CODE OF PRACTICE FOR CITY SERVICES & LAND DEVELOPMENT

ENGINEERING STANDARDS MANUAL

SECTION 3: Appendix C

PARKING & DRIVEWAY GUIDELINES

Transportation

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1 INTRODUCTION

1.1 Effects of Activities and Provision for Parking Loading and Access

Human activities result inevitably in a need to move vehicles from place to place and a need to stop and load/unload them. Site generated demands for movement and parking/loading have potentially significant adverse effects. These may occur within the site, in the vicinity of the site entrance, and at worst further away.

The potential adverse effects of parking, loading and movement include but are not limited to:

- inefficient apportionment of the development site to parking space
- visual intrusion and inferior urban design
- excessive travel in motor cars
- excessive delay, fuel use and other operating costs
- excessive noise, gaseous and particulate emissions
- injury or death by accident
- damage to property and vehicles
- infrastructure maintenance costs

The frequency and severity of these effects depend on the following influential factors*:*

- on site activity and its scale
- amount and arrangement of parking and loading space provided on site
- available and planned parking and loading space elsewhere
- available and planned road infrastructure and services
- available and planned alternative transport modes and 'travel plans'[1]
- prevailing and future neighbourhood traffic
- site entrance design
- site driveway and circulation roads design

1.2 Waitakere District Plan Rules and the Parking and Driveway Guideline

The Waitakere District Plan has rules designed to acceptably limit the adverse transport effects of parking loading and access as listed above. The notified Plan refers to the use of the Parking and Driveway Guideline.

The Parking and Driveway Guideline is designed to facilitate applications for planning and building consent under the District Plan through providing advice on how the factors influencing adverse effects, listed above, should be treated or applied. The Guideline will also assist the formulation of conditions of consent for proposals that do not directly comply with the Plan but may be acceptable if the conditions are imposed.

The document is a guide to the Council's expectations and cannot be entirely prescriptive; knowledge, data, and methods improve over time; parking, loading, and access issues are linked inextricably with other transportation issues and may in some cases need to be considered along with broad transport strategy and policy objectives.

Applicants may use different data/methods to those presented herein, but such must be supported by an expert report that clearly presents the data and methods employed, demonstrating their reliability, and the reliability of the technical conclusions reached for the proposed planning or building consent.

[1] A 'travel plan' is a plan to reduce private car travel; examples of techniques included in such plans include carpooling, car sharing, walking school buses and so on.

1.3 Overview of the Guideline

The Parking and Driveway Guideline deals with three broad themes:

- Chapters 2, 3, 4, and 5 cover the amount of parking (and loading) space to be provided.
- Chapters 6, 7, 8, 9, and 10 cover the safe and efficient arrangement of this space and associated driveways.
- Chapters 11, 12, 13, and 14 cover the safe and efficient integration of site and neighbourhood traffic.

Salient features of these themes are indicated under the corresponding subheadings below.

Car Parking Demand and Supply

District Plans have traditionally prescribed the minimum amount of parking to be allowed in developments. This section of the overview is intended to demonstrate how this approach has resulted in substantial wasteful oversupplies of parking, especially so when the minimum permitted levels have been set high, as has been common practice.

Historically the amount of car-parking prescribed for a specific development type has been enough to ensure the full car-parking demand is satisfied on-site for most of the year, and for the great majority of developments of that type. In theory the demand to be satisfied has been expressed as **"**the 30th highest hour in year demand associated with the 85-percentile intensity for the development type". In practice, at least for retail activities, these demands have been measured by surveys of "busier" establishments in November/early-December.

In reality any development of a given type has its own activity intensity, and within any extensive developed area a range of parking demand levels is distributed across similar establishments operating in the area. Therefore, important outcomes of using high-end-of-range parking demand levels for design are:

- on-site car-parking space is under-utilised in most cases (an unfortunate side effect)
- overflow parking occurs in a small minority of cases (the historic objective)

In contrast the use of middle-of-range parking demand levels for design would generally result in a greater overflow to road-side or public off-road parking, a greater utilisation of the on-site parking provided, and a net reduction in the overall parking supply.

An appreciation of the potential outcomes is afforded by the results tabled below from modelling[2] 100,000sqm gross leasable floor area (GLFA) with a distribution of parking demands in the range 1 space per 20sqm GLFA to 1 space per 40sqm GLFA. Hypothetical permitted minimum parking supplies for this comparison are taken as 1 space per 23sqm GLFA (high-end-of-range) and 1 space per 28sqm GLFA (middle-of range).

Permitted Minimum Parking Ratio		Total On-site (spaces)	Surplus On-site (spaces)	Overflow (spaces)	Total (spaces)	Demand (spaces)
High	(1 space per 23sqm GLFA)	4,122	817 (20%)	85	4,207	3,389
Middle	(1 space per 28sqm GLFA)	3,386	279 (8%)	282	3,668	3,389
Difference		-736 (18%)	-539 (66%)	197 (232%)	-539 (13%)	-

The middle-of-the-range design outcomes are a net *overall reduction* in parking space of 539 spaces (approximately 15,100sqm), an *on-site reduction* in parking of 736 spaces (approximately 20,600m^2), but an *off-site increase* in parking demand of 197 spaces (approximately 5,500m^2). These results may be surprising; they support a compelling case for the changed and changing approach to parking requirements in the District Plan rules and in this guideline.

It is apparent that setting minimum permitted parking levels at middle-of-range demand levels would tend to significantly:

[2] This entails splitting the 100,000sqm into parts each characterised by a different parking demand level in the specified range. The amount of utilised, unutilised and overflow parking for each part is determined from the fixed permitted minimum level specified (for each scenario). This done for a distribution of demand over the parts, determined from a weighted combination of plausible trial distributions. The results for the parts are summed for the 'high' permit and 'middle' permit scenarios, and these sums are the tabulated entries above.

- reduce the overall land and building resources required for car-parking
- increase productive development density
- for mixed use development reduce car travel owing to an increased potential for walk/cycle trips
- increase overflow to the public domain increasing the demand management potential of car-parking charges (a desirable outcome)
- increase parking infrastructure in the public domain but increase the profitability of charged public parking (a desirable outcome)

Furthermore, a change from setting minimum permitted to setting maximum permitted levels would tend to be even more affective is achieving efficient and desirable urban development. The use of minimum permitted levels is a new feature of the District Plan rules and of this guideline.

Car Parking Demand Management

National, regional, and local strategies for transport movement have a substantial potential to reduce parking demand and hence the size of the necessary parking supply: they seek to have the amount of motorised travel relatively-reduced through:

- increasing the proportion of trips made in walk/cycle, public-transport, and ride sharing modes
- reducing the proportion of trips made in private motor-cars
- removing the need to travel

With the implementation of these strategies car-parking demand will be reduced and the historical high-end-of-range parking demands used for design will be rendered even more inappropriate. A range of initiatives that may now apply or be planned for travel reduction and hence parking reduction in an area include:

- quality public-transport services
- bus-priorities
- transport interchanges
- cycle-ways, cycle-lanes, and cycle priorities
- travel plans for businesses and institutions
- encouraged personal travel planning
- mixed-use development in centres and along corridors
- fuel prices and parking charges

Waitakere District Plan Maximum and Minimum Permitted Parking Supplies

Chapter 2 of this guideline deals with the estimation of car-parking demand taking into account the matters summarised above. It also deals with the matter of planning consents for parking supply under the Waitakere District Plan Rules. Of particular note are the Plan's limitations on the parking supply permitted for any proposed development. Historically all the limits set have been in terms of the minimum amounts of parking to be provided and these limits have tended to be high-end-of-scale.

The operative plan, while generally retaining the permitted minimum controls, introduces maximum permitted parking supply limits. The minimums and maximums are assigned to separate parts of the city. Currently maximum controls apply only to the Hobsonville Base Village Special Area and the Massey North Town Centre Special Area.

The intention is to progressively convert to maximum controls in all main growth centres and growth corridors. The concept of maximum limits directly addresses the disadvantages of minimum limits referred to above, while anticipating where the resultant on-site parking supply does not match demand:

- some shift to the walk/cycle and public transport modes
- public / private sector provision for and management of overflow parking on a user-pays market-driven basis.

Safe and Efficient Arrangement of Parking and Loading Space and Driveways

The guidelines for these matters are straight forward prescriptions for the geometric layout of parking and loading areas, and for the horizontal and vertical geometric parameters applying to circulation and driveways.

Safe and/Efficient Integration of Site and Neighbourhood Traffic

The guidelines for these matters deal with:

- traffic movement to/from site entrances on the frontage road(s) and the estimation of:
  - safe sight distances for drivers
  - safe gaps in the passing traffic for drivers
  - volume of trips generated by the site development
  - delays and queues relating to site generated traffic
- the acceptability of the estimated outcomes
- safety and management of proposed overflow parking arrangements

1.4 Currency of The Guideline

This guideline may be altered from time to time to account for changes to the District Plan and to match ongoing improvement to the information and planning pertaining to the development of Waitakere. Consent applicants should ensure that they use the current issue. This guideline is intended to apply from the date of adoption and will endure after the inception of the Auckland Council.

2 CAR-PARKING SPACE

2.1 Parking Ratios

The amount of parking for a development is generally expressed as a ratio to the scale of the activity on the development site. It is useful to review this concept as it is a common basis for the consideration of parking demand and supply.

The number of spaces for a particular activity is often referred to as 1 space per ‘X’ sqm of productive floor area on site (or other variable representing the site activity such as number of employees). The value of ‘X’ depends on the activity: for example X is approximately 10sqm for fast food restaurants and 100sqm for bulk stores. The productive floor area is always the gross floor area including wall thicknesses etc, but excludes car circulation and parking space, and pedestrian circulation and standing space (akin to public footpaths). Productive floor area generally corresponds to gross leasable floor area, “GLFA”.

‘1 car-parking space per 40 sqm GLFA’ is an example of a car-parking ratio; this is equivalent to the ratio ‘2.5 car-parking spaces per 100 sqm GLFA’. The former is customary but is an inverse relationship; the higher the value the less the parking space; the latter relates directly to the amount of parking implied, the higher the value the more the parking space.

For analytical purposes the ‘direct’ ratio is assumed and N = R*A where N is the number of car-parking spaces for a given parking ratio, R, and development activity measure, A. The latter variables are expressed in compatible units: for example if R is spaces per 100sqm GLFA then A is in hundreds of sqm GLFA.

For the parking supply ***permitted*** by the District Plan rules for a proposed development an after-script ‘**p**’ is used. For the parking ***demand*** estimated for a proposed development the after-script ‘d’ is used:

$$Np = Rp*A \quad \text{and} \quad Nd = Rd*A$$

Designs in which Nd spaces are not accommodated on site result in an overflow of ‘No’ spaces: the after-script ‘o’ denotes ***overflow***.

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2.2 Permitted Minimum and Permitted Maximum Parking Ratios

The Waitakere City Council District Plan Rules for Parking, Loading and Driveway Access in the Living, Community, and Working Environments, and in certain Special Areas state the limited amounts of parking that are permitted for various activities. The District Plan's permitted ratios, Rp, are summarised in Appendix A1 "District Plan Permitted Minimum and Maximum Car-parking Ratios".

It is vital to note that in two parts of the city (the Massey North Town Centre and Hobsonville Base Village Special Areas) the permitted ratios are maximums. Designs with less than Np = Rp*A spaces are permitted; designs with more than Np spaces require specific Council consent, and if granted certain conditions of consent may be imposed.

In other parts of the city (for example Henderson and New Lynn Town Centres) the permitted ratios are minimums. Designs with more than Np = Rp*A spaces are permitted: designs with less than Np spaces require specific Council consent, and certain conditions of consent may be imposed.

The Council intends that the minimum ratios be changed progressively to maximum ratios in main growth centres and growth corridors. The reasons for this are evident in Section 1.3 above.

The maximum concept is incorporated in the Auckland Regional Parking Strategy 2009 and the Waitakere City Parking Plan 2009-2040. Parking maximums are to apply to growth centres and growth corridors designated for intense development and supported by rapid transit or quality transit networks, and a good standard of urban design. Also crucial is the Council's development of Parking Management Plans (PMP) and formation of Parking Management Associations (PMA) for these areas. The plans provide a context for the assessment of parking proposals that are not compliant with the District Plan rules, and the associations will among several allocated functions provide a medium for brokering the sharing of surplus off-road parking space.

2.3 Estimation of Parking Demand

Three methods may be used to produce/justify the parking demand for a proposed development.

Method 1: Survey a Similar Development

The parking demand associated with a similar existing development may be surveyed and the ratio for that development applied to the proposed development.

Example: observations of the parking utilised over a full business weekday and Saturday for a neighbourhood shopping centre result in a maximum observed demand for 40 spaces. The measured GLFA is 1100 sqm. For the purpose of this example the location and other influential factors of the proposed centre are expected to become similar to those of the centre surveyed.

Hence the expected Rd = 40*100/1100 = 3.64 spaces per 100sqm GLFA. For the proposed centre A = 1500 sqm = GLFA. Hence Nd = 3.64*1500/100 = 55 spaces or 55*1.1 = 60 spaces allowing for a practical working capacity. Accordingly, if the design is a good fit to the site 60 parking spaces would be included. If the design exceeds the capacity of the site the GLFA can be reduced, or a case made for a parking overflow and dispensatory consent. If the design does not fill the site the GLFA might be increased to match the capacity of the site.

Method 2: Use of Existing Data for a Similar Development

Rd may be selected from a reliable data base of surveyed parking demands for existing developments. The New Zealand Trips And Parking Database Bureaux database [NZTPDB (*www.nztpdb.org.nz*)] is an example of such a database; it contains the results of surveys of trip making and parking utilisation for a wide variety of New Zealand establishments and each establishment is characterised by type, GLFA, and other parameters. Appendix F references "d" through "j" refer to other databases of Australian, United Kingdom and American origin that may also provide information suitable for formal applications.

Example: the NZTPDB includes the results of 130 surveys of shopping centres for which the minimum, average, median, and maximum results are respectively 0.9, 3.7, 3.6, and 7.2 spaces utilised per 100 sqm GLFA.

It is apparent from this wide ratio range that the use of the database entails scrutiny of the characteristics of each case to find those cases that are likely to be similar in nature to the proposed case and therefore appropriate as a basis for design. In some cases not all the defining parameters for the establishments surveyed are recorded and so the relevance of the parking and trip rates provided cannot be ascertained.

The table below provides an overview of data for some of the main activities included in the NZTPDB database.

Activity	NZ Trips and Parking Database Bureaux ~ Base Parking Ratio [Rd] Ranges[3]								
	Sample	(spaces per 100sqm GLFA)				(sqm GLFA per space)			
	Size	Min	Max	Average	Median	Max	Min	Average	Median
General Retail	10	0.8	4.1	2.2	2.2	125	25	45	45
Large Format Retail	5	0.9	3.7	2.0	1.8	110	25	50	55
Supermarket	5	4.5	6.2	5.1	5.0	35	15	20	20
Shopping Centre	130	0.9	7.2	3.7	3.6	110	15	25	30
Office	9	1.9	6.2	3.2	3.0	55	15	30	35
Industry	13	0.1	3.8	1.2	0.7	770	25	80	140
Storage/Warehouse	10	0.2	3.3	1.0	0.4	590	30	100	235

The use of a surveyed or database sourced Rd needs to account for significant differences between the base and proposed developments, their transport environments, and fluctuations in demand that occur over the days of the week and months of the year. Factors for dealing with such variations are presented in the Sections 2.4 and 2.5 of this guideline.

Method 3: Use of an Operational Rationale (Model) for the Proposed Development

An estimate of demand may be made directly on the basis of a well defined operational rationale for the proposed development. This would be produced by the designer to match the client's brief.

Example: new premises for a consultancy office are proposed. Provision is required for 5 principals and 40 staff. 20 sqm GLFA is proposed per person, giving a total 900 sqm GLFA. It is expected on the basis of past experience that at any time 2 principals may have client visits involving 3 cars and that 10% of staff may have client visits involving 1 car. At any time 1 principal and 5% of staff and may be out off office. The location is well served by public transport; census data suggests that 30% of commuters use public transport and that the peak hour car occupancy is 1.3 person/car for the locality, which is remote from residential development.

From the brief the parking demand of principals and staff = 70% of (5+40)/1.3 = 24 cars; during the day the following fluctuations may occur: +3 (visits to principals) + 10%*40 = 4 (visits to staff) - 1 (principals out of office) – 5%*40 = 2 (staff out of office). The fluctuation range is between + 7 and -3 cars. The designer proposes 24+6 = 30 parking spaces with 24 reserved for principals and staff; these together with the 900 sqm office can be accommodated on site. The proposed ratio is therefore 30/ (900/100) = 3.3 spaces per 100 sqm GLFA. This compares favourably with the average ratio of 3.2 spaces per 100 sqm GLFA for offices in the NZTPDB.

The use of an operational rationale for the development has the disadvantage that it may be subject to bias. However, the risk of bias should be small if the rationale is logical and clearly presented: also, outcomes can be checked with reference to database data as indicated in the example above.

Methods 1, 2, and 3: Factoring for Future Conditions

Each of the 3 methods is applied to obtain an unbiased estimate of parking demand at the time the design for the proposed development is being prepared. National, regional and local strategies for transport aim to reduce travel in motorcars over time and so adjustments should be made to ensure that parking supplies provided now do not include long run waste. The required adjustment is to be made by applying the following future factors (FF) to the current demand estimates produced by any of the 3 methods above.

[3] The data for sales activities in this table has been adjusted to a November month and Thursday/Saturday day using factors Ft from Section 2.4

Locality	Future Factor Staff Parking	Future Factor Visitor Parking
Massey North Town Centre[4]	0.90	0.96
Henderson Town Centre	0.87	0.95
New Lynn Town Centre	0.84	0.93
Intensively Developed Transport Corridors	0.87	0.95
Other parts of Waitakere City	0.93	0.97

These factors are appropriate for applications submitted in year 2010 through to year 2020, but may be updated from time to time by the Council. They are based on:

- a linear growth in car occupancy (to increases of 0.075 per/car and 0.05 per/car by year 2026 for staff and visitor trips respectively).
- contractions in car-mode share over 15 year periods owing to linear increases in walk/cycle-mode share and public-transport-mode share between the shares predicted by the Auckland Regional Council's transportation models for the subject locations at horizon years.

2.4 Treatment of Parking Ratios

Rd for a development consent application can generally be calculated from a base ratio Rb according to:

Rd = Rb * [Ft * Fo * Fwc * Fpt * Fss * Fstp * Fe] * FF

The future factor FF is treated in Section 2.3 above. The "F" factors in brackets are applied to the base ratio to arrive at a justified ratio for the proposed development at present or imminent; they are described under separate headings below.

As already stated in Section 2.1 above, Rb may be obtained from surveys of the usage of the car-parking, Nb, and the activity measure, Ab, of an existing development, similar to the proposed development, or obtained from a suitable reputable data-base.

Appendix A 2 provides some base parking ratios and refers to generally available databases that may be useful to designers. Traffic planning consultancies are likely to have assembled proprietary databases for their exclusive use.

Rb = k *max(N)/A where N is the average number of parking spaces observed to be occupied in any hour, and max(N) is the maximum value of N for the survey. k is a constant greater than 1 chosen to correspond to an acceptable level of service for users. Example: it is desirable that 10% of spaces are always empty for retail customer car parking and so for this activity k =1.11.

Temporal Factor Ft

Ft is temporal factor to correct for the timing of the base-data collection if this does not correspond a Thursday/Saturday and November month. Well timed base data is preferred. Transport reporting must be explicit in regard to the month, and day pertaining to the supporting data for the demand estimate.

The intention is to design for conditions occurring on a Thursday and Saturday of the month of November. These are the periods when parking demand is higher but not excessive, and provision for which is considered cost effective.

Excessive demands for retail uses leading up to Christmas are to be catered for by appropriate parking management measures; for example staff may be required to park at a suitable remote location and walk the last segment of their trip-to-work.

A table of Ft for months[5] is provided below for sales activities; establishments should not be surveyed in January or February owing to the extreme influences that occur in these months.

[4] The Massey North factors are taken as the average of the 'Henderson' and 'Other' cases.
[5] The month factors are based on NZ Department of Statistics electronic sales data and Road Traffic Authority NSW temporal factors for retail activity.

Tables of Ft for days[6] are also provided below.

Month Factors for Sales Activities											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.14	1.19	1.06	1.11	1.06	1.11	1.06	1.06	1.11	1.06	1.00	0.85

For all other uses the Month Factor Ft = 1.

Day Factors for Sales Activities						
Mon	Tue	Wed	Thu	Fri	Sat	Sun
1.15	1.14	1.10	1.08	1.05	1.00	1.16

Day Factors for Other Activities				
Mon	Tue	Wed	Thu	Fri
1.05	1.04	0.98	1.00	1.03

Car Occupancy Factor Fo

Fo is a car-occupancy factor to align the occupancy, Ob, of the base data catchments with the occupancy, Od, for the catchments of the subject development: Fo = Ob/Od (e.g. 1.25/1.35 = 0.93). An increase of 0.1 relative to a base occupancy of 1.25 person/car would, if all the additional car-occupants are previous car drivers, be associated with a reduction in car-trips and hence car-parking of 7%.

Occupancies might be higher where there are “T2” or “T3” prioritised traffic lanes, a strong general uptake of travel-plans for businesses/institutions, and so on, and can be found by survey using unbiased samples of size 60, at appropriate times.

The Council’s May 2010, inter-peak observations of occupancies (children excluded) for the Westgate, Henderson, Lynn Mall and St Lukes community environment land uses are respectively 1.30, 1.47, 1.34, and 1.30; the corresponding results for the pm-peak are 1.27, 1.25, 1.32, and 1.39.

The default value for Fo = 1. If the default is not used transport reporting must be explicit in regard to the supporting data pertaining to Fo as submitted. The Council would expect Fo to lie in the range [0.9, 1.1].

Walk/cycle Mode Share Factor Fwc

Fwc is a walk-cycle mode share factor to align the walk-cycle mode share, Mwcb, of the base data catchments with the walk-cycle mode share, Mwcd, applying to the catchments of the subject development: Fwc = (1-Mwcd)/(1-Mwcb). Example: (1-0.08)/ (1-0.02) = 0.94.

Walk-cycle mode shares may be higher where there are cycle-lanes, cycle-ways, cycle priorities, a strong general uptake of travel-plans for businesses/institutions, substantial mixed-use development within 800m walking distance, and more congested main roads. Factors of [0.95, 0.90] for relatively walkable communities and 0.95 for developments with trip end facilities including showers and lockers have been recorded[7].

The default value for Fwc = 1. If the default is not used transport reporting must be explicit in regard to the supporting data pertaining to Fwc as submitted. The Council would expect Fwc to lie in the range [0.9, 1.1].

Public Transport Mode Share Factor Fpt

Fpt is a public-transport mode share factor to align the public-transport mode share Mptb of the base data with the public-transport mode share Mptd, applying to the catchments of the proposed development: Fwc = (1-Mptd)/ (1-Mptb). Example: (1-0.15)/ (1-0.05) = 0.89.

[6] The day factors are based on the daily am-peak and inter-peak 2 hour volumes for the eleven roads of the central traffic cordon Waitakere City.
[7] ‘Parking Management Best Practice’, T Litman, Planners Press 2006

Public-transport mode shares may be higher in catchments having improved bus-services and bus-fleets, bus-lanes and bus-priorities, rail-services and improvements including electrification, transport interchange facilities and integrated ticketing, a strong general uptake of travel-plans for businesses/institutions, substantial mixed-use development, more congested main roads, and higher parking fees. Factors of [0.8, 0.9] for areas relatively well served by bus and rail services have been recorded[8].

The default value for Fpt = 1. If the default is not used transport reporting must be explicit in regard to the supporting data pertaining to Fpt as submitted. Council would expect Fpt to lie in the range [0.8, 1.2].

Site Specific Factor Fss

Fss is a factor to allow for site specific design characteristics of the development and its operational management. Being specific to the development it is not possible to generalise the estimation of Fss. The default factor for Fss =1. If the default is not used transport reporting must be explicit in regard to the supporting data pertaining to Fss as submitted.

Example: if the base case for an office block is an establishment operating with 18 sqm GLFA per employee and visitor parking at 1 per 9 spaces, but the proposed office block has a higher specification of 25 sqm GLFA per employee and visitor parking at 1 per 5 spaces then it would be appropriate, other operational factors being "equal", to set Fss = (1-1/9)*18/25*(1+1/5) = 0.77.

Other applicable site specific influences include:

- Unbundled parking: this refers to allowing multiple owners/occupiers to purchase/rent on-site parking space in accordance with need rather than a strict proportionate amount. Studies find that factors of [0.9, 0.7] are practical for application to the total for a normal 'bundled' supply. The developer's choice of reduction factor entails the risk of an inadequate parking supply.
- Shared Parking: this refers to allowing multiple users whose peak demands do not coincide to share the space that would otherwise be empty. The factors for shared parking are treated separately in Section 2.12.
- Mixed-use Environment: Where there is a good balance of mixed retail, office and residential development studies find that factors of [0.95, 0.90] relative to homogeneous development are appropriate.

For residential development a site specific reduction factor is not normally appropriate since parking ratios are available for a full range of residential development types[9]. Nevertheless, reduction factors[10] of [0.8, 0.6] may be appropriate to developments for the young, elderly or disabled, of [0.9, 0.8] for the bottom 20-percentile of income households, [0.8, 0.7] for the bottom 10-percentile of income households, and [0.8, 0.6] for rental housing.

Site Travel Plan Factor Fstp

This factor recognises the potential effectiveness of travel plans, and is offered as an incentive to include travel plans in development consent applications.

Fstp is a site travel plan factor which can be applied only if:

- a travel plan forms part of the consent application
- the Council considers the travel plan likely to be effective in achieving a specified reduction in on-site parking
- the plan includes a binding commitment ensuring its effectiveness in the long term and if the ownership/occupation of the development changes.

The default factor for Fstp =1 and applies if an effective travel plan is not part of the consent application. Council would expect Fstp to lie in the range [0.85, 0.95] although greater reductions may be able to be justified on the basis of careful research.

[8] 'Parking Management Best Practice', T Litman, Planners Press 2006
[9] Guide to Traffic Generating Developments Road Traffic Authority of NSW 2002
[10] 'Parking Management Best Practice', T Litman, Planners Press 2006

The Sustainable Transport Plan 2006/16[11] indicates the most effective travel plans can achieve a 12% reduction in weekday AM - peak car trips to work. Australian examples include: Dandenong where car travel generally reduced by 10% and public transport use increased by 27%, two universities where TravelSmart reduced student car trips to campus by 9%, and Subiaco and Melville in Perth where TOD schemes apply an where reductions of 12% and 9% respectively.

Techniques that might be part of a travel plan include, ride sharing [0.9, 0.95], car sharing [0.90, 0.95], charged rather than free car parking [0.9, 0.7], shared parking [0.95, 0.60], institutional bus service [0.9, 0.8], formal personal advice pertaining to public transport services and other alternatives [0.9]. Not all techniques will be suitable for all development types and transport reporting must be explicit in regard to the supporting data pertaining to Fstp as submitted.

Economic Conditions Factor Fe

Fe presents an opportunity for economic influences to be taken into account for major developments if economic drivers are expected to be substantial and justifiable.

Fe is also intended to allow for a significant difference in the economic conditions associated with the base data collection and with the economic condition expected to apply when a development is commissioned. Observed switches in general traffic growth from +2% to -2% with adverse economic change suggest that an Fe of in the order of 1.04 may be applicable if the base survey corresponds to a relatively and moderately repressed economic condition.

Council will normally accept a default value of 1 for Fe. Otherwise Council would expect Fpt to fall in the range [0.95, 1.05].

Caveats on F Factors

In producing the F factors care must be taken to avoid double-counting the effects each factor is intended to represent by allowing correctly for any interdependencies (usually referred to as “elasticities” and “cross-elasticities”). For example, substantial differences in prevailing passenger transport services may mainly affect car-passengers and cyclists rather than car-drivers and so have lesser than expected impact on the quantity of car-trips and car-parking appertaining.

Often new developments draw custom from the existing frontage road traffic “driving by”. Although the amount of traffic and parking-demand generated by such developments is not reduced as a result, the volume of traffic added to the frontage road(s) is not increased by the total amount generated. As a guide, reductions to additional traffic on the frontage road may be able to be justified in the range 0% to 30%, but no reduction to the on-site parking requirement can be attributed to “drive-by”.

2.5 Example: Base Ratio Adjustment

In February 2008 a parking survey of the New Lynn Town Centre was undertaken. Sub-areas were surveyed on different days spread over a week. The GLFA inventory and the car-parking ratios of the Parking and Driveway Guideline were used to determine the amount of off-street parking that “should have been provided”. For the “Lynn Mall’ and adjacent “Merchants Quarter” blocks the parking demand based directly on the guideline ratios was calculated to be 1855 spaces, whereas the peak usage from the parking survey was 1050 spaces. The raw data suggests that the Parking and Driveway Guideline ratios over estimate the parking demand by 1855 - 1050 = 805 spaces (76%).

However, the Regional Mall ratio comes from the Council’s comprehensive survey of St Lukes Mall in December 1992: a meaningful application of the guideline ratios requires aligning-adjustments.

