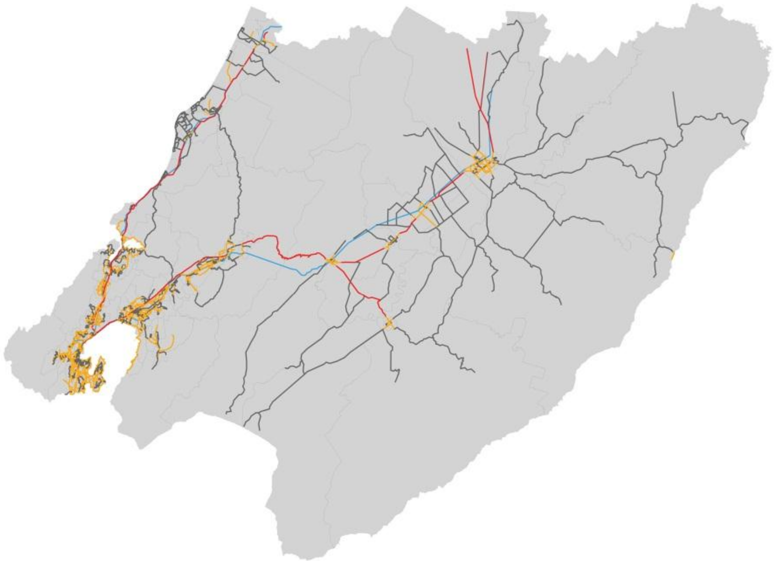
OPUS INTERNATIONAL CONSULTANTS AND ARUP

WELLINGTON TRANSPORT MODELS

Contract No C3079



TN19 : WPTM Calibration and Validation

Date: December 2012

ARUP OPUS

Wellington Transport Models

TN19 : WPTM Calibration and Validation

prepared for

Greater Wellington Regional Council

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This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

John Bolland: ____________________________
(Peer Reviewer)

Nick Sargent: ____________________________
(GWRC)

Contents

Table of Figures

1 Introduction

1.1 Aims and Approach

This technical note (TN) documents the calibration and validation of the Wellington Public Transport Model (WPTM). Whilst there are a lot of comparisons of modelled versus observed undertaken and reported on in this document, the aim is to ensure that the agreed upon validation criteria (documented in TN17) has been achieved.

A high-level summary of the validation guidelines and criteria reported in TN17 is given below for reference. A summary table is available in Section 6, detailing each criterion, how well it is met, and where the data can be found in this report.

Bus Demand

- Scatter-gram of boardings by route: modelled vs. reference [R^2 > 85% cf. ETM];
- Maximum load vs. seated / standing capacity, by route [load <= capacity];
- Passenger volume between fare-zones, adult and child [±15% cf. ETM];
- CBD inbound volume [±15% cf. ETM];
- Adult journey purposes [= on-board survey]; and
- Distribution of bus access / egress trip lengths [cf. on-board survey: judgement].

Rail Demand

- Passenger volumes between Territorial Authority (TA) sectors [±15% cf. expanded on-board survey data];
- Boardings and alightings by station group [±10% cf. Boarding & Alighting data];
- Maximum load by line / direction, compared against seated / standing capacities [load <= capacity];
- Adult journey purposes and car availability [=on-board survey];
- Distribution of rail access / egress trip lengths by access mode [cf on-board survey – judgement]; and
- CBD inbound volume [cf. survey of arrivals at Wellington – report only].

Access Choice

- Demand by access mode by station [±20% cf. on-board survey data]; and
- Demand by access mode by station group [±10% cf. on-board survey data].

Network

- Check list of coded services against definitive list [matching];
- Scatter-gram of end-to-end running times by route [R^2 > 85% cf. combined reference data created from combination of ETM & timetabled data];
- Scatter-gram of sectional running times in the critical Wellington Station – Courtenay Place – Newtown corridor [R^2 > 85% cf. reference data created from combination of ETM & timetabled data]; and
- Scattergram of adult and child fares by fare-zone movement [R^2 > 85% cf. Metlink fare table].

Assignment

- Bus and rail volumes at screenlines [±15%];
- Bus/rail shares in competition corridors: Ngauranga Gorge, Ngaio Gorge, SH2 south of Petone [±10%]; and
- O to D comparisons: Metlink journey planner [reasonable match of alternative route options and travel times – judgement].

1.2 Structure of TN

This TN is broken down into the following sections:

- Section 1: Introduction (this section)
- Section 2: Network checks
- Section 3: Demand calibration and validation
- Section 4: Access choice model calibration and validation
- Section 5: Assignment and full model calibration and validation
- Section 6: Discussion, conclusions and further work

At this point it is important to draw a distinction between Sections 3, 4 and 5. Whilst all of these sections report calibration and validation statistics, the calibration and validation is undertaken at different stages of the model development process, as follows:

- Section 3 – calibration and validation of base input matrices assigned separately for each modelled mode;
- Section 4 – calibration and validation of the access choice model using combined (all mode) PT matrices and basic assignment parameters and structure; and
- Section 5 – calibration and validation of full WPTM incorporating combined (all mode) PT matrices and final assignment parameters and structure.

The step-by-step calibration / validation approach was considered important to ensure the model was performing well at each key stage of the model development. Whilst we could have reported only on the final validation results in this Technical Note it has been reported in this step-by-step manner to give the reader an understanding of the process and level of validation at each given step.

1.3 Screenlines / Cordons Used

The screenlines and cordons used for the comparison of modelled versus observed data throughout this document broadly falls into two groups:

- Screenlines/cordons used in the WTSM validation (see Figure 1-1 and Figure 1-2), and;
- Cordons specifically developed for the WPTM validation - Wellington CBD, Lower Hutt, Porirua, Paraparaumu (see Figures Figure 1-3 to Figure 1-6).

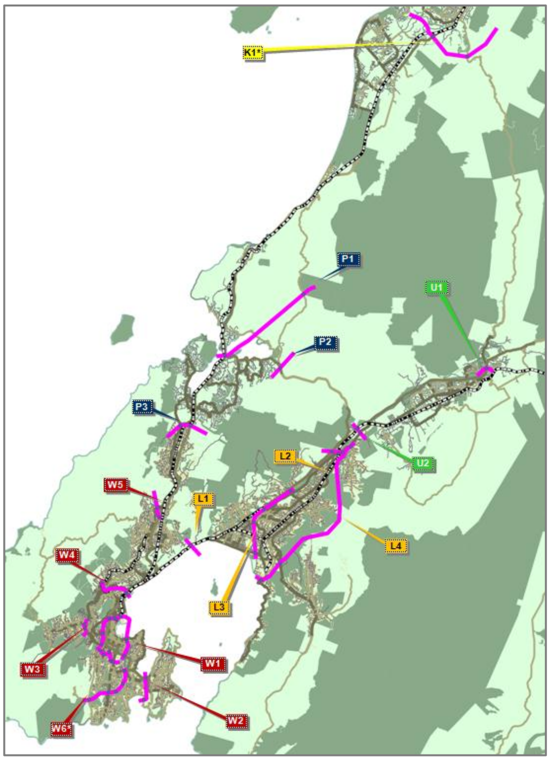


Figure 1-1: WTSM Screenlines and Cordons, Regional

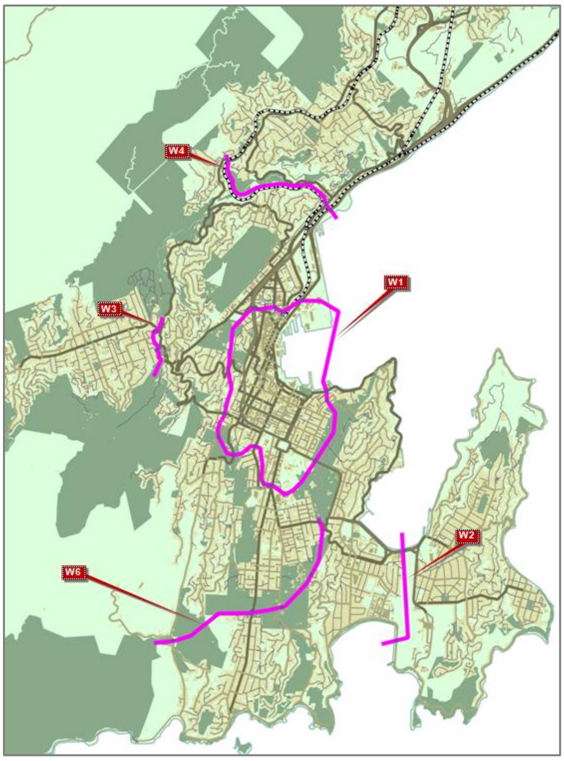


Figure 1-2 : WTSM Screenlines and Cordons, Wellington

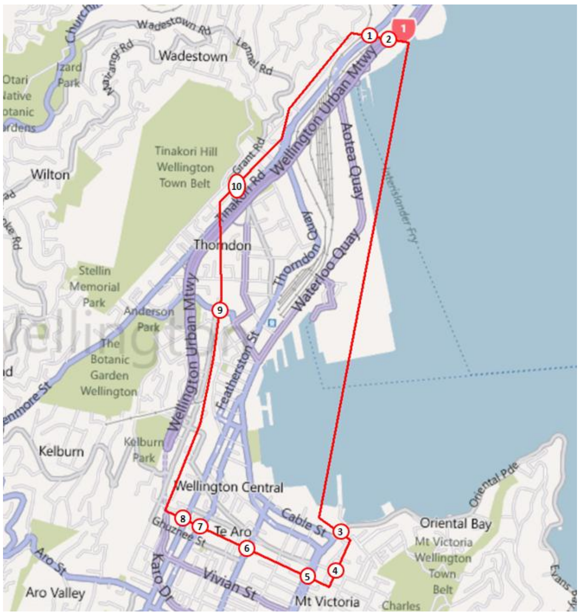


Figure 1-3: WPTM Cordon, Wellington CBD (C1)

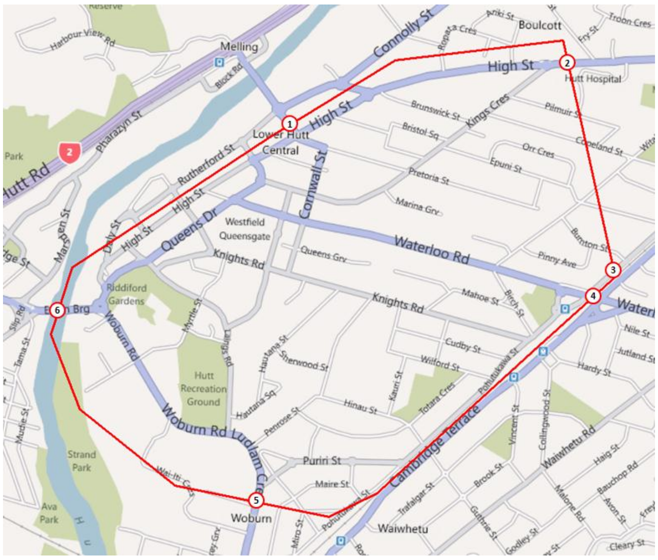


Figure 1-4: WPTM Cordon, Lower Hutt (C3)

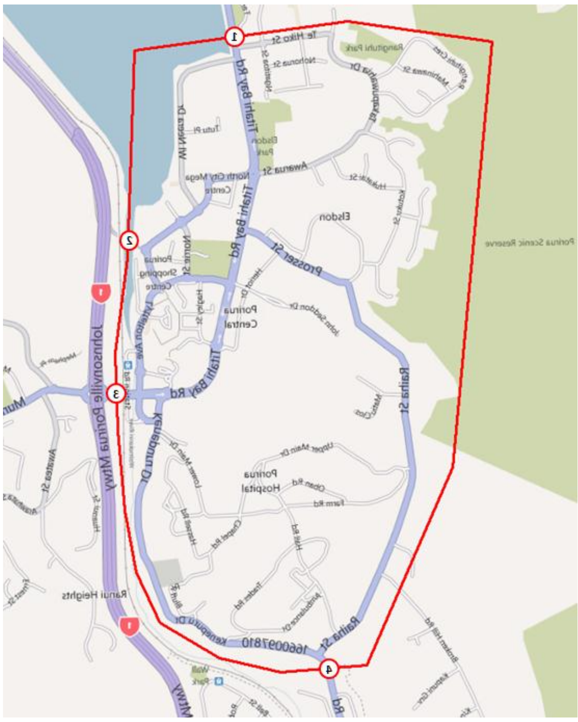


Figure 1-5: WPTM Cordon, Porirua (C2)

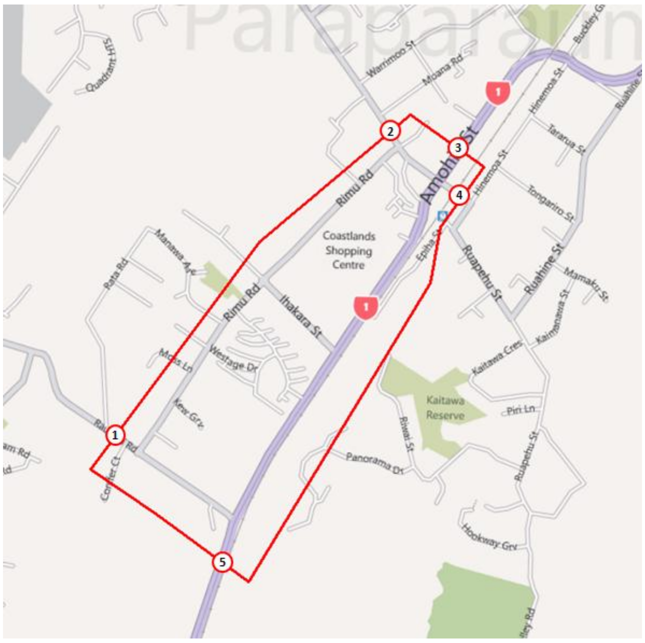


Figure 1-6: WPTM Cordon, Paraparaumu (C4)

2 Network

2.1 Introduction

This section documents the checks undertaken on the networks and transit line data received and passed from WTSM to WPTM. The checks are only undertaken on items that are pertinent to the WPTM, namely:

- Public transport (PT) service supply and routing (PT lines files); and
- Network attributes (free-flow speeds and bus lanes).

Checks on other network parameters and attributes can be seen in TN1.

2.2 Data sources

- Metlink timetable data, extracted 17/01/2012; and
- General Transit Feed (GTF), extracted 04/07/2011.

2.3 Calibration

2.3.1 IP Service Supply Period

The initial Inter peak (IP) transit line files output from the GTF convertor process developed for WTSM (detailed in TN1) covered an average 2 hour service period from 9am-3pm. This period matched the WPTM modelled IP demand period. Upon further investigation, it was discovered that by using the average 2 hours of the full IP period as the definition for the transit supply led to the inclusion of services that are primarily for staging and operational purposes. These services occur at the end of the AM peak and at the start of the PM peak.

To eliminate this issue, it was decided that the public transport service supply period be shortened to cover the average period from 10.30am to 2.30pm only. IP services are those that arrive after 10:30am or depart before 2:30pm.

2.3.2 Route Rationalisation

The direct output from the GTF convertor contained variants of routes which were almost, but not quite, identical. For example, some routes have a variant that terminates at Molesworth St, and one at Wellington Station. These variants were combined, and the frequencies increased accordingly. The charts below (Figure 2-1, Figure 2-2) show how this process reduced the number of variants.

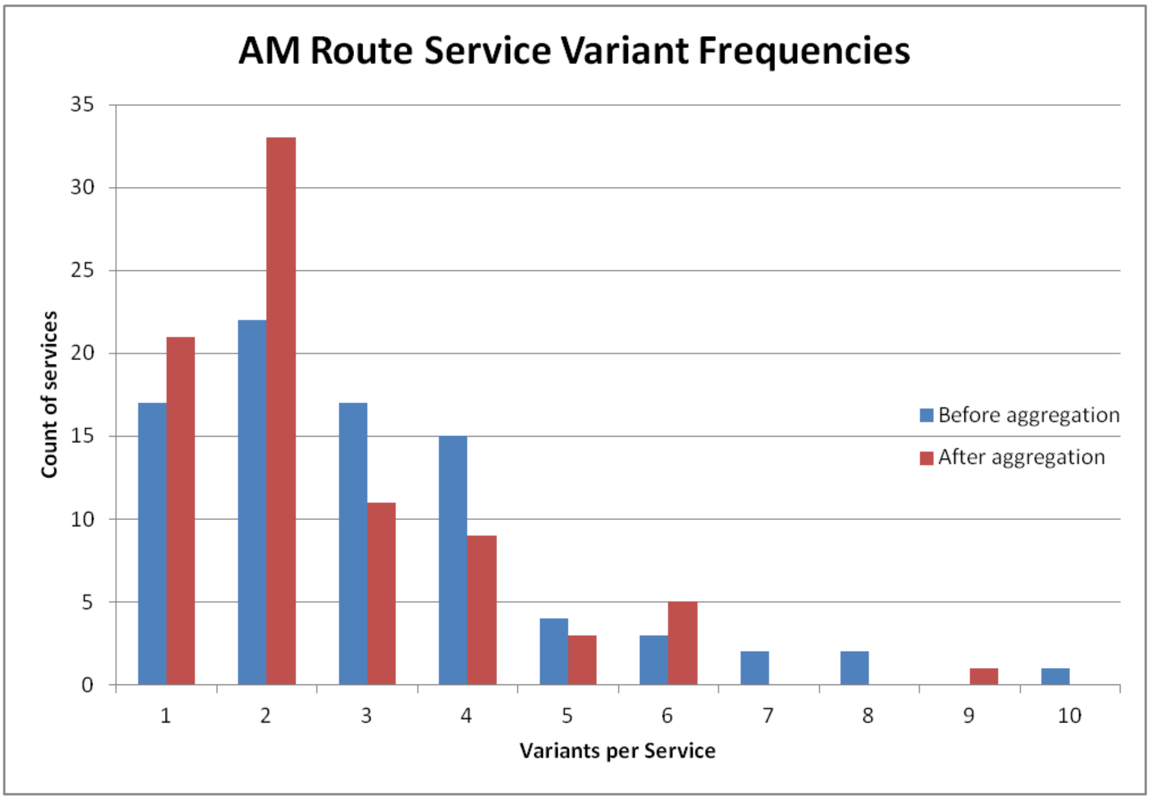


Figure 2-1: AM Route Service Variant Frequencies

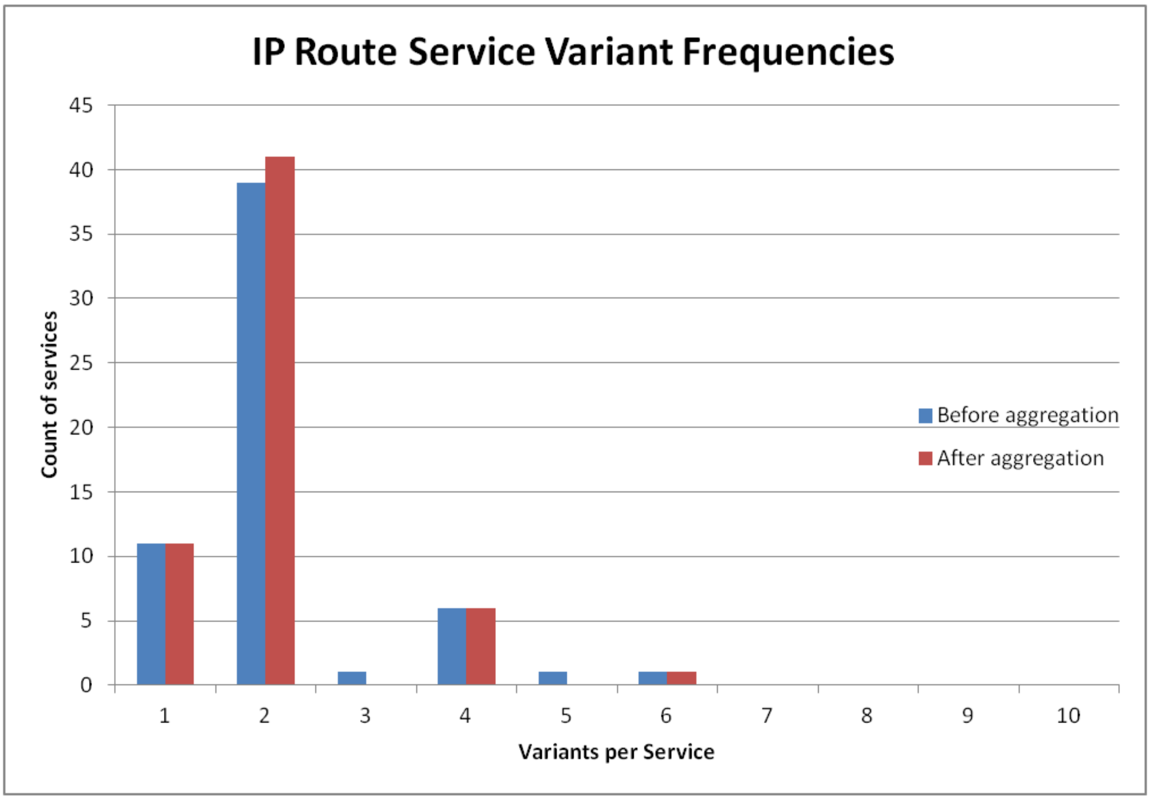


Figure 2-2: IP Route Service Variant Frequencies

2.4 Validation

2.4.1 PT Service Supply

Table 2-1 shows the number of services in 2 hours at the WPTM cordons for the AM peak period.

Table 2-1: PT Service Supply (2hr No. of Services) at WPTM Cordons, Inbound, AM Peak

Cordon	Stop Number	Cordon Point	Location	Timetable	Modelled
CBD	5492	1	Thorndon Quay at Motorway (Handy Rentals)	75.0	77.4
	4113	10	Murphy Street - Wellington Girls	46.0	46.4
	4312	9	Tinakori Road at St Mary Street (near 360)	35.0	33.6
	4915	9	Victoria University - Kelburn Parade (near 42)	22.0	21.4
	7711	8	Willis Street - Abel Smith Street	24.0	23.6
	7913	6	Taranaki Street (near 274)	30.0	30.4
	7013	5	Cambridge Terrace at Basin Reserve	57.0	56.8
	7212	4	Elizabeth Street at Kent Terrace	62.0	62.6
	7514	3	Oriental Parade at Freyberg Pool (opposite)	13.0	12.6
	TOTAL			364.0	364.8
Lower Hutt	8123	2	Hutt Hospital - High Street	24.0	25.4
	9100	3	Oxford Terrace at Epuni Street (near 77)	4.0	5.0
	9166	4	Waterloo Road (near 259)	9.0	13.2
	8142	5	Guthrie Street at Trafalgar Street (near 6)	17.0	17.0
	9157	5	Ludlam Crescent at Wai-iti Crescent (near 41)	10.0	9.2
	9112	6	Victoria Street at Weltec, Block F	20.0	19.0
	9106	6	Railway Avenue (near 21)	4.0	3.8
	9150	1	Melling Station (bus Stop)	9.0	8.2
	TOTAL			97.0	100.8
Porirua	2866	1	Titahi Bay Road at Whanga Cres Walkway (opposite)	10.0	9.6
	2356	3	Champion Street at Mepham Place (Shell)	5.0	4.2
	2178	3	Mungavin Park - Mungavin Avenue (opposite)	8.0	7.4
	3934	4	Kenepuru Drive at Bowland (opposite)	5.0	3.4
	3926	4	SDA School - Raiha Street	10.0	9.4
	2026	2	Porirua Library - Norrie Street (opposite)	22.0	22.2
	TOTAL			60.0	56.2
Paraparaumu	1007	5	Raumati Road, Chocolate Factory (near 156)	0.0	1.0
	1380	1	Raumati Road at Matai Road (opposite 68)	7.0	6.6
	1194	2	Kapiti Road at Moana Road (near 36)	18.0	16.8
	1072	4	Ruapehu Street (near 48B)	4.0	4.0
	TOTAL			29.0	28.4

Table 2-2: PT Service Supply (2hr No. of Services) at WPTM Cordons, Outbound, AM Peak

Cordon	Stop Number	Cordon Point	Location	Timetable	Modelled
CBD	5024	1	Thorndon Quay at Motorway (Hirequip)	29.0	31.4
	5113	10	Molesworth Street - New World	19.0	24.8
	5312	9	Tinakori Road at St Mary Street	14.0	14.8
	5915	9	Victoria University - Kelburn Parade	18.0	18.8
	6710	7	Victoria Street - Vivian Street	16.0	16.2
	6913	6	Taranaki Street (near 217)	21.0	22.2
	6013	5	Kent Terrace at Basin Reserve	37.0	40.8
	6212	4	Elizabeth Street at Kent Terrace (near 7)	18.0	20.8
	6514	3	Oriental Parade at Freyberg Pool	8.0	7.2
	TOTAL			180.0	197.0
Lower Hutt	9223	2	Hutt Hospital - High Street (opposite)	21.0	19.4
	8100	3	Oxford Terrace at Epuni Street (opposite 77)	5.0	3.8
	8166	4	Waterloo Road (near 260)	13.0	9.2
	9142	5	Guthrie Street at Brook Street (near 11)	9.0	11.6
	8157	5	Ludlam Crescent at Wai-iti Crescent (near 28)	11.0	11.4
	8112	6	Victoria Street at Weltec, Block F (near 64)	18.0	19.6
	8107	6	Railway Avenue (Brendan Foot Motors)	0.0	1.0
	8106	1	Marsden Street at Bridge Street	6.0	5.0
	TOTAL			83.0	81.0
Porirua	2816	1	Titahi Bay Road at Whanga Cres Walkway	8.0	8.6
	2300	3	Champion Street at Mepham Place (opposite Shel	4.0	4.0
	2100	3	Mungavin Park - Mungavin Avenue	6.0	6.6
	3942	4	Kenepuru Drive at Bowland	11.0	11.0
	3929	4	SDA School - Raiha Street (opposite)	8.0	7.6
	2024	2	Porirua - Pak n Save	5.0	5.4
	2012	2	Porirua Library - Norrie Street	17.0	18.2
	TOTAL			59.0	61.4
Paraparaumu	1008	5	Raumati Road, Chocolate Factory (near 139)	0.0	1.0
	1306	1	Raumati Road at Matai Road (near 68)	3.0	3.0
	1102	2	Kapiti Road at Ngahina Street (near 39)	15.0	17.2
	1062	4	Ruapehu Street at Redwood Close (opposite)	4.0	4.0
	TOTAL			22.0	25.2

2.5 Fares

The fares were developed based on data from Greater Wellington Regional Council (GWRC), Electronic Ticketing Machine (ETM) data and Metlink. This process is described in detail in TN1.

3 Demand

3.1 Introduction

This section considers the validation of the WPTM modelled demand. This is represented in WPTM by input matrices of public transport demand. These input matrices were created by a methodology described in full in TN7. In short, several observed data sources were combined to produce zone-to-zone matrices for different time periods, modes and purposes. These data sources included electronic ticketing machine data, rail boarding and alighting data and on-board surveys.

In this section, the input demand is checked against the data sources used to produce it, to check the validity of the matrix-building process. It is also checked against separate data sources, such as the CBD cordon survey and KiwiRail counts, to provide a more objective validation. While doing this, some inconsistencies were identified, and the matrices revised to remedy these.

3.2 Data Sources

- Wellington City Council annual cordon survey - This survey is carried out each year in March. It records the number of passengers entering the Wellington CBD by rail, bus, cable car and ferry, over a one day survey period. To prepare these counts for use, they were factored to Annual Average Weekday Travel (AAWT) 2011, and school buses were removed.
- Rail boarding and alighting counts - These counts were carried out during June 2011. They record the number of passengers boarding and alighting at each station for each train within a two hour period. They have been factored to AAWT 2011, and the Inter peak counts have been factored to an average two hour value.
- GWRC monthly report - GWRC has collected and summarised bus and rail monthly patronage data between 1999 and 2011. Monthly and yearly indexes have been produced from this data.
- KiwiRail guard counts - These are “high counts” of the maximum load of passengers on each train. This data is available for all weekdays between 30 May 2011 and 2 December 2011.
- KiwiRail ticket sales - This data gives the number of rail tickets sold and revenue earned, by ticket type, for each month from December 2010 to November 2011.
- Rail and bus on-board surveys - These surveys were carried out in June, August and October 2011. Refer to TN5 for more details.
- ETM data - This is a record of bus tickets sold and journeys taken during March 2011. Refer to TN3 for a description of how this data was cleaned and analysed. This data provides the percentage of child passengers, who were not surveyed in the on-board surveys.

The ETM data was also used to obtain bus passenger volumes at cordons and screenlines. However due to the nature of the data, it was found to be very difficult to obtain volumes directly. Instead, it was decided to use a ‘Reference assignment’ in EMME. The basic idea of this is to assign observed matrices to the correct mode. Bus and rail matrices are assigned to their respective modes only. The assigned rail matrices are from origin station to final destination, so that the access choice model does not come into play. This may mean that some bus / walk trips from initial origin to origin station are missed, but this number should be small. Given that the matrix building process is thorough and correct, this 'Reference assignment' will provide a reliable proxy for the observed bus volumes on the network.

3.3 Calibration

The creation and calibration of the input matrices is described in detail in TN7.

3.4 Validation

3.4.1 CBD Cordon Survey

Table 3-1 compares the observed passenger volumes from the annual CBD cordon survey with the modelled 'reference' volumes in WPTM. The CBD cordon survey recorded volumes for individual buses at different cordon points, for the AM period only. School buses were counted, but removed to obtain the number below. For rail, surveyors were positioned at all exits to Wellington Station, to count people leaving. This may have meant a slight overcount, as some people may not have been passengers, but inside the station on other business.

It should be noted that the time period definitions for observed and modelled are slightly different. The survey counted passengers entering the CBD between 7AM and 9AM, while the model includes trips that first board between 7AM and 9AM. So for example, passengers on the 6:40 Taita to Wellington train, arriving at 7:06, are included in the observed but not modelled data. Considering this, some slight differences between the modelled and observed for bus and rail are to be expected.

Ferry and cable car matrices were created using the CBD cordon survey so modelled volumes are very close to observed. Given the comparatively small amount of people who use these modes, this is an acceptable method.

The validation criterion specifies that the bus passenger CBD inbound volume should be within 15% of the ETM (observed) data. The ETM data was checked against the CBD cordon survey during the matrix creation process, so it is appropriate to use the CBD cordon as the observed. This shows that modelled is within 6% of observed, satisfying the criterion. The rail inbound volume is within 4% of observed, although this criterion required only reporting, and no specified percentage.

Table 3-1: CBD Cordon Count vs. Reference Assignment, by Mode (AM inbound only)

Mode	Cordon Count	Reference Assignment	Difference
Rail	10972	11366	4%
Bus	9754	9192	-6%
Ferry	188	188	0%
Cable Car	81	81	0%
Total	20995	20826	-1%

3.4.2 Boarding and Alighting Graphs

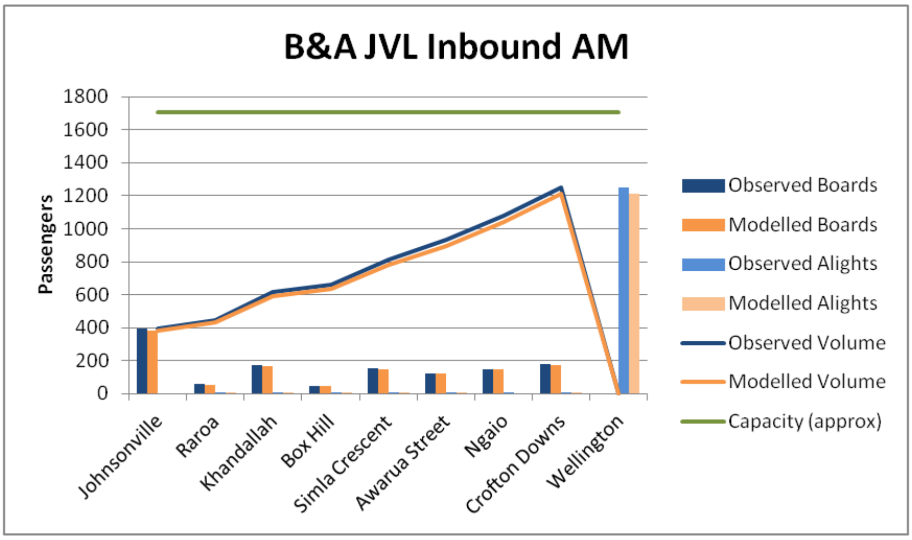
The graphs below compare the observed boarding and alighting counts with the reference demand, for rail line groups. The Hutt Valley, Melling and Wairarapa lines are combined. The Capital Connection was only modelled for the AM inbound; it is combined with the Kapiti line for this segment. In general, there is very good agreement between the observed and modelled plots, particularly for inbound AM routes. It should be noted that the outbound and IP graphs have much fewer passengers than the AM inbound, hence are on a very different scale.

