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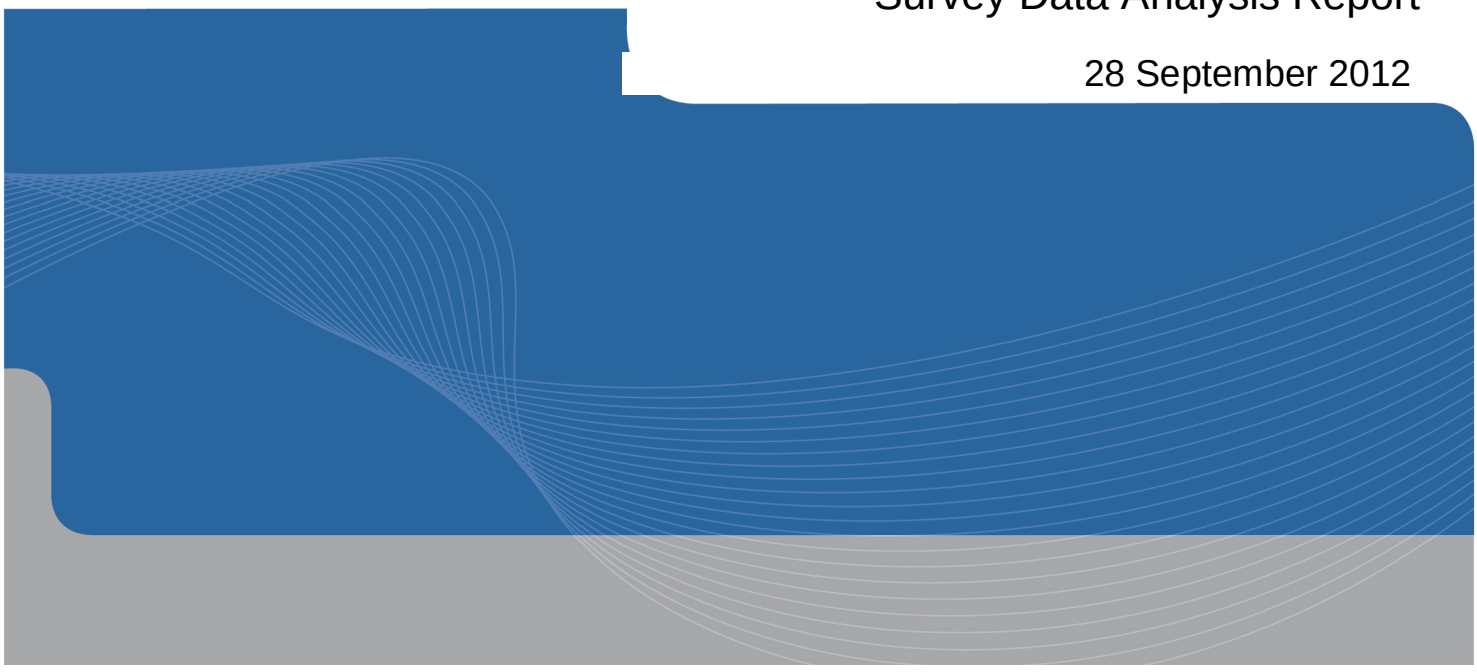
Roads and Maritime Services

Report for High Density Residential Trip Generation Surveys

Survey Data Analysis Report

28 September 2012



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1. Introduction

1.1 Background

New South Wales (NSW) is a experiencing rapid growth in key areas mandated by the Department of Planning and Infrastructure metropolitan plans, which identify areas of NSW targeted for increases in population and residential density. To support this continuing increase in residential population, high density residential developments are being built across the state, requiring guidelines for the treatment of traffic associated with them.

The NSW Roads and Traffic Authority (RTA) published its *Guide to Traffic Generating Developments* (the Guide) in the 1990's to aid traffic planners in assessing the traffic impacts and requirements of developments including high-density residential developments. This document is used extensively by Councils and developers in traffic impact assessments and relies on data collected and updated since 1978.

For high density residential developments, the last trip generation and parking studies were undertaken in 1993. Since that time, the trip generation and parking layout requirement data in the Guide is becoming increasingly out of date. Since that time, there has been an increasing awareness that public transport is not adequately accounted for in previous trip and parking generation surveys. A new analytical method has now been proposed to more accurately account for public transport accessibility in determining future trip behaviour and parking requirements for various land uses.

Furthermore, trip generation and parking demand databases have been developed overseas and are now available to subscribers online that may provide additional confidence to the current trip generation and parking demand requirements stated in the Guide.

More generally, updating the Guide with new survey data also helps in accounting for changes in demographics, trading operations, housing affordability, car ownership and costs of travel that have occurred in the intervening time since the last time surveys were undertaken. It is envisaged that the RMS will continue to update the Guide with more recent surveys, in this case surveys of high density residential developments.

1.2 Study Purpose and Approach

GHD has been commissioned by New South Wales Roads and Maritime Services (NSW RMS) to undertake surveys of high density residential developments to determine the trip generation and parking demand characteristics associated with these developments. This information will be used to update the *RTA Guide to Traffic Generating Developments (2002)*, which is currently used as the guide to assessing the traffic generation and traffic impacts of new developments.

Surveys were undertaken at ten (10) high density developments around Sydney and NSW, to determine the traffic generation of these sites during the weekday and weekends. This report presents the results of analysis of the survey data to calculate trip generation rates, including:

- Peak person movements;
- Vehicle movements generated by surveyed developments during the weekday morning and evening peak periods of peak vehicle flow on the adjacent road network;
- Vehicle movements generated by the surveyed developments during their peak periods on weekdays and weekends; and
- Peak parking demand of the surveyed developments for residents and visitors.

1.3 Extent of Study

The surveys undertaken for the study have been based on the following:

- The number of developments surveyed (10 high density residential developments).
- Automatic Traffic Counts (ATC) over one week, provided by Austraffic.
- Weekday (1 day) and Weekend (1 Day) traffic, pedestrian and cyclist counts, provided by Austraffic.
- Weekday (1 day) and Weekend (1 Day) parking occupancy surveys, provided by Austraffic.
- Resident questionnaires (interview on 1 weekday and 1 Saturday, letter box drop on 1 weekday and 1 Saturday), provided by Austraffic.
- Information regarding the developments (i.e. number of dwellings, number of bedrooms, number of parking spaces, floor area, other use, year of opening) provided by Strata/building Managers.

1.4 Report Structure

The remainder of this report is structured as follows:

- Section 2 – **Survey Methodology** identifies the surveyed sites used for the analysis, and provides a summary survey process;
- Section 3 – **Survey Review** presents an overview of the survey results;
- Section 4 – **Statistical Analysis** presents the findings of the statistical regression analysis;
- Section 5 – **Comparison of NSW Findings with Other Databases** provides a comparison of NSW survey results with other country's trip generation databases, including United Kingdon (TRICS), United States (ITE) and New Zealand (NZTDB);
- Section 6 – **Summary and Conclusions** provides a summary of the analysis and the main conclusions of the study;

This report is also accompanied by a Data Report that documents the survey results and provides greater detail regarding the survey sites.

2. Survey Methodology

In order to capture the trip generation behaviour of high density residential developments, a survey of suitable sites was undertaken to count trips ain and out of these developments. The details of the site selection and survey design are documented in this section.

2.1 Site Selection

2.1.1 Site Selection Methodology

Sites for this survey were selected on the basis of the following criteria, as agreed with RMS:

- Sites to be primarily residential land use only, with no additional land uses on the site, and if there were additional land uses on site, trip generation associated with other land uses should be separable from residential trip generation.
- Sites to be a distribution of developments with greater than six (6) floors in height.
- Sites to have countable vehicle and non-vehicle accesses.
- Sites to be distributed across inner city, greater metropolitan and regional areas of NSW.
- Sites to have a distribution of public transport accessibility.
- Sites to be comprised of generally owner-occupier or long-term rent households and not serviced apartments or tourist accommodation.

While every attempt was made to satisfy these criteria, it should be noted that only a small number of buildings matched the selection criteria, and it was not possible to find more than two sites in regional areas. This is partly because planning policy for high density residential development generally favours inner city areas and is also generally in favour of mixed use developments with retail in the ground floor, commercial in the lower floors and residential in the upper floors.

High density residential development is also generally concentrated in areas with good public transport accessibility, such as train stations, strategic bus corridors or within walking distance of commercial or retail centres.

Furthermore, high density residential developments in regional locations are most often found in tourist areas and are used mostly for short stay accommodation, often exhibiting temporal or seasonal variations in trip generation.

2.1.2 Selected Sites

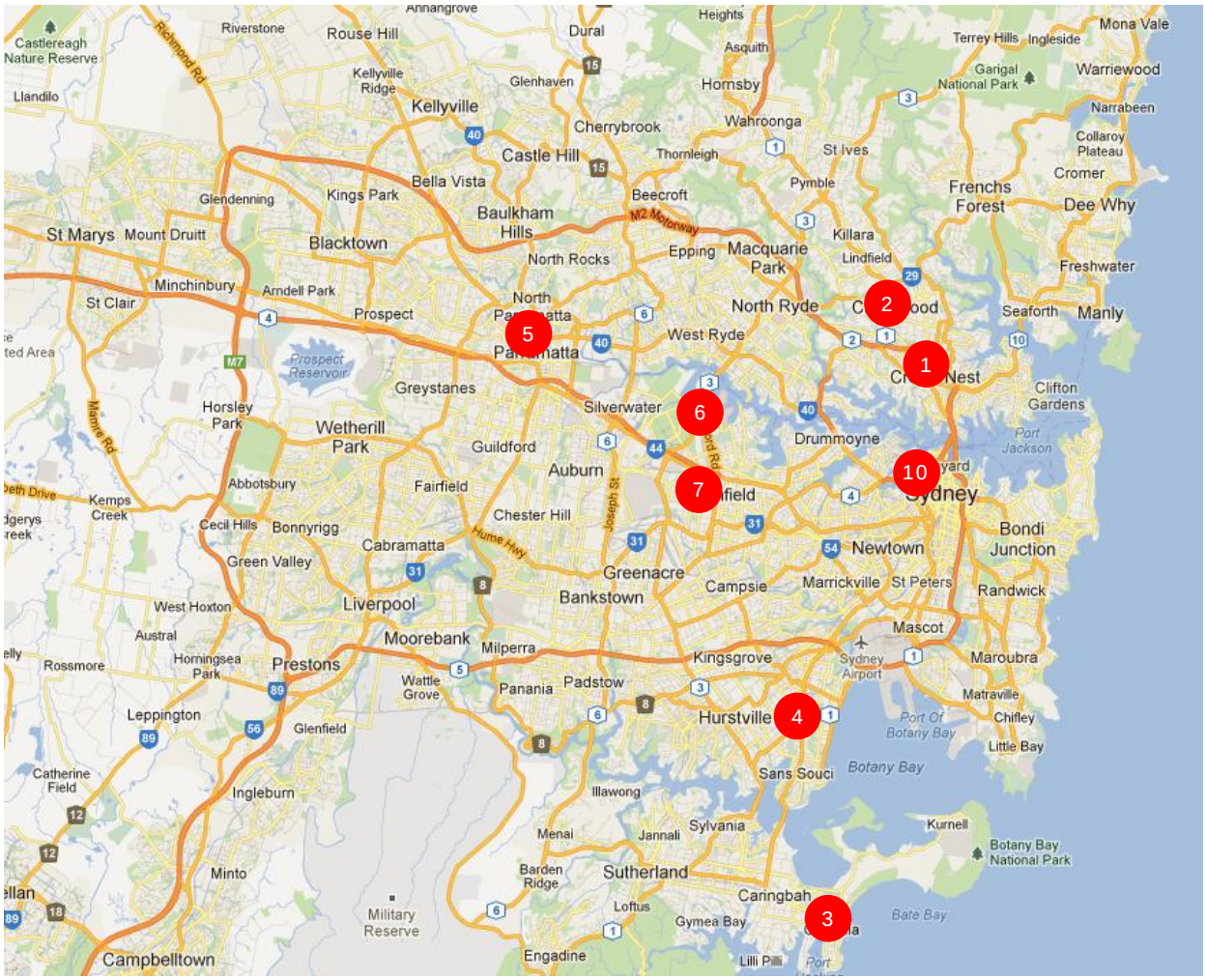
A total of ten (10) high density residential developments were surveyed as part of this work. A list of the surveyed sites is shown below in Table 1.

Table 1 - Summary of Survey Site Locations

Site ID	Site Address	Local Government Area (LGA)
1	13 Herbert Street, St Leonards	Willoughby City Council
2	1 Cambridge Lane, Chatswood	Willoughby City Council
3	8-12 Waratah Street, Cronulla	Sutherland Shire Council
4	2-8 Ashton Street, Rockdale	Rockdale City Council
5	26-30 Hassall Street, Parramatta	Parramatta City Council
6	10 Wentworth Drive, Liberty Grove	City of Canada Bay
7	2 Everton Road, Strathfield	Strathfield Council
8	316 Charlestown Road, Charlestown	Lake Macquarie City Council
9	3-5 Corrimal Street, Wollongong	Wollongong City Council
10	208 Harris Street, Pyrmont	City of Sydney Council

The majority of the high density residential sites are located within the Sydney Greater Metropolitan Area (GMA). The locations for these Sydney sites are shown below in Figure 1.

Figure 1 - Sydney Survey Site Locations



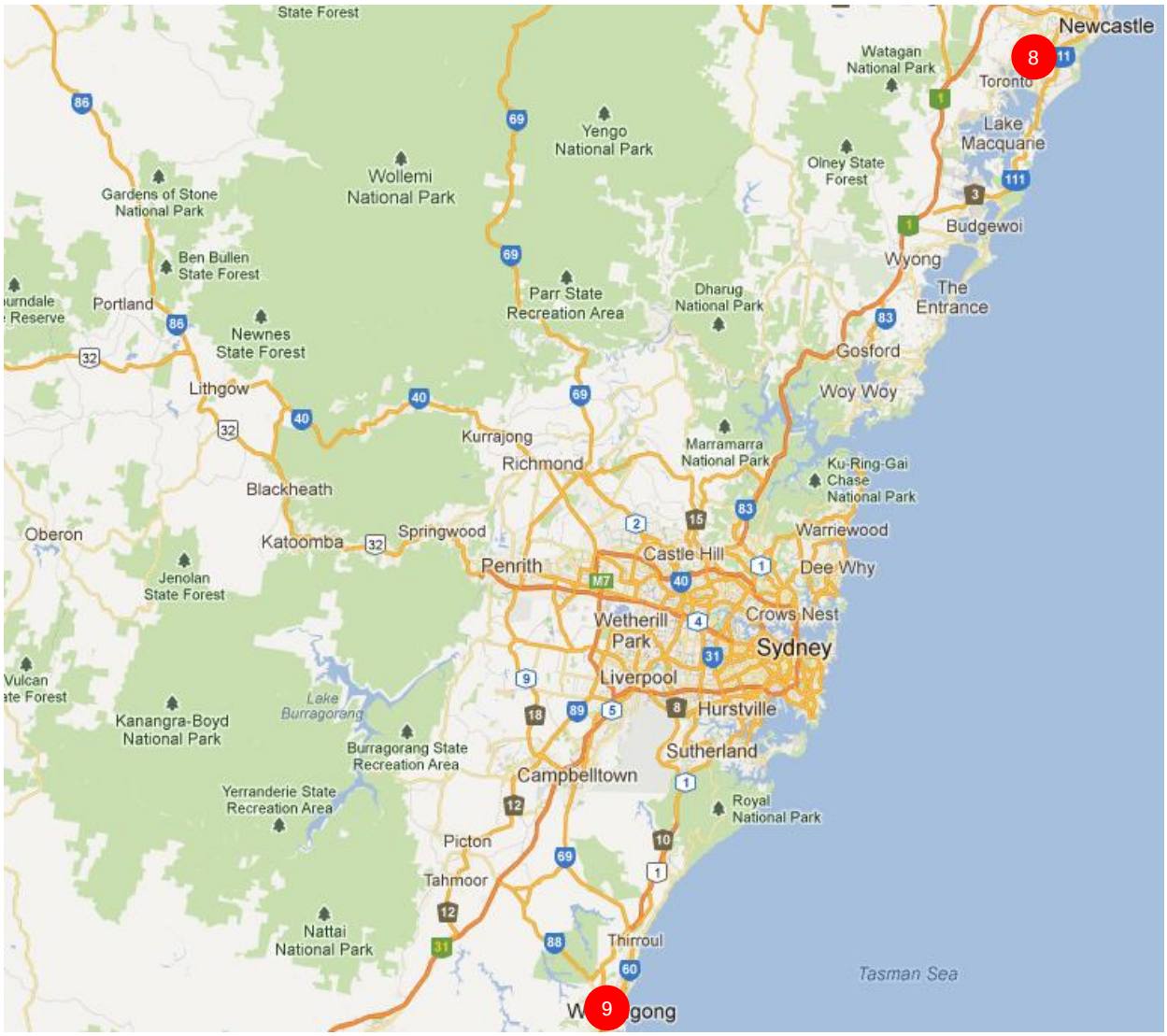
Source: Google Maps, 2012

A number of high density residential developments were sought outside of the Sydney GMA, however only two (2) sites were approved for surveys. These sites were:

- 316 Charlestown Road, Charlestown; and
- 3-5 Corrimal Street, Wollongong.