[11] Sustainable Transport Plan 2006-16, Auckland Regional Transport Authority, 2007

The table below derives a factor to estimate the February demand at Lynn Mall from the December demand at St Lukes Mall taking into account the prevailing transportation and site conditions.

Attribute	Factor	Value	Justification
Temporal	Ft	0.71	Alignment of months to February (0.71 = 0.85/1.14); refer to Section 2.4
Occupancy	Fo	0.97	St Lukes = 1.30 New Lynn = 1.34; (0.97 = 1.30/1.34); refer to Section 2.4
PT-mode share	Fpt	0.90	New Lynn transport interchange (Littman: Planners Press 2006)
WC-mode share	Fwc	0.98	Relative density of walkable catchments: (Littman: Planners Press 2006)
All	Product	0.61	

The aligned car-parking demand from the guideline base ratio is about 1855 * 0.61 = 1132 spaces. This is an overestimate of the actual usage but by the much lesser amount of 1132 - 1050 = 82 spaces (8%).

The example highlights the importance of treating raw data with appropriate discretion.

2.6 Proposed Parking Supply Less than a Permitted Minimum

Application for consent to a development with a parking supply not compliant with the permitted parking limit requires a transport specialist's supporting report. *However, if Np <= 25 spaces a specialist's report will normally not be required see Section 2.10.*

The table below indicates the basic reporting requirements for all the cases that can potentially arise.

Case	Np is a Minimum	Development Application Report
All cases		Derives the parking demand Nd and ratio Rd
Case 1	Nd >= Np and No = 0	States that the parking on site is a permitted number
Case 2	Nd >= Np and No > 0	Identifies and justifies the proposed off-site parking for the overflow No
Case 3	Nd < Np and No = 0	Justifies the proposed value for Nd being less than Np
Case 4	Nd < Np and No > 0	As for case 2 and case 3

The above table is intended to elucidate reporting requirements in regard to the proposed parking supply only. The geometric arrangements for parking and access need to comply with Parts 7, 8, 9, and 10 of this guideline, the effects of generated traffic movement need to be assessed in terms of Parts 11, 12, and 13 of this guideline, and proposals for the management of significant adverse traffic effects need to be submitted.

2.7 Proposed Parking Supply Greater than the Permitted Maximum

Application for consent to a development with a parking supply not compliant with the permitted parking limit requires a transport specialist's supporting report. *However, if Np <= 25 spaces a specialist's report will normally not be required, see Section 2.10.*

The table below indicates the basic reporting requirements for cases where more than the permitted maximum parking supply is proposed on site:

Case	Np is a Maximum	Development Application Report
All		Derives the parking demand Nd and ratio Rd
Case 1	Nd > Np and No = 0	Justifies the proposed value for Nd being greater than Np
Case 2	Nd > Np and No > 0	As for Case 1 and identifies/justifies proposed off-site parking for overflow No on another site

However, when Np is a maximum the developer does not have to provide any parking on site, or can decide on any amount less than or equal to the permitted maximum. Although in such cases there is no obligation to estimate the parking demand generated by the proposal or to report on its effects it is considered to be in the developer's best interest to take into account the accessibility implications of the proposed design.

The geometric arrangements for parking and access need to comply with Parts 7, 8, 9, and 10 of this guideline, the effects of generated traffic movement need to be assessed in terms of Parts 11, 12, and 13 of this guideline, and proposals for the management of significant adverse traffic effects need to be submitted.

2.8 Consents Where the Permitted Ratios Rp are Minimums

This section is intended to facilitate the required reporting on a proposed parking supply as summarised in the table of Section 2.6. Consent to a proposed parking supply less than the permitted minimum may be granted but depending on:

- the appropriateness of the magnitude of A for the site
- the derivation and justification of the ratio Rd
- the magnitude of the parking deficiency Rp*A - Rd*A
- the magnitude of overflow parking No by time of day and day
- the applicant's proposed parking supply for overflow No in the private and/or public domain
- the Council's neighbourhood parking management plan and its capacity to serve the applicant's proposed overflow into the public domain

The justification of Rd (bullet point 2 above) is of prime importance, and should:

- include a travel plan for the development to reduce employee parking demand by circa 10%
- allow for existing/imminent public domain initiatives that reduce car travel to/from the neighbourhood

Off-site parking for high seasonal parking peaks such as for Christmas shopping, and high peak parking for infrequent events, will be consented to but applications should include a plan for the efficient management of such peaks. Likewise off-site parking in excess of the permitted amount for town centre residents will normally be consented to, and particularly where the overnight parking is shared off-street parking or otherwise vacant on-street parking.

2.9 Consents Where the Permitted Ratios Rp are Maximums

This section is intended to facilitate the required reporting on a proposed parking supply as summarised in the table of Section 2.7.

Consent to a proposed parking supply exceeding the permitted maximum may be granted but depending on:

- the appropriateness of the magnitude of A for the site
- the derivation and justification of the ratio Rd
- the magnitude of the parking excess Rd*A - Rp*A
- the magnitude of overflow parking No by time of day and allocation to off-road parking off-site
- the applicant's proposal for additional off-road parking on another site in the private/public domain

The justification of Rd (bullet point 2 above) is of prime importance, and will normally need to:

- include a travel plan for the development to reduce employee parking demand by circa 10%
- allow for existing/imminent public domain initiatives that reduce car travel to/from the neighbourhood.

Consents for parking greater than a permitted maximum are likely to be more difficult to achieve than those for parking less than a permitted minimum, owing to the Council's objectives: to efficiently match the supply of parking to the demand for parking, maximise the space available for productive activity, and reduce the demand for travel in motorcars.

The following special cases are noted:

- Commercial Parking Facilities: consent may be granted if the facility is proven to cater for demands not provided on other active sites in the neighbourhood. Such demands may include short stay parking for shoppers and other visitors, long stay employee parking, and overnight parking for residents. The proposed value of Nd should cater for the net summations by time of day of the component unsatisfied demands to be served and should be less than the sum of the individual maximums. The calculations for this requirement are detailed in Section 2.12 Shared Parking Space.

Commercial parking buildings may contribute to good urban design in that they compliment consenting to lower parking ratios in surrounding development. This can increase the density of productive activity and walk/cycle mode share, and reduce the total amount of parking required in the neighbourhood (see also Section 1.3 above).

Consent may be given for construction of a commercial parking building before construction of the development it is intended to serve, but only where there is proven pressure for such development to take place within a timeframe considered by the Council to be acceptable.

- Park and Ride Facilities: consent may be granted if the proposal is in accordance with a Council parking management plan for the locality and/or a regional park and ride strategy. Also, the full capacity must be available between 6am and 6.30pm for Park and Ride users; it may be shared by other users at other times.

- Supermarkets: consent applications may be supported by comprehensive industry based information and standards or operational models. However, Council will expect design features and a suitable travel plan to be included in the design to minimise the provision for staff parking, and reduce provision for shopper parking to the extent practical.

On-site parking for high seasonal parking peaks such as for Christmas shopping, high peak parking for infrequent events, will not be consented and applications should include a plan for the efficient management of such peaks. Likewise consent will not be granted for on-site parking in excess of that permitted for town centre residential activity, shared overnight parking excepted.

2.10 Consents Where the Np <= 25 Parking Spaces

The simplified guidelines presented in this section are intended to reduce the burden and cost of transport reporting in regard to the proposed parking supply Nd. The method is justified on the basis that any difference from the result of the full procedure will be small, and that over many development cases surpluses and deficiencies are likely to have a neutral outcome in the public domain.

Office Developments

Office Staff Parking: sqm GLFA per Parking Space (spaces per 100sqm GLFA)[12]

Location	**GLFA per Employee**		
	20 sqm	**25 sqm**	**30sqm**
Town Centres and Corridors with Intensive Development	40 (2.5)	50 (2.0)	60 (1.7)
Massey North and Hobsonville	37 (2.7)	46 (2.2)	56 (1.8)
Other Areas	35 (2.9)	43 (2.3)	52 (1.9)

These results assume: a car-occupancy of 1.3, am-peak commuter car-mode shares of 0.65 for travel to town centres and intensively developed corridors with quality public transport, and of 0.75 to other places. These parameters are based on Auckland Regional Council advice and account for trends expected to year 2026. The tabled values are considered to be appropriate for base years up to 2020, but will be updated by Council as necessary from time to time.

Consent applications will provide for additional visitor parking space based on the expected visitor demand. This will depend on the office type: real estate agency, consulting engineering, financial services and so on. Council would expect visitor parking expressed as a percentage of staff parking to fall in the range [10%, 30%].

The Council will not normally require an associated travel plan to justify parking for office developments of this scale, but if a travel plan is submitted it will be taken into account in the processing of the consent.

An assessment of the queuing characteristics associated with developments of this scale will only be required if the daily traffic on the frontage road exceeds 11,000 veh/day.

[12] sqm glfa per parking space = glfa per employee *car occupancy/car mode share

Other Developments

In the formula for Rd at the beginning of Section 2.4 Ft, Fe, Fss, and Fstp are set to 1.

Rd = Rb * [Fo * Fwc * Fpt]

Values are prescribed for Fo * Fwc * Fpt in the table below:

Non-office Parking: Total Adjustment Factors		
Location	**Staff**	**Visitors**
Massey North Town Centre	0.86	0.93
Henderson Town Centre and Intensive Corridors with Quality Public Transport	0.80	0.90
New Lynn Town Centre	0.76	0.90
Other Parts of Waitakere City	0.89	0.94

The base parking selected for the proposed development must be split into staff and visitor parking components. The tabled adjustment factors are applied to these components. The transport reporting must provide a reasonable justification for the assumed split.

The results in this table are derived consistently with the future factors given in Section 2.3 but incorporate an additional common factor of 0.95 in lieu of the various adjustments required for larger developments (permitted parking > 15 spaces). The tabled values are considered to be appropriate for base years up to 2020, but will be updated by Council as necessary from time to time.

An assessment of the queuing characteristics associated with developments of this scale will only be required if the daily traffic on the frontage road exceeds 11,000 veh/day.

2.11 Shared Parking Space

If more than one but different activities have access to a common parking area the number of spaces Nd required for each activity on its own may be reduced. Example: an office block with a ground level restaurant. Restaurant parking peaks at 9pm when office parking demand is negligible, and office parking peaks during the day when restaurant parking may reach about 50% of its evening peak level. The same principle applies to compatible activities on different sites given that the walking distance between sites is not excessive.

The Nd for shared parking is the maximum of the Kij*Ndj summed for the j activities in each time period i of the day, where Kij is the fraction of peak demand Ndj for activity j occurring in time period i, and referred to as the "parking utilisation factor". In the absence of site specific data the utilisation factors tabled[13] below may be used for parking consent applications.

Activity	**Weekdays**			**Saturday / Sunday**		
	8am/5pm	**6pm/12am**	**12am/6am**	**8am/5pm**	**6pm/12am**	**12am/6am**
Residential	0.60	1.00	1.00	0.80	1.00	1.00
Office/Warehouse/Industrial	1.00	0.20	0.05	0.05	0.05	0.05
Commercial	0.90	0.80	0.05	1.00	0.70	0.05
Hotel	0.70	1.00	1.00	0.70	1.00	1.00
Restaurant	0.70	1.00	0.10	0.70	1.00	0.20
Cinema	0.40	0.80	0.10	0.80	1.00	0.10
Entertainment	0.40	1.00	0.10	0.80	1.00	0.50
Conference/Convention	1.00	1.00	0.05	1.00	1.00	0.05
Institutional (non-church)	1.00	0.20	0.05	0.10	0.10	0.05
Institutional (church)	0.10	0.05	0.05	1.00	0.50	0.05

Example: Nd for shared parking in the case of an office block for which Nd is 50 spaces and an apartment block for which Nd is 40 spaces is calculate as:

[13] These factors are from 'Shared Parking Facilities', Traffic Demand Management Encyclopaedia, Victoria Planning Institute, July 2008

Nd = max (50*1.00+40*0.60, 50*0.20+40*1.00, 50*0.5+40*1.00, 50*0.05+40*0.80, 50*0.05+40*1.00, 50*0.05+40*1.00)
= max (74, 50, 43, 35, 43, 43) = 74 spaces and this is less than the sum of the individual Nd (50+40 =90 spaces).

The table below is a guide to acceptable walking distances to/from off-site shared parking.

Desirable Maximum Walking Distances			
Adjacent (< 30m)	**Short (< 250m)**	**Medium (< 350m)**	**Long (< 500m)**
People with disabilities	Grocery stores	General retail	Airport parking
Deliveries and loading	Professional services	Restaurant	Major sport
Emergency services	Medical clinics	Employees	Major cultural event
Convenience store	Residents	Entertainment centre	Overflow parking

2.12 Dispensation for Motor-scooter/Motor-cycle Parking

Motor-scooter and motor-cycle parking space equates to 5 for 2 cars; demand equates at approximately 2%.

The Council will, if provision is made for such parking at approximately 2% of Np, give consent to a reduction in car-parking space in accordance with the table below:

Np	Dispensation (Car Spaces)	Condition (Motor-scooter/cycle Spaces)
[0,24]	0	0
[25,74]	1	1
[75,124]	2	2
[125,174]	3	3
[175,224]	4	4
[225,275]	5	5
Each extra 250 spaces or part thereof	5	5

2.13 Consenting Expectations

The Council can be expected to consent to well-justified parking less than the minimum amount permitted if no overflow is predicted. Indeed, Council seeks to achieve a more productive and attractive use of development resources, to support the walking and cycling modes, and stem the creation of under utilised parking.

If there is a predicted overflow proposed for service in the public domain, transport reporting should include the outcome of consultation with Council on this. Consent can be expected to depend on some or all of the following:

- the robustness of transport reporting
- the magnitude of No by time of day
- the availability of convenient on-street parking by time of day (supported by survey)
- identification of safety issues owing to overflow parking and if any issues the proposed solutions for these
- the availability of convenient off-street public car parking by time of day (supported by survey)
- the Council's Parking Management Plan for the locality and intentions for surplus parking utilization
- the Councils knowledge of plans to increase the proportion of walk/cycle and public-transport travel
- whether the site is in a growth node or corridor planned for land use intensification

If the Council agrees that overflow parking cannot be accommodated on site a 'cash in lieu' payment may required as a condition of consent. The cash in lieu amount set will be equivalent to the developer's cost saving through not providing the parking on site. Such payment will be used to provide public parking, or used to improve the quality of travel by alternative to car modes in the neighbourhood, including contributions to a shuttle bus operation, bus priority measures, cycling and walking infrastructure, transport interchange enhancement.

If there is a predicted overflow proposed for service in the private domain, transport reporting will include the outcome of negotiations for a sustainable arrangement. Consent can be expected to depend on:

- the robustness of transport reporting
- the magnitude of No by time of day
- the identification of sufficient, convenient, compact private off-street car parking by time of day
- a shared parking analysis (see Section 2.9 above)
- a formal legal agreement to the ongoing use of the planned shared parking by time of day.
- whether the site is in a growth node or corridor planned for land use intensification

3 MOBILITY CAR-PARKING SPACE

Car-parking for disabled persons shall be provided in accordance with the ratios of "*NZTS4121:2001"* applied to the District Plan's permitted minimum/maximum car-parking provision as follows:

Permitted Minimum/Maximum Number of Car-parking Spaces	Number of Accessible Car-parking Spaces for the Disabled
Up to 20	At least 1
21 up to 50	At least 2
Every additional 50	At least 1

Should it be agreed that it is not practical to provide this parking on site and that the same can be established conveniently in the public domain then the Council will require cash in lieu payment sufficient for such establishment.

4 LOADING SPACE

This guideline does not propose changes to the loading space ratios permitted in the District Plan. Those ratios are summarised in Appendix A3 "District Plan Loading Space Ratios"

However, consent may be granted in the case of a custom design having a reduced loading space ratio, provided this can be justified in the expert report by an operational analysis of the design, or an operational survey of a directly comparable existing development.

5 CYCLE-PARKING SPACE

Reference should be made to "*Guidance Note on Cycle Parking" ARTA 200:* the Council supports the amounts of cycle parking proposed in that note for various activities/establishments. These are summarised in Appendix A4, "ARTA Cycle-parking Ratios".

An indication of the desired order of cycle-parking recommended is as follows:

- 1 cycle-parking space per 20 permitted office car-parking spaces.
- 1 cycle-parking space per 10 permitted retail car-parking spaces.
- 1 cycle-parking space per 10% of intermediate, secondary, and tertiary students and staff

In addition lockers and shower-facilities are recommended in most cases.

Applicants seeking a reduction to the permitted number of car-parking spaces may be conditionally required to provide cycle-parking to the ARTA guideline ratios, especially for establishments in locations served by cycle-lanes, cycle-ways, and cycle-priorities.

6 PARKING SPACE: SPECIAL CONSIDERATIONS

6.1 Location

To ensure that parking and loading spaces proposed are used they must be located in convenient locations with direct access to the relevant pathways for movement within the development. Disabled spaces should be ramped to footpaths leading conveniently to doorways and lifts; loading bays should also be close to the lifts in storied-buildings. Cycle-parking should have priority over car-parking in regard to convenient access on foot.

6.2 Personal Security

The design of car-parking should address the issue of personal security and the Car Park Safety Manual (see Appendix F "References") presents principles and measures that should be taken into the design to achieve the objective of safe parking. The design will be assessed against these principles/measures for accreditation as a safe design.

The manual goes into fine detail with regard to principles/measures including the following:

- access control
- surveillance (informal, formal, and closed circuit television) and clear sight lines
- grid parking layouts avoiding dead ends
- white lighting to New Zealand standards
- one-way traffic circulation
- concentration of pedestrian movement
- separation of pedestrian and car movement
- direct linkages to outside of the car park and clear signage
- landscaping and amenity

6.3 Use and Identification of Spaces

The number of spaces required is intended to provide for all users including occupiers, staff, customers and visitors. For efficiency and safety it will often be appropriate to designate spaces for the use of specific users, such as staff, visitors, or specific tenancies, etc.

When Council requires spaces to be reserved appropriate signs and markings must be installed to clearly indicate the intended use of the spaces. Signs and markings should be designed in accordance with the Manual of Traffic Signs and Markings published by the New Zealand Transport Agency.

In residential development visitor spaces must be grouped and presented in such way as to be apparent to visitors, secure and available on a first come first served basis.

7 CAR-PARKING GEOMETRY

7.1 Introduction

Car-parking areas should provide for safe/efficient car manoeuvring and circulation, and safe access for the cars themselves, and for drivers and passengers.

7.2 Safety

Part 7 is a guide to providing for the safe layout of car-parking spaces and isles. The matter of personal safety and convenience is covered in Part 6.2.

7.3 Vertical Geometry for Car-parking

The gradient of a car-parking area should not exceed 6.0%, nor, where surface drainage is necessary be less than 2% for a concrete surface, or 3% for a bituminous seal.

7.4 Horizontal Geometry for Car Parking

Appendix B1 tables the layout dimensions that should be achieved in car-parking areas. These provide for efficient access to spaces by 90-percentile cars, and circulation aisles suitable for 99-percentile cars.

Spaces suitable for small cars only may be provided at random locations within a car-parking area, provided that it would be impractical to provide all spaces to 90-percentile standard, and that the number of small spaces is no more than 10% of the total number. Alternatively spaces suitable for small cars only up to 10% of the total number required may be provided in a group (or groups) provided these are in the most readily accessible part(s) of the car-parking area.

Intersections of aisles, driveways and circulation roads should allow for efficient turns by the 99-percentile car. Minimum turn path templates for a “small” car, 90-percentile car, and 99-percentile car are given in Appendix B 4,5,6,7, and 8.

All aisles and manoeuvring space must be clear of obstructions. The safety and efficiency of exceptional cases must be proven for the manoeuvring requirements of the small or 90-percentile car as appropriate, and the circulation requirements of the 99-percentile car.

Appropriate space-widths are required:

- all-day car-parking spaces (e.g.: for employees or tertiary-students) should be at least 2.4m wide
- medium-term car-parking spaces (e.g.: for town-centres or office-visitors) should be at least 2.5m wide
- short-term car-parking spaces where goods, children, sick-people are passengers (e.g.: for supermarkets, big-box retail, or medical-centres) should be at least 2.6m wide
- car-parking spaces for the disabled must be at least 3.2m wide and 3.5m wide where restraints at the edge of the space exist, including kerbs, columns, and walls.

A space next to a column, wall or other restraint should always be wide enough to function as if there were no restraint; this will be considered to be so if 0.3m is added to the space width tabled, and if car doors would not be obstructed. Open car doors fully extend to about 0.9 m, but offer reasonable access when extending 0.6 m. AS/NZS 2890.1:2004 provides detailed dimensions for positioning columns between car-parking spaces.

To preclude unsafe reverse movement along aisles, blind aisles will be accepted only in the case of 90-degree angle parking. In such cases the aisle must extend 1.0 m beyond the end spaces to facilitate egress from these spaces.

Normally every car parking space should be able to be used without the need to move another parked vehicle. A stacked-row means a double-row of parking, where one row blocks the other and where the un-parking of any blocking car allows a blocked car to be un-parked. Stacked rows containing up to 20% of the total parking capacity, may be accepted, provided the subject percentage is required for and designated for staff-parking, and provided the operation of the remainder of the car park is not compromised. In such cases the expert report must clearly justify the number of staff parking spaces proposed.

8 CYCLE-PARKING GEOMETRY

Cycle-parking requirements are covered fully in the AUSTROADS “Guide to Traffic Engineering Practise Part 14 Bicycles. The following extracts are indicative of the space needed for cycle-parking spaces:

- Commuters (Transport Interchanges): Secure lockers for 2 bicycles accessed from opposite ends are 1015 mm wide by 1840 mm deep. These can be arranged in rows with aisles 1500 mm wide.
- Employees and Students (Locked Compounds): Single rows of right angle parking require spaces 1200 mm wide by 1700 mm deep with aisles 1500 mm wide. Front-to-front rows can be overlapped to reduce the total depth for the doubled rows from 3400 mm to 3000 mm. The 1200 mm space width allows for the inclusion of ground mounted frames (750 mm high by 800 mm deep) against which the bicycles stand (and to which the bicycles can be locked in open compounds).
- Shoppers and Office Visitors (On-street and Open Compounds): Space requirements are as for the second bullet above.
- Less space is required if bicycles are hung vertically from overhead hooks. In this case modules are 1700mm high by 600mm wide and 1200mm deep

9 HEAVY VEHICLE PARKING AND DOCKING GEOMETRY

9.1 Introduction

Transit New Zealand Research Report, Number 32, 1994, (TNZ RR 32) “Site Design for Heavy Vehicle Facilities” provides data for the design of heavy-vehicle parking and loading layouts. The information in this guideline has been extracted from TNZ RR 32; it will be advantageous for consent applicants to refer to the full report.

9.2 Design Vehicles

Various truck types and sizes are employed on New Zealand Roads. An appropriate choice needs to be made for any particular site; the points below are a guide to the choice of the design truck for a development

- Van [V] — Offices, Non goods activities with GLFA less than 1500m².
- Medium Rigid Truck [MRT] — Larger Offices, Hotels/Motels, Shops, Domestic-refuse, Fire Service.
- Large Rigid Truck [LRT] — Warehouses, Industries, Local Distribution Depots, Industrial refuse, Fire Service.
- Semi-trailer [ST] — Line Haul Freight Depots, Container Terminals, Wharves, Commercial and Retail Centres, Service Stations.
- B-Train [BT] — Line Haul Freight Depots, Container Terminals, Wharves, some Warehouses and Industries, Heavy Vehicle Stops.
- Midi-Bus [MB] — See City Transit Bus (but where small buses only are allowed).
- City Transit Bus [CB] — City Transport Stations/Depots, Hospitals, Shopping Complexes.
- Tour Coach [TC] — Hotels and Motels (as appropriate), Tour Depots.

Minimum off-road turning path templates for these design heavy-vehicles are reproduced in Appendix B9, 10, 11, 12, 13, 14, and 15; for greater turning radii up to 25 m refer to TNZ RR 32. These templates offer a guide to the minimum turning space applicable. However, from time to time the New Zealand Transport Agency changes the dimensional specifications for design vehicles permitted to use New Zealand roads: the expert report must confirm that such changes have been properly allowed for in proposed designs for off-road heavy-vehicle movement: fully documented use of computer aided design modules for vehicle tracking will be acceptable.

9.3 Vertical Geometry

The maximum gradient for a heavy vehicle parking or loading area should not exceed 3%, with appropriate provision for surface water run off, i.e. not less than 2% for a concrete surface, or 3% for a bituminous seal; refer also to Part 10.5.1

9.4 Horizontal Geometry

Appendix B2 tables the layout dimensions that should be achieved in truck/bus-parking areas. A minimum bay width of 3.5 m is assumed; the heavy-vehicle turning path templates can be used to develop more spacious layouts. B-Trains are not intended to be reverse-manoeuvred; B-Train spaces should be open ended.

Appendix B3 “Truck-docking Layout Dimensions” tables layout dimensions for design-trucks to back up to a loading platform in a dock. Trucks are assumed to arrive by a path laid at 90-degree to the dock, and to swing left away from the dock to a prescribed angle before reversing to finish abutting the loading platform when positioned centrally in the dock. The “entry length” is determined by the extent of movement required beyond the dock and measured parallel to the approach path, and the “entry depth” by the extent of movement out from the dock and measured parallel to the dock. Appendix B3 provides dimensions for representative dock-widths entry-angles, and design-trucks. The bay-length tabled is the minimum enabling the back of the design-truck to abut the loading platform and be positioned central in the bay. For the design-truck to recess fully behind the face of the building housing the dock, the bay length must be increased to match the length of the design-truck.

The dimensions do not take into account the required space for exiting; the heavy vehicle turning path templates should be used for that determination.

10 ENTRANCE AND DRIVEWAY GEOMETRY

10.1 Introduction

Drivers must be able to stop and start safely and for this there must be adequate visibility to conflicting vehicles and pedestrians, and suitable carriageway gradients. There must also be adequate space for safe passage: safe side-clearances, overhead-clearances and under-vehicle-clearances.

10.2 Entrance Visibility: Motor Vehicles

10.2.1 Background

For a safe and efficient site entrance drivers must be able to see whether the way is clear. Even with ‘good’ visibility entrance movements can result in the slowing of through traffic; with lesser visibility the effect on the efficiency of through traffic is greater; conditions can be dangerous where visibility distances are short. The visibility required increases the greater the speed of the frontage road traffic. It is also affected by road gradient: more distance is needed to slow or stop when going down hill than when going up.

Should the application of this Part find that visibility is insufficient the District Plan allows for the consideration of remedies, such as traffic signals, or physical traffic calming works to reduce frontage traffic speeds, or etc. The chosen measure must be compatible with the Council’s overall management of traffic in the neighbourhood, and consultation with Council should be at the first opportunity.

10.2.2 Scope of Application

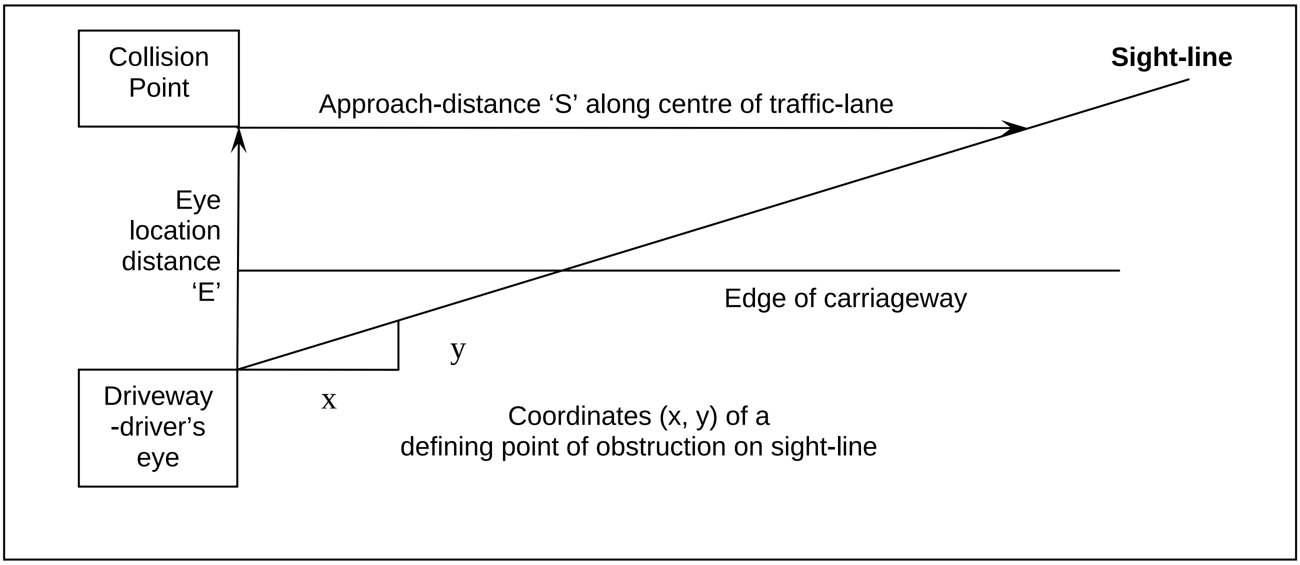
These guidelines for visibility assessment apply to the design of driveways for developments on individual sites. They also apply to the design of subdivision and precinct roads to ensure that safe efficient driveways can be provided wherever required.