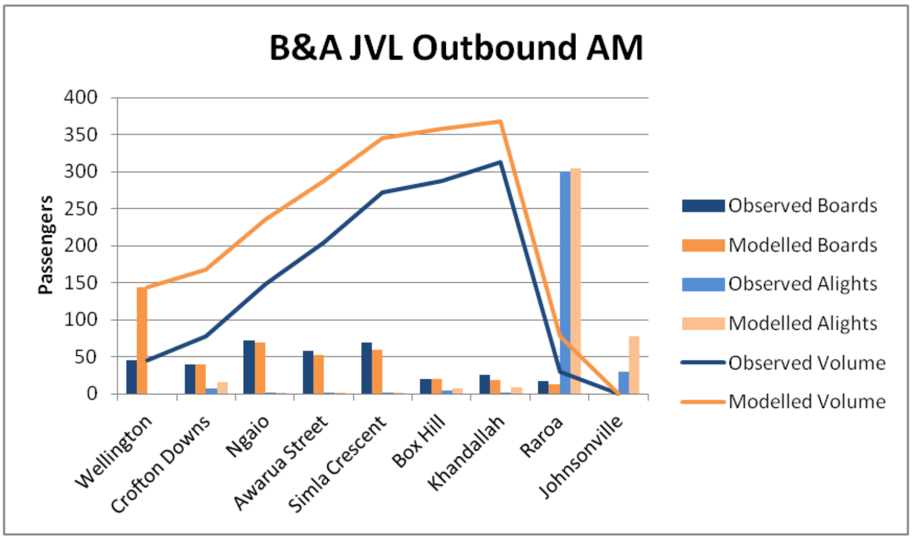
The validation criterion stated that boardings and alightings by station (line) group should be within 10% of the boarding and alighting data. The graphs and the summary table (Table 3-2) demonstrate that this is so for all cases except the Johnsonville Line in the IP. However, there are very few boards in this case, so the difference is not considered significant.

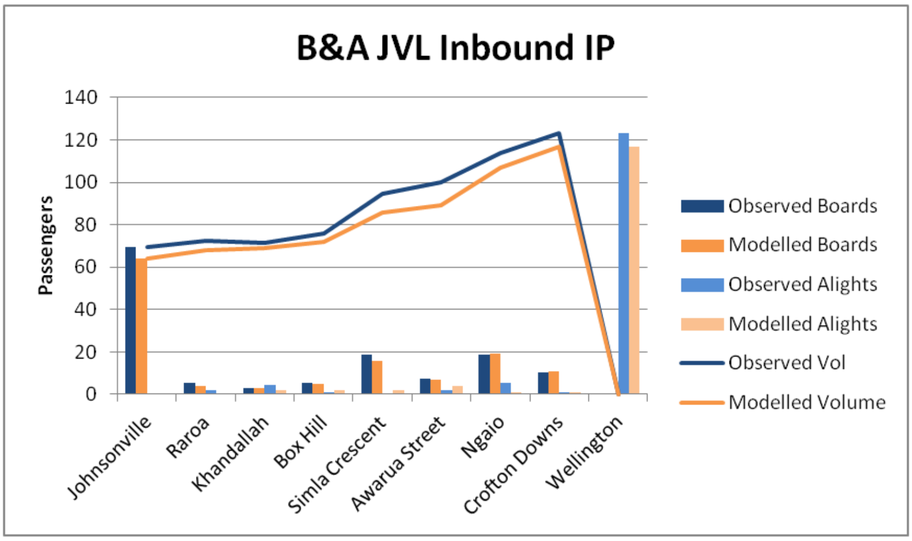
The other validation criterion that is relevant here relates to the maximum load. It states that maximum load should be lower than seated and standing capacity. The approximate seating capacities are shown on inbound AM lines, these being the only lines that come anywhere near to reaching capacity. On the Hutt Valley and Kapiti lines the volume exceeds capacity, but only slightly, and would remain within the standing capacity.

Table 3-2: Total Rail Boards by Line, Observed (Counts) and Reference Demand

	AM			IP		
Line	Observed Boards	Reference Boards	Diff	Observed Boards	Reference Boards	Diff
JVL (Johnsonville)	1618	1644	2%	336	300	-11%
HVL (Hutt Valley), MEL (Melling), WRL (Wairarapa)	6209	6059	-2%	654	594	-9%
KPL (Kapiti), CC (Capital Connection)	5152	5061	-2%	750	687	-8%




B&A JVL Outbound AM
Passengers
400
350
300
250
200
150
100
50
0
Wellington
Crofton Downs
Ngaio
Awarua Street
Simla Crescent
Box Hill
Khandallah
Raroa
Johnsonville
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Volume
Modelled Volume


B&A JVL Inbound IP
Passengers
140
120
100
80
60
40
20
0
Johnsonville
Raroa
Khandallah
Box Hill
Simla Crescent
Awarua Street
Ngaio
Crofton Downs
Wellington
Observed Boards
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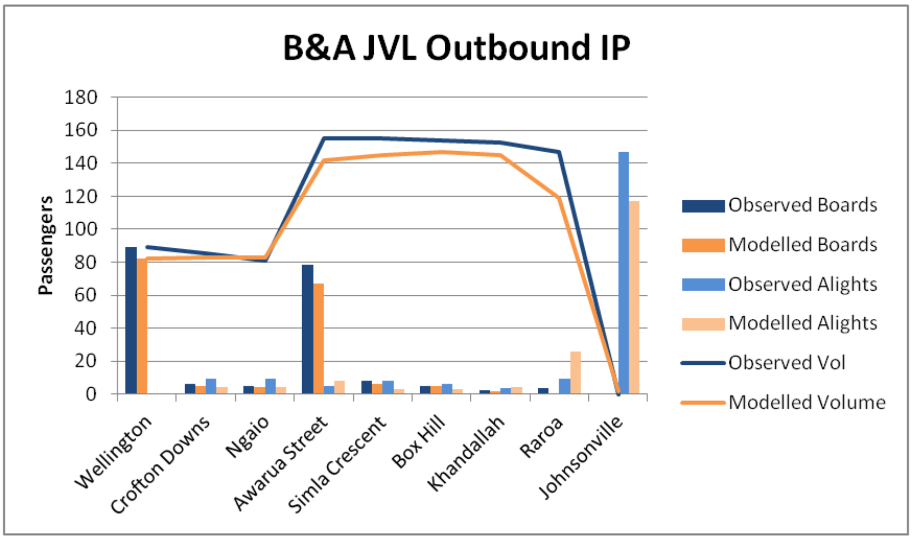
Observed Alights
Modelled Alights
Observed Vol
Modelled Volume


B&A JVL Outbound IP
Passengers
180
160
140
120
100
80
60
40
20
0
Wellington
Crofton Downs
Ngaio
Awarua Street
Simla Crescent
Box Hill
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Johnsonville
Observed Boards
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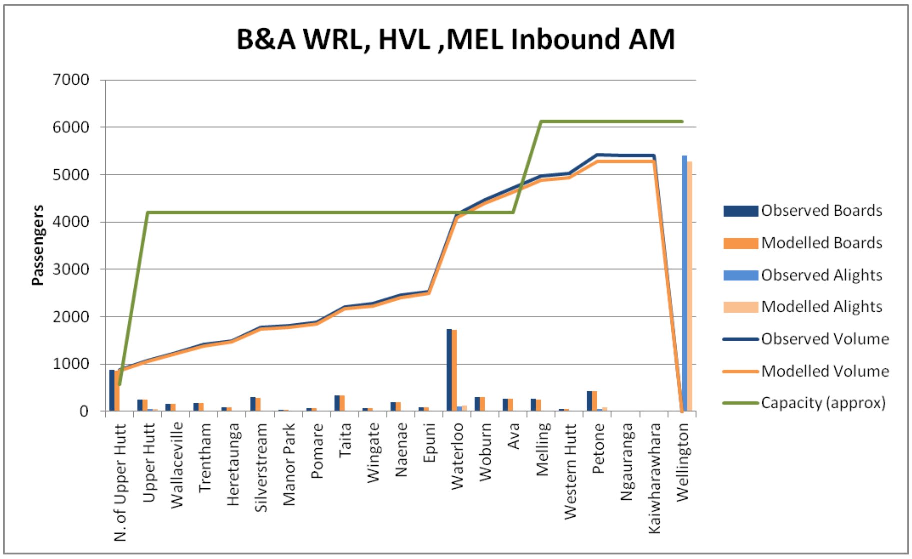
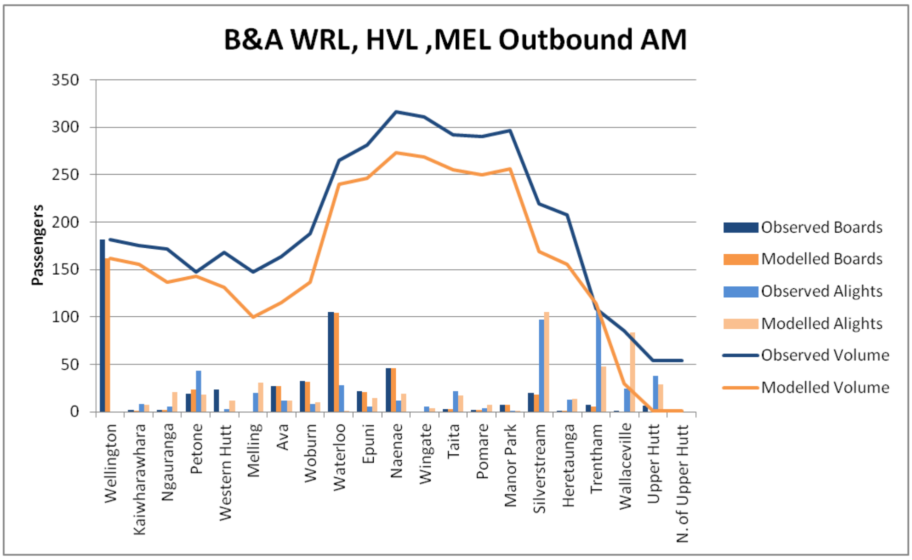
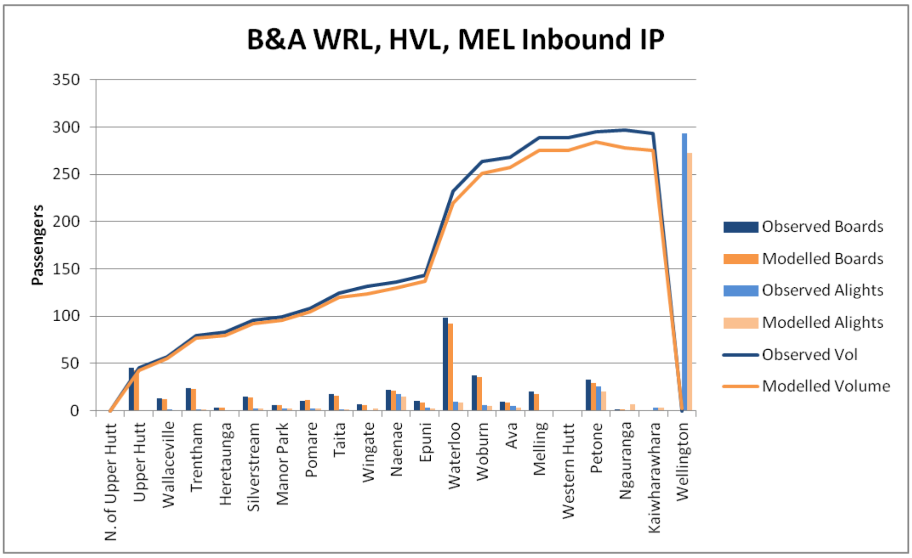
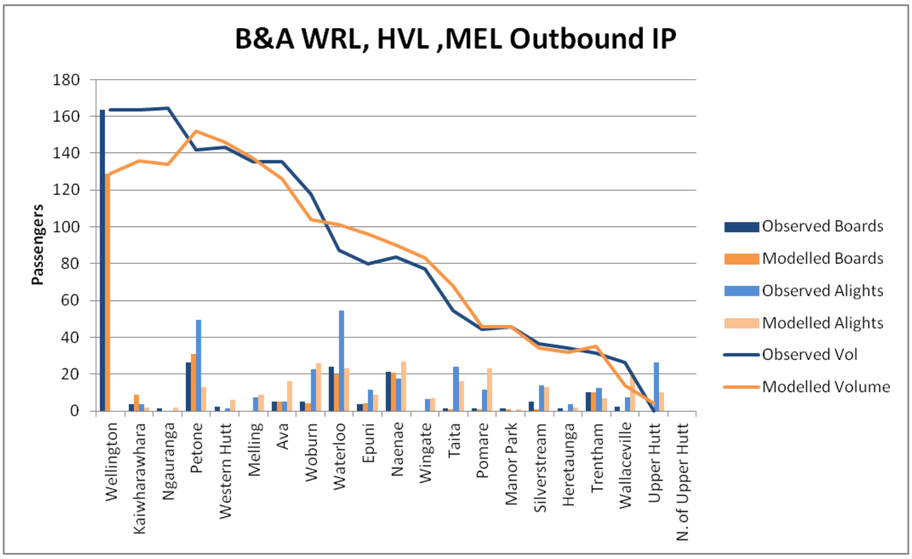
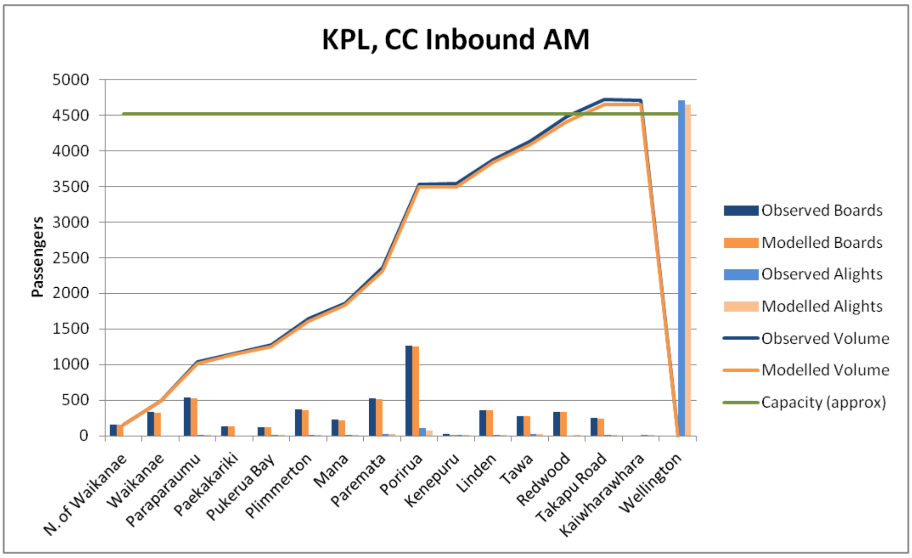
Observed Vol
Modelled Volume

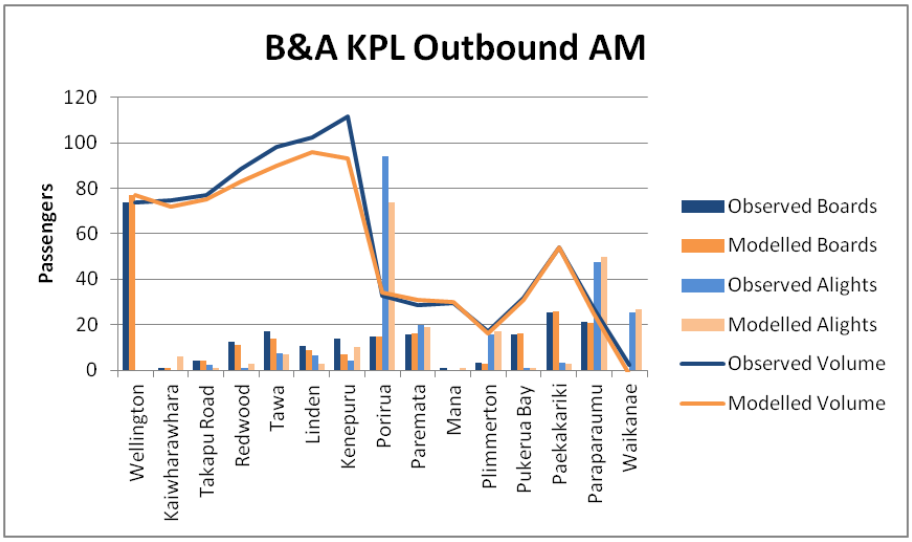

B&A WRL, HVL ,MEL Inbound AM
Passengers
7000
6000
5000
4000
3000
2000
1000
0
N. of Upper Hutt
Upper Hutt
Wallaceville
Trentham
Heretaunga
Silverstream
Manor Park
Pomare
Taita
Wingate
Naenae
Epuni
Waterloo
Woburn
Ava
Melling
Western Hutt
Petone
Ngauranga
Kaiwharawhara
Wellington
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Volume
Modelled Volume
Capacity (approx)

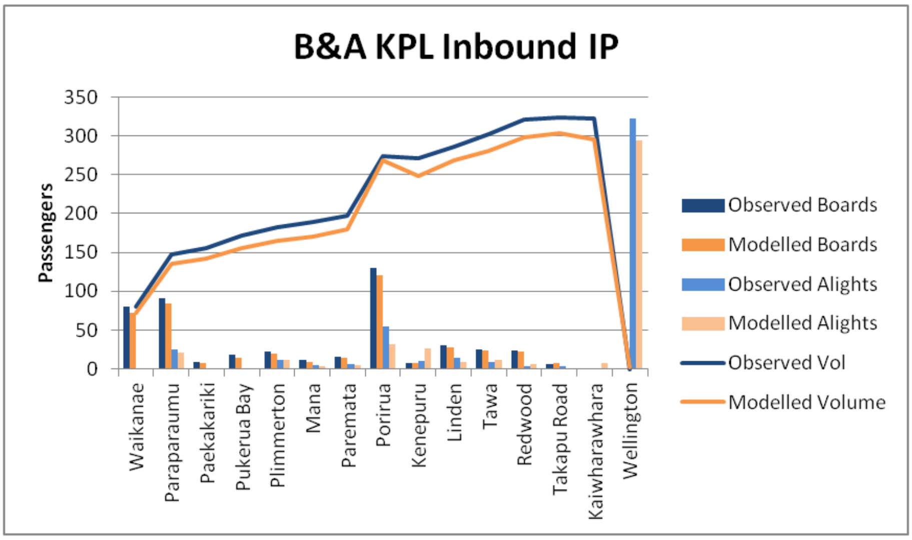

B&A WRL, HVL ,MEL Outbound AM
Passengers
350
300
250
200
150
100
50
0
Wellington
Kaiwharawhara
Ngauranga
Petone
Western Hutt
Melling
Ava
Woburn
Waterloo
Epuni
Naenae
Wingate
Taita
Pomare
Manor Park
Silverstream
Heretaunga
Trentham
Wallaceville
Upper Hutt
N. of Upper Hutt
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Volume
Modelled Volume

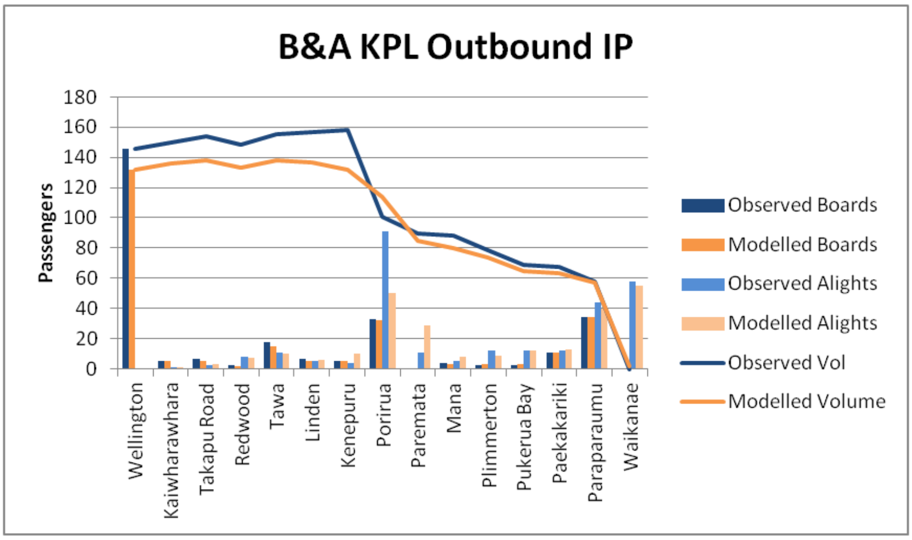

B&A WRL, HVL, MEL Inbound IP
Passengers
350
300
250
200
150
100
50
0
N. of Upper Hutt
Upper Hutt
Wallaceville
Trentham
Heretaunga
Silverstream
Manor Park
Pomare
Taita
Wingate
Naenae
Epuni
Waterloo
Woburn
Ava
Melling
Western Hutt
Petone
Ngauranga
Kaiwharawhara
Wellington
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Vol
Modelled Volume


B&A WRL, HVL ,MEL Outbound IP
Passengers
180
160
140
120
100
80
60
40
20
0
Wellington
Kaiwharawhara
Ngauranga
Petone
Western Hutt
Melling
Ava
Woburn
Waterloo
Epuni
Naenae
Wingate
Taita
Pomare
Manor Park
Silverstream
Heretaunga
Trentham
Wallaceville
Upper Hutt
N. of Upper Hutt
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Vol
Modelled Volume


KPL, CC Inbound AM
Passengers
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
N. of Waikanae
Waikanae
Paraparaumu
Paekakariki
Pukerua Bay
Plimmerton
Mana
Paremata
Porirua
Kenepuru
Linden
Tawa
Redwood
Takapu Road
Kaiwharawhara
Wellington
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Volume
Modelled Volume
Capacity (approx)


B&A KPL Outbound AM
Passengers
120
100
80
60
40
20
0
Wellington
Kaiwharawhara
Takapu Road
Redwood
Tawa
Linden
Kenepuru
Porirua
Paremata
Mana
Plimmerton
Pukerua Bay
Paekakariki
Paraparaumu
Waikanae
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Volume
Modelled Volume





3.4.3 KiwiRail Guard Counts

Another data source used to validate is the KiwiRail passenger counts made by the train guards. These are counts of the maximum number of passengers on each train. This data was available for all weekdays between 30 May 2011 and 2 December 2011. It is assumed that this is equivalent to the number of passengers on the train on arrival or departure from Wellington Station. Table 3-3 compares the average KiwiRail guard counts with the modelled volume at Wellington Station.

When first investigated, some of the observed guard counts were significantly higher than the modelled counts. Similarly, the CBD cordon counts were higher than the initial modelled data. This prompted further investigation. It was found that the boarding and alighting survey that was used to create the rail matrices did not correspond exactly with the modelled time period. In general, the boarding and alighting survey counted passengers at stations between 7AM and 9AM, but several trains operating on the Hutt and Kapiti lines in the first hour of the AM peak period were omitted from the survey, making the total volume of rail passenger in the survey (and therefore the WPTM matrices) lower than expected.

The volumes on the omitted trains were estimated by taking the board/alight patterns from similar services that were surveyed, and controlling to KiwiRail guards counts. The WPTM matrix building process was re-run with the revised boarding and alighting counts, producing a better validation.

Table 3-3: KiwiRail High Counts

		AM		
Line	**Direction**	**KiwiRail**	**Volume at Wellington Station**	**Difference**
JVL	I	1136	1213	7%
HVL / MEL / WRL	I	5259	5270	0%
KPL / CC	I	4565	4650	2%

3.4.4 GWRC Monthly Passenger Counts

Another source of validation data is the GWRC monthly passenger counts, available from 1999 onwards for rail and bus. Table 3-4 compares the GWRC monthly passenger counts to the total number of passengers modelled in WPTM for all bus and rail trips. The modelled totals were obtained by summing all trips in the input PT matrices.

The observed average monthly total was obtained by averaging all months from 2011. The GWRC counts were then factored down to weekday two-hourly values using the following formula:

AM/IP trips = (Monthly total trips)
* (weekday trips as % of weekly trips)
÷ (Average weekdays in month)
* (% of weekday trips in the AM / IP period)

For buses, the weekday trips as a percentage of weekly trips was found to be 74% based on the ETM data. For rail, it was approximated as 85%, as rail has more of a commuter focus than bus. The percentage of weekday trips in the AM and IP periods were found from the ETM data for bus, and the KiwiRail high counts data for rail.

The factoring process means that the observed numbers for each time period should be taken as an indication of general magnitude rather than exact volumes. Given this, the modelled numbers appear reasonable.

Table 3-4: GWRC Monthly Passenger Counts vs. All Modelled Trips

		AM			IP		
Mode	Observed Average Monthly Total	Observed (factored)	Modelled	Difference	Observed (factored)	Modelled	Difference
Rail	951145	12547	12601	0%	1842	1541	-16%
Bus	2009254	17788	14842	-17%	7225	6349	-12%
Total	2960399	30334	27443	-10%	9067	7890	-13%

3.4.5 Purpose, Car Availability and Age Splits

The tables below relate to the splits by purpose (Table 3-5 – (W)ork, (E)ducation, (O)ther, (C)hild) and car availability (Table 3-6). The observed proportions for work, education and other purposes, and car availability, were obtained from the bus and rail on-board surveys. Because children were not surveyed, child proportions were found from the ETM data for bus and the KiwiRail ticket sales data for rail. The modelled data was calculated from the input matrices used in WPTM.

This table demonstrates that the matrix-building process replicates the original purpose splits well. This is one of the validation criteria.

Table 3-5: Splits by Purpose and Mode, Observed vs. Modelled

		Rail				Bus			
		W	E	O	C	W	E	O	C
AM	Observed	76%	9%	3%	12%	58%	14%	9%	19%
	Modelled	79%	8%	3%	10%	63%	11%	7%	18%
IP	Observed	26%	22%	52%	0%	25%	20%	47%	8%
	Modelled	40%	13%	47%	0%	25%	21%	45%	8%

Table 3-6: Split by Car Availability, Observed vs. Modelled

		CA	NCA
AM	Observed	60%	40%
	Modelled	55%	45%
IP	Observed	50%	50%
	Modelled	50%	50%

Table 3-7 shows the split between child and adult trips. The observed values are obtained from the ETM data for bus, and the KiwiRail data for rail. The modelled values are from the WPTM input matrices. This ignores school bus trips which are not modelled. As described in TN7 lack of detail in relation to child rail trips has led to the assumption that there are few child trips; and any that do exist have been included as adult trips in the matrix.

Table 3-7: Adult / Child Split, Observed vs. Modelled

		Rail		Bus	
		Adult	Child	Adult	Child
AM	Observed	88%	12%	81%	19%
	Modelled	90%	10%	82%	18%
IP	Observed	100%	0%	92%	8%
	Modelled	100%	0%	92%	8%

3.4.6 Access and Egress Trip Length Distribution

The graphs below (Figure 3-1 and Figure 3-2) show the distribution of the access and egress distances for bus trips with walking as the access or egress mode. The observed distances were obtained from the bus on-board surveys, by finding the distance between a passenger's initial origin and boarding stop, or alighting stop, and final destination. These trip length distributions are compared to the modelled distributions from WPTM. It was judged that these graphs match well, and thus fulfil the validation criterion.

The observed graphs have a jump at >1400m, creating a mismatch between observed and modelled. This may be due to the fact that everything over 1.4km is classified in one group. If similar length categories were continued a smoother pattern may be seen. In addition, there may be some car or PT transfer trips being misreported as walk in the observed data.

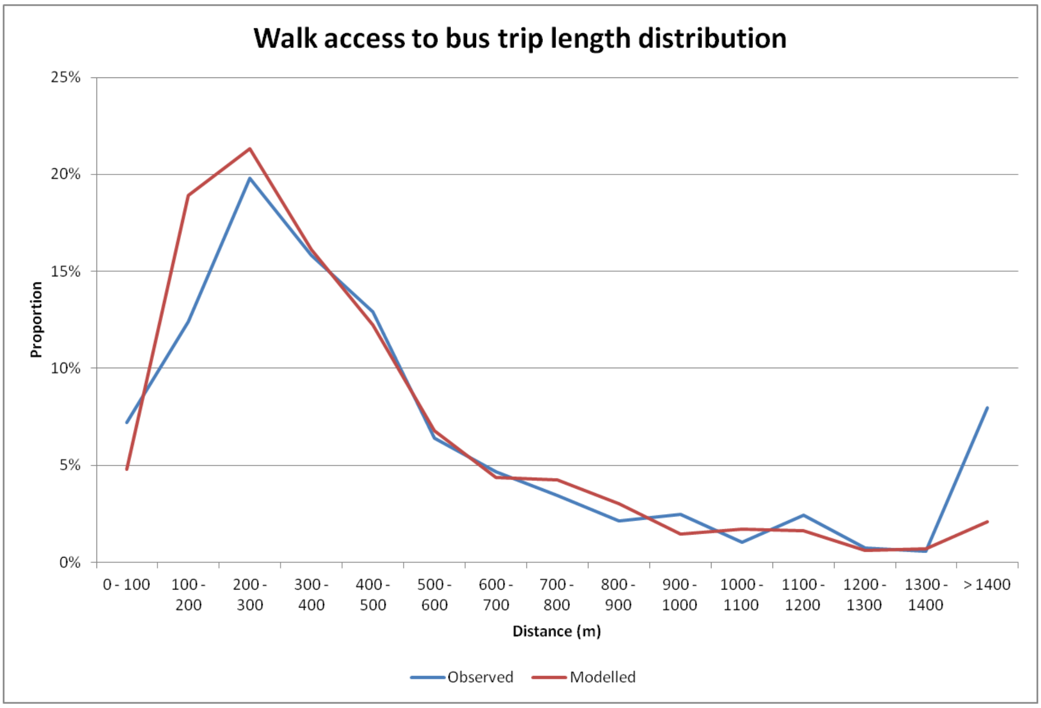


Figure 3-1: Walk Access to Bus Distance Distribution (All purposes)

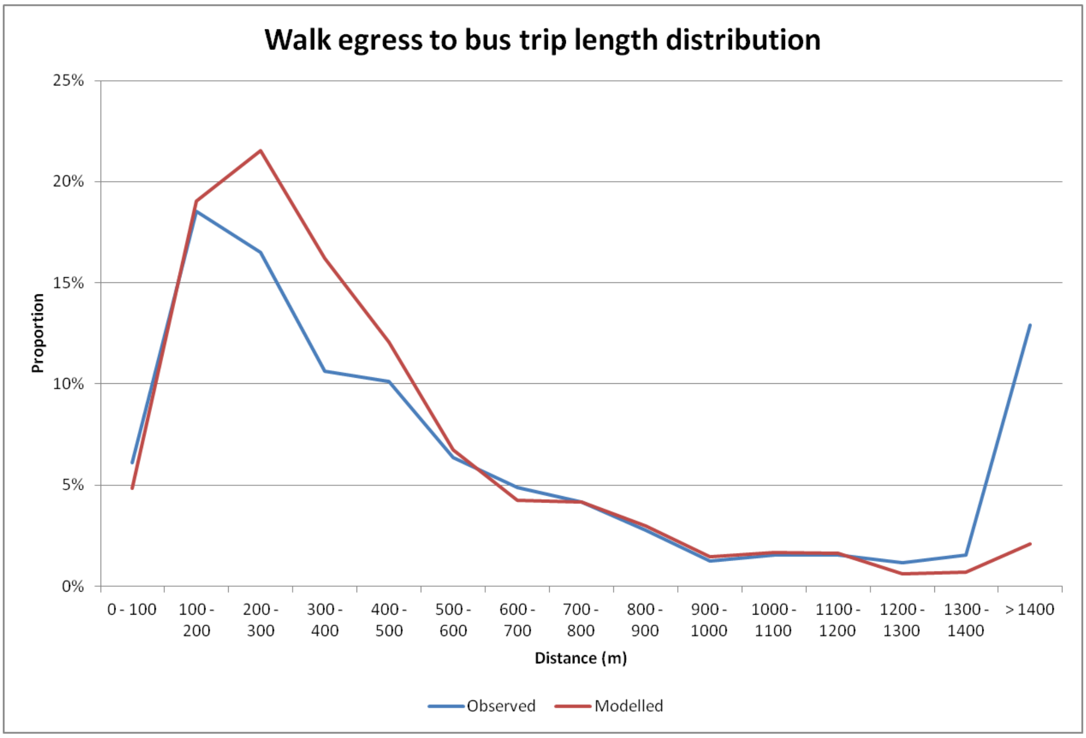


Figure 3-2: Walk Egress from Bus Distance Distribution (All purposes)

3.4.7 Territorial Authority Matrices

The tables below show the TA to TA demand matrices for AM (Table 3-8) and IP (Table 3-9), including both bus and rail modes. The territorial authorities are as follows:

1. Wellington City
2. Lower Hutt City
3. Upper Hutt City
4. Porirua City
5. Kapiti Coast District
6. All stops to north of normal TAs – not used in current model
7. South Wairarapa District
8. Carterton District
9. Masterton District

The general pattern appears correct, with the majority of AM trips travelling to Wellington City, due to the commuter dominance of this area. There are also reasonable numbers of trips within TA's, which makes sense as non-commuter trips such as social or shopping are likely to be within a passenger's local area. This occurs in the IP period also, where the majority of trips are within TA's. There are many zero values in both tables. This is due to the large size of the TA's and the limited PT links available between some of them making PT a very unattractive choice for such journeys.

Trips on the Capital Connection travelling from north of Otaki are included as trips from TA5 rather than TA6, due to the structure of the model.