Both Charlestown and Wollongong are regional cities, with Charlestown located approximately 150 km north of the Sydney CBD on the Central Coast and Wollongong located approximately 80 km south of the Sydney CBD. The locations of these regional sites are shown below in Figure 2.

Figure 2 - Regional Survey Site Locations



2.2 Survey Design

To determine the trip making behaviour associated with residential developments, it was necessary to survey people movements in and out of the development over the period of a day. This count survey seeks to identify the following factors associated with trip generation from the site:

- Quantum and profile of trip generation;
- Modes of transport used by trips;
- Trip purpose;
- Trip duration;
- Parking accumulation; and
- Traffic profile of nearby roads.

To capture this data, the count survey design consisted of five components:

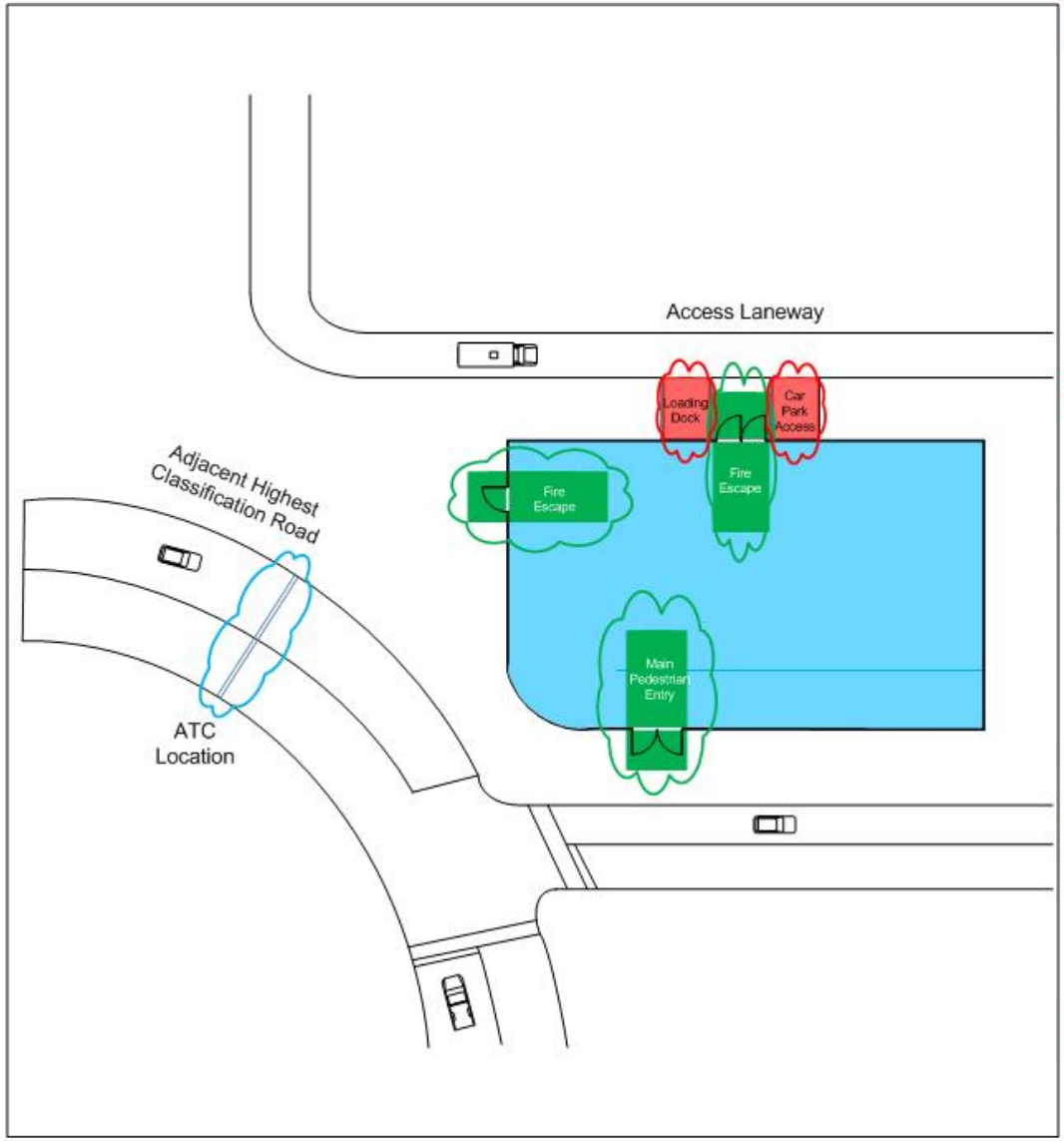
- Parking occupancy survey;
- Resident questionnaires (interview and letter box drop);
- Automatic Traffic Counts on up to two roads adjacent to the site;
- Vehicle counts at all vehicular accesses; and

- Pedestrian counts at all pedestrian accesses.

GHD commissioned Austraffic to undertake all of the above mentioned surveys.

A plan of a typical site with each of the survey elements specified above is shown in Figure 3.

Figure 3 – Typical Survey Design



General Site Data		
Survey Task	**Methodology**	**Typical Requirement**
Parking Inventory	An inventory of parking spaces by type (resident, visitor, business tenant, disabled, service, bicycle)	On-site survey of parking spaces prior to day of survey
Automatic Traffic Counts	An automatic traffic count covering both survey days (24 hours) on the highest-order adjacent road	Four-lane automatic traffic count
Mail-back forms	Trip making questionnaire to be dropped in mailboxes covering number and time of trips made, modes taken and trip purpose	Target response rate of 20%

Trip Making Information (vehicles)		
Survey Task	**Methodology**	**Typical Requirement**
Parking occupancy	Survey of parking space occupancy at the start of the survey period (6AM)	Parking occupancy survey undertaken at 5:00AM on day of survey
Access entry and exit counts	Video or staff survey over the day (6AM to 7PM) of all vehicles entering and exiting the development including vehicle occupancy, and numberplate	Typical site assumed to have one vehicle access only
Cyclist counts	Vehicle exit and entry to include cyclists (if cycle access is through carpark)	Typical site assumed to have cyclist access through vehicle and pedestrian accesses

Trip Making Information (pedestrians)		
Survey Task	**Methodology**	**Typical Requirement**
Access entry and exit counts	Video or staff survey over the day (6AM to 7PM) of all pedestrians exiting and entering the development via all accesses (including fire escapes) also including cyclists if using pedestrian accesses	Typical site assumed to have all pedestrian accesses visible from one location
Interview questionnaire	Trip making interviews to be conducted covering number and time of trips made, modes taken and trip purpose	On site interviews to be conducted for two 2-hour shifts on a weekday and one 2-hour shift on the weekend

Automatic traffic counts were undertaken on the highest-order road adjacent to the development. These counts were in place for the week of the survey period, covering both the weekday and weekend survey. Automatic traffic counts provide the general traffic profile on the network surrounding the development.

Automatic traffic counters were also placed across driveways of developments with a single vehicular access to try to capture the vehicle trip making behaviour for the whole 24 hour period of each survey day, however in all cases these automatic traffic counter failed to produce usable volume data due to the low speed and frequent stopping of vehicles using these accesses. Consequently, full 24-hour trip making data is not available, and is limited to the 12 hour duration noted above.

A single-page travel survey was delivered to all resident letter boxes within the developments, with completed copies of the survey collected in a box at the foyer of the building on the week following the survey date. Interview surveys were also undertaken using the survey sheet. The survey sheet included questions regarding:

- The dwelling size (number of bedrooms);
- Number of residents in the dwelling;
- Number of cars and parking spaces;
- Trips made on the day of survey;
- Modes used on the day of survey;
- Travel time;
- Number of passengers (if car trip); and
- Purpose of trips.

On the day of the survey, an initial parking occupancy survey was undertaken to determine the initial parking demand for the parking accumulation survey. This was undertaken prior to the commencement of other surveys, when the vehicle and pedestrian surveys began. It should be noted that for the Cronulla site (Site #3), some of the parking spaces were closed off, making it difficult to determine the initial parking occupancy for this site. Consequently, this site has been omitted from any parking accumulation analysis.

A vehicle count was undertaken on the day of the survey, to count all vehicle movements into and out of the resident car park accesses. This included a survey of vehicle movements, occupancy and numberplates, to allow for an estimate of the accumulation of parking demand and trip durations over the course of the day.

A similar count was undertaken at pedestrian accesses to determine the number of pedestrian trips made during the day, with interviews of pedestrians taken during key periods in the day to help determine the trip making behaviour of visitors as well as residents. The interview survey was undertaken using the single page letter box survey sheet.

Both pedestrian and vehicle access counts also include cyclists, who may enter and exit via both vehicle and pedestrian accesses depending on the layout of each development.

For each of the survey sites, spot checks were undertaken on survey data (pedestrian and vehicle counts) during peak hours to ensure that the data collected is of a high and consistent quality.

2.3 Data Recorded

The following information was recorded by the surveyors on site:

- Number of vehicles parked on site at the commencement of the survey;
- Number of vehicles and the number of occupants in each vehicle entering and leaving the parking areas;
- Number of pedestrians/cyclists entering and leaving via the pedestrian access points of the building; and
- Number of vehicles parked on site at the completion of the survey.

The collected information has been used to establish person trips, vehicle trips and parking accumulation.

Automatic “tube” traffic counts (ATCs) were undertaken on the principal frontage access roads to determine background peak hours using.

3. Data Review

3.1 Introduction

The high density residential surveys were undertaken in order to inform an update to the RMS Guide to Traffic Generating Developments (The Guide). The Guide provides a methodology for estimating the likely traffic generation of a number of land uses for the purposes of assessing the impacts of these developments. Estimation of trip generation is done using a “trip generation rate”. The trip generation rate is usually given as a number of trips (for a particular period, say peak hour or daily) generated by a particular metric of land use. In the case of residential buildings, this metric is usually related to the number of households in the proposed development.

With this methodology in mind, an analysis of the survey results has been undertaken based on deriving relationships between the trip generation (referred to as “trip making statistics” or “dependent variable”) and land use metrics (referred to as the “independent” variable) and testing whether these relationship are accurate predictors of trip generation.

This section identifies and characterises both the trip making statistics and the independent variables that have been considered as a part of this study.

3.2 Trip Making Statistics

The trip making statistics that have been identified for this study are as follows:

- Person trip generation (i.e. the number of inbound and outbound person trips for the given time period).
- Vehicle trip generation (i.e. the number of inbound and outbound vehicle trips for the given time period).
- Peak Parking Accumulation (the highest number of vehicles parked in the development, over an hour, during the survey period).
- Person trip and vehicle trip generation have been examined for the following periods:
- Weekday Morning Network Peak (the period of highest weekday morning hourly flow on the adjacent road network).
- Weekday Evening Network Peak (the period of highest weekday evening hourly flow on the adjacent road network).
- Saturday Network Peak (the period of highest Saturday hourly flow on the adjacent road network).
- Weekday Daily (the entire weekday survey period from 0600 to 1900).
- Saturday Daily (the entire Saturday survey period from 0600 to 1900).

Unlike shopping centres or commercial developments, residential developments generally have their highest parking demand during the off-peak period when people are at home, so for this reason the peak parking accumulation during the times surveyed is most likely to be either during the morning or the evening. For this reason, peak parking has only been analysed for the highest parking accumulation for either a weekday or Saturday.

In addition to the trip making statistics listed above, this study also sought to determine the significance of the relationships of other key metrics for residential developments. These additional metrics included:

- The ratio of vehicle trips and person trips (effectively the car mode share).
- The parking provision (ratio of parking spaces to units).

3.3 Independent Variables

The independent variables that have been considered in this study relate to the key characteristics of a development from a trip generation perspective. It is generally accepted that trip generation is driven by population. As the population of a residential development is generally not known until after a development has been built, number of households is generally used as a proxy for population. In high-density residential developments, these households are units, which generally (although not always) have one or more parking spaces allocated to them. The independent variables that were surveyed as a part of this study, then, are as follows:

- Number of units in the Development.
- Number of 1-Bedroom, 2-Bedroom and 3+Bedroom units in the Development.
- Number of Levels in the Development.
- Number of On-Site Resident Parking Spaces provided in the Development.
- The Accessibility Score; a measure of the proximity, scale and frequency of nearby public transport facilities.

When using the relationships of these independent variables to predict trip making statistics, it is important to consider the range of each of these independent variables, as the predictive power of any relationship derived from these surveys may be reduced in the development being assessed is outside of this range. This chapter presents a summary of these independent variables and their ranges.

3.3.1 Number of Units

The number of units in the development has been taken as the number of individual households, generally taken as the number of letterboxes for the development. This includes dual-key residences, which are usually larger units that are subdivided into smaller units behind a common door. For sites with multiple buildings, the number of units is taken as the sum of all buildings in the development. The number of units ranged from 9 units (Site #9) to 234 units (Site #4).

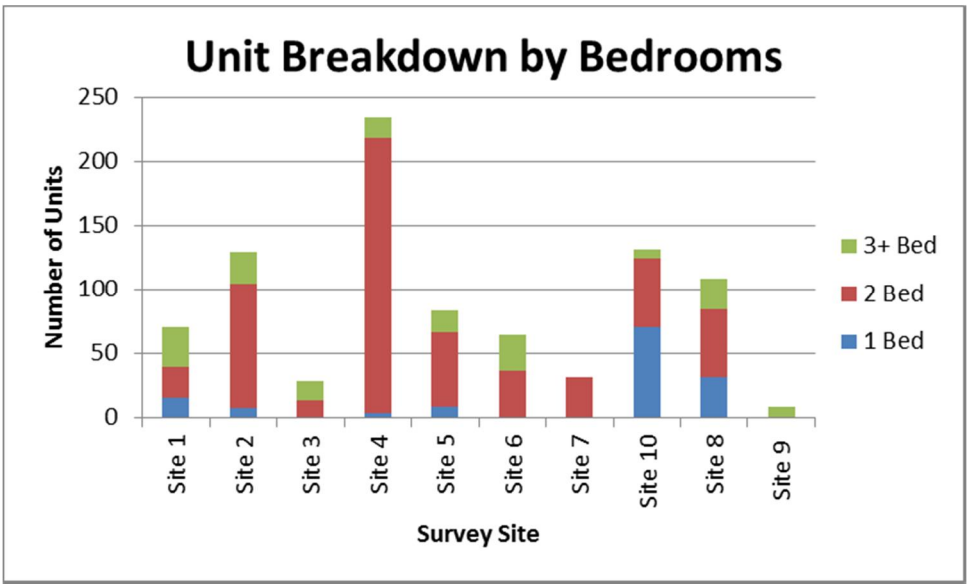
3.3.2 Number of Bedrooms

The number of bedrooms for the development was originally used as an independent variable in previous surveys undertaken by Project Planning Associates in 1993. As the total number of bedrooms is a very coarse variable and does not directly relate to the number of households in the development, this study has looked at the number of units, broken down by bedroom brackets. These brackets were:

- Number of 1 Bedroom Units
- Number of 2 Bedroom Units
- Number of 3+ Bedroom Units

A plot of the bedroom distributions for the sites surveyed is shown below in Figure 4.

Figure 4 - Breakdown of Units by Number of Bedrooms



The survey sites included unit breakdowns that ranged from

- 0-70 1-bedroom units
- 0-214 2-bedroom units
- 0-31 3-bedroom units

The predominant unit layout was 2-bedroom units, with one site comprised solely of 3+ bedroom units (Wollongong).

3.3.3 Number of Levels

Previous surveys undertaken by Project Planning Associates in 1993 also examined the number of levels in the development as an independent variable; however their analysis showed that this was a weak predictor of vehicle trip generation. Similar to the total number of bedrooms, the number of levels is not directly related to the number of households in a development, and is difficult to define for developments with more than one building. For this reason, number of levels has been omitted as an independent variable in this study.

3.3.4 Number of Parking Spaces

The number of parking spaces provided in a development (sometimes referred to at the parking provision), is linked to the number of vehicle trips that can be made by car from a development, although not necessarily to the total person trip generation. In general, parking provision is seen to constrain vehicle trip generation, in the sense that residents that do not have a parking space will not be able to travel to and from their building by car. While this is generally true, it should be noted that current planning policy in NSW is generally aimed at specifying minimum parking provision, rather than maximum parking provision, although there are some inner-city areas of Sydney where the planning policy does specify maximum parking provision, of which some of the survey sites fall within.

The number of parking spaces for the surveyed sites ranged from 18 spaces to 260 spaces, and number of parking spaces per unit ranged from 0.64 to 2.11

3.3.5 Accessibility Score

The Accessibility Score aims to reflect the proximity of a site to public transport facilities and considers the type of public transport, how close it is to the development and the frequency of the service, to arrive at a cumulative score of public transport accessibility. A more detailed examination of the Accessibility Score is provided in Appendix A.

3.4 Trip Rates

Trip rates were calculated for each site for each of the following time periods, as agreed with RMS:

- Weekday Morning Network Peak (the period of highest weekday morning flow on the adjacent road network).
- Weekday Evening Network Peak (the period of highest weekday evening flow on the adjacent road network).
- Saturday Network Peak (the period of highest Saturday flow on the adjacent road network).
- Weekday Daily (the entire weekday survey period from 0600 to 1900).
- Saturday Daily (the entire Saturday survey period from 0600 to 1900).

A summary of the Trip Generation Statistics surveyed for each development is provided in Table 2 and Table 3. A summary of the calculated trip generation rates for each site is shown in Table 4.

