SINCLAIR KNIGHT MERZ

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greater WELLINGTON
REGIONAL COUNCIL

Update of the Wellington Transport Strategy Model (WTSM)

WTSM UPDATE VALIDATION REPORT

- Final
- June 2008

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1. Introduction

Greater Wellington Regional Council (GWRC) commissioned Sinclair Knight Merz Ltd to update the Wellington Transport Strategic Model (WTSM) to a 2006 base year and to review, investigate and advise on a number of specific model aspects.

The reviews and investigations related to the base year have been undertaken, documented in a series of technical notes and the WTSM Update Specification Report. Reference should be made to the latter, to which the technical notes are appended.

This report documents the update of WTSM to a 2006 base year and sets out the 2006 validation. The validation date is nominally March 2006 to coincide with the 2006 Census. The land use (demographic) input data, transport networks and observed data for validation reflect this as far as possible. The traffic counts undertaken prior to this commission were taken at the time of the Census, and further counts were obtained for 2006 and taken in 2007 as required. The travel time surveys were undertaken in 2007.

Some of the information used in the model validation provided by Passenger Transport Service Providers is confidential and commercially sensitive. Where appropriate this information has been removed from this report.

Subsequent to the completion of this Validation Report, modifications were made to the base 2006 model related to Peer Review comments and discussions with GWRC. These modifications are detailed in a file note included in Appendix C. This note reports key 2006 WTSM validation statistics and compares outputs from the previous 2016 and 2026 forecasts with the new forecasts. The validation achieved is at the same level as detailed in this Validation Report.

1.1. Project Brief

The project brief classified the tasks into those that were to be implemented (Primary Tasks) and those that a decision would be made on following the investigation phase (Secondary Tasks) as follows:

Primary Tasks

- Task 5.2.1 Update Input Rates
- Task 5.2.2 Update networks
- Task 5.2.3 Enhance road network detail
- Task 5.2.4 Validate auto assignment
- Task 5.2.5 Validate PT assignment
- Task 5.2.6 Commercial Vehicle Model

- Task 5.2.7 Changing 2001 HTS trip rates
- Task 5.2.8 Actually vs usually resident population
- Task 5.2.9 Higher PCE factor for CVs
- Task 5.2.10 Update to 2005 Vehicle Fleet Emissions Factors
- Task 5.2.11 Demographic projections
- Task 5.2.12 Car ownership
- Task 5.2.13 Traffic data and screenline review
- Tasks 5.2.14/15 PT data and screenline review

Secondary Tasks

- Task 5.3.1 Intersection delays and merges
- Task 5.3.2 Park & ride sub mode choice model
- Task 5.3.3 Passenger capacity constraint for rail and bus services
- Task 5.3.4 Multi-class assignment
- Task 5.3.5 CV route choice function
- Task 5.3.6 Adjust flight related airport trips
- Task 5.3.7 Including interisland traffic

1.2. Structure of Report

The remainder of the report is structured as follows:

- Chapter 2: summarises the outcomes of the investigations to date
- Chapter 3: presents the 2006 land use inputs and makes comparisons with the 2001 data
- Chapter 4: lists the changes made to the 2001 networks to create the 2006 networks
- Chapter 5: sets out the development of 2006 input values
- Chapter 6: describes the development of the 2006 commercial vehicle matrices
- Chapter 7: describes other changes made to the 2006 model
- Chapter 8: compares the 2001 and 2006 matrix totals and network statistics
- Chapter 9: sets out the 2006 validation
- Chapter 10: summarises the report and makes conclusions

2. Summary of Investigations

This chapter summarises the status of each task listed in the project brief (refer to Section 1.1) and in particular sets out the outcomes of the investigations undertaken for the 2006 base model.

2.1. Primary Tasks

- Task 5.2.1 Update Input Rates: Rates updated to 2006 values using the same approach as for 2001 (refer to Chapter 5)
- Task 5.2.2 Update networks: Networks updated to 2006 (refer to Chapter 4)
- Task 5.2.3 Enhance road network detail: Network reviewed, possible enhancements proposed and implemented (refer to Chapter 4)
- Task 5.2.4 Validate auto assignment: undertaken (refer to Chapter 9)
- Task 5.2.5 Validate PT assignment: undertaken (refer to Chapter 9)
- Task 5.2.6 Commercial Vehicle Model: undertaken (refer to Chapter 6)
- Task 5.2.7 Changing 2001 HTS trip rates: changing rates over time was investigated with no change recommended
- Task 5.2.8 Actually vs usually resident population: use of the two was investigated with the recommendation that factors for converting between the two be developed
- Task 5.2.9 Higher PCE factor for CVs: implementing this in assignment was reviewed with the recommendation that, if necessary, HCV count data and travel time comparisons be used as the basis for adjusting capacities on the motorway network; no adjustments have been made.
- Task 5.2.10 Update to 2005 Vehicle Fleet Emissions Factors: part of forecasting phase and detailed in the Future Year Forecasting Report
- Task 5.2.11 Demographic projections: undertaken as part of forecasting phase and detailed in the Future Year Forecasting Report
- Task 5.2.12 Car ownership: being undertaken as part of the forecasting phase and detailed in the Future Year Forecasting Report
- Task 5.2.13 Traffic data and screenline review: screenlines reviewed and recommendations made, travel time surveys undertaken and some counts redone (refer to Chapter 9)
- Tasks 5.2.14/15 PT data and screenline review: ETM data processed, available rail data analysed

2.2. Secondary Tasks

- Task 5.3.1 Intersection delays and merges: issues identified, range of possible solutions investigated, recommended changes to procedures implemented (refer to Section 7.3)
- Task 5.3.2 Park & ride sub mode choice model: investigation and review carried out, recommendation to retain existing procedures but with some enhancements, which have been implemented (refer to Section 4.2)
- Task 5.3.3 Passenger capacity constraint for rail and bus services: investigated and recommendations made; removed from the scope of the project
- Task 5.3.4 Multi-class assignment: the need for multi-class assignment was reviewed with the recommendation to implement two classes in the final assignment only (refer to Section 7.4)
- Task 5.3.5 CV route choice function: issue identified and approaches for dealing with this reviewed, recommendation to ban HCVs from specified routes in the final assignment (refer to Section 7.4).
- Task 5.3.6 Adjust flight related airport trips: relevant existing data sought, no action required
- Task 5.3.7 Including interisland traffic: relevant existing data sought, no action required

3. Input Land Use Data

The 2006 land use input data was developed by MERA Ltd at the same time as new forecast inputs were produced as part of the update project (Task 5.2.11). The data was produced from 2006 Census data provided by Statistics New Zealand using the same definitions as for 2001.

The details of their development are reported separately in the report: *2006 Base Run, Demographic Development Model Summary Report, February 2008*. The results of this are summarised here and compared with the corresponding 2001 data (Table 1). Appendix A lists the data by zone. The data show that there has been a 7% increase in population between 2001 and 2006, while households have increased by 6% - indicating a slight reduction in average household size.

Total employment has increased by 9%, made up of reductions in transport and communications and “other” and fairly uniform percentage increases in the remaining three sectors.

Education rolls show an increase of 29%, largely due to an 80% growth in tertiary rolls. The latter is due to different methods for determining the tertiary rolls; for 2001 they are from a combination of published statistics and other estimates, while for 2006 they are from Ministry of Education counts which then required allocation to each site. Hence comparing the two figures is not particularly valid, though it is useful to note that national enrolments rose by 40% over this period.

- **Table 1 Summary 2001 and 2006 Land Use Data**

Data	2001	2006	Difference	% Difference
Infants	30,707	30,516	-191	-1%
Children 5-10 yrs	37,196	37,099	-97	0%
Children 11-16 yrs	36,381	38,753	2,372	7%
Young Adult Full-Time Employed	23,512	24,609	1,097	5%
Young Adult Part-Time Employed	10,461	11,962	1,501	14%
Young Adult Other	19,305	22,971	3,666	19%
Adult Full-Time Employed	139,885	149,258	9,373	7%
Adult Part-Time Employed	29,614	30,712	1,098	4%
Adult Other	52,286	57,375	5,089	10%
Older Adult Full-Time Employed	2,209	3,208	999	45%
Older Adult Part-Time Employed	2,840	3,731	891	31%
Older Adult Other	39,151	41,524	2,373	6%
Population Total	**423,547**	**451,204**	**27,657**	**7%**
1 Adult Employed	25,617	28,813	3,196	12%
1 Adult Non-Employed	25,094	24,558	-536	-2%
2 Adults (Min of 1 Employed)	65,636	71,037	5,401	8%
2 Adults Neither Employed	14,685	13,992	-693	-5%
3+ Adults	26,265	28,455	2,190	8%
Household Total	**157,297**	**166,899**	**9,602**	**6%**
Manufacturing	30,999	34,284	3,285	11%
Retail	42,356	49,265	6,909	16%
Transport & Communications	12,551	11,204	-1,347	-11%
Services	121,275	133,840	12,565	10%
Other	6,339	4,971	-1,368	-22%
Employment Total	**213,520**	**233,565**	**20,045**	**9%**
Primary	35,647	37,024	1,377	4%
Secondary	36,614	42,757	6,143	17%
Tertiary	26,449	47,521	21,072	80%
Education Rolls Total	**98,710**	**127,302**	**28,592**	**29%**

4. Networks

4.1. Road networks

The AM, IP and PM road networks have been updated to 2006 from 2001 (Task 5.2.2) using information provided by Transit and the Territorial Authorities. This included any new roads of relevance to the model, new and upgraded intersections, changes to numbers of lanes – including the impact of new bus lanes – and an extensive review of link free flow speeds and lanes.

The following changes were implemented:

Kapiti Coast

- Nil

Porirua

- Lyttelton Avenue: new link and roundabouts added

Southern Wairarapa and Masterton

- Nil

Upper Hutt

- Norana Road to SH2 link added

Hutt

- Upgrade Parkside Rd/Seaview Rd intersection to roundabout
- Upgrade Seaview Rd/Randwick Rd/Waione St roundabout to 2 lanes
- Northbound bypass lane heading north onto Hutt Rd at Esplanade/Hutt Rd
- Roundabouts at High St/Fairway Dr/Daysh St, Rutherford St/Queens Dr, High St/Queens Dr, Melling Rd/High St and Naenae Rd/Daysh St intersections.

Wellington City Council

- Wakefield St and Cable St: increased to three lanes
- Dixon St (Victoria St - Willis St): changed to one-way west-bound
- Buslanes: Kaiwharawhara Rd (AM), Adelaide Rd (AM), Chaytor St (AM, IP), Manners St AM, IP), Dixon St (AM, IP), Lambton Quay (AM, IP), Lambton Quay (AM, IP), Hunter St (AM, IP), Willis St (AM, IP)
- Roundabouts: Onepu Rd/Lyall Bay Pde and Miramar Ave / Park Rd intersections
- Signals: Birdwood St/ Chaytor St, Waring Taylor St/ Featherston Stand Willis/Dixon St intersections

Transit New Zealand

- SH1 Plimmerton to Mana Upgrade: Bridge duplication, HOV lane
- SH1 Pukerua to Plimmerton 4-laning
- SH2 Kaitoke to Te Marua Realignment (increase capacity and free flow speed)
- SH1 Raumati Straights 4-laning
- Basin Reserve Alterations: School to Adelaide Road increased to 2 lanes with new signals

In addition to the above a review of the network detail in relation to the zoning system was undertaken (Task 5.2.3). This resulted in the following further additions to the road network in order to improve model definition:

Kapiti

- Paraparaumu: Rimu Road (Kapiti to Raumati Roads)

Porirua

- Tawa: Hinau Street–Duncan Street
- Mana: Pope Street (SH1 to Grays)

Southern Wairarapa and Masterton

- Nil

Upper Hutt

- Akatarawara Road (Brown Owl to Waikanae)

Hutt:

- Taita: Taine Street –Reynolds Street
- Stellin Street to Fairway Drive
- Wainuiomata: Parkway
- Daly Street and Rutherford Street
- Petone: Udy Street

Wellington

- Newlands: Helston Road-Bracken Road
- Johnsonville: Fraser Avenue (Johnsonville-Burma Road)
- Brooklyn: Washington Street north end (Cleveland Street to Brooklyn)
- Brooklyn/Vogeltown: Connaught Terrace-Moffitt Street
- Mornington: Liardet Street-Britomart Street
- Newtown/Melrose: Mansfield-Roy-Manchester Streets
- Rongotai: Tirangi Road-Coutts Street

The Mana HOV lane is modelled simply in terms of the appropriate road capacity which reflects the use of it; this does not include a feedback loop to a change of demand and/or occupancy. Hence the HOV lane is represented as 0.3 of a lane, based on the estimated proportion of traffic that could use the lane. The section of road with the HOV lane is coded as 1.3 lanes to reflect the capacity of 1 lane for general traffic and 0.3 of a lane for HOV traffic. This operates in the peak-flow directions in the AM and PM peak periods.

The 0.3 of a lane is based on information from a study undertaken by Pinnacle Research in 2003, which showed that in the peak around 73% of cars have one occupant and 27% 2 or more occupants. With around 2,900 vehicles in the peak southbound along the Mana Esplanade, some 790 cars have more than one occupant. Assuming that all of these vehicles use the HOV lane, an additional 30% capacity (790/2600) is created due to the HOV lane. Hence the overall capacity is increased from 1 lane to 1.3 lanes.

In addition to the above a review of the network detail in relation to the zoning system was undertaken (Task 5.2.3). This resulted in the following additional roads or sections of roads being added to the road network in order to improve model definition:

Kapiti

- Paraparaumu: Rimu Road (Kapiti to Raumati Roads)

Porirua

- Tawa: Hinau Street–Duncan Street
- Mana: Pope Street (SH1 to Grays)

Southern Wairarapa and Masterton

- Nil

Upper Hutt

- Akatarawara Road (Brown Owl to Waikanae)

Hutt:

- Taita: Taine Street –Reynolds Street
- Stellin Street to Fairway Drive
- Wainuiomata: Parkway
- Daly Street and Rutherford Street
- Petone: Udy Street

Wellington

- Newlands: Helston Road-Bracken Road
- Johnsonville: Fraser Avenue (Johnsonville-Burma Road)
- Brooklyn: Washington Street north end (Cleveland Street to Brooklyn)
- Brooklyn/Vogeltown: Connaught Terrace-Moffitt Street
- Mornington: Liardet Street-Britomart Street
- Newtown/Melrose: Mansfield-Roy-Manchester Streets
- Rongotai: Tirangi Road-Coutts Street

4.2. PT Networks

The AM peak and Interpeak PT services were updated from 2001 to 2006, and the PM peak PT network was coded for use in a final assignment.

The AM peak and Interpeak bus services were updated (Task 5.2.2) initially by obtaining a list of changes since 2001 from GWRC and then using the information on Metlink to modify the 2001 services. This was followed by a comprehensive review of the timetabled versus modelled services.

Bus Service Changes

The main changes to bus services identified initially were:

- New services:
  - Kapiti Coast, Waikanae-Paraparaumu
  - Kapiti Coast, Otaki
  - Valley Heights, Route 121
  - Petone-Emerald Heights & Upper Hutt
  - Petone- Stokes Valley
  - Petone-Naenae
  - Petone-Kelson
  - Korokoro
  - Ranui Heights
  - Johnsonville West: Route 53
  - Evans Bay
- Deleted services:
  - Seatoun express
- Increased frequency:

- Churton Park (AM peak)
- Green route (AM peak)
- Seatoun: Breaker Bay and Scorching Bay expresses
- Island Bay: Route 32
- Petone-Upper Hutt
- Eastern Porirua: Castor Crescent – Porirua
- Johnsonville-Porirua
- Miramar/Evans Bay: Routes 27 & 42

- Route changes:
  - Island Bay: Route 32

Rail Service Changes

The changes to rail services were:

- AM Peak:
  - Increased frequency of these services: Johnsonville, Masterton, Melling, Paraparaumu express, Upper Hutt express;
  - Reduced frequency of this service: Porirua-Wellington;
  - Modification of this service: Plimmerton-Wellington extended to Paraparaumu-Wellington, Wellington-Paraparaumu;
  - Removal of these services: Wellington-Porirua, Upper Hutt-Petone.
- Interpeak:
  - Increased frequency of these services: Melling-Wellington, Paraparaumu-Wellington both directions);
  - Removal of these services: Wellington-Porirua/Paraparaumu, Wellington-Plimmerton both directions (replaced by Wellington-Paraparaumu), Wellington-Taita, Upper Hutt/Petone-Wellington.

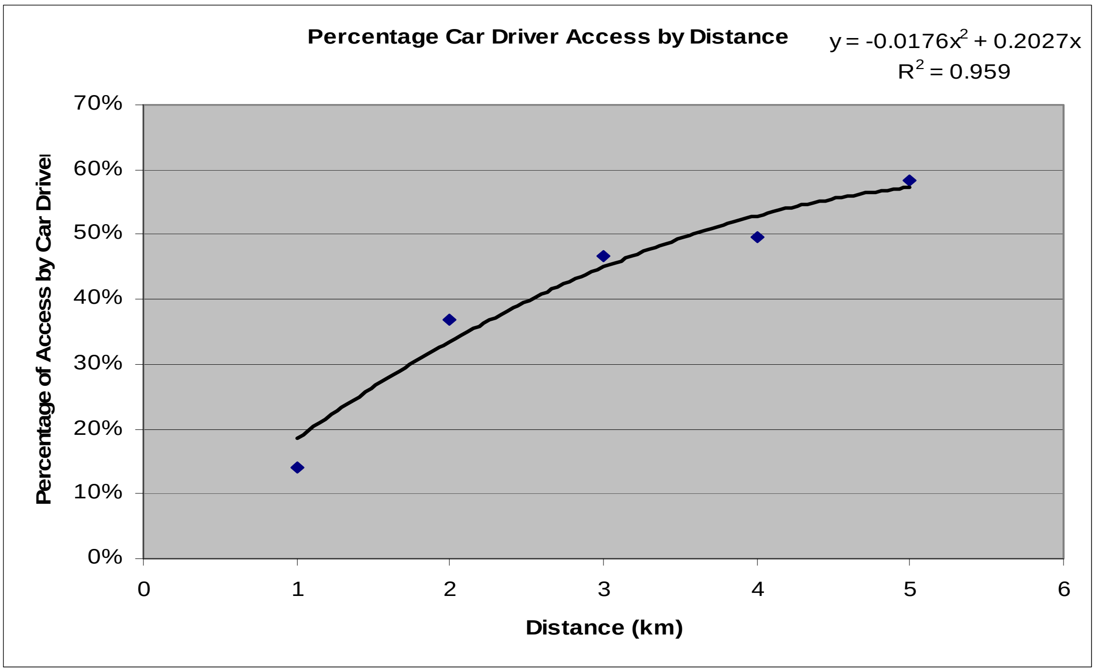
P-Connectors

Following consideration of implementing a park-and-ride sub-mode choice model in WTSM (Task 5.3.2), two enhancements to the long-distance access links (p-connectors) to rail stations were implemented:

- The network was modified so that situations of p-connectors being used for through trips and not as PT access/egress were eliminated. An additional node was added to the rail network at each station, and walk and p-connector access adjusted to use separate station nodes. This means that boarding is now required if p-connectors are used.

- The car component of trips on the p-connectors has been identified, extracted from the links and inserted into the car trip matrices. The original 2001 rail survey data was used to develop a relationship between the proportion of car access trips and the distance from the station (Figure 1).

- **Figure 1 Car Driver Access vs Distance**



This function is applied to each p-connector for distances less than 6km and for greater distances the proportion of car access trips is kept constant at 60%. The car trips on each link added to the AM peak car matrix with each station being represented by the zone closest to it. The reverse trips are added to the PM peak car matrix. This process occurs just prior to the generalised cost assignments in each iteration of the distribution-mode choice models.

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5. Input Rates

This section sets out the updated 2006 values of time and private vehicle operating costs that are used in WTSM for both generalised costs and assignment, and updated PT fares to reflect the increases since 2001. (Task 5.2.1)

5.1. Values of Time

The same procedure as used for the 2001 model has been carried out to update to 2006 values. The values of time from the EEM were factored to 2006 values, and then combined with the proportions of trip purposes in the 2001 Wellington HTS to give the updated values. The Statistics New Zealand Website, gives the GDPs for 2002 and 2006 as 109,852 and 126,009 respectively. Based on this uplift factor would be $^{126,009}/_{109,852}$ = 1.15. The EEM gives, as guidance, an 11% increase between 2002 and 2006, which has been used as the uplift factor.

The basic values of time for 2002 were taken from NZ Economic Evaluation Manual Vol1, Section A4, Table A4.1 (Table 2). Table 3 gives the 2006 values of time by mode, the HTS trip numbers by mode and purpose and the resulting 2006 values of time by purpose.

- **Table 2 2002 Values of Time, EEM**

Mode	Work Travel Purpose		Commuting to/from Work		Other Non-work travel purpose	
	$/hr	c/min	$/hr	c/min	$/hr	c/min
Car Driver	23.85	39.75	7.80	13.00	6.90	11.50
Car Passenger	21.70	36.17	5.85	9.75	5.20	8.67
LCV Driver	23.45	39.08	7.80	13.00	6.90	11.50
LCV Passenger	21.70	36.17	5.85	9.75	5.20	8.67
Truck Driver	20.10	33.50	7.80	13.00	6.90	11.50
Truck Passenger	20.10	33.50	5.85	9.75	5.20	8.67
Public Transport	21.70	36.17	4.70	7.83	3.05	5.08

- **Table 3 2006 Values of Time (c/min) and HTS Trips**

Purpose	Car Availability	2006 VOT (c/min)				Trips				2006 VOT
		Car Dr	Car Pax	PT	CV	Car Dr	Car Pax	PT	CV	
HBW	Captive	14.4	10.8	8.7		423	717	3048		9.6
HBW	Competition & Choice	14.4	10.8	8.7		141940	26803	37245		12.9
HBEd	Captive	12.8	9.6	5.6		64	626	3615		6.3
HBEd	Competition & Choice	12.8	9.6	5.6		37596	48967	30268		9.6
EB	All	44.1	40.1	40.1	43.3	79792	9007	4291	32765	43.5
Other	Captive	12.8	9.6	5.6		1876	18043	13395		8.2
Other	Competition & Choice	12.8	9.6	5.6		569006	213199	32759		11.7

The 2001 and 2006 values are given in Table 4. For all purposes but EB, the 2006 values are slightly lower than in 2001; this is due to the 2001 values being based on the PEM values at that time, whereas the 2006 values are based on EEM 2002 values.

Table 4 2001 and 2006 Values of Time

Purpose	Car Availability	2001 VOT ($/min)	2006 VOT ($/min)
HBW	Captive	0.103	0.096
HBW	Competition and Choice	0.136	0.130
HBEd	Captive	0.065	0.063
HBEd	Competition and Choice	0.102	0.097
EB	All	0.392	0.435
Other	Captive	0.085	0.083
Other	Competition and Choice	0.121	0.116

The fixed cost weighting used in the assignment is calculated from the above values as the average weighted by the HTS trips for each purpose, and for 2006 is 6.3 min/$, which is the same as used in 2001.

For the 2006 model the CV fixed cost weighting is required for the final multiclass assignment; this is 2.7 min/$.

5.2. Vehicle Operating Costs

Overview

Vehicle operating costs (VOC) have been implemented as network-wide global values rather than with reference to travel conditions on each link, and as such the VOC do not vary as congestion levels change.

The costs to be taken into account according to NZ Economic Evaluation Manual Section A5 are:

- Base costs with respect to speed and gradient (A5.2)
- Road surface condition (A5.3)
- Congestion (A5.4)
- Stoppages (A5.5)
- Changes in Speed (A5.6)

In addition to this, the Road User Charges for diesel vehicles will also be included. The costs are calculated in units of cents/km.

