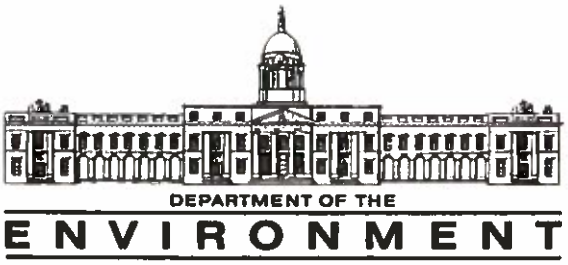

9. TRAFFIC SIGNALS

CHAPTER 9

DEPARTMENT OF THE ENVIRONMENT

Chapter 9 Traffic Signals

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Chapter 9 Traffic Signals

9.1 Introduction

9.1.1 Traffic signals are power operated traffic control devices by which traffic is directed to take specific actions. They are used mainly to improve the safety of vehicle users and pedestrians and to obtain the most efficient use of available road space.

9.1.2 The function of traffic signal control is to assign right of way between conflicting streams of traffic at intersections so as to accomplish some or all of the following objectives:

- To provide for safe and orderly movement of road users.
- To increase the handling efficiency of a junction.
- To reduce the frequency of accidents.
- To reduce overall delay.
- To enable traffic from minor roads to enter through routes without undue delay.
- To meet pedestrian needs.
- To promote driving comfort and convenience by supplying decision making at complex intersections.

9.1.3 The following types of traffic signals are discussed in this chapter of the Manual: Traffic signals, Pedestrian signals (including signals for Pelican and Zebra crossings) and Signals at Railway Crossings.

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9.2 Traffic Signal Displays

9.2.1 Traffic signals are a type of signal by which traffic is alternately directed to stop and permitted to proceed. They can provide for the orderly movement of traffic and increase the traffic handling capacity of a junction, while providing improved safety for both vehicular users and pedestrians.

9.2.2 Traffic control is achieved by means of red, amber and green light signals, arranged vertically and supplemented by additional green or amber aspect light signals as necessary. The signal sequence is: red, green, amber, red and signals are switched by means of an electronic controller. The diameter of the lenses should normally be 200mm excepting the green arrow which should be 300mm diameter. The standard period during which the amber signal is displayed is fixed at three seconds. The green signals and red signals are shown for periods which are variable. The significance of the specific light signals are explained in the Road Traffic Signs Regulations and Rules of the Road.

9.2.3 The lens dimensions and spacing together with the height above the ground are specified in the Road Traffic Signs Regulations.

9.2.4 The lower edge of the lower lamp shall be not less than 1.52m and not more than 3.05m above the surface of the ground in the immediate vicinity. The maximum spacing between centres of adjacent lenses is 380mm. Replicated signals, (e.g. high level signals) shall only be additional to the primary signals.

9.2.5 A green arrow light signal can be introduced in place of the full green light signal indicating a specific movement to the left or straight ahead only.

9.2.6 Additional green arrows may be fitted to indicate a permissible direction of travel.

9.2.7 The additional arrows may or may not be combined with red and amber lights. Sample arrangements of traffic signals including green arrow signals are shown graphically in Figure 9.1.

9.2.8 It should be noted that where green arrows are used, drivers have come to expect an exclusive right of way, so it is recommended that there should be no conflicting traffic in the junction.

9.2.9 Filter movements should be restricted to sites where a substantial advantage in handling traffic can be achieved and pedestrian needs can be satisfactorily met under the prevailing traffic conditions.

9.2.10 When a section of roadway (normally a junction slip lane off a dual carriageway) requires signalisation to facilitate a pedestrian phase or for strategic reasons when traffic making that movement must stop, confusion regarding vehicle priority can occur if the slip road traffic and traffic crossing the mouth of the slip road, have received the green or green arrow aspect. In this situation, amber arrow or flashing amber arrow should be used on the slip road instead of a green or green arrow aspect to indicate that one can proceed with a second level of prioity and that one can expect to meet a conflicting traffic movement. The signal should also display a red aspect only. 'YIELD' road markings without a 'YIELD' sign should be provided at the mouth of the slip road in accordance with Chapter 7.

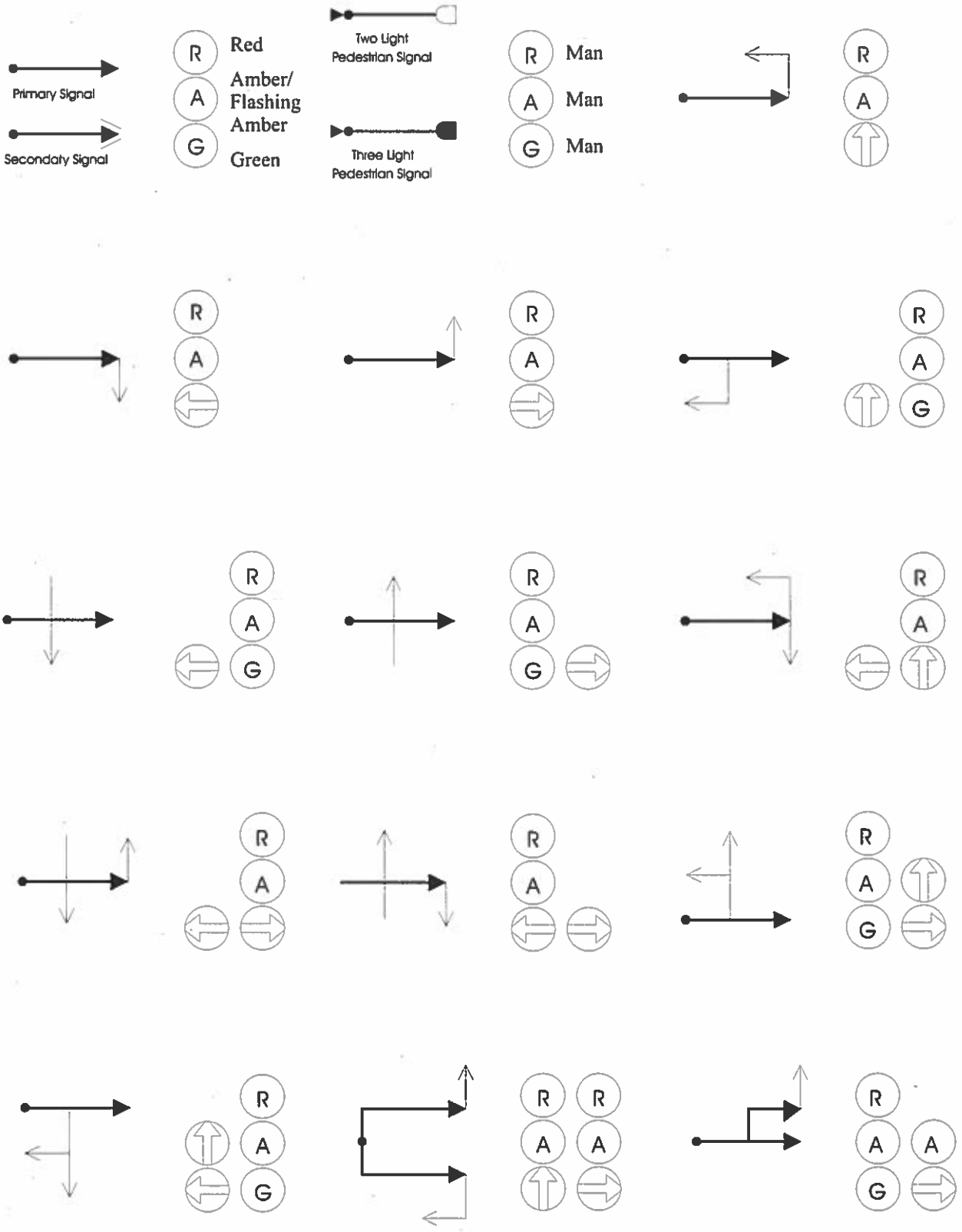

FIG. 9.1 Sample Traffic Signals & Symbols

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9.3 Traffic Signal Control Systems

Definitions

9.3.1 A phase is defined as a set of conditions relating to traffic movement, which fixes, for one or more streams during the cycle, the pattern of movement or waiting. The number of phases will depend on the number of roads entering the junction, the amount of turning traffic and the number of pedestrian movements. A series of phases is usually arranged in a predetermined order but some phases may be omitted if not demanded.

9.3.2 A stage is a condition of the signal lights during the period of the cycle which gives right of way to one or more particular traffic movements. Staging diagrams can be used to show phases of a signal installation.

9.3.3 A cycle is one complete sequence of signalling operations during which all traffic movements are served in turn. In practice, cycle lengths lie in the range of 40-120 seconds, but in specific situations, cycle times in excess of this may be necessary.

9.3.4 To achieve high capacity and reduce delay, as much traffic as possible should be kept moving at the same time and main traffic streams which do not conflict should be arranged to run at the same time. Two-phase control should be adopted where possible but additional phases may be needed:

(i) Where troublesome conflicting movements cannot be eliminated.

(ii) Where right turns are too heavy to be dealt with by other means of control

(iii) At complex junctions with five or more legs.

(iv) At junctions where pedestrian phases are required.

9.3.5 The control of traffic signals can be carried out by one of the following methods:

(i) Fixed Time Signals: Fixed time signals are signals where the green periods and hence the cycle times are predetermined and of fixed duration. The controllers are simple and relatively inexpensive, but they are necessarily inflexible and require careful setting.

(ii) Varied Fixed Time Signals: Varied fixed time signals are fixed time signals with time switches which can alter the settings at certain periods of the day to cover different traffic conditions.

(iii) Vehicle Actuated Signals: Vehicle Actuated signals are signals which respond to traffic demands by using vehicle detectors. In the absence of demands the signals will generally revert to main road. Vehicle detection can by achieved by:

(a) Inductive Loop Vehicle Detection: This consists of equipment which detects the passage or presence of a vehicle by means of the change which the vehicle produces in the self or mutual inductance of a conductor or conductors placed in or on the road surface. Detection is performed by a loop or loops, consisting of one or more turns of wire laid in or on the carriageway leading up to the STOP line.

