HOV operation should start before the onset of congestion when there is space in the mixed-flow lanes for non-eligible vehicles. The extent of the peak period should be monitored on a regular basis so that the hours of HOV operation can be adjusted to accommodate expansions of the peak period. Ultimately a full time operation may be appropriate.

Frequently associated with peak period operation, the part time use of a freeway shoulder as an HOV lane should be considered interim in nature and used only after all safety aspects, including limited sight distances and potential motorist confusion, are analyzed. Part time HOV operations on a shoulder requires clearly designed delineation and signing. Enforcement could be a problem for both peak and off-peak periods. The Route 91 demonstration project near Los Angeles indicated that some motorists still used the shoulder as a freeway lane during the off-peak period after it reverted to a shoulder. Route 91 is currently a continuous HOV operation.

The outside shoulder on Route 237 in Santa Clara County is currently operating as a part-time shoulder and part-time HOV lane. The occupancy violation rate is close to the statewide average for HOV facilities. However, there is no apparent problem with off-peak violations of the shoulder as there was on Route 91. This part time operation is an interim measure until new HOV lanes are constructed in the median area.

2.4.2 Continuous HOV Operation

Compared to a peak period operation, continuous HOV operation presents the following benefits:

A. Signing and delineation are simpler.

B. Violation rates tend to be lower and enforcement is easier.

C. There is less motorist confusion concerning operational hours.

D. Since continuous HOV operation occurs frequently on buffered or barrier separated facilities, freeway incidents are less likely to affect HOV lane operation.

E. Since the ridesharing concept is encouraged at all times of the day, there could be a greater mode shift to ridesharing.

Continuous HOV operations can be applied on all types of geometric configurations.

2.5 VEHICLE OCCUPANCY

The occupancy requirements for HOV facilities should be based on the following considerations:

A. Maximizing the person-per-hour throughput.

B. Allowing for HOV growth and increased usage of the HOV facility.

C. Maintaining a free-flow condition, preferably a LOS-C.

D. Conforming to the occupancy requirements of the region, particularly connecting HOV routes.

E. Completion of a region's HOV system or adjacent HOV facilities could redistribute the HOV traffic, thereby making occupancy adjustments unnecessary.

F. Adjust occupancy requirements to avoid the perception of lane underutilization.

The predominant occupancy requirement for existing HOV facilities is 2+ and it is expected that most new HOV facilities will be 2+ as well. However, as some existing HOV facilities approach LOS-C, the District should initiate studies for solutions to maintain a desirable level of service. For buffered or contiguous HOV facilities, LOS-C occurs at approximately 1500 vehicles per hour, less if there is significant bus volume or if there are physical constraints.

Increasing the occupancy requirement may be the logical solution if adding a second HOV lane is inappropriate. However, going from 2+ to 3+ may reduce vehicular demand by

75% to 85%. Such adjustments may be too severe if only a 10% to 20% reduction in demand is necessary to maintain free-flow conditions.

Although not used in California, varying occupancy requirements by time of day is a useful option and could be used in conjunction with computer traffic surveillance and technology currently being implemented by the urban Districts. To avoid public confusion over varying occupancy requirements, it is essential that signs and other motorist information devices clearly relate the necessary message.

Changing occupancy requirements, whether permanently or by time of day, is enforcement sensitive and should be coordinated with the California Highway Patrol.

Once a decision has been made to change the occupancy requirement, an intense public information and education effort should precede actual implementation. An adequate period should be allowed for public comment and response.

2.6 VEHICLE TYPES

The Federal Surface Transportation Assistance Act of 1982, in part, permits motorcycles in HOV facilities unless their presence create a safety hazard. If a documented engineering analysis indicates that motorcycles present more of a safety problem in the HOV facility than in the mixed-flow lanes, then consideration should be given to restricting motorcycles from the HOV facility. Prohibition of motorcycles requires approval by the U.S. Secretary of Transportation through the Federal Highway Administration. The Districts are advised to consult with Headquarters Traffic Operations when such prohibitions are being considered. On those facilities that already do not allow motorcycles, periodic review of the safety aspects of the facility should be performed to determine if motorcycles should continue to be disallowed. Exclusions and changes concerning vehicle types in HOV facilities must be approved by the Director. See Appendix A-10.

2.7 DEADHEADING

The term "deadheading" refers to the use of HOV facility by transit vehicles occupied only by the driver. While there is some disagreement on whether buses should be allowed to deadhead, there is statewide agreement that deadheading by other transit vehicles such as airport shuttles should only be allowed on a case-by-case basis. A "blanket" approval to deadhead could lead to the perception that occupancy violations are not being enforced and could result in violations, enforcement problems and congestion in the HOV facility.

In response to requests from airport shuttle companies, the Department in 1990 agreed to accept applications for deadheading by transit vehicles which can carry 8 or more people. See Appendix C.

The completed applications will be evaluated and approved by the Districts. If approved, the District will notify the CHP that deadheading has been granted to the transit operator along with pertinent information for identification purposes. Two identification stickers will be issued by the District to the permittee for each vehicle covered under the permit. The permit to deadhead is valid for two years, after which the operator must apply for an extension of the permit. The District will be responsible for monitoring the operations of the permittee to ensure adherence to permit conditions and revoke the permit if necessary.

2.8 INCIDENT HANDLING /SPECIAL EVENTS ON HOV LANES

2.8.1 Incidents

Since the HOV facility is designed to operate at a higher level of service (LOS) than mixed-flow lanes during commute periods, it is important to isolate the performance patterns of the system. As traffic operations systems (TOS) are developed or upgraded in the metropolitan areas, it is essential that such systems provide discrete HOV performance data, e.g. speeds, volumes and lane occupancies so that adjustments can be made to maintain the desirable LOS.

The TOS design should include incident detection verification and handling capabilities for the HOV facility. Frequently, incidents in the HOV lane will result in HOV traffic merging into the adjacent mixed-flow lane. In most cases, the mixed-flow lane should not be closed to mixed-flow traffic and designated a temporary HOV lane. For major incidents in the mixed-flow lanes, Caltrans and the CHP should jointly decide whether to open the HOV facility to mixed-flow traffic.

Service patrol considerations for HOV facilities should also be an integral element of incident management. This need is particularly acute for barrier separated HOV facilities and service patrol activities for the mixed-flow traffic do not extend into the HOV facility.

Barrier separated facilities present different operational problems and possibilities from other types of HOV facilities for handling incidents both in the HOV lane and in the mixed-flow lanes. Incidents in the HOV lane frequently close the lane and require the re-routing of HOV traffic into the mixed-flow lanes. A major incident in the mixed-flow lanes, with multiple lane blockage, may result in utilization of the HOV lane by non-eligible vehicles. Such use of a barrier separated HOV facility by mixed-flow traffic, particularly for a reversible HOV operation, should be approached with caution. Barrier separated HOV facilities have very restrictive access points and generally should not be used for incident management unless the incident is of extended duration and where traffic diversion is not possible. If such facilities are to be used, the decision should be made jointly by CHP and Caltrans, who must ensure that all disabled vehicles are removed prior to resuming HOV operation.

2.8.2 Special Events

Special events and weekend traffic normally consist of vehicles with higher occupancy levels than recurrent weekday traffic. Therefore, there should be no need to allow mixed-flow traffic to use a 24-hour HOV facility. For those HOV facilities operating on a part-time basis, consideration should be given to operating the facility as HOV during special events. This would require careful joint planning with the CHP, including the routing of traffic and the use of temporary signing.

2.8.3 Agency Responsibilities

CHP and Caltrans responsibilities regarding incident handling and special events shall adhere to all of the policies contained in the joint operational policy statements.

2.9 USING HOV FOR TRAFFIC MANAGEMENT PLANS

Traffic management plans (TMPs) are required for major reconstruction projects where significant delays are anticipated due to construction. One of the possible TMP elements is the use of an interim HOV lane during reconstruction. The interim lane can be achieved by restriping or by reconstructing the existing median or shoulder.

There have been several projects nationwide which have included the use of interim HOV lanes as a TMP element including the following:

A. I-376 in Pittsburgh (Parkway East) - Interim HOV lanes for on-ramps resulted in a 21% increase in the passenger occupancy rate with a 66% reduction in the number of vehicles using the corridor.

B. I-394 in Minneapolis (US 12) - The installation of the interim HOV lane ("Sane Lane") coupled with free carpool parking in downtown Minneapolis led to a 35% increase in peak hour person-trips.

C. I-395 in the Washington D.C. Metropolitan area (The Shirley Highway) - During the morning peak periods the HOV lane saved 12 to 18 minutes of commute time when compared to mixed-flow lanes. Within two months, the bus ridership increased by 20%.

2.10 PASSING LANES

Operational experience in California indicates that vehicular speeds in HOV lanes vary to the extent that passing lanes may be justified. Although trucks are normally excluded from the facility, variations in vehicular speed are such that tailgating occurs with regularity. For those situations, passing lanes should be considered where right-of-way is not a constraint. Such lanes are particularly appropriate for lengthy buffered or barrier facilities in hilly or mountainous terrain with high bus volumes.

2.11 TRANSIT STATIONS

A viable strategy to increase person trips on an HOV facility is to provide express bus service. When planning this service it is often necessary to provide intermediate passenger access when a high level of transit service is desired. Two types of facilities show the most promise in providing access. They are On-Line Transit Stations and Off-Line Transit Stations.

2.11.1 On-Line Transit Stations

On-Line transit stations are bus transfer facilities located contiguous to the HOV facility. They may serve walk-in passengers from nearby residences or park and ride lots, feeder transit lines or nearby activity centers. Transfers between other express buses operating on the HOV facility can also be accommodated. Stations can be designed to serve either two-way or reversible HOV lanes.

On-Line stations may produce right-of-way savings, eliminate costly ramp construction that is necessary for off-line stations and provide maximum time savings. Negative aspects include added noise and air pollution to the users, long walking distances, an increase in transfers between vehicles, and expensive handicap access.

Platform loading facilities may be located in the center of the HOV lanes or on the sides. Center platforms usually require less width, provide for easy transfers, and are less expensive to construct. A major drawback occurs because buses are built to load on the right side of the vehicle. This requires that buses crossover in some manner to orientate themselves for loading. It is necessary for both types that bypass lanes be provided through the platform location to allow other HOVs to proceed without delay.

2.11.2 Off-Line Transit Stations

Off-Line transit stations are bus facilities which are not contiguous to the HOV facility, but are close enough to receive direct bus service. They could be located at nearby park and ride lots, at large employment centers, or be a major transit center.

A major cost in providing service to an off-line station is the necessity of constructing either direct connector ramps or a drop-ramp facility. There could also be a considerable time penalty involved in serving this type of facility when compared to an on-line station. Many of the problems involving on-line stations such as pedestrian access, platform location, and other amenities can more easily be resolved with off-line stations.

Each corridor will require detailed studies to determine which type of station should be constructed to provide the desired transit service. Early consultation with the Project Development Coordinator and Headquarter Traffic Reviewer is recommended when transit stations are being considered.

Chapter Three

GEOMETRIC DESIGN

3.1 GENERAL

HOV projects can be developed as part of new freeway construction, freeway reconstruction, restriping existing freeways, or some combination of these. Since the majority of HOV projects in California involve some form of retrofitting within the existing freeway right-of-way, this chapter will focus on a set of guidelines for the "preferred" and "acceptable" geometric configurations for HOV facilities.

In general, "preferred" geometrics conform to the Highway Design Manual (HDM) and the "acceptable" option is an alternative to be used only after every effort to conform to the HDM is unsuccessful. It is emphasized that "acceptable" geometrics are not new standards. Their application must be evaluated on a case-by-case basis, with safety the primary consideration.

Justification for the use of anything less than "preferred" geometrics must be well documented by a sound engineering analysis and a design exception approved by the Project Development Coordinator. Refer to Topic 82, Chapter 80 of the HDM.

HOV facilities separated by barriers or buffers are generally regarded as the design option which offers more operational benefits than non-separated, or contiguous HOV facilities. Right-of-way constraints, however, sometimes preclude the separated option. Whether separated or contiguous, the operational differences among the various HOV geometric options are minor when they are compared to the differences between any HOV lane and a mixed-flow lane.

The designer should consider the operation of the HOV facility when designing the facility. Operational characteristics such as part-time operations, reversible flow or contraflow operation are essential to the configuration being considered.

"Preferred" and "acceptable" geometric configurations are used in the following sections to illustrate situations most often encountered in California. Because existing freeway geometric sections and right-of-way availability vary from one location to the next, situations will arise for which none of the scenarios will apply. For those situations, the District designer should consult with the Project Development Geometrician or Coordinator for advice.

It is not the intent of this chapter to advocate one form of geometric configuration over another. Although different existing conditions for various routes frequently make it extremely difficult to achieve geometric uniformity, every effort should be made to provide consistency in geometrics, signing and delineation within a contiguous region, particularly for the same route or for connecting routes.

3.2 GENERAL DESIGN CRITERIA

3.2.1 Horizontal Stopping Sight Distance

Stopping sight distance (SSD) shall conform to HDM standards. Where conformance is not feasible due to median barriers, the height of the object can be increased from 0.5 foot to 2.5 feet (the assumed height of a cars taillights) above the pavement surface. This should provide taillight SSD in all situations except crest vertical curves. However, its use must be documented by an engineering analysis and an approved design exception fact sheet.

3.2.2 Decision Stopping Sight Distance

Decision stopping sight distance should be provided to the nose of all HOV drop ramps, flyovers, and freeway-to-freeway connectors. (Refer to HDM, Section 201.7.)

3.2.3 Vertical Clearance

The required minimum vertical clearance for freeways and expressways is 16.5 feet. This may be reduced to 15 feet in accordance with Section 309.2 (1) (a) of the HDM. Any reduction from the 16.5 foot minimum must be justified by a engineering analysis and an approved design exception fact sheet.

3.2.4 Drainage

The narrow median widths on retrofit HOV facilities often create drainage problems in superelevated areas or when the HOV lane slopes toward the median. A water-carrying barrier, a slotted pipe or an approved alternate must be provided in these areas. The HOV lane should be designed to meet the drainage requirements for a 25-year design storm.

3.2.5 Structural Section

The structural section of HOV lanes on new facilities should be equal to that of the adjacent mixed-flow lane unless a greater thickness is required due to anticipated high bus usage.

The existing shoulder or paved median should not be converted to an HOV lane unless a materials investigation, including deflection test and field review, concludes that the projected service life of the existing pavement is at least six years. The documentation of this materials investigation must be incorporated into the PSR. Typical problems encountered when converting shoulders to traffic lanes are: (1) poor ride quality, (2) inadequate structural strength, (3) rolled up asphalt concrete (AC) at the edge of the portland cement concrete (PCC) pavement, and (4) surface cracking and/or raveling.

The structural section for retrofit HOV lanes should be structurally adequate for ten years after construction when reconstruction is warranted. The surface material and cross slope should be the same as the existing lanes. However, when the widening is contiguous to PCC pavement, and a Pavement Management System (PMS) survey data and field review indicate that PCC pavement will need rehabilitation in less than ten years, the widening should be done with AC. If the existing pavement requires immediate rehabilitation, the work should be included in the HOV facilities project.

3.2.6 Lane Width

Twelve-foot lanes are preferable. Eleven-foot lanes may be acceptable if justified by an engineering analysis and an approved design exception fact sheet. However, the outside mixed-flow lane should remain at 12 feet unless truck volume is less than 3%.
When adjacent to a wall or barrier, shoulder widths between 4 feet and 8 feet on mainline HOV facilities should be avoided except as spot locations.

3.3 GEOMETRIC CONFIGURATIONS

Geometrics for mainline HOV facility configurations can be divided into these categories:

A. Barrier separated
B. Buffer separated
C. Contiguous

The following factors should be considered when determining which configuration is appropriate:

A. Existing Geometric Cross-Section
The majority of HOV projects are retrofitted within the existing right-of-way by restriping or reconstruction. However, if right-of-way is economically and environmentally feasible and the project is not interim in nature, the HOV project should conform to HDM standards.

B. Operations
Operational characteristics such as part-time vs. full-time operation, reversible HOV lanes, contraflow lanes and continuous or restricted ingress/egress are essential considerations in determining a suitable geometric configuration.

C. Enforcement
HOV-related violations such as occupancy and crossing buffers must be enforced to maintain the integrity of the lanes. The designer should consider providing enforcement opportunities as discussed in Chapter 6, "HOV Enforcement".

3.4 BARRIER SEPARATED HOV FACILITIES

Barrier-separated HOV facilities can be used for reversible or for two way operation, Two-way operation is the most desirable when space and cost considerations are not major concerns. Barrier separated HOV facilities, whether two-way or reversible, offer operational advantages such as: (1) ease of enforcement (violations can be enforced at the ingress/egress locations), (2) ease of incident management, (3) unimpeded HOV operation without interference from the mixed-flow lanes, (4) low violation rates, and (5) a high level of driver comfort.

3.4.1 Two-Way Barrier Separated HOV Facilities

Geometric cross sections for a two-way barrier separated HOV facility are shown on page 3-6 and an elevated HOV facility shown on page 3-7. The elevated option can be used when right-of-way is limited.

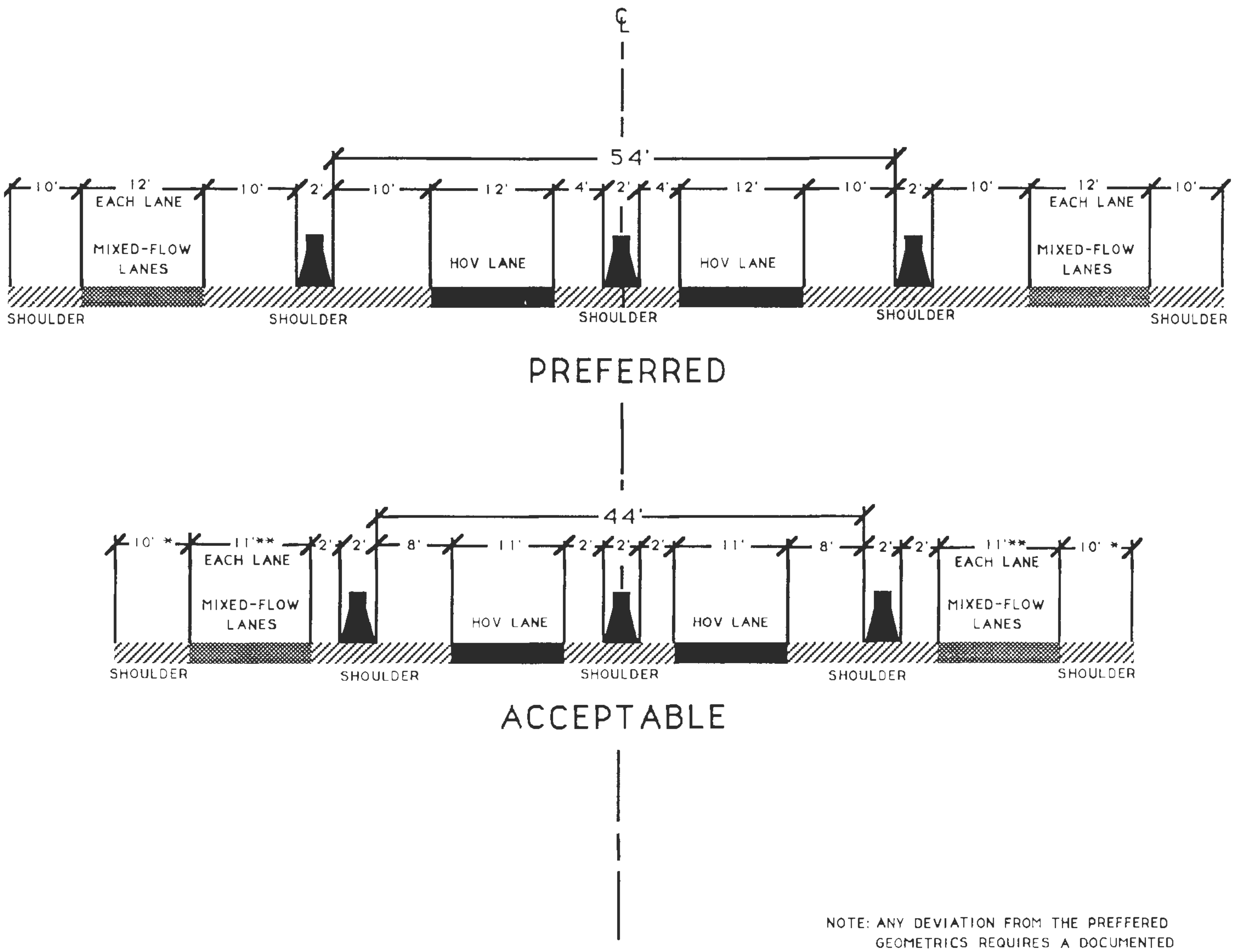
The distance between barriers should not be reduced to less than 21 feet. This ensures that a stalled bus will not block the HOV lane. Reduction of this width, even at local obstructions, should be avoided unless absolutely necessary.

Elevated HOV facilities should be 26 feet or wider between barriers. The 26-foot width between barriers provides flexibility for future conversion to two 11-foot lanes with 2-foot shoulders.

3.4.2 Reversible Barrier Separated HOV Facilities

A reversible barrier separated HOV facility should be considered when the project is severely constrained by right-of-way and environmental considerations. In addition, it is essential that the traffic directional split (after allowing for traffic growth) is 65% or more in the heavier direction of flow. Once implemented, conversion of a reversible operation to other modes can be extremely difficult. However, if the appropriate directional splits can be maintained, this option provides capacity in the needed direction with far less right-of-way than otherwise required by permanent two-way HOV configurations.

A typical geometric cross-section for a barrier separated, reversible HOV facility is shown on page 3-8.