The validation criterion states that passenger volumes between TA sectors should be within 15% of the expanded on-board survey data. The process of expanding the on-board survey data was fundamental to the creation of the demand matrices, meaning these two sets of data will be almost identical. The patterns shown appear reasonable. Overall it is considered this validation criterion is achieved.

Table 3-8: TA to TA Demand Matrix; AM Peak

	TA1	TA2	TA3	TA4	TA5	TA7	TA8	TA9	**TOTAL**
TA1	14408	292	31	157	1	0	0	0	**14889**
TA2	4228	1375	290	2	0	0	0	0	**5896**
TA3	966	230	249	0	0	0	0	0	**1445**
TA4	2496	0	10	416	33	0	0	0	**2955**
TA5	1092	0	0	83	209	0	0	0	**1385**
TA7	363	16	16	0	0	0	0	0	**395**
TA8	185	34	15	0	0	0	0	0	**234**
TA9	193	33	16	0	0	0	0	0	**243**
TOTAL	**23932**	**1981**	**628**	**658**	**244**	**0**	**0**	**0**	**27443**

Table 3-9: TA to TA Demand Matrix, IP

	TA1	TA2	TA3	TA4	TA5	TA7	TA8	TA9	**TOTAL**
TA1	4794	211	16	118	29	0	0	0	**5168**
TA2	413	962	78	3	1	0	0	0	**1458**
TA3	73	101	149	0	0	0	0	0	**323**
TA4	168	6	0	364	28	0	0	0	**566**
TA5	82	0	0	61	233	0	0	0	**376**
TA7	0	0	0	0	0	0	0	0	**0**
TA8	0	0	0	0	0	0	0	0	**0**
TA9	0	0	0	0	0	0	0	0	**0**
TOTAL	**5530**	**1281**	**243**	**545**	**292**	**0**	**0**	**0**	**7890**

4 Access Choice

4.1 Introduction

A key requirement for WPTM is the modelling of access choice for public transport, in particular for rail. The WPTM choice and assignment models were calibrated iteratively, but for clarity they are described in separate chapters. This chapter describes the choice model.

For any rail journey between home and work, the journey can be split into three distinct elements:

- Leg 1 – Home to Origin station (Access Leg);
- Leg 2 – Origin Station to Destination station (Rail Leg); and
- Leg 3 – Destination Station to Final Destination (Egress Leg).

There are several modes than can be used for access and egress legs:

- Park and Ride (P&R) – from home to the station, either as the driver or a passenger;
- Kiss and Ride (K&R) – being driven from home to the station by someone who will not be travelling by train;
- Train – transfer from another train;
- Walk;
- Cycle; and
- Bus.

People decide on their access mode based upon a number of factors:

- Car Availability – is a car available for the access leg of their journey (either as a driver or passenger);
- Distance – how far is it from their initial origin to origin station;
- Cost – how much does it cost to take the bus or drive from their initial origin to origin station;
- Time – how long does it take to drive from their initial origin to origin station; and
- Parking Capacity – how many parking spaces are available at the station.

If car access has been chosen, travellers must also decide which station to drive to. Whilst most walk access trips will be to their nearest station, P&R and K&R access trips may not necessarily access their nearest station. A number of factors will influence people's choice of station, including:

- Service Frequency – do you drive further to a station that has a more frequent service?
- Fare – do you drive further to a station in a different fare-zone?
- Station Facilities – do you drive further to a station with superior waiting facilities? and
- P&R Capacity / Quality – do you drive further to a station with superior parking facilities?

Table 4-1 was extracted from TN6, and shows the access mode to public transport, for bus and rail. It can be seen that car access to bus is low, at around 3% to 5%. This is not surprising as there are no specific bus based P&R sites in Wellington, as all potential P&R corridors are currently catered for by rail. The majority of bus services in Wellington are suburban services, predominantly accessible by foot. It should be noted that this table was extracted from the initial rail surveys, so there are slight differences when comparing with other results based on the final surveys, and the definition of P&R and K&R.

Table 4-1: Access Modes to PT

	Train		Bus	
Access	**AM**	**IP**	**AM**	**IP**
Walk / cycle	44%	59%	85%	94%
Bus	6%	13%	3%	2%
Train	1%	1%	4%	2%
Car driver (P&R)	26%	12%	3%	1%
Car passenger	24%	15%	5%	2%

Source: On-board bus and initial rail surveys, 2011. Excludes missing data.

For rail, around 50% of passengers use a car to access the rail network, either as a driver, passenger or a drop-off (kiss and ride).

Given the low level of car access to the bus network, it was decided that the access choice model would be calibrated for rail only, and applied to the base model for rail and ferry (Days Bay). In option testing, it is also possible to apply the model to formal bus P&R.

4.2 Choice Model Specification

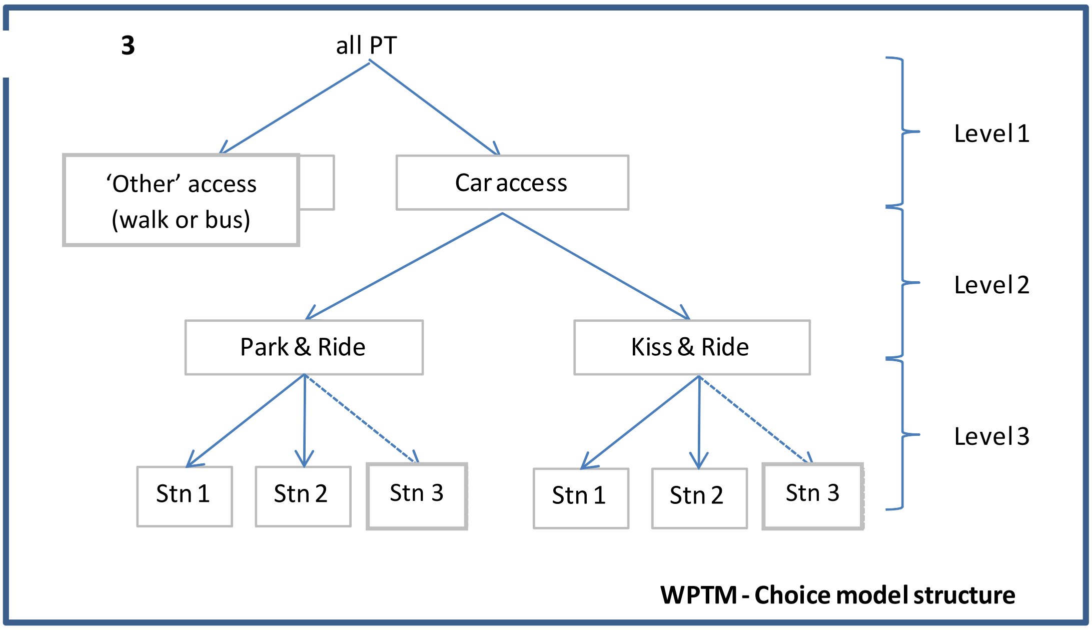
A nested logit model was deemed the most appropriate tool for determining access choice. Logit models are generally suitable where mode choices are quite distinct e.g. walk, P&R and K&R.

Whilst this approach is fairly new in terms of public transport modelling in New Zealand, similar processes and principles have been used in Australia and the UK. The final WPTM parameters are checked against those used in models around the world, in order to confirm that they lie within acceptable bounds.

It should be noted that the choice model will only determine the Level 1 choice between car access and ‘other’. For ‘other’ access, the assignment model will determine the split between walk access and bus access.

Figure 4-1 below outlines the choice model structure and should be studied in conjunction with the subsequent text that describes each of the three levels of the model in more detail.

Figure 4-1: WPTM Choice Model Structure



4.2.1 Level 1

Total PT demand is allocated to 'other' access or car access. Car access is restricted to rail only in the base year. For example:

- Zone 1742 (9km southeast of Waterloo Station), 100 trips to Wellington:
  - Car Access probability = 70% (70 car access trips); and
  - 'Other' Access probability = 30% (30 'other' access trips).

4.2.2 Level 2

Car access is split between P&R and K&R. The definition of P&R includes both drivers and passengers of cars that park at the station. K&R includes those who are dropped off:

- Zone 1742 – car access trips
  - P&R probability = 90% - 63 trips; and
  - K&R probability = 10% - 7 trips.

4.2.3 Level 3

P&R and K&R are allocated proportionately to the three 'best' stations (highest utility), as calculated by the model. For example:

- Zone 1742 – P&R access trips
  - Waterloo probability– 80% - 50 trips;
  - Epuni probability – 5% - 3 trips; and
  - Petone probability – 15% - 9 trips.
- Zone 1742 – K&R access trips
  - Waterloo probability – 80% - 5.5 trips;

- Epuni probability – 5% - 0.5 trips; and
- Petone probability – 15% - 1 trip.

The probabilities (and subsequent demands) at each level are determined by the relative utilities of the options.

4.3 Data Sources

In order to accurately calibrate and validate the choice model, observed data is required, against which the modelled outputs can be compared.

The rail survey information provides a rich source of data covering all rail journeys within the region (excluding the Wairarapa Line). This data was expanded using boarding and alighting counts, in order to create a rail matrix. This process is documented in TN7.

Table 4-2 is created from the expanded rail survey data and shows the number of people accessing each station, segmented by access mode.

Table 4-2: Observed Rail Demand, by Station, Access Mode and Time Period

	AM Access Mode					IP Access Mode				
Station	**Bus**	**K&R**	**P&R**	**Walk**	**Total**	**Bus**	**K&R**	**P&R**	**Walk**	**Total**
Ava		9	74	214	297			2	13	14
Awarua Street		8	83	84	176	5			82	86
Box Hill		2	2	64	69			2	8	10
Crofton Downs		8	78	129	216	1	1	1	14	16
Epuni			14	100	114			4	11	14
Heretaunga	3		20	60	82	0			4	5
Johnsonville		10	266	115	391	3		14	49	67
Kenepuru			1	32	34				13	13
Khandallah		16	60	123	198		0		5	6
Linden			121	251	372			2	35	37
Mana		18	77	132	228				16	16
Manor Park		7	16	20	43				7	7
Melling	25	21	97	117	259			2	18	20
Naenae	5	8	27	197	237		2	8	34	44
Ngaio		6	92	121	220	0		9	15	24
Paekakariki		3	56	96	155			4	16	20
Paraparaumu	118	120	220	101	560	23	8	41	51	123
Paremata	119	64	245	114	542	2		8	5	16
Petone	10	25	275	128	438	10	2	12	35	59
Plimmerton		6	135	225	367	3		2	21	25
Pomare		10	53	14	77	3			9	12
Porirua	206	238	703	126	1274	46	14	32	62	154
Pukerua Bay		4	18	111	133			10	11	21
Raroa		0	24	49	73			1	8	9
Redwood		9	154	188	351		3	5	18	26
Silverstream	3	31	147	133	314		1	5	15	20
Simla Crescent		12	46	165	223	0		4	23	27

	AM Access Mode					IP Access Mode				
Station	**Bus**	**K&R**	**P&R**	**Walk**	**Total**	**Bus**	**K&R**	**P&R**	**Walk**	**Total**
Taita	27	30	175	106	337	5		6	8	19
Takapu Road		42	112	95	249		1	1	12	13
Tawa		5	103	189	296			6	37	43
Trentham		11	81	100	191				34	34
Upper Hutt	30	22	124	69	245	8		11	26	46
Waikanae	18	27	202	87	334	10	3	32	32	77
Wallaceville		28	35	99	163			1	14	15
Waterloo	78	151	852	754	1835	8	12	35	64	119
Wellington	45	17	5	191	258	62	1	16	305	383
Western Hutt		3	20	53	76				3	3
Wingate			6	60	66			1	6	7
Woburn		4	85	247	336	1	1	7	34	43
Total	**687**	**975**	**4905**	**5258**	**11825**	**190**	**48**	**282**	**1172**	**1693**
%	**6%**	**8%**	**41%**	**44%**	**100%**	**11%**	**3%**	**17%**	**69%**	**100%**

Two factors influencing people’s choice of station are service frequency and the quality of each rail station. For example, whilst someone may live only 2 minutes’ drive from Epuni station as opposed to 10 minute drive from Waterloo, the improved service frequency at Waterloo (including a number of non-stop services), superior parking facilities and superior security may result in this person choosing Waterloo over Epuni.

Whilst frequency and in-vehicle time should be accounted for when the rail impedance (total rail generalised time) is calculated, the quality and quantity of car parking at each station is not.

To represent the attractiveness and capacity of P&R sites, a parking capacity term is included in the utility function. The simplest way to do this was to add a car park utility onto the P&R access leg utility, based upon car park size, which we believe, is a proxy for safety, security and the general attractiveness of a station.

Table 4-3 below shows the parking capacity for all stations within the Greater Wellington region. The Johnsonville capacities are initial values supplied by GWRC, while the Kapiti and Hutt Valley ones are from parking surveys carried out during April 2012.

Table 4-3: Parking Capacity

Node	Station	Capacity	Node	Station	Capacity
30234	Porirua	898	30236	Linden	92
30212	Waterloo	679	30232	Mana	92
30228	Paraparaumu	492	30225	Ngaio	91
30201	Upper Hutt	334	30226	Crofton Downs	84
30227	Waikanae	321	30207	Pomare	82
30215	Petone	319	30223	Simla Crescent	80
30233	Paremata	202	30206	Manor Park	76
30219	Johnsonville	200	30230	Pukerua Bay	71
30240	Melling	195	30210	Naenae	58
30213	Woburn	179	30224	Awarua Street	54
30238	Redwood	166	30211	Epuni	54
30208	Taita	149	30221	Khandallah	43
30205	Silverstream	149	30220	Raroa	41
30202	Wallaceville	136	30204	Heretaunga	40
30203	Trentham	136	30209	Wingate	36
30229	Paekakariki	132	30214	Ava	25
30237	Tawa	124	30218	Wellington	21
30231	Plimmerton	100	30222	Box Hill	20
30239	Takapu Road	95	30235	Kenepuru	18

The parking capacities were established by a survey taken by the study team and compared against GWRC information. The totals include the formal Kiwirail-operated parking spaces plus secondary or overspill areas plus an estimate of parking capacity available to park-and-riders in the local streets. It is not possible to determine with any great certainty which spaces in local streets are used by park and riders, and it is possible that this component of capacity has been understated. At some stations, notably Ava and Johnsonville, more park and ride trips were reported from the rail survey than would appear to be possible given the estimated capacities.

4.3.1 Sectored Rail Demand

Table 4-4 and Table 4-5 show the expanded rail survey data (AM peak and Inter peak combined), sectored according to the origin and destination of each trip and segmented according to access mode (P&R / K&R or Other).

Table 4-4 shows the sectored rail demand where the access mode was recorded as bus, train, walk or bike. It shows that across the AM peak and Inter peak, around 65% of walk access trips have a final destination within Wellington CBD. The majority of these trips come from the Hutt Valley, followed by Kapiti (Waikanae and Paraparaumu) and Porirua (Porirua and Paremata). Around 28% of walk access trips do not have Wellington as either their origin or destination station. Most of these trips are short distance trips, within one sector. For example, 10% of all trips are shorter distance trips along the Hutt Valley Line.

Table 4-4: Sectored Rail Demand, Walk Access Trips Only, AM peak and Inter Peak Combined

	CBD	Hutt	Johnsonville	Kapiti	Porirua	RoW	Total
CBD	0%	4%	2%	1%	1%	0%	8%
Hutt	31%	10%	1%	0%	0%	1%	42%
Johnsonville	9%	0%	3%	0%	0%	0%	13%
Kapiti	13%	0%	0%	3%	2%	1%	20%
Porirua	10%	0%	0%	1%	1%	1%	13%
RoW	2%	1%	0%	0%	0%	0%	4%
Total	65%	15%	6%	6%	5%	3%	100%

Table 4-5 shows the sectored rail demand for trips where the access mode was recorded as car (driver, passenger or drop-off). Whilst only 65% of walk access trips had Wellington recorded as their destination station, this figure rises to 91% for car access trips. No other sector to sector movements across the network show any significant number of car-access trips. Given this insignificant use of P&R and K&R for non-CBD trips, the car-access option in the choice model is restricted to journeys to fare-zones 0 and 1: the CBD and inner suburbs of Wellington City. This has been validated by examination of the car-access rail destinations on a map background.

Table 4-5: Sectored Rail Demand, Car Access Trips Only, AM Peak and Inter Peak Combined

	CBD	Hutt	Johnsonville	Kapiti	Ngauranga	North	Porirua	RoW	Total
CBD	0%	0%	0%	0%	0%	0%	0%	0%	0%
Hutt	41%	1%	0%	0%	0%	0%	0%	1%	43%
Johnsonville	10%	0%	2%	0%	0%	0%	0%	0%	13%
Kapiti	26%	0%	0%	1%	0%	0%	1%	1%	29%
Ngauranga	0%	0%	0%	0%	0%	0%	0%	0%	0%
North	2%	0%	0%	0%	0%	0%	0%	0%	2%
Porirua	10%	0%	0%	0%	0%	0%	0%	0%	11%
RoW	1%	0%	0%	0%	0%	0%	0%	0%	2%
Total	91%	1%	3%	1%	0%	0%	2%	2%	100%

4.4 Calibration

An iterative process was used to calibrate the choice model, following the steps and principles listed below:

- Determine the correct Level 1 split between car and walk access at a global level;
- Determine the correct Level 2 split between P&R and K&R at a global level;
- Refine the Level 3 process to ensure that modelled and observed P&R / K&R / Walk access volumes at key stations are replicated; and

- Changes made in order to calibrate Level 3 impact upon Level 2 and Level1. Therefore steps 1 to 3 were repeated, in order to further refine the calibration of the model.

The choice model and assignment model were calibrated iteratively, ensuring that the balance of demand between bus and train for the walk-access trips was satisfactory, particular in areas such as Khandallah, Johnsonville and Lower Hutt where bus and rail are competing for patronage. The mode-specific parameters (see Section 5) were calibrated to achieve this balance, and the influences of these parameters are passed through to the choice models in the network time and cost skims.

4.4.1 Choice Model Utilities

For each discrete choice an input utility is calculated. These utilities are negative and, when compared against each other, will reflect the relative attractiveness of a number of different choices that are available for making the each journey. The utility functions are outlined in Table 4-6 below:

Table 4-6: Choice Model Utilities

Utility	Leg	Calculation
Level 3		
P&R	O to Stn1	$U_{p1c} = \lambda_3 * \beta_{ca} *(IVT_{car} + (0.5*ParkCost+VoC) / (VoT*Occ)) + aP^b + c.\exp(d.D)$
	Stn1 to D	$U_{p1p} = \lambda_3 *(\alpha_{1,m}.IVT_m + \alpha_2.wait + \alpha_3.walk + \alpha_{4,m}.boardings_m + fare/VoT)$
	O to D	$U_{p1} = U_{p1c} + U_{p2p}$
P&R Stn2 & Stn3	U_{p2} and U_{p3} (formulation as above)	
K&R Stn1 (best)	O to Stn1	$U_{k1c} = \lambda_3 * \beta_{ca} *(IVT_{car} + VoC / (VoT*Occ)) + aP^b + c.\exp(d.D)$
	Stn1 to D	$U_{k1p} = \lambda_3 *(\alpha_{1,m}.IVT_m + \alpha_2.wait + \alpha_3.walk + \alpha_{4,m}.boardings_m + fare/VoT)$
	O to D	$U_{k1c} + U_{k1p}$
K&R Stn2 & Stn3	U_{k2} and U_{k3} (formulation as above)	
Level 2		
P&R	$U_p = \lambda_2/\lambda_3 * \ln(\exp(U_{p1}) + \exp(U_{p2}) + \exp(U_{p3}))$	
K&R	$U_k = \lambda_2/\lambda_3 * \ln(\exp(U_{k1}) + \exp(U_{k2}) + \exp(U_{k3})) + ASC_k$	
Level 1		
Car access	$U_c = \lambda_1/\lambda_2 * \ln(\exp(U_p) + \exp(U_k)) + ASC_c$	
Walk access	$U_w = \lambda_1 *(\alpha_{1,m}.IVT_m + \alpha_2.wait + \alpha_3.walk + \alpha_{4,m}.boardings_m + fare/VoT)$	

Table 4-7 and Table 4-8 outline the parameters and variables respectively that are used in the choice model. The initial values for most of the parameters were set according to WTSM, best practice from other models and the survey data. These parameters were subsequently changed during the course of the choice model calibration process in order to improve the choice model validation.

Table 4-7: Model Parameters

	Description	Source
λ_1	Scaling parameter for Level 1	See notes below
λ_2	Scaling parameter for Level 2	
λ_3	Scaling parameter for Level 3	
β_{ca}	Car access coefficient	Other models + calibration
$\alpha_{1,m}$	IVT coefficient; m={bus, rail, lrt, brt…}	WTSM / WPTM + calibration
VoT	Value of time	WTSM + calibration
Occ	Car occupancy	WTSM + survey data
α_2	Wait time weight	WTSM / WPTM + calibration
α_3	Walk time weight	WTSM / WPTM + calibration
$\alpha_{4,m}$	Boarding penalty; m={bus, rail, lrt, brt…}	WTSM / WPTM + calibration
ASC_k	Alternative specific constant for K&R	Calibration
ASC_c	Alternative specific constant for car access	Calibration
a	Parameter 1 for parking attraction	Calibration
b	Parameter 2 for parking attraction	Calibration
c	Parameter 1 for short car-access deterrent	Calibration
d	Parameter 2 for short car-access deterrent	Calibration

Table 4-8: Model Variables

	Description	Source
IVT_{car}	Car time from origin to station	WTSM skim
ParkCost	Parking cost at P&R site (currently free)	GWRC
VoC	Vehicle operating cost from origin to access station	WTSM
Fare	PT fare from access station to destination	WPTM skim
IVT_m	IVT by mode; m={bus, rail, lrt, brt…}	WPTM skim
Wait	Waiting time	WPTM skim
Walk	Walking time	WPTM skim
$Boardings_m$	Boardings by mode; m={bus, rail, lrt, brt…}	WPTM skim
P	Car parking capacity	Actual / user-defined
D	Distance to nearest rail station	WPTM skim

During the course of calibration it was judged that an extra term, not anticipated in TN6, was required to deter very short car-access trips: people do not tend to drive to rail stations if there is a station local to their home. This is the term: c.exp(d.D). This term increases the walk access share and reduces the car access share for zones close to stations, in line with the observed data.

4.4.2 Level 3 Utility Calibration

The components of utility at Level 3 are shown in Table 4-9.

Table 4-9: Level 3 Utility

Utility	Leg	Calculation
Level 3		
P&R	O to Stn1	$U_{p1c} = \lambda_3 * \beta_{ca} * (IVT_{car} + (0.5*ParkCost+VoC) / (VoT*Occ)) + aP^{b} + c.exp(d.D)$
	Stn1 to D	$U_{p1p} = \lambda_3 * (\alpha_{1,m}.IVT_m + \alpha_2.wait + \alpha_3.walk + \alpha_{4,m}.boardings_m + fare/VoT)$
	O to D	$U_{p1} = U_{p1c} + U_{p2p}$
P&R Stn2 & Stn3	U_{p2} and U_{p3} (formulation as above)	
K&R Stn1 (best)	O to Stn1	$U_{k1c} = \lambda_3 * \beta_{ca} * (IVT_{car} + VoC / (VoT*Occ)) + aP^{b} + c.exp(d.D)$
	Stn1 to D	$U_{k1p} = \lambda_3 * (\alpha_{1,m}.IVT_m + \alpha_2.wait + \alpha_3.walk + \alpha_{4,m}.boardings_m + fare/VoT)$
	O to D	$U_{k1c} + U_{k1p}$
K&R Stn2 & Stn3	U_{k2} and U_{k3} (formulation as above)	

For each origin zone, the choice model determines the best 5 stations for P&R and K&R access, based upon factors such as travel times, travel distances, vehicle operating costs, values of time and parking capacities. Access leg utilities are calculated using the formulae in Table 4-9 above.

Corresponding rail leg utility functions are calculated from these 5 chosen stations to the final destination, using factors such as rail in-vehicle time, walk time between the destination station and final destination (constant across all three choices), wait time, boarding penalties and fares.

The access and rail leg utilities are then combined, creating 5 utilities. The best three utilities are selected, corresponding to the three best paths between the initial origin and final destination. A logit model determines the probability of choosing each station, based on relative utilities. The demand for each particular origin / destination pair is then multiplied by these probabilities to generate P&R and K&R demand.

The parameters that were adjusted during the calibration process were as follows:

- Car Access Coefficient – a negative number, designed to weight the car access leg relative to the rail leg. A lower (less negative) number reduces the access leg disutility, enabling people to travel further in order to access the best park and ride station as the access leg disutility is less negative, relative to the rail leg disutility; and
- P&R Coefficient 2 – the power function is a means of increasing the attractiveness of stations with larger car parks (and better overall facilities), relative to smaller stations. As this element of the access leg disutility is positive, a higher coefficient results in a lower disutility for the access leg in question. As the coefficient is applied exponentially, it is very sensitive to small changes.

It was found that people are more likely to drive further in the AM peak to a station with a superior service and better parking facilities than in the Inter peak, when people are more likely to just drive to their nearest station.

4.4.3 Level 2 Utilities

The two components of utility at Level 2 are shown in Table 4-10.

Table 4-10: Level 2 Utility

Utility	Leg	Calculation
Level 2		
P&R	$U_p = \lambda_2/\lambda_3 * \ln(\exp(U_{p1}) + \exp(U_{p2}) + \exp(U_{p3}))$	
K&R	$U_k = \lambda_2/\lambda_3 * \ln(\exp(U_{k1}) + \exp(U_{k2}) + \exp(U_{k3})) + ASC_k$	

The alternative specific kiss and ride parameter was modified during the calibration process. This parameter was found to be negative, implying that kiss and ride is less popular than park and ride than the utilities time and costs suggest, because of limited relevance in many households of this type of arrangement. The more negative the coefficient, the greater the K&R disutility (relative to P&R), resulting in a decrease in the K&R mode split.

According to the observed data a small amount of P&R occurs at stations that do not have any formal parking facilities. Analysis of aerial photographs confirmed that whilst there were no formal parking spaces available at these stations, some informal park and ride was occurring on local roads in the vicinity of the station.

Following a review of the data and the aerial photographs, P&R trips were allowed at the following stations:

- Linden; and
- Ava.

4.4.4 Level 1 Utilities

The components of utility at Level 1 are shown in Table 4-11.

Table 4-11: Level 1 Utility

Utility	Leg	Calculation
Level 1		
Car access	$U_c = \lambda_1/\lambda_2 * \ln(\exp(U_p) + \exp(U_k)) + ASC_c$	
Walk access	$U_w = \lambda_1 * (\alpha_{1,m}.IVT_m + \alpha_2.wait + \alpha_3.walk + \alpha_{4,m}.boardings_m + fare/VoT)$	

The alternative specific car access constant was calibrated during this process. The more negative the value is, the greater the car disutility and therefore the greater the probability of choosing the alternative, which is walk access.

4.4.5 Vehicle Occupancies

The vehicle occupancy used in WPTM is 1.3 people per vehicle in the AM, and 1.6 in the IP, based on a number of sources:

- Vehicle occupancies were calculated from the rail surveys, based on the split between P&R drivers and passengers. The average occupancy over all lines was found to be 1.66, but the Johnsonville Line had exceptionally high occupancies of around 3 or 4. This seemed erroneous, but double-checking proved no error had been introduced during data processing. Removing this line gave a value of around 1.4;
- NZTA research suggests a value of around 1.4 for an average weekday, and a value of around 1.15 for work trips. However, very little direct research has been undertaken with regard to rail P&R occupancies; and
- WTSM uses occupancies of between 1.1 and 1.4, depending on purpose.

Several values (1.66, 1.4 and 1.3) were tested in calibration, and the impact of changing these was found to be minimal. A value of 1.3 is reasonable as it applies to all purposes, and is within the NZTA and WTSM ranges. It also corresponds well to the surveys, when Johnsonville is excluded.

4.4.6 Final Calibrated Choice Model Parameters

Table 4-12 below sets out the final parameters, by time period, alongside the initial parameters and some guideline parameters, taken from other models and best international practice.

Table 4-12: Final Choice Model Parameters

	Description	Initial Parameters	Guideline Parameters	AM Peak Final	Inter Peak Final
λ_1	Scaling parameter for Level 1	-0.05		-0.05	-0.05
λ_2	Scaling parameter for Level 2	-0.09		-0.08	-0.08
λ_3	Scaling parameter for Level 3	-0.16		-0.15	-0.15
ASC_k	Alternative specific constant for K&R	-1.0		-3.1	-3.0
ASC_c	Alternative specific constant for car access	-2.0		0.28	-0.6
β_{ca}	Car access coefficient	3.5		2.8	3.8
Occ	Car occupancy	1.66		1.3	1.6
P&R VoT	P&R VoT	6.25		See 5.2	See 5.2
K&R VoT	K&R VoT	6.25		See 5.2	See 5.2
P&R VoC	P&R VoC	0.25		0.21	0.21
K&R VoC	K&R VoC	0.25		0.21	0.21
α_2	Wait time weight	See Table 5-4			
α_3	Walk time weight	See Table 5-4			
$\alpha_{4,m}$	Boarding penalty; m={bus, rail, lrt, brt…}	See Table 5-4			
$\alpha_{1,m}$	IVT coefficient; m={bus, rail, lrt, brt…}	See Table 5-4			
a	Parameter 1 for parking attraction	0.0001		0.0001	0.0001
b	Parameter 2 for parking attraction	1.5		1.45	1.40
c	Parameter 1 for short car-access deterrent	-6.0		-6.0	-6.0
d	Parameter 2 for short car-access deterrent	-1.7		-2.5	-1.7

4.5 Validation

This section reports on the results of the access choice model, to demonstrate that the model has been successfully calibrated and produces reasonable results:

- Access Mode Split – modelled and observed P&R, K&R and 'Other' access mode splits are presented, to demonstrate that the model is producing accurate access mode splits, both in percentage and absolute terms, at a global, line and individual station level;
- Walk Access / Bus Access Mode Split – this piece of detailed analysis, comparing modelled and observed walk / bus access to the main stations within the region, shows that the assignment model is generally assigning the correct numbers of people onto both modes;
- Trip Length Distribution – this analysis shows the observed and modelled trip length distribution for car and 'other' access, to show the correlation between observed and modelled trip length distribution; and

- Station Catchment plots – plots from EMME, showing the initial origin of modelled car access trips using certain stations within the region, are compared against plots showing this same information using the observed data. This piece of analysis is designed to show that, for the main stations within the region, the modelled and observed catchment areas are similar.

4.5.1 Access Mode Split

Table 4-13 below shows the observed and modelled access mode split at all stations across the Greater Wellington network.

Table 4-13: AM Peak Choice Model Validation – Access Mode Split

	Observed			Modelled			Total			Car Split		Other Split	
Line / Station	**P&R**	**K&R**	**Other**	**P&R**	**K&R**	**Other**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**	**Obs**	**Mod**
Hutt Valley Line													
Upper Hutt	124	22	100	112	22	162	245	296	51	59%	45%	41%	55%
Wallaceville	35	28	99	64	12	92	163	169	6	39%	45%	61%	55%
Trentham	81	11	100	114	21	106	191	242	51	48%	56%	52%	44%
Heretaunga	20	0	62	0	8	58	82	66	-16	24%	13%	76%	87%
Silverstream	147	31	136	118	20	162	314	300	-14	57%	46%	43%	54%
Manor Park	16	7	20	1	0	6	43	7	-36	55%	18%	45%	82%
Pomare	53	10	14	50	9	18	77	78	1	82%	76%	18%	24%
Taita	175	30	133	139	25	212	337	375	38	61%	44%	39%	56%
Wingate	6	0	60	0	2	41	66	43	-23	9%	4%	91%	96%
Naenae	27	8	202	65	15	176	237	257	19	15%	31%	85%	69%
Epuni	14	0	100	41	8	150	114	199	85	12%	24%	88%	76%
Waterloo	852	151	832	810	134	716	1835	1660	-175	55%	57%	45%	43%
Woburn	85	4	247	75	12	212	336	299	-36	26%	29%	74%	71%
Ava	74	9	214	44	6	128	297	178	-119	28%	28%	72%	72%
Petone	275	25	138	303	52	176	438	532	94	69%	67%	31%	33%
Melling	97	21	141	76	19	165	259	260	1	45%	36%	55%	64%
Western Hutt	20	3	53	0	8	24	76	32	-44	30%	26%	70%	74%
Subtotal	**2100**	**360**	**2650**	**2013**	**375**	**2604**	**5110**	**4991**	**-118**	**48%**	**48%**	**52%**	**52%**
Johnsonville Line													
Johnsonville	266	10	115	120	20	15	391	155	-237	71%	90%	29%	10%
Raroa	24	0	49	110	16	16	73	142	69	33%	89%	67%	11%
Khandallah	60	16	123	88	9	67	198	163	-35	38%	59%	62%	41%
Box Hill	2	2	64	0	16	44	69	59	-9	6%	27%	94%	73%
Simla Crescent	46	12	165	63	7	95	223	165	-57	26%	42%	74%	58%
Awarua Street	83	8	84	70	8	121	176	198	22	52%	39%	48%	61%
Ngaio	92	6	121	58	7	61	220	126	-94	45%	51%	55%	49%
Crofton Downs	78	8	129	26	4	186	216	216	0	40%	14%	60%	86%
Subtotal	**651**	**62**	**852**	**533**	**86**	**604**	**1565**	**1224**	**-341**	**46%**	**51%**	**54%**	**49%**

	Observed			Modelled			Total			Car Split		Other Split	
Line / Station	**P&R**	**K&R**	**Other**	**P&R**	**K&R**	**Other**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**	**Obs**	**Mod**
Kapiti Line													
Waikanae	202	27	105	157	37	161	334	355	22	68%	55%	32%	45%
Paraparaumu	220	120	219	205	41	323	560	569	9	61%	43%	39%	57%
Paekakariki	56	3	96	38	8	81	155	128	-28	38%	36%	62%	64%
Pukerua Bay	18	4	111	27	4	114	133	145	12	17%	22%	83%	78%
Plimmerton	135	6	225	58	16	181	367	255	-112	39%	29%	61%	71%
Mana	77	18	132	86	16	118	228	220	-7	42%	46%	58%	54%
Paremata	245	64	233	162	35	296	542	493	-48	57%	40%	43%	60%
Porirua	703	238	332	731	159	586	1274	1476	202	74%	60%	26%	40%
Kenepuru	1	0	32	0	4	3	34	7	-27	4%	60%	96%	40%
Linden	121	0	251	75	16	152	372	243	-129	33%	37%	67%	63%
Tawa	103	5	189	125	28	204	296	357	61	36%	43%	64%	57%
Redwood	154	9	188	96	22	126	351	243	-108	47%	48%	53%	52%
Takapu Road	112	42	95	182	38	97	249	316	68	62%	69%	38%	31%
Subtotal	**2148**	**537**	**2208**	**1941**	**426**	**2442**	**4893**	**4808**	**-85**	**55%**	**49%**	**45%**	**51%**
Wellington	5	17	374	0	0	239	75	54	-20	6%	0%	94%	100%
TOTAL	**4905**	**975**	**6084**	**4487**	**886**	**5889**	**11642**	**11078**	**-565**	**49%**	**48%**	**51%**	**52%**

At both a global and line level, the observed and modelled car access splits correlate well.