(b) Microwave Vehicle Detection: This operates by the direction of a beam of microwave energy along the carriageway towards an approaching vehicle and the detection of the signals reflecting back from the moving vehicle. The equipment is generally mounted on top of the signal head or below the green aspect.

(c) Infra Red Vehicle Detection: Vehicle detection can also be carried out by illumination of the carriageway with infra red light from a source unit placed on top of the signal head. Vehicles travelling through the detection zone are focused by an optical system into a detector. The use of infra red vehicle detection is currently limited.

(iv) Linked System: When two or more junctions are in close proximity on a main traffic route, some form of linking is necessary to reduce delays and to ensure the maximum amount of traffic passes without enforced halts while also allowing for the claims of cross street traffic. Linked systems can be: (a) cableless (b) cable linked or (c) radio linked. On a cableless linked system, co-ordination of two or more junction controllers can be achieved by the use of units synchronised by the mains supply frequency and incorporating a solid state memory store. Stage timings

and cycle times are stored on the memory and can be selected according to the time of day to cater for variations in overall traffic pattern. Cable linked systems can be used where junctions are very close together. Information is passed between two or more controllers by buried cable to arrange that the commencement of a selected stage at one intersection (termed the key intersection), by vehicle activation, shall control the beginning or end of any selected stage or stages at other intersections (known as controlled intersections).

9.3.6 Traffic signal installations in a wide area can be controlled by the controller responding to instructions from a central computer. Signals are controlled by the computer using traffic plans generated by historical data. Plans are normally selected according to the time of day and the day of the week. Urban Traffic Control can be further enhanced by the use of an adaptive urban traffic control system which responds in a programmed fashion to variations in pedestrian and traffic demand.

Traffic Engineering of Signalled Junctions

9.3.7 Opposing streams of traffic are managed at signal controlled junctions by holding certain streams stationary while others are allowed to pass. A traffic signal installation should reduce the delay, maximise the capacity and maintain a high degree of safety. This can be achieved by allowing conflicting moves (e.g. right turn on full green), by restricting movements (e.g. banned right turn) or by the separation of traffic streams which conflict, by assigning them to different stages. The following facilities are available on vehicle actuated signal installations to assist with traffic control:

(i) Minimum Green and Vehicle Extension Periods: The minimum green period is the shortest period of right of way which is given to any phase and is long enough for vehicles waiting between the detector and the stop line to get into motion and clear the stop line. The minimum green period is 6 seconds. A vehicle extension period allows the shortest period of right of way which is given to any phase to be varied depending on the number of vehicles waiting at the start of the green period. The minimum green period may be further extended by vehicles which cross the detector during the green period. This extension depends on the speed of the vehicle as measured by the detector but it is recommended that the extension should be 2 seconds per vehicle for normal traffic conditions. If the green is held too long the phase is

terminated at the maximum green setting. Green period extensions should be provided on all traffic signals on roads with 85 percentile approach speeds in the range of 55 to 105 km/h.

(ii) Preset and Variable Maximum Running Period: To prevent vehicles on a halted phase from waiting indefinitely because of a continuous stream of traffic on the running phase, a maximum period is timed off, after which the signals change right-of-way, irrespective of the state of the vehicle extension period. The maximum running period can be extended beyond its pre-set value if the average rate of traffic flow at the end of the maximum period exceeds a predetermined critical value.

(iii) Variable Intergreen Period: The standard period between the end of the green display for one phase and the start of the green display for the next phase is normally set at five seconds, comprising 3 seconds amber and 2 seconds all-red. The intergreen period can be varied by vehicle actuation when a longer clearance is necessary to protect clearing traffic. Extra clearance is thus provided only when vehicles are clearing the junction. A one second all-red can be used if specifically required, provided adequate clearance is allowed after the last vehicle extension before the intergreen period.

(iv) Early Cut Off: To facilitate a heavy right turn movement from one approach, the green time of the opposing stream can be cut a few seconds earlier. The duration of the early cut-off period can be readily adjusted by detectors operated by the turning traffic.

(v) Exclusive Stages: Where both right turn movements are heavy, the right turns can be held on a red signal while the straight ahead traffic proceeds on green. The straight through traffic is then stopped and the right turn traffic on both approaches is then released simultaneously. This should be achieved by separating right turn traffic into exclusive lanes by traffic islands with separate signal displays for each approach. This method, which is shown in Figure 9.5, should normally be used on all roads where the 85 percentile approach speed is greater than 70 km/h on any arm of the junction, provided the space is available.

9.4 Layout of Traffic Signals

General

9.4.1 The main consideration of traffic signal installation placement is visibility. Drivers approaching a signalised junction should be given a clear and unmistakable indication of which directions they can take at that junction. In addition, they should be guided in advance into the correct lane by means of road markings. There should be at least two signals visible from each approach if there is no waiting traffic, usually comprising a primary and a secondary signal.

9.4.2 Primary signals are light signals erected on or near the carriageway on the left hand side and sited in the vicinity of either or both ends of the STOP line facing approaching traffic. On wide approach roads with refuges, or a central reserve or on roads with an 85 percentile appoach speed between 55 to 105 km/h, the primary signal should be supplemented by a second primary signal on the refuge or reserve. On one way streets a second primary signal should always be provided.

9.4.3 Secondary signals are light signals erected on or near the carriageway facing traffic in the same direction as the primary signals but sited on the offside of the road beyond the junction. They are often placed on the back of the primary signal which faces opposing traffic. On roads with refuges or a central reserve the secondary signal should be sited on the further refuge or reserve, if it will then be more conspicuous to traffic. Secondary signal displays must not conflict with the primary display.

9.4.4 The primary signal should be located 1m to 5m beyond the STOP line on the near side of the approach. The secondary signal should be sited within an angle bounded by the centreline of the carriageway extended through the junction and a line 35° to the right of it, drawn from the intersection of the stop and the centreline and should be as close as possible.

9.4.5 Where two approaches share a common stop line and are not separated by an island, the primary signal for the right hand approach may have to be placed on the offside of that approach.

9.4.6 In certain circumstances it may not be practicable or desirable to site the secondary signal beyond the junction on a particular approach. On these occasions it may be positioned on the entry side of the junction beyond the STOP line on the offside.

9.4.7 The distance from the kerb edge and any part of the signal should not normally be less than 350mm to prevent damage from lateral overhang of vehicles.

9.4.8 The signal controller cabinet should be positioned so that it does not obstruct the view to motorists of pedestrians, particularly children, beginning to cross and it should cause minimum obstruction on the footway. Should it be necessary to site the controller adjacent to the kerb, then it shall not be possible for the access doors to open over the carriageway. When the doors are open they should not completely block the footway. In addition, the cabinet should be sited so that the complete function of the signals are visible to assist an operator when the signals are under manual control or being tested.

9.4.9 The normal width of the lanes at signalled junctions should be 3-3.7m depending on the type and speed of traffic and width of the carriageway. This width may need to be adjusted to allow for additional lanes for straight through and turning traffic having regard to the overall width available. The absolute minimum width of 2.4m is allowable alongside refuges at signals and at the stop line but nowhere else. Guidance on road markings at signalised junctions is given in Chapter 7.

9.4.10 Where possible, refuges and islands should have a regulatory keep left sign mounted in illuminated bollards or on short posts.

T-Junction Layout

9.4.11 Figure 9.2 shows a possible layout of signals at a simple T-Junction.

Major/Minor Crossroad Intersections.

9.4.12 Figure 9.3 shows a possible layout of signals for a typical crossroad intersection with a major road with two lanes per approach crossed by a minor road with one lane per approach.

9.4.13 Figures 9.4-9.6 show further examples of the layout of junctions between major and minor roads which are all variations on the same theme. For these, the opposing right hand turns are opposite each other, which facilitates non-hooking turning movements on the major road phases. Figure 9.5 shows the right turn separately signalled and segregated by a traffic island.

Staggered Junctions

9.4.14 Staggered junctions can be either left/right or right/left as illustrated in Figures 9.7 and 9.8 with each case presenting different problems. The major problems are junction blocking causing tailing-back and turning movements which can lead to conflict. Before a layout is designed every effort should be made to employ traffic management techniques to eliminate as many turning movements as possible. If the two staggered arms are less than 250m apart, local linking will be required. If the staggered junctions are more than 250m apart they should be treated as two isolated T-junctions as shown in Figure 9.8.

9.4.15 Where the roads intersect at angles other than 90°, the major problems encountered are turning radii and location of secondary signals. Figure 9.11 shows the limits applicable. The maximum allowable distance between a stop line and the associated secondary signal is 50m.

9.5 Design of Traffic Signals

9.5.1 To obtain the maximum benefits from the provision of traffic signal control, it is essential that they are installed in accordance with uniform criteria. Following an analysis of traffic operations at a series of differing junctions, warrants were established defining the minimum conditions under which signal installations may be justified. The current applicable warrants are those outlined in RT181, 'Geometric Design Guidelines' - An Foras Forbartha. The use of these warrants should form part of a comprehensive investigation of traffic conditions and physical characteristics of the location which shold provide the necessary data for the proper design and operation of a signal that is found to be warranted. The following data is required to enable the need for traffic signals to be properly assessed and the design of the signal to be carried out:

(a) Traffic volumes. Pedestrian and vehicular directional counts over a ten-hour period of a representative day on each approach.
(b) Approach Speeds. 85 percentile speed of vehicles on each approach.
(c) Site Conditions. These should include approach widths, gradients and approach distances.
(d) Accident History

Instructions on the use of these warrants and the final design of the signals system is outside the scope of this document.

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9.6 Visibility and Illumination

9.6.1 The main consideration of traffic signal installation placement is visibility. Drivers approaching a signalled junction should be given a clear and unmistakable indication of which directions they can take at that junction. Signal faces should be adjusted to face the approaching traffic for which they are intended.

9.6.2 The minimum visibility distances, with no traffic present, required to the primary signal(s) are given in Table 9.1. These are based on vehicle stopping distances including an allowance for the drivers reaction to the signal.