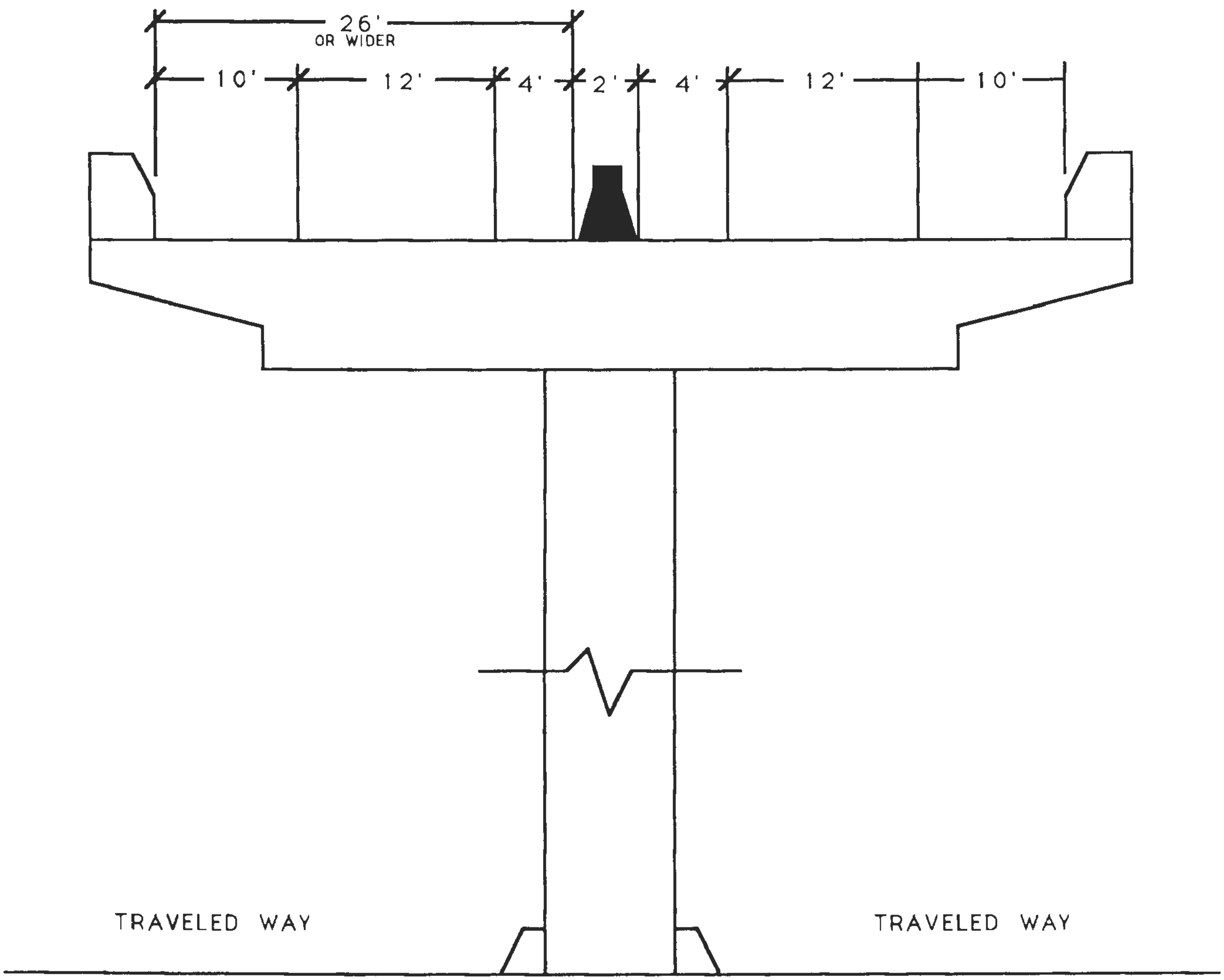


NOTE: ANY DEVIATION FROM THE PREFFERED GEOMETRICS REQUIRES A DOCUMENTED ENGINEERING ANALYSIS AND A DESIGN EXCEPTION APPROVAL

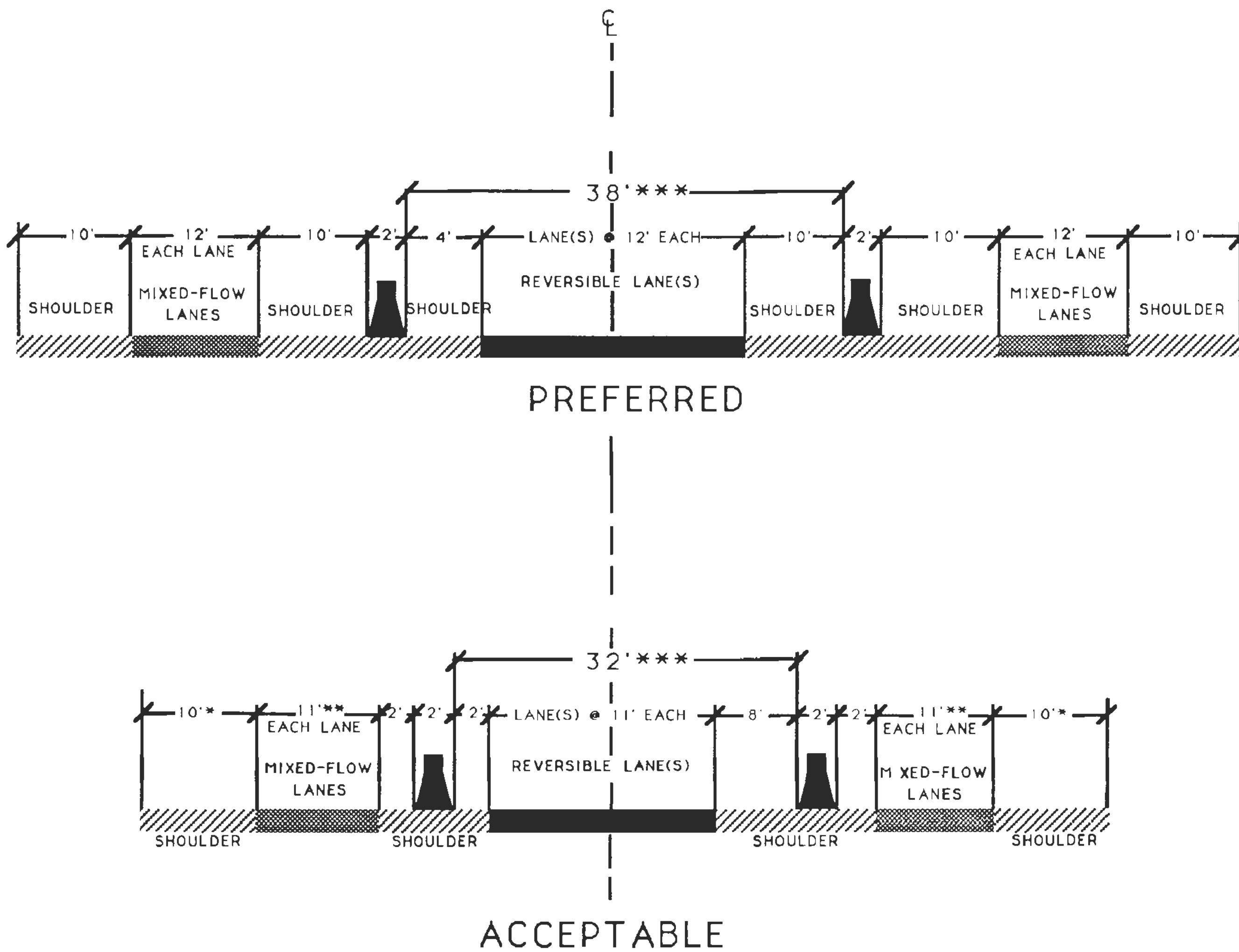
* MAY USE EXISTING SHOULDER WIDTH IF NO OUTSIDE WIDENING IS REQUIRED.

** OUTSIDE MIXED FLOW LANE SHOULD REMAIN AT 12-FEET UNLESS TRUCK VOLUMES <3%

TWO WAY BARRIER SEPARATED HOV FACILITY



ELEVATED HOV FACILITY



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* MAY USE EXISTING SHOULDER WIDTH IF NO OUTSIDE WIDENING IS REQUIRED.

** OUTSIDE MIXED FLOW LANE SHOULD REMAIN AT 12-FEET UNLESS TRUCK VOLUMES <3%

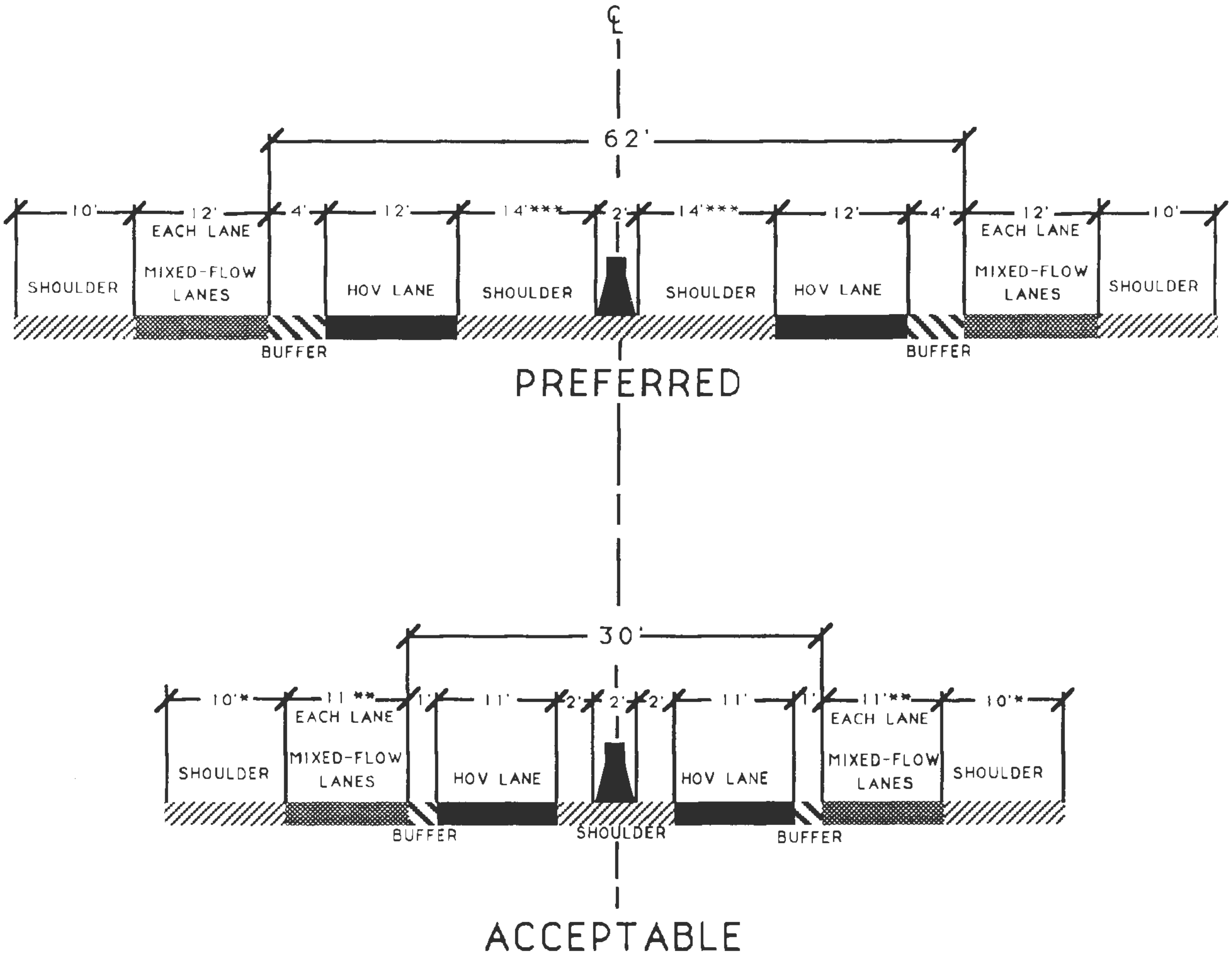
*** DIMENSION IS FOR TWO HOV LANES

BARRIER SEPARATED REVERSIBLE HOV FACILITY

3.5 BUFFER-SEPARATED HOV FACILITIES

The buffered-separated HOV facility is separated from the mixed-flow lanes by a buffer of variable widths, generally 4 feet or less. Buffers 12 feet to 16 feet are occasionally used, particularly if used in conjunction with ingress/egress acceleration and deceleration lanes with potential conversion to additional traffic lanes. However, such wide buffers should only be used when there is adequate width to provide 10-foot or wider shoulders left of the HOV lane. Buffer widths between 4 and 12 feet are not to be used. This will discourage the use of buffers as a refuge area. Compared to contiguous HOV facilities, buffered HOV facilities generally provide the motorists with a better level of service. This includes higher driver comfort, extra margin of safety through providing extra maneuvering room, and a lessening of the impact from incidents on adjoining HOV/mixed-flow lanes.

"Preferred" and "acceptable" geometrics for buffer-separated HOV facilities are shown on page 3-10.



*** FOURTEEN-FOOT WIDE SHOULDER FOR HOV ENFORCEMENT. SEE CHAPTER 6 "HOV ENFORCEMENT"

NOTE: ANY DEVIATION FROM THE PREFFERED GEOMETRICS REQUIRES A DOCUMENTED ENGINEERING ANALYSIS AND A DESIGN EXCEPTION APPROVAL

* MAY USE EXISTING SHOULDER WIDTH IF NO OUTSIDE WIDENING IS REQUIRED.

** OUTSIDE MIXED FLOW LANE SHOULD REMAIN AT 12-FEET UNLESS TRUCK VOLUMES <3%

*** FOURTEEN-FOOT WIDE SHOULDER FOR CONTINUOUS HOV ENFORCEMENT. SEE SECTION 6.4 FOR OTHER ENFORCEMENT ALTERNATIVES.

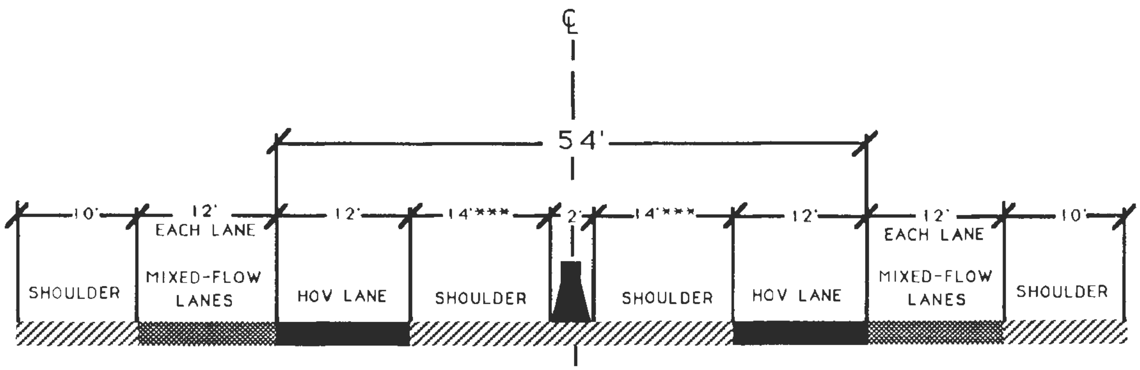
BUFFER SEPARATED HOV FACILITY

3.6 CONTIGUOUS HOV FACILITIES

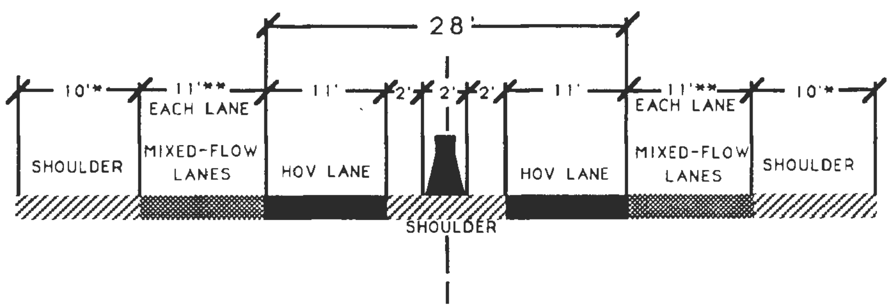
Contiguous HOV facilities are normally associated with extreme right-of-way limitations. Although contiguous HOV facilities offer a lower level of service than separated HOV facilities, their use may be justified when right-of-way limitations preclude separation of the HOV lane from the mixed-flow traffic. Since the HOV traffic is free to enter and exit the lane throughout its length, no design details are required for ingress/egress except at the ends of the HOV facility.

Although frequently used for peak period HOV operation, contiguous HOV facilities can also be effective for full-time use. Part-time HOV facilities provide optimum use of all lanes during off-peak periods, particularly for construction and maintenance purposes. Additionally, part-time operation may be more acceptable to the motorist not totally convinced of the need for the HOV facility, (particularly if the facility appears to be underutilized during off-peak periods). Because the lane reverts to mixed-flow operation after the peak period, reductions from the "preferred" geometrics need to be carefully analyzed. Part-time use of the shoulder as an HOV lane is recommended only as a short term measure or when all other HOV alternatives have been determined to be unacceptable.

The typical geometric cross section for a contiguous HOV facility is shown on page 3-12.



PREFERRED



ACCEPTABLE

NOTE: ANY DEVIATION FROM THE PREFFERED GEOMETRICS REQUIRES A DOCUMENTED ENGINEERING ANALYSIS AND A DESIGN EXCEPTION APPROVAL

* MAY USE EXISTING SHOULDER WIDTH IF NO OUTSIDE WIDENING IS REQUIRED.

** OUTSIDE MIXED FLOW LANE SHOULD REMAIN AT 12-FEET UNLESS TRUCK VOLUMES <3%

*** FOURTEEN-FOOT WIDE SHOULDER FOR CONTINUOUS HOV ENFORCEMENT. SEE SECTION 6.4 FOR OTHER ENFORCEMENT ALTERNATIVES.

CONTIGUOUS HOV LANES

3.7 HOV DIRECT CONNECTORS

A recent development in HOV design is direct HOV connectors at intersecting freeways. Since few operational or support data are available for planning and designing direct connectors, these guidelines will become more definitive as operational experiences accumulate.

The following factors, which are not presented in order of priority, should be analyzed when direct connectors are being considered. These factors are goals to strive for and it is not necessary to conform to every factor when planning and designing direct connectors.

A. Will the direct connector provide HOV system continuity and will it be an integral element of the overall HOV system?

B. Is forecasted HOV peak hour volume for the connector greater than 500 vehicles per hour per lane (vphpl) or 1100 persons per hour per lane within five years from opening? If not, will space be provided in the interchange for the eventual construction of direct connectors?

C. If the alternative to direct connectors are weaving movements across mixed flow traffic, will a weaving analysis show the development of a major bottleneck, resulting in a net loss in overall time savings? If so, this situation may justify building HOV connectors, particularly if bus volume is high.

D. Although direct connectors should not be categorically rejected because of cost, will the cost/benefit analysis imply a reasonable rate of return? Anticipated benefits of direct connectors are: (1) net travel time savings, and (2) safety benefits when compared to a ground level merging maneuver. Travel time savings must consider potential increased delay for the mixed-flow traffic. Time savings may be based on a "per passenger" basis rather than on the number of vehicles, (i.e. person-minutes rather than vehicle-minutes). Safety benefits for direct connectors are difficult to evaluate and should be discussed qualitatively until there is sufficient operational experience.

E. Will the community accept the additional structural height which may be necessary for direct connectors?

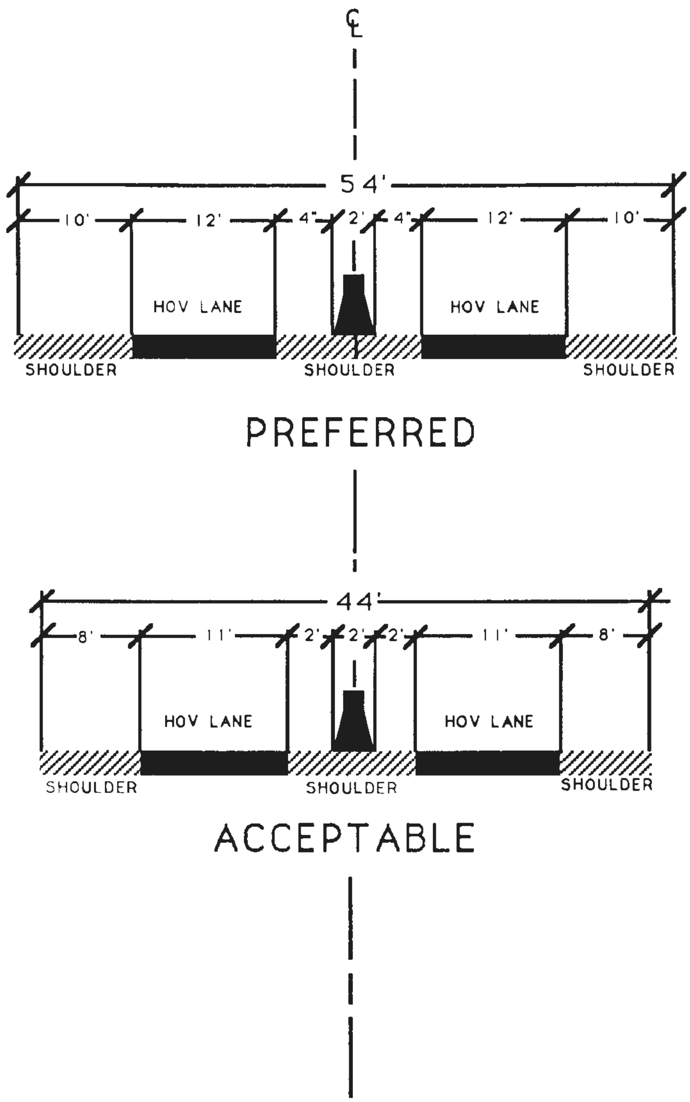
F. Is there a plan to maintain a desirable level of service for the HOV traffic by: (1) converting to a higher occupancy requirement, or (2) providing an additional HOV lane to maintain a desirable level of service for the HOV traffic?

