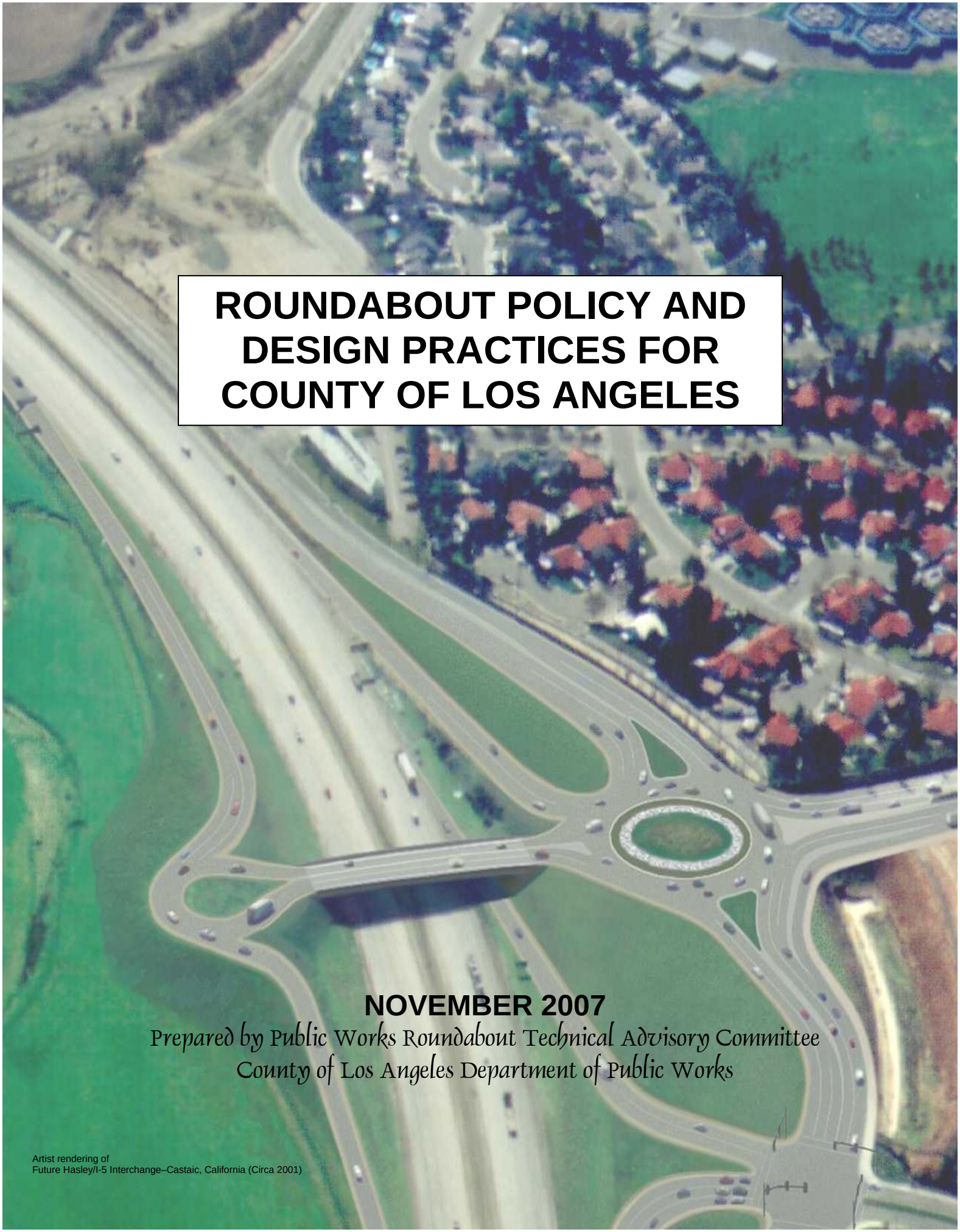
ROUNDABOUT POLICY AND DESIGN PRACTICES FOR COUNTY OF LOS ANGELES



NOVEMBER 2007

Prepared by Public Works Roundabout Technical Advisory Committee
County of Los Angeles Department of Public Works

Artist rendering of
Future Hasley/I-5 Interchange–Castaic, California (Circa 2001)

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ROUNDABOUT POLICY AND DESIGN PRACTICES FOR LOS ANGELES COUNTY

1.0. INTRODUCTION

1.1. Background

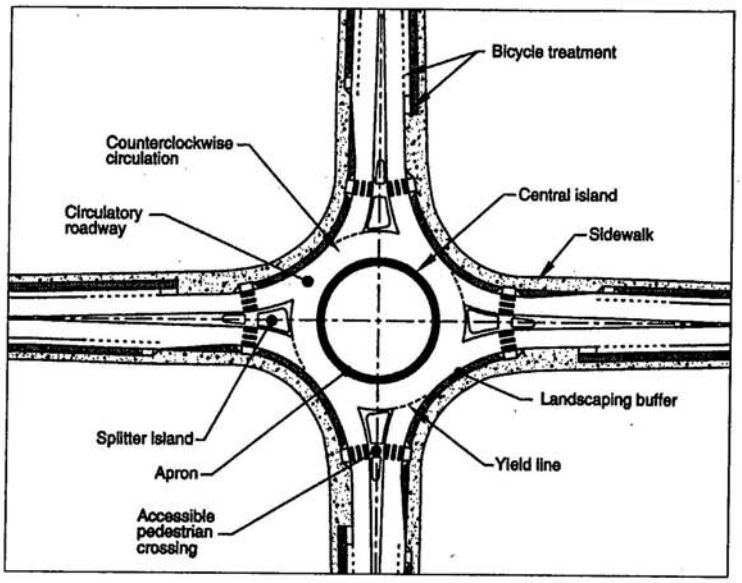
The County of Los Angeles has joined the Federal Highway Administration (FHWA), the State of California, and numerous other state and local jurisdictions nationwide in recognizing the modern roundabout as an intersection type and traffic control treatment capable of providing unique and significant operational and safety benefits over a wide range of traffic volumes and conditions.

Traffic circles in the United States date back to 1905 when Columbus Circle opened in New York City. The "modern roundabout" was developed in the United Kingdom in the 1960s and brought to the United States around 1990. Modern roundabouts were developed to rectify problems associated with traditional traffic circles. Because of the wide ranging acceptance of modern roundabout technology since the turn of the century, the term "roundabout" is now generally used when referring to modern roundabouts. Roundabouts should not be confused with "nonconforming" traffic circles such as neighborhood traffic calming circles, rotaries, circular roadways, etc.

Roundabouts **are circular intersections with specific design and traffic control features. These features include yield control of all entering traffic, channelized approaches utilizing splitter islands, and appropriate curvature to ensure that travel speeds on the circulatory roadway are low. Priority is given to circulating traffic rather than entering traffic.**

Exhibit 1.1 from the FHWA publication "Roundabouts: An Informational Guide" is included to illustrate and define roundabout design features.

Exhibit 1-1. Drawing of key roundabout features.



Splitter islands have multiple roles. They:

- **Separate entering and exiting traffic**
- **Deflect and slow entering traffic**
- **Provide a pedestrian refuge**

Exhibit 1-2. Description of key roundabout features.

Feature	Description
Central island	The *central island* is the raised area in the center of a roundabout around which traffic circulates.
Splitter island	A *splitter island* is a raised or painted area on an approach used to separate entering from exiting traffic, deflect and slow entering traffic, and provide storage space for pedestrians crossing the road in two stages.
Circulatory roadway	The *circulatory roadway* is the curved path used by vehicles to travel in a counterclockwise fashion around the central island
Apron	If required on smaller roundabouts to accommodate the wheel tracking of large vehicles, an *apron* is the mountable portion of the central island adjacent to the circulatory roadway.
Yield line	A *yield line* is a pavement marking used to mark the point of entry from an approach into the circulatory roadway and is generally marked along the inscribed circle. Entering vehicles must yield to any circulating traffic coming from the left before crossing this line into the circulatory roadway.
Accessible pedestrian crossings	*Accessible pedestrian crossings* should be provided at all roundabouts. The crossing location is set back from the yield line, and the splitter island is cut to allow pedestrians, wheelchairs, strollers, and bicycles to pass through.
Bicycle treatments	*Bicycle treatments* at roundabouts provide bicyclists the option of traveling through the roundabout either as a vehicle or as a pedestrian, depending on the bicyclist's level of comfort.
Landscaping buffer	*Landscaping buffers* are provided at most roundabouts to separate vehicular and pedestrian traffic and to encourage pedestrians to cross only at the designated crossing locations. Landscaping buffers can also significantly improve the aesthetics of the intersection.

1.2 Layout of this Document

Section 2, the policy section of this document, defines Public Works' position with respect to the application of roundabout technology by addressing the questions of when roundabouts should be allowed, recommended, or required. The County's approach is similar in nature to that of the FHWA and other jurisdictions. County policy will set forth criteria that when combined with good engineering judgment and actual field conditions generally yield a clear cut decision on whether to allow, encourage, or require the installation of a roundabout.

Section 3 entitled, "Design Criteria" details design criteria that are specific to Los Angeles County and also provides criteria that the County subscribes to from other source documents, primarily the FHWA Roundabout Guide.

This document will not cover all the aspects of policy and design practices and is expected to evolve over time in response to technological improvements and revisions to Federal and state policies and practices. It is intended to be used in conjunction with other key sources identified herein.

The FHWA publication entitled, "Roundabouts: An Informational Guide" (FHWA-RD-00-067) dated June 2000 is referred to throughout this document and will be referred hereon forth as the "FHWA Guide."

Section 4 lists references that Public Works has found to be reliable sources of information regarding design criteria, site selection, and various other topics relating to roundabouts.

The **Appendices** include a single lane roundabout design drawing, typical layouts, a gallery of drawings and example photos of well-designed roundabouts, and other pertinent information.

2.0. ROUNDABOUT POLICY

2.1 Recognition of Importance

The County of Los Angeles recognizes the roundabout as a standard form of intersection control. When constructed in appropriate locations based on criteria contained herein, roundabouts can provide increased efficiency of operation, enhanced safety, cost savings, enhanced aesthetics, and diminished impacts on surrounding property. In all cases, when appropriately applied and properly designed, roundabouts provide one of the safest forms of intersection control due to the creation of a low speed environment and the elimination of conflict points.

It is recognized that roundabouts are not appropriate for all traffic conditions and intersection volumes. Especially in intersection retrofit situations, there are evaluation factors that could lead to decisions against roundabout selection.

2.2 Education/Training

Public Works engineers who are involved with intersection type selection or design should be familiar with the contents of this document. Depending on their level of involvement, additional training opportunities should be pursued ranging from introductory courses aimed at raising awareness and providing criteria for appropriate site selection to more comprehensive courses appropriate for engineers tasked with design and review of roundabouts.

The Department should continue to send appropriate personnel to training courses hosted by other agencies and private firms. In-house training should also be considered when outside courses are not readily available.

Public Works should take a lead role for the County of Los Angeles in the development and use of this emerging technology.

2.3 Reasons to Use or Reject Roundabouts

Intersection type should be determined based on analysis of factors including but not limited to: efficiency of operation, safety, cost, right of way requirements, impacts on the surrounding area, aesthetics, and neighborhood characteristics.

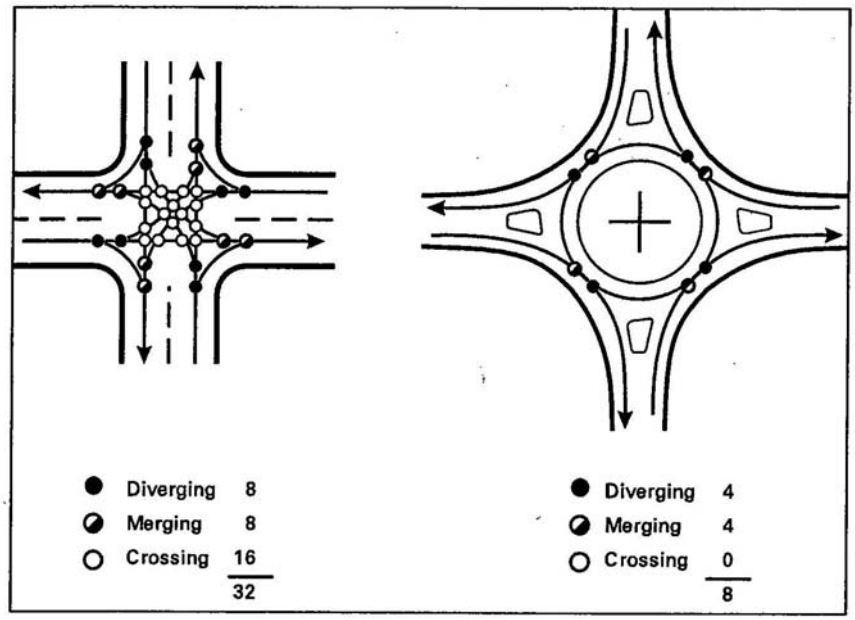
Roundabouts should be considered for the following reasons:

- Efficiency of Operation. Roundabouts operate continuously allowing traffic to move through the intersection whenever gaps are available. For certain traffic volume ranges, roundabouts will operate with greater efficiency than signalized or 4-way stop controlled intersections.

- Safety. Roundabouts cause intersections to be slow speed environments due to their geometric characteristics. They do not depend on traffic regulation to slow down traffic. Roundabouts minimize conflict points and simplify the decision making process for motorists and pedestrians by converting all movements to right turns. (See Exhibit 2-3 from FHWA Roundabout Guide below). Head-on and high speed accidents are substantially reduced. Worldwide and U.S. studies confirm reduction of deaths of about 90%, serious injuries of about 70% and general accident reductions at various levels depending on roundabout size and type when compared to conventional intersections.

Exhibit 2-3. Comparisons of vehicle-vehicle conflict points for intersections with four single-lane approaches.

Types of intersection conflicts.



- Potential Right of Way and Cost Savings. Roundabouts take more right of way at intersections but save right of way on approaches and intervening roads by providing capacity where it is needed. Projects incorporating roundabouts may have a net reduction in right of way requirements and therefore cost savings. This is particularly important where bridge widths can be reduced.

- Aesthetics/Compatibility with Surrounding Community. The central island in a roundabout can be landscaped or decorated (hardscape, water features, etc.) to fit the community and enhance the environment. In some cases, splitter islands may also be landscaped or decorated.

Roundabouts may be rejected for the following reasons:

- Safety and Efficiency of Operation. As traffic volumes increase, the diameter of the circular roadway must also increase allowing higher speeds for circulating traffic. The safety and efficiency diminish with increased speed. As a rule of thumb, roundabouts should not be considered for Average Daily Traffic (ADT) total intersection volumes of 70,000 or greater. For low volume roads (less than 6,000 ADT), the inclusion of a roundabout can decrease efficiency by causing unnecessary slowing and stopping, especially when cross traffic volumes are low in comparison to the primary traffic movement. Roundabouts may still be considered for traffic calming when efficiency is not an important factor.

- Higher Costs. Right of way costs at intersections may exceed cost savings for the approach roads. This is especially true in built up areas where structures or utilities may exist close to intersection corners.

- Right of Way and Surrounding Area Impacts. As mentioned above, impacts from increased right of way requirements at intersections may not be acceptable.

- Steep Grades. Placement of a roundabout on grades greater than 3 percent are generally not recommended. A landing area may be created at 3 percent or less if adequate vertical sight distance is provided.

- Proximity of Signalized Intersections. Signalized intersections in close proximity may cause traffic to back up into the roundabout.

- Pedestrian or Bicycle Traffic. Heavy pedestrian or bicycle traffic could hamper the efficiency of operation.

2.4 Analysis Requirements

2.4.1. Long Term Volume Projections Should be Used. Potential roundabout sites should be evaluated based on long term (20 years or more) traffic volume projections for peak hours. Preferably the projections should result from a build out analysis of the surrounding area. Long term volumes are used in order to identify the ultimate right of way footprint for the project. Interim year volumes can be used to identify interim improvements that are different from the ultimate footprint.

2.4.2. Software Requirements. There are several software products designed to analyze roundabouts. The most popular are ARCADY, RODEL and SIDRA. RODEL is the only analysis program based on empirical data for all ranges of volumes which incorporates user-specified confidence levels.

The County requirement for roundabout analysis and selection of geometric parameters is to use the RODEL program set at the 85 percent confidence level yielding a Level of Service (LOS) of A. A lower level of service (B or C) can be accepted if the operational efficiency is better than that of a conventional intersection alternative or other factors are present to support selection of a roundabout alternative.

2.5 Criteria for Considering Implementation of Multi-lane Roundabouts

The RODEL analysis performed as specified in Section 2.4.2 will determine the lane requirements for each of the legs of the roundabout and within the circular roadway. For moderate (15,000 to 40,000 ADT) to high (40,000 to 70,000 ADT) volumes up to about 70,000 ADT or about 7,000 vehicles per peak hour, properly designed roundabouts will generally operate more efficiently than stop controlled or signalized intersections. The size and complexity increases with volume, and safety benefits diminish. After about 70,000 ADT (depending on distribution between the legs), unless some form of grade separated roundabout is considered, the operation of a signalized intersection may be superior. Note that only traffic entering the roundabout is considered in the analysis described in Section 2.4.2. High right-turn traffic volumes can be removed from consideration by providing bypass lanes, which would increase the right-of-way requirements.

Multi-lane roundabouts would generally involve highways on one or both cross streets. The decision to select a multilane roundabout intersection should be arrived at by weighing the factors discussed in Section 2.3 against other design options. In all cases within the desirable range of volumes for roundabouts, roundabouts will provide greater safety than stop controlled or signalized intersections, and in nearly all cases will provide greater efficiency. Consequently the factors that could weigh heavily toward a conventional alternative usually have to do with higher costs and greater right-of-way requirements often associated with urban settings.

2.6 Criteria for Selecting Single Lane Roundabouts

A single lane roundabout is a roundabout with all single lane legs and one circulating lane. Single lane roundabouts can be selected for one or more of the following reasons:

- Safety–The slow speed environment, minimization of conflict points, and easy decision making makes it safer than stop controlled or signalized intersections.

- Efficiency of Operation–In general, roundabouts will operate more efficiently than 4-way stop controlled or signalized intersections. However, when cross traffic is small in relation to the primary movement (less than 10% as a rule of thumb), a roundabout will slightly increase delay at the intersection by causing unnecessary slowing of the primary traffic movement.

- Traffic Calming–Roundabouts can be used to control speeds by interrupting long road segments. As such, they are a good choice in residential subdivisions where they can be placed in series.

- Aesthetics–The ability to incorporate a variety of acceptable aesthetic designs can enhance the look of a subdivision, thereby providing additional value to developers.

- Cost Savings–A single lane roundabout may suffice for an intersection that would require additional approach lanes if signalized.

2.7 Fire Truck and Truck Accommodation

All roundabouts in the County must be able to accommodate a Van Pelt Tower fire truck including overhangs. No part of the fire truck should encroach within 2 feet of the non-mountable curb line of the central island. The Van Pelt Tower fire truck dimensions and turning template are included as Appendix F.

Roundabouts at highway intersections in general should accommodate STAA Design Vehicle.[1]

3.0 DESIGN CRITERIA

The following section is intended to provide guidance in the design of roundabouts in Los Angeles County and should be used in conjunction with the FHWA Guide. The FHWA Guide will serve as a primary source of technical guidance in the design of roundabouts, except for any additions and deviations noted in this document.

3.1 Pedestrian & Bicyclist Facilities

The design of roundabouts should anticipate the needs of pedestrians and bicyclists. While studies have shown that roundabouts tend to have fewer accidents involving pedestrians and bicyclists, it is imperative that the design addresses all users including the elderly and people with disabilities.

3.1.1 Pedestrian Crossings

The basic recommendations from the FHWA Guide (Section 6.3.7) are as follows:

At single lane approaches and departures, the pedestrian crossing should be located one car length (approximately 25 feet) away from the inscribed circle. At multi-lane approaches and departures, the pedestrian crossing should be located two car lengths (approximately 50 feet) away from the inscribed circle.

[1] STAA stands for "Surface Transportation Assistance Act," which specifies the Federal design vehicle. See Appendix C.

- Splitter Islands should be at least 6 feet wide at pedestrian crossings to accommodate persons pushing strollers or walking bicycles.

- The pedestrian crossing through the splitter island should be designed at street level to avoid the need for curb ramps at the island.

- Curb ramps should be provided at each end of the crosswalk.

- Detectable warning surfaces should be installed at all curb ramps and splitter islands.

3.1.2 Splitter Islands (FHWA Guide – Section 6.3.8)

In general, splitter islands should be provided on all roundabouts to provide refuge for pedestrians, controlling traffic speed, and install traffic signs. Exhibit 6-24 and Exhibit 6-25 in the FHWA Guide shows the design of splitter islands for single lane roundabouts. Exhibit 6-26 in the FHWA Guide illustrates the minimum dimensions of a splitter island.

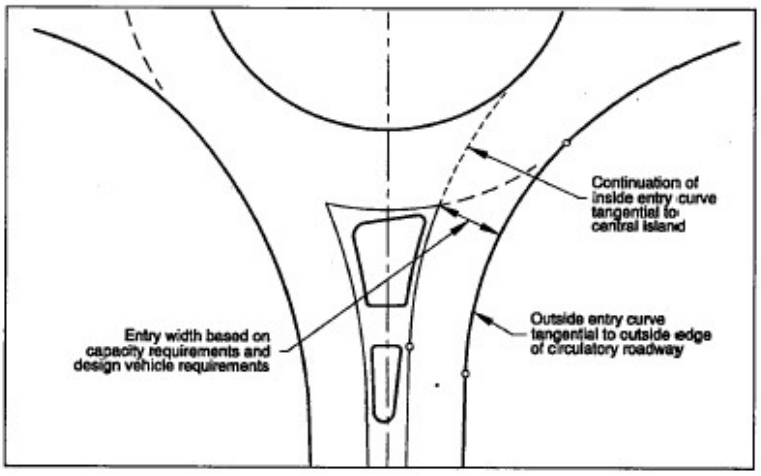
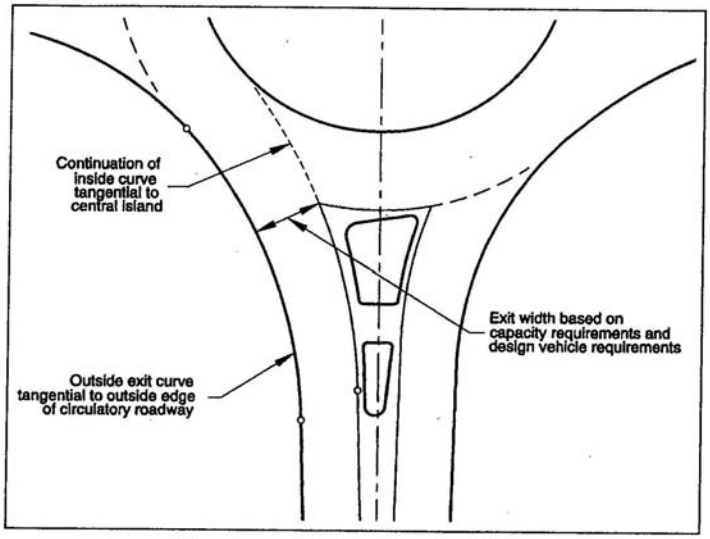


Exhibit 6-24. Single-lane roundabout entry design.

Exhibit 6-25. Single-lane roundabout exit design.