Road surface condition is considered a repair and maintenance (R&M) cost. *Congestion*, *Stoppages* and *Changes in Speed* are all to be attributed as fuel costs.

All costs are calculated separately for the following vehicle types

- Private Car (PC)
- Light Commercial Vehicle (LCV)
- Medium Commercial Vehicle (MCV)
- Heavy Commercial Vehicle Category I (HCVI)
- Heavy Commercial Vehicle Category II (HCVII)
- Bus

Base costs

An average speed of 45 kph and an average grade of 1% have been assumed.

Base costs are disaggregated into constituent cost components using the distributions in Table A5.0(a) (Table 5).

- **Table 5 Component Cost Distribution from A5.0 (a)**

Class	Fuel/Oil	Tyres	R&M	Depreciation
PC	30.0%	7.0%	29.3%	33.7%
LCV	32.3%	8.3%	27.3%	32.1%
MCV	30.4%	7.2%	45.4%	17.0%
HCVI	34.7%	10.5%	44.3%	10.5%
HCVII	31.3%	13.5%	43.4%	11.8%
Bus	29.9%	6.3%	45.5%	18.3%

The total costs extracted are given in Table 6.

- **Table 6 Base Costs from Tables A5.1 to A5.6 and Components**

Class	Base Cost (c/Km)	Component Costs (c/Km)			
		Fuel/Oil	Tyres	R&M	Depreciation
PC	15.5	4.7	1.1	4.5	5.2
LCV	15.3	4.9	1.3	4.2	4.9
MCV	26.6	8.1	1.9	12.1	4.5
HCVI	50.3	17.5	5.3	22.3	5.3
HCVII	86.9	27.2	11.7	37.7	10.3
Bus	40.6	12.1	2.6	18.5	7.4

Road surface condition

The roughness costs account for wear and tear on the vehicle due to the roughness of the roads. All these costs are assumed to be R&M. For this calculation, the international roughness index (IRI) is assumed to be 4.5. The costs from Table A5.12 are given in Table 7.

- **Table 7 Roughness Costs (Table A5.12)**

Class	Costs (c/km)
PC	1.6
LCV	1.5
MCV	4.1
HCVI	5.9
HCVII	8.2
Bus	5.6

Congestion

The congestion costs account for the additional fuel vehicles use due to the busyness of the roads. This is measured using the Volume-Capacity (VC) ratio. The higher the ratio, the more congested the roads are.

A VC of 0.7 was assumed and the resulting values from Table A5.16 are given in Table 8.

- **Table 8 Congestion Costs (Table A5.16)**

Class	Costs (c/km)
PC	0.9
LCV	1.1
MCV	1.5
HCVI	5.7
HCVII	16.6
Bus	3.6

Stoppages

Stoppage costs account for fuel used whilst a vehicle is idle due to bottlenecks in the road network. Values from the Table A5.22 are given in cents per minute [stopped] so assumptions on the stops per kilometre and the average stop time were made to transform this value to cents per kilometre.

Assumptions are:

- 1 stop per 10km travelled
- 4min per stop

- **Table 9 Costs from Table Af.22 and Output VOC**

Class	Costs (c/min)	Costs (c/km)
PC	1.11	0.44
LCV	1.24	0.50
MCV	1.38	0.55
HCVI	2.06	0.82
HCVII	2.06	0.82
Bus	1.62	0.65

Changes in Speed

The *changes in speed* costs account for additional fuel used when the vehicle slows has to slow down and then speed back up. This is known as a "cycle" and can be caused by road geometry or intersections. Values are given in cents per cycle.

Assumptions are:

- 1 intersection stops per kilometre (as opposed to bottleneck stops in the *Stoppages*)
- Lower speed is 0kph
- Upper speed is 65 kph

- **Table 10 Cycle Costs from Tables A5.25/.27/.29./31/.33/.35**

Class	Costs (c/cycle)	Costs (c/km)
PC	0.9	0.9
LCV	1.2	1.2
MCV	3	3
HCVI	8.3	8.3
HCVII	18.5	18.5
Bus	6.3	6.3

Summary

Table 11 contains the final calculations for vehicle operating costs.

- **Table 11 VOC (c/Km)**

Financial Costs		PC	LCV	MCV	HCVI	HCVII	Bus
Fuel	Base Costs: Fuel/Oil	4.7	4.9	8.1	17.5	27.2	12.1
	Congestion	0.9	1.1	1.5	5.7	16.6	3.6
	Stoppages	1.1	1.2	1.4	2.1	2.1	1.6
	Changes in Speed	0.9	1.2	3.0	8.3	18.5	6.3
	Total 2002	7.6	8.5	14.0	33.5	64.4	23.7
	Total 2006	12.4	13.9	22.9	55.0	105.6	38.8
R&M	Base Costs: R&M	4.5	4.2	12.1	22.3	37.7	18.5
	Road Surface Condition	1.6	1.5	4.1	5.9	8.2	5.6
	Total 2002	6.1	5.7	16.2	28.2	45.9	24.1
	Total 2006	7.0	6.4	18.3	31.9	52.0	27.3
Other	Base Costs: Tyres	1.1	1.3	1.9	5.3	11.7	2.6
	Base Costs: Depreciation	5.2	4.9	4.5	5.3	10.3	7.4
	Total 2002	6.3	6.2	6.4	10.6	22.0	10.0
	Total 2006	7.2	7.0	7.3	12.0	24.9	11.3
Total 2002 excl GST		20.0	20.3	36.6	72.3	132.3	57.7
Total 2006 excl GST		26.5	27.4	48.5	98.9	182.5	77.4

Final values need to be expressed in terms of Cars – Employers business, Cars – Other and Trucks. The proportions of each vehicle type used are:

- Cars – Employers Business
  - 89.5% Cars, 10.5% LCVs
  - GST not included
- Cars – Other
  - 89.5% Cars, 10.5% LCVs
  - Fuel Costs only
  - GST include (12.5%)
- Trucks
  - 40% MCVs, 20% HCVI, 40% HCVII (within M/HCVs)

To convert from 2002 to 2006 prices, the 2002 price of fuel in a Reserve Bank of NZ report was compared to the current price of fuel. The 2002 price was 94.5c/L, compared with 155c/L for 2006. Non-fuel costs were factored by the 2002 to 2006 increase in the CPI, 1.13

Table 12 gives the 2002 and 2006 values as well as the 2001 values used in WTSM; for EB purpose and trucks this includes the separate fuel and non-fuel costs.

- **Table 12 Vehicle Operating Costs**

Class	2002 Cost (c/Km)	2006 Cost (c/Km)
Car – EB total	20.0	26.6
Car-EB fuel	7.6	12.5
Car-EB non-fuel	12.4	14.1
Car - Other (Inc GST)	8.6	14.1
Trucks total	79.3	108.5
Trucks fuel	36.7	60.2
Trucks non-fuel	42.7	48.4

The EEM gives the increase in VOC 2002 to 2006 as 30% for the evaluation of projects. The increases of the values in the above table are 24% for Car-EB and 30% for Trucks, while for Car-Other (fuel only) it is 64% reflecting the increase in fuel costs. The above values are considered consistent with the EEM and have been implemented as per the table.

5.3. PT Fares

Information provided by GWRC indicated increases in rail fares of around 10% between 2001 and 2006, but no increase in bus fares. The increases for individual services and different trips and fare types ranged from zero to about 25%. From this an average figure of 10% increase was agreed and, given the range of increases, has been used as a real increase.

In WTSM fares are included in the generalised costs as a matrix. Given that all PT modes are combined in the demand models, the rail fare increase has been implemented using sectors of the matrix in terms of Territory Authorities, that is by applying the increase to those TA-TA movements that occur largely by rail. Note that fares are not included in the PT assignment but incorporated in the generalised costs following assignment.

Table 13 indicates (yellow cells) the inter-sector movements to which the 10% fare increase has been applied. Intra-sector movements have no fare increase - except for within Wairarapa, given the use of rail here - plus those between Upper and Hutt.

- **Table 13 Fare Increases**

	Wairarapa	Upper Hutt	Hutt	Kapiti	Porirua	Wellington
Wairarapa						
Upper Hutt						
Hutt						
Kapiti						
Porirua						
Wellington						

6. Commercial Vehicle Matrices

6.1. Introduction

This section describes the procedure for developing 2006 base year CV matrices (Task 5.2.6).

In WTSM the CV (HCV and MCV) matrices are fixed for a particular modelled year and are developed from factoring the base year (2001) 24-hour matrix and then applying time period factors. The 2001 matrices were developed from matrix estimation on screenlines using MVESTM in TRIPS.

It was initially proposed to replicate the estimation in MVESTM using 2006 CV count data. However the 2006 counts are not for 24-hours, but are for the 2-hour assignment periods only. It would be possible to undertake three separate estimations, but given the low proportions that CVs are in the full trip matrices, the need to carry out the estimation three times, plus uncertainties in the count data, a more efficient procedure was developed.

6.2. Adopted Procedure

The procedure is undertaken within a spreadsheet using CV screenline counts and by sectoring the zone system (matrix) according to screenlines.

The forecast 2006 matrices for the three time periods are used as the starting matrices and are adjusted on a sector basis so that the screenline counts are matched as far as possible, while attempting to minimise the change from the initial matrix. In doing so, the adjustments take account of trips that cross more than one screenline, and the resulting adjustment factors for each sector are the product of those made across each relevant screenline.

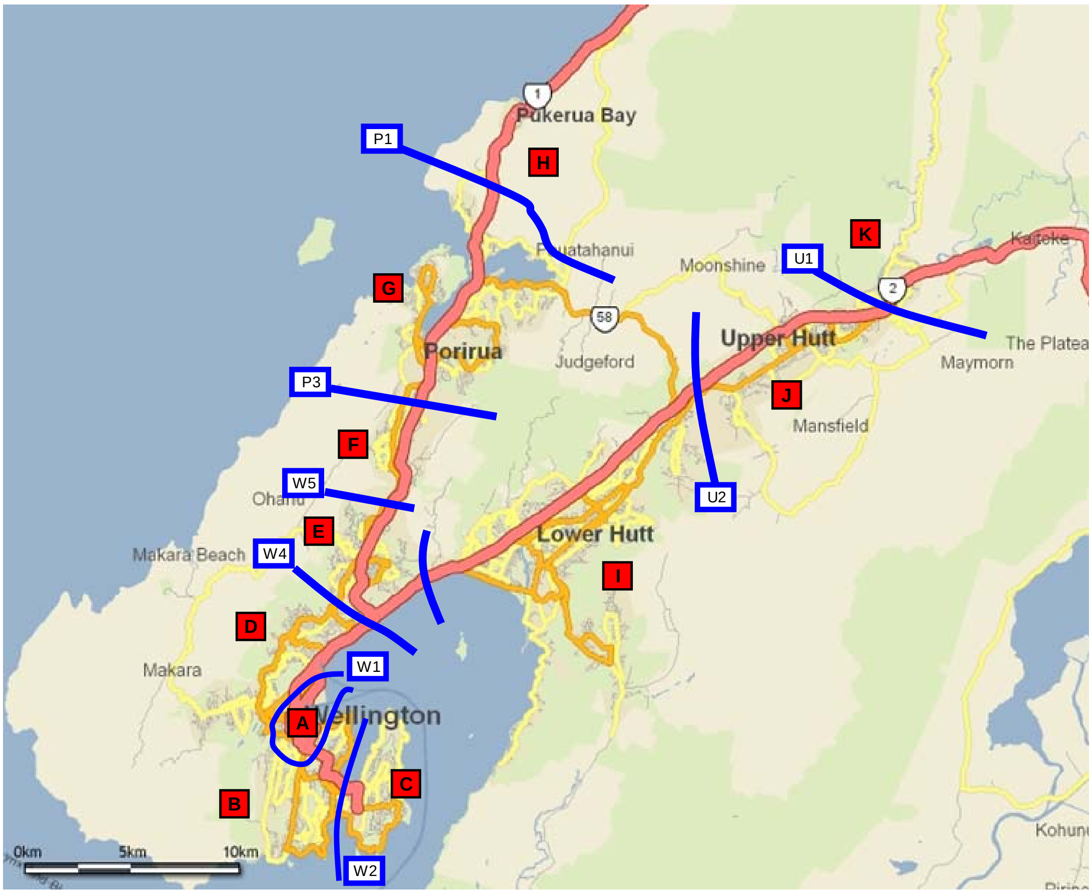
Intra-sector flows are adjusted using the average of adjacent inter-sector factors.

The result is a set of multiplicative factors between and within each sector.

The sectors and screenlines used are given in Figure 2.

SKM

Figure 2 CV Sectors and Screenlines



The sets of adjustment factors are given in Table 14, Table 15, and Table 16, including the row, column and overall averages (these are weighted by the number of trips in each case).

Table 14 AM Peak CV Adjustment Factors

	A	B	C	D	E	F	G	H	I	J	K	E1	E2	Average
A	0.88	0.88	0.85	0.90	0.70	0.42	0.46	1.04	0.42	0.38	0.20	0.95	0.95	0.82
B	0.88	0.88	0.85	0.90	0.70	0.42	0.46	1.04	0.42	0.38	0.20	0.95	0.95	0.84
C	0.90	0.90	0.78	0.90	0.63	0.38	0.42	0.94	0.38	0.34	0.18	0.95	0.95	0.84
D	0.85	0.85	0.85	0.88	0.70	0.42	0.46	1.04	0.42	0.38	0.20	0.95	0.95	0.79
E	2.40	2.40	2.04	2.40	1.01	0.60	0.66	1.49	0.60	0.54	0.28	0.95	0.95	1.33
F	0.84	0.84	0.71	0.84	0.35	0.86	1.10	2.48	0.21	0.54	0.28	0.95	0.95	0.78
G	1.18	1.18	1.00	1.18	0.49	1.40	1.66	2.25	0.29	0.76	0.39	0.95	0.95	1.52
H	2.23	2.23	1.90	2.23	0.93	2.66	1.90	1.47	0.40	1.71	0.89	0.95	0.95	1.46
I	0.60	0.60	0.51	0.60	0.25	0.60	0.66	1.35	0.56	0.90	0.47	0.95	0.95	0.57
J	0.39	0.39	0.33	0.39	0.16	0.16	0.18	1.35	0.65	0.82	0.52	0.95	0.95	0.73
K	0.47	0.47	0.40	0.47	0.20	0.20	0.21	1.76	0.78	1.20	0.86	0.95	0.95	0.83
E1	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
E2	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Average	0.92	0.90	0.83	0.98	0.65	0.82	1.41	1.46	0.55	0.85	0.75	0.95	0.95	0.88

- **Table 15 Interpeak CV Adjustment Factors**

	A	B	C	D	E	F	G	H	I	J	K	E1	E2	Average
A	0.85	0.85	1.00	0.70	0.55	0.30	0.38	0.87	0.44	0.44	0.35	0.90	0.90	0.77
B	0.85	0.85	1.00	0.70	0.55	0.30	0.38	0.87	0.44	0.44	0.35	0.90	0.90	0.82
C	0.70	0.70	0.56	0.70	0.39	0.21	0.26	0.61	0.31	0.31	0.25	0.90	0.90	0.63
D	1.00	1.00	1.00	0.85	0.55	0.30	0.38	0.87	0.44	0.44	0.35	0.90	0.90	0.85
E	0.55	0.55	0.55	0.55	0.69	0.55	0.69	1.58	0.80	0.80	0.64	0.90	0.90	0.66
F	0.61	0.61	0.61	0.61	1.10	1.00	1.25	2.88	0.88	0.80	0.64	0.90	0.90	1.01
G	0.67	0.67	0.67	0.67	1.21	1.10	1.51	2.30	0.97	0.88	0.70	0.90	0.90	1.43
H	0.93	0.93	0.93	0.93	1.69	1.54	1.40	1.55	1.23	1.40	1.12	0.90	0.90	1.49
I	0.41	0.41	0.41	0.41	0.75	0.55	0.69	1.27	0.50	1.00	0.80	0.90	0.90	0.53
J	0.23	0.23	0.23	0.23	0.41	0.41	0.52	1.27	0.55	0.89	0.80	0.90	0.90	0.79
K	0.27	0.27	0.27	0.27	0.50	0.50	0.62	1.52	0.66	1.20	1.00	0.90	0.90	0.92
E1	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
E2	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Average	0.83	0.81	0.78	0.70	0.71	0.75	1.30	1.52	0.52	0.92	0.92	0.90	0.90	0.84

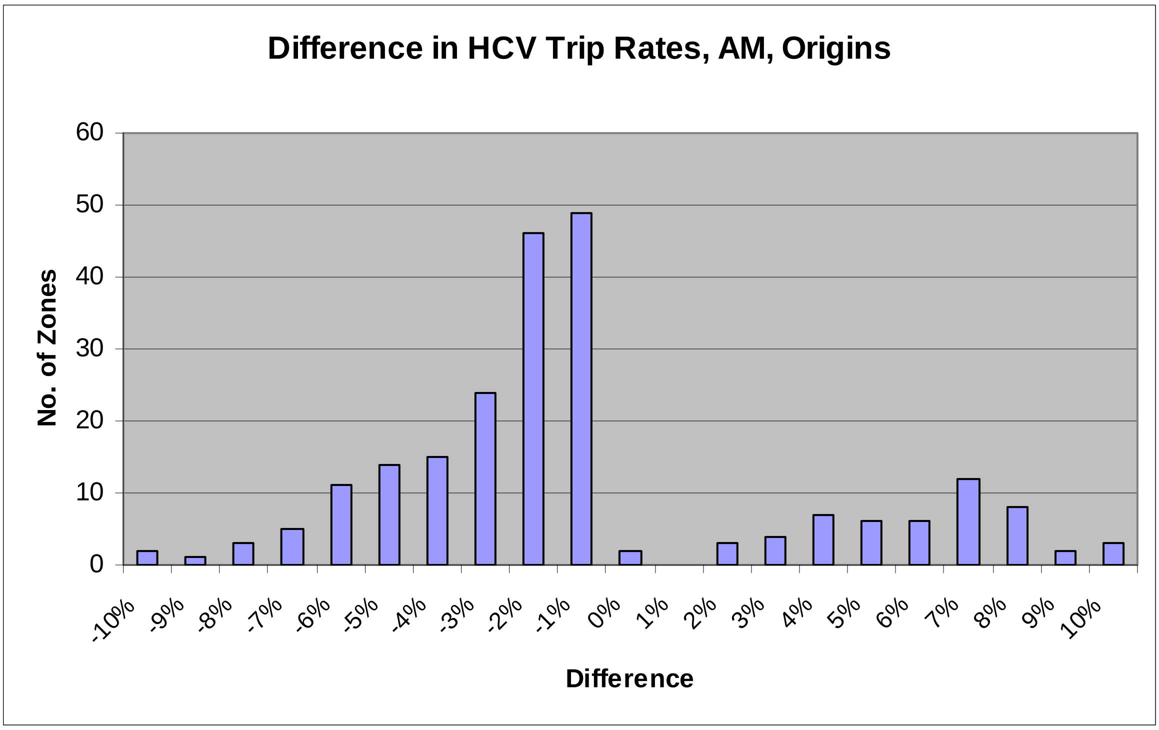
- **Table 16 PM Peak CV Adjustment Factors**

	A	B	C	D	E	F	G	H	I	J	K	E1	E2	Average
A	0.95	0.95	1.00	0.90	2.10	0.78	0.58	1.34	0.53	0.42	0.25	0.90	0.90	0.95
B	0.95	0.95	1.00	0.90	2.10	0.78	0.58	1.34	0.53	0.42	0.25	0.90	0.90	0.94
C	0.90	0.90	0.74	0.90	1.89	0.70	0.52	1.21	0.47	0.38	0.23	0.90	0.90	0.84
D	1.00	1.00	1.00	0.95	2.10	0.78	0.58	1.34	0.53	0.42	0.25	0.90	0.90	1.00
E	1.00	1.00	1.00	1.00	1.01	0.37	0.28	0.64	0.25	0.20	0.12	0.90	0.90	0.72
F	0.55	0.55	0.55	0.55	0.55	0.72	0.75	1.73	0.14	0.20	0.12	0.90	0.90	0.62
G	0.66	0.66	0.66	0.66	0.66	1.20	1.49	2.30	0.17	0.24	0.14	0.90	0.90	1.36
H	1.12	1.12	1.12	1.12	1.12	2.04	1.70	1.27	0.23	1.36	0.82	0.90	0.90	1.25
I	0.35	0.35	0.35	0.35	0.35	0.37	0.28	0.85	0.48	0.80	0.48	0.90	0.90	0.47
J	0.16	0.16	0.16	0.16	0.16	0.16	0.12	0.85	0.45	0.66	0.60	0.90	0.90	0.59
K	0.13	0.13	0.13	0.13	0.13	0.13	0.09	0.83	0.36	0.80	0.70	0.90	0.90	0.62
E1	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
E2	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Average	0.91	0.91	0.86	0.86	1.21	0.74	1.23	1.28	0.46	0.68	0.64	0.90	0.90	0.82

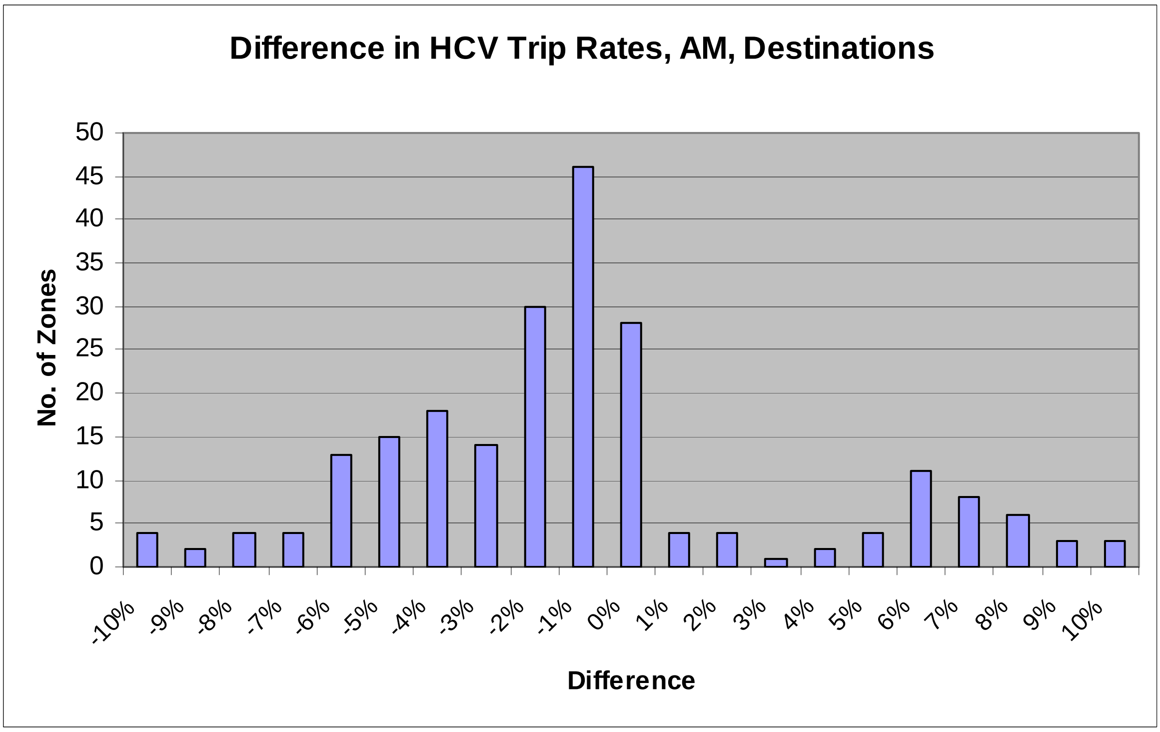
The final HCV trip ends have been checked against the 2006 land use data in terms of frequency distributions of the differences in HCV trip rates between the initial and final matrices. In this case the trip rates are defined as trip ends (origins or destinations) over the sum of land use weighted by the HCV rates for each category as given in the 2001 HCV report.

