University of Southern Queensland
Faculty of Engineering and Surveying

Evaluation of the Queensland Streets Concept in Residential Streets in Logan City

A dissertation submitted by

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towards the degree of

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Abstract

The Queensland Streets document was published in May 1993 to provide the basis for uniform design standards for residential streets in Queensland. This document incorporated new design principles and techniques for the control of traffic volumes and traffic speeds in residential streets.

This dissertation investigates the traffic calming control devices that have been installed in the residential streets of Logan City. The investigation includes assessing traffic calming devices in Logan City to predict the likely speeds through the devices, carrying out on-site measurement of speeds through devices, making comparisons with the Queensland Streets document to assess if these devices meet the objectives of Queensland Streets, and, if satisfactory devices were found, determining a small number of devices that could be adopted as standard devices for use in Logan City.

The investigation has shown that the devices installed in the residential streets of Logan City do not meet the recommended speed objectives of Queensland Streets, that is, 20 km/hr through devices. The second edition of Queensland Streets has suggested that the actual speed through these devices is 25 km/hr. The average recorded site speeds of the selected traffic calming devices have been generally in excess of 30 km/hr.

Because of the findings of this investigation and the need to control the speed through traffic calming devices to 20 km/hr to accord with Queensland Streets, the recommendations are:-

- That the designs of a roundabout and a central island speed control device need to be developed and field tested using a small passenger vehicle to limit the speed of this vehicle through these devices to 20 km/hr.
- That the selected roundabout and selected central island speed control device be field tested using medium and large passenger vehicles, ambulances, fire trucks, State Emergency Service vehicles, garbage trucks, and delivery trucks to ensure that these vehicles can negotiate the devices in relative comfort and to gauge the through speed and/or impacts of the devices on the performance of these vehicles.
- That the standard traffic calming devices be restricted to one roundabout and one central island speed control device.

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Signature

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Chapter 1 INTRODUCTION

The Queensland Streets concept or philosophy embraces the achievement of traffic calming objectives in residential streets through a reduction in traffic volumes, traffic speeds and traffic noise, and through improving the safety and amenity of residents in residential streets. Traffic calming measures can be separated in two groups, namely, volume control and speed control. Volume control measures are primarily used to divert unnecessary traffic (cut-through traffic) that intrude into the residential street to other higher level streets better able to handle the traffic volume. Speed control measures are primarily used to address speeding problems by changing vertical alignment, horizontal alignment, or narrowing the roadway. This evaluation of the Queensland Streets concept in residential streets in Logan City focuses on the traffic calming measures that have been installed for speed control.

Logan City is a major city of South East Queensland, Australia and is surrounded by Brisbane City to the north (the capital of Queensland), Redland Shire to the east, Gold Coast City and Beaudesert Shire to the south, and Ipswich City to the west. Logan City has experienced rapid population growth since its inception in 1976. In the ensuing years between Logan City's formation and the introduction of the Queensland Streets concept in the designs of residential developments in Logan City in 1993, all streets were designed in accordance with the Queensland Main Roads Department and Austroads design manuals. During this time, the streets in new residential developments were categorised as Access Streets, Collector Streets and Major Collector Streets based on the number of lots contributing to each street. The standard pavement widths and road reserve widths for these streets were 8 metres and 16 metres, 10 metres and 18 metres, and 12 metres and 20 metres respectively. The design of these streets incorporated the concepts of appropriate vertical and horizontal curves to ensure that satisfactory stopping sight distances were achieved for vertical curves and satisfactory curve radii were achieved for horizontal curves for the nominated design speeds in these streets in accordance with the Queensland Main Roads Department and Austroads design manuals.

During this period of rapid development growth and prior to the introduction of the Queensland Streets concept, there were no established concepts that considered the amenity and safety issues of the communities in these developments particularly with respect to the control of traffic volumes, traffic speeds and traffic noise, that is, no traffic calming philosophies existed.

In 1993, Logan City Council required that the design philosophy of the Australian Model Code for Residential Development (AMCORD) and Queensland Streets be incorporated in the design of new residential developments. However, because it was a new concept, Logan City Council relied upon the civil engineering consultants that were engaged by the developers of these residential developments to design traffic calming treatments in accordance with the Queensland Streets document.

This decision allowed the introduction of many different types of traffic calming devices in conjunction with reduced pavement widths that have received mixed reaction from a number of sources. Logan City Council has also installed traffic calming treatments in the existing streets that were constructed prior to the introduction of the Queensland Streets philosophy.

The initial relative inexperience of Council staff and civil engineering consultants in the design of the installed traffic calming treatments may have allowed the introduction of some treatments that are not strictly in accordance with Queensland Streets or that may not have achieved the desired effect intended by the Queensland Streets philosophy.

This project seeks to review and evaluate the types and effectiveness of the traffic calming devices that have been installed in Logan City and provide guidance for the determination of the most effective and most acceptable forms of traffic calming treatments. Additionally, the review and evaluation may provide suggestions and justifications for potential modifications to the Queensland Streets document.

The evaluation of the traffic calming treatments that have been installed in the residential streets of Logan City will be based on the investigation of:

- Those traffic calming treatments that have been installed by developers in residential developments since the implementation of the Queensland Streets concept in Logan City.
- Those traffic calming treatments that have been installed by Logan City Council in the residential streets that were constructed prior to the implementation of the Queensland Streets concept in Logan City.

This investigation will involve the extraction of design and/or as constructed drawings of traffic calming devices from the Logan City Council database, the preparation of Autocad drawings of the devices, checking the aspects of these devices such as maximum vehicle path radii to determine the likely achievable speeds through these devices to verify compliance or otherwise with Queensland Streets, on site observations of driver behaviour and speed behaviour through these devices and assess any damages to these devices and associated signage, and gather information from stakeholders such as Council officers (Traffic Branch), drivers/residents, police, ambulance, fire brigade and State Emergency Service (SES) to gain their perceptions of the effects and effectiveness of these treatments.

The objectives of the investigation and subsequent evaluation of these traffic calming treatments are:

- To determine whether the installed traffic calming treatments have been designed in accordance with the objectives of Queensland Streets.
- To determine the effects and effectiveness of the traffic calming treatments.
- To investigate and evaluate driver behaviour through the traffic calming treatments.
- To determine the most effective and most acceptable forms of traffic calming treatments.

The outcomes from this evaluation will be:

- To determine a small number of traffic calming treatments that could be adopted as standard and acceptable types of devices for use in Logan City.
- To suggest and justify potential modifications to the Queensland Streets document.

Chapter 2 BACKGROUND

Many years ago (late 1970's), the south-eastern group of the Local Government Engineers Association of Queensland (now the Queensland Division of the Institute of Public Works Engineering Australia) recognised the desirability of developing uniform engineering standards for the south-east region of Queensland. Established working committees were formed to achieve these objectives for roads, stormwater drainage and standard drawings. Due to the work load constraints of the committee members' normal duties, these standards were not completed at that time.

In June 1989, the Australian Model Code for Residential Development (AMCORD) was prepared under the auspices of the Model Code Task Force of the Joint Venture for More Affordable Housing, a Commonwealth Government initiative. The preparation of this document considered a wholistic approach to residential developments as it provides a complete code for residential development for dwellings of up to two (2) stories in height and covers the following aspects of residential development design:

- Allotment size and orientation.
- Building siting and design.
- Private and Public Open Space.
- Vehicle parking.
- Streetscape.
- Transport networks.
- Street design and construction.
- Pedestrian and cyclist facilities.

- Utilities provision and location.
- Drainage network.

This document was subsequently superseded by AMCORD Second Edition in November 1990 and a supplementary document entitled AMCORD URBAN: Guidelines for Urban Housing was released in 1992. Both these documents have now been superseded by AMCORD: A National Resource Document for Residential Developments Parts 1 and 2 which was released in 1995.

The release of the first edition of the AMCORD document proved to be the catalyst for the creation of the Queensland Streets document. Following the release of AMCORD, funding became available under the Residential Regulation Review Program for projects which would promote the adoption of the recommendations of AMCORD.

The Queensland Division of the Institute of Municipal Engineers Australia (now the Queensland Division of the Institute of Public Works Engineering Australia) took advantage of this opportunity and through the sponsorship of Logan City Council and Redland Shire Council, and the support and assistance of the Queensland Department of Housing, Local Government and Planning, they were able to obtain a grant for the preparation of a "Standard Design Code for Subdivisional Roadworks". The resultant document was entitled "Queensland Streets – Design Guidelines for Subdivisional Streetworks".

As stated in the Queensland Streets document,
"The purpose of these guidelines is:

- To provide the basis for a uniform standard of residential streetworks design, incorporating "state-of-the-art" principles and techniques, for use throughout Queensland.
- As a technical support to AMCORD, to provide the more detailed design criteria necessary for the design of streetworks for residential developments in accordance with AMCORD principles."

Whereas AMCORD covered all aspects of residential development in a broad sense, it could not cover all aspects sufficiently for the preparation of detailed residential development design. Queensland Streets was created to provide the necessary additional technical design criteria specifically for the design of streets in Queensland and the use of the Queensland Streets document must be considered as a supplement to AMCORD.

Both the AMCORD and Queensland Streets documents are orientated to achieving design outcomes that are based on "Performance Orientated Criteria" as opposed to the prescriptive and rigid criteria that were used before the introduction of these documents. The performance standards of Queensland Streets identify the objectives that are sought and the performance criteria that are required to satisfy each design aspect. The guidelines also include acceptable solutions for each design aspect which, if incorporated totally, becomes the prescriptive standard for that design aspect.

The release of the first edition of the AMCORD document also proved to be the catalyst for the completion of the stormwater drainage design standard and standard drawings projects.

The Queensland Urban Drainage Manual (QUDM) was completed in 1992 to provide the standards for stormwater drainage design in the south-east Queensland region and has proved to be an acceptable stormwater drainage design guideline for all Councils in the region.

The standard drawings project was completed in December 1995 however this document simply contains some selected/preferred standard drawings from each of the Councils in the south-east Queensland region and these drawings were compiled into one document. This document has not achieved the required standardisation in the region mainly because of the great variation between Councils in the locations of services in road reserves.

Chapter 3 METHODOLOGY

To achieve the objectives and outcomes sought for this dissertation, the evaluation process included:

- Literature Research and Review.
- Assessment of Traffic Calming Treatments Installed by Developers and by Logan City Council in Logan City.
- Researching Perceptions of Other Stakeholders.
- Evaluation of the Collected Data.
- Provision of Conclusions and Recommendations.

3.1 Literature Research and Review

Before embarking on the physical aspects of the investigation and evaluation of the Queensland Streets concept in residential streets in Logan City, it is important and indeed necessary to research and review relevant literature on traffic calming treatments to ensure that an informed procedure is used to produce satisfactory and meaningful outcomes. The literature research and review encompasses national and international literature dealing with the implementation and effectiveness of traffic calming treatments in Australia and overseas.

A research of the Queensland Streets document was undertaken to review:

- The design parameters required to achieve the objectives and the performance criteria for each design aspect of traffic calming treatments to accord with this document.

- The designs and installations of traffic calming treatments developed from these guidelines in other cities in Queensland.
- Studies carried out on the performance of these traffic calming treatments including driver behaviour, speed control, effects and effectiveness of these devices.

Comparisons between the design parameters of Queensland Streets and the design parameters of other Australian States has been made to evaluate whether there are common or conflicting design parameters and philosophies.

3.2 Assessment of Traffic Calming Devices in Logan City

The steps involved in this review encompassed the following actions:

- Search the design and as constructed database of Logan City Council to obtain details of the various types of traffic calming treatments that have been installed by developers and Logan City Council in residential streets in Logan City since the implementation of the Queensland Streets concept.
- Produce Autocad drawings of all traffic calming devices that were tested.
- Assess whether the design of the traffic calming treatments meet the requirements of Queensland Streets and report findings.
- Procure a speed gun for recording speeds through the traffic calming devices.
- Undertake on site inspections of traffic calming treatments and observe and report findings on such aspects as driver behaviour, travel speeds through the devices, and any damages to the devices and associated signage.
- Make assessments of the effects and effectiveness of the each traffic calming treatment.
- Determine the most effective and the most acceptable traffic calming treatments.

3.3 Researching Perceptions of Other Stakeholders

This assessment includes a compilation of perceptions of traffic calming treatments from stakeholders such as Council officers (Traffic Branch), drivers/residents, police, ambulance, fire brigade and State Emergency Service (SES). The perceptions of the emergency services (police, ambulance, fire brigade and State Emergency Service) provides an important insight to the acceptability or otherwise of these devices by these services.

3.4 Evaluation of the Collected Data

The evaluation of the collected data will:

- Determine whether the installed traffic calming treatments have been designed in accordance with the objectives of Queensland Streets.
- Determine the effects and effectiveness of the traffic calming treatments.
- Determine the most effective and most acceptable forms of traffic calming treatments.

3.5 Conclusions and Recommendations

The outcomes from this evaluation if satisfactory traffic calming devices were found will be:

- To determine a small number of traffic calming treatments that could be adopted as standard and acceptable types of devices for use in Logan City.
- To suggest and justify potential modifications to the Queensland Streets document.

Chapter 4 LITERATURE REVIEW – QUEENSLAND STREETS

The review of the Queensland Streets document will focus on Section 2.0 (The Residential Street) of the guidelines so that the total concept for residential streets that is presented in this document is discussed before fully examining traffic calming treatments that have been installed at intersections and along streets in the residential streets of Logan City.

The Queensland Streets guidelines provide the necessary additional technical design criteria in the specific field of street design and some other related aspects that embodies the AMCORD principles of residential design. In an attempt to create innovative solutions to residential streets design, the Queensland Streets guidelines are performance based standards as opposed to the prescriptive orientated standards that existed prior to the advent of AMCORD. Consequently, the guidelines identify the objectives that are sought to be achieved, and the performance criteria that are required to be satisfied in respect of each design aspect. The guidelines also include acceptable solutions for each design aspect which, if incorporated totally, becomes the prescriptive standard for that design aspect. With this performance criteria philosophy which allows the designer to develop innovative designs, it was hoped that better quality and more cost efficient residential developments would be achieved.

In direct contrast to the approach of most publications which firstly consider the requirements of the major road system and work downwards to the local residential street, the unique approach of the Queensland Streets guidelines is that it firstly considers the requirements of the individual residential street and works upwards to the major road system.

The goal of Queensland Streets guidelines is to promote and encourage residential street design and construction practices which will provide the optimum combination of safety, amenity, convenience and economy for residents, street users and the community generally. Consequently, the achievement of safety, amenity, convenience and economy are the primary objectives of Queensland Streets.

The philosophy or principle of the residential street as described in Queensland Streets is to provide a compromise between the perceived needs of motor vehicles and the needs of other street users through limiting traffic volume and traffic speed in residential streets, and to incorporate the basic principle that vehicles do not have unrestricted two-way movements at all times.

The guidelines require conformity with the objectives and performance criteria specified for the following aspects:

- Traffic Volume.
- Traffic Speed.
- Parking – on-street and on-site.
- Provision for Passing.
- Carriageway Width.
- Street Classification.
- Street Reserve and Verge Width.
- Geometric Design.
- Turning Areas.
- Intersections.
- Speed Control Devices.

4.1 Traffic Volume

The recommended range of maximum acceptable traffic volumes for residential streets with direct frontage access to lots is 2000 vehicles per day (Desirable

Maximum) to 3000 vehicles per day (Absolute Maximum). This traffic volume limit is known as the Environmental Capacity of the street which is different to Traffic Capacity which is a measure of the ability of the street to carry traffic. Traffic Capacity is generally several times the Environmental Capacity. To achieve acceptable environmental capacity limits in residential streets, it is necessary to ensure the following parameters are incorporated in the design of residential precincts:

- Limit/define the catchment that will contribute traffic flows to the street.
- Prevent/exclude through traffic from entering the street, that is, the traffic generation will be from within the defined catchment only.

These parameters can easily be achieved by developing small precincts with only one street connection. However, for other cases with more than one street connection, the layout needs to be critically examined to ensure that through traffic generation is positively discouraged.

Although the generation rate for a residential catchment is dependent upon a number of factors such as size of catchment, geographical location, demography of the population, location of and distance to facilities and workplaces, economic situation of residents, availability of public transport, and time as the demography of the area changes, the generally accepted design generation rate is 10 vehicles per dwelling per day. This equates to a Desirable Maximum of 200 dwellings to an Absolute Maximum of 300 dwellings in a Residential Precinct. For residential developments that have more than one street connection, the distribution of the total traffic generation needs to be analysed based on such factors as the extent and location of facilities within the neighbourhood (shops, schools, child care centres), location of employment centres external to the neighbourhood, and location of major retail centres and other attractions external to the neighbourhood.

4.2 Traffic Speed

To effectively control traffic speed, the street geometry needs to be such that it will actively discourage speeds in excess of the design speed for the street.

The control of traffic speed in the residential street is achieved by incorporating the following aspects:

- Determine the minimum street carriageway widths for satisfactory traffic operation along the entire length of the street.
- Restrict the maximum length of uncontrolled straight (or virtually straight) street between speed control devices (such as intersections, bends and speed control devices) to the length in which the design speed may be reached.
- Introduce curved alignment.

The first edition of Queensland Streets required the use of speed restrictive design to reduce the vehicle speed through bends and speed control devices to 20 km/hr or less. However the second edition of Queensland Streets claims that research suggests that speeds through intersections and speed control devices are closer to 25 km/hr which is in contradiction to the parameters of Queensland Streets.

Queensland Streets advocates that a design speed of 30 km/hr needs to be sought for the majority of residential streets (Access Places and Access Streets). However if the through device speed of 25 km/hr, this creates a requirement for spacing of devices such that the street leg between devices is only 45 metres. This is obviously an unacceptable situation. Consequently, there is a need to restrict the speed through devices to 20 km/hr in Access Places and Access Streets where the design speed of 30 km/hr is to be achieved or alternatively restrict the speed through devices to 25 km/hr in Access Places and Access Streets and allow a design speed of 40 km/hr.

It is interesting to note that the first edition of Queensland Streets required the incorporation of speed control devices in an otherwise straight alignment for speed restrictive design however the second edition of Queensland Streets recommends that speed control devices be used as sparingly as possible due to their cost and possibly intrusive nature.

4.3 Parking

Whilst part of the philosophy of the AMCORD document promotes the introduction of narrow streets, smaller lots and reduced building setbacks and the Queensland Streets document promotes the concept of reduced pavement widths and restrictive street geometry, these factors create limited opportunities for parking areas within the allotments which, in turn, creates the necessity for on-street parking facilities. The Queensland Streets document provides guidance in alternative on-street parking design options however the parking requirements need to be determined in conjunction with the requirements for carriageway widths and provision for passing. This aspect appears to be difficult to implement without designating specific parking areas for those residential developments that provide no on-site parking facilities because of smaller lots and reduced building setbacks.

4.4 Provision for Passing

The principle of the provision for passing places is based on the concept of a single moving lane where there are adequate opportunities for vehicles that are travelling in opposite directions to pass each other. The provision for passing as nominated in Queensland Streets can be either specifically designed, random, or a combination of specifically designed and random passing places. The selected type of passing place is dependent on the incidence of opposing meetings which varies with the traffic volume of opposing traffic. This traffic volume is dependent on the number of lots in the catchment, the time of day, and the travel time which varies with the travel distance and travel speed. Whilst the single moving lane concept is used in the philosophy of provision for passing places, the second edition of Queensland Streets acknowledges that the concept has not been accepted in practice by Councils, developers or designers in single lane carriageways. The single moving lane concept is more widely accepted for two lane carriageways (5.5 metres) and three lane carriageways (7.5 metres).

The type and layout of the residential development has a significant impact on the development of a satisfactory solution for the combination of carriageway widths, parking requirements and provision for passing.

4.5 Carriageway Width

The carriageway width for a residential street is a function of design traffic volume, design traffic speed, on-street and off-street parking provisions, and provision for passing. The carriageway width that is determined for the street must ensure that are single moving lane is maintained for the full length of the street, that the provision of on-street parking provisions is met, and that the provision for passing is met. The guidelines requires that at any point in the street, the carriageway width must be an exact number of lanes, that is, one lane (3.5 metres), two lanes (5.5 metres) or three lanes (7.5 metres).

4.6 Street Classification

The following street classification has been developed in Queensland Streets for residential streets:

- Access Place – A single cul-de-sac street with contributing catchment less than 75 lots, one or two lane carriageway, and design speed of 30 km/hr.
- Access Street – A "stem" from which two or more cul-de-sac streets branch with contributing catchment less than 75 lots, one or two lane carriageway, and design speed of 30 km/hr.
- Collector Street – A "branch" from which Access Streets branch and connects to a Trunk Collector Street or a major street or road with contributing catchment from 75 to 300 lots, two or three lane carriageway, and design speed of 40 km/hr.
- Trunk Collector Street – A "branch" from which Collector or Access Streets branch and connects to a major road with contributing catchment from 300 to 1000 lots, two lane carriageway, and design speed of 60 km/hr.

Access Place, Access Streets and Collector Streets provide direct frontage access to residential lots and on-street parking facilities. These streets require the incorporation of speed restrictive design.

Trunk Collector Streets do not provide frontage access to residential lots and do not provide on-street parking however it may provide access for multi-unit development, schools or shopping centres where on-site manoeuvring is provided to allow forward gear ingress and egress and on-site parking is provided. These streets require the incorporation of speed restrictive design however it is recommended that these streets are short in length.

Residential lots abutting Trunk Collector Streets will require noise attenuation measures to be implemented through the use of fencing, landscaped mounds, and appropriate house design either individually or a combination of these options.

4.7 Street Reserve Width and Verge

In relation to street reserve and verge widths, Queensland Streets seeks to promote residential streets that vary in widths along their lengths to achieve high aesthetic values in the streets. To this end, the Queensland Streets guidelines provide minimum and average street reserve and verge widths but emphasise that greater widths are required in some sections to achieve the designated average street reserve and verge widths. The variation in street reserve and verge widths may allow the incorporation of designated parking areas, passing places and landscape areas. The verge is an important section of the street reserve because it provides an area for parking, landscaping, footpaths/bikepaths/dual use paths, street lights, and the installation of services such as water supply, electricity, telecommunications, sewerage and gas. It also acts as a buffer between the carriageway and the lots.

4.8 Geometric Design

The recommended maximum design speeds for residential streets are:

- Access Place and Access Street – 30 km/hr.
- Collector Street – 40 km/hr.
- Trunk Collector Street – 60 km/hr.

The geometric design of streets needs to incorporate the defined parameters of the Queensland Streets guidelines. These parameters include the requirements for horizontal alignment, general minimum sight distance, longitudinal grade, vertical alignment, pavement crossfall, and carriageway drainage in accordance with Queensland Urban Drainage Manual (QUDM). These parameters need to be determined in conjunction with the required objectives for on-street parking, provision for passing, carriageway width, street reserve and verge widths, intersections and speed control devices.

4.9 Turning Areas

The Queensland Streets guidelines has recognised the need for turning areas to be provided in residential streets either as a single movement facility (conventional cul-de-sac end) or as a three point turn facility (Tee head or Wye head cul-de-sac ends). The primary vehicles of concern are cars and garbage trucks with an accepted view that larger vehicles will encroach onto the verge area to turn. The second edition of Queensland Streets has provided a number of design options to provide the single movement facility and the three point turn facility.

4.10 Intersections

The typical types of intersections in residential streets are T - junctions (three way) and roundabouts (usually three way or four way). The network of intersections should be developed such that streets intersect with streets of the same or immediately adjacent classification. This ensures that the progressive graduation of speed environment from the minor street to the major road system is achieved, that is, from Access Place and Access Street (30 km/hr) to Collector Street (40 km/hr) to Trunk Collector Street (60 km/hr).

The important considerations in intersection design include:

- Spacing of the intersections such that they are located sufficiently apart to separate traffic movements at each intersection and to provide a reasonable time interval between driver decisions.
- The application of two sight distance criteria, namely Approach Sight Distance (ASD) - stopping distance, and Safe Intersection Sight Distance (SISD) – recognition and reaction distance applicable for drivers on the through street and equivalent to the General Minimum Sight Distance.
- Angle of approach to the T - junction intersections.
- Design of roundabout intersections to accommodate speed control requirements and to accommodate the vehicles expected through the roundabout, eg, garbage trucks, buses.
- Design of T - junction and roundabout intersections in accordance with the relevant Austroads design guidelines.
- Lighting.

- Truncations of property boundaries at intersections to provide the required sight distances.

4.11 Speed Control Devices

As indicated previously, one of the basic principles of residential street design in Queensland Streets is the limitation of vehicle speed at every location along the street to the acceptable maximum design speed for the relevant street. This is achieved by restricting the length of straight (or nearly straight) street to the length in which a vehicle can reach the selected design speed. This limitation of street leg length can be achieved by the use of sharp bends and continuous curves in the horizontal alignment of the street, and by the use of speed control devices.

Speed control devices are physical obstructions in the carriageway for the purpose of controlling traffic speed. These devices can be categorised according to their geometry as:

- Horizontal deflection – roundabouts, central island, median strip, one lane or two lane angled slow point, deflected T – junction.
- Vertical deflection – road humps, raised thresholds.

The Queensland Streets guidelines consider that horizontal deflection devices are more appropriate for new development because:

- They are highly visible and more likely to mitigate speed at a distance.
- They can be readily landscaped.
- They are less aggressive in their effect on traffic.
- They are less noise generating.

The second edition of Queensland Streets emphasises that speed control should be provided by street alignment whenever possible and that the use of speed control devices should be used as a last resort because of their capital and maintenance cost, and possibly intrusive nature.

Other features/options that need to be considered in the design of speed control devices are:

- A design that achieves the desirable through device speed of 20 km/hr – particularly relevant to Access Place and Access Streets where the design speed is 30 km/hr.
- Kerb profile – barrier kerb and channel or kerb may be appropriate depending on the type of device.
- Allotment access – ensure appropriate allotment access is achievable.
- Stormwater Drainage – design to be in accordance with QUDM.
- Signage – design to be in accordance with the Queensland Manual of Uniform Traffic Control Devices (MUTCD).
- Landscaping to enhance the effective operation of the devices by increasing the visual barrier effect.
- Street lighting – design to be in accordance with the relevant Australian Standards.
- Staged construction – option of construction of the devices after a majority of housing construction has been completed.

The Queensland Streets guidelines provide geometric diagrams for a central island speed control device, a deflected T speed control device and a roundabout. These geometric diagrams are shown in Figures 1, 2 and 3 respectively.