TAble 9.1 VISIBILITY DISTANCES

85 Percentile Approach Speed	Visibility Distance
40 km/h	40m
60 km/h	80m
80 km/h	130m
100 km/h	190m
120 km/h	270m

9.6.3 Each lens should be illuminated independently and the optical system should be in accordance with current specifications.

9.7 Pedestrian Signals

9.7.1 Pedestrian signals are traffic signals intended for the exclusive purpose of controlling pedestrian traffic. Their objective is to assist pedestrians to cross safely with the minimum delay to traffic. Pedestrian facilities should be provided in accordance with current warrants.

9.7.2 Pedestrians are catered for by providing a special phase for pedestrians where their movements are signalled. This pedestrian phase is best activated by demand from push buttons but can be activated automatically if the circumstances justify it (for example to prevent phases getting out of step with adjacent signals on linked signal systems).

9.7.3 New pedestrian Signals should consist of:

- A figure of a pedestrian in green on a black background.
- A figure of a standing man in amber on a black background.
- A figure of a standing man in red on a black background.

The nominal diameter of the lenses should be 200mm.

9.7.4 The pedestrian signal sequence is red, green, amber, red. The duration of the green man signal, which indicates that pedestrians may start to cross the road, is 6 seconds. The duration of the amber man should be based on the time to cross the full road width at a walking speed of 1.2m per second. The all red times before and after the pedestrian crossing should be at least 1 second but can be increased depending on the road speed. Thus the green man and all red after times represent a significant margin of safety.

9.7.5 Where it is possible to permanently prohibit some vehicle movements, a combination of vehicle and pedestrian stages can be installed. By virtue of banned turns, pedestrian facilities can be provided across appropriate arms. For wider carriageways it is possible to economise on cycle time by the provision of a large island in place of the normal refuge. The two parts of the carriageway are controlled by separate pedestrian signals which are offset at the opposite ends of the island and pedestrian right of way is demanded by button. The recommended minimum island size is 5m x 1.8m.

9.7.6 If the junction is close to capacity, a pedestrian facility should be considered up to 50m from the mouth of the junction with the stage included in the junction signal cycle where warranted.

9.7.7 If required, audible signals can be provided at non-junction pedestrian phases to indicate the green man period for the benefit of the visually impaired, if there is no danger of the unit being heard at adjacent signalised pedestrian crossings.

9.7.8 Where it is impracticable to install audible signals it may be desirable to provide tactile signals (a knorled knob mounted beneath the push button box which vibrates when the steady green man is shown)

9.7.9 Sloping ramps are essential where there is a need for wheelchair users to cross the carriageway. Tactile surfaces behind the kerb are of benefit to the visually impaired.

9.7.10 Guard rails should be provided if it is required to restrict the crossing of pedestrians to certain approaches or locations or to prevent crossing at dangerous places.

9.7.11 Zebra crossings are pedestrian crossings marked by pedestrian lines and alternate black and white stripes and flashing beacons, on which pedestrians have priority over vehicles. They are not normally considered suitable for roads not subject to 30 mph speed limits or where there is more than one lane in each direction.

9.7.12 Consideration should be given to the provision of adequate lighting, to ensure that the crossing can readily be seen against the background of other lights and signs. This can be achieved by the provision of good road lighting.

9.8 Pelican Crossings

9.8.1 Pelican crossings are crossings which control both vehicular and pedestrian traffic by light signals. They differ from conventional pedestrian light signals by incorporating two unique signal phases, flashing green man signal to pedestrians and a flashing amber signal to drivers. Both phases are displayed simultaneously with the flashing amber signal slightly overlapping the red to pedestrian phase. The flashing green pedestrian signal commences immediately after the non-flashing green pedestrian signal. Pedestrians who arrive at the crossing after the green signal starts to flash, may not cross. For motorists, the flashing amber signal is displayed after the red phase and it indicates that drivers may proceed if the crossing is clear. However, if there are pedestrians on the crossing, drivers must continue to give way to them.

9.8.2 The decision on whether a crossing is to be provided is normally based on the warrant analysis which includes safety and other site related considerations. The decision on whether to use a Pelican rather than a Zebra crossing will be based on road width, vehicle speed and pedestrian volumes and reference should be made to the pedestrian crossing facilities warrant.

9.8.3 The crossing should be located where pedestrians are most likely to use it and where it does not confuse or cause conflict for vehicular movement. The minimum recommended distance between pedestrian crossings, or between a pedestrian crossing and a signal controlled junction is 100m. Adequate footway capacity should be provided at each end of the crossing for assembly and dispersal.

9.8.4 The crossing should be located away from conflict points at uncontrolled junctions and care should be taken when siting close to roundabouts.

9.8.5 An audible signal device may accompany the green walking man period. The audible signal device should be switched to a lower signal at night.

Visibility.

9.8.6 Minimum distances for drivers visibility of crossings are as set out in Table 9.1.

Crossing Width

9.8.7 The minimum pedestrian crossing width for both pelican and pedestrian crossings is 2.4m. An additional 0.5m may be provided for each 125 pedestrians per hour above 600 (average over the 4 hours of peak pedestrian use) up to a maximum of 5m.

9.8.8 Typical layouts for pelican crossings are shown in Figures 9.15 and 9.16. The guiding principle regarding the provision of signals is that a driver must have a clear view of at least one signal head on approaching the crossing and when stationary at stop line.

9.8.9 Pelican crossing timings are similar to the pedestrian crossing timings set out in Section 9.7.4. The green man time should be a minimum of 6 seconds and the flashing green man duration should not be less than the time to cross the full road width at a walking speed of 1.2 metres per second.

9.8.10 Pelican crossings are generally not suitable if there are more than two lanes on either approach or if there is a central island.

9.9 Railway Level Crossings

9.9.1 Full details of railway level crossing signals are contained in 'Requirements and Guidelines for the Provision of Automatically Operated Half-Barriers at Railway Crossings' issued by the Department of Transport, 1982.

9.10 Maintenance of Traffic Control Signals

9.10.1 The responsibility for maintenance of traffic control facilities lies with the appropriate Road Authority. Regular maintenance of signals is clearly important because any failure can cause considerable uncertainty and confusion to drivers with consequent accident risk.

9.10.2 Regular servicing, including inspection of signals, should be carried out annually at a minimum. This service should include a check on all lamps, timings etc. and any defective parts should be repaired immediately.