These are shown in Figure 3 to Figure 8, and indicate that for the great majority of zones the adjustment of the matrices has resulted in less than 3% change in the trip rates.

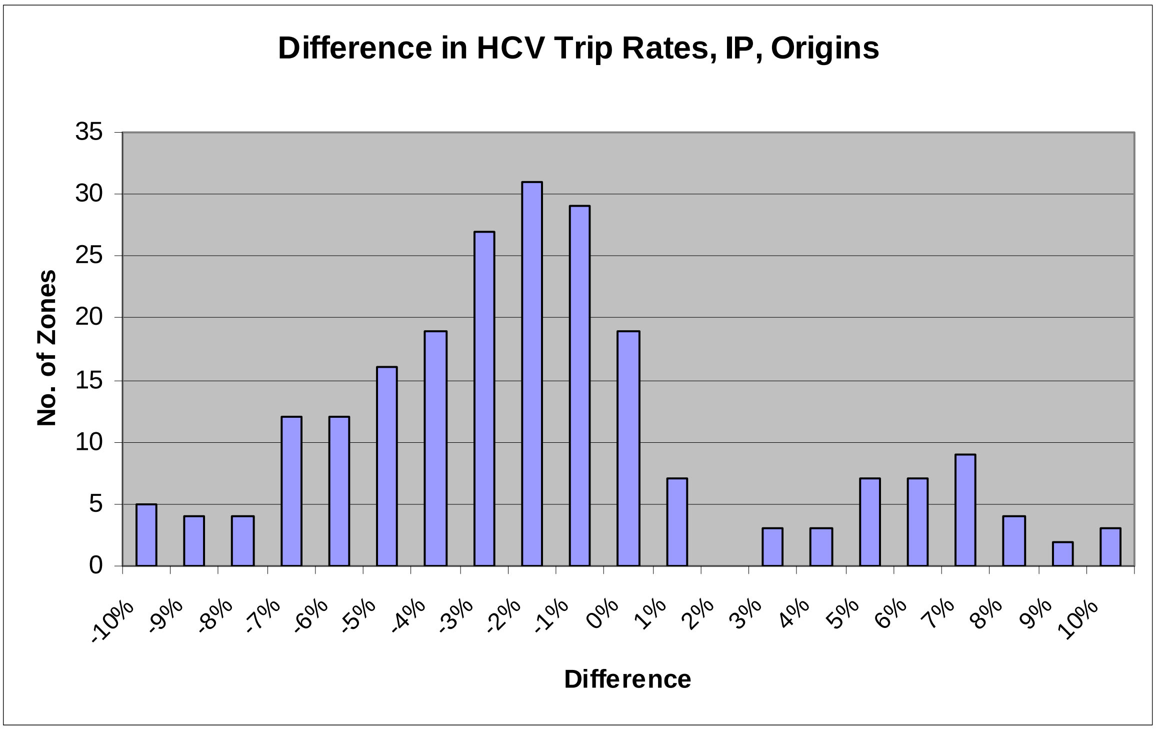
- **Figure 3 Difference in HCV Trip Rates, AM, Origins**



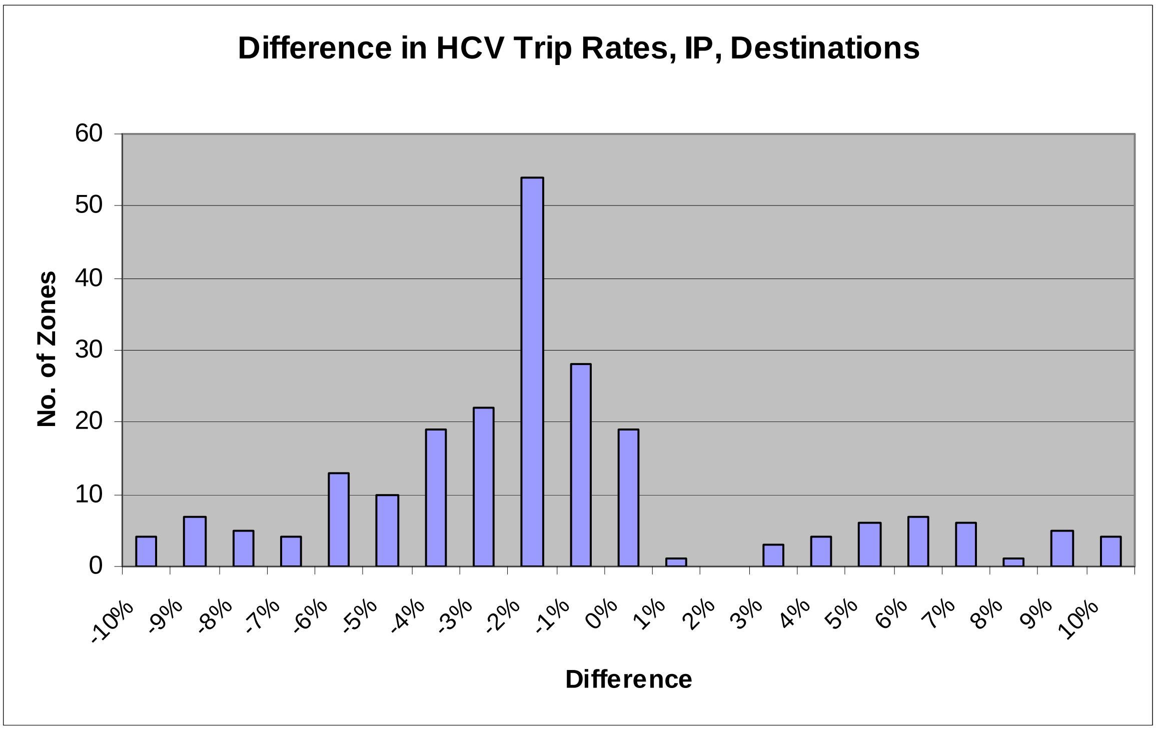
- **Figure 4 Difference in HCV Trip Rates, AM, Destinations**



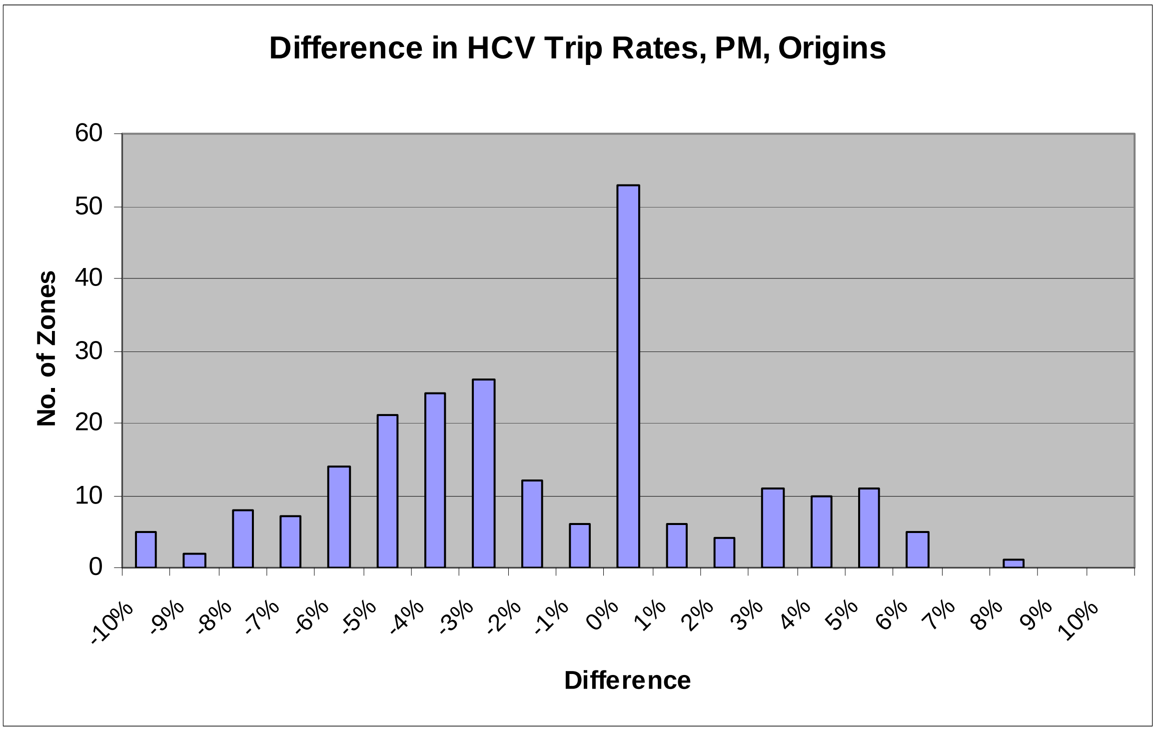
- **Figure 5 Difference in HCV Trip Rates, IP, Origins**



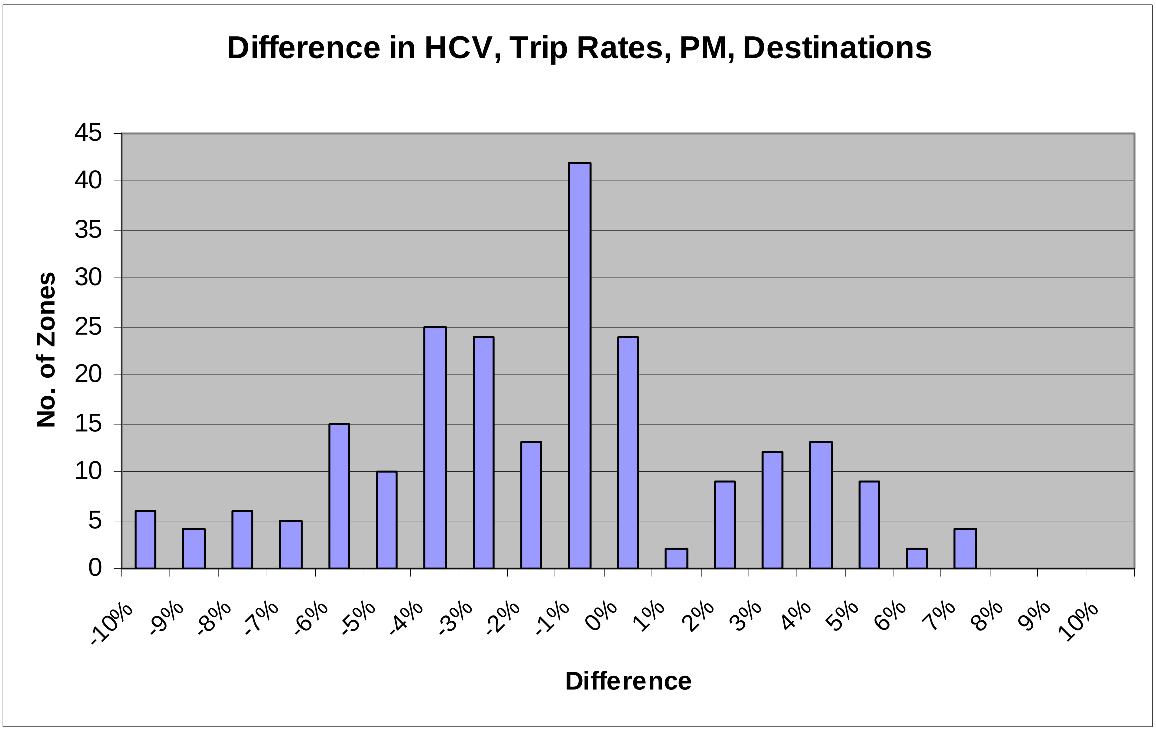
- **Figure 6 Difference in HCV Trip Rates, AM, Destinations**



- **Figure 7 Difference in HCV Trip Rates, PM, Origins**



- **Figure 8 Difference in HCV Trip Rates, PM, Destinations**



6.3. HCV Forecasting

The methodology for forecasting HCV's was reviewed. The implemented procedure for HCV trip ends is:

$$HCV_F = HCV_{2001} \text{ x } TE_F/TE_{2001} \text{ x } (GDPPC_F/GDPPC_{2001})^s$$

Where:

HCV_F	= Future year HCV trip ends by zone
HCV_{2001}	= Year 2001 HCV trip ends by zone
TE_{2001}	= Synthesised year 2001 trip ends
TE_F	= Synthesised Future year trip ends
$GDPPC_{2001}$	= GDP per capita Year 2001
$GDPPC_F$	= GDP per capita in Future year
S	= Sensitivity to GDP per capita growth

The synthesised trip ends are calculated for each zone whereas the economic factor (GDP per capita) is a global factor. A value of 1.3 for the GDP per capita sensitivity factor, (s) was found to give a reasonable fit to the trend data in both HCV registrations and HCV VKT.

This approach is considered appropriate and is retained for the updated model.

6.4. Implementation

The adjustment factors are implemented as follows:

- The 2006 24-hour and 2-hour time period matrices are produced as per the 2001-based model, that is by forecasting from 2001,
- The adjustment factors are applied (multiplicatively) to each time period matrix to give the final 2006 CV matrices,
- In forecasting from 2006, the change in synthesised future trip ends from 2006 are applied to the final 2006 matrices.

The trips in the initial and final (adjusted) 2006 HCV matrices are given in Table 17. The final 2006 trips have only small differences from the 2001 matrices due to the count data used in each case: in the AM peak there is 5% growth, but in the Interpeak and PM peak periods there are slight reductions compared with 2001.

- **Table 17 CV Trips**

	AM	IP	PM
2006 initial	13,704	14,529	12,777
2006 final	12,108	12,155	10,516
% Difference	-12%	-16%	-18%

7. Other Changes

7.1. Car Ownership

The modelled car ownership levels for 2006 have been compared with the 2006 Census data for the Wellington Region. The zonal constants calibrated to match the 2001 Census have been adjusted so that the 2006 model matched the 2006 Census.

Table 18 gives the proportion of households by car ownership levels for the 2006 Census (Wellington), the initial 2006 model and the final 2006 model. This suggests that the forecasting (temporal) component of the car ownership model may underestimate the growth in car ownership. Any adjustments to the car ownership model in forecasting beyond 2006 will be considered in the forecasting phase of this project, where the intention is to make use of the temporal model recently developed for the new Auckland regional model.

Table 18 Car Ownership

	Census (Wellington)		WTSM Initial		WTSM Final	
	Households	%	Households	%	Households	%
0 cars	19,600	11.74%	20,091	12.0%	19,583	11.74%
1 car	72,615	43.49%	77,605	46.5%	72,559	43.49%
2+ cars	74,761	44.77%	69,158	41.4%	74,714	44.78%
Total	166,977	100%	166,854	100%	166,855	100%

7.2. Delay Functions

During the course of this project, an error in the WTSM functions was identified which has been in place since their original development. This arose as the delay functions for the new Auckland model were being developed; these, like those for WTSM, are based on Akcelik speed flow models, and a query was put to Rahmi Akcelik to clarify and confirm the error.

The capacity term, Q, in his time-dependent function is given units of vehicles/ hour in his 1991 and 2002 papers, and has to date been applied in this manner. This is a mis-specification and the units should be vehicles/hour/lane.

Hence the WTSM delay functions for links and intersections have been changed to reflect this. This has required modifying the “Q” term and adjusting the Ja term back to the ranges recommended by Akcelik, as it is understood that these were adjusted to achieve a better 2001 validation.

For links with intersection delay the network-wide average ratio of intersection lanes to mid-block lanes (0.50) is added to the number of lanes in the function to reflect the actual number of lanes available at each approach. That is, “lanes” becomes “lanes + 0.50”.

The values of Ja have been modified to better match those suggested by Akcelik. Table 19 gives the values of Ja by road type suggested by Akcelik (1991), and Table 20 gives the values adopted in WTSM 2001 and applied in WTSM 2006 applied.

Table 19 Ja Values Suggested by Akcelik

Road Type	Suggested Ja
Secondary (high friction)	1.6
Secondary (interrupted)	0.8
Arterial (interrupted)	0.4
Arterial (uninterrupted)	0.2
Freeway	0.1

Table 20 Ja Values in WTSM

Link Type	Description	WTSM 2001	WTSM 2006
3	CBD/Shopping – high friction	1.8	1.8
4	CBD/Shopping – low friction	1.6	1.6
5	Local	1.2	1.2
6	Collector (high friction/poor alignment)	1.2	1.2
7	Collector (low friction/good alignment)	1.0	1.0
8	Urban arterial – low speed	1.0	1.0
9	Urban arterial – high speed	0.8	0.8
10	Expressway	0.8	0.2
11	Motorway	0.4	0.2
12/13	On ramp / Off ramp	0.6	0.6
14/15	Rural – restricted speed / unrestricted speed	1.4	1.4

The above changes had little effect on the validation and overall demands.

The road travel time functions in the 2006-based WTSM are (with the change from the original functions in **bold**):

- fd16 = length*ul1*(1+0.25*60/ul1*(((put(volau*((el3-1)*(1-1/(1+exp(-1*(110*el3-134)*(volau/ul2-1))))+1)))/ul2-1)+ sqrt((get(1)/ul2-1)^2+8*ul3*get(1)/ul2/(ul2/2/**lanes**))))
- fd26 = length*ul1*(1+0.25*60/ul1*((volau/ul2-1)+ sqrt((volau/ul2-1)^2+8*ul3* volau/ul2/(ul2/2/lanes))))+ el1*(1+15/el1*((put(volau*((el3-1)*(1-1/ (1+exp(-1*(110*el3-134)*(volau/el2-1))))+1))/el2-1)+ sqrt((get(1)/el2-1)^2+8*get(1)/el2/(el2/2/**(lanes+.50**)))))

7.3. Intersection Delay Procedures and Merges

One of the specific tasks was to investigate alternative ways of implementing the intersection delay procedures and to consider the need for modelling merges explicitly (Task 5.3.1).

Intersection Delay Procedures

The need for examining the intersection delay procedures arose from evidence of changes in flows and delays in areas removed from small network changes.

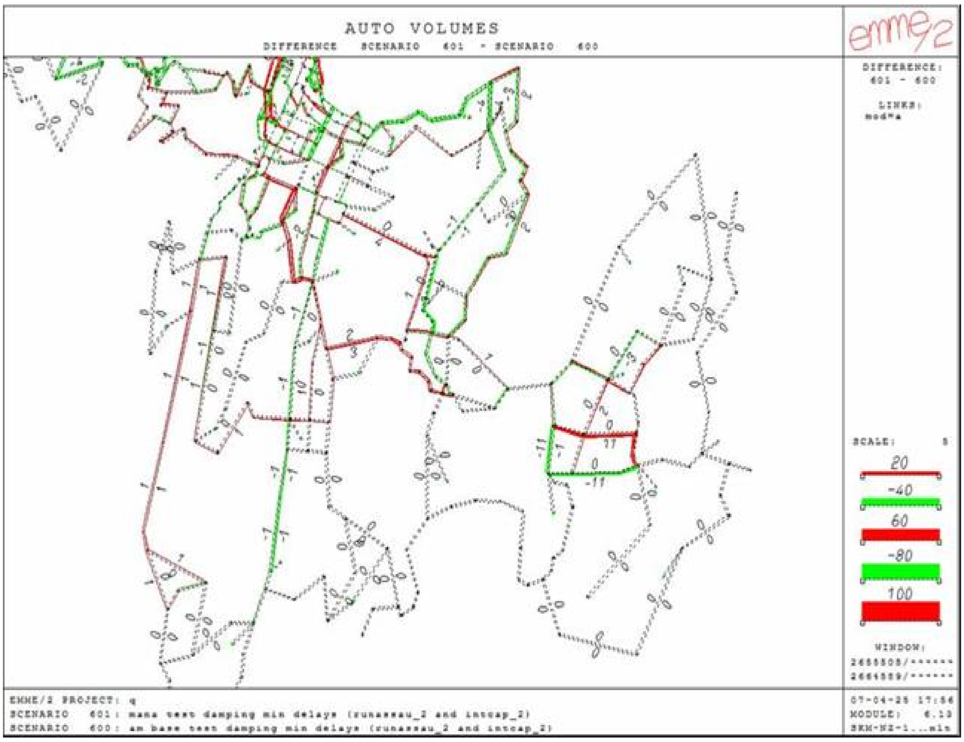
A series of tests were carried out in which the change being investigated was applied to assignments to the base network and to one with a small network change (a one-lane increase at Mana). The differences in link volumes and times were assessed via plots as were detailed outputs from a sample of intersections (approach capacities, minimum approach delay, green time, cycle time, approach volume and approach delay)

The result of these investigations was to implement the following:

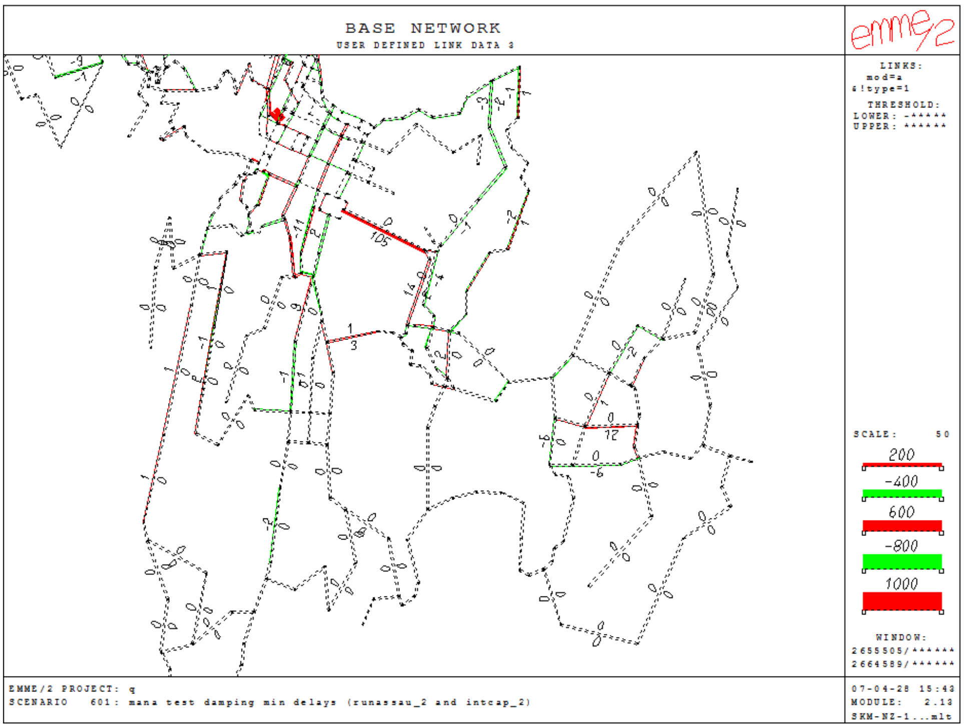
- Damping of capacities between the warm-up and main assignments using 80% of the warm-up capacities,
- Capping of the maximum green times to 50% of the cycle times,
- Increasing the assignment iterations to, say, 300

While these did not completely resolve the issues, some improvement resulted. For example, Figure 9 and Figure 10 show differences in flows and VMT, in the Wellington CBD/Miramar area, between networks without and with the extra lane at Mana, using the above changes to the assignment. A check on the prevalence of green times greater than 50% showed that there were just two intersections in the AM peak network that required capping.