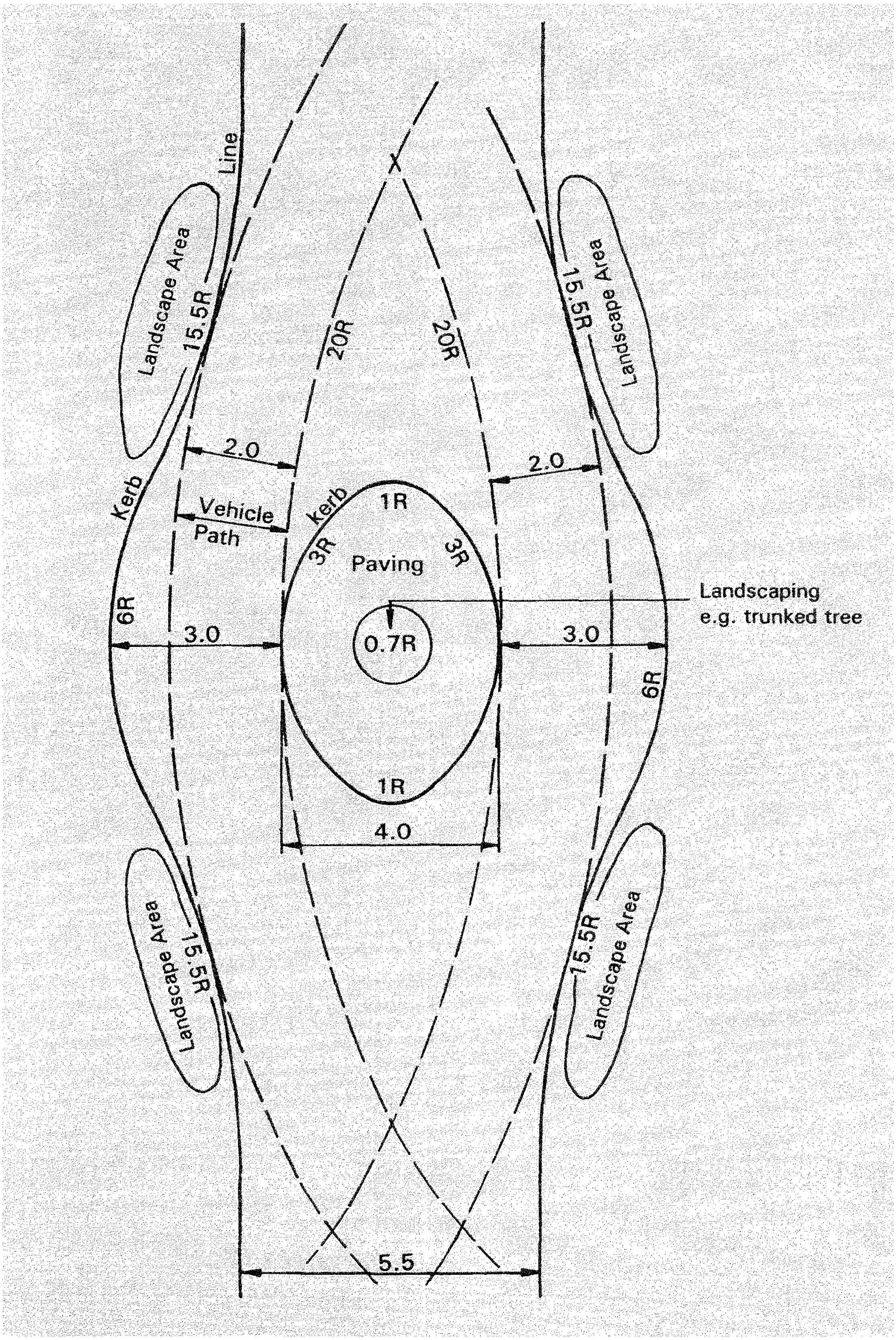

Figure 1: Central Island Speed Control Device (Weathered Howe Pty Ltd 1995)

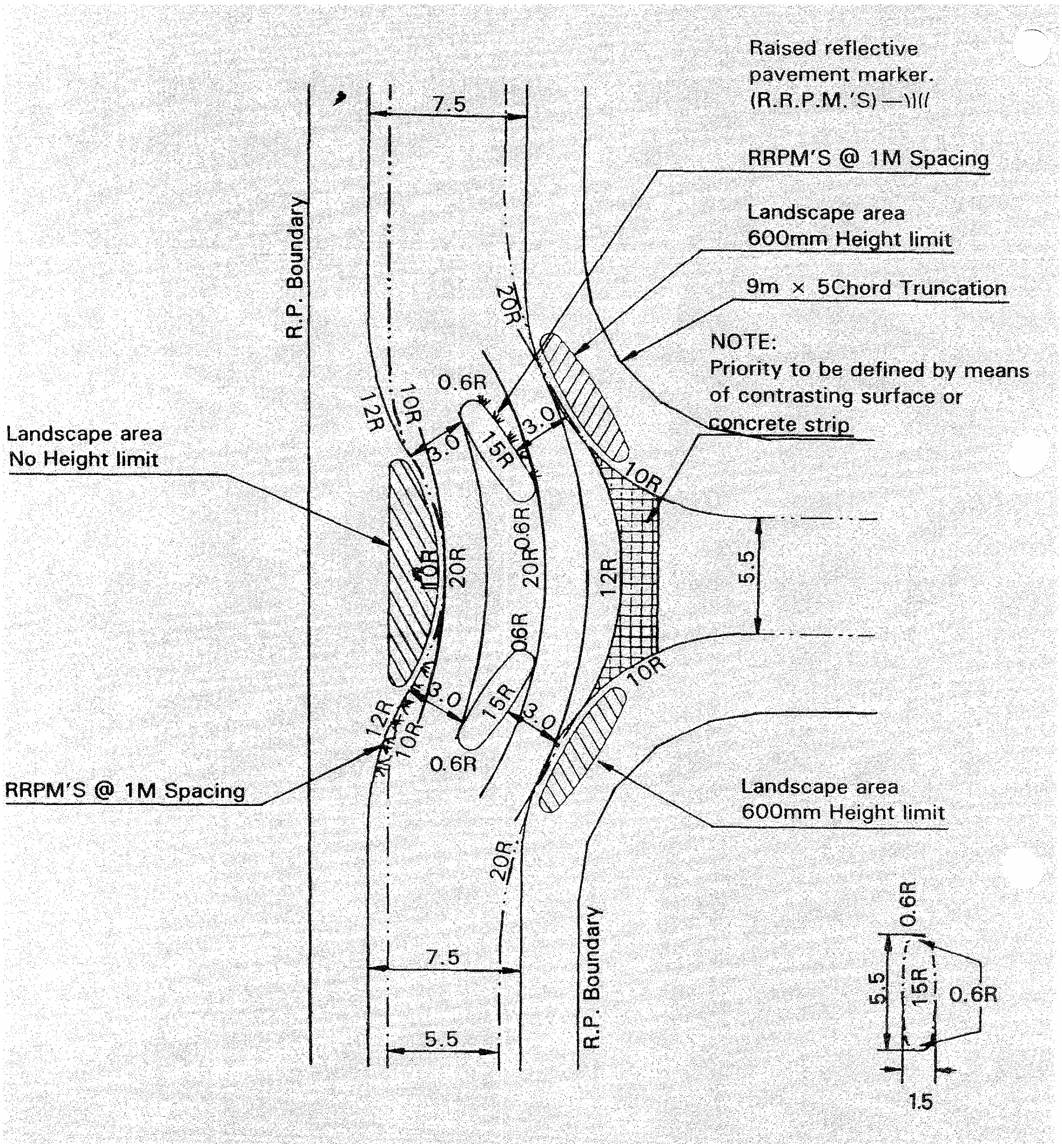

Figure 2: Deflected T Intersection (Weathered Howe Pty Ltd 1995)

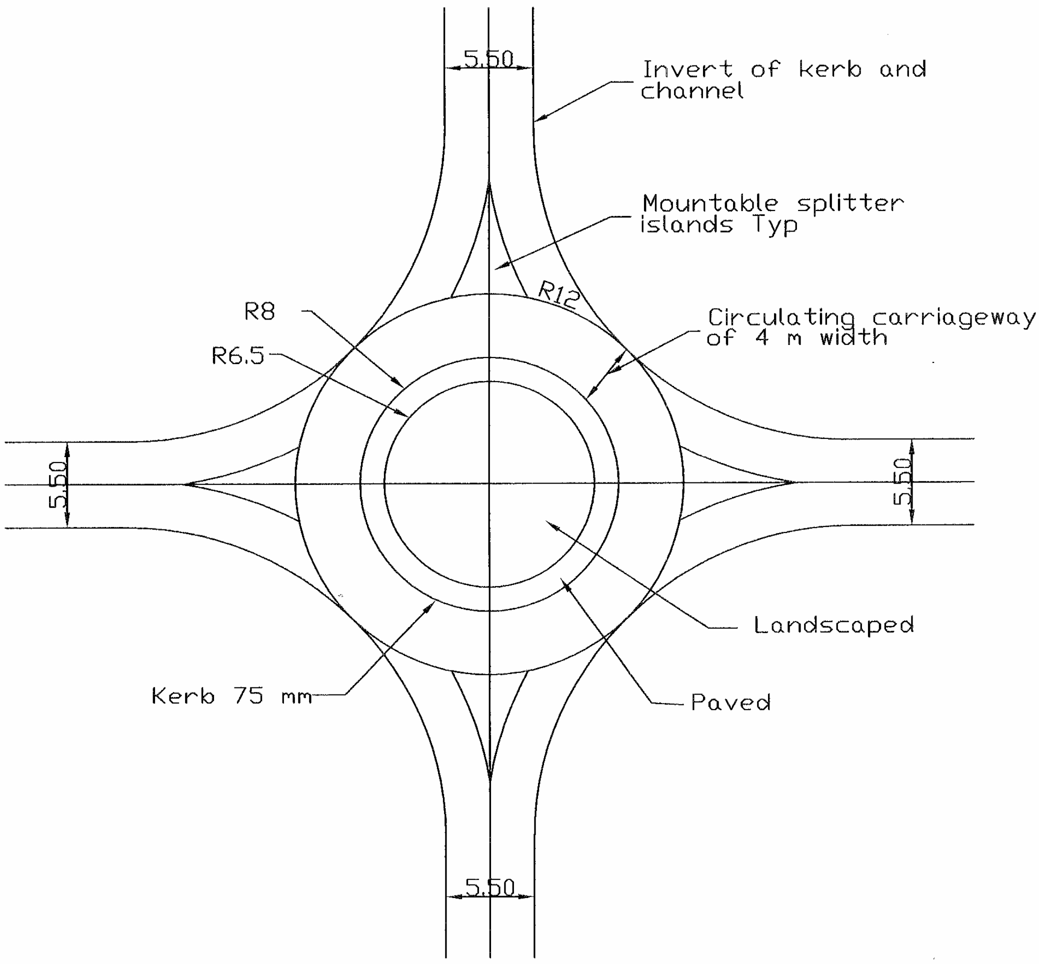

Figure 3: Minor Roundabout (Weathered Howe Pty Ltd 1995)

Chapter 5 LITERATURE REVIEW - AUSTRALIA

AMCORD: A National Resource Document for Residential Developments which was released in 1995 is the adopted residential design guideline for Victoria. Whilst the street design philosophy in AMCORD mirrors the objectives and performance criteria of Queensland Streets, there are differences in the street hierarchy and design details between the AMCORD and Queensland Streets documents. These differences can be seen in the comparison between AMCORD and Queensland Streets data as shown in Table 1. The main variations between AMCORD and Queensland Streets relate to the street classification and the associated limits for traffic volumes, design speeds and verge widths.

Table 1: Comparison between AMCORD and Queensland Streets

AMCORD					
Street Type	**Maximum Traffic Volume (vpd)**	**Design Speed (km/hr)**	**Minimum Street Reserve Width (m)**	**Carriageway Width (m)**	**Minimum Verge Width (m)**
Access Lane	100	15	Varies	Varies - 3 m minimum	Not Specified
Access Place	0 - 300	15	10	One lane/3.5 - 3.7	Varies
Access Street	0 - 300	40	12	5.0 only	3.5
Access Street	300 - 1000	40	13	5.0 - 5.5 only	4
Access Street	1000 - 2000	40	13.5	5.5 or 7.0	4
Minor Collector Street	1000 - 3000	50	16.5	7.0 - 7.5 or 6.0 - 6.5 plus indented parking	4.5
Major Collector Street	3000 - 6000	>50	Subject to design	Subject to design	Subject to design
Queensland Streets					
Street Type					
Access Place	0 – 75	30	14	3.5 or 5.5 (1 or 2 lanes)	3
Access Street	0 - 75	30	14	5.5 (2 lanes)	3
Collector Street	76 - 300	40	16	7.5 (3 lanes)	3.5
Trunk Collector Street	301 - 1000	60	20	9.0 (2 lanes)	4.5

The differences in design speeds for Access Places, Access Streets and Collector Streets as noted in Table 1 allows for greater spacing of bends and speed control devices under AMCORD guidelines than under Queensland Streets guidelines.

The South Australian Government publication entitled "Good Residential Design SA: A resource for planning, designing and developing neighbourhoods and homes" which was released in 1999 is strongly aligned with AMCORD in relation to the objectives and performance criteria for the design of residential streets, street classifications, target speeds, and carriageway widths except this document has included additional details for Major Collector Streets – target speed of 60 km/hr, maximum traffic volume <6000 and the carriageway width details that match those specified for Minor Collector Streets. In relation to speed control devices, this document has deleted "speed humps and dips" from the list of vertical deflection devices and, in agreement with AMCORD, the literature generally discourages the use of speed humps and platforms (it states that these devices are unpopular with drivers and cause problems with buses, motorcycles and emergency vehicles) and specifies total avoidance of these devices on bus routes. The document further states that vertical deflection should not be used as a means of controlling traffic speed for Central Median and Median Island slow down devices. The tables in relation to street leg lengths between slow down devices and deflections at bends are based on achieving 20 km/hr or less speeds through slow down devices and bends. The document appears to support the use of roundabouts, bends, central medians and median islands as the most acceptable slow down devices.

In the Western Australian Government publication entitled "Liveable Neighbourhoods: A Western Australian Government Sustainable Cities Initiative" Edition 2 which was published in 2000, the street classifications and associated traffic volumes, maximum design speeds and carriageway widths for residential streets in this document vary from AMCORD and Queensland Streets. The characteristics of the residential streets in Western Australia are shown in Table 2.

Table 2: Western Australia Residential Street Data

Street Type	Maximum Traffic Volume (vpd)	Design Speed (km/hr)	Minimum Street Reserve Width (m)	Carriageway Width (m)
Laneways	300	15	6 (Subject to design)	6 (Subject to design)
Access Street	1000	40	14 - 16	5.5 - 6.0
Access Street	up to 3000	50	16	7.0 - 7.5
Neighbourhood Collector	3000 - 7000	60	20 - 25	13.4 m including parking indents and on street bike lane, or 2 x 6.8 m including parking indents, on street bike lane and median.

All other Australian States require the design speed through traffic calming devices to be 20 km/hr and the design speed in the street legs between devices to be 40 km/hr. Accordingly, it is not known why Queensland Streets has a requirement for 30 km/hr speed in the street legs between devices.

In 1993, the Logan City Council Development Manual incorporated the requirements for new residential streets in Logan City to be designed in accordance with AMCORD and Queensland Streets principles. The only variations from the Queensland Streets guidelines were:

- The requirements for 4 metre minimum width verges for Access Place, Access Street and Collector Street and 4.5 metre minimum width verges for Trunk Collector. These requirements were necessary to ensure street light poles and street trees that must be located at standard alignment of 3.05 metres were adequately clear of the carriageway.
- The minimum longitudinal grade of 0.5% for all streets with kerb and channel.
- The minimum longitudinal grade of 1.0% for all streets with earth table drains however flexibility would be entertained on this aspect.
- The non requirement for speed control devices on Trunk Collector Streets. By this statement, these streets would have 60 km/hr speed signs installed and major intersections would incorporate appropriate roundabouts.

In March 2000, the Councillors of Logan City Council passed a resolution "that the minimum pavement width on any street shall be 8 metres". This decision was made following continuous complaints made to Councillors over several years from the public and essential services providers such as ambulance, fire brigade, police, and

State Emergency Services. The complaints mainly related to the lack of mobility, particularly in emergency situations, on the narrow streets when vehicles are parked opposite one another or when parked in close proximity to speed control devices. Consequently, the second edition of the Development Manual released in August 2001 incorporated Council's resolution.

The publication entitled "Towards Traffic Calming" is not a guide to the detail design of Local Area Traffic Management schemes (LATM) or traffic calming devices but it is a source book of a large number of implemented local area traffic management and blackspot devices in existing residential streets throughout Australia. The broad aims of traffic calming as identified by this manual are:

- To improve safety.
- To diminish area-wide impact of cars.
- To improve residential amenity.

Generally, the design of speed control devices and LATM schemes in existing residential streets is much more difficult than for the design of these devices in new residential developments. This situation primarily exists because the following factors have to be taken into consideration for the design and installation of these devices in existing residential streets:

- Existing property boundaries. In the case of roundabouts, deflected T-junctions, and central island devices, land resumptions may be required to maintain an acceptable verge width at each device and to achieve the required deflection through each device for the design speeds for the device and the street.
- Existing access locations to lots.
- Existing infrastructure within the road reserve and the lots.
- Acceptance or resistance from residents in the street where the proposed speed control devices are to be installed.

Towards Traffic Calming has identified various types of devices and/or measures that have been installed across Australia at the time of publication of the manual. Each device has been evaluated including a table of advantages and disadvantages of each device and a section of comments in relation to community acceptance for some of the devices however the manual does not attempt to provide acceptable design solutions for each type of device.

Towards Traffic Calming has also included a literature review of some studies that were undertaken in various states prior to its publication. The various literature reviews clearly demonstrate that the studies included in this manual have provided conflicting community acceptance and nonacceptance of similar types of devices across Australia.

In summary, the other states of Australia require a design speed of 20 km/hr through the traffic calming devices and a design speed of 40 km/hr in the street legs between devices however it is likely that the design speed of 20 km/hr through traffic calming devices is not being achieved in other states based on the diagrammatic details of the implemented traffic calming devices installed across Australia as shown in the Towards Traffic Calming document.

In discussing human factors in traffic engineering, Ogden (1996, p.9) states that driver behaviour is largely governed by habit, experience, and expectation, and that any design or operation which violates these considerations is likely to be unsatisfactory, and possibly unsafe. Accordingly, the design should ensure that:

- Drivers' expectations are recognised, and unexpected, unusual or non-standard design or operational situations are avoided or minimised.
- Predictable behaviour is encouraged through familiarity and habit.
- Consistency of design and driver behaviour is maintained from element to element.
- The information which is provided should decrease the driver's uncertainty, not increase it.

An important aspect of driver behaviour is reaction time which is usually considered to comprise four elements Ogden (1996, p. 9):

- Perception: the use of visual capabilities to see a visual signal.

- Identification: the driver identifies the signal and thus understands the stimulus.
- Emotion: the driver decides what action to take in response to the stimulus.
- Violation: during which the driver actually executes the action decided upon.

Ogden (1996, p. 10) states that traffic design and operations should aim to reduce both average reaction times and reduce the variance of reaction times, especially inordinately long reaction times. These objectives can be achieved in the following ways:

- Encourage familiarity.
- Minimise the number of alternatives.
- Provide positive information.
- Provide prior warning.
- Provide clear sight distance.
- Use symbolic signs.

Bliss (1996, p. 136) states that traffic control devices may be formally defined as all the signs, traffic signals, pavement markings, traffic islands, or other devices placed or erected with the approval of a applicable traffic authority , to regulate, warn or guide traffic. The function of a traffic control device Bliss (1996, p. 136) is to:

- Regulate traffic.
- Warn motorists of hazards or regulatory controls ahead.
- Guide traffic.

Bliss (1996, p.136) states that to fulfil its function, a traffic control device must:

- Command attention.
- Make its meaning clear at a glance.
- Allow adequate response time.
- Command respect.

The views expressed by Ogden (1996) and Bliss (1996) equally apply to all road classifications including residential streets. In Australia, the implementation of traffic control devices in residential streets is usually referred to as “Local Area Traffic

Management" (LATM) but sometimes referred to as "Residential Street Management" (RSM) or "Traffic Calming Measures". These traffic calming devices in residential streets need to achieve the objectives of safety and amenity to the benefits of residents mainly but also to all road users including motorists, cyclists and pedestrians.

The available alternative LATM measures according to Daff and Wilson (1996, p. 180) and Ogden (1996) fall into six categories as follows:

- Regulatory Devices.
- Network modifications.
- Devices used at intersections.
- Devices relying on vertical displacement.
- Devices relying on horizontal displacement.
- Gateways.

For the design of devices for LATM schemes, Daff and Wilson (1996) make reference to the use of relevant state guidelines, Austroads publications and the Manual of Uniform Traffic Devices, Part 13 – Local Area Traffic Management.

Underwood (1990, p. 124) states that the basic purpose of local area traffic management is to control the movement and speed of traffic in residential areas to discourage through traffic, minimise accidents and improve the level of environmental amenity.

Underwood (1990, p. 124) states that the following objectives are common to most local area traffic management schemes:

- To improve the safety and sense of security of all users of local streets, and in particular children and other vulnerable groups.
- To improve the physical environment by reducing traffic noise, vibration, and vehicle-generated air pollution, and to improve the visual appearance of streets.

- To maintain an acceptable level of accessibility for all residents, customers of local businesses, emergency vehicles, delivery and maintenance services and public transport.
- To provide equitable conditions for all residents.

None of the reference sources provide real design parameters that will achieve a design speed of 20 km/hr through traffic calming devices. There were no sources found that had recorded speeds through traffic calming devices to ascertain whether the devices achieved the traffic calming objectives.

Chapter 6 LITERATURE REVIEW - INTERNATIONAL

The initial implementation of traffic calming strategies occurred in the Dutch town of Delft. This design called "woonerf" or residential yards integrated the road pavement and verge with the use of narrow pavements, dedicated parking areas, signage for the exclusion of through traffic and low speed signage. This concept proved successful at the time in Holland, Germany and other European countries however the high cost of implementing this strategy has resulted in many areas of Holland and Germany in particular to resorting to the implementation of 30 km/hr speed zones using signage only. The traffic calming concept has been adopted by many countries. Around the world.

Kathleen Calongne of Boulder Colorado in the United States of America who has researched traffic calming projects in the United States since 1996 is the author of a 400 page report entitled "Problems Associated With Traffic Calming Devices". Through her research, Calongne identified that the installations of traffic calming devices have:

- Severely impacted on the effectiveness of emergency response vehicles (ambulance and fire brigade).
- Severely impacted on people with disabilities.
- Created division of communities.
- Increased vehicle emissions.

Calonge has found that both horizontal and vertical deflection devices have impacted on the effectiveness of emergency response vehicles. Because ambulance emergency vehicles have longer wheel-bases, stiff suspensions, high vehicle weights, as well as transporting sensitive equipment and injured victims, drivers are required to slow almost to a stop to negotiate the devices safely. Similarly, fire trucks have longer wheel-bases, stiff suspensions and high vehicle weights which necessitates coming almost to a stop to negotiate the devices safely. The cumulative effects of series of devices severely impact on response times. Calongne states that there are documented injuries to firefighters who have suffered compressed vertebrae from hitting the roofs of their cabs after encountering speed humps unexpectedly. Calongne's study found that people with disabilities were complaining of lasting pain and injury caused by travelling over vertical deflection devices, namely, speed humps, speed tables and raised crosswalks.

The impact of traffic calming devices was analysed by scientist Ronald Bowman for the City of Boulder Colorado. He predicted that even minor delays in emergency response impose dramatically greater risks on the population than speeding vehicles. Bowman's analysis showed a risk factor of 85 to 1, that is, there is a probability that 85 deaths will occur from delayed emergency response before one life is saved in the neighbourhoods by the devices.

Calongne cites United States statistics that there are 250,000 deaths from sudden cardiac arrest (SAC) per year of which 90% occur outside the hospital environment compared with 5,000 pedestrian deaths per year of which 35% were intoxicated. An American Heart Association study in 1996 showed that Seattle with a response time of less than 7 minutes saved 30 % of its SAC victims whereas New York with an average response time of 12 minutes saved only 2% of its victims. Calongne states that traffic calming devices impose permanent 24-hour delays to emergency response compared to traffic congestion which occurs periodically.

Calongne's study cites some emission studies that show increases in vehicle emissions in all areas where traffic calming devices were installed. In Portland Maine, it was shown that speed humps increased emissions by 48 % without taking into consideration increased emissions from braking and accelerating in negotiating the devices. An Austrian study in 1994 using a mobile exhaust fume measuring device registered an increase in vehicle emissions of ten times on streets with speed humps.

The Transport Research Laboratory (TRL) in the United Kingdom conducted emission tests in 1997 on roads with speed humps (TRL Report 307). The traffic calming scheme consisted of speed humps at 75 metre spacings and the emission results showed increases in CO and HC of around 70-80% and 70-100% respectively and an increase in CO_2 of around 50-60%. A more recent study by the TRL in 2001 (Report 482), registered increases in all average emission pollutants after the installation of traffic calming devices (a variety of types) for petrol catalyst vehicles with CO at 59%, HC at 54%, NO_2 at 8% and CO_2 at 26%. The study states that speed humps created the largest increases in pollutants of all the traffic calming devices that were tested. The increase in emissions effectively means that there is an increase in fuel consumption and a reduction in the environmental amenity of neighbourhoods which is the opposite of what traffic calming is supposed to embody.

A report entitled "Neighbourhood Traffic Calming: Seattle's Traffic Circle Program" was presented at the Institute of Engineers (ITE) District 6 Annual Meeting, July 20-23, 1997, Salt Lake City, Utah. The City of Seattle in the United States of America implemented demonstration projects for traffic control devices in 1973 and throughout the 1970's where a variety of traffic control devices such as traffic circles (mini roundabouts), star diverters, diagonal diverters, and partial and full road closures on a system-wide basis. The experiences gained from these demonstration projects were used to establish the Neighbourhood Traffic Calming Program (NTCP) in 1978. This program found that the most successful device was the traffic circle as this device has proven to be the most effective at solving neighbourhood concerns surrounding speeding and traffic accidents with a minimum of controversy. Between 1991 and 1994, a total of 119 traffic circles were installed and from a comparison of the number of accidents and injuries occurring in the calendar year before and after construction of these intersections, there were a considerable drop in accidents and injuries. There were 187 accidents and 153 injuries in the year before construction compared to 11 accidents and 1 injury in the year after construction. The investigation also revealed that the number of accidents and injuries remained very low in subsequent years following construction. The significant decreases in traffic accidents and injuries were also experienced at previously signed intersections (two-way stop or yield signs) that were changed to traffic circles. Traffic accidents and injuries decreased from 49 and 38 respectively in the year before construction to 5 and 1 respectively in the year after construction. After 25 years of experience, the City of Seattle has found traffic circles to be an effective device for controlling traffic and improving traffic safety of residential streets.

LaToya Johnson and A. J. Nedzesky produced a paper entitled “A Comparative Study of Speed Humps, Speed Slots and Speed Cushions”. The primary objective of the study was to compare speed humps with speed slots and speed cushions in the Washington DC metropolitan area. This study was undertaken in 2003 with the subject devices being 12 ft (3.66 m) and 22 ft (6.71 m) speed humps, 14 ft (4.27 m) prefabricated speed humps, 22 ft (6.71 m) speed slots and 10 ft (3.05 m) speed cushions.

The goal of the study was to perform a comparative analysis of speed humps, speed slots and speed cushions by examining crossing speed, driver behaviour and brake pedal use.

Speed humps are typically 24 ft (7.32 m) wide, 12 ft (3.66 m) long and 3 to 4 inches (75 to 100 mm) in height similar to the circular speed hump shown Figure 4.

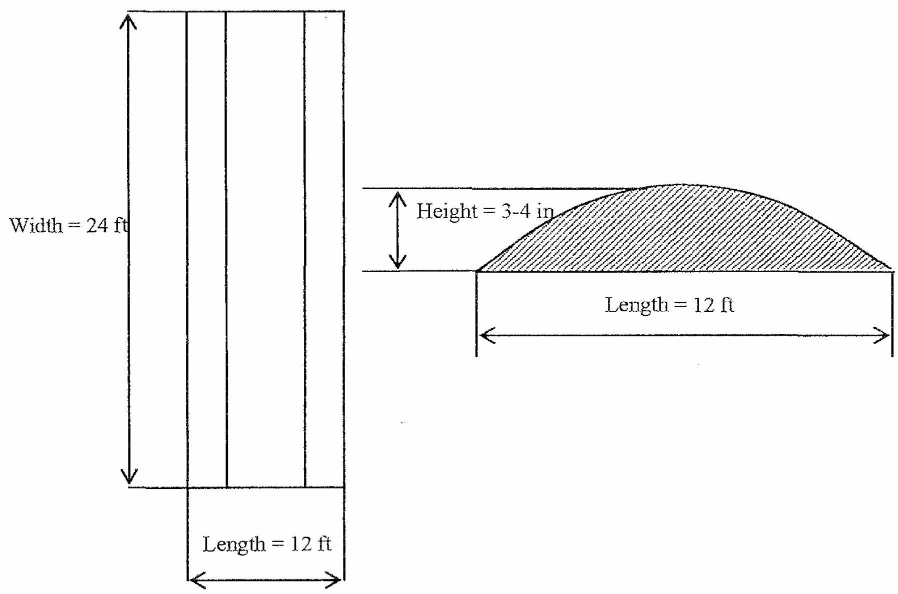

Figure 4: Schematic of a Typical Circular Speed Hump (Johnson and Nedzesky 2003)

The speed hump profiles can be circular, parabolic or flat-topped. These profiles are shown in Figure 5.