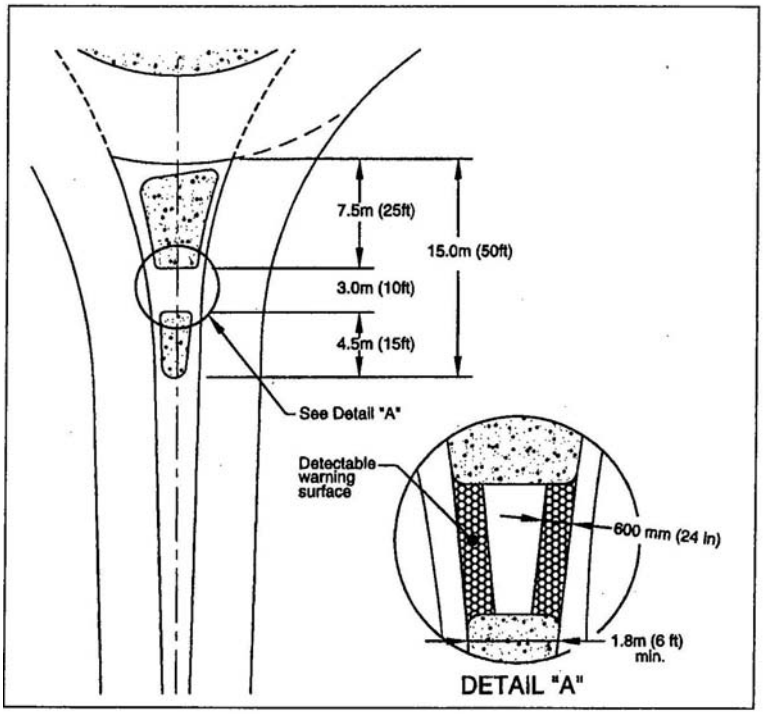
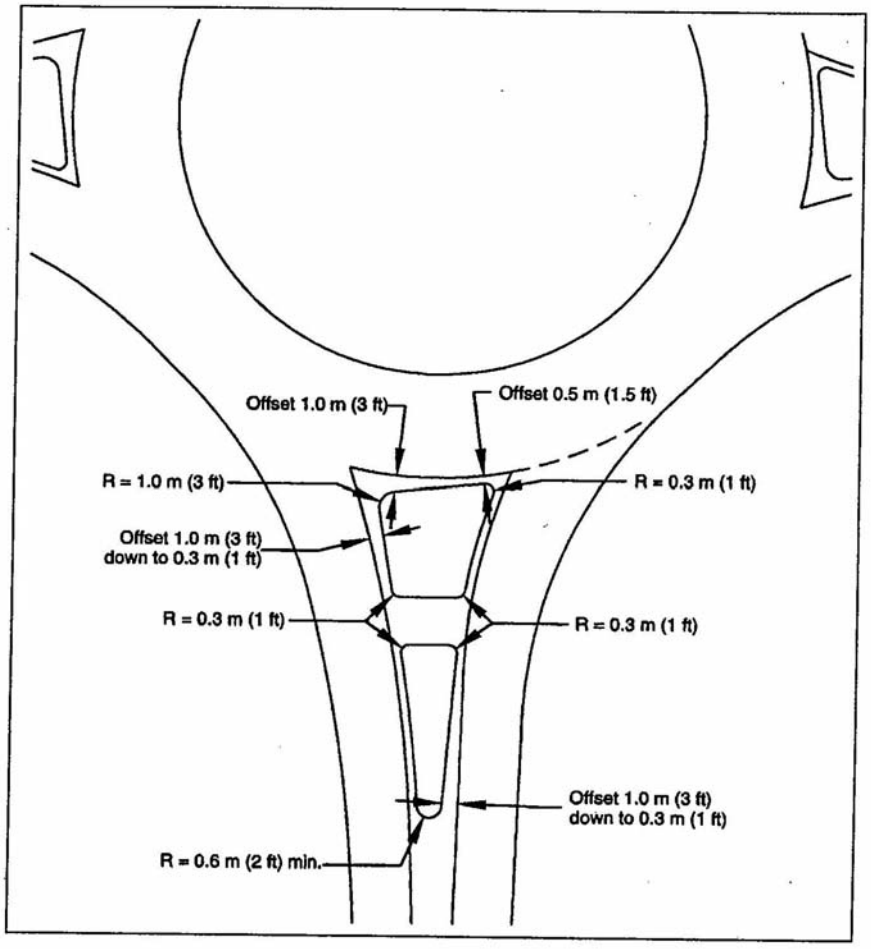


Exhibit 6-26. Minimum splitter island dimensions.

The splitter island pedestrian opening may be angled at the midpoint to create radial crossing.

American Association of State Highways and Transportation Officials (AASHTO) guidelines for island design also apply to splitter island. Exhibit 6-27 in the FHWA Guide shows the minimum nose radii and offsets of splitter islands based on the AASHTO standards.

Exhibit 6-27. Minimum splitter island nose radii and offsets.



3.1.3 Sidewalks

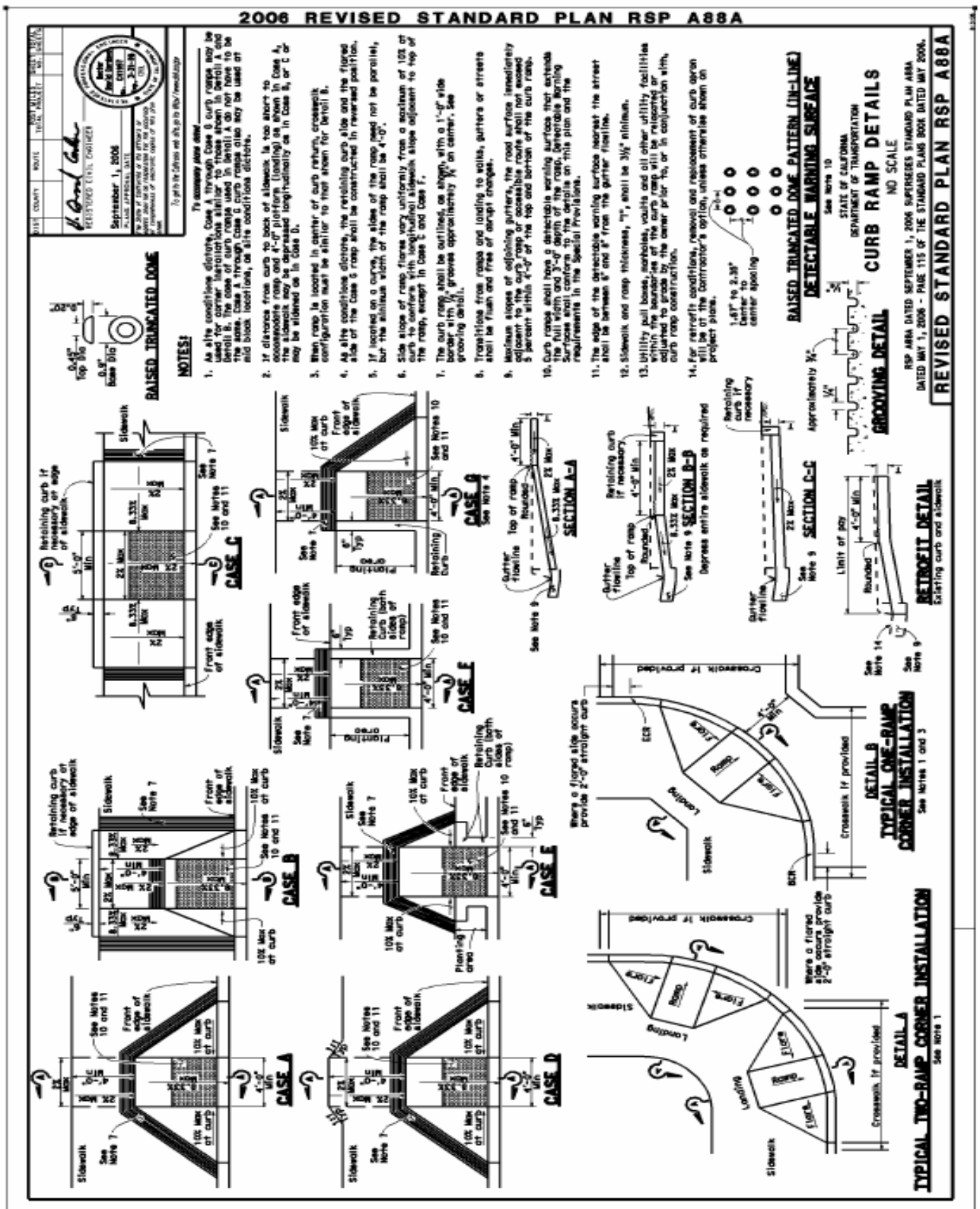
Sidewalks at a roundabout should be set back from the edge of the circular roadway in order to discourage pedestrians from crossing to the center island. The roundabout should be designed so that pedestrians will be guided to cross at the designated crosswalks. A set back area with low shrubs and/or grass planted between the curb and the sidewalk should be provided.

3.1.4. Accommodations for Bicyclists

Bicyclists may share the circular roadway with motorists. Bicyclists using pedestrian facilities should walk their bicycles.

3.1.5 Accommodations for Persons with Disabilities

All pedestrian curb ramps and detectable warning surfaces used in the design of the roundabout should be based on the 2006 Caltrans Standard Plans (RSP A88A).



3.2 Drainage

The inscribed circle of a roundabout should be free of nuisance water and surface flows. To achieve this, the following should be considered:

- The raised central island (with or without landscaping) should have adequate collection, detention, and underground conveyance of water away from the island. This will eliminate standing water by connecting to a drainage system or by expelling water through parkway drains sufficiently down grade of the intersection.

- In general, the circulatory roadway should slope away from the central island at a preferred slope of 2 percent.

- Nuisance water accumulated along the approach roadways shall be confined to the concrete gutter of the outer radii; or shall be collected before the intersection and conveyed through an underground drainage system.

- Drainage inlets should be placed on the approach roads to curb returns.

If nuisance water cannot be diverted before entering the intersection due to profile grades, or other site conditions, the following measures should be taken:

- Construct the intersection with Portland Cement Concrete.

- Provide drainage inlets in the central island (see example photo in Appendix E).

Manhole covers should be placed to minimize the impact on traffic. Placing manhole covers within the central island is preferred.

3.3 Pavement Structural Section

To prevent roadway grade alteration within the circular roadway and approaches (beginning at splitter island noses) due to future pavement rehabilitation, provide a **minimum pavement thickness of 6 inches** on recommended base, to allow for cold-milling and overlay at the same finished grade. Geotechnical and Materials Engineering Division should recommend or approve pavement cross sections.

3.4 Geometric Design

3.4.1 Standard Single Lane Roundabouts

The drawing in Appendix A depicts the design of a single lane roundabout that may be used under the following conditions without further analysis subject to Public Works approval.

- Cross streets form a 90 degree angle. Any deviation from 90 degrees will be at the discretion of Public Works.
- Local and local collector streets only.

The design of multi-lane roundabouts will vary a great deal depending on traffic volumes, field conditions, etc. See Appendices D and E for examples.

3.4.2 Multi-Lane Roundabouts

- The RODEL analysis output will specify key design parameters.
- Example layouts and drawings and photos are provided in Appendices D and E.

3.5 Signage

3.5.1 General

The contractor or developer shall not install signs without the approval of Public Works. Fabrication and application of all signs should be consistent with California Manual on Uniform Traffic Control Devices for Streets and Highways (see Appendix B).

Any developer or contractor proposal for nonstandard signs shall be presented to Public Works well before the required installation date and shall include details for fabrication.

Types and Colors

The above signage requirements pertain to Regulatory signs (white, red), Warning signs (yellow), Guide signs (green, brown, blue), and Construction signs (orange).

3.5.2 Construction Zone Signage

Construction zone signage is normally the responsibility of the contractor or developer unless alternative arrangements have been made.

3.5.3 Visibility

Standard size signs should be used on single lane roundabouts. Oversize signs may be used at locations with visibility concerns or for multi-lane roundabouts. The dimensions of the oversize sign shall be clearly delineated on shop drawings and be subject to the approval of Public Works.

3.5.4 Placement

Approved signage may be situated in advance of the roundabout, within splitter islands, within the central island, and/or outside the inscribed circle. Placement of signs in advance of the roundabout shall be determined to the satisfaction of Public Works based on field conditions.

Splitter islands should have a minimum nose radius of 2 feet to allow for effective placement of required signs.

3.6 Striping

3.6.1 Single Lane Roundabouts

- All striping details for single lane or multi-lane roundabouts shall be consistent with current Caltrans standard specifications.
- A double yellow line (Caltrans Detail 22[2]) or painted island (Caltrans Detail 29[2]) shall precede the splitter island for at least 50 feet.
- The roundabout central island shall have a left edge line next to the traveled way consistent with Caltrans Detail 26[2] with reflectors placed 24 feet apart.
- The width of a single lane roundabout circular roadway measured from the curb line of the central island (mountable curb if truck apron is provided) to the inscribed circle shall be determined using at least the fire truck template to the satisfaction of the Department but in no case shall be less than 20 feet.
- Within the approach splitter island area the minimum lane width shall be 16 feet.

[2] See Appendix B – Excerpts from *California Manual on Uniform Traffic Control Devices for Streets and Highways*.

3.6.2 Multi-Lane Roundabouts

- Striping within the multi-lane circulatory roadway shall have lane line delineation using Caltrans Detail 27C[2], with 4-inch solid white line treatment at locations where cross-over traffic is discouraged.

- A double yellow line (see Caltrans Detail 22[2]) or painted island (see Caltrans Detail 29[2]) shall precede the splitter island for at least 50 feet.

The roundabout central island shall have a left edge line consistent with Caltrans Detail 26[2] with reflectors placed 24 feet apart.

- The lane widths within the circular roadway shall be at least 12 feet with the outside lane a minimum 14 feet.

- For the approaches, the minimum lane width shall be 12 feet for the number one lane and 14 feet for the right curb side lane. Eleven foot lanes can be acceptable for lanes in between. The striping shall be consistent with Caltrans Detail 9[2].

3.7 Bicycle Lanes

Bicycle lanes shall be consistent with intersection treatment in accordance with Caltrans standards with the bicycle users having the option to share the road within the roundabout circle. Bicycle users from trails or bicycle paths that choose to cross the roadway within the crosswalk locations are required to walk the bicycle when using the crosswalk.

3.8 Pavement Markings-Types and Colors

- **Yield lines** shall be broken 12 inch white lines placed along the inscribed circle between the splitter island and the right curb line.

- **Arrow Pavement Markings** shall be placed within multi-lane approaches and multilane circulatory roadway.

- **Directional Arrows** for lane delineation can be used appropriately.

- **12-inch Yellow Chevron/Diagonal Pavement Markings** may be used subject to Public Works' approval within shoulder areas

[2] See Appendix B – Excerpts from *California Manual on Uniform Traffic Control Devices for Streets and Highways*.

at least 5 feet in width adjacent to the central island in place of a textured apron.

- **Pedestrian/Crosswalk Markings**. Ladder crosswalk shall be used for all marked crosswalk locations to the satisfaction of Public Works. The color patterns shall be white on black asphalt for regular crosswalk and yellow on black asphalt for school zone crosswalk.

3.9 Street Lighting

The following requirements and considerations should be addressed:

- The illuminance method should be used to determine the adequacy of the lighting condition.
- Streetlights will be required at the BCR and ECR of the approaches.
- Lighting is required along the inscribed circle at a spacing of 120 feet apart.
- Lighting from within the central island is necessary for any circular roadway 40 feet wide or greater (multi-lane roundabouts). Spacing between lighting poles within this area shall be 110 feet.
- Consideration should be given to the streetlight placement in the vicinity of each approach to the roundabout for overlaps.

3.10 Roundabout Road Maintenance Issues

The following requirements will facilitate accessibility and efficiency of maintenance operations and minimize disruption of traffic operation.

- For roundabouts with truck aprons, the central island outer curb shall be APWA Type B3-100(4), w=12".
- Locations of trees within central island shall be placed in accordance with the following:

  a. Minimum of 6 feet from curb (inner curb if truck apron included).

  b. Minimum of 20 feet from light standards.

  c. Minimum of 10 feet from fire hydrants.

  d. Tree species to be slow growing as approved by Public Works.

4.0 REFERENCES

The following key references were consulted in the preparation of this document. They cover important topics for roundabout designers and individuals who have a role in the selection of roundabouts.

1. "*Roundabouts: An Informational Guide*," U.S. Department of Transportation, Federal Highway Administration Publication No. FHWA-RD-00-067. Available on the Internet at report.center@fhwa.dot.gov. The FHWA Guide covers the whole range of roundabout topics in a comprehensive format. It was formulated from 1997 to 1999 and may be out of date in a few areas. The FHWA Guide is heavily influenced by the "Australian school of thought" and provides little guidance in regard to the design of multi-lane roundabouts, which are best addressed by the technology pioneered in the United Kingdom.

2. *"Roundabout Design Guidelines,"* Ourston Roundabout Engineering (2001). Available on the Internet at mlenters@ourston.com or by mail at Mark S. Lenters, President, Ourston Roundabout Engineering, Inc., 110 Scotia Court, Unit 41, Whitby, Ontario Canada L1N8Y7. Based on British publication, "*Geometric Design of Roundabouts*" it was adapted for use in the US by Leif Ourston, P.E. It covers principles associated with geometric design.

3. "*Revised Design Information Bulletin 80-Roundabouts*," State of California Department of Transportation (Caltrans) dated October 3, 2003, available on the Internet at http://www.dot.ca.gov/hq/oppd/dib/dibprg.htm. This document presents Caltrans roundabout policy and should be consulted for roundabouts on the State highway system.

4. "*Roadway Lighting Design Guide,*" Chapter 7 entitled "Roundabouts," Amercian Association of State Highway and Transportation Officials (AASHTO) dated October 2005. Available through AASHTO.

5. "*Internationally Recognized Roundabout Signs*," Paper for the Transportation Research Board National Roundabout Conference, Vail, CO. May 22-25, 2005, dated March 24, 2005. Available at Public Works. Contact Phil Weber, P. Eng. (philweber@roundabouts.com or [416] 703-2612 x228) and Scott Retchie, P.E., (scott@roundabouts.us or [530] 550-1181) with any questions.

6. "*Appendix B, Approved Roundabout Sections Proposed for 2008 MUTCD*," National Committee on Uniform Traffic Control Devices Regulatory and Warning Sign TC (Technical Committee) dated January 19, 2006. This reference includes layout drawings of various roundabout types illustrating good geometric design. It has not been adopted but is a good source of information on signage and marking practices. Copies are available at Public Works.

5.0 ACKNOWLEDGEMENTS/CONTACTS

5.1 Document Preparation Team

The following members of the Roundabout Technical Advisory Committee contributed to the formulation of this document:

Farhad Agahi – Design Division
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John Kelly - Administration
Sree Kumar – Design Division
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5.2 Special Acknowledgement

Public Works would like to acknowledge and thank the following individuals for providing guidance and/or materials employed in the formulation of this document.

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A special thank you to Leif Ourston, P.E., who has propagated and taught excellent roundabout design practices and inspired a generation of roundabout designers.

A special thank you to Linda Ayers, Land Development Division, for assembling and formatting this document for publication.

5.3 Questions

For any questions, please contact Mr. Andy Narag at (626) 458-5916 or anarag@dpw.lacounty.gov or Sam Richards at (626) 458-4921 Ext. 3835 or srich@dpw.lacounty.gov.

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APPENDIX A

Standard Single Lane Roundabout Drawing

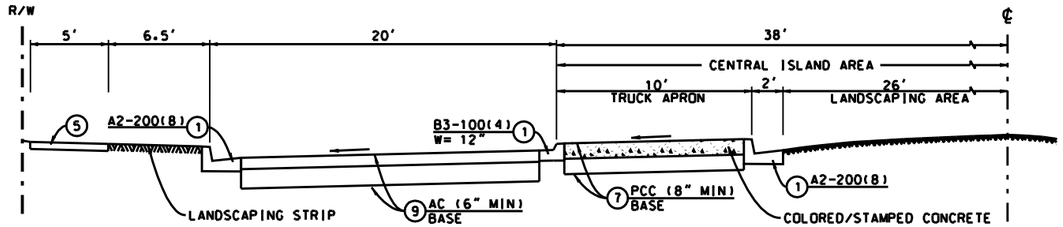
CONSTRUCTION LEGEND

(1) PORTLAND CEMENT CONCRETE CURB AND GUTTER PER APWA STANDARD 120-1, 121-1

(5) PORTLAND CEMENT CONCRETE SIDEWALK, (4" THICK)

(7) PORTLAND CEMENT CONCRETE PAVEMENT ON BASE MATERIAL

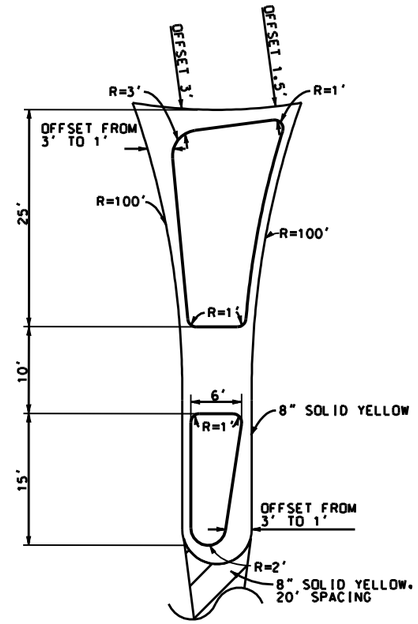
(9) ASPHALT CONCRETE PAVEMENT ON BASE MATERIAL



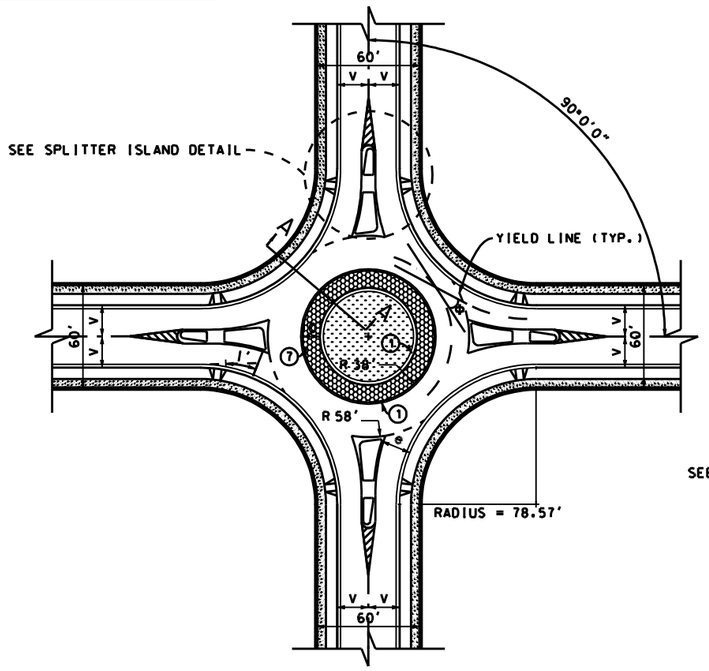
SECTION A-A
N.T.S.

e = ENTRY WIDTH
r = ENTRY RADIUS
v = APPROACH HALF WIDTH
l' = AVERAGE EFFECTIVE FLARE LENGTH
Φ = ENTRY ANGLE

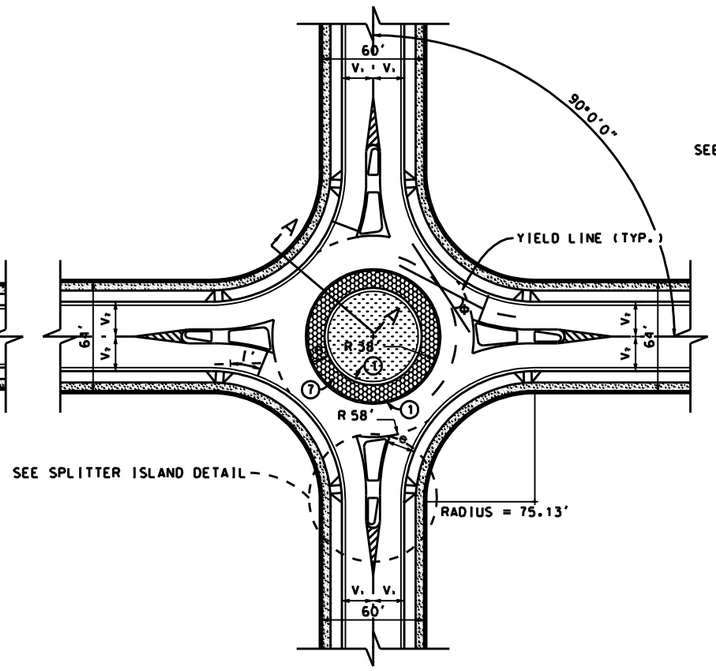
RECOMMENDED VALUES	
e	16' MIN
Φ	30°



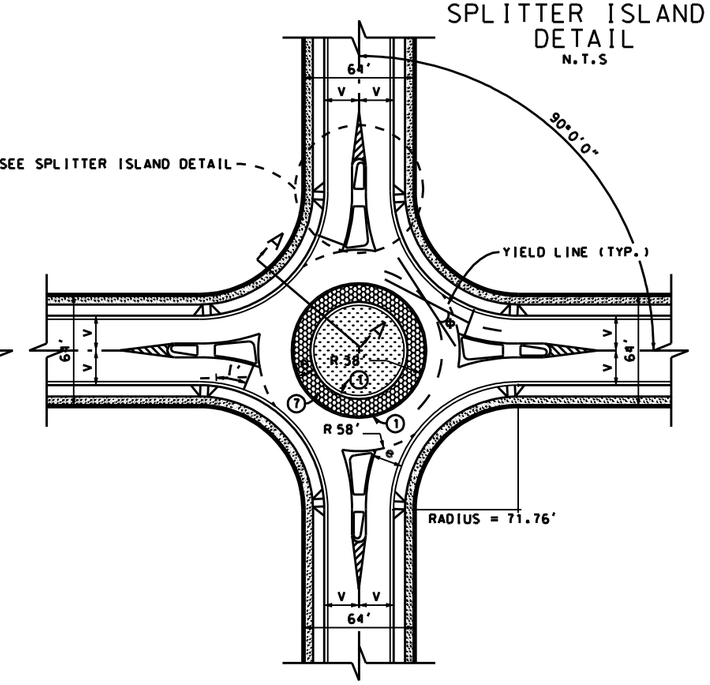
SPLITTER ISLAND DETAIL
N.T.S



PLAN VIEW
(V=18')
SCALE: 1" = 40'



PLAN VIEW
(V₁=18', V₂=20')
SCALE: 1" = 40'



PLAN VIEW
(V=20')
SCALE: 1" = 40'

DRAFTER	DESIGNER	CHECKER	CADD PROJECT FILE NAME	REVIEWED BY	DATE

DATE: $DATE$ TIME: $TIME$ FILE: $FILE$

APPENDIX B

Excerpts from CALIFORNIA MANUAL on UNIFORM TRAFFIC CONTROL DEVICES for STREETS AND HIGHWAYS

California
Manual on Uniform
Traffic Control Devices
for Streets and Highways
**(FHWA's MUTCD 2003 Edition,
as amended for use in California)**

STATE OF CALIFORNIA
BUSINESS, TRANSPORTATION AND HOUSING AGENCY
DEPARTMENT OF TRANSPORTATION

STATE OF CALIFORNIA
BUSINESS, TRANSPORTATION AND HOUSING AGENCY
DEPARTMENT OF TRANSPORTATION

California
Manual on Uniform
Traffic Control Devices
for Streets and Highways
**(FHWA's MUTCD 2003 Edition,
as amended for use in California)**

Issued by:

DIVISION OF TRAFFIC OPERATIONS

September 26, 2006

ARNOLD SCHWARZENEGGER
Governor

SUNNE WRIGHT McPEAK
Secretary, Business, Transportation and Housing Agency

WILL KEMPTON
Director, Department of Transportation

California
Manual on Uniform Traffic Control Devices
for Streets and Highways
**(FHWA's MUTCD 2003 Edition,
as amended for use in California)**

PART 3
Markings

STATE OF CALIFORNIA
BUSINESS, TRANSPORTATION AND HOUSING AGENCY
DEPARTMENT OF TRANSPORTATION

PART 3. MARKINGS

TABLE OF CONTENTS

CHAPTER 3A. GENERAL

Section 3A.01 Functions and Limitations

Support:

Markings on highways have important functions in providing guidance and information for the road user. Major marking types include pavement and curb markings, object markers, delineators, colored pavements, barricades, channelizing devices and islands. In some cases, markings are used to supplement other traffic control devices such as signs, signals and other markings. In other instances, markings are used alone to effectively convey regulations, guidance, or warnings in ways not obtainable by the use of other devices.