10.2.3 Visibility Formulation

Visibility between a driveway and a particular frontage traffic lane is dependent on:

- the horizontal and vertical alignments of the lane
- the position of the driveway driver's eye
- intervening obstructions including major obstructions such as buildings and walls, and partial obstructions such as power-poles, trees, and utility-cabinets

The diagram below shows the fundamental dimensions pertaining to the assessment of the visibility to/from driveways and intersections. The 'visibility' of a particular traffic lane is considered relative to an origin at the driveway-driver's eye, fixed at a distance E from the centre-line of the traffic lane along the perpendicular to the lane through the drivers' eye. E = L + D where L is the distance from the carriageway-edge to the centre of the subject traffic lane, and D is the distance from the carriageway-edge to the diver's eye.



The absolute minimum value for D is 3m, but 4m is a desirable minimum for urban conditions; up to 7m may be desirable in a high speed environment where speed-change tapers are proposed on the frontage road.

The potential collision point is the point on the centre-line of the traffic lane at the perpendicular referred to above. A sight-line is defined by any point with rectangular coordinates (x, y) on the sight-line relative to the driver's eye, the Y-axis being along the aforementioned perpendicular. The point of intersection of the sight-line with the traffic lane centre line defines an approach-distance S relevant to the safety of the potential collision point. S is the distance between the two points and measured along the centreline of the traffic lane, whether or not it is straight or curved.

To account for the effect of crest vertical curves on driveway-driver visibility the sightlines are taken from a prescribed height for the driveway-driver's eye, 1.05 m, to a prescribed height for the headlights of the observed vehicle, 0.6m. For existing roads and in exceptional circumstances Council may allow these heights to be increased by 10%. The corresponding dimensions apply for the approach-driver's visibility to the driveway-driver's vehicle.

However, for side-roads, as distinct from driveways, the approach driver's visibility is taken to a height of 0.0 m to ensure all features of the intersection (including road markings) can be seen.

10.2.4 Assessment of Collision Points

The following approach-distances are required to assess the safety of the potential collision point:

- the available visible approach-distance Sa
- the safe visible approach-distance Ss
- the visible approach-distance left of a partial obstruction Sl
- the visible approach-distance right of a partial obstruction Sr

In the case of a partial obstruction the interval between Sl and Sr, SB, is taken to be the distance over which the visibility of an approaching vehicle is blocked.

For a safe driveway the following conditions must be satisfied:

All cases:

- Sa >= Ss

For the driveway-driver's right approach with Sa = Ss

- Sl >= Ss OR
- Sr < = Ss AND [Ss-Sr] <= 80% of Ss AND SB <= 10% of Ss

For the driveway-driver's right approach when Sa > Ss

- Sl >= Ss OR
- Sl < Ss < Sr AND [Sa – Sr] >= 20% of Ss AND SB <= 10% of Ss OR
- Sr <= Ss AND [Sa – Sr] >= 20% of Ss AND SB <= 10% of Ss

For the left approach identical formulations apply but Sr is interchanged with Sl.

Where there are multiple partial obstructions the above conditions apply to each obstruction, but in addition the sum of the SB values should not exceed 25% of Ss.

Put simply these algorithms state that the visibility distance chosen for design must be clear at the remote end from the driveway for 20% of its total, that any individual interference must be no more than 10% of its total, and that if there is more than one partial obstruction, the sum of interferences must be no more than 25% of its total. Allowance is made for cases where the available visibility distance is greater than the design visibility distance.

However, the algorithms can be applied to determine acceptable locations for partial obstructions to driveway visibility for a variety of conditions. Results for a straight road are mapped at Appendix C4 for 85-percentile speeds of 40 km/hr, 60 km/hr and 80 km/hr, and partial-obstruction widths of 300 mm, 600 mm, and 900 mm. It is clearly apparent that the lateral and longitudinal coordinates of partial obstructions, and their width, and traffic speed, are crucial to safe driveway and intersection visibility. These maps of acceptable location for partial-obstructions offer an appreciation of the scope of design required to achieve a safe roadside.

10.2.5 Available Approach Distances

The values for Sa, Sl, and Sr are most simply determined by scaling S values, computer-aided-design scaling is preferred, using the engineering drawings for the frontage road in the vicinity of the driveway: the drawings required are the road layout with physical features, and the vertical and horizontal alignments. Alternatively, the formulas provided in Appendix C5 can be used to calculate S values where the horizontal road alignment is a straight, a circle, a straight followed by circle, or a circle followed by a straight.

10.2.6 Safe Approach Distances

The values for Ss depend on driver, vehicle, and roadway characteristics.

It is *essential* that visible approach-distances be sufficient for:

- the approach-driver to stop before the collision-point should an entering vehicle be stalled in the approach-lane, a developed collision situation. This distance is referred to herein as the Stopping Approach Distance (SAD).

It is *desirable* that visible approach-distances be sufficient for:

- the approach-driver to stop safely should that driver discern a developing collision situation: this distance is referred to herein as the Desirable Stopping Approach Distance (DSAD). DSAD is taken, in accordance with widely accepted practise, to be SAD plus the distance travelled in 3 sec by an approach-driver at the 85-percentile approach speed.

The likelihood of encountering a developing collision situation is considerably less than the low-likelihood of encountering a developed collision situation. For this reason the achievement of DSAD by design is not always mandatory.

It is *essential* that visible approach-distances be sufficient for:

- the driveway-driver to assess and utilise a suitable critical-acceptance-gap in the approaching traffic stream(s). This distance is referred herein to as the Gap Approach Distance (GAD).

10.2.7 Acceptable SAD and DSAD Values

The safe approach-distance is the distance travelled at the design speed (taken to be the 85-percentile traffic speed) during the time the approach-driver perceives the need to stop and applies braking (approach-driver perception reaction time), plus the distance travelled to a stop during braking at the relevant AUSTROADS emergency deceleration rate. The latter distance is a function of the design speed, the surface friction, and the gradient of the roadway.

SAD = V*R/3.6+V^2/ (254*(G+1.197-0.175*lnV))
DSAD = SAD + V*3/3.6

V is the design speed in km/hr
R is the approach driver perception-reaction time in seconds
G is the decimal value of the approach gradient: uphill being positive and downhill negative

Appendix C1 tables SAD and DSAD values, for ranges of V, R, and G.

V and G for any particular driveway (or road intersection) are fixed by the prevailing traffic and topographical conditions. V should be measured, but a default value of 1.15 times the posted speed limit will normally be acceptable to the Council; these default values for V are included in Appendix C1. G should be measured, or determined from approved engineering drawings for the frontage road.

In regard to R, the additional reaction time of 3s for DSAD may be difficult to achieve in many cases. However, the designed approach-distances should be as close to DSAD as reasonably practical. The Council will require more weight to be given to DSAD the greater the volume of conflicting traffic movements at an entrance, and the greater the frontage traffic speeds, that is, to potentially busy driveways on busy main roads.

Appendix C1 highlights the weighting for DSAD recommended by the New Zealand Transport Authority (NZTA) for driveways in terms of driveway usage and the road classification[14]. For the busiest situations the NZTA recommends visibility to be DSAD with R = 2 sec; for the least busy situations the visibility recommendation is SAD with R = 1.5 sec.

[14] Reference: Land Transport Safety Authority 2001, RTS-6 ‘Guidelines for Visibility at Driveways’.

The methodology for driveways applies to the design of side-road intersections except that different parameter values are required. For intersections:

- the object height is taken to be 0.0m to ensure all road markings are visible to approaching drivers.
- for major urban road intersections the visibility requirement is to be DSAD with desirable-minimum and absolute-minimum approach-driver reaction times of 2.5 s and 2.0 s respectively. Council may admit 1.5 s in exceptional topographical circumstances where the design speed is 70 km/hr or less and a high expectation of flow interruption appertains, in which case the provision of advance warning signs will be required.
- for rural intersections the visibility requirement is to be DSAD with desirable-minimum and absolute-minimum approach-driver reaction times of 2.5 sec and 2.0 sec respectively.

10.2.8 Acceptable GAD Values

Gaps between vehicles in the frontage traffic are measured in seconds or in metres.

gs = gt*V/3.6

V is the 85th%le approach speed (design speed) in km/hr
gs is the gap in metre and gt is the gap in seconds.

The gaps accepted by drivers wishing to enter a traffic stream vary greatly depending on the characteristics of the entering drivers and vehicles, of the drivers and vehicles in the traffic stream, also the road/driveway or intersection geometry. The size of gaps accepted affects the delay imposed on entering drivers and the deceleration required of approaching drivers.

The so called "critical acceptance-gap" is a hypothetical minimal gap such that most drivers accept larger gaps and most drivers reject smaller gaps. The priority-delay-model is based on this concept. The acceptance-gaps for the various types of turning-movement differ owing to the differing tasks and risks associated with their negotiation; the acceptance gap size is also affected by the speed of the opposing flow.

The acceptable GAD is taken to be equivalent to the critical-acceptance-gap.

Appendix C2 tables acceptable GAD values expressed in metres. These are to be used to ensure the availability of clear sightlines to acceptable gaps in the passing traffic. Acceptable GAD values expressed in seconds are presented at Appendix E4 and are to be used for the calculation of driveway-driver delays.

Published values for critical acceptance gaps GAD are generally such that SAD<GAD<DSAD. It is paradoxical that SAD is insufficient for the achievement of acceptable service levels in regard to vehicles entering/leaving the frontage traffic stream. The opportunity must be taken in the design of new roads to make DSAD available wherever practical and affordable.

10.2.9 Transitory Visibility Blocks

There must be safe visibility for drivers **of** vehicles following vehicles that stop and/or slow down in the roadway to enter the site and allowance must be made for expected queue lengths. The occurrence of transitory blocks to visibility, including moving, parked, and queued vehicles, must be assessed and remedied in the applicants' expert reports.

10.3 Entrance Visibility for Cyclists and Pedestrians

Safe visibility distance should be provided to/from cyclists approaching vehicle entrance points along a cycle-lane or cycle-way in the road reserve.

Visibility distance and end-point definitions for cycle-ways and cycle-lanes are identical to those above for traffic lanes: the driveway drivers sight-line is from a point situated 1.05 m high 4 m back from the cycle path to a point situated 0.6 m high in the centre of the relevant cycle lane: this ensures that the upper-body of the cyclist is visible even though the cyclist's eye is taken to be situated 1.4 m high. Appendix C3 tables design approach visibilities for entrances with crossings to cycle-lanes having various 85-percentile cycle speeds, and approach gradients.

For pedestrians the minimum visibility distance should be 4 m for walking and 9 m or for jogging. Adequate visibility to pedestrians from a narrow driveway between buildings can be achieved through corner building splays 2.5 m into the driveway and 2.0 m along the frontage footpath. Where adequate visibility cannot be achieved a ‘car coming’ signal triggered by a vehicle detector in the driveway, or other warning device, may be acceptable.

10.4 Number and Location of Entrance Points

The number of entrance points should be the smallest that would result in reasonable delay for entrance traffic; see Part 12 of this guideline. Typically, one entrance may be sufficient per 500 parking spaces on site; some special activities require two accesses even though the number of spaces is small (e.g. petrol stations).

Accesses should be located to achieve maximum visibility, but with due consideration for possible interference to other entrances in the vicinity, or to nearby road intersections.

When a site has more than one road-frontage the entrance will be provided on the minor of the two roads and as far from the major road as feasible. This eliminates the hazard of unexpected speed changing and turning in the major road near the intersection, and provides site traffic with better intersection, rather than driveway, levels of service in turning to/from the major road.

For the safety and amenity of pedestrians, a proposed vehicle-crossing for an entrance should be separated from the vehicle-crossing of an adjacent site. The separation should be at least 2.0m.

10.5 Vertical Alignment: Entrances and Driveways

The design of the vertical alignment of the driveway and vehicle-crossing must be integrated, and must provide a safe approach to road-side pedestrian and cycle routes.

10.5.1 Driveway Gradients

Driveway gradients are not to exceed the following maximums:

- For public driveways and cars only: 10% where queuing is required, otherwise 15% if the driveway-length exceeds 20 m, and 20% if the driveway-length is less than 20 m.
- For private driveways and cars only: 20% is the desirable-maximum and 33% absolute-maximum gradient.
- For heavy vehicles: the absolute-maximum is 10%

Where a driveway gradient is to exceed 20%, high friction surfacing and a separate footpath should be provided; emergency stopping controls such as high kerbs will be required if gradients exceed 25%. For heavy vehicles high friction surfacing should be used if the proposed gradient exceeds 5%.

Sloping driveways can significantly increase the adverse effect of rain water run-off to the road reserve or to the site, especially if the driveway gradient exceeds 15%. Run-off will be controlled through the provision of suitable drainage channels (see WCC Code of Practice for City Infrastructure and Land Development).

10.5.2 Safety Platforms

A safety platform between the site and any walking (or cycling) path in the road-side reserve is essential. A safety platform enables exiting drivers to stop/check/start safely and conveniently clear of the footpath or cycleway. The platform length should be at last 5m for cars and at least the design heavy-vehicle length for heavy-vehicles. The platform gradient should be no more than 5% for an up-approach to the frontage road, nor more than 10% for a down-approach. A safety platform should be provided even if there is no footpath or cycleway between the site and the carriageway.

10.5.3 Under-body Clearance – Gradient Changes

Gradient changes need to be transitioned to prevent cars ground-scraping, and to prevent heavy-vehicle and heavy-vehicle-coupling strain. Driveway gradient-changes are not to exceed the following maximums:

- For cars: 14% (8 degrees). A design car under-body clearance template is produced at Appendix B16.
- For rigid heavy vehicles: 8% (4.6 degrees) over a minimum of 4 m
- For articulated heavy vehicles: 6% (3.4 degrees) over a minimum of 10 m.

These controls can be used to check transition designs; an 8 m radius circular curve will usually be sufficient for heavy vehicles.

10.5.4 Overhead Clearance

Minimum overhead clearances that ensure design vehicles can pass safely under overhead structures are as follows, but where there is gradient change 0.1 m, or more as expertly determined, must be added:

- Cars: absolute minimum 2.1 m
- Cars where access and parking is required for disability-vehicles: 2.5 m.
- Vans: 2.5 m
- Midi-buses: 4.0 m
- Medium-rigid-trucks, city-transit-buses, tour-coaches: 4.5 m
- Large-rigid-trucks, semi-trailers, B-trains: 5.0 m

10.6 Layout of Entrance

Normally, the vehicle crossing designs in the Council’s Engineering Design Code will be acceptable.

However, crossings serving high traffic generating uses on roads of higher classification require specific detailed design. Layouts should allow turns to/from the site to be made smoothly in regard to geometry and speed. Speed should be balanced by the need to minimise interruption of road traffic and maximise the safety of pedestrians and cyclists. Larger radius turning should be restrained by the use of a ramped pedestrian platform across the entrance.

Two exit lanes about 25 m long should be provided where the exit flow is expected to exceed 75 veh/hr and the average exit delay is expected to be up to about 50 seconds. The exit lanes should each be 2.5 m to 3.0 m wide and the entry lane 4.0 m to 4.5 m wide, depending whether heavy vehicles are to be serviced. In any case the spatial requirements for major accesses must optimised and proven through drawings showing the swept paths of appropriate design vehicles with adequate clearances of no less than 0.5 m.

For left-turn exit movements the angle between the axis of a waiting vehicle and a perpendicular line to the frontage road should not exceed 20 degrees; greater angles hamper the search for acceptable gaps in the frontage traffic, efficiency and safety are compromised.

The desired minimum swept path for cars on major roads is the 99-percentile car on an outer wheel track of 7.5 m radius, but an absolute minimum outer wheel track radius of 6.5 m may be justified for some major road cases, and is desirable for minor road cases. The off-road heavy-vehicle turning templates referred to in Part 5 are not acceptable for the purpose of designing accesses for major roads: drawings showing computer generated swept paths for design vehicles to current New Zealand Transport Agency specifications will be required to justify proposed designs.

10.7 Layout of Driveways

10.7.1 Residential Driveways

The layouts and on-site turning requirements for residential driveways prescribed in District Plan Rule 12 “Car Parking and Driveways (Living Environment)” are appropriate and summarised below:

- If the number of living-units is no more than 1 dwelling-unit plus 1 minor household-unit, the carriageway should be 2.5 m wide, and reverse car-movement egress is permitted but only if the frontage road is not a major road and the driveway-length is less than 20 m. Otherwise provision must be made for on site turning to enable forward egress from the site.
- If dwelling-units and/or minor household-units number 2, the carriageway should be 2.5 m wide. In order to maximise on-site safety reverse car-movement egress is not permitted, but passing bays are not required. The additional width required for service strips adjacent driveways is 0.7 m.
- If dwelling-units and/or minor household-units number 3, 4 or 5, the carriageway should be 2.7 m wide. In order to maximise on-site safety reverse car-movement egress is not permitted, and passing bays are required at maximum intervals of 50 m but not necessarily at the property boundary. The additional width required for service strips adjacent driveways is 1.3 m.
- If dwelling-units and/or minor household-units number 6, 7, 8, 9, or 10, the carriageway should be 3.5 m wide. In order to maximise on-site safety reverse car-movement egress is not permitted, and passing bays at maximum intervals of 50 m with separate in and out lanes at the property boundary are required. The additional width required for service strips adjacent driveways is 1.5 m.
- In all cases overhead clearance of 4.2 m is required to allow for occasional truck access.
- In all cases any bend will have minimum inside and out side radii of 6.5 m and 12.0m to allow for occasional truck access.

District Plan Rule 12 further details the requirements for the service strips each side of residential driveways.

When reverse car-movement egress is not permitted, the car-parking geometry for 90 degree parking, tabled at Appendix B1, can be used to dimension the minimum “3-point-turn” space required for each living unit.

As a guideline passing-bays should be 7 m long with additional 45-degree tapers and of such depth as to achieve a total carriageway plus parking-bay width of 6.3 m.

10.7.2 Public Driveways for Cars Only

For public driveways for use by cars only, as distinct from parking-isles, the guideline carriageway widths are 3.5 m and 6.5 m for one-way and two-way operation respectively. The number of lanes at the frontage road will depend on the capacity, delay and queuing analysis as described in Part 12 herein. The minimum width of exit lanes should be 3.0 m and entry lane 4.0 m but suited to appropriate turning path requirements as indicated in Part 10.6.

For one-way circular sections, including circular ramps, the carriageway minimum inside and outside kerb-face radii should be 4.0 m and 7.6 m respectively, with additional lateral clear space beyond the kerb faces of 0.3 m and 0.5 m respectively. The carriageway width is 3.6 m for the radii given and for outside radii up to 12 m: for greater radii up 20 m the carriageway can be reduced to 3.1 m, and for all greater radii again to 3.0 m. The maximum super-elevation should be 5%.

For two-way circular sections with a 0.5 m separator, the same dimensions apply except that the minimum outside radius is 11.8 m.

Reverse car-movements to the frontage road are not permitted.

10.7.3 Heavy Vehicle Driveways

For driveways for use by trucks or buses guideline carriageway widths are 4.0 m and 7.5 m for one-way and two-way operation respectively. Widening on bends will be sufficient to ensure 0.5 m clearance to obstructions each side and 1.0 m clearance between opposing vehicles on the bend.

Provision will be made to ensure that heavy vehicle movements to and from the frontage road can be made without reversing. Reverse movements from the frontage road may be acceptable where there is generous manoeuvring space, good visibility, and the frontage traffic volume is never expected to exceed 175 veh/hr. Otherwise provision will be made for on-site turning.

These characteristics will be assessed and reported with reference to swept path tracking lines for the design vehicle on geometric plans for proposed site parking, loading and access facilities, and the frontage road. The information provided in Part 5 and computer aided design for vehicle tracking will be required in the expert report.

11 TRIP-GENERATION

11.1 Introduction

The delays and queues associated with traffic entering/leaving a site depend on the volume of traffic generated by the activities on the site and on the volume of frontage traffic. Also, the volume of site generated traffic can adversely affect neighbourhood amenity. Part 11 of the Guideline deals with the estimation of the amount of traffic generated by activities; Part 12 deals with the associated queuing effects.

The estimation of trip generation is analogous to the estimation of parking demand as presented in Part 2.3 of the Guideline; Part 11 should be considered in conjunction with Part 2.3. Trip-generation is expressed in terms of ratios. Example; vehicle in-trip per hour per 100 sqm GLFA and vehicle out-trip per hour per 100 sqm GLFA.

$V = R*A$ where V is the volume of vehicle-trips for a given trip-generation ratio, R, and development activity measure, A, the latter variables being expressed in compatible units.

In contrast to parking demand the treatment of trip-generation requires six and sometimes eight ratios rather than one. In-trip and out-trip ratios are required for the November Thursday AM-peak hour, main INTER-peak hour, and PM-peak hour, also the Saturday-peak hour if significant queuing and delay outcomes are a possibility (as may well be the case for sales activities).

Development applications will include transport reporting on traffic effects, including the estimation of the design trip-generations. However, if the number of parking spaces proposed is <= 25 spaces and the average daily traffic is <= 11,000 veh/day the trip-generation estimation and queuing assessments are not required. The traffic assessment then reduces to the matters dealt with in Parts 6, 7, 8, 9 and 10 of the guideline, essentially safe efficient geometric design including provision for safe sight lines at the entrance.

Furthermore, the burden of trip estimation may be reduced if a rough estimate of the PM-peak traffic generation be made as the basis for a preliminary queuing assessment in accordance with Part 12 of the guideline. The PM peak period is normally the peak with least capacity to serve trips going to/from development. If the preliminary queuing assessment clearly indicates queuing effects to be minor then it will not be necessary to refine the traffic generation estimates.

It is essential to understand that trip generation estimates must be consistent with the proposed parking supply. If all associated parking is not provided on site then the trip generation must be appropriately shared to and effects assessed for each proposed parking supply site; the allocation of trips needs to account for the staff and visitor components of the total parking demand.

11.2 Design Trip-generation Ratios

As for parking demand (see Part 2.3) three methods may be used to produce/justify the traffic generation for a proposed development:

1. survey of a similar development
2. use of existing data for a similar development from a reputable data base
3. use of an operational rationale or model for the proposed development

Methods 1 and 2: Use of Survey or Database

The table below provides an appreciation the level of traffic generated by various activities in the PM peak period; the source of data for this table is the NZTPDB database. Data for sales activities has been temporally adjusted using the Ft values of Part 2.4.

Activity	NZ Trips & Parking Database Bureaux PM peak Trip Generation Ratio [Rd] Ranges					
	Trip Direction	Sample Size	(trips per hour per 100sqm GLFA) Minimum	Maximum	Average	Median
General Retail	In	10	0.3	23.0	6.4	3.0
	Out	10	0.5	25.3	6.7	2.9
Large Format Retail	In	12	0.4	6.7	2.7	2.2
	Out	12	0.6	8.2	3.1	2.6
Supermarket	In	5	8.1	9.3	8.9	8.9
	Out	5	8.5	8.9	8.7	8.7
Shopping Centre	In	130	0.6	32.4	7.9	8.0
	Out	130	0.9	33.7	8.1	7.9
Office	In	12	0.0	1.8	0.6	0.5
	Out	12	0.3	2.5	1.1	1.0
Industry	In	10	0.1	1.7	0.7	0.7
	Out	10	0.8	1.3	0.6	0.4
Storage/Warehouse	In	5	0.2	0.8	0.4	0.4
	Out	5	0.3	1.6	0.7	0.5

Appendix D1 provides some base trip generation ratios and refers to generally available databases that may be useful to designers; these databases are of New Zealand, Australian, United Kingdom, and American origin. Traffic planning consultancies are likely to have assembled proprietary databases for their exclusive use.

The base ratios Rb found by survey or from a database data must be aligned to account for differences between the base case and the proposed design, the dates of the specific or database surveys and other factors. This is achieved using exactly the same procedure and factors presented in Part 2.3 of the Guideline (for the conversion of the base parking ratios Rb to the design parking ratios Rd).

$$Rd = Rb * [Ft * Fo * Fwc * Fpt * Fss * Fstp * Fe] * FF$$

Method 3: Operational Rationale (Model)

An estimate of trip generation may be made directly on the basis of a well defined operational rationale for the proposed development. This would be produced by the designer to match the client's brief. The use of an operational rationale for the development has the disadvantage that it may be subject to bias. The risk of bias should be small if the rationale is logical and clearly presented, and outcomes can be checked with reference to database data as indicated in the example of Part 2.3 Method 3. However, it will not always be straightforward to produce a convincing model and the use of methods 1 or 2 may often be preferable. In regard to Method 3 and adjustment factors, only the future factor FF is relevant: Rd = Rb * FF.

For this method some useful relationships and examples are presented below:

For shoppers car parks Council's surveys have revealed that $t = 7.9*A^{0.37}$ veh/hour each way where t is the time parked and A is in 100sqm GLFA, and A is in the range 250 sqm GLFA to 35,000 sqm GLFA.

Car park turnover is in equilibrium

$$V = k*N*(60/t)$$

where V = volume of in-trips = volume of out-trips per hour, N is the number of parking spaces proposed, k is the percentage of N that are productive, and t is the average time parked in minutes.

Example: A 7000 sqm mall with supermarket is to be provided with 7*70 = 490 spaces, 15% being for staff. The provision also allows for 10% of customer spaces to be vacant when the GLFA is fully productive. The average customer stay time is expected to be 7.9*70^0.37= 38 min. 75% of spaces are productive and the traffic generation is 75%*490*(60/38) = 580 in-trips and 580 out-trips per hour (8.3 trips per 100sqm GLFA).

Complex arrivals and departures

The in-trip/out-trip shopper car park equilibrium that occurs during the inter-peak road traffic period may become asymmetrical during the PM peak traffic period; the directional trips rates may increase or decrease depending on the site activity. It is recommended that the inter-peak equilibrium rates modelled as above be scaled to peak period rates using the trip data for all traffic periods given in Appendix D1.

Example: data for malls less than 10,000 sqm GLFA suggests the PM peak trip rates are symmetrical and 95% of the symmetrical inter peak rates. For the equilibrium example above, PM peak in-trip and out-trip rates scale to 580 * 0.95 = 550 in-trips and 550 out-trips per hour.

Simple one-directional arrivals or departures

$$\mathbf{V = N/D}$$

where V is the departure or arrival volume in veh/hour, N is the number of parking spaces allocated and D is the duration of the arrival period in hours.

Example: in Part 2.3 of the Guideline 'Estimation of Parking Demand', Method 3, new premises for a consultancy office are proposed. Provision is required for 5 principals and 40 staff. 20 sqm GLFA is proposed per person, giving a total 900 sqm GLFA. It is expected on the basis of past experience that at any time 2 principals may have client visits involving 3 cars and that 10% of staff may have client visits involving 1 car. At any time 1 principal and 5% of staff and may be out off office. The location is well served by public transport; census data suggests that 30% of commuters use public transport and that the peak hour car occupancy is 1.3 person/car for the locality, which is remote from residential development.

The number of parking spaces required is modelled in Part 2.3 as 24 spaces for principals and staff with 6 extra spaces reserved for visitors. A rationale for deriving the trip generation for this case is as follows.

Visits to staff and principals are known to average 30 minutes and so the trips per hour cannot exceed 6 * 60/30 uses per hour = 12 arrivals per hour. Of the staff and principal's parking approximately 1 + 5% of 40 = 3 spaces are notionally used for business trips. Business trips are known to average 90 minutes and so the trips per hour for staff and principals business trips are likely to average 3 * 60/90 uses per hour = 2 departures per hour. The inter peak generation is therefore approximately 14 arrivals and 14 departures per hour.

The office is to open at 8.30am and close at 5.00pm and there is to be flexitime of one hour either way at each end of the day. There will be approximately 24/1.5 = 16 in-trips per hour in the morning peak and 16 out-trips per hour in the evening peak, plus say quarter the inter peak generation = 3.5 in-trips per hour. The AM-peak and PM-peak generations are approximately 19 arrivals with 3 departures per hour, and 3 arrivals with 19 departures per hour respectively.

The PM-peak generation is 3/9 = 0.3 in-trip per hour per 100sqm GLFA and 19/9 2.1 out-trip per hour per 100 sqm GLFA. These rates fall within the NZTPDB database recorded range for offices tabled above.

Treatment for Multiple Purpose Trips

An additional downward adjustment is required in the case of any commercial development proposed for a locality containing or to contain many commercial establishments. This is because a single vehicle-trip to such an area allows more than one establishment to be accessed in the walk-mode; a number of trip purposes can be satisfied by one vehicle-trip. It is emphasised that the amount of parking does not change significantly, since the durations of the visits for the separate activities are substantially the same whether or not separate vehicle visits are made.

An appreciation of the order of reduced trip-generation for multiple activities is afforded by the results tabled below for the surveyed peak traffic generation of a regional mall, a district mall, and an isolated discount fruit-and-vegetable shop. The data was collected by Waitakere City Council through surveys in December 1992.

Establishment	GLFA (sqm)	In-trip + Out-trip (veh/hr/100 sqm GLFA)
St Lukes Mall	32,740	10
Lincoln North Mall	6,230	22
Fruit-and-Vegetable Shop	355	62

It is apparent, referring to the GLFA that an effect of increasing the number of activities in close proximity is to very substantially reduce the vehicle-trip generation rates, at least for retailing activities.