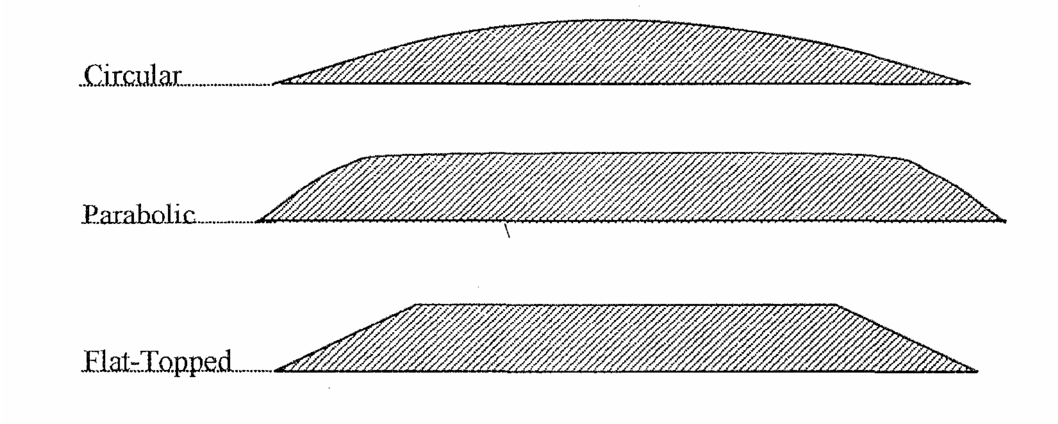

Figure 5: Typical Design Profiles of Speed Humps (Johnson and Nedzesky 2003)

The differences between speed humps, speed slots and speed cushions are illustrated in Figure 6.

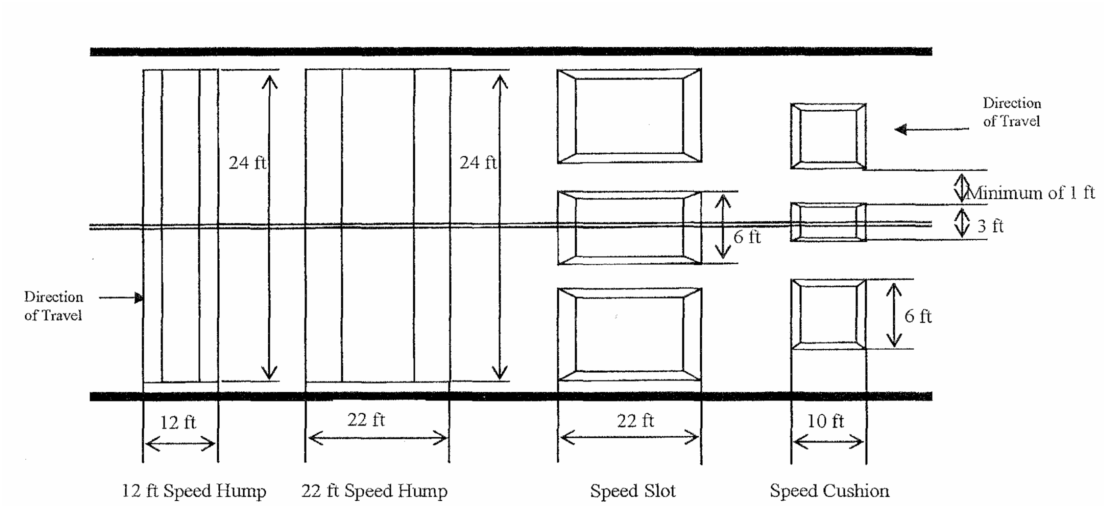

Figure 6: Schematic of Speed Hump, Speed Slot and Speed Cushion (Johnson and Nedzesky 2003)

The introduction of speed slots and speed cushions was instigated because of the concerns with response times and passenger comfort of emergency response vehicles. As can be seen from Figure 6, speed slots and speed cushions retain the concept of raised areas within and across the road pavement with the intent of reducing vehicle speeds however the raised sections do not extend continuously across the road pavement like a speed hump. Speed slots are designed to allow emergency response vehicles to avoid the device by driving through the slots and along the middle of the road. This scenario forces the emergency vehicle in straddling the centreline and travel in both lanes of the roadway, increasing the risk to both the emergency vehicle as well as on coming vehicles. Speed cushions are smaller than lane width and allow emergency vehicles to straddle the device while remaining in its respective lane.

Ten sites were selected in the Washington DC metropolitan area where the streets were classified as local streets and with one lane in each direction and 25 mph (40 km/hr) speed signage. All data collection was undertaken using video camera surveillance and the data extracted to assess and/or determine vehicle types, vehicle speeds, and driver behaviour. The results of the study showed that the average speed and 85th percentile speeds for the 12 ft (3.66 m) speed hump, the 14 ft (4.27 m) prefabricated speed hump and the speed cushion were approximately 10 mph (16 km/hr) and less than 15 mph (24 km/hr) respectively. The 22 ft (6.71 m) speed hump recorded average speeds of 15.2 mph (24.3 km/hr) and 85th percentile speeds of 18.8 mph (30.1 km/hr) while the speed slots recorded average speeds of 20.5 mph (32.8 km/hr) and 85th percentile speeds of 26.5 mph (42.4 km/hr).

Driver behaviour at speed humps was predictable with vehicles maintaining a travel path at the centre of the lane. At speed slots, driver behaviour was also consistent with vehicles travelling through the device with their left tyres along the groove of the slot but with the vehicle totally within their lane. At speed cushions, driver behaviour was varied with most drivers either maintaining a travel path along the centre of the lane and straddling the device or travelling through the device with their left tyres along the groove of the cushion but with the vehicle totally within their lane. However some drivers, particularly a high percentage of pick-up drivers and service vans, were observed to straddle the centreline of the road with their left and right tyres in the grooves on each side of the centreline. Johnson and Nedzesky were concerned with the percentage of pick-up trucks and service vans that straddled the centreline at speed cushions because of the obvious safety risk to on coming vehicles created by this manoeuvre.

Chapter 7 DATA COLLECTION, ON SITE OBSERVATIONS AND DATA ANALYSIS

7.1 Types of Traffic Calming Devices in Logan City

The main traffic calming devices used in residential streets in Logan City Council since the release of the Development Manual and the Queensland Streets guidelines were:

- Roundabouts – major and minor.
- Central Island Speed Control Devices – commonly called "Footballs".
- "Deflected T" intersections – commonly called "Chicanes".
- Spitter Island in the give way leg of minor T – junctions.

Other devices that had been rarely used in the initial years were:

- Median strips at bends to prevent corner cutting.
- One lane angled slow point.
- Speed humps.

The "Deflected T" intersection has not been used extensively after the initial years because of the:

- Vehicle access problems for lots on the opposite side of the give way leg of the intersection due to the installation of the median islands in this type of intersection.
- Difficulties associated with the combination of designing the intersection for satisfactory manoeuvrability of garbage trucks, delivery trucks and emergency

vehicles through the intersection due to the installation of the median islands in this type of intersection and of maintaining speed control for passenger vehicles.

- Continuous maintenance by Council of traffic signs located in the medians within this type of intersection following damage to the signs caused primarily by large vehicles.

Speed humps, in particular, and one lane angled slow points were very unpopular with residents and emergency services. The concerns that Logan City Council received from residents and emergency services in relation to speed humps and one lane angled slow points included:

- Increased noise for residents near speed humps from vehicles when braking before the device, crossing the device and accelerating from the device.
- Increased air pollution for the residents from unsteady vehicle operation (braking and accelerating).
- Discomfort for passenger and other vehicles when crossing speed humps.
- Difficulty in negotiating the devices – vertical displacement for speed humps and horizontal displacement for one lane angled slow point.
- Concerns with travelling to the wrong side of the road to negotiate the one lane angled slow points.
- Loss time at speed humps because ambulance vehicles need to slow almost to a stop to negotiate the speed hump without creating discomfort to the patients.

Whilst the increase in the minimum pavement width to 8 metres by Logan City Council in March 2000 is in direct contradiction to the objectives of the Queensland Streets guidelines, speed control devices are still required in new residential streets in Logan City. This situation has led to:

- The reintroduction of one lane angled slow points.
- Larger roundabouts at 3 way and 4 way intersections.
- Continued rejection of “Deflected T” intersections. A splitter island in the give way leg of the T – junction has been utilised at all T intersections with speed control devices along street legs between intersections.

- A reduction in the use of central island speed control devices unless pavement narrowing is incorporated at the entrance and exit of these devices.

A research of the design and as constructed database of Logan City Council has revealed that civil consultants and Logan City Council have produced many different designs for roundabouts, central island speed control devices, deflected T intersections, and one lane angled slow points. The predominant form of traffic calming device in Logan City is the central island speed control device.

Where these devices have been installed by Logan City Council, the design of the devices have generally been restricted or controlled by the existing road boundaries and the locations of the existing services within the road reserves. This situation has resulted in the installation of devices that provide visual barriers rather than the necessary deflections for traffic control and speed control in some instances.

In the case of roundabouts, the central median island location varies from a central location within the intersection for 3 way and 4 way intersections to a pronounced offset towards the side street for 3 way intersections. For the central island speed control devices, the variations in design include a range in width of the central island (1.28 to 4 metres), and a variety of overall shapes in these devices due to the locations or orientations of the central islands and due to the radii or angles of the approaches and departures of the devices. The design of deflected T intersections varied from the provision of narrow median islands in each leg of the intersection or the provision of narrow median islands in the through road of the intersection to no median islands where the reverse curves of the through road were relied upon for deflection and speed control. Whilst the one lane angled slow points have only been recently reintroduced in new residential developments, the variation in design mainly relates to the width of the "one lane" within the device (3.5 to 5 metres).

At the time of writing, the Development Assessment Branch of Logan City Council which assesses and approves all residential development designs has instructed civil engineering consultants that one lane angled slow points were not to be used in Logan City.

7.2 Preparation of Drawings of Traffic Calming Devices

After extracting relevant design and as constructed details of several traffic calming devices from the Logan City Council database, a computer generated drawing of each device was prepared. Because the design and as constructed details of the traffic calming devices were in microfilm format only, it was necessary to mathematically calculate setout details for most of the devices before producing the drawings using Autocad 2002 computer package.

The primary criteria used for the selection of traffic calming devices was to select residential streets that had a series of traffic calming devices along their length which could be observed concurrently. The residential streets that were selected for testing and the number and type of traffic calming devices in each residential street are detailed in Table 3.

Table 3: Selected Residential Streets

Street Name/Suburb	Number of Traffic Calming Devices	Types of Traffic Calming Devices
Billiluna Street Shailer Park	2	Roundabouts
Blackwell Street Hillcrest	4	Central Island Device/Two Speed Humps/ Central Island Device
Brabham Street Crestmead	1	Roundabout
Cumberland Crescent Heritage Park	1	Central Island
Garfield Road Woodridge	3	Central Island Devices
Gaven Way Cornubia	3	Central Island Devices
Geaney Boulevard Crestmead	2	Central Island Devices
Glengala Drive Rochedale South	1	Central Island Device
Glenvale Street Cornubia	3	Roundabout/Two Central Island Devices
Kilsay Crescent Meadowbrook	2	Central Island Devices
Kununurra Street Shailer Park	2	Central Island Devices
Pinelands Street Loganlea	2	Central Island Devices
Powell Street Heritage Park	1	Central Island Device
Richards Street Loganlea	1	Deflected T Intersection
Robert South Drive Crestmead	3	Deflected T Intersections
Rundell Street Crestmead	3	Central Island Device/Roundabout/Central Island Device
Ryedale Street Heritage Park	2	Deflected T Intersections
Samba Place Underwood	2	Central Island Device/Deflected T Intersection
Solandra Circuit Regents Park	1	Roundabout
Solandra Circuit Regents Park	2	Central Island Devices
Stubbs Road Woodridge	2	One Lane Angled Slow Points
Vedders Drive Heritage Park	2	Deflected T Intersections

7.3 Determination of the Predicted Speed for Each Device

When the Autocad drawing of each traffic calming device was completed, the maximum radius of travel in each direction through the device was determined and the predicted (achievable) speed was calculated for each maximum radius of travel.

The formula used to calculate the predicted speed for each device was:

$$\mathbf{V^2 = 127\ R\ (e + f)}$$

where:

V = Speed in km/hr on the maximum radius of travel through the device.

R = Maximum radius of travel through the device in metres.

e = Superelevation in m/m (this is negative if the pavement crossfall slopes away from the device).

f = Coefficient of side frictional force developed between the vehicle tyres and the road pavement.

This formula is usually used for determining the minimum radii of horizontal curves when the desirable maximum values for superelevation and for coefficient of side friction and the design speed are known. This formula is considered appropriate for determining the predicted speeds because the values of e, f and R are known for each device and the travel path through each device is a horizontal curve. Referring to Queensland Streets (Weathered Howe 1995, p. 22), Table 2.3.C shows that the combination of e + f = 0.35 is the acceptable combination for e and f for chicanes. In the absence of any other literature source that details the likely values of the coefficient of friction at the lower speed of 20 km/hr , e + f = 0.35 has been adopted for determining the predicted speed through all traffic calming devices that were tested for this dissertation. The superelevation e through each device is -0.025 because the pavement crossfall is 2.5% and slopes away from the device. Consequently, the value of the coefficient f is 0.375.

Using the above formula, the maximum radius of travel for a design speed of 20 km/hr through traffic calming devices is 9 metres. The maximum radius of travel for a design speed of 25 km/hr is 14.1 metres.

7.4 On Site Data Collection and Observations

To observe the on site speed behaviour of drivers through traffic calming devices, a speed gun was hired from Decatur Radar Australia. The speed gun was relatively easy to use and allowed recording of speeds in both directions through the devices. The speed recordings at each traffic calming device in each selected residential street were undertaken from 17 December to 26 December 2005.

As the recording of the speeds through the devices generally required setting up in the verge area of the street, a safety vest was worn (bright orange). The vest may have affected some of the recorded data because I could be seen clearly by approaching drivers in most instances. Some speed data was able to be collected when I was set up in a vehicle on the roadway at an acceptable distance from the traffic calming device where interference with the vehicle movement through the device was avoided. Some speed data also affected by the proximity of the device from the residence that the vehicle entered or exited from.

In Appendix B, the data for each selected residential street includes:

- An Autocad drawing of each type of traffic calming device that is associated with the street.
- A table of speed recordings in each direction for each traffic calming device in the street.
- A table of the calculated average speed and the calculated 85th percentile speed in each direction through each traffic calming device.
- The spacing between traffic calming devices where two or more devices were in series in the street.
- The maximum radius of travel in each direction through the traffic calming device and the associated predicted (achievable) speed through the device.

Refer to Table 4 for the Figure Numbers and Page Numbers in Appendix B that are associated with each selected residential street. The Figure Numbers represent the Autocad drawings of the devices in the street, and the recorded and calculated data for the street.

Table 4: Appendix B References for the Selected Residential Streets

Street Name	Appendix B Figure Nos/Page Nos
Billiluna Street	B1a, B1b, B1c/B1 - B3
Blackwell Street	B2a, B2b, B2c/B4 - B6
Brabham Street	B3a, B3b/B7 - B8
Cumberland Crescent	B4a, B4b/B9 - B10
Garfield Road	B5a, B5b/B11 - B12
Gaven Way	B6a, B6b/B13 - B14
Geaney Boulevard	B7a, B7b/B15 - B16
Glengala Drive	B8a, B8b/B17 - B18
Glenvale Street	B9a, B9b, B9c, B9d/B19 - B22
Kilsay Crescent	B10a, B10b/B23 - B24
Kununurra Street	B11a, B11b/B25 - B26
Pinelands Street	B12a, B12b/B27 - B28
Powell Street	B13a, B13b/B29 - B30
Richards Street	B14a,B14b/B31 - B32
Robert South Drive	B15a, B15b/B33 - B34
Rundell Street	B16a, B16b, B16c, B16d/B35 - B38
Ryedale Street	B17a, B17b, B17c/B39 - B41
Samba Place	B18a, B18b, B18c/B42 - B44
Solandra Circuit (Roundabout)	B19a, B19b/B45 - B46
Solandra Circuit (Central Islands)	B20a, B20b, B20c/B47 - B549
Stubbs Road	B21a, B21b/B50 - B51
Vedders Drive	B22a, B22b, B22c, B22d/B52 - B55

7.5 Data Analysis

Because there were differences in the designs of the traffic calming devices that were selected for testing, it was expected that there would be some variations in the recorded speeds between devices. After determining the maximum radius of travel and after calculating the predicted speed for each device, it was clearly evident that none of the tested traffic calming devices met the speed criteria of the Queensland Streets document, that is, a design speed of 20 km/hr through the traffic calming device.

Table 5 shows a comparison of the predicted speed, average speed, and the lowest speed and the highest speed that were recorded for each street. Where the maximum radius of travel is different in each direction through the traffic calming device, two values are shown for the predicted speed, the average speed and the 85th percentile speed.

Assessments of the designs of the traffic calming devices showed that the predicted speeds for most of the devices were in excess of 30 km/hr. The range of the predicted speed for each type of device was:

- Roundabouts – 27.9 to 57.7 km/hr.
- Central Island Speed Control Devices – 27.5 to 103.3 km/hr.
- Deflected T Intersections – 29.4 to 57.0 km/hr.

A summary of the maximum radius of travel, the predicted speed, the average speed and the 85th percentile speed for the tested roundabouts, central island speed control devices, deflected T intersections, speed humps, and one lane angled slow points are shown in Tables 6, 7, 8, 9 and 10 respectively. Where the maximum radius of travel is different in each direction through the traffic calming device, two values are shown for the maximum radius of travel with two corresponding values of the predicted speed, the average speed and the 85th percentile speed.

Table 5: Comparison of Predicted Speed, Average Speed, and the Lowest Speed and the Highest Speed

Street Name	Device Number	Predicted Speed (km/hr)	Lowest Speed (km/hr)	Highest Speed (km/hr)	Average Speed (km/hr)
Billiluna Street	R1	28.7/39.4	20/30	25/35	21.1/32.2
	R2	42.2/49.4	21/23	44/35	32/32.3
Blackwell Street	F1	36.5	20	71	41.8
	H1	-	13	43	38.6
	H2	-	12	40	35.8
	F2	36.5	20	58	44
Brabham Street	R1	34.6/27.9	12./17	38/28	25.9/19.2
Cumberland Crescent	F1	37.1	20	40	26.5
Garfield Road	F1	63.3/68.3	23	47	35.1/33
	F2	63.3/68.3	23	47	33.5/28.5
	F3	63.3/68.3	26	47	37/33.5
Gaven Way	F1	84.3	22	57	43.9
	F2	84.3	22	57	43.7
	F3	84.3	20	56	43
Geaney Boulevard	F1	27.5	13	40	28.4
	F2	27.5	14	40	28.9
Glengala Drive	F1	60.4/63.1	27/31	52/50	42.7/39.8
Glenvale Street	R1	57.7/37.1	22/23	43/48	32.7/35.4
	F1	84.3	28	51	38.4
	F2	84.3	24	51	35.9
Kilsay Crescent	F1	103.3	26	57	39.3
	F2	103.3	31	51	40.7
Kununurra Street	F1	49.4	15	50	36.6
	F2	49.4	23	50	34.5
Pinelands Street	F1	44.2	27	49	37.4
	F2	44.2	24	46	37.2
Powell Street	F1	73.0	20	48	33.9
Richards Street	C1	44.7/53.8	23/22	31/24	27.5/23
Robert South Drive	C1	37.4/42.5	22/17	30/32	27/25.3
	C2	37.4/42.5	24/17	31/32	27.5/24.8
	C3	37.4/42.5	No Rec/17	No Rec/29	No Rec/21.8
Rundell Street	F1	47.1/49.4	26/26	46/40	34.1/30.5
	R1	49.9/50.3	24/22	37/23	27.7/22.5
	F2	37.7	28	37	32.5
Ryedale Street	C1	30.9/29.4	14/.12	24/23	19.2/18.2
	C2	29.4/30.9	16/.12	23/24	18/18.9
Samba Place	F1	29.8/28.3	20/20	33/30	28.5/24
	C1	57.0/45.7	22/17	28/28	25/21.7
Solandra Circuit (R/about)	R1	43.0/30.2	23/15	34/22	27.3/18.2
Solandra Circuit (Central	F1	45.5/72.0	23/26	32/26	28
Island)	F2	46.0/67.7	20/-	35/-	29.4
Stubbs Road	OL1	Infinity	22/31	60/53	36.5/40.9
	OL2	Infinity	29/31	58/41	35.9/36.8
Vedders Drive	C1	44.7	26	34	30.6
	C2	42.2	20	34	29.3

Table 6: Condensed Roundabout Data

Street Name	Device Number	Roundabout Median Diameter (m)	Maximum Radius of Travel (m)	Predicted Speed (km/hr)	Average Speed (km/hr)	85th Percentile Speed (km/hr) (km/hr)
Billiluna Street	R1	8	18.5/35	28.7/39.4	21.1/32.2	22.4/33.8
	R2	7	40/55	42.2/49.4	29.4/28	32/32.3
Brabham Street	R1	6	27/17.5	34.6/27.9	25.9/19.2	31.8/22.2
Glenvale Street	R1	6	75/31	57.7/37.1	32.7/35.4	38.8/44.1
Rundell Street	R1	6	56/57	49.9/50.3	27.6/22.5	32.5/22.9
Solandra Circuit	R1	14	20.5/41.5	30.2/43.0	18.2/27.3	22/30.1

Table 7: Condensed Central Island Speed Control Device Data

Street Name	Device Number	Island Width (m)	Maximum Radius of Travel (m)	Predicted Speed (km/hr)	Average Speed (km/hr)	85th Percentile Speed (km/hr)
Blackwell Street	F1	2.91	30	36.5	41.8	52
	F2	2.91	30	36.5	44	54.4
Cumberland Crescent	F1	3.05	31	37.1	26.5	31.5
Garfield Road	F1	3.00	90/110	63.3/68.3	35.1/33	47/34.4
	F2	3.00	90/110	63.3/68.3	33.5/28.5	44/30.3
	F3	3.00	90/110	63.3/68.3	37/33.5	44.3/33.9
Gaven Way	F1	3.25	160	84.3	43.9	48.7
	F2	3.25	160	84.3	43.7	50.1
	F3	3.25	160	84.3	43	48.7
Geaney Boulevard	F1	3.00	17	27.5	28.4	37.8
	F2	3.00	17	27.5	28.9	36
Glengala Drive	F1	2.80	82/89.5	60.4/63.1	42.7/39.8	50/45
Glenvale Street	F1	3.25	160	84.3	38.4	47.3
	F2	3.25	160	84.3	35.9	45
Kilsay Crescent	F1	4.50	240	103.3	39.3	46.4
	F2	4.50	240	103.3	40.7	47
Kununurra Street	F1	3.00	55	49.4	36.6	47.3
	F2	3.00	55	49.4	34.5	43
Pinelands Street	F1	2.95	44	44.2	37.4	44
	F2	2.95	44	44.2	37.3	44.2
Powell Street	F1	1.28	120	73.0	33.9	40.9
Rundell Street	F1	2.86	50/55	47.1/49.4	32.75	41.5
	F2	3.00	32	37.7	27.7	32.5
Samba Place	F1	4.00	20	29.8/28.3	28.5/24	32.3/27
Solandra Circuit	F1	3.72	46.5/116.5	45.5/72.0	28	30.2
	F2	3.76	47.5/103	46.0/67.7	29.4	35

Table 8: Condensed Deflected T Intersection Data

Street Name	Device Number	Medians (Yes/No)	Maximum Radius of Travel (m)	Predicted Speed (km/hr)	Average Speed (km/hr)	85th Percentile Speed (km/hr) (km/hr)
Richards Street	C1	Yes	65/45	53.8/44.7	27.5/23	29.9/23.4
Robert South Drive	C1	Yes	31.5/50	37.4/42.5	27/25.3	28.8/29.1
	C2	Yes	31.5/44	37.4/42.5	27.5/24.8	30/31
	C3	Yes	31.5/44	37.4/42.5	No rec/21.8	No rec/27.2
Ryedale Street	C1	Yes	21.5/19.5	30.9/29.4	19.2/18.2	22/19.7
	C2	Yes	19.5/21.5	29.4/30.9	18/18.9	20.6/20.4
Samba Place	C1	Yes	73/47	57.0/45.7	25/21.7	27.1/24.2
Vedders Drive	C1	No	45	44.7	30.6	32.8
	C2	No	40	42.2	29.3	33.7

Table 9: Condensed Speed Hump Data

Street Name	Device Number	Maximum Radius of travel (m)	Predicted Speed (km/hr)	Average Speed (km/hr)	85th Percentile Speed (km/hr)
Blackwell Street	H1	Infinity	-	26.5	38.6
	H2	Infinity	-	25.7	35.8

Table 10: Condensed One Lane Angled Slow Point Data

Street Name	Device Number	Maximum Radius of travel (m)	Predicted Speed (km/hr)	Average Speed (km/hr)	85th Percentile Speed (km/hr)
Stubbs Road	OL1	Infinity	-	38.3	41.9
	OL2	Infinity	-	36.3	39.2

From the calculations of the predicted speed data, no traffic calming device met the criteria of 20 km/hr speed through traffic calming devices as required by Queensland Streets. However it can be seen that for a large majority of the devices the average speed and the 85th percentile speed determined for each device were lower than the predicted speed for the device. The only devices that recorded average speeds of less than 20 km/hr were the deflected T intersections in Ryedale Street.

From Tables 6 to 10 inclusive, it can be seen that four of the six roundabouts, eight of the nine deflected T intersections, the two speed humps, and seven of the twenty-six central island speed control devices restricted drivers to an average speed of less than 30 km/hr.

The findings of the analysis of the collected and calculated data were very disappointing because the aim of this dissertation was to find traffic calming devices in Logan City that met the Queensland Streets objectives and to determine the most effective devices that could be used as standard devices in future residential streets in Logan City. This aim could not be achieved because none of the devices met the objectives of reducing the design speed through traffic calming devices to 20 km/hr.

7.6 Driver Behaviour

The observed driver behaviour ranged from an extremely conservative to an extremely aggressive approach with several of the aggressive drivers mounting the kerb and channel as they pass through the device. Very few instances of vehicular contact with the islands of the devices were observed.

The speeds that were recorded through each device varied significantly and would likely be attributed to such factors as:

- Driver experience of the street/traffic calming device.
- Driver ability.
- Urgency of the trip.
- Alertness of the driver.
- Driver tolerance of the traffic calming device.
- Driver perception of the difficulty of negotiating the device.
- Driver observance of the residential amenity of the street.

7.7 Signage and Linemarking

The observed variations in the use of signage and linemarking on the traffic calming devices were extreme in nature with many devices that are not in accordance with the Manual of Uniform Traffic Control Devices.

Generally, the signage and linemarking practices for the roundabouts were very good and generally in accordance with the Manual of Uniform Traffic Control Devices for minor roundabouts. The minor roundabouts had linemarked islands with rumble bars instead of kerbed islands, signage and linemarking in all approaches to the roundabout, with a R1-3 (Roundabout Give Way) sign to each approach to the roundabout, and a D4-1-2 (Directional hazard) sign in the central median facing each approach to the roundabout.

The different types of signage and linemarking concepts used in the deflected T intersections were:

- Median islands in all legs of the intersection (Richards Street, Samba Place, Robert South Drive) with a R2-3(L) (Keep Left) sign at each end of all median islands, approach linemarking, and white reflectorised paint to the noses of all median islands.
- Median islands in the through leg of the intersection (Ryedale Street) with a R2-3(L) (Keep Left) sign at the approach end of the median islands, no approach linemarking, and white reflectorised paint to the noses of all median islands.
- No median islands, no signage, and no linemarking (Vedders Drive).