Markings have limitations. Visibility of the markings can be limited by snow, debris, and water on or adjacent to the markings. Marking durability is affected by material characteristics, traffic volumes, weather, and location. However, under most highway conditions, markings provide important information while allowing minimal diversion of attention from the roadway.

Pavement markings can enhance roadway delineation with the addition of audible and tactile features such as bars, differential surface profiles, raised pavement markers, or other devices intended to alert the road user that a delineation on the roadway is being traversed.

The general functions of longitudinal lines are:

A. A double line indicates maximum or special restrictions,
B. A solid line discourages or prohibits crossing (depending on the specific application),
C. A broken line indicates a permissive condition, and
D. A dotted line provides guidance.

Section 3A.02 Standardization of Application

Standard:

Each standard marking shall be used only to convey the meaning prescribed for that marking in this Manual. When used for applications not described herein, markings shall conform in all respects to the principles and standards set forth herein.

Guidance:

Before any new highway, paved detour, or temporary route is opened to traffic, all necessary markings should be in place.

Standard:

Markings that are no longer applicable for roadway conditions or restrictions and that might cause confusion for the road user shall be removed or obliterated to be unidentifiable as a marking as soon as practical. Markings that must be visible at night shall be retroreflective unless ambient illumination assures that the markings are adequately visible. All markings on Interstate highways shall be retroreflective.

Option:

Markings may be temporarily masked with tape until they can be removed or obliterated.

Standard:

All longitudinal pavement markings shall be retroreflective except non-reflective pavement markers and directional markings for tourists. Refer to CVC 21374.

Guidance:

If used, the masking tape should match the pavement surface color and not provide undue contrast.

Support:

Use of black tape for temporary "masking" is effective for new Asphalt Concrete pavement. However, for faded Asphalt Concrete pavement or Portland Cement Concrete pavements, black "masking" pavement markings could appear as a stripe in low light conditions and result in confusion to road users.

Section 3A.03 Materials

Support:

Pavement and curb markings are commonly placed by using paints or thermoplastics; however, other suitable marking materials, including raised pavement markers and colored pavements, are also used.

Delineators, object markers, barricades, and channelizing devices are visibly placed in a vertical position similar to signs above the roadway.

Guidance:

The materials used for markings should provide the specified color throughout their useful life.

Consideration should be given to selecting pavement marking materials that will minimize tripping or loss of traction for pedestrians and bicyclists.

Object markers and delineators should not present a vertical or horizontal clearance obstacle for pedestrians.

Section 3A.04 Colors

Standard:

Markings shall be yellow, white, red, green or blue. The colors for markings shall conform to the standard highway colors. Black in conjunction with one of the above colors shall be a usable color.

The color of curb markings shall conform to CVC 21458. Refer to CVC 21374 for exceptions.

When used, white markings for longitudinal lines shall delineate:

A. The separation of traffic flows in the same direction.

B. The right edge of the roadway.

When used, yellow markings for longitudinal lines shall delineate:

A. The separation of traffic traveling in opposite directions.

B. The left edge of the roadways of divided and one-way highways and ramps.

C. The separation of two-way left turn lanes and reversible lanes from other lanes.

When used, red raised pavement markers shall delineate roadways that shall not be entered or used.

Support:

Red pavement markers are used to alert possible wrong way drivers on freeways as shown in Figure 3A-102(CA), Details 14 and 14A.

When used, blue markings shall supplement white markings for parking spaces for persons with disabilities. When used, blue raised pavement markers shall indicate locations of fire hydrants along a roadway.

Option:

Black may be used in combination with the above colors where a light-colored pavement does not provide sufficient contrast with the markings.

A 75 mm (3 in) black line may be placed between the 100 mm (4 in) wide yellow lines on streets and highways under local jurisdiction.

Standard:

A 75 mm (3 in) black line shall be placed between the 100 mm (4 in) wide yellow lines on State highways.

Support:

When used in combination with other colors, black is not considered a marking color, but only a contrast-enhancing system for the markings.

Section 3A.05 Widths and Patterns of Longitudinal Pavement Markings

Standard:

The widths and patterns of longitudinal lines shall be as follows:

A. A normal line is 100 to 150 mm (4 to 6 in) wide.

B. A wide line is at least twice the width of a normal line. The width of the line indicates the degree of emphasis.

C. A double line consists of two parallel lines separated by a discernible space.

D. A broken line consists of normal line segments separated by gaps.

E. A dotted line shall consist of noticeably shorter line segments separated by shorter gaps than used for a broken line. The width of a dotted line shall be at least the same as the width of the line it extends.

Guidance:

Broken lines should consist of 3 m (10 ft) line segments and 9 m (30 ft) gaps, or dimensions in a similar ratio of line segments to gaps as appropriate for traffic speeds and need for delineation.

Option:

A dotted line for line extensions may consist of 0.6 m (2 ft) line segments and 0.6 m (2 ft) to 1.8 m (6 ft) gaps. A dotted line for lane drop/add markings may consist of 0.9 m (3 ft) line segments and 2.7 m (9 ft) gaps.

Standard:

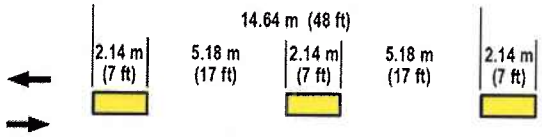
The widths and patterns of longitudinal lines shall conform to the details shown in Figures 3A-101(CA) through 3A-112(CA).

(This space left intentionally blank)

Figure 3A-101 (CA). Centerlines - 2 Lane Highways

FOR SPEEDS 65 km/h (40 mph) OR LESS

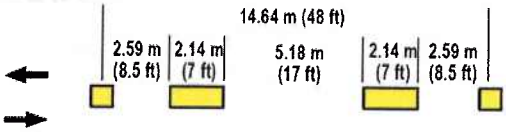
DETAIL 1



POLICY

Centerline pattern for use on two-lane streets and highways (normally used on local streets and highways).

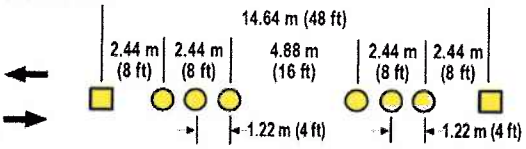
DETAIL 2



Centerline pattern with pavement markers for use on two-lane streets and highways.

DETAIL 3
(Deleted)

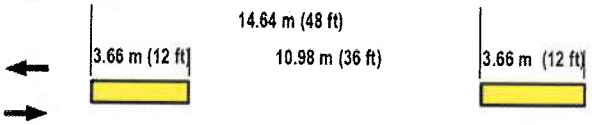
DETAIL 4



Alternate to Detail 2. For use at problem locations where it is difficult to place and maintain centerline because of moisture, sand, etc.

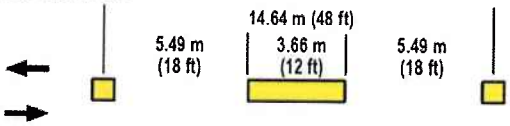
FOR SPEEDS 70 km/h (45 mph) OR MORE

DETAIL 5



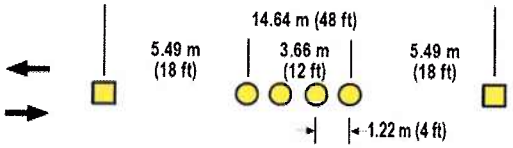
Centerline pattern for use on two-lane streets and highways (normally used on local streets and highways).

DETAIL 6



Centerline pattern with pavement markers for use on two-lane streets and highways.

DETAIL 7



Alternate to Detail 6. For use at problem locations where it is difficult to place and maintain centerline because of moisture, sand, etc.

LEGEND

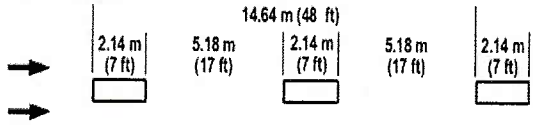
100 mm (4 in) Yellow
Two-Way Yellow Retroreflective Markers
Direction of Travel
Non-Retroreflective Yellow Markers

NOT TO SCALE

Figure 3A-102 (CA). Lane Lines - Multilane Highways

FOR SPEEDS 65 km/h (40 mph) OR LESS

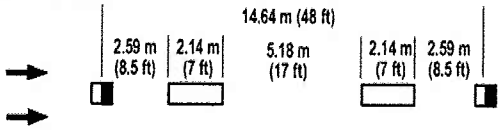
DETAIL 8



POLICY

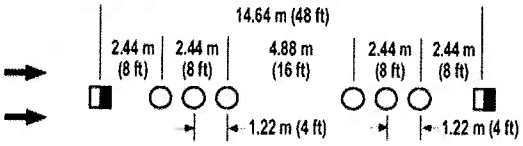
Lane Line pattern for use on multilane streets and highways (normally used on local streets and highways).

DETAIL 9



Lane Line pattern with pavement markers for use on multilane streets, highways and freeway ramps.

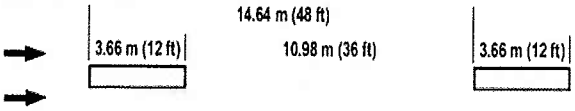
DETAIL 10



Lane Line pattern with pavement markers for use on multilane streets, highways and freeway ramps.

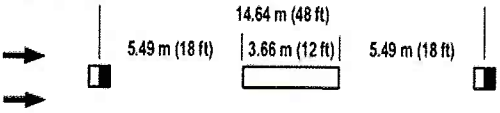
FOR SPEEDS 70 km/h (45 mph) OR MORE

DETAIL 11



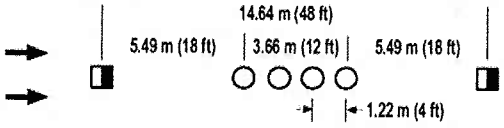
Lane Line pattern for use on multilane streets and highways (normally used on local streets and highways).

DETAIL 12



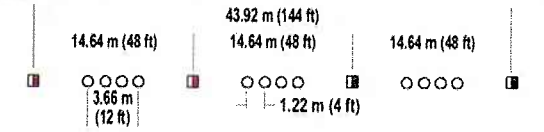
Lane Line pattern with pavement markers for use on multilane conventional streets and highways, State freeways, expressways, freeway ramps, freeway to freeway connectors and collector roads. See Detail 14A.

DETAIL 13

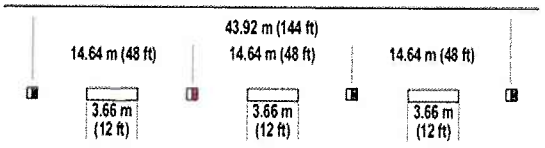


Lane Line pattern with pavement markers for use on State freeways, expressways, freeway ramps, freeway to freeway connectors and collector roads. See Detail 14.

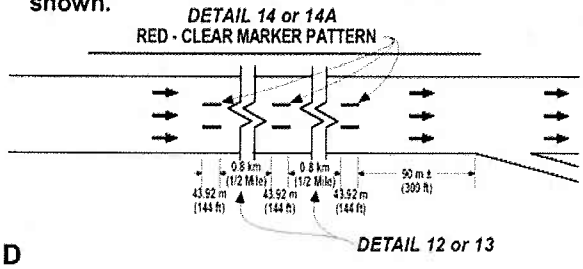
DETAIL 14



DETAIL 14A



Lane Line pattern with red-clear pavement markers shall be used on freeways approaching exit ramps. Detail 14 is used with Detail 13 and Detail 14A is used with Detail 12, in a pattern of four red-clear pavement markers, at intervals as shown.



LEGEND

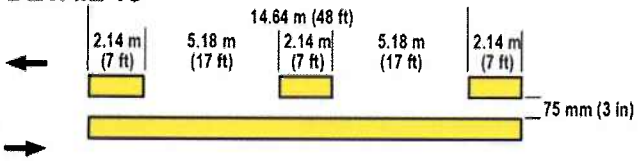
100 mm (4 in) White — One-Way Clear Retroreflective Markers — Non-Retroreflective White Markers

Direction of Travel — Red-Clear Retroreflective Markers — NOT TO SCALE

Figure 3A-103 (CA). No Passing Zones - One Direction

FOR SPEEDS 65 km/h (40 mph) OR LESS

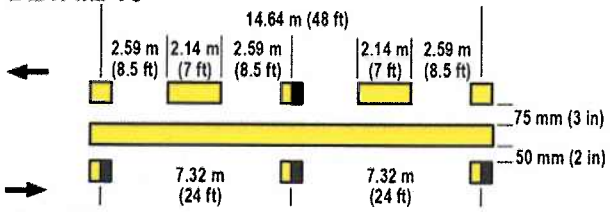
DETAIL 15



POLICY

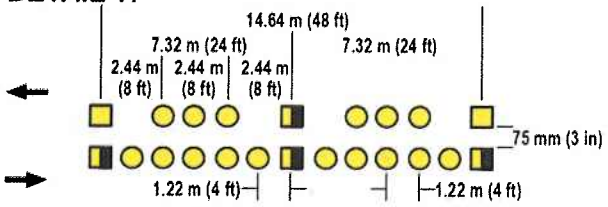
One direction no-passing pattern for use on two-lane streets and highways (normally used on local streets and highways). See Note 2.

DETAIL 16



One direction no-passing pattern with pavement markers for use on two-lane streets and highways. See Notes 1 and 2.

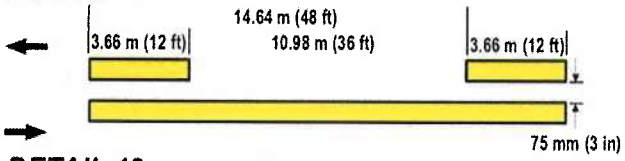
DETAIL 17



Alternate to Detail 16. For use with Detail 4.

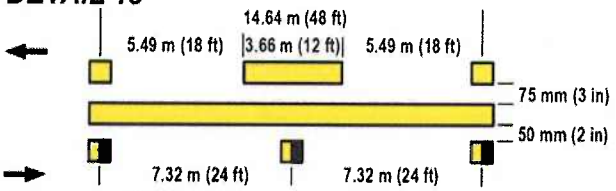
FOR SPEEDS 70 km/h (45 mph) OR MORE

DETAIL 18



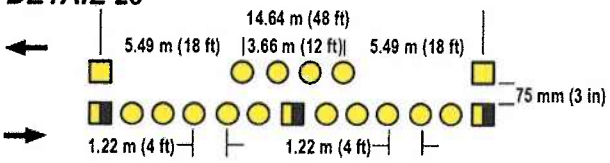
One direction no-passing pattern for use on two-lane streets and highways (normally used on local streets and highways). See Note 2.

DETAIL 19



One direction no-passing pattern with pavement markers for use on two-lane streets and highways. See Notes 1 and 2.

DETAIL 20



Alternate to Detail 19. For use with Detail 7.

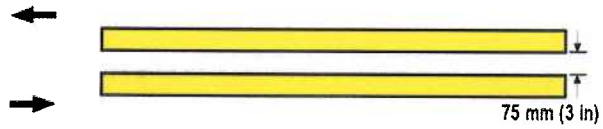
NOTES: 1. Pavement markers shown off the solid line in Details 16 and 19 may be placed on the line.
2. A 75 mm (3 in) black line shall be placed between the 100 mm (4 in) yellow lines on State highways and may be placed on streets and highways under local jurisdiction.

LEGEND

100 mm (4 in) Yellow
Direction of Travel
Two-Way Yellow Retroreflective Markers
One-Way Yellow Retroreflective Markers
Non-Retroreflective Yellow Markers
NOT TO SCALE

Figure 3A-104 (CA). No Passing Zones - Two Direction

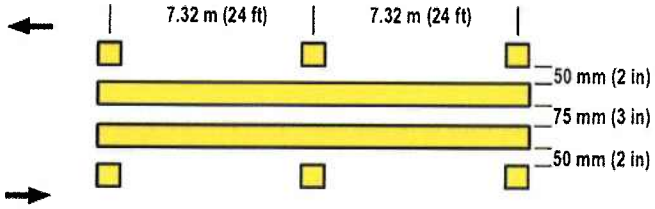
DETAIL 21



POLICY

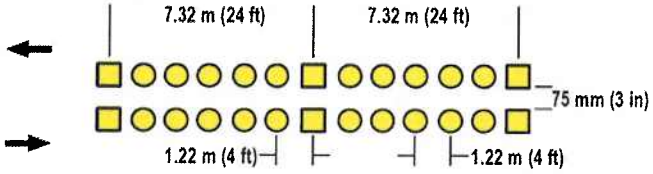
Two-direction no-passing pattern for use on two-lane streets and highways (normally used on local streets and highways). See Note 2.

DETAIL 22



Two-direction no-passing pattern with pavement markers for use on two-lane streets and highways. See Notes 1 and 2.

DETAIL 23



Alternate to Detail 22. For use with either Detail 4 or Detail 7.

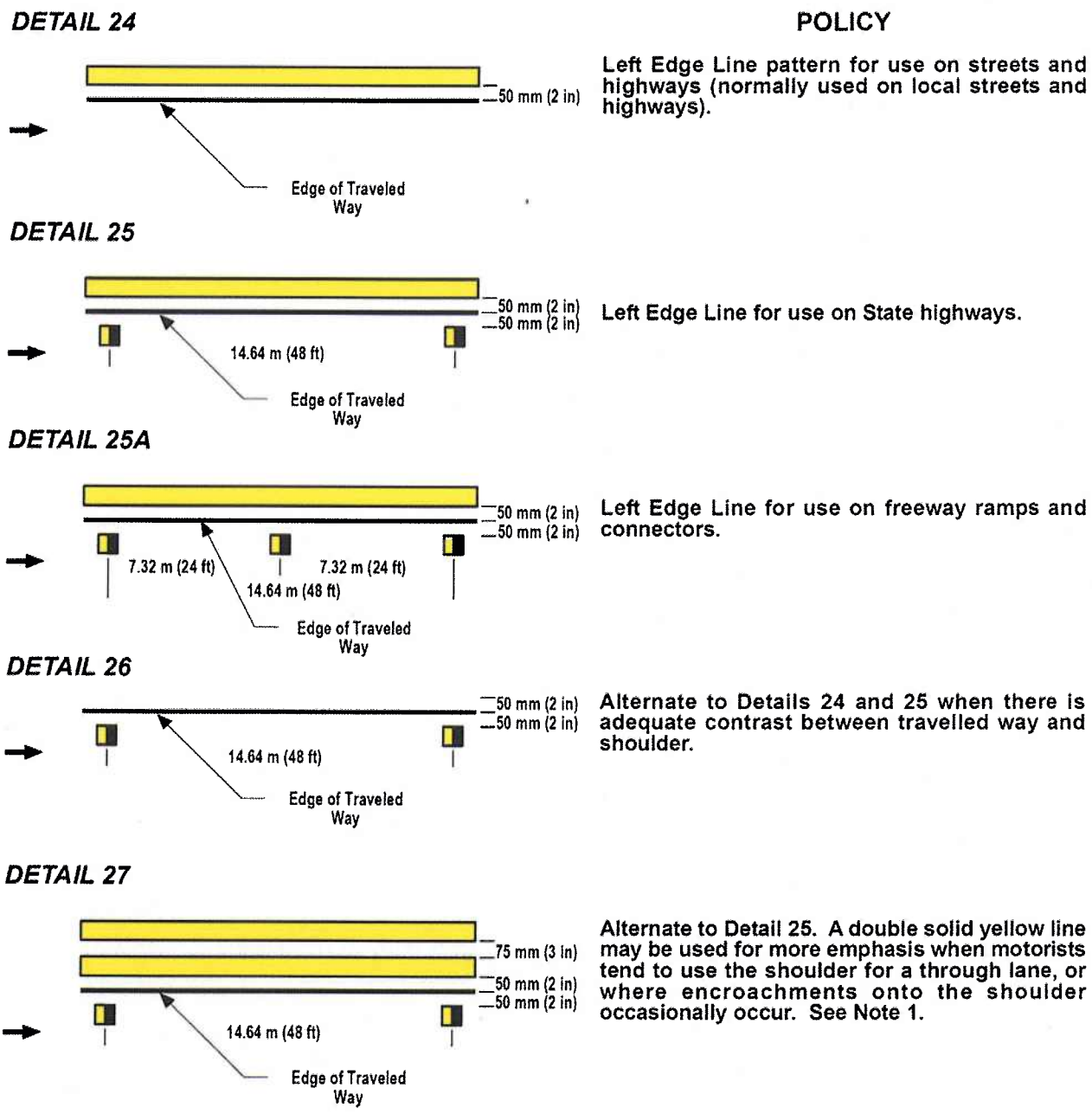
NOTES: 1. Pavement markers shown off the solid line in Detail 22 may be placed on the line.
2. A 75 mm (3 in) black line shall be placed between the 100 mm (4 in) yellow lines on State highways and may be placed on streets and highways under local jurisdiction.

LEGEND

- 100 mm (4 in) Yellow
- Two-Way Yellow Retroreflective Markers
- Direction of Travel
- Non-Retroreflective Yellow Markers

NOT TO SCALE

Figure 3A-105 (CA). Left Edge Lines for Divided Highways



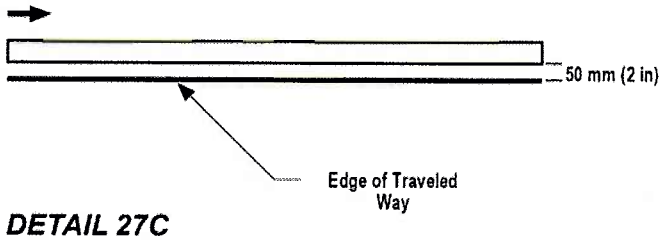
NOTE: 1. A 75 mm (3 in) black line shall be placed between the 100 mm (4 in) yellow lines on State highways and may be placed on streets and highways under local jurisdiction.