9.10.3 A maintenance service should be available to repair signal malfunctions at short notice.

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NOTES

1. For details of road markings see Chapter 7
2. For symbols used see Fig. 9.1

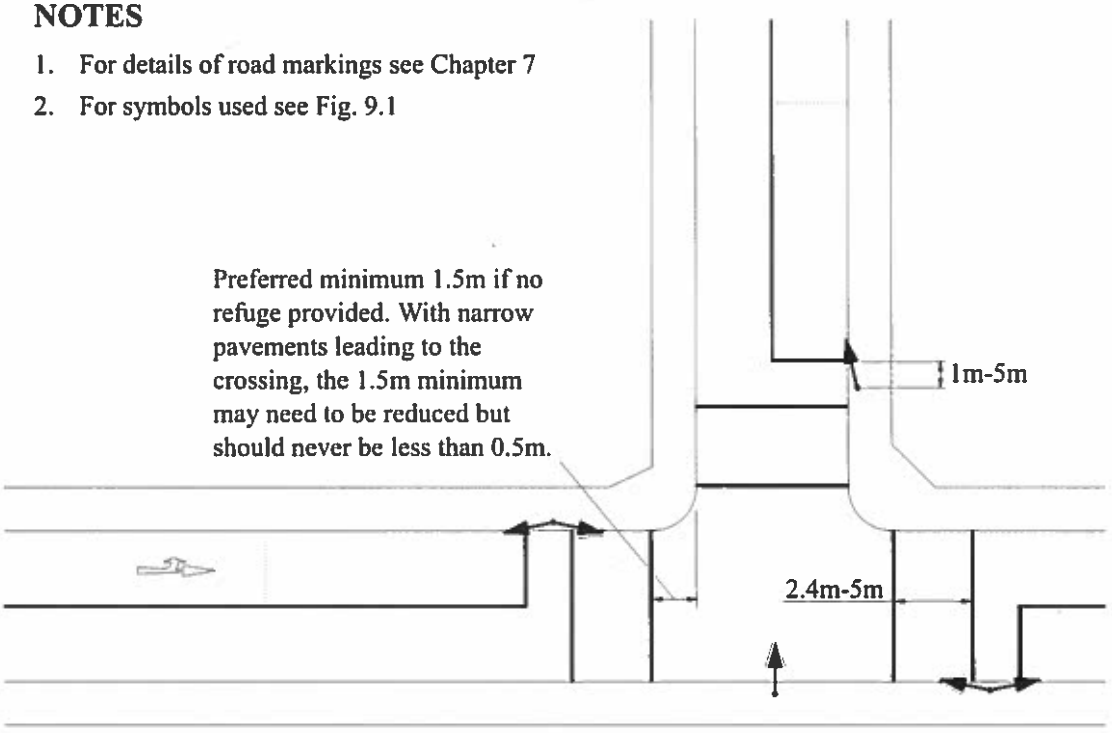

FIG. 9.2 T-Junction Layout

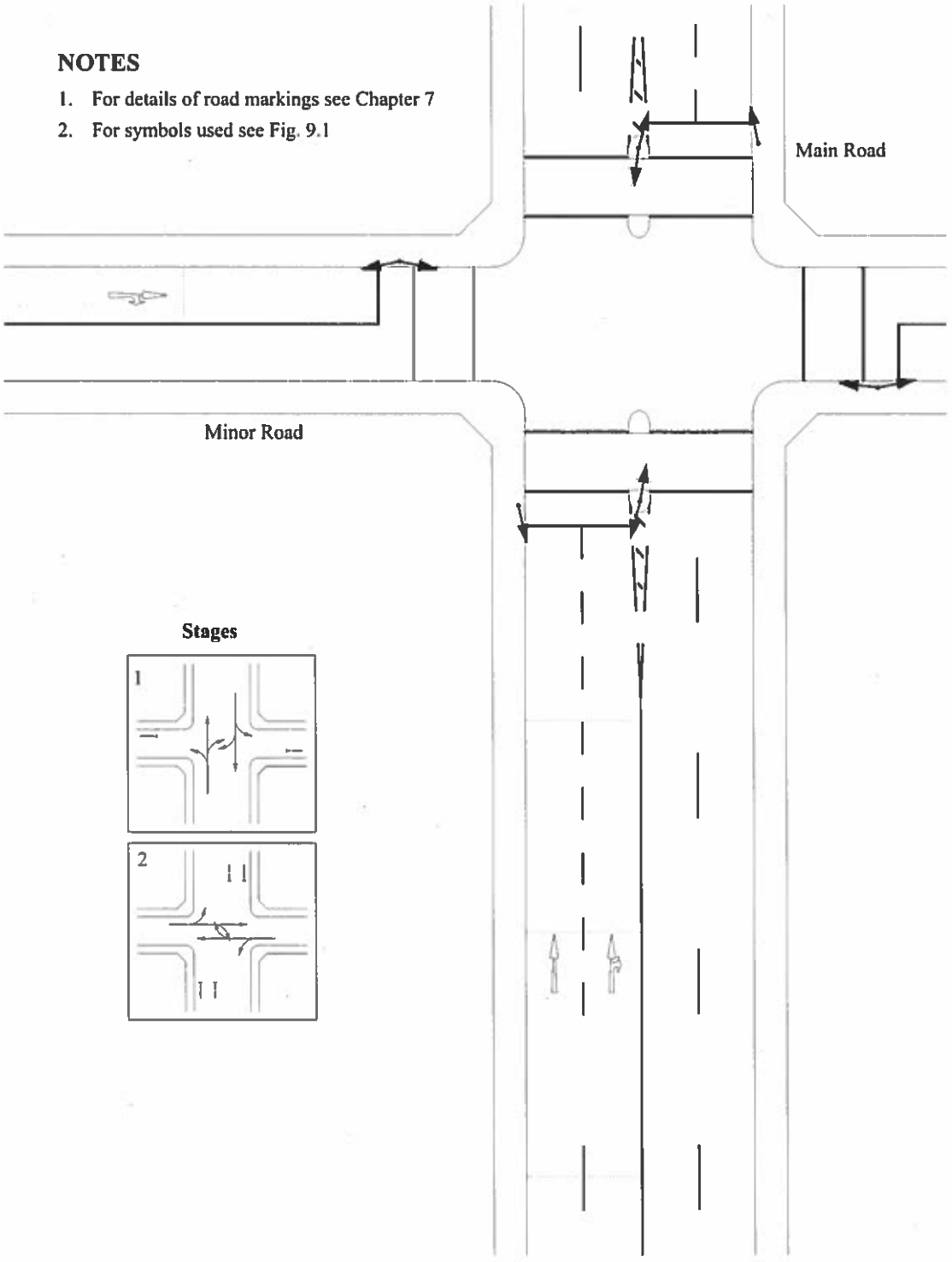