With central island speed control devices, the observed variations in signage and linemarking were:

- No signage, no linemarking, and white reflectorised paint to the noses of the central island (Rundell Street – F2).
- No linemarking, R2-3(L) (Keep Left) signs with or without D4-1-2 (Directional hazard) signs in the central island, and white reflectorised paint to the noses of the central island.
- Single line approach linemarking, R2-3(L) (Keep Left) signs with or without D4-1-2 (Directional hazard) signs in the central island, and white reflectorised paint to the noses of the central island.
- No linemarking, R2-3(L) (Keep Left) signs and D4-1-2 (Directional hazard) signs in the central island, W5-33 (Slow Point) sign and 30 km/hr speed sign to each approach to the device, and white reflectorised paint to the noses of the central island (Geaney Boulevard).

The large variation in the installation of signage and linemarking is of concern and Logan City Council should develop standards for the minimum requirements that would be necessary for each type of device where such requirements are in accordance with the Manual of Uniform Traffic Control Devices.

In general, there was no obvious damage to the signage or to the central median island to the selected roundabouts. With the central island speed control devices, there were very few devices that had suffered any damage. Where damage was identified, the effected areas were the outer edge of the central island and signage to the central island.

The deflected T intersections that incorporated median islands were found to show the highest rate of damage in comparison to roundabouts and central island speed control devices. Several keep left signs had been flattened by vehicles despite some of the keep left signs being changed from conventional keep left signs to the unconventional vertical keep left sign. The noses of several median islands also showed signs of damage from vehicle impacts. The reverse curves through this type of intersection are obviously restrictive and causing inconvenience to some drivers considering the damage occurring at these devices.

It would appear that the more desirable traffic calming devices are roundabouts and central island speed control devices. This statement is made because of the following factors:

- The complaints received by Logan City Council from the public and emergency services in relation to speed humps and one lane angled slow points as highlighted in Chapter 7, Section 7.1.
- The observed damage to deflected T intersections that have median islands where the maintenance costs over time would be unacceptable to Logan City Council.
- The unacceptable manoeuvre onto the opposite side of the roadway through the deflected T intersection without median islands.

Chapter 8 FURTHER WORK

It is evident that the traffic calming devices currently installed in the residential streets of Logan City are not in accordance with the Queensland Streets philosophy with regards to controlling speeds through these types of devices to 20 km/hr. Some of the devices have created a visual barrier without achieving the speed reduction requirement for these devices.

Bearing in mind that the range of passenger vehicles using residential streets includes small, medium and large passenger vehicles, it would be necessary to develop designs of traffic calming devices that restrict small passenger vehicles to 20 km/hr through these devices if the objectives of safety and amenity in residential streets as stated in Queensland Streets are to be achieved. The other vehicles such as emergency vehicles (ambulances, fire trucks, and State Emergency Service vehicles), garbage trucks, and delivery trucks, must also be catered for. Small, medium and large passenger vehicles and ambulances need to be able to negotiate the traffic calming devices without mounting the central island whilst fire trucks, State Emergency Service vehicles, garbage trucks, and delivery trucks should be allowed to mount the outer edge of the central island.

Chapter 9 CONCLUSIONS AND RECOMMENDATIONS

The investigation of traffic calming devices shows that the traffic calming devices currently installed in the residential streets of Logan City are not in accordance with the Queensland Streets philosophy with regards to controlling the speed through these types of devices to 20 km/hr. Consequently, this situation has not allowed me to achieve the outcomes that were sought from this investigation, namely,

- To determine a small number of traffic calming treatments that could be adopted as standard and acceptable types of devices for use in Logan City.
- To suggest and justify potential modifications to the Queensland Streets document.

If Logan City Council is serious about implementing the Queensland Streets requirement for 20 km/hr speed through traffic calming devices in residential streets, further designs of traffic calming devices, particularly roundabouts and central island control devices, need to be undertaken.

It is therefore recommended that further designs of roundabouts and central island speed control devices be investigated and that these devices be field tested using a small passenger vehicle and a competent test driver. When a roundabout and a central island speed control device have been developed that limits the speed through the devices by a small passenger vehicle to 20 km/hr, the devices should be field tested using medium and large passenger vehicles, ambulances, fire trucks, State Emergency Service vehicles, garbage trucks, and delivery trucks to ensure that these vehicles can negotiate the devices in relative comfort and to gauge the through speed and/or impacts of the devices on the performance of these vehicles.

This investigation may lead to other recommendations should the developed roundabout and/or central island speed control device prove to be too restrictive for vehicles other than small passenger vehicles. If this becomes the case, further designs of roundabouts and central island speed control devices would need to be investigated based on recommendations from this investigation.

Because of the possibly too restrictive maximum radius of travel of 9 metres that is required to restrict the vehicle speed to 20 km/hr through traffic calming devices, some of the possible recommendations may likely include the need to increase the speed through traffic calming devices for a small passenger vehicle to 25 km/hr (maximum radius of travel of 14.1 metres) to ensure that the other types of vehicles can negotiate the devices in relative comfort and increase the design speed in street legs between devices to 40 km/hr to allow reasonable spacings between devices.

Should the final designs of a roundabout and a central island speed control device be developed for a design speed of 20 km/hr through traffic calming devices, these designs should be incorporated in the Queensland Streets document as satisfactory devices that achieve the objectives of Queensland Streets.

Similarly, should the final designs of a roundabout and a central island speed control device need to be developed for a design speed of 25 km/hr through traffic calming devices, the Queensland Streets document needs to be amended to incorporate a design speed of 25 km/hr through traffic calming devices and a design speed of 40 km/hr for the street leg between devices and these designs should be incorporated in the Queensland Streets document as satisfactory devices that achieve the objectives of Queensland Streets.

Subsequent to the final determination of satisfactory designs of a roundabout and a central island speed control device design, appropriate signage and linemarking requirements must be incorporated in accordance with the Manual of Uniform Traffic Control Devices for uniformity across Logan City and to promote familiarity to all drivers.

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APPENDIX A

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

ENG4111/2 Research Project

PROJECT SPECIFICATION

FOR: **Neil John TUCKER**

TOPIC: **Evaluation Of The Queensland Streets Concept For Residential Streets In Logan City**

SUPERVISOR: **Associate Professor Ron Ayers**
Mr Deva Naiker (Senior Traffic Engineer – Logan City Council)

ENROLMENT: **ENG 4111 – S1, X,2005**
ENG 4112 – S2, X, 2005

PROJECT AIM: **To determine the effectiveness and acceptance of the Queensland Streets concept in residential streets in Logan City.**

BACKGROUND: The document "Queensland Streets was prepared under the auspices of the Institute of Municipal Engineering Australia, Queensland Division, and was published in May 1993. The document states its purpose as 'the basis for uniform standard of residential streetworks design, incorporating "state-of-the-art" principles and techniques'. A major thrust of the document was to consider the key issues of safety, amenity, convenience and economy in the design process. The concepts espoused in the document have been used in new residential area design, as well as in trying to improve existing residential areas by the use of traffic control treatments.

PROGRAMME: Issue A, March 2005

1. Undertake a literature review of the background/history of events that led to the formulation of the concepts used in Queensland Streets for residential design and the document itself.

2. Undertake a review of national and international literature dealing with the implementation and effectiveness of traffic control treatments which have been used to try and achieve the concepts proposed in Queensland Streets.

3. Undertake a review of the Queensland Streets document to determine the critical requirements and/or design concepts of traffic control treatments to accord with these concepts.

4. Undertake a review of the types of traffic control treatments that have been used in Logan City since the introduction of Queensland Streets in May 1993. This review will target both the design of new subdivisions and the use of speed control treatments installed by Logan City Council in existing streets.

5. Interrogate Logan City data to evaluate why speed control treatments were installed and to evaluate if the objectives of the treatments have been achieved.

6. Investigate the various types of treatments used in Logan city to determine if such treatments have been designed in accordance with the requirements of Queensland Streets.

7. Gather information from stakeholders (e.g. Council officers (Traffic Branch), drivers/residents, police, ambulance, fire brigade and State Emergency Services on their perceptions of the effects and effectiveness of these treatments.

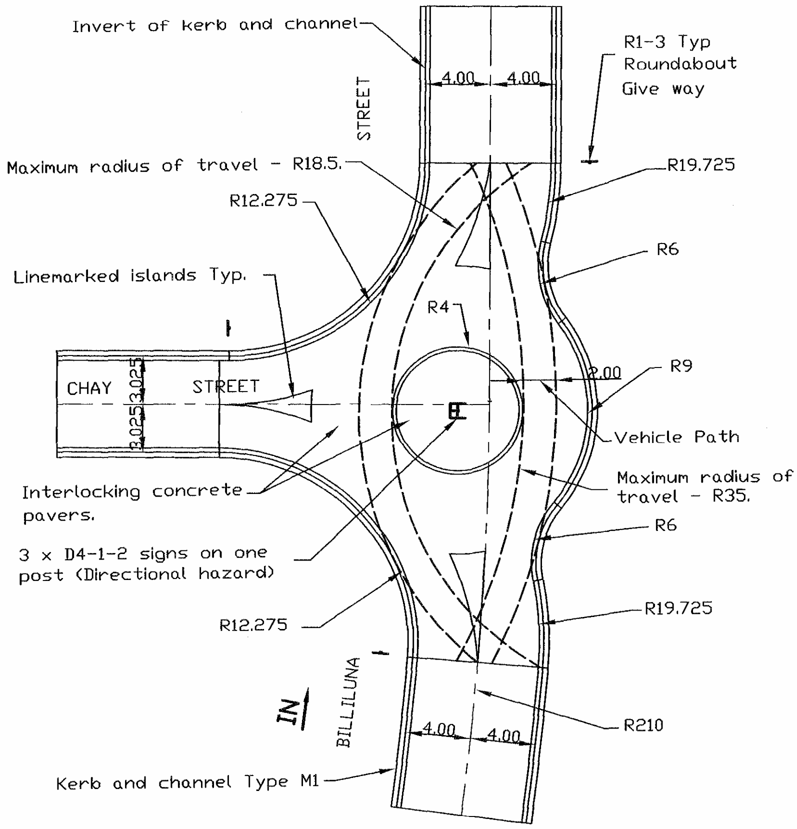
8. Evaluate and analyse the collected data to determine the effectiveness of the Queensland Streets concepts, and suggest and justify potential modifications to the document.

9. Report findings through an oral presentation at the Project Conference and in the written Dissertation.

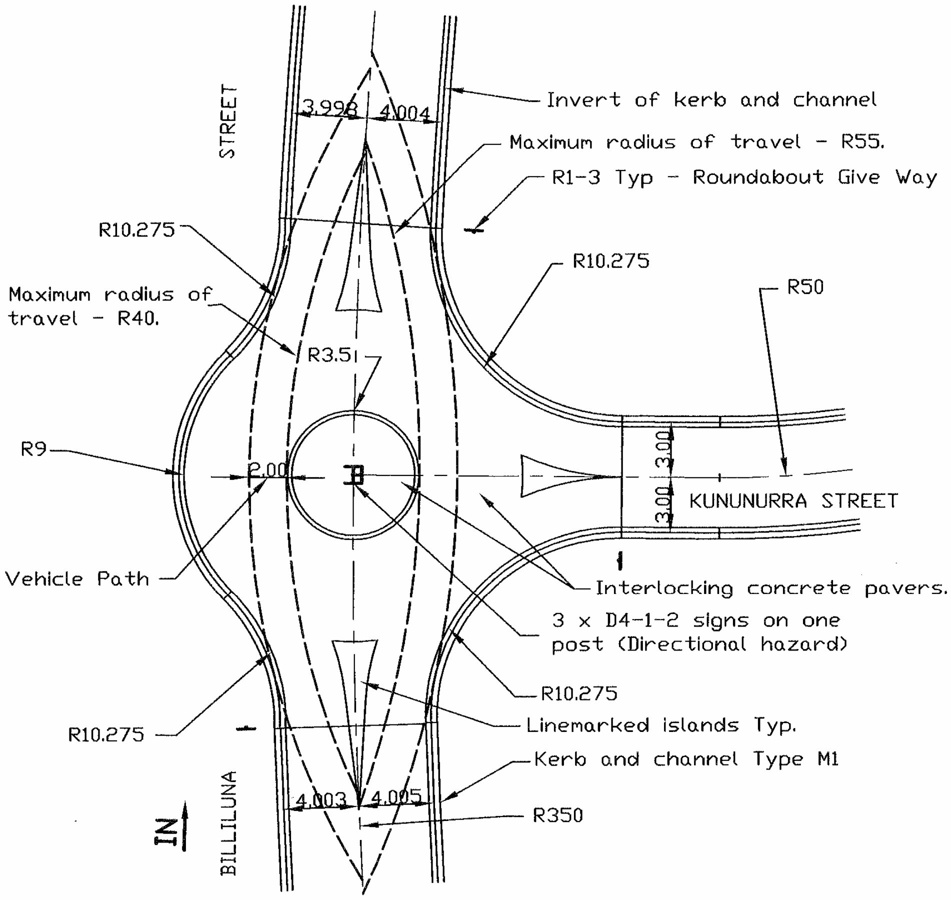
AGREED: ________________________ ________________________

Date: 17/03/05 01/04/05

APPENDIX B



BILLILUNA STREET
SHAILER PARK - R1
Not to Scale
FIGURE B1a



BILLILUNA STREET
SHAILER PARK - R2
Not to Scale
FIGURE B1b

Billiluna Street Shailer Park - Two Different Roundabouts in Series

R1	R2	Direction (In/Out)
23	32	I
20	22	I
21	32	I
20	32	I
20	25	I
20	30	I
21	32	I
21	27	I
20	21	I
20	28	I
25	44	I
22	28	I
35	35	O
30	26	O
30		O
33		O
33	23	O

	All R1	R1 In	R1 Out
Average	24.35294	21.08333	32.2
85th Percentile	31.8	22.35	33.8

	All R2	R2 In	R2 Out
Average	29.13333	29.41667	28
85th Percentile	32	32	32.3

R1 - Offset roundabout at the intersection of Billiluna Street and Chay Street

Maximum radius of travel (inbound) is 18.5 metres.
Predicted (achievable) speed through the roundabout (inbound) is 28.7 km/hr.
Maximum radius of travel (outbound) is 35 metres.
Predicted (achievable) speed through the roundabout (outbound) is 39.4 km/hr.

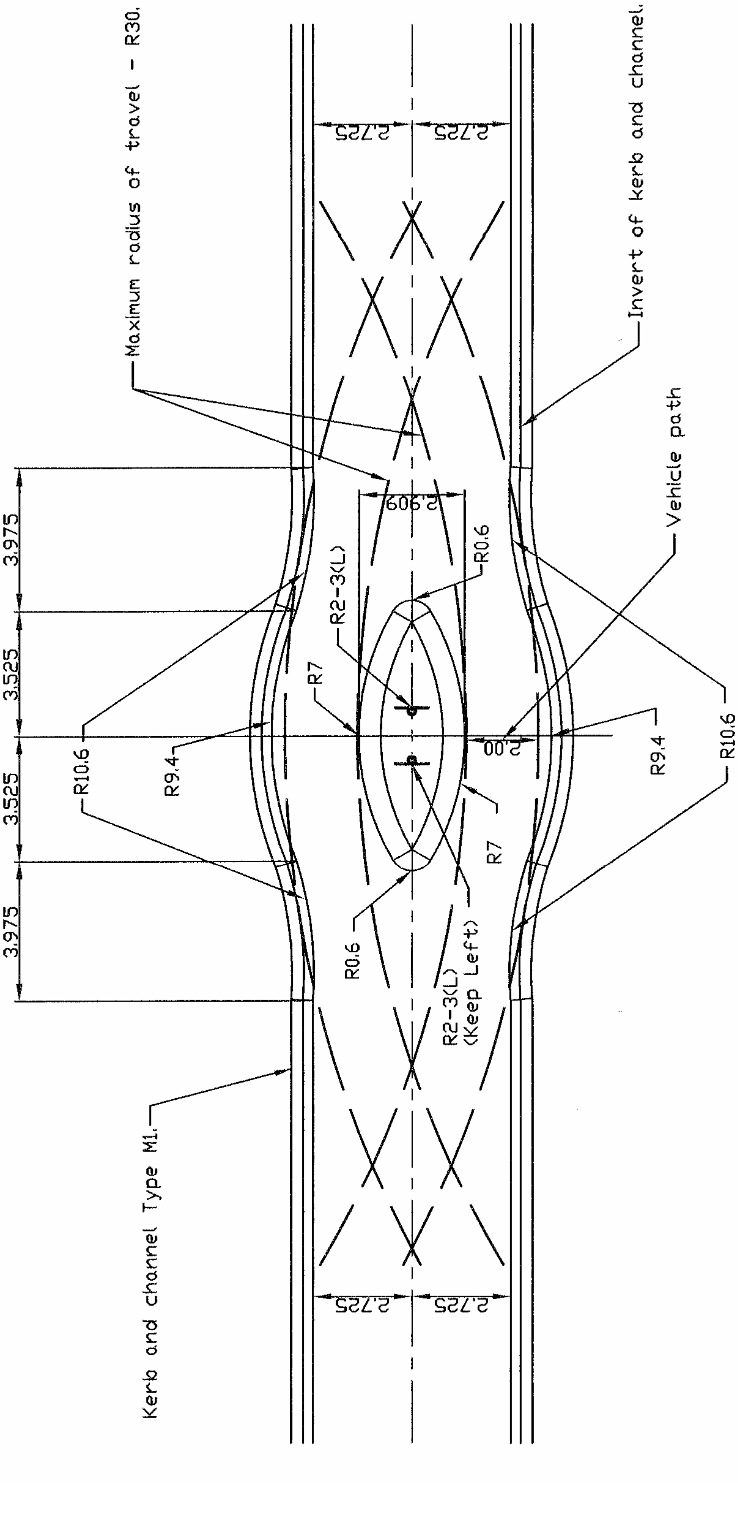
R2 - Centrally located roundabout at the intersection of Billiluna Street and Kununurra Street

Maximum radius of travel (inbound) is 40 metres.
Predicted (achievable) speed through the roundabout (inbound) is 42.2 km/hr.
Maximum radius of travel (outbound) is 55 metres.
Predicted (achievable) speed through the roundabout (outbound) is 49.4 km/hr.

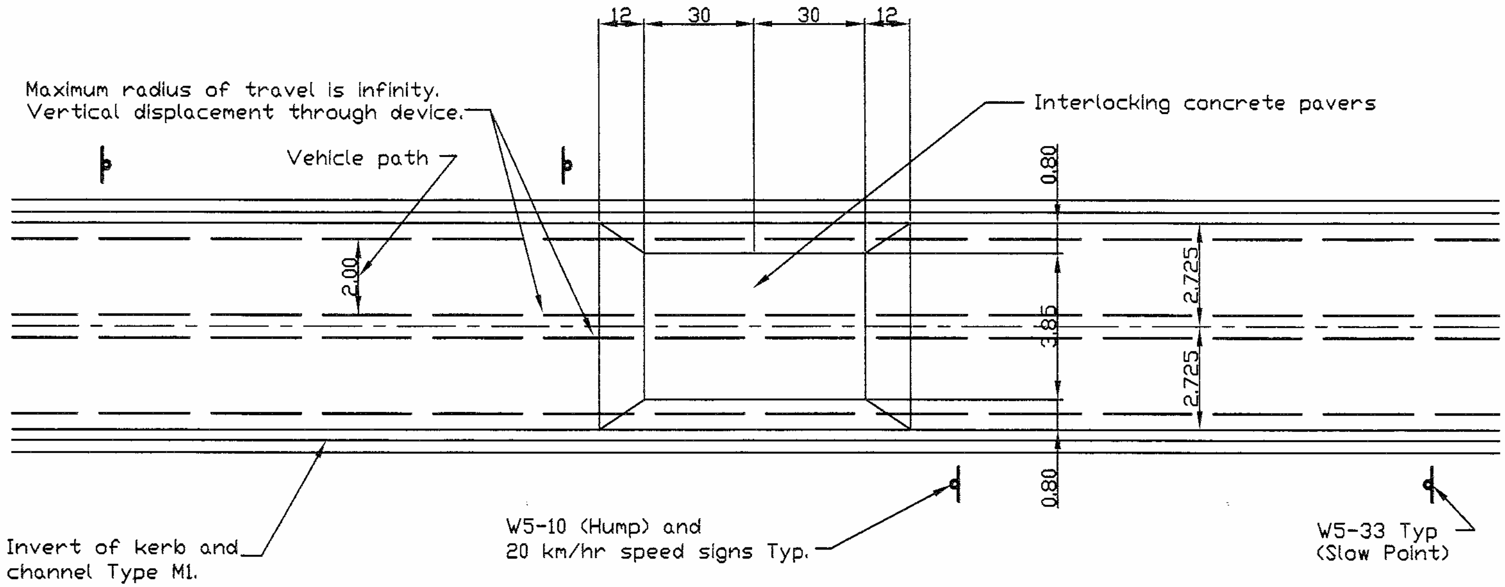
Note

The spacing between these devices (centre to centre) is 137.6 metres.

FIGURE B1c



BLACKWELL STREET HILLCREST
Not to Scale
FIGURE B2a



BLACKWELL STREET HILLCREST
Not to Scale
FIGURE B2b

Blackwell Street Hillcrest
Central Island Speed Control Device/Two Speed Humps/Central Island Speed Control Device in Series

F1	H1	H2	F2
34	19	21	34
44	33	31	44
44	39	37	49
53	26	20	52
35	26	25	36
48	41	40	46
43	31	23	45
21	17	12	20
45	39	35	52
44	27	25	45
71	23	36	58
43	27	27	42
20	21	18	24
39	24	24	49
44	23	24	49
54	40	38	55
43	29	29	45
39	15	14	45
48	24	24	55
48	21	25	45
44	23	28	43
31	27	21	39
54	37	34	55
36	13	13	35
27	21	20	29
39	31	31	46
31	13	18	40
34	15	13	40
57	43	40	58

	All F1
Average	41.82759
85th percentile	52

	All F2
Average	43.96552
85th percentile	54.4

	All H1
Average	26.48276
85th percentile	38.6

	All H2
Average	25.72414
85th percentile	35.8

	All F's
Average	42.89655
85th percentile	53.45

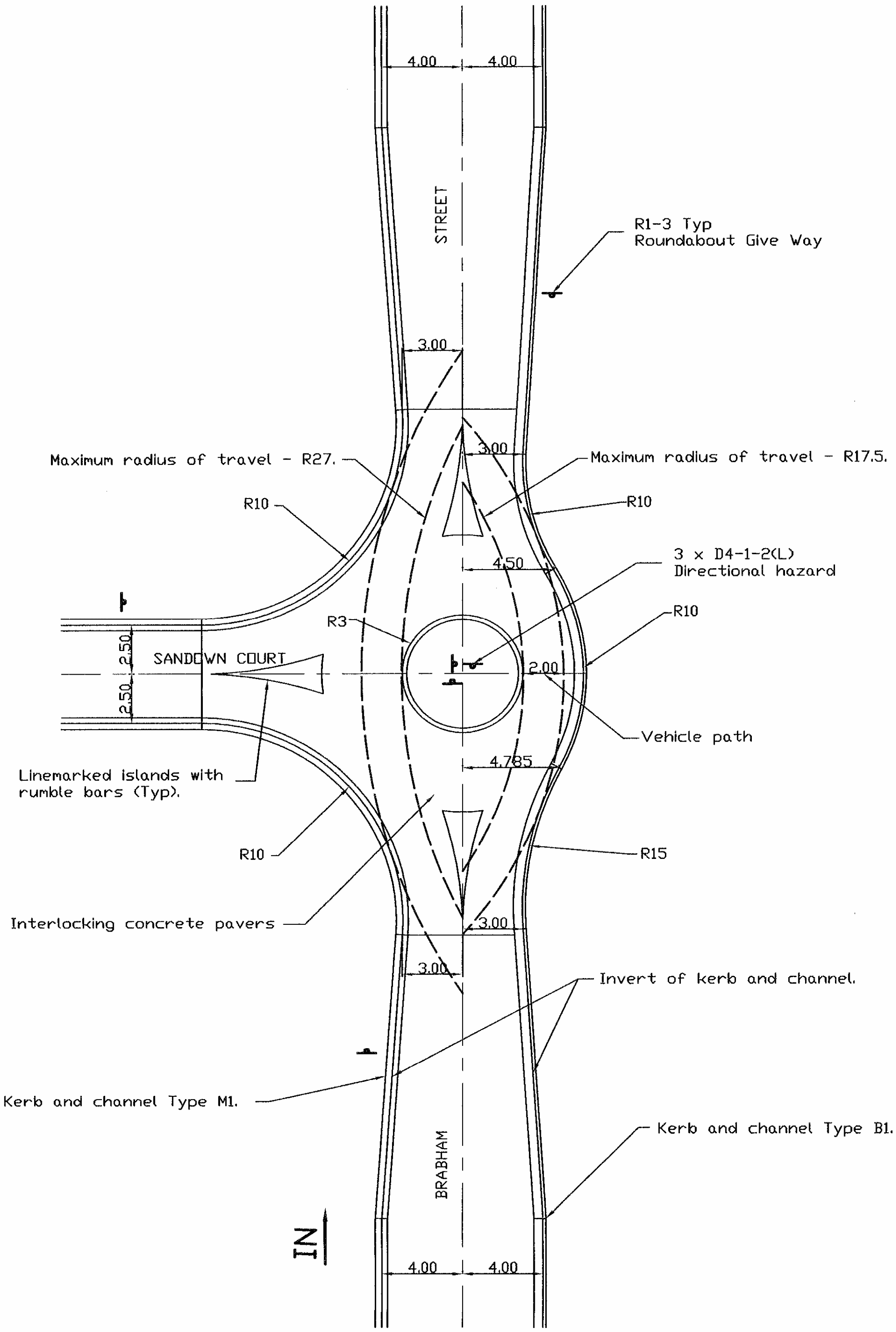
	All H's
Average	26.10345
85th percentile	37

F1 & F2 - Similar Central Island Speed Control Devices
Maximum radius of travel in both directions is 30 metres.
Predicted (achievable)speed through each device is 36.5 km/hr.

H1 & H2 - Similar Speed Humps
No horizontal displacement.

Spacings Between Devices (centre to centre)
F1 - H1 - 116.5 metres
H1 - H2 - 90 metres
H2 - F2 - 128 metres

FIGURE B2c



BRABHAM STREET CRESTMEAD

Not to Scale

FIGURE B3a

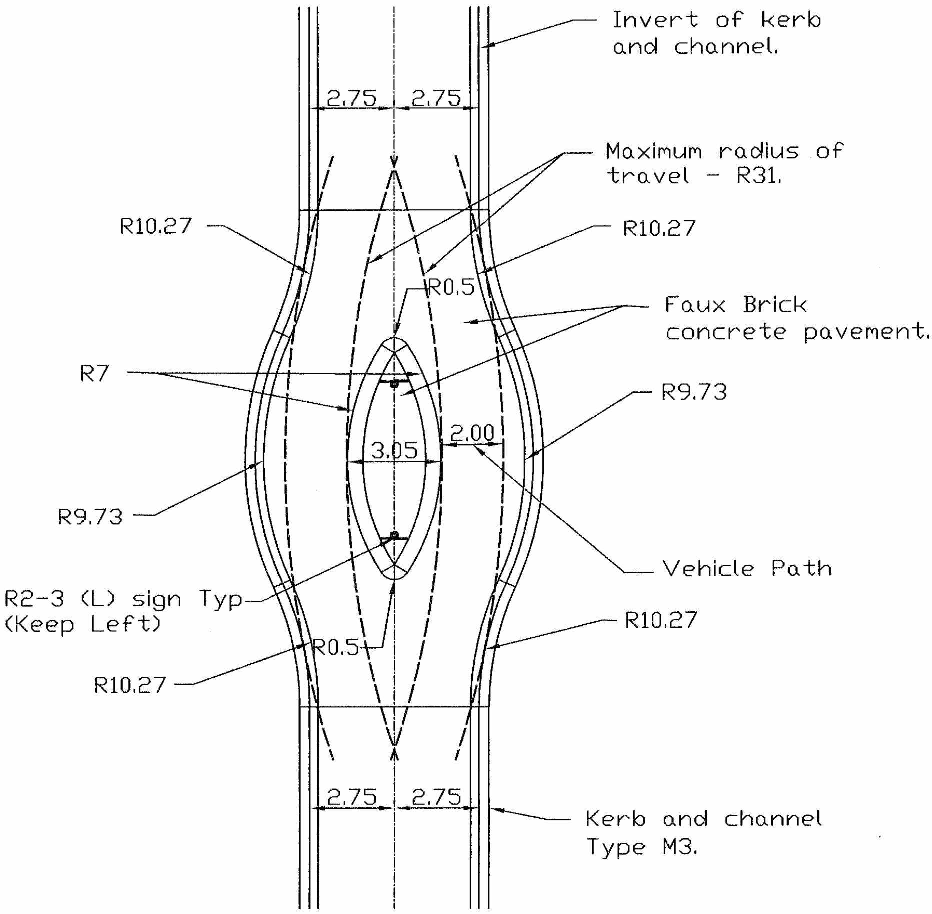
Brabham Street Crestmead - Roundabout at the intersection of Brabham Street and Sandown Court

R - In	R - Out
31	21
23	25
23	28
25	23
25	17
38	18
24	12
24	18
24	12
28	19
24	16
26	19
37	15
32	21
32	19
28	17
20	20
27	20
26	22
31	21
19	
28	
18	
24	
32	
25	
23	
18	
17	

	R - In	R - Out
Average	25.93103	19.15
85th Percentile	31.8	22.15

Maximum radius of travel (inbound) is 27 metres.
Predicted (achievable) speed (inbound) is 34.6 km/hr.
Maximum radius of travel (outbound) is 17.5 metres.
Predicted (achievable) speed (outbound) is 27.9 km/hr.