At both a global and individual station level there is a good correlation between total observed and total modelled boardings, when aggregated across all access modes. This demonstrates that the model is generally sending trips to the correct station.

At an individual station level, the most popular P&R sites (according to the observed data) are, in general, the most popular according to the model;

- Waterloo (modelled: 810, observed: 852);
- Porirua (731, 703);
- Petone (303, 275);
- Johnsonville (120, 266);
- Paremata (162, 245); and
- Paraparaumu (205, 220).

Both Porirua and Paremata stations are close together and, as such, there will be some overlap between the catchment areas for both of these stations. Furthermore, both stations have sizeable car parks, so it is hard to distinguish between the two. Whilst Porirua station has a superior service frequency compared to Paremata, most of these extra services are stopping services, so the express service frequency is similar for both stations. Taking the combined P&R / K&R observed (1251) and modelled (1087) demand for these stations, the catchment area as a whole validates well. Observed 'other' demand to Porirua / Paremata (565) is lower than modelled 'other' demand (882). This could be because both stations are served by a number of good, fast, feeder bus services into both stations (this is apparent from the rail survey data).

Table 4-14 below shows the observed and modelled access mode split at all the stations across the Greater Wellington network for the Inter peak.

Table 4-14: IP Choice Model Validation – Access Mode Split

	Observed			Modelled			Total			Car Split		Other Split	
Line / Station	**P&R**	**K&R**	**Other**	**P&R**	**K&R**	**Other**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**	**Obs**	**Mod**
Hutt Valley Line													
Upper Hutt	11	0	35	8	1	26	46	36	-10	24%	26%	76%	74%
Wallaceville	1	0	14	5	1	15	15	21	5	10%	28%	90%	72%
Trentham	0	0	34	6	1	14	34	22	-12	0%	35%	100%	65%
Heretaunga	0	0	5	0	0	5	5	5	1	0%	9%	100%	91%
Silverstream	5	1	15	4	1	11	20	16	-4	28%	29%	72%	71%
Manor Park	0	0	7	0	0	3	7	3	-4	0%	9%	100%	91%
Pomare	0	0	12	4	1	4	12	9	-3	0%	54%	100%	46%
Taita	6	0	13	5	1	13	19	18	-1	32%	30%	68%	70%
Wingate	1	0	6	0	0	3	7	3	-4	18%	5%	82%	95%
Naenae	8	2	34	5	1	20	44	26	-18	21%	22%	79%	78%
Epuni	4	0	11	3	0	12	14	15	0	26%	22%	74%	78%
Waterloo	35	12	72	25	3	53	119	81	-38	39%	35%	61%	65%
Melling	2	0	18	2	0	2	20	4	-16	8%	55%	92%	45%
Western Hutt	0	0	3	0	0	0	3	0	-3	0%	-	100%	-
Woburn	7	1	35	8	1	20	43	30	-13	19%	32%	81%	68%
Ava	2	0	13	1	0	3	14	4	-10	12%	37%	88%	63%
Petone	12	2	45	17	2	25	59	43	-16	24%	42%	76%	58%
Subtotal	**93**	**18**	**370**	**93**	**14**	**229**	**480**	**336**	**-144**	**23%**	**32%**	**77%**	**68%**
Johnsonville Line													
Johnsonville	14	0	52	6	1	10	67	17	-50	22%	39%	78%	61%
Raroa	1	0	8	12	1	7	9	21	12	9%	65%	91%	35%
Khandallah	0	0	5	5	0	11	6	16	11	6%	34%	94%	66%
Box Hill	2	0	8	0	1	10	10	10	0	23%	7%	77%	93%
Simla Crescent	4	0	23	5	0	33	27	38	11	15%	14%	85%	86%
Awarua Street	0	0	20	4	0	48	20	52	32	0%	7%	100%	93%
Ngaio	9	0	15	3	0	16	24	19	-4	36%	16%	64%	84%
Crofton Downs	1	1	14	2	0	12	16	14	-2	12%	13%	88%	87%
Subtotal	**31**	**1**	**145**	**36**	**4**	**147**	**178**	**187**	**10**	**18%**	**22%**	**82%**	**78%**
Kapiti Line													
Waikanae	32	3	42	18	5	63	77	85	8	46%	27%	54%	73%
Paraparaumu	41	8	74	13	2	92	123	107	-16	40%	14%	60%	86%

	Observed			Modelled			Total			Car Split		Other Split	
Line / Station	**P&R**	**K&R**	**Other**	**P&R**	**K&R**	**Other**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**	**Obs**	**Mod**
Paekakariki	4	0	16	1	0	22	20	23	3	18%	3%	82%	97%
Pukerua Bay	10	0	11	2	0	15	21	17	-4	46%	11%	54%	89%
Plimmerton	2	0	23	2	0	13	25	15	-10	6%	13%	94%	87%
Mana	0	0	16	2	0	15	16	17	1	0%	13%	100%	87%
Paremata	8	0	7	8	2	12	16	22	6	52%	46%	48%	54%
Porirua	32	14	108	28	7	77	154	111	-43	30%	31%	70%	69%
Kenepuru	0	0	13	0	1	15	13	15	2	0%	3%	100%	97%
Linden	2	0	35	5	1	18	37	24	-13	6%	26%	94%	74%
Tawa	6	0	37	8	1	21	43	30	-13	13%	30%	87%	70%
Redwood	5	3	18	6	1	15	26	22	-4	30%	34%	70%	66%
Takapu Road	1	1	12	9	1	7	13	18	4	13%	59%	87%	41%
Subtotal	**142**	**28**	**414**	**100**	**22**	**383**	**584**	**506**	**-79**	**29%**	**24%**	**71%**	**76%**
Wellington	16	1	372	0	0	197	389	197	-191	4%	0%	96%	100%
TOTAL	**282**	**48**	**1301**	**230**	**40**	**957**	**1631**	**1227**	**-404**	**20%**	**22%**	**80%**	**78%**

The paucity of data in the Inter peak is such that it could not be calibrated independently from the AM peak model. Instead the IP calibration was a variant of the AM peak, with only the major constants and parameters adjusted.

Overall the car access mode split validates well at a global level, with the majority of the modelled and observed demand accessing stations by foot or bus in the Inter peak.

When looking at the access mode split across the whole model, the choice model validation is as good as can be reasonably expected. Because different stations will have subtly different characteristics, access mode split and catchment areas, it is impossible to accurately replicate the observed boardings and mode split across all stations using a ‘one size fits all’ approach, whereby the same set of parameters applies to all stations. What is satisfying, however, is that the model accurately replicates observed trends and patterns and that the major stations validate well.

Whilst calibrating station specific parameters would probably result in a superior level of validation, this could be interpreted as ‘fixing’ the results. Should a new P&R site be proposed and tested in the future, it would be difficult for the user to pick an appropriate set of parameters to be used at such a site as all existing parameters would be station specific.

Therefore the chosen approach results in a choice model that validates well and that can be used, with confidence, for future forecasting and option testing.

Figure 4-2 and Figure 4-3 below give a graphical representation of the access mode split in the tables above.

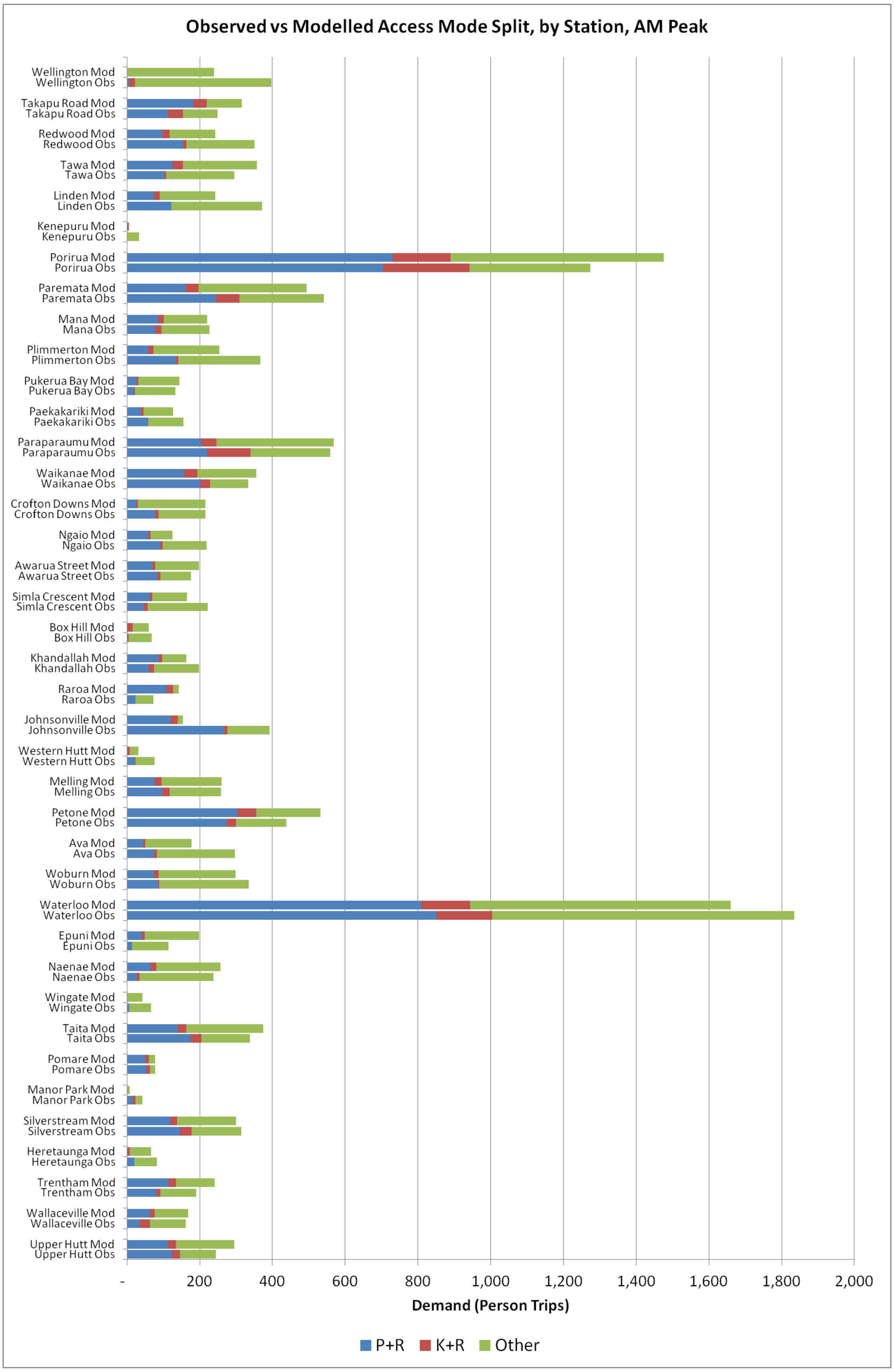


Figure 4-2: Observed vs. Modelled Access Mode Split, AM

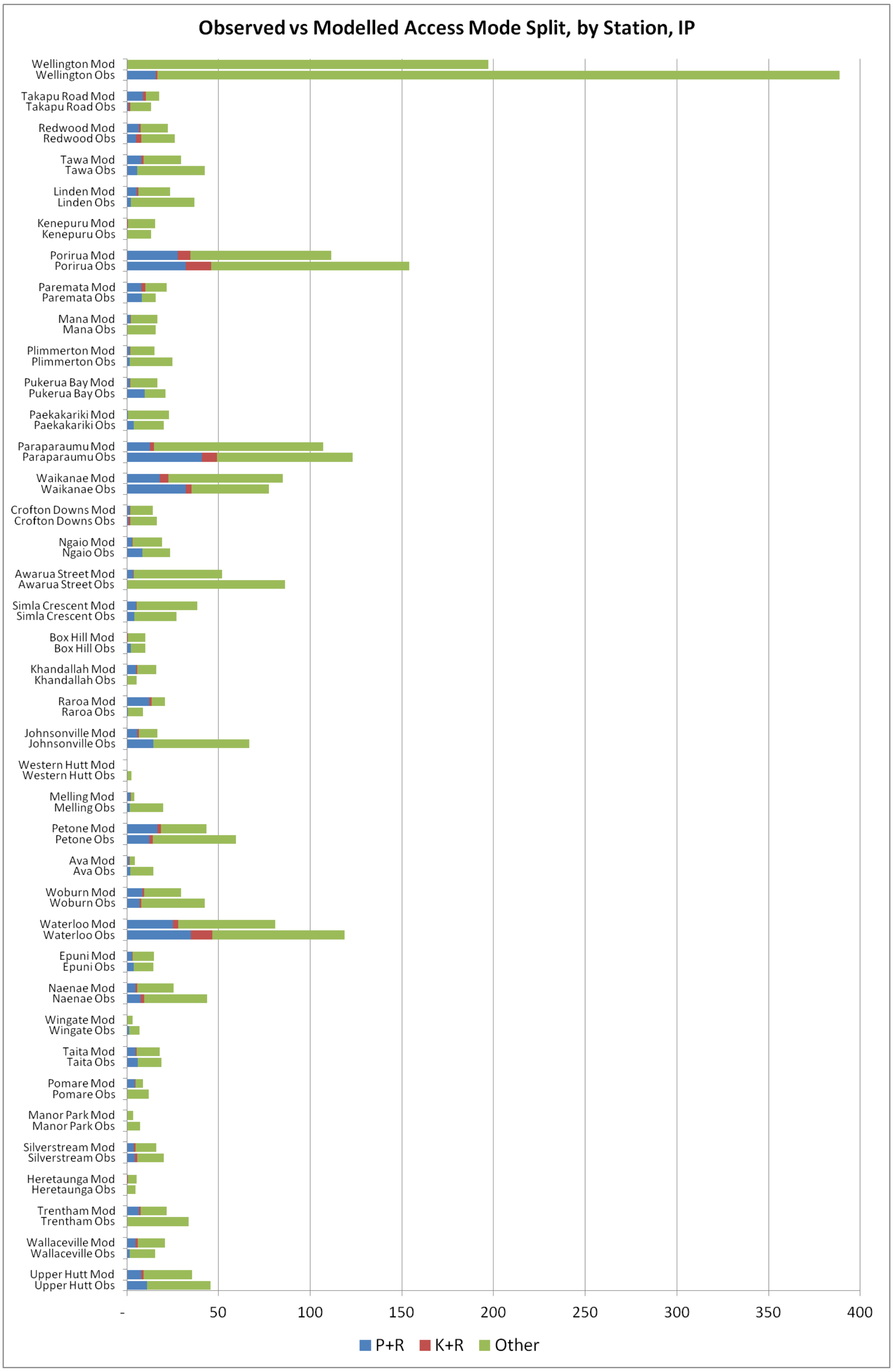


Figure 4-3: Observed vs. Modelled Access Mode Split, IP

4.5.2 Walk and Bus Access

The previous section demonstrates that the choice model is working well when it comes to choosing between the three discrete access modes, namely P&R, K&R and 'Other'.

From the rail survey data, 'Other' access trips can be split into bus and walk access trips. This split can also be obtained from the model, enabling comparisons between observed and modelled walk and bus access to rail stations to be made.

Table 4-15 below shows observed and modelled walk / bus access mode split for all rail stations within the region that, according to the observed data, have a significant number of bus / rail transfer trips.

Table 4-15: Walk and Bus Access Mode Split, AM Peak

Station	Modelled Walk Access	Modelled Bus Access	Modelled Walk Split	Modelled Bus Split	Observed Walk Access	Observed Bus Access	Observed Walk Split	Observed Bus Split
Upper Hutt	79	83	49%	51%	69	30	70%	30%
Silverstream	144	18	89%	11%	133	3	98%	2%
Taita	110	102	52%	48%	106	27	80%	20%
Waterloo	473	243	66%	34%	754	78	91%	9%
Petone	66	110	38%	63%	128	10	93%	7%
Melling	153	12	93%	7%	117	25	83%	17%
Hutt Valley Line	**2036**	**568**	**78%**	**22%**	**2469**	**181**	**93%**	**7%**
Johnsonville Line	**600**	**5**	**99%**	**1%**	**852**	**0**	**100%**	**0%**
Waikanae	66	95	41%	59%	87	18	83%	17%
Paraparaumu	112	211	35%	65%	101	118	46%	54%
Paremata	117	179	40%	60%	114	119	49%	51%
Porirua	223	363	38%	62%	126	206	38%	62%
Kapiti Line	**1594**	**848**	**65%**	**35%**	**1747**	**462**	**79%**	**21%**
Total	**4230**	**1421**	**75%**	**25%**	**5068**	**642**	**89%**	**11%**

Table 4-15 shows that too many modelled access trips are using the bus to access their origin station, whilst too few are walking to their origin station. On the Hutt Valley Line, there are 181 observed bus access trips to the rail network, whilst the model is showing 591 bus access trips.

On the Kapiti Line, the model is showing twice as many bus access trips to the rail network than there are in reality according to the observed data. This explains why there are too few car access trips and too many 'other' access trips to these stations in the AM peak.

Given most bus services within the Johnsonville rail line catchment area will actually serve Wellington CBD, therefore providing competition for rail instead of feeding passengers onto the rail network, it is not surprising that there are virtually no bus access trips to the rail network along the Johnsonville Line.

We believe the problem may lie in the fact that there is a greater aversion to interchanging between bus and rail among the Wellington population than modelled: more people choose to walk to the train with certainty, than awaiting a bus that may be late and to lose that certainty. In the EMME modelling package there is no facility to apply different penalties to bus-rail transfers vs. boardings generally. This severely limits our ability to control the appeal of bus-rail interchanging.

Table 4-16 below shows that, for the Inter peak, both modelled and observed bus access to rail stations is very low, compared to walk access. The number of modelled walk access trips is slightly lower than the number of observed walk access trips, implying that some people are actually walking or taking the bus for the whole length of their journey rather than taking the train. Overall, the IP walk / bus split validates better than the AM.

Table 4-16: Walk and Bus Access Mode Split, Inter Peak

Station	Modelled Walk Access	Modelled Bus Access	Modelled Walk Split	Modelled Bus Split	Observed Walk Access	Observed Bus Access	Observed Walk Split	Observed Bus Split
Upper Hutt	23	3	88%	12%	26	8	76%	24%
Silverstream	11	0	100%	0%	15	0	100%	0%
Taita	7	6	54%	46%	8	5	59%	41%
Waterloo	49	4	92%	8%	64	8	89%	11%
Petone	22	3	88%	12%	35	10	78%	22%
Melling	2	0	100%	0%	18	0	100%	0%
Hutt Valley Line	**212**	**17**	**93%**	**7%**	**334**	**36**	**90%**	**10%**
Johnsonville Line	**455**	**24**	**95%**	**5%**	**641**	**59**	**92%**	**8%**
Waikanae	46	17	73%	27%	32	10	76%	24%
Paraparaumu	69	23	75%	25%	51	23	69%	31%
Paremata	8	4	67%	33%	5	2	70%	30%
Porirua	40	37	52%	48%	62	46	57%	43%
Kapiti Line	**304**	**81**	**79%**	**21%**	**330**	**84**	**80%**	**20%**
Total	**971**	**122**	**89%**	**11%**	**1305**	**179**	**88%**	**12%**

4.5.3 Access Trip-Leg Distance Distribution

Figure 4-4 shows the modelled and observed trips length distribution for P&R (dark) and K&R (light) access trips. The figure demonstrates that the model accurately replicates the observed trip length distribution for car access trips. The majority of car access trips lie within the 0 to 3km distance band. There are slightly more modelled than observed trips in this range, although the difference is not significant. As the model allocates car access trips to stations according to the best (generally closest) P&R site, we might expect there to be slightly fewer longer distance access trips, where people choose other P&R sites for a variety of reasons, some of which the model will be unable to represent. Therefore it appears as though some of these longer distance rail access trips are instead being allocated to the nearest station.

Overall, however, there is a good correlation between modelled and observed trip length distribution for car access trips in the AM peak.

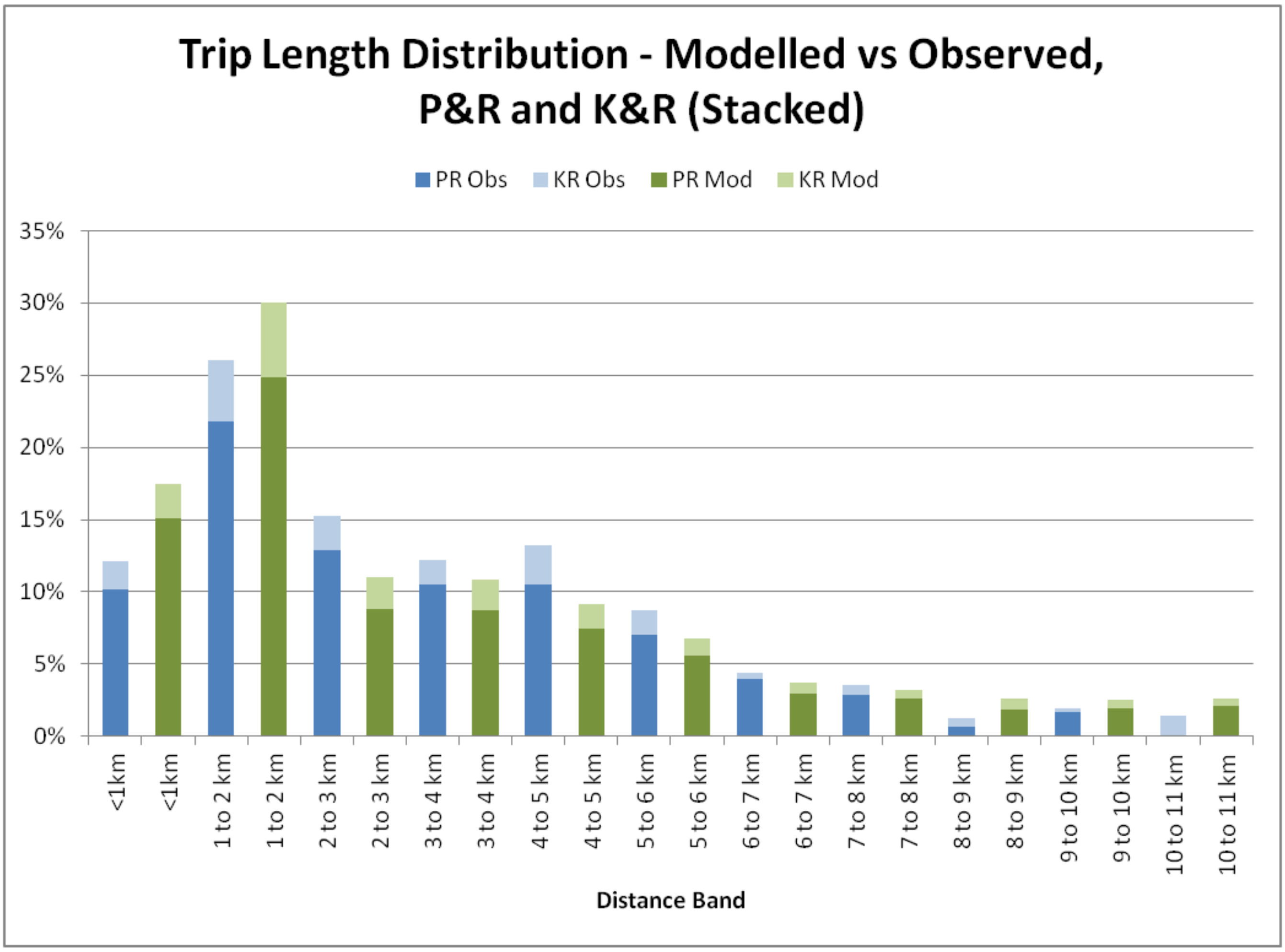


Figure 4-4: Comparison of Observed and Modelled Trip Length Distribution, P&R and K&R Trips, AM Peak, Trips Less Than 10km

Figure 4-5 shows the modelled and observed trips length distribution for walk (dark) and bus (light) access trips. Overall, the observed trip length distribution is accurately replicated by the model. The vast majority of walk access trips are between 1km and 2km in length. There are slightly more modelled 'other' access trips within the 4km to 6km range (presumably bus access trips) than there are observed 'other' access trips within this range. In summary, however, the model accurately replicates the observed trip length distribution.

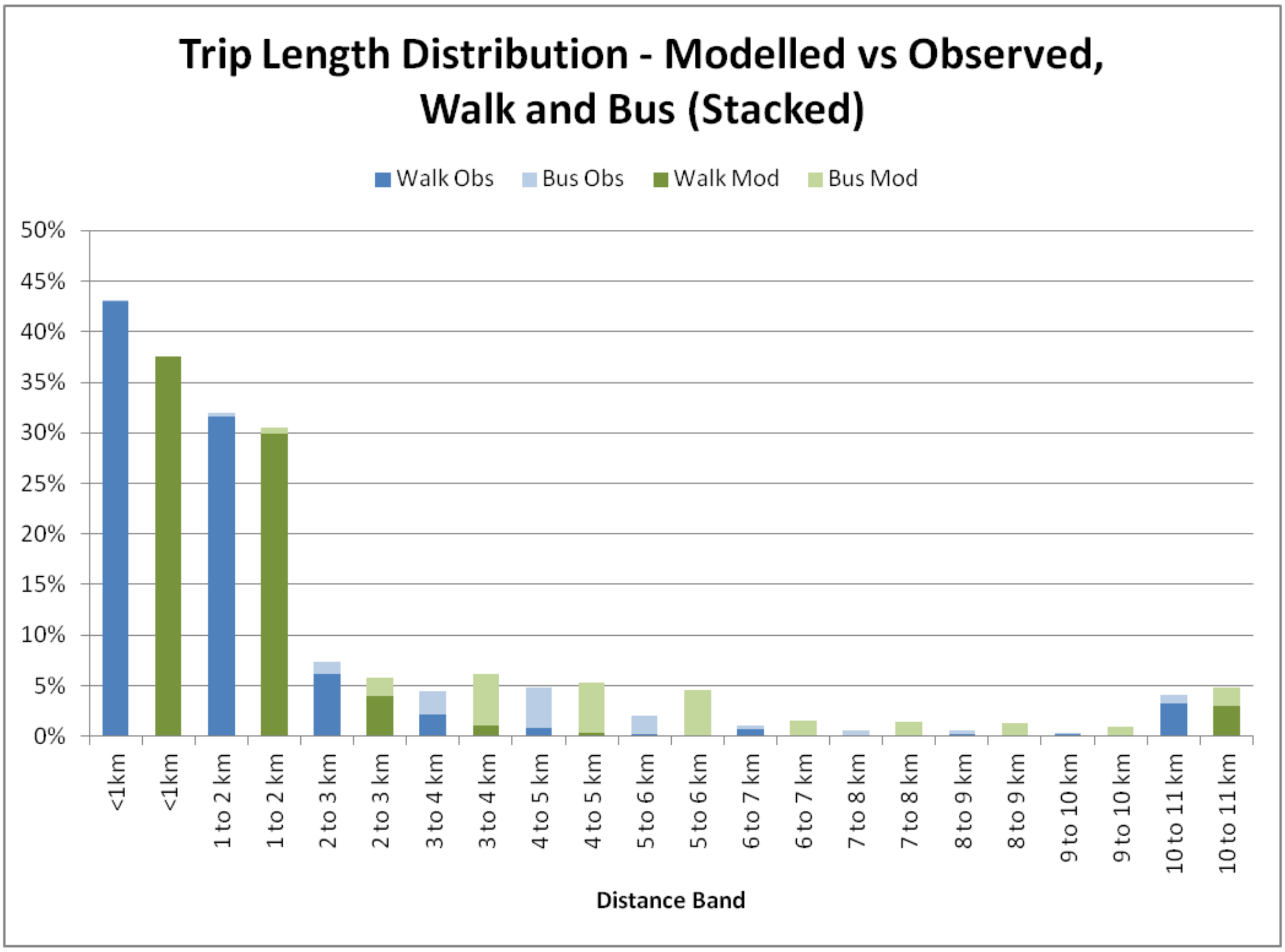


Figure 4-5: Comparison of Observed and Modelled Trip Length Distribution, Walk Access Trips, AM peak, Trips Less Than 10km

4.5.4 Station Catchment Areas

In order to further validate the choice model, a series of plots have been produced showing the origin zone for car access trips to certain key stations in the region in the AM peak. Both observed and modelled data is presented:

- Observed (red) – origin zone for car access trips to key stations, taken from rail survey data; and
- Modelled (green) – origin zone for car access trips to key stations, obtained by extracting the 'access' leg for all P&R and K&R trips.

A detailed assessment of the magnitude of modelled and observed car access trips cannot be accurately undertaken using these plots, as the scale differs between the observed and modelled plots. However, the results presented in Table 4-13 show that, for the key stations reported in the plots below, there is generally a good match between modelled and observed car access trips.

What the plots do show is that observed and modelled car access catchment areas are similar, demonstrating that the choice model is selecting the correct station for the vast majority of car access trips.

The input demand matrices were ‘smoothed’ before being assigned, a process designed to remove lumpiness that might result from matrices being built from relatively small sample of survey data. This explains why, particularly for Waterloo, the modelled distribution of trips appears less lumpy that the observed distribution. The smoothing process is documented in TN7.