Table 2 – Weekday Trip Generation Statistics Summary

	Sydney Metropolitan Area					Regional Area				
Site No.	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 10**	**Site 8**	**Site 9**
Location	**St Leonards**	**Chatswood**	**Cronulla**	**Rockdale**	**Parramatta**	**Liberty Grove**	**Strathfield**	**Pyrmont**	**Charlestown**	**Wollongong**
Total Units	**70**	**129**	**28**	**234**	**83**	**64**	**31**	**131**	**108**	**9**
1 Bed	15	8	0	4	9	0	0	70	31	0
2 Bed	24	96	14	214	57	36	31	54	53	0
3+ Bed	31	25	14	16	17	28	0	7	24	9
Parking Spaces	97	206	18	260	108	93	30	199	113	19
Parking Ratio	1.39	1.60	0.64	1.11	1.30	1.45	0.97	1.52	1.05	2.11
Person Based Trips										
Daily Person Based Trips*										
- Car Based	65	245	27	720	177	284	40	160	527	53
- Other	179	445	56	535	239	132	89	240	124	25
- Total	244	690	83	1255	416	416	129	400	651	78
Average Person Trips Per hour*	19	53	6	97	32	32	10	31	50	6
Peak Person Trips	47	129	18	194	104	73	28	91	79	14
Peak Vehicle-Hour Person Trips	47	129	16	194	104	66	28	91	86	10
Peak Network Hour Person Trips										
- AM Peak	45	83	9	189	79	46	16	91	57	8
- PM Peak	38	106	4	123	54	58	13	60	70	10
% Mode Split										
Car Driver	22%	23%	31%	42%	33%	48%	28%	34%	73%	55%
Car Passenger	5%	12%	1%	15%	9%	20%	3%	6%	8%	13%
Non-Car	73%	64%	67%	43%	57%	32%	69%	60%	19%	32%
Vehicle-Based Trips										
Daily Vehicle Trips*	54	159	26	527	139	201	36	135	472	43
Peak Vehicle Trips	13	25	7	76	22	38	5	23	67	8
Peak Network Hour Vehicle Trips										
- AM Peak	10	18	2	76	22	18	3	23	42	6
- PM Peak	5	15	3	43	10	26	2	13	45	2
- % Car Parking Occupancy	62%	62%	-*	75%	77%	73%	73%	50%	78%	74%
Average Vehicle Occupancy										
- AM Peak	1.5	1.4	1.0	1.3	1.3	1.1	1.0	1.1	1.0	1.2
- PM Peak	1.4	1.6	1.0	1.4	1.5	1.4	1.0	1.1	1.2	1.0
- Average Over the Day*	1.2	1.5	1.0	1.4	1.3	1.4	1.1	1.2	1.1	1.2

Table 3 - Saturday Trip Generation Statistics Summary

	Sydney Metropolitan Area								Regional Area	
Site No.	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 10**	**Site 8**	**Site 9**
Location	**St Leonards**	**Chatswood**	**Cronulla**	**Rockdale**	**Parramatta**	**Liberty Grove**	**Strathfield**	**Pyrmont**	**Charlestown**	**Wollongong**
Total Units	**70**	**129**	**28**	**234**	**83**	**64**	**31**	**131**	**108**	**9**
1 Beds	15	8	0	4	9	0	0	70	31	0
2 Beds	24	96	14	214	57	36	31	54	53	0
3+ Bed	31	25	14	16	17	28	0	7	24	9
Parking Spaces	97	206	18	260	108	93	30	199	113	19
Person Based Trips										
Daily Person Based Trips*										
- Car Based	220	288	26	589	181	252	75	217	304	55
- Other	494	501	90	683	306	175	158	420	205	40
- Total	714	789	116	1272	487	427	233	637	509	95
Average Person Trips*	55	61	9	98	37	33	18	49	39	7
Peak Person Trips	217	132	23	181	70	64	31	104	66	17
Peak Vehicle-Hour Person Trips	106	92	23	154	70	59	27	63	63	16
Peak Network Hour Person Trips	44	92	15	154	34	50	26	93	55	8
% Mode Split										
Car Driver	18%	23%	15%	31%	24%	30%	22%	23%	50%	35%
Car Passenger	12%	13%	8%	15%	14%	29%	10%	11%	10%	23%
Other	69%	63%	78%	54%	63%	41%	68%	66%	40%	42%
Vehicle-Based Trips										
Daily Vehicle Trips*	132	182	17	394	115	129	51	145	252	33
Peak Vehicle Trips	22	27	5	54	18	20	10	25	42	7
Peak Network Hour Vehicle Trips	17	21	3	54	9	14	6	21	35	2
Peak Parking Accumulation										
- % Car Parking Occupancy	56%	58%	-*	77%	68%	69%	63%	44%	65%	79%
Average Vehicle Occupancy										
- Peak Hour	1.5	1.6	1.7	1.3	1.9	2.0	1.8	1.4	1.1	2.0
- Average Over the Day*	1.7	1.6	1.5	1.5	1.6	2.0	1.5	1.5	1.2	1.7

**Parking accumulation for the Cronulla site could not be determined accurately as some car spaces were enclosed*

Table 4 - Summary of Surveyed Trip Generation Rates

	Sydney Metropolitan Area								Regional Area	
Site No.	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 10**	**Site 8**	**Site 9**
Location	**St Leonards**	**Chatswood**	**Cronulla**	**Rockdale**	**Parramatta**	**Liberty Grove**	**Strathfield**	**Pyrmont**	**Charlestown**	**Wollongong**
Weekday										
AM Peak Person Trips per Unit	0.64	0.64	0.32	0.81	0.95	0.72	0.52	0.69	0.53	0.89
AM Peak Person Trips per Car Space	0.39	0.51	0.22	0.47	0.50	0.62	0.43	0.30	0.62	0.53
AM Peak Person Trips per Bedroom	0.29	0.30	0.13	0.39	0.45	0.29	0.26	0.46	0.27	0.30
PM Peak Person Trips per Unit	0.54	0.82	0.14	0.53	0.65	0.91	0.42	0.46	0.65	1.11
PM Peak Person Trips per Car Space	0.54	0.82	0.14	0.53	0.65	0.91	0.42	0.46	0.65	1.11
PM Peak Person Trips per Bedroom	0.24	0.39	0.06	0.26	0.31	0.37	0.21	0.30	0.33	0.37
Daily Person Trips per Unit	3.49	5.35	2.96	5.36	5.01	6.50	4.16	3.05	6.03	8.67
Daily Person Trips per Car Space	2.52	3.35	4.61	4.83	3.85	4.47	4.30	2.01	5.76	4.11
Daily Person Trips per Bedroom	1.56	2.51	1.19	2.61	2.39	2.67	2.08	2.01	3.11	2.89
AM Peak Vehicle Trips per Unit	0.14	0.14	0.07	0.32	0.27	0.28	0.10	0.18	0.39	0.67
AM Peak Vehicle Trips per Car Space	0.10	0.09	0.11	0.29	0.20	0.19	0.10	0.12	0.37	0.32
AM Peak Vehicle Trips per Bedroom	0.06	0.07	0.03	0.16	0.13	0.12	0.05	0.12	0.20	0.22
PM Peak Vehicle Trips per Unit	0.07	0.12	0.11	0.18	0.12	0.41	0.06	0.10	0.42	0.22
PM Peak Vehicle Trips per Car Space	0.05	0.07	0.17	0.17	0.09	0.28	0.07	0.07	0.40	0.11
PM Peak Vehicle Trips per Bedroom	0.03	0.05	0.04	0.09	0.06	0.17	0.03	0.07	0.22	0.07
Daily Vehicle Trips per Unit	0.77	1.23	0.93	2.25	1.67	3.14	1.16	1.03	4.37	4.78
Daily Vehicle Trips per Car Space	0.56	0.77	1.44	2.03	1.29	2.16	1.20	0.68	4.18	2.26
Daily Vehicle Trips per Bedroom	0.35	0.58	0.37	1.10	0.80	1.29	0.58	0.68	2.26	1.59
Saturday										
Peak Hour Person Trips per Unit	3.10	1.02	0.82	0.77	0.84	1.00	1.00	0.79	0.61	1.89
Peak Hour Person Trips per Car Space	2.24	0.64	1.28	0.70	0.65	0.69	1.03	0.52	0.58	0.89
Peak Hour Person Trips per Bedroom	0.68	0.33	0.33	0.32	0.40	0.38	0.44	0.32	0.30	0.59
Daily Person Trips per Unit	10.20	6.12	4.14	5.44	5.87	6.67	7.52	4.86	4.71	10.56
Daily Person Trips per Car Space	7.36	3.83	6.44	4.89	4.51	4.59	7.77	3.20	4.50	5.00
Daily Person Trips per Bedroom	4.58	2.87	1.66	2.65	2.80	2.74	3.76	3.20	2.44	3.52
Peak Hour Vehicle Trips per Unit	0.31	0.21	0.18	0.23	0.22	0.31	0.32	0.19	0.39	0.78
Peak Hour Vehicle Trips per Car Space	0.23	0.13	0.28	0.21	0.17	0.22	0.33	0.13	0.37	0.37
Peak Hour Vehicle Trips per Bedroom	0.14	0.10	0.07	0.11	0.10	0.13	0.16	0.13	0.20	0.26
Daily Vehicle Trips per Unit	1.89	1.41	0.61	1.68	1.39	2.02	1.65	1.11	2.33	3.67
Daily Vehicle Trips per Car Space	1.36	0.88	0.94	1.52	1.06	1.39	1.70	0.73	2.23	1.74
Daily Vehicle Trips per Bedroom	0.85	0.66	0.24	0.82	0.66	0.83	0.82	0.73	1.21	1.22

Plots of the trip rates and their ranges of variation for each of the periods identified above is provided in Figure 5 and Figure 6.

Figure 5 - Peak Hour and Daily Vehicle Trip Rate Range (per unit)

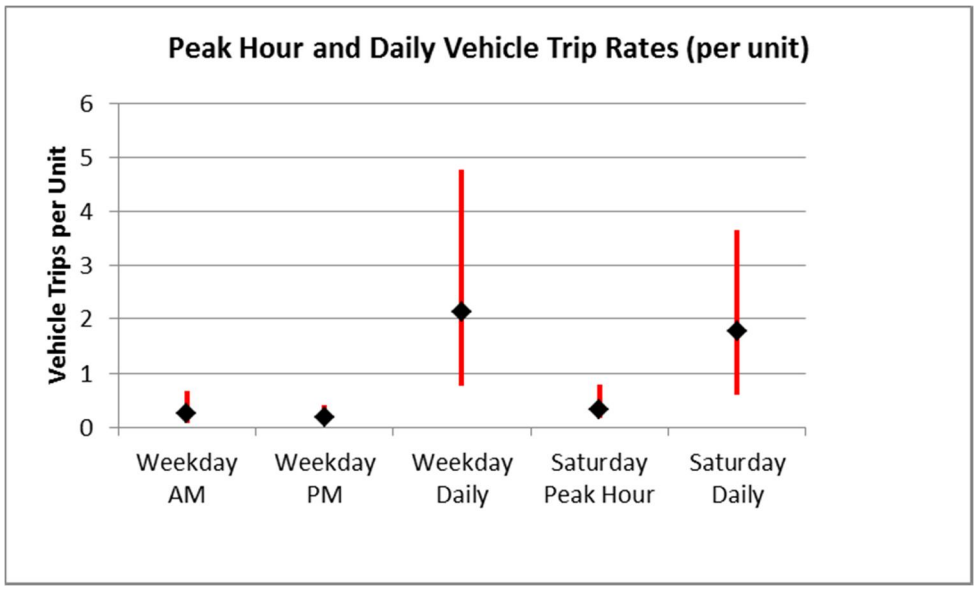


Figure 6 - Peak Hour and Daily Person Trip Rate Range (per unit)

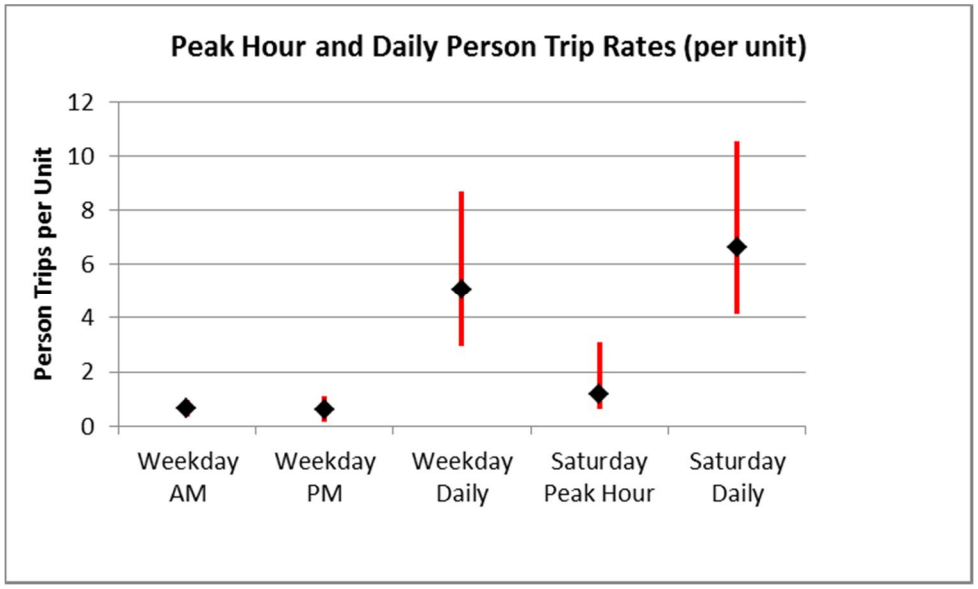


Figure 7 - Peak Hour and Daily Vehicle Trip Rate Range (per bedroom)

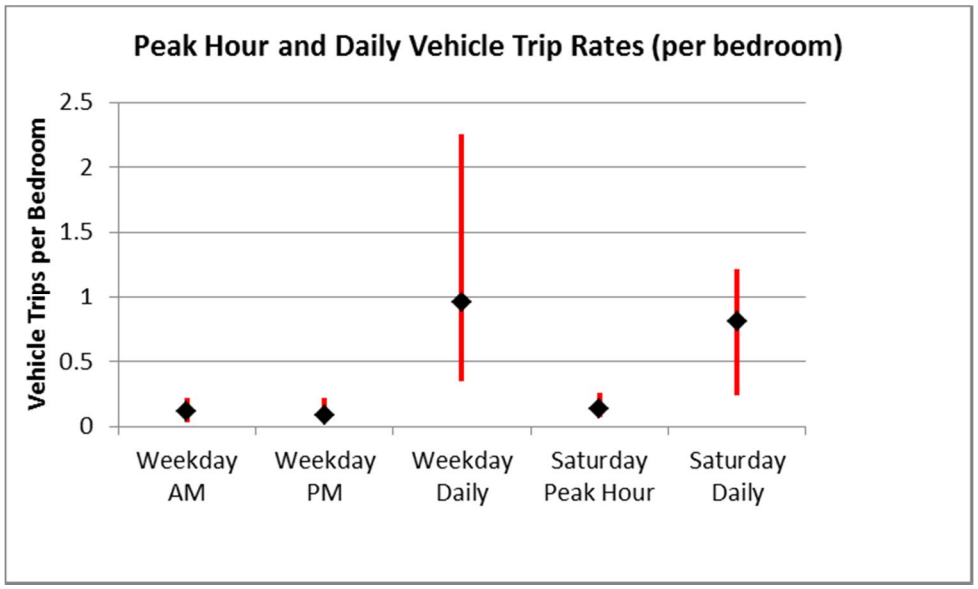
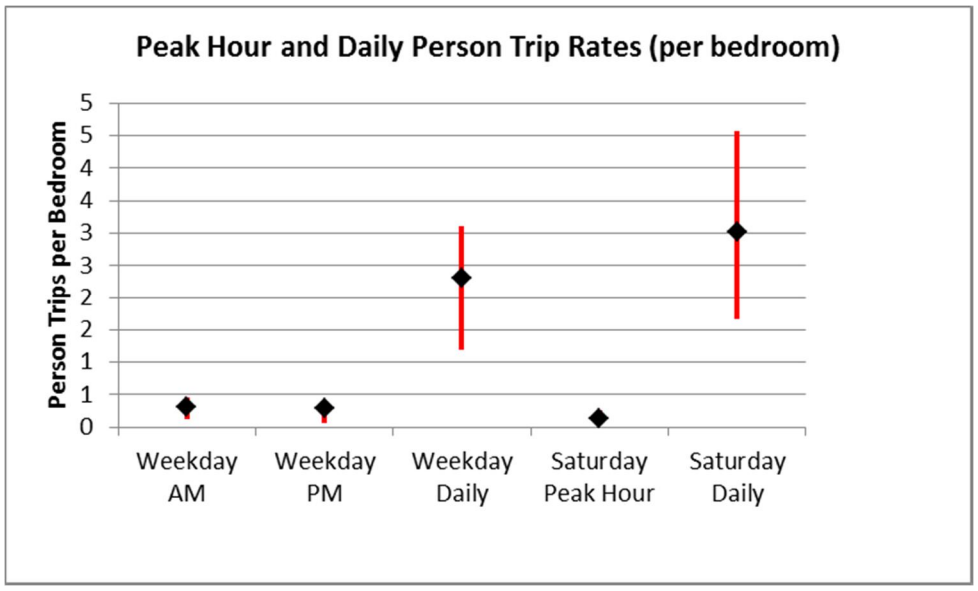


Figure 8 - Peak Hour and Daily Person Trip Rate (per bedroom)



Analysis of the trip rates shows the following trends:

- The range in daily trip rates for both weekdays and Saturdays is much higher that for the corresponding peak periods.
- The range in Saturday Peak Hour person trip rates is much greater than the Weekday Peak Hour person trip rates.