FIG. 9.3 Signal Layout at Major/Minor Intersection

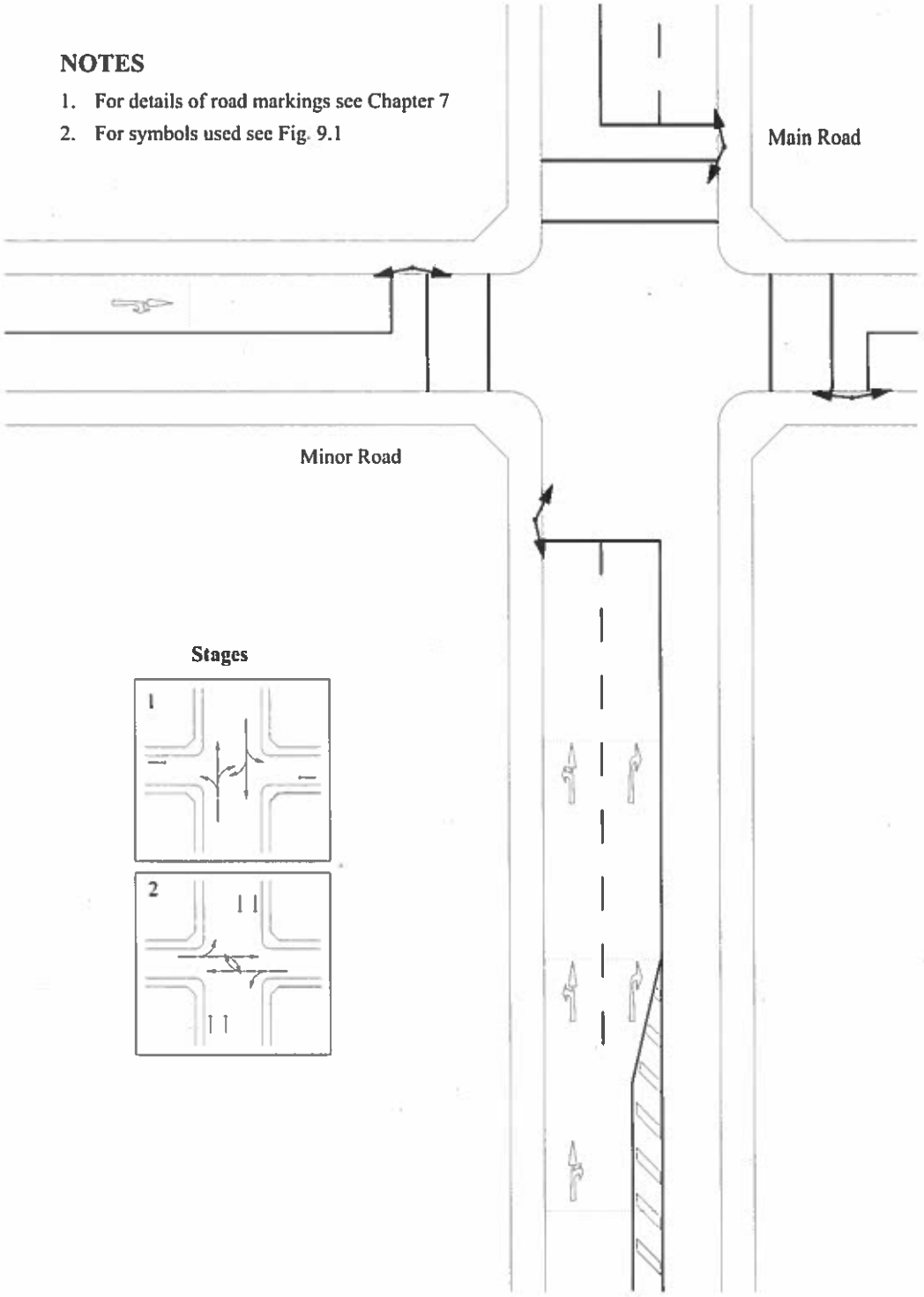

FIG. 9.4 Signal Layout at Major/Minor Intersection

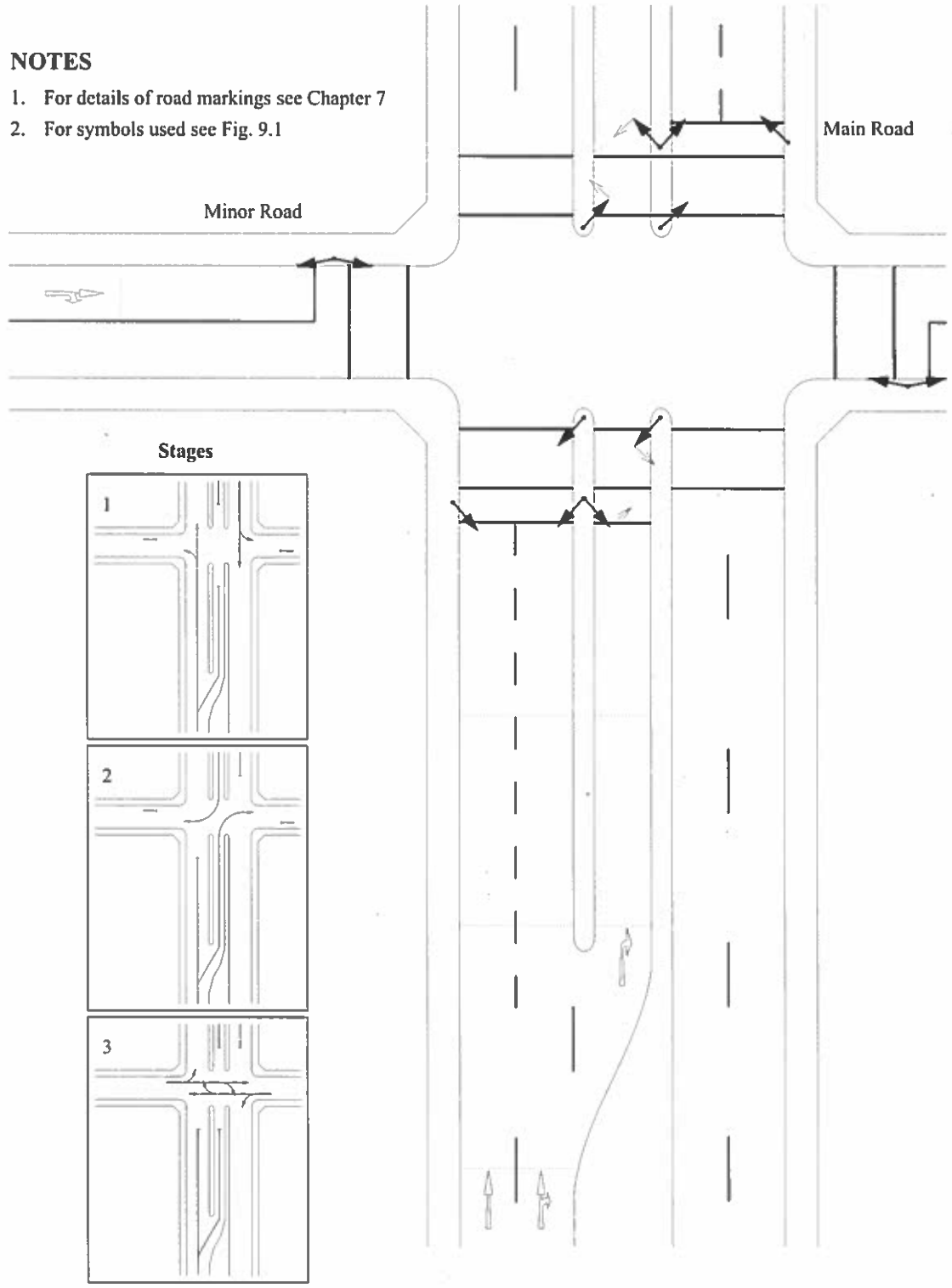

FIG. 9.5 Signal Layout at Maior/Minor Intersection

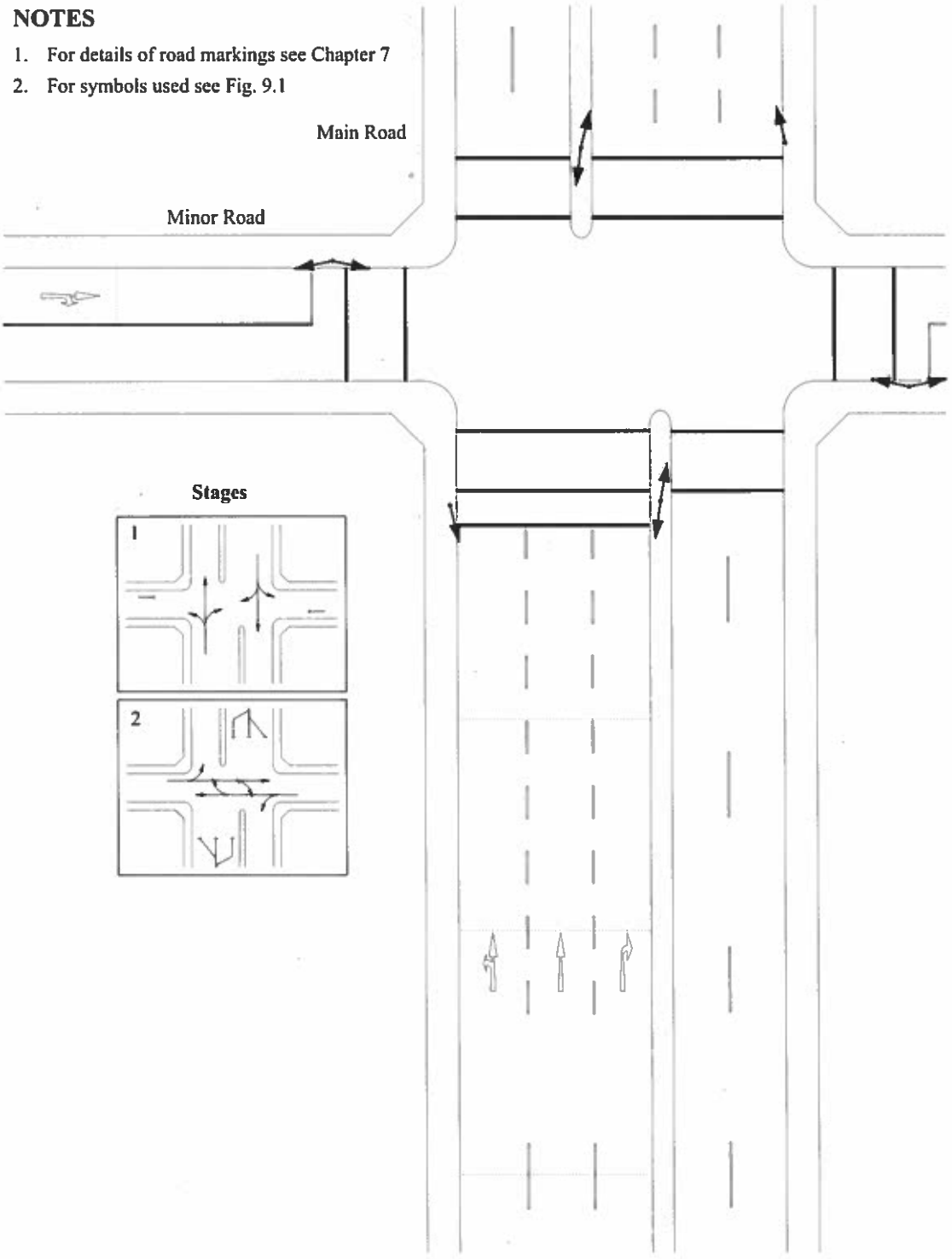

FIG. 9.6 Signal Layout Major/Minor Intersection

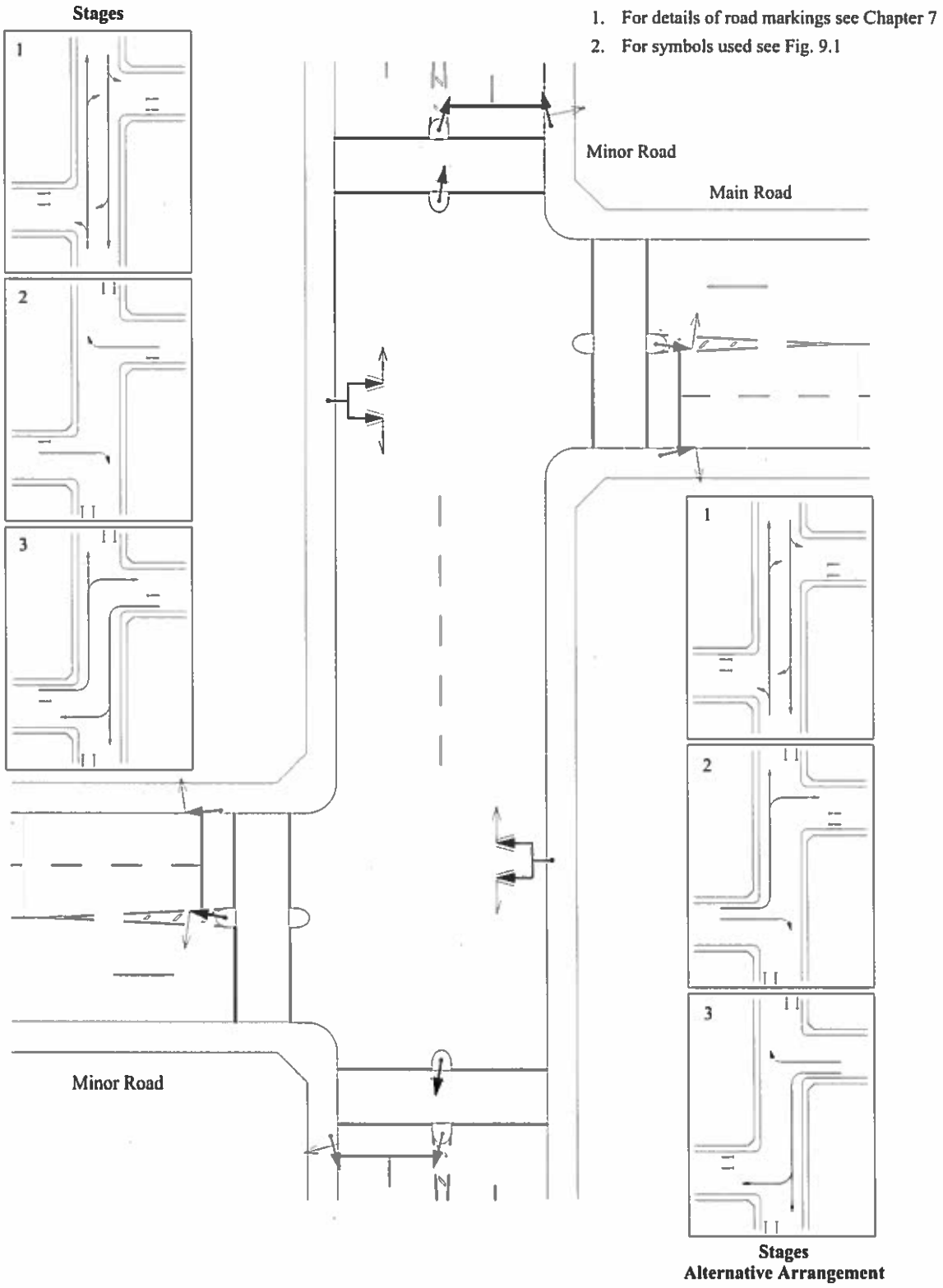