- **Figure 9 Volume Differences in CBD/Miramar**



- **Figure 10 Differences in VMT in CBD/Miramar**



Merges

During the investigation phase of the update it was not possible to identify the issues that lead to consideration of implementing specific merge delays. As such this has been considered during the validation, and comparisons made between observed and modelled travel times on specific localised sections of the travel time routes. The results of this are discussed in the validation chapter and the outcome was to not implement any alternative procedures or functions to the existing.

7.4. Final Multi-Class Assignment and HCVs

The need for undertaking multi-class assignments throughout the full model was investigated (Task 5.3.4), from which it was recommended that this would be implemented for the final assignments only, and for two vehicle classes, light vehicles and CVs.

This enables different routeing parameters to be applied to each class:

- Light vehicles: 6.3 min/$
- HCVs: 2.7 min/$

The networks have two vehicle classes:

- “a” for light vehicles, and
- “h” for HCVs

The multi-class assignment also enables specified roads to be banned for CVs, which fits with the recommended approach for dealing with CVs using unsuitable roads (Task 5.3.5). The following roads are currently banned from use by CVs:

- Local/collector roads banned as through routes:
  - Hataitai Road /Grafton Road
  - Mills Road/Britomart Street
  - Bidwell, Thompson, and Tasman Streets
  - Birdwood, Plymouth, Gipps and Donald Streets
  - Paekakariki Hill Road

- Road with legal restrictions on HCV Traffic:
  - Bidwell Street

7.5. Parking Costs

Parking costs are incorporated in WTSM by purpose for two Wellington CBD areas, lower and upper. The actual costs applied take into account the proportion of trips that do pay, which was derived from the 2001 HTS.

Parking costs for 2006 have been increased from 2001 levels using information available from Wellington City Council and an assumed 20% increase in the proportion of cars that do pay for parking.

The information provided by WCC was 2006 costs for three metered on-street areas and for the designated commuter area. In 2001 WCC operated parking buildings in the CBD. These were sold around 2004 and are now operated privately. Hence it was not possible to obtain information on 2001-2006 increases for these, so a 50% increase has been assumed for commuter parking in parking buildings.

These have been used in combination, along with the assumed 20% increase in the proportion of trips paying, to determine the percentage increases by purpose - with the on-street increases being applied to non-commuting purposes. The parking cost information obtained and assumed the percentage increases and the 2001 and 2006 WTSM parking costs are given in Table 21.

- **Table 21 Parking Costs**

Type of Parking	2001	2006	% Increase
Metered on-street ($/hr)	1.00	1.50	50%
	2.00	3.00	50%
	3.00	4.00	33%
Commuter ($/day)	4.00	5.00	25%
Other (assumed) ($/day)	4.00	6.00	50%
WTSM Parking Costs ($/trip)	**2001**	**2006**	**% Increase**
HBW Lower Wellington	1.700	2.805	38%
HBW Upper Wellington	2.750	4.538	38%
EB Lower Wellington	0.585	0.995	42%
EB Upper Wellington	1.040	1.768	42%
Other Lower Wellington	0.480	0.816	42%
Other Upper Wellington	0.960	1.632	42%

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7.6. TA Attraction Factors

The WTSM trip generation model includes TA factors applied to trip attractions, developed in the 2001 model based on the HTS data. For the 2006 update some small adjustments to some of these have been made, based on comparisons of observed and modelled flows by car, bus and rail across screenlines.

Table 22 gives, for HBW and HBO purposes, the 2001 TA attraction factors, the adjustments made to the factors - which are applied multiplicatively – and the final 2006 factors.

- **Table 22 Adjustments to TA Factors**

	2001 Factors		2006 Adjustments		2006 Factors	
TA	**HBW**	**HBO**	**HBW**	**HBO**	**HBW**	**HBO**
Kapiti Coast District	1.031	1.112	0.900	1.000	0.928	1.112
Porirua City	0.813	0.986	1.400	1.100	1.139	1.084
Upper Hutt City	1.305	1.054	0.900	1.000	1.175	1.054
Hutt City	1.030	0.923	1.000	1.000	1.030	0.923
Wellington City	1.024	0.959	1.000	1.000	1.024	0.959
Masterton District	0.992	1.065	1.000	1.000	0.992	1.065
Carterton District	1.429	1.257	1.000	1.000	1.429	1.257
South Wairarapa District	0.759	0.729	1.000	1.000	0.759	0.729

7.7. Rail Adjustments

The initial validation gave good results for rail loadings on the Paraparaumu and Hutt Lines, but lower modelled flows on the Johnsonville Line – which was similar to that obtained in the 2001 validation. Following discussions with GWRC, the rail waiting time factor and some walk and p-connector link lengths were adjusted in order to achieve a better match with the observed data.

The outcome of this was:

- the rail wait time factor changing from 0.25 to 0.20 on the basis that rail can be more reliable than bus, *(note that this change was subsequently not implemented – refer to Appendix C)*
- walk and p-connector link lengths being adjusted for the following station: Johnsonville, Raroa, Khandallah, Awarua, Crofton, Paremata, Porirua, Redwood, Lindale, Waterloo, Taita, and Petone,

In the final stages of the validation the manner in which rail travel times was revised. The existing method was the specification of fixed speeds within the coding for each service, with no differentiation between running time and stopped time. This has now been changed to specified running speeds between stations which apply to all services using the line (specified via an input file), and 0.8 minutes of time associated with station stops applied at the first station node approached by each service (specified as part of the coding of each service). This approach gave good comparisons with timetabled times.

8. Trip Matrices and Statistics

8.1. Introduction

This chapter presents statistics on WTSM 2006 trips by purpose, mode and time period and compares them to the corresponding 2001 data

8.2. 24-Hour Trips by Purpose and Mode

Table 23 gives the WTSM 24-hour trips by mode and purpose for 2001 and 2006.

Trips by purpose have increased by 7-8% between 2001 and 2006, except for EB trips, which have increased by 5%.

This is due to the household and employment categories (land use variables) used in the EB trip attraction model, the trip rates of each, and the changes in categories since 2001. The categories used in the EB model and the corresponding trip rates are Households (0.28), Transport and Communications (1.43, 0.64 for Kapiti/Porirua), Services (0.28), and Retail (1.43, 0.64 for Kapiti/Porirua). Transport and Communications employment, which has relatively high trip rates, has reduced since 2001 while the other land use variables have increased (refer Table 1). The effect of this is a lower increase in EB trips compared with other purposes. By way of comparison the NHBO attraction model uses Households (0.63) and Retail (10.21, 5.49 for Hutt); that is NHBO uses variables that have all increased since 2001 and has higher rates for these variables.

The different changes in trips within each segment are largely related to increased car ownership, which tends to increase the choice segment (i.e. where the number of cars is greater than or equal to the number of adults) and reduce the competition (cars less than the number of adults) and captive segments (no car available):

- Commuting trips increase for most segments, with the largest being for the choice segments. There are small reductions in the competition car and walk/cycle segments.
- Within education trips, the largest proportional increase is in competition/choice PT trips. The largest segment, competition/choice car trips increases by 7%.
- For shopping trips, car increase by 9% and walk/cycle trips by 6%, while there is a small reduction in trips by PT.
- All three mode segments within HBO increase similarly at around 8%.
- Non-home-based Other trips by car have increased at almost twice the rate of PT, and over three times that of walk/cycle trips.

- **Table 23 24-Hour Trips by Purpose and Mode**

	2001	2006	Difference	% Difference
HBEd	73,589	79,011	5,422	7%
HBSh	290,384	313,281	22,897	8%
HBO	374,596	404,067	29,471	8%
NHBO	490,466	528,383	37,917	8%
EB	149,527	157,288	7,761	5%
HBW	266,780	285,632	18,853	7%
Home-Based Work				
HBW Cap Car	1,601	1,703	101	6%
HBW Cap PT	6,091	6,243	152	2%
HBW Cap W/C	5,995	6,508	513	9%
HBW Comp Car	74,350	70,807	-3,543	-5%
HBW Comp PT	23,805	25,628	1,823	8%
HBW Comp W/C	14,122	13,531	-591	-4%
HBW Choice Car	121,433	137,430	15,997	13%
HBW Choice PT	14,027	16,808	2,781	20%
HBW Choice W/C	5,356	6,976	1,619	30%
Home-Based Education				
HBEd Cap PT/Car	2,401	2,339	-62	-3%
HBEd Cap W/C	3,559	3,812	253	7%
HBEd Comp/Choice Car	35,534	38,005	2,471	7%
HBEd Comp/Choice PT	16,194	18,148	1,953	12%
HBEd Comp/Choice W/C	15,900	16,707	807	5%
Home-Based Shopping				
HBSh Car	238,505	259,560	21,056	9%
HBSh PT	14,515	14,033	-482	-3%
HBSh W/C	37,364	39,687	2,323	6%
Home-Based Other				
HBO Car	299,457	323,568	24,111	8%
HBO PT	9,436	10,141	704	7%
HBO W/C	65,702	70,358	4,656	7%
Non-Home-Based Other				
NHBO Car	352,871	387,030	34,158	10%
NHBO PT	10,061	10,617	556	6%
NHBO W/C	127,534	130,736	3,202	3%

8.3. Trips by Modelled Time Period

Table 24 gives the WTSM trips by modelled time period – vehicle, public transport and CV - for 2001 and 2006.

AM peak and PM peak trips by car (that is light vehicle) increased by 10% and 6% respectively, whereas peak PT trips have increased more – by 13% and 6%. In the Interpeak trips by car have increased at a higher rate than PT trips.

HCV trips have changed only marginally since 2001; a small increase in the AM peak and slight reductions in the Interpeak and PM peak. These trips are highly dependent on the count data used to develop the base year matrices (refer to Chapter 6).

▪ **Table 24 Trips by Modelled Time Period**

	2001	2006	Difference	% Difference
Car Trips				
AM	139,798	153,770	13,972	10%
IP	131,604	142,565	10,962	8%
PM	173,395	183,801	10,406	6%
PT Trips				
AM	26,957	30,411	3,454	13%
IP	9,153	9,619	467	5%
PM	23,269	24,577	1,308	6%
HCV Trips				
AM	11,578	12,108	529	5%
IP	12,275	12,155	-120	-1%
PM	10,795	10,516	-278	-3%

8.4. Vehicle Statistics

Table 25 gives 2001 and 2006 WTSM vehicle statistics and compares them.

They show that the average travel speeds in the AM peak and Interpeak are slightly lower than in the 2001 model, whereas there is a slight increase in the PM peak. It should be noted that in 2001 the PM peak average speed was lower than in the AM peak, but in 2006 these are now almost the same.

The average distance increases declines slightly in all periods.

Table 25 Vehicle Statistics

	2001	2006	Difference	% Difference
AM Peak				
Trips	139,798	153,770	13,972	10%
Vehicle-kilometres	1,287,122	1,402,603	115,481	9%
Vehicle-minutes	1,591,512	1,780,159	188,647	12%
Average Distance (km)	9.2	9.1	-0.1	-1%
Average Time (min)	11.4	11.6	0.2	2%
Average Speed (kph)	48.5	47.3	-1.2	-3%
Interpeak				
Trips	131,604	142,565	10,962	8%
Vehicle-kilometres	979,269	1,023,242	43,973	4%
Vehicle-minutes	1,078,028	1,140,417	62,388	6%
Average Distance (km)	7.4	7.2	-0.3	-4%
Average Time (min)	8.2	8.0	-0.2	-2%
Average Speed (kph)	54.5	53.8	-0.7	-1%
PM Peak				
Trips	173,395	183,801	10,406	6%
Vehicle-kilometres	1,446,759	1,522,713	75,954	5%
Vehicle-minutes	1,863,225	1,918,033	54,808	3%
Average Distance (km)	8.3	8.3	-0.1	-1%
Average Time (min)	10.7	10.4	-0.3	-3%
Average Speed (kph)	46.6	47.6	1.0	2%

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8.5. Mode Shares

Table 26 gives 2001 and 2006 WTSM and Census all-day journey-to-work mode shares for the region and Table 27 gives the PT mode shares for each TA and Table 28 for trips to the CBD from each TA.

The first set of WTSM results are for all purposes during the modelled periods and are not entirely comparable with the Census data as not all commuting trips are made during the AM peak and the AM peak includes other purposes. This data does indicate that modelled mode shares have changed little between 2001 and 2006, and essentially remain at 2001 levels. The most noticeable change is the PT mode share, which increases by 2.1% AM peak and declines by a similar proportion in the Interpeak.

The second set of WTSM data is for 24-hour HBW trips and is directly comparable with the Census data. This shows that the modelled PT shares are slightly lower than those in the Census in both 2001 and 2006, but the PT share in both increases over that time.

- **Table 26 Mode Shares, Modelled and Census JTW, Region-wide**

		2001 Mode Shares (%)	2006 Mode Shares (%)	% Difference
WTSM (separate periods, all purposes)	AM Peak Vehicle	84	83	-0.4%
	AM Peak PT	16	17	2.1%
	Interpeak Vehicle	93	94	0.2%
	Interpeak PT	7	6	-2.8%
	PM Peak Vehicle	88	88	0.0%
	PM Peak PT	12	12	-0.3%
WTSM HBW (24-hours)	Vehicle	82	81%	-1%
	PT	18	19%	3%
Census (24-hours, journey-to- work	Vehicle	80	78	-1%
	PT	20	22	6%

As well as the Census and WTSM PT mode shares by TA Table 27 includes the WTSM PT trips and the larger movements (>1000) are highlighted. The modelled PT mode share compares well with the Census for most of these larger movements; Kapiti, Hutt and Upper Hutt to Wellington are close to the Census shares, while the modelled Porirua to Wellington is 9% higher and within Wellington is 7% lower.

- **Table 27 Mode Shares, Modelled and Census JTW, by TA**

Census JTW PT Mode Shares		1	2	3	4	5	6	7	8	Total
Carterton	1	1%	0%	41%	0%	0%	8%	18%	61%	9%
Kapiti	2	33%	3%	1%	60%	10%	17%	2%	44%	15%
Hutt	3	11%	13%	8%	10%	4%	39%	6%	38%	19%
Masterton	4	0%	0%	32%	1%	0%	5%	18%	59%	3%
Porirua	5	50%	7%	3%	14%	7%	50%	1%	27%	17%
South Wairarapa	6	4%	0%	30%	3%	0%	2%	25%	62%	16%
Upper Hutt	7	0%	22%	7%	10%	2%	0%	4%	40%	15%
Wellington	8	7%	20%	8%	16%	7%	24%	11%	32%	28%
Total		2%	4%	8%	1%	7%	6%	5%	33%	21%
WTSM PT Mode Shares		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Carterton	1	1%	0%	12%	4%	5%	5%	9%	71%	3%
Kapiti	2	1%	3%	7%	2%	8%	1%	2%	46%	14%
Hutt	3	5%	5%	7%	5%	4%	3%	8%	40%	19%
Masterton	4	3%	0%	18%	1%	8%	7%	13%	83%	1%
Porirua	5	2%	8%	4%	2%	7%	1%	1%	36%	20%
South Wairarapa	6	11%	1%	8%	7%	3%	2%	6%	57%	8%
Upper Hutt	7	3%	2%	11%	3%	2%	2%	4%	44%	16%
Wellington	8	8%	9%	9%	9%	7%	5%	6%	25%	23%
Total		4%	3%	7%	2%	6%	2%	5%	29%	19%
WTSM PT Trips		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Carterton	1	24	0	1	49	0	6	1	18	99
Kapiti	2	0	400	63	1	124	0	6	2,307	2,901
Hutt	3	7	4	2,221	10	62	3	203	8,298	10,809
Masterton	4	13	0	1	124	0	2	0	11	151
Porirua	5	1	22	103	1	702	0	10	4,526	5,366
South Wairarapa	6	83	0	8	90	1	37	7	122	346
Upper Hutt	7	10	1	458	15	20	4	443	2,637	3,588
Wellington	8	3	13	583	6	269	1	47	24,339	25,262
Total		142	441	3,439	296	1,176	53	717	42,258	48,523

The PT mode shares to the CBD (Table 28) indicate that the modelled shares compare reasonably well with Census data; they are higher (by 4-9%) for trips from outside Wellington City, and some 6% lower for trips from Wellington City.

- **Table 28 Mode Shares, Modelled and Census JTW, to CBD**

	JTW PT Mode Share	WTSM PT Mode Share	WTSM PT Trips
Carterton	72%	80%	17
Kapiti	54%	59%	2,122
Hutt	48%	50%	7,582
Masterton	75%	89%	10
Porirua	39%	48%	4,025
South Wairarapa	72%	68%	114
Upper Hutt	50%	55%	2,426
Wellington	43%	37%	19,609
Total	45%	42%	36,047

9. Validation

9.1. Introduction

This chapter presents the WTSM 2006 update validation results which incorporate Tasks 5.2.4, 5.2.5, 5.2.13, and 5.2.14. The same statistics have been used as in the original 2001 validation, which enables comparisons to be made between them.

The validation encompasses:

- Vehicle assignment validation across screenlines (screenline totals and links on screenlines), using absolute and percentage differences, GEH[1] statistics, and RMSE.
- Vehicle travel time validation,
- Public transport assignment validation (screenline totals for bus plus sectors of the CBD screenline, and inbound boardings on lines for rail),
- HCV validation across screenlines (totals), using absolute and percentage differences, GEH statistics, and RMSE.

The screenlines are largely the same as those in 2001, except that for 2006 there is only one CBD screenline and this has some differences to the 2001 sites. Figure 11 shows the 2006 screenlines.

The vehicle assignment validation has used some of statistical measures given in the EEM, though the guidelines and targets are designed for traffic project models and are much less relevant for strategic multi-modal models such as WTSM.

The lower the GEH value the better the modelled flow is comparing with observed. A value of 5 or less on an individual link is very good, between 5 and 10 is good, and 10 to 12 is reasonable. In the EEM criteria (for project models) the targets include 60% links having a GEH of 5 or less and 100% having 12 or less.

The EEM guideline for screenline totals is that the GEH should be less than 4 in most cases and for all compared flows that the RMSE is less than 30%.

The EEM guidance for scattergrams of observed vs. modelled flows is that the R2 should be greater than 0.85 in general.

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[1] GEH= $(((q_{model}-q_{obs})^2/((q_{model}+q_{obs})/2))^{0.5}$ where q_{obs} = observed hourly flow and q_{model} = modelled hourly flow

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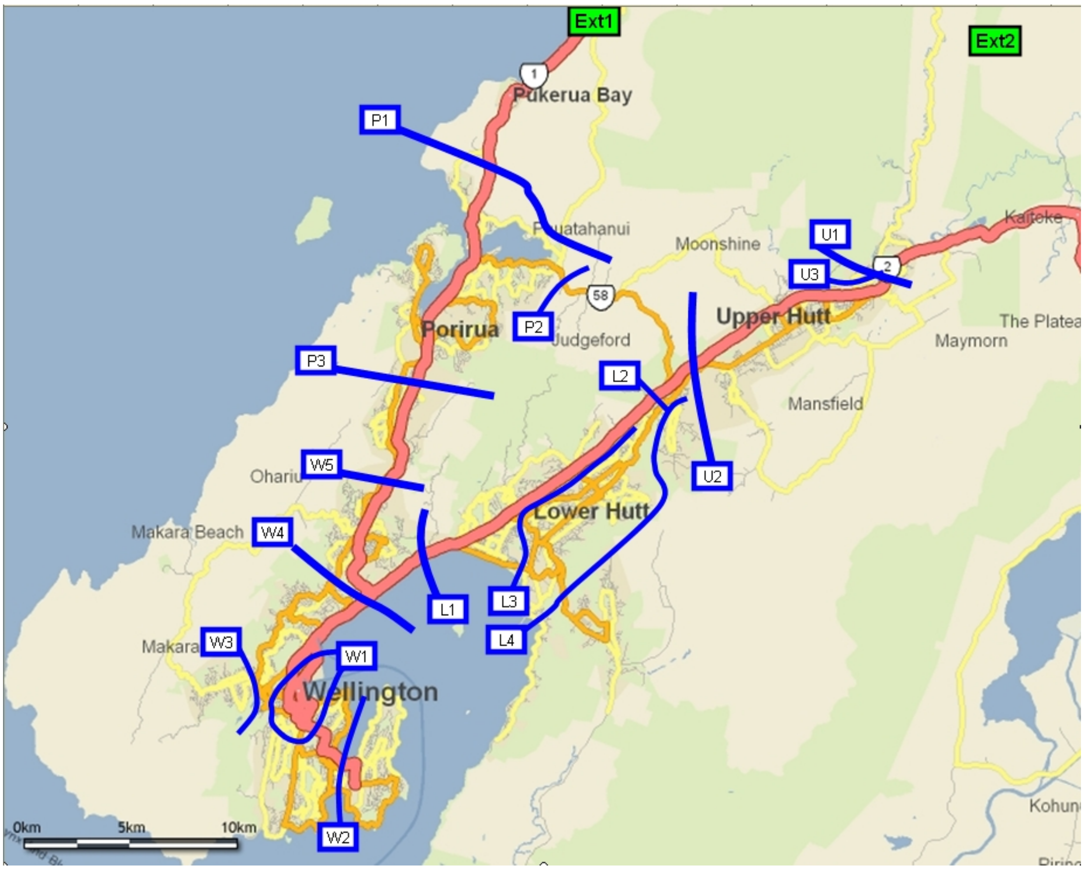
- **Figure 11 2006 Screenlines**



9.2. Observed Data for Validation

The traffic counts which have been used for the vehicle assignment validation are generally from the count survey undertaken prior to this project in 2006 (refer to Task 5.2.13). As concerns arose over some of the data, including recognition of the difficulty of obtaining accurate counts in congested conditions, counts from other existing sources were obtained, and then some further counts were carried out at some sites in September 2007.

Additionally the location of several counts does not fit well with the model zone system and zone connectors; these are noted in the commentary below.

Given the above, in some cases the count data can be used only as a guide, and, as such, the model validation needs to be considered in this light.

The vehicle travel time data has come from a specially designed travel time survey carried out during 2007; no issues with this data has arisen from its use in the validation.

The counts of bus patronage have been derived from ETM data provided by the operators for the month of March 2006. This required considerable processing into a form that could be used in the validation. From this potential anomalies in the data were identified and discussed with the operators. These included patronage data for some services in the reverse direction to the service (e.g. outbound data for supposedly inbound services) and difficulties in interpreting the labelling of fare boundaries and relating the labelling to actual fare boundaries.

Available 2006 rail data suitable for validation purposes was limited, so following analysis of historic patronage trends and discussion with GWRC, the 2001 rail survey (inbound only) was factored by 10% for the AM peak and 14% for the Interpeak. This means that there is little value in investigating modelled versus observed travel patterns more than is presented in Section 9.5.2. For example, the 2001 observed IP rail total patronage was for one direction only (inbound), but was compared with modelled patronage for both directions; the 2001 observed figure has been factored by 14% and compared with the 2006 modelled patronage in both directions.

9.3. Vehicle Assignment Validation

9.3.1. Screenline Totals

The model fit across the screenlines is presented in three ways:

- The observed and modelled total flows on each of the screenlines in the AM peak, Interpeak and the PM peak are given in Table 29, Table 30, and Table 31 respectively, and the percentage differences in each modelled period are shown graphically in Figure 12, Figure 13, and Figure 14.
- Figure 15, Figure 16, and Figure 17 present the comparison in terms of scattergrams, and
- Table 32 gives an overall summary.