3.5 Mode Splits

An attempt was made during the surveys to capture the modal split of trips that were made to or from the development, by way of a letterbox survey and interview survey of residents and visitors to each

development. In all cases, the response rate to these surveys was much lower than the minimum sample size required to for a 95% level of confidence with a margin of error of 5%, and it was not possible to get a representative sample rate to determine the model of travel for all trips to and from the development.

It was possible, however, to determine the share of trips to car (driver and passenger) and non-car trips based on the pedestrian and vehicle surveys. A plot of the car and non-car mode shares for each development for the Weekday daily and Saturday Daily is provided below in Figure 9 and Figure 10.

Figure 9 - Weekday Mode Share by Survey Site

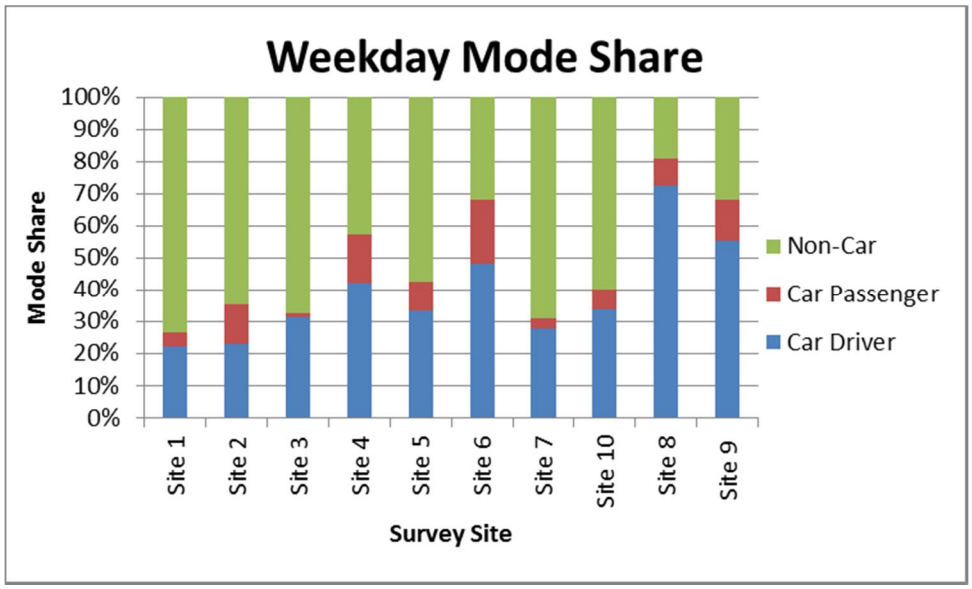
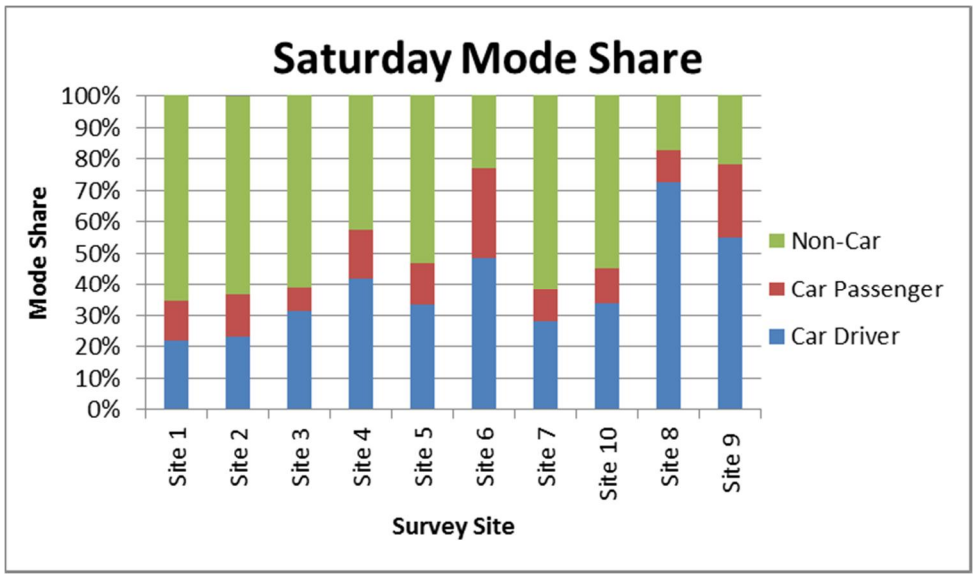


Figure 10 - Saturday Mode Share by Survey Site



Mode share analysis for the sites surveyed in this study showed that there is a much greater mode share to car on Saturday than on Weekdays. This may be due to the majority of weekday trips being journey-

to-work trips, whereas Saturday trips are more likely to be discretionary trips for recreation or shopping, which may be more amenable to non-car modes.

3.6 Seasonal Variation

Trip generation surveys for other land uses (such as retail and commercials) have previously taken into account seasonal variation, which is usually a result of changing economic trends throughout the year, relating to school and work holiday periods. Unlike these land uses, however, the trip generation for residential activities is generally related to journey-to-work travel in the weekday and to a lesser extent recreational or shopping travel on a Saturday. For this reason, rather than analyse survey data for seasonal variation, surveys were scheduled such that they did not take place during public or school holidays.

3.7 Peak Parking Demand and Parking Provision

Parking provision is the number of parking spaces provided per unit. In NSW, the parking provision required for residential developments is specified by the Local Government's Local Environment Plan (LEP) or Development Control Plan (DCP) which can vary across Local Government Areas (LGAs). For the majority of LGAs in NSW, the parking provision set out in the LEP or DCP is a minimum parking rate, however there are some Councils in NSW (e.g. City of Sydney, Leichhardt and Parramatta) that specify parking provision based on a maximum rate rather than a minimum rate.

As a number of the developments surveyed are in Councils where the parking provision is a maximum standard rather than a minimum, an assessment of the parking requirements for high-density residential developments is difficult to determine from this study. Peak parking demand for residential developments is influenced by factors that were not a part of this study, including car ownership, Council Codes, and the availability of parking at the place of employment.

It is possible, however to determine whether there is a relationship between the parking provision and the vehicle mode share. This analysis is presented in Section 4.

3.8 Directional Split

The current Guide does not provide guidance on the directional split of trips generated by high density residential developments. Common practice in the transport planning profession is to assume that trip generation for weekday peak periods is dominated by journey to work travel and that the directional split is strongly in favour of the peak direction, i.e. the majority of trip generation in the morning peak is out and the majority of trip generation in the evening peak is in. It is common for developments to be assessed based on the assumption of an 80%/20% or 90%/10% directional split for the peak periods, in favour of the peak direction.

High density residential developments are not generally assessed for their trip generation on a Saturday, and if they are, it is common practice in the transport planning profession to assume that these trips are related to either recreation or shopping uses, and that the split of inbound and outbound trips is generally 50%/50%.

The sites surveyed in this study were analysed for directional split during the morning, evening and Saturday peak periods, for both the vehicle trips directional split and the person trips directional split. The results of this analysis are shown in Table 5.

Table 5 - Summary of Average Directional Splits for Surveyed Sites

Period	Vehicle Trips		Person Trips	
	In	Out	In	Out
Weekday AM	26%	74%	20%	80%
Weekday PM	66%	34%	66%	34%
Saturday Peak	41%	59%	43%	57%

Analysis of the directional split of surveyed sites shows that the standard industry assumptions for directional split of residential trips are not supported by survey evidence. In general, the directional split in the morning is more pronounced in favour of the peak journey-to-work direction, but this does not hold true for the evening peak, where travel demand appears to be more diffuse by direction. Similarly, during the Saturday peak periods, trips are generally evenly distributed between inbound and outbound directions.

4. Statistical Analysis

4.1 Overview

A statistical analysis of the trip making statistics that were surveyed as a part of the high density residential development surveys has been undertaken to determine whether there are any relationships between the trip making statistics and the features of the developments that would assist in predicting the trip making statistics for new developments.

By determining what these relationships are and the degree of correlation that these relationships represent, the statistical analysis will be able to identify which of these relationships are statistically significant and assist in determining which design features of new developments, such as the number of units, the number of parking spaces or the distribution of bedrooms across a development is a good indicator for predicting the likely trip generation for a new development. This section details the statistical analysis that has been undertaken for this study and the results of this analysis.

4.2 Statistical Analysis Methodology

The statistical analysis of the trip making statistics has been undertaken using linear regression. Linear regression is a means of analysing the relationships between dependent variables that are influenced by a combination of one or more independent variables. In this study, the trip making statistics have been taken as the dependent variables and these are assumed to be influenced by the features of the development, such as number of dwellings or parking spaces.

Ordinary linear regression has been undertaken on the basis of both single variable relationships as well as multi variable analysis. In both cases, the R^2 value (or coefficient of determination) has been adopted as a measure of the "goodness of fit" of a given relationship to the data. The R^2 value ranges for 0 to 1, with 1 representing a perfect fit to the observed data. While it is not the purpose of this report to recommend a "cutoff" for goodness of fit based on R^2 values, for a study of this size, with a relatively low sample size, an R^2 value of greater than 0.7 could be considered as an acceptable lower limit for the relationships identified in this study.

In addition to the R^2 value, an examination of the statistical significance of the regression coefficients has also been undertaken. In this instance, the P-value has been used to determine whether the coefficient in question is statistically significant. In the context of this analysis, the P-value represents the probability that the coefficients are statistically significant from zero. For example, a P-value of 0.056 indicates that there is a 5.6% chance that the coefficient for that variable is not significantly different from zero (i.e., not statistically significant), and the variable should be included in the relationship. A P-value close to 1 indicates that the coefficient is not significantly different from zero, and that there is little justification for including that variable in the relationship.

The dependent variables that have been considered in this analysis include and examined in further detail in Section 3 are:

- Number of Vehicle Trips (inbound and outbound).
- Number of Person Trips (inbound and outbound).
- Peak Parking Demand (the highest parking demand during the surveyed period).

The independent variables that have been considered in this analysis include:

- Number of Units.
- Number of Parking Spaces.
- Number of 1 Bedroom Units.
- Number of 2 Bedroom Units.
- Number of 3+ Bedroom Units.

A number of other independent variables were considered, but omitted from the analysis. These variables are discussed below:

- Number of Levels: This independent variable was used in the previous study undertaken by Project Planning Associates in 1993. The 1993 analysis showed that there was little correlation between number of levels and the primary trip making statistics. This is likely due to the high degree of variability in floor plate and footprint sizes between buildings.
- Total number of Bedrooms: This independent variable was used in the previous study undertaken by Project Planning Associates in 1993. In the 1993 study, it was determined that the total number of bedrooms is not a good indicator of the number of households, or the household size, so this was discarded in favour of a multi variable analysis of apartments bracketed by number of bedrooms. A comparison of these two methods (total bedrooms and units broken down by bedrooms) has been presented for completeness.
- Location of Development: The location of the development, whether within the Greater Sydney Metropolitan Area or in a Regional location, was considered as an independent variable, however when selecting survey sites, it was found that the overwhelming majority of high-density residential developments tend to occur within metropolitan areas. Similarly, the majority of high-density residential developments in regional areas tend to be serviced apartments that are intended for short stay accommodation purposes. As a result it was not possible to obtain survey results for more than two regional sites, so this segmentation has been discarded.

In all cases, a regression analysis has been undertaken for the following periods:

- Weekday Morning Network Peak hour (based on surveys of adjacent roads).
- Weekday Evening Network Peak Hour (based on surveys of adjacent roads).
- Saturday Network Peak Hour (based on surveys of existing roads).
- Weekday Daily (based on the surveyed 12 hour period).
- Weekend Daily (based on the surveyed 12 hour period).

4.2.1 Single Variable Linear Regression

Single variable linear regression has been undertaken to test the relationships of the trip-making statistics to individual independent variables. Dependent and independent combinations were graphed and their relationships assessed on the basis of their R^2 value and the P-values of the independent variable coefficients. The following independent variables were used in the single variable linear regression:

- Number of units

- Number of parking spaces

In addition to these regression analyses, single variable regression was also undertaken to determine if there was any statistical significance in the following relationships:

- Parking provision (dependent variable) and number of units (independent variable)
- Ratio of vehicle trip to person trip (dependent variable) and Accessibility Score.

A review of the statistical analysis of each independent variable in single variable regressions is provided in the following Section 4.3.1.

4.2.2 Multi Variable Linear Regression

Multi variable linear regression has been undertaken to test the relationships of the trip-making statistics to combinations of individual independent variables. Dependent and independent combinations were assessed on the basis of their R^2 value and the P-values of the independent variable coefficients. High P-values for one or more coefficients would suggest that that independent variable is not statistically significant, and does not have much influence on the dependent variable. The following independent variable combinations were used in the multi variable linear regression:

- Number of units and number of parking spaces
- Number 1 bedroom units, number of 2 bedroom units and number of 3+ bedroom units.

A review of the statistical analysis of each independent variable combination in multi variable regressions is provided in the following section.

4.3 Statistical Analysis Results

4.3.1 Single Variable Linear Regression

Number of Units

Graphs of the single variable analysis for number of units as the dependent variable are shown below in Figure 11 to Figure 13. A summary of the regression coefficients and their P-values is shown in Table 6. The acceptability of any given relationship is based on the R^2 value being greater than 0.7. It should be noted that the single-variable linear analysis takes the form:

Trip making statistic = coefficient * dependent variable + intercept

For example, for the weekday AM vehicle trip generation relationship shown in Table 6, the relationship would be:

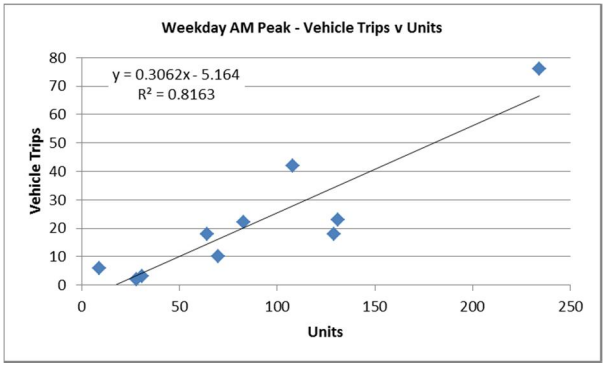
Number of vehicle trips = 0.36 * (number of units) + (-5.2)

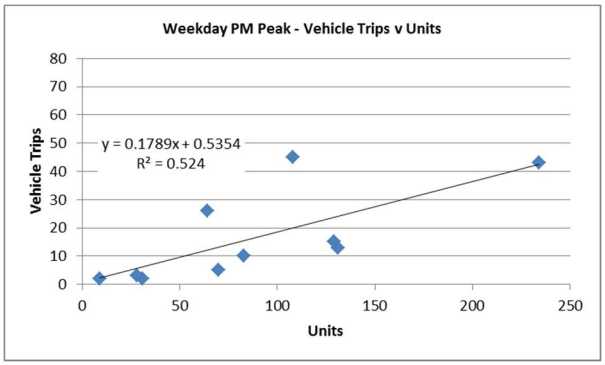
Table 6 – Summary of Regression Statistics for Number of Units

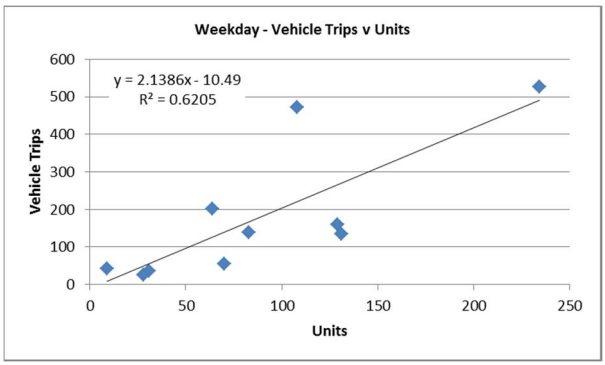
Period	Coefficient	Intercept	R^2	P (Coeff.)	P (Intercept)	Acceptable?
Vehicle Trips						
Weekday AM	0.306	-5.2	0.816	0.000	0.382	Y
Weekday PM	0.179	0.5	0.524	0.018	0.937	N
Weekday Daily (12 hr)	2.139	-10.5	0.620	0.007	0.874	N
Saturday Peak	0.213	4.1	0.837	0.000	0.287	Y
Saturday Daily (12 hr)	1.596	3.4	0.878	0.000	0.885	Y
Person Trips						
Weekday AM	0.795	-8.2	0.951	0.000	0.268	Y
Weekday PM	0.555	4.4	0.855	0.000	0.632	Y
Weekday Daily (12 hr)	5.190	-24.1	0.906	0.000	0.717	Y
Saturday Peak	0.559	18.0	0.770	0.001	0.163	Y
Saturday Daily (12 hr)	5.061	79.0	0.894	0.000	0.272	Y
Peak Parking						
Weekday	0.814	6.5	0.968	0.000	0.344	Y
Saturday	0.823	-0.1	0.954	0.000	0.991	Y

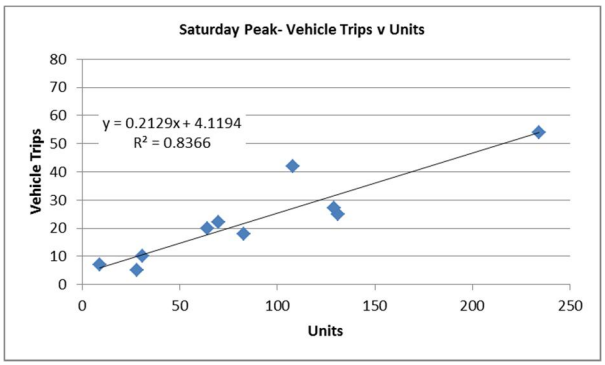
Analysis of the regression statistics for relationships with number of units as the independent variable shows that number of units provides a high correlation with the trip making statistics for all periods, with the exception of vehicle trip demand for the weekday evening peak and weekday 12 hour daily. The analysis shows that the residual intercepts for these relationships are not likely to be different from zero, based on P-values, and these terms can be omitted from the regression relationships.