FIGURE B3b



CUMBERLAND CRESCENT HERITAGE PARK

Not to Scale

FIGURE B4a

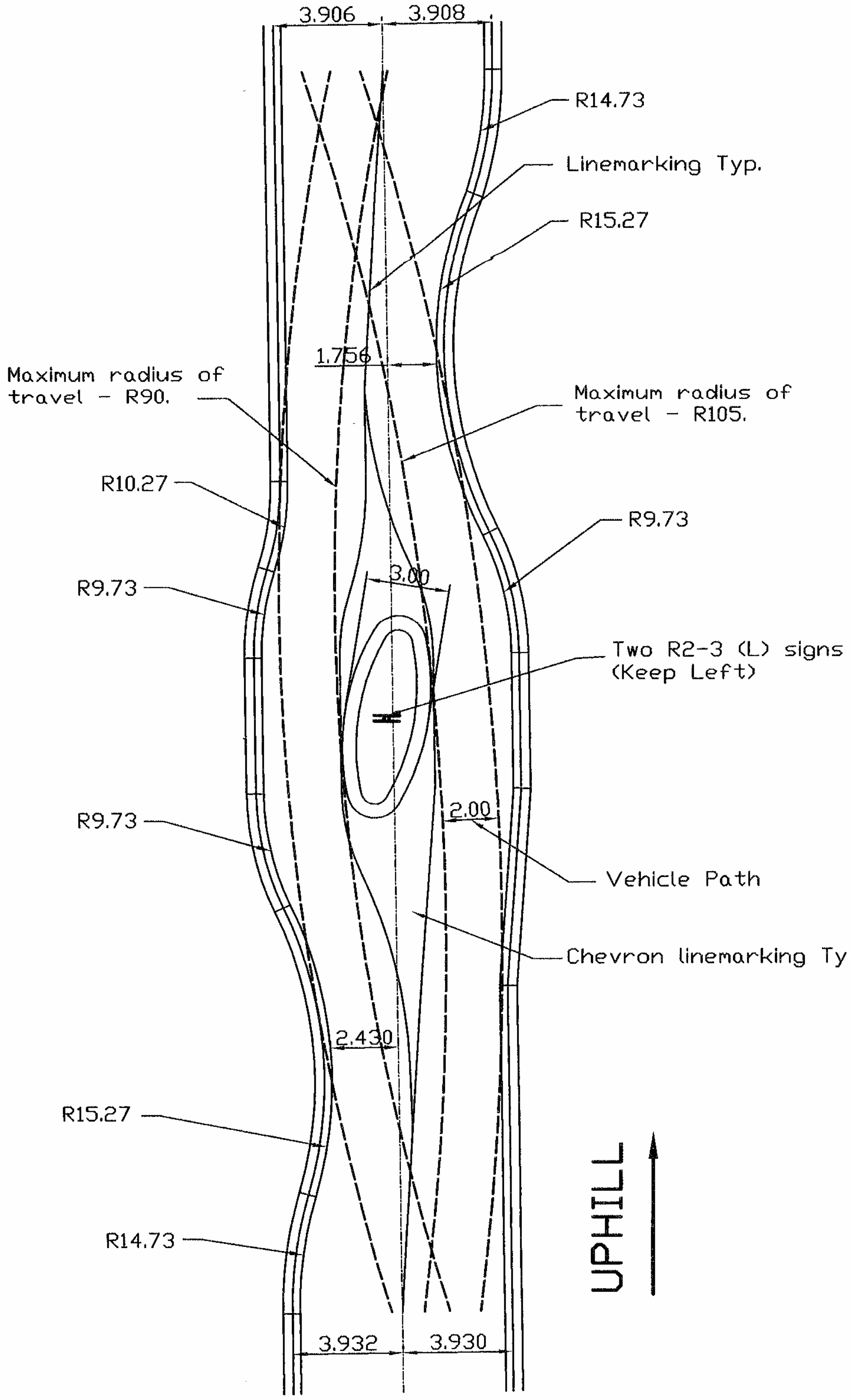
Cumberland Crescent Heritage Park - Central Island Speed Control Device

F - Both Directions
40
28
23
27
21
20
23
25
26
23
35

	F
Average	26.45455
85th percentile	31.5

Maximum radius of travel in both directions is 31 metres.
Predicted (achievable) speed through the device is 37.1 km/hr.

FIGURE B4b



GARFIELD ROAD WOODRIDGE

Not to Scale

FIGURE B5a

Garfield Road Woodridge - Three Central Island Speed Control Devices in Series

F1	F2	F3	Direction (Up/Down)
35	26	33	D
31	31	34	D
47	47	47	U
41	44	41	U
38	41		U
34			U
29	31		U
47			U
38	26		U
47	44		U
27	23		U
24	23	26	U
33	34		U
38	36	34	U
23	24		U
26	29		U

	All F1	F1 Up	F1 Down
Average	34.875	35.14286	33
85th percentile	45.5	47	34.4

	All F2	F2 Up	F2 Down
Average	32.78571	33.5	28.5
85th percentile	44	44	30.25

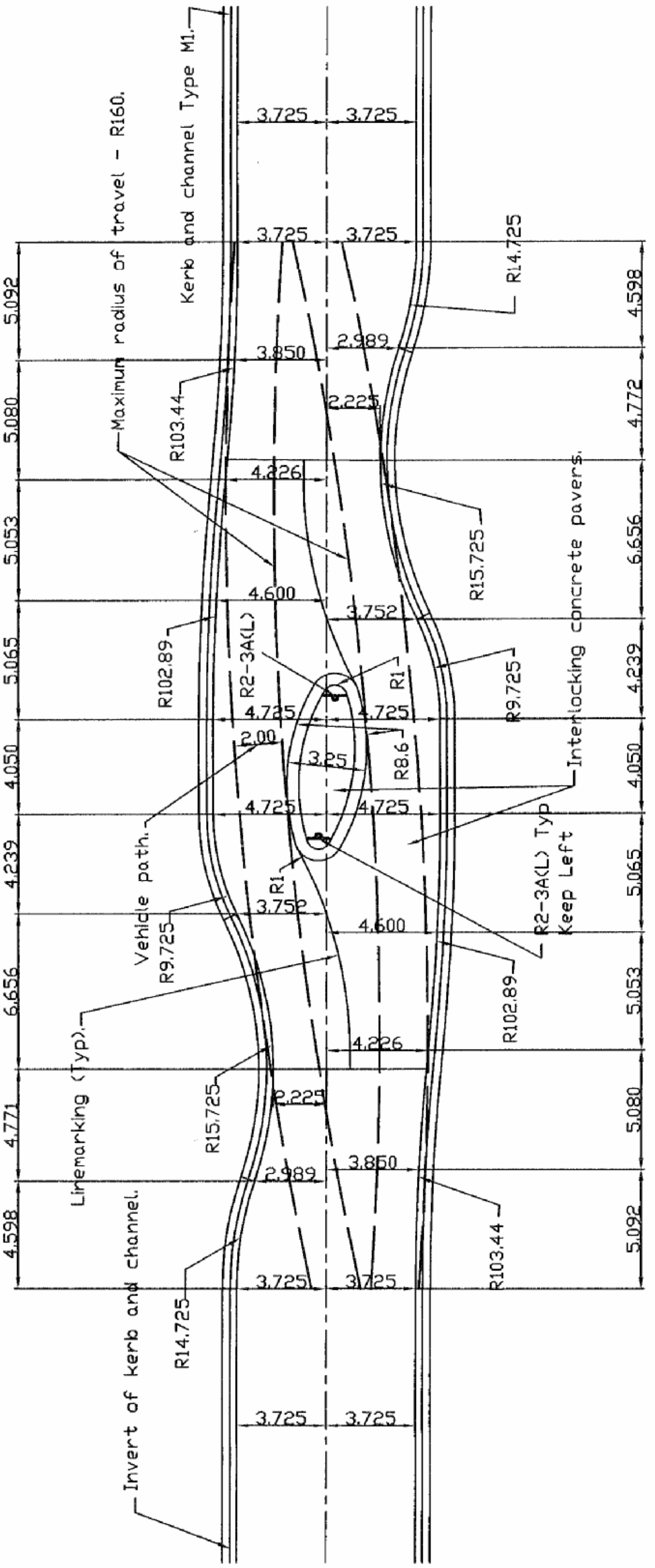
	All F3	F3 Up	F3 Down
Average	35.83333	37	33.5
85th percentile	42.5	44.3	33.85

	All F's	All F's Up	All F's Down
Average	34.22222	34.73333	31.6666667
85th percentile	44	45.95	34.25

F1. F2 & F3 - Similar Central Island Speed Control Devices
Maximum radius of travel (uphill) is 90 metres.
Predicted (achievable) speed (uphill) is 63.3 km/hr.
Maximum radius of travel (downhill) is 105 metres.
Predicted (achievable) speed (downhill) is 68.3 km/hr.

Spacing between each device (centre to centre)
F1 - F2 - 97 metres
F2 - F3 - 112.5 metres

FIGURE B5b



GAVEN WAY CORNUBIA
Not to Scale
FIGURE B6a

Gaven Way Cornubia - Three Central Island Speed Control Devices in Series

F1	F2	F3	Direction (In/Out)
35	35	35	O
42	42	40	O
43	44	44	O
48	44	42	O
47	49	47	O
46	47	46	O
46	47	45	O
47	47	45	O
41	45	45	O
46	46	48	O
40	41	41	O
50	52	48	O
46	46	37	O
41	40	40	O
38	38	35	O
57	57	55	O
43	41	38	O
22	22	20	O
53	52	52	O
46	43	43	O
52	52	50	O
37	35	37	O
44	39	44	O
43	45	43	O
43	44	43	I
53	55	55	I
44	41	37	I
45	44	43	I
45	46	46	I
48	46	56	I
39	43	46	I
35	31	30	I

	All F1	F1 In	F1 Out
Average	43.90625	44	43.875
85th percentile	48.7	47.85	49.1

	All F2	F2 In	F2 Out
Average	43.71875	43.75	43.70833
85th percentile	50.05	46	50.65

	All F3	F3 In	F3 Out
Average	43	44.5	42.5
85th percentile	48.7	54.55	48

	All F's
Average	43.54167
85th percentile	49.75

F1, F2 & F3 - Similar Central Island Speed Control Devices

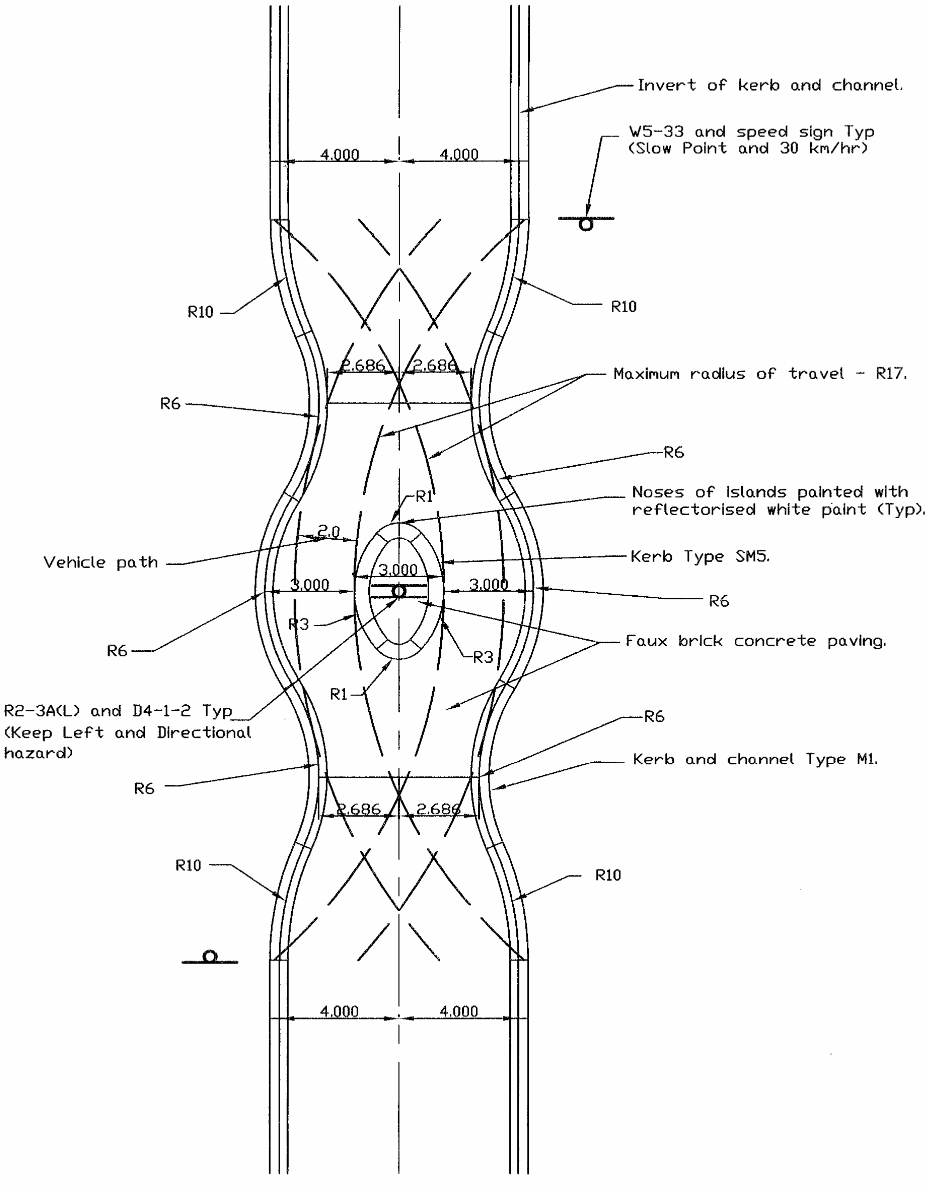
Maximum radius of travel in both directions is 160 metres.

Predicted (achievable) speed through each device is 84.3 km/hr.

Note

The spacing between each device (centre to centre) is 100 metres.

FIGURE B6b



GEANEY BOULEVARD CRESTMEAD

Not to Scale

FIGURE B7a

Geaney Boulevard Crestmead - Two Central Island Speed Control Devices in Series

F1	F2	Direction (In/Out)	Notes
37	38	I	small car
29	28	I	
31	36	I	
22	22	I	
31	32	I	
13	14	I	SU truck
40	38	I	
21	32	I	
34	31	I	
39	42	I	
23	27	I	
27	30	I	
20	20	O	
28	26	O	
24	23	O	
40	40	O	
16	17	O	SU truck
28	30	O	
28	25	O	
38	31	O	
24	28	O	
32	35	O	
23	26	O	
30	32	O	
23	21	O	
20	20	O	
37	35	O	
38	30	O	

	All F1	F1 Out	F1 In
Average	28.428571	29	28.91667
85th percentile	37.95	37.75	37.7

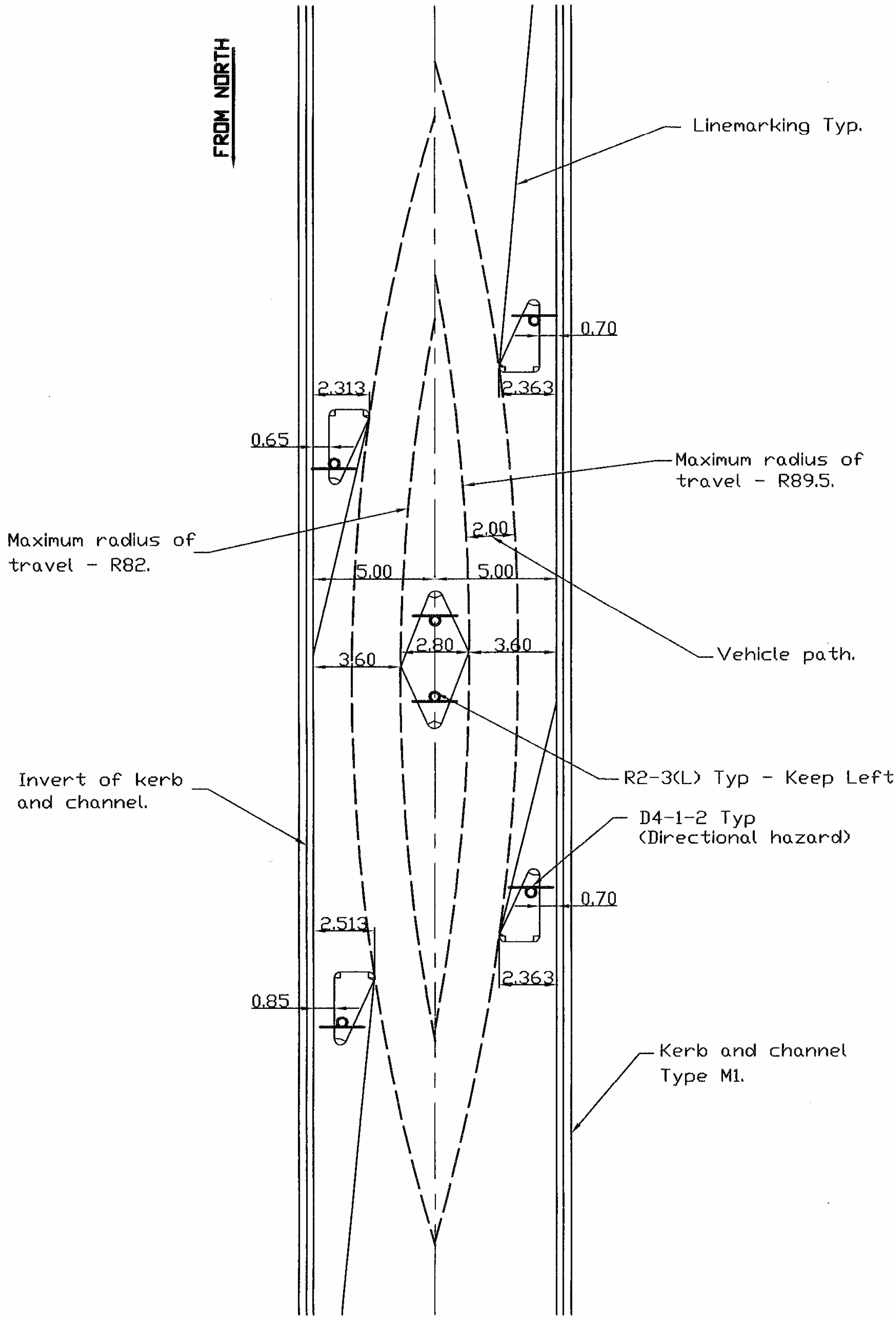
	All F2	F2 Out	F2 In
Average	28.892857	28.461538	30.83333
85th percentile	35.95	34.25	38

	All F's	All F's Out	All F's In
Average	28.660714	27.75	29.875
85th percentile	37.75	35.7	38

F1 & F2 - Similar Central Island Speed Control Devices
Maximum radius of travel through each device is 17 metres.
Predicted (achievable)speed through each device is 27.5 km/hr.

Note
The spacing between the devices (centre to centre) is 64 metres.

FIGURE B7b



GLENGALA DRIVE ROCHEDALE SOUTH

Not to scale

FIGURE B8a

Glengala Drive Rochedale South - Central Island Speed Control Device

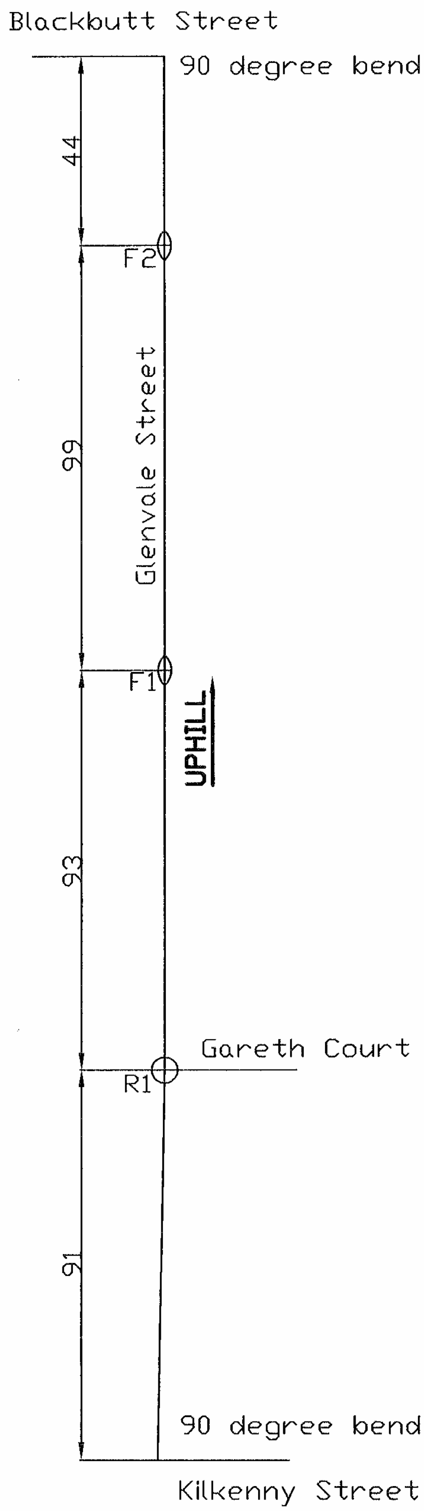
C - North	C - South
52	31
43	36
48	49
51	37
40	39
41	50
46	49
36	32
33	41
50	35
50	43
43	41
27	34
40	35
41	45
48	37
36	32
44	45
	39
	39
	41
	45

	C - North	C - South	All C's
Average	42.72222	39.77273	41.1
85th Percentile	50	45	49

C - North
Maximum radius of travel is 82 metres.
Predicted (achievable) speed is 60.4 km/hr.

C - South
Maximum radius of travel is 89.5 metres.
Predicted (achievable) speed is 63.1 km/hr.

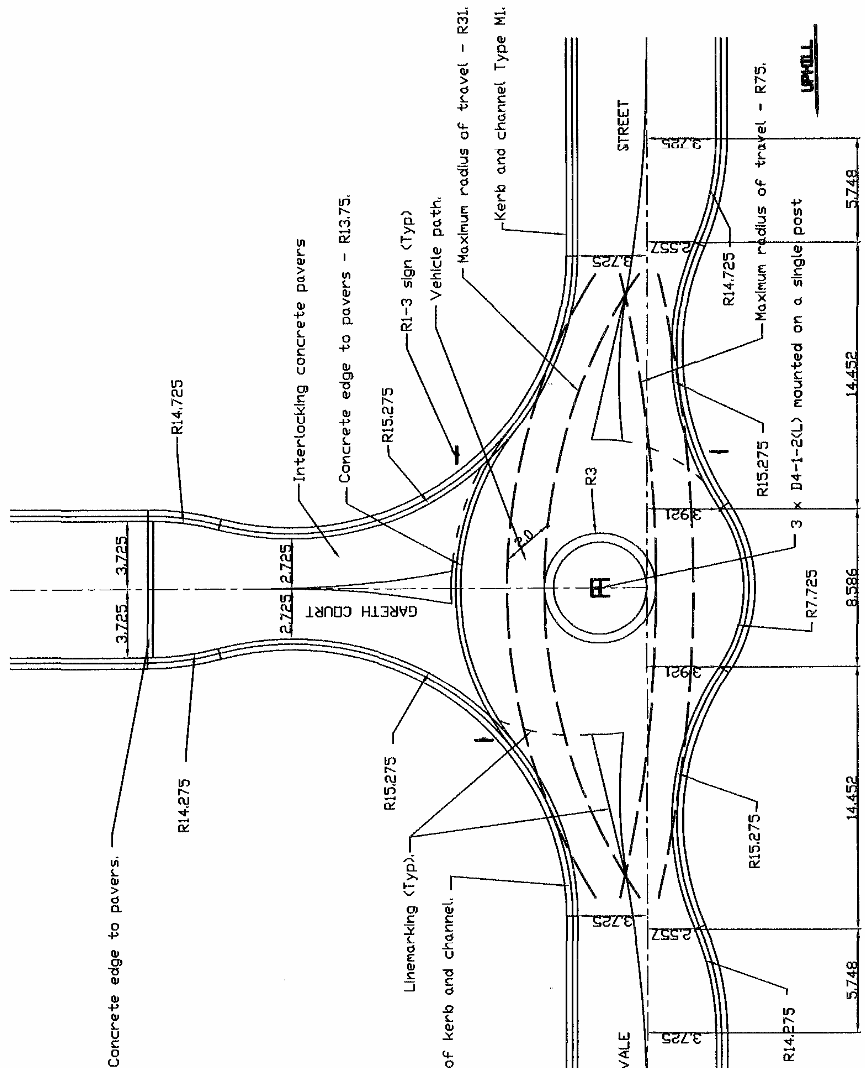
FIGURE B8b



GLENVALE STREET CORNUBIA

Not to Scale

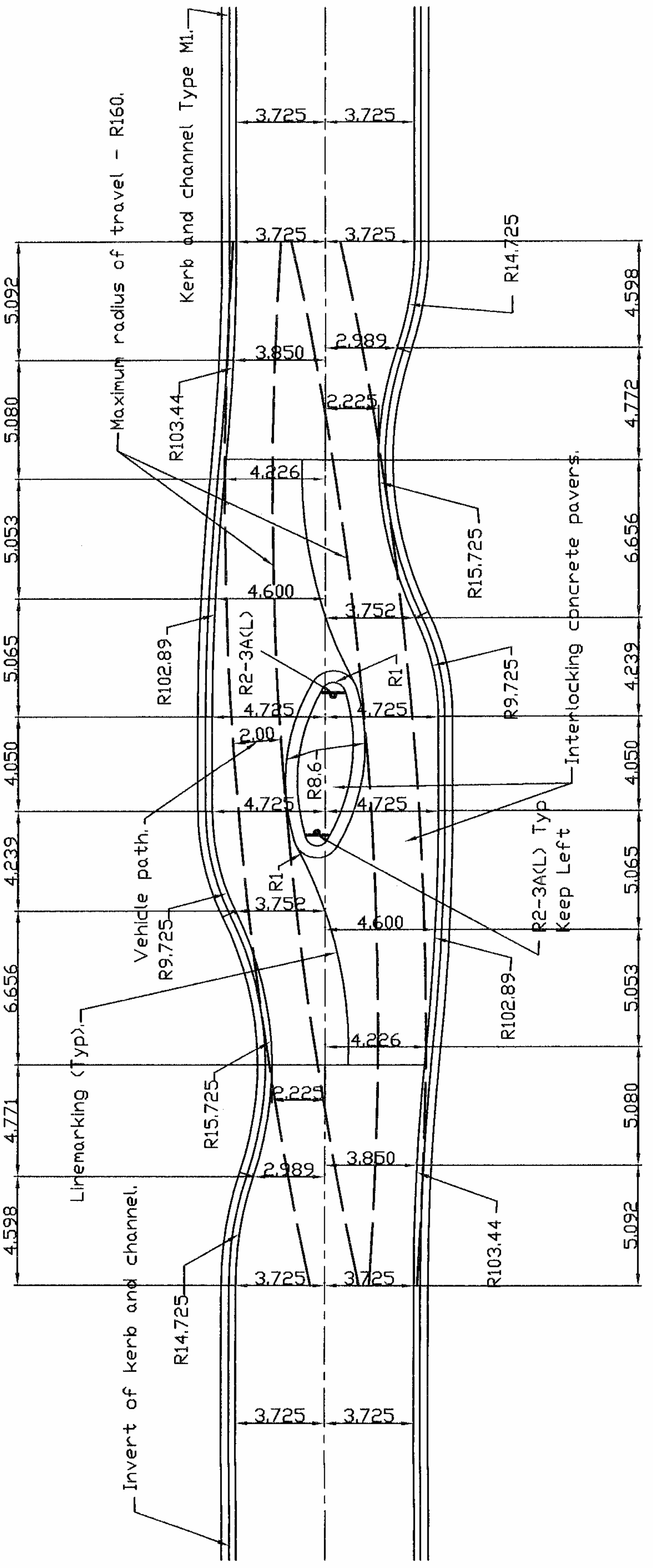
FIGURE B9a



GLENVALE STREET CORNUBIA

Not to Scale

FIGURE B9b



GLENVALE STREET CORNUBIA

Not to Scale

FIGURE B9c

Glenvale Street Cornubia - Roundabout and Two Central Island Speed Control Devices in Series