When a development with multiple-activities is proposed supporting data from a survey for a similar mix is desirable. Alternatively if generations for the separate activities are to be added due allowance must be made for visitors being attracted to more than one activity during a single visit. Such allowance may be difficult to justify but Council would expect a reduction factor in the range [0.5, 1] depending on the scale of development and the range of uses available to visitors within a convenient walking distance: also the time of day because for example there will be very few multiple purpose trips in the AM peak period.

A rationalisation of the issue for inter-peak and PM peak periods is afforded by the table below showing credible distributions of car trips to 1, 2, 3, 4, or 5 trip purposes. For each case the average visits per car trip are derived. The inverse of the average is the car trips per visit to a specific establishment. The sensitivity analysis indicates this factor to be fairly stable subject to moderate changes to the assumed percentages.

1	2	3	4	5	Average	veh/trip
30%	45%	21%	3%	1%	1.90	0.53
45%	30%	21%	3%	1%	1.85	0.54
30%	50%	16%	3%	1%	1.95	0.51
50%	30%	16%	3%	1%	1.75	0.57

Transport reporting must be clear in regard to the base data used for trip-generation and its adjustment to suit the subject development case. Isolated developments and developments adjoining multiple uses must be appropriately assessed as indicated above.

'Drive By' Trips

A proportion of the trips generated will be drawn from existing frontage traffic. Council would expect this proportion of so called 'drive by' traffic to fall in the range [0.1, 0.3]. This does not alter the amount of traffic in/out of the proposed development. It reduces the amount of traffic added to the existing frontage road traffic as a result of the proposed development. Due allowance should be made for this in the assessment of queuing effects as prescribed in Part 12 of the Guideline.

12 ENTRANCE CAPACITY DELAYS AND QUEUES

12.1 Introduction

Excessive delays or queues owing to traffic entering or leaving a site will generally result in unsafe and/or inefficient traffic conditions in the vicinity of the entrance. The magnitude of entrance generated delays and queues depend on:

- the volume of site generated traffic
- the design of the entrance
- the volume of frontage road traffic
- the design of the frontage road

Advice should be obtained form the Council and other relevant authorities in regard to the frontage road traffic volumes and frontage road design. Either or both of these factors could be subject to change as a result of intended transportation development projects; widening for bus lanes, completion of new road links, and corridor management plans are examples.

Part 12 of this guideline is concerned with the estimation and assessment of entrance capacity, delay, and queuing characteristics for an entrance under typical priority control. This is the commonly occurring situation.

An access-movement demand is referred to as Va vehicle/hour, an opposing traffic flow as Vo vehicle/hour, an access movement capacity as C vehicle/hour, an average delay as D seconds, and an average maximum queue length as L metre. X, the 'traffic load', is the ratio of access demand to access capacity (Va/C). Va must be factored to allow suitably for demand fluctuations within the design hour. The factor to be applied is "the average hour-rate for the quarter hours with an hour-rate greater than the hour-rate for the whole hour, divided by this latter hour-rate".

If the application of Part 12 finds that typical priority controls would not work then alternatives must be investigated. These could include measures to reduce the amount of traffic generated: such as a reduction in the scale of the development, or a viable travel management plan for the development. Traffic engineering alternatives that might be acceptable include traffic signal control, a roundabout island for the entrance, a second entrance, right-turn prohibitions, and a median lane in the frontage road to facilitate right turns, traffic calming works in the frontage road to reduce traffic speeds, and so forth.

Any such alternative proposed must be compatible with the Council's overall transport planning for the neighbourhood, and the frontage road in particular: pertinent advice should be sought from the Council, at the earliest opportunity, as to the likely suitability of alternatives proposed for investigation.

Alternative designs will be developed in accordance with best practice; traffic signal controls and roundabouts for example will follow the AUSTROAD Guides to Traffic Engineering Practice and Urban Road Design.

All associated in road-corridor works-costs will be born by the developer.

12.2 Preliminary Assessment

For a proposed access lane with Va being the access demand for that lane, and Vo the opposing flow, a preliminary assessment can be made using the relationships below.

Ca = 700 – 0.5*Vo and X = Va/Ca

Should Ca be greater than 400 veh/hr, and X be less than 0.7, the access lane is likely to have adequate capacity and queuing effects are likely to be not significant.

12.3 General Assessment: Limiting of Effects

The average delay and maximum queue length for each access movement of a proposed development should be estimated using the method described in Part 12.4 below, for a certain design year. The design year should be the third year following the construction year but depending on the outcome of consultation with Council and relevant transport authorities, see Part 11.1 above.

For each movement the average delay calculated should not exceed a desirable-maximum average delay of about 50 seconds, in each of the following design hours; a late-November/early-December Thursday AM-peak , most trafficked INTER-peak, and PM-peak hour, and the most trafficked Saturday hour. A calculated average delay of up to about 90 seconds may be acceptable if the calculated queue length is small (up to about 18 metre).

Where a right turn entry movement of Va vehicle/hour shares a lane with frontage through traffic of Vt veh/hr in that lane, the delay should be limited in accord with D < (3000 - Vt*2)/Va seconds.

Queue lengths should be such as not to interfere with other access points, general frontage road traffic operations, and safe and efficient on-site traffic movement including walking.

12.4 Capacity Delay and Queue Calculation

12.4.1 Input Data: Frontage Road

For each of the design hours required by the Waitakere City Council to be studied, the frontage road traffic volumes and speeds, and proportions of traffic platooned, are required. These should be obtained by survey or from the Council's databank and factored to design year levels.

The proportion of frontage traffic that is platooned has a large affect on the capacity available for movement to/from a site. Traffic leaving a traffic signal, that is efficiently set, is normally fully platooned, but spreads out with distance travelled, tending to become fully randomised at about 1250m away. A guideline for the proportion, P, of traffic platooned at a distance "S" metre is given by P = maximum [0 and 1 – S/1250].

An entrance movement that is opposed by two or more major flows, for example the right turn from a mid-block site is subject to an effective proportion of platooned traffic that depends on the "overlap" of platoons arriving at the entrance. Suppose the directional opposing flows are characterised by (V1, P1) and (V2, P2). The proportion of the combined opposing flows (V = V1 + V2) that is platooned, lies in the interval given by the expression, P = [max (P1V1/V, P2V2/V), (P1V1+P2V2)/V]; the design proportion can be taken as the midpoint of this interval and a sensitivity check undertaken if the outcomes are critical. It may be necessary to calculate the design proportion from the platoon generating characteristics of the intersections either side of the proposed development entrance.

The frontage road traffic lanes, including any median lane facilitating right-turns, are also a necessary input.

12.4.2Input Data: Site Entrance

The site entrance movement volumes should be derived from the site trip-generations estimated in accordance with the method in Part 11 "Trip-generation" The separate trip-volumes to and from the site will be split rationally into turning volumes and this will be clearly justified.

The proposed entrance traffic-lane layout is required; delay and queue length can be reduced by increasing the number of access lanes. Normally 2 exit lanes and 1 entry lane are sufficient.

12.4.3 "Acceptance-gap" and Multi-lane Opposing Flows

The delay to a driver turning into or across frontage traffic is dependent on:

- the volume of opposing traffic
- the size of the "gap" a driver is prepared to accept.
- the headways between 2 or more drivers in a single lane accepting a single gap
- the proportion of platooned traffic in the opposing traffic
- whether the opposing traffic is in a single or in multiple lanes

The so called "critical acceptance-gap" is a hypothetical minimal gap such that most drivers accept larger gaps and most drivers reject smaller gaps. The priority-delay-calculation is based on this concept. The acceptance-gaps for the various types of turning-movement differ owing to the differing tasks and risks associated with their negotiation; the acceptance gap size is also affected by the speed of the opposing flow. Platooning and multi-laning of the opposing flow increases the proportion of "acceptable gap" and hence the capacity of the opposing traffic to accept development traffic movements.

Appendix E1 tables delays and queues for site turning-movements based on their traffic loads; Appendix E2 table's capacities for single and multiple lane opposing flows: Appendix E3 tables opposing-flow factors: Appendix E4 tables critical-acceptance-gaps; Appendix E5 presents the priority delay function that is the basis for Appendices E1 and E2

The following procedure is used to estimate the delay and queue-length for each turning-movement at an entrance using the appropriate tables in Appendix E.

12.4.4 Estimation Procedure

For each site-access movement:

- the required critical-acceptance-gap is selected from the table at Appendix E4.
- the opposing-traffic volume is calculated using the factors from the table at Appendix E3.
- using the critical-acceptance-gap and opposing-traffic volume from the previous steps the available capacity is recorded from the values tabled at Appendix E2.
- The capacity of a blocked entrance, for example one blocked by a queue on the approach to a traffic signal, can be found by using the method of the previous step, and then applying a capacity reduction factor equal to the proportion of time the entrance is not blocked. The latter could be measured, or estimated from analysis of the queuing characteristics of the blocking generator.
- using the capacity from the previous step(s) and the entrance-movement volume the traffic-load X is calculated as Va / C.
- using the traffic-load and the capacity from the previous steps the average access-movement delay, D is read from the table at Appendix E1. The higher average delay for vehicles that are actually delayed can be calculated using the appropriate factor also tabled at Appendix E1.
- the average queue length is calculated using the expression, L = D * Va / 300 metre
- the maximum queue length is taken to be 2.5 times L.

Alternatively the results can be calculated using the formulae at Appendix E5.

Where two or more turning movements share a lane, the delay for each movement type can be calculated using the total volume in the shared lane. The average delay for the combined movements in the shared lane can then be taken as the average of the separately calculated delays but weighted by volume.

Initial sensible assumptions for inputs and a quick application of the method may indicate no possibility of the permitted limits for delays and queues being exceeded, (refer Section 12.3). Such assessments may be accepted, but in marginal cases careful use of the method will be necessary, particularly if the effects could be severe.

12.4.5 Worked Example

The frontage road daily traffic is 20,000 veh/day. The proportion of traffic platooned is 0.5. The peaks have 10% of ADT split 65:35. The inter-peak has 8% of ADT split 55:45. The 85th %le speed is 60 km/hr. There is one lane each way with a flush median.

The site entrance is at mid-block and the site trip-generation (tabled below), is equivalent to that for some 8000 sqm retail-GLFA. Two exit lanes and one entry lane, with good visibility and geometry, are proposed for the site entrance.

The pertinent frontage traffic flows are:

AM-peak	through eastbound and westbound 1,300 veh/hr and 700 veh/hr
INTER-peak	through eastbound and westbound 880 veh/hr and 720 veh/hr
PM-peak	through eastbound and westbound 700 veh/hr and 1,300 veh/hr

The opposing flow calculations are:

AM-peak	left-out westbound	0.2 * 50 + 700 = 710 veh/hr
	right-out eastbound	710 + 0.25 * 1300 + 50 = 1085 veh/hr
	right-in from the west	710 veh/hr
	left-in from the east	0.5 * 50 = 25 veh/hr
INTER-peak	left-out westbound	0.2 * 250 + 720 = 770 veh/hr
	right-out eastbound	770 + 0.25 * 880+ 250 = 1240 veh/hr
	right-in from the west	770 veh/hr
	left-in from the east	0.5 * 250 = 125 veh/hr

Transportation

PM-peak	left-out westbound	0.2 * 100 + 1300 = 1320 veh/hr
	right-out eastbound	1320 + 0.25 * 700+ 100 = 1595 veh/hr
	right-in from the west	1320 veh/hr
	left-in from the east	0.5 * 100 = 50 veh/hr

Period	Movement	Va	gap	Vo	Vo	Ca	X	D	Lmax
		(veh/hr)	(sec)	(veh/hr)	(lanes)	(veh/hr)		(sec)	(m)
AM-peak	LO	50	4.75	710	1	575	0.09	7	3
AM-peak	RO	50	4.50	1085	2	595	0.08	7	3
AM-peak	RI	50	4.50	710	1	630	0.08	6	3
AM-peak	LI	50	4.25	25	1	1376	0.04	3	1
INTER-peak	LO	250	4.75	770	1	522	0.48	14	29
INTER-peak	RO	250	4.50	1240	2	515	0.49	14	29
INTER-peak	RI	250	4.50	770	1	570	0.44	13	27
INTER-peak	LI	250	4.25	125	1	1278	0.20	4	8
PM-peak	LO	220	4.75	1320	1	118	**1.86**	**366**	**671**
PM-peak	RO	220	4.50	1595	1	50	**4.40**	**507**	**930**
PM-peak	RI	100	4.50	1320	1	139	**0.72**	**81**	**68**
PM-peak	LI	100	4.25	50	1	1358	0.07	3	3

- The table above summarises the application of the procedure for capacity, delay, and queue estimation
- Opposing flows to RO-movements in the AM and INTER peak periods are taken to be in 2 lanes as eastbound traffic is 60-65 % of total
- Opposing flows to RO-movements in the PM peak period taken to be in 1 lane as eastbound traffic is 85 % of total
- Results are extrapolated from the appended tables having regard to “vehicles per hour”
- For “traffic load” and “percent-platooned” the closest tabled values are used (e.g. X=0.1 for X<0.1, X=0.5 for X=0.48, X= 1.1 for X>1.1)

It is concluded for this example that alternative access arrangements must be investigated owing to the severe delays and queues that would be generated in the PM-peak period by the proposed priority controlled entrance.

13 NEIGHBOURHOOD TRAFFIC EFFECTS

Site generated traffic can have significant adverse effects at places beyond the vicinity of the site entrance.

In cases where the volume of generated traffic is substantial, meaning that neighbourhood network performance is likely to be measurably affected, the Council may require the effects of the generated traffic to be assessed on the basis of its assignment to a modelled network. The Council’s city-wide analogue road traffic assignment model or local-area micro-simulation models may be used to facilitate such investigations.

For developments with neighbourhood significance the safety impacts will also have to be quantified and assessed using best practice.

Remedies for any significant adverse impacts need to be determined, and early consultation with the Council over proposals is recommended.

14 APPENDICES

Appendix A1 – WCC Permitted Minimum and Maximum Car Parking Space Ratios

Waitakere City Council ~ District Plan ~ Minimum Permitted Car-parking Ratios ~ As at August 2010			
Environment	**Activities**		
	Residential	**Retail**	**Other**
Living	2 per dwelling		
	1 per minor household		
	1 per apartment		
	1 for home occupation		
Living: New Lynn Town Centre L5 and L6 Areas		1 per 16 sqm GFA	1 per 30 sqm GFA
Working	1 per dwelling	1 per 20 sqm GFA	1 per 35 sqm GFA
Community	1 per dwelling	1 per 16 sqm GFA	1 per 30 sqm GFA
Community: New Lynn Town Centre and Henderson Town Centre Core	1 per dwelling	1 per 25 sqm GFA at ground level	1 per 25 sqm GFA at ground level
		1 per 35 sqm GFA at other levels	1 per 35 sqm GFA at other levels
Community: New Lynn Town Centre	If site < 1000sqm	If site < 1000 sqm	If site < 1000 sqm
	0 per dwelling	0 per dwelling	0 per dwelling
Community: New Lynn Town Centre adjoining Type-1 Mainstreet	1 per dwelling	If site > 1000 sqm	If site > 1000 sqm
		1 per 35 sqm GFA at ground level	1 per 35 sqm GFA at ground level
		1 per 50 sqm GFA at other levels	1 per 50 sqm GFA at other levels
Community: New Lynn Town Centre adjoining TC Commercial Street	1 per dwelling	1 per 25 sqm GFA at ground level	1 per 25 sqm GFA at ground level
		1 per 35 sqm GFA at other levels	1 per 35 sqm GFA at other levels
These ratios can be regarded as' high end' and prone to produce substantial on-site parking under-utilisation			
These ratios can be regarded as moderately ' high end' and prone to produce significant on-site parking under-utilisation			

Waitakere City Council ~ District Plan ~ Maximum Permitted Car-parking Ratios ~ As at August 2010			
Environment	**Activities**		
	Residential	**Retail**	**Other**
Hobsonville Base Village Special Area Massey North Town Centre Special Area	<= 1 per 1 bedroom dwelling	<= 1 per 25 sqm GFA (ground and mezzanine levels)	<= 1 per 25 sqm GFA (ground and mezzanine levels)
Hobsonville Base Village Special Area Massey North Town Centre Special Area	<=2 per 2 or 2+ bedroom dwelling	<= 1 per 35 sqm GFA (other levels)	<= 1 per 35 sqm GFA (other levels)
It is intended to progressively change from minimum ratios to maximum ratios in other town centres and intensively developed corridors.			
Direct reference should always be made to the District Plan Rules; the tables above are intended to provide a convenient perspective of permitted parking levels (as at August 2010).			

Appendix A2 – Base Car Parking Space Ratios

The table below provides some base ratios from the original version of this guideline.

Appendix F references “d” through”j” provides detailed information that may be suitable for formal submissions.

Some Base Car-parking Ratios for Preliminary Development Investigations

Activity	Example	Note	Car-parking Ratios	
			Unit as Stated	# / 100sqm GLFA
Cultural	Art Galleries		1 /40 sqm GLFA	2.5
	Bowling Allies		2 /1 lane	
	Bowling Greens		12 /1 rink	
	Churches		1 /5 seats of main assembly area	
	Cinemas/Theatres		2 /3 staff + 1 /25 seats	
	Football Clubs		33 /football field	
	Golf Clubs		65 /18 hole golf course	
	Golf Driving Ranges		1 /1 staff + 1 /1 driving bay + 1 /35 sqm GLFA-sales	
	Gymnasiums	peak use	1 /25 sqm GLFA	4.0
		Inter-peak	1 /40 sqm GLFA	2.5
	Licensed Clubs		1 /4 sqm GLFA	5.0
	Squash Club with Sauna		7 /1 squash court	
	Tennis Clubs		6 /1 tennis court	
Dining	Licensed Restaurants	9 pm peak	4 /10 sqm eating/bar-waiting area 20% for staff	
		lunch peak	2 /10 sqm eating/bar-waiting area 5% for staff	
		circa 6pm	1 /10 sqm eating/bar-waiting area 35% for staff	
	Family style and Fast Food		1 /10 sqm GLFA	10.0
	Takeaway Bars		1 /20 sqm GLFA	5.0
	Taverns		1 /10 sqm GLFA	10.0
Education	Child-care Informal		1 /4 child places in a day	
	Child-care Sessions		1 /2 child places in a session	
	Kindergarten		1 /2 child places in a session	
	Primary School		3 /2 classrooms for pickup/drop-off + 2 /3 staff for staff	
	Secondary School		1 /10 pupils over 16 years old + 2 /3 staff	
	Tertiary		1 /40 sqm GLFA	
Industrial	Large Factories and Warehouse Storage		1 /50 sqm GLFA	2.0
	Road Freight Depots		1 /100 sqm GLFA	1.0
	Factory/Warehouse Shops		1 /35 sqm GLFA	2.9
	Laboratories		1 /50 sqm GLFA	2.0
Medical	Neighbourhood Medical Centre		1 /18 sqm GLFA	5.6
	Veterinary Clinics		1 /18 sqm GLFA	5.6
	Public Hospital		1 /4 beds + 2 /3 staff	
Office	Community Environment		1 /35 sqm GLFA	2.9
	Working Environment		1 /35 sqm GLFA	2.9
	Living environment		3 /2 staff	
	Welfare Services		1 /30 sqm GLFA	3.3
	High Visitor		1 /20 sqm GLFA	5.0
	Real Estate		1 /15 sqm GLFA	6.7
	Small Consultancies		3 /2 staff	

The table below provides some base ratios from the original version of this guideline.

Appendix F references "d" through"j" provides detailed information that may be suitable for formal submissions.

Some Base Car-parking Ratios for Preliminary Development Investigations

Activity	Example	Note	Car-parking Ratios: Unit as Stated	Car-parking Ratios: # / 100sqm GLFA
Residential	Low Density Housing	1/3 bedrooms	2 /1 house + 1 /3 houses for visitors	
	Low Density Housing	>3 bedrooms	3 /1 house + 1 /3 houses for visitors	
	Medium Density Housing	1/2 bedrooms	1 /1 unit + 1 /3 units for visitors	
	Medium Density Housing	>2 bedrooms	3 /2 units + 1 /3 units for visitors	
	Home Occupations		3 /2 staff	
	Rest Homes		1 /5 resident-places + 2 /3 day staff	
	Homes for the Disabled		1 /4 resident-places + 2 /3 day staff	
	Boarding Houses		1 /4 resident-places + 2 /3 day staff	
	Camping Grounds		1 /campsite, caravan-site, unit + 2 /3 day staff	
	Motels + Travellers Accommodation		1 /1 unit + 1 /2 day staff	
	Hotels		1 /4 bedrooms + 1 /2 day staff	
	Catteries + Kennels		1 /20 animal places	5.0
Services	Car service stations		1 /30 sqm GLFA-sales +	
			4 /repair, tyre, lube bay + 2 /vacuum, air bay	
	Truck service depots		1 space/250 sqm site-area	
	Banks		1 /25 sqm GLFA	4.0
	Commercial Centres		1 /35 sqm GLFA	2.9
	Computer and Equipment Service Centres		1 /50 sqm GLFA	2.0
Retail	Neighbourhood shops		1 /30 sqm GLFA	3.3
	District Mall		1 /20 sqm GLFA	5.0
	Regional Mall		1 /18 sqm GLFA	5.5
	Supermarkets		1 /20 sqm GLFA	5.0
	Dairies		1 /30 sqm GLFA	3.3
	Liquor stores		1 /20 sqm GLFA	5.0
	Fruit and Vegetable shops	discount type	1 /16 sqm GLFA	
	Toy shops	discount type	1 /20 sqm GLFA	5.0
	BBQ sales		1 /75 sqm GLFA	1.3
	Variety goods	discount type	1 /18 sqm GLFA	5.5
	Equipment hire		1 /30 sqm GLFA	3.3
	Auction rooms		1 /35 sqm GLFA	2.9
	Furniture/Carpet shops		1 /45 sqm GLFA	2.2
	Home improvement centres		1 /45 sqm GLFA	2.2
	Garden centres		1 /20 sqm GLFA + 1 /100 sqm outdoor display area	5.0 and 1.0
(orange)	These are known to be "high end" ratios			

Appendix A3 – WCC Permitted Loading Space Ratios

Waitakere City Council District Plan ~ Permitted Minimum Loading Space Ratios			
Environment	**Activities**		
	Residential	Goods-handling (e.g. Retail/Wholesale, Manufacturing)	Non-goods-handling (e.g. Offices)
Living			
Working		1 space per 5,000 sqm GFA	1 space per 5,000 sqm GFA
Community: New Lynn Town Centre Henderson Town Centre Core Massey North Town Centre Special Area Hobsonville Base Village Special Area		< 5000 sqm GFA 1 space < 10,000 sqm GFA 2 spaces > 10,000 sqm GFA 3 spaces + 1 space per additional 7,500 sqm GFA	< 20,000 sqm GFA 1 space < 50,000 sqm GFA 2 spaces > 50,000 sqm GFA 3 spaces +1 space per additional 40,000 sqm GFA
Community: Other		1 space per 500 sqm GFA	1 space per 500 sqm GFA

Appendix A4 – Recommended Cycle Parking Space Ratios

Auckland Regional Transport Authority ~ Recommended Cycle-parking Ratios							
Development / Activity	**Short-term Customer/Visitor**	**Long-term Customer/Visitor**	**Long-term Public**	**Long-term Private**	**Temporary**	**Showers**	**Lockers**
Retail and Malls		1/10 car-spaces [1]		1/10 to 15 staff [2]		yes	yes
Office	2 minimum or 1/800 sqm GLFA			1/10 to 15 staff [2]		yes	yes
Education	2 minimum					yes	yes
Primary	1/500 students and staff			1/ 0 to 15 staff [2]			
Intermediate	1/500 students and staff			1/10 to 15 staff and students [2]			
Secondary	1/500 students and staff			1/10 FTE students + 1/10 to 15 staff [2]			
Tertiary	1/800 sqm GLFA-office		1/10 to 20 students	1/10 to 15 staff [2]			
Residential Apartments	2 minimum or 1/20 units			1 / unit		no	no
Industrial Activities	2 minimum			1/10 to 15 staff [2]			
Recreational Establishments	2 minimum	1/10 to 20 visitors [2]		1/5 staff		yes	yes
Hospitals	2 minimum	1/50 visitors		1/10 to 15 staff [2]		yes	yes
Assembly Places	2 minimum	1/50 visitors		1/10 to 15 staff [2]		yes	yes
including churches, theatres, arenas, stadiums							
Public Gatherings					1/50 to 200 attendees	no	no
including outside concerts, markets							
Note [1] Car-park spaces as required by District Plan		Note [2] Greater end of range is desirable, lower end acceptable					

Appendix B1 – Car Parking Layout Dimensions

Car-parking Layout Dimensions							
Parking Angle	**Space Width**	**Space Length**	**Space Depth**	**Aisle Width**	**Total Depth**	**Total Depth**	**Total Depth**
To Wall or Kerb		Along Wall or Kerb	90-degree to Wall or Kerb	90-degree to Wall or Kerb	One Row Between Walls	Two Rows Between Walls	Reduction for Each Wall Replaced by Kerb
90	2.4	2.40	5.0	7.5	12.5	17.5	1.0
	2.5	2.50	5.0	7.0	12.0	17.0	1.0
	2.6	2.60	5.0	6.5	11.5	16.5	1.0
75	2.4	2.48	5.5	5.5	11.0	16.5	1.0
	2.5	2.59	5.5	5.0	10.5	16.0	1.0
	2.6	2.69	5.5	4.5	10.0	15.5	1.0
60	2.4	2.77	5.5	5.0	10.5	16.0	1.0
	2.5	2.89	5.5	4.5	10.0	15.5	1.0
	2.6	3.00	5.5	4.0	9.5	15.0	1.0
45	2.4	3.39	5.0	3.0	8.0	13.0	0.8
	2.5	3.53	5.0	3.0	8.0	13.0	0.8
	2.6	3.68	5.0	3.0	8.0	13.0	0.8
30	2.4	4.80	4.5	3.0	7.5	12.0	0.6
	2.5	5.00	4.5	3.0	7.5	12.0	0.6
	2.6	5.20	4.5	3.0	7.5	12.0	0.6
0 (back-in)	2.5	6.00	2.5	3.5	6.0	8.5	0.3
0 (front-in)	2.8	7.50	2.8	3.5	6.3	9.1	0.3
Angles are in degree and other dimensions in metre.							
Spaces and no-stopping zones will be durably marked to Code of Practise Standards.							
The paint-marked depth will be 2.0 m for 90-degree parking, and 4.0 m otherwise.							
0-degree front-in parking is exceptionally efficient compared to 0-degree back-in parking and must be used on main roads where interference to frontage traffic needs to be minimised.							
The 7.5 m spaces will be 5.0m long with white hockey-stick markings each end, and with yellow diagonally-crossed boxes in the 2.5 m gaps between them.							
Where a kerb replaces a wall the space beyond the kerb-face must be clear to the extent of the reduction allowance.							