Figure 11 - Summary of Vehicle Trip Regression by Number of Units









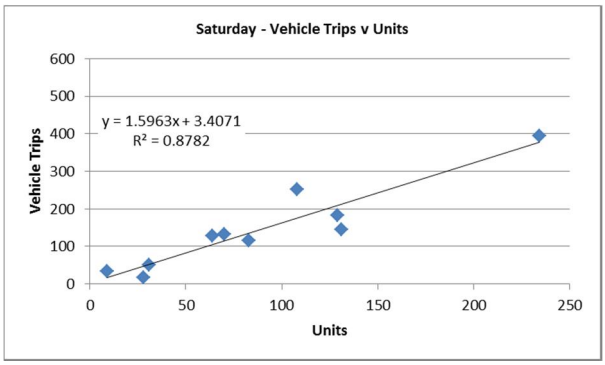
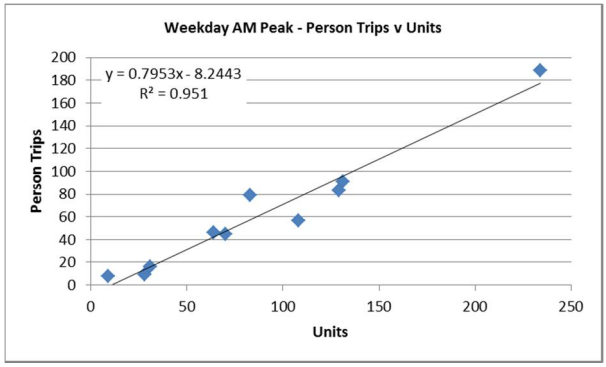
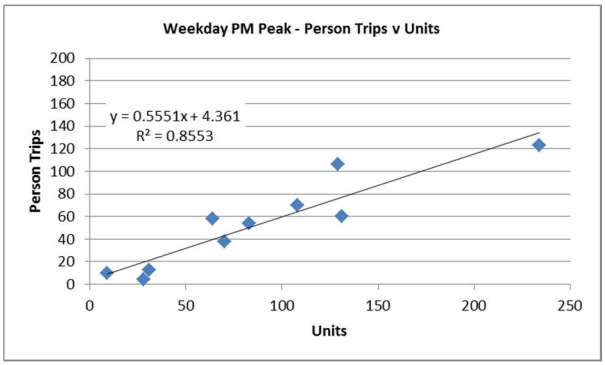
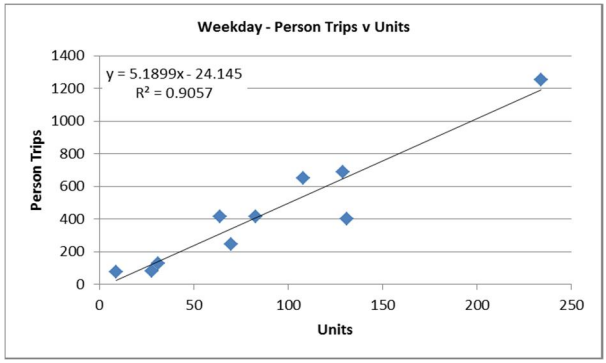
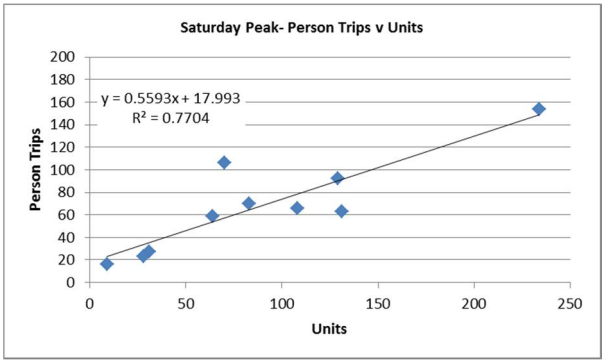


Figure 12 - Summary of Person Trip Regression by Number of Units









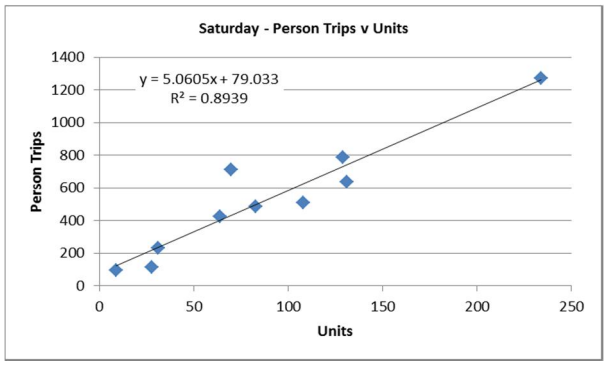
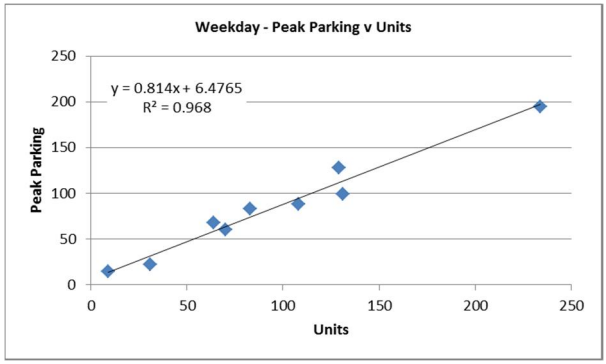
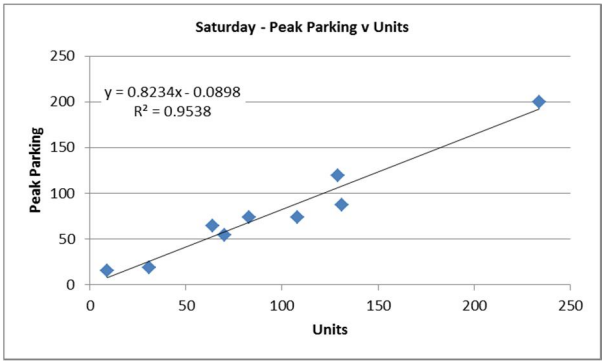


Figure 13 - Summary of Peak Parking Regression by Number of Units





Total Number of Bedrooms

Graphs of single variable analysis for total number of bedrooms as the dependent variable are shown below in Figure 14 to Figure 16. A summary of the regression coefficients and their P-values is shown in Table 7. The acceptability of any given relationship is based on the R^2 value being greater than 0.7.

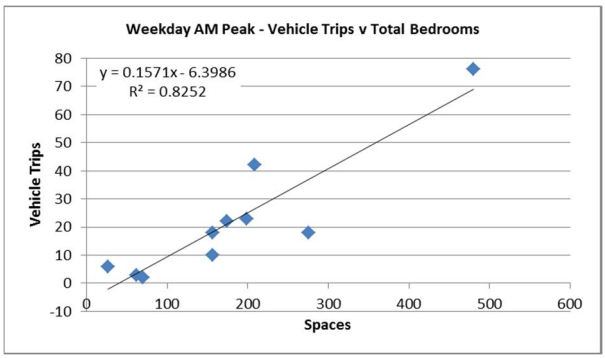
Table 7 – Summary of Regression Statistics for Total Number of Bedrooms

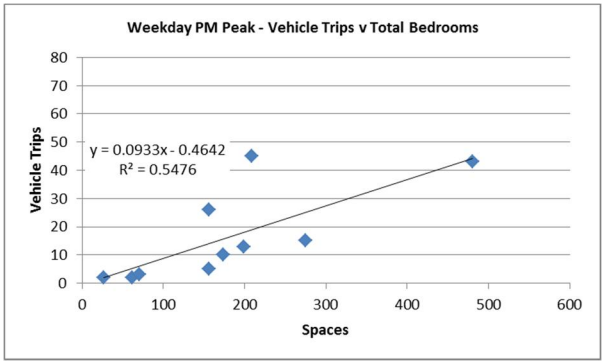
Period	Coefficient	Intercept	R^2	P (Coeff.)	P (Intercept)	Acceptable?
Vehicle Trips						
Weekday AM	0.157	-6.4	0.825	0.000	0.285	Y
Weekday PM	0.093	-0.5	0.548	0.014	0.945	N
Weekday Daily (12 hr)	1.110	-21.4	0.642	0.005	0.747	N
Saturday Peak	0.108	3.4	0.834	0.000	0.390	Y
Saturday Daily (12 hr)	0.825	-4.2	0.902	0.000	0.845	Y
Person Trips						
Weekday AM	0.402	-10.5	0.936	0.000	0.235	Y
Weekday PM	0.289	1.4	0.890	0.000	0.866	Y
Weekday Daily (12 hr)	2.721	-55.7	0.956	0.000	0.249	Y
Saturday Peak	0.298	13.7	0.841	0.000	0.208	Y
Saturday Daily (12 hr)	2.613	55.5	0.916	0.000	0.392	Y
Peak Parking						
Weekday	0.414	4.2	0.978	0.460	0.460	Y
Saturday	0.424	-3.3	0.985	0.000	0.484	Y

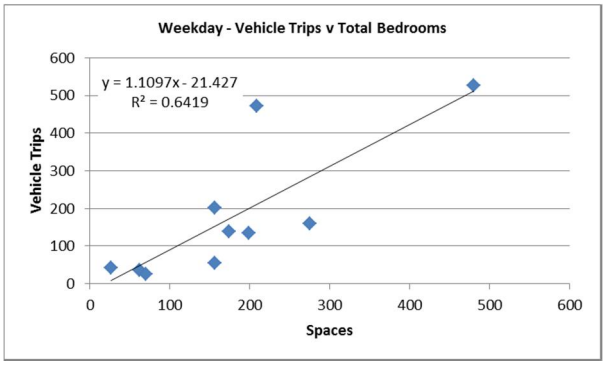
Analysis of the regression statistics for relationships with total number of bedrooms as the independent variable shows that total number of bedrooms provides a good correlation with person trip generation, but not with vehicle trip generation, particularly evening peak and daily vehicle trip generation. There is also a high degree of correlation between total number of bedrooms and peak parking demand, as would be expected. The analysis shows that the residual intercepts for these relationships are not likely to be different from zero, based on P-values, and these terms can be omitted from the regression relationships.

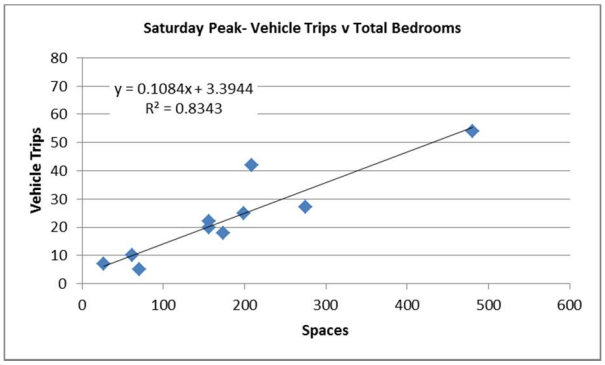
This generally agrees with the results from the 1993 study, which determined that vehicle trip generation was not well correlated with total number of bedrooms. While there is some correlation with person trips, for trip generation, the multi-variable analysis does provide a better fit both person and vehicle trip generation with number of bedrooms, as would be expected when introducing a greater number of independent variables.

Figure 14 - Summary of Vehicle Trip Regression by Total Number of Bedrooms









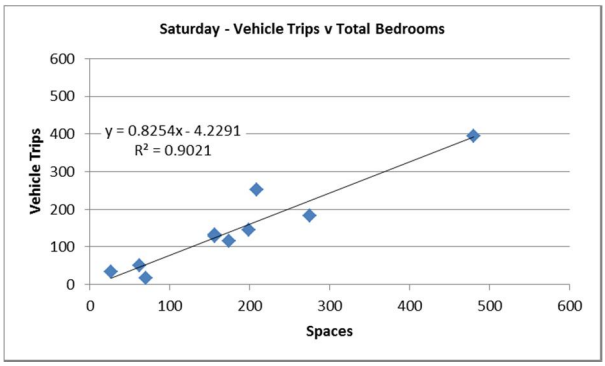
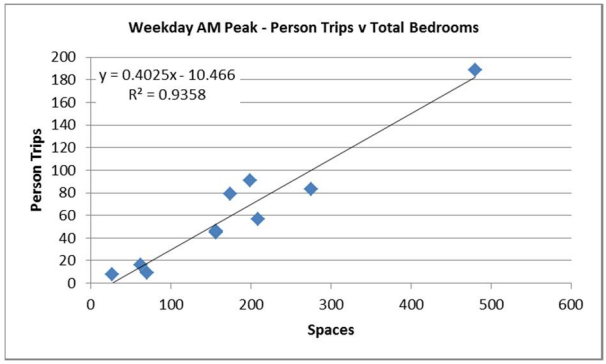
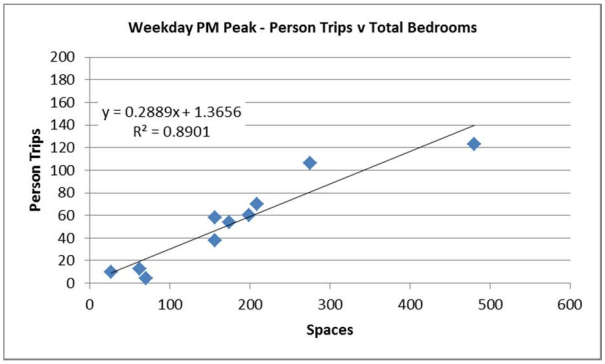
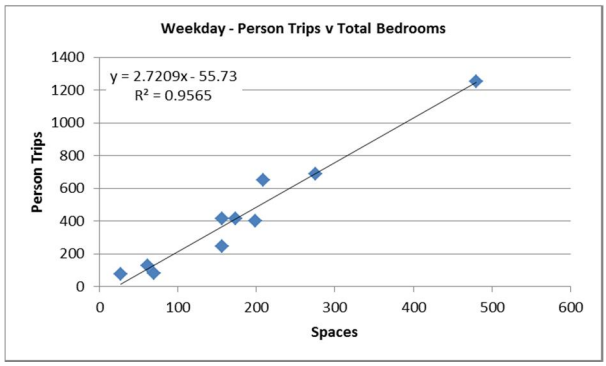
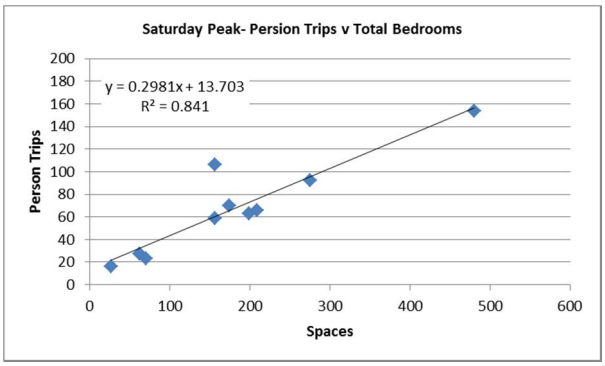


Figure 15 - Summary of Person Trip Regression by Total Number of Bedrooms









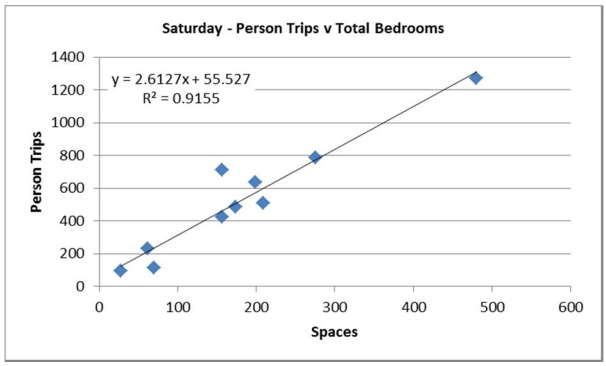
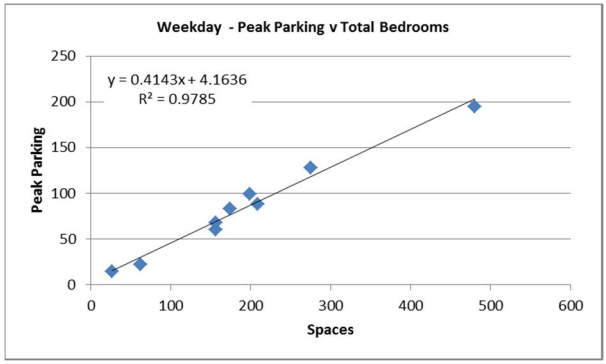
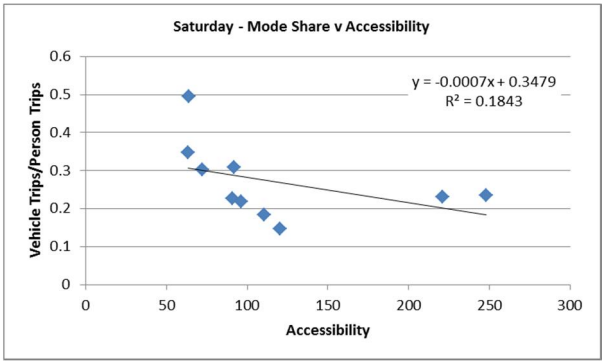


Figure 16 - Summary of Peak Parking Regression by Total Number of Bedrooms





Number of Parking Spaces

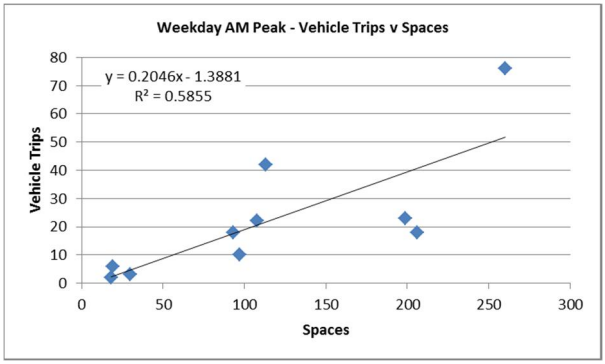
Graphs of the single variable analysis for number of parking spaces as the dependent variable are shown below in Figure 17 to Figure 19. A summary of the regression coefficients and their P-values is shown in Table 8. The acceptability of any given relationship is based on the R^2 value being greater than 0.7.