F2	F1	R1	Direction (Up/Down)
51	50	48	D
34	34	36	D
34	34	34	D
24	34	36	D
30	31	30	D
34	31	31	D
28	31	23	D
45	46	31	D
33	33	31	D
28	34	33	D
39	46	41	D
36	44	33	D
49	49	44	D
37	44	45	D
45	48	38	U
28	28	26	U
34	38	38	U
31	31	28	U
34	33	31	U
45	51	31	U
28	32	22	U
39	39	39	U
33	33	31	U
35	41	35	U
35	37	33	U
34	34	32	U
41	43	43	U
35	37	31	U
29	34	24	U
49	51	41	U

	All F2	F2 Up	F2 Down
Average	35.9	35.9375	35.85714
85th percentile	45	44	45.2

	All F1	F1 Up	F1 Down
Average	38.36667	38.125	38.64286
85th percentile	47.3	46.75	46.15

	All R1	R1 Up	R1 Down
Average	33.96667	32.6875	35.42857
85th percentile	41	38.75	44.05

	All F's
Average	37.13333
85th percentile	46

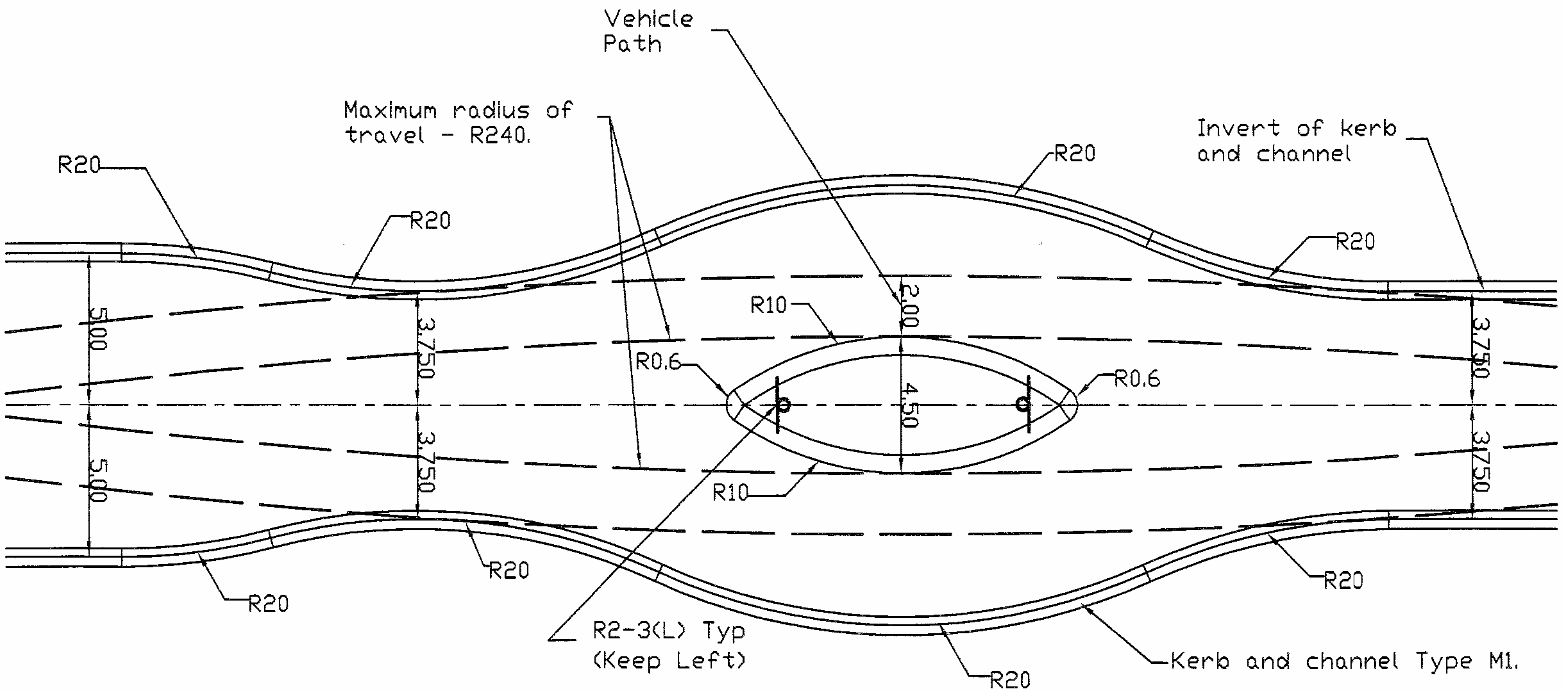
F1 & F2 - Central Island Speed Control Devices

Maximum radius of travel in both directions is 160 metres.
Predicted (achievable) speed through each device is 84.3 km/hr.

R1 - Offset roundabout at the intersection of Glenvale Street and Gareth Court

Maximum radius of travel (uphill) is 75 metres.
Predicted (achievable) speed (uphill) is 57.7 km/hr.
Maximum radius of travel (downhill) is 31 metres.
Predicted (achievable) speed (downhill) is 37.1 km/hr.

FIGURE B9d



KILSAY CRESCENT MEADOWBROOK
Not to Scale
FIGURE B10a

Kilsay Crescent Meadowbrook - Central Island Speed Control Device each side of a Roundabout

F1 - Both Directions	F2 - Both Directions
57	51
38	49
38	41
49	40
44	35
48	41
40	39
40	47
39	43
35	42
34	41
35	45
40	36
31	45
32	44
42	31
26	38
	56
	44
	35
	47
	43

	F1
Average	39.29412
85th percentile	46.4

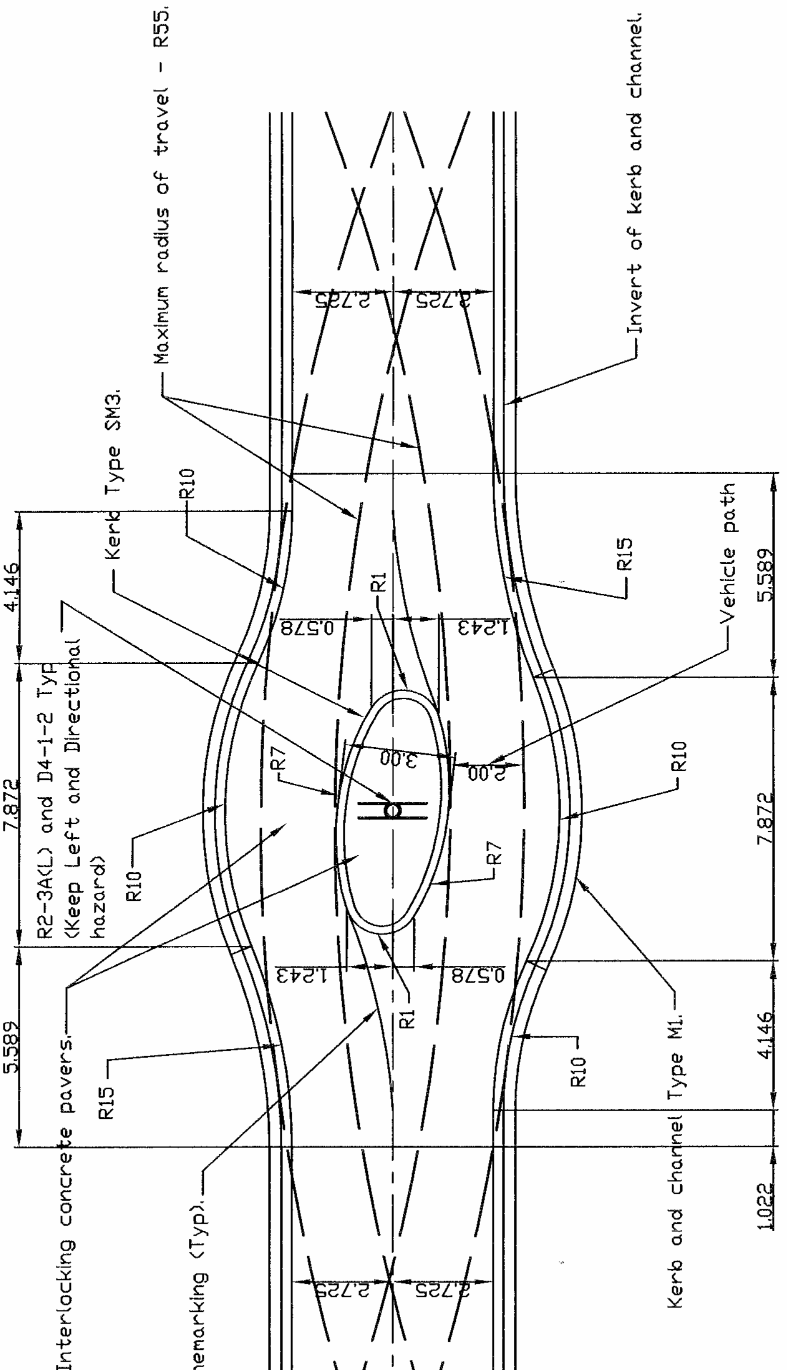
	F2
Average	42.40909
85th percentile	47

	All F's
Average	41.05128
85th percentile	47.3

F1 & F2 - Similar Central Island Speed Control Devices
Maximum radius of travel in both directions is 240 metres.
Predicted (achievable) speed through each device is 103.3 km/hr.

Note
Each Central Island Speed Control Device is 90 metres each side of a roundabout.

FIGURE B10b



KUNUNURRA STREET SHAILER PARK
Not to Scale
FIGURE B11a

Kununurra Street Shailer Park - Two Central Island Speed Control Devices in Series

F1	F2	Direction (In/Out)	Notes
37	33	I	
49	44	I	
50	50	I	
39	31	I	
41	32	I	
42	36	I	
28	26	I	
15	23	I	Sightseeing
21	29	O	
44	41	O	Motorbike

	All F1	F1 Out	F1 In
Average	36.6	32.5	37.625
85th percentile	47.25	40.55	48.65

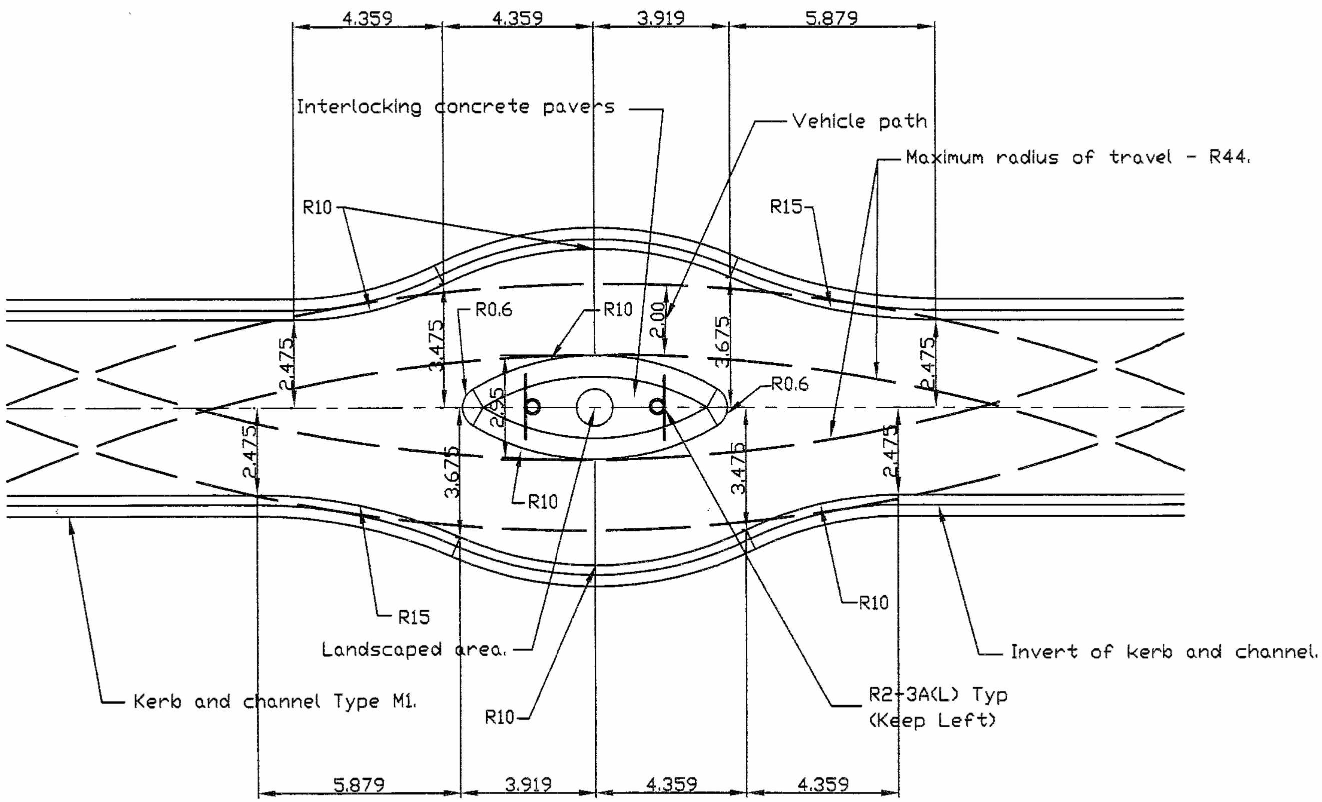
	All F2	F2 Out	F2 In
Average	34.5	35	34.375
85th percentile	42.95	39.2	43.6

	All F's	All F's Out	All F's In
Average	35.55	33.75	36
85th percentile	44.75	42.65	47.75

F1 & F2 - Similar Central Island Speed Control Devices
Maximum radius of travel through each device in both directions is 55 metres.
Predicted (achievable) speed through these devices is 49.4 km/hr.

Note
The spacing between these devices (centre to centre) is 76 metres.

FIGURE B11b



PINELANDS STREET LOGANLEA
Not to Scale
FIGURE B12a

Pinelands Street Loganlea - Two Central Island Speed Control Devices in Series

F1	F2	Direction (Up/Down)
40	42	D
30	30	D
27	24	D
38	37	D
42	42	D
27	29	D
43	44	D
38	39	U
31	32	U
35	36	U
38	38	U
48	46	U
49	45	U

	All F1	F1 Up	F1 Down
Average	37.38462	39.83333	35.28571
85th percentile	44	48.25	42.1

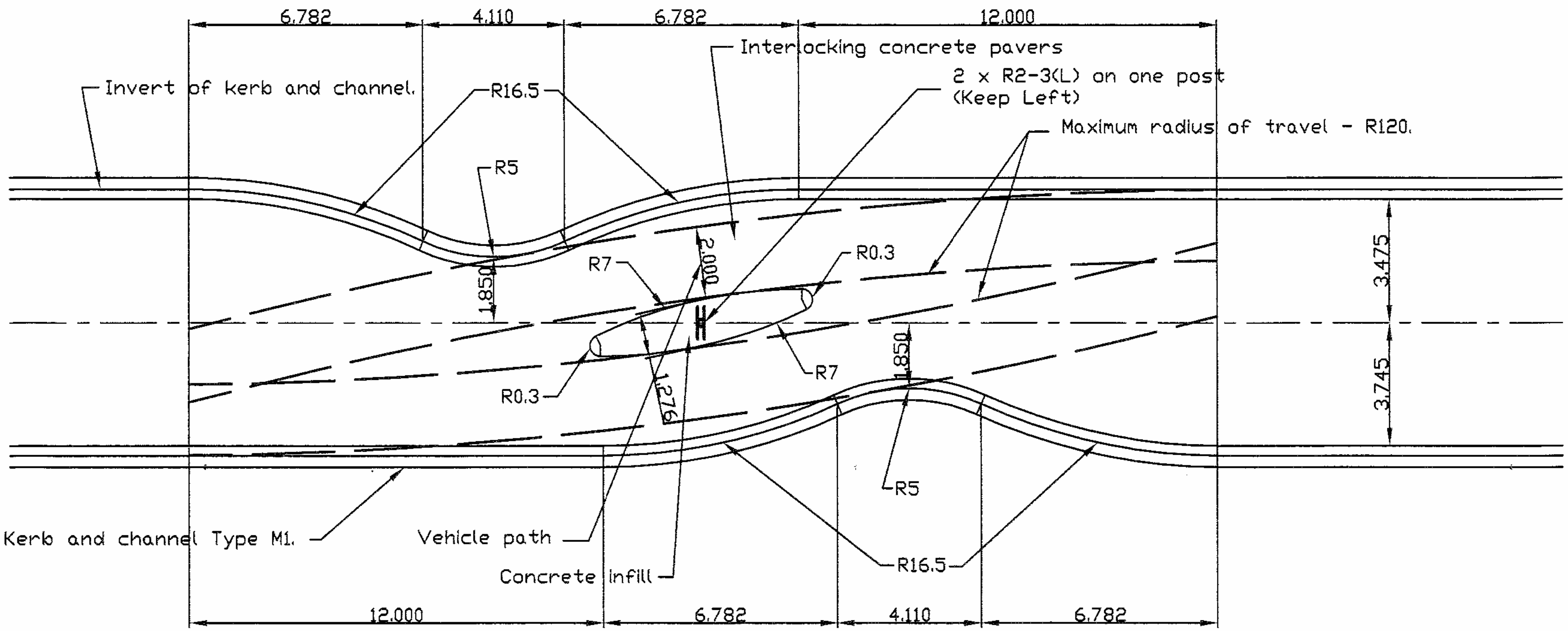
	All F2	F2 up	F2 down
Average	37.23077	39.33333	35.42857
85th percentile	44.2	45.25	42.2

	All F's
Average	37.30769
85th percentile	44.25

F1 & F2 - Similar Central Island Speed Control Devices
Maximum radius of travel in both directions is 44 metres.
Predicted (achievable) speed through each device is 44.2 km/hr.

Note
The spacing between devices (centre to centre) is 100 metres.

FIGURE B12b



POWELL STREET HERITAGE PARK

Not to Scale

FIGURE B13a

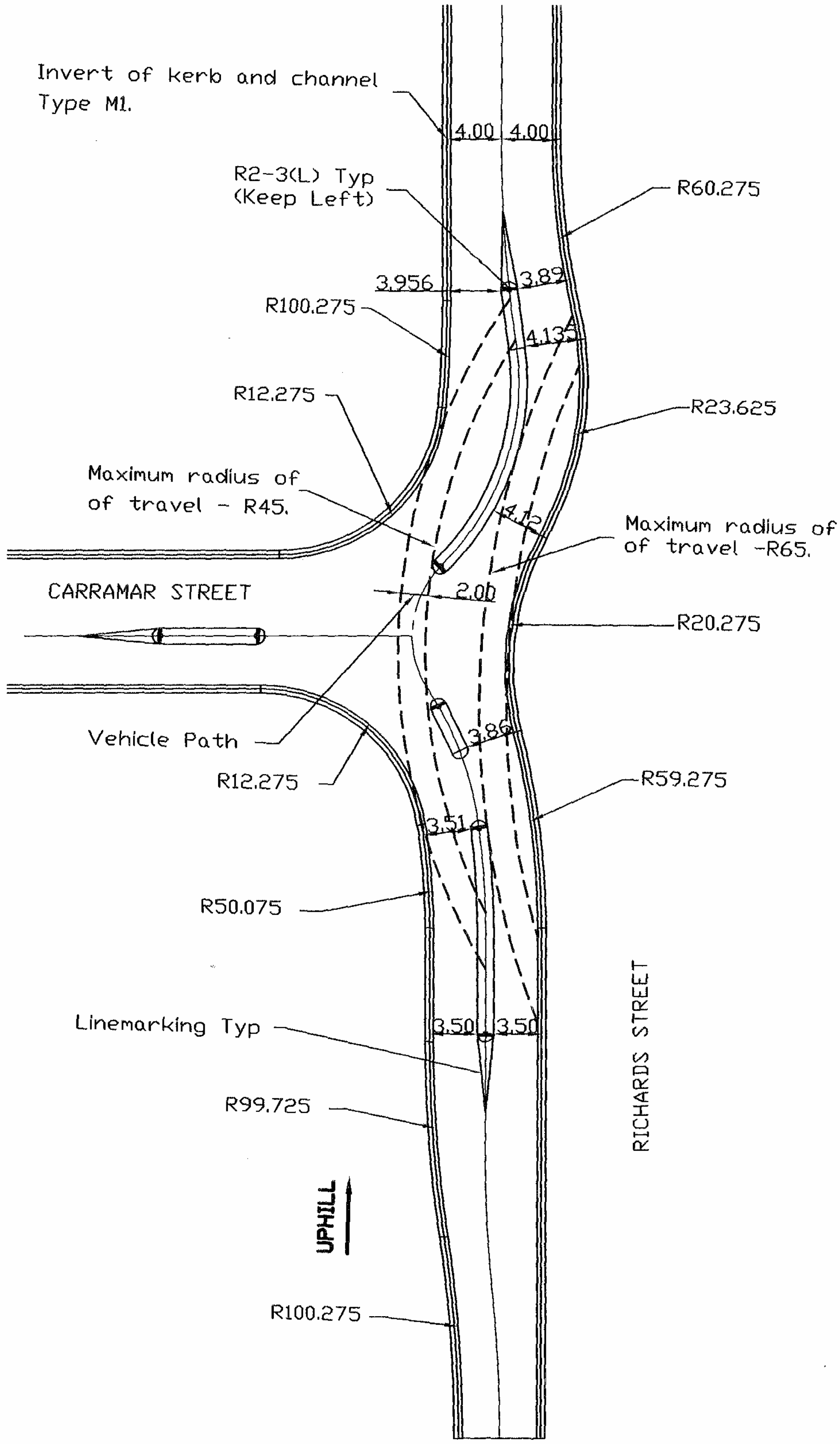
Powell Street Heritage Park - Central Island Speed Control Device

F- Both directions
42
28
28
21
29
38
38
32
40
20
45
35
48
33
26
36
36
36

	F
Average	33.94444
85th percentile	40.9

Maximum radius of travel in both directions through
the device is 120 metres.
Predicted (achievable) speed through the device is 73.0 km/hr.

FIGURE B13b



RICHARDS STREET LOGANLEA

Not to Scale

FIGURE 14a

Richards Street Loganlea - Deflected Tee Intersection

C1	Direction (Up/Down)
31	U
27	U
27	U
25	U
30	U
25	U
27	U
31	U
25	U
23	U
29	U
27	U
27	U
29	U
29	U
23	D
23	D
24	D
22	D
23	D

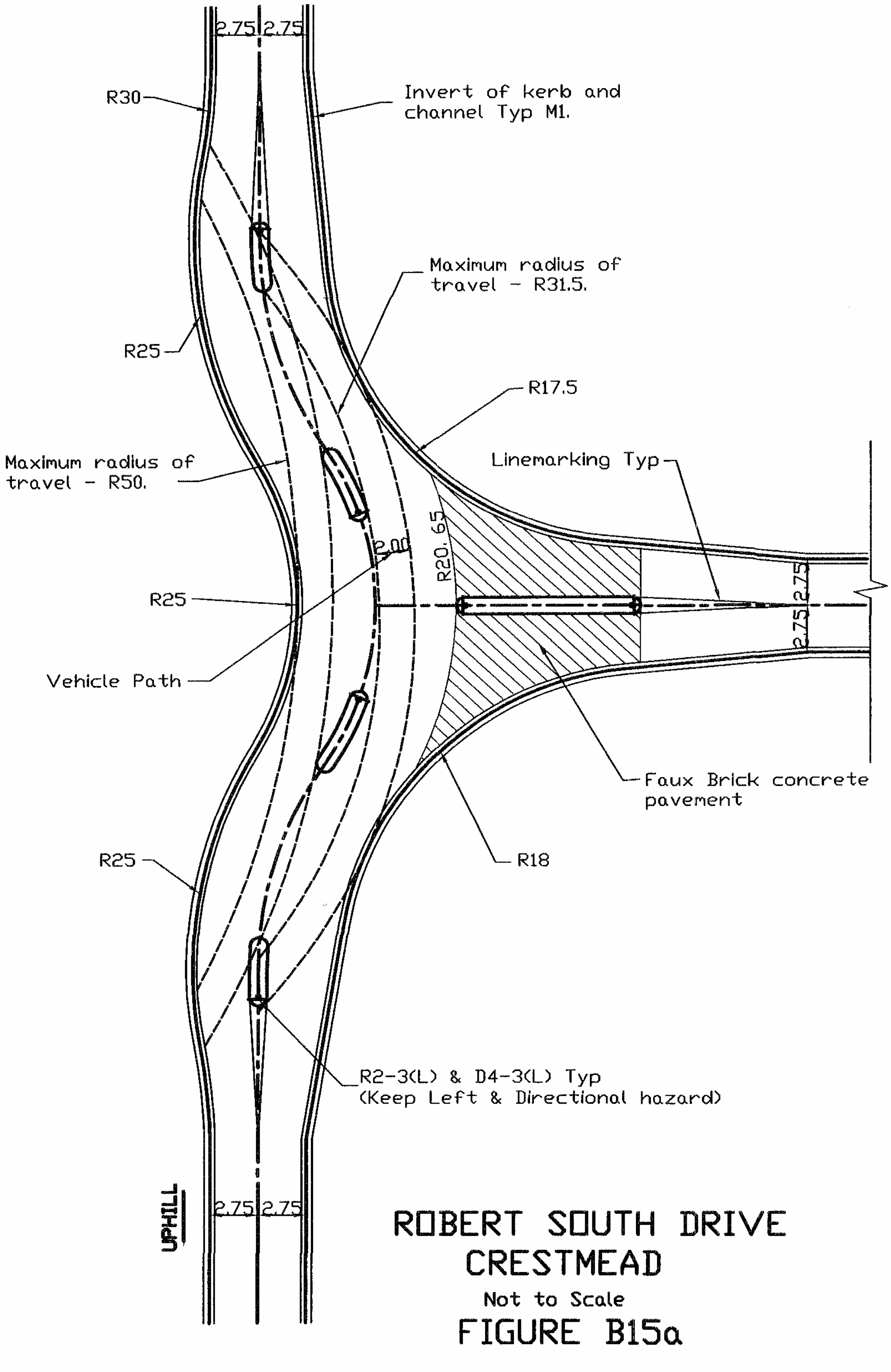
	C1 (Up)
Average	27.466667
85th percentile	29.9

	C1 (Down)
Average	23
85th percentile	23.4

C1 - Deflected Tee Intersection of Richards Street and Carramar Street

Maximum radius of travel (uphill) is 45 metres.
Predicted (achievable speed (uphill) is 44.7 km/hr.
Maximum radius of travel (downhill) is 65 metres.
Predicted (achievable) speed (downhill) is 53.8 km/hr.