G. Will it be fundable? Typically, much of a direct connector is a structure. Care must be taken when planning and funding an HOV system so that expensive direct connectors do not prevent large portions of the system from being built.

H. With regard to the buffered separated or barrier separated HOV facility, would an additional ingress point be impractical due to the high cost of providing lateral space in the median?

If a direct HOV connector is feasible after consideration of the above factors, freeway-to-freeway direct connector geometric standards, except for 4-foot left shoulders, should be used. However, when space is limited and the design exception fact sheet is approved, the use of "acceptable" ramp geometrics may be justified. HOV connectors may merge or diverge from either the right or left side of the through HOV lanes.

The recommended "preferred" and "acceptable" geometrics for direct HOV connectors are shown on page 3-15.



NOTE: ANY DEVIATION FROM THE PREFFERED GEOMETRICS REQUIRES A DOCUMENTED ENGINEERING ANALYSIS AND A DESIGN EXCEPTION APPROVAL

DIRECT HOV CONNECTORS

3.8 HOV RAMPS

Direct ramp connectors to provide ingress and egress between HOV lanes and conventional highways, streets, roads, transit facilities or park and ride facilities are sometimes referred to as HOV drop ramps. As is the case with freeway-to-freeway HOV connectors, operational data for existing drop ramps is lacking for planning and design purposes. Until more data becomes available, it is recommended that the following factors be considered when drop ramps are being considered:

A. Does the benefit/cost analysis regarding time savings and safety benefits indicate a reasonable rate of return?

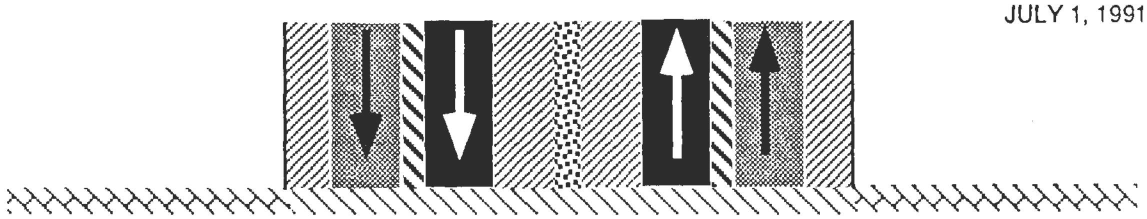
B. Is there a high concentration of HOV demand due to major attractions such as transit facilities, park and ride facilities, central business districts, or industrial concentrations?

C. Are HOV volumes using the interchange large enough to have a significant negative impact on the through traffic lanes due to weaving maneuvers?

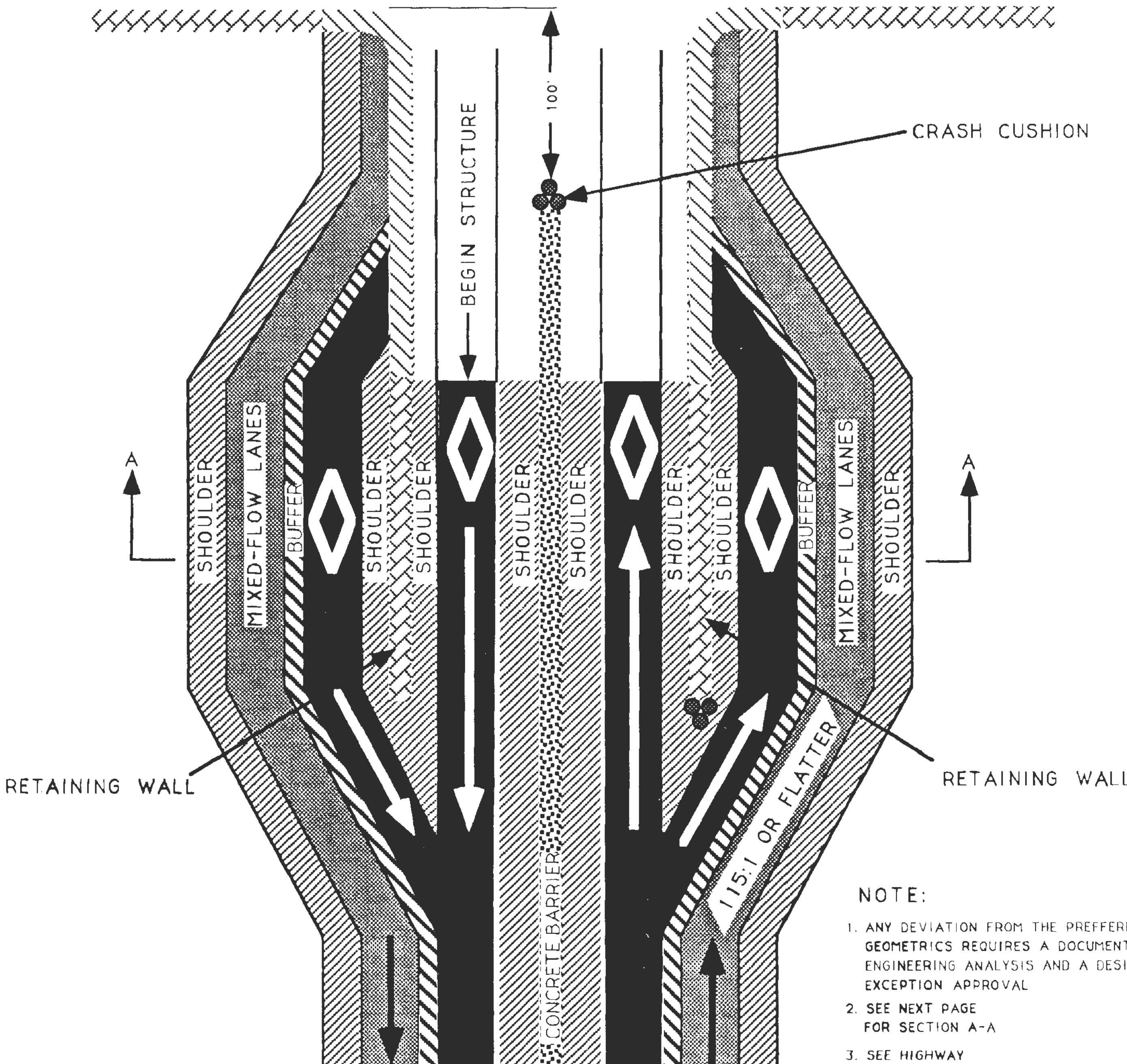
D. Does removal of HOV traffic improve the operating level of service for the freeway, the interchange, or the cross streets?

It may be difficult, particularly in retrofit situations, to fit HOV drop ramps into the available space. The exhibits on page 3-17 and 3-18 is a schematic plan and a typical section for a typical HOV drop ramp connection to an overcrossing. Pages 3-19 and 3-20 is a schematic plan and a typical section for a drop ramp connection to an undercrossing or parking facility on one side of the freeway.

JULY 1, 1991



OVERCROSSING



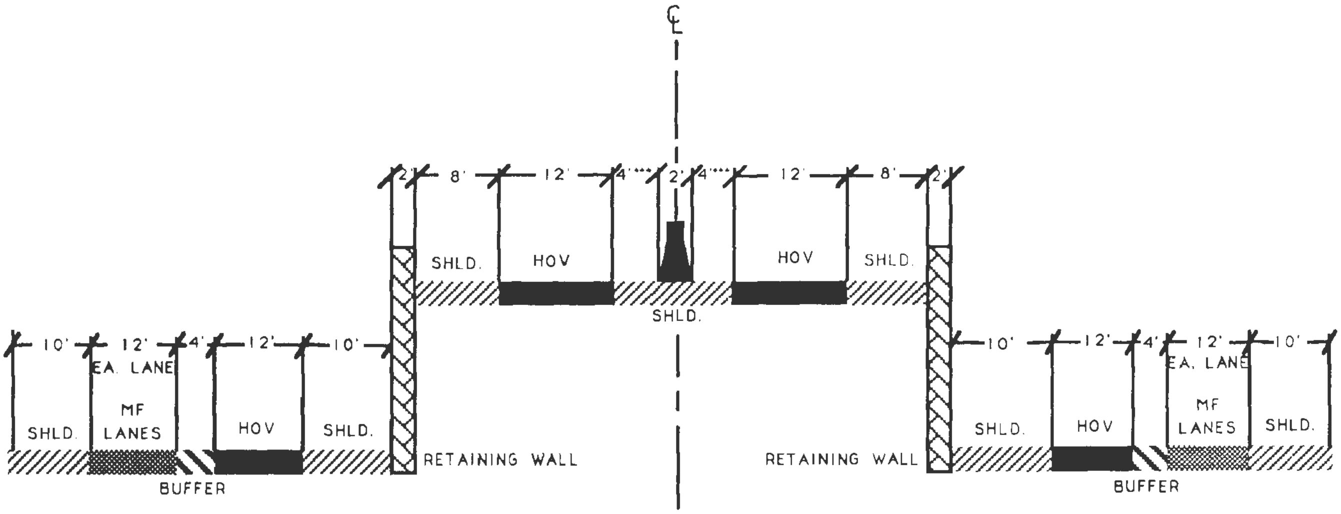
NOTE:

1. ANY DEVIATION FROM THE PREFFERED GEOMETRICS REQUIRES A DOCUMENTED ENGINEERING ANALYSIS AND A DESIGN EXCEPTION APPROVAL
2. SEE NEXT PAGE FOR SECTION A-A
3. SEE HIGHWAY DESIGN MANUAL FOR OFFSETS, TAPERS & OTHER DIMENSIONS NOT SHOWN.

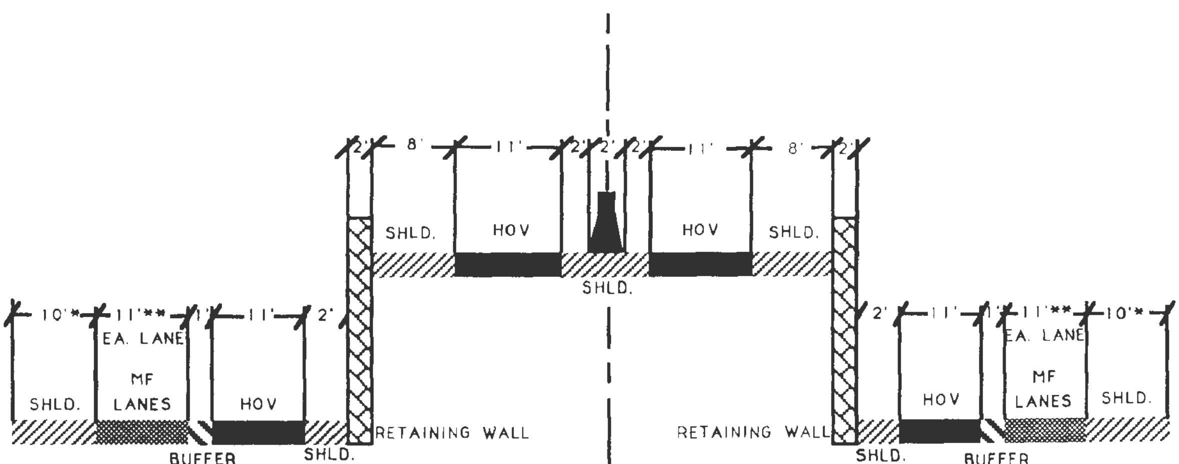
TYPICAL HOV DROP RAMP

TO OVERCROSSING

NO SCALE



PREFERRED



ACCEPTABLE

NOTE: ANY DEVIATION FROM THE PREFFERED GEOMETRICS REQUIRES A DOCUMENTED ENGINEERING ANALYSIS AND A DESIGN EXCEPTION APPROVAL

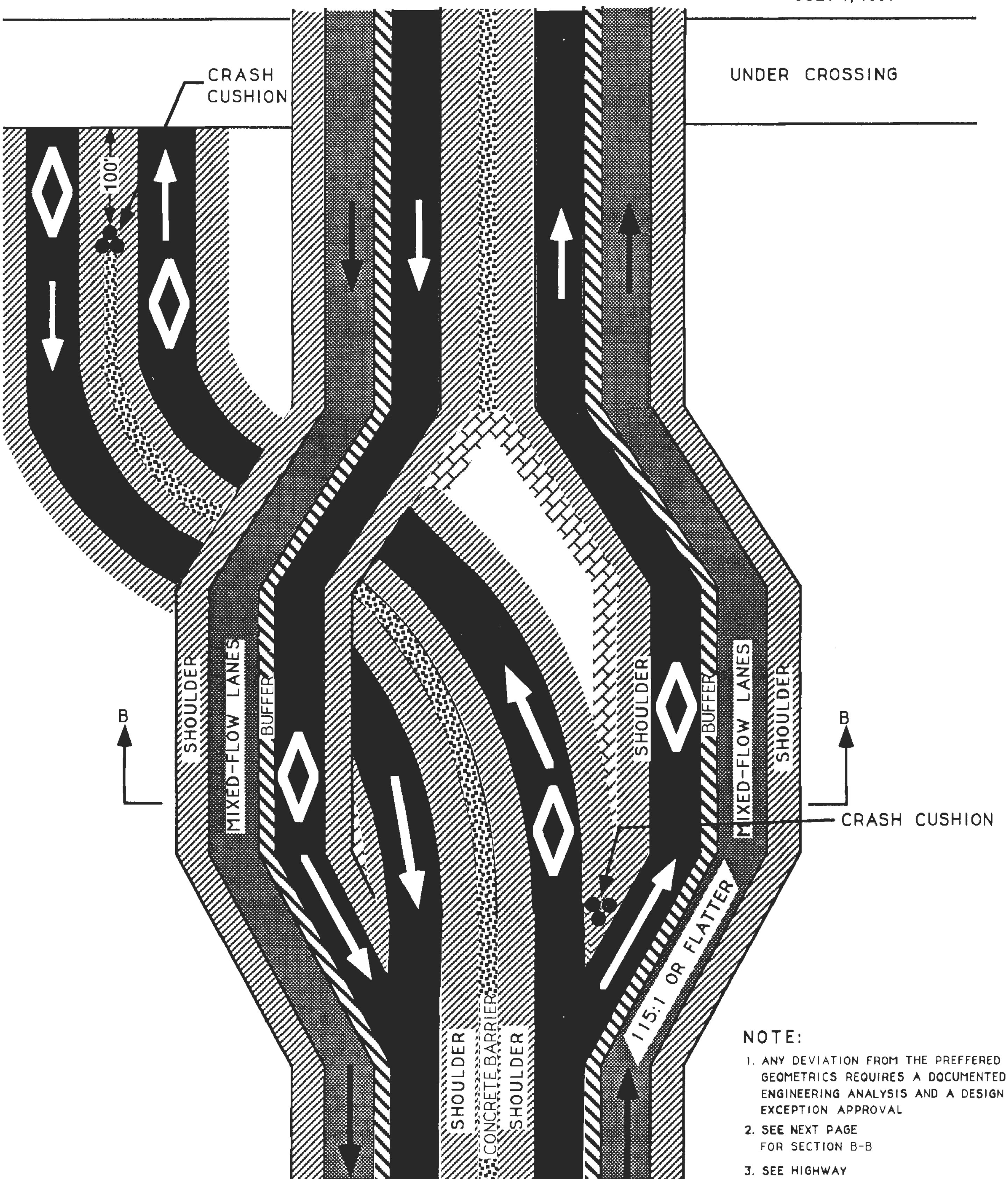
* MAY USE EXISTING SHOULDER WIDTH IF NO OUTSIDE WIDENING IS REQUIRED.

** OUTSIDE MIXED FLOW LANE SHOULD REMAIN AT 12-FEET UNLESS TRUCK VOLUMES <3%

*** MAY BE 2 FEET WITHOUT REQUIRING A DESIGN EXCEPTION.

HOV DROP RAMP

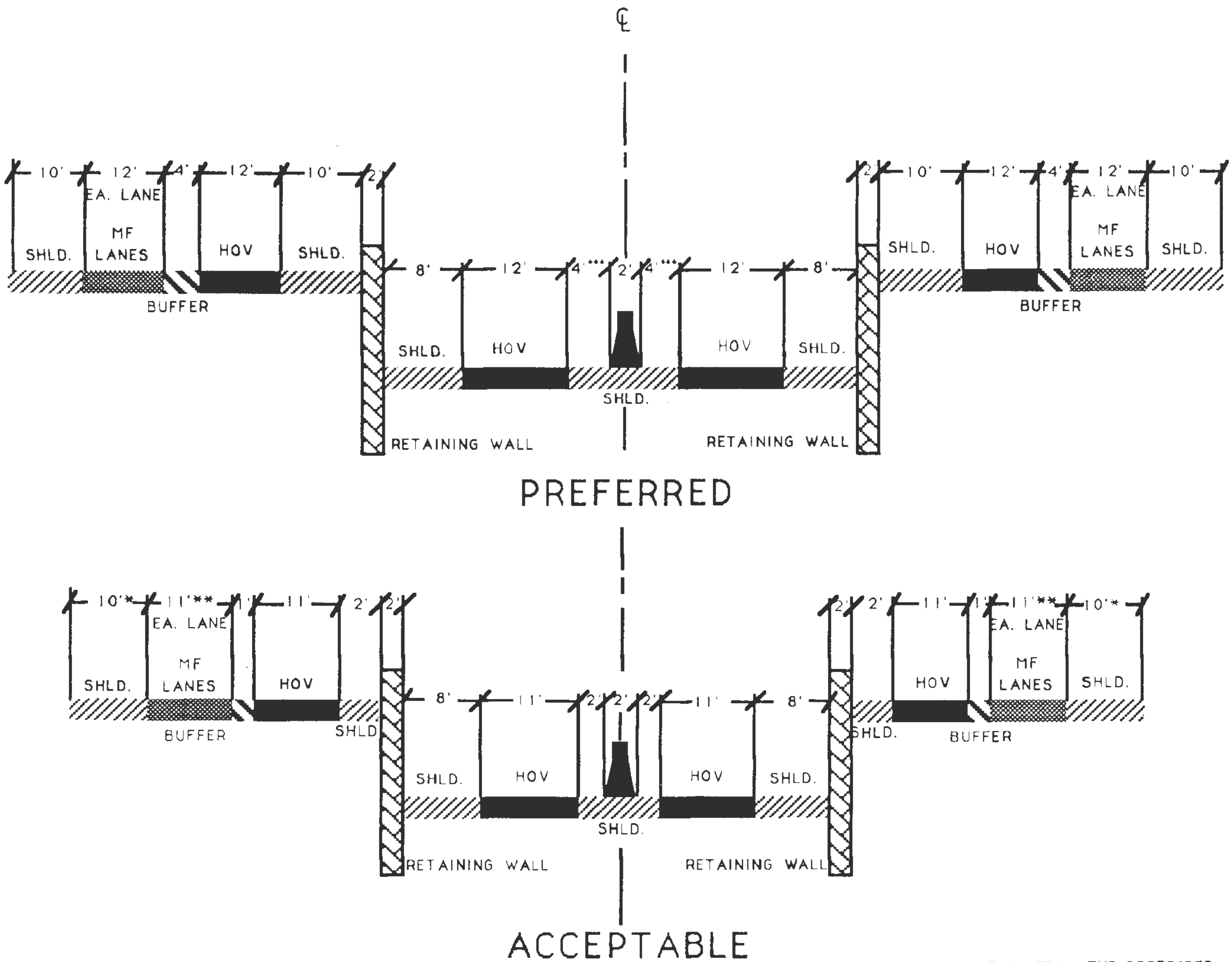
(SECTION A-A)



NOTE:

1. ANY DEVIATION FROM THE PREFFERED GEOMETRICS REQUIRES A DOCUMENTED ENGINEERING ANALYSIS AND A DESIGN EXCEPTION APPROVAL
2. SEE NEXT PAGE FOR SECTION B-B
3. SEE HIGHWAY DESIGN MANUAL FOR OFFSETS, TAPERS & OTHER DIMENSIONS NOT SHOWN.

TYPICAL HOV DROP RAMP
TO UNDERCROSSING
NO SCALE



NOTE: ANY DEVIATION FROM THE PREFFERED GEOMETRICS REQUIRES A DOCUMENTED ENGINEERING ANALYSIS AND A DESIGN EXCEPTION APPROVAL

* MAY USE EXISTING SHOULDER WIDTH IF NO OUTSIDE WIDENING IS REQUIRED.