Some 63% of screenlines (19 out of 30) in the AM peak model have a GEH value of less than 5, 60% (18) in the Interpeak and 57% (17) in the PM peak models. (In 2001 these percentages were 59%, 53% and 47% respectively). All but one screenline in each of the modelled periods have a GEH of 12 or less. High R^2 statistics of over 0.98 are achieved which are comparable to those for the 2001 model (these are reported as 0.973, 0.971 and 0.975 for the three time periods).

Each Screenline is commented on in turn:

Screenline W1:

- The modelled flows on Screenline W1, around the CBD, compare favourably with the observed counts, though are higher in all cases.

- Many of the counts have come from sources other than the counts provided by GWRC (WCC, Transit and recounts).
- The AM peak inbound flows are some 10% greater than observed as are the PM outbound are 10% higher.
- The maximum GEH value is 12 for the AM Peak inbound.

Screenline W2:

- The modelled flows on this screenline, which is to the west of the airport, compare well with observed counts in the Interpeak and the AM peak eastbound and less favourably in the PM peak (21% difference) and the AM peak westbound (16% difference), though the GEH values are 8 or better.
- WCC counts and a new count (AM peak inbound) have been used on Cobham Drive in place of the counts provided.

Screenline W3:

- Screenline W3, which separates out Karori, has large differences of mostly around 30%, but up to 50%, between modelled and observed flows with the model overestimating the observed in each case.
- The relatively low flows on this screenline mean that the GEH values are still reasonable, the highest being 11.
- WCC counts have been used on Karori Rd in place of the counts provided.

Screenline W4:

- The Hutt Road and SH1 south of Ngauranga make up this screenline
- The modelled flows compare well with the observed counts in all periods;
- The maximum difference is in the Interpeak northbound; GEH = 4, 7% difference.
- The counts are those obtained as part of the Transmission Gully model development.

Screenline W5:

- This screenline has two links and is dominated by SH1 near Newlands.
- The modelled flows compare well with the observed in the peak periods, and in the Interpeak the modelled are less than the observed by 16% and 8%; the highest GEH is 7 in the Interpeak northbound
- Transit counts have been used on SH1 in place of the counts provided.

Screenline L1:

- SH2 north of Ngauranga is Screenline L1.
- The 2006 peak direction flows as counted were lower than in 2001 by 9% (AM peak southbound) and 17% (PM peak northbound), so the 2001 counts have been used for this validation.

- The modelled flows compare well with the counts, the largest differences being in the AM peak southbound, +7% (GEH=4), and in the Interpeak northbound by -7% (GEH=4).

Screenline L2:

- The modelled flows across this screenline compare well with the observed.
- The maximum difference occurs in the Interpeak at around 13% with GEH values of 5, and the PM peak northbound, -12%.

Screenline L3:

- The modelled flows across this screenline generally compare well with the observed.
- The PM peak inbound (towards SH2) has the greatest difference, -16%, GEH 12. While the counts have been verified as much as possible (new counts were undertaken for some periods on Ewan, Melling, and Kennedy Good Bridges, and Transit counts were obtained) it is noted that the PM inbound count is 18% higher than the AM outbound count; if it were similar the modelled difference would be less than 5%.

Screenline L4:

- The modelled flows across this screenline compare well with the observed in the AM peak and the PM peak outbound.
- They compare less well in the other cases; some 30% higher than observed and with GEH values of 10 to 12.
- Note that the Wainuiomata Road outbound count in the AM peak has been adjusted from that provided to be more consistent with the PM peak inbound count.

Screenline U1:

- This screenline is a single link (SH2). The modelled flows do not match the observed particularly well, and are greater than the observed in all periods and both directions; the maximum GEH being 18.
- The count used was obtained from Transit in place of the counts provided by GWRC.
- The location of the count south of Akatarawa Road does not fit well with the zoning system and zone connectors. Traffic to/from zones and the south has to cross the screenline in the model, whereas in reality they have some activity (residential development) which can access SH2 south of the screenline. Hence the large differences can be discounted to some extent at least.

Screenline U2:

- The model matches the observed well in both directions and all modelled periods, the highest GEH being 76in the AM peak southbound (-12%).
- Transit counts have been used on SH2 in place of the GWRC counts.

Screenline U3:

- This screenline is a single link to the Manor Park residential area, and in the review of the screenlines it was recommended that this should be removed in future updates to WTSM given its localised nature.
- The model matches the observed well in terms of GEH, the highest being 6 in the PM peak westbound

Screenline P1:

- This screenline has three links of which SH1 is the most dominant. It is the most northern screenline and separates the Kapiti Coast from the rest of the region.
- The modelled flows compare well with the observed.
- The modelled flow in the AM peak southbound fits with the observed very well (-2%) and in the PM peak northbound the difference is slightly more at -7%. The HBW TA attraction factors were adjusted to achieve a better fit with observed person travel (car + rail) (refer to Section 7.6).

Screenline P2:

- This screenline is on SH58 alone.
- The modelled flows compare well with the observed counts in the peak periods, and less so in the Interpeak, where the model overestimates the observed flow by 30-40%% (GEH=6-7).

Screenline P3:

- This screenline, just south of Porirua commercial centre, compares very well in the AM peak southbound direction, and well in the PM peak northbound, but has some significant differences in the other cases with the model underestimating flows.
- The modelled flows are 800 to 1000 lower than observed in the AM peak northbound, the Interpeak both directions and the PM peak southbound, with GEH values of 10 to 13.

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Table 29 AM Peak Screenline Flows

SL	Dir	Observed Count	Modelled Volume	Diff	% Diff	GEH	Comments on Modelled Volume
W1	In	27,718	30,592	2,874	10%	12	High, just acceptable
W1	Out	15,444	16,705	1,261	8%	7	Slightly high, but acceptable
W2	East	2,934	2,917	-17	-1%	0	Acceptable
W2	West	3,635	4,212	577	16%	7	High, but acceptable
W3	East	2,422	3,100	678	28%	9	High, but relatively low flows
W3	West	1,102	1,696	594	54%	11	High, but relatively low flows
W4	North	6,190	6,280	90	1%	1	Acceptable
W4	South	14,195	13,744	-451	-3%	3	Acceptable
W5	North	3,831	3,944	113	3%	1	Acceptable
W5	South	7,474	7,325	-148	-2%	1	Acceptable
L1	North	5,331	5,479	148	3%	1	Acceptable
L1	South	7,510	8,042	532	7%	4	Acceptable
L2	North	3,253	3,364	112	3%	1	Acceptable
L2	South	5,948	5,793	-155	-3%	1	Acceptable
L3	In	10,364	9,872	-491	-5%	3	Acceptable
L3	Out	9,432	8,391	-1,041	-11%	8	Slightly low, but acceptable
L4	North	6,114	6,051	-63	-1%	1	Acceptable
L4	South	2,119	2,503	384	18%	6	Slightly high, but acceptable
U1	North	666	1,497	831	125%	18	High, but issue with location of screenline
U1	South	1,900	2,163	263	14%	4	High, but issue with location of screenline
U2	North	3,254	3,464	210	6%	3	Acceptable
U2	South	5,241	4,598	-643	-12%	6	Slightly low, but acceptable
U3	East	954	815	-139	-15%	3	Slightly low, but acceptable
U3	West	281	379	98	35%	4	High, but low flows, acceptable
P1	North	1,169	1,397	229	20%	5	High, but acceptable
P1	South	2,750	2,708	-42	-2%	1	Acceptable
P2	East	1,684	1,585	-99	-6%	2	Acceptable
P2	West	1,417	1,468	52	4%	1	Acceptable
P3	North	3,742	2,921	-820	-22%	10	Low, but acceptable
P3	South	5,542	5,632	90	2%	1	Acceptable

Table 30 IP Screenline Flows

SL	Dir	Observed Count	Modelled Volume	Diff	% Diff	GEH	Comments on Modelled Volume
W1	In	16,387	16,931	544	3%	3	Acceptable
W1	Out	15,821	16,417	596	4%	3	Acceptable
W2	East	2,998	2,980	-17	-1%	0	Acceptable
W2	West	2,798	2,979	181	6%	2	Acceptable
W3	East	1,334	1,812	478	36%	9	High % difference, low flows, acceptable
W3	West	1,315	1,764	449	34%	8	High % difference, low flows, acceptable
W4	North	6,059	5,877	-183	-3%	2	Acceptable
W4	South	5,739	6,118	379	7%	3	Acceptable
W5	North	3,813	3,204	-609	-16%	7	Quite high % difference, but low flows, acceptable
W5	South	3,659	3,378	-281	-8%	3	Acceptable
L1	North	4,815	4,457	-358	-7%	4	Acceptable
L1	South	4,319	4,531	213	5%	2	Acceptable
L2	North	2,787	3,143	356	13%	5	Slightly high, low flows, acceptable
L2	South	2,748	3,160	412	15%	5	Slightly high, low flows, acceptable
L3	In	7,538	7,186	-351	-5%	3	Acceptable
L3	Out	6,910	7,059	150	2%	1	Acceptable
L4	North	2,294	3,177	883	39%	12	High % difference, low flows, just acceptable
L4	South	2,376	3,104	728	31%	10	High % difference, low flows, acceptable
U1	North	943	1,494	551	58%	11	High, but issue with location of screenline
U1	South	919	1,494	575	63%	12	High, but issue with location of screenline
U2	North	2,723	2,954	231	8%	3	Acceptable
U2	South	2,644	2,999	355	13%	5	Slightly high, acceptable
U3	East	384	482	98	26%	3	High % difference, low flows, acceptable
U3	West	415	512	97	23%	3	High % difference, low flows, acceptable
P1	North	1,315	1,444	129	10%	2	Slightly high, acceptable
P1	South	1,368	1,405	38	3%	1	Acceptable
P2	East	688	961	274	40%	7	High % difference, low flows, acceptable
P2	West	743	976	233	31%	6	High % difference, low flows, acceptable
P3	North	3,651	2,656	-995	-27%	13	High % diff, low flows
P3	South	3,586	2,759	-827	-23%	10	High % diff, low flows, acceptable

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Table 31 PM Peak Screenline Flows

SL	Dir	Observed Count	Modelled Volume	Diff	% Diff	GEH	Comments on Modelled Volume
W1	In	17,933	19,936	2,002	11%	10	Slightly high, acceptable
W1	Out	26,663	28,965	2,302	9%	10	Slightly high, acceptable
W2	East	3,870	4,406	536	14%	6	Slightly high % difference, low flows, acceptable
W2	West	2,890	3,500	610	21%	8	High % difference, low flows, acceptable
W3	East	1,547	2,144	597	39%	10	High % difference, low flows, acceptable
W3	West	2,260	2,995	735	33%	10	High % difference, low flows, acceptable
W4	North	13,112	12,828	-284	-2%	2	Acceptable
W4	South	7,575	7,731	156	2%	1	Acceptable
W5	North	7,512	6,912	-600	-8%	5	Slightly low, acceptable
W5	South	4,490	4,565	75	2%	1	Acceptable
L1	North	7,484	7,877	393	5%	3	Acceptable
L1	South	6,051	6,314	263	4%	2	Acceptable
L2	North	6,163	5,452	-711	-12%	7	Slightly low, acceptable
L2	South	3,677	3,954	277	8%	3	Acceptable
L3	In	11,163	9,409	-1,754	-16%	12	Low, just acceptable
L3	Out	11,114	10,574	-540	-5%	4	At acceptable
L4	North	2,589	3,367	779	30%	10	High but low flows, acceptable
L4	South	5,939	5,910	-28	0%	0	Acceptable
U1	North	2,087	2,196	109	5%	2	Screenline location issue, acceptable
U1	South	1,025	1,786	761	74%	14	High but issue with location of screenline
U2	North	4,875	4,544	-330	-7%	3	Acceptable
U2	South	3,733	3,921	188	5%	2	Acceptable
U3	East	535	519	-15	-3%	0	Acceptable
U3	West	1,107	856	-251	-23%	6	High % difference, low flows, acceptable
P1	North	2,749	2,555	-194	-7%	3	Slightly low, acceptable
P1	South	1,541	1,721	180	12%	3	Slightly high, low flows, acceptable
P2	East	1,327	1,550	223	17%	4	High, low flows, acceptable
P2	West	1,742	1,555	-187	-11%	3	Slightly low, low flows, acceptable
P3	North	5,915	5,267	-648	-11%	6	Slightly low, acceptable
P3	South	4,434	3,560	-874	-20%	10	Low, but acceptable

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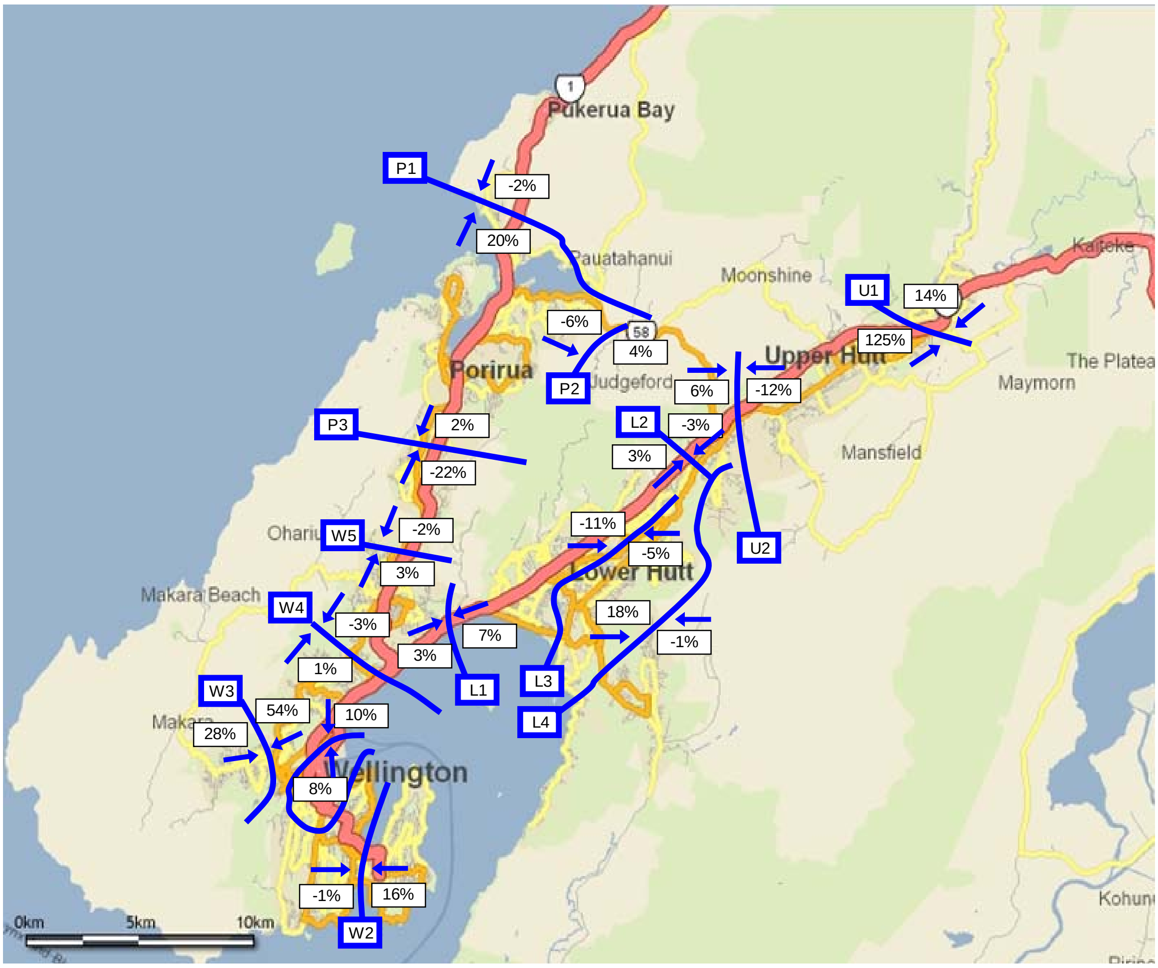
- **Figure 12 AM Peak Vehicle Percentage Difference on Screenlines**



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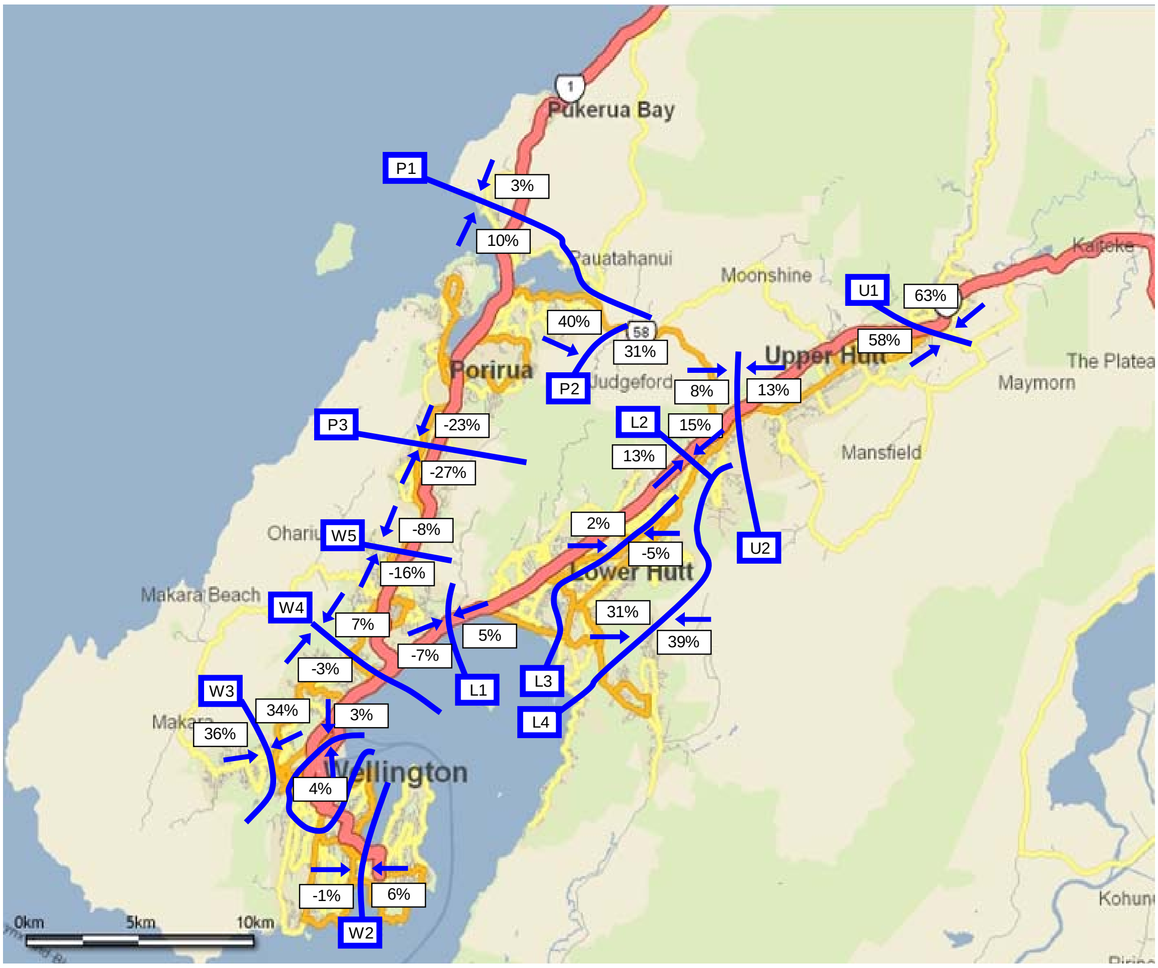
- **Figure 13 Interpeak Vehicle Percentage Difference on Screenlines**



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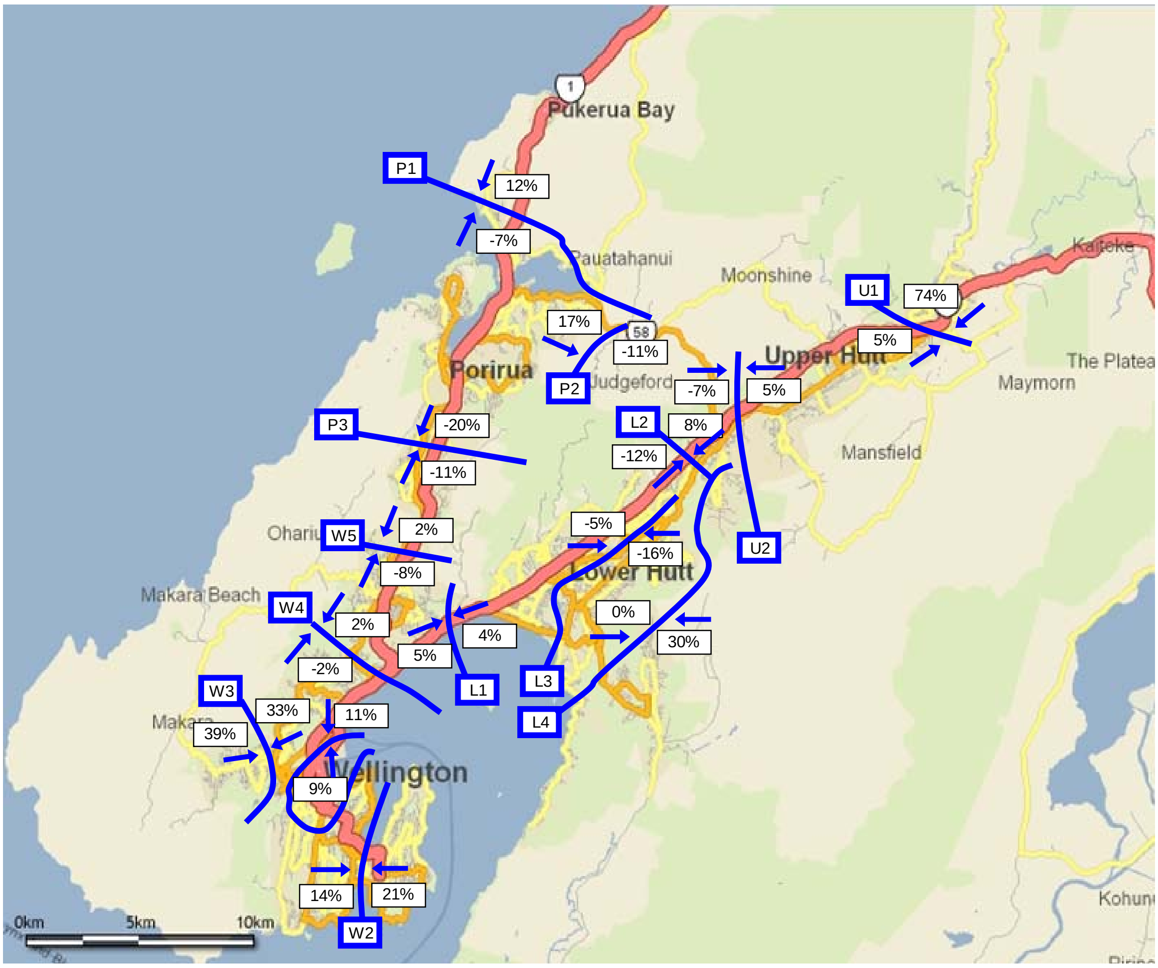
▪ Figure 14 PM Peak Vehicle Percentage Difference on Screenlines