LEGEND

100 mm (4 in) Yellow — One-Way Yellow Retroreflective Markers
Direction of Travel — NOT TO SCALE

Figure 3A-106 (CA). Right Edge Line and Right Edge Line Extension Through Intersections

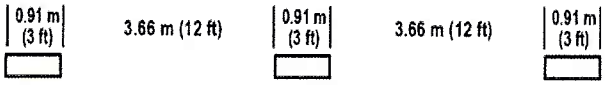
DETAIL 27B
Right Edge Line



POLICY

Right Edge Line pattern for use on all State highways may be used on local streets and highways. It is generally dropped at the beginning of the intersection flares on conventional highways. See also Detail 27C. On freeways, it may be flared in advance of the exit ramp as shown in Figure 3B-8 (CA).

DETAIL 27C
Right Edge Line Extension Through Intersections



Right Edge Line Extension Through Intersections pattern for use to extend the right edgeline through an intersection where climatic conditions, such as areas of heavy fog, may require additional guidance.

LEGEND

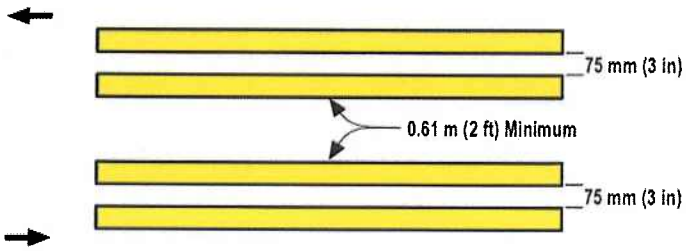
100 mm (4 in) White — Direction of Travel

NOT TO SCALE

(This space left intentionally blank)

Figure 3A-107 (CA). Median Islands

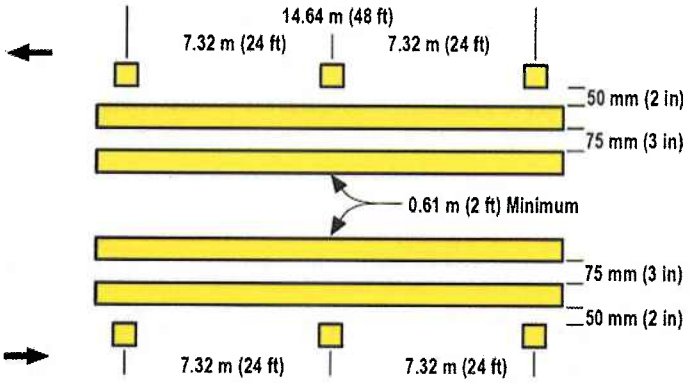
DETAIL 28



POLICY

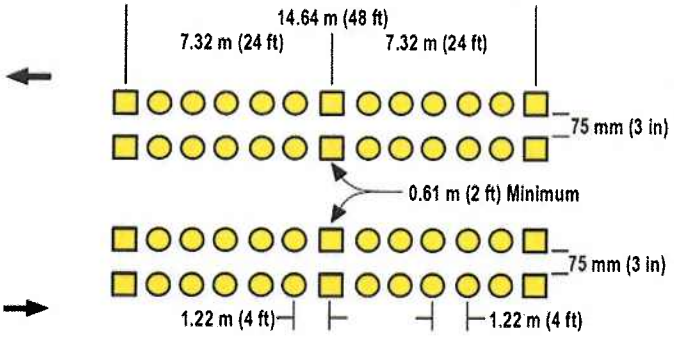
Double Left Edge Line pattern for use on all-paved sections of streets and highways (normally used on local streets and highways). See Note 2.

DETAIL 29



Double Left Edge Line pattern with pavement markers for use on all-paved sections of streets and highways. See Notes 1 and 2.

DETAIL 30



Alternate to Detail 29. For use at problem locations where it is difficult to place and maintain lines because of moisture, sand, etc.

NOTES: 1. Pavement markers shown off the solid line in Detail 29 may be placed on the line.
2. A 75 mm (3 in) black line shall be placed between the 100 mm (4 in) yellow lines on State highways and may be placed on streets and highways under local jurisdiction.

LEGEND

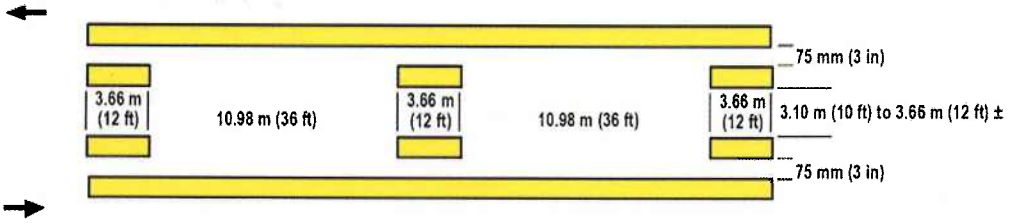
100 mm (4 in) Yellow
Direction of Travel
Two-Way Yellow Retroreflective Markers
Non-Retroreflective Yellow Markers

NOT TO SCALE

Figure 3A-108 (CA). Two-Way Left-Turn Lanes

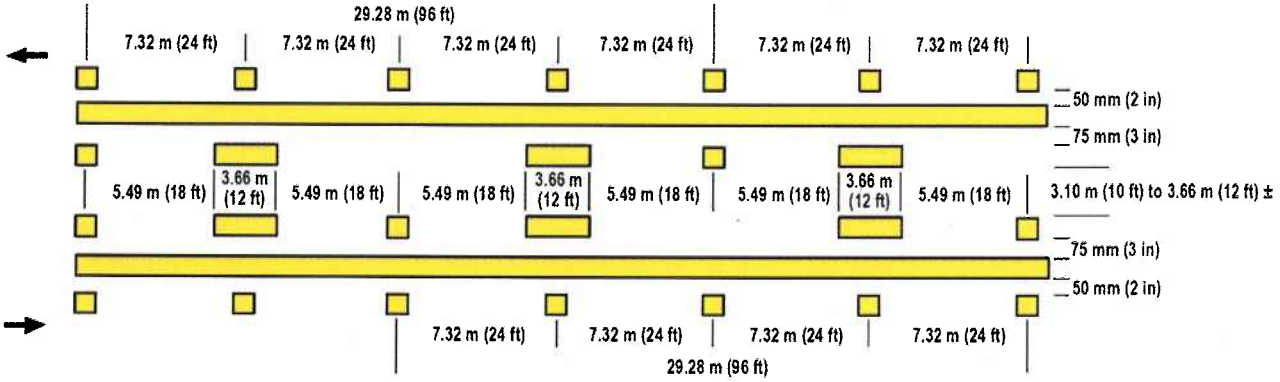
DETAIL 31 **POLICY**

Two-way left-turn lane pattern for use on streets and highways (normally used on local streets and highways). See Note 2.



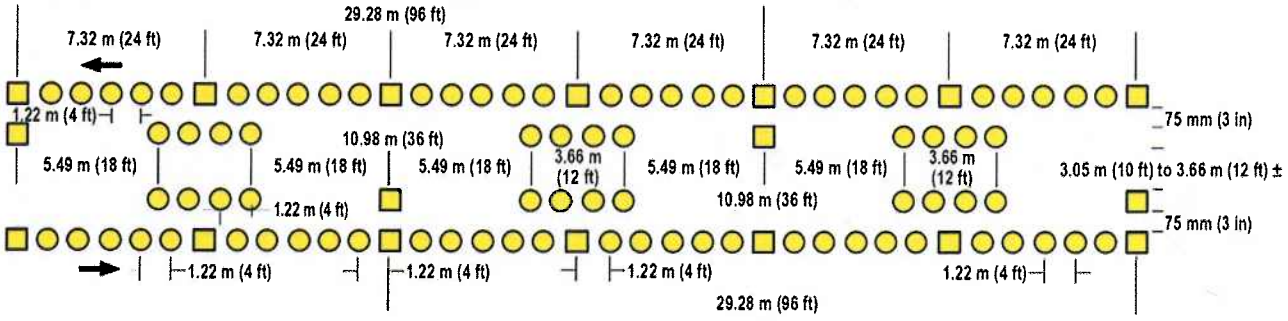
DETAIL 32 **POLICY**

Two-way left-turn lane pattern for use on streets and highways. See Note 2.



DETAIL 33 **POLICY**

Two-way left-turn lane pattern for use on streets and highways.



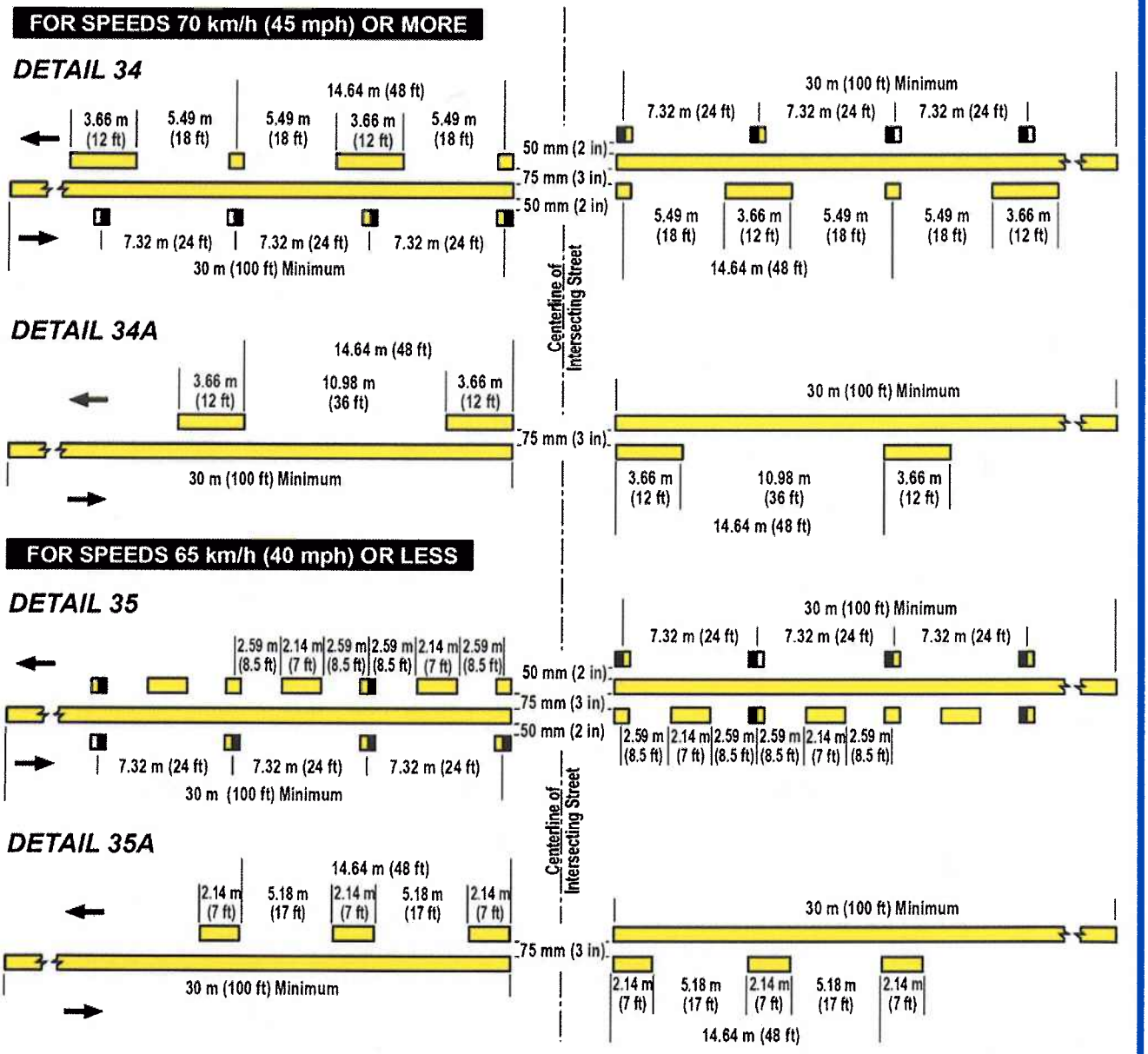
NOTES: 1. Pavement markers shown off the solid line in Detail 32 may be placed on the line.
2. A 75 mm (3 in) black line shall be placed between the 100 mm (4 in) yellow lines on State highways and may be placed on streets and highways under local jurisdiction.

LEGEND

100 mm (4 in) Yellow
Two-Way Yellow Retroreflective Markers
Direction of Travel
Non-Retroreflective Yellow Markers

NOT TO SCALE

Figure 3A-109 (CA). Intersection Markings

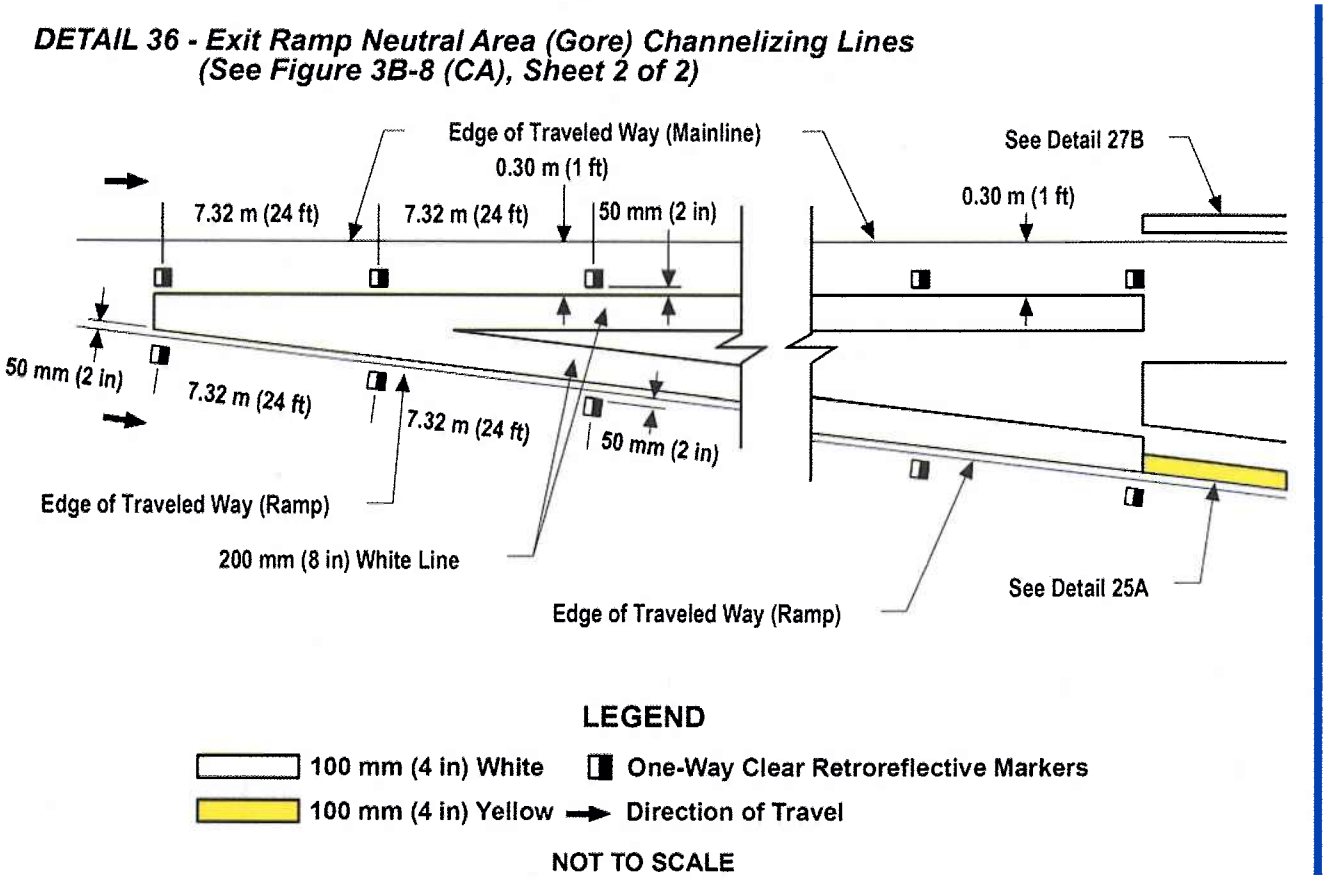


NOTES:
1. **Raised Pavement Markers are optional on non-state highways.**
2. **Raised Pavement Markers shown off the solid line may be placed on the line.**
3. **A 75 mm (3 in) black line shall be placed between the 100 mm (4 in) yellow lines on State highways and may be placed on streets and highways under local jurisdiction.**

LEGEND

100 mm (4 in) Yellow
Direction of Travel
Two-Way Yellow Retroreflective Markers
One-Way Yellow Retroreflective Markers
NOT TO SCALE

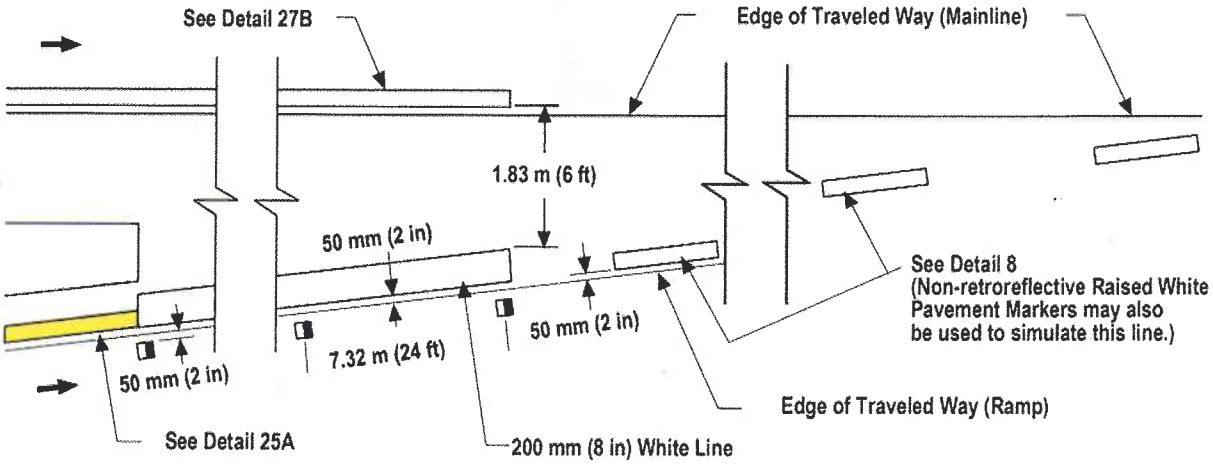
Figure 3A-110 (CA). Freeway Exit and Entrance Ramp Channelizing Line (Sheet 1 of 2)



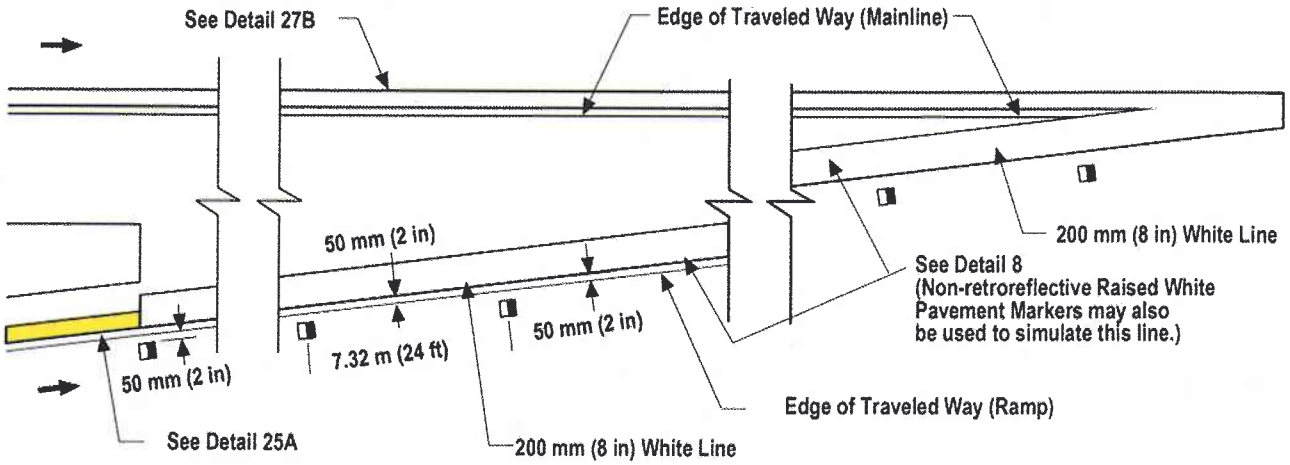
(This space left intentionally blank)

Figure 3A-110 (CA). Freeway Exit and Entrance Ramp Channelizing Lines (Sheet 2 of 2)

DETAIL 36A - Entrance Ramp Neutral Area (Merge) Channelizing Lines (See Figure 3B-9 (CA), Sheet 1 of 2)



DETAIL 36B - Entrance Ramp Neutral Area (Acceleration Lane) Channelizing Lines (See Figure 3B-8 (CA), Sheet 3 of 3)



LEGEND

100 mm (4 in) White — One-Way Clear Retroreflective Markers

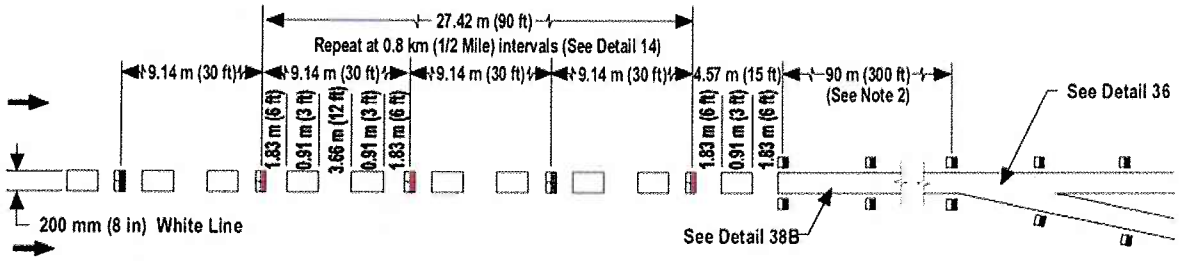
100 mm (4 in) Yellow — Direction of Travel

NOT TO SCALE

Figure 3A-111 (CA). Lane Drop Markings

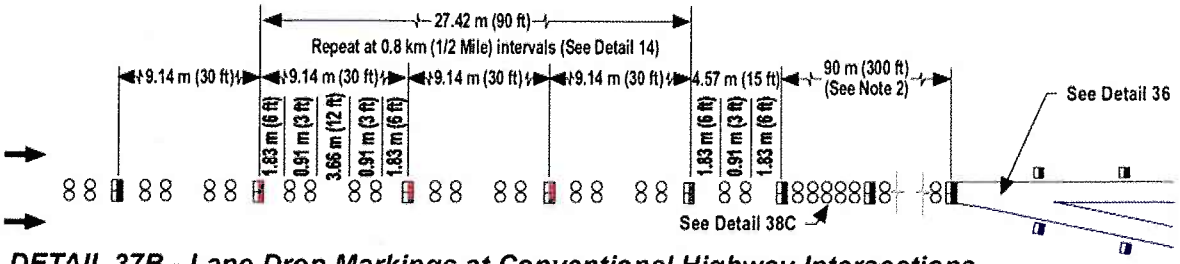
DETAIL 37 - Lane Drop Markings at Exit Ramps

Marking pattern for use on mandatory lane drops at freeway exit ramps and freeway to freeway connectors.



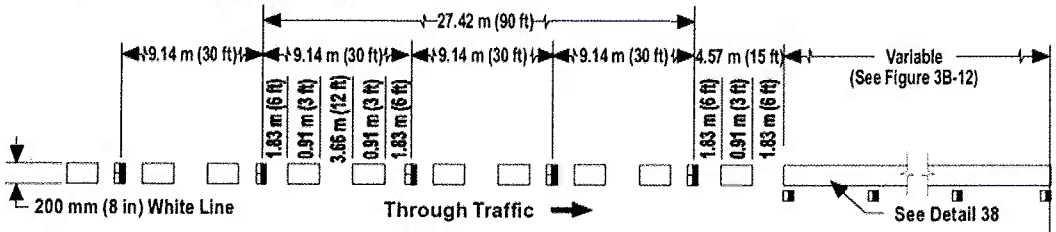
DETAIL 37A - Alternate to Detail 37

For use with Detail 10 and 13.