FIG. 9.7 Signal Layout at Left / Right Stagger

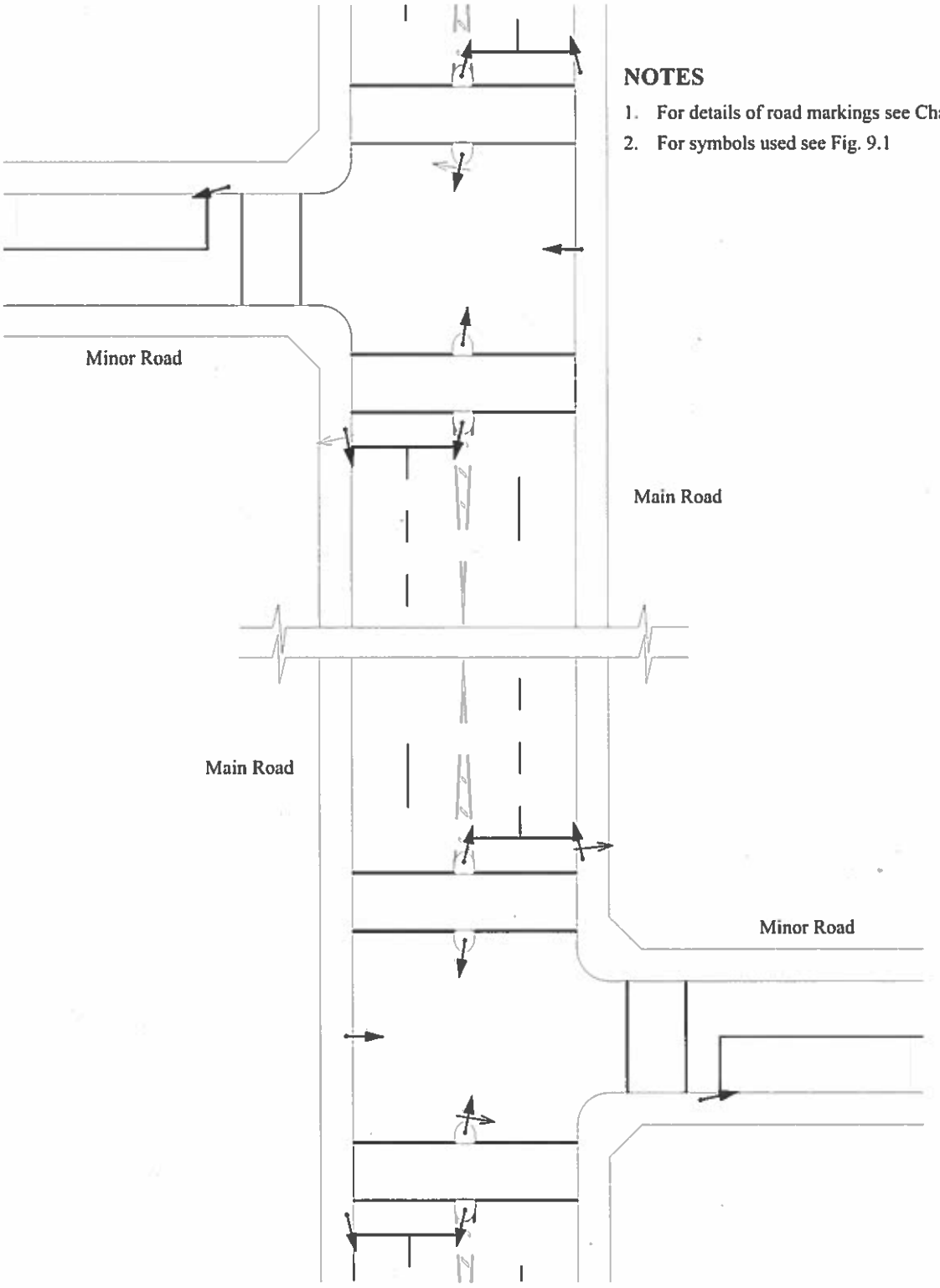

FIG. 9.8 Right / Left Staggered Junction

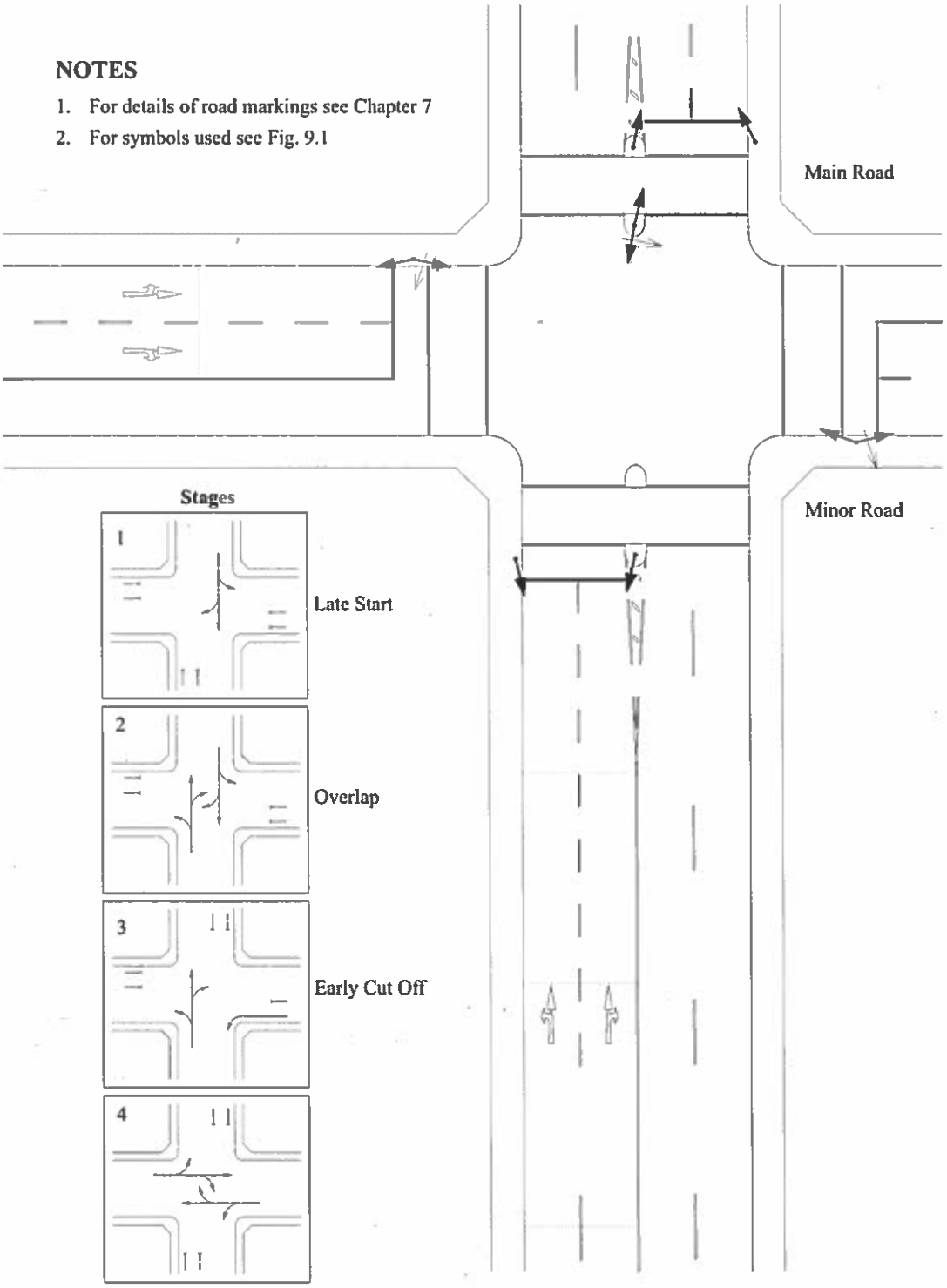

FIG. 9.9 Staging Arrangement for Late Release, Early Cut-off and Filter

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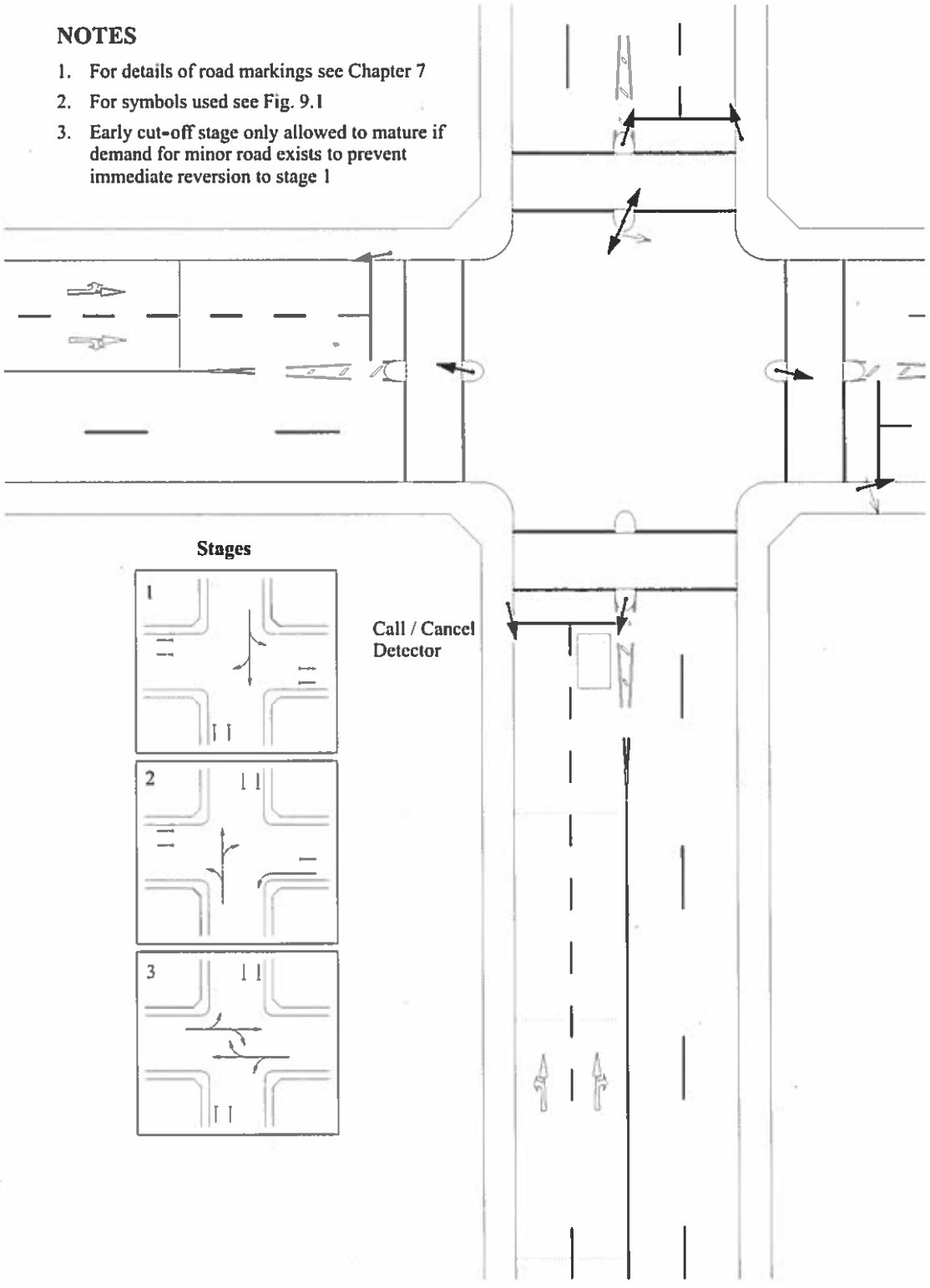