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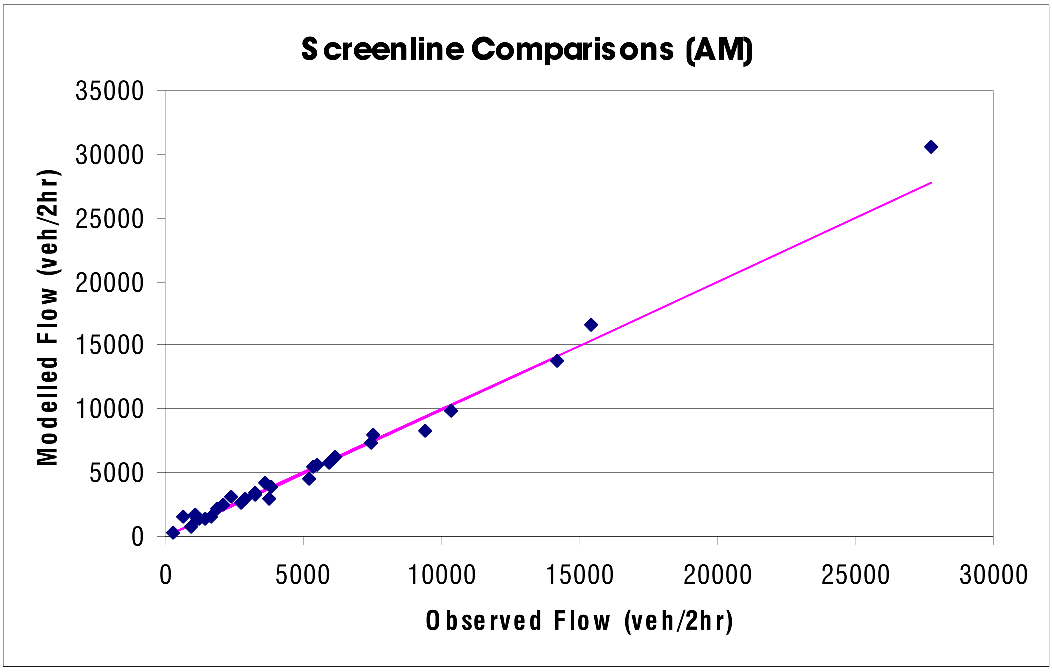
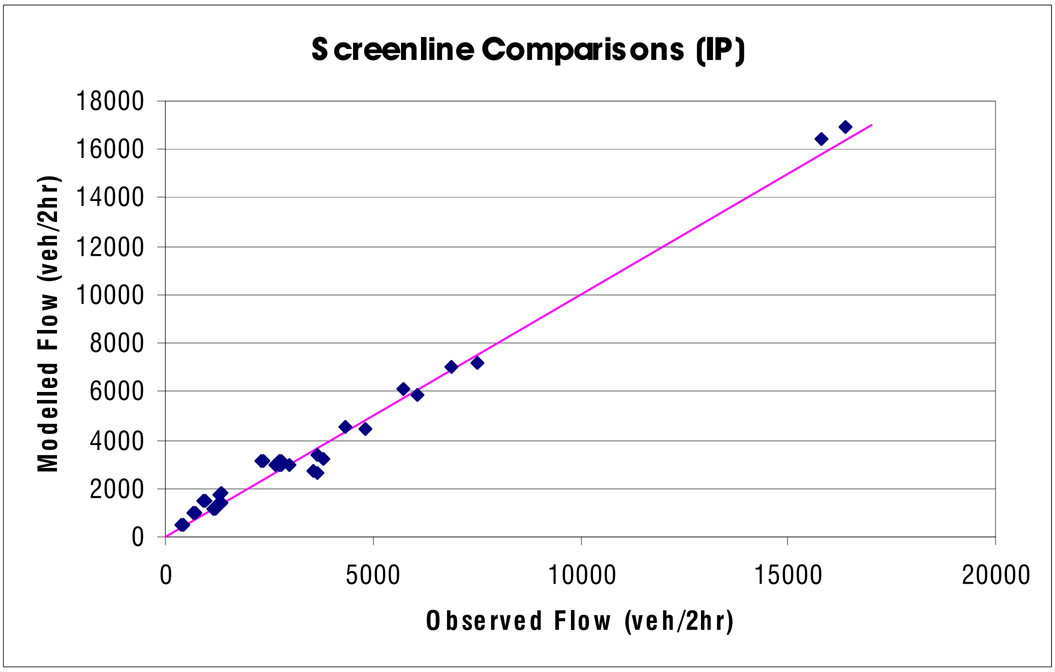
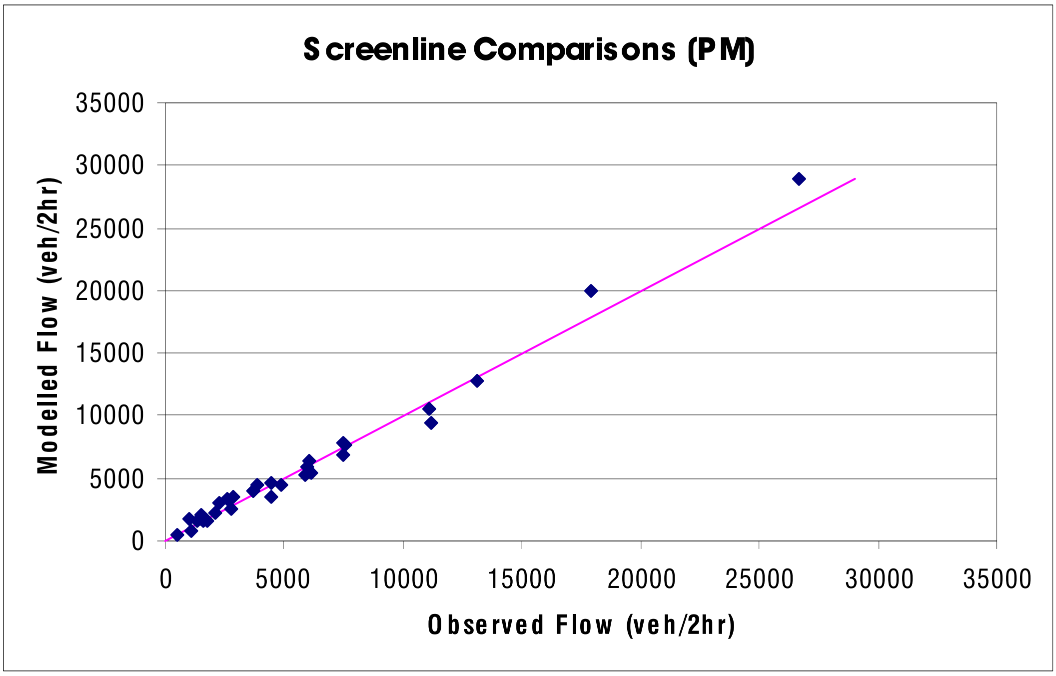
- **Figure 15 AM Peak Vehicle Fit on Screenlines**



- **Figure 16 IP Vehicle Fit on Screenlines**



▪ **Figure 17 PM Peak Vehicle Fit on Screenlines**



▪ **Table 32 Screenline Fit for Vehicles**

Statistic	AM	IP	PM
Proportion of screenlines with GEH < 5	67%	60%	57%
Proportion of screenlines with GEH < 10	87%	83%	83%
Proportion of screenlines with GEH < 12	97%	97%	93%
Proportion of screenlines with % difference < 10	70%	57%	70%
R^2	0.989	0.987	0.985

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9.3.2. Links on Screenlines

The comparisons between observed counts and modelled flows on individual links on the screenlines are made in terms of:

- Scattergrams of the two as in Figure 18 (AM peak), Figure 19 (Interpeak), and Figure 20 (PM Peak), and
- An overall summary (Table 33).

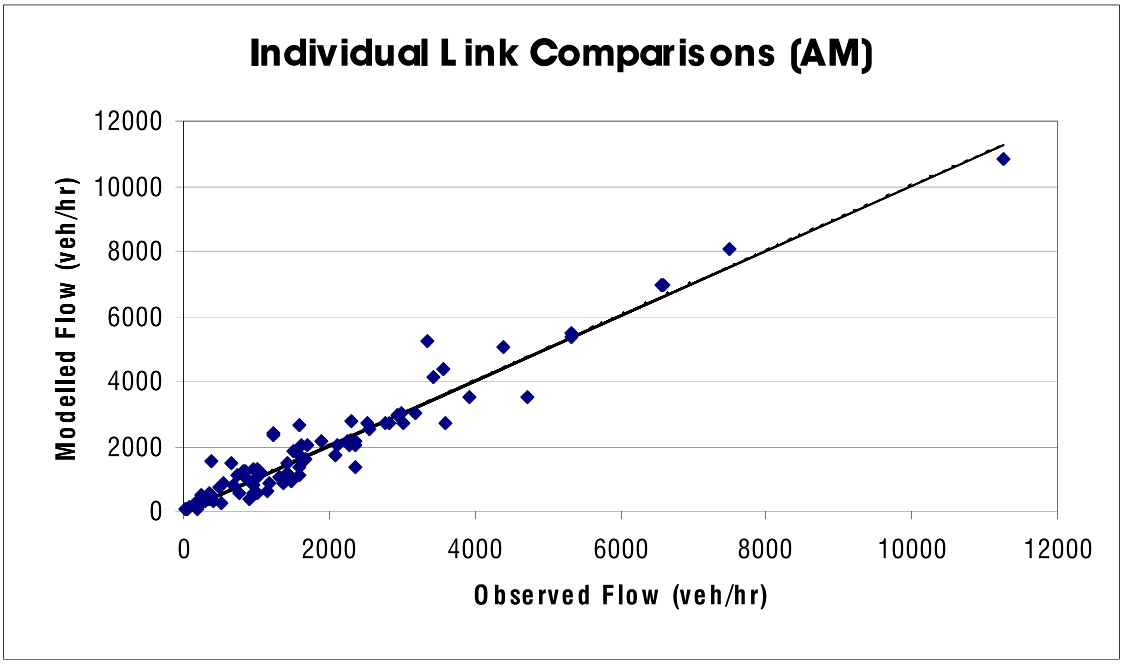
The scattergrams and statistics indicate that the model provides a good fit to the observed flows on links.

Around half of the links have a GEH value of less than 5 (in 2001 this varied between 35% and 45%) and around 90% of links have values of 12 or less.

High R^2 values of over 0.94 in the peak period models and 0.90 in the Interpeak (in 2001 these were similar, though lower).

The most noticeable outliers are in the Interpeak where two links have observed and observed flows of about 4,500 and 3,200 respectively. These are for SH1 near Bowen Street on the CBD screenline. The screenline totals match well, and these link differences are balanced by lower modelled flows on Thorndon and Waterloo Quays,

- **Figure 18 AM Peak Vehicle Fit on Individual Screenline Links**



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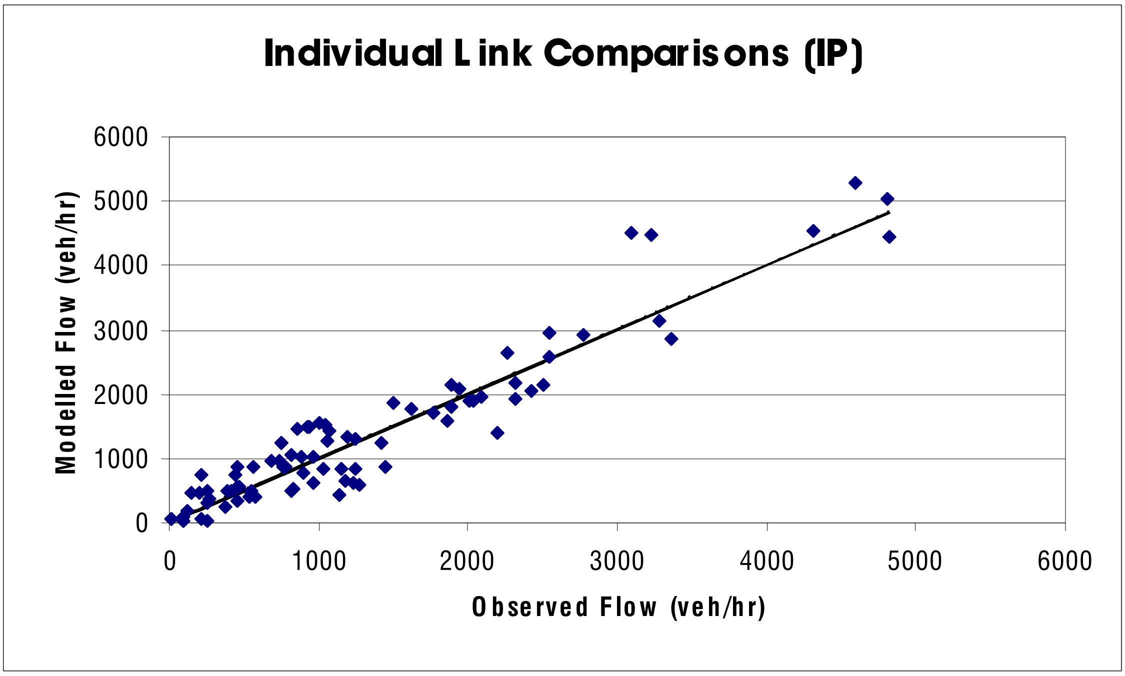
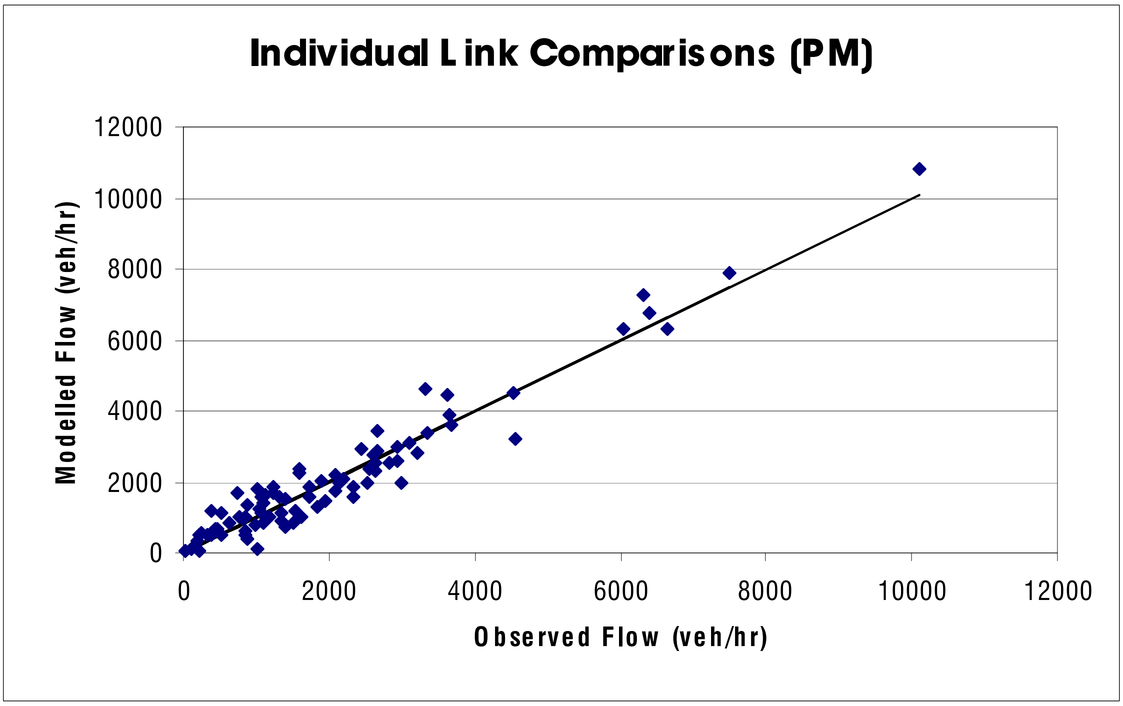
- **Figure 19 IP Vehicle Fit on Individual Screenline Links**



- **Figure 20 PM Peak Vehicle Fit on Individual Screenline Links**



- **Table 33 Summary of Fit for Vehicles on Individual Links, AM Peak**

Statistic	AM	IP	PM
Proportion of screenlines with GEH < 5	51%	49%	46%
Proportion of screenlines with GEH < 10	84%	77%	75%
Proportion of screenlines with GEH < 12	89%	86%	86%
Proportion of screenlines with % difference < 20	75%	73%	73%
R^2	0.938	0.899	0.938
RMSE	25%	29%	24%

9.4. Vehicle Travel Time Validation

Vehicle travel times have been collected on seven routes in both directions on seven routes for the purposes of comparing with modelled times; the routes are the same as those used in 2001:

- Route 1 Waikanae Railway Station - Wellington Airport;
- Route 2 Upper Hutt Railway Station - Wellington Airport;
- Route 3 Porirua – Seaview (via SH58);
- Route 4 Wellington Railway Station - Island Bay;
- Route 5 Featherston - Upper Hutt Railway Station;
- Route 6 Wellington Railway Station - Karori West;
- Route 7 White Lines / Randwick Rd - Waterloo Quay / Bunny St.

The full results of cumulative travel times on each route in each period are graphed in Appendix B; this includes the minimum and maximum observed times as well as the mean observed times.

In most cases the modelled times fit well with observed, being close to the averages and within the range of variation in the observed.

Each travel time route is commented on in turn:

Route 1:

- The modelled times match the observed well, including the additional delays through the Wellington CBD.
- The AM peak southbound time is just outside the maximum observed between 30 and 38 km (Mana to Porirua) though the range between minimum and maximum is narrow, but otherwise compares well with the observed, including any merging effects at Ngauranga Junction.

- In the AM peak northbound the modelled time is higher than the average observed between the airport and the Basin Reserve; this section includes a merge from 2 lanes to 1 lane on Wellington Road, where the model has higher delays than the observed.
- Northbound in the PM peak, the modelled time fits well with the average observed. The merge from 2 lanes to 1 at Pukerua does not show up in the observed data as additional delay at that point and the modelled times are slightly slower than the observed from this point north. The observed times show a wide range with the maximum being 37% higher than the average, most of which occurs over the second half of the route.

Route 2:

- Southbound the modelled times match the observed well, though is close to the maximum from Ngauranga onwards in the AM peak and the Interpeak.
- Northbound in the AM peak the same effect between the airport and the Basin Reserve as in Route 1 is seen.
- In the PM peak northbound the modelled time is at the maximum observed on SH2 between Ngauranga and Korokoro. The modelled time here is particularly sensitive to the flow as this section of SH2 is running at capacity and providing more capacity in the model results in increased flows and a similar travel time. Adjustments have been made to the trip attraction factors aimed at achieving demands which match observed flows and provide travel times comparable with observed; this was partially successful. Some further PM peak travel time surveys were carried out over this section, which indicated a range between 5:05 and 13:40 minutes, compared to 5:45 to 9:20 for the times used in the validation. This confirmed the sensitivity and variability of travel times to traffic conditions over this section (refer also to Route 7), and indicates that this is an area of the model that is less robust than others generally and hence care is required in interpreting forecast travel times along this section of road as well as any associated benefits.

Route 3:

- The modelled times compare well with the observed.

Route 4:

- Generally the modelled times on this route compare favourably with the observed.
- In the AM peak southbound (i.e. out of the city) the modelled time is slightly higher than the maximum observed through the CBD to Adelaide Road- though the range is very narrow, then matches the maximum observed for the remainder of the route.
- In the PM peak northbound, the modelled times are just below the minimum observed over the second half of the route, and the overall time is slightly lower than the minimum observed.

Route 5:

- The modelled times compare well with the observed, given that the narrow range of the observed.

Route 6:

- The modelled times match the observed well on this route in the AM peak and Interpeak and PM peak southbound.
- In the AM peak northbound the modelled time shows a significant delay (about 2 minutes) at the intersection of Glenmore and Upland Roads, which brings the time back close to the average observed.
- In the PM peak northbound the modelled is lower than the average observed for the middle part of the route, but the overall times are between the minimum and the average.

Route 7:

- The modelled times compare well with the observed in the Interpeak and the contra-peak directions in the peak periods, but less so in the peak directions.
- In the AM peak southbound and the PM peak northbound the modelled time is greater than average observed between Petone and Ngauranga Interchanges, as discussed under Route 2.

9.5. Public Transport Assignment Validation

The public transport assignment has been validated as follows:

For bus:

- Comparison with ETM data as counts across screenlines (Table 34 and Table 35),
- Scattergrams of screenline flows (Figure 21 and Figure 22), and
- An overall summary of statistics (Table 36).

For rail:

- total boardings and alightings at Wellington Station, and
- inbound rail loadings by corridor.

9.5.1. Bus Validation

Because some information provided by service providers is considered confidential and commercially sensitive, this information has been removed where appropriate.

Table 34 and Table 35 give the observed (based on ETM data) and modelled bus patronages across the screenlines plus for sectors of the CBD screenline for the AM peak and Interpeak modelled periods respectively. As discussed in Section 9.2, some concerns with the ETM data were identified as it was processed and the validation results need to be considered in this light.

Overall, given the relatively low numbers, the modelled bus flows compare well with the observed. Of the 24 screenlines shown in the tables, almost half in the AM peak have GEH of less than 5 and over two thirds in the Interpeak.

W1 inbound in the AM peak, which has the highest bus flows, is very close to the observed (GEH=2).

Other screenlines have large percentage differences, but low GEH values due to the low flows. The highest GEH values occur with the CBD screenline in the Interpeak.

The CBD screenline sectors indicate lower bus patronage than the observed from the west in the AM peak, and higher flows from the east and the north.

- **Table 34 AM Peak Bus Screenline Comparison**

REMOVED

- **Table 35 IP Bus Screenline Comparison**

REMOVED

- **Figure 21 AM Peak Bus Screenline Comparison**

REMOVED

- **Figure 22 Interpeak Bus Screenline Comparison**

REMOVED

- **Table 36 Screenline Fit for Buses**

Statistic	AM	IP
Proportion of screenlines with GEH < 5	46%	71%
Proportion of screenlines with GEH < 10	67%	83%
Proportion of screenlines with GEH < 12	79%	88%
Proportion of screenlines with % difference < 10	42%	50%
R^2	0.959	0.781

9.5.2. Rail Validation

The observed data for validation has been based on factoring up the 2001 rail survey data using growth rates from analysis of available existing data; growth factors of 10% and 14% have been applied to the 2001 AM and IP data respectively.

Table 37 gives the estimated observed and modelled regional boardings and Wellington Station alightings. The Wellington Station alightings match well with the model, overestimating the observed by 6% in the AM peak and underestimated by 6% in the Interpeak. The modelled regional boardings are not wholly comparable as the observed estimates are for the inbound direction only; given that the differences with the modelled of 11% in the AM peak and 54% in the Interpeak seem reasonable.

- **Table 37 Rail Boarding & Alighting at Wellington Station**

	Observed Estimates	Modelled	Difference	% Difference
AM - Region Boardings	11,319 *	12,521	1,202	11%
AM - Wellington Station Alightings	9,736	10,292	556	6%
IP - Region Boardings	1,570 *	2,423	853	54%

IP - Wellington Station Alightings	943	884	-59	-6%

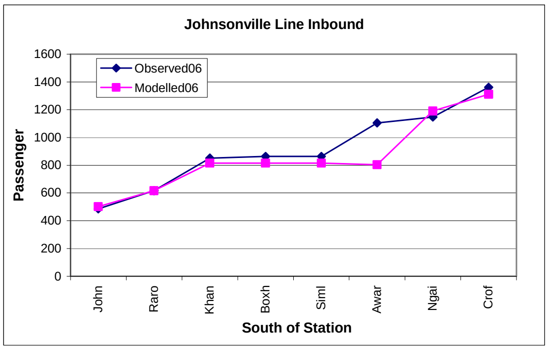
* inbound only

Figure 23 gives the estimated observed and modelled rail boardings by corridor for the AM peak and Interpeak. The two compare well for all three corridors, and the most noticeable differences occur in the Interpeak where the flows are very low.