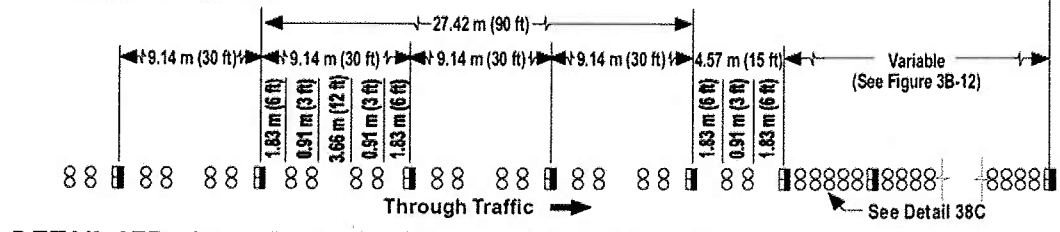
DETAIL 37B - Lane Drop Markings at Conventional Highway Intersections

Marking pattern for use on mandatory turn lanes at intersections. Pavement markers shown are optional on local streets and highways.



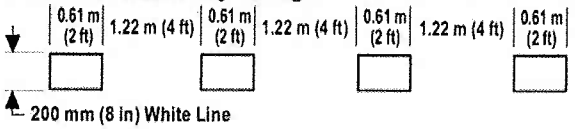
DETAIL 37C - Alternate to Detail 37B

For use with Detail 10 and 13.



DETAIL 37D - Lane Drop Line For Two-Lane Roundabouts

For use on mandatory exiting lanes from two-lane roundabouts.



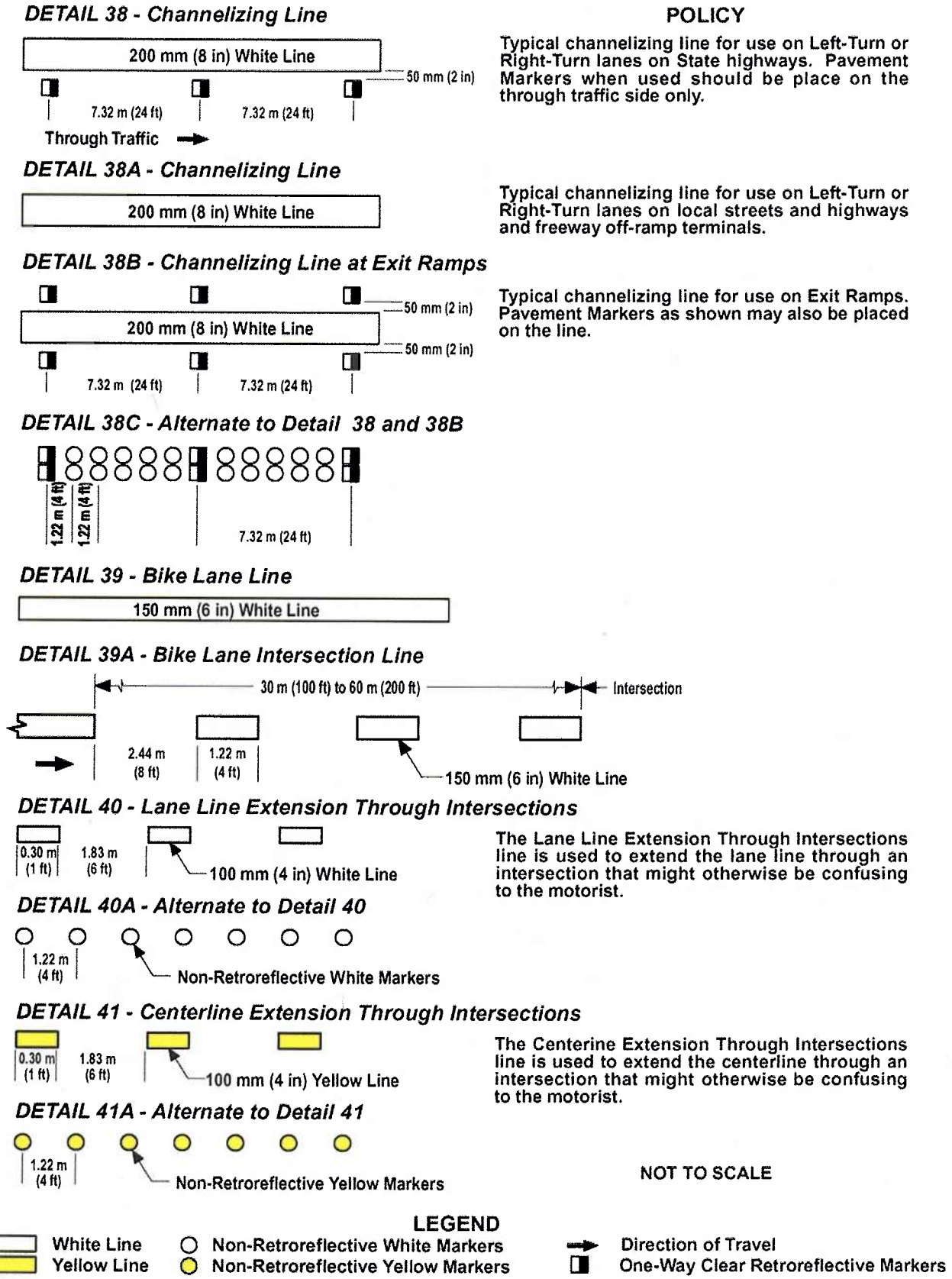
NOT TO SCALE

NOTES:
1. Pavement markers shown off the solid line in Detail 37 may be placed on the line.
2. The Solid Channelizing Line shown in Detail 37 and 37A may be omitted on short auxiliary lanes where weaving length is critical.

LEGEND

- Non-Retroreflective White Markers
- Direction of Travel
- One-Way Clear Retroreflective Markers
- Red-Clear Retroreflective Markers

Figure 3A-112 (CA). Channelizing Line and Lane Line/Centerline Extensions



APPENDIX C

STAA Design Vehicle

Excerpt from
"Roundabout Design Guidelines,"
Ourston Roundabout Engineering (2001)

Figure 7/24b

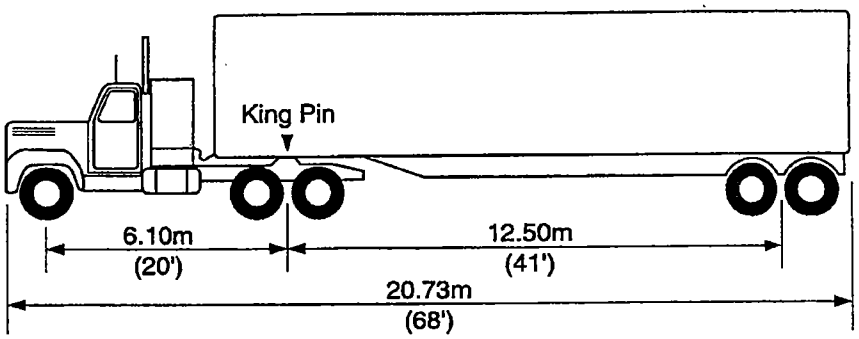
Design Vehicles

The circulatory roadways (Figure 7/24a) and right turn bypass lanes (Table 7/3) of roundabouts should be designed wide enough for one of the three California Design Vehicles.

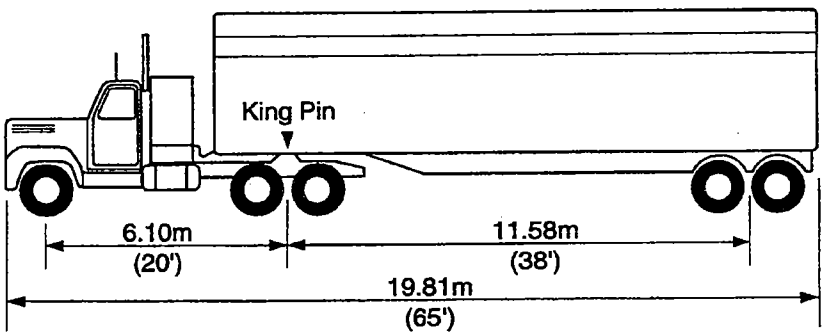
STAA truck. Roadways should be wide enough for the STAA truck, stipulated in the Surface Transportation Assistance Act of 1982 (STAA), on all roundabouts in new interchanges on the National Network and on routes leading from the National Network to designated service and terminal points. On rehabilitation projects they should be wide enough for STAA trucks at interchanges proposed as service or terminal access points. In some cases, factors such as cost and right of way may indicate widths only large enough for the California truck.

California truck. Roadways should be wide enough for the California truck on highways not on the National Network.

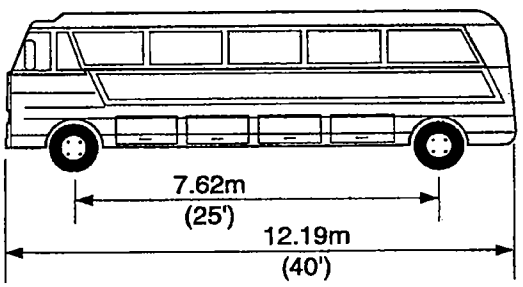
Bus. At intersections where truck volumes are light or where the predominant truck traffic consists of mostly 3-axle and 4-axle units, bus roadway widths may be used. The wheel paths will sweep a greater width than 3-axle delivery trucks and smaller buses such as school buses, but a slightly lesser width than that of a 4-axle truck.



1 - STAA Design Vechicle



2 - California Design Vehicle



3 - Bus Design Vehicle

APPENDIX D

Excerpts from "Approved Roundabout Sections Proposed for 2008 MUTCD" by National Committee on Uniform Traffic Control Devices Regulatory and Warning Sign TC (Technical Committee) dated January 19, 2006

This material **has not been adopted** for the 2008 MUTCD.

Figure 3H-01. Example of Markings for Approach and Circulatory Roadway Markings at a Roundabout

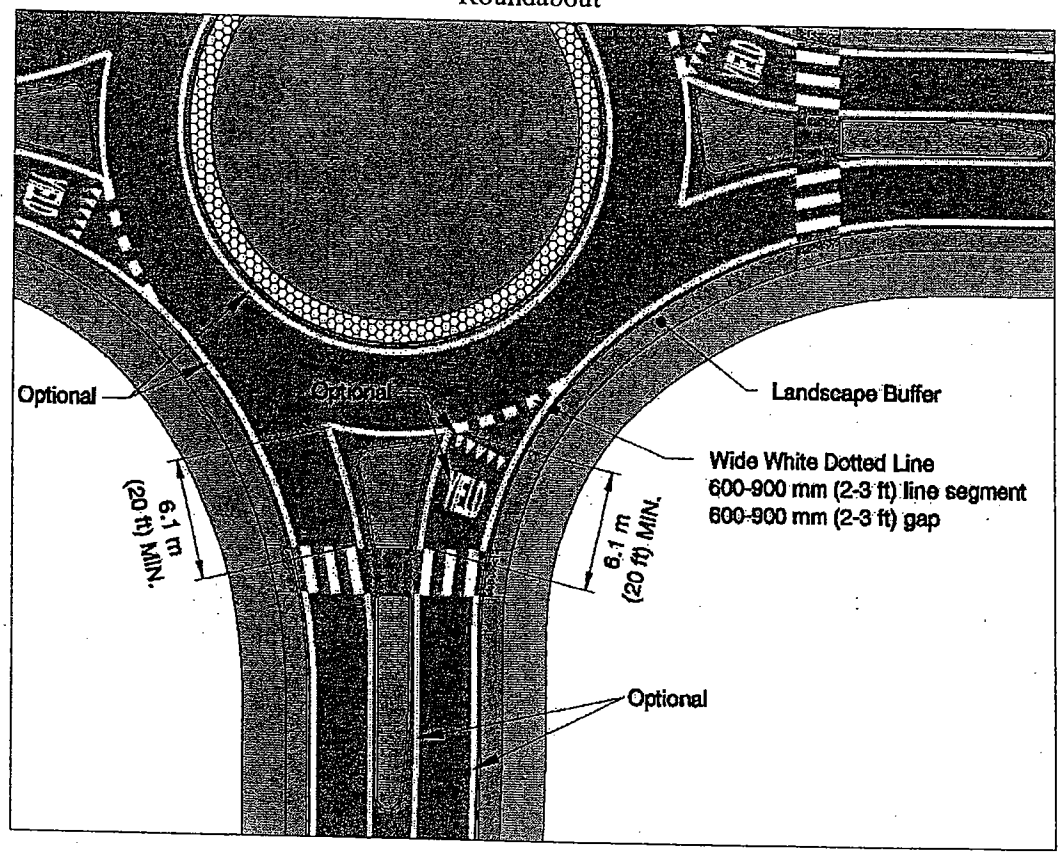
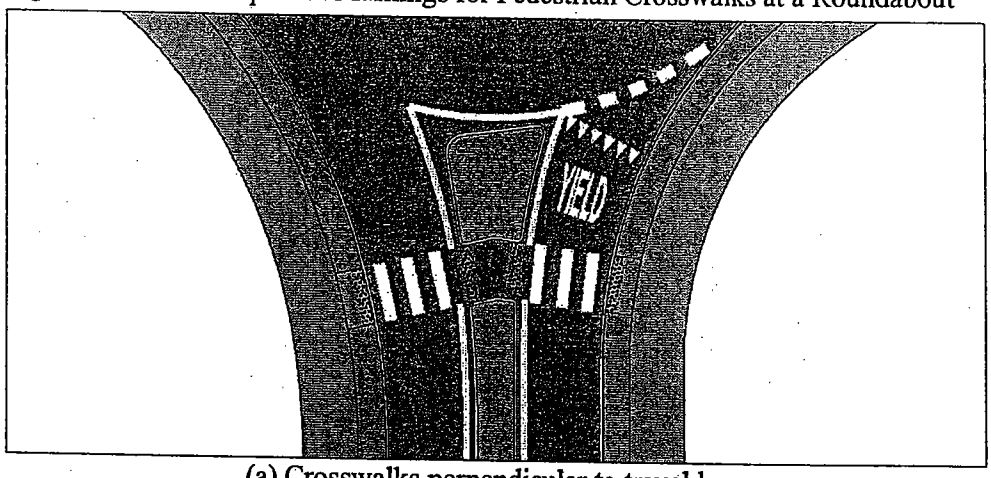
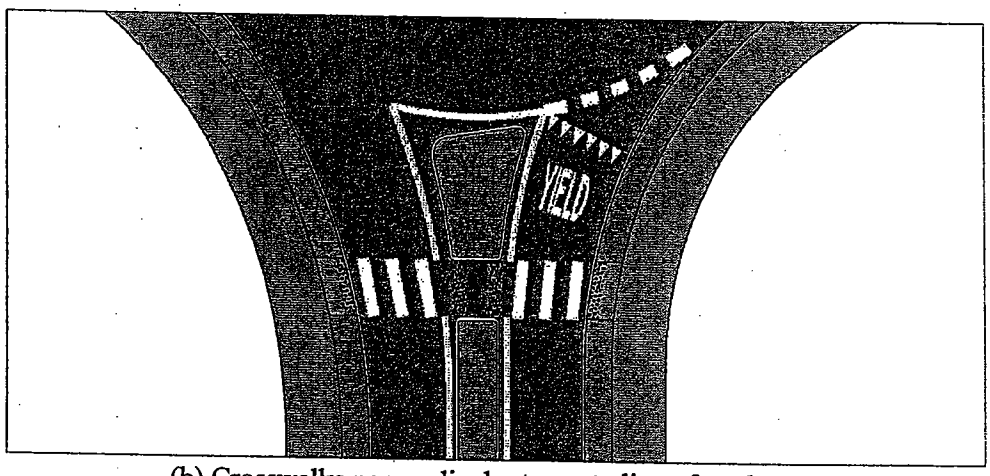


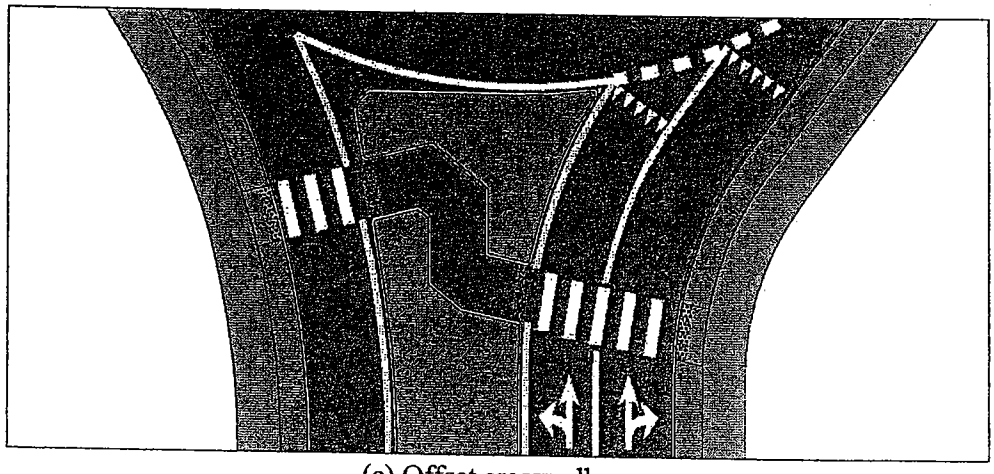
Figure 3H-02. Examples of Markings for Pedestrian Crosswalks at a Roundabout



(a) Crosswalks perpendicular to travel lanes



(b) Crosswalks perpendicular to centerline of roadway



(c) Offset crosswalks

Figure 3H-04. Example of Markings for Mini-Roundabout

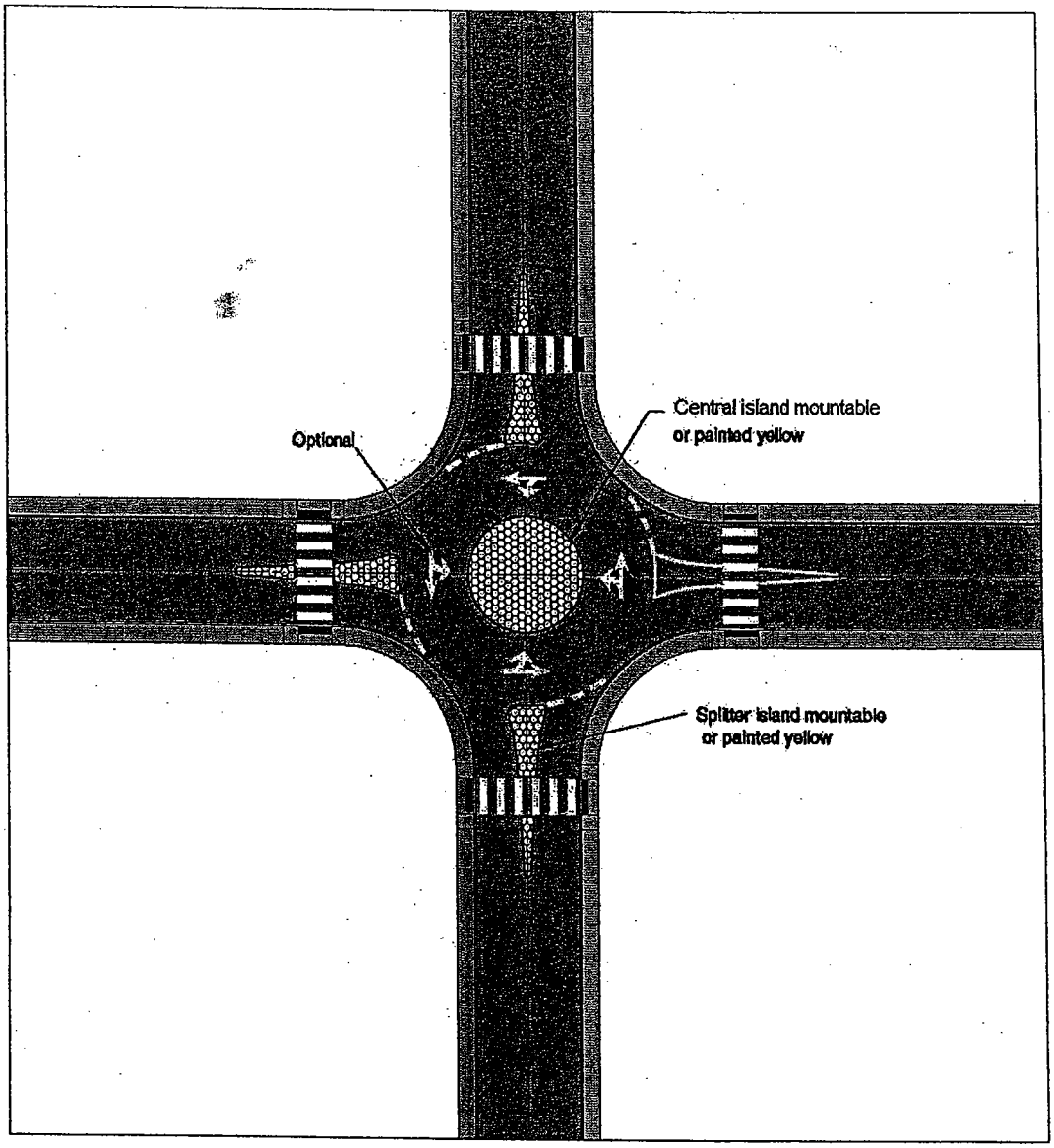


Figure 3H-04. Example of Markings for Mini-Roundabout

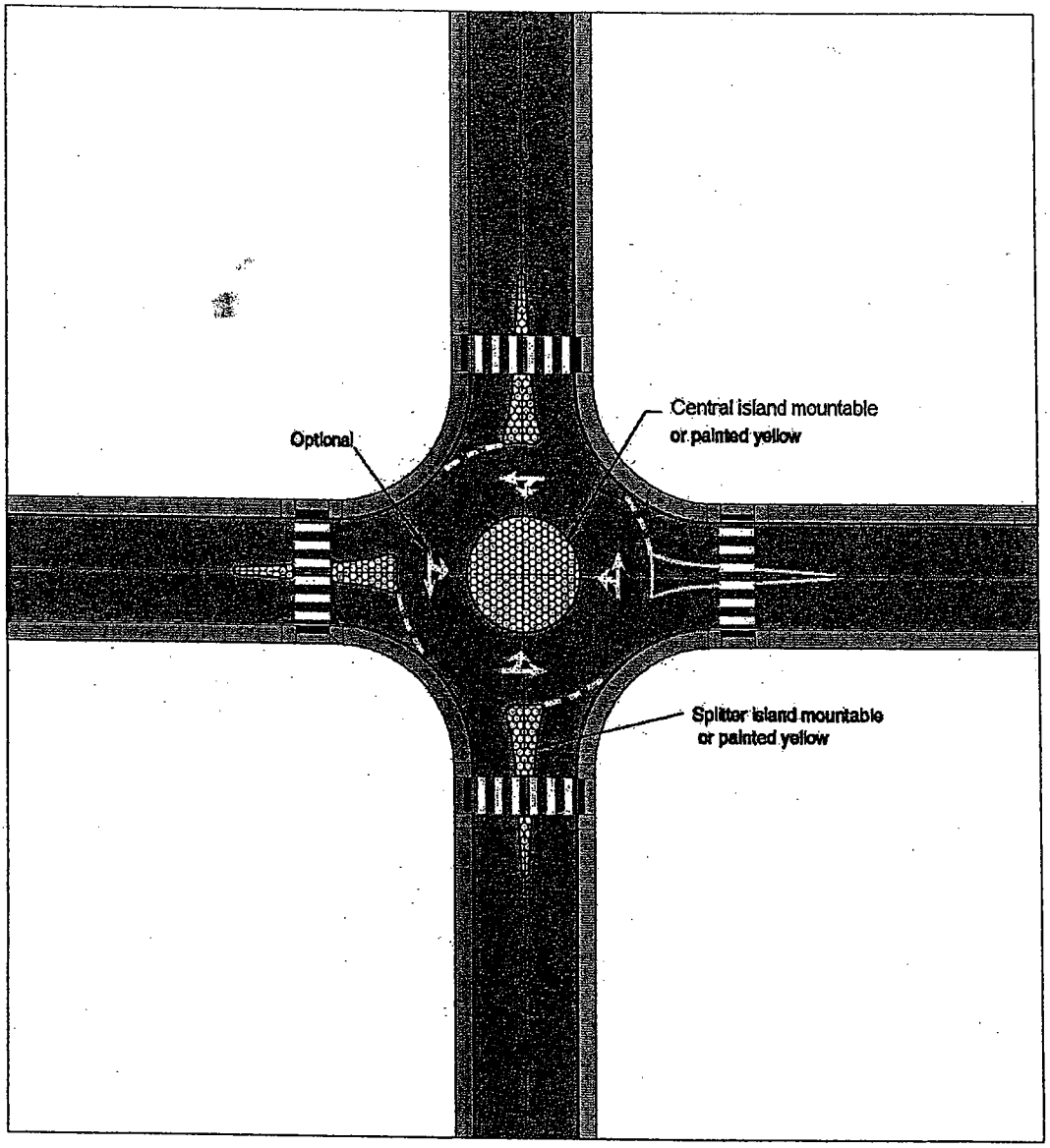


Figure 3H-06. Example of Markings for One-Lane Roundabout with Dedicated Right-Turn Lane