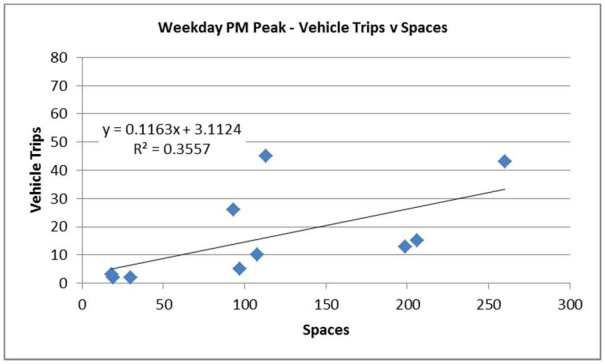
Table 8 – Summary of Regression Statistics for Number of Parking Spaces

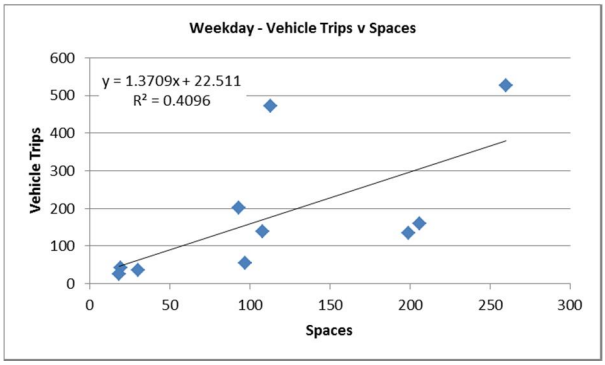
Period	Coefficient	Intercept	R^2	P (Coeff.)	P (Intercept)	Acceptable?
Vehicle Trips						
Weekday AM	0.205	-1.4	0.586	0.010	0.874	N
Weekday PM	0.116	3.1	0.356	0.069	0.697	N
Weekday Daily (12 hr)	1.371	22.5	0.410	0.046	0.788	N
Saturday Peak	0.151	5.8	0.672	0.004	0.295	N
Saturday Daily (12 hr)	1.129	15.9	0.706	0.002	0.668	Y
Person Trips						
Weekday AM	0.595	-5.7	0.856	0.000	0.645	Y
Weekday PM	0.443	2.9	0.877	0.000	0.731	Y
Weekday Daily (12 hr)	3.760	6.4	0.764	0.001	0.952	Y
Saturday Peak	0.421	19.4	0.703	0.002	0.188	Y
Saturday Daily (12 hr)	3.910	81.0	0.857	0.000	0.332	Y
Peak Parking						
Weekday	0.647	3.3	0.918	0.000	0.768	Y
Saturday	0.646	-2.3	0.881	0.000	0.868	Y

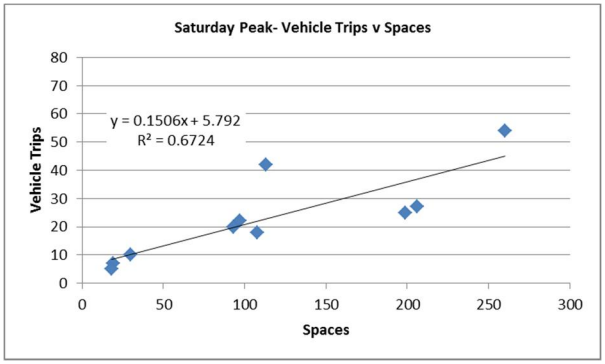
Analysis of the regression statistics for relationships with number of parking spaces as the independent variable shows that number of parking spaces provides a high correlation with person trip generation, but not with vehicle trip generation. There is also a high degree of correlation between parking spaces an peak parking demand, as would be expected. The analysis shows that the residual intercepts for these relationships are not likely to be different from zero, based on P-values, and these terms can be omitted from the regression relationships.

Figure 17 - Summary of Vehicle Trip Regression by Number of Parking Spaces









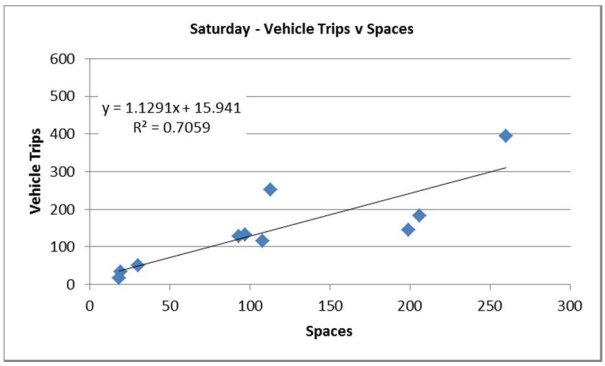
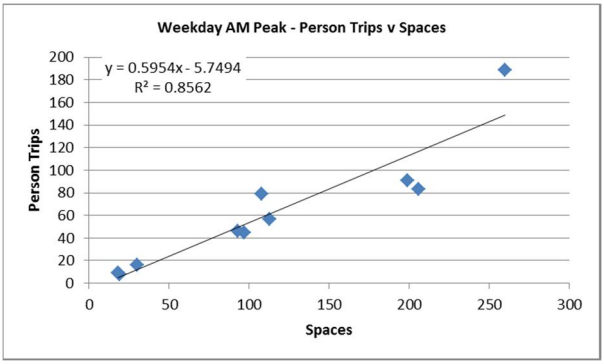
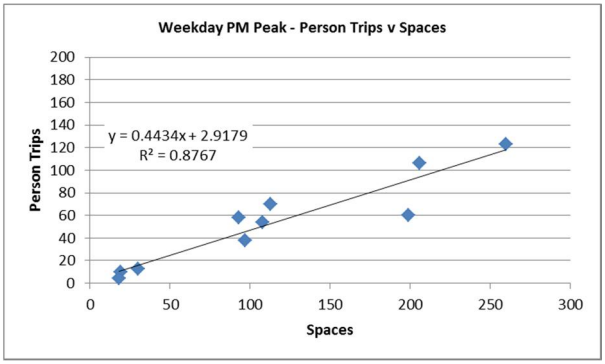
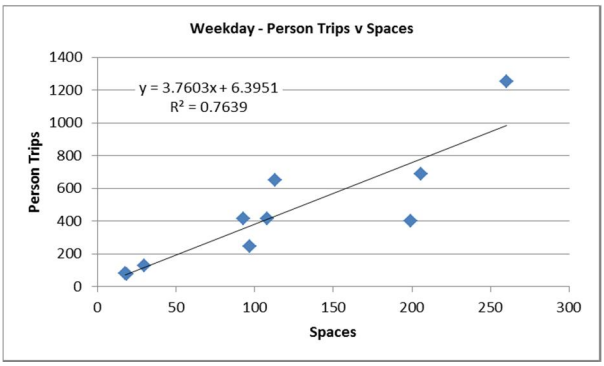
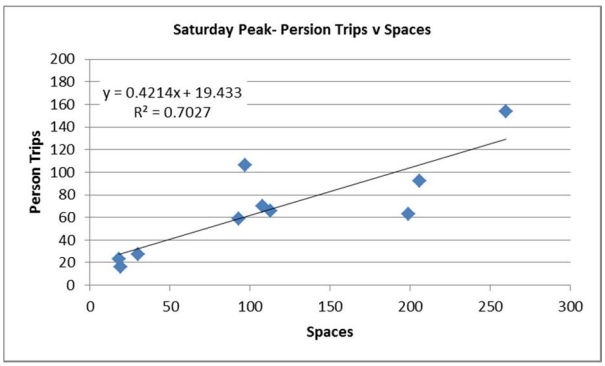


Figure 18 - Summary of Person Trip Regression by Number of Parking Spaces









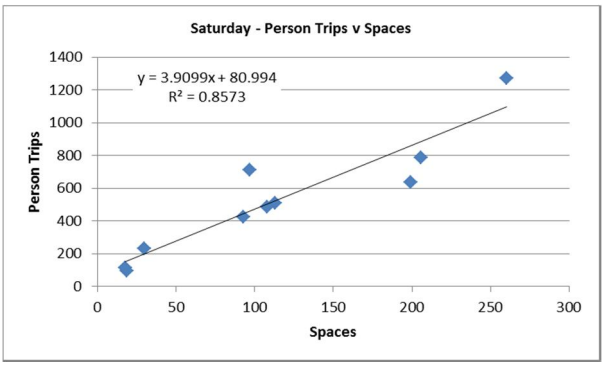
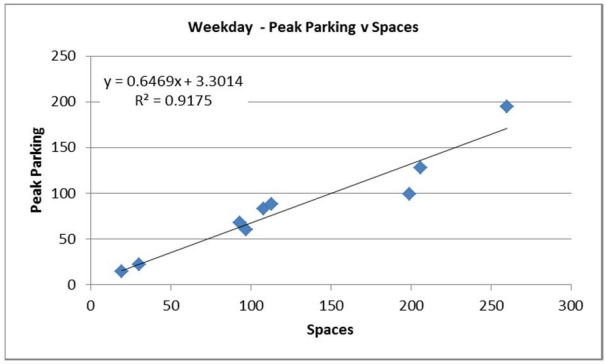
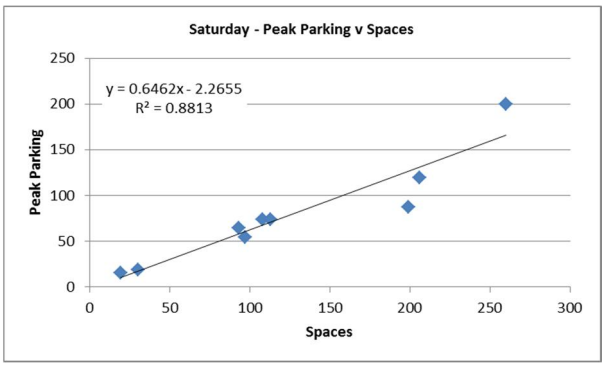


Figure 19 - Summary of Peak Parking Regression by Number of Parking Spaces





Accessibility Score

Graphs of the single variable analysis for accessibility score as the dependent variable are shown below in Figure 20. A summary of the regression coefficients and their P-values is shown in Table 8. The acceptability of any given relationship is based on the R^2 value being greater than 0.7.

Table 9 – Summary of Regression Statistics for Accessibility Score

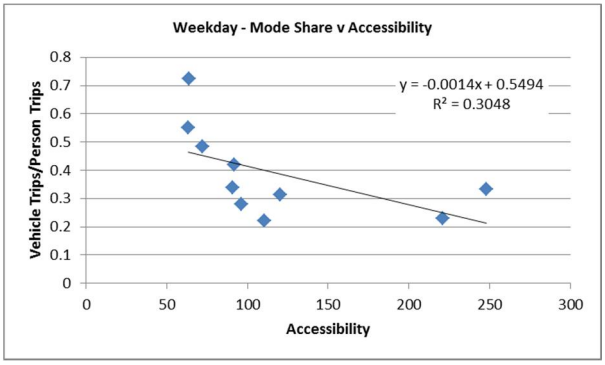
Period	Coefficient	Intercept	R^2	P (Coeff.)	P (Intercept)	Acceptable?
Vehicle Mode Share						
Weekday Daily (12 hr)	-0.001	0.55	0.305	0.098	0.000	N
Saturday Daily (12 hr)	0.000	0.35	0.184	0.216	0.001	N

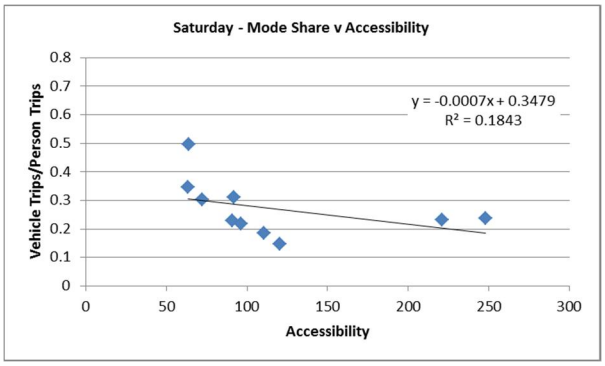
Analysis of the regression statistics for relationships with Accessibility Score as the independent variable shows that Accessibility Score does not provide a high correlation with vehicle mode share. Analysis of the graphs, however, shows that there are two key outliers that result in this low correlation. These sites are Parramatta and Chatswood. These two sites have much higher accessibility scores than other sites that were surveyed, and without these two outliers, there is a much clearer relationship between car mode share and accessibility score, with mode share to car increasing as accessibility score decreases. This indicates that the accessibility score is out-of-scale for Parramatta and Chatswood, both sites that are close to both railway stations and bus corridors.

When computing the Accessibility Scores for sites in this study, it was found that the methodology for computing Accessibility Score places much greater weight in buses than trains, and this should be investigated further.

The analysis shows that the residual intercepts for these relationships are not likely to be different from zero, based on P-values, and these terms can be omitted from the regression relationships.

Figure 20 - Summary of Vehicle Mode Share Regression by Accessibility Score





Parking Provision

Graphs of the single variable analysis for parking provision (expressed as parking spaces per unit) as the dependent variable are shown below in Figure 21. A summary of the regression coefficients and their P-values is shown in Table 10. The acceptability of any given relationship is based on the R^2 value being greater than 0.7.

Table 10 – Summary of Regression Statistics for Parking Provision

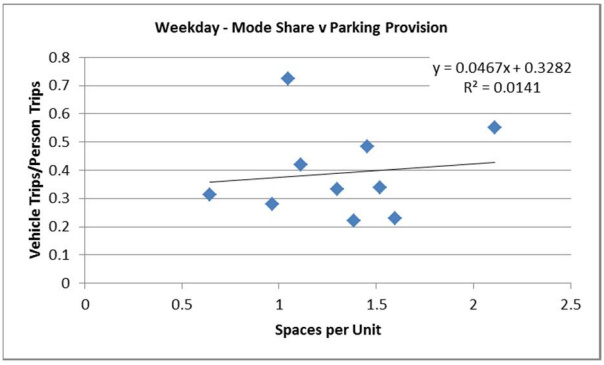
Period	Coefficient	Intercept	R^2	P (Coeff.)	P (Intercept)	Acceptable?
Vehicle Mode Share						
Weekday Daily (12 hr)	0.047	0.328	0.141	0.7434	0.112	N
Saturday Daily (12 hr)	0.0497	0.205	0.041	0.576	0.118	N

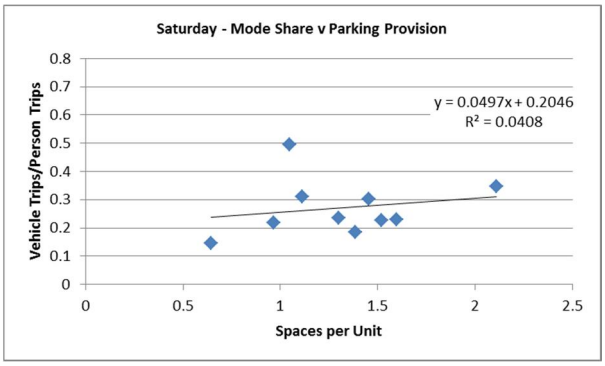
Analysis of the regression statistics for relationships with parking spaces per unit as the independent variable shows that parking provision does not provide a high correlation with vehicle mode share.

While it would be expected that developments with lower parking provisions would also have lower mode shares to vehicles, it should be noted that the parking provision at the point of origin (for journey to work trips) does not account in any way for parking provision at the destination. In other words, for mode share to be affected by parking provision, it would need to be parking provision at both ends of the trip, not simply at the origin.

The analysis shows that the residual intercepts for these relationships are not likely to be different from zero, based on P-values, and these terms can be omitted from the regression relationships.

Figure 21 - Summary of Mode Share Regression by Parking Provision





4.3.2 Multi Variable Linear Regression

Number of Units and Number of Parking Spaces (Combined)

A summary of the regression coefficients and their P-values for the multi variable analysis of trip making statistics against number of units and number of parking spaces combined is shown in Table 11. The acceptability of any given relationship is based on the R^2 value being greater than 0.7.