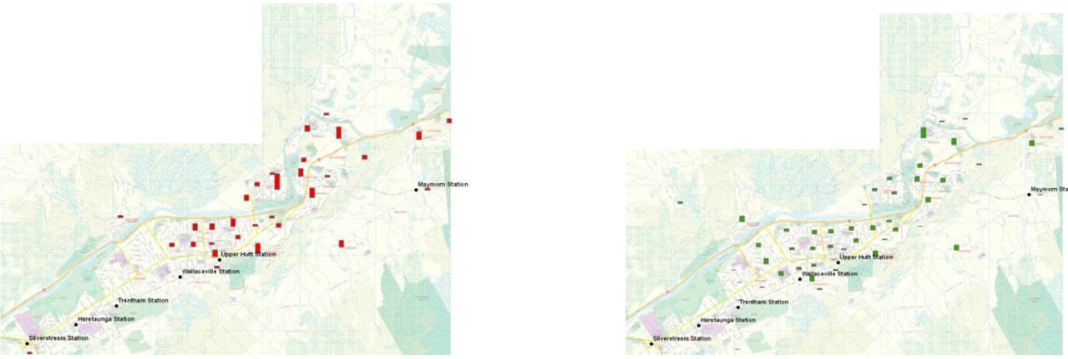


Figure 4-6: Upper Hutt Car Access Demand by Origin Zone, Observed and Modelled

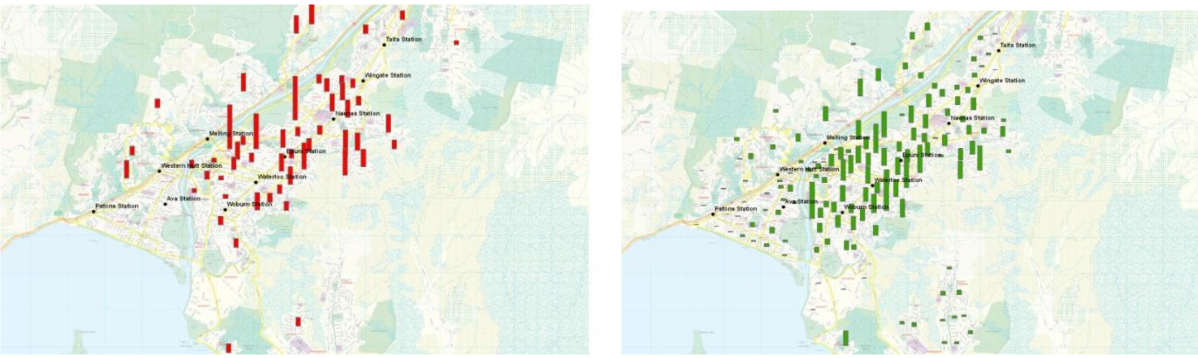


Figure 4-7: Waterloo Car Access Demand by Origin Zone, Observed and Modelled

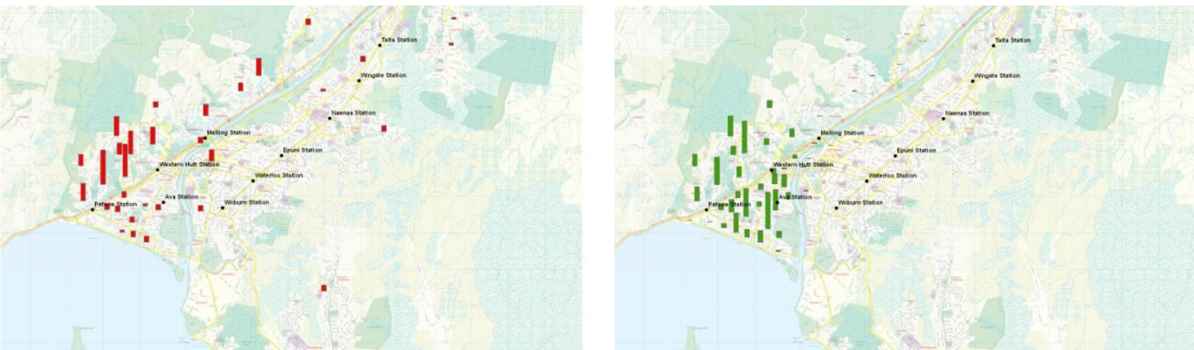


Figure 4-8: Petone Car Access Demand by Origin Zone, Observed and Modelled

Figure 4-9: Waikanae Car Access Demand by Origin Zone, Observed and Modelled

Figure 4-10: Paraparaumu Car Access Demand by Origin Zone, Observed and Modelled

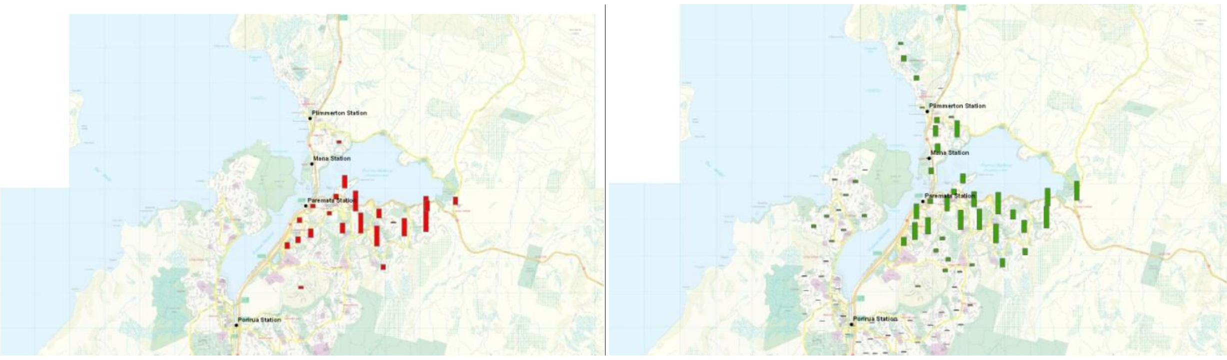


Figure 4-11: Paremeta Car Access Demand by Origin Zone, Observed and Modelled

Figure 4-12: Porirua Car Access Demand by Origin Zone, Observed and Modelled

4.5.5 Car Park Capacity

Table 4-17 shows the car park capacity for each station in the Greater Wellington region, together with the modelled and observed car trips associated with each station and an estimate of car park occupancy. Each line is colour coded – Johnsonville (Blue), Kapiti (Green) and Hutt Valley / Melling (Red).

The following assumptions have been used when deriving these broad brush estimates:

- The AM modelled and observed passenger demand has been factored up by 13% to account for trips made before 7am (based on KiwiRail guards counts, demand between 5am and 7am equates to 13% of the 7am to 9am demand – this is only an approximate measure);
- The Inter peak modelled and observed demand has been factored by 3 to translate from a 2hr to 6hr modelled time period;
- Car occupancies of 1.3 and 1.6 (obtained from the rail surveys) have been used for the AM and Inter peak, respectively, to convert from trips to cars; and
- The car parking capacity may not take into account all of the informal P&R that might take place at the surveyed stations.

From Table 4-17 it can be seen that, according to both the observed and modelled data, the car parks at all of the main stations do not reach capacity during the day, or exceed it very slightly. This is re-assuring as it confirms that the access choice model does not result in a situation where the demand exceeds the supply.

On the Johnsonville Line, both the observed and (to a lesser extent) modelled demand exceeds parking capacity, particularly at some stations with small car parks. One possible reason for this is that because the car parks at stations on this line are fairly small, an element of informal P&R will exist at such stations.

Even in cases where this does not validate well, it should be noted that it is unlikely to be very important to the overall model, given that rail boarding and alighting counts and surveyed access mode percentages match up well.

The choice model does not have the ability to model parking capacity restraint, and therefore would not ‘cap’ demand if it exceeded supply at any station on the network.

Table 4-17: AM Parking Capacity

Node	Station	Car Park Capacity	Total Cars (Observed)	Occupancy (Observed)	Total Cars (Modelled)	Occupancy (Modelled)
30234	Porirua	898	672	75%	688	77%
30212	Waterloo	679	806	119%	751	111%
30228	Paraparaumu	492	268	55%	202	41%
30201	Upper Hutt	334	129	38%	112	33%
30227	Waikanae	321	235	73%	170	53%
30215	Petone	319	262	82%	295	92%
30233	Paremata	202	228	113%	156	77%
30219	Johnsonville	200	258	129%	115	58%
30240	Melling	195	87	45%	69	35%
30213	Woburn	179	87	49%	81	45%
30238	Redwood	166	144	87%	96	58%
30208	Taita	136	163	120%	130	96%
30205	Silverstream	136	136	100%	110	81%
30202	Wallaceville	132	33	25%	64	49%
30203	Trentham	124	70	56%	111	90%
30229	Paekakariki	100	56	56%	34	34%
30237	Tawa	91	100	110%	123	135%
30231	Plimmerton	84	120	143%	53	63%
30239	Takapu Road	82	99	121%	175	213%
30236	Linden	80	109	137%	75	93%
30232	Mana	71	67	94%	78	109%
30225	Ngaio	58	96	166%	56	96%
30226	Crofton Downs	54	70	129%	25	47%
30207	Pomare	43	47	108%	52	120%
30223	Simla Crescent	41	47	115%	64	156%
30206	Manor Park	36	14	39%	1	4%
30230	Pukerua Bay	25	34	135%	26	106%
30210	Naenae	21	37	178%	66	313%
30224	Awarua Street	20	73	363%	67	336%
30211	Epuni	18	19	106%	41	228%
30221	Khandallah	14	52	370%	86	612%
30220	Raroa	10	22	223%	119	1186%
30204	Heretaunga	0	18	-	0	-
30209	Wingate	0	8	-	0	-
30214	Ava	0	67	-	41	-
30218	Wellington	0	34	-	0	-
30222	Box Hill	0	6	-	0	-
30235	Kenepuru	0	1	-	0	-

5 Assignment

5.1 Introduction

The assignment model in WPTM takes the output of the choice model, combines the bus and rail matrices, and assigns the public transport demand to the PT network. It decides which modes, routes, and walk access paths will be taken.

The assignment function assigns demand from the three access modes (park and ride, kiss and ride, walk) separately within one scenario. For each access mode, the four segments (work, education, other, child) are assigned individually with the volumes being summed up. The results are copied back to the base scenario.

5.2 Data sources

- Highway times from WTSM, available for all links that cars travel along. The highway times feed into the bus travel time function;
- Metlink information on fares, stages and costs. Also ETM data that records the fares paid. Refer to TN1 for details;
- KiwiRail data on ticket sales and revenue;
- Bus running times from ETM data, real-time information data (for September 2011) and the 'Central Area Bus Operational Review' written by Opus in November 2009. Refer to TN1 for details;
- Timetables for rail, ferry, cable car. All timetables can be downloaded off the Metlink website, accessed through the GWRC PT database, or from the General Transit Feed (accessed 04/07/2011);
- The passenger volumes at screenlines from the 'Reference' assignment for comparison; and
- ETM data route level boards. These were extracted from the ETM database before transfer trips were removed. They were factored to an average month.

The values of time (VoTs) in WPTM are based on those in WTSM, shown in Table 5-1. The choice model segments are shown in

Table 5-2. They correspond directly to those from WTSM, so the same VoTs were used for both. The assignment model segments are slightly different, combining car available (CA) and no car available (NCA). The VoTs have been calculated by weighting the WTSM VoTs by the percentage of CA and NCA from WPTM (see

Table 5-3). For example:

AM Work = (% AM work trips with CA) * (WTSM HBW Competition & Choice VoT)

+ (% AM Work trips with NCA) * (WTSM HBW Captive VoT)

Table 5-1: WTSM Values of Time ($/hr)

Purpose	Car Availability	2011 VoT
HBW	Captive	12.95
	Competition & Choice	17.36
	Combined	17.28
HBEd	Captive	8.50
	Competition & Choice	12.90
	Combined	12.74
Other	Captive	11.02
	Competition & Choice	15.66
	Combined	15.48

Table 5-2: WPTM Choice Model Values of Time ($/hr)

Segment	Car Availability	Choice Model VoT (P&R and K&R)	WTSM segment based on
AM Work	CA	17.36	HBW Competition & Choice
	NCA	12.95	HBW Captive
AM Education	CA	12.90	HBEd Competition & Choice
	NCA	8.50	HBEd Captive
AM Other	CA	15.66	Other Competition & Choice
	NCA	11.02	Other Captive
AM Child	All	9.80	HBEd Competition & Choice
IP Work	CA	17.36	HBW Competition & Choice
	NCA	12.95	HBW Captive
IP Education	CA	12.90	HBEd Competition & Choice
	NCA	8.50	HBEd Captive
IP Other	CA	15.66	Other Competition & Choice
	NCA	11.02	Other Captive
IP Child	All	10.15	HBEd Competition & Choice

Table 5-3: WPTM Assignment Model Values of Time ($/hr)

Segment	VoT	WTSM segment based on
am_work	16.07	HBW
am_educ	9.83	HBEd
am_other	12.67	Other
am_child	9.80	HBEd
ip_work	15.28	HBW
ip_educ	10.73	HBEd
ip_other	13.60	Other
ip_child	10.15	HBEd

Alternative values of time were tested – it was expected that behavioural values of time for PT route choice may differ from those applied in WTSM – however, this did not result in a significantly improved validation, and VoT consistency with WTSM was considered the best outcome on balance. In the past some studies in Wellington have assumed significantly lower VoTs for PT than these, however, this was rejected in the validation of WPTM.

5.3 Calibration

Some different assignment methods were trialled in EMME – standard, optimal strategies and strategies with variants. It was decided to use the strategies with variants, as this method closely replicates the results of the other two assignment methods, while giving more flexibility in options.

For the initial calibration, a shortened assignment-only version of the model was run. This meant the observed matrices were used as input. This eliminated any effect the choice model may have on the results. After calibration of the assignment model alone, the choice and assignment models were combined, requiring further calibration. This means parameters were optimised for the full choice model run, rather than assignment-only. Results in this section are from the full choice model run.

The key results that were checked with each set of new parameters were the CBD cordon survey, bus vs. rail splits in key corridors, rail boarding and alighting graphs, screenlines and the Airport Flyer.

Some of the parameters changes that were trialled to improve the results (but not necessarily adopted) were:

- Changing the method of distributing flow between attractive lines from “frequency” to “frequency and transit time”;
- Changing the effective headway calculation (and hence perceived wait time), both overall and for different modes;
- Changing the wait time perception factor;
- Changing the walk time weight;
- Changing the in-vehicle time factors;
- Increasing the VoT (value of time) parameters by 50%, 100% and 70% from the base values;
- Changing the line boarding penalties; and
- Changing the boarding fares.

Many of these parameter changes made little difference to the mode split and other key results. This is perhaps not so surprising considering that for many of the main movements in the Wellington region there are no mode options, hence the model is insensitive to small changes. However several of the parameter changes were effective, these are discussed below.

The effective headway calculation measures how the wait time for a mode is perceived. Generally, the wait time for bus is perceived as more unreliable and unpleasant due to more basic facilities (such as no seating or shelter).

The cable car and ferry modes had little or no share initially, and were quite resistant to change. Firstly, the effective headway calculation was changed to make them more attractive, as for rail. However, this alone did not have enough of an impact. Reducing the boarding penalties was found to make them more attractive. While value of time is another way to approach this issue, changing this made very little difference to travel patterns.

The Airport Flyer is a bus route of particular interest in the network. This service is representative of premium bus services (limited stop, high quality vehicle, freeway running, premium fare) and in future model application, other premium quality services may be tested. Initially, the modelled volumes were too low for the AM inbound direction. The ETM data shows that many passengers catch this service from Lower Hutt to the CBD, in addition to passengers going to the airport. They are likely commuters attracted by its reliable and comfortable service. The model was capturing airport passengers, but not commuters. In order to fix this, the boarding penalties and treatment of premium fares were altered to make it more attractive.

When modelling fares, two components are modelled:

- The boarding fare; and
- The difference in fare compared to the cheapest mode (bus) per fare-zone boundary crossing.

Attempts to represent the zone boundary crossing fares in full were unsuccessful due to limitations of the EMME software in respect of zonal fares. Considerable effort was expended on calibrating to Airport Flyer, which is the only premium priced PT service in Wellington. It was found that modelling the premium component of the fare at 2 x value of time gave the best validation in the AM peak, possibly because Airport Flyer users have higher values of time, on average, than the population as a whole.

Table 5-4 below compares the initial and final assignment model parameters.

Table 5-4: Initial and Final Assignment Model Parameters

Parameter	Segment	WTSM	Initial WPTM	Final WPTM
Walk time weight	All	2	2	1.8
Wait time	All	0.25*headway	0.22*headway	If headway<15: 0.5*headway If headway>15: 7.5+0.22*(headway-15)
Wait time perception factor	Rail	2	2	1.6
	Bus	2	2	2.0
	Flyer	2	2	AM = 1.8, IP = 2.0
	Ferry	2	2	0.4
	Cable Car	2	2	1.6
Boarding Fare	Rail, Adult	n/a – see below	AM = 1.89, IP = 1.96	AM = 1.89, IP = 1.96
	Rail, Child	n/a – see below	AM = 0.99, IP = 0.90	AM = 0.99, IP = 0.90
	Bus, Adult	n/a – see below	AM = 1.89, IP = 1.57	AM = 1.89, IP = 1.57
	Bus, Child	n/a – see below	AM = 1.28, IP = 1.29	AM = 1.28, IP = 1.29
	Flyer, Adult	n/a – see below	4.07	4.07
	Flyer, Child	n/a – see below	3.16	3.16
	Ferry	n/a – see below	8.39	8.39
	Cable Car	n/a – see below	3.00	3.00
In-vehicle time factor	Rail	0.9	0.9	AM = 0.88, IP = 0.84
	Bus	1.0	1.0	1.0
	Flyer	1.0	1.0	AM = 0.95, IP = 1.0
	Ferry	0.9	1.0	0.7
	Cable Car	0.5	1.0	0.7

Boarding times are applied as a combination of line and node boarding times. Line boarding times depend on the mode, and node boarding times depend on the characteristics of the particular stop. The total boarding times for each mode and stop type are shown in Table 5-5. WTSM uses a different system which cannot be compared directly, combining boarding fares and times into a total generalised cost penalty.

Table 5-5: Initial and Final WPTM Boarding Times (Generalised Minutes)

Mode	Stop Type	Initial Boarding Time (AM/IP)	Final Boarding Time AM	Final Boarding Time IP
Rail	Regular station	2.5	2.5	2.5
	Interchange with good facilities	2.5	1	1
Bus	Regular stop	7.5	5.5	5.5
	Interchange with good facilities	7.5	4.5	4.5
Premium Bus (Flyer)	Regular stop	7.5	4.5	5.5
	Interchange with good facilities	7.5	3.5	4.5
Ferry	All	2.5	2.5	2.5
Cable Car	All	7.5	3.5	3.5

5.4 Validation

This section uses various sources of data to validate the assignment. First, the inputs are examined by considering travel time functions and assignment splits. Then the outputs are considered, including screenline counts and board counts.

5.4.1 Bus Travel Time Comparison

Table 5-6 compares the observed route level travel times from the GWRC PT database with the modelled travel times. The modelled times are based on a travel time function that is applied to the highway times from WTSM. Often, routes have several variants with different run times, for example Route 30 sometimes travels to Scorching Bay and sometimes to Breaker Bay. In these cases, the travel times have been weighted by the headway for each variant and averaged.

A fuller analysis of bus transit times can be found in TN1. This analysis looked at the ETM data travel times also, to produce a transit time function. As described in this note, it is very difficult to get the travel times for entire routes from the ETM data, so the GWRC PT database is used here to get a wider sample. It is to be expected that there are slight differences in the times, as the timetable will not always represent reality, due to delays and traffic.

Table 5-6: Timetable vs. Modelled Bus Times

		AM			IP		
Route	Dir	Timetable (minutes)	Modelled (minutes)	Difference	Timetable (minutes)	Modelled (minutes)	Difference
1	I	33.9	33.2	-2%	38.0	28.9	-24%
1	O	36.7	33.7	-8%	39.0	31.8	-18%
2	I	42.5	38.1	-10%	43.0	35.0	-19%
2	O	34.6	35.0	1%	40.0	36.4	-9%
3	I	48.4	44.0	-9%	53.1	46.3	-13%
3	O	51.2	51.5	1%	56.3	45.2	-20%
4	I	36.7	42.5	16%	-	-	-
5	I	33.5	26.5	-21%	-	-	-
5	O	27.0	21.9	-19%	-	-	-
6	I	40.0	39.6	-1%	-	-	-
7	I	29.3	26.1	-11%	26.0	23.0	-12%
7	O	24.4	24.0	-2%	26.0	23.8	-9%
8	I	28.0	29.8	7%	24.5	27.4	12%
8	O	23.0	26.9	17%	24.0	29.0	21%
9	I	16.0	15.5	-3%	16.0	12.6	-21%
9	O	16.7	15.8	-6%	19.0	14.7	-22%
10	I	28.1	25.9	-8%	27.0	21.3	-21%
10	O	24.2	24.1	0%	24.0	21.5	-10%
11	I	44.2	40.3	-9%	45.0	36.9	-18%
11	O	36.1	37.3	3%	40.0	35.9	-10%

		AM			IP		
Route	Dir	Timetable (minutes)	Modelled (minutes)	Difference	Timetable (minutes)	Modelled (minutes)	Difference
13	O	34.4	30.2	-12%	-	-	-
14	I	43.2	45.9	6%	32.9	32.0	-3%
14	O	37.6	36.0	-4%	37.2	35.8	-4%
17	I	33.3	29.6	-11%	10.0	7.8	-22%
17	O	19.1	19.1	0%	10.0	7.4	-26%
18	I	51.3	46.7	-9%	52.0	51.2	-2%
18	O	41.4	43.1	4%	55.0	49.1	-11%
20	I	38.0	42.2	11%	40.0	40.2	0%
20	O	35.6	42.0	18%	39.0	39.4	1%
21	O	61.8	64.2	4%	84.0	90.0	7%
22	I	40.0	49.8	24%	55.0	62.8	14%
22	O	46.8	51.2	9%	55.0	62.7	14%
23	I	41.7	45.6	9%	55.0	55.4	1%
23	O	53.0	61.7	16%	53.0	57.2	8%
24	I	52.0	58.3	12%	51.0	53.6	5%
24	O	33.0	40.9	24%	43.0	53.7	25%
25	O	40.5	45.7	13%	-	-	-
28	I	10.0	13.0	30%	-	-	-
29	I	37.8	49.3	31%	32.3	42.3	31%
29	O	0.0	53.6	-	25.0	44.4	77%
30	I	42.0	41.8	0%	-	-	-
31	I	40.8	36.0	-12%	-	-	-
31	O	-	-	-	37.0	30.8	-17%
32	I	35.6	33.3	-6%	-	-	-
43	O	66.8	66.9	0%	109.3	114.1	4%
44	O	77.4	71.4	-8%	112.0	120.7	8%
45	I	20.0	21.7	8%	-	-	-
45	O	23.7	27.6	17%	-	-	-
46	I	42.0	40.7	-3%	-	-	-
47	I	44.0	46.5	6%	42.0	40.8	-3%
47	O	38.5	48.4	26%	42.0	42.2	0%
50	O	25.0	21.0	-16%	25.0	21.7	-13%
52	I	50.0	57.5	15%	50.0	54.0	8%
52	O	50.0	57.9	16%	50.0	55.1	10%
53	I	35.8	39.7	11%	15.0	14.0	-7%
53	O	-	-	-	15.0	12.6	-16%
54	I	50.5	55.1	9%	55.0	49.3	-10%
54	O	29.6	29.2	-1%	55.0	49.4	-10%
55	I	40.0	45.5	14%	40.0	40.5	1%
55	O	40.0	42.2	5%	40.0	38.8	-3%

Route	Dir	AM			IP		
		Timetable (minutes)	Modelled (minutes)	Difference	Timetable (minutes)	Modelled (minutes)	Difference
56	I	35.0	41.3	18%	-	-	-
57	I	31.2	39.3	26%	-	-	-
58	I	35.0	41.4	18%	-	-	-
80	I	68.0	72.8	7%	-	-	-
81	I	48.6	66.0	36%	45.0	50.4	12%
81	O	47.5	54.1	14%	45.0	50.7	13%
83	I	66.7	81.7	22%	60.0	67.9	13%
83	O	63.8	71.8	13%	60.0	67.1	12%
84	I	39.5	52.0	32%	-	-	-
84	O	41.0	56.9	39%	-	-	-
85	I	50.0	60.9	22%	-	-	-
90	I	65.0	63.2	-3%	-	-	-
91	I	64.2	81.3	27%	56.4	54.0	-4%
91	O	60.9	64.5	6%	58.0	52.5	-10%
92	I	77.0	72.6	-6%	-	-	-
93	I	77.0	75.3	-2%	-	-	-
98	O	35.0	42.7	22%	-	-	-
99	O	45.0	53.2	18%	-	-	-
110	I	68.7	61.4	-11%	54.9	56.0	2%
110	O	54.0	55.8	3%	54.0	55.7	3%
111	O	13.3	19.6	47%	10.3	11.7	13%
112	I	21.0	18.1	-14%	21.0	17.3	-17%
112	O	21.0	21.1	0%	21.0	20.5	-3%
114	I	18.0	17.5	-3%	18.0	17.9	-1%
114	O	18.0	18.1	0%	18.0	18.2	1%
115	O	24.0	29.1	21%	24.0	29.4	22%
120	I	30.0	30.4	1%	28.0	30.7	10%
120	O	28.0	28.8	3%	28.0	29.7	6%
121	I	43.6	48.3	11%	58.0	70.2	21%
121	O	51.8	49.2	-5%	56.0	72.1	29%
130	I	32.3	36.7	14%	37.3	41.6	11%
130	O	40.1	44.6	11%	39.5	43.4	10%
145	I	25.0	28.0	12%	-	-	-
145	O	19.0	14.2	-26%	-	-	-
150	I	45.0	49.9	11%	45.0	49.3	10%
150	O	45.2	49.7	10%	46.0	48.6	6%
154	O	-	-	-	-	-	-
154	I	27.0	30.0	11%	-	-	-
160	I	32.0	35.5	11%	35.0	40.6	16%
160	O	31.3	36.0	15%	37.0	41.8	13%

		AM			IP		
Route	Dir	Timetable (minutes)	Modelled (minutes)	Difference	Timetable (minutes)	Modelled (minutes)	Difference
170	I	34.9	29.8	-15%	28.0	28.9	3%
170	O	36.6	34.9	-5%	32.0	33.6	5%
210	I	46.0	43.1	-6%	52.0	42.4	-19%
210	O	38.7	35.5	-8%	49.0	41.6	-15%
211	I	55.0	56.2	2%	55.0	56.4	3%
211	O	55.0	59.9	9%	55.0	55.1	0%
220	I	49.3	36.6	-26%	39.0	30.5	-22%
220	O	36.9	31.5	-15%	37.5	31.3	-17%
226	O	36.2	25.4	-30%	28.5	17.7	-38%
230	I	21.0	24.3	16%	21.0	23.6	12%
230	O	21.0	27.2	30%	21.0	25.0	19%
235	I	20.0	21.0	5%	20.0	17.6	-12%
235	O	20.0	15.2	-24%	20.0	15.7	-22%
236	I	28.0	31.5	13%	28.0	31.0	11%
236	O	28.0	32.3	16%	28.0	31.2	11%
250	I	21.0	21.4	2%	28.0	19.8	-29%
250	O	18.7	19.5	5%	28.0	19.7	-30%
260	I	20.0	18.5	-8%	23.0	22.1	-4%
260	O	20.0	18.3	-9%	22.0	21.2	-4%
261	I	16.0	17.9	12%	20.0	19.0	-5%
261	O	15.7	18.9	20%	17.0	19.0	12%
262	I	20.0	20.5	3%	25.0	21.5	-14%
262	O	19.7	20.5	4%	20.0	21.1	6%
270	O	7.2	5.7	-21%	8.0	5.5	-31%
271	I	5.0	5.2	3%	-	-	-
271	O	5.0	5.0	0%	5.0	4.3	-13%
280	O	31.0	44.3	43%	36.0	54.0	50%

The following plots (Figure 5-1 and Figure 5-2) illustrate the timetable data from the table above. They indicate a reasonable correspondence between timetabled and observed travel times. The correlation is better for the IP period, which seems reasonable given the higher level of congestion and hence variability in the AM period. The validation criterion for travel times was a R^2 value of 85% or above, which is satisfied for both periods.

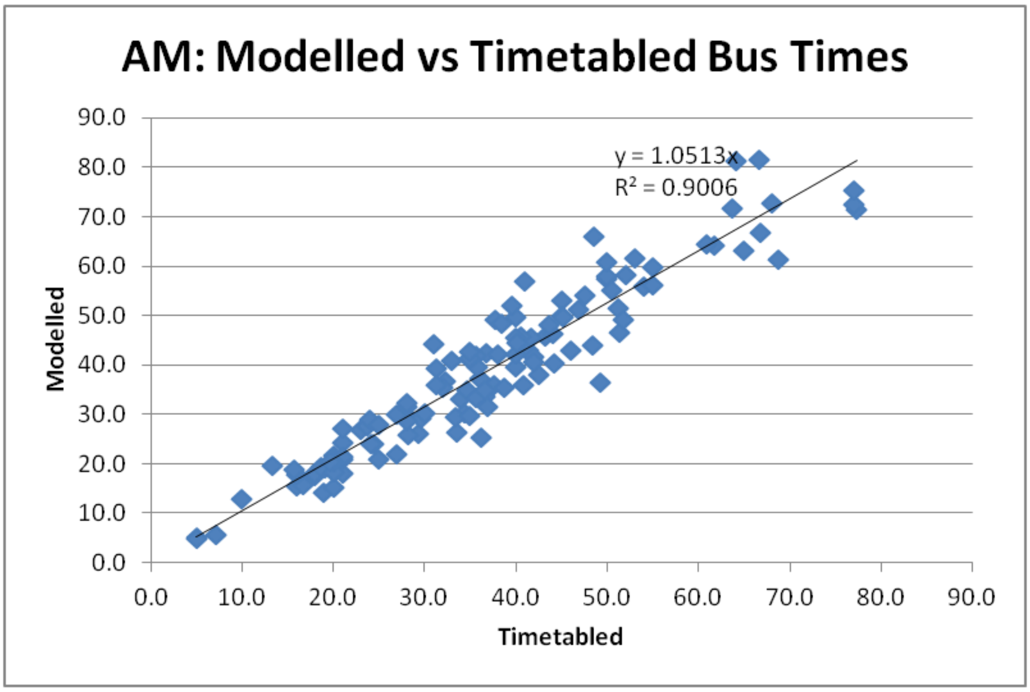


Figure 5-1: Modelled vs. Timetabled Bus Travel Times, AM

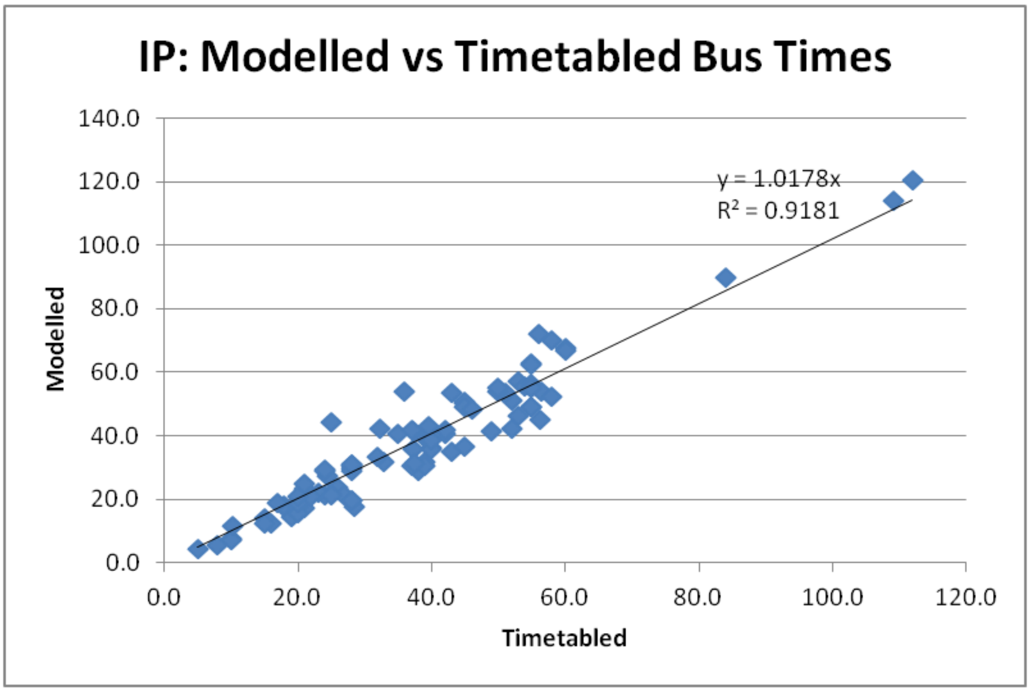


Figure 5-2: Modelled vs. Timetabled Bus Travel Times, IP

5.4.2 Bus Golden Mile Travel Time

The other validation criterion related to travel times in the critical Wellington – Courtenay Place – Newtown corridor. This corridor was split into four sections, the sectional observed vs. modelled run times are plotted in Figure 5-3 and Figure 5-4. The validation criterion was that the R^2-value for such scattergrams should be above 85%. This is satisfied for the IP, but not the AM. However the AM times actually correspond better to observed, while the IP times are too low. TN1 contains a more detailed analysis. Refinement to the transit time function, to incorporate bus congestion and a more detailed treatment of intersection delay might improve travel time validation in the Golden Mile. However this is beyond the current capability of WTSM / WPTM.