Appendix B2 – Heavy Vehicle Parking Layout Dimensions

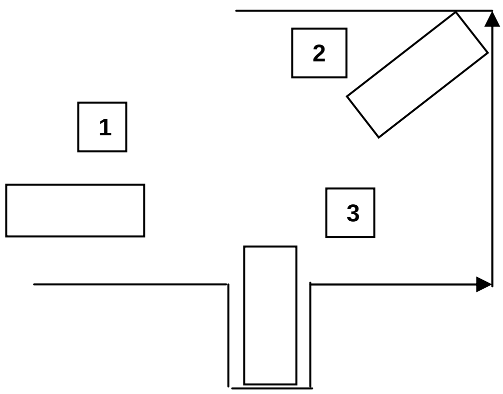
Heavy-vehicle Parking Layout Dimensions						
Design Heavy- vehicle	Parking Angle					
	30		60		90	
	Space Depth	Aisle Width	Space Depth	Aisle Width	Space Depth	Aisle Width
VAN	5.5	3.5	6.0	4.5	5.5	7.0
MRT	7.3	6.0	13.4	10.5	9.0	16.0
LRT	8.8	8.0	12.0	14.0	12.0	19.5
ST	11.8	11.0	17.2	19.0	18.0	26.0
BT	13.3	11.0	19.8	19.0	21.0	26.0
MB	8.0	6.0	10.6	10.5	10.5	16.0
CB	8.9	8.0	13.3	14.0	12.5	19.5
TC	9.6	10.0	13.4	18.0	13.5	24.5
Angles are in degree and other dimensions in metre						
The parking space-widths are all 3.5 m						
B-train spaces must be open ended: B-trains are not back manoeuvred						

Transportation

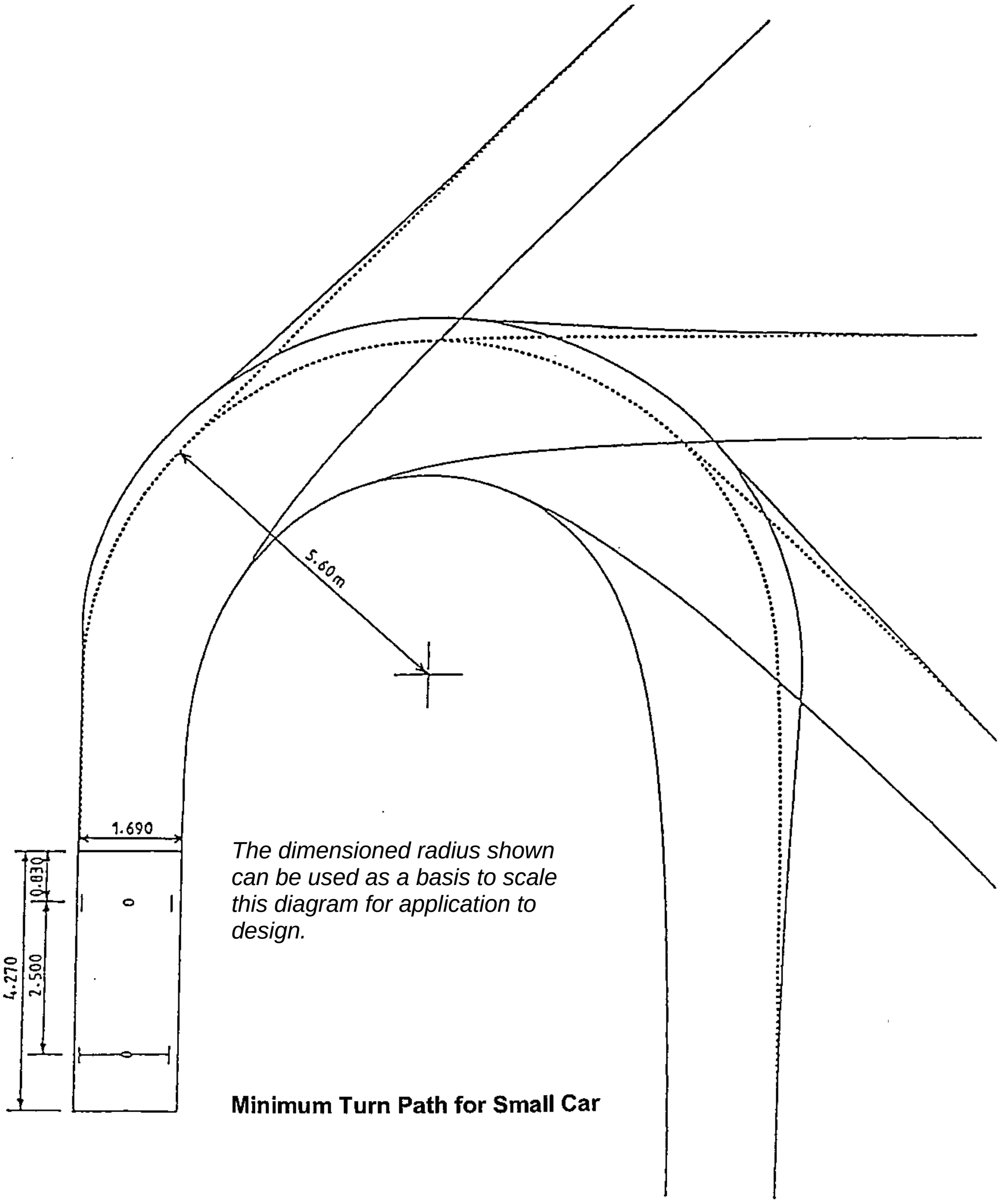
Appendix B3 – Heavy Vehicle Docking Dimensions

Heavy-vehicle Docking Dimensions										
Entry Angle	**Dock Width**	**MRT**			**LRT**			**ST**		
		Dock Depth	Entry Depth	Entry Length	Dock Depth	Entry Depth	Entry Length	Dock Depth	Entry Depth	Entry Length
0	3.5	4.8	9.7	15.3	4.0	13.0	19.4	5.8	19.2	32.8
	4.0	5.4	9.2	15.3	5.0	12.9	19.2	7.5	17.5	32.6
	4.5	5.8	8.7	15.0	5.7	12.2	18.9	9.5	15.5	32.3
30	3.5	3.8	12.7	10.7	5.0	15.2	13.2	5.7	25.3	23.2
	4.0	5.0	11.5	10.5	6.4	13.8	13.0	7.2	23.8	23.0
	4.5	5.6	10.9	10.2	6.6	13.6	12.7	8.0	23.0	22.7
60	3.5	2.0	16.7	6.4	4.5	18.2	8.2	5.5	29.3	12.8
	4.0	4.3	14.4	6.2	5.6	17.1	8.0	7.7	27.1	12.6
	4.5	4.3	14.4	5.9	6.7	16.0	7.7	8.7	26.1	12.3
90	3.5	0.0	18.9	1.0	0.0	22.3	2.7	0.0	36.8	2.6
	4.0	0.0	18.9	0.8	0.0	22.3	2.5	0.0	36.8	2.4
	4.5	0.0	18.9	0.5	0.0	22.4	2.2	0.0	36.8	2.1

Docking is by approaching at 90-degree to the dock, swinging left to the "entry angle" and away from the dock to the "entry depth" and beyond the dock to the "entry length", then reversing from the entry angle to be central to and parallel to the dock. The vehicle will then protrude to the extent of its length less the depth of the dock: if complete entry is required the dock depth must be increased accordingly.



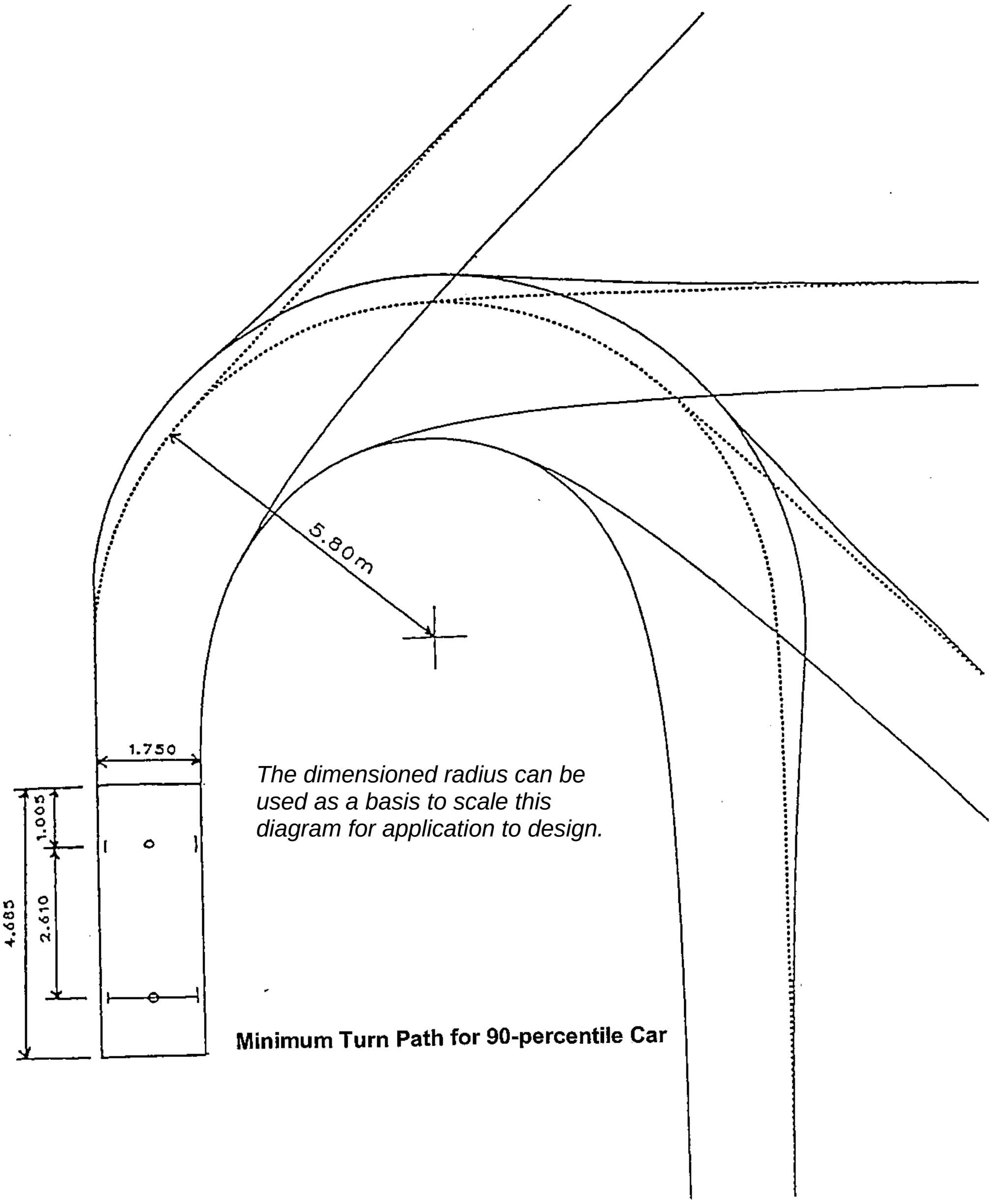
Appendix B4 – Minimum Turn Path for Small Car



The dimensioned radius shown can be used as a basis to scale this diagram for application to design.

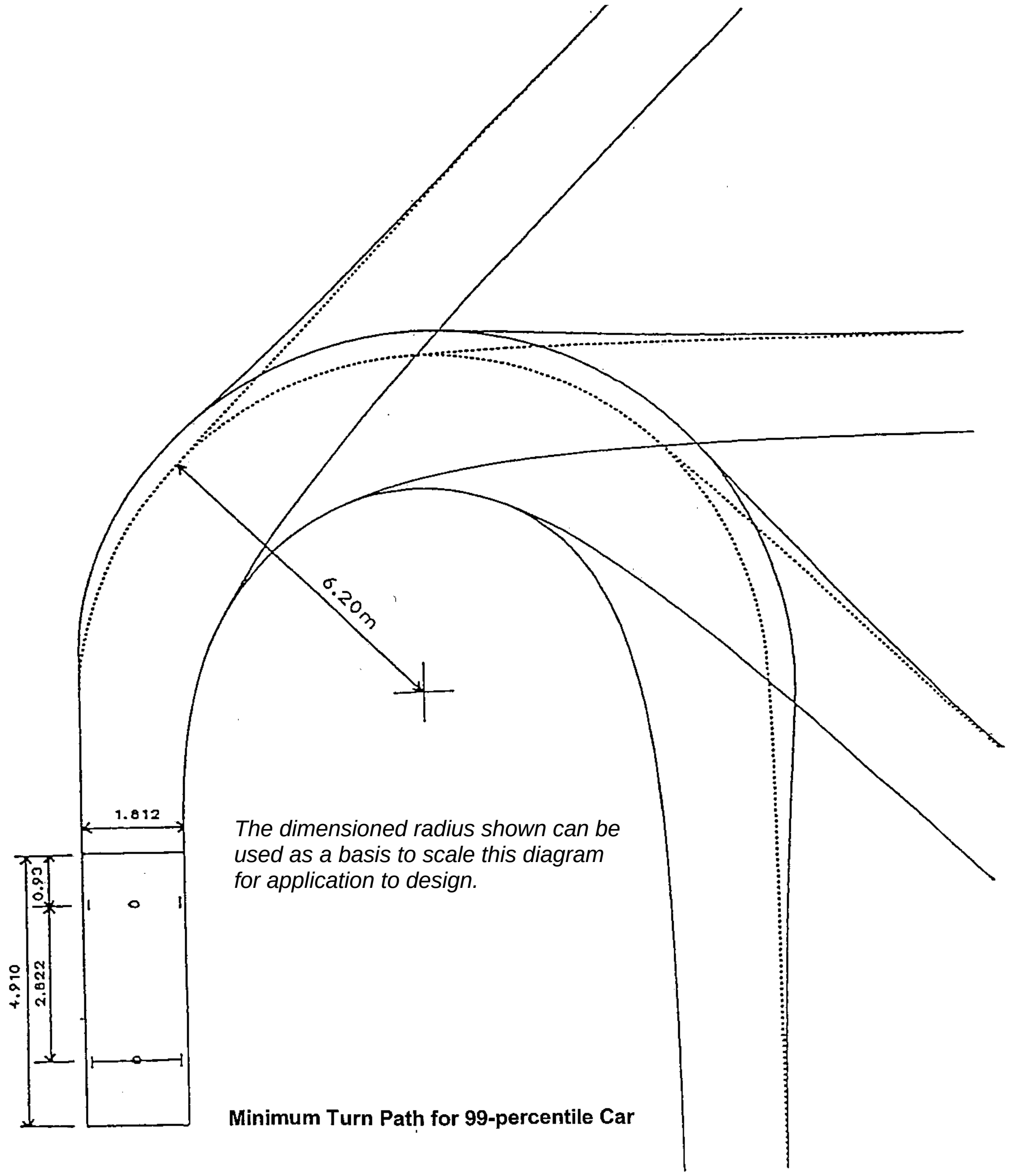
Minimum Turn Path for Small Car

Appendix B5 – Minimum Turn Path for 90-percentile Car



Minimum Turn Path for 90-percentile Car

Appendix B6 – Minimum Turn Path for 99-percentile Car

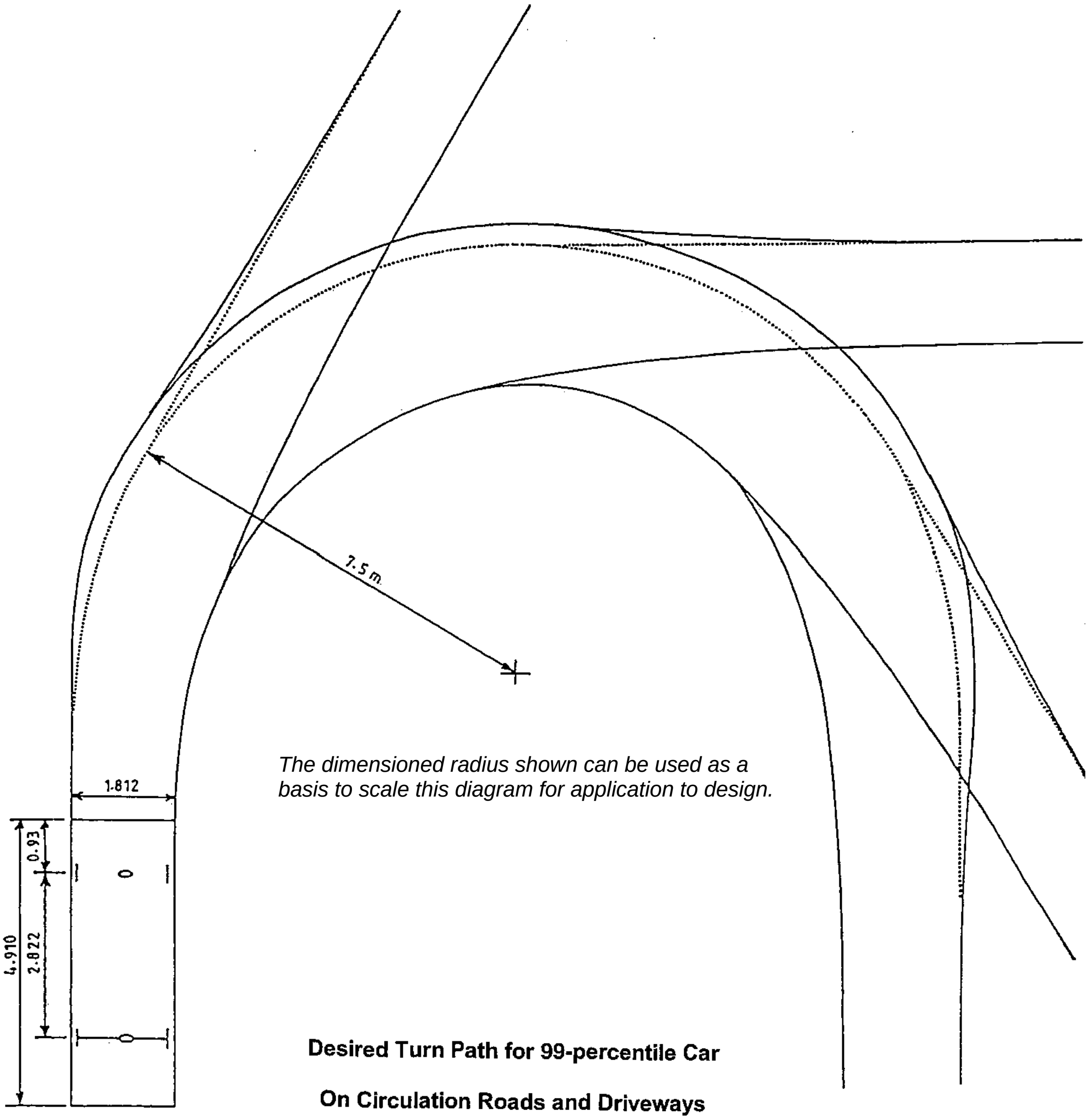


The dimensioned radius shown can be used as a basis to scale this diagram for application to design.

Minimum Turn Path for 99-percentile Car

Transportation

Appendix B7 – Desired Turn Path for 99-percentile Car on Circulation Roads & Driveways

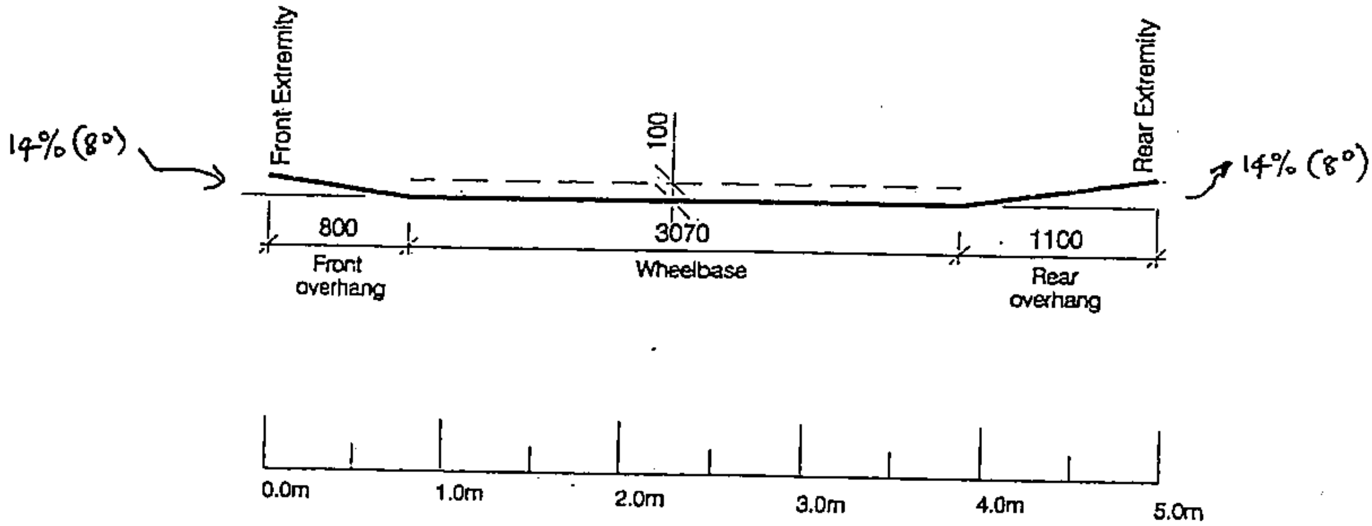


The dimensioned radius shown can be used as a basis to scale this diagram for application to design.

Desired Turn Path for 99-percentile Car

On Circulation Roads and Driveways

Appendix B8 – Car Under body Template for Checking Grade Change Clearance



Car Under-body Template for Grade Change Checks

Transportation

Appendix B9 – Heavy Vehicle Off-road Turns List

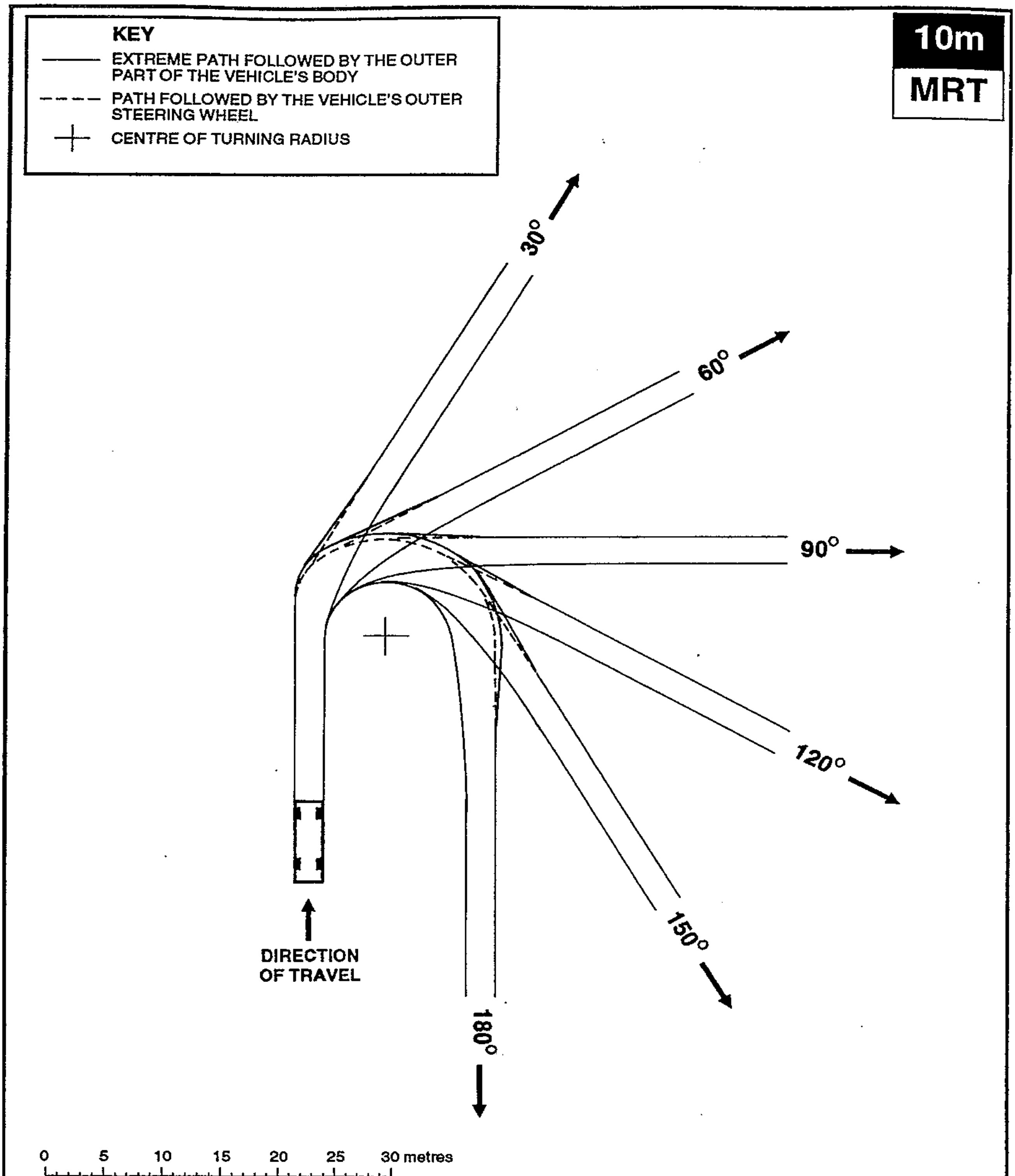
Turning Paths for Heavy Vehicles

The following 7 pages provide minimum radius off-road turning paths for medium rigid trucks (8m long), large rigid trucks (11m long), semi-trailers (17m long), B-trains (19.8m long), midi-buses (9.2m long), city buses (11.2m long), and tour coaches (12.5m long).

These diagrams are a useful sample from the publication 'Site Design for Heavy Vehicle Facilities', Transit New Zealand Research Report 32, 1994. This document also provides turning paths for larger radii up to 25m, and a considerable range of other information for the design of off-road heavy vehicles facilities.

Computer aided drafting of geometric schemes now commonly includes the modelling of vehicle tracking paths using specific modules for this. The parameters that determine the turning characteristics of design vehicles are input to these modules. The parameters for design vehicles change from time to time; current parameters are available from the New Zealand Transport Authority and should be applied. It is noted for example that the current city bus is 13.6m long.

Appendix B10 – Medium Single Unit Truck – 10 m radius Turn

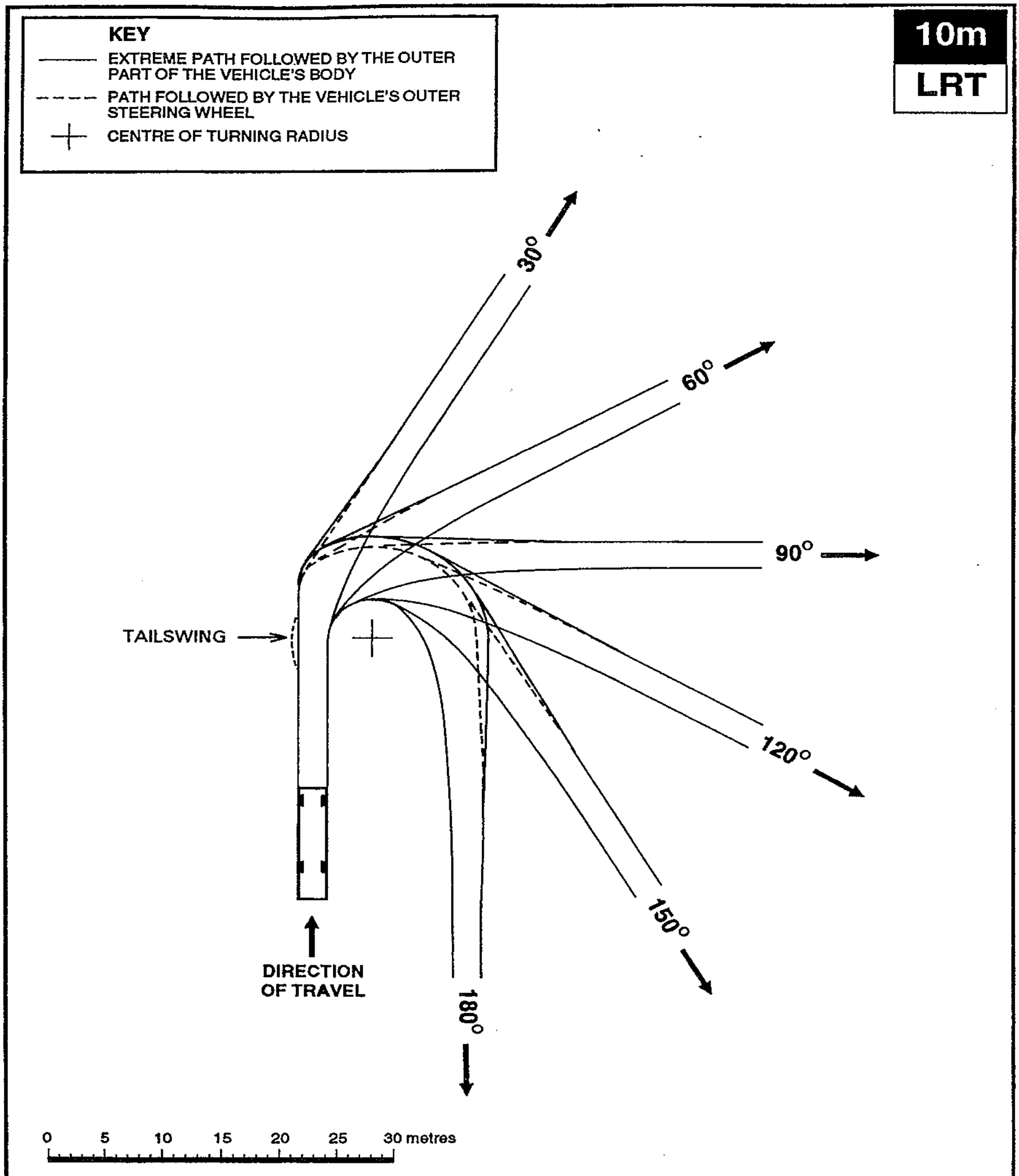


The dimensioned scale can be used as a basis to scale this diagram for application to design.