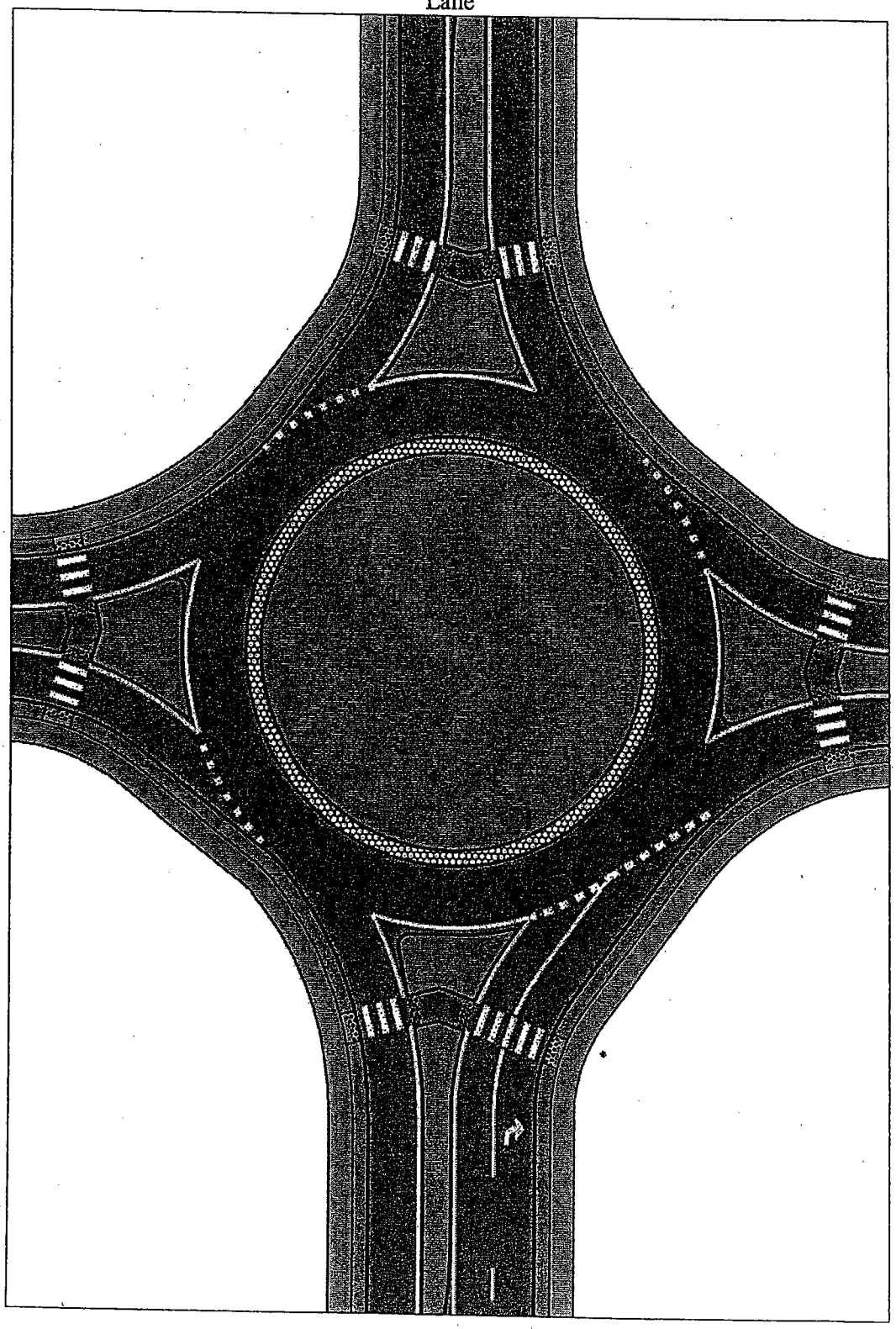


Figure 3H-07A. Example of Markings for Two-Lane Roundabout with One- and Two-Lane Approaches, Option A

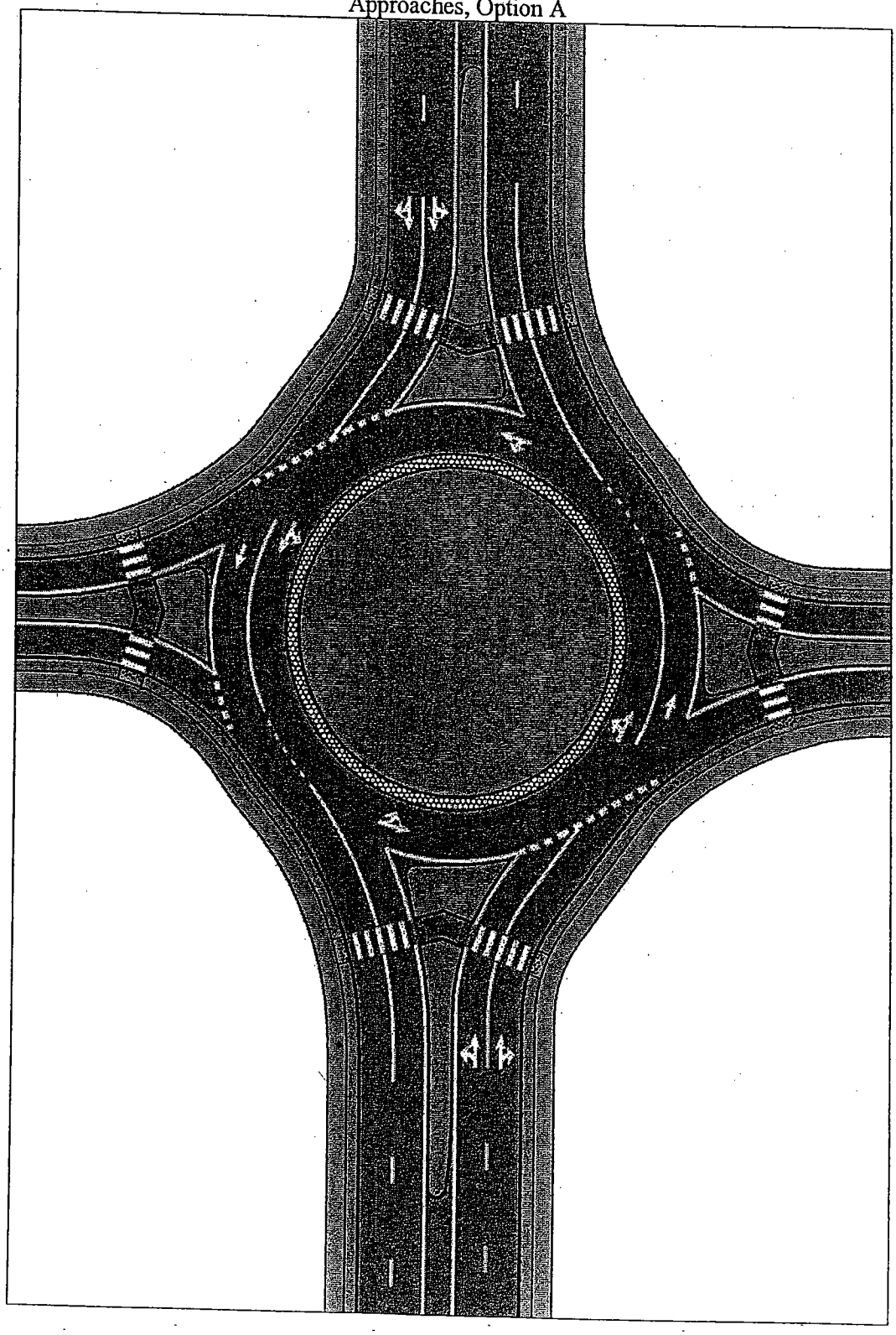


Figure 3H-07B. Example of Markings for Two-Lane Roundabout with One- and Two-Lane Approaches, Option B

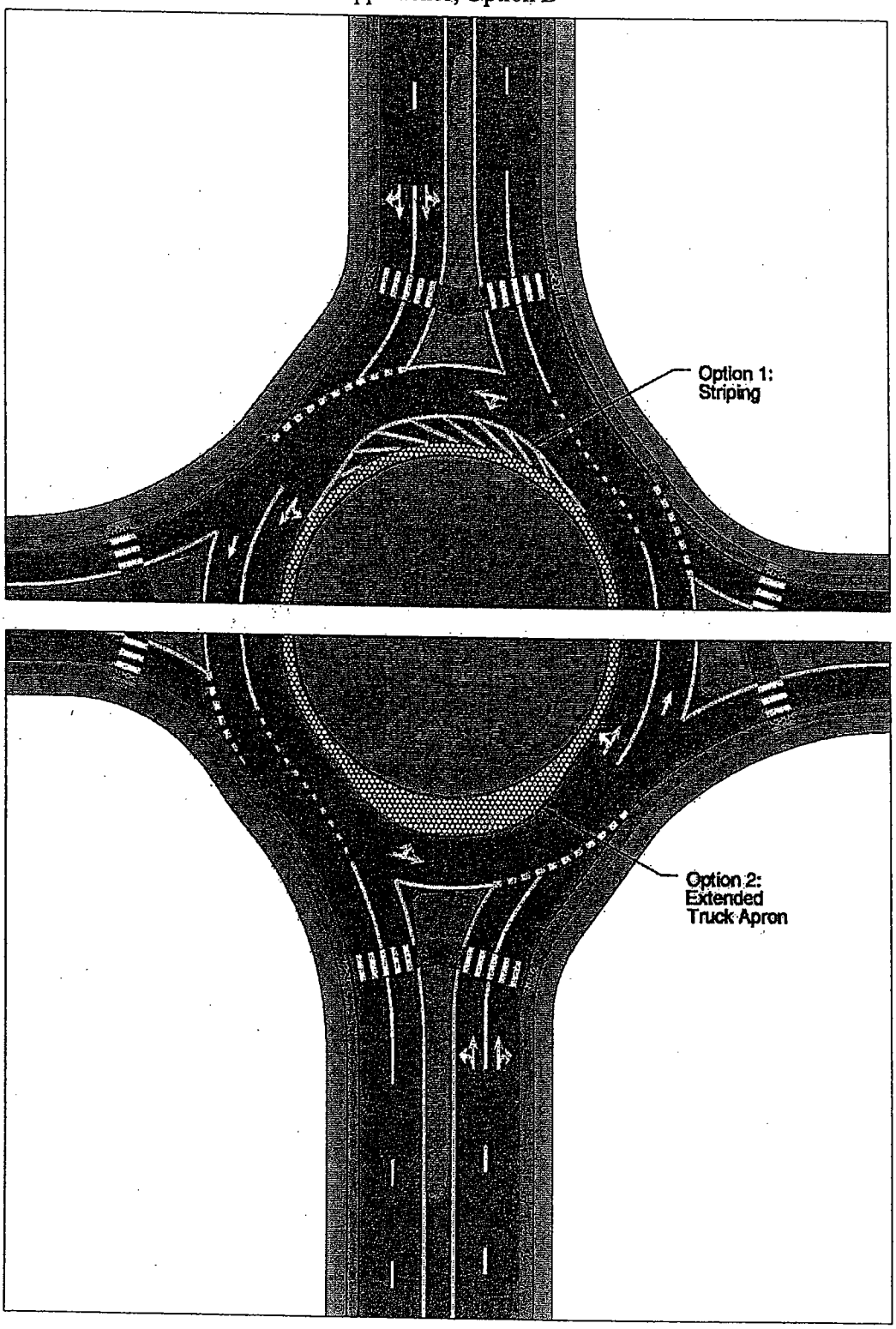


Figure 3H-08. Example of Markings for Two-Lane Roundabout with One-Lane Exits

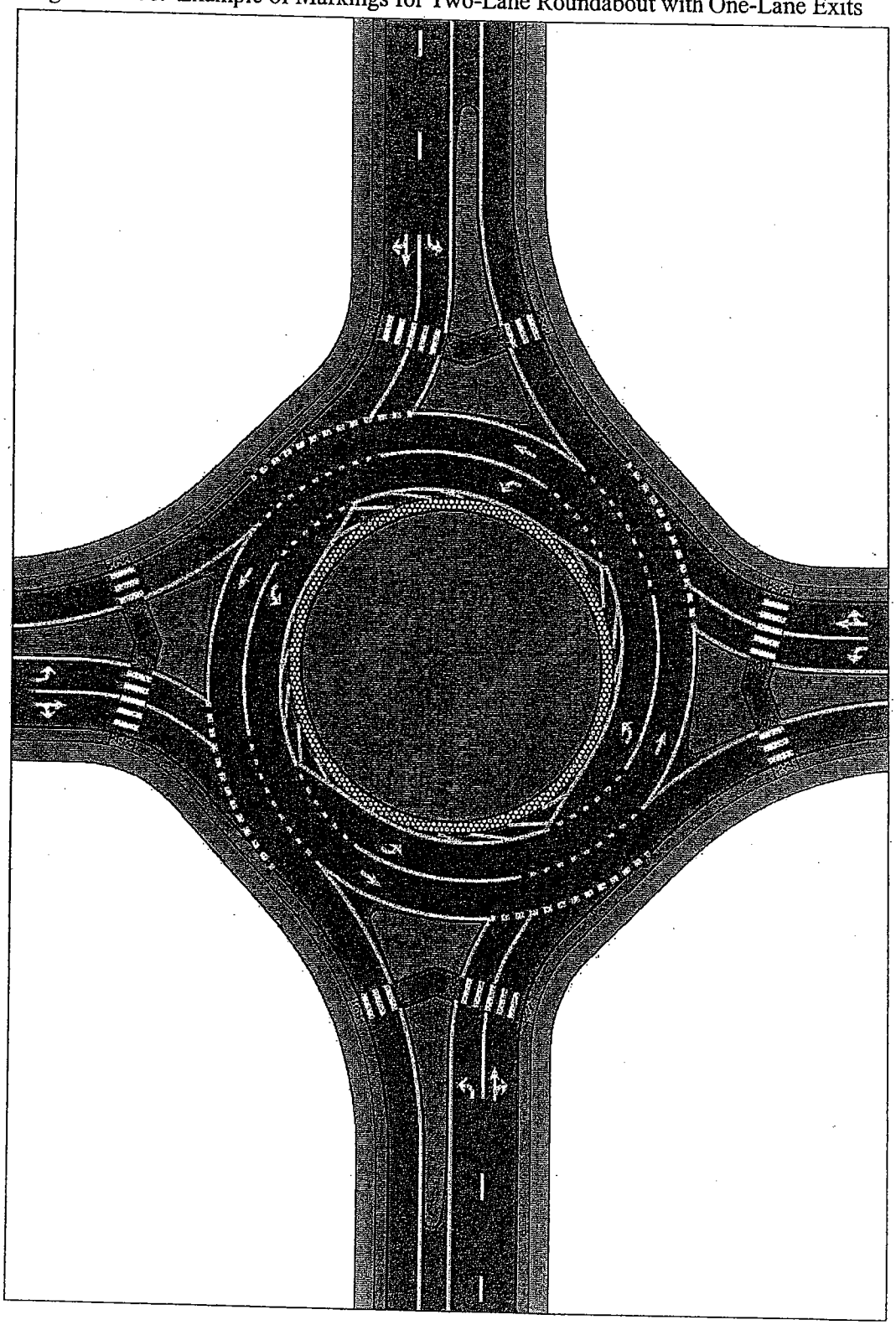


Figure 3H-09. Example of Markings for Two-Lane Roundabout

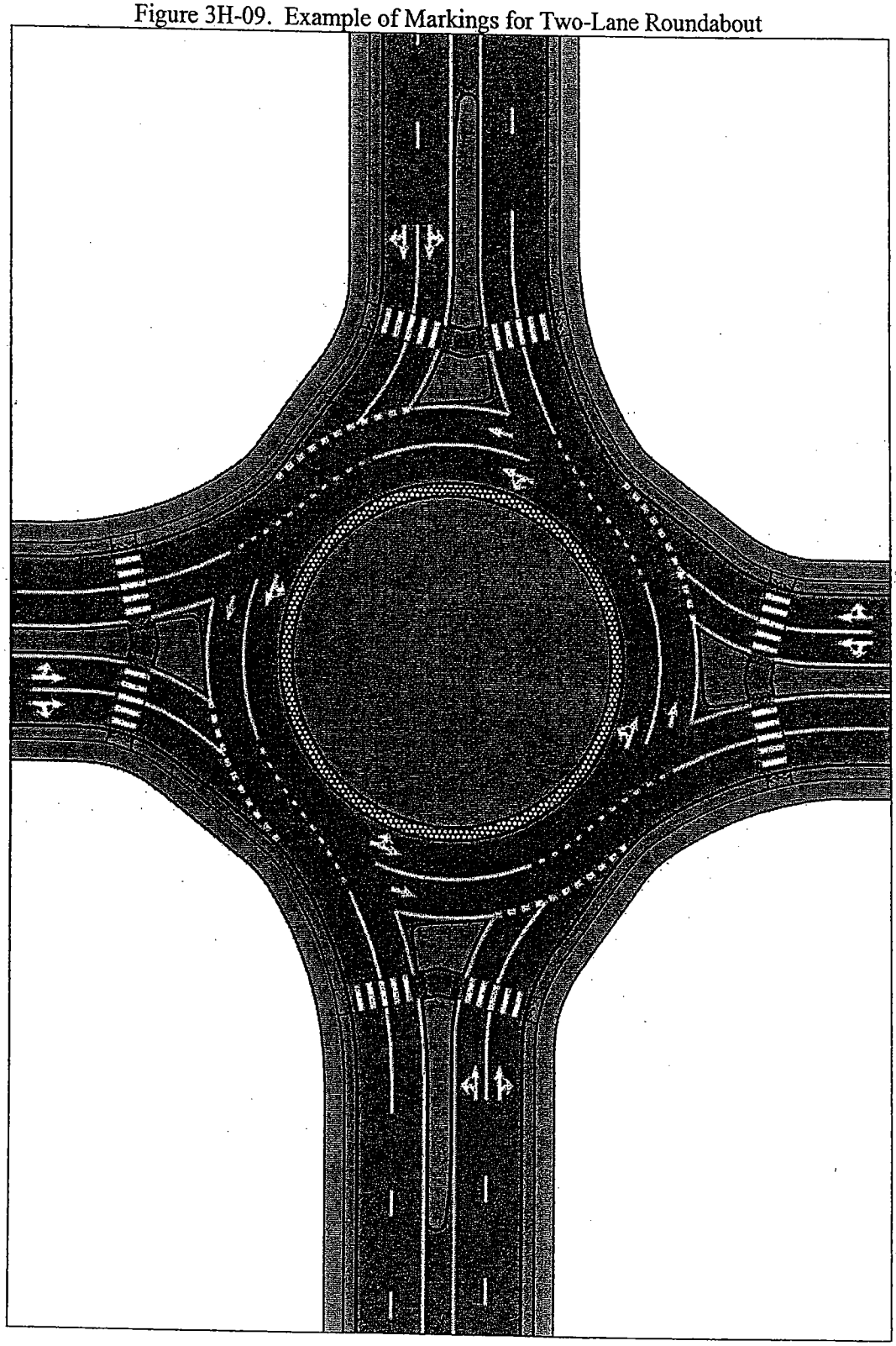


Figure 3H-10. Example of Markings for Two-Lane Roundabout with Double Left Turn

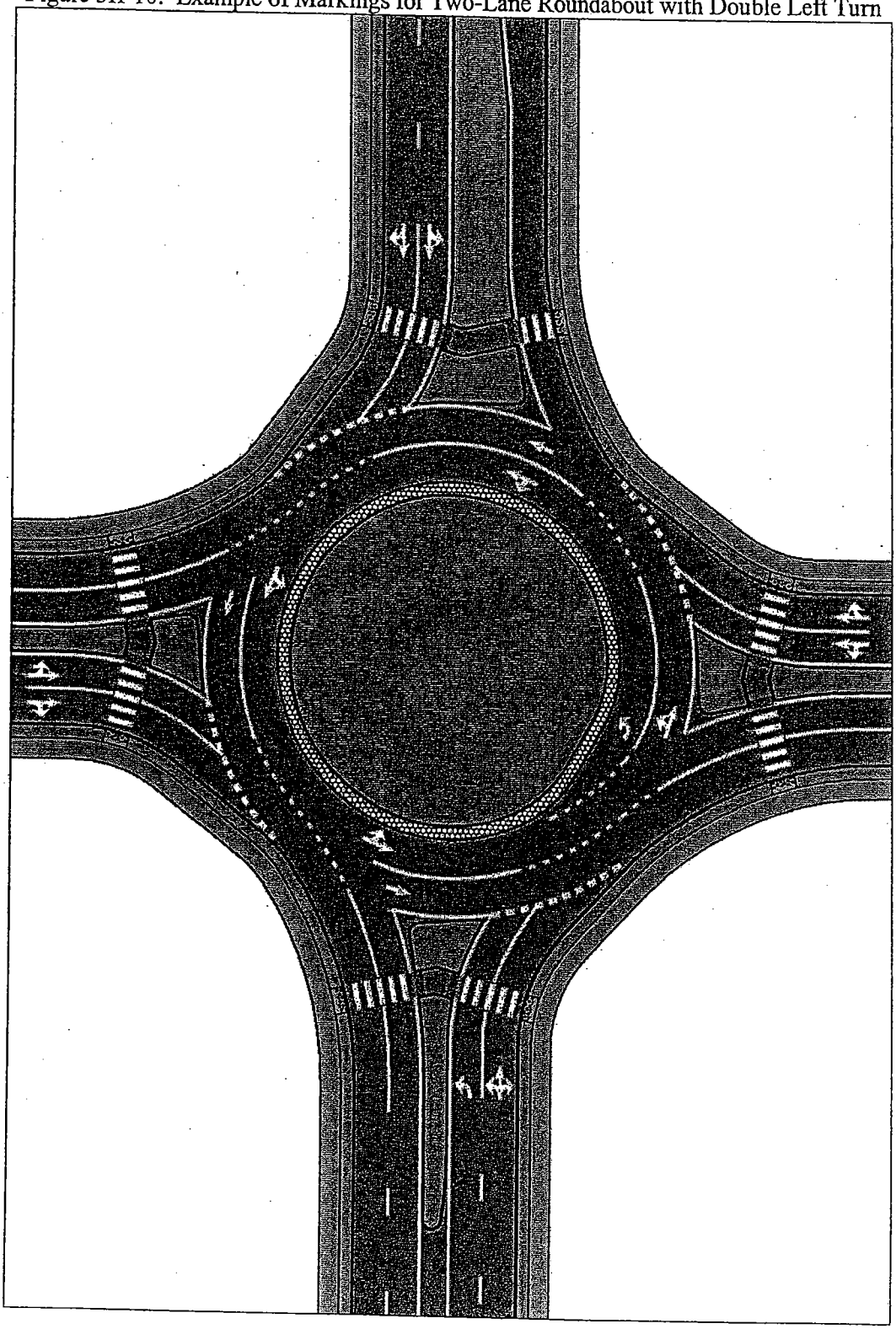


Figure 3H-11. Example of Markings for Two-Lane Roundabout with Double Right Turn

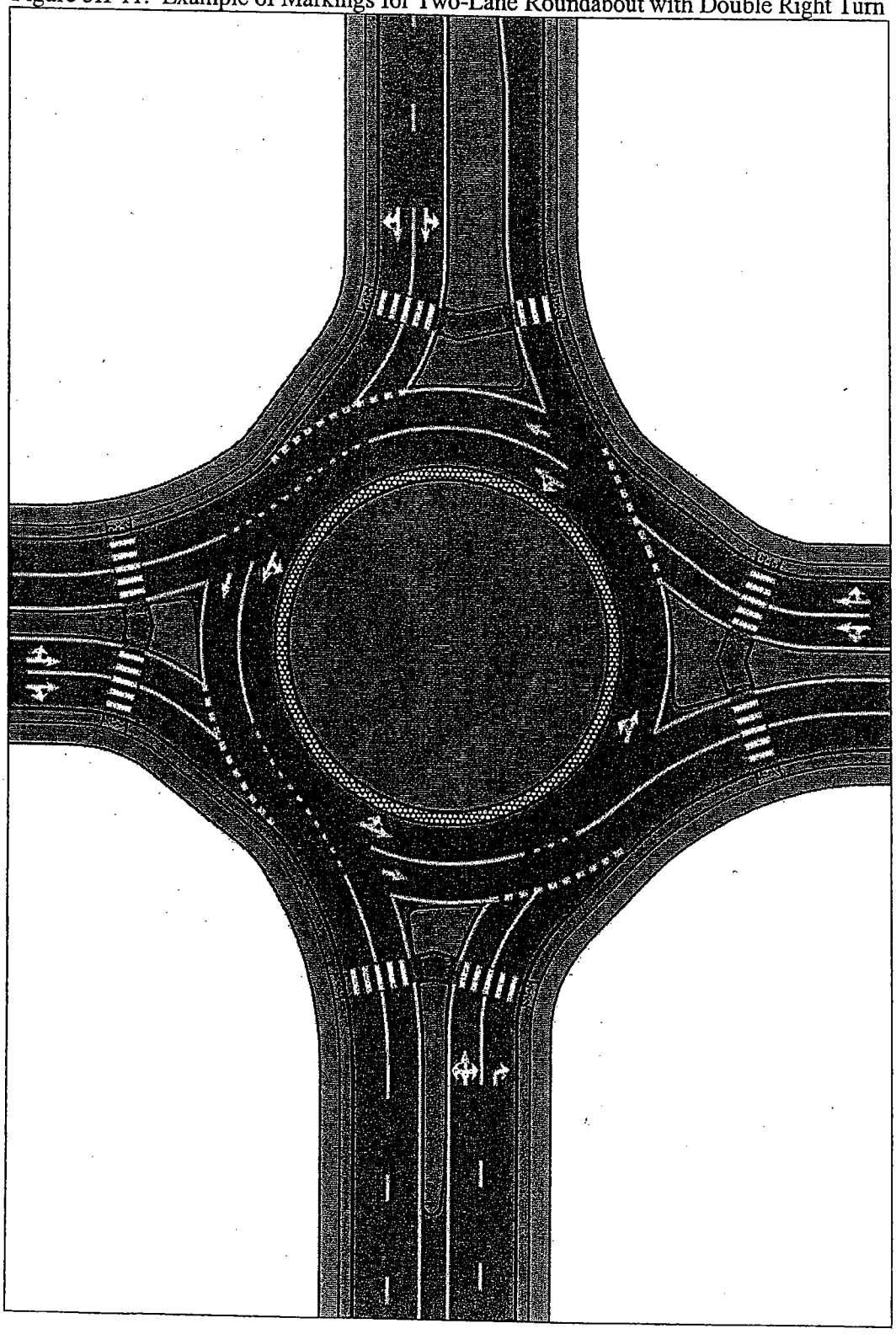


Figure 3H-12. Example of Markings for Two-Lane Roundabout with Consecutive Double Lefts