** OUTSIDE MIXED FLOW LANE SHOULD REMAIN AT 12-FEET UNLESS TRUCK VOLUMES <3%

*** MAYBE 2 FEET WITHOUT REQUIRING A DESIGN EXCEPTION.

HOV DROP RAMP

(SECTION B-B)

3.9 LOCAL OBSTRUCTIONS

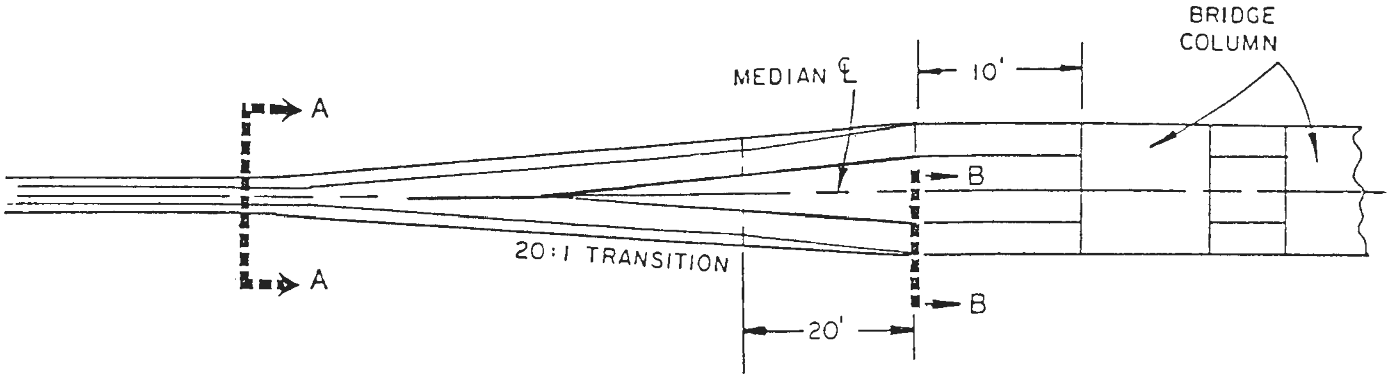
If the "preferred" and the "acceptable" geometric configurations for retrofit HOV facilities prove inadequate at localized obstructions, the geometrics may be further reduced provided the necessary design exception fact sheets are approved. For example, FHWA has agreed to one-foot median shoulders at local obstructions such as sign posts. To retain existing overcrossings, they have also agreed to 11-foot mixed-flow and HOV lanes, no buffer, and 2-foot left and right shoulders. In extreme cases, where the cost or impact is great, the right shoulder of ramps or auxiliary lanes may be eliminated. Additional horizontal clearance may be obtained by eliminating the safety shape on the concrete barrier adjacent to structure columns, abutments, or median sign bases as shown on page 3-22. The safety shape may be retained at median sign bases by utilizing a steel plate in lieu of concrete.

If the minimum clearance is not achieved by any of the above methods, movement of the columns and replacement or modification of the overcrossing structure should be considered. The length of the new structure should accommodate a full standard facility with the number of lanes indicated in the Route Concept Report.

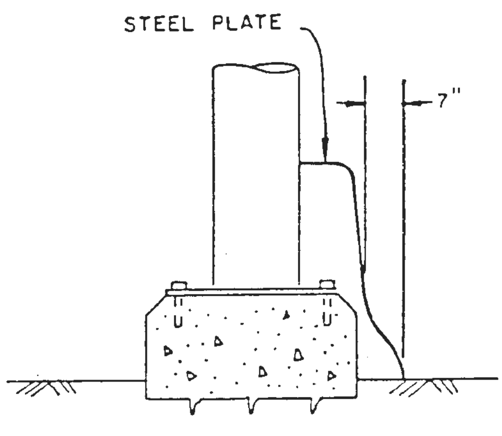
When the approach roadway is widened as part of the HOV project, undercrossing structures should be widened to accommodate the approach roadway.

3.10 RELATIVE PRIORITY OF CROSS SECTIONAL ELEMENTS

A compromise in traditional standards for cross-sectional elements will be required for most retrofit HOV projects. For the mixed-flow lanes, widths for the outside shoulder and the outside lane generally should not be altered. Suggested priority for reduction of the cross-sectional elements for the various geometric configurations are outlined below. Any deviation from these recommendations should be approved by FHWA area engineer and Project Development Coordinator. Any deviation from the HDM will require approved design exception fact sheets.

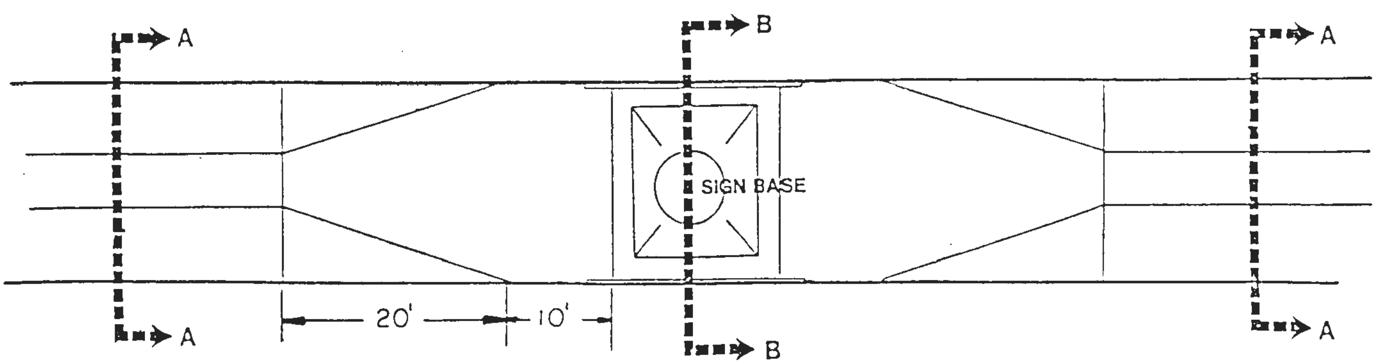


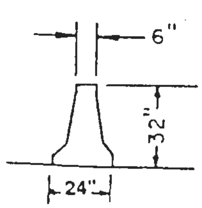
MEDIAN BARRIER TRANSITION AT A BRIDGE COLUMN



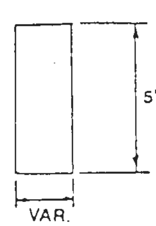
NOTE: All Structural Design Details to be Provided by the Division of Structures

ALTERNATE 2





SECTION A-A
TYPE 50
CONCRETE BARRIER



SECTION B-B

ALTERNATE 1

NO SCALE

MEDIAN BARRIER TRANSITION AT A SIGN

3.10.1 Two-Way Barrier Separated HOV Facilities

First, reduce the left HOV lane shoulder to 2 feet.

Second, reduce the HOV lane to 11 feet.

Third, reduce the right HOV lane shoulder to 8 feet.

See exhibit on page 3-6.

If the above reductions are not sufficient to meet right-of-way constraints, then buffer separated or contiguous HOV facilities should be considered.

3.10.2 Barrier Separated Reversible HOV Facilities

First, reduce one HOV shoulder to a minimum of 2 feet.

Second, reduce the HOV lanes to a minimum of 11 feet.

Third, reduce the other HOV shoulder to a minimum of 8 feet.

Fourth, reduce the mixed-flow lanes to 11 feet, starting with the left lane and moving to the right as needed. The outside mixed-flow lane should remain at 12 feet unless truck volumes is less than 3%.

Fifth, reduce the left shoulder for the mixed-flow lanes to a minimum of 2 feet.

See exhibit on page 3-8.

3.10.3 Buffer Separated HOV Facilities

First, reduce the median shoulders to a minimum of 8 feet.

Second, reduce the HOV lane to 11 feet.

Third, reduce the mixed-flow lanes to 11 feet, starting with the left lane and moving to the right as needed. The outside mixed-flow lane should remain at 12 feet unless truck volume is less than 3%.

Fourth, reduce the buffer to 1 foot.

Fifth, reduce the median shoulders to a minimum of 2 feet.

See exhibit on page 3-10.

The reduction of the median shoulders from 14 feet to either 8 feet or 2 feet should be combined with the construction of enforcement areas.

3.10.4 Contiguous HOV Facilities

First, reduce the median shoulder to 8 feet.

Second, reduce the HOV lane to 11 feet.

Third, reduce the mixed-flow lanes to 11 feet, starting with the left lane and moving to the right as needed. The outside mixed-flow lane should remain at 12 feet unless truck volumes are less than 3%.

Fourth, reduce the median shoulders to a minimum of 2 feet.

See exhibit on page 3-12.

Chapter Four

INGRESS/EGRESS

4.1 Beginning and Termination Points

An entry into the HOV facility should require a conscious movement. A design configuration which requires mixed-flow traffic to exit could be susceptible to violations.

A. Start of Facility

Normally an HOV lane should begin on the left of the number one mixed-flow lane as a new lane with a short taper to full width. For a buffer separated facility, a minimum of 1300 feet of dashed white line should be provided on the right to provide consistency of appearance with ingress and egress areas. See exhibit on page 5-4. The beginning of any buffer should begin no earlier than a distance equivalent to 500 feet per lane change required to enter the HOV lane from the nearest on-ramp. Additional length of dashed white lines may be required if visibility of the striping is compromised within the 1300 foot distance.

B. End of Facility

Every effort should be made to end a HOV lane into a continuing lane which enables the HOV traffic to continue without a merge. When a lane end has to occur it is preferable to drop the outside mixed-flow lane approximately 1/2 mile after the end of the HOV lane. At times, where traffic volumes permit, dropping an outside mixed-flow lane as a mandatory exit to a ramp is possible, and thereby minimize merges. Where bottlenecks are unavoidable, the HOV traffic should be given preferential access to the head of the queue.

If the HOV lane has to be merged back into the freeway traffic, a minimum of 1300 feet of dashed white line (2600 feet is desirable) should be provided before the end of the HOV lane taper begins. Additional length may be required to achieve desired visibility of dashed striping. No less than 500 feet per lane change should be provided from the end of the buffer to the next off-ramp or connector.

An exit where the HOV lane merges into an adjacent lane could result in a bottleneck condition at the merging point, but may be useful where the concept is to allow HOVs preferential access to the head of the bottleneck.

4.2 Ingress/Egress For Barrier Separated Facilities

The at-grade ingress and egress from the mixed-flow lanes to a barrier separated HOV facility can be achieved with at-grade channelized openings in the physical barriers. Typical geometric configurations are shown on pages 4-3 and 4-4. The at-grade opening can be accomplished with the use of a weave lane to assist the merging of HOV traffic with the mixed-flow traffic. The preferable length of the weaving area for ingress and egress designs is 2000 feet although 1600 feet is acceptable.

4.3 Ingress and Egress For Buffer Separated Facilities

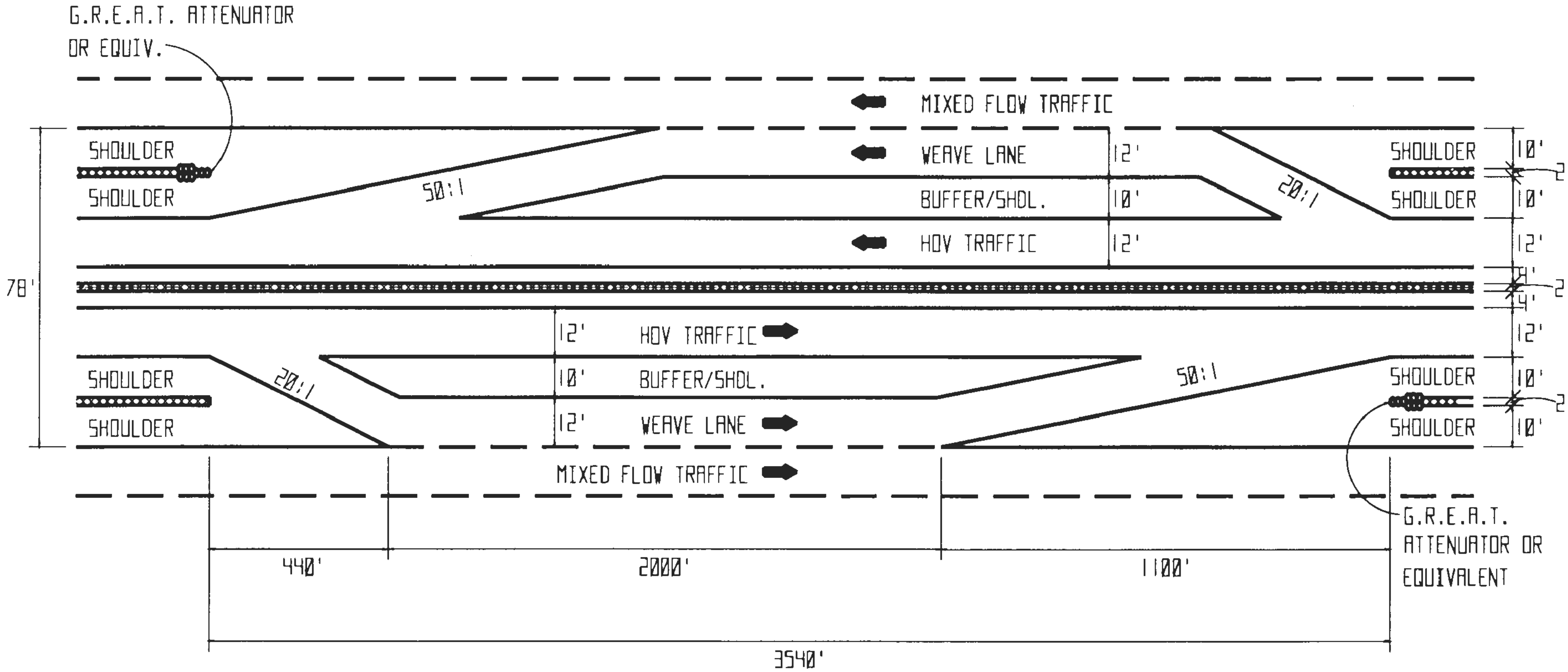
Access to and from the HOV lane should be provided by any of the following four general types of ingress and egress designs:

A. At-grade ingress and egress
B. Median drop ramps from overcrossings or undercrossings
C. Freeway-to-freeway connection
D. Beginning and termination points (as described above)

At-grade access is not intended to serve every on and off-ramp. When it is operationally possible, ingress and egress locations are based on the following criteria:

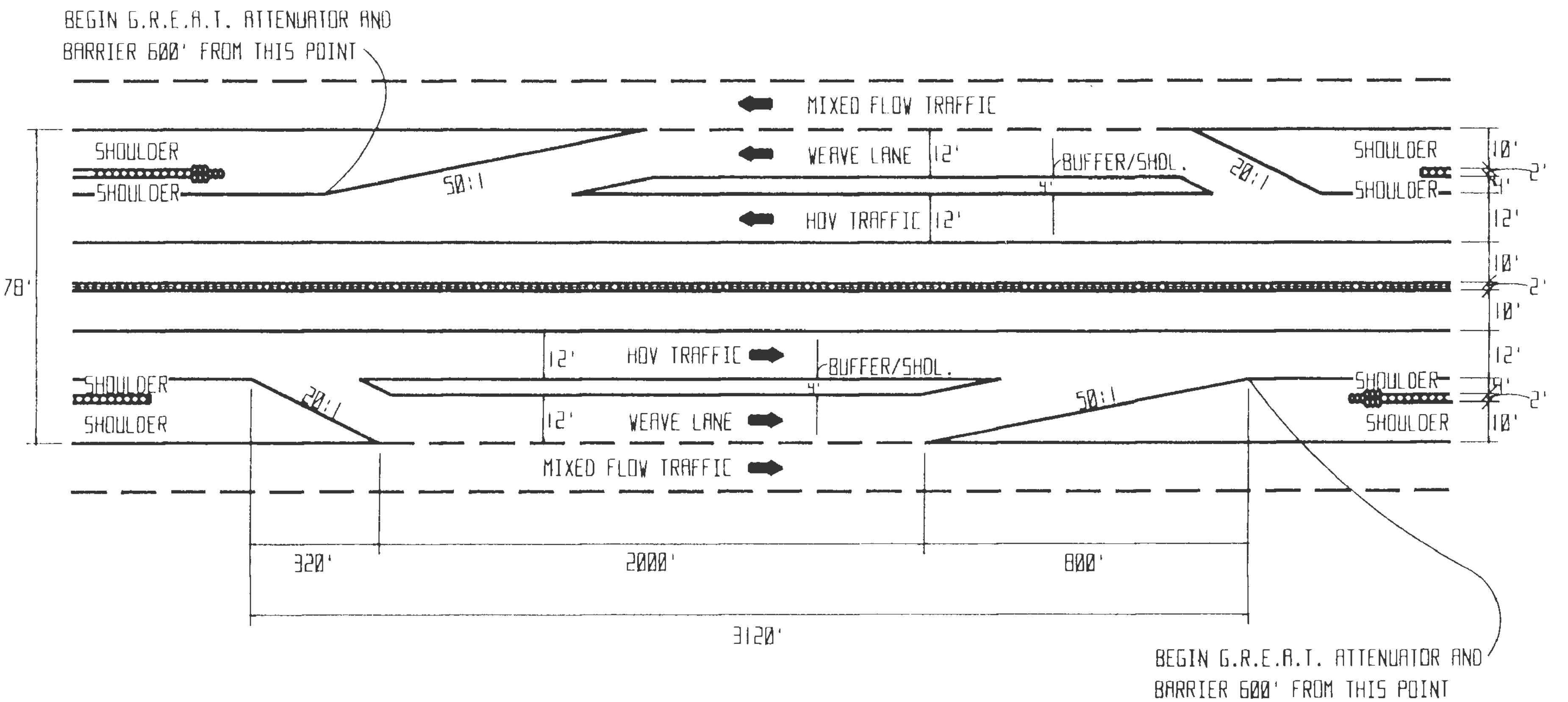
1. To serve every freeway-to-freeway connection
2. To serve high volume ramps
3. Ramps with high number of carpools
4. When requested by transit districts
5. When adjacent to park and ride facilities

INGRESS/EGRESS FOR BARRIER SEPARATED HOV FACILITIES



NOT TO SCALE

INGRESS/EGRESS FOR BARRIER SEPARATED HOV FACILITIES



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As applied to the buffer separated facilities, ingress and egress are relative to the origin and destination patterns of HOVs. If the majority of HOVs originate upstream and have destinations downstream of the facility, they will all use the lane facility and there will be little impact related to intermediate access points. However, intermediate access points will allow fuller use of the facility.

The operation of weaving sections needs to be considered. It is important that ingress and egress locations be of proper length and located to provide the best possible access, especially to adjoining freeways. There could be situations in which merging to and from the HOV lane can create queueing in the HOV lane. One example would be providing ingress and egress near ramp locations on a freeway that has many closely spaced ramps in a bottleneck section. This could create conflicts in the flow of both the HOV and mainline facilities. Design should include the consideration of additional lane between these ramps to allow ingress/egress to the HOV facility without adversely impacting either it or the mixed-flow lanes. The exhibit on page 4-6 indicates recommended weaving distances for buffer separated facilities.

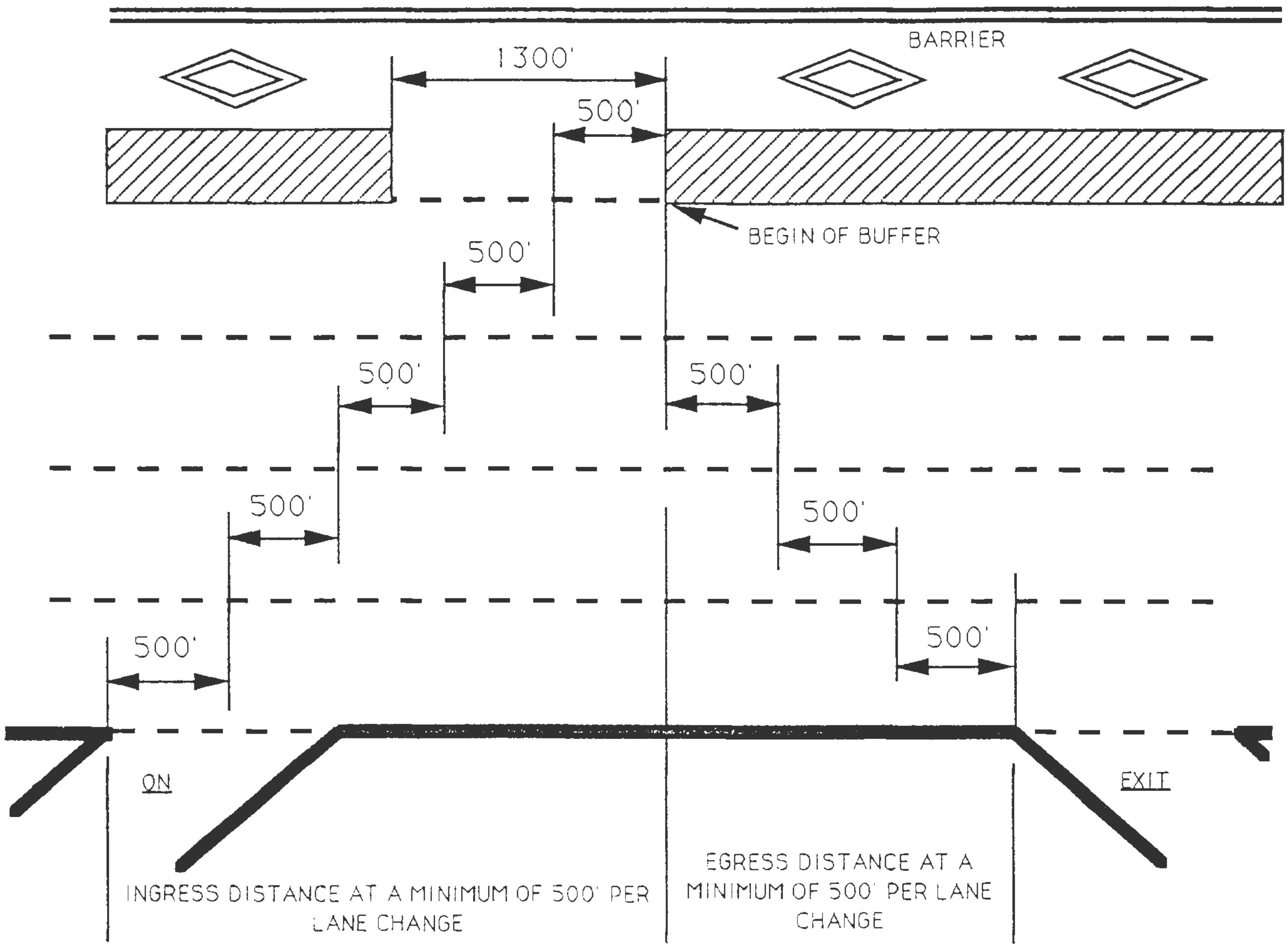
Provision for the traffic to enter and leave the HOV facility should be provided at every freeway-to-freeway interchange. Ingress and egress to State highways and major arterials should be considered where demand exists and where operation is not severely impacted.