TRACKING CURVE WITH TURNING RADIUS OF 10 METRES FOR A MEDIUM RIGID TRUCK (MRT)

Transportation

Appendix B11 – Large Single Unit Truck – 10 m radius Turn

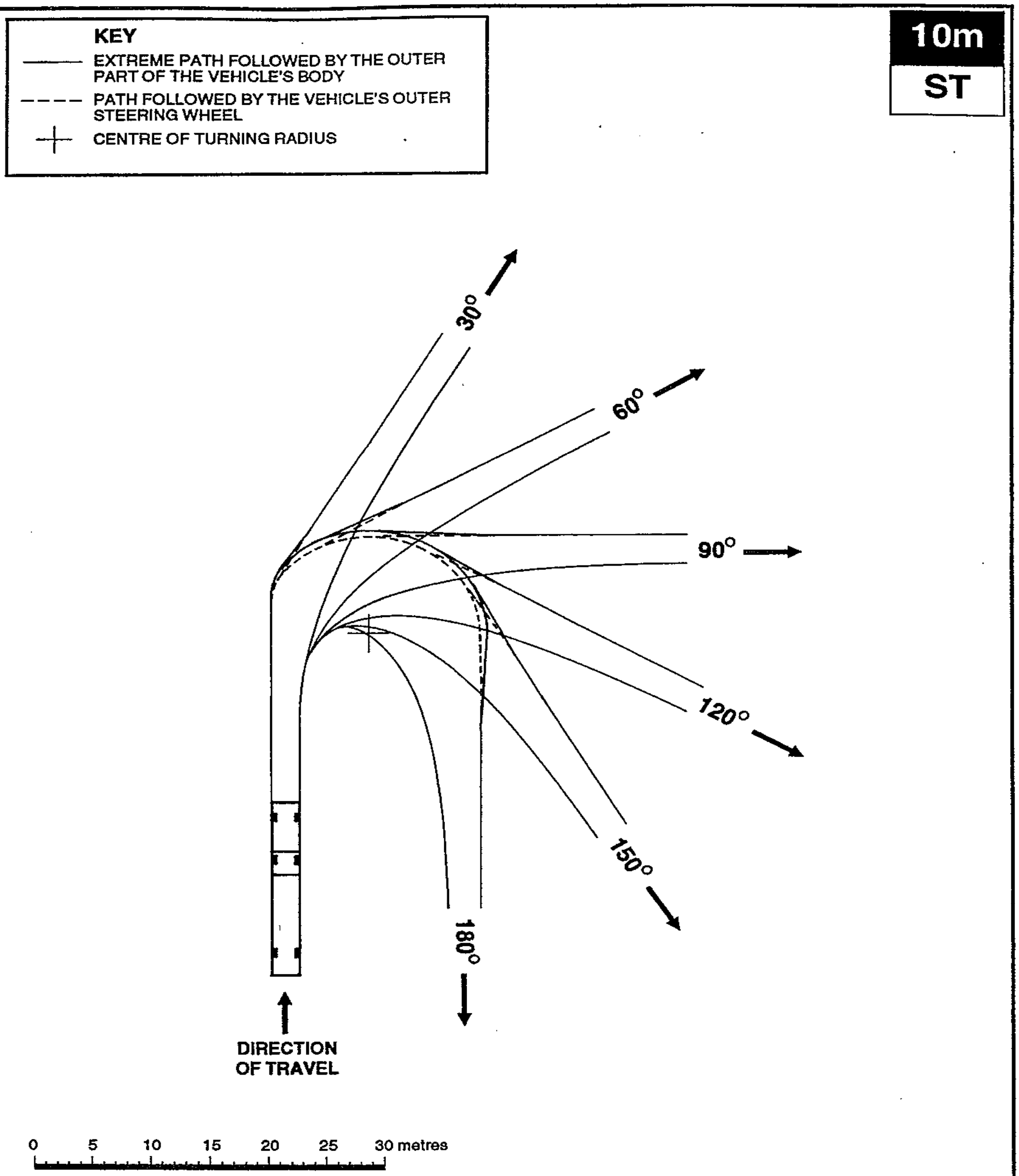


The dimensioned scale can be used as a basis to scale this diagram for application to design.

TRACKING CURVE WITH TURNING RADIUS OF 10 METRES FOR A LARGE RIGID TRUCK (LRT)

Transportation

Appendix B12 – Semi-trailer – 10 m radius Turn

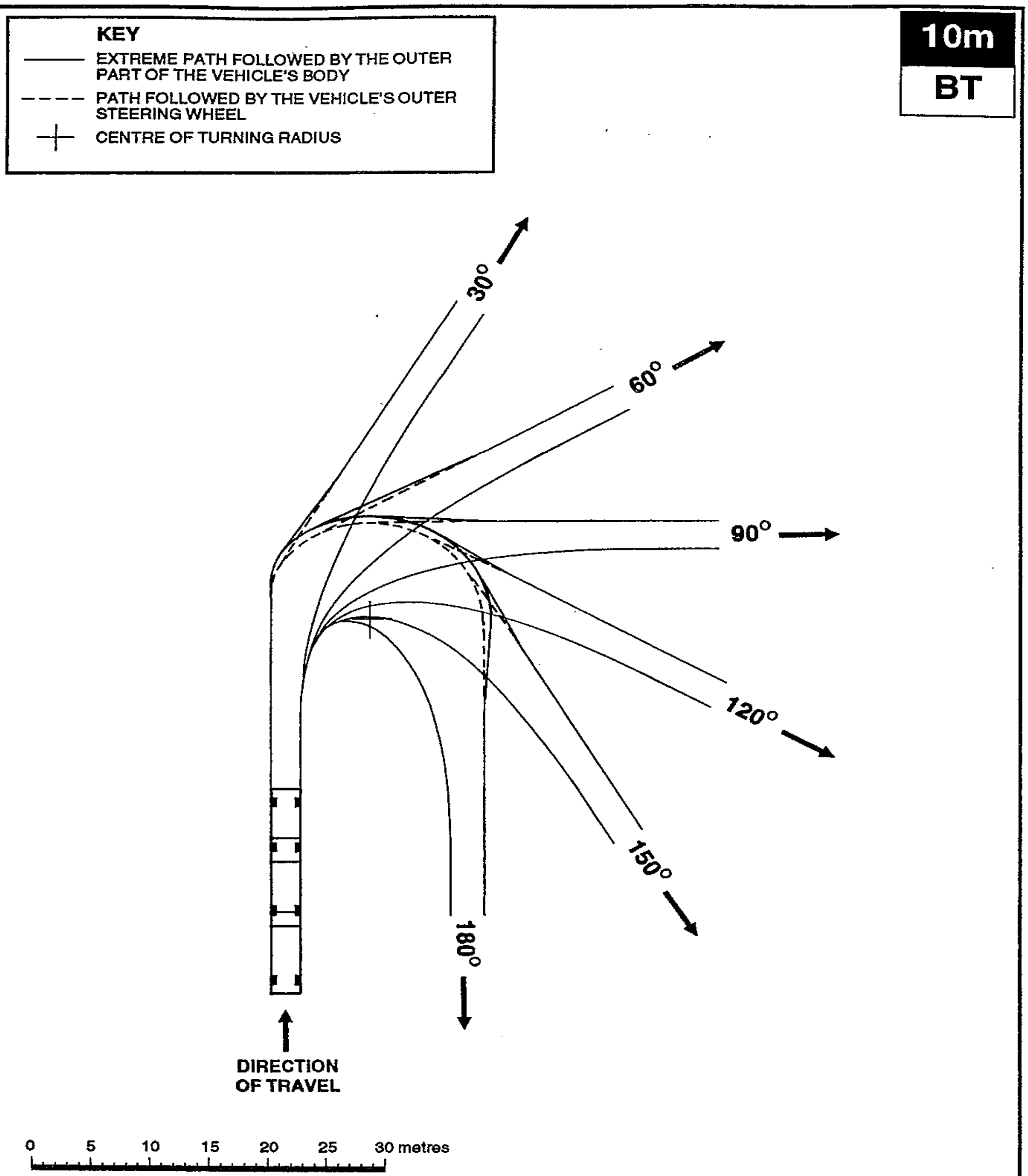


The dimensioned scale can be used as a basis to scale this diagram for application to design.

TRACKING CURVE WITH TURNING RADIUS OF 10 METRES FOR A SEMI-TRAILER (ST)

Transportation

Appendix B13 – B-train – 10 m radius Turn

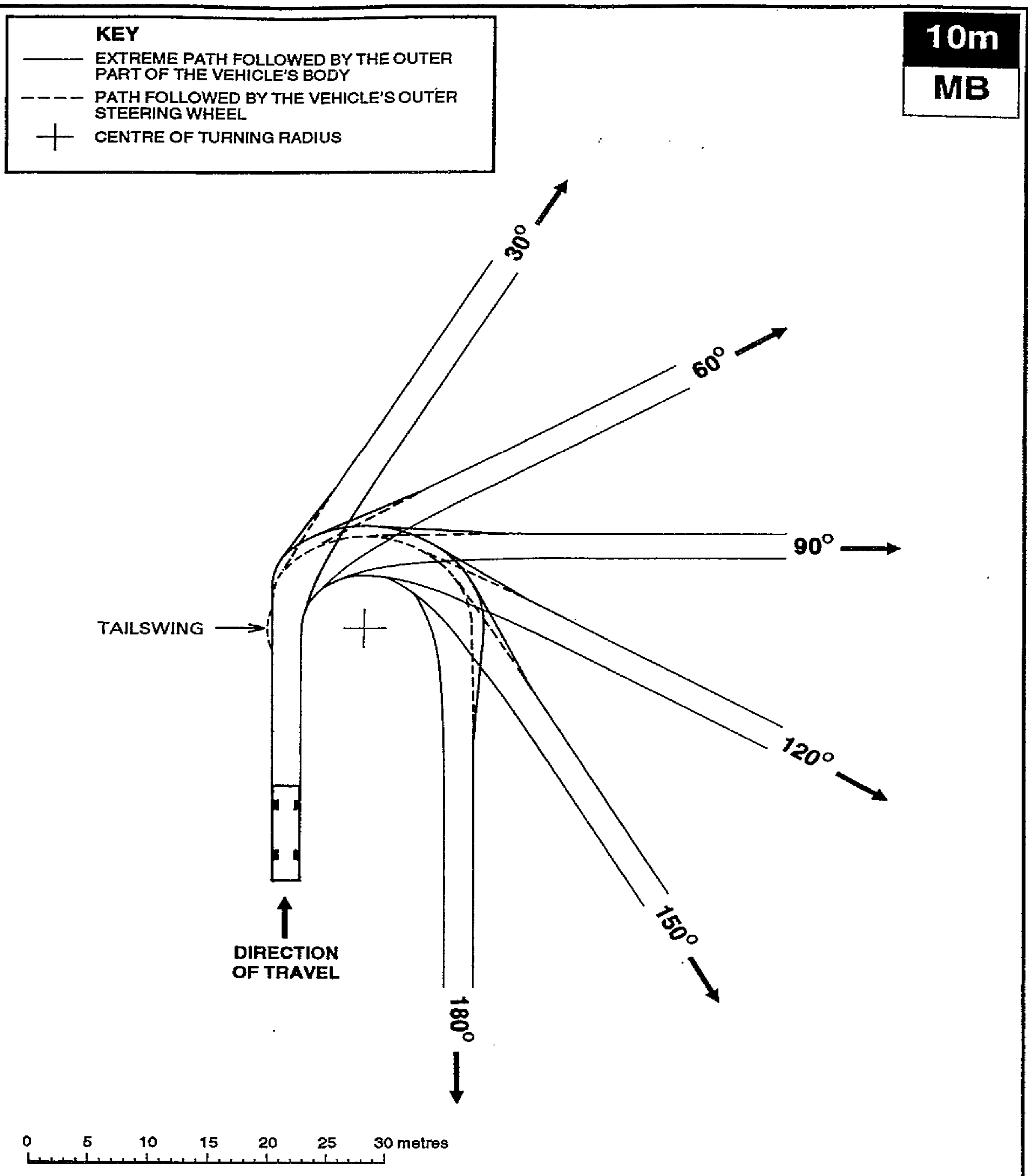


The dimensioned scale can be used as a basis to scale this diagram for application to design.

TRACKING CURVE WITH TURNING RADIUS OF 10 METRES FOR A B-TRAIN (BT)

Transportation

Appendix B14 – Midi-bus – 10 m radius Turn

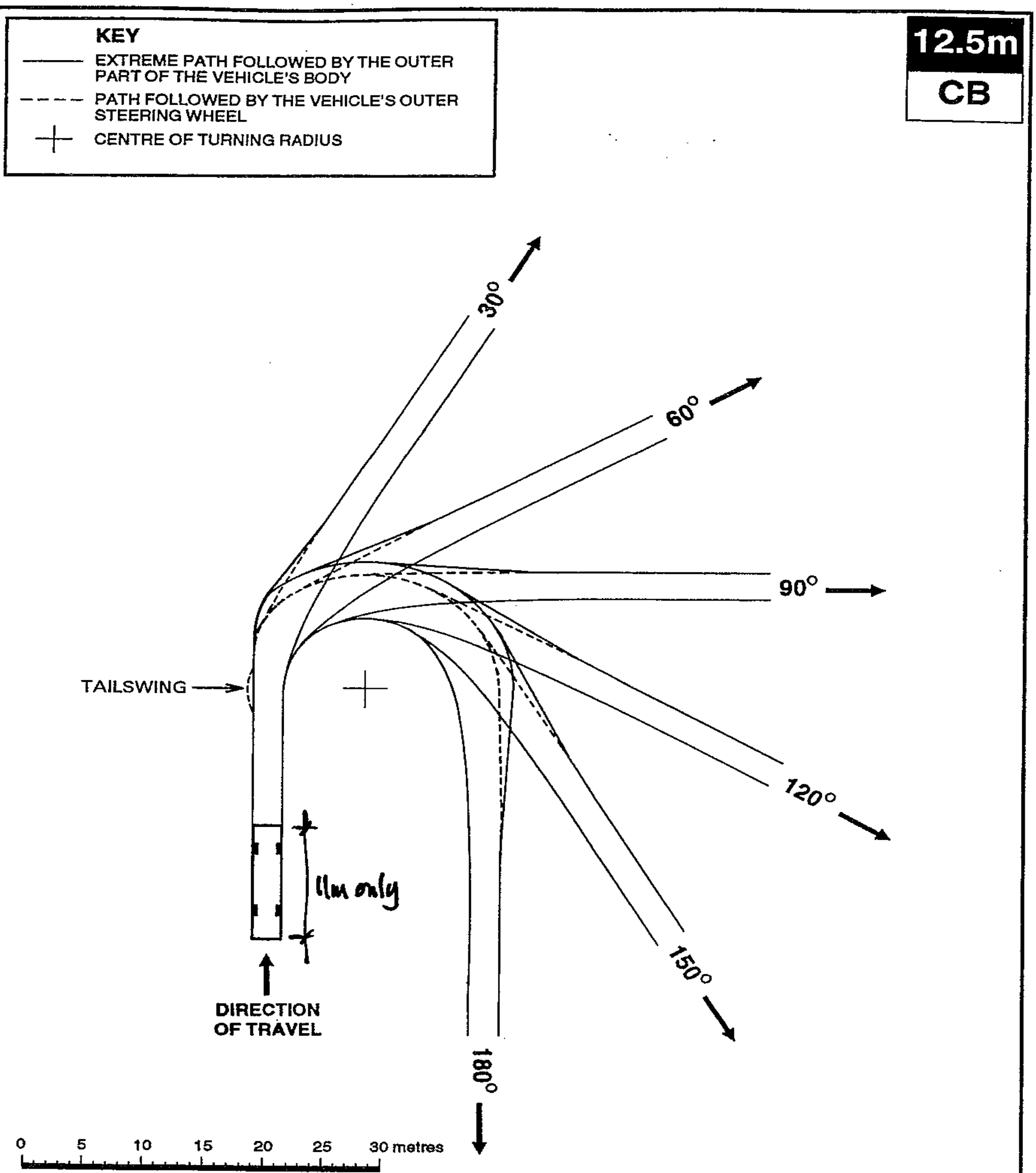


The dimensioned scale can be used as a basis to scale this diagram for application to design.

TRACKING CURVE WITH TURNING RADIUS OF 10 METRES FOR A MIDI-BUS (MB)

Transportation

Appendix B15 – City bus – 10 m radius Turn

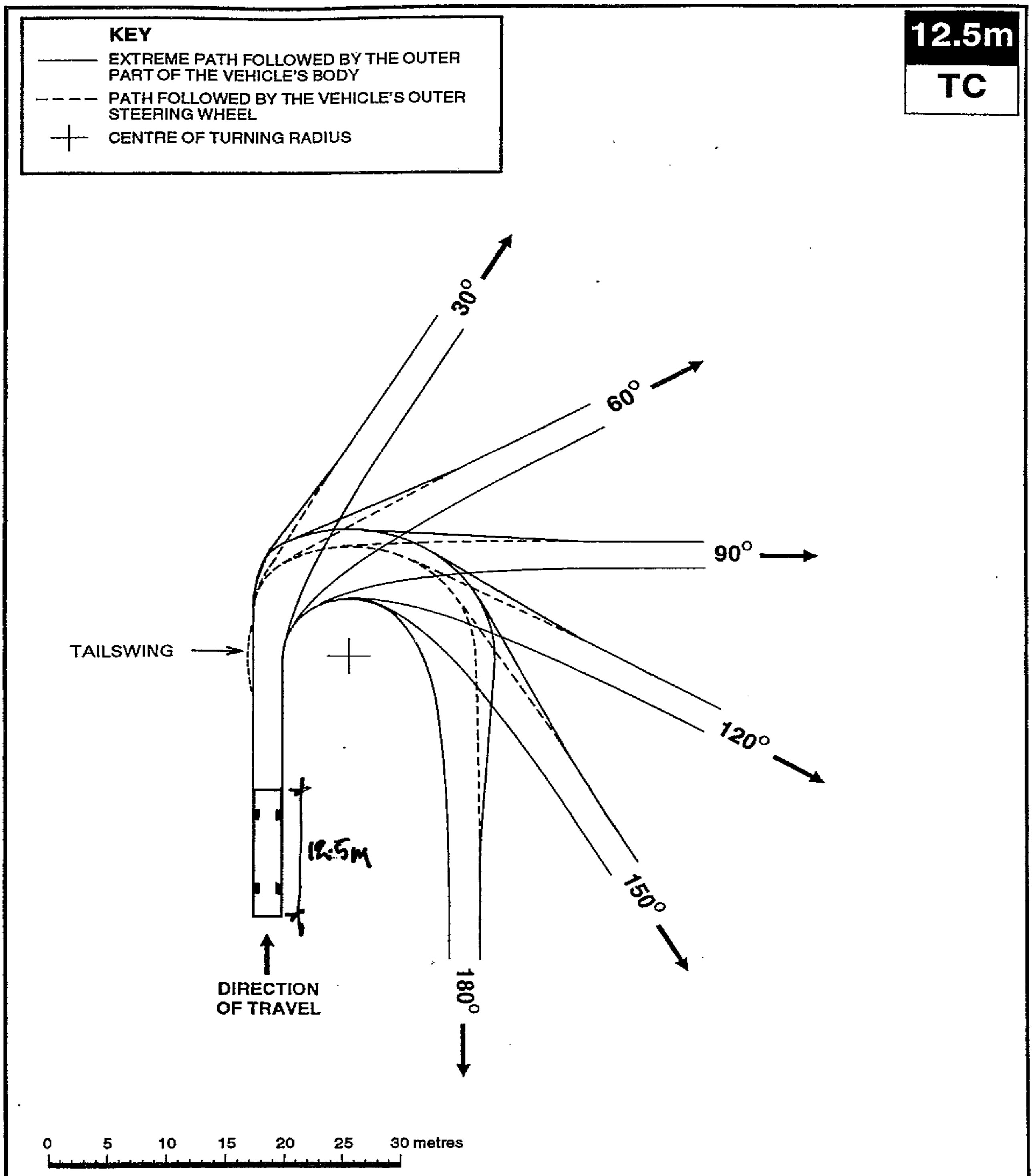


The dimensioned scale can be used as a basis to scale this diagram for application to design.

TRACKING CURVE WITH TURNING RADIUS OF 12.5 METRES FOR A CITY BUS (CB)

Transportation

Appendix B16 – Tour coach – 10 m radius Turn



The dimensioned scale can be used as a basis to scale this diagram for application to design.

TRACKING CURVE WITH TURNING RADIUS OF 12.5 METRES FOR TOUR COACH (TC)

Transportation

Appendix C1 – Stopping and Desirable Stopping Approach Distances

Stopping and Desirable Stopping Approach-distances for Entrances and Intersections

V (km/h)	SAD				SAD				SAD				SAD				SAD				
	-10%	-10%	-10%	-10%	-5%	-5%	-5%	-5%	0%	0%	0%	0%	5%	5%	5%	5%	10%	10%	10%	10%	<G(%)
	1	1.5	2	2.5	1	1.5	2	2.5	1	1.5	2	2.5	1	1.5	2	2.5	1	1.5	2	2.5	< R(s)
20	8	11	14	17	8	11	14	16	8	11	13	16	8	11	13	16	8	10	13	16	**20**
25	12	15	19	22	11	15	18	22	11	14	18	21	11	14	18	21	10	14	17	21	**25**
30	15	20	24	28	15	19	23	27	14	18	23	27	14	18	22	26	13	18	22	26	**30**
35	20	25	30	35	19	24	29	34	18	23	28	33	18	22	27	32	17	22	27	32	**35**
40	25	31	36	42	24	29	35	40	23	28	34	39	22	27	33	38	21	26	32	37	**40**
45	31	37	44	50	29	35	42	48	28	34	40	46	26	32	39	45	25	31	38	44	**45**
50	38	45	52	59	35	42	49	56	33	40	47	54	31	38	45	52	30	37	44	51	**50**
55	45	53	60	68	42	49	57	65	39	47	54	62	37	45	52	60	35	43	50	58	**55**
60	54	62	71	79	50	58	66	75	46	55	63	71	43	52	60	68	41	49	58	66	**60**
65	63	72	81	90	58	67	76	85	53	62	72	81	50	59	68	77	47	56	65	74	**65**
70	75	84	94	104	68	77	87	97	62	72	82	91	58	68	77	87	55	64	74	84	**70**
75	86	96	107	117	78	88	98	109	71	82	92	102	66	76	87	97	62	72	83	93	**75**
80	99	110	121	132	89	100	111	122	81	92	103	114	75	86	97	108	70	81	92	103	**80**
85	113	124	136	148	100	112	124	136	91	103	115	127	84	96	108	120	78	90	102	114	**85**
90	128	140	153	165	114	126	139	151	103	115	128	140	94	107	119	132	88	100	113	125	**90**
95	145	158	171	184	128	141	154	167	115	128	142	155	105	119	132	145	97	111	124	137	**95**
100	164	177	191	205	144	157	171	185	129	143	157	170	117	131	145	159	108	122	136	150	**100**
105	184	199	213	228	161	175	190	204	143	158	173	187	130	145	159	174	120	134	149	163	**105**
110	207	222	238	253	179	195	210	225	159	175	190	205	144	159	175	190	132	147	162	178	**110**
115	225	241	257	273	195	211	227	243	173	189	205	221	156	172	188	204	143	159	175	191	**115**

	Any driveway on an Access Road
	Low volume driveway on a Collector Road
	Low volume driveway on a Collector Road
	High volume driveway on a Collector Road
	Any driveway on an Arterial Road

The colour highlighted values are the guideline values for driveways and are consistent with NZTA Driveway Standard.

Other values indicate sensitivity to perception reaction times and may apply to intersection design (see Part 10.2.7)

Speed (km/hr): Posted and Default 85-percentile

Limit	20	30	35	40	45	55	60	65	70	80	85	90	95	100
85%le	25	35	40	45	50	65	70	75	80	90	100	105	110	115

Transportation

V (km/h)	DSAD				DSAD				DSAD				DSAD				DSAD				
	-10%	-10%	-10%	-10%	-5%	-5%	-5%	-5%	0%	0%	0%	0%	5%	5%	5%	5%	10%	10%	10%	10%	<G(%)
	1	1.5	2	2.5	1	1.5	2	2.5	1	1.5	2	2.5	1	1.5	2	2.5	1	1.5	2	2.5	< R(s)
20	25	28	31	33	25	28	30	33	25	27	30	33	24	27	30	33	24	27	30	33	**20**
25	32	36	39	43	32	35	39	42	32	35	39	42	31	35	38	42	31	35	38	42	**25**
30	40	45	49	53	40	44	48	52	39	43	48	52	39	43	47	51	38	43	47	51	**30**
35	49	54	59	64	48	53	58	63	47	52	57	62	47	52	56	61	46	51	56	61	**35**
40	58	64	70	75	57	63	68	74	56	61	67	73	55	60	66	72	54	60	65	71	**40**
45	69	75	81	87	67	73	79	85	65	71	78	84	64	70	76	82	63	69	75	81	**45**
50	80	87	93	100	77	84	91	98	75	82	89	96	73	80	87	94	72	79	86	93	**50**
55	91	99	106	114	88	95	103	110	85	93	100	108	83	90	98	106	81	89	96	104	**55**
60	104	112	121	129	100	108	116	125	96	105	113	121	93	102	110	118	91	99	108	116	**60**
65	117	126	135	144	112	121	130	139	108	117	126	135	104	113	122	131	101	110	119	128	**65**
70	133	143	152	162	126	136	145	155	121	130	140	150	116	126	136	146	113	123	132	142	**70**
75	148	159	169	180	140	151	161	171	134	144	154	165	129	139	149	160	124	135	145	156	**75**
80	165	176	187	199	155	166	177	189	147	159	170	181	141	152	164	175	136	148	159	170	**80**
85	183	195	207	219	171	183	195	207	162	174	186	198	155	167	179	190	149	161	173	185	**85**
90	203	215	228	240	189	201	214	226	178	190	203	215	169	182	194	207	163	175	188	200	**90**
95	224	237	250	264	207	220	233	247	194	208	221	234	185	198	211	224	177	190	203	216	**95**
100	247	261	275	289	227	241	255	269	212	226	240	254	201	214	228	242	191	205	219	233	**100**
105	272	286	301	315	248	263	277	292	231	245	260	275	218	232	247	261	207	222	236	251	**105**
110	299	314	329	344	271	286	302	317	251	266	282	297	236	251	266	281	224	239	254	269	**110**
115	321	337	353	369	290	306	322	338	268	284	300	316	252	268	284	300	239	255	271	286	**115**

(green)	Any driveway on an Access Road
(yellow)	Low volume driveway on a Collector Road
(olive green)	Low volume driveway on a Collector Road
(orange)	High volume driveway on a Collector Road
(orange)	Any driveway on an Arterial Road

The colour highlighted values are the guideline values for driveways and are consistent with NZTA Driveway Standard.

Other values indicate sensitivity to perception reaction times and may apply to intersection design (refer Part 10.2.7)

Speed (km/hr): Posted and Default 85-percentile

Limit	20	30	35	40	45	55	60	65	70	80	85	90	95	100
85%le	25	35	40	45	50	65	70	75	80	90	100	105	110	115

Appendix C2 – Gap Approach Distances (m)

Gap Approach Distances (m) for Entrances and Intersections														Comparative SAD and DSAD		
Move >	Out-left 2-lane	Out-left 4-lane	Out-right 2-lane-l	Out-right 2-lane-r	Out-right 4-lane-l	Out-right 4-lane-r	Out-right 2-lane-m	Out-right 4-lane-m	Out-thru 2-lane	Out-thru 4-lane	Out-thru 4-lane-m	In-right 2-lane	In-right 4-lane	0% 2	0% 2	<G(%) < R(s)
V km/h	GAD(m)	GAD(m)	GAD(m)	GAD(m)	GAD(m)	GAD(m)	GAD(m)	GAD(m)	GAD(m)	GAD(m)	GAD(m)	GAD(m)	GAD(m)	SAD(m)	DSAD(m)	V km/h
20	20	20	25	30	30	35	25	30	30	35	35	20	25	15	30	**20**
25	25	30	30	35	40	45	30	35	35	45	45	25	30	15	40	**25**
30	30	35	40	45	45	50	35	40	45	55	55	30	40	25	50	**30**
35	40	45	45	55	55	60	40	50	50	65	65	40	45	25	55	**35**
40	45	50	55	60	65	70	45	55	60	75	75	45	55	35	65	**40**
45	55	60	65	70	75	80	55	65	70	85	85	55	65	40	80	**45**
50	60	70	75	75	85	90	60	70	75	95	100	60	75	50	90	**50**
55	70	80	85	85	100	100	65	80	85	105	110	70	80	55	100	**55**
60	80	90	95	95	110	110	75	90	95	115	120	75	90	65	115	**60**
65	90	100	105	100	125	120	80	95	105	125	130	85	100	70	125	**65**
70	100	110	115	110	135	130	90	105	115	140	145	90	110	85	140	**70**
75	110	120	130	120	150	140	95	115	125	150	155	100	120	95	155	**75**
80	120	135	140	130	160	150	105	120	135	160	165	110	135	105	170	**80**
85	130	145	155	140	175	160	110	130	145	175	180	120	145	110	185	**85**
90	145	160	165	150	190	175	120	140	155	185	190	125	155	125	200	**90**
95	155	175	180	160	205	185	130	150	165	195	205	135	165	140	220	**95**
100	170	185	195	170	220	200	140	160	175	210	220	145	180	160	245	**100**
105	180	200	205	185	240	210	145	170	185	220	230	155	190	175	265	**105**
110	195	215	220	195	255	225	155	185	200	235	245	160	200	190	285	**110**
115	210	230	235	205	270	235	165	195	210	250	260	170	210	210	305	**115**

Speed Limit and Default 85-percentile Speed (km/hr)																
Limit	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	100
V	25	30	35	40	45	50	60	65	70	75	80	85	90	100	105	115

Appendix C3 – Required Visible Approach Distances for Cycle lanes

Cycle-lane 85-percentile Speed (km/hr)	Required Visible Approach Distances for Cycle-lanes (m) At Entrances and Intersections						
	Cycle-lane Gradient (%)						
	-15	-10	-5	0	5	10	15
10	10	10	10	10	10	10	10
20	30	25	20	20	20	20	20
30	55	45	40	35	35	30	30
40	95	75	65	60	55	50	50
50	145	115	100	90	80	75	75

Appendix C4 – Sample Mappings for Safe Tree and Pole locations

Mapping of roadside locations suitable/un-suitable for poles/trees of given size

Cross-section intervals (y) 0.25m. Long Section intervals (x) 2.5m. Obstruction widths (Wobs) 0.3m, 0.6m, 0.9m. Eye position (E) 8.5 m from centre of approach lane. Available approach and stopping distances (SA and SS) hypothetical for design speeds 40 km/hr, 60 km/hr, 80 km/hr.]