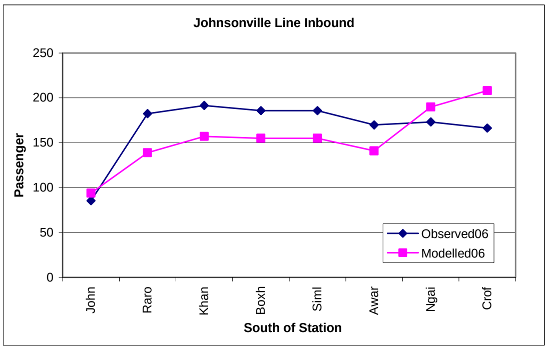
As noted in Section7.7 the rail wait time factor and some walk and p-connector link lengths have been adjusted to achieve a better match with the observed data, and the rail speeds have been revised as part of the validation.

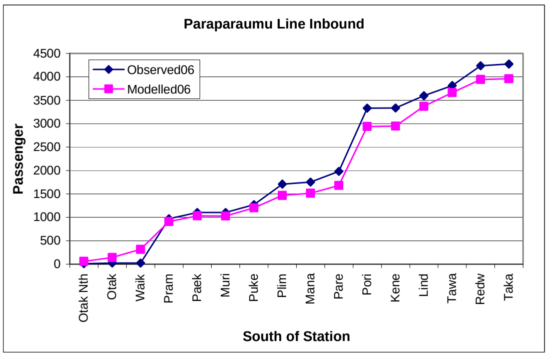
Figure 23 Rail Loading Comparison

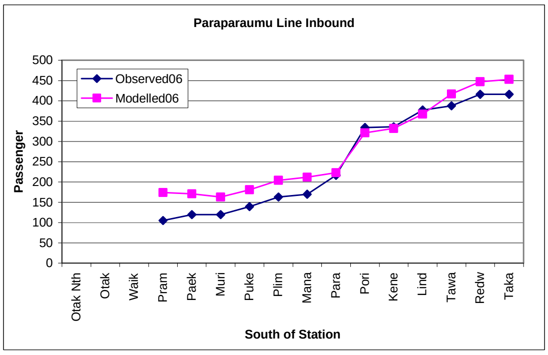
AM

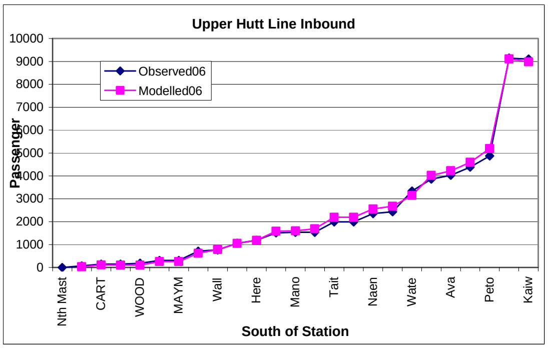


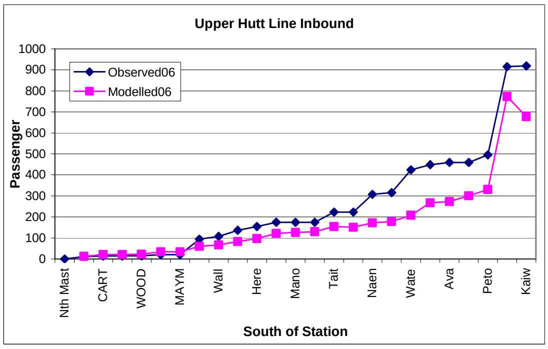
IP











9.6. HCV Validation

The model fit of HCV's is presented as:

- The observed and modelled total flows on each of the screenlines in the AM peak, Interpeak and the PM peak are given in Table 38, Table 39, and Table 40;
- Scattergrams of observed and modelled HCV flows in each modelled period in Figure 24, Figure 25, and Figure 26;
- Table 41 gives an overall summary of the screenline fit.

It needs to be noted that, while the observed data on some of the screenlines has been used in the development of the 2006 HCV matrices (refer to Figure 2), generally there is uncertainty in the observed data and a number of different sources has been used as noted previously.

Generally, as expected, the numbers of HCVs are low and small differences between observed and modelled result in large percentage differences while the GEH statistic remains low. All but 3 screenlines in the AM peak have a GEH of less than 5, and all but one in the Interpeak. The largest HCV flows occur on the Wellington CBD screenline, W1, and the modelled compares well with the observed in all three time periods.

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Table 38 AM Peak HCV Screenline Flows

SL	Dir	Observed Count	Modelled Volume	Diff	% Diff	GEH
W1	In	1,338	1,532	194	15%	4
W1	Out	1,295	1,469	174	13%	3
W2	East	207	173	-34	-17%	2
W2	West	244	221	-23	-9%	1
W3	East	73	51	-21	-29%	2
W3	West	60	82	22	36%	2
W4	North	372	349	-23	-6%	1
W4	South	897	636	-261	-29%	7
W5	North	206	220	14	7%	1
W5	South	203	229	26	13%	1
L1	North	223	241	19	8%	1
L1	South	233	255	23	10%	1
L2	North	223	210	-13	-6%	1
L2	South	182	200	19	10%	1
L3	In	534	389	-145	-27%	7
L3	Out	676	454	-222	-33%	5
L4	North	237	119	-118	-50%	6
L4	South	171	105	-66	-39%	4
U1	North	78	83	5	7%	0
U1	South	151	147	-3	-2%	0
U2	North	137	148	12	9%	1
U2	South	217	205	-12	-5%	1
U3	East	10	13	3	33%	1
U3	West	8	42	34	421%	5
P1	North	149	216	67	45%	3
P1	South	140	209	69	49%	4
P2	East	59	27	-31	-53%	3
P2	West	63	55	-8	-12%	1
P3	North	208	234	27	13%	1
P3	South	245	258	13	5%	1

- **Table 39 IP HCV Screenline Flows**

SL	Dir	Observed Count	Modelled Volume	Diff	% Diff	GEH
W1	In	1,361	1,299	-62	-5%	1
W1	Out	1,200	1,340	140	12%	3
W2	East	220	203	-17	-8%	1
W2	West	207	182	-25	-12%	1
W3	East	65	62	-3	-4%	0
W3	West	65	66	1	1%	0
W4	North	366	345	-21	-6%	1
W4	South	345	246	-98	-28%	4
W5	North	197	229	32	16%	2
W5	South	259	279	20	8%	1
L1	North	337	351	15	4%	1
L1	South	265	205	-60	-23%	3
L2	North	206	246	40	20%	2
L2	South	182	198	16	9%	1
L3	In	372	441	69	18%	0
L3	Out	412	418	6	2%	2
L4	North	146	116	-30	-20%	2
L4	South	154	118	-36	-23%	2
U1	North	141	141	1	1%	0
U1	South	137	146	9	7%	1
U2	North	195	205	10	5%	1
U2	South	188	190	3	2%	0
U3	East	6	14	8	140%	2
U3	West	5	48	43	854%	6
P1	North	148	222	74	50%	4
P1	South	107	166	59	55%	4
P2	East	49	49	0	0%	0
P2	West	50	48	-2	-5%	0
P3	North	229	265	37	16%	2
P3	South	222	244	22	10%	1

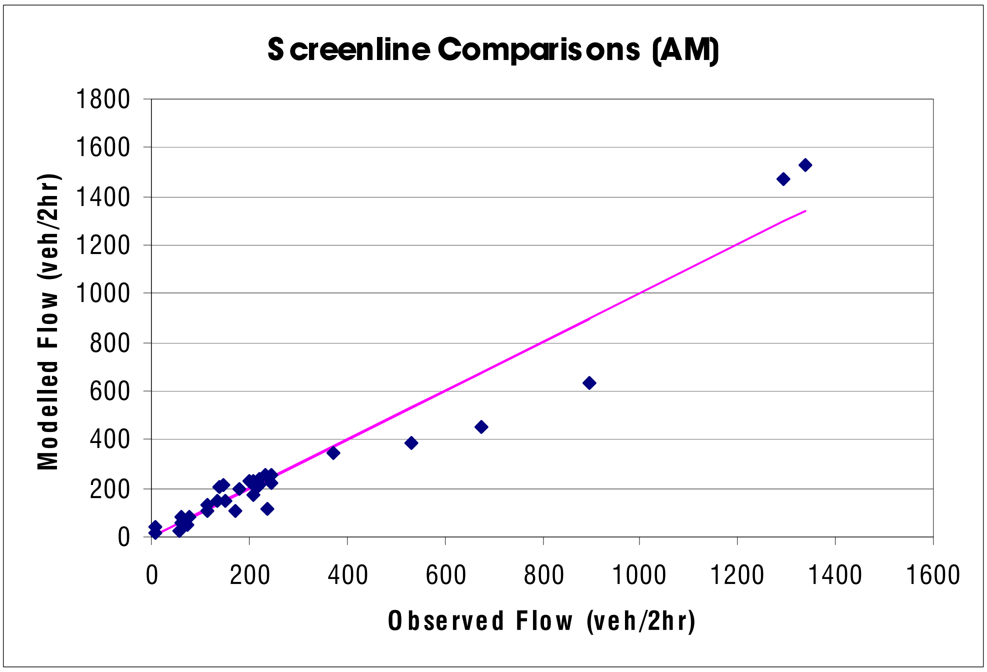
SKM

- **Table 40 PM Peak HCV Screenline Flows**

SL	Dir	Observed Count	Modelled Volume	Diff	% Diff	GEH
W1	In	1,148	1,278	130	11%	3
W1	Out	1,386	1,582	196	14%	4
W2	East	269	180	-90	-33%	4
W2	West	214	211	-2	-1%	0
W3	East	70	57	-12	-17%	1
W3	West	57	73	16	29%	1
W4	North	791	558	-233	-29%	6
W4	South	423	309	-114	-27%	4
W5	North	196	198	2	1%	0
W5	South	133	153	21	16%	1
L1	North	190	213	24	13%	1
L1	South	147	149	2	2%	0
L2	North	187	158	-29	-15%	2
L2	South	154	115	-39	-25%	2
L3	In	463	315	-148	-32%	6
L3	Out	488	326	-161	-33%	5
L4	North	141	83	-58	-41%	4
L4	South	222	82	-139	-63%	8
U1	North	73	78	5	7%	0
U1	South	67	73	6	9%	1
U2	North	122	121	0	0%	0
U2	South	106	109	4	4%	0
U3	East	7	9	3	46%	1
U3	West	4	31	27	672%	5
P1	North	127	193	66	52%	4
P1	South	95	144	50	53%	3
P2	East	44	20	-24	-54%	3
P2	West	36	26	-10	-27%	1
P3	North	161	182	22	14%	1
P3	South	149	175	26	18%	1

SKM

- **Figure 24 AM Peak HCV Fit on Screenlines**



- **Figure 25 IP HCV Fit on Screenlines**

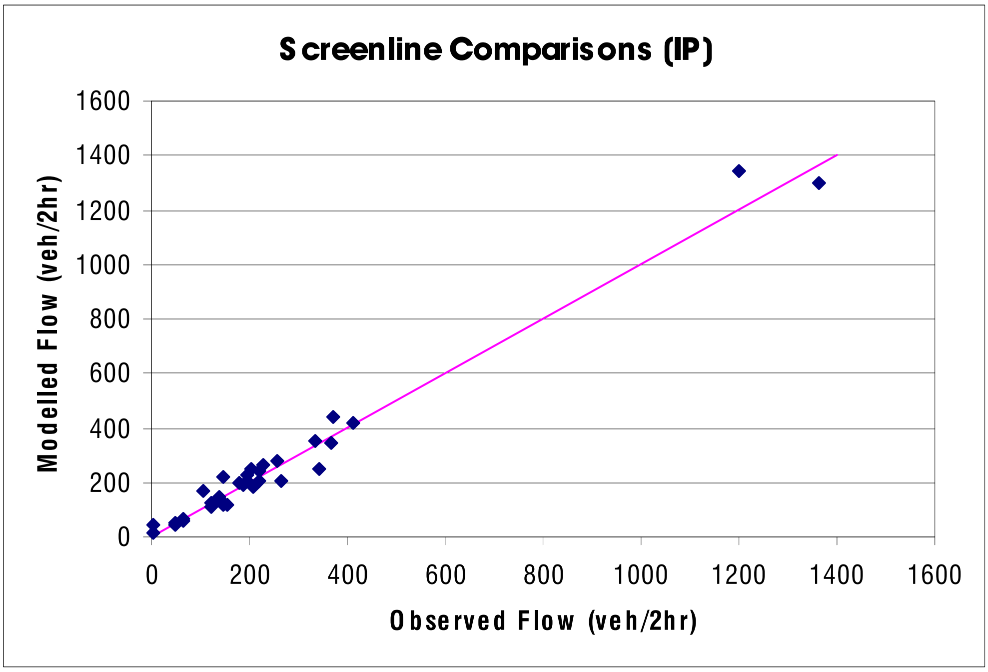


Figure 26 PM Peak HCV Fit on Screenlines

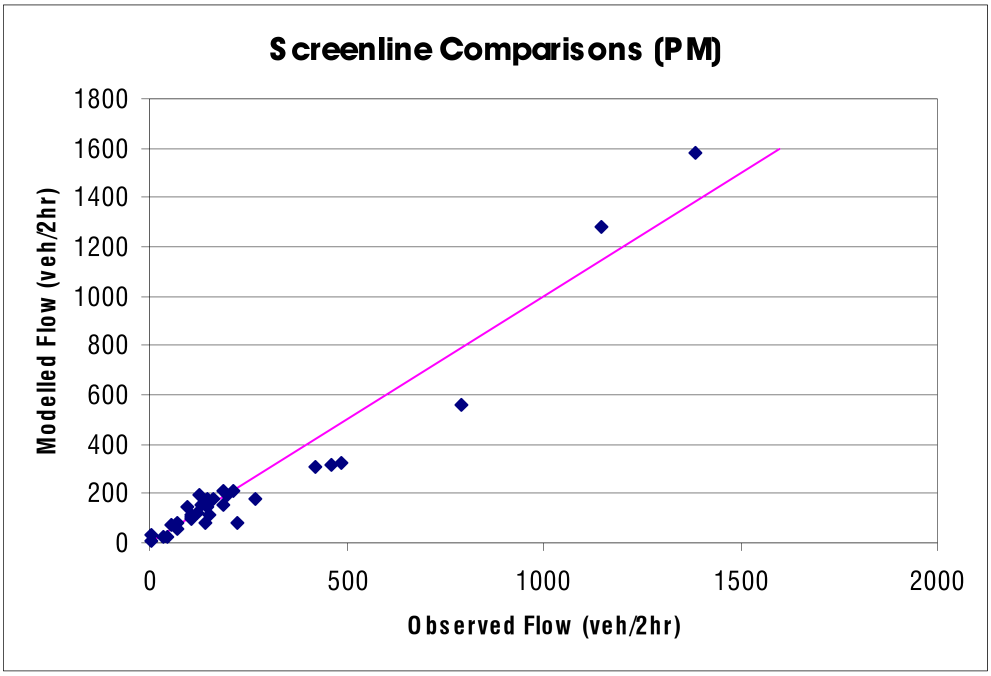


Table 41 Screenline Fit for HCVs

Statistic	AM	IP	PM
Proportion of screenlines with GEH < 5	90%	97%	87%
Proportion of screenlines with GEH < 10	100%	100%	100%
Proportion of screenlines with GEH < 12	100%	100%	100%
Proportion of screenlines with % difference < 10	67%	70%	63%
R^2	0.936	0.978	0.941

10. Summary and Conclusions

The Wellington Transport Strategic Model (WTSM) has been updated to a 2006 base year as documented in this report. In conjunction with the update a series of investigations were carried out resulting in some implemented changes to the model.

The key aspects of the update relevant to the 2006 validation are:

- Use of 2006 Census land use data inputs;
- Transport networks updated to 2006;
- Updated values of time, vehicle operating costs, PT fares, parking costs, car ownership, and commercial vehicle matrices;
- Changes to delay functions and their implementation;
- A final multiclass assignment;
- 2006 observed data (traffic counts, travel times, ETM data).

The validation has involved comparisons between observed and modelled flows across screenlines and the links on the screenlines, travel times on routes, and rail boardings at stations.

The validation results for the updated model need to be considered in light of some uncertainties in the observed data as noted in this report. The results are considered reasonable for a strategic regional model such as WTSM and are comparable or better than those achieved for the original 2001 model.

While the validation statistics used are drawn from the EEM, the guidelines for achieving validation are designed for traffic project models and not strategic multi-modal models such as WTSM. Nevertheless the validation achieved here gives a reasonable comparison against those criteria. For example, the EEM requirements include that 60% of links on screenlines should have a GEH of 5 or less and 100% should be less than 12; the 2006 WTSM has, in all three modelled periods around half of links on the screenlines with GEH of 5 or less and around 90% less than 12.

As such the 2006-based WTSM is considered suitable for use in the development of strategy (such as the RLTS), for assisting in investigations of major transport corridors, and for providing demands to more-detailed traffic project models.

Nevertheless, as with any model of this nature, its strengths and weaknesses should be recognised and corresponding care taken when interpreting specific model outputs. Such an area is on SH2 between Ngauranga and Petone and Korokoro, where the modelled travel time in the PM peak northbound was at the maximum of the observed range. Care is also required in using detailed modelled PT outputs, given the uncertainty in the observed PT data as noted in this report.

It is likely that when the model is used for some purposes that it would benefit from corridor-specific adjustments and enhancements as necessary.

Appendix A 2006 Land Use Data

Zone	Infants	Children 5-10 yrs	Children 11 16 yrs	Young Adult Full-Time Employed	Young Adult Part-Time Employed	Young Adult Other	Adult Full-Time Employed	Adult Part-Time Employed	Adult Other	Older Adult Full-Time Employed	Older Adult Part-Time Employed	Older Adult Other	Population Total
1	129	151	178	114	56	96	694	130	274	12	10	163	2007
2	296	354	353	195	95	178	1405	272	508	30	42	440	4164
3	245	295	303	138	84	135	1258	275	397	32	40	336	3534
4	460	551	562	247	115	313	1892	393	815	33	37	480	5895
5	115	193	161	44	30	57	626	156	172	15	22	129	1714
6	59	106	83	22	16	28	307	81	83	5	12	67	868
7	2	2	2	1	1	1	10	2	4	0	0	2	28
8	307	296	254	216	87	162	1592	301	528	11	20	314	4090
9	277	326	317	306	136	238	1536	289	693	30	39	594	4781
10	228	223	232	406	136	212	1615	238	374	24	21	142	3849
11	158	134	128	212	79	126	937	148	294	19	14	135	2386
12	55	81	54	135	33	71	644	103	194	13	11	88	1481
13	38	29	102	201	134	229	403	68	174	6	3	90	1480
14	280	274	336	479	255	490	1738	322	919	19	19	327	5456
15	171	172	178	129	56	93	1069	183	307	10	13	164	2544
16	297	290	284	176	95	122	1410	266	393	27	17	239	3615
17	243	240	244	147	72	104	1136	215	315	21	15	181	2936
18	154	147	118	80	36	61	615	139	184	10	5	99	1648
19	131	96	116	246	122	196	765	149	295	11	13	137	2279
20	227	197	201	268	139	214	1106	237	536	19	16	367	3532
21	55	43	144	282	209	318	494	86	231	3	6	44	1917
22	229	189	230	233	111	157	1443	249	373	24	20	147	3409
23	147	136	138	173	64	115	876	169	277	17	13	145	2268
24	220	214	237	241	106	141	1419	220	333	20	23	162	3343
25	98	87	187	411	326	409	971	200	444	13	13	144	3300
26	86	86	135	174	140	293	474	96	354	11	14	73	1812
27	82	126	231	232	190	317	756	144	177	16	20	95	2381
28	205	246	243	304	143	184	1433	270	336	22	27	154	3563
29	149	149	144	125	52	84	881	161	215	16	18	122	2111
30	399	570	562	219	196	290	2066	482	614	47	68	514	6024
31	420	474	525	270	180	327	2227	410	623	37	44	423	5960
32	162	168	183	107	61	115	824	146	234	12	14	148	2175
33	33	41	42	24	7	14	170	36	39	4	3	21	435
34	101	105	100	80	36	54	598	109	144	11	13	80	1425
35	264	247	242	173	81	116	1391	241	316	23	25	157	3276
36	42	45	63	214	66	67	808	69	147	14	13	98	1646
37	5	5	7	25	8	8	93	8	17	2	1	11	190
38	33	34	48	165	51	51	623	53	113	11	10	76	1270
39	3	3	4	13	4	4	49	4	9	1	1	6	99
40	26	31	39	109	36	55	487	83	183	21	37	171	1281
41	47	42	62	243	71	91	777	96	167	10	10	66	1681
42	54	48	70	277	81	104	888	109	191	11	11	76	1921
43	45	41	59	233	68	88	747	92	160	9	9	64	1615
44	47	37	128	255	186	285	453	76	208	3	6	39	1725
45	15	12	40	81	55	90	159	26	68	2	1	27	578
46	5	5	34	102	53	98	216	22	76	3	2	11	628
47	7	7	44	134	70	128	283	29	100	4	3	14	824
48	3	3	20	61	32	58	128	13	45	2	1	6	372
49	0	0	0	0	0	0	0	0	0	0	0	0	0
50	7	7	46	140	73	133	295	30	103	4	3	15	856
51	5	5	33	100	52	96	211	22	74	3	2	11	614
52	4	4	27	83	43	79	175	18	61	2	2	9	507
53	5	6	34	104	54	99	219	23	77	3	2	11	638
54	14	15	97	169	113	242	356	52	152	5	7	47	1270
55	11	14	29	39	30	48	108	21	34	2	2	14	352
56	21	21	87	162	115	208	353	59	155	5	6	49	1240
57	12	14	88	153	102	218	322	47	138	4	6	42	1147
58	1	1	5	9	6	13	20	3	8	0	0	3	70
59	0	0	2	3	2	4	6	1	3	0	0	1	21
60	7	8	52	90	60	129	189	27	81	2	4	25	675
61	17	24	64	94	63	121	254	39	78	4	5	32	797
62	1	1	9	16	11	23	35	5	15	0	1	5	123
63	0	0	0	0	0	0	0	0	0	0	0	0	0
64	2	2	12	21	14	30	44	6	19	1	1	6	155
65	3	3	8	19	9	16	56	6	15	1	1	7	144
66	13	13	18	63	20	20	239	20	43	4	4	29	487
67	0	0	0	0	0	0	0	0	0	0	0	0	0
68	106	104	118	53	29	44	561	113	153	16	16	118	1431
69	159	156	122	57	33	48	704	136	160	16	10	93	1690
70	373	427	378	161	109	125	1992	372	460	37	44	228	4704
71	251	269	271	120	69	100	1310	266	329	31	31	225	3269
72	136	163	168	62	50	71	703	153	195	15	17	149	1881
73	163	169	167	83	42	59	860	167	208	20	20	147	2102
74	0	0	0	0	0	0	0	0	0	0	0	0	0
75	199	236	237	127	78	121	1041	193	308	17	23	298	2880