Ingress and egress locations should be on tangent and away from CHP enforcement areas.

4.4 Ingress and Egress For Contiguous HOV Facilities

At-grade access for contiguous HOV facilities is unlimited since no buffer or barrier separates the HOV lane from the mixed-flow traffic (See Detail 13, Traffic Manual). When a lane has to be discontinued, it is preferable to drop the outside mixed-flow lane approximately 1/2 mile after the end of the HOV facility.

INGRESS AND EGRESS WEAVE DISTANCE AT BUFFER SEPARATED FACILITIES



NOT TO SCALE

START OF FACILITY - The buffer should begin at a minimum distance equivalent to 500 feet per lane change from the nearest on-ramp.

END OF FACILITY - Given the HOV lane merges back to mixed flow traffic, the buffer should end at a minimum distance of 500 feet per lane change prior to the next off-ramp or connector.

INGRESS/EGRESS - A minimum of 500 feet per lane change for ingress is required from any on-ramp to the beginning of the buffer. A minimum of 500 feet per lane change for egress is required from the beginning of the buffer prior to the following off-ramp.

A MINIMUM OF 1300 FEET OF DASHED WHITE LINE SHOULD BE PROVIDED AT ALL INGRESS, EGRESS AND INGRESS/EGRESS LOCATIONS PRIOR TO THE BEGIN OR END OF THE BUFFER.

Refer to the Highway Design Manual for locating weaving sections at ramps and direct connectors.

Chapter Five

SIGNING AND DELINEATION

5.1 GENERAL

Signing and delineation for HOV facilities should conform to standard signing and delineation practices whenever possible. If guidance is lacking in the Traffic Manual and other documents, the recommendations in the following sections may be used.

5.2 SIGNING

Regulatory signing for HOV facilities should follow the standard regulatory signing principles: black legend on white reflective background, and rectangular shape. The diamond symbol should be incorporated into the sign format. It should be a white symbol on a black background.

Guide signing may be necessary on HOV facilities that have designated ingress, ingress/egress, or egress points to inform the motorist of the appropriate HOV lane entry or exit point to use. These points can be at the beginning, end, or intermediate locations along the HOV facility. The guide signing should follow the standard guide signing format: white reflective legend on green opaque background, and rectangular shape. The diamond symbol should also be incorporated into the sign format, preferably in the upper left corner of the signs, It should be a green opaque symbol on a white reflective background. The only exception is where ramps are provided exclusively for HOV traffic. In this case, the color and format should be the same as for regulatory HOV signs.

Illumination for overhead signs should follow the current policy for standard guide signs.

Where lateral clearance is limited at locations such as a ground mounted sign affixed to the median barrier, the sign panel should not project beyond the outer edge of the barrier. The width for sign panels at these locations should be a maximum of 30 inches to minimize the amount a sign panel may have to be skewed to keep it within the width of the barrier.

Signs R86 (ground mounted), or R87 (overhead) are intended for use with a HOV facility to indicate the particular restrictions applying to that facility. When used, sign

R86 should be located adjacent to the HOV lane and the R87 should be mounted directly over the lane. The message format of a Bus-Carpool lane sign R86 should have the following sequence:

Top Lines: lane(s) applicable (e.g. RIGHT LANE, LEFT LANE, THIS LANE).

Middle Lines: applicable vehicles (e.g. BUSES ONLY, BUSES AND CARPOOLS, BUSES, AND CARPOOLS WITH 2 OR MORE).

Bottom Lines: applicable time and day (e.g. 7-9 AM, 4-6 PM, MON-FRI).

The message format of sign R87 should have this sequence:

Top Lines: applicable vehicles (e.g. BUSES ONLY, BUSES AND CARPOOLS, BUSES, CARPOOLS WITH 2 OR MORE).

Bottom Lines: applicable time and day (e.g. 7-9 AM, 4-6 PM, MON-FRI). The time and day are separated by a down arrow. The diamond symbol on these signs should appear in the top left quadrant.

When HOV lanes use control signals or changeable message signs to convey the HOV lane use restrictions, signs R86 and R87 are not mandatory but may be used to supplement the other controls. The required pavement markings for these lanes is an elongated diamond symbol, in the center of the lane, at approximately 1/4 mile intervals.

Advance notification of HOV lanes is desirable. BUS-CARPOOL LANE AHEAD signs, R82 for ground mounting and R83 for overhead mounting may be used for this purpose.

At the end of the signed section of HOV facilities, a BUS-CARPOOL LANE ENDS sign (R84 or R85) shall be used.

Although the legend format of the signs R82 through R87 should be retained, other messages may be used to fit a specific HOV lane-use operation. Frequency with which signs are placed is a matter of engineering judgement based on prevailing speed, block length, distance from intersections, and other considerations necessary to communicate adequately with the driver. Spacing as close as 500 feet may be appropriate for a city street, while spacing up to a 1/4 mile or more may be appropriate for freeways.

Signing for reversible HOV facilities must be done on a case-by-case basis. However, it will probably require overhead changeable message signs at both ends of the facility and the general HOV regulatory signs (R93, R86) mounted back-to-back between the entrance and exit.

Signing to direct connectors between freeways within the HOV system will need HOV guide signs, both advance and action, in addition to the normal regulatory signs.

Direct connector on-ramps (drop ramps) must have HOV regulatory signing at the entrance with the usual messages pertaining to the type of vehicle allowed, the number of vehicle occupants required to qualify for a carpool, and the diamond symbol.

Direct connector off-ramps will require HOV guide signs, both advanced and action, in addition to the normal HOV regulatory signs. Typical signing and delineation for HOV facilities are shown on pages 5-4 through 5-9.

5.3 DELINEATION

When a facility is assigned full or part-time HOV use to a particular class or classes of vehicles, the HOV lane markings shall be used. Engineering judgement should be exercised to determine the need for supplemental devices such as tubular markers, traffic cones, and flashing lights.

The HOV lane marking shall be the elongated diamond symbol detailed in the State of California, Department of Transportation, Standard Plans. The diamond shall be placed coincident with the longitudinal center of each restricted lane.

The marking is intended to convey a restriction on the class or classes of the vehicles permitted to use the lane and is supplemental to the signs or signals conveying the specific restriction. Signs or signals shall be used with the HOV lane markings.

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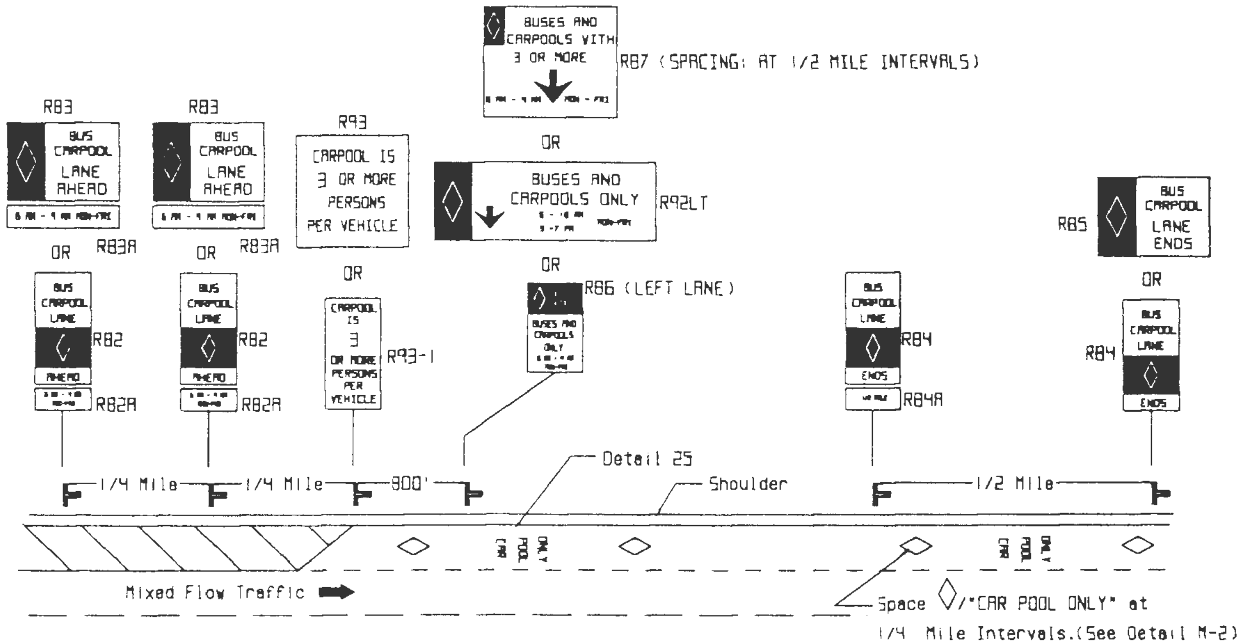
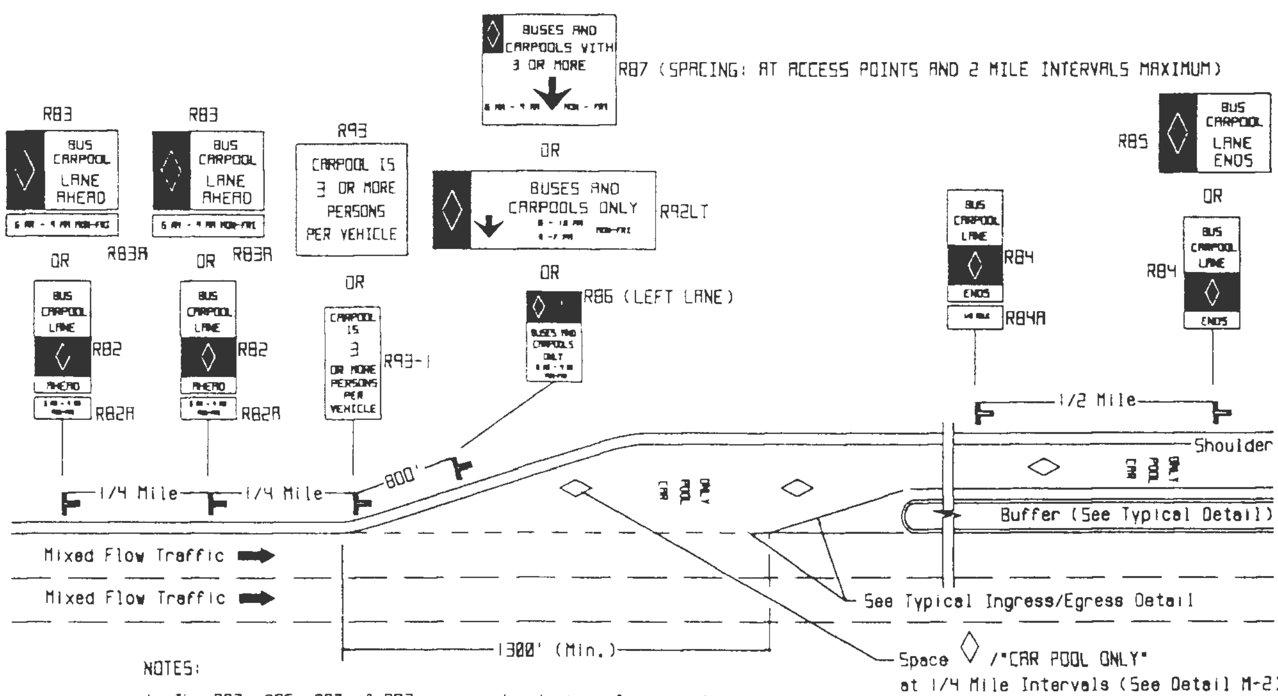
TYPICAL BEGINNING AND TERMINATION POINT SIGNING AND PAVEMENT MARKING FOR HOV FACILITIES

CONTIGUOUS FACILITIES



BUFFER SEPARATED FACILITIES

(Similar for Barrier Separated Facilities)

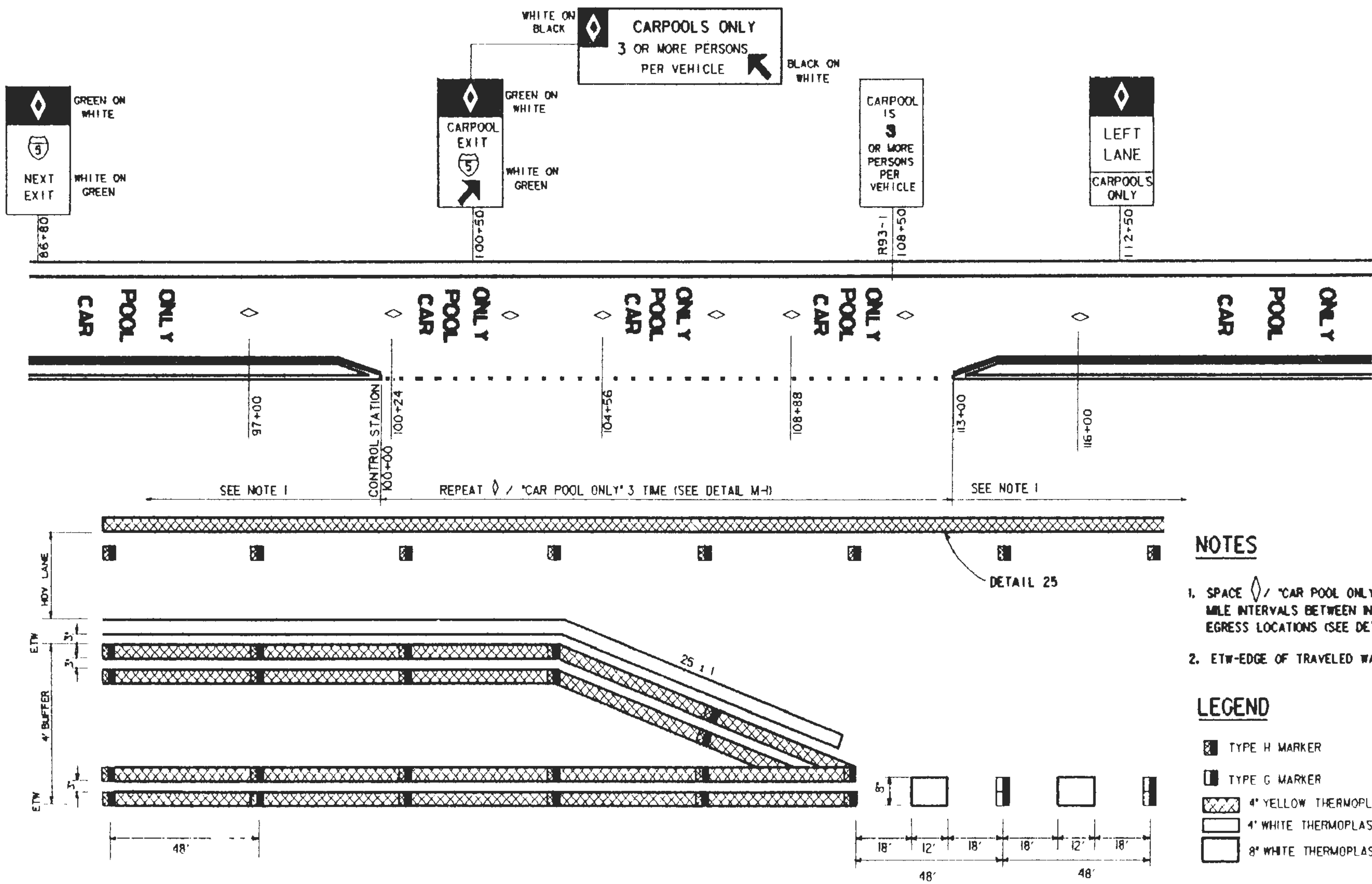


NOTES:

1. The R83, R85, R87, & R92 are overhead signs for use where structures are available.
2. The R82, R84, R85, R93 and R93-1 are ground mounted signs. When used on Median Barrier, the edge of the sign should not project beyond the Median Barrier Base.
3. All quantities, times, distances and vehicle restrictions as shown are varible and may be changed for specific projects.

NOT TO SCALE

TYPICAL INGRESS/EGRESS SIGNING AND PAVEMENT MARKING FOR HOV FACILITIES WITH 4' BUFFER



NOTES

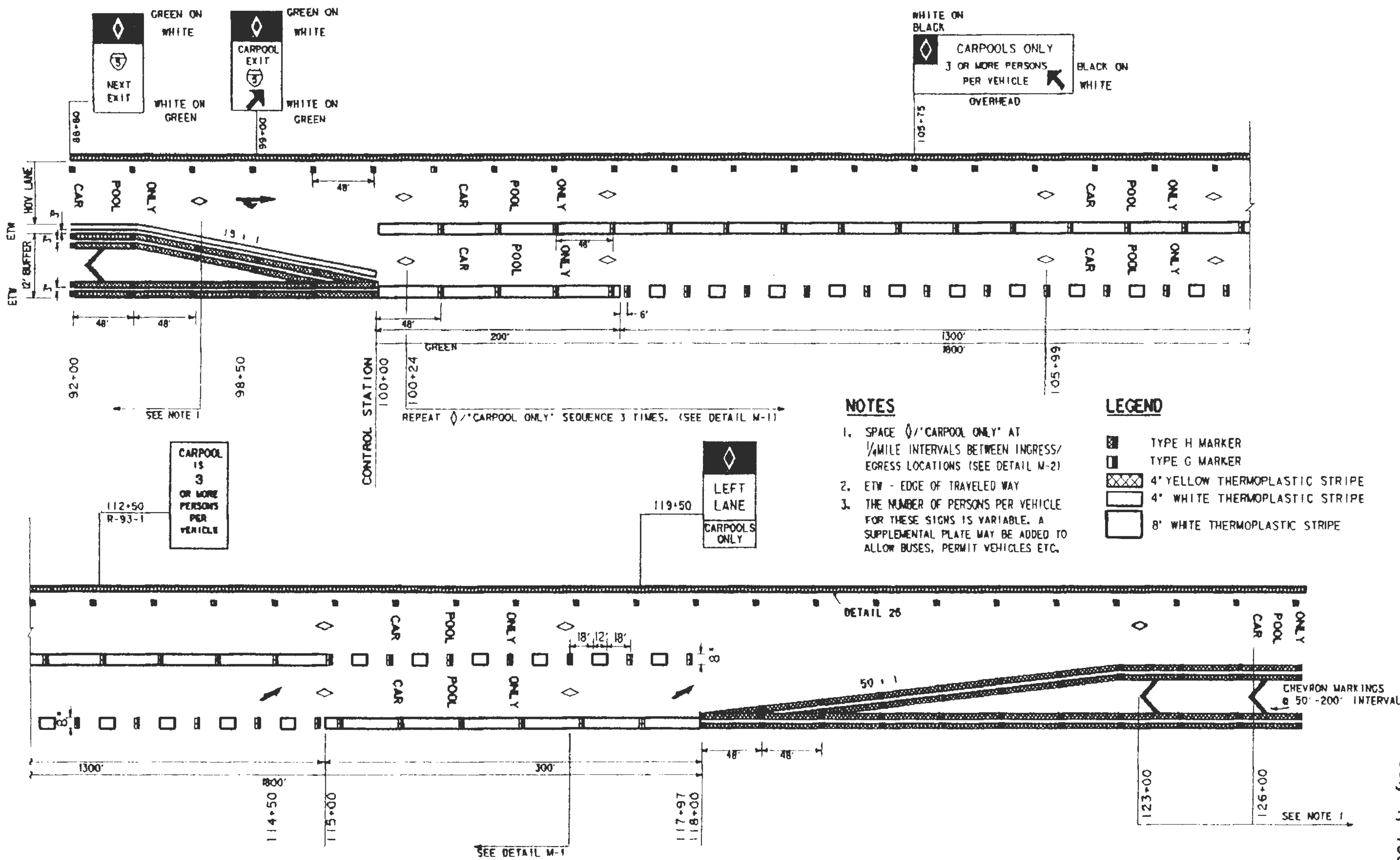
1. SPACE ◊ / "CAR POOL ONLY" AT 1/4 MILE INTERVALS BETWEEN INGRESS/ EGRESS LOCATIONS (SEE DETAIL M-2)
2. ETW-EDGE OF TRAVELED WAY

LEGEND

- TYPE H MARKER
- TYPE G MARKER
- 4" YELLOW THERMOPLASTIC STRIPE
- 4" WHITE THERMOPLASTIC STRIPE
- 8" WHITE THERMOPLASTIC STRIPE

NOT TO SCALE

TYPICAL INGRESS/EGRESS SIGNING AND PAVEMENT MARKING FOR HOV FACILITIES WITH BUFFERS 12 FEET OR GREATER



NOTES

1. SPACE ◊/"CARPOOL ONLY" AT ¼MILE INTERVALS BETWEEN INGRESS/EGRESS LOCATIONS (SEE DETAIL M-2)
2. ETW - EDGE OF TRAVELED WAY
3. THE NUMBER OF PERSONS PER VEHICLE FOR THESE SIGNS IS VARIABLE. A SUPPLEMENTAL PLATE MAY BE ADDED TO ALLOW BUSES, PERMIT VEHICLES ETC.