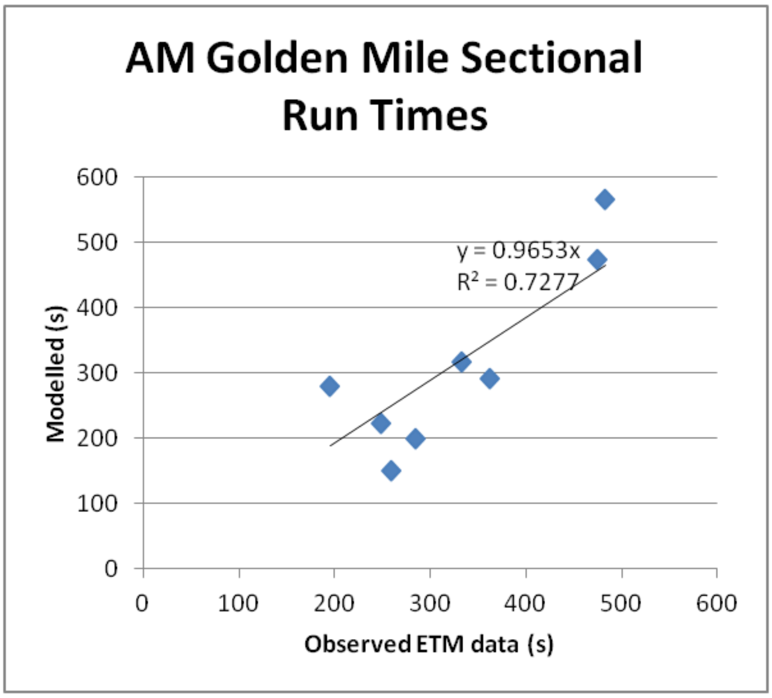


Figure 5-3: AM Golden Mile Sectional Run Times

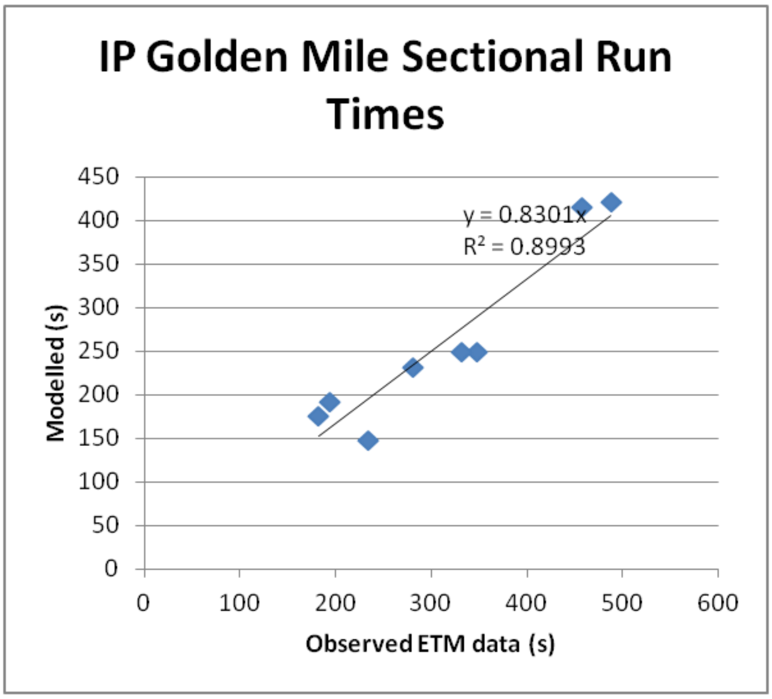


Figure 5-4: IP Golden Mile Sectional Run Times

5.4.3 Routes Between Selected Origin – Destination Pairs

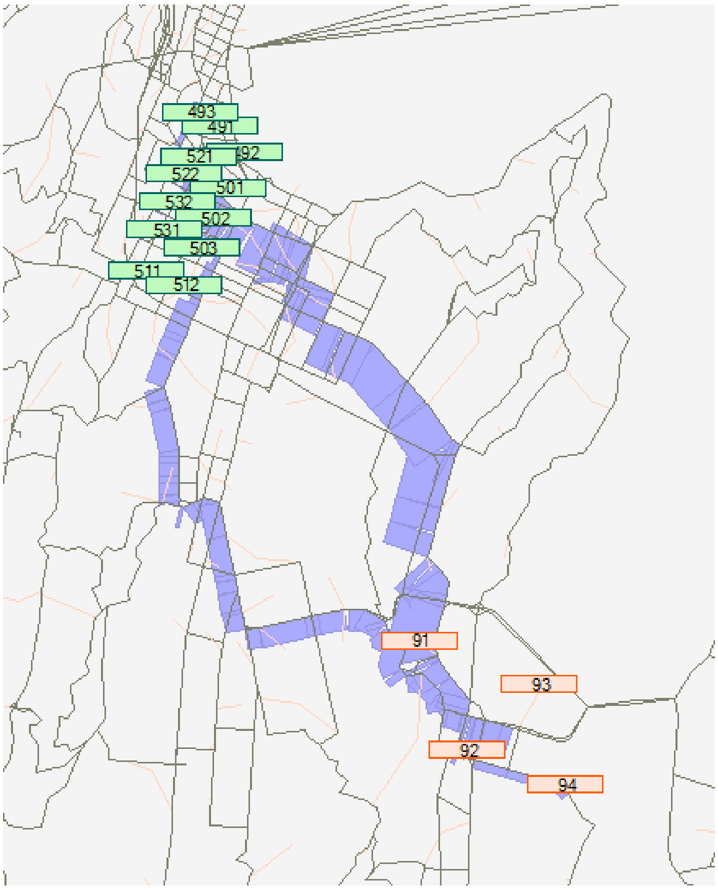
These plots show the assigned split between various modes and routes for walk access trips. These plots were produced by assigning 100 walk access trips from each origin to destination, using the costs from the AM peak model run. The plots show travel from particular origins (red nodes) to destinations (green nodes), for work purpose in the AM period. They only relate to walk trips, routings for P&R and K&R trips are not shown. Bus volumes are shown in purple and rail volumes in orange.

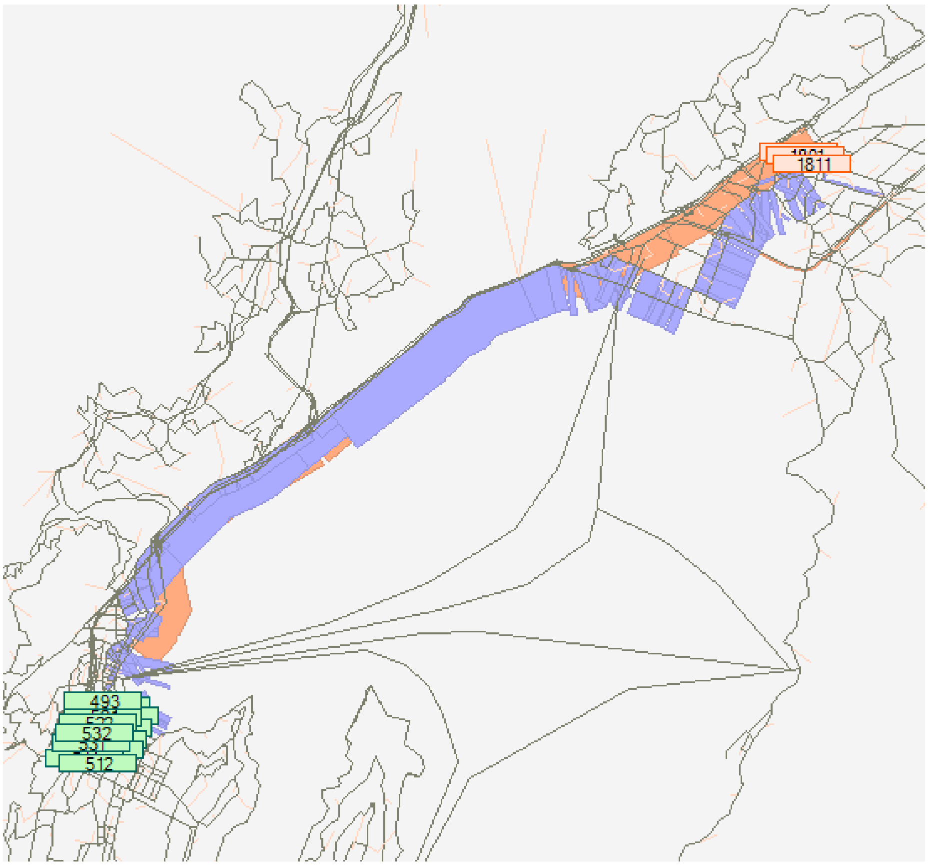
Overall the plots appear reasonable when considering modes, number of routes available, access distance, egress distance and travel times from Metlink. They also provide interesting insights into the results of the assignment, and passenger behaviour.

Kilbirnie to CBD mid-city

Kilbirnie is a significant location for bus travel in Wellington, with the Kilbirnie Shops bus stop having the highest number of boards in the entire network for both AM and IP periods (according to ETM data). Unlike the north, this area is not served by rail. There are 12 separate bus routes that pass through Kilbirnie. They travel along several different paths to reach the CBD.

The plot below shows the routes that passengers take travelling from Kilbirnie to CBD Mid-city (defined here as the area bounded by Taranaki St, Willis St, Webb St and Harris St). A larger percentage of passengers choose routes that travel through the Hataitai Bus tunnel, with the rest going through Newtown. This seems reasonable, as the bus tunnel has more frequent services. It takes 25-30 minutes from Kilbirnie to Wellington Station via Hataitai, while Newtown routes take around 35 minutes. However the Newtown routes may be more convenient depending on the final destination, as they travel a different route through the CBD.

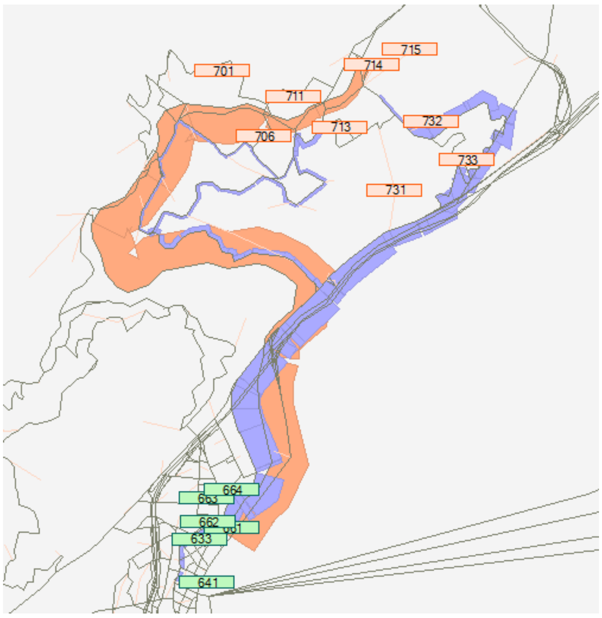




Lower Hutt Queensgate to CBD mid-city

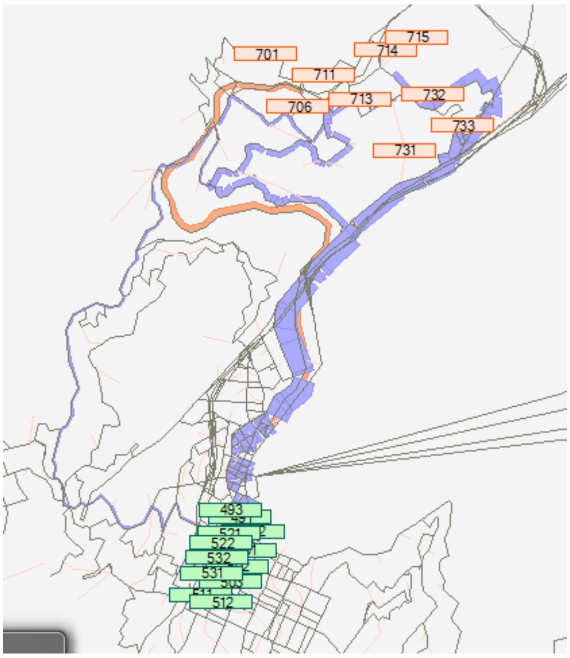
The Lower Hutt to CBD is a significant commuter route, served by both rail and bus. The plot below shows that bus gets a larger share. According to Metlink, rail trips from Melling to Wellington take around 20 minutes, while bus trips from Queensgate to Wellington Station take 30 to 40 minutes. However, buses depart from directly outside Queensgate, while Melling is a short walk away. Also, many buses continue past the Wellington station into the city. So, rail has the advantage in comfort and time, while bus has shorter distances to walk for both access and egress legs. Given these conflicting factors, the split between bus and rail appears reasonable.

It should be remembered that this only considers trips from Queensgate, Lower Hutt, not total volumes on each mode. In that case, rail would be much higher, due to passengers from further up the line



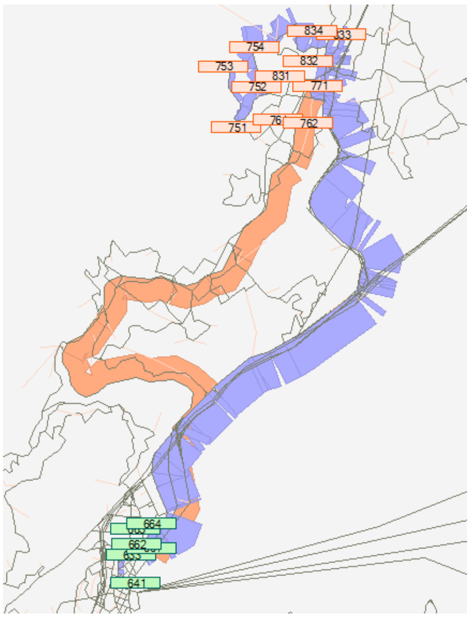
Khandallah to Wellington Station

This plot shows the split between rail and bus from Khandallah to the area surrounding Wellington Station. The modes are split fairly evenly. Rail has a slight time advantage, but bus routes are more convenient, as they travel along roads directly near to zones.



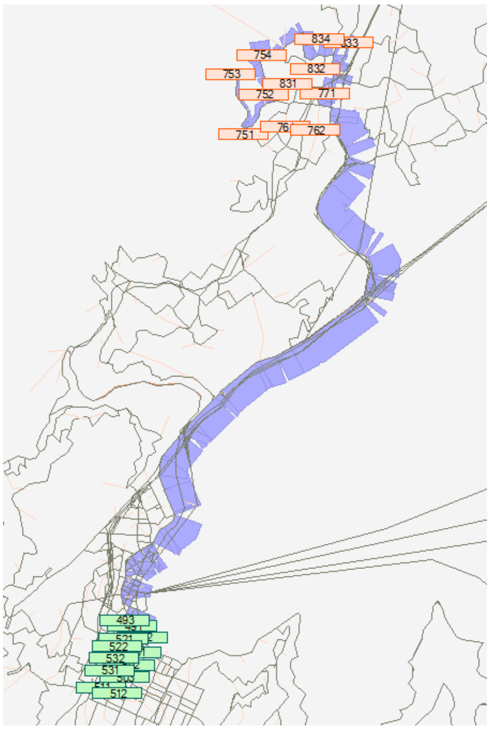
Khandallah to CBD mid-city

This plot has the same Khandallah origin zones as above, but destination zones further south in the CBD. It is interesting to compare the two plots. Rail passengers now have further to walk to reach their destination after alighting at Wellington Station. This makes bus a more attractive option than before, as most bus routes travel right into the CBD. Because this suburb is quite close to the city, the comfort and reliability benefits of rail (represented with a different weighting in the model) are not enough to overcome the increased walk time.



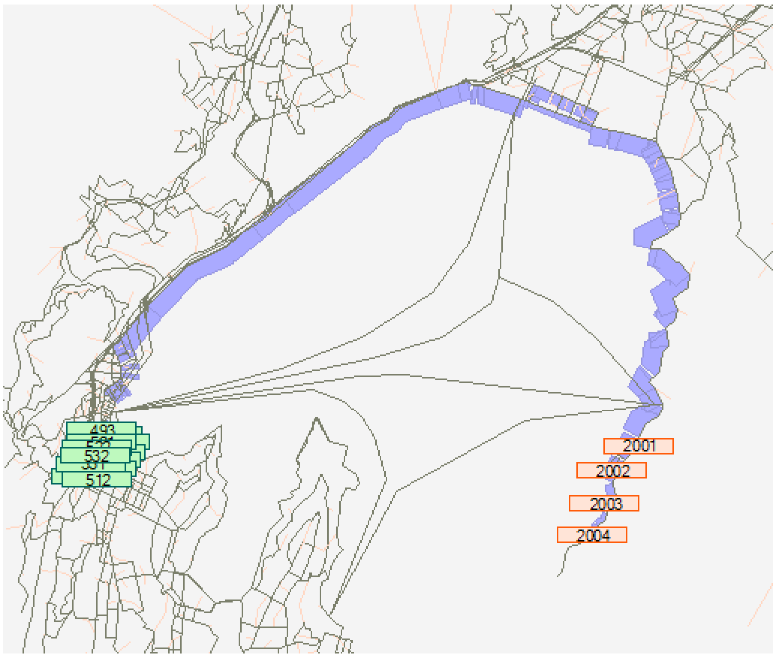
Johnsonville to Wellington Station

For Johnsonville to Wellington Station is fairly evenly split between rail and bus. This is expected, as Metlink suggests they have similar frequencies and transit times.



Johnsonville to CBD mid-city

For this route, all passengers are assigned to bus, even though rail is another option. However there is a mid-length egress walk from Wellington Station to the CBD mid-city, whereas bus routes go right through this area.



Eastbourne to CBD mid-city

Eastbourne to CBD is an interesting route to look at as it has three alternative modes – ferry, bus and bus then interchanging to rail. However as the plot below shows, all demand is assigned to bus. Investigation shows that the only people who choose to use ferry are travelling from Eastbourne to zones very near the ferry terminal in Wellington. Mid-city is a further distance to walk from here. It also shows that there is no interchange to rail at Petone. Bus services from Eastbourne to CBD do not stop very often, so the slight time benefit would be not worth the interchange penalty or extra egress penalty.

5.4.4 CBD Cordon Survey

Table 5-7Table 5-8**Error! Reference source not found.** below compares the observed CBD cordon counts (factored to average month) with the modelled assignment volumes. These show a reasonable fit and the overall screenline total is within the validation criterion of 15%.

The cable car is a niche transport service used mainly by tourists visiting the botanic gardens. Few passengers are assigned to this service, probably because choices in reality are not driven by time and cost considerations

Table 5-7: CBD Cordon, Survey vs. Modelled

Mode	Cordon Count	Modelled Assignment	Difference
Rail	10972	10727	-2%
Bus	9754	9405	-4%
Ferry	188	182	-3%
Cable Car	81	2	-97%
Total	20995	20316	-3%

5.4.5 Rail Screenline Volumes

Table 5-8 compares the observed and modelled transit passenger volumes at screenlines for rail. Observed values are taken from the boarding and alighting survey, by calculating volumes on each rail line when they cross the screenlines. Screenlines with no rail crossings have been excluded, as has W1, as it is identical in this respect to C1.

Table 5-8: Rail Passenger Volumes at Screenlines, Observed vs. Modelled (Assignment)

		AM				IP			
ID	Direction	Observed	Modelled	Diff %	GEH	Observed	Modelled	Diff %	GEH
C1	In	11366	10727	-6%	4.30	739	584	-21%	4.28
C1	Out	301	333	11%	1.26	398	199	-50%	8.17
C2	In	2476	2296	-7%	2.61	356	293	-18%	2.46
C2	Out	3557	3648	3%	1.07	374	327	-12%	1.76
C3	In	2701	2923	8%	2.95	261	227	-13%	1.52
C3	Out	4411	4434	1%	0.25	320	270	-15%	2.02
C4	In	550	581	6%	0.92	148	143	-4%	0.33
C4	Out	756	1094	45%	7.87	205	177	-14%	1.45
W4	NB	332	353	6%	0.78	395	200	-49%	7.99
W4	SB	11192	10550	-6%	4.35	730	576	-21%	4.26
L1	NB	172	156	-9%	0.90	165	77	-53%	5.63
L1	SB	5416	5343	-1%	0.70	296	236	-20%	2.57
L2	NB	269	198	-26%	3.28	44	35	-21%	1.04
L2	SB	1810	1883	4%	1.20	100	98	-2%	0.11
L3	EB	142	118	-17%	1.49	135	78	-42%	3.91
L3	WB	4467	4470	0%	0.04	264	223	-15%	1.84
U2	NB	275	199	-28%	3.52	46	35	-24%	1.20
U2	SB	1774	1878	6%	1.71	96	98	2%	0.10
P1	NB	28	29	3%	0.12	89	72	-20%	1.38
P1	SB	1864	1758	-6%	1.76	189	167	-12%	1.17
P3	NB	102	83	-19%	1.45	157	107	-32%	3.05
P3	SB	3537	3597	2%	0.71	271	225	-17%	2.07
K1	NB	27	28	1%	0.03	58	48	-17%	0.95
K1	SB	496	525	6%	0.88	81	85	5%	0.34
TOTAL		**58023**	**57203**	**-1%**	**2.41**	**5915**	**4580**	**-23%**	**13.03**

Table 5-9 below shows the ranges of GEH values for each time period.

Table 5-9: Distribution of Rail Screenline GEH values

	AM		IP	
GEH	#	%	#	%
<5	23	96%	21	88%
5-10	1	4%	3	13%
>10	0	0%	0	0%

Figure 5-5 and Figure 5-6 illustrate the screenline data. These show that the AM rail volumes have very good agreement between the modelled and observed volumes. IP volumes are too low. The validation criterion details that screenlines be within 15% of observed. This is satisfied for the AM trend overall, and the majority of AM screenlines.

Many of the IP screenlines are outside this value, although the GEH values are often acceptable because of the low volumes.

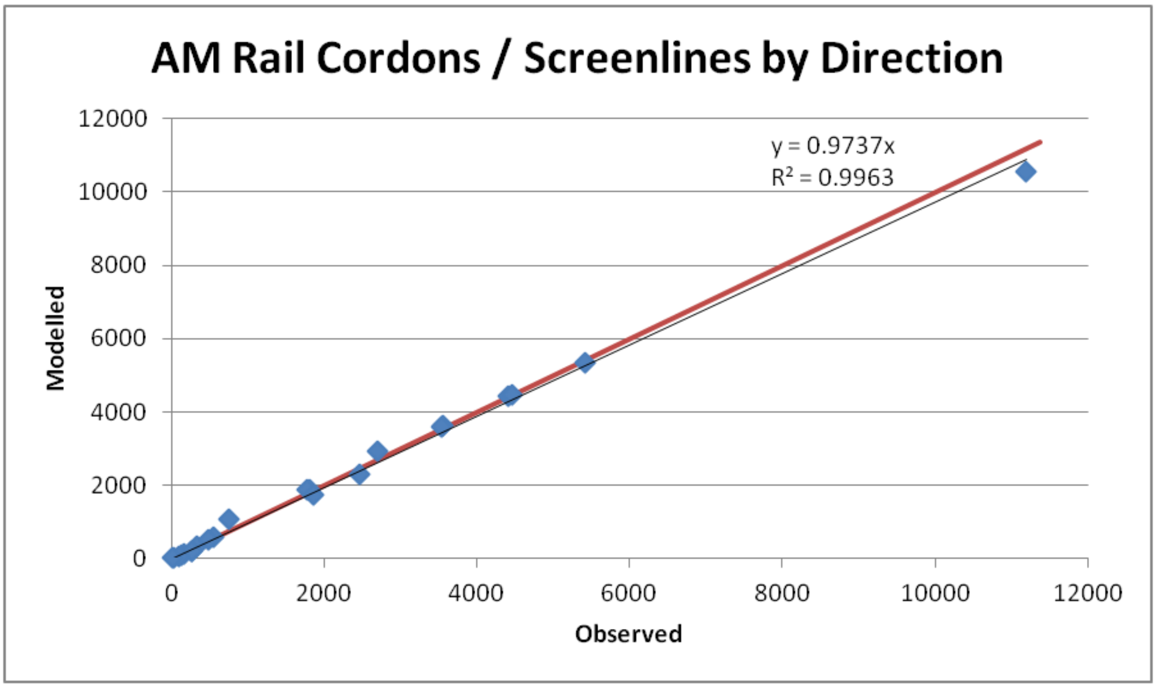


Figure 5-5: AM Rail Cordons / Screenlines, Modelled (Assignment) vs. Observed

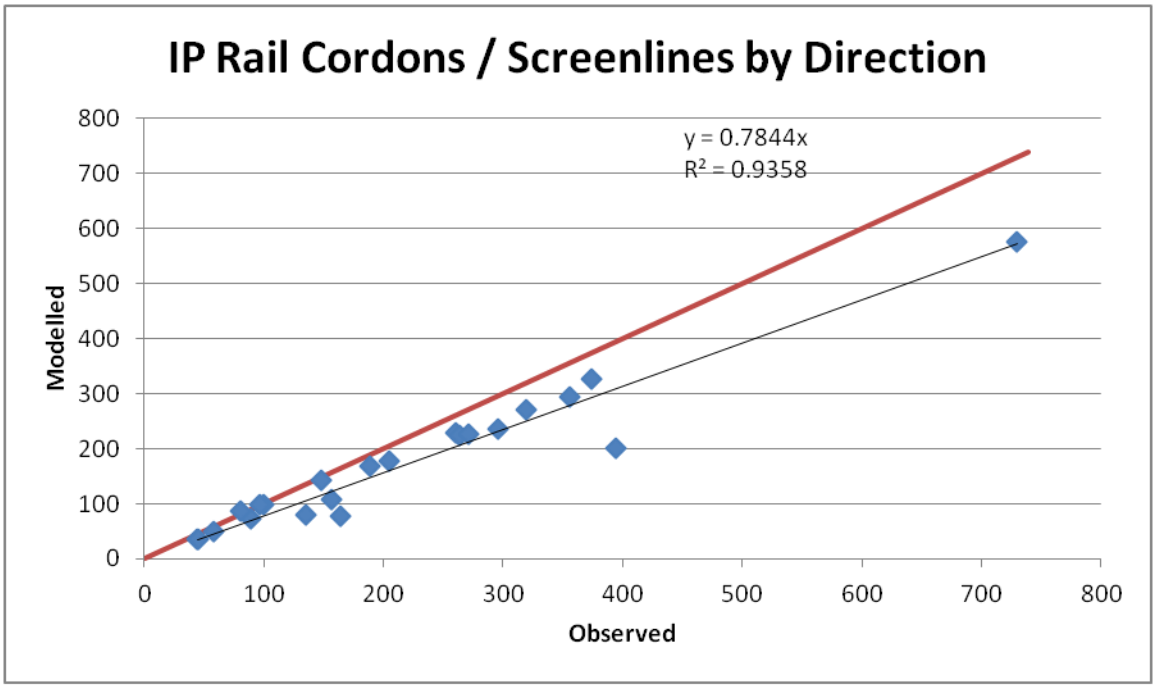


Figure 5-6: IP Rail Cordons / Screenlines, Modelled (Assignment) vs. Observed

5.4.6 Rail Boarding and Alighting Counts

The graphs below compare the observed boarding and alighting counts with the overall modelled data, for all rail lines. The Hutt Valley, Melling, Johnsonville and Kapiti lines are shown for both AM and IP time periods, while the Wairarapa was only surveyed during the AM peak.

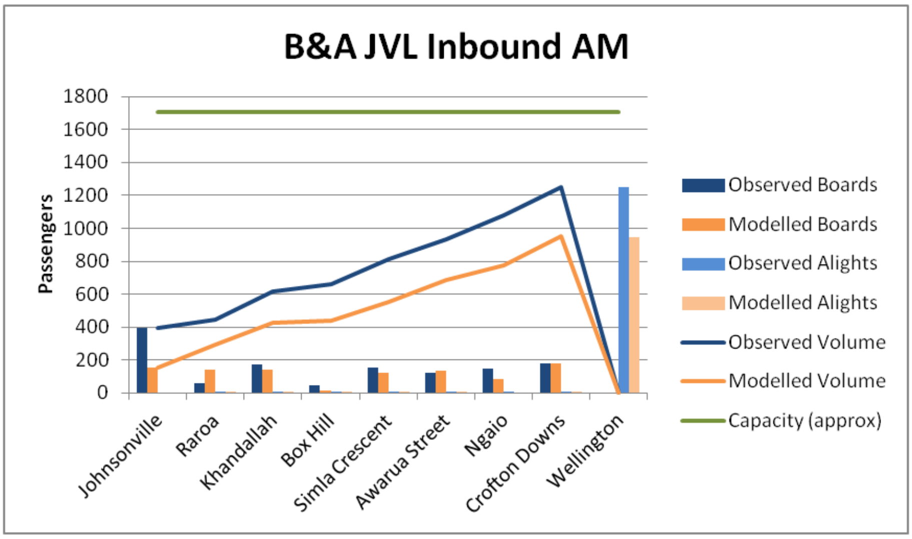
The graphs are similar to those in Section 3. They have the same observed data, but the modelled numbers are the results of the full model, meaning passengers could have chosen different modes or stations to use.

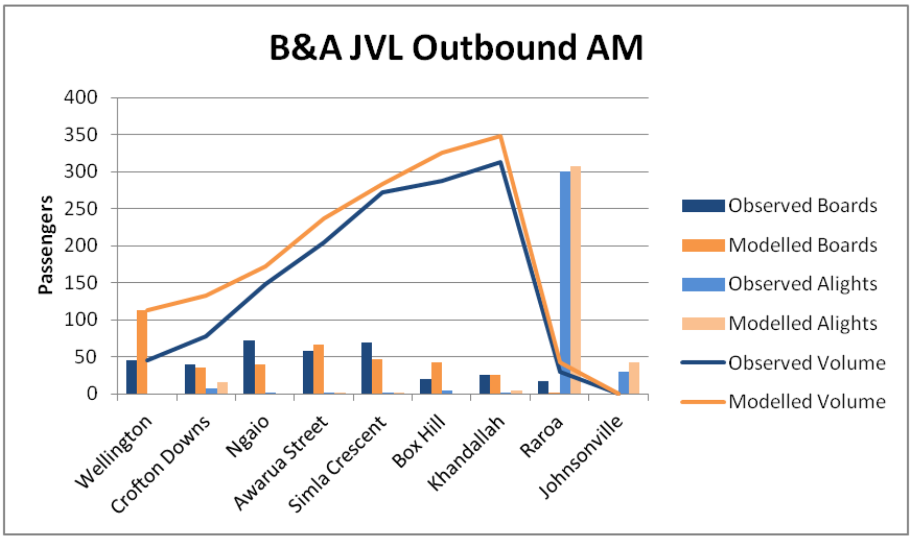
Given this, the graphs appear reasonable. It should be noted that the outbound and IP graphs have much smaller volumes, making any differences appear larger. The Kapiti and Capital Connection inbound AM graph has a larger number of modelled alights at Kaiwharawhara Station than observed. This was due to a slight coding error for the Capital Connection service, which was corrected and is dealt with in an addendum.

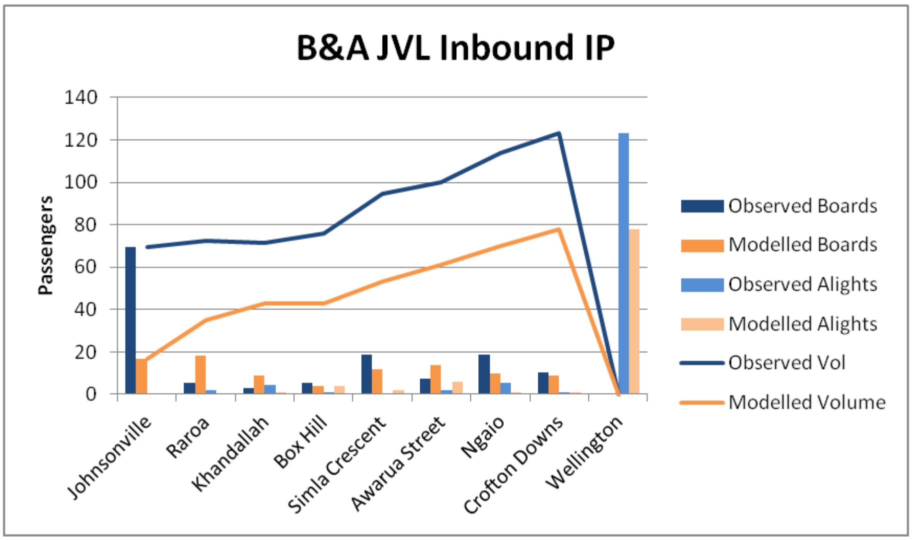
In the Johnsonville Line corridor, around 300 trips which should assign to rail instead assign to bus. Most of the deficit relates to trips travelling the full length of the line from Johnsonville to Wellington. A comparison of bus and train timetables indicates that journey time, frequency and accessibility (walk time) are all lower by bus than by train for this movement, even for those heading to the area around Wellington Station. Therefore, the model assigns the vast majority of Johnsonville-Wellington travellers onto bus; yet the counts show that people do choose rail in significant numbers. There may be influences on behaviour not captured by the model, such as reliability or limited capacity of bus. It would be possible to apply specific parameters to the Johnsonville corridor to rectify this, but this is rejected as it would detract from the integrity of the model.