FIG. 9.10 Signal Layout with Early Cut-off Stage

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NOTES

1. For details of road markings see Chapter 7
2. For symbols used see Fig. 9.1

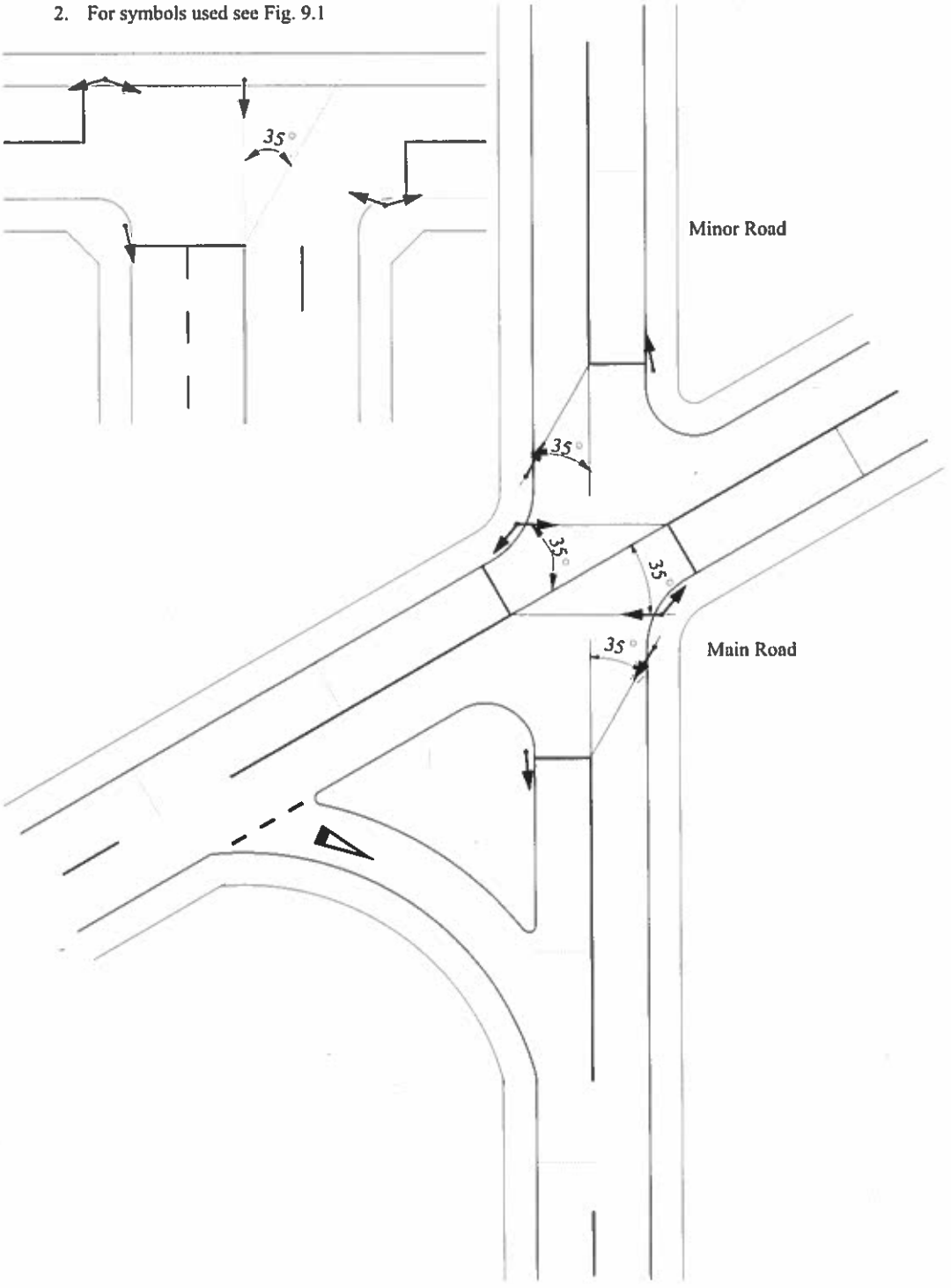
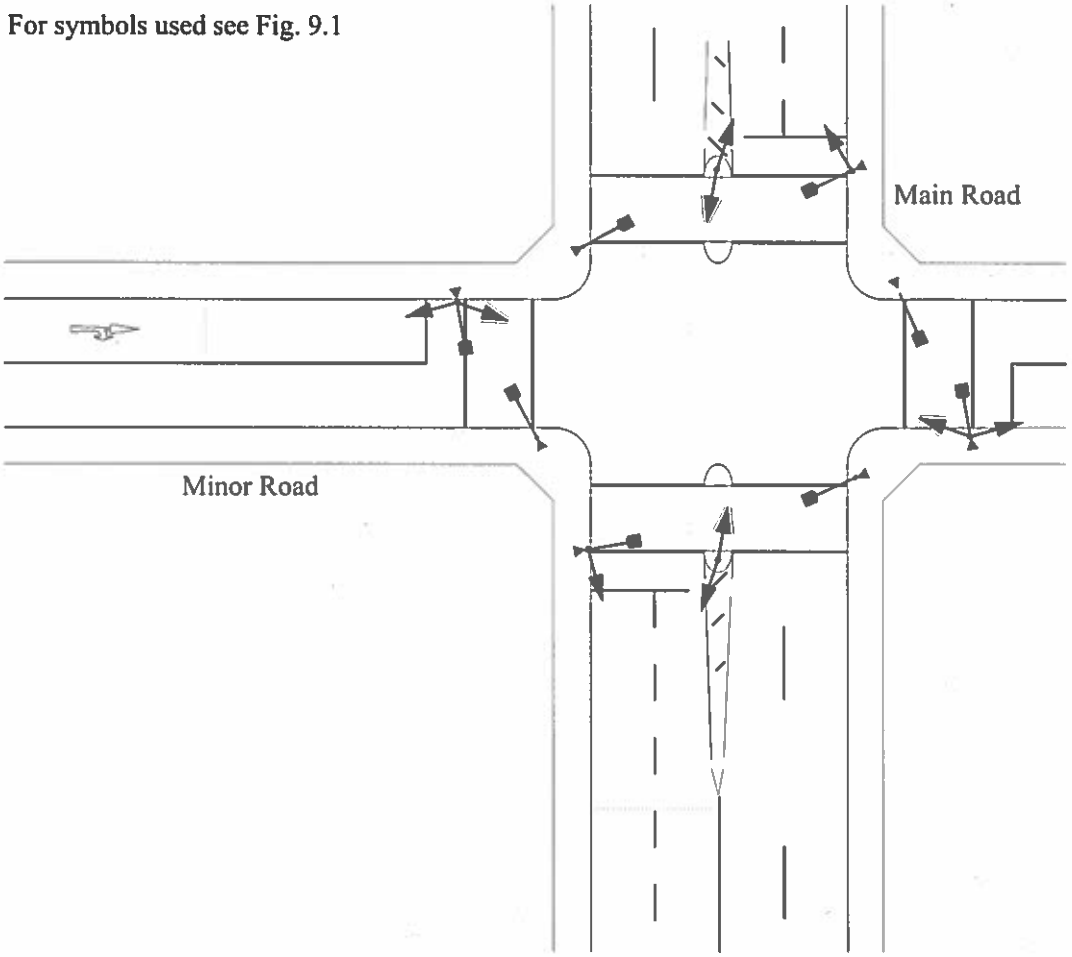