SA	60	Obstruction Position		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SS	55			2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	40.0	42.5	45.0	47.5	50.0	52.5	55.0
D	3.5	y	2.50						xxx	xxx															
L	5	y	2.25					xxx	xxx																
E	8.5	y	2.00				xxx	xxx																	
Wobs	**0.3**	y	1.75				xxx	xxx																	
DSAD%	20%	y	1.50			xxx	xxx																		
OBS%	10%	y	1.25		xxx	xxx	xxx																		
40 km/hr		y	1.00		xxx	xxx																			
		y	0.75	xxx	xxx																				
		y	0.50	xxx	xxx																				
		y	0.25	xxx																					
D	3.5	y	2.50				xxx	xxx	xxx	xxx	xxx														
L	5	y	2.25			xxx	xxx	xxx	xxx	xxx															
E	8.5	y	2.00			xxx	xxx	xxx	xxx																
Wobs	**0.6**	y	1.75		xxx	xxx	xxx	xxx	xxx																
DSAD%	20%	y	1.50		xxx	xxx	xxx	xxx																	
OBS%	10%	y	1.25	xxx	xxx	xxx	xxx																		
40 km/hr		y	1.00	xxx	xxx	xxx	xxx																		
		y	0.75	xxx	xxx	xxx																			
		y	0.50	xxx	xxx																				
		y	0.25	xxx	xxx																				
D	3.5	y	2.50			xxx	xxx	xxx	xxx	xxx	xxx														
L	5	y	2.25			xxx	xxx	xxx	xxx	xxx	xxx														
E	8.5	y	2.00		xxx	xxx	xxx	xxx	xxx	xxx															
Wobs	**0.9**	y	1.75		xxx	xxx	xxx	xxx	xxx																
DSAD%	20%	y	1.50		xxx	xxx	xxx	xxx	xxx																
OBS%	10%	y	1.25	xxx	xxx	xxx	xxx	xxx																	
40 km/hr		y	1.00	xxx	xxx	xxx	xxx																		
		y	0.75	xxx	xxx	xxx	xxx																		
		y	0.50	xxx	xxx	xxx																			
		y	0.25	xxx	xxx																				

Transportation

Mapping of roadside locations suitable/un-suitable for poles/trees of given size

Cross-section intervals (y) 0.25m. Long Section intervals (x) 2.5m. Obstruction widths (Wobs) 0.3m, 0.6m, 0.9m. Eye position (E) 8.5 m from centre of approach lane.
Available approach and stopping distances (SA and SS) hypothetical for design speeds 40 km/hr, 60 km/hr, 80 km/hr.]

SA	100	Obstruction Position		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SS	90			2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	40.0	42.5	45.0	47.5	50.0	52.5	55.0
D	3.5	y	2.50										xxx	xxx											
L	5	y	2.25									xxx	xxx												
E	8.5	y	2.00							xxx	xxx	xxx													
Wobs	**0.3**	y	1.75						xxx	xxx	xxx														
DSAD%	20%	y	1.50				xxx	xxx	xxx	xxx															
OBS%	10%	y	1.25			xxx	xxx	xxx	xxx																
60 km/hr		y	1.00		xxx	xxx	xxx	xxx																	
		y	0.75		xxx	xxx	xxx																		
		y	0.50	xxx	xxx	xxx																			
		y	0.25	xxx	xxx																				
D	3.5	y	2.50						xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx									
L	5	y	2.25					xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx										
E	8.5	y	2.00				xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx											
Wobs	**0.6**	y	1.75			xxx	xxx	xxx	xxx	xxx	xxx	xxx													
DSAD%	20%	y	1.50			xxx	xxx	xxx	xxx	xxx	xxx														
OBS%	10%	y	1.25		xxx	xxx	xxx	xxx	xxx	xxx															
60 km/hr		y	1.00		xxx	xxx	xxx	xxx	xxx																
		y	0.75	xxx	xxx	xxx	xxx	xxx																	
		y	0.50	xxx	xxx	xxx	xxx																		
		y	0.25	xxx	xxx	xxx																			
D	3.5	y	2.50					xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx								
L	5	y	2.25				xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx									
E	8.5	y	2.00			xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx										
Wobs	**0.9**	y	1.75			xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx											
DSAD%	20%	y	1.50		xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx												
OBS%	10%	y	1.25		xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx													
60 km/hr		y	1.00	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx														
		y	0.75	xxx	xxx	xxx	xxx	xxx	xxx																
		y	0.50	xxx	xxx	xxx	xxx	xxx																	
		y	0.25	xxx	xxx	xxx	xxx																		

Transportation

Mapping of roadside locations suitable/un-suitable for poles/trees of given size

Cross-section intervals (y) 0.25m. Long Section intervals (x) 2.5m. Obstruction widths (Wobs) 0.3m, 0.6m, 0.9m. Eye position (E) 8.5 m from centre of approach lane.

Available approach and stopping distances (SA and SS) hypothetical for design speeds 40 km/hr, 60 km/hr, 80 km/hr.]

SA	150	Obstruction Position		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SS	135			2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	40.0	42.5	45.0	47.5	50.0	52.5	55.0
D	3.5	y	2.50															xxx	xxx	xxx					
L	5	y	2.25													xxx	xxx	xxx	xxx						
E	8.5	y	2.00										xxx	xxx	xxx	xxx	xxx								
Wobs	0.3	y	1.75								xxx	xxx	xxx	xxx	xxx	xxx									
DSAD%	20%	y	1.50						xxx	xxx	xxx	xxx	xxx	xxx											
OBS%	10%	y	1.25					xxx	xxx	xxx	xxx	xxx													
		y	1.00			xxx	xxx	xxx	xxx	xxx	xxx														
80 km/hr		y	0.75		xxx	xxx	xxx	xxx	xxx																
		y	0.50	xxx	xxx	xxx	xxx	xxx																	
		y	0.25	xxx	xxx	xxx																			
D	3.5	y	2.50							xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
L	5	y	2.25						xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx		
E	8.5	y	2.00					xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx				
Wobs	0.9	y	1.75				xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx						
DSD%	20%	y	1.50			xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx							
OBS%	10%	y	1.25		xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx									
		y	1.00		xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx										
80 km/hr		y	0.75	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx												
		y	0.50	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx														
		y	0.25	xxx	xxx	xxx	xxx	xxx	xxx	xxx															
D	3.5	y	2.50									xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx			
L	5	y	2.25							xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx				
E	8.5	y	2.00						xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx						
Wobs	0.6	y	1.75					xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx								
DSD%	20%	y	1.50				xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx									
OBS%	10%	y	1.25			xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx											
		y	1.00		xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx												
80 km/hr		y	0.75		xxx	xxx	xxx	xxx	xxx	xxx	xxx														
		y	0.50	xxx	xxx	xxx	xxx	xxx	xxx																
		y	0.25	xxx	xxx	xxx	xxx	xxx																	

Appendix C5 – Equations for Approach Distances

Although approach distances are most simply found by scaling from the engineering drawings they can be calculated; the equations for 4 situations S are presented below.

The notation is as defined in Part 10.2.3 of the guidelines. In addition R is the radius of the circular arc (Cases 2, 3, and 4), and T is the length of the straight (Case 3).

1. Straight Alignment

$S = E/t$

$t = y/x$

2. Circular Alignment

$S = R*A$

$A = \text{inverse SIN } [(-t*e + (t^2*e^2 - (1 - t^2)*(e^2 - 1))^{0.5})/ (1+ t^2)]$

$t = y/x$

$e =(R-E)/R$

A is the deflection angle experienced by the approaching vehicle going from the sight line point to the collision point.

3. Straight followed by Circular Alignment

$S = T + R*A$

$A = \text{inverse SIN } [(-r*t + ((t^2 + 1) - r^2)^{0.5})/ (t^2 + 1)]$

$t = y/x$

$r = (R - E + t*T)/R$

A is the deflection angle experienced by the approaching vehicle going from the sight line point to the common tangent point

4. Circular followed by Straight Alignment

$S = R*A + R*(e + \cos A - t*\sin A -1)/ (\sin A + t*\cos A)$

$t = y/x$

$e = E/R$

A is the deflection angle experienced by the approaching vehicle going from the common tangent point to the collision point

Appendix D1 – Base Trip Generation Ratios

The table below provides some base ratios form the original version of this guideline

Appendix F references "d" through"j" provides further detailed information that may be suitable for formal submissions.

Some Base Car-trip Ratios

Activity	Example	Unit	Note	AM-peak		INTER-peak		PM-peak		SAT-peak		DAY
				in	out	in	out	in	out	in	out	all
Dining	**Restaurants**	per hour and per day per 100 sqm GLFA	0	0	0	10	10	20	20	20	20	na
	Family											
	Fast Food											
Education	**Child-care Informal**	per hour per child place per session	1,2	0.8	0.8			0.8	0.8			
	Child-care Sessional	per hour per child place per session	1,3	0.8	0.8	0.8	0.8	0.8	0.8			8
	Kindergarten	per hour and per day per 100 sqm GLFA		15.0	15.0	26.0	26.0	11.0	11.0			100
	Kohanga Reo	per hour and per day per 100 sqm GLFA		7.5	7.0	4.5	4.0					28
	Primary School	per hour and per day per 100 sqm GLFA		8.0	7.0	7.5	7.0					35
	Secondary School	per hour and per day per 100 sqm GLFA		8.0	5.0	4.5	3.5					30
	Tertiary	per hour and per day per 100 sqm GLFA		1.5	0.2	0.5	1.5					13
Industry	**Small Units**	per hour and per day per 100 sqm GLFA		3.0	1.7	2.5	2.5	1.7	3.0			49
	Large Factories	per hour and per day per 100 sqm GLFA		0.7	0.0	0.3	0.3	0.3	1.1			7
Medical	**Neighbourhood Medical Centre**	per hour and per day per 100 sqm GLFA		7.5	5.0	7.0	7.0	4.0	7.0			135
	Public Hospital	per hour and per day per 100 sqm GLFA		1.5	0.5	0.8	0.8	0.5	1.0			16
Office	**Financial**	per hour and per day per 100 sqm GLFA		2.5	0.2	1.5	1.5	0.7	2.5			30
	High Visitor and Public Service	per hour and per day per 100 sqm GLFA		1.5	1.5	2.5	2.5	1	2.5			47
	Professional	per hour and per day per 100 sqm GLFA		2	0.5	1	1	5	1.5			21
	Real Estate	per hour and per day per 100 sqm GLFA		4	2	2	2	2	2			40
Residential	**Low Density**	per hour and per day per 100 Units		15	55	25	25	45	25			900
	Medium Density 1/2 bedroom	per hour and per day per 100 Units	4	10	40	18	18	30	20			450
	Medium Density 2+ bedroom	per hour and per day per 100 Units	4	10	50	20	20	35	45			600
	High Density Apartments	per hour and per day per 100 Units	4	5	20	10	10	15	10			350
	Motels	per hour and per day per 100 Units	4	5	30	5	5	25	10			255
	Housing for the elderly	per hour and per day per 100 Units	4	2	10	9	9	10	2			150

The table below provides some base ratios form the original version of this guideline

Appendix F references "d" through"j" provides further detailed information that may be suitable for formal submissions.

Some Base Car-trip Ratios

Activity	Example	Unit	Note	AM-peak		INTER-peak		PM-peak		SAT-peak		DAY
				in	out	in	out	in	out	in	out	all
Service	Petrol Stations	per 100 veh/hr or /day of frontage road		2.3	2.3	2.5	2.5	2.5	2.5			2.4
Shopping	BBQ Shop	per hour and per day per 100 sqm GLFA				3.5	3.5	1.5	1.5			30
	Discount Toys	per hour and per day per 100 sqm GLFA				7.5	7.5	5	5	6	6	100
	Discount Fruit and Vegetables	per hour and per day per 100 sqm GLFA				25	25	22	22	31	31	440
	Discount Plastics	per hour and per day per 100 sqm GLFA		1.5	0.5	4	4	2				40
	Discount Super Market	per hour and per day per 100 sqm GLFA		3	2	4	4	3	3			60
	Discount Variety Goods	per hour and per day per 100 sqm GLFA				11.5	11.5	9	9	17	17	180
	Equipment Hire	per hour and per day per 100 sqm GLFA				12	12	7.5	7.5	3.5	3.5	150
	Factory Furniture	per hour and per day per 100 sqm GLFA		3	3	5	5	2	2			40
	Furniture Carpets Flooring	per hour and per day per 100 sqm GLFA				5	5	2	2			40
	Garden Centres	per hour and per day per 100 sqm GLFA		0.6	0.4	1.2	1.2	0.2	0.5	1.5	1.5	13
	Home Improvement Centres	per hour and per day per 100 sqm GLFA		2	1	6.5	6.5	4	4			80
	Link Drive North Shore City	per hour and per day per 100 sqm GLFA		3	2	5	5	3.5	3.5			70
	Liquor Stores	per hour and per day per 100 sqm GLFA				8	8	10	10	15	15	200
	Oriental Market	per hour and per day per 100 sqm GLFA				1.5	1.5	0.5	0.5			18
	Neighbourhood Shops	per hour and per day per 100 sqm GLFA	5			10	10	10	10			200
	Malls <= 10,000 sqm	per hour and per day per 100 sqm GLFA	6	3.5	1.5	10	10	11	11	11	11	220
	Malls <= 20,000 sqm	per hour and per day per 100 sqm GLFA	6	3	1	9	9	10	10	10	10	200
	Malls <= 30,000 sqm	per hour and per day per 100 sqm GLFA	6	2.5	1	7	7	5	5	5	5	100
	Malls > 10,000 sqm	per hour and per day per 100 sqm GLFA	6	1.5	0.5	5	5	4	4	4	4	80
	Supermarket	per hour and per day per 100 sqm GLFA		5.5	3.5	8	8	8	8			160
Note 1	Informal pre-schools assumed to have 1 session per day ~ Sessional pre-schools assumed to have 2 sessions per day											
Note 2	Set down and pick up occur over 1.5 hours ~ apply peaking factor of 0.7 for queuing and delay calculations											
Note 3	Set down and pick up occur over 0.5 hours ~ apply peaking factor of 2.0 for queuing and delay calculations											
Note 4	Australian data associated with good public transportation											
Note 5	Small suburban centres with no supermarket											
Note 6	Anchor supermarket plus comparison shopping											

Appendix E1 – Delays and Queues for Entrance Movements

Capacity (veh/hr)	Average Delay "D" for Entry/Exit Movements (sec) at Entrances and Intersections																		
	Traffic Load "X": Entry/Exit Movement Flow (veh/hr) / Capacity of Opposing Flow to Accept Entry/Exit Movements (veh/hr)																		
	0.10	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**	**0.92**	**0.94**	**0.96**	**0.98**	**1.00**	**1.02**	**1.04**	**1.06**	**1.08**	**1.10**
20	197.8	219.1	244.6	275.6	313.5	360.0	417.0	486.3	569.2	587.5	606.3	625.8	645.7	666.3	687.4	709.0	731.1	753.8	777.0
30	132.3	147.2	165.5	188.1	216.7	253.2	300.0	360.0	435.7	452.9	470.8	489.4	508.7	528.6	549.3	570.6	592.5	615.1	638.4
40	99.4	110.9	125.1	143.0	166.0	196.1	236.1	289.5	360.0	376.4	393.6	411.6	430.4	450.0	470.4	491.6	513.5	536.2	559.5
50	79.6	89.0	100.6	115.4	134.6	160.3	195.4	243.7	310.0	325.8	342.4	360.0	378.4	397.8	418.0	439.1	461.1	483.9	507.4
60	66.4	74.3	84.1	96.7	113.3	135.7	166.9	211.2	274.1	289.3	305.5	322.7	340.9	360.0	380.1	401.2	423.2	446.1	469.9
70	56.9	63.7	72.3	83.3	97.8	117.7	145.9	186.9	246.7	261.5	277.3	294.1	312.1	331.1	351.1	372.2	394.2	417.3	441.2
80	49.9	55.8	63.4	73.1	86.1	104.0	129.7	167.8	225.0	239.4	254.8	271.4	289.1	308.0	328.0	349.1	371.2	394.4	418.5
90	44.3	49.7	56.4	65.1	76.9	93.1	116.7	152.4	207.3	221.3	236.5	252.8	270.3	289.1	309.0	330.1	352.3	375.7	400.0
100	39.9	44.7	50.8	58.8	69.4	84.3	106.2	139.7	192.5	206.2	221.1	237.2	254.6	273.2	293.1	314.2	336.5	360.0	384.5
150	26.6	29.9	34.0	39.4	46.8	57.3	73.3	99.3	144.0	156.3	170.0	185.2	201.9	220.2	240.0	261.3	284.1	308.2	333.5
200	20.0	22.4	25.6	29.7	35.3	43.5	56.1	77.3	116.4	127.7	140.5	155.0	171.2	189.2	209.0	230.5	253.7	278.4	304.4
250	16.0	18.0	20.5	23.8	28.4	35.0	45.4	63.4	98.2	108.7	120.9	134.8	150.6	168.4	188.2	209.9	233.4	258.6	285.3
300	13.3	15.0	17.1	19.9	23.7	29.3	38.2	53.8	85.3	95.1	106.6	120.0	135.5	153.1	172.9	194.9	218.7	244.4	271.5
350	11.4	12.8	14.6	17.0	20.3	25.2	32.9	46.7	75.5	84.7	95.7	108.7	123.8	141.3	161.2	183.3	207.5	233.6	261.2
400	10.0	11.2	12.8	14.9	17.8	22.1	28.9	41.3	67.8	76.6	87.1	99.6	114.5	131.9	151.8	174.1	198.6	225.0	253.0
450	8.9	10.0	11.4	13.3	15.9	19.7	25.8	37.0	61.6	69.9	80.0	92.2	106.8	124.1	144.0	166.5	191.3	218.0	246.4
500	8.0	9.0	10.3	11.9	14.3	17.7	23.3	33.5	56.5	64.4	74.1	86.0	100.3	117.5	137.5	160.1	185.2	212.3	241.0
550	7.3	8.2	9.3	10.9	13.0	16.1	21.2	30.7	52.2	59.7	69.1	80.6	94.8	111.9	131.9	154.7	180.0	207.4	236.4
600	6.7	7.5	8.6	10.0	11.9	14.8	19.5	28.3	48.5	55.7	64.8	76.0	90.0	107.0	127.0	150.0	175.5	203.2	232.5
650	6.2	6.9	7.9	9.2	11.0	13.7	18.0	26.2	45.4	52.3	61.0	72.0	85.8	102.7	122.8	145.9	171.6	199.5	229.1
700	5.7	6.4	7.3	8.5	10.2	12.7	16.8	24.4	42.6	49.2	57.7	68.4	82.0	98.8	119.0	142.2	168.2	196.3	226.1
750	5.3	6.0	6.8	8.0	9.5	11.9	15.7	22.9	40.1	46.5	54.7	65.2	78.7	95.4	115.6	139.0	165.1	193.5	223.5
800	5.0	5.6	6.4	7.5	9.0	11.1	14.7	21.5	37.9	44.1	52.1	62.4	75.6	92.3	112.5	136.0	162.4	190.9	221.1
850	4.7	5.3	6.0	7.0	8.4	10.5	13.9	20.3	36.0	42.0	49.7	59.8	72.9	89.5	109.7	133.4	159.9	188.6	219.0
900	4.4	5.0	5.7	6.7	8.0	9.9	13.1	19.2	34.2	40.0	47.5	57.4	70.3	86.9	107.2	131.0	157.7	186.6	217.2

Capacity (veh/hr)	Average Delay "D" for Entry/Exit Movements (sec) at Entrances and Intersections																		
	Traffic Load "X": Entry/Exit Movement Flow (veh/hr) / Capacity of Opposing Flow to Accept Entry/Exit Movements (veh/hr)																		
	0.10	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**	**0.92**	**0.94**	**0.96**	**0.98**	**1.00**	**1.02**	**1.04**	**1.06**	**1.08**	**1.10**
950	4.2	4.7	5.4	6.3	7.5	9.4	12.4	18.2	32.7	38.2	45.5	55.2	68.0	84.5	104.8	128.8	155.6	184.7	215.4
1000	4.0	4.5	5.1	6.0	7.2	8.9	11.8	17.3	31.2	36.6	43.7	53.3	65.9	82.3	102.7	126.7	153.7	183.0	213.9
1050	3.8	4.3	4.9	5.7	6.8	8.5	11.3	16.5	29.9	35.1	42.1	51.4	63.9	80.3	100.7	124.9	152.0	181.4	212.5
1100	3.6	4.1	4.7	5.4	6.5	8.1	10.8	15.8	28.7	33.8	40.5	49.7	62.1	78.4	98.9	123.1	150.4	180.0	211.2
1150	3.5	3.9	4.5	5.2	6.2	7.8	10.3	15.1	27.6	32.5	39.1	48.2	60.4	76.6	97.1	121.5	149.0	178.7	210.0
1200	3.3	3.7	4.3	5.0	6.0	7.5	9.9	14.5	26.5	31.3	37.8	46.7	58.8	75.0	95.5	120.0	147.6	177.4	208.9
1250	3.2	3.6	4.1	4.8	5.7	7.2	9.5	14.0	25.6	30.3	36.6	45.3	57.3	73.5	94.0	118.6	146.3	176.3	207.8
1300	3.1	3.5	4.0	4.6	5.5	6.9	9.1	13.4	24.7	29.2	35.4	44.0	55.9	72.0	92.6	117.3	145.1	175.2	206.9
1350	3.0	3.3	3.8	4.4	5.3	6.6	8.8	13.0	23.9	28.3	34.4	42.8	54.6	70.6	91.3	116.0	144.0	174.2	206.0
1400	2.9	3.2	3.7	4.3	5.1	6.4	8.5	12.5	23.1	27.4	33.4	41.7	53.3	69.3	90.0	114.9	143.0	173.3	205.1
1450	2.8	3.1	3.5	4.1	5.0	6.2	8.2	12.1	22.4	26.6	32.4	40.6	52.2	68.1	88.8	113.8	142.0	172.4	204.4
1500	2.7	3.0	3.4	4.0	4.8	6.0	7.9	11.7	21.7	25.8	31.5	39.6	51.0	66.9	87.7	112.7	141.0	171.6	203.6
1600	2.5	2.8	3.2	3.7	4.5	5.6	7.4	11.0	20.4	24.4	29.9	37.7	49.0	64.8	85.6	110.8	139.3	170.1	202.3
1700	2.4	2.6	3.0	3.5	4.2	5.3	7.0	10.4	19.3	23.1	28.4	36.0	47.1	62.8	83.7	109.1	137.8	168.7	201.1
1800	2.2	2.5	2.9	3.3	4.0	5.0	6.6	9.8	18.3	22.0	27.1	34.5	45.4	61.0	81.9	107.5	136.4	167.5	200.0
1900	2.1	2.4	2.7	3.2	3.8	4.7	6.3	9.3	17.4	20.9	25.8	33.1	43.8	59.4	80.3	106.1	135.1	166.4	199.0
2000	2.0	2.2	2.6	3.0	3.6	4.5	6.0	8.8	16.6	20.0	24.7	31.8	42.3	57.8	78.9	104.7	134.0	165.4	198.2
2100	1.9	2.1	2.4	2.9	3.4	4.3	5.7	8.4	15.9	19.1	23.7	30.6	41.0	56.4	77.5	103.5	132.9	164.5	197.4

Conversion Factor: Average Delay for All Vehicles (as above) to Average Delay for Vehicles Actually Delayed																		
Opposing Flow (veh/hr)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800
Factor	7.91	4.22	3.00	2.40	2.04	1.80	1.64	1.52	1.42	1.35	1.30	1.25	1.21	1.18	1.15	1.13	1.11	1.10

Average Queue (L)	L = D*Va/300 (m) where Va is the entry/exit volume (veh/hr) @ 6 m per vehicle in Queue	Desirable Maximum Average Delay	50 sec (all vehicles)
Maximum Queue	Lm = 2.5*L (m)	Absolute Maximum Average Delay	90 sec (all vehicles)

Transportation

Appendix E2A – Capacity of 2 or More Traffic Lanes for Entrance Movements

Capacity of Opposing-traffic in a More Than a Single Lane to Accept Entry/Exit Movements (veh/hour)

Opposing Flow (veh/hr)	Critical Acceptance Gap (sec) 3.50					Critical Acceptance Gap (sec) 3.75					Critical Acceptance Gap (sec) 4.00					Critical Acceptance Gap (sec) 4.25					Critical Acceptance Gap (sec) 4.50				
	% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned				
	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10
50	1694	1684	1670	1654	1646	1580	1572	1556	1542	1532	1482	1472	1458	1442	1434	1394	1384	1370	1356	1346	1316	1308	1292	1278	1268
200	1632	1598	1540	1484	1452	1522	1488	1430	1374	1342	1426	1390	1334	1278	1248	1340	1306	1248	1194	1164	1264	1230	1174	1120	1088
400	1552	1482	1374	1272	1214	1446	1376	1268	1168	1112	1352	1284	1176	1078	1024	1270	1202	1096	1000	944	1198	1130	1024	928	876
600	1472	1370	1216	1078	1004	1368	1268	1116	982	908	1280	1180	1030	898	826	1200	1102	954	824	756	1130	1032	886	760	692
800	1392	1260	1068	904	816	1292	1164	974	814	732	1206	1078	892	738	658	1130	1004	822	670	594	1062	938	758	612	538
1000	1312	1154	930	746	654	1218	1060	842	666	578	1134	980	766	596	512	1062	908	700	536	456	996	846	640	484	408
1200	1232	1050	800	608	514	1142	962	718	536	448	1062	884	648	474	392	994	818	588	420	344	932	758	534	376	302
1400	1154	948	680	486	394	1068	866	606	422	338	992	794	542	368	292	926	730	488	324	252	866	674	440	284	218
1600	1076	850	570	380	296	994	772	504	326	250	922	704	446	280	210	858	646	398	242	178	802	594	356	210	152
1800	1000	756	472	290	216	920	684	412	246	178	852	620	362	208	148	792	566	318	176	122	738	518	282	150	102
2000	922	666	382	216	152	848	600	330	180	124	784	540	286	148	100	728	490	250	124	80	676	446	218	104	66
2200	848	580	304	156	104	778	518	260	126	82	716	466	222	104	64	662	420	190	84	50	616	378	164	68	50
2400	772	500	236	108	68	708	444	198	86	52	650	394	168	68	50	600	354	142	54	50	556	316	120	50	50
2600	700	424	178	72	50	638	372	146	56	50	586	330	122	50	50	538	292	102	50	50	496	260	84	50	50
2800	628	352	130	50	50	570	308	104	50	50	522	270	86	50	50	478	236	70	50	50	440	208	56	50	50
3000	558	286	90	50	50	504	248	72	50	50	460	214	56	50	50	420	188	50	50	50	384	164	50	50	50
3200	488	228	60	50	50	440	194	50	50	50	400	166	50	50	50	364	144	50	50	50	332	124	50	50	50
3400	422	176	50	50	50	378	148	50	50	50	342	124	50	50	50	308	106	50	50	50	280	90	50	50	50
3600	358	130	50	50	50	320	108	50	50	50	286	90	50	50	50	258	74	50	50	50	232	62	50	50	50
3800	298	92	50	50	50	264	74	50	50	50	234	60	50	50	50	208	50	50	50	50	188	50	50	50	50
4000	240	60	50	50	50	210	50	50	50	50	186	50	50	50	50	164	50	50	50	50	146	50	50	50	50
4200	186	50	50	50	50	162	50	50	50	50	140	50	50	50	50	122	50	50	50	50	108	50	50	50	50
4400	136	50	50	50	50	118	50	50	50	50	100	50	50	50	50	86	50	50	50	50	76	50	50	50	50
4600	94	50	50	50	50	78	50	50	50	50	66	50	50	50	50	56	50	50	50	50	50	50	50	50	50
4800	58	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
5000	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Capacity of Opposing-traffic in a More Than a Single Lane to Accept Entry/Exit Movements (veh/hour)																									
Opposing Flow (veh/hr)	Critical Acceptance Gap (sec) 4.75					Critical Acceptance Gap (sec) 5					Critical Acceptance Gap (sec) 5.25					Critical Acceptance Gap (sec) 5.5					Critical Acceptance Gap (sec) 5.75				
	% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned				
	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10
50	1246	1238	1222	1208	1200	1184	1176	1160	1146	1138	1128	1118	1104	1090	1080	1076	1066	1052	1038	1030	1028	1020	1006	990	982
200	1198	1162	1106	1052	1022	1136	1102	1046	992	962	1082	1046	990	938	908	1030	996	940	888	858	986	950	896	844	814
400	1132	1064	960	866	814	1072	1006	902	810	758	1020	952	850	758	708	972	904	804	712	664	928	860	760	672	622
600	1066	970	826	702	636	1010	914	772	650	586	958	862	722	604	542	912	816	678	562	502	870	776	638	524	466
800	1002	878	702	560	488	948	824	652	514	444	898	776	606	472	406	854	732	566	434	370	814	692	528	402	340
1000	938	790	590	438	366	886	738	544	398	328	840	694	502	362	296	796	652	464	330	266	758	614	432	300	242
1200	876	704	488	336	266	826	658	446	300	236	780	614	408	270	210	740	576	376	244	186	702	540	346	220	166
1400	814	624	398	250	190	766	580	360	222	164	722	540	328	196	144	684	504	298	174	126	648	470	272	156	110
1600	752	548	318	182	130	706	506	286	158	110	666	468	258	138	94	628	436	232	122	82	594	404	210	106	70
1800	692	474	250	128	86	648	436	222	110	72	610	402	198	94	60	574	372	176	82	50	542	344	158	70	50
2000	632	406	190	88	54	592	372	168	74	50	554	340	148	62	50	522	314	130	52	50	492	288	114	50	50
2200	574	344	142	56	50	536	312	122	50	50	500	284	106	50	50	470	260	92	50	50	442	238	80	50	50
2400	516	286	102	50	50	480	258	86	50	50	448	232	74	50	50	420	210	64	50	50	394	192	54	50	50
2600	460	232	70	50	50	428	208	60	50	50	398	186	50	50	50	370	168	50	50	50	346	152	50	50	50
2800	406	184	50	50	50	376	164	50	50	50	348	146	50	50	50	324	130	50	50	50	302	116	50	50	50
3000	354	144	50	50	50	326	126	50	50	50	302	110	50	50	50	278	98	50	50	50	258	86	50	50	50
3200	304	106	50	50	50	278	92	50	50	50	256	80	50	50	50	236	70	50	50	50	218	62	50	50	50
3400	256	76	50	50	50	234	66	50	50	50	214	56	50	50	50	196	50	50	50	50	180	50	50	50	50
3600	210	52	50	50	50	190	50	50	50	50	174	50	50	50	50	158	50	50	50	50	144	50	50	50	50
3800	168	50	50	50	50	152	50	50	50	50	136	50	50	50	50	124	50	50	50	50	112	50	50	50	50
4000	130	50	50	50	50	116	50	50	50	50	104	50	50	50	50	92	50	50	50	50	84	50	50	50	50
4200	96	50	50	50	50	84	50	50	50	50	74	50	50	50	50	66	50	50	50	50	58	50	50	50	50
4400	66	50	50	50	50	56	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4600	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4800	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
5000	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Capacity of Opposing-traffic in a More Than a Single Lane to Accept Entry/Exit Movements (veh/hour)