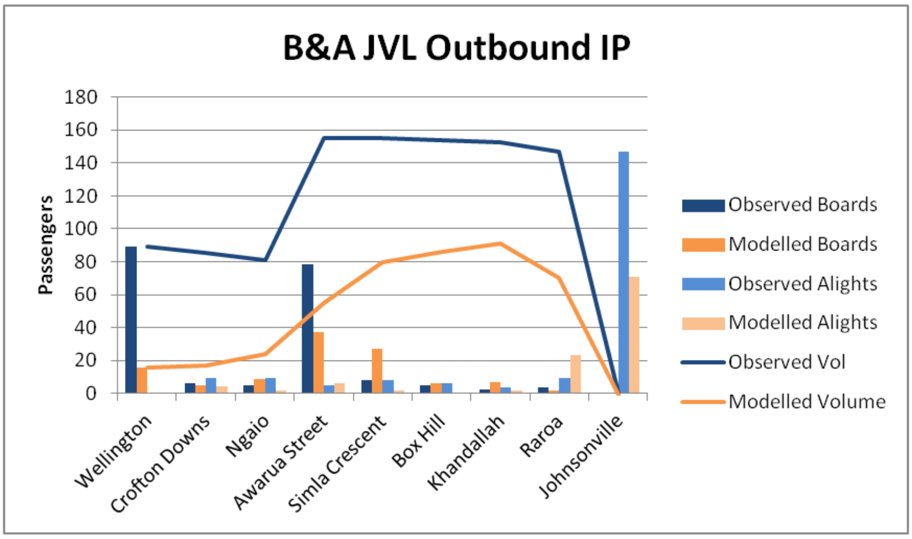
Table 5-10: Total Rail Boards by Line, Observed (Counts) and Modelled Demand

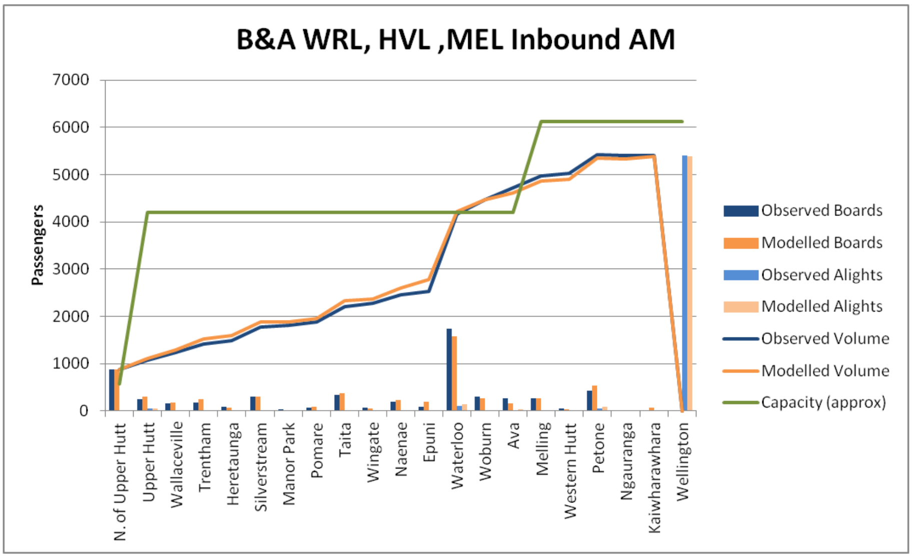
	AM			IP		
Line	Observed Boards	Modelled Boards	Diff	Observed Boards	Modelled Boards	Diff
JVL (Johnsonville)	1618	1340	-17%	336	202	-40%
HVL (Hutt Valley), MEL (Melling), WRL (Wairarapa)	6209	6108	-2%	654	413	-37%
KPL (Kapiti), CC (Capital Connection)	5152	5192	1%	750	631	-16%

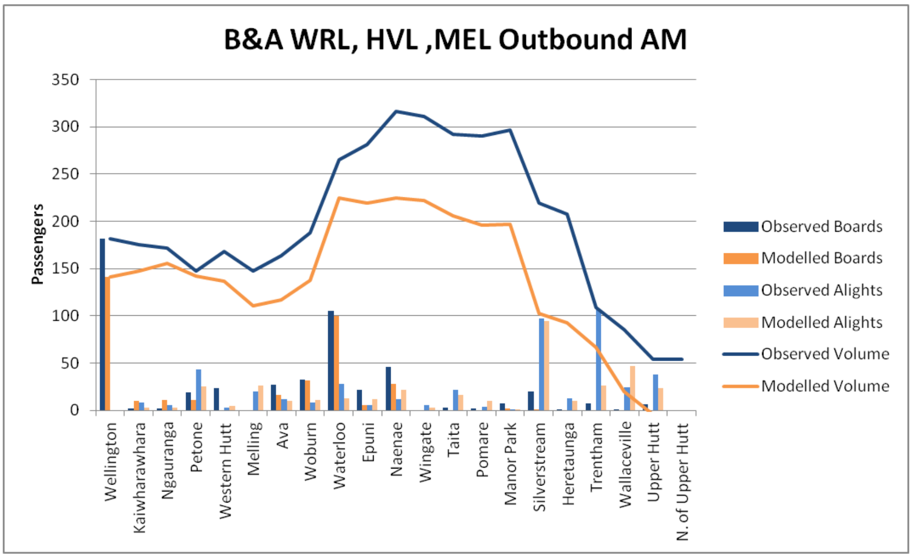

B&A JVL Inbound AM
Passengers
1800
1600
1400
1200
1000
800
600
400
200
0
Johnsonville
Raroa
Khandallah
Box Hill
Simla Crescent
Awarua Street
Ngaio
Crofton Downs
Wellington
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Volume
Modelled Volume
Capacity (approx)

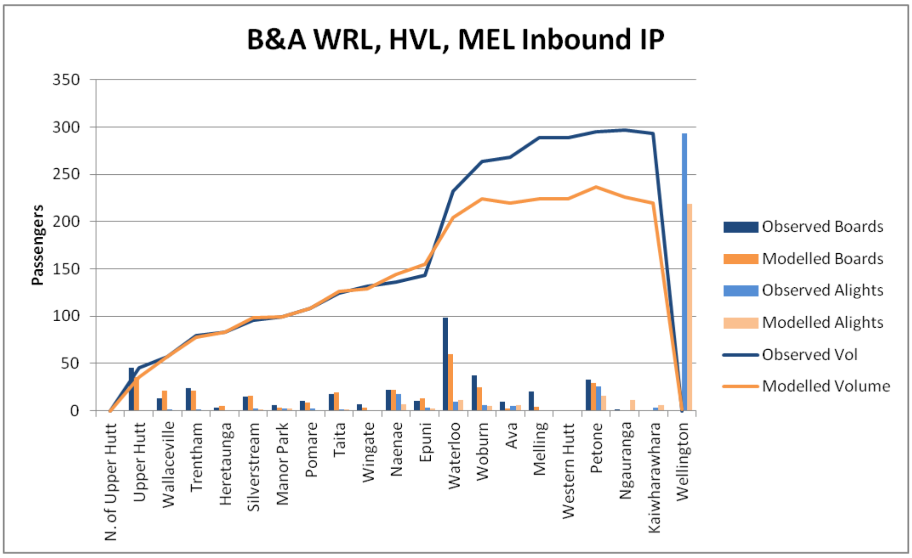

B&A JVL Outbound AM
Passengers
400
350
300
250
200
150
100
50
0
Wellington
Crofton Downs
Ngaio
Awarua Street
Simla Crescent
Box Hill
Khandallah
Raroa
Johnsonville
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Volume
Modelled Volume

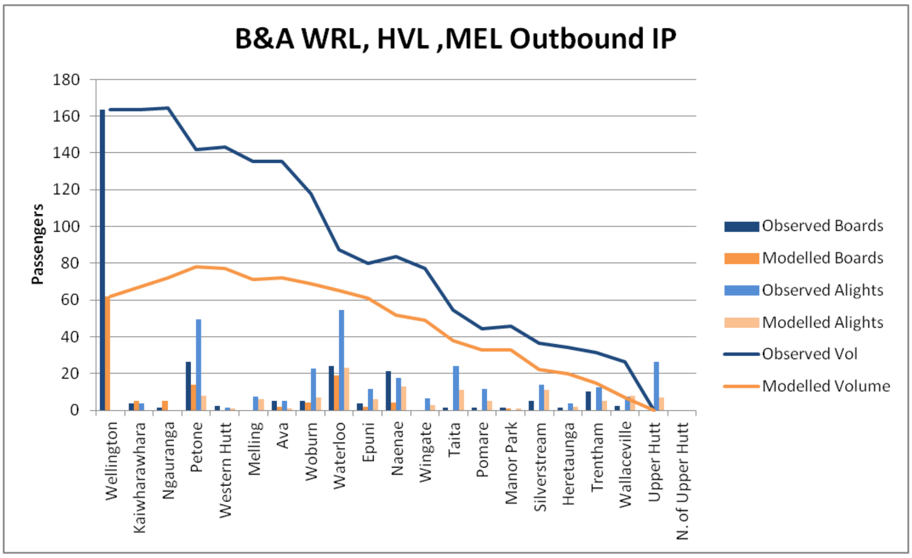

B&A JVL Inbound IP
Passengers
140
120
100
80
60
40
20
0
Johnsonville
Raroa
Khandallah
Box Hill
Simla Crescent
Awarua Street
Ngaio
Crofton Downs
Wellington
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Vol
Modelled Volume

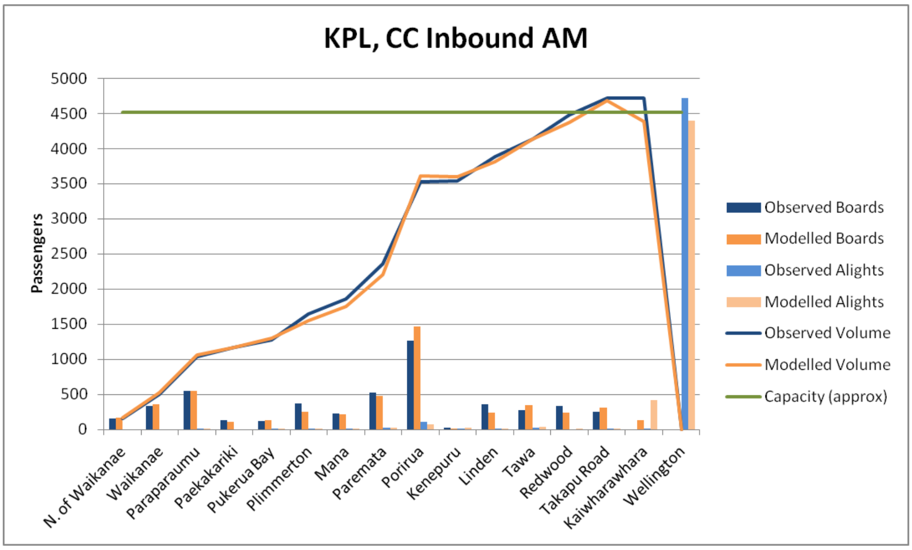

B&A JVL Outbound IP
Passengers
180
160
140
120
100
80
60
40
20
0
Wellington
Crofton Downs
Ngaio
Awarua Street
Simla Crescent
Box Hill
Khandallah
Raroa
Johnsonville
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Vol
Modelled Volume

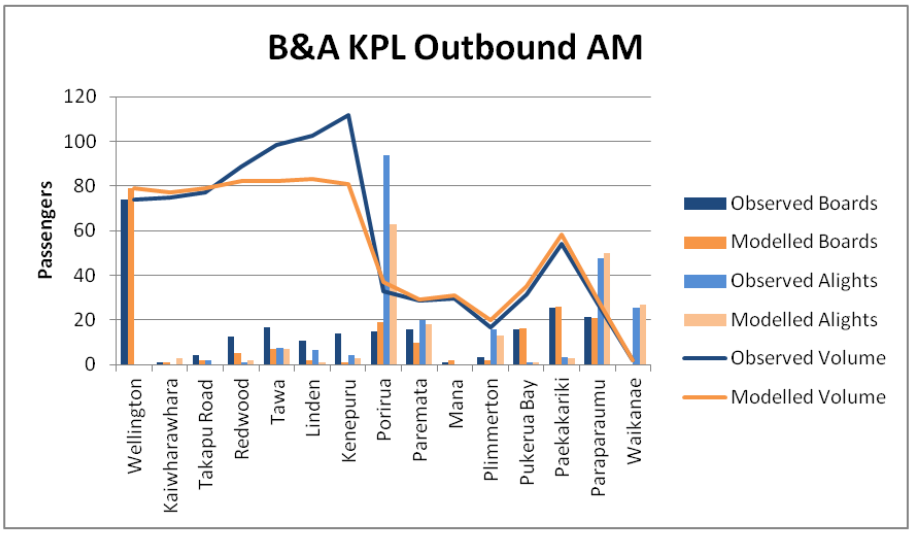

B&A WRL, HVL ,MEL Inbound AM
Passengers
7000
6000
5000
4000
3000
2000
1000
0
N.of Upper Hutt
Upper Hutt
Wallaceville
Trentham
Heretaunga
Silverstream
Manor Park
Pomare
Taita
Wingate
Naenae
Epuni
Waterloo
Woburn
Ava
Melling
Western Hutt
Petone
Ngauranga
Kaiwharawhara
Wellington
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Volume
Modelled Volume
Capacity (approx)

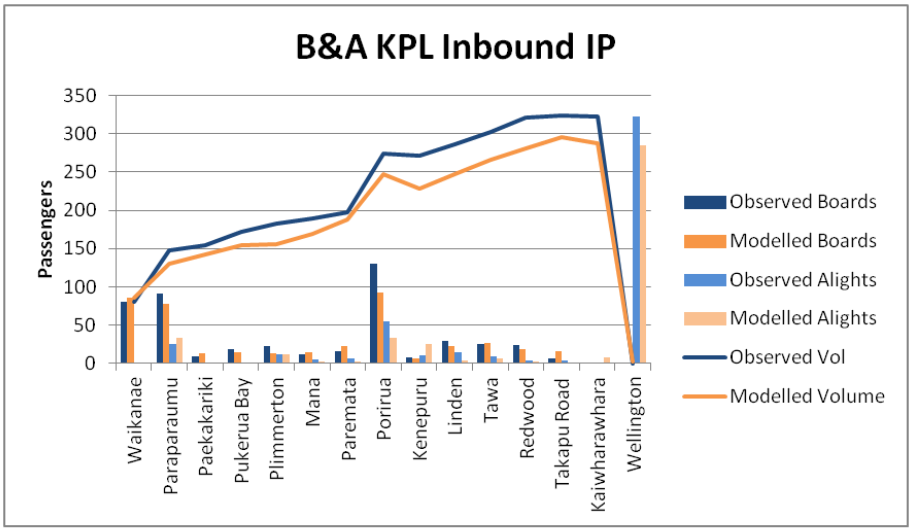

B&A WRL, HVL ,MEL Outbound AM
Passengers
350
300
250
200
150
100
50
0
Wellington
Kaiwharawhara
Ngauranga
Petone
Western Hutt
Melling
Ava
Woburn
Waterloo
Epuni
Naenae
Wingate
Taita
Pomare
Manor Park
Silverstream
Heretaunga
Trentham
Wallaceville
Upper Hutt
N. of Upper Hutt
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Volume
Modelled Volume

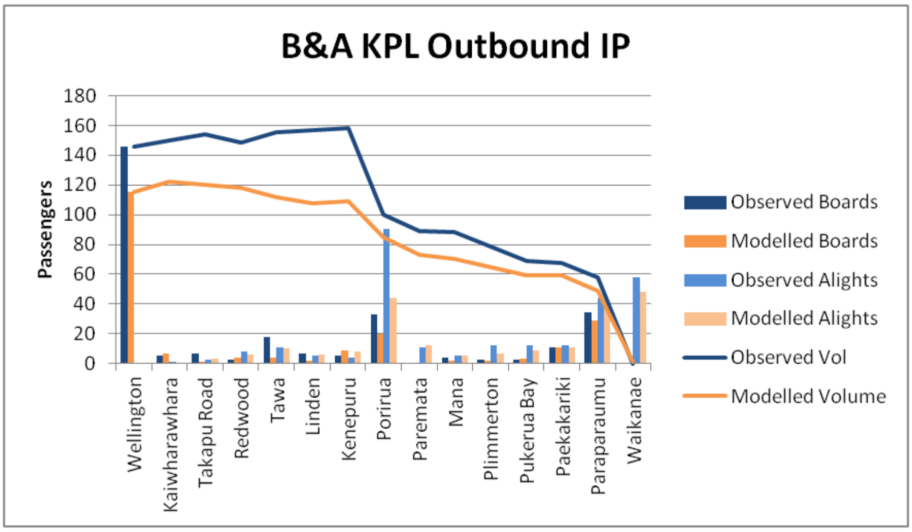

B&A WRL, HVL, MEL Inbound IP
Passengers
350
300
250
200
150
100
50
0
N. of Upper Hutt
Upper Hutt
Wallaceville
Trentham
Heretaunga
Silverstream
Manor Park
Pomare
Taita
Wingate
Naenae
Epuni
Waterloo
Woburn
Ava
Melling
Western Hutt
Petone
Ngauranga
Kaiwharawhara
Wellington
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Vol
Modelled Volume


B&A WRL, HVL ,MEL Outbound IP
Passengers
180
160
140
120
100
80
60
40
20
0
Wellington
Kaiwharawhara
Ngauranga
Petone
Western Hutt
Melling
Ava
Woburn
Waterloo
Epuni
Naenae
Wingate
Taita
Pomare
Manor Park
Silverstream
Heretaunga
Trentham
Wallaceville
Upper Hutt
N. of Upper Hutt
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Vol
Modelled Volume


KPL, CC Inbound AM
Passengers
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
N. of Waikanae
Waikanae
Paraparaumu
Paekakariki
Pukerua Bay
Plimmerton
Mana
Paremata
Porirua
Kenepuru
Linden
Tawa
Redwood
Takapu Road
Kaiwharawhara
Wellington
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Volume
Modelled Volume
Capacity (approx)


B&A KPL Outbound AM
Passengers
120
100
80
60
40
20
0
Wellington
Kaiwharawhara
Takapu Road
Redwood
Tawa
Linden
Kenepuru
Porirua
Paremata
Mana
Plimmerton
Pukerua Bay
Paekakariki
Paraparaumu
Waikanae
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Volume
Modelled Volume


B&A KPL Inbound IP
Passengers
350
300
250
200
150
100
50
0
Waikanae
Paraparaumu
Paekakariki
Pukerua Bay
Plimmerton
Mana
Paremata
Porirua
Kenepuru
Linden
Tawa
Redwood
Takapu Road
Kaiwharawhara
Wellington
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Vol
Modelled Volume


B&A KPL Outbound IP
Passengers
180
160
140
120
100
80
60
40
20
0
Wellington
Kaiwharawhara
Takapu Road
Redwood
Tawa
Linden
Kenepuru
Porirua
Paremata
Mana
Plimmerton
Pukerua Bay
Paekakariki
Paraparaumu
Waikanae
Observed Boards
Modelled Boards
Observed Alights
Modelled Alights
Observed Vol
Modelled Volume

5.4.7 Bus CBD Cordon Counts

Table 5-11 compares the observed Wellington City Cordon survey bus passenger counts to the modelled counts at the individual links.

Table 5-11: CBD Cordon Bus Passengers, Observed vs. Modelled, AM 2 hour Inbound

Links of CBD Cordon	Cordon Counts Average Month	Modelled	Difference
Oriental Parade	268	189	-29%
Cambridge Terrace	1507	1548	3%
Elizabeth Street	1876	1597	-15%
Willis Street	643	546	-15%
Taranaki Street	754	621	-18%
Tinakori Road	1056	1001	-5%
Kelburn Parade	672	567	-16%
Murphy Street	811	931	15%
Thorndon Quay	2166	2405	11%
	9754	**9405**	**-4%**

The overestimation of bus passengers at Thorndon Quay and Murphy Street is due to the model routing around 300 too many trips from the Johnsonville Line corridor onto bus. The other differences are likely partly due to short bus trips being assigned as walk trips, and partly due to a difference in time period between the cordon count and the WPTM demand.

5.4.8 Bus Screenline Volumes

Table 5-12 compares the reference and modelled bus passenger volumes at screenlines. Reference in this case includes both transit volumes (people crossing the screenline on a bus) and auxiliary volumes (people walking across the screenline), while the modelled includes only transit volumes. This allows the reference assignment to capture all demand from the ETM matrices. It would be preferable to have a true observed value, but no surveys were undertaken.

In general, the match between reference and modelled is good, with GEH values below five. One case that warrants further investigation is that the city cordon (C1 and W1) out volumes are significantly lower than reference. This is likely to be due to the location, as some high demand zones are situated just outside the cordon. For example the Bowen Street cordon for C1 is situated between The Terrace and Lambton Quay. Zones 651 and 652 are located just outside the cordon, in locations with quite high job density. It seems reasonable that people would exit a bus at Lambton Quay and travel to these zones. So the volax volume is quite high, and because reference includes volax while modelled does not, reference values will be higher. Another location where this is likely to be an issue is around Victoria University.

It should be noted that neither C1 nor W1 correspond exactly to the CBD cordon counts locations, hence values are slightly different.

Table 5-12: Bus Passenger Volumes at Screenlines, Reference vs. Modelled

		AM				IP			
ID	Direction	Reference (voltr + volax)	Modelled voltr	Diff %	GEH	Reference (voltr + volax)	Modelled voltr	Diff %	GEH
C1	In	8571	8710	2%	1.06	1753	1697	-3%	0.96
C1	Out	2869	1839	-36%	15.01	1227	1137	-7%	1.86
C2	In	304	640	111%	10.94	211	251	19%	1.87
C2	Out	113	81	-29%	2.32	115	142	24%	1.69
C3	In	1150	1102	-4%	0.99	575	642	12%	1.92
C3	Out	468	380	-19%	3.03	502	590	18%	2.66
C4	In	20	233	1042%	13.36	45	63	40%	1.72
C4	Out	79	79	-1%	0.03	68	49	-27%	1.70
W1	OUT	2763	2016	-27%	10.81	1444	1462	1%	0.33
W1	IN	9007	9156	2%	1.11	2010	2034	1%	0.37
W2	EB	163	163	0%	0.01	183	180	-2%	0.17
W2	WB	1186	1197	1%	0.22	247	254	3%	0.31
W3	EB	1116	1076	-4%	0.87	210	202	-4%	0.39
W3	WB	118	116	-2%	0.17	131	125	-5%	0.40
W4	NB	234	301	29%	2.93	202	344	70%	6.06
W4	SB	2734	3033	11%	3.94	451	538	19%	2.76
W5	NB	46	39	-14%	0.67	22	22	1%	0.04
W5	SB	67	64	-4%	0.23	27	23	-14%	0.53
W6	NB	2959	2979	1%	0.26	583	589	1%	0.19
W6	SB	339	336	-1%	0.14	348	364	5%	0.59
L1	NB	191	215	13%	1.19	103	186	81%	4.91
L1	SB	716	617	-14%	2.71	211	265	26%	2.48
L2	NB	63	115	82%	3.89	88	95	8%	0.53
L2	SB	327	406	24%	2.92	123	127	3%	0.21
L3	EB	393	392	0%	0.05	211	278	32%	3.04
L3	WB	595	507	-15%	2.66	273	314	15%	1.72
L4	EB	454	532	17%	2.48	302	324	7%	0.88
L4	WB	1032	1262	22%	4.82	318	331	4%	0.52
U1	NB	3	3	-11%	0.15	12	11	-3%	0.08
U1	SB	67	103	54%	2.77	14	14	0%	0.01
U2	NB	81	133	64%	3.54	52	59	15%	0.72
U2	SB	163	146	-11%	0.99	82	77	-6%	0.37
P1	NB	0	0	-	-	0	0	-	-
P1	SB	0	7	1255%	2.32	0	0	-	-
P2	EB	0	0	-	-	0	0	-	-
P2	WB	0	0	-100%	0.62	0	0	-	-
P3	NB	54	77	42%	1.98	28	43	51%	1.71
P3	SB	65	38	-42%	2.68	21	26	22%	0.68
K1	NB	0	0	-	-	0	0	-	-

		AM				IP			
ID	Direction	Reference (voltr + volax)	Modelled voltr	Diff %	GEH	Reference (voltr + volax)	Modelled voltr	Diff %	GEH
K1	SB	1	7	1166%	2.38	0	0	-	-
TOTAL		**38511**	**38098**	**-1%**	**1.49**	**12190**	**12856**	**5%**	**4.21**

The table below shows the distribution of GEH values for the bus screenlines.

Table 5-13: Distribution of Bus Screenline GEH values

	AM		IP	
GEH	#	%	#	%
<5	33	89%	33	97%
5-10	0	0%	1	3%
>10	4	11%	0	0%

The following plots illustrate the data from the table above. They indicate good agreement for both the AM and IP. The validation criterion specifies bus volumes at screenlines should be within 15% of reference. The general trend for both periods is within this, as are the majority of individual screenlines.

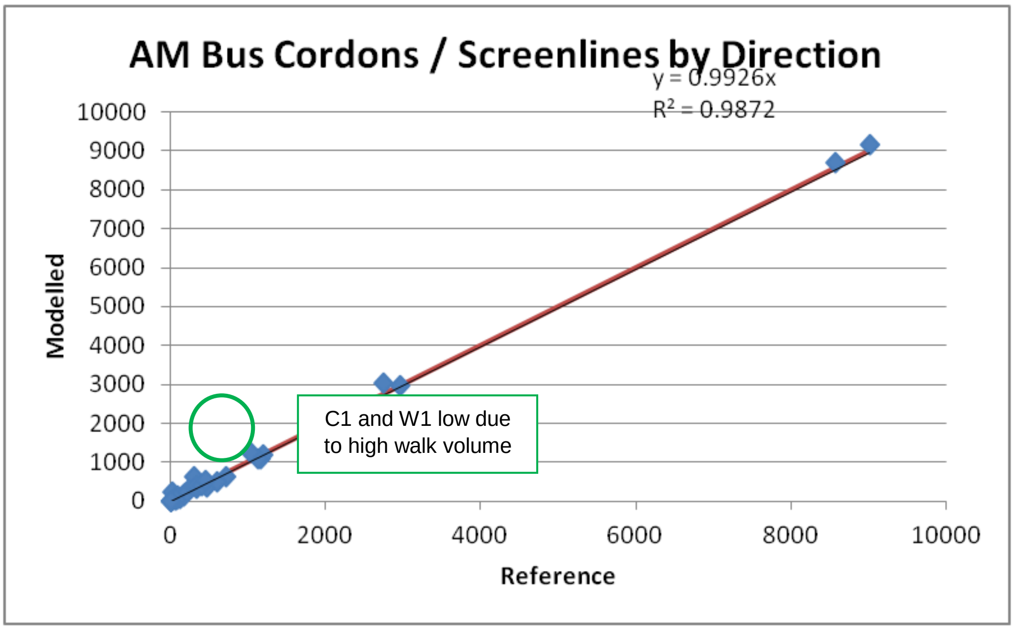


Figure 5-7: AM Bus Cordons / Screenlines, Modelled (Assignment) vs. Reference

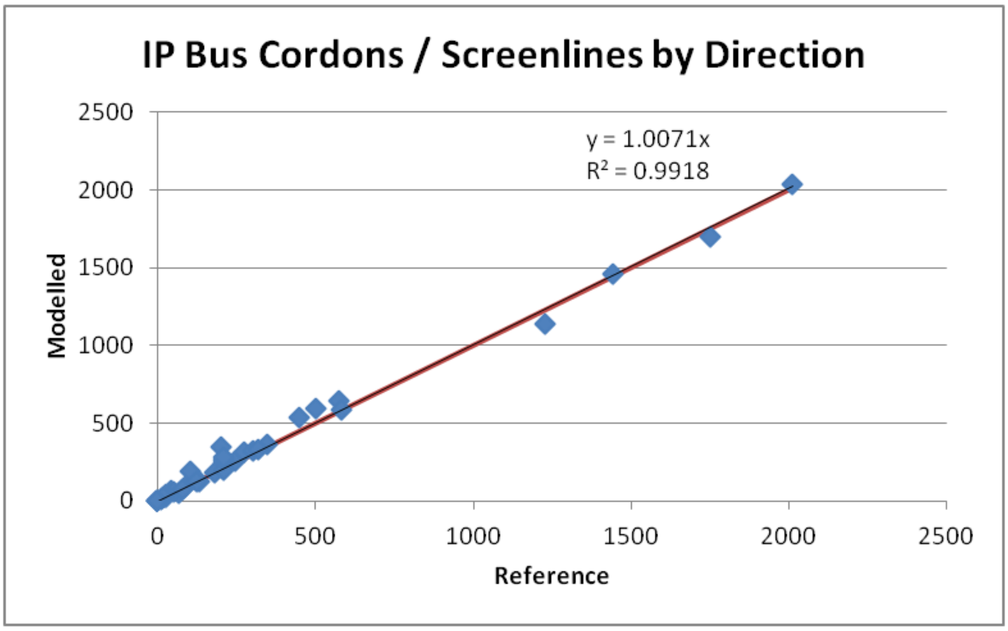


Figure 5-8: IP Bus Cordons / Screenlines, Modelled (Assignment) vs. Reference

5.4.9 Bus Boards

Figure 5-9 and Figure 5-10 below compare the modelled and observed bus boards for each route and direction. The observed data was extracted from the ETM database before transfer trips were removed.

The validation criterion states that a scattergram of boardings by route, modelled vs. reference should have a R^2 value of 85% or greater. This is satisfied for the AM graph but the IP graph is very slightly outside, with an R^2 of 84%.

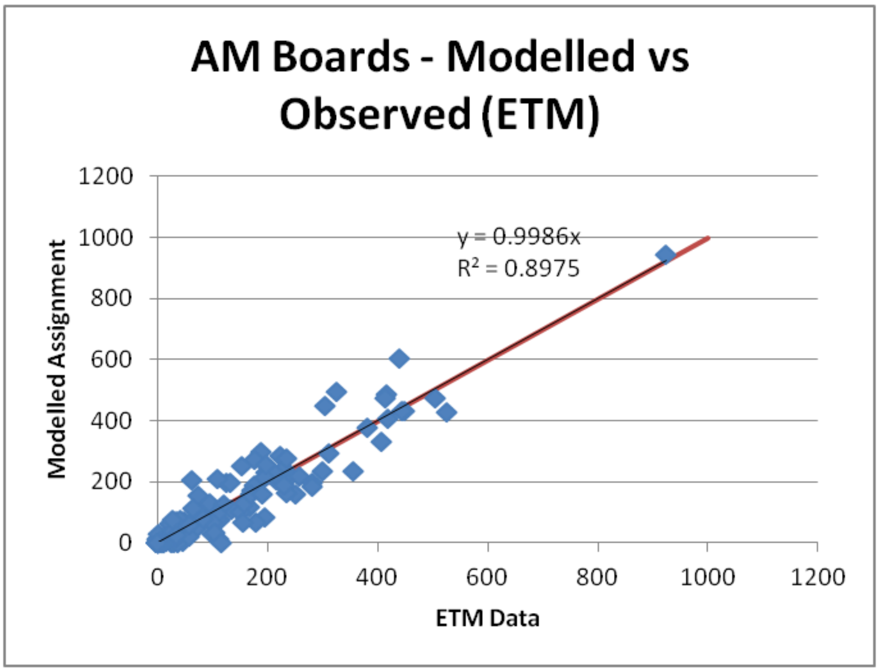


Figure 5-9: AM Boards, Modelled vs. Observed

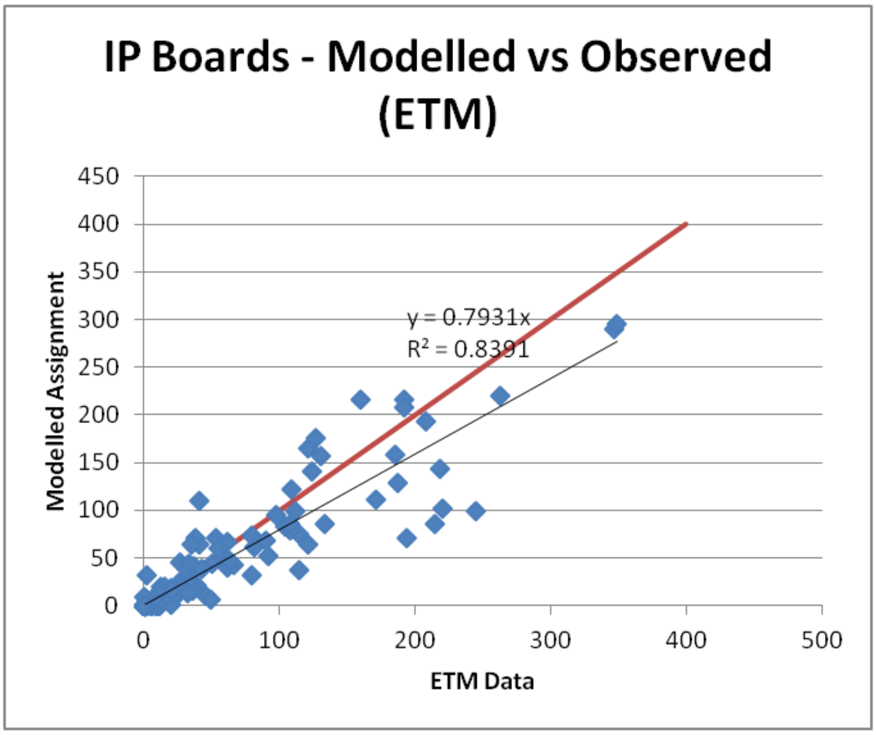


Figure 5-10: IP Boards, Modelled vs. Observed

5.4.10 Bus Maximum Load

The graphs below compare the seated capacity (based on 45 people per bus, default assumed in the PT cordon surveys) and modelled maximum load for each bus route and direction. The majority of routes are within seated capacity. Several routes exceed it slightly, but would still be within standing capacity. This satisfies the validation criterion.