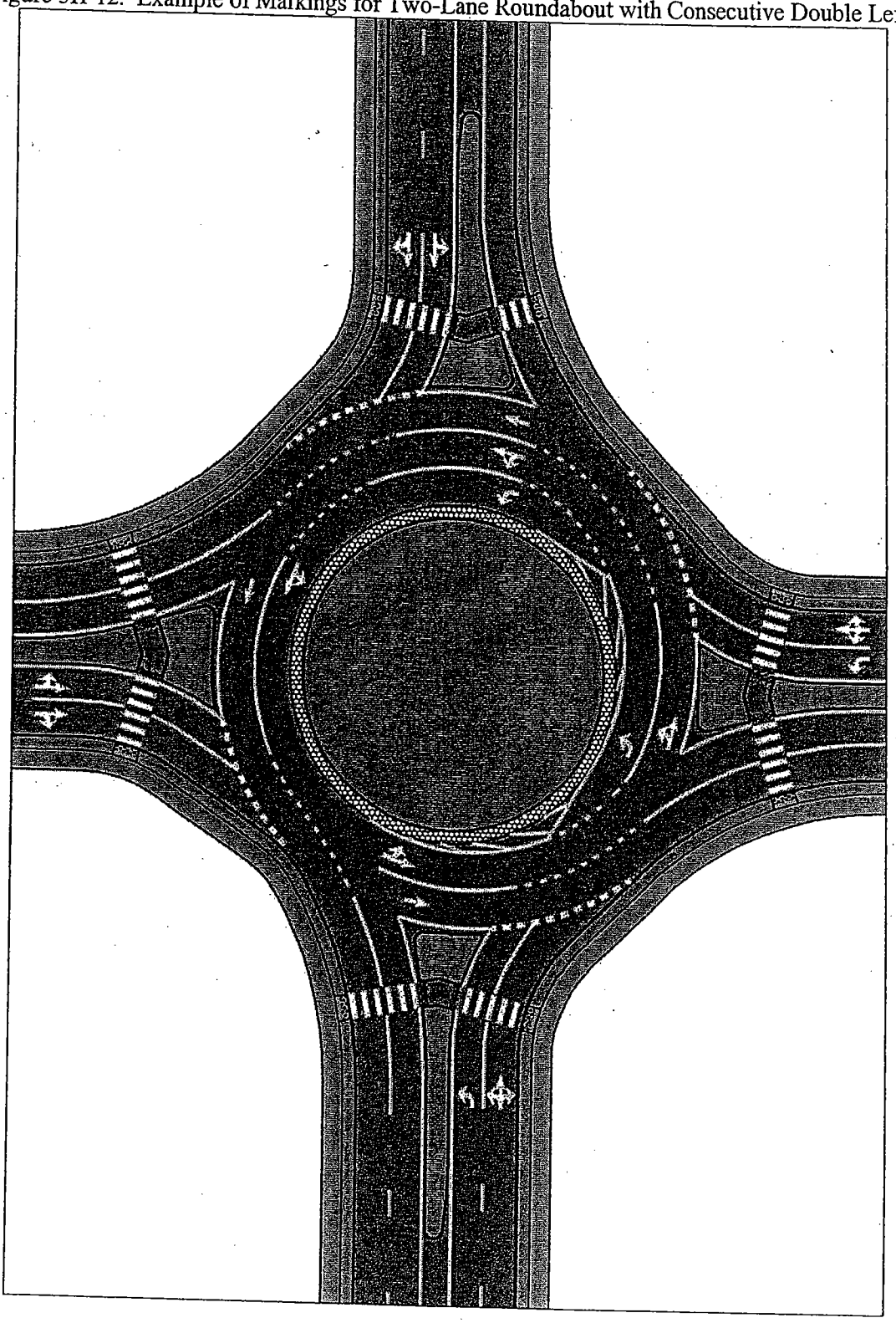


Figure 3H-13. Example of Markings for Three-Lane Roundabout with Two- and Three-Lane Approaches

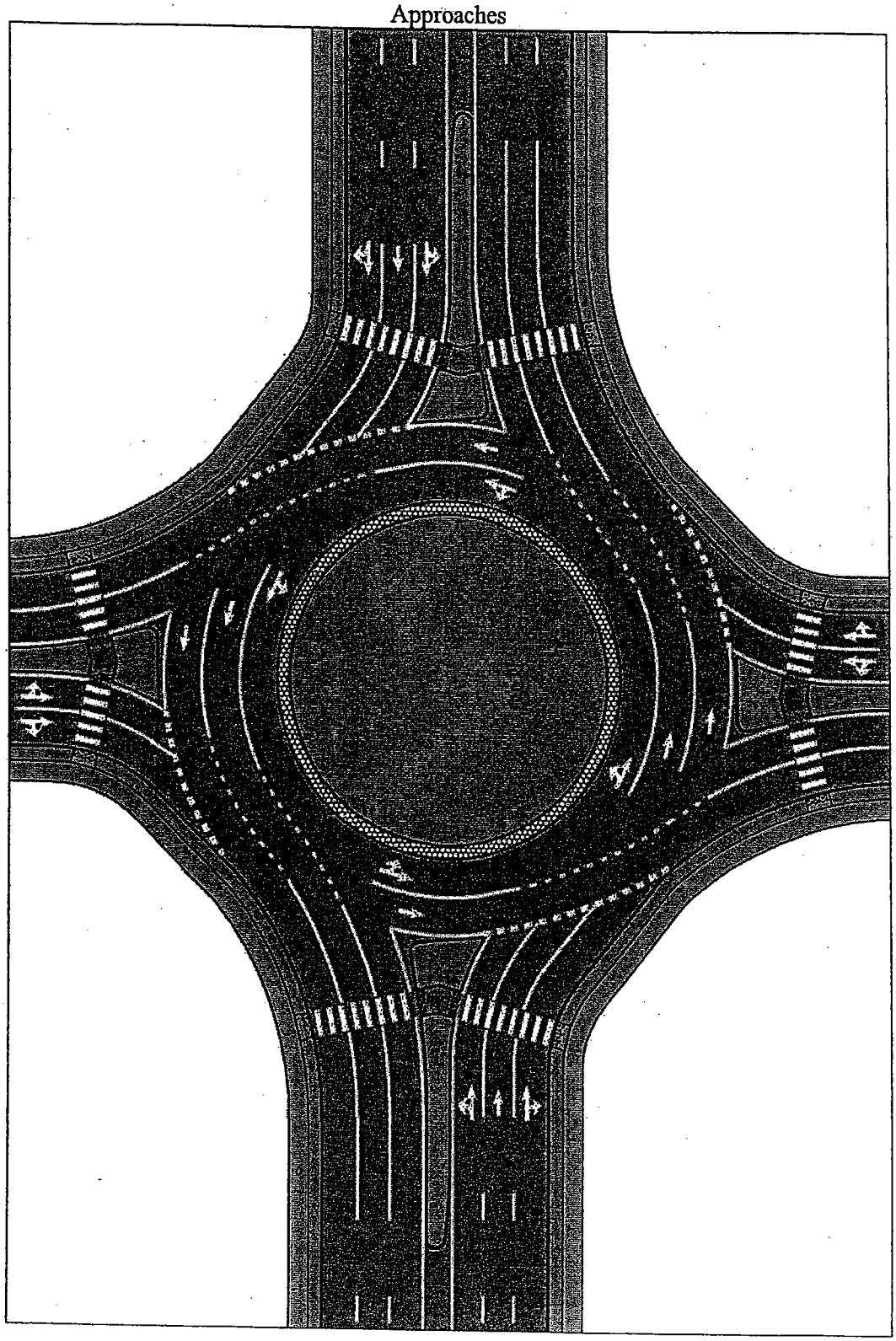


Figure 3H-14. Example of Markings for Three-Lane Roundabout with Three-Lane Approaches

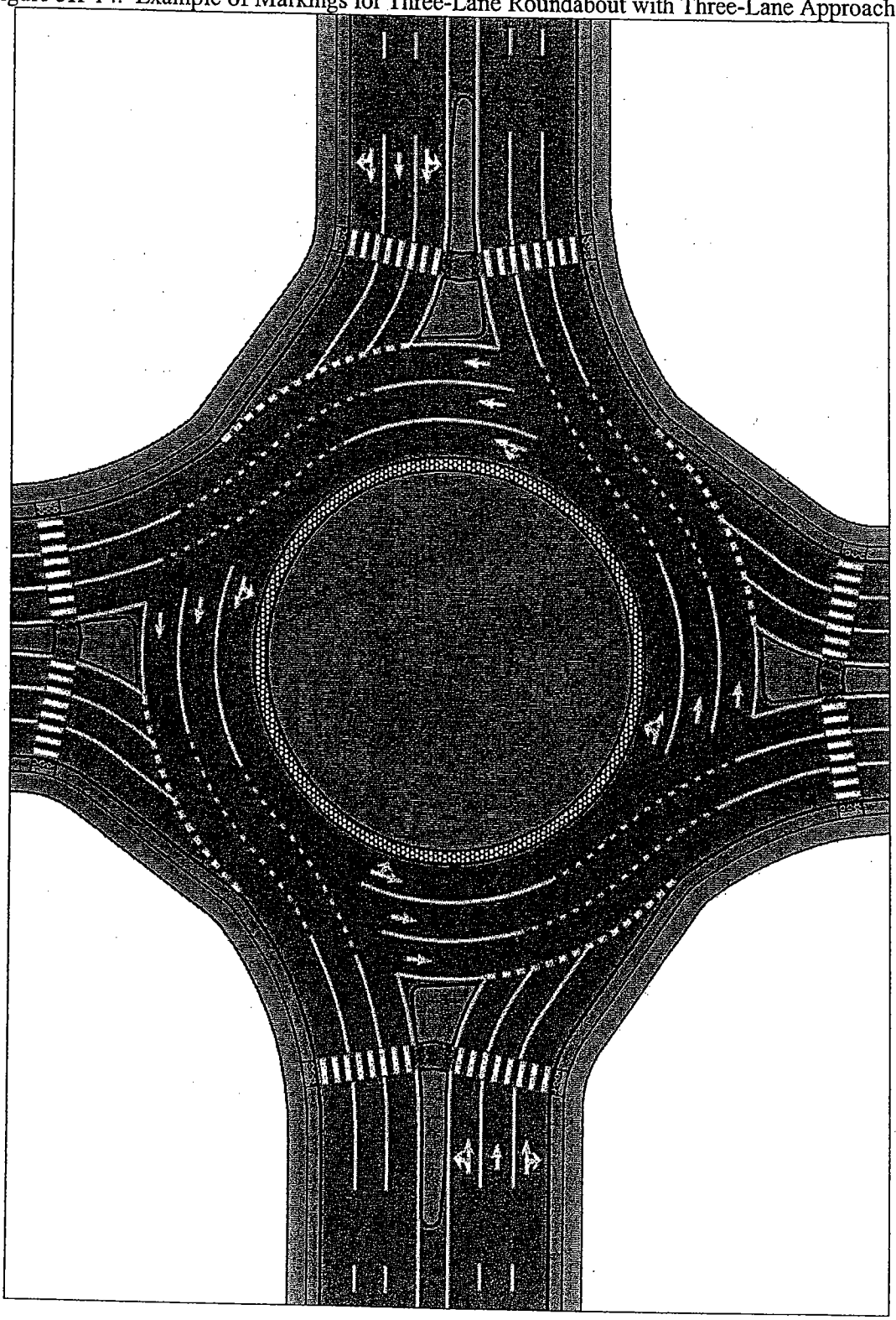


Figure 3H-15. Example of Markings for Three-Lane Roundabout with Two-Lane Exits

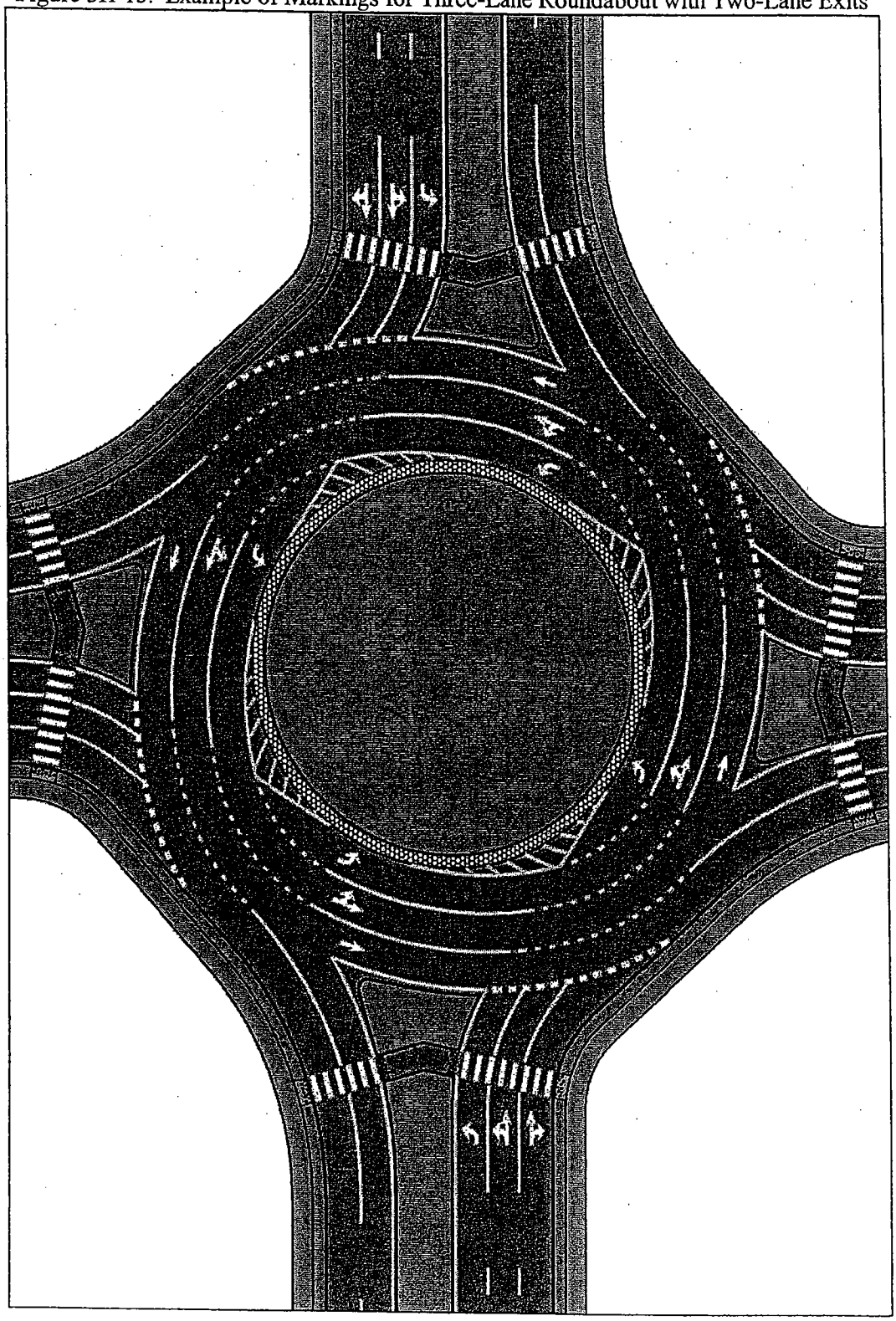


Figure 3H-16. Example of Markings for Two Linked Roundabouts

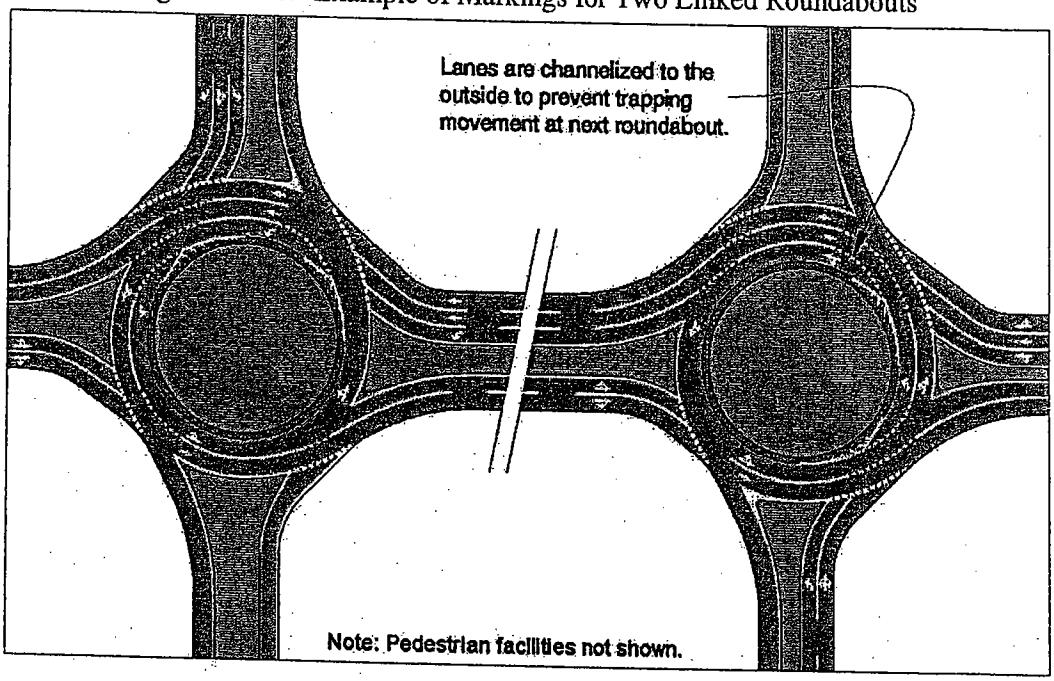


Figure 3H-17. Example of Markings for Diamond Interchange with Two Circular-Shaped Roundabout Ramp Terminals