LEGEND

- TYPE H MARKER
- TYPE G MARKER
- 4" YELLOW THERMOPLASTIC STRIPE
- 4" WHITE THERMOPLASTIC STRIPE
- 8" WHITE THERMOPLASTIC STRIPE

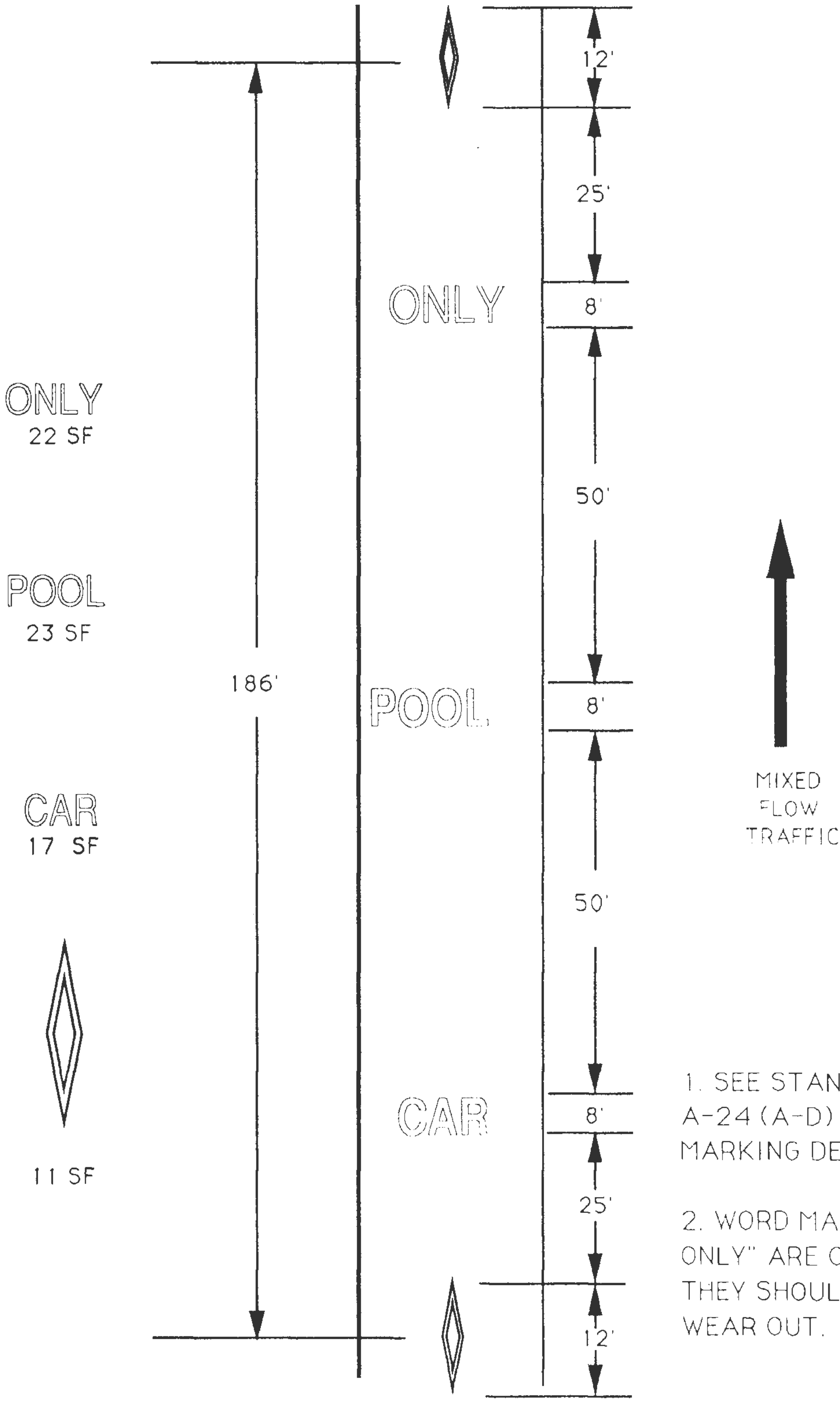
NOT TO SCALE

July 1, 1991

July 1, 1991

HOV LANE PAVEMENT MARKING DETAIL

FOR RAMPS AND INGRESS /EGRESS LOCATIONS



1. SEE STANDARD PLANS A-24 (A-D) FOR PAVEMENT MARKING DETAILS.

2. WORD MARKINGS "CARPOOL ONLY" ARE OPTIONAL. IF USED THEY SHOULD BE ALLOWED TO WEAR OUT.

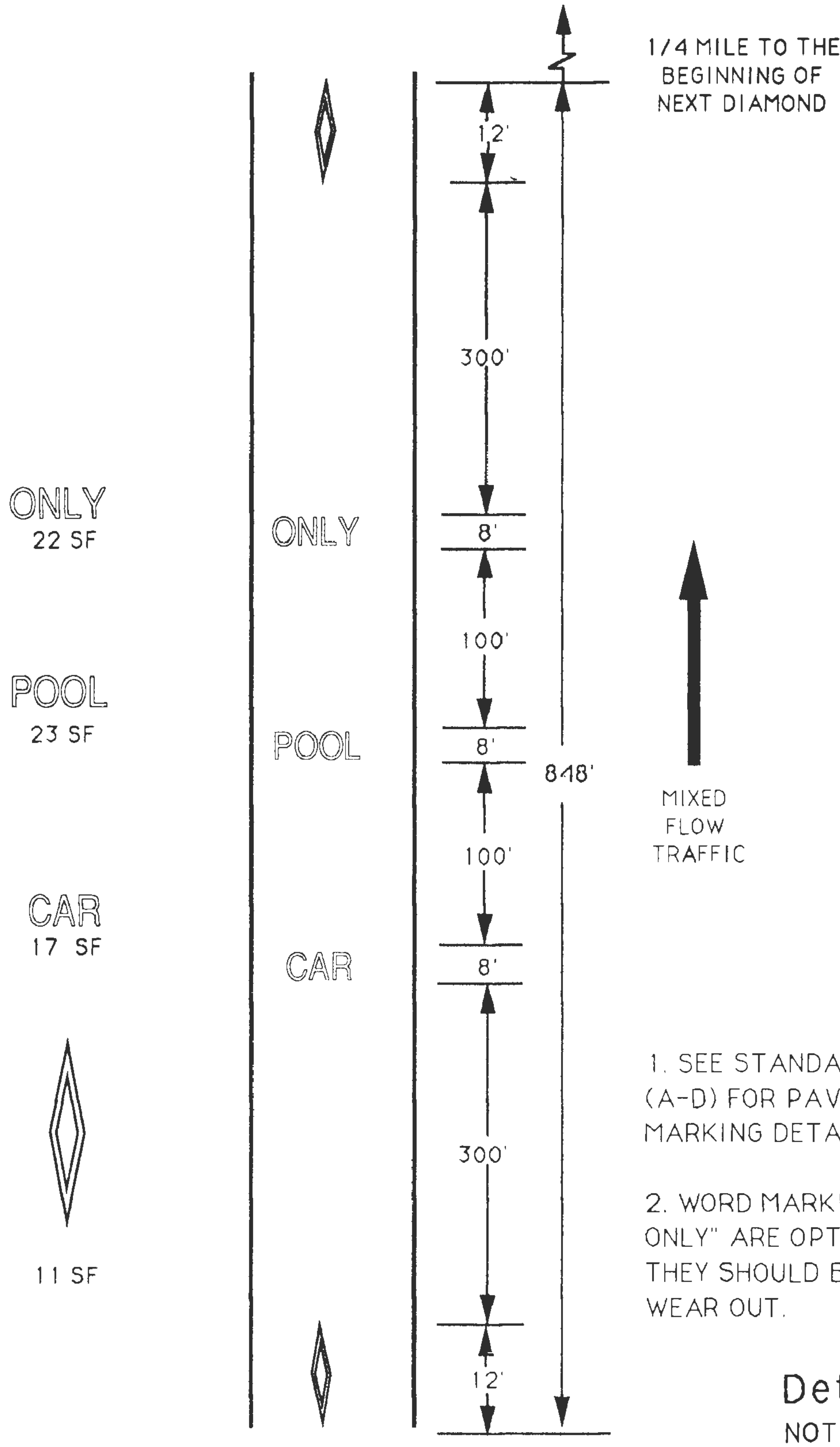
Detail M-1

NOT TO SCALE

July 1, 1991

HOV LANE PAVEMENT MARKING DETAIL

EXCEPT AT INGRESS/EGRESS AND RAMP LOCATIONS



1. SEE STANDARD PLANS A-24 (A-D) FOR PAVEMENT MARKING DETAILS.

2. WORD MARKINGS "CARPOOL ONLY" ARE OPTIONAL. IF USED THEY SHOULD BE ALLOWED TO WEAR OUT.

Detail M-2

NOT TO SCALE

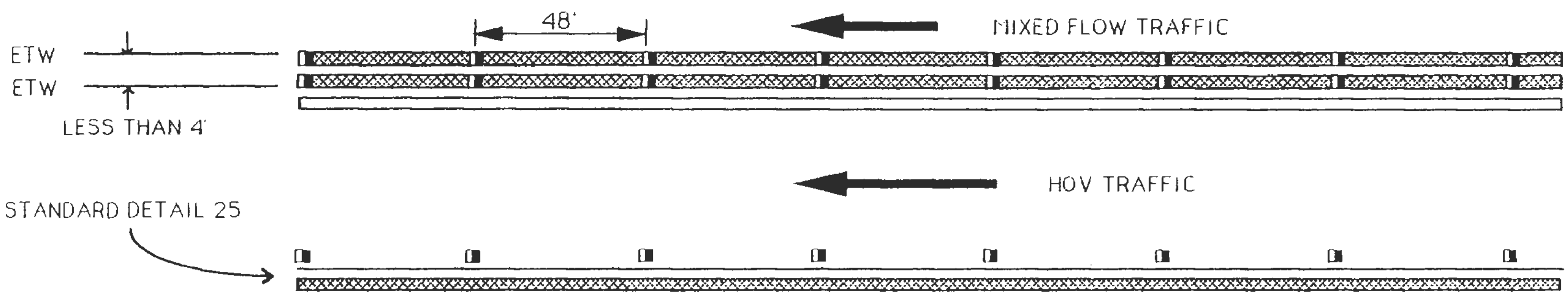
TYPICAL STRIPING FOR BUFFERS LESS THAN 4 FEET

LEGEND

TYPE H PAVEMENT MARKER

4" YELLOW STRIPING

4" WHITE STRIPING



NOTE: ETW- EDGE OF TRAVELED WAY

NOT TO SCALE

The frequency with which the marking is placed is a matter of engineering judgement based on prevailing speed, block lengths, distance from intersections, and other considerations necessary to communicate adequately with the driver. Spacing as close as 80 feet may be appropriate for a city street, while spacing of 1/4 mile may be appropriate along a freeway. A number may be placed in the center of the diamond symbol to indicate occupancy requirement.

Word markings "CAR" "POOL" "ONLY" may be painted between the diamond symbols on new projects to supplement, but not to substitute for, the HOV lane markings. The word markings should then be allowed to wear out.

The striping pattern for the lane line between the HOV lane and the adjacent mixed-flow lane will vary depending on the conditions, as follows:

A. HOV Lane(s) on the Left.

1. Barrier Separated
   The left edge line of the mixed-flow lane will be the normal 4" single solid yellow stripe. The right edge line of the HOV lane will be the normal 4" single solid white stripe.

2. Buffer Separated
   Striping for a buffer separated HOV facility varies according to the width of the buffer.

   If the width of the buffer is less than 4 feet, the recommended striping is 2 solid single yellow stripes and a solid white stripe (edge line). See exhibit on page 5-9.

   If the width of the buffer is 4 feet or wider than 12 feet (buffer widths between 4 and 12 feet are not to be used), the recommended striping is 2 solid double yellow stripes and a solid white stripe (edge line). See exhibits on pages 5-5 and 5-6.

When the buffers are 12 feet or wider, yellow chevron pavement markings or diagonal lines are recommended between the two sets of double yellow stripes. They should be placed at 50 feet to 200 feet intervals, as needed.

3. Contiguous

The recommended striping is the conventional dashed 4" white stripe for both part-time and full-time contiguous HOV facilities.

If the HOV lane is a part-time facility which reverts to a left shoulder during off peak periods, the recommended striping is a 4" solid white stripe. In addition, the diamond symbol and the "CAR" "POOL" "ONLY" pavement word markings are not to be used.

B. HOV Lane(s) on the Right

An HOV lane to the right of the mixed-flow lanes is normally associated with reversion to a right shoulder during the off peak periods. A 4" single solid white stripe is recommended. The diamond symbol and the "CAR" "POOL" "ONLY" pavement word markings are eliminated in this case.

Chapter Six

HOV ENFORCEMENT

6.1 General

Adequate enforcement of HOV violations is a necessary element for a successful HOV system. The threat of receiving a citation for an occupancy violation is a strong deterrent to the illegal use of the HOV lanes and studies have shown that violation rates increase when enforcement levels are low. Therefore, enforcement considerations must be accounted for during the planning, design, and operational phases of all HOV projects. Typically, these processes will require participation from the California Highway Patrol (CHP).

6.2 Role of Enforcement

Experience with HOV facilities has clearly demonstrated that enforcement is required to develop an appropriate public attitude toward these facilities. In fact, just the presence of a CHP officer has a beneficial impact. Such benefits usually correlate directly to the level of the officer's presence and is related to the motorist's perception of the extent of enforcement. In addition, this perception can be affected also by the following factors:

A. Is the enforcement unit moving with the flow of traffic or is it parked?

B. How frequently are enforcement units observed?

C. Are enforcement units observed issuing citations?

D. Are the fines sufficiently high to deter the illegal use of the HOV facility?

Public attitude toward enforcement is dependent upon the perceived benefit from obeying the law and the consequence from violating it. However, the violation of occupancy laws relative to HOV facilities represents no immediate personal danger to the violator and results in a perceived personal benefit from violating it. Therefore, a properly designed enforcement program is essential to the success of the HOV facility. The role of enforcement is to ensure that the program is properly executed. California Vehicle Code (CVC) section 2400 places enforcement responsibility for State highways constructed as freeways under the jurisdiction of the California Highway Patrol (CHP). It follows that the enforcement of laws relative to HOV facilities falls under the jurisdiction of the CHP.

6.3 Violation Rates

The task of keeping violation rates within reasonable bounds implies an ability to determine an acceptable violation rate. Although there are facilities which operate successfully with violation rates up to 20%, a rate below 10% is preferable. While there is no established standard, establishing a standard for acceptable violation rates should include safety considerations, freeway operations, public attitudes, and practicality.

A. Safety
Past studies suggest there is no correlation between accident rates and occupancy violation rates on any of California's HOV facilities. However, the practice of weaving in and out of a HOV lane creates a direct safety problem for the violator as well as for other traffic.

B. Freeway Operations
Most of California's HOV facilities are currently operating below capacity. However, as traffic flow approaches capacity, violations represent a threat to the time savings and other benefits of HOV facilities.

C. Public Attitudes
Over three quarters of the drivers surveyed in a recent California HOV study felt that the illegal use of HOV lanes is a problem. Even where there is intense public sentiment against the HOV facility, drivers recognized violations as a problem. Drivers tend to over-estimate violation rates and as such are likely to be critical if actual violation rates are above ten percent.

D. Practicality
Experience suggests that steady doses of routine enforcement combined with moderate applications of special enforcement can keep HOV violation rates within the five to ten percent range. Heavy consistent doses of special enforcement would be necessary to drive violation rates below five percent

and would have little effect on freeway performance. It is recommended that a target level of 10 percent maximum be considered for mainline HOV facilities until more data is available to establish a standard.

6.4 Enforcement Alternatives

Detection of occupancy violations by video technology is not yet sufficiently reliable to eliminate on-the-scene verification by an officer. Therefore, every effort should be made to provide the maximum amount of enforcement areas for all HOV facilities. The following enforcement area configurations are listed in order of preference:

1. Continuous paved median 14 feet or wider in both directions for the length of the HOV facility. If space is available, additional enforcement areas may be built in conjunction with the 14-foot median.

2. When 14 foot continuous median shoulders are not possible, paved bi-directional enforcement areas spaced 2 to 3 miles apart should be built. A separation in the median barrier should be provided for CHP motorcycle officers to patrol the HOV facility in both directions of travel.

3. Where median width is limited, some combination of 1 and 2 should be included.

4. Paved directional enforcement areas spaced 2 to 3 miles apart and staggered to accommodate both directions when space limitations do not allow any of the above outlined considerations.

5. Where space is limited, directional enforcement areas located wherever right-of-way is available.

No new HOV facilities should be built without giving full consideration to provide adequate enforcement areas, and consideration should be given to adding them to existing facilities with enforcement problems.

Exhibits on pages 6-5, 6-6 and 6-7 represent typical enforcement areas for various median configurations mutually agreeable to Caltrans and the CHP. The widths shown for enforcement areas are 15 feet and 16 feet. However, design variations due to restrictive right-of-way and other reasons may indicate a lesser width is necessary. In such cases, 14 feet should be the minimum width for enforcement areas. The typical length is 1300 feet although a minimum of 1000 feet is acceptable. Any deviation from these typical configurations could lead to a perception of unsafe conditions by the CHP officer and result in non-use. Therefore, District alternatives which deviate from the above options should be resolved with the local CHP command and the appropriate Headquarters representatives. It is likely that building any enforcement areas will require compromises in design standards and will require an approved design exception fact sheet.

Other considerations for the design and operation of enforcement areas include the following:

A. For buffered HOV facilities, the buffer should be carried full width adjacent to the enforcement area.

B. Audible warning markers spaced 6 feet apart should be spaced just inside the enforcement area on the traffic side, running parallel with the enforcement area boundary. See exhibit on page 6-5.

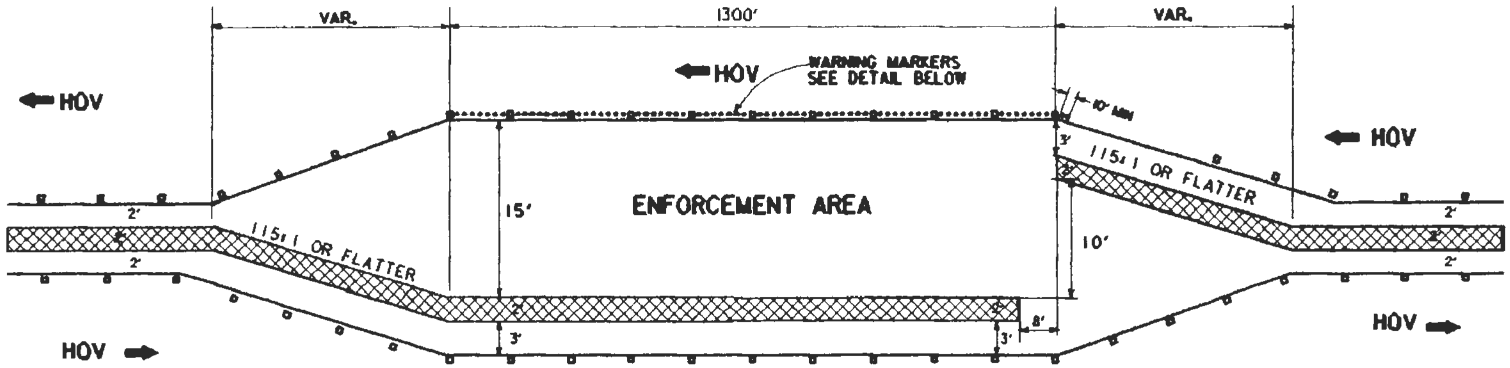
C. The right shoulder should not be sacrificed to provide room for enforcement areas in the median except for extreme circumstances and only with the necessary approvals.

D. Maintenance of enforcement areas should be routinely provided to avoid accumulation of debris. Excessive debris in enforcement ares may present hazards to CHP units and motorists.