FIG. 9.11 Signals Layout Showing Positioning of Secondary Signals

ENVIRONMENT

NOTES

1. For details of road markings see Chapter 7
2. For symbols used see Fig. 9.1



Stages

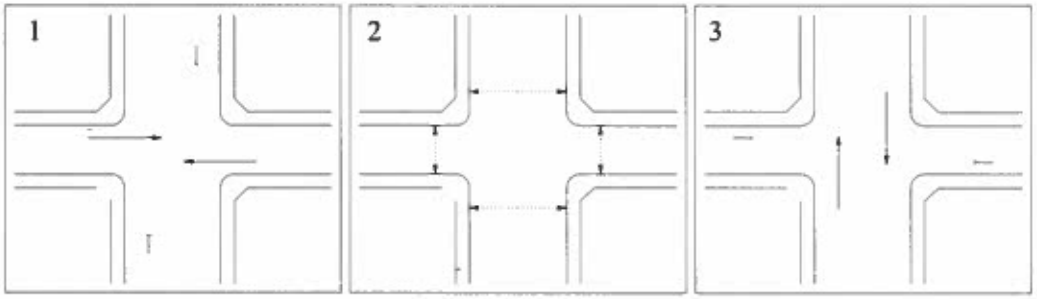


FIG. 9.12 Pedestrian Signals with Full Pedestrian Stage

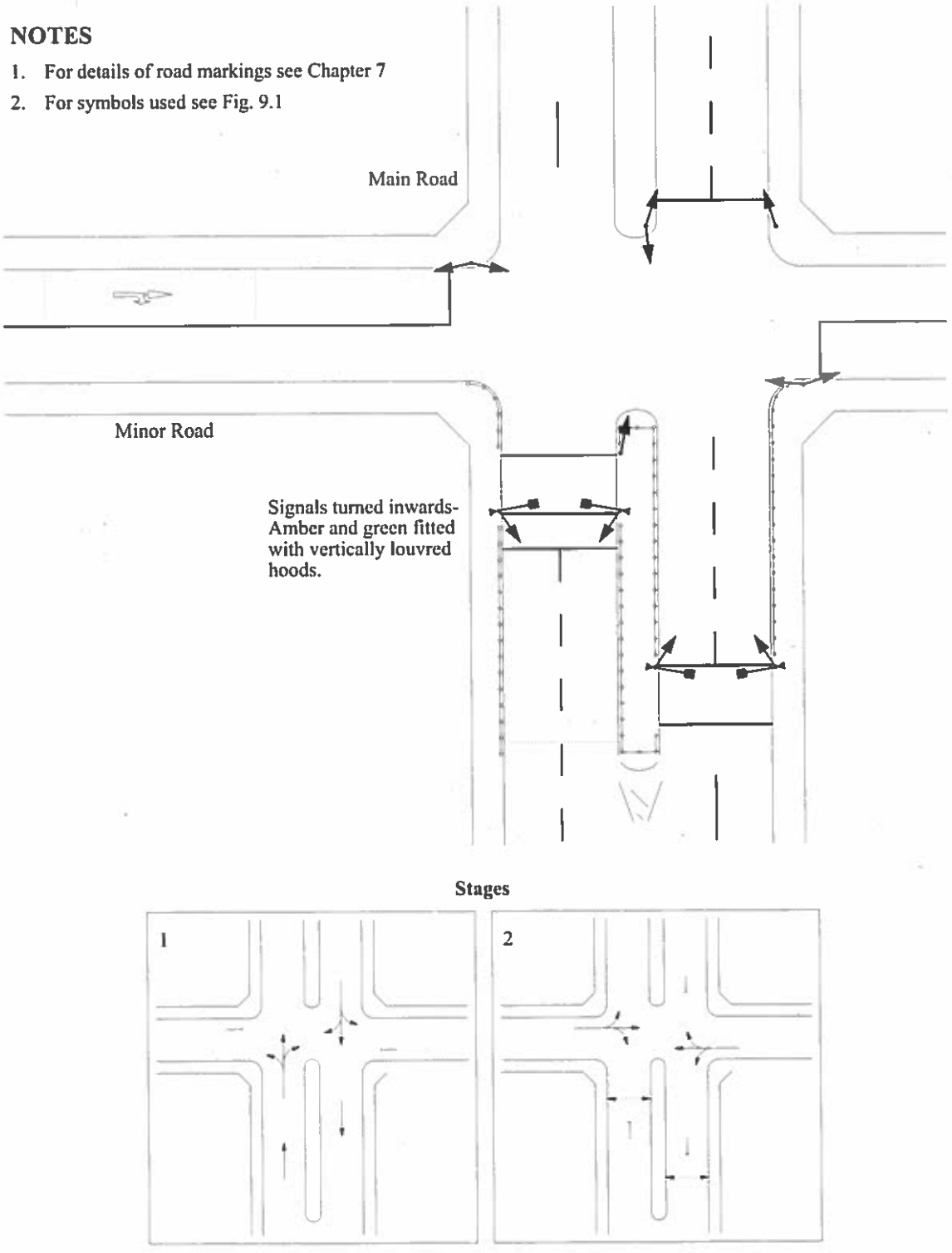
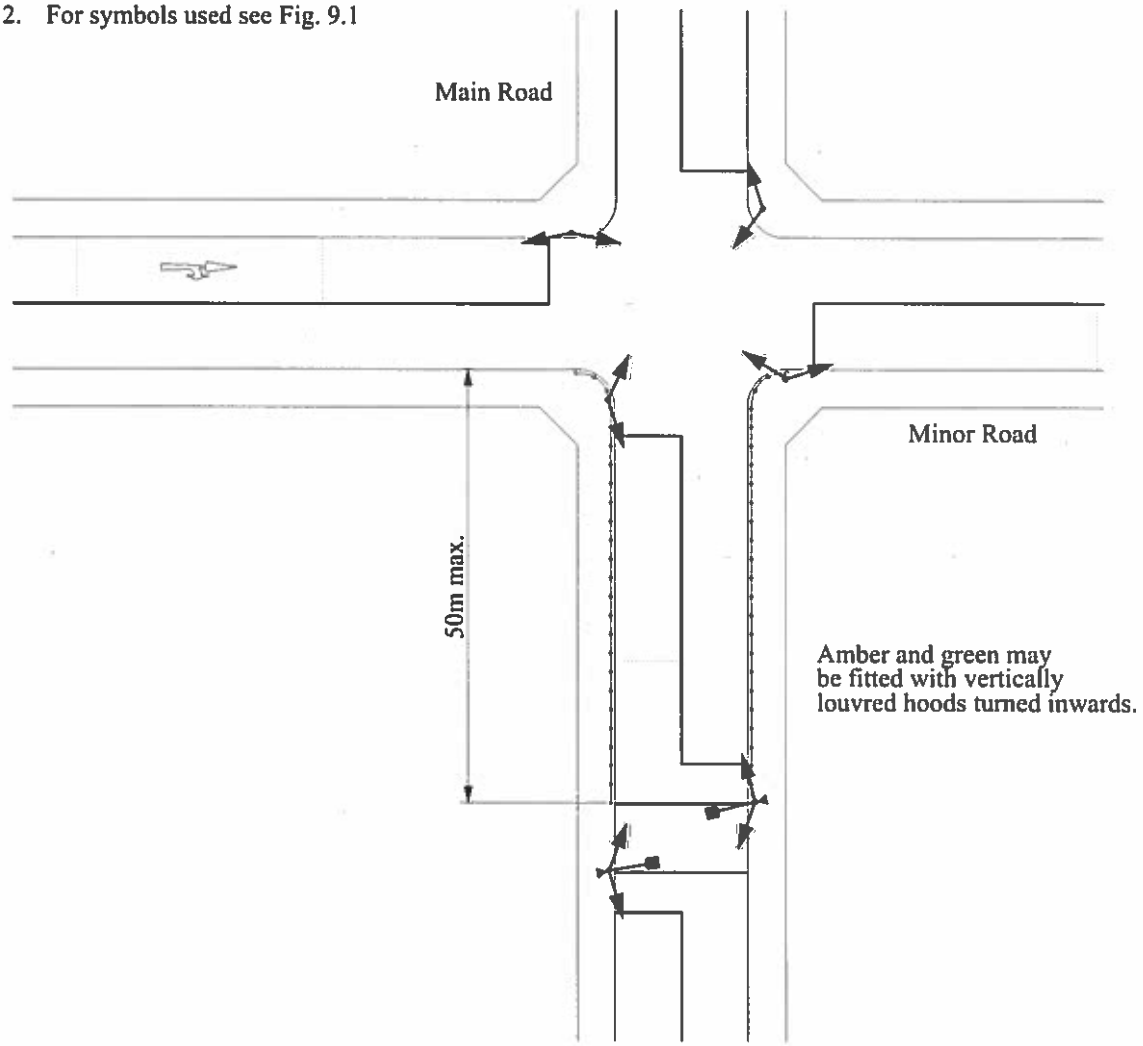


FIG. 9.13 Staggered Pedestrian Facility

NOTES

1. For details of road markings see Chapter 7
2. For symbols used see Fig. 9.1



Stages

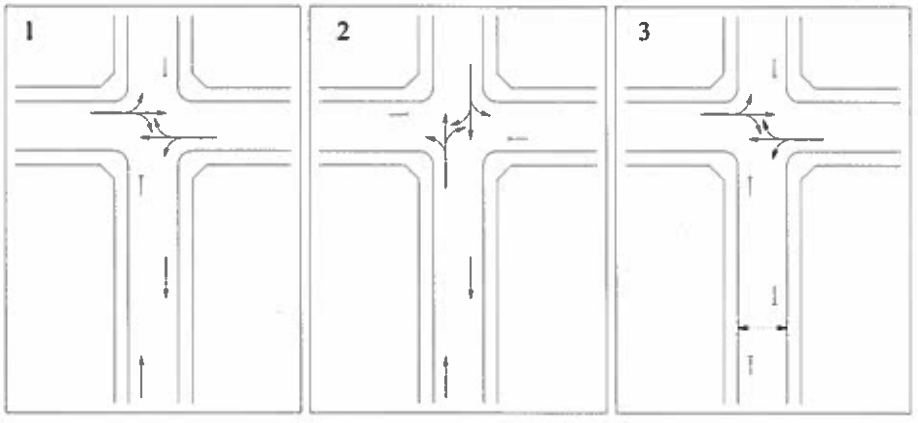


FIG. 9.14 Displaced Pedestrian Facility

DEPARTMENT OF THE ENVIRONMENT

NOTES

1. For details of road markings see Chapter 7
2. For symbols used see Fig. 9.1

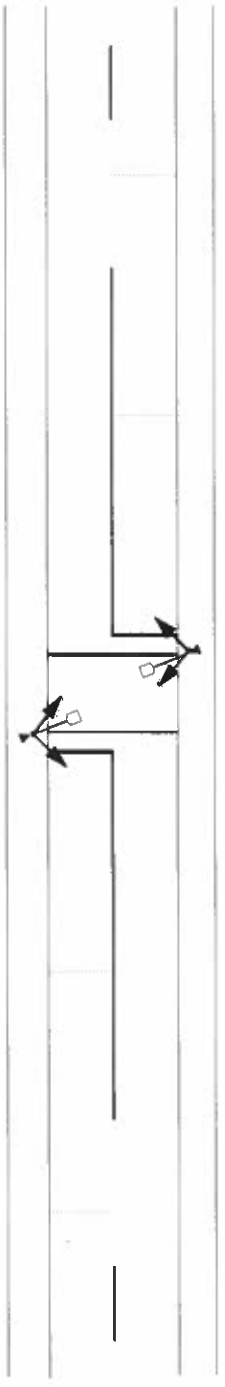


FIG. 9.15 Pelican Crossing on Two Way Street

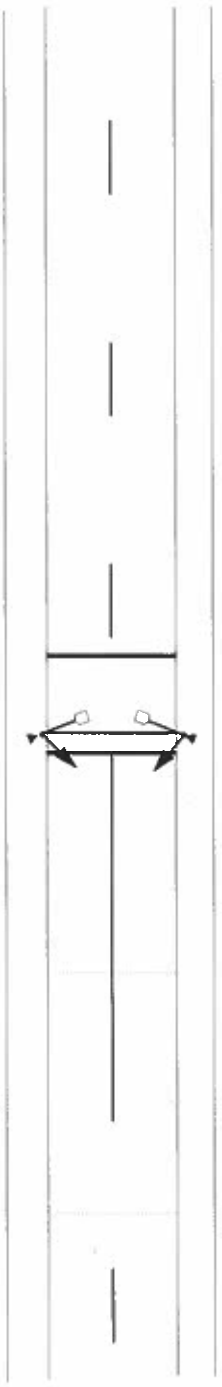


FIG. 9.16 Pelican Crossing on One Way Street