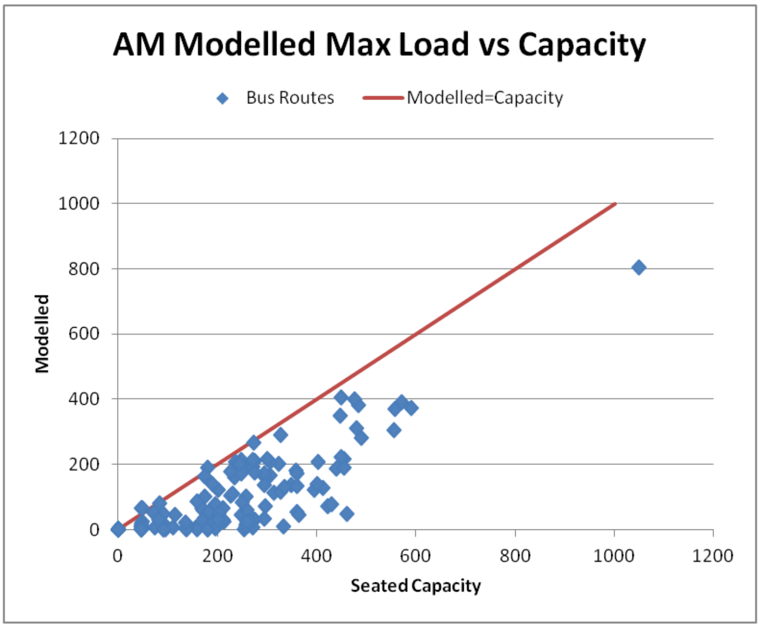


Figure 5-11: AM Maximum Load

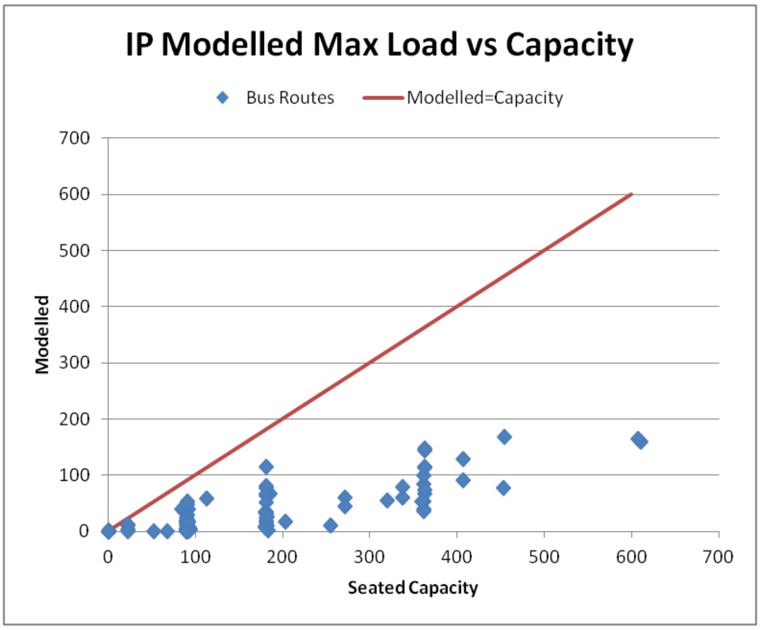


Figure 5-12: IP Maximum Load

5.4.11 Bus vs. Rail in Competing Corridors

Figure 5-13 and Figure 5-14 show the observed /reference and modelled bus/ rail shares in corridors where these modes compete. These corridors are Ngauranga Gorge (Kapiti Line vs. bus), Ngaio Gorge (Johnsonville Line vs. bus) and State Highway 2 between Petone and Ngauranga (Hutt Valley, Melling and Wairarapa lines vs. bus). It also compares the bus / ferry share from Eastbourne to the CBD. Similarly to the screenlines, the observed data for rail is taken from the rail boarding and alighting surveys, while the 'reference' data for bus is from an EMME assignment where bus and rail observed matrices are assigned separately.

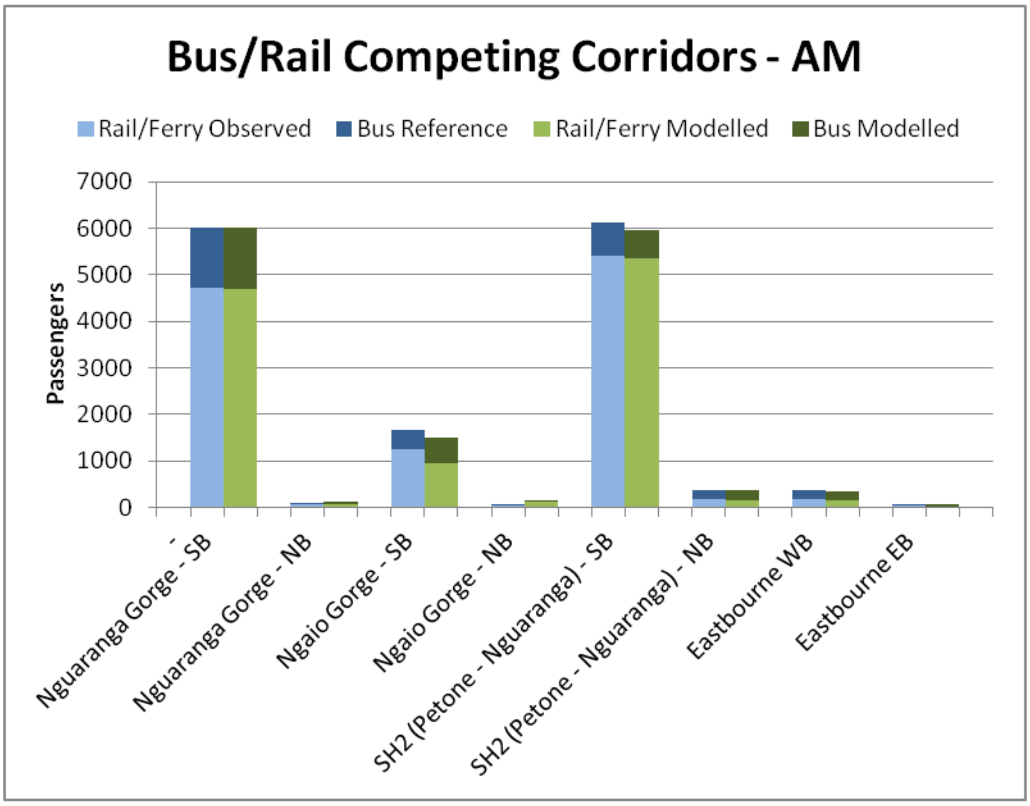


Figure 5-13: Bus vs. Rail Competing Corridors, AM

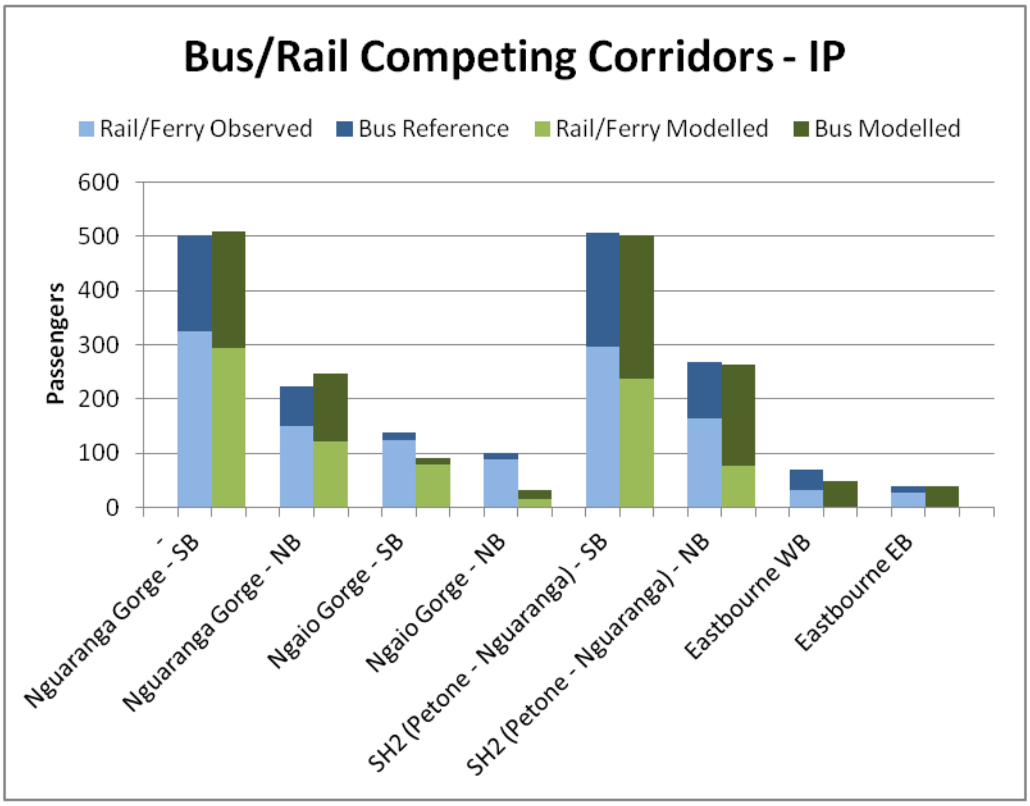


Figure 5-14: Bus vs. Rail Competing Corridors, IP

The key AM city bound movements are shown in Table 5-14. The validation criterion state that bus rail shares in competition corridors should be within 10% of observed, which is satisfied for these key movements.

Table 5-14: Percentage Shares in Key Competition Corridors

	AM Percentage Share				IP Percentage Share			
	Rail		Bus		Rail		Bus	
Corridor	Obs	Mod	Obs	Mod	Obs	Mod	Obs	Mod
Ngauranga Gorge SB	78%	78%	22%	22%	64%	58%	36%	42%
Ngaio Gorge SB	75%	63%	25%	37%	89%	86%	11%	14%
SH2 SB	88%	90%	12%	10%	58%	47%	42%	53%

5.4.12 Bus vs. Walk from Wellington Station

The plot below investigates bus vs. walk trips from Wellington Station to other zones along the Golden Mile. Red circles show zones which all people choose to walk to, whereas blue shows zones that some or all people choose to catch a bus to.

5.4.13 Airport Flyer (Route 91)

The Airport Flyer route is an important route in the Wellington network. It is perceived as a premium service by customers, hence using different parameters than bus was justified. If other services in the future have “Flyer” qualities, it will be up to modeller’s judgement on how to represent this.

The graphs (Figure 5-15 and Figure 5-16) below compare the observed boards, alights and volume for the Airport Flyer route in the AM period. We have tried to obtain a good validation for both inbound and outbound directions. However, sometimes it does not work out, and it is necessary to accept a poor match in one direction in order to get a good match in the other. This compromise can be seen within the Airport Flyer, for which model parameters were calibrated principally to replicate inbound movements – inbound being the more important of the two directions in the AM peak.

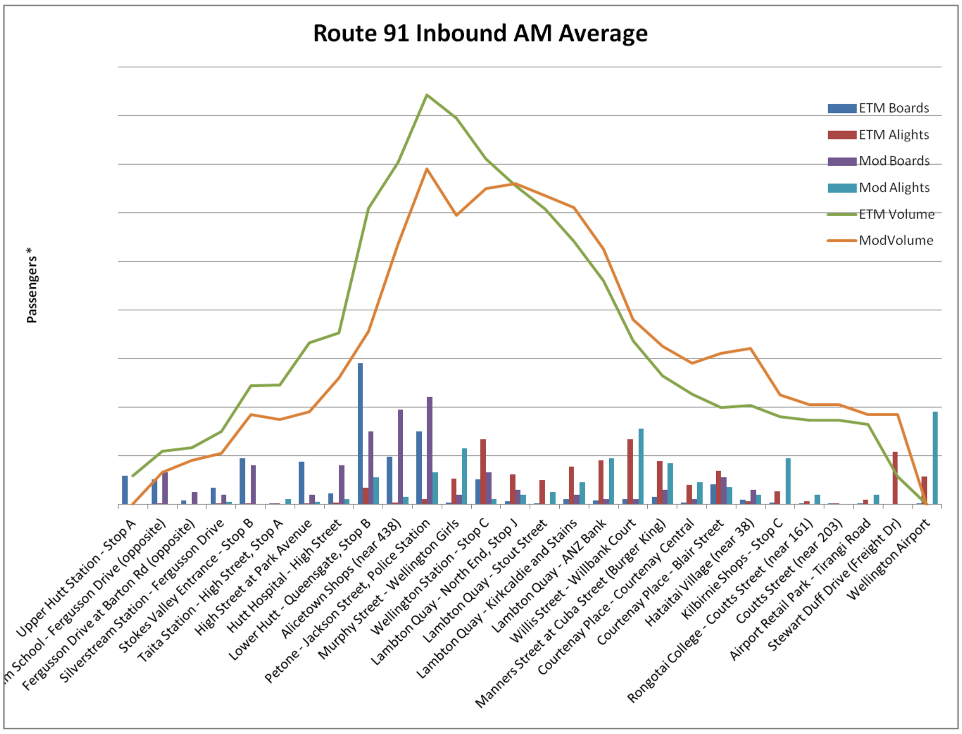


Figure 5-15: Airport Flyer Volumes, Inbound AM

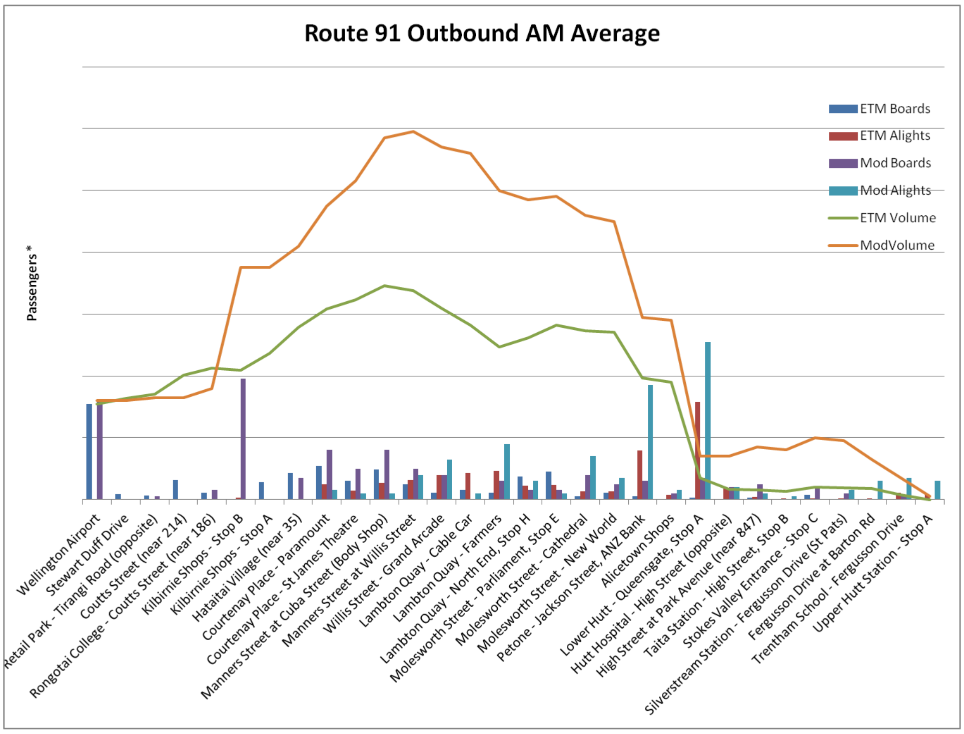


Figure 5-16: Airport Flyer Volumes, Outbound AM

*Numbers on y-axis removed for confidentiality reasons.

6 Conclusions

6.1 Discussion

The table below details the validation criteria, whether they are judged to have been met and a reference to the report section where the data can be found.

Criterion	Measurement	Acceptable?	Reference
Bus Demand			
Scatter-gram of boardings by route: modelled vs. reference	[R2 > 85% cf. ETM]	Acceptable	5.4.9
Maximum load vs. seated/standing capacity, by route	[load <= capacity]	Acceptable	5.4.10
Passenger volume between fare-zones, adult and child	[±15% cf. ETM]	Appears reasonable – see TA to TA section for a similar check.	3.4.7
CBD inbound volume	[±15% cf. ETM]	Acceptable (-6% demand only / -4% full model)	3.4.1 and 5.4.4
Adult journey purposes	[= on-board survey]	Acceptable	3.4.5
Distribution of bus access / egress trip lengths	[cf. on-board survey: judgement]	Acceptable	3.4.6
Rail Demand			
Passenger volumes between TA sectors	[±15% cf. expanded on-board survey data]	Acceptable	3.4.7
Boardings and alightings by station group	[±10% cf. Boarding & Alighting data]	**Demand** – acceptable - AM max 2%, IP max 11%. **Full model** – acceptable in AM except JVL. IP % differences high, although actual differences comparatively low.	3.4.2 and 5.4.6
Maximum load by line/direction, compared against seated/standing capacities	[load <= capacity]	Acceptable	3.4.2 and 5.4.6
Adult journey purposes and car availability	[=on-board survey]	Acceptable	3.4.5
Distribution of rail access / egress trip lengths by access mode	[cf on-board survey – judgement]	Acceptable	4.5.1
CBD inbound volume	[cf. survey of arrivals at Wellington – report only]	Acceptable (+4% demand only / -2% full model)	3.4.1 and 5.4.4
Access Choice			
Demand by access mode by station	[±20% cf. on-board survey data]	Acceptable	4.5.1

Criterion	Measurement	Acceptable?	Reference
Demand by access mode by station group	[±10% cf. on-board survey data]	Acceptable	4.5.1
Network			
Check list of coded services against definitive list	[matching]	Acceptable – checked against General Transit Feed	n/a
Scatter-gram of end-to-end running times by route	[R^2 > 85% cf. combined reference data created from combination of ETM & timetabled data]	Acceptable	5.4.1
Scatter-gram of sectional running times in the critical Wellington Station – Courtenay Place – Newtown corridor	[R^2 > 85% cf. reference data created from combination of ETM & timetabled data]	Differences – see TN1 for a further discussion	5.4.2
Scattergram of adult and child fares by fare-zone movement	[R^2 > 85% cf. Metlink fare table]	See TN1 for discussion	TN1
Assignment			
Bus and rail volumes at screenlines	[±15%]	Majority of screenlines meet this criterion, some do not.	5.4.5, 5.4.8
Bus/rail shares in competition corridors: Ngauranga Gorge, Ngaio Gorge, SH2 south of Petone	[±10%]	Acceptable in key competition corridors.	5.4.11
O to D comparisons: Metlink journey planner	[reasonable match of alternative route options and travel times – judgement]	Acceptable – bus, rail, ferry split appears ok for a selection of trips.	5.4.3

Appendix A– Enlarged Figures

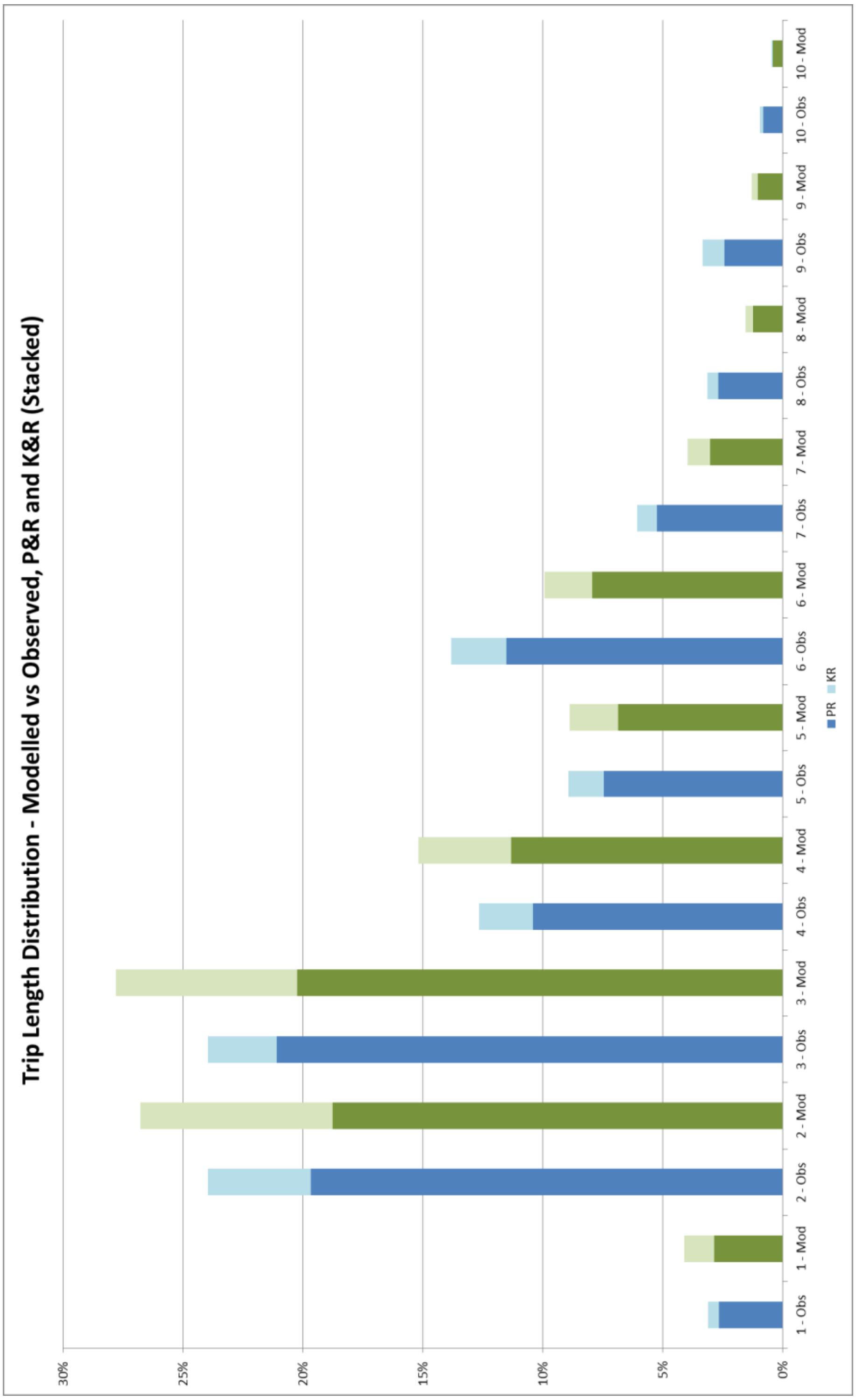


Figure 4-4: Comparison of Observed and Modelled Trip Length Distribution, P&R and K&R Trips, AM Peak, Trips Less Than 10km

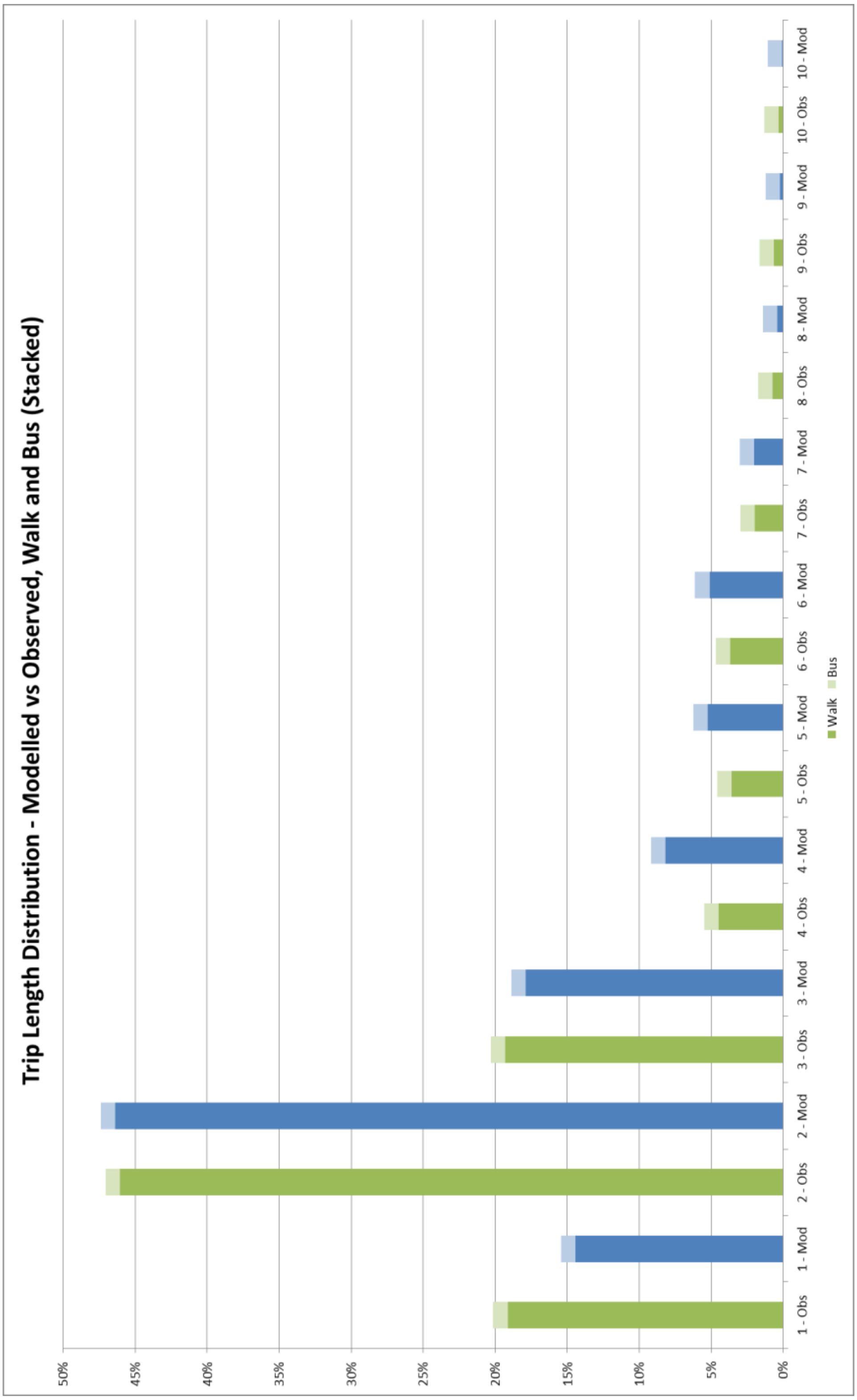


Figure 4-5: Comparison of Observed and Modelled Trip Length Distribution, Walk Access Trips, AM peak, Trips Less Than 10km

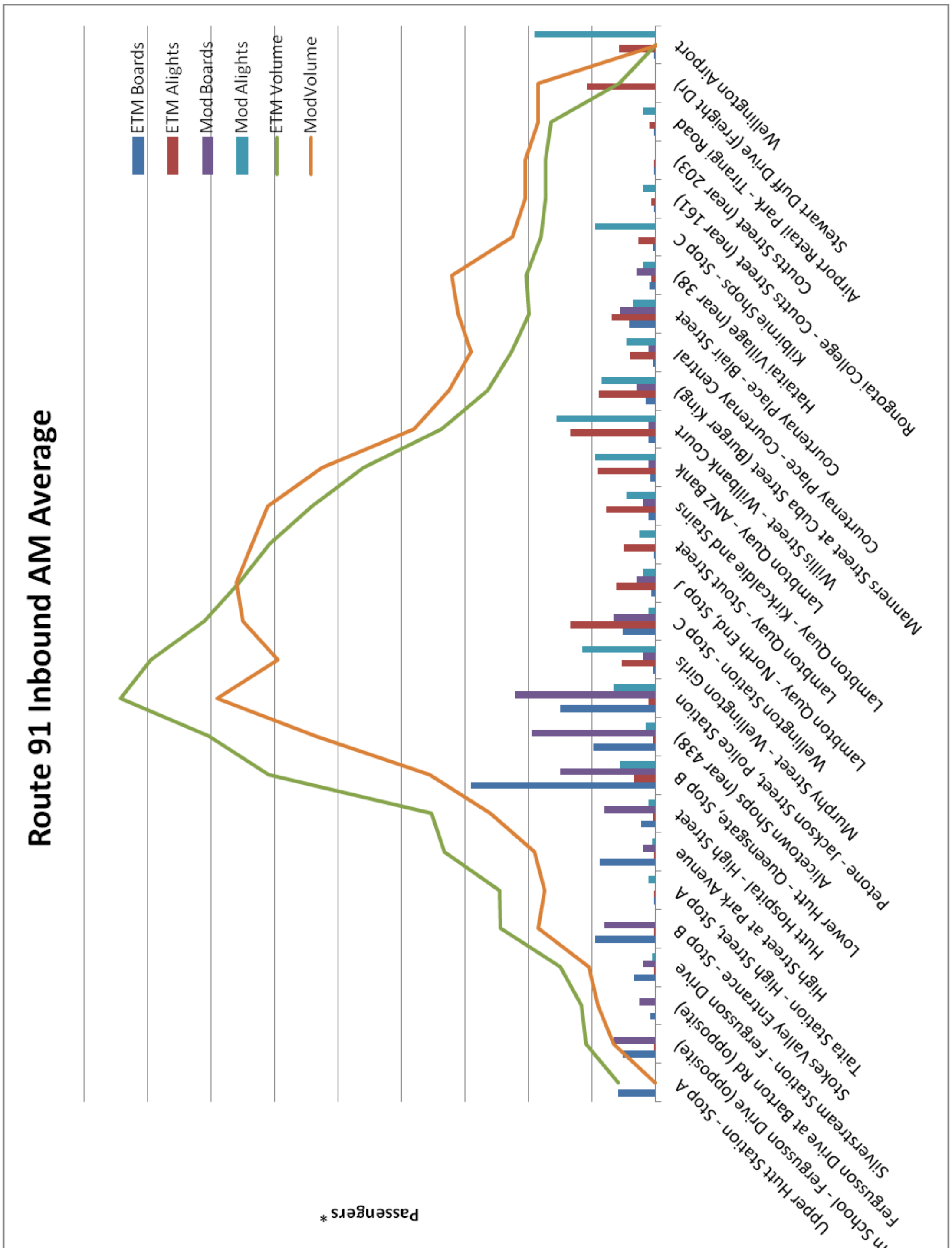


Figure 5-15: Airport Flyer Volumes, Inbound AM

*Numbers on y-axis removed for confidentiality reasons.

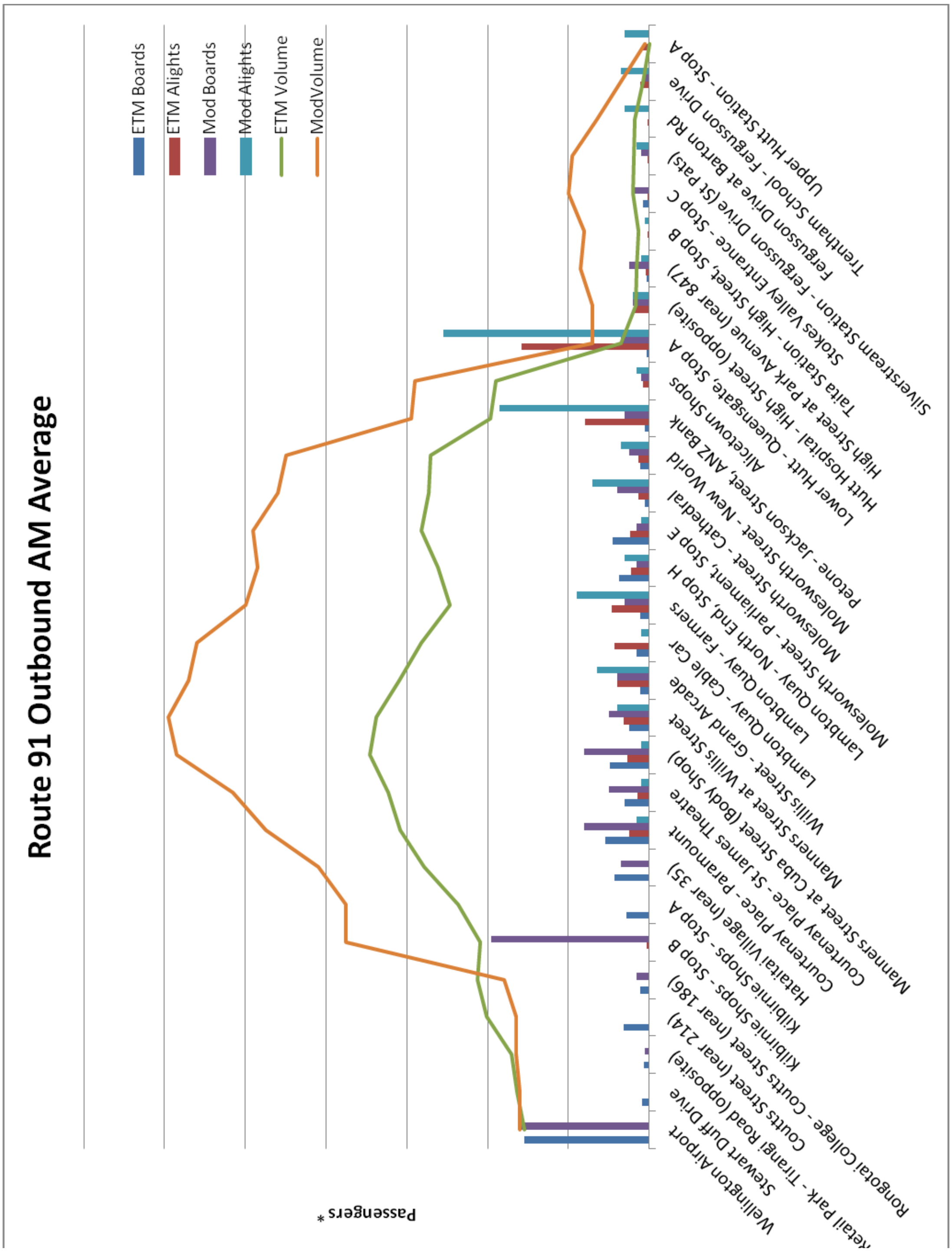


Figure 5-16: Airport Flyer Volumes, Outbound AM

*Numbers on y-axis removed for confidentiality reasons.