E. Ensure adequate drainage.

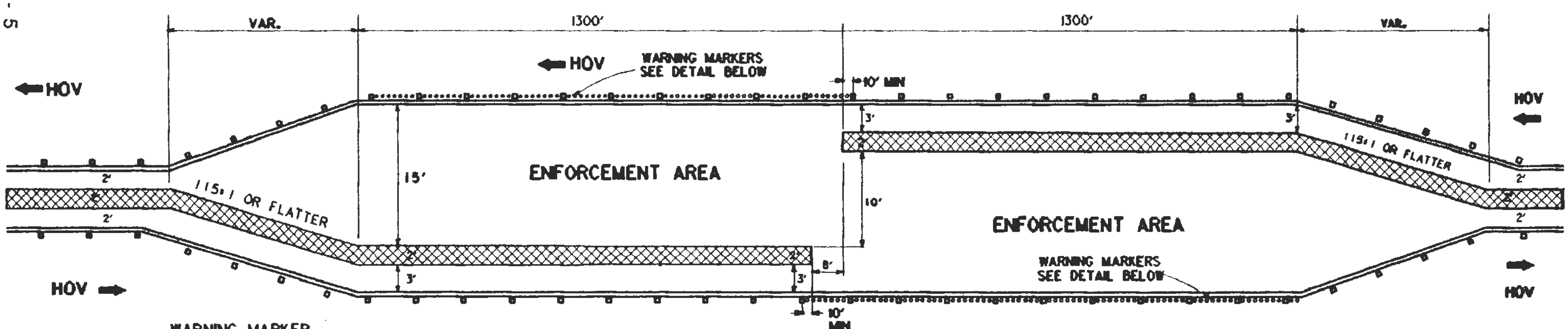
ENFORCEMENT AREAS FOR MEDIANS LESS THAN 22'

(NO SCALE)



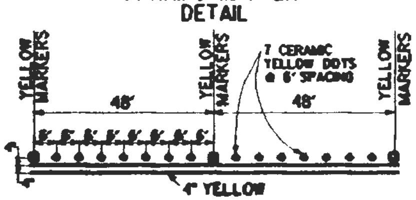
DIRECTIONAL ENFORCEMENT AREA

NO GLARE SCREEN WITHIN THE ENFORCEMENT AREA (INCLUDING TAPER AREAS)



HOV

WARNING MARKER DETAIL

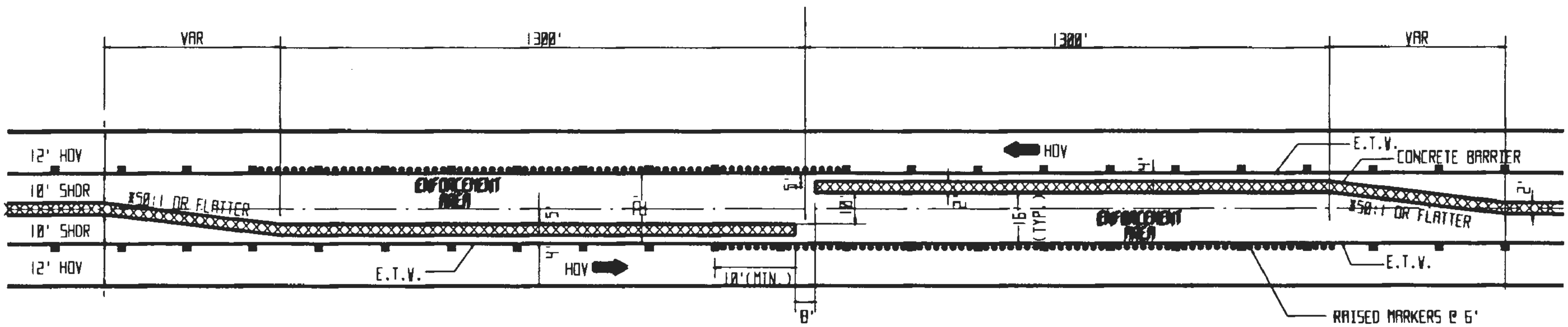


DIRECTIONAL ENFORCEMENT AREA

NO GLARE SCREEN WITHIN THE ENFORCEMENT AREA (INCLUDING TAPER AREAS)

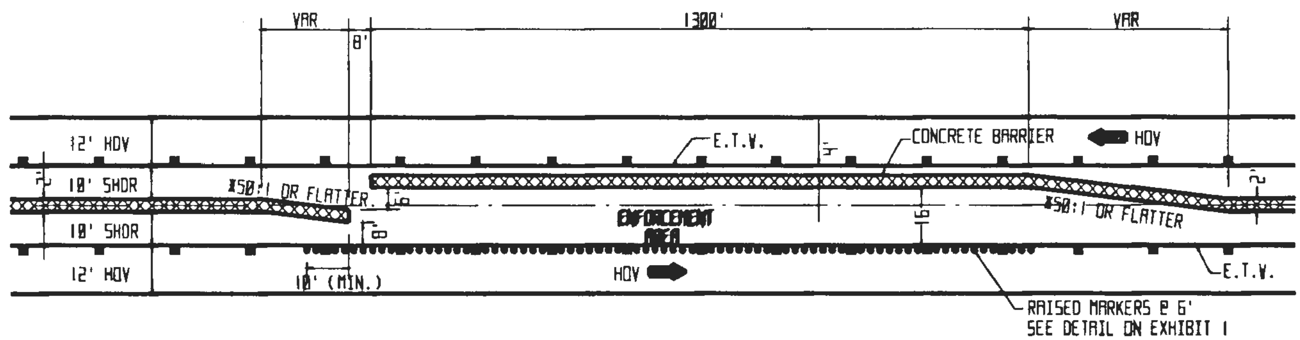
ENFORCEMENT AREAS FOR 22' MEDIANS

NO SCALE



BI-DIRECTIONAL ENFORCEMENT AREA

NO GLARE SCREEN WITHIN THE ENFORCEMENT AREA INCLUDING TAPER AREAS



DIRECTIONAL ENFORCEMENT AREA - ALTERNATIVE No. 1

NO GLARE SCREEN WITHIN THE ENFORCEMENT AREA INCLUDING TAPER AREAS

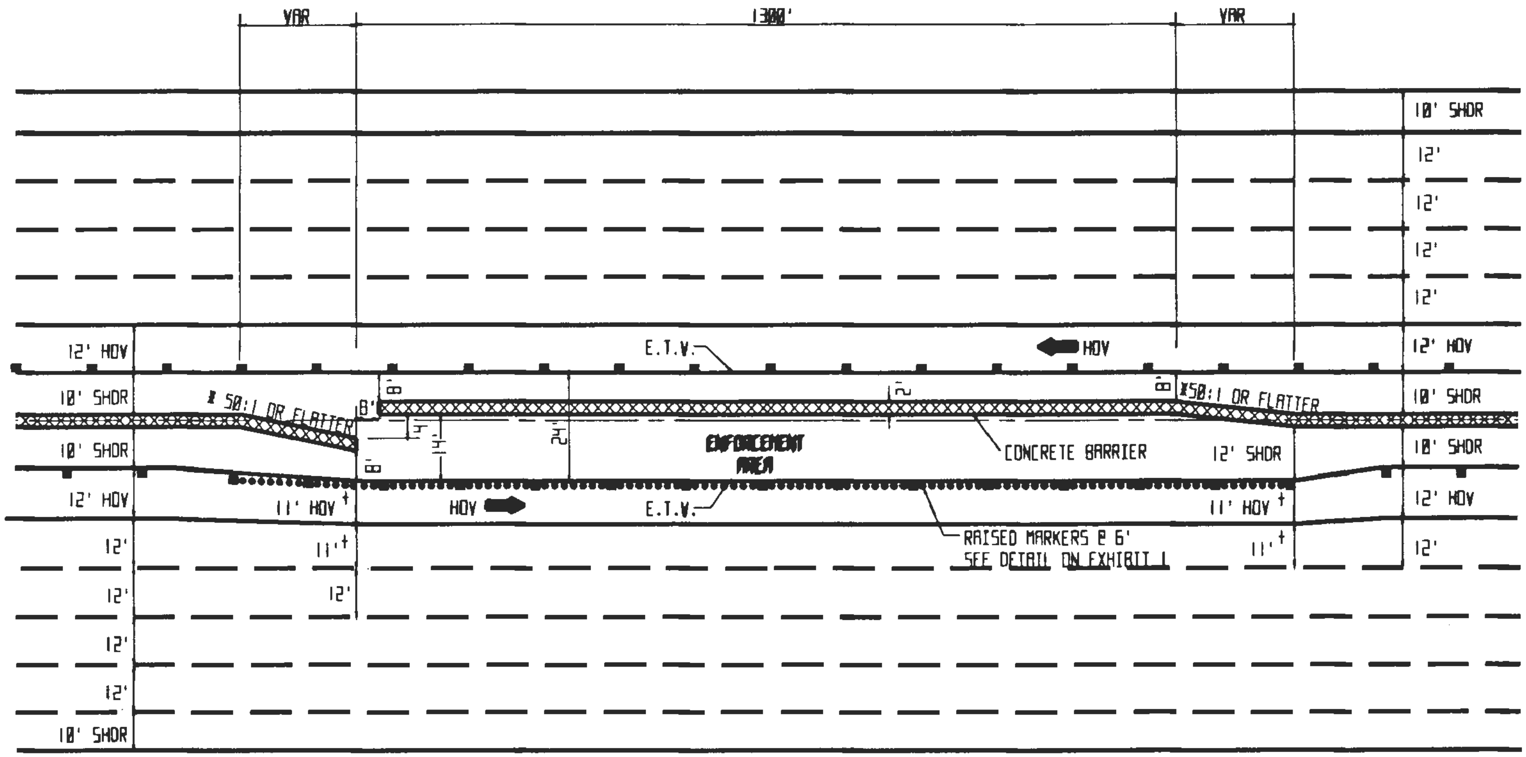
NOTE :

* USE 50:1 AS ABSOLUTE MINIMUM.

JULY 1, 1991

ENFORCEMENT AREAS FOR 22' MEDIANS

NO SCALE



DIRECTIONAL ENFORCEMENT AREA - ALTERNATIVE No. 2

NO GLARE SCREEN WITHIN THE ENFORCEMENT AREA INCLUDING TAPER AREAS

NOTES:

*. USE 50:1 AS ABSOLUTE MINIMUM.
USE 115:1 OR FLATTER FOR ANY LANE TRANSITIONS.

†. USE 12' WHEN RIGHT OF WAY IS AVAILABLE.

JULY 1, 1991

F. Glare screens should not be installed adjacent to HOV enforcement areas. This will improve visibility and allow officers a possible escape route if an errant vehicle enters the enforcement area.

G. Enforcement pockets should be avoided at ingress/egress locations for buffer or barrier separated HOV facilities.

H. Enforcement pockets should be avoided at curves. If possible, adequate sight distance should be provided.

I. To protect officers from thrown or falling objects, enforcement pockets should not be placed near overcrossings.

J. Design features should ensure that enforcement areas are not perceived as traffic lanes.

6.5 OTHER ENFORCEMENT CONSIDERATIONS

Enforcement techniques used on mainline HOV facilities will vary according to the design of the facility. While 14-foot paved median or enforcement pockets are preferred options for new HOV facilities, they may not be possible for retrofit HOV facilities on existing freeways due to the lack of right-of-way. Existing facilities have a number of different geometric characteristics that impact enforcement strategies, as follows:

A. Median Width

HOV facilities created by retrofitting within the median frequently have no usable enforcement areas in the center of the freeway. The absence of a center median shoulder has an adverse impact on two important aspects of enforcement on these facilities: safety and visibility. Enforcement action on this facility requires that the violator be taken across normally congested mixed-flow lanes to the right shoulder. This maneuver is potentially hazardous and reduces the beneficial impact from visible enforcement.

B. Buffers

Three types of separations are currently in use on California HOV facilities:

1. Single barrier stripe (double yellow)
2. Painted barrier (two double yellow stripes)
3. Fixed barricade (Jersey barrier)

Each type of separation presents a special enforcement problem. The single barrier stripe provides little restriction to traffic passing between the mixed-flow lane and the HOV lane. On those facilities, officers will need to enforce occupancy requirements as well as frequent buffer violations. By its nature, this type of facility will experience a higher rate of violation than other facilities.

The painted barrier (buffer separated) with 2 double yellow stripes presents a different problem to the enforcement officer. If the buffer is wider than 4 feet, it creates the illusion that it may be a safe place to stop. Therefore, buffers between 4 feet and 12 feet should not be used.

The HOV facilities that are physically separated from the mixed-flow lanes by a fixed barrier (barrier separated) have the least number of occupancy violations and will not have buffer violations. Any enforcement that takes place on these facilities requires an officer dedicated to that lane. The barrier wall may create an access problem for emergency vehicles.

The planning and design of enforcement areas must consider the impact on safety and visibility. Where geometric standards are reduced, an approved design exception fact sheet is required. The optimum design is the availability of adequate enforcement areas in the median area. Where existing facilities do not have these enforcement areas or new facilities are not designed with them, it can be expected that enforcement on the facility will be difficult and less effective.

APPENDIX

Contents of Appendix

Appendix A-1

POLICY AND PROCEDURES MEMORANDUM P89-01

DEPARTMENT OF TRANSPORTATION
DAS-MA-4

policy & procedure

NO	P89-01
TITLE	BUS AND CARPOOL (HOV) LANES
APPROVED BY	J. F. MALONEY
DATE ISSUED	3/16/89
PAGE	1 OF 4
SUBJECT AREA	HOV LANES
ISSUING UNIT	Division of Traffic Operations
SUPERSEDES	
DISTRIBUTION	Division and Districts through Office Chiefs

I. BACKGROUND

Congestion and motorist delay on California's metropolitan freeways are increasing rapidly. Building new freeways or expanding existing facilities are often constrained by cost, right of way, environmental, and other factors. In such areas, high occupancy vehicle (HOV) lanes for ridesharing and transit vehicles can be an effective strategy to make the existing corridor more efficient. The objectives of properly designed, free flowing HOV lanes are as follows:

1. Increase the people-moving capacity of the freeway system.

2. Reduce overall vehicular congestion and motorist delay by encouraging greater HOV use.

3. Provide time and commute cost savings to the users of HOV lanes.

4. Increase overall efficiency of the system by allowing HOVs to bypass congestion on lanes designed for their use.

5. Improve air quality by decreasing vehicular emissions.

The authority for establishing HOV lanes is given in Section 25485 of the Public Resources Code, in Section 149 of the Streets and Highways Code, and in Section 21655.6 of the Vehicle Code. Requirements for approval of HOV lane projects by the regional transportation planning agencies or county transportation commissions are included in Section 21655.6 of the Vehicle Code.

Resolution G-87-8 passed by the California Transportation Commission (CTC) on July 23, 1987, and the Federal Highway Administration (FHWA), California Division, policy dated December 15, 1987, require the Department to consider the HOV lane alternative whenever capacity is added to existing metropolitan freeways. The CTC also requires the consideration of HOV lane alternatives for new metropolitan freeways, the development of regionwide HOV lane systems, and the inclusion of these systems in the regional transportation plans. These policies describe the processes for the planning and the project development of HOV lanes.

II. POLICY

A. The Department will consider an HOV lane alternative for all capacity additions to metropolitan freeways or new metropolitan freeways.

B. The Department will work with regional transportation planning agencies in the conceptual planning phase to develop regionwide HOV lane system plans in metropolitan areas and to include these systems in the regional transportation plans.

C. The Department will recommend the programming of HOV lane projects which meet established criteria and are included in the regional transportation plans.

D. The Department will recommend HOV preferential lanes at ramp meters where appropriate.

III. PROCEDURE

A. Each of the Districts with major metropolitan areas (Districts 3, 4, 6, 7, 8, 10, 11 and 12) will work with the appropriate regional transportation planning agencies to develop regionwide HOV lane system plans for the metropolitan areas.

HOV lanes included in the system plans should conform to the following criteria:

1. One or more through lanes is being constructed by either a new freeway or adding capacity to an existing freeway.

2. The concept of an HOV facility is supported by the public and by local and regional agencies and officials.

3. The existing corridor is congested or will become congested within ten years from the finish of construction.

4. The HOV lane users would realize a significant savings in travel time.

5. The HOV lanes would be cost-effective based on an analysis of traffic projections including modal shift to HOVs.

6. There would be sufficient numbers of vehicles in the HOV lane to use the facility effectively.

7. The HOV lane contributes to the continuity of the planned regionwide HOV lane system and is not an isolated segment.

B. A range of HOV applications may be appropriate for a given freeway segment. The specific design and operational features will be based on such factors as transportation demand, timing, costs, safety, maintenance, enforcement needs, funding availability, environmental considerations, and community support. Specific applications include the following:

1. The goal is to optimize the people-moving capability of the HOV lanes. Because of greater capacity potential, bus transit of the several ridesharing modes shall be given preference in project planning with vanpooling and carpooling following.

2. Proposals for lane additions or new facilities will be analyzed for mixed-flow and HOV operation. The HOV lane alternative should:

   a. Ultimately result in less overall person delay or increased person-carrying capacity due to a modal shift to HOVs.

   b. Result in less delay to the HOVs because they bypass congestion, thereby encouraging modal shift.

3. Separate roadways for HOVs should be proposed when travel demand, cost-effectiveness and operational needs justify those facilities.

4. Subject to specified conditions, Section 162 of the Streets and Highways Code requires accommodation of rail in the design of HOV lanes on new alignment or on new structures. When warranted under these conditions, Caltrans shall provide for rail along with HOV lane projects on the freeway system when approved by local agencies.

IV. RESPONSIBILITY

A. The District Directors of Transportation are responsible for the following:

1. Implementing this policy.

2. Constructing HOV projects programmed in the STIP.

3. Coordinating with the CHP.

4. Seeking support from local legislators, the public and local governments for HOV projects identified in the regional transportation plans.

5. Coordinating with regional agencies in the regional transportation planning process.

B. The Chief, Division of Traffic Operations, is responsible for the following:

1. Establishing procedures and criteria to ensure policy implementation and propose policy revisions as necessary to address changing conditions.

2. Reviewing and evaluating policy implementation by the Districts and providing follow-up action as appropriate.

Attachment

Appendix A-2

CALIFORNIA TRANSPORTATION COMMISSION
RESOLUTION G-87-8
and
POLICY STATEMENT

July 23, 1987

CALIFORNIA TRANSPORTATION COMMISSION
Bus and Carpool Lane Facilities
Resolution G-87-8

WHEREAS, Fiscal and environmental resources necessary for the continuing development of freeway facilities are increasingly constrained; and

WHEREAS, The costs of owning and operating a private passenger vehicle are generally out-pacing the consumer price index; and

WHEREAS, In most of California's metropolitan areas, occupancy of private passenger vehicles averages no more than 1.2 persons; and

WHEREAS, Bus and carpool lanes offer demonstrated benefit in time and cost savings to those individuals already choosing to use transit, carpools, or vanpools for home-to-work commute trips; and

WHEREAS, Bus and carpool lanes also offer an incentive to individuals to commence use of these modes, and maximum incentive results with effective operation and enforcement; and

WHEREAS, Vehicles eligible to use bus and carpool lanes often result in reduced emissions per person trip, reduced fuel consumption per person trip, and more efficient use of publicly financed capital facilities;

NOW, THEREFORE, BE IT RESOLVED, That in the planning of any new freeway facility or freeway capacity addition in and around a metropolitan area, the Department of Transportation and/or the regional transportation planning agency shall examine and report to the California Transportation Commission on the feasibility and potential benefits -- both short term and long term of the new project's operation -- of designating bus and carpool lane operation within that project, for at least peak, week-day commute hours; and

BE IT FURTHER RESOLVED, That such examinations should consider the possible extension of bus and carpool lane operation into existing, adjacent facilities to determine their contribution to the feasibility and beneficial operation of the bus and carpool lane facility within the new project; and

BE IT FURTHER RESOLVED, That in considering the approval of such projects, the California Transportation Commission shall also consider the aforementioned bus and carpool lane facility reports; and

BE IT FURTHER RESOLVED, That the Commission shall give serious consideration to the inclusion of at least a commute hour bus and carpool facility in every new freeway facility or freeway capacity addition in and around a metropolitan area when it is demonstrated to be both feasible and of likely benefit within either the short or long term; and

BE IT FURTHER RESOLVED, That the Commission shall also give serious consideration to extending such a bus and carpool facility to existing adjacent facilities when it is demonstrated to be feasible and of likely benefit and to contribute to the operation of the bus and carpool facility within the new project.

BE IT FURTHER RESOLVED, That in the metropolitan Districts the Department of Transportation shall work with the regional transportation agencies to plan region-wide bus and carpool lane systems and to include these systems in the regional transportation plans.

BE IT FURTHER RESOLVED, That the Commission shall continue to consider the inclusion of bus and carpool facilities in new metropolitan freeway construction and in metropolitan freeway capacity additions on a case by case basis until such time as acceptable bus and carpool lane systems for all major metropolitan areas are incorporated in regional transportation plans; thereafter, the Commission shall only determine whether such proposed urban freeway projects are included in the regional plans.

BE IT FURTHER RESOLVED, That it is the intent of the Commission to pursue all reasonable opportunities to support the concept of bus and carpool lanes and bus and carpool lane projects in general and particularly when meeting with elected officials, representatives of public and private organizations and the general public.

PASSED BY
CTC
JUL 23 1987
CALIFORNIA
TRANSPORTATION COMMISSION

CTC Policy, October 1980 - Requires Caltrans to examine HOV option for any new freeway or widening project.

October 24, 1980

CALIFORNIA TRANSPORTATION COMMISSION
Policy Statement on Bus and Carpool Lanes

In the planning of any new freeway facility or freeway widening in and around an urban area, Caltrans and/or the regional transportation planning agency shall examine and report to the Commission on the feasibility and potential benefits (both short term and long term of the new project's operation) of designating a bus and carpool lane operation within that project, at least for peak, week-day commute hours. In addition, each such study shall consider the possibility of extension of a bus and carpool lane operation into already existing, adjacent facilities to determine potential advantages of such extensions to the operation of the bus and carpool lane facility within new projects.

The Commission will give serious consideration to the inclusion of at least a commute hour bus and carpool facility in every new freeway or freeway-widening project. The Commission will also give serious consideration to extending such a bus and carpool facility to existing adjacent facilities when it is demonstrated to be feasible and will contribute to the operation of the bus and carpool facility within the new projects.

Reasons for this policy include air pollution benefits, reduced fuel consumption per person trip, and more efficient use of publicly financed capital facilities.

Appendix A-3

FHWA PROCEDURE MEMORANDUM D 6103

FEDERAL HIGHWAY ADMINISTRATION CALIFORNIA DIVISION OFFICE PROCEDURE MEMORANDUM	
SUBJECT: Urban Freeway Reconstruction and HOV Projects	D6103
	Dec. 15, 1987

BACKGROUND

As our freeway systems mature, traffic increase has caused a continued reduction in the level of service. Professional transportation planners and engineers have found that there is no practical way to provide sufficient freeways to accommodate demand. In most urbanized areas, no new freeway corridors are proposed or available, except at extremely high cost. The existing freeway system, therefore, must be operated as efficiently as possible considering the collective publics. One method of increasing existing freeway people-carrying capacity is to increase vehicle occupancy rate. More people can be moved with less energy and less air pollution while saving overall trip time. HOV lanes on urban freeways increase occupancy rates, and can move the equivalent person-trips of at least 3 conventional traffic lanes in peak hours thus often relieving overall congestion on the freeway.

As freeways are reconstructed, opportunities often exist to cost effectively add HOV lanes and thus substantially add people-carrying capacity to the reconstructed freeways. These opportunities should be fully considered in the planning and project development processes.