Opposing Flow (veh/hr)	Critical Acceptance Gap (sec) 6.00					Critical Acceptance Gap (sec) 6.25					Critical Acceptance Gap (sec) 6.50					Critical Acceptance Gap (sec) 6.75					Critical Acceptance Gap (sec) 7.00				
	% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned				
	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10
1695	1686	1670	1656	1646	1580	1570	1556	1540	1536	1480	1470	1456	1446	1436	1396	1386	1370	1356	1346	1316	1306	1290	1280	1270	798
1635	1596	1540	1486	1450	1526	1486	1430	1376	1340	1426	1390	1336	1280	1246	1340	1306	1250	1196	1166	1266	1230	1176	1120	1090	638
1550	1486	1376	1270	1216	1446	1376	1270	1170	1110	1350	1286	1176	1080	1026	1270	1200	1096	1000	946	1196	1130	1026	930	876	464
1470	1370	1216	1080	1006	1370	1270	1116	980	910	1280	1180	1030	900	826	1200	1100	956	826	756	1130	1030	886	760	690	328
1390	1260	1070	906	816	1296	1166	976	816	730	1206	1080	896	740	656	1130	1006	820	670	596	1066	936	760	610	536	226
1310	1156	930	746	656	1216	1060	840	666	580	1136	980	766	596	510	1060	910	700	536	456	996	846	640	486	410	150
1235	1050	800	606	516	1140	960	720	536	446	1066	886	650	476	390	996	816	590	420	346	930	760	536	376	300	96
1155	950	680	486	396	1070	866	606	420	340	990	796	546	370	290	926	730	490	326	250	866	676	440	286	220	58
1075	850	570	380	296	996	776	506	326	250	920	706	446	280	210	860	646	400	240	180	800	596	356	210	150	50
1000	756	470	290	216	920	686	410	246	180	850	620	360	206	150	790	566	320	176	126	740	516	280	150	100	50
925	666	386	216	156	850	600	330	180	126	786	540	286	150	100	726	490	250	126	80	676	446	220	106	66	50
845	580	306	156	106	776	520	260	126	80	716	466	220	106	66	666	420	190	86	50	616	380	166	70	50	50
775	500	236	110	66	706	446	200	86	50	650	396	166	70	50	600	356	140	56	50	556	316	120	50	50	50
700	426	180	70	50	640	370	146	56	50	586	330	120	50	50	540	290	100	50	50	496	260	86	50	50	50
630	350	130	50	50	570	306	106	50	50	520	270	86	50	50	480	236	70	50	50	440	210	56	50	50	50
555	286	90	50	50	506	250	70	50	50	460	216	56	50	50	420	186	50	50	50	386	166	50	50	50	50
490	230	60	50	50	440	196	50	50	50	400	166	50	50	50	366	146	50	50	50	330	126	50	50	50	50
420	176	50	50	50	380	150	50	50	50	340	126	50	50	50	310	106	50	50	50	280	90	50	50	50	50
360	130	50	50	50	320	106	50	50	50	286	90	50	50	50	256	76	50	50	50	230	60	50	50	50	50
295	90	50	50	50	266	76	50	50	50	236	60	50	50	50	210	50	50	50	50	186	50	50	50	50	50
240	60	50	50	50	210	50	50	50	50	186	50	50	50	50	166	50	50	50	50	146	50	50	50	50	50
185	50	50	50	50	160	50	50	50	50	140	50	50	50	50	126	50	50	50	50	110	50	50	50	50	50
135	50	50	50	50	116	50	50	50	50	100	50	50	50	50	86	50	50	50	50	76	50	50	50	50	50
95	50	50	50	50	80	50	50	50	50	66	50	50	50	50	56	50	50	50	50	50	50	50	50	50	50
60	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Capacity of Opposing-traffic in a More Than a Single Lane to Accept Entry/Exit Movements (veh/hour)																									
Opposing Flow (veh/hr)	Critical Acceptance Gap (sec) 7.25					Critical Acceptance Gap (sec) 7.5					Critical Acceptance Gap (sec) 7.75					Critical Acceptance Gap (sec) 8.00					Critical Acceptance Gap (sec) 8.25				
	% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned				
	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10
50	814	806	792	778	768	788	778	764	750	742	762	752	738	724	716	738	730	714	700	692	716	706	692	678	670
200	776	742	688	640	610	750	716	662	614	584	724	692	638	588	560	702	668	614	566	538	680	646	594	544	518
400	726	662	566	484	440	700	636	542	460	416	676	612	518	438	396	654	590	496	418	376	632	570	476	398	358
600	676	586	458	358	308	652	560	436	336	288	628	538	414	318	270	608	518	394	300	254	586	498	376	284	238
800	628	514	364	258	208	604	490	344	240	192	582	470	326	224	178	562	450	308	210	166	542	430	292	196	154
1000	580	446	284	180	136	558	424	266	166	124	536	404	250	154	114	516	386	236	142	104	498	368	222	130	96
1200	532	382	218	122	86	512	364	202	110	76	492	344	188	102	68	472	328	176	92	62	454	312	164	84	56
1400	486	326	162	80	50	466	306	150	72	50	448	290	138	64	50	430	274	128	58	50	412	260	118	52	50
1600	442	272	118	50	50	422	256	108	50	50	404	240	98	50	50	388	226	90	50	50	372	214	82	50	50
1800	398	224	82	50	50	380	210	74	50	50	364	196	68	50	50	348	184	60	50	50	332	172	54	50	50
2000	356	182	56	50	50	340	168	50	50	50	324	158	50	50	50	308	146	50	50	50	296	136	50	50	50
2200	316	144	50	50	50	300	132	50	50	50	286	122	50	50	50	272	114	50	50	50	258	106	50	50	50
2400	276	112	50	50	50	262	102	50	50	50	248	94	50	50	50	236	86	50	50	50	224	78	50	50	50
2600	240	84	50	50	50	226	76	50	50	50	214	68	50	50	50	202	62	50	50	50	192	58	50	50	50
2800	204	60	50	50	50	192	54	50	50	50	180	50	50	50	50	170	50	50	50	50	162	50	50	50	50
3000	170	50	50	50	50	160	50	50	50	50	150	50	50	50	50	142	50	50	50	50	132	50	50	50	50
3200	140	50	50	50	50	130	50	50	50	50	122	50	50	50	50	114	50	50	50	50	106	50	50	50	50
3400	112	50	50	50	50	104	50	50	50	50	96	50	50	50	50	90	50	50	50	50	84	50	50	50	50
3600	86	50	50	50	50	80	50	50	50	50	74	50	50	50	50	68	50	50	50	50	62	50	50	50	50
3800	64	50	50	50	50	58	50	50	50	50	54	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4000	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4200	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4400	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4600	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4800	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
5000	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Appendix E2B – Capacity of a Single Traffic Lane for Entrance Movements

Capacity of Opposing-traffic in a Single Lane to Accept Site Entry/Exit Movements (veh/hour)																									
Opposing Flow (veh/hr)	Critical Acceptance Gap (sec) 3.50					Critical Acceptance Gap (sec) 3.75					Critical Acceptance Gap (sec) 4.00					Critical Acceptance Gap (sec) 4.25					Critical Acceptance Gap (sec) 4.50				
	% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned				
	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10
50	1668	1664	1656	1648	1642	1556	1552	1544	1534	1530	1458	1454	1444	1436	1430	1372	1368	1358	1350	1344	1296	1290	1282	1272	1266
100	1622	1612	1596	1580	1572	1514	1504	1486	1470	1460	1418	1408	1390	1372	1362	1334	1322	1304	1286	1276	1260	1248	1230	1210	1200
200	1530	1510	1480	1448	1430	1426	1406	1374	1342	1322	1336	1314	1280	1248	1228	1256	1234	1198	1164	1144	1184	1162	1126	1090	1070
300	1438	1410	1364	1318	1292	1340	1310	1262	1214	1186	1254	1222	1172	1124	1096	1178	1146	1094	1044	1014	1110	1078	1024	974	944
400	1346	1308	1248	1190	1156	1254	1214	1150	1090	1054	1172	1130	1066	1002	966	1100	1058	990	926	890	1036	992	924	858	822
500	1254	1208	1132	1062	1022	1166	1118	1040	966	926	1090	1040	960	884	842	1022	970	888	812	768	962	908	824	748	704
600	1162	1106	1020	938	890	1080	1022	932	848	800	1008	948	854	770	722	944	882	788	700	652	888	826	728	640	594
700	1070	1006	906	816	764	994	926	824	730	680	926	858	752	658	606	868	796	688	594	544	814	742	634	538	488
800	978	906	796	696	642	906	832	718	618	564	844	768	652	550	498	790	710	592	492	440	742	660	542	442	390
900	886	806	688	582	526	820	738	616	510	456	764	678	554	450	396	712	626	500	398	344	668	578	452	352	302
1000	795	708	580	474	416	734	644	516	408	354	682	590	460	354	302	636	542	410	308	258	594	498	368	270	222
1100	703	610	478	370	316	648	552	418	314	262	600	502	368	266	218	558	458	326	228	182	522	420	288	196	154
1200	612	514	378	274	226	562	462	326	228	182	520	416	284	190	146	482	378	246	158	120	448	344	216	132	98
1300	521	418	284	190	146	478	372	242	152	114	440	334	204	122	88	406	300	174	98	70	376	270	150	80	54
1400	430	326	198	116	84	392	286	164	90	62	360	252	136	70	50	330	224	112	54	50	306	200	94	50	50
1500	340	236	122	60	50	308	204	98	50	50	280	178	78	50	50	256	154	62	50	50	234	134	50	50	50
1600	252	154	62	50	50	226	128	50	50	50	204	108	50	50	50	184	92	50	50	50	166	78	50	50	50
1700	165	80	50	50	50	146	64	50	50	50	128	52	50	50	50	114	50	50	50	50	102	50	50	50	50
1800	83	50	50	50	50	70	50	50	50	50	60	50	50	50	50	52	50	50	50	50	50	50	50	50	50
1900	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2000	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2100	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2200	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2300	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2400	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2500	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Opposing Flow (veh/hr)	Capacity of Opposing-traffic in a Single Lane to Accept Site Entry/Exit Movements (veh/hour)																								
	Critical Acceptance Gap (sec)					Critical Acceptance Gap (sec)					Critical Acceptance Gap (sec)					Critical Acceptance Gap (sec)					Critical Acceptance Gap (sec)				
	4.75					5					5.25					5.5					5.75				
	% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned				
	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10
50	1228	1222	1212	1202	1196	1166	1160	1150	1140	1134	1110	1104	1094	1084	1078	1060	1054	1042	1032	1026	1014	1006	996	986	980
100	1192	1180	1162	1142	1132	1132	1120	1100	1082	1070	1078	1066	1046	1026	1014	1028	1016	996	976	964	982	970	950	930	918
200	1122	1098	1060	1024	1004	1064	1040	1002	966	944	1012	988	950	912	890	966	940	902	864	842	922	898	858	820	796
300	1050	1016	962	910	880	996	962	906	854	822	948	912	856	802	772	902	866	810	756	724	862	826	768	714	682
400	980	934	864	798	762	928	882	812	744	706	882	836	762	696	658	840	792	720	652	614	802	754	680	612	574
500	908	854	768	690	648	860	804	718	640	596	818	760	672	594	552	778	720	632	554	510	742	682	594	516	474
600	838	774	676	588	540	794	728	628	540	494	752	686	586	498	452	714	648	546	460	414	682	612	512	426	382
700	768	694	584	490	440	726	650	540	446	398	688	612	500	408	360	652	576	466	374	328	622	544	434	344	298
800	698	614	496	398	348	658	574	456	360	310	622	538	420	324	278	590	506	388	294	248	562	476	358	268	224
900	628	538	412	312	264	592	500	376	278	232	558	466	342	250	204	528	436	314	222	180	502	408	288	200	160
1000	558	460	332	236	190	524	426	300	206	164	494	396	270	182	142	468	368	246	160	124	442	344	222	142	108
1100	488	386	256	168	128	458	356	228	144	108	430	328	204	124	92	406	304	184	108	78	384	282	164	94	66
1200	418	314	188	110	80	392	286	166	92	64	368	262	146	78	54	346	242	128	66	50	326	222	114	56	50
1300	350	244	128	64	50	326	220	110	52	50	306	200	96	50	50	286	182	82	50	50	268	166	70	50	50
1400	282	178	78	50	50	262	158	66	50	50	244	142	54	50	50	228	128	50	50	50	212	116	50	50	50
1500	216	118	50	50	50	198	104	50	50	50	184	90	50	50	50	170	80	50	50	50	158	70	50	50	50
1600	152	66	50	50	50	138	56	50	50	50	126	50	50	50	50	116	50	50	50	50	106	50	50	50	50
1700	90	50	50	50	50	82	50	50	50	50	74	50	50	50	50	66	50	50	50	50	60	50	50	50	50
1800	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
1900	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2000	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2100	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2200	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2300	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2400	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2500	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Capacity of Opposing-traffic in a Single Lane to Accept Site Entry/Exit Movements (veh/hour)																									
Opposing Flow (veh/hr)	Critical Acceptance Gap (sec) 6.00					Critical Acceptance Gap (sec) 6.25					Critical Acceptance Gap (sec) 6.50					Critical Acceptance Gap (sec) 6.75					Critical Acceptance Gap (sec) 7.00				
	% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned				
	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10
50	970	964	954	944	936	932	926	914	904	898	896	888	878	868	860	862	856	844	834	828	832	824	814	802	796
100	942	928	908	888	876	904	890	870	848	836	868	854	834	812	800	836	822	800	780	768	806	792	770	748	736
200	882	858	818	778	756	846	822	780	742	718	814	788	746	708	684	782	756	714	676	652	754	728	686	646	624
300	824	788	730	674	644	790	752	694	640	608	758	720	662	606	576	730	690	632	576	546	702	664	604	548	518
400	766	718	644	576	538	734	684	610	542	506	704	654	580	512	474	676	626	550	484	448	650	600	524	458	422
500	708	648	560	482	440	678	618	528	452	410	650	590	500	424	382	624	562	474	398	358	598	538	450	374	334
600	650	580	480	396	352	622	552	452	368	324	594	524	424	342	300	570	500	400	318	278	548	478	378	298	256
700	592	514	404	316	272	566	486	378	290	248	540	462	354	268	226	518	438	330	248	208	496	418	310	228	190
800	534	448	332	244	202	510	424	308	222	182	486	400	286	202	164	466	378	266	184	148	446	360	248	170	134
900	478	384	264	180	142	454	362	244	162	126	434	340	224	146	112	414	320	208	132	100	396	304	192	118	88
1000	420	322	202	126	94	400	302	184	110	80	380	282	168	98	70	362	266	154	88	62	346	250	140	78	54
1100	364	262	148	80	56	344	244	132	70	50	328	228	120	62	50	312	212	108	54	50	296	198	98	50	50
1200	308	204	100	50	50	292	190	88	50	50	276	176	78	50	50	262	162	70	50	50	248	150	62	50	50
1300	252	152	62	50	50	238	138	54	50	50	224	128	50	50	50	212	116	50	50	50	202	108	50	50	50
1400	198	104	50	50	50	186	94	50	50	50	176	84	50	50	50	164	76	50	50	50	156	70	50	50	50
1500	146	62	50	50	50	136	56	50	50	50	128	50	50	50	50	120	50	50	50	50	112	50	50	50	50
1600	98	50	50	50	50	90	50	50	50	50	84	50	50	50	50	76	50	50	50	50	72	50	50	50	50
1700	54	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
1800	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
1900	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2000	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2100	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2200	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2300	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2400	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2500	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Opposing Flow (veh/hr)	Capacity of Opposing-traffic in a Single Lane to Accept Site Entry/Exit Movements (veh/hour)																								
	Critical Acceptance Gap (sec) 7.25					Critical Acceptance Gap (sec) 7.5					Critical Acceptance Gap (sec) 7.75					Critical Acceptance Gap (sec) 8					Critical Acceptance Gap (sec) 8.25				
	% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned					% of Opposing Flow Platooned				
	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10	90	75	50	25	10
50	802	796	784	774	766	776	768	758	746	740	750	744	732	720	714	726	720	708	696	690	704	698	686	674	668
100	778	764	742	720	708	750	738	716	694	680	726	712	690	668	656	704	690	666	646	632	682	668	646	624	610
200	726	700	658	618	596	702	676	632	592	570	678	652	610	570	546	656	630	586	546	524	636	608	566	526	504
300	676	638	578	522	492	652	614	554	498	468	630	592	532	476	446	610	570	510	456	426	590	550	490	436	406
400	626	576	500	434	398	604	554	478	412	376	584	532	456	390	356	564	512	436	372	336	546	494	418	354	320
500	576	516	426	352	314	556	494	406	332	294	536	474	386	312	276	518	456	368	296	258	500	438	350	280	244
600	526	456	356	278	238	508	436	338	260	222	488	418	320	244	206	472	400	304	228	192	456	384	288	214	178
700	478	398	292	212	174	458	380	274	196	160	442	362	258	182	148	426	346	244	170	136	410	332	230	158	124
800	428	342	232	154	122	412	324	216	142	110	396	308	202	130	100	380	294	190	120	90	366	280	178	110	82
900	380	286	178	108	78	364	272	164	98	70	350	258	152	88	62	336	244	142	80	56	322	232	132	72	50
1000	330	234	130	70	50	316	222	118	62	50	304	208	108	54	50	292	198	100	50	50	280	186	92	50	50
1100	284	186	88	50	50	270	174	80	50	50	258	162	72	50	50	248	152	66	50	50	238	144	60	50	50
1200	236	140	56	50	50	226	130	50	50	50	214	120	50	50	50	204	112	50	50	50	196	106	50	50	50
1300	190	98	50	50	50	180	90	50	50	50	172	84	50	50	50	164	78	50	50	50	156	72	50	50	50
1400	146	64	50	50	50	138	58	50	50	50	130	52	50	50	50	124	50	50	50	50	116	50	50	50	50
1500	104	50	50	50	50	98	50	50	50	50	92	50	50	50	50	86	50	50	50	50	82	50	50	50	50
1600	66	50	50	50	50	62	50	50	50	50	56	50	50	50	50	52	50	50	50	50	50	50	50	50	50
1700	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
1800	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
1900	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2000	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2100	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2200	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2300	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2400	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2500	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Appendix E3 – Factors for Flows opposing Entrance Movements

Entrance Movement Opposing-Flow Factors			Entrance Movements Out-bound			Entrance Movements In-bound		
			left	through	right	left	through	right
Frontage Traffic Arriving (As viewed by Outbound Drivers)	From Left	right	0	**1**	**1**	**0.5**	**1**	0
		through	0	**1**	**k1**	0	**1**	0
		left	0	**1**	0	0	**0.2**	0
	From Opposite	right	**1**	0	**k2**	0	0	0
		through	0	0	**1**	0	0	0
		left	0	0	0	0	0	0
	From Right	right	0	**1**	**1**	0	**1**	**k2**
		through	**1**	**1**	**1**	0	**1**	**1**
		left	**0.2**	**0.2**	**0.2**	0	**1**	**0.2**
k1 = 0.25 if a flush median exists for right turns					k1 = 0 otherwise			
k2 = 0.50 if opposing right turns block each other					k2 = 0 otherwise			
If a road exists opposite the entrance then it assumed to be under priority control								

Appendix E4 – Critical Acceptance Gaps (sec)

Critical-acceptance-gaps (sec) for Entrances and Intersections												
Movement >	**Out-left 2-lane**	**Out-left 4-lane**	**Out-right 2-lane**	**Out-right 4-lane**	**Out-right 2-lane-m**	**Out-right 4-lane-m**	**Out-thru 2-lane**	**Out-thru 4-lane**	**Out-thru 4-lane-m**	**In-right 2-lane**	**In-right 4-lane**	**In-left**
V km/h	CAG(sec)	CAG(sec)	CAG(sec)	CAG(sec)	CAG(sec)	CAG(sec)	CAG(sec)	CAG(sec)	CAG(sec)	CAG(sec)	CAG(sec)	CAG(sec)
20	3.25	4.00	5.25	6.25	4.25	5.00	5.25	6.25	6.50	3.75	4.25	4.25
25	3.50	4.25	5.25	6.25	4.25	5.00	5.25	6.25	6.75	3.75	4.50	4.25
30	3.75	4.25	5.50	6.25	4.25	5.00	5.25	6.50	6.75	4.00	4.75	4.25
35	4.00	4.50	5.50	6.25	4.25	5.00	5.25	6.50	6.75	4.00	4.75	4.25
40	4.00	4.75	5.50	6.25	4.25	5.00	5.50	6.50	7.00	4.25	5.00	4.25
45	4.25	4.75	5.50	6.25	4.25	5.25	5.50	6.75	7.00	4.25	5.00	4.25
50	4.50	5.00	5.50	6.50	4.25	5.25	5.50	6.75	7.00	4.25	5.25	4.25
55	4.50	5.25	5.50	6.50	4.25	5.25	5.75	6.75	7.25	4.50	5.25	4.25
60	4.75	5.25	5.75	6.50	4.50	5.25	5.75	7.00	7.25	4.50	5.50	4.25
65	5.00	5.50	5.75	6.50	4.50	5.25	5.75	7.00	7.25	4.75	5.75	4.25
70	5.00	5.75	6.00	6.75	4.50	5.25	5.75	7.00	7.25	4.75	5.75	5.00
75	5.25	5.75	6.25	6.75	4.50	5.50	6.00	7.25	7.50	4.75	6.00	5.00
80	5.50	6.00	6.25	6.75	4.75	5.50	6.00	7.25	7.50	5.00	6.00	5.00
85	5.50	6.25	6.50	6.75	4.75	5.50	6.00	7.25	7.50	5.00	6.00	5.00
90	5.75	6.50	6.75	7.00	4.75	5.75	6.25	7.50	7.75	5.00	6.25	5.00
95	6.00	6.50	6.75	7.00	5.00	5.75	6.25	7.50	7.75	5.00	6.25	5.00
100	6.00	6.75	7.00	7.00	5.00	5.75	6.25	7.50	7.75	5.25	6.50	5.00
105	6.25	7.00	7.00	7.25	5.00	6.00	6.50	7.75	8.00	5.25	6.50	5.00
110	6.25	7.00	7.25	7.25	5.25	6.00	6.50	7.75	8.00	5.25	6.50	5.00
115	6.50	7.25	7.50	7.50	5.25	6.00	6.50	7.75	8.00	5.25	6.75	5.00
"2-lane" means 1 lane each way ~ "4-lane" means 2 lanes each way ~ "-m" means flush median exists for benefit of right-turn movements												

Appendix E5 – The Priority Delay Function

The priority delay function, D(x) minute, selected for the Parking Loading and Driveway Guideline is due to Fisk [11] but with a capacity module due to Joubert and Van As [12].

D(x) =	{60 +15*[SQRT((2+Q*T*(1-x))^2+(8*Q*T*x))-(2+Q*T*(1-x))]}/Q	
C =	MAX{Cmin, fi*(Vo+0.1)*[EXP(-(A+d-H)*V1)]/[1-EXP(-F*V1)]}	
V1 =	fi*[((Vo+0.1)/3600)]/[1-H*((Vo+0.1)/3600)]	if Vo <= (3600/H)-1
V1 =	fi*[((3600/H)+1)/3600)]/[1-H*((3600/H)+1)/3600]	if Vo > (3600/H)-1
x =	Va*P/(C*T*n)	

Va	is the flow for which the delay is being calculated	(veh/hour)
C	is the absorption capacity of the opposing flow(s)	(veh/hour)
Cmin	is the minimum value for Q (Q = 50 in guideline table)	(veh/hour)
Vo	is the aggregate of factored opposing flows	(veh/hour)
A	is the acceptance gap	(second)
d	is 0.35*standard deviation of A (SD of A = 2 sec[15])	(second)
F	is the follow up headway (F = 0.6*A approximately)	(second)
fi	is the un-bunched traffic in the opposing flow[16]	(ratio)
H	is the headway in platoons (H = 1.8 for one lane 0.6 otherwise)	(second)
T	is the analysis period (T = 1 for the guideline)	(hour)
P	is the flow peaking factor for the analysis period (P = 1.05 for the Guideline)	(ratio)
n	is the number of lanes for the turn	(number)

This delay function is the same function as used in the Council's city-wide road traffic assignment model. The delay function choice was made because the function can cope with traffic loads well in excess of capacity. The capacity module was chosen because it has been shown to produce results that correlate well with the results of detailed simulations.

[15] Joubert and van As

[16] fi = MAX (0.05, 0.95-0.90*m/1000) where m is the distance in metre from the nearest upstream traffic signal. Where there are 2 or more lanes use the volume weighted average of the fi of each lane.

Appendix F – References

a. ‘Auckland Regional Parking Strategy” Auckland Regional Council 2009

b. “Strategic Parking Report” Waitakere City Council 2008

c. “Waitakere City Parking Plan 2009-2040”

d. “Guide to Traffic Generating Developments” Road Traffic Authority NSW 2002

e. “ Trips and Parking Related to Land Use” Research Report 209, Transfund New Zealand 2001

f. “Trip Generation” Volumes 1, 2, 3 Institute of Transportation Engineers 2003

g. “Parking Generation” 3rd Edition Institute of Transportation Engineers 2004

h. “Trips and Parking Database” New Zealand Trips and Parking Data Base Bureau Inc. 2008

i. ‘Best Practice Guide” Trip Rate Information Computer System (TRICS) Data Base UK 2008.

j. “Comparisons of NZ and UK Trips and Parking Rates” NZTA Research Report LTR 79 2008

k. “Accessible Car-parking Spaces”, NZ Department of Building and Housing 2008

l. “Parking Facilities Part 1: Off-street car-parking”, AS/NZS 2890.1:2004

m. “Site Design for Heavy Vehicle Facilities” Research Report 32 Transit New Zealand

n. “Urban Road Design’ AUSTROADS

o. “Guide to Traffic Engineering Practice Part 5 Intersections at Grade” AUSTROADS

p. “Guide to Traffic Engineering Practice Part 7 Traffic signals” AUSTROADS

q. “Guide to Traffic Engineering Practice Part 14 Bicycles” AUSTROADS

r. “The Effect of Platooning on the Capacity of Priority Controlled Intersections”, Joubert and Van As, Second International Symposium on Highway Capacity, Sydney. (1994).

s. “Priority Intersection Delay Model”, Auckland Regional Council, Auckland Transport Models Working Paper 11, Fisk and Tan, (1993).

t. “Gap Acceptance Studies in the Mayaguez Area” J Rodriguez, University of Puerto Rico 2006

u. “How Long Does It Take To Stop?” M Green Transportation Human Factors 2000

v. Synthetic Critical Gap Acceptance (working file): R O’N Hill, Waitakere City Council 2009

w. Partial Visibility Obstruction Algorithms (working file): R O’N Hill, Waitakere City Council 2009

x. Permitted Parking Ratio Effects Model (working file): R O’N Hill, Waitakere City Council 2009

y. Geometric-formulae for Visibility Distances (working file): R O’N Hill, Waitakere City Council 2009