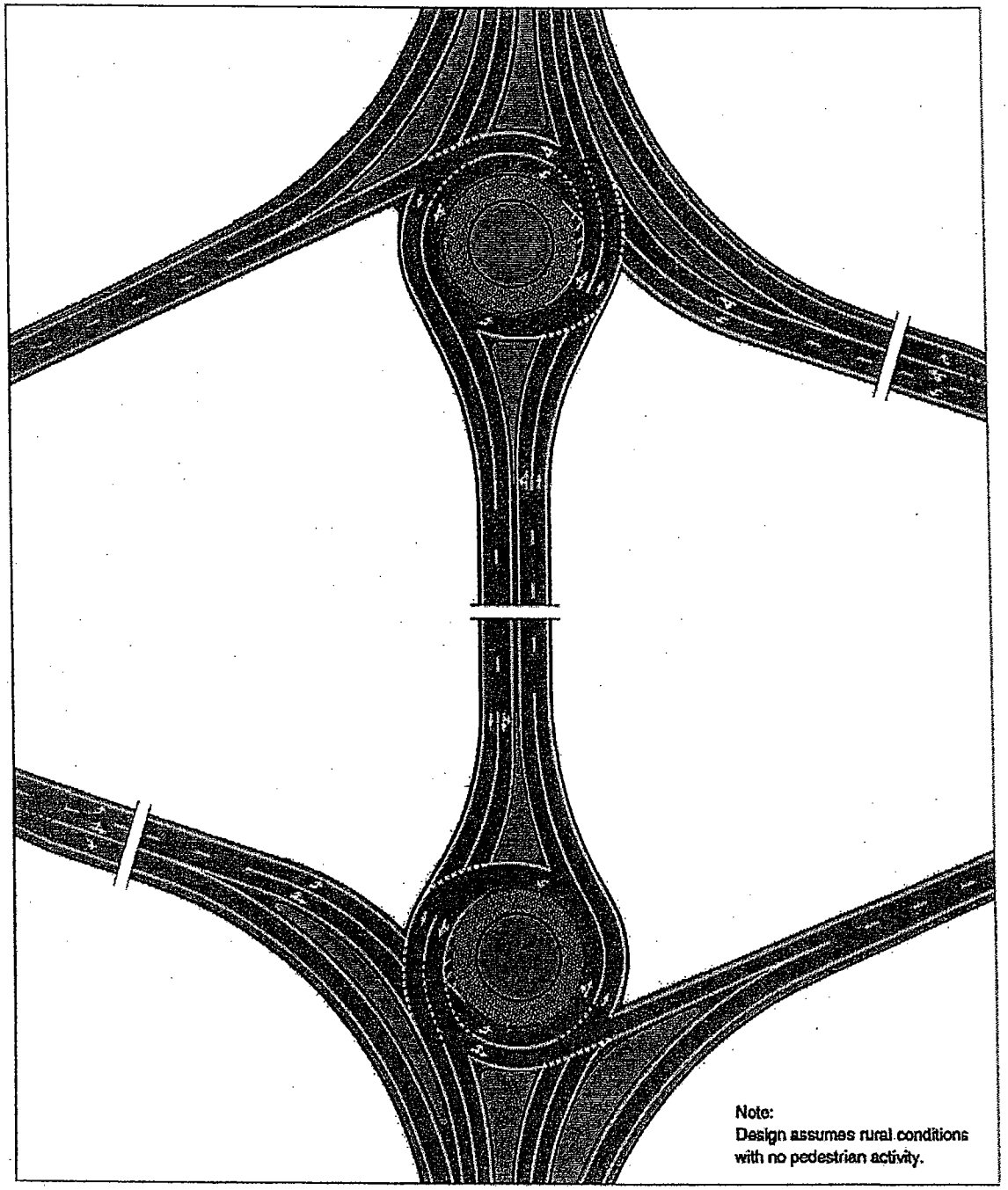
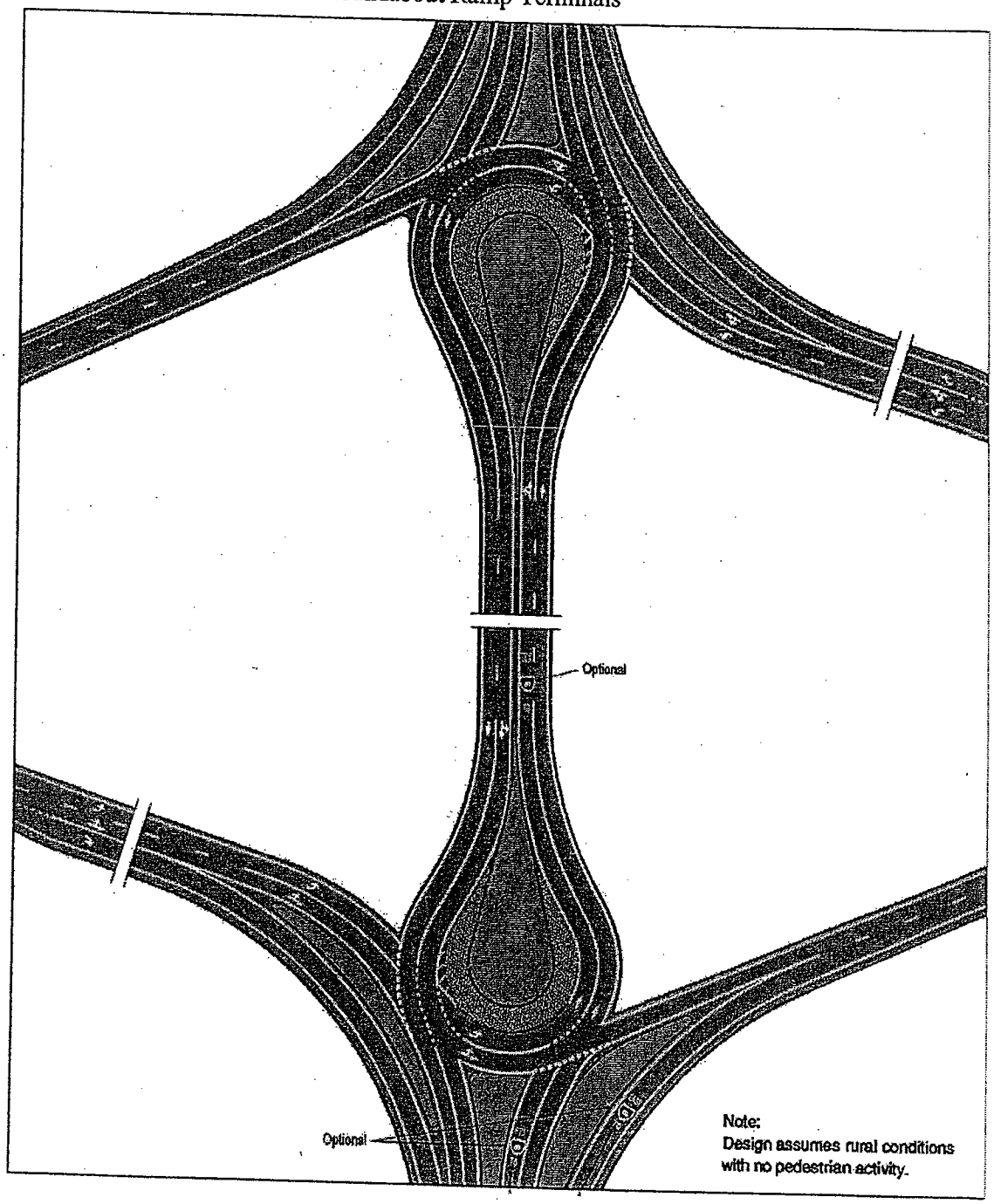
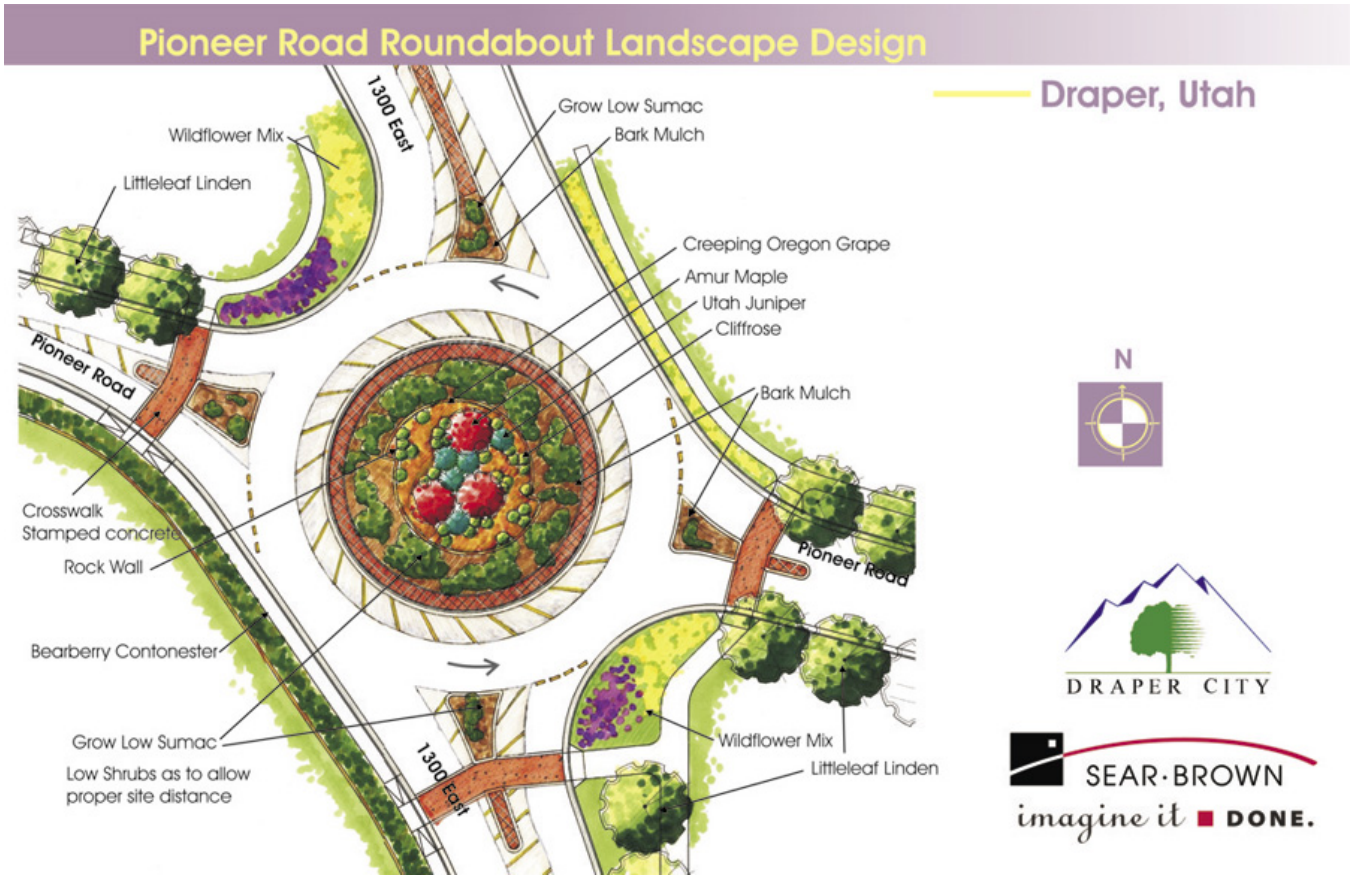


Figure 3H-18. Example of Markings for Diamond Interchange with Two Raindrop-Shaped Roundabout Ramp Terminals



APPENDIX E

Sample Drawings and Photos



Draper, Utah – Landscape Design

Draper, Utah – Roundabout with equestrian trail underpass

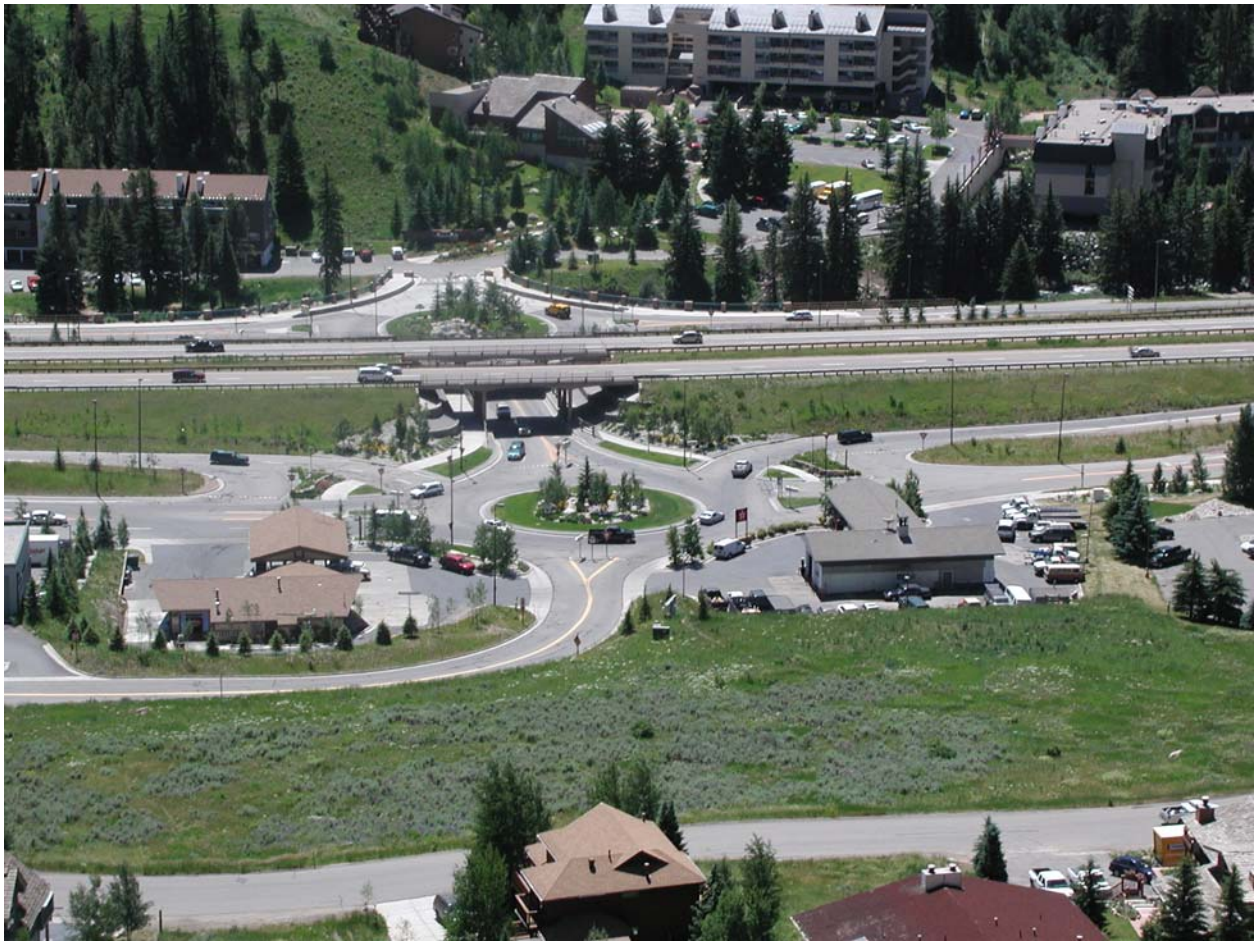
Salt Lake, Utah - 2002 Winter Olympics (roundabout in the snow)

Orem, Utah – Utah Valley State College

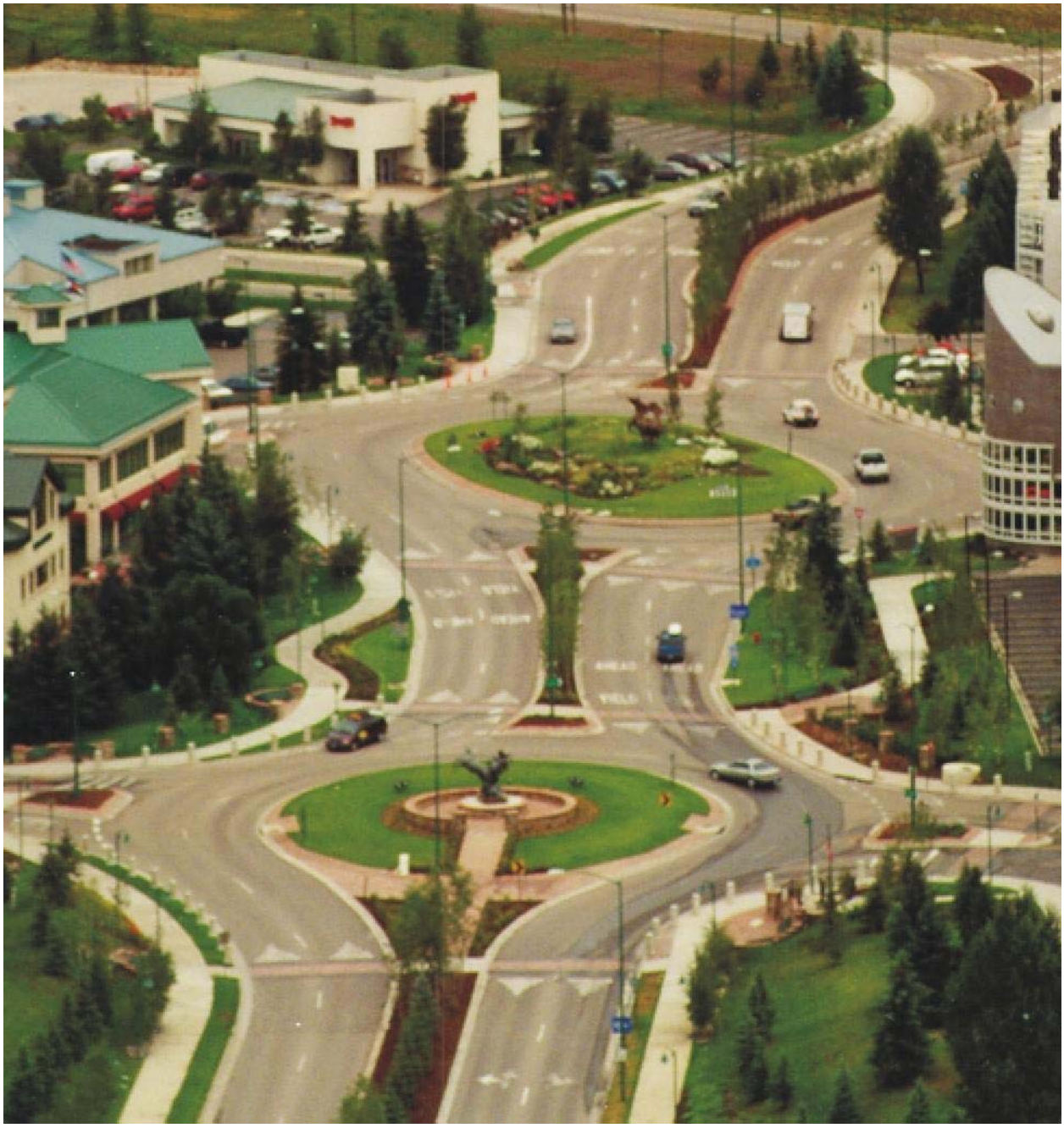
Riverdale, Utah – Ribbon cutting (2001)

Nashua, New Hampshire

Port Orchard, Washington



Vail, Colorado – Interstate 70



Avon, Colorado

Carlsbad, California – Near Legoland

St. George, Utah – Interchange under construction

Long Beach, California – Old time traffic circle conversion (1991)

Las Vegas, Nevada – Hillcenter South (example of drain in central island)

Okemos, Michigan

Ashville, North Carolina

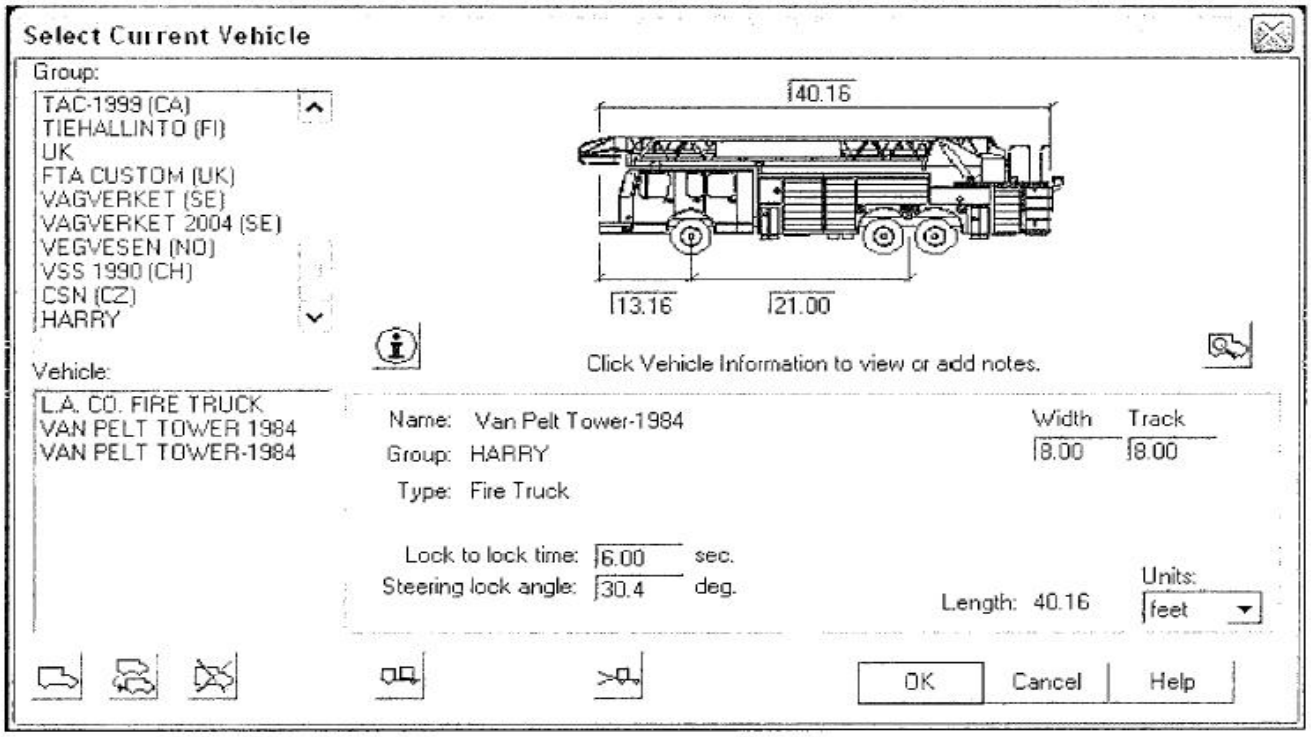
Budapest, Hungry

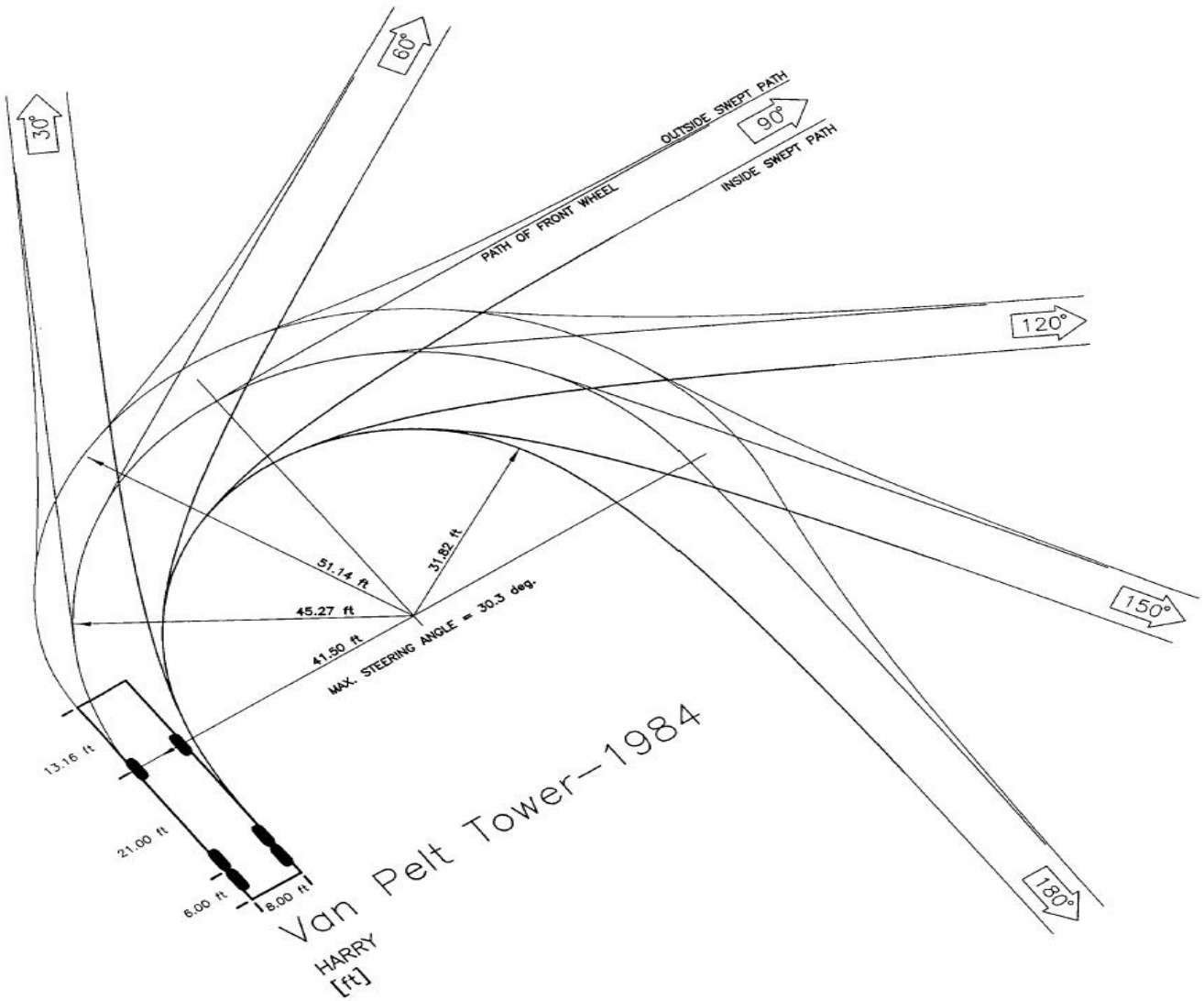
Clearwater, Florida
(Changes have been made to improve geometry since this photo was taken.)

Orange, California

APPENDIX F

VAN PELT TOWER FIRE TRUCK DIMENSIONS AND TURNING TEMPLATE


Select Current Vehicle
Group:
TAC-1999 (CA)
TIEHALLINTO (FI)
UK
FTA CUSTOM (UK)
VAGVERKET (SE)
VAGVERKET 2004 (SE)
VEGVESEN (NO)
VSS 1990 (CH)
CSN (CZ)
HARRY
40.16
13.16
21.00
Click Vehicle Information to view or add notes.
Vehicle:
L.A. CO. FIRE TRUCK
VAN PELT TOWER 1984
VAN PELT TOWER-1984
Name: Van Pelt Tower-1984
Group: HARRY
Type: Fire Truck
Width
Track
8.00
8.00
Lock to lock time: 6.00 sec.
Steering lock angle: 30.4 deg.
Length: 40.16
Units:
feet
OK
Cancel
Help


30°
60°
90°
120°
150°
180°
OUTSIDE SWEPT PATH
INSIDE SWEPT PATH
PATH OF FRONT WHEEL
51.14 ft
31.82 ft
45.27 ft
41.50 ft
MAX. STEERING ANGLE = 30.3 deg.
13.16 ft
21.00 ft
6.00 ft
8.00 ft
Van Pelt Tower-1984
HARRY
[ft]