The independent variables were as follows:

- Variable 1: Number of Units
- Variable 2: Number of Parking Spaces

Analysis of the regression statistics for relationships with number of units and number of parking spaces as the independent variables shows that this combination of independent variables provides a high correlation with the trip making statistics for all periods, with the exception of vehicle trip demand for the weekday evening peak. The analysis shows that the residual intercepts for these relationships are not likely to be different from zero, based on P-values, and these terms can be omitted from the regression relationships.

In most cases, the P-values for parking spaces shows that this variable is far less significant than number of units, which suggests that generating trips rates using this method is not significantly better than simply using number of units alone.

Table 11 – Summary of Regression Statistics for Number of Units and Number of Parking Spaces

Period	Coefficient 1	Coefficient 2	Coefficient 3	Intercept	R^2	P (Coeff. 1)	P (Coeff. 2)	P (Coeff. 3)	P (Intercept)	Acceptable ?
Vehicle Trips										
Weekday AM	0.114	-0.315	-	-3.046	0.934	0.001	0.010	-	0.430	Y
Weekday PM	0.195	-0.223	-	2.031	0.634	0.054	0.190	-	0.754	N
Weekday Daily (12 hr)	0.642	-0.902	-	9.463	0.916	0.004	0.118	-	0.659	Y
Saturday Peak	0.108	-0.120	-	4.928	0.873	0.013	0.201	-	0.197	Y
Saturday Daily (12 hr)	1.680	-2.890	-	8.919	0.774	0.012	0.066	-	0.873	Y
Person Trips										
Weekday AM	0.007	-0.060	-	-7.840	0.952	0.007	0.753	-	0.328	Y
Weekday PM	0.461	0.288	-	2.424	0.887	0.461	0.207	-	0.782	Y
Weekday Daily (12 hr)	0.007	-1.872	-	-11.571	0.922	0.007	0.271	-	0.861	Y
Saturday Peak	0.194	-0.010	-	18.058	0.770	0.194	0.976	-	0.198	Y
Saturday Daily (12 hr)	0.132	1.061	-	71.907	0.899	0.132	0.562	-	0.343	Y
Peak Parking										
Weekday	0.648	0.142	-	4.577	0.972	0.014	0.395	-	0.525	Y
Saturday	0.765	0.050	-	-0.760	0.954	0.021	0.812	-	0.934	Y

Number of Units Broken Down by Number of Bedrooms

A summary of the regression coefficients and their P-values for the multi variable analysis of trip making statistics against number of units broken down by number of bedrooms is shown in Table 12. The acceptability of any given relationship is based on the R^2 value being greater than 0.7.

The independent variables were as follows:

- Variable 1: Number of 1 Bedroom Units
- Variable 2: Number of 2 Bedroom Units
- Variable 2: Number of 3+ Bedroom Unit

Analysis of the regression statistics for relationships with number of 1, 2 and 3+ bedroom units as the independent variables shows that this combination of independent variables provides a high correlation with the trip making statistics for all periods, with the exception of vehicle trip demand for the weekday evening peak and the weekday daily. The analysis shows that the residual intercepts for these relationships are not likely to be different from zero, based on P-values, and these terms can be omitted from the regression relationships

In most cases, the P-values for the coefficients show that these relationships are dominated by the 2 bedroom units variable, which is to be expected, based on the high proportion of 2 bedroom units in most of the buildings that were surveyed. The P-values for the other variable coefficients shows that while they are less likely to be different from zero, they should still be included in the relationship.

Table 12 – Summary of Regression Statistics for Number of Units by Bedroom (1-Bed, 2-Bed, 3+ Bed)

Period	Coefficient 1	Coefficient 2	Coefficient 3	Intercept	R^2	P (Coeff. 1)	P (Coeff. 2)	P (Coeff. 3)	P (Intercept)	Acceptable ?
Vehicle Trips										
Weekday AM	0.173	0.324	0.250	-3.423	0.836	0.347	0.002	0.531	0.698	Y
Weekday PM	0.147	0.170	0.552	-4.893	0.580	0.484	0.054	0.255	0.635	N
Weekday Daily (12 hr)	1.359	2.165	4.144	-35.632	0.645	0.521	0.024	0.385	0.731	N
Saturday Peak	0.214	0.204	0.469	0.245	0.864	0.090	0.002	0.093	0.964	Y
Saturday Daily (12 hr)	1.114	1.603	3.117	-16.387	0.908	0.130	0.000	0.069	0.622	Y
Person Trips										
Weekday AM	0.576	0.834	0.444	-1.475	0.963	0.024	0.000	0.339	0.882	Y
Weekday PM	0.399	0.546	1.390	-7.238	0.911	0.121	0.000	0.030	0.534	Y
Weekday Daily (12 hr)	1.881	5.500	7.887	-42.922	0.959	0.215	0.000	0.040	0.548	Y
Saturday Peak	0.271	0.552	1.808	1.022	0.890	0.338	0.001	0.020	0.940	Y
Saturday Daily (12 hr)	3.908	5.001	10.936	-2.180	0.929	0.068	0.000	0.031	0.981	Y
Peak Parking										
Weekday	0.606	0.822	1.251	1.516	0.985	0.006	0.000	0.008	0.837	Y
Saturday	0.422	0.858	1.054	-0.168	0.987	0.021	0.000	0.012	0.981	Y

4.4 Summary of Statistical Analysis

The statistical analysis of the proposed trip making statistics showed the following:

- The single variable analysis shows that the strongest relationships are for number of units as the independent variable. Number of parking spaces has a much weaker correlation with the trip making statistics and is probably not appropriate to use as the parking provision can vary widely based on the location of a development, and may be either a maximum or minimum provision.
- The single variable analysis showed that when looking at time periods, the strongest relationships are for the weekday peak periods. This is likely due to the fact that the morning peak hour is very well defined, with journey to school and work trips generally all taking place in a narrower period than the evening peak, where this travel is more diffuse.
- Analysis of the relationship between peak parking demand and the number of parking spaces in a development are very strongly correlated, as would be expected.
- Analysis of the relationship between vehicle mode share and Accessibility Score showed that there was no relationship between these statistics; however this is likely due to some outlying accessibility scores for Chatswood and Parramatta. Adjustment of the Accessibility Score methodology to correct for over-weighting of buses is likely to improve this relationship and show that an increase in accessibility score corresponding to a decrease in vehicle mode share.
- Analysis of the relationship between parking provision and vehicle mode share showed that there was no relationship between these statistics. This is likely to be because the parking provision at only one end of the trip does not fully capture the parking availability for the trip as a whole.
- The multiple linear regression generally shows that adding additional variables to the analysis generally increases the goodness of fit, however this is to be expected, and any comparison multiple variable against single variable analysis should weigh the increase in goodness of fit with the significance of the additional variables.
- Multiple linear regression using number of units and number of parking spaces in the same relationship showed that while this combination of independent variables does provide a greater correlation, the significance of the number of parking spaces as an additional variable is not high. It is therefore not recommended that this be used as a means of predicting vehicle trip generation.
- Multiple linear regression using number of units in 1, 2 and 3+ bedroom brackets showed that this combination of independent variables has a high correlation with the trip making statistics, and while this relationship is dominated by the 2 bedroom unit variable, this relationship is a good candidate for use in predicting vehicle trip generation.

5. Comparisons of NSW Findings with Other Databases

5.1 Overview

This section of the report examines trip generation and parking rates from a number of Australian and International guidance documents and traffic generation databases and provides a comparison of the rates from these sources with the results established from this study. The purpose for undertaking this comparison of rates is to establish whether it is necessary to develop trip rates and parking provision rates specifically for NSW rather than use rates from other sources.

5.2 Australian Sources

5.2.1 National Sources

The Austroads document, "The Guide to Traffic Management Part 12: Traffic Impacts of Development" is designed to help traffic and transport practitioners identify and manage the impacts on the road system arising from land use developments. The aim of this guide is to ensure consistency in the assessment and treatment of traffic impacts, including addressing the needs of all road users.

The Austroads document provides guidance on how to:

- Identify the types of traffic impacts and interactions which will result from a specific land use development;
- Assess the magnitude of potential impacts and determine how impacts will need to be managed;
- Report on these matters in a way that provides the road authority (and others) with an understanding of the issues and required mitigation measures
- Assessing other associated impacts, including on safety, infrastructure and environmental impacts.

For high density residential developments, vehicle trip generation rates are provided metropolitan (CBD) centres and sub-regional centres. Trip rates per unit are provided for "peak hour" only, with no daily or weekend trip rates provided. These trip rates provided are the same as those provided in the Roads and Maritime Services (RMS) document "Guide to Traffic Generating Developments" (RMS, 2002).

5.2.2 State Sources

A number of Australian States provide guidance documents for undertaking traffic impact assessments, with most of these documents refer to sources of traffic generation data. Table 13 provides a summary of these policy guidance documents for each State.

Table 13 – Summary of Trip Generation Guidance Documents used in Australia

State	Policy Guidance	Comments
NSW	Guide to Traffic Generating Developments (RMS, 2002)	Much of the data is around 20 years old. Some consultancies also use their own data collection to establish rates. Guide includes both traffic generation and parking impact information for a range of land uses. For high density residential developments, vehicle trip generation rates are provided metropolitan (CBD) centres and sub-regional centres. Person trip rates are not provided. Trip rates are provided per residential unit, with no separate rates provided depending on the number of bedrooms. Peak hour rates are provided only (with no daily or weekend trip rates provided). Minimum car parking standards are provided.
Victoria	Guide to Traffic Generating Developments (RMS, 2002) Guidelines for Transport Impact Assessment Reports for major land use and development proposals (2006)	Guide to Traffic Generating Developments is generally used along with the Transport Impact Assessment Report (TIAR) Guidelines. Institute of Transportation Engineers (ITE) Trip Generation, 8th Edition publication is used to a lesser extent. Some consultancies also use their own data collection to establish rates. TIAR discusses the provision of traffic generation information although does not provide trip generation information or where this might be obtained.
Queensland	Guide to Traffic Generating Developments (RMS, 2002) Guidelines for Assessment of Road Impacts for Developments (Queensland Transport , 2006)	Most Council Planning Guidelines refer to both the RMS Guide to Traffic Generating Developments and the "Guidelines for Assessment of Road Impacts for Developments. Guidelines for Assessment of Road Impacts for Developments states “traffic generation can be forecast using trip generation rates established for particular land uses. These are available from a number of sources including Main Roads and local government. The use of locally derived trip generation rates is preferred to that applicable elsewhere”. The document also references the RMS Guide to Traffic Generating Developments, Institute of Transportation Engineers (ITE) Trip Generation, Main Roads and local government databases.
South Australia	Guide to Traffic Generating Developments (RMS, 2002) Land use traffic generation guidelines (Director-General of Transport South Australia, 1987)	RMS Guide to Traffic Generating Developments is generally used. Director General Transport South Australia has published a Guide to Traffic Generating Developments but its use is not extensively. The 1987 South Australia document states that the ‘trip rates’ used in the document are appropriate for the 1980s and “care should be taken in applying them after 1980”.

State	Policy Guidance	Comments
Western Australia	Transport Assessment Guidelines for Developments (Department for Planning and Infrastructure, 2006)	Transport Assessment Guidelines for Developments was issued in 2006 as a "working" document for trial and evaluation. Transport officers within the Dept for Planning and Infrastructure are using these guidelines for assessing transport impacts of land use developments. South Australia Land Use Traffic Generation Guidelines, the RMS Guide to Traffic Generating Developments, and the ITE Trip Generation Handbook (USA) are also used by local government planning departments. Volume 5 of the WA document contains some very old data suggesting "person-trip generation rates for residential land uses may be derived from household travel surveys such as the 1986 Perth Travel Surveys, the more recent TravelSmart surveys in particular suburbs and the current Perth and regions travel survey (PARTS).' For vehicle trip rates, Volume 2 of the WA document refers to the South Australia Land Use Traffic Generation Guidelines, the RMS Guide to Traffic Generating Developments, and the ITE Trip Generation document.
Australian Capital Territory	Guide to Traffic Generating Developments (RMS, 2002)	RMS Guide to Traffic Generating Developments is generally used.
Northern Territory	Unknown	
Tasmania	Guide to Traffic Generating Developments (RMS, 2002)	RMS Guide to Traffic Generating Developments is generally used. Some consultancies also use their own data collection to establish rates

5.2.3 Current NSW Policy - Guide to Traffic Generating Developments (RMS, 2002)

Current guidance trip generation and parking standards is generally provided from the RMS document "Guide to Traffic Generating Developments". However a number of Councils have adopted their own parking standards, with some authorities adopting maximum parking standards (as detailed in Section 3).

Guide to Traffic Generating Developments defines a high density residential flat building as:

> "(A) *building containing 20 or more dwellings. This does not include aged or disabled persons' housing. High density residential flat buildings are usually more than five levels, have basement level car parking and are located in close proximity to public transport services. The building may contain a component of commercial use.*"

Trip Generation Rates

The trip generation rates provided in the Guide to Traffic Generating Developments document includes vehicle trip rates on a weekday only. Person trip rates and Saturday trip rates are not provided. The trip rates include visitors, staff, service/delivery and on-street movements such as taxis and pick-up/set-down activities. The rates do not include vehicle generation for commercial use. The peak hour trip rates provided are two-way trip rates, and the split between arrivals and departures is not provided.

Table 14 - Current Weekday RMS Trip Rates for "High Density Residential Flat Building" (Trip Rates per Residential Unit)

Trip Type	Metropolitan Regional (CBD) Centres Network Peak hour			Metropolitan Sub-Regional Centres Network Peak hour		
	In	Out	Total	In	Out	Total
Person Trips	-	-	-	-	-	-
Vehicle Trips	-	-	0.240	-	-	0.290
Parking Demand	-	-	-	-	-	-

Parking Provision

The recommended minimum number of off-street resident parking spaces for high density residential development is as follows:

- Metropolitan Regional (CBD) Centres:
  - 0.4 spaces per 1 bedroom unit
  - 0.7 spaces per 2 bedroom unit
  - 1.20 spaces per 3 bedroom unit
  - 1 space per 7 units (visitor parking)
- Metropolitan Sub-Regional Centres:
  - 0.6 spaces per 1 bedroom unit.
  - 0.9 spaces per 2 bedroom unit.
  - 1.40 spaces per 3 bedroom unit.
  - 1 space per 5 units (visitor parking).

Metropolitan Regional Centres (CBD) provide high levels of local employment as well as access to rail and bus services and therefore may have less parking requirements. The recommended minimum number of off-street visitor parking spaces is one space for every 5 to 7 dwellings. Councils may wish to reduce this requirement for buildings located in close proximity to public transport, or where short term unit leasing is expected.

5.2.4 Australian Policy Summary

In summary, although other guidance documents are used throughout the different Sates in Australia, the *RMS Guide to Traffic Generating Developments (RMS, 2002)* document is generally the first point of reference for establishing trip rates. However, the current RMS guide provides limited trip generation data for high density residential developments which is based on survey information which is around 20 years old.

In addition, the RMS document acknowledges that the trip rates are only a guide and recent surveys of comparable developments undertaken by a developer could be used for establishing generation rates for a particular development. As such, many developers/transport consultants also seem to undertake their

own surveys to establish the traffic generating capabilities of a particular site, which could be at the request of some local authorities outside of NSW.

5.3 Overseas Sources

A number of overseas trip generation sources have been examined in order to undertake a comparison with the trip rates established for this study. Table 15 identifies these countries and associated data sources. Details of the database sources adopted by each country are provided in Sections 5.3.1 to 5.3.3.

Table 15 - Trip Generation Guidance Documents Recommended by State

Country	Database
New Zealand	Trips Database Bureau (TDB) New Zealand Transport Agency Report 453 – Trips and Parking Related to Land Use (2011)
United States of America	Institution of Transportation Engineers "Trip Generation"
United Kingdom and the Republic of Ireland	TRICS Database

5.3.1 New Zealand

Trips Database Bureau (TDB)

The Trips Database Bureau was formed in 2002 and expanded in 2008 to include both New Zealand and Australian members, including RMS. The Bureau continues to collect surveys of trip rates, parking demand and travel information relative to different land uses from across the country.

From 2009 the TDB database was supplemented with a database of Australian trip and parking surveys data provided by the RMS. The data provided is the basis of the RMS's 'Guide to Traffic Generating Developments' publication.

The TDB database is supplied to members as a Microsoft Excel spreadsheet on CD which is updated annually.

The database is sorted according to nine Land Use Groups, and within each Land Use Activity there are between 5 and 13 primary activity subgroups. The subgroup in which high density residential development would fall under within the TDB database is "multi-unit" which is categorised as "residential units attached and grouped together and numbering more than 10 individual household units collectively."

The TDB database spreadsheet can be used to filter sites in order to select the most comparable sites to a proposed land use development. There is only one high density residential development in the TDB database, which is a mixed use site with some high density residential development. A single site is not sufficient for the purposes of comparison to the rates identified in this study, which are derived from a number of sites.

New Zealand Transport Agency Report 453 – Trips and Parking Related to Land Use (2011)

The New Zealand Transport Agency (NZTA) Report 453 updated and provided additional information to the Transfund NZ research report 209 "Trips and Parking Related to Land Use" (Douglass and Mckenzie, 2001). The purpose of the report is to contribute to a national overview of travel related land use at an individual site level. The document uses trip surveys of land uses by all modes including car drivers, car passengers, pedestrians, cyclists, public transport users and considers observations from car park demand surveys. The document supports the principal for retaining surveyed information in the TDB database on a site by site basis, so that comparisons can be made with sites with similar land-use and location characteristics.