POLICY

o Regional Transportation Planning Agencies (RTPA) should develop in concert with Caltrans and local agencies, route specific region-wide HOV system plans as a part of the regional transportation plan in metropolitan areas. The RTPA shall have the opportunity to comment on projects which deviate from the HOV system plan.

o An HOV lane shall be an essential alternative for evaluation in the project development process when considering an additional lane by restriping and/or reconstruction or widening on freeways with three or more lanes in one direction.

o Support by the public is an essential factor for a successful HOV facility. It is therefore desirable that a public relations program be incorporated into the project development process for all HOV facilities. This public relations program is necessary to create public awareness and acceptance of the positive attributes of the HOV option in reducing congestion and air pollution.

o Freeway lanes, including HOV lanes, which are added by restriping and/or reconstruction or widening, and all other adjacent lanes and shoulders, shall be constructed to full AASHTO geometric standards except as outlined below under Design Standards.

- o There is a minimum vehicle occupancy criterion of 3 persons per vehicle for HOV facilities. Exceptions to this criterion require FHWA approval.

DESIGN STANDARDS

The AASHTO publication "Guide for the Design of High Occupancy Vehicle and Public Transfer Facilities" gives guidance for design of HOV lanes. In general, lane width should be 12 feet. A 10-foot inside shoulder is desirable. Additional width within the median is encouraged at locations designated for enforcement.

Configurations which use less than full standard lane and shoulder widths require design exceptions. HOV facilities requiring design exceptions are considered staged development and serve as an interim means to relieve existing traffic congestion. When demonstrated effective, plans should be made to provide a standard cross-section to enhance safety and operational characteristics.

When a lane is added, either by restriping and/or reconstruction or widening, to a freeway with 3 or more lanes in one direction, exceptions to the AASHTO geometric standards will be considered in, but not limited to, the following situations:

- o The new lane proposed is an HOV lane.
- o The regional transportation plan includes an HOV system element favorably reviewed by Caltrans and FHWA and the proposed project is consistent with the HOV system element.
- o The regional transportation plan does not yet include a region-wide HOV system; the new lane could be a mixed-flow lane if five years after opening, at the peak commute hour and operating as an HOV lane, the lane would carry fewer person-trips than a mixed-flow lane.

Bruce Cannon

Bruce E. Cannon
Division Administrator

Appendix A-4

STREETS AND HIGHWAYS CODE - SECT. 149

Streets and Highways Code - Authority for Caltrans to Construct HOV Lanes

Section 149. The department may construct exclusive or preferential lanes for buses only or for buses and other high-occupancy vehicles, and may authorize or permit such exclusive or preferential use of designated lanes on existing highways that are part of the State Highway System. Prior to constructing such lanes, the department shall conduct competent engineering estimates of the effect of such lanes on safety, congestion, and highway capacity.

To the extent they are available, the department may apply for and use federal aid funds appropriated for the design, construction, and use of such exclusive or preferential lanes, but may also use other State Highway Account funds, including other federal aid funds, for those purposes where proper and desirable.

This section shall be known and may be cited as the Carrell Act.

Appendix A-5

SURFACE TRANSPORTATION ASSISTANCE ACT - SECTION 167

Surface Transportation Assistance Act of 1982 - Authorizes the department to allow carpool lane use by motorcycles. Motorcycle use may be restricted if the State certifies such use would create a safety hazard.

> Section 167. Notwithstanding any provision of this Act or any other law, no funds shall be appropriated for the construction or resurfacing of Federal aid highways which have lanes designated as carpool lanes unless the use of such lanes includes use by motorcycles. Upon certification by the State to the Secretary of Transportation, the State may restrict such use by motorcycles if such use would create a safety hazard.

Appendix A-6

CALIFORNIA VEHICLE CODES
21655.5 & 21655.6

Exclusive - or Preferential - Use Lanes for High-Occupancy Vehicles

21655.5 The Department of Transportation and local authorities, with respect to highways under their respective jurisdictions, may authorize or permit exclusive or preferential use of highway lanes for high-occupancy vehicles. Prior to establishing the lanes, competent engineering estimates shall be made of the effect of the lanes on safety, congestion, and highway capacity.

The Department of Transportation and local authorities, with respect to highways under their respective jurisdictions, shall place and maintain, or cause to be placed and maintained, signs and other official traffic control devices to designate the exclusive or preferential lanes, to advise motorists of the applicable vehicle occupancy levels, and, except where ramp metering and bypass lanes are regulated with the activation of traffic signals, to advice motorists of the hours of high-occupancy vehicle usage. No person shall drive a vehicle upon those lanes except in conformity with the instructions imparted by the official traffic control devices.

It is the intent of the Legislature, in amending this section, to stimulate and encourage the development of ways and means of relieving traffic congestion on California highways and, at the same time, to encourage individual citizens to pool their vehicular resources and thereby conserve fuel and lessen emission of air pollutants.

Approval of Transportation Planning Agency or County Transportation Commission

21655.6 Whenever the Department of Transportation authorizes or permits exclusive or preferential use of highway lanes for high-occupancy vehicles on any highway located within the territory of a transportation planning agency, as defined in Section 99214 of the Public Utilities Code, or a county transportation commission, the department shall obtain the approval of the transportation planning agency or county transportation commission prior to establishing the exclusive or preferential use of the highway lanes.

If the department authorizes or permits additional exclusive or preferential use of highway lanes for high-occupancy vehicles on that portion of State Highway Route 101 located within the boundaries of the City of Los Angeles, the department shall obtain the approval of the Los Angeles County Transportation Commission by at least a two-thirds majority vote of the entire membership eligible to vote prior to establishing the additional exclusion or preferential use of the highway lanes. For purposes of this section, eight of the 11 voting members constitute a two-thirds majority of the commission.

Pursuant to Section 146 of the federal Surface Transportation Assistance Act of 1982 (P.L. 97-424), the department shall not restrict or require the restriction of the use of any lane on any federal-aid highway in the unincorporated areas of Alameda County to high-occupancy vehicles, exclusive of approaches to controlled access highways, toll roads or bridges.

Appendix A-7

FEDERAL HIGHWAY ACT, TITLE 23, CHAPTER 1 - SECTION 810.102

Federal Highway Act, Title 23, Chapter 1 - Authority for Department of Transportation to approve HOV facilities on Federal Aid Systems to increase the capacity for the movement of persons.

> Section 810.102 Eligible projects.
> Under this subpart the Federal Highway Administrator may approve on any Federal-aid system projects which facilitate the use of high-occupancy vehicles and public mass transportation systems so as to increase the traffic capacity of the Federal-aid system for the movement of persons. Eligible projects include:
>
> > (a) Construction of exclusive or preferential high-occupancy vehicle, truck, or emergency vehicle lanes, except the construction of exclusive or preferential lanes limited to use by emergency vehicles can be approved only on Federal-aid Interstate System;
> > (b) Highway traffic control devices;
> > (c) Passenger loading areas and facilities (including shelters) that are on or serve a Federal-aid system; and
> > (d) Construction or designation of fringe and transportation corridor parking facilities to serve high-occupancy vehicles and/or public mass transportation systems, including rail.

Appendix A-8

PUBLIC RESOURCES CODE - SECTION 25485
and
FHWA Memorandum Deleting 3+ Occupancy Requirement

Public Resources Code, Chapter 5.8 - Requires programs to develop preferential lanes for carpools of at least three or more persons.

> Section 25485. The department shall develop programs and undertake any necessary construction to establish, for the use of carpool vehicles carrying at least three persons, preferential lanes on major freeways in metropolitan areas where the total benefits to the carpool vehicles will bear a reasonable relationship to the total adverse effects on the remaining vehicles, as established on the basis of an engineering study. The department shall also permit such carpool vehicles to have access to preferential bus lanes established on major freeways, unless congestion seriously impeding the travel of buses will result or will present a serious traffic hazard.

rec'd OCT 17 1988

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
REGION NINE
CALIFORNIA DIVISION
P. O. Box 1915
Sacramento, California 95812-1915

ARIZONA
CALIFORNIA
NEVADA
HAWAII
GUAM
AMERICAN SAMOA

October 6, 1988

IN REPLY REFER TO
HPO-CA
File: 520.9

RECEIVED
OCT 1 1988
OFFICE OF PROJECT PLANNING & DESIGN

Mr. Robert K. Best, Director
CALTRANS, 1120 N Street
Sacramento, California 95814

Attention: Federal-aid Branch, Room 3309
for Mr. Richard DeRosa

Dear Mr. Best:

The enclosed September 22 memorandum from our Washington office changes our approval policy regarding HOV-3. We continue to support the highest vehicle occupancy needed to ensure the success of an HOV facility. That determination should evolve through the normal project development phase, and be approved at the Division level.

Sincerely yours,

Michael A. Cook

For
Bruce E. Cannon
Division Administrator

Enclosure

Memorandum

US Department
of Transportation
Federal Highway
Administration

Washington, D.C. 20590

Subject: Criteria for Use of High Occupancy Vehicle (HOV) Facilities

Date: SEP 22 1988

From: Director, Office of Engineering

Reply to Attn of: HNG-14
HTO-34

To: Regional Federal Highway Administrators
Direct Federal Program Administrator

Our February 4, 1985, and March 2, 1987, memorandums provided guidance on FHWA's policy regarding minimum vehicle occupancy criteria for HOV facilities constructed with Federal-aid funds.

We have reviewed our policy requiring a minimum of three persons per vehicle, with the means for exceptions to be granted by either Headquarters or regional offices, and have determined that it is no longer needed. While we continue to support the highest vehicle occupancy needed to ensure the success of an HOV facility, that determination should evolve through the normal project development phase.

The approval of HOV occupancy requirements will now be part of the normal process of FHWA review of proposed projects. The Office of Engineering and the Office of Traffic Operations will continue to provide technical assistance on HOV design and HOV operations, respectively.

Thomas O. Willett

Appendix A-9

EXECUTIVE SUMMARY - HOV SYSTEMS PLANS AS AIR QUALITY CONTROL MEASURES

The complete guidance document and a related document titled *Transportation Performance Standards of the California Clean Air Act,* are available from the California Air Resources Board

CARB Public Information Office
P.O. Box 2815
Sacramento, CA 95812
(916) 322-2990

EXECUTIVE SUMMARY

Traffic congestion is a growing problem in California and across the nation. One way to improve air quality and mobility and reduce fuel consumption is to provide incentives for persons to use regional transportation systems more efficiently. A system of exclusive lanes for high-occupancy vehicles (HOV system) is being recognized as a powerful tool in these efforts.

This guidance focuses on regional HOV system plans as air pollution control measures and recommends that all urban nonattainment areas include an HOV system plan as part of their air quality management plan. This guidance recommends that:

- Freeway and expressway segments that are expected to experience congestion by 2010 form the backbone of a connected HOV lane system.

- New limited access roadways include HOV lanes and, where feasible, adequate right-of-way for rail, express bus, and bikeway facilities.

- Bypass lanes for HOV use be provided at bottlenecks, wherever they will carry more persons at ramps, bridges, tunnels or interchanges.

- Private toll roads and bridges be required to operate under the same carpool definition and vehicle-occupancy standards as public facilities.

- Arterial HOV/bus lanes to improve transit travel times operate during peak periods as links between transit hubs and freeway HOV system.

In summary, it is recommended that HOV system plans provide for a network that is continuous both in time and in space. A comprehensive HOV system plan might include 24-hour HOV median lanes for mainline travel, exclusive transitway with reversible lanes, peak-hour-only HOV lanes that convert back to roadway shoulder or curbside parking, and HOV bypass at bottlenecks.

Generally, to develop the HOV system, new lanes will be added. To fill gaps where lane additional are not feasible, and where traffic studies and public support shows that there is enough demand to justify extending the HOV lane, it is recommended that an existing mixed-flow lane be converted to HOV use.

It is recognized that many areas have initiated and some have completed HOV facility elements. It is recommended that the 1991 air quality plans (AQPs) contain commitments to develop HOV system plans and action programs that specifically address achievement of the transportation performance standards of the California Clean Air Act. The content and timetables for district action are discussed in Chapter X.

New working agreements between transportation and air quality agencies will need to be developed to meet requirements of the state and federal Clean Air Acts. Therefore, this guidance is addressed to all parties responsible for making these decisions.

Appendix A-10

DELEGATION OF AUTHORITY FOR HOV OCCUPANCY DETERMINATION

State of California

Business, Transportation and Housing Agency

Memorandum

To: District Directors
Districts 2-12

Date: December 4, 1989

File:

From: **DEPARTMENT OF TRANSPORTATION**
DIRECTOR'S OFFICE

Subject: DELEGATION OF AUTHORITY FOR HOV OCCUPANCY DETERMINATION

My August 3, 1989 memorandum stated that notwithstanding the Delegation of Authority by my Executive Order dated July 5, 1988; I will be approving any change to occupancy requirements on existing or proposed HOV lanes. I am also retaining approval of decisions regarding vehicle type use of HOV lanes.

for

ROBERT K. BEST
Director

AKennedy:

bcc: LFDeter
CDBartell
AKennedy
GMeis
Ops.
Director's Files

Appendix B

HOV REPORT GUIDELINES

HOV REPORT GUIDELINES

This report is designed specifically as a "stand alone" document to conform with the requirements of Section 149 of the Streets and Highways Code and Section 21655.5 of the Vehicle Code. It is an attachment to the project report to address the effects of the HOV facility on safety, congestion and highway capacity.

I. INTRODUCTION

Describe project area and attach location map. The map should show the HOV system (if any) for the area, including existing HOV lanes, the proposed project and future HOV projects.

II. EXISTING CONDITIONS

Discuss and quantify delay* from recurrent congestion. This information may be obtained from the District's Statewide Highway Congestion Monitoring Program (HICOMP) report. Otherwise, field observations would be necessary to determine vehicle hours of delay.

* Delay is defined as the difference in travel time between the congested speed and 35 mph. Recurrent congestion occurs when speeds are at 35 mph or less on incident-free weekdays during rush hours and last 15 minutes or longer.

III. PROJECT ALTERNATIVES

Describe design and operational details of each alternative, including:

A. Existing Facility -
   1. Typical cross section

B. HOV -
   1. Typical cross section.
   2. Buffer type and width.
   3. Ingress/egress.
   4. Substandard features, if any.
   5. Enforcement areas.
   6. Will the facility operate one or both directions?
   7. What are the operating times?
   8. Minimum vehicles occupancy requirements?
   9. Will motorcycles be allowed?

C. Mixed Flow -
   1. Typical cross section.
   2. Substandard features, if any.

IV. COMPARISON OF ALTERNATIVES

Discuss the effect of each alternative on congestion, capacity and safety. State assumptions and cite references as necessary. Traffic data may be available in PMCS, TASAS, or may be obtained by field measurement.

A. Effect on Congestion/Capacity - (In all cases, projected data shall be based on the volumes anticipated 5 years after opening traffic).

1. Peak Period Volumes. (Show hours used for peak period - AM /PM).

   a. Do Nothing - Show existing and projected peak period volumes for the existing facility.

   b. HOV - Estimate projected peak period volumes based on comparisons with existing similar HOV freeways statewide.

   c. Mixed Flow - Use projected peak period volumes based on the addition of an assumed mixed flow lane.

2. Persons Moved per Peak Period - Existing and Projected.

   a. Do Nothing - Estimate existing vehicle occupancy distribution and multiply by present peak period volumes to equal total number of persons presently moved during the peak period. Repeat using projected peak period volumes for projected number of persons moved per peak period.

   b. HOV - Estimate vehicle occupancy distribution for both mixed flow and HOV lanes by comparing with existing similar HOV freeways statewide. Multiply each factor by projected peak volumes to estimate total # of person moved.

   c. Mixed Flow - Use existing vehicle occupancy distribution and multiply by projected peak period flows for mixed flow option.

3. Peak hour volumes (PHV) and Level of Service (LOS) - (Refer to PMCS and the Highway Capacity Manual).

   a. Do Nothing - Calculated existing and projected LOS using the existing and projected PHV.

   b. HOV - Calculate a projected LOS for the HOV lane, and a projected LOS for the remaining mixed flow lanes, using the projected PHV.

   c. Mixed Flow - Calculate a projected LOS for a mixed flow freeway, using the projected PHV.

B. Effect on Safety

1. Accidents per Million Vehicle Miles (MVM). List actual and/or expected accident rates for each alternative.

   a. Do Nothing - Show actual rate for the 12 months prior to projected opening and expected rates 12 months after projected opening.

   b. HOV - Show expected rate for 12 months after opening by comparing with statewide average.

V. <u>OTHER CONSIDERATIONS</u>

A. Approval of Regional Planning Agencies

B. Approval of FHWA (if required).

C. Compliance with Air Quality Management District (AQMD) Regulations.

VI. <u>SUMMARY AND CONCLUSIONS</u>

A. Discuss the preferred project based on conclusions drawn from data presented.

B. Summary of Results

SAMPLE TABLE

SUMMARY

ALTERNATIVES	DIRECTION/ # LANES	CONGESTION / CAPACITY										SAFETY	
		PEAK PERIOD VOLUMES				PERSONS MOVED/ PEAK PERIOD				LEVEL OF SERVICE (LOS)- PEAK HR		ACCIDENTS/ MILLION VEHICLE MILE (MVM)	
		EXISTING		PROJECTED		EXISTING		PROJECTED		EXISTING	PROJECTED	ACTUAL	EXPECTED
		AM	PM	AM	PM	AM	PM	AM	PM				
DO NOTHING	NB/ 4	22,000	22,000	24,000	24,000	25,300	25,300	27,600	27,600	E	F	.75	.60
	SB/ 4	22,000	22,000	24,000	24,000	25,300	25,300	27,600	27,600	E	F		
HOV	NB/ 4+1			ME 24,000	ME 24,000			ME 26,400	ME 26,400		ME E		.60
				HOV 3,600	HOV 3,600			HOV 7,920	HOV 7,920		HOV B		
	SB/ 4+1			ME 24,000	ME 24,000			ME 26,400	ME 26,400		ME E		
				HOV 3,600	HOV 3,600			HOV 7,920	HOV 7,920		HOV B		
MIXED FLOW	NB/ 5			30,000	30,000			34,500	34,500		F		.60
	SB/ 5			30,000	30,000			34,500	34,500		F		

PEAK PERIOD: AM 6:00 to 9:00
PM 3:00 to 6:00

Notes:

1. Projected data is based on volumes anticipated 5 years after opening to traffic.
2. Peak period varies according to area.
3. Actual and expected rates shown for Accidents/ MVM are yearly rates. Expected rates are based on comparisons with similar freeways.

SUMMARY

ALTERNATIVES	DIRECTION/ # LANES	CONGESTION / CAPACITY										SAFETY	
		PEAK PERIOD VOLUMES				PERSONS MOVED/ PEAK PERIOD				LEVEL OF SERVICE (LOS)- PEAK HR		ACCIDENTS/ MILLION VEHICLE MILE (MVM)	
		EXISTING		PROJECTED		EXISTING		PROJECTED		EXISTING	PROJECTED	ACTUAL	EXPECTED
		AM	PM	AM	PM	AM	PM	AM	PM				
DO NOTHING													
HOV				ME	ME			ME	ME		ME		
				HOV	HOV			HOV	HOV		HOV		
				ME	ME			ME	ME		ME		
				HOV	HOV			HOV	HOV		HOV		
MIXED FLOW													

PEAK PERIOD: AM ________ to ________
PM ________ to ________

Notes:

1. Projected data is based on volumes anticipated 5 years after opening to traffic.
2. Peak period varies according to area.
3. Actual and expected rates shown for Accidents/ MVM are yearly rates. Expected rates are based on comparisons with similar freeways

Appendix C

DEADHEADING APPLICATION FORM

CALIFORNIA DEPARTMENT OF TRANSPORTATION

HOV LANE OCCUPANCY EXEMPTION PERMIT

TR-0013

APPROVAL OF THIS FORM WILL EXEMPT THE APPLICANT FROM THE SIGNED OCCUPANCY REQUIREMENTS OF THE HIGH OCCUPANCY FACILITY FOR A PERIOD OF 2 YEARS AFTER DATE OF APPROVAL. THIS PERMIT MAY BE REVOKED AT ANY TIME AT THE DISCRETION OF THE DEPARTMENT.

NAME OF FIRM: ______________________________

ADDRESS: ______________________________

CITY/ STATE/ ZIP: ______________________________

PHONE: ______________________________

THE APPLICANT MUST PROVIDE THE FOLLOWING INFORMATION FOR EACH FACILITY ON WHICH "DEADHEADING" PRIVILEGES ARE REQUESTED (attach additional sheets as necessary):

1. Will the vehicles that operate in a deadheading mode have a seating capacity of 8 or more? [ ] YES (proceed with this application)
   [ ] NO (if no, this request will be denied.)

2. Identify route and limits of transit service, and show hourly volumes of vehicles operating in a deadheading mode for each direction.

3. Identify ramps with HOV bypass lanes to be used in a deadheading mode. List times and number of vehicles.

4. Number of vehicle identification stickers requested (two per vehicle).

I CERTIFY THAT THE ABOVE INFORMATION IS COMPLETE AND CORRECT.

AUTHORIZED AGENT:

____
PRINT NAME AND TITLE

______________________________ ______________________
SIGNATURE DATE

IF APPROVED, A COPY OF THIS PERMIT MUST BE CARRIED IN THE VEHICLE AT ALL TIMES, AND IS SUBJECT TO SPOT CHECKS. PERMIT STICKERS MUST BE PERMANENTLY AFFIXED TO ASSIGNED VEHICLES AND ARE NON-TRANSFERRABLE. IF THESE PROVISIONS ARE VIOLATED, THIS PERMIT MAY BE REVOKED FOR A 4 - YEAR PERIOD. ANY CHANGES TO THIS PERMIT MUST BE AGREED UPON BY THE DEPARTMENT IN WRITING .

(for State use only)

District Approval -____ YES ____ NO ______________________________ ________
DISTRICT REVIEWER / DATE STICKER # (s)

If NO, reason for denial - ______________________________

Appendix C

WHITE - PERMITTEE YELLOW - DISTRICT OFFICE PINK - HEADQUARTERS

★U.S. GOVERNMENT PRINTING OFFICE: 1991- 282- 65355520