FIGURE B14b



ROBERT SOUTH DRIVE
CRESTMEAD
Not to Scale
FIGURE B15a

Robert South Drive Crestmead - Three Deflected T Intersections in Series

C1	C2	C3	Direction (U/D)
26	31	26	D
17	17	17	D
28	29	29	D
17	17	20	D
32	32		D
21	24		D
17	17	17	D
26			D
29			D
26			D
30	31		D
29			D
27			D
29			D
27			U
22			U
30	24		U
28			U
28	31		U

	All C1	C1 (U)	C1 (D)
Average	25.73684	27	25.28571
85th percentile	29.3	28.8	29.05

	All C2	C2 (U)	C2 (D)
Average	25.3	27.5	24.75
85th percentile	31	29.95	31

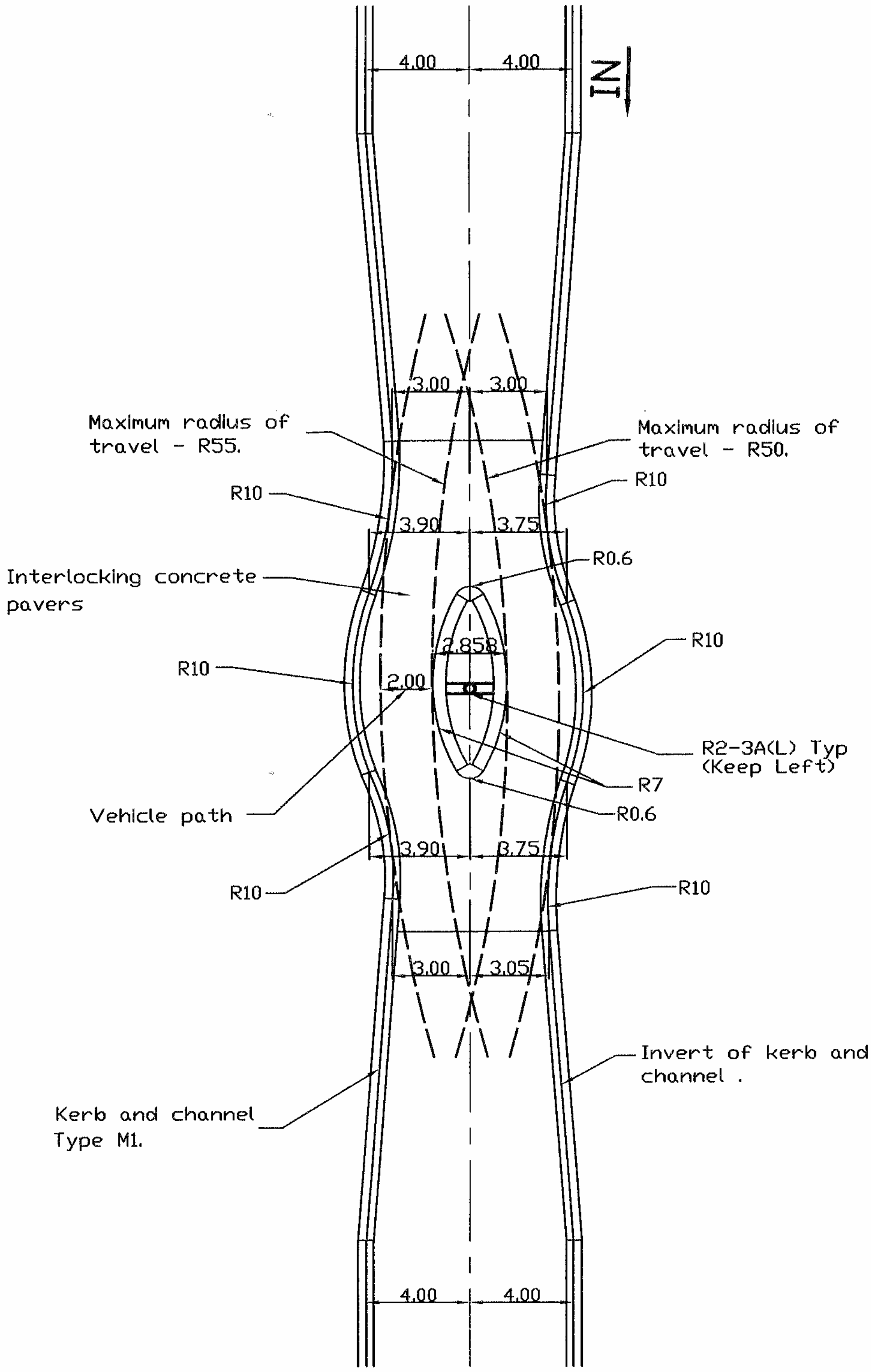
	All C3 (D)
Average	21.8
85th percentile	27.2

	All C's
Average	25.02941
85th percentile	30.05

C1, C2 & C3 - Similar Deflected Tee Intersections

Maximum radius of travel (uphill) is 31.5 metres.
Predicted (achievable) speed (uphill) is 37.4 km/hr.
Maximum radius of travel (downhill) is 44 metres.
Predicted (achievable) speed (downhill) is 42.5 km/hr.

FIGURE B15b

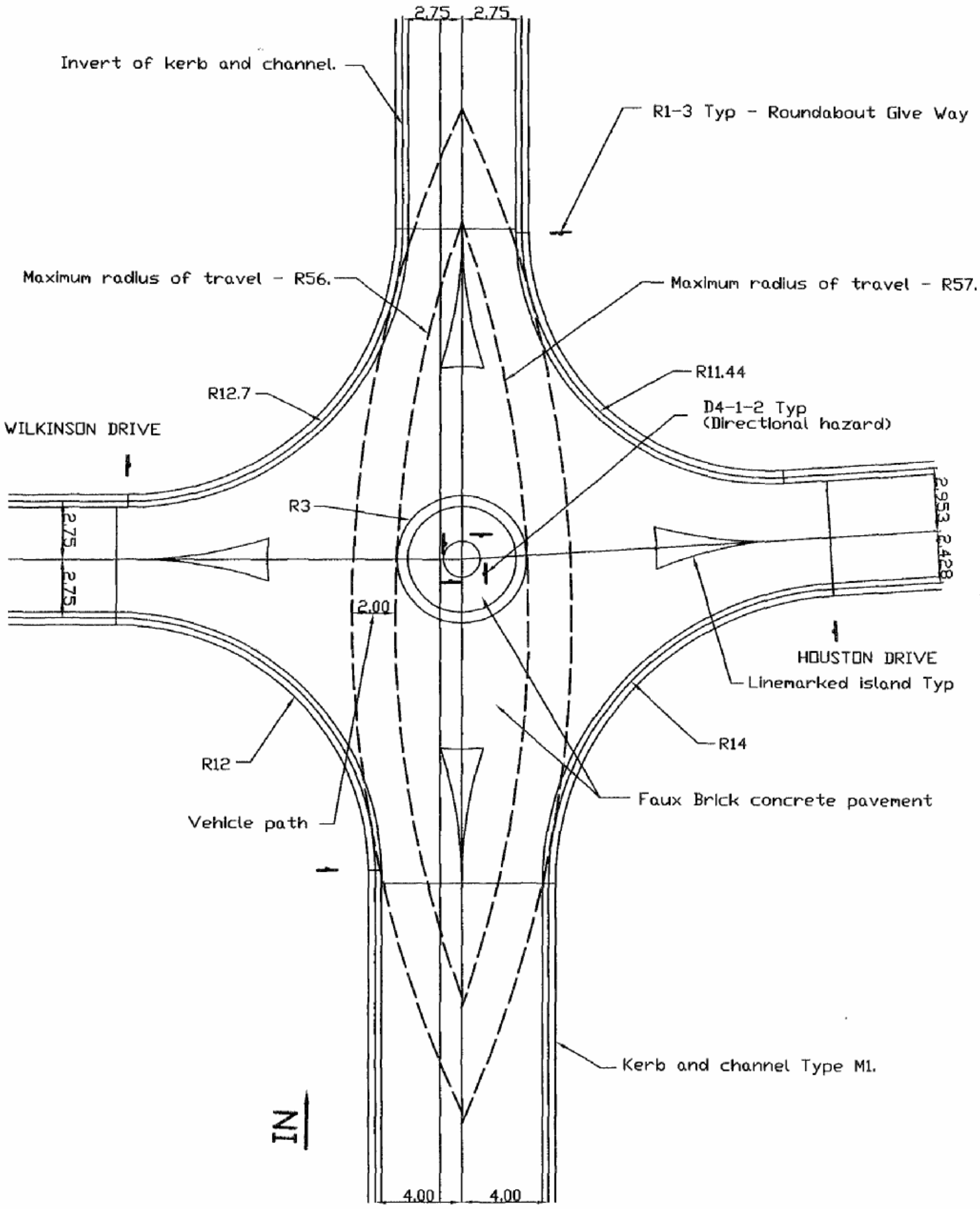


DEVICE F1

RUNDELL STREET CRESTMEAD

Not to Scale

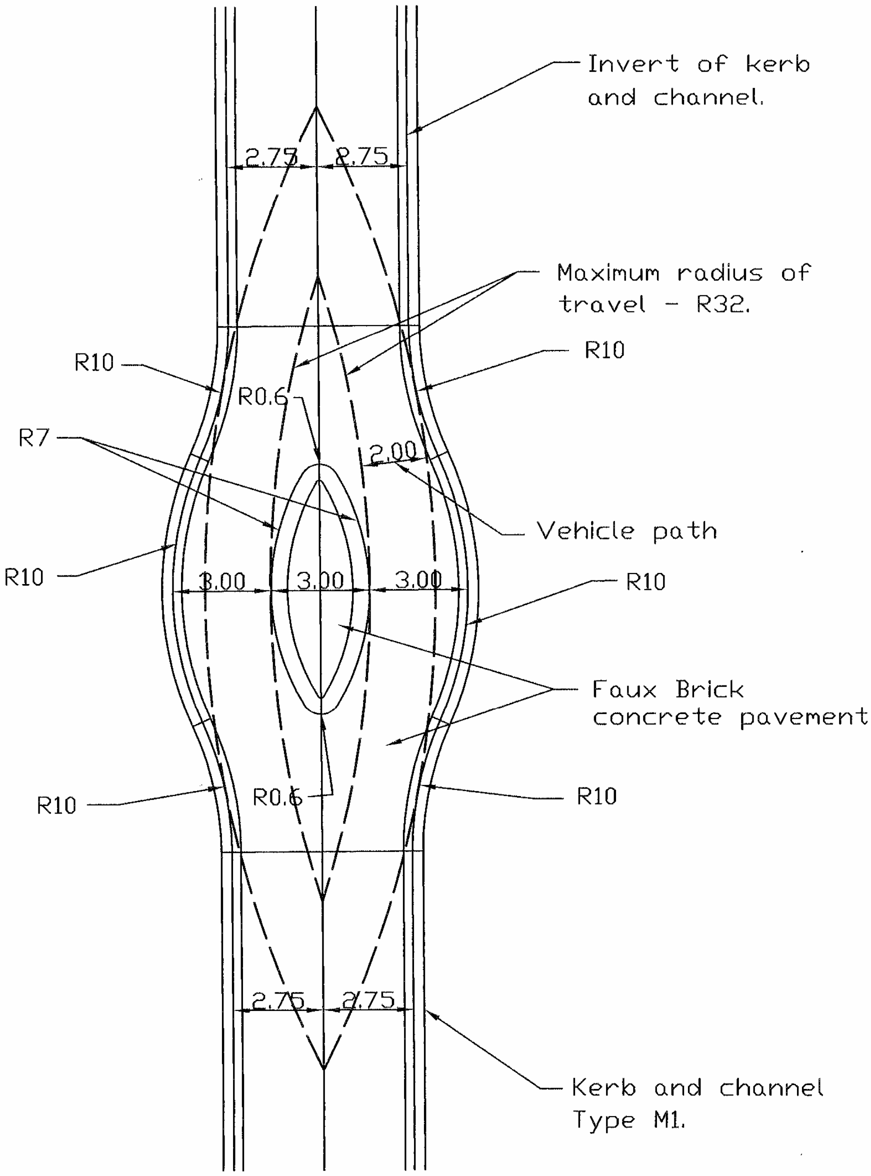
FIGURE B16a



RUNDELL STREET CRESTMEAD

Not to Scale

FIGURE B16b



DEVICE F2
RUNDELL STREET CRESTMEAD
Not to Scale
FIGURE B16c

Rundell Street Crestmead - Central Island/Roundabout/Central Island in Series

F1	R1	F2	Direction (In/Out)
26	31	28	I
26			I
30	24		I
42	29		I
29			I
46	37	37	I
45			I
30			I
31			I
36			I
31	23	35	O
28	22	30	O
26			O
32			O
40			O
26			O

Note
The spacing between devices (centre to centre) are:
F1 - R1 - 71 metres.
R1 - F2 - 91 metres.

	All F1	F1 In	F1 Out
Average	32.75	34.1	30.5
85th Percentile	41.5	43.95	34

	All R1	R1 In	R1 Out
Average	27.66667	27.66667	22.5
85th Percentile	32.5	32.5	22.85

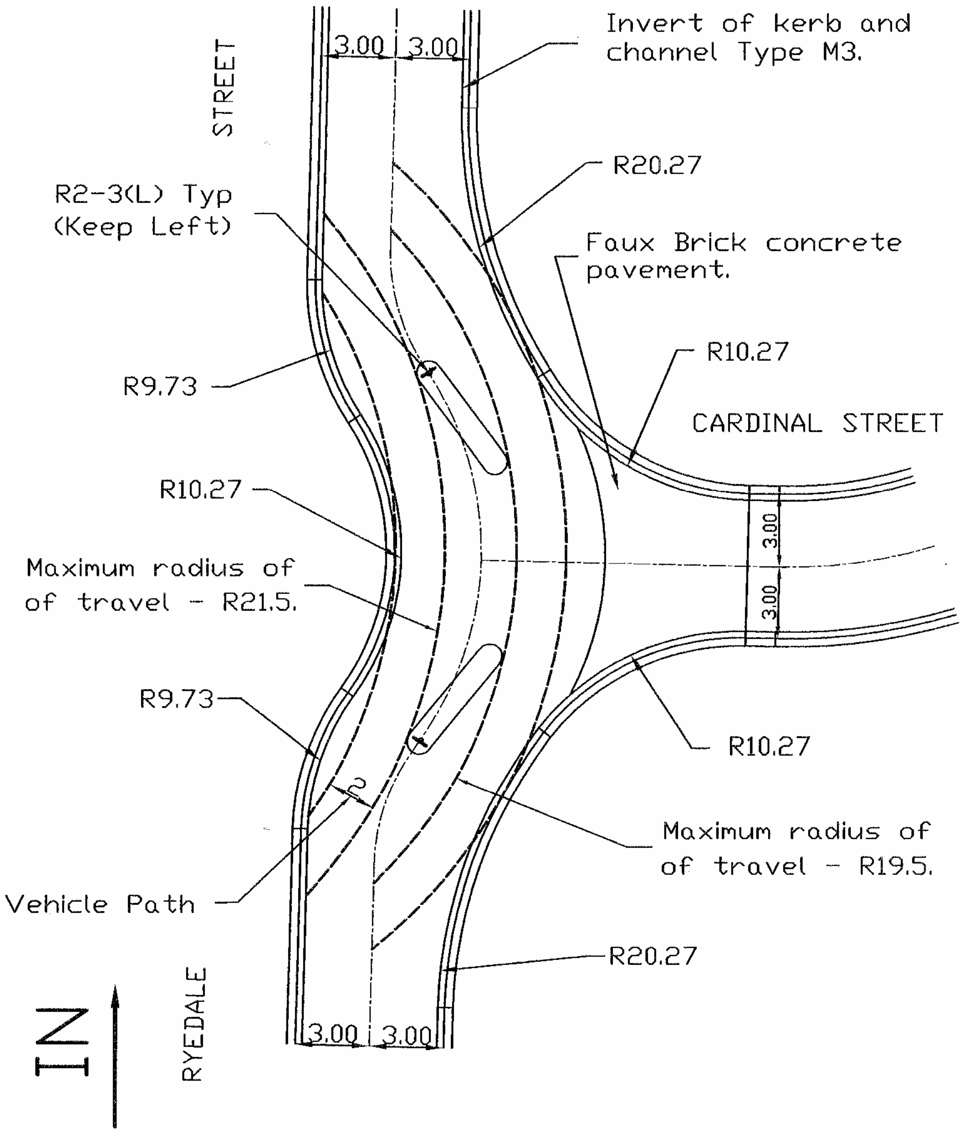
	All F2	F2 In	F2 Out
Average	32.5	32.5	32.5
85th Percentile	36.1	35.65	34.25

F1 - Central Island Speed Control Devices
Maximum radii of travel through the device are 50 and 55 metres.
Predicted (achievable) speeds through the device are 47.1 and 49.4 km/hr respectively.

R1 - Centrally located roundabout at the intersection of Rundell Street, Wilkinson Drive and Houston Drive
Maximum radii of travel through the device are 56 and 57 metres.
Predicted (achievable) speeds through the device are 49.9 and 50.3 km/hr. respectively.

F2 - Central Island Speed Control Devices
Maximum radius of travel through the device is 32 metres.
Predicted (achievable) speed through the device is 37.7 km/hr.

FIGURE B16d

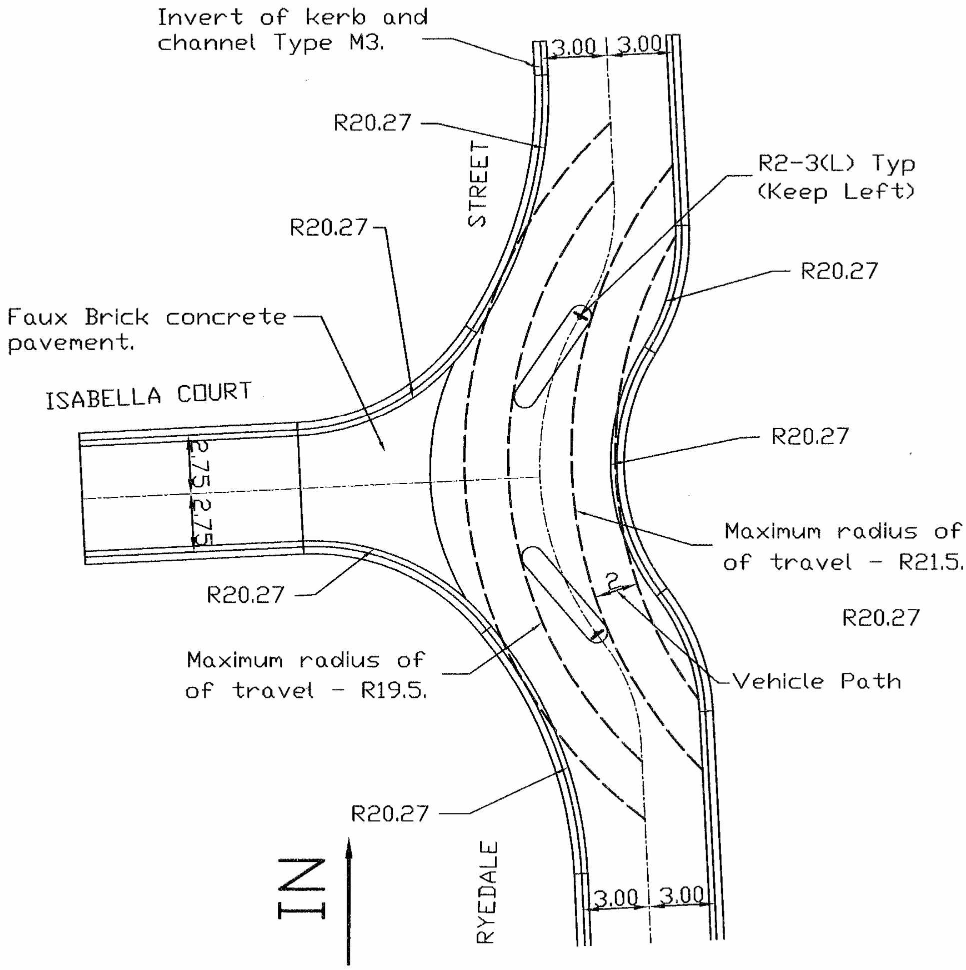


DEVICE C1

RYEDALE STREET HERITAGE PARK

Not to Scale

FIGURE 17a



DEVICE C2
RYEDALE STREET HERITAGE PARK
Not to Scale
FIGURE 17b

Ryedale Street - Two Deflected Tee Intersections (Chicanes) in Series

C1 (Day 1)	C1 (Day 2)	C2 (Day 2)	Direction (In/Out)
19	17	20	O
19	16	19	O
18	21	24	O
20	19	19	O
18	12	12	O
23	19	19	O
19	19	19	O
18			O
19			O
18			O
18			O
19			O
19			O
21			O
16			O
12			O
20			I
14			I
	20		I
	16	16	I
	17	16	I
	22	19	I
	22		I
	18	16	I
	24	23	I

	C1 Out	C1 In
Average	18.21739	19.22222
85th Percentile	19.7	22

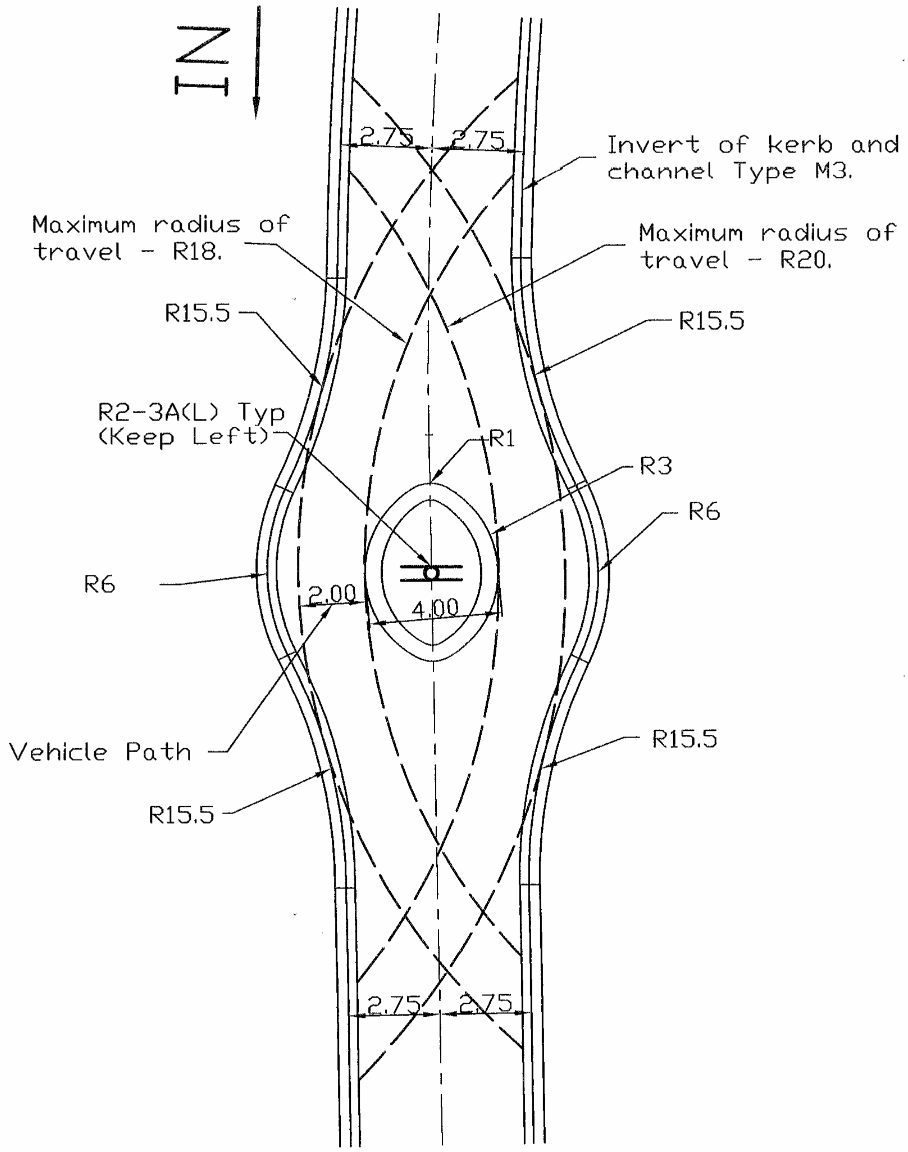
	C2 Out	C2 In
Average	18.85714	18
85th Percentile	20.4	20.6

C1 - Intersection of Ryedale Street and Cardinal Street
Maximum radius of travel (inbound) is 21.5metres.
Predicted (achievable) speed (inbound) is 30.9 km/hr.
Maximum radius of travel (outbound) is 19.5 metres.
Predicted (achievable) speed (outbound) is 29.4 km/hr.

C2 - Intersection of Ryedale Street and Isabella Court
Maximum radius of travel (inbound) is 19.5 metres.
Predicted (achievable) speed (inbound) is 29.4 km/hr.
Maximum radius of travel (outbound) is 21.5 metres.
Predicted (achievable) speed (outbound) is 30.9 km/hr.

Note
Both devices are similar however are in reverse orientation.
The spacing between devices (centre to centre is 125 metres.