NZTA R453 provides daily trip rates for "inner-city apartments" which is based on trip surveys undertaken in 2000 by Christchurch City Council. The purpose of this survey was to quantify the level of daily household vehicle trip generation based on a survey of 27 multi-unit residential apartments. All of the surveyed developments included over 20 units and were located in within Christchurch central area.

NZTA R453 document provides average, maximum and 85th percentile trip rates However, the publication does not provide person trip rates, peak hour trip rates or Saturday trip rates.

Table 16 provides a summary of the daily (24 hour) vehicles trip rates for the "inner-city apartments" from the NZTA R453 publication.

Table 16 - NZTA R453 Trip Rates for "Inner-City Apartments"

Number of Bedrooms	Units Surveyed	Daily Vehicle Trip Generation (In + Out)		
		Average	Maximum	85th Percentile
1 Bedroom Units	15	3.100	13	6.000
2 or More Bedroom Units	12	4.800	17	8.000
Total	27	3.900	17	6.800

Parking standards are not provided within this document and it is not stated whether the parking standards relating to the surveyed developments are maximum or minimum standards.

5.3.2 United States - Institution of Transportation Engineers "Trip Generation"

The most recent (8th) edition of the Institution of *Transportation Engineers (ITE) "Trip Generation"* was published in 2008. The document consists of two data volumes with land use descriptions, trip generation rates, equations and data plots, with survey data from more than 4,800 sites and 162 land uses included. The document is not available in digital format which encourages the use of average values rather than the most appropriate data.

In addition, the *Institution of Transportation Engineers (ITE) "Parking Generation" (4th edition)* has 91 land uses represented. This document includes parking demand data by hour of day.

High density residential developments are defined in ITE as high-rise apartments located in rental buildings that have more than ten levels (floors) and most likely have one or more elevators. The document also states that the peak hour of the generator typically coincides with the peak hour of the adjacent street.

The site survey data provided within the ITE database is old and was undertaken between the late 1960s to the late 1980s, throughout the United States. Vehicle trip rates are provided, although person trip rates are only provided for the weekday AM and PM peak hours. The publication does not provide any information on relevant parking standards for the surveyed sites.

The ITE "Trip Generation" database identifies number of sites and average number of dwellings for each time period. The average trip rate is provided along with the range and standard deviation of trip rates. The results of the surveys are also presented in a data plot chart. However, specific details of each site, such as site location details, survey dates and population density of the surrounding area are unknown.

Table 17 and Table 18 provide the weekday and Saturday trip rates from obtained from the *8th edition of the ITE "Trip Generation"* publication.

Table 17 - Weekday ITE Average Trip Rates for "High-Rise Apartment" (Trip Rates per Residential Unit)

Trip Type	AM Peak (08:00-09:00)			PM Peak (017:00-18:00)			Daily (24 hour)		
	In	Out	Total	In	Out	Total	In	Out	Total
Person Trips	0.035	0.185	0.220	0.146	0.054	0.200	-	-	-
Vehicle Trips	0.075	0.265	0.340	0.248	0.152	0.400	2.200	2.200	4.200
Peak Parking Demand	-	-	-	-	-	-	-	-	-

Table 18 - Saturday ITE Trip Rates for "High-Rise Apartment" (Trip Rates per Residential Unit)

Trip Type	Development Peak hour			Daily (24 hour)		
	In	Out	Total	In	Out	Total
Person Trips	-	-	-	-	-	-
Vehicle Trips	0.228	0.172	0.400	2.490	2.490	4.980
Peak Parking Demand	-	-	-	-	-	-

5.3.3 United Kingdom and the Republic of Ireland – TRICS Database

TRICS is the UK and Ireland's national system of trip generation analysis, which contains over 6,300 directional transport surveys for over 100 types of development. TRICS was founded and is owned by 6 County Councils in England, and is managed by JMP Consultants Limited. However, its annual data collection programme covers regions across the whole of the United Kingdom and Republic of Ireland. TRICS is the accepted database for nearly all councils and traffic consultancies.

The TRICS database provides a wide variety of data across many land use types across all regions of the UK and Ireland. The program contains some multi-modal trip rate information and can provide trip rates for the following trip types:

- Person trips;
- Vehicle trips;
- Vehicle occupants;
- Service vehicle trips;
- Public transport user trips;
- Taxi trips;
- Pedestrian trips;
- Cyclist trips.

Individual trip rates for a given time period for a number of surveys can be calculated and ranked, displaying the worst and best case scenarios. This can be useful for the purposes of trip rate selection, or

for calculating the 15th or 85th percentile trip rates from a selection of sites. This approach can also identify the range of sites used in the site selection.

The TRICS database does not provide parking demand rates. However, the hourly vehicle trip rate profile provided from TRICS can be used for estimating parking accumulations for a development, if the number of vehicles parked at the start of the study period is known.

The database uses a flexible system of filtering, to allow users to interrogate trip rates for sites (including range of land use categories). For the "privately owned flats" category, there are a number of data filter options within the TRICS database to allow the user to select the most appropriate survey sites, including;

- Date range - for example, surveys older than 5 years old can be discounted from the site selection;
- Location – including town centre, edge of town centre, suburban area (out of centre), edge of town and neighbourhood centre locations (between one to all of these options can be selected);
- Area region and – sites can be selected or discounted by region or area (for example, sites within the Republic of Ireland or Greater London could be discounted);
- Location sub-categories – including commercial zone, development zone, residential zone, built-up zone (between one to all of these options can be selected);
- Data rage (for examples, a range of the number of dwellings);
- Survey days – surveys for particular days of the week;
- Survey types – i.e. manual or directional ATC surveys;
- Population density - a range of population densities within 1 mile and 5 miles of the site can be selected;
- Car ownership within 5 miles - a range of car ownership (per household) values can be selected;
- Travel Plan – sites with or without an adopted Travel Plan can be selected.

A summary of the weekday and Saturday person trip rates and vehicles trip rates provided for "privately owned flats" from the TRICS database is provided in Table 19 and Table 20 respectively. All sites with over 50 residential units were selected for the analysis.

Parking provision for residential developments in the United Kingdom varies across the country and is based on local authority parking standards. In many cases, different parking standards are also provided for town centre and sub-urban locations. It should be noted that these are different to Australian parking standards and are generally maximum parking standards, as opposed to the minimum parking standards adopted in NSW.

Table 19 - Weekday TRICS Trip Rates for "Privately Owned Flats" (Trip Rates per Residential Unit)

Trip Type	AM Peak (08:00-09:00)			PM Peak (017:00-18:00)			Daily (24 hour)		
	In	Out	Total	In	Out	Total	In	Out	Total
Person Trips	0.083	0.491	0.574	0.398	0.160	0.558	2.552	2.585	5.137
Vehicle Trips	0.047	0.183	0.230	0.157	0.068	0.225	1.007	1.091	2.098
Peak Parking	-	-	-	-	-	-	-	-	-

Trip Type	AM Peak (08:00-09:00)			PM Peak (017:00-18:00)			Daily (24 hour)		
	In	Out	Total	In	Out	Total	In	Out	Total
Demand									

Table 20 - Saturday TRICS Trip Rates for "Privately Owned Flats" (Trip Rates per Residential Unit)

Trip Type	Peak hour (12:00-13:00)			Daily (24 hour)		
	In	Out	Total	In	Out	Total
Person Trips	0.210	0.355	0.565	0.210	0.355	0.565
Vehicle Trips	0.119	0.131	0.250	1.256	1.344	2.600
Peak Parking Demand	-	-	-	-	-	-

5.4 Summary and Comparison

Table 21 below provides a summary of the vehicle trip generation rates for a number of databases from Australia and other countries and provides a comparison these rates with the rates determined as a result of this study.

Table 21 - Comparison of Trip Rates for high Density Residential Developments (Trip Rates per Residential Unit)

Database Source	2-Way Weekday Trip Rate			2-Way Saturday Trip Rate	
	AM Peak	PM Peak	Daily	Peak Hour	Daily
New Survey Data					
Vehicle Trips	0.306	0.179	2.139*	0.213	1.596
Person Trips	0.795	0.555	5.190	0.559	5.061
RMS (2002)					
Vehicle Trips – CBD Centres	0.240	0.240	-	-	-
Vehicle Trips – Sub-Regional	0.290	0.290	-	-	-
Person Trips	-	-	-	-	-
NZTA R453					
Vehicle Trips	-	-	3.900	-	-
Person Trips	-	-	-	-	-
ITE					
Vehicle Trips	0.340	0.400	4.200	0.400	4.980
Person Trips	-	-	-	-	-
TRICS					
Vehicle Trips	0.230	0.225	2.098	0.250	2.600†
Person Trips	0.574	0.558	5.137	0.565	0.565†

** R^2 value was less than 0.7 indicating low correlation for this relationship.*

† *Indicated TRICS daily trip rate is for a 24 hour period.*

Analysis of existing Australian and international trip generation databases concluded the following:

- Current RMS guidance is based on vehicle trips only for weekday peak periods. Trip rates are based on 20 year old survey data.
- Based on an average of AM and PM peak vehicle trip generation, the trip generation rates derived from this study is 0.242 trips per unit. This is very similar to the current RMS rate for high density residential development in Metropolitan CBD centres.
- Analysis of databases from other countries showed that the weekday peak TRICS vehicle trip rates are also similar to the current RMS rate for comparable developments.
- Vehicle trip rates derived from the ITE publication were not comparable to the current RMS vehicle trip rates. These vehicle trip rates were derived from surveys undertaken up to 50 years ago and are not likely to be relevant to current Australian trip making behaviour.
- Vehicle trip rates from the NZTA R453 publication are based on a limited number of survey sites which are all located in a particular area of on city (Christchurch).

- TRICS was found to be the only other database source that provides person trip generation rates for high density residential developments.

Based on this analysis of other trip generation data sources, the current RMS vehicle trip rates are sufficiently different from these sources to justify the need for an approach which is specific to NSW. TRICS was found to be the only other trip generation database that could provide a comparable trip generation rate for both vehicle and person trips. This is due to the flexibility of the database for selecting comparable sites and producing detailed trip making statistics as well as having a much greater number of survey sites, which is continually updated. As a result, continuing usage of the TRICS database for the review of RMS trip generation rates for high density residential developments is a worthwhile exercise for ensuring the appropriateness of these rates into the future.

6. Conclusions and Recommendations

GHD has undertaken a survey and analysis of the trip making behaviour of high density residential developments in NSW. As a result of these surveys and analyses, the following conclusions can be drawn:

- High density residential developments conforming to the site selection criteria were uncommon, recent planning policy in NSW has generally favoured mixed-use high density residential developments in inner-city and urban areas with good access to public transport.
- Parking provision and parking demand for high density residential developments is not easily related any particular independent variable. Peak parking demand usually occurs at night, and parking codes are generally the domain of Council LEPs or DCPs, resulting in a wide spread of parking provision rates, which can be either minimum provision rates or maximum provisions rates.
- Analysis of direction split (inbound vs outbound) for the peak hours suggested that the current practice of assuming highly directional trip generation is not supported by the surveys.
- Trip generation, particularly vehicle trip generation, has a very strong relationship with the number of units in a development. This relationship is generally stronger than any other single variable relationship for trip making statistics.
- The trip generation rate can be further refined using a multi variable analysis. Based on the surveys undertaken in this study, it was found that the combination of number of units and number of parking spaces was not significantly better than the number of units alone in predicting the trip generation, however breaking the number of units into bedroom brackets did result in a highly correlated relationship with trip making statistics. Multivariable analysis for number of bedrooms also provided greater correlation that single variable analysis based on total number of bedrooms.
- Analysis of the peak parking demand showed a very strong relationship with the number of spaces in the development, as would be expected.
- Analysis of mode share showed that neither parking provision (spaces per unit) or the Accessibility Score were closely related to vehicle mode share (as a proportion of all trips). Analysis of the outliers however, indicated that the Accessibility Score could be modified to account for bus routes in such a way that would show a strong relationship between mode share and Accessibility Score.
- Comparison of the vehicle trip rate per unit derived from this study (based on an average of the morning and evening peak rates) is very close to that previously published in the latest version of the Guide to Traffic Generating Developments.
- Analysis of other databases of trip generation, both in Australia and abroad showed that the current rate and the rate identified in this study is different to similar rates used in the USA and New Zealand, however it is quite similar to the rates that can be derived from the UK TRICS database.
- It is recommended that the rate calculated in this study be adopted for morning and evening peak trip generation and that this rate continue to be monitored against new data from the TRICS database as it gets updated.

Appendix A

Accessibility Score Methodology

Appendix A

Public Transport accessibility-based survey methodology

1. Background

The approach outlined below has the effect of constraining parking supply compared to the traditional "unconstrained" rates generally quoted in various trip generation guides, in response to the proximity of public transport and other centres, and the particular landuse involved. It is based on the calculation of:

a) an accessibility discount factor reflecting the site's accessibility to public transport and other centres; and

b) a landuse policy factor reflecting the extent to which parking supply can or should be modified for a particular landuse.

It is envisaged that this draft methodology will be further refined over time. It is presented here as background information only, to assist contractors in selecting a set of suitable survey locations, and is not to be distributed externally.

2. Methodology

The proposed parking supply formula is:

$$PA_{max} = PH_{max} [1-(AD \times PF)]$$

where PA_{max} is the new *accessibility-based* parking supply and PH_{max} is the historic *unconstrained* parking provision rate.

AD is the Accessibility Discount factor reflecting the site's accessibility to public transport and other centres. It has a range of 0 (sites remote from any public transport) to 0.9 (CBD areas, well-served by public transport).

PF is a landuse policy factor which reflects the extent to which parking supply can be, or should be, modified for a particular landuse.

The Accessibility Score is the relevant factor when candidate sites are being considered for any particular survey. It has two components – a public transport proximity score and a centre proximity score.

Table 1 below outlines the calculation of the Accessibility Score. **Table 2** describes how the Accessibility Score is then converted to the Accessibility Discount *factor* (AD), and is included here for information only.

STEP	SCORING METHODOLOGY
1. Determine walking distance from site to nearest dominant stop/station for each mode corridor or bus route. (Each route is counted once only)	**Rail scores:** Rail station 0 – 400m .....Score = 24 Rail station 400 – 800m .....Score = 12 Rail station > 800m .....Score = 0 **Light rail / ferry scores:** Light rail or ferry route 0 – 400m .....Score = 8 Light rail or ferry route 400 – 800m .....Score = 4 Light rail or ferry route >800m .....Score = 0 **Bus scores:** Each bus route 0 – 400m .....Score = 4 Each bus route 400 – 800m .....Score = 1 Each bus route > 800m .....Score = 0
2. Determine infrastructure priority treatment (This is a proxy for public transport reliability, connectivity and speed)	For each mode corridor, multiply the score in Step 1. above with the factor below: Heavy rail, light rail or ferry route .....Multiply by 1 Bus Transitway .....Multiply bus route score by 3 Other Strategic Bus Corridor* .....Multiply bus route score by 2 Corridor with express services .....Multiply bus route score by 1.5 Standard bus route .....Multiply bus route score by 1 * If bus route is on a Strategic Bus Corridor for less than 50% of its length, treat as an express corridor
3. Determine frequency of services for each mode (NB: only those actually setting down at route stop/station)	For each mode corridor, multiply the score in Step 2. above with the factor below: > 20 services in the 2hr AM peak both ways..... Multiply mode score by 3 13-20 services in the 2hr AM peak both ways..... Multiply mode score by 2 8-12 services in the 2hr AM peak both ways..... Multiply mode score by 1 ≤ 7 services in the 2hr AM peak both ways..... Multiply mode score by 0.5
4. Add up all the scores for each mode corridor, to produce a total Public Transport Score	
5. Determine walking proximity of site to a centre (as defined in the Metropolitan Strategy)	Determine the **Centre Score**, using the following scores: Within 800m of boundary of existing Global/Regional City:.....Score = 60 Within 800m of boundary of existing/developing Major Centre .....Score = 40 Within 800m of boundary of existing/developing Smaller Centre and Specialised Centre .....Score = 20
6. Add the <u>Public Transport Score</u> from Step 4. above to <u>Centre Score</u> from Step 5. above, to produce a total Accessibility Score	
7. Use Table 2 below to convert the Accessibility Score to the Accessibility Discount factor (AD)	

Table 1 – Estimating the Accessibility Score

Accessibility Score	Accessibility Discount factor (AD)	Indicative examples
250+	**0.9**	Sydney CBD; North Sydney CBD
220 - 249	**0.75**	Sydney CBD fringe; Parramatta CBD
180 – 219	**0.6**	Fringes of larger centres; Major centres
140 – 179	**0.4**	Fringes of Major centres; medium centres
80 – 139	**0.3**	Smaller centres on Strategic Bus Corridors
21 - 79	**0.2**	Odd pockets and corridors
0 - 20	**0**	"Standard" background public transport levels; remote areas. No parking reduction necessary.

Table 2 – Estimating the Accessibility Discount factor

Figure 1 overleaf shows the distribution of Accessibility Scores based on public transport timetable information currently available for the greater Sydney area.

GHD

133 Castlereagh St Sydney NSW 2000

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T: 2 9239 7100 F: 2 9239 7199 E: sydmail@ghd.com.au

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Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
1	O Peel	I Smith		S Konstas		28/9/2012
2	O. Peel	I Smith		S Konstas		21/12/2012