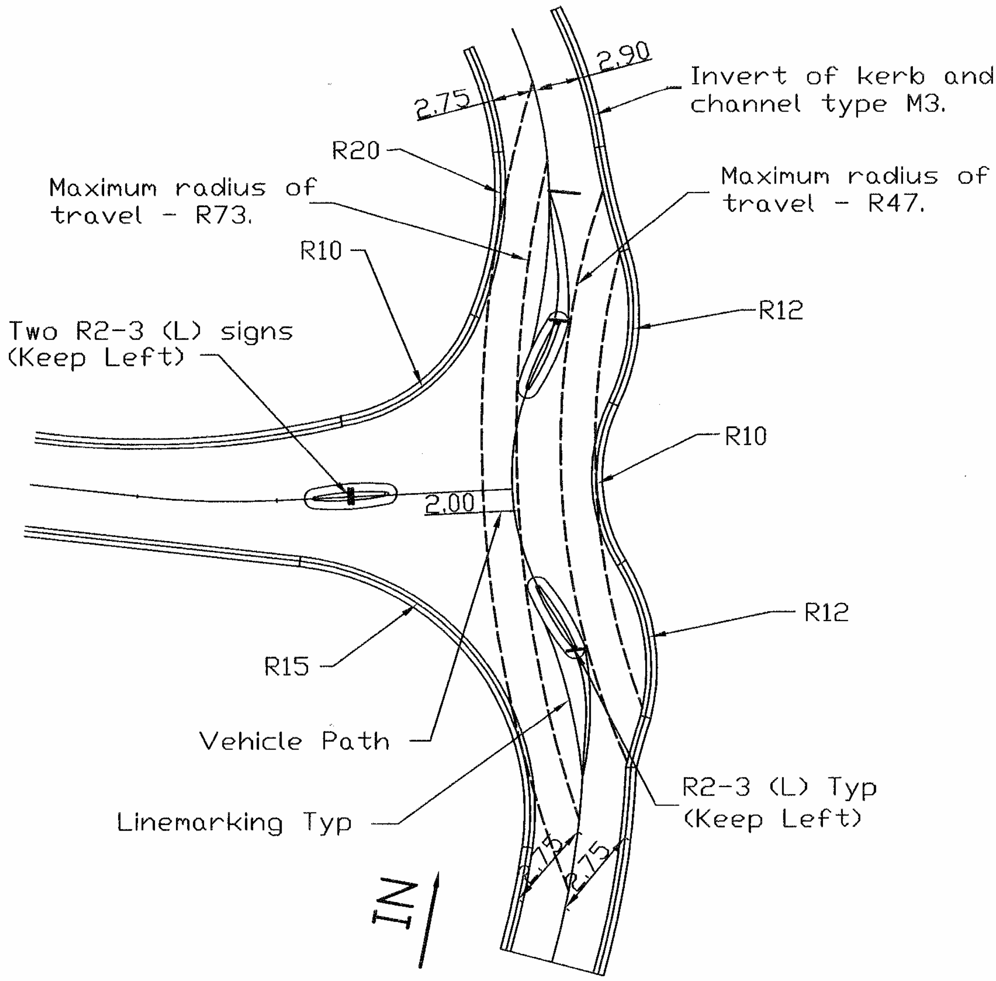
FIGURE B17 c



SAMBA PLACE UNDERWOOD

Not to Scale

FIGURE B18a



SAMBA PLACE UNDERWOOD

Not to Scale

FIGURE 18b

Samba Place Underwood - One Central Island Speed Control Device and one Deflected Tee intersection

F1	C1	Direction (In/Out)
26	28	I
30	22	I
30	25	I
32		I
20		I
33		I
25	24	O
24	20	O
30	24	O
23	19	O
27	28	O
24	24	O
20	19	O
23	21	O
25	25	O
27	22	O
21	18	O
21	21	O
22	17	O

	All F1	F1 In	F1 Out
Average	25.42105	28.5	24
85th Percentile	30	32.25	27

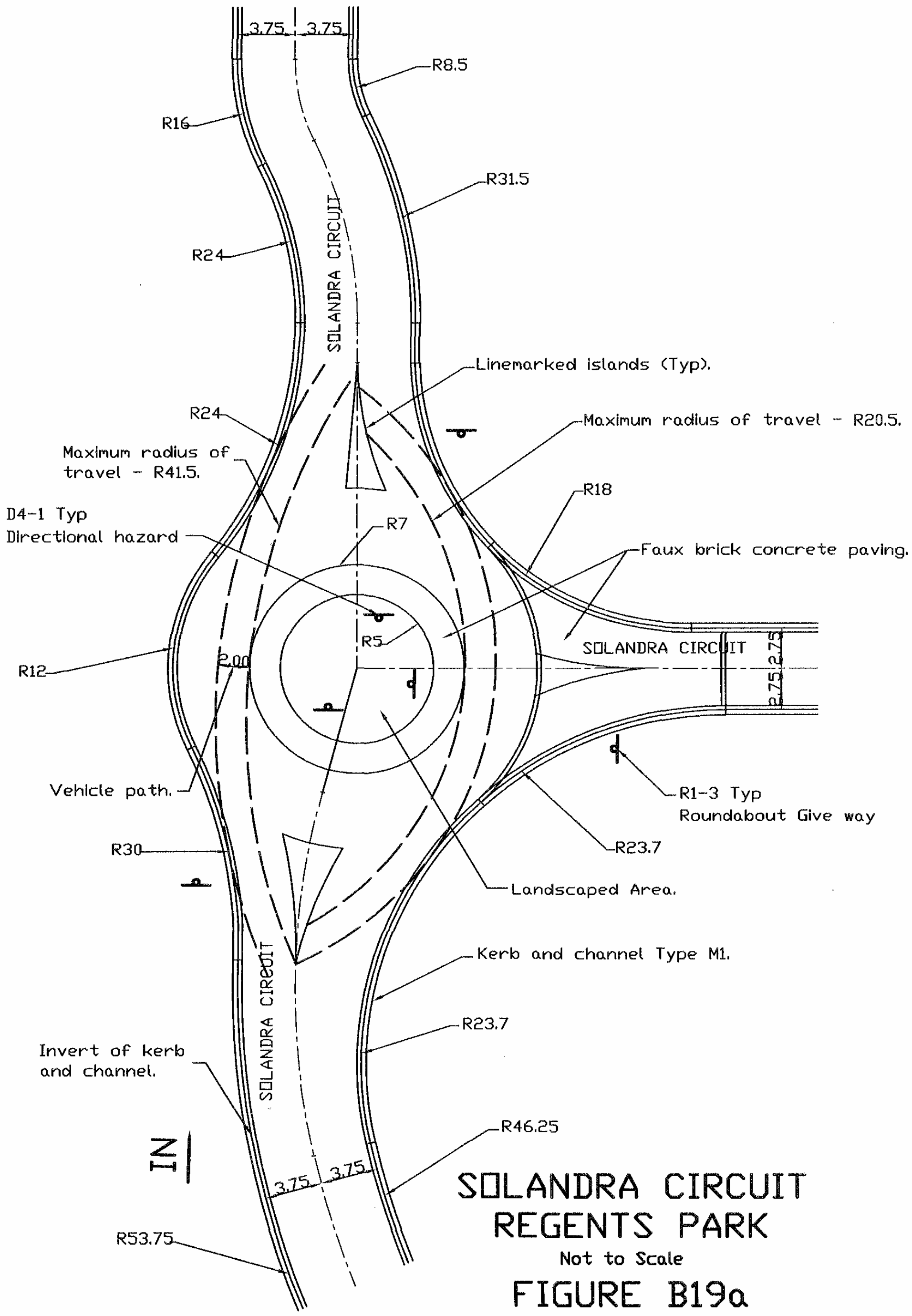
	All C1	C1 In	C1 Out
Average	22.3125	25	21.69231
85th Percentile	25	27.1	24.2

F1 - Central Island Speed Control Device
Maximum radius of travel (inbound) is 20 metres.
Predicted (achievable) speed (inbound) is 29.8 km/hr.
Maximum radius of travel (outbound) is 18 metres.
Predicted (achievable) speed (outbound) is 28.3 km/hr.

C1 - Deflected T Intersection
Maximum radius of travel (inbound) is 73 metres.
Predicted (achievable) speed (inbound) is 57.0 km/hr.
Maximum radius of travel (outbound) is 47 metres.
Predicted (achievable) speed (outbound) is 45.7 km/hr.

Note
Each device was 85 metres each side of a central island speed control device.

FIGURE B18c



SOLANDRA CIRCUIT
REGENTS PARK
Not to Scale
FIGURE B19a

Solandra Circuit Regents Park - Offset Roundabout

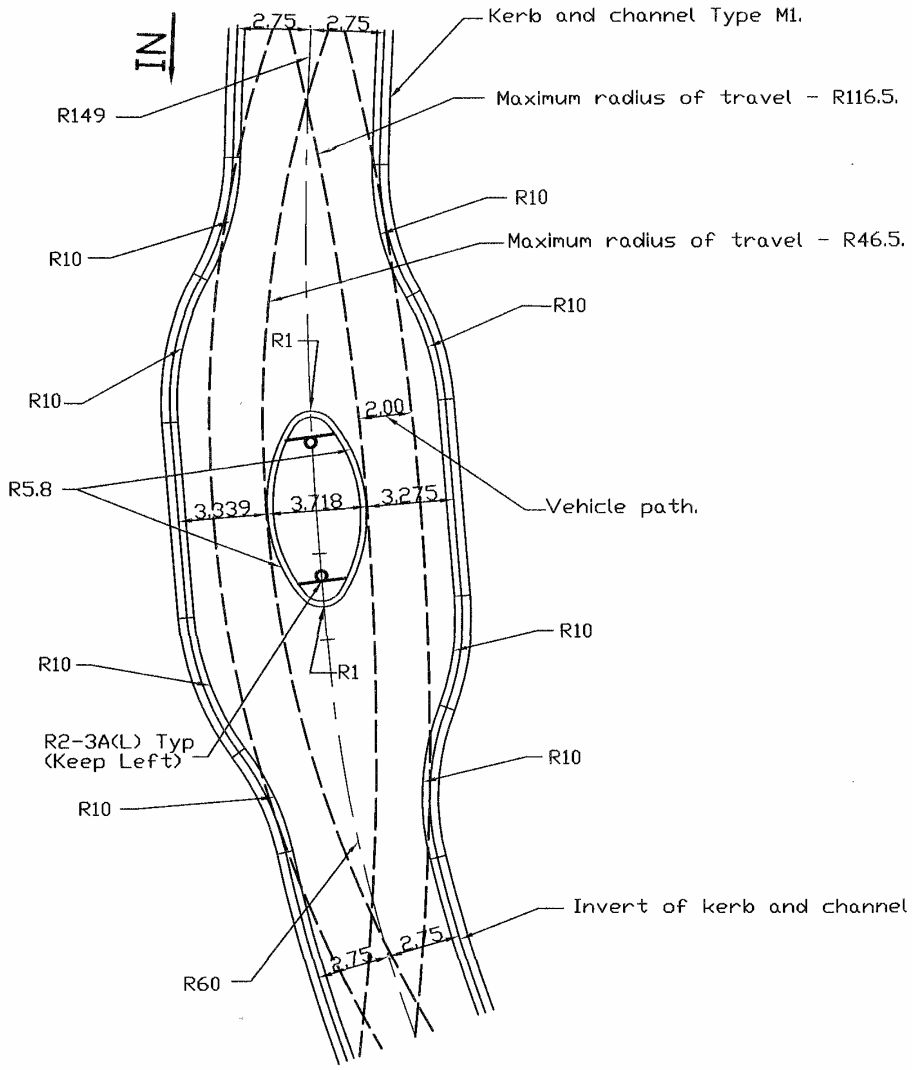
R	Direction (In/Out)
23	I
27	I
25	I
34	I
34	I
23	I
23	I
28	I
27	I
28	I
27	I
28	I
22	O
18	O
16	O
15	O
20	O
20	O
15	O
16	O
22	O
16	O
19	O
16	O
22	O

	R In	R Out
Average	27.25	18.23077
85th Percentile	30.1	22

Maximum radius of travel (inbound) is 41.5 metres.
Predicted (achievable) speed (inbound) is 43.0 km/hr.

Maximum radius of travel (outbound) is 20.5 metres.
Predicted (achievable) speed (outbound) is 30.2 km/hr.

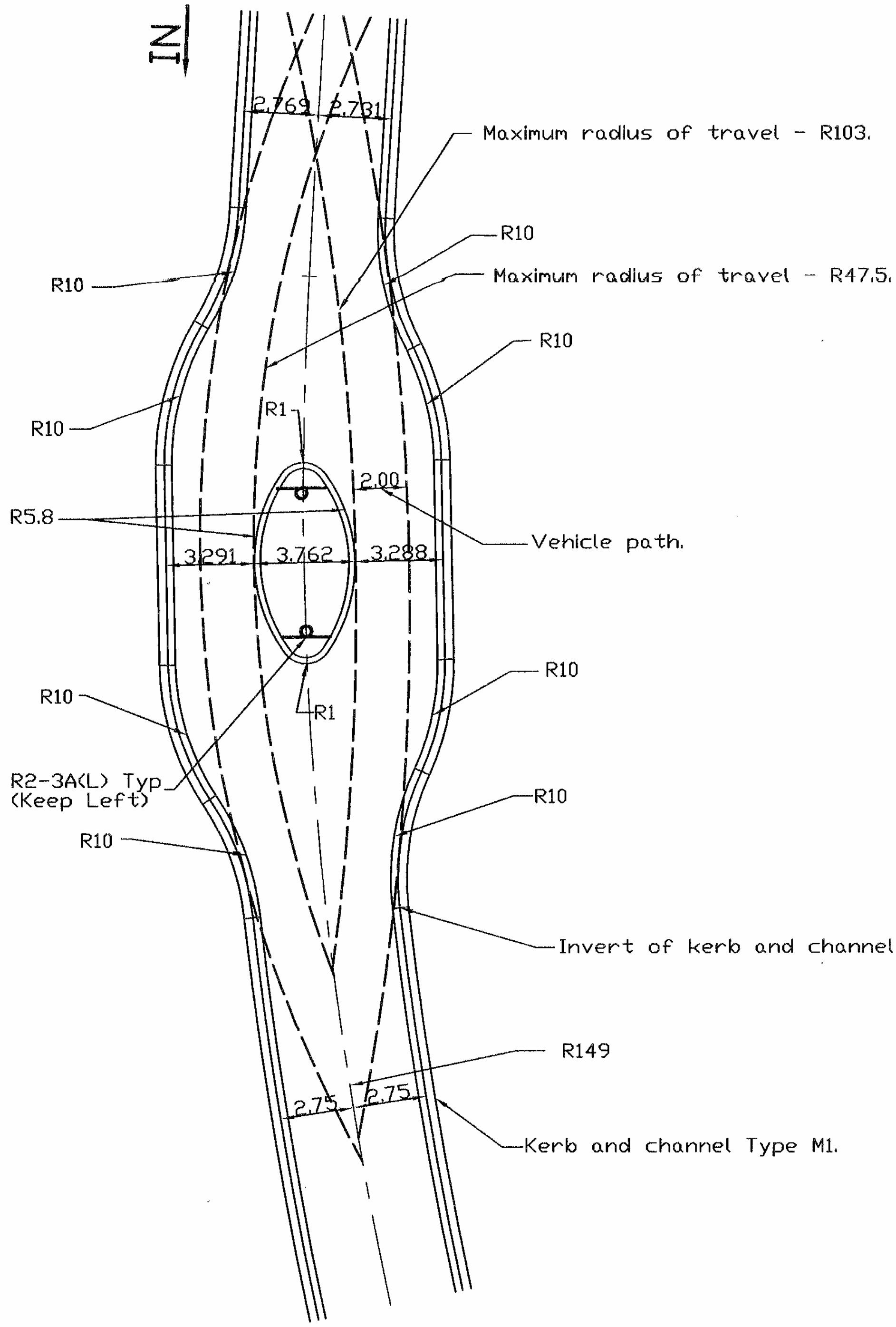
FIGURE B19b



SOLANDRA CIRCUIT - F1

Not to Scale

FIGURE B20a



SOLANDRA CIRCUIT - F2

Not to Scale

FIGURE B20b

Solandra Circuit Regents Park - Two Central Island Speed Control Devices in Series

F1	F2	Direction (In/Out)
	20	O
32	35	O
27	35	O
29	27	O
29	27	O
	29	O
30	35	O
	30	O
23	27	O
26		I

	F1	F2	All F's
Average	28	29.44444	28.8125
85th Percentile	30.2	35	34.25

F1 & F2 Similar Central Island Speed Control Devices

F1

Maximum radius of travel (outbound) is 46.5 metres.
Predicted (achievable) speed outbound is 45.5 km/hr.
Maximum radius of travel (inbound) is 116.5 metres.
Predicted (achievable) speed inbound is 72.0 km/hr.

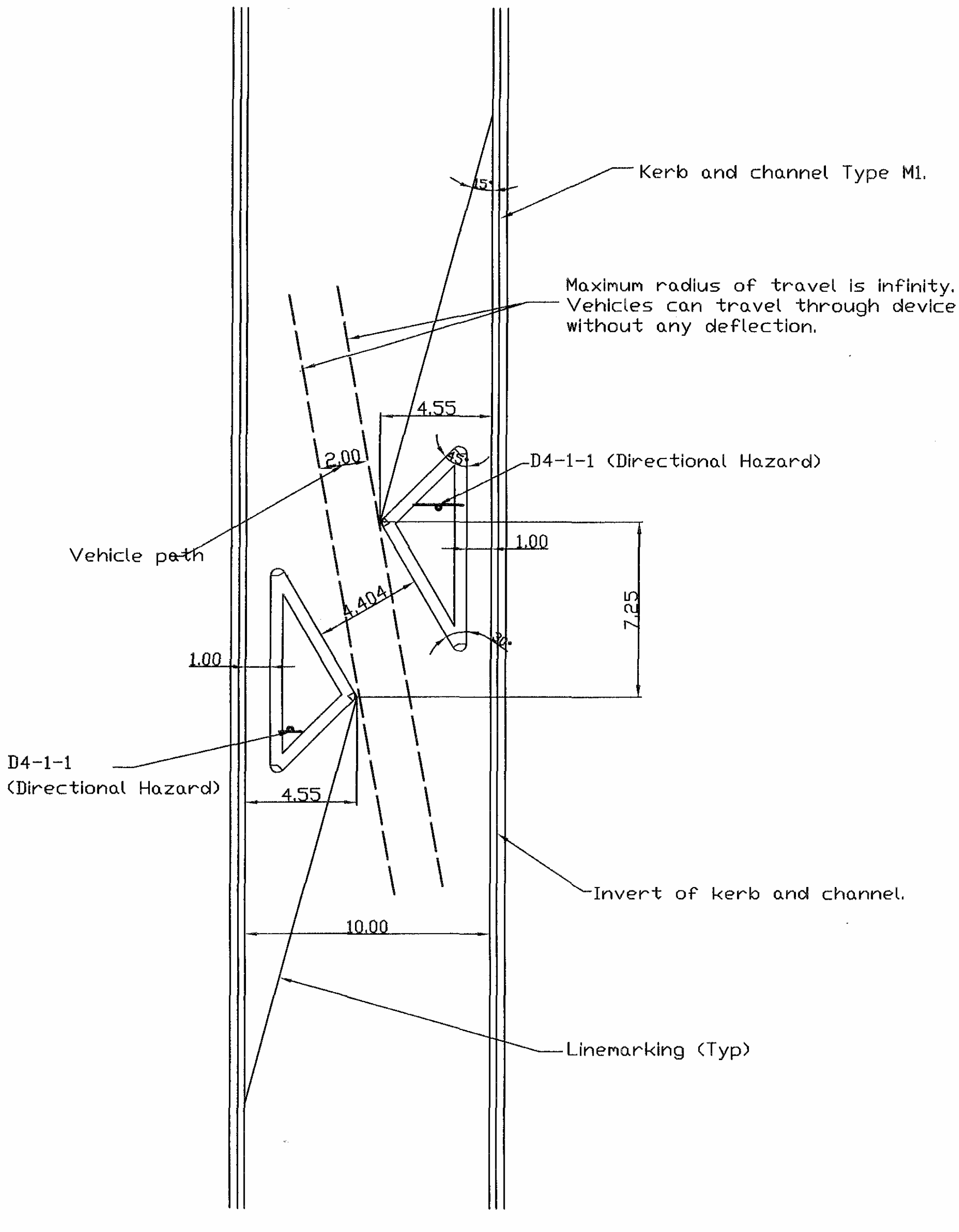
F2

Maximum radius of travel (outbound) is 47.5 metres.
Predicted (achievable) speed outbound is 46.0 km/hr.
Maximum radius of travel (inbound) is 103 metres.
Predicted (achievable) speed inbound is 67.7km/hr.

Note

The spacing between these devices (centre to centre) is 113 metres.

FIGURE B20b



STUBBS ROAD WOODRIDGE

Not to Scale

FIGURE B21a

Stubbs Road Woodridge - Two One Lane Slow Points in Series

OL1	OL2	Direction (U/D)	Notes
36	34	D	
31	33	D	
40	41	D	
41	40	D	
40	39	D	
53	38	D	
47	38	D	
39	31	D	
35	35	U	
30	31	U	
38	34	U	
60	58	U	
32	31	U	
37	35	U	
39	37	U	
39	39	U	
35	35	U	
38	38	U	
22	29	U	
33	29	U	

	All OL1	OL1 Up	OL1 Down
Average	38.25	36.5	40.875
85th percentile	41.9	39	46.7

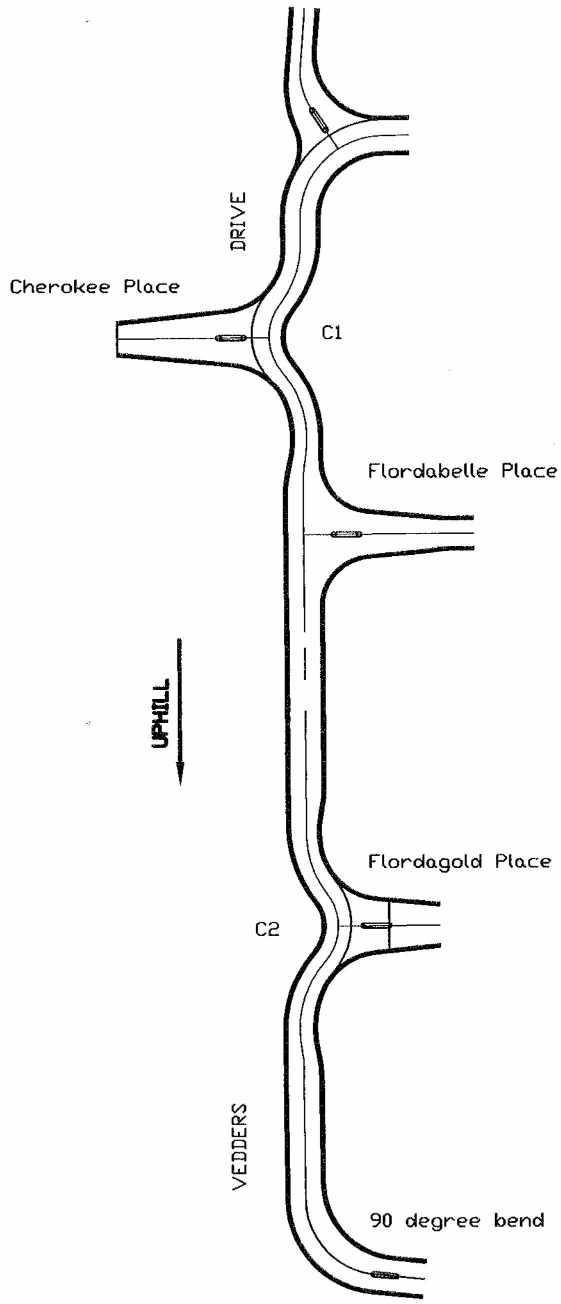
	All OL2	OL2 Up	OL2 Down
Average	36.25	35.91667	36.75
85th percentile	39.15	38.35	39.95

	All OL's
Average	37.25
85th percentile	40.15

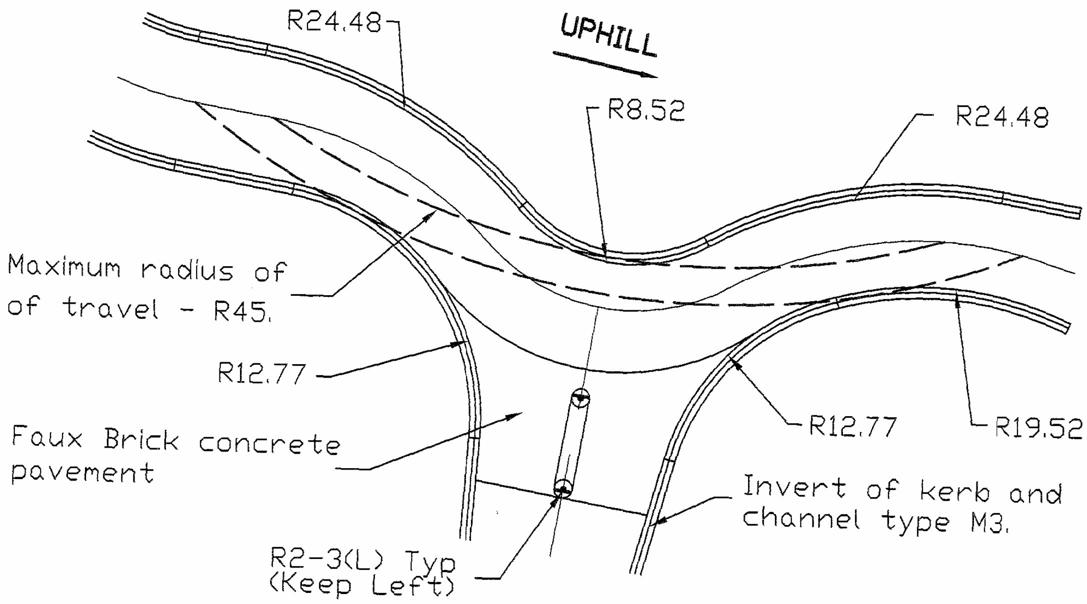
Maximum radius of travel is infinity. Very high speeds could be achieved through this device.

Note
The spacing between these devices (centre to centre) is 100 metres.

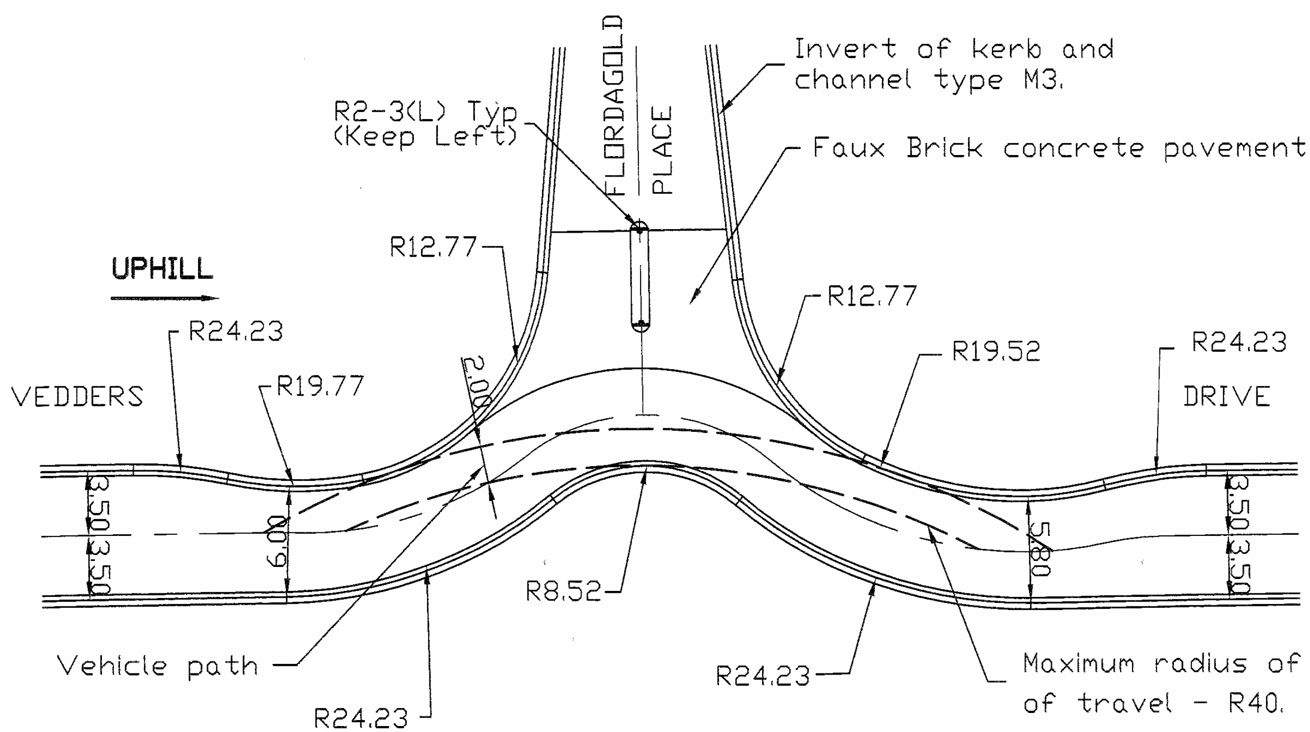
FIGURE B21b



VEDDERS DRIVE
HERITAGE PARK
Not to Scale
FIGURE 22a



VEDDERS DRIVE - C1
HERITAGE PARK
Not to Scale
FIGURE 22b



VEDDERS DRIVE - C2
HERITAGE PARK
Not to Scale
FIGURE 22c

Vedders Drive Heritage Park - Two Deflected Tee Intersections in Series

C1	C2	Direction (Up/Down)
26	26	D
34	34	D
31	34	D
32	32	D
33		D
	33	D
	32	D
29	20	D
31		D
30		D
29	29	U
	23	U
	30	U

	C1 Up	C1 Down	All C1
Average	29	30.75	30.55556
85th Percentile	29	32.95	32.8

	C2 Up	C2 Down	All C2
Average	27.33333	30.14286	29.3
85th Percentile	29.7	34	33.65

C1 - Intersection of Vedders Drive and Cherokee Place

Because there are no islands in this intersection, the maximum radius of travel in both directions is 45 metres. Predicted (achievable) speed is 44.7 km/hr.

C2 - Intersection of Vedders Drive and Flordagold Place

Because there are no islands in this intersection, the maximum radius of travel in both directions is 40 metres. Predicted (achievable) speed is 42.2 km/hr.

Note

The spacing between the devices (centre to centre) is 122 metres approx.

FIGURE B22d