Zone	Infants	Children 5-10 yrs	Children 11-16 yrs	Young Adult Full-Time Employed	Young Adult Part-Time Employed	Young Adult Other	Adult Full-Time Employed	Adult Part-Time Employed	Adult Other	Older Adult Full-Time Employed	Older Adult Part-Time Employed	Older Adult Other	Population Total
76	135	162	164	93	57	92	738	135	229	13	19	254	2091
77	2	2	2	1	1	1	8	2	3	0	0	2	23
78	203	223	195	156	55	84	1036	193	267	15	18	198	2644
79	364	395	349	248	98	177	1892	260	492	29	18	171	4493
80	345	374	356	242	81	233	1332	264	715	26	16	193	4137
81	24	30	30	17	5	10	123	26	28	3	2	15	314
82	442	539	520	238	150	225	2012	386	657	32	28	242	5431
83	242	259	287	199	101	144	1353	252	383	27	26	280	3555
84	17	22	23	0	0	25	0	0	119	0	0	4	211
85	84	98	101	52	21	34	426	69	79	5	2	24	993
86	191	337	401	146	105	166	1165	290	362	31	25	413	3624
87	39	57	59	0	0	58	0	0	309	0	0	14	535
88	229	304	343	173	97	141	1035	221	362	14	29	299	3243
89	74	98	111	56	31	45	333	71	117	4	10	96	1044
90	270	332	391	209	75	188	1248	266	457	15	19	352	3822
91	121	153	198	69	49	64	514	112	169	2	10	87	1552
92	12	21	20	0	0	52	0	0	202	0	0	17	324
93	38	54	55	21	12	36	126	25	70	4	3	31	474
94	145	205	210	79	44	135	480	94	265	14	10	116	1800
95	306	282	306	148	54	212	895	198	445	20	13	395	3273
96	348	394	392	204	90	244	1326	285	646	20	34	328	4314
97	0	0	0	0	0	0	0	0	0	0	0	0	0
98	229	242	224	106	32	139	561	97	347	5	6	117	2105
99	123	118	102	83	18	59	499	76	172	10	8	79	1350
100	558	597	582	197	85	467	992	221	947	17	22	209	4886
101	372	511	486	161	49	341	712	158	751	20	16	202	3785
102	507	632	571	261	88	392	1049	247	818	26	16	226	4834
103	243	326	342	139	44	185	812	136	371	13	8	116	2736
104	72	106	108	77	28	27	494	100	112	15	12	111	1263
105	181	239	227	142	60	75	1056	215	252	28	25	178	2680
106	330	434	410	186	124	148	1679	328	385	35	24	226	4306
107	268	400	367	106	79	114	1352	274	348	7	18	144	3468
108	65	119	107	33	13	31	396	102	115	10	10	30	1038
109	122	129	135	90	46	54	715	150	145	16	18	168	1788
110	47	50	53	34	18	21	279	57	54	6	7	67	695
111	131	137	136	107	35	57	733	180	196	14	14	141	1876
112	141	181	162	57	40	50	626	168	191	5	7	121	1749
113	9	14	10	0	0	11	0	0	91	0	0	10	144
114	13	19	18	5	3	4	80	22	23	3	2	15	207
115	114	154	146	39	32	59	583	154	191	10	13	127	1623
116	226	334	338	152	64	114	1201	301	473	13	34	313	3564
117	259	371	399	143	78	140	1206	354	479	46	75	866	4407
118	131	175	177	78	36	82	563	143	276	16	22	453	2152
119	38	50	51	22	10	23	161	41	79	4	6	130	618
120	302	403	408	179	84	189	1296	330	638	36	51	1048	4966
121	247	337	342	156	77	128	1356	326	566	55	73	1083	4748
122	216	353	379	131	69	129	1046	293	482	22	43	533	3695
123	109	138	150	58	28	45	544	155	185	18	22	180	1632
124	189	250	209	82	36	71	821	268	439	33	44	452	2895
125	219	274	294	115	54	96	1122	335	765	67	131	2142	5619
126	98	130	124	44	28	39	496	143	225	25	38	425	1816
127	29	46	45	13	11	22	109	31	155	4	5	68	527
128	51	82	90	27	22	43	254	65	273	5	8	86	991
129	343	469	461	174	75	206	1372	373	838	66	96	1029	5500
130	32	93	85	18	13	23	336	99	119	26	18	63	927
131	15	44	40	9	6	11	160	47	57	12	8	30	442
132	24	45	31	6	5	24	0	0	208	0	0	28	360
133	42	70	53	33	14	64	0	0	364	0	0	43	636
134	84	109	119	46	16	49	374	90	110	10	8	77	1083
135	213	298	293	138	41	134	833	161	319	10	13	110	2562
136	195	314	271	136	57	94	981	190	304	12	16	176	2745
137	231	293	293	143	55	94	1084	214	286	13	22	145	2874
138	149	142	167	116	45	71	674	140	258	18	24	228	2031
139	37	41	36	17	7	33	100	21	115	3	3	45	456
140	24	25	25	0	0	56	0	0	152	0	0	47	329
141	123	161	198	110	50	82	623	148	245	16	17	388	2160
142	174	277	299	127	73	120	952	195	388	20	30	550	3201
143	147	185	181	149	57	87	713	136	227	13	26	257	2173
144	99	183	180	42	34	46	557	123	157	10	8	52	1491
145	20	37	53	98	20	105	283	51	277	1	5	217	1171
146	210	182	216	171	52	132	860	172	337	20	26	397	2772
147	150	205	222	108	46	79	736	147	234	18	19	264	2232
148	186	208	221	114	53	137	610	136	292	14	8	145	2121
149	60	81	74	26	11	47	328	50	196	2	0	25	903
150	110	177	212	87	56	74	762	158	216	33	29	326	2236
151	89	132	157	74	39	59	546	110	157	15	19	166	1565
152	102	154	165	73	47	54	615	113	175	15	17	159	1688
153	120	182	187	81	55	58	717	128	203	16	18	174	1938
154	24	29	23	17	0	30	0	0	223	0	0	68	396
155	251	309	318	153	60	138	1166	227	315	19	13	270	3239
156	153	202	187	109	40	95	721	119	232	16	11	108	1991
157	281	333	297	116	52	179	630	165	479	12	15	235	2794
158	25	30	27	10	5	16	57	15	43	1	1	21	251
159	255	267	246	158	84	103	1253	233	249	28	11	115	3000
160	309	318	301	144	56	178	797	192	490	15	14	230	3044

Zone	Infants	Children 5-10 yrs	Children 11-16 yrs	Young Adult Full-Time Employed	Young Adult Part-Time Employed	Young Adult Other	Adult Full-Time Employed	Adult Part-Time Employed	Adult Other	Older Adult Full-Time Employed	Older Adult Part-Time Employed	Older Adult Other	Population Total
161	240	251	250	116	47	162	612	117	412	13	13	152	2382
162	88	138	173	66	36	53	636	129	160	17	10	146	1656
163	246	284	259	139	46	153	679	137	374	10	16	225	2567
164	210	243	221	119	39	131	581	117	320	8	14	192	2194
165	97	96	100	61	21	56	291	73	164	4	8	66	1037
166	236	234	241	148	51	137	706	176	398	11	19	161	2514
167	165	179	199	124	55	107	666	151	332	15	29	283	2307
168	182	265	252	132	69	103	972	243	334	27	39	641	3259
169	232	297	350	177	92	126	1346	292	288	22	26	140	3384
170	168	248	252	133	68	103	949	222	322	21	30	489	3009
171	126	183	183	118	47	78	713	149	254	10	15	219	2093
172	225	248	260	163	64	146	998	190	406	20	16	258	2994
173	345	432	397	202	77	213	1076	215	440	26	23	202	3651
174	222	256	224	140	55	136	800	124	314	13	10	176	2475
175	287	398	388	188	104	154	1454	338	418	28	43	419	4219
176	104	155	172	77	49	67	602	142	171	14	18	244	1813
177	68	112	144	54	43	55	468	112	131	12	13	254	1468
178	7	12	16	6	5	6	51	12	14	1	1	27	159
179	0	0	0	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0	0	0	0
181	0	0	0	0	0	0	0	0	0	0	0	0	0
182	2	3	4	2	1	2	14	3	4	0	0	7	43
183	2	4	5	2	1	2	16	4	4	0	0	8	49
184	64	80	86	90	28	37	370	52	120	2	2	63	996
185	140	107	122	104	33	52	597	83	162	8	9	86	1506
186	33	55	71	27	21	27	230	55	64	6	7	125	722
187	93	146	191	74	55	97	451	104	353	17	19	201	1771
188	300	323	358	226	85	197	1326	273	481	29	32	344	3972
189	132	145	154	89	28	106	476	102	247	10	8	121	1620
190	160	172	169	132	52	119	796	155	253	15	12	186	2222
191	155	159	145	147	51	102	797	127	222	8	6	139	2056
192	136	169	203	128	65	71	931	154	165	18	21	94	2157
193	279	289	276	179	76	98	1517	267	344	28	26	187	3570
194	69	86	110	56	38	53	557	114	119	8	11	73	1295
195	104	93	78	85	36	52	487	78	162	9	11	117	1313
196	82	74	62	68	29	42	388	62	129	7	9	93	1045
197	0	0	0	0	0	0	0	0	0	0	0	0	0
198	222	279	277	140	55	151	900	120	278	9	16	189	2628
199	33	42	42	21	8	23	136	18	42	1	2	28	396
200	143	225	224	71	58	72	947	227	268	34	38	277	2586
201	118	187	186	59	48	60	785	188	222	28	32	230	2145
202	162	172	210	109	44	103	605	125	247	5	22	170	1968
203	192	232	245	154	47	145	766	135	287	28	18	244	2487
204	280	354	387	194	87	196	952	197	570	21	24	258	3499
205	11	16	17	9	2	22	0	0	111	0	0	13	191
206	86	85	82	34	13	46	456	117	160	21	21	203	1321
207	150	244	203	66	22	83	717	167	394	20	30	251	2343
208	115	157	162	55	30	39	629	182	236	35	41	382	2064
209	255	343	329	159	70	122	1224	304	558	32	56	673	4122
210	219	309	326	157	62	128	1092	329	457	38	51	716	3885
211	448	607	694	291	157	334	1894	545	1041	58	82	1209	7343
212	467	619	614	312	112	342	1627	471	903	42	64	903	6469
213	42	52	47	17	7	34	82	19	253	5	4	44	591
214	102	146	153	61	31	78	453	126	390	17	19	104	1647
215	56	73	75	30	12	22	290	87	96	7	14	31	791
216	116	218	281	90	60	82	1016	272	265	45	42	164	2651
217	88	114	116	32	20	69	353	104	223	17	11	71	1217
218	50	64	60	25	12	18	275	64	72	17	13	51	721
219	23	30	28	12	6	9	127	30	33	8	6	24	334
220	28	43	48	19	10	24	127	37	117	4	5	31	483
221	43	55	52	22	10	16	236	55	62	14	11	44	619
222	57	70	64	25	13	20	283	77	74	14	10	44	753
223	45	57	53	21	10	20	211	49	107	13	10	46	637
224	17	22	21	9	4	7	98	24	26	6	4	16	252
225	37	51	55	16	7	28	207	52	95	11	7	29	598

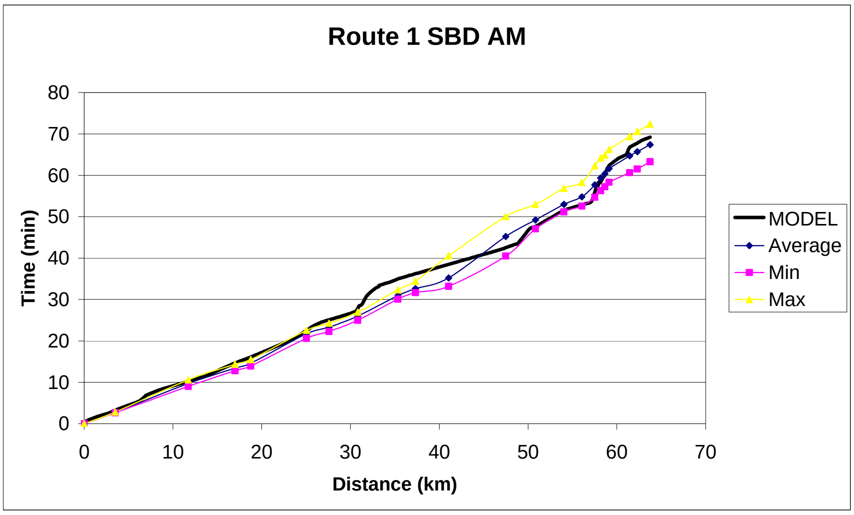
Zone	1 Adult Employed	1 Adult Non-Employed	2 Adults (Min of 1 Employed)	2 Adults Neither Employed	3+ Adults	Household Total	Other	Manufac	Retail	TransCom	Services	primary	secondary	tertiary
1	139	91	269	61	154	714	0	89	42	19	223	0	0	0
2	274	262	639	122	300	1597	5	254	229	188	540	529	92	0
3	221	187	550	88	182	1228	11	219	206	42	641	272	19	0
4	317	331	837	172	432	2090	10	181	201	134	352	252	630	0
5	112	60	332	50	82	636	5	108	62	1	214	580	215	0
6	51	26	147	23	39	287	1	40	21	0	77	0	0	0
7	4	2	6	1	2	15	0	125	151	177	160	0	0	0
8	360	215	671	117	257	1620	1	252	281	315	339	347	0	0
9	344	427	619	140	385	1915	0	392	813	563	1126	99	2020	0
10	277	108	661	52	328	1427	6	91	103	3	430	227	65	0
11	201	119	389	48	194	951	2	46	47	3	220	229	0	0
12	148	61	261	36	118	623	3	33	20	3	115	100	12	0
13	71	43	127	22	138	400	1	155	323	123	3078	0	0	0
14	447	390	661	138	511	2148	10	208	427	46	1263	346	328	0
15	180	103	471	69	167	990	3	79	43	7	153	185	0	0
16	220	131	610	76	235	1271	0	113	199	8	387	380	4	0
17	197	112	524	63	196	1093	0	55	100	3	173	186	44	0
18	118	57	265	20	106	567	3	125	19	19	147	97	1	0
19	188	117	302	58	200	866	2	77	185	27	481	0	0	0
20	313	242	517	103	262	1438	13	78	73	10	388	155	9	0
21	113	78	188	40	236	656	1	35	42	1	103	0	0	0
22	317	101	643	67	241	1369	0	121	78	17	376	356	119	0
23	201	90	381	63	168	903	0	25	20	8	121	134	41	0
24	283	105	590	54	251	1283	0	73	36	7	205	0	0	0
25	316	282	422	82	351	1453	0	42	87	6	291	0	0	6367
26	146	58	304	36	146	689	0	10	15	7	150	0	0	2995
27	152	63	331	44	202	793	2	51	85	3	583	254	97	1725
28	286	135	654	57	241	1373	15	76	107	6	295	296	101	0
29	221	86	448	48	126	930	0	49	19	4	157	121	33	0
30	302	236	1065	126	362	2091	5	125	367	23	1101	692	756	0
31	404	261	1025	133	376	2200	0	119	112	31	453	152	58	0
32	148	94	373	48	138	800	3	36	39	8	144	263	56	0
33	22	10	76	7	28	143	8	29	21	6	76	23	7	795
34	131	51	272	28	75	556	1	87	94	7	270	131	1	0
35	233	109	666	51	179	1239	0	76	66	20	356	233	53	0
36	208	68	291	29	97	693	0	21	45	46	331	0	0	0
37	25	8	35	3	12	83	1	75	163	165	1197	145	703	0
38	193	64	271	27	91	646	2	134	289	293	2124	282	1816	0
39	12	4	17	2	6	42	2	112	242	245	1777	0	0	0
40	128	81	226	55	86	576	0	26	134	12	164	0	0	0
41	183	56	276	27	155	698	3	57	181	6	360	0	0	0
42	216	67	326	32	183	824	5	81	260	8	517	155	54	0
43	173	53	261	25	147	659	2	41	129	4	257	0	0	0
44	125	84	207	44	251	710	5	260	328	14	801	31	1027	4153
45	38	23	66	12	73	212	2	75	139	10	440	238	2544	0
46	61	24	103	23	69	279	1	85	360	79	808	102	40	0
47	77	30	130	29	87	354	3	284	1194	261	2683	0	0	0
48	32	13	54	12	36	147	2	190	807	176	1806	0	0	0
49	1	1	2	1	1	6	7	251	924	184	4858	0	0	0
50	78	31	131	29	88	357	3	224	943	206	2118	0	0	0
51	32	13	54	12	36	147	2	136	573	126	1288	0	0	5032
52	43	17	72	16	48	195	3	269	1133	248	2544	0	0	0
53	51	20	86	19	57	234	2	182	767	168	1723	0	86	0
54	109	88	150	42	106	494	1	35	120	22	874	0	0	0
55	24	14	47	7	31	123	4	113	192	9	1287	0	0	19856
56	94	79	128	32	97	430	0	13	31	3	146	142	50	0
57	109	88	150	42	106	494	8	231	785	146	5738	0	0	0
58	2	2	3	1	2	9	3	95	323	60	2359	0	0	0
59	1	1	1	0	1	3	7	218	740	137	5406	0	0	0
60	74	59	101	28	72	335	9	258	875	162	6393	36	15	0
61	52	31	86	16	52	237	1	29	50	4	346	0	0	0
62	22	18	30	8	21	99	6	168	570	106	4164	0	0	0
63	1	1	2	1	1	6	6	161	547	102	4001	0	0	0
64	13	11	18	5	13	60	3	73	249	46	1820	0	0	0
65	14	7	19	3	10	54	5	195	522	299	3826	0	0	0
66	84	28	117	12	39	280	4	239	517	524	3800	0	0	0
67	3	0	12	0	9	24	11	390	273	175	181	0	0	0
68	82	56	268	37	81	524	1	30	44	5	89	0	0	0
69	122	51	334	17	74	599	1	38	58	2	118	0	0	0
70	372	148	968	77	231	1796	2	131	140	22	377	430	10	0
71	206	115	642	70	183	1216	4	153	162	19	476	526	72	0
72	106	67	328	37	109	647	1	39	14	3	102	0	1150	0
73	138	76	410	44	111	779	1	167	163	17	276	269	1	0
74	0	0	0	0	0	15	0	704	488	103	530	0	0	0
75	161	138	404	52	158	912	0	91	32	5	105	335	0	0

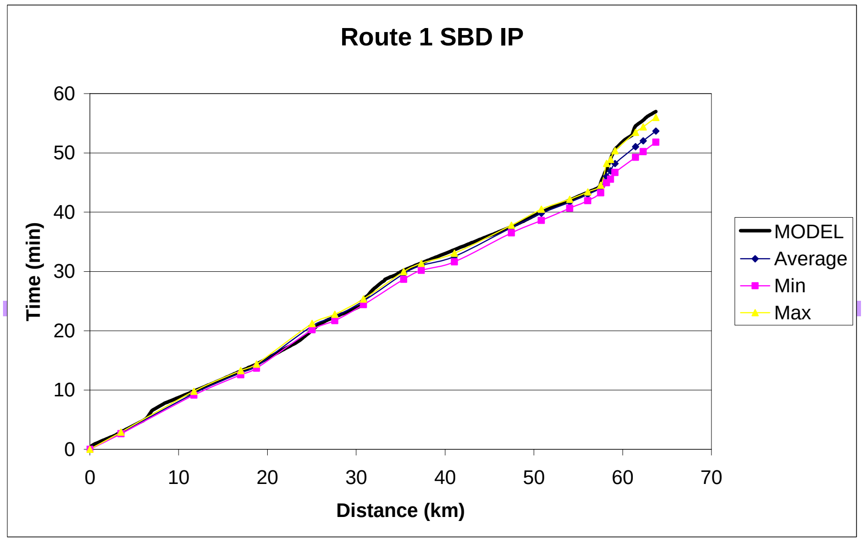
Zone	1 Adult Employed	1 Adult Non-Employed	2 Adults (Min of 1 Employed)	2 Adults Neither Employed	3+ Adults	Household Total	Other	Manufac	Retail	TransCom	Services	primary	secondary	tertiary
76	176	165	389	56	155	941	1	385	315	30	567	0	547	0
77	1	1	3	0	1	6	2	98	658	32	646	0	0	0
78	187	78	488	50	154	957	11	60	59	8	213	163	1	0
79	314	116	834	79	308	1650	7	110	146	20	311	91	1289	0
80	278	105	712	81	284	1461	7	81	81	120	269	476	7	0
81	16	7	54	5	20	101	34	125	91	26	333	0	0	0
82	270	108	987	83	358	1808	10	233	61	12	283	442	15	0
83	229	150	626	73	235	1314	1	104	303	19	379	579	76	0
84	7	3	36	3	19	67	0	14	3	0	11	0	0	0
85	54	15	207	6	54	336	0	7	0	0	22	0	0	0
86	144	130	520	127	259	1179	31	291	210	4	362	595	5	0
87	24	8	77	8	42	160	21	449	382	149	67	0	0	0
88	184	160	447	107	206	1104	1	47	140	7	262	171	1	0
89	70	60	169	41	78	417	3	94	277	14	519	273	1872	0
90	217	217	539	118	274	1365	4	79	102	5	230	102	0	0
91	62	34	224	28	123	471	1	105	9	4	72	221	0	0
92	12	6	9	0	12	39	6	352	686	47	1050	63	545	616
93	26	26	50	13	42	157	3	536	993	89	1179	222	8	655
94	92	92	174	44	149	551	0	50	90	9	90	0	538	2538
95	178	277	422	96	202	1176	12	71	67	0	279	488	172	0
96	256	235	569	147	323	1530	0	98	72	16	184	124	59	0
97	0	0	0	0	0	0	8	438	853	58	1308	0	0	0
98	98	107	241	46	147	639	0	19	41	10	164	175	0	0
99	102	40	206	34	83	465	0	27	9	0	73	0	0	0
100	150	247	372	159	414	1341	0	22	66	0	303	779	101	0
101	78	135	258	120	354	945	0	7	40	0	206	341	850	0
102	122	158	361	114	444	1200	4	51	68	91	217	624	192	0
103	102	90	306	39	234	771	0	35	9	0	74	268	96	0
104	56	21	196	28	79	381	0	73	80	7	736	0	887	0
105	139	61	516	65	175	957	0	65	61	10	267	451	161	0
106	174	86	817	99	271	1446	0	135	165	27	399	773	277	0
107	117	47	673	35	190	1062	23	68	52	4	196	0	0	0
108	40	19	207	16	60	342	70	111	57	6	234	161	41	0
109	119	86	319	50	102	675	11	88	125	5	191	169	1	0
110	56	43	155	24	48	342	19	73	213	15	223	0	0	0
111	138	77	320	51	116	702	9	97	90	2	182	295	131	0
112	103	61	324	45	88	621	0	47	52	6	120	118	45	0
113	10	0	32	0	6	48	8	40	0	0	32	0	0	0
114	9	5	39	9	9	70	20	21	15	6	36	0	0	0
115	147	119	272	43	79	660	23	49	103	17	118	126	40	0
116	263	192	616	131	160	1362	0	120	62	37	300	416	201	0
117	272	451	663	265	182	1833	21	118	207	12	693	430	1119	0
118	92	179	257	132	84	744	2	108	238	33	223	334	103	900
119	32	63	90	47	30	262	10	460	1014	140	950	190	81	0
120	269	526	748	386	245	2174	6	304	669	92	627	0	0	0
121	291	504	720	347	183	2046	4	163	285	42	577	445	187	0
122	201	279	543	197	184	1405	9	140	90	32	404	383	1478	0
123	70	64	286	63	65	550	33	71	63	15	160	0	0	0
124	181	215	505	203	91	1194	1	70	133	29	180	0	0	0
125	273	781	754	643	168	2619	63	407	470	55	792	368	142	0
126	108	136	290	149	70	753	21	75	74	5	174	333	135	0
127	26	22	94	25	21	188	32	32	17	7	47	0	37	0
128	83	40	195	35	41	395	98	73	106	6	91	151	1	0
129	423	620	720	374	196	2331	96	381	520	49	940	531	737	1888
130	39	35	201	37	37	350	164	89	66	9	84	0	0	0
131	19	17	99	18	18	172	57	31	23	3	29	0	0	0
132	22	9	77	9	12	129	19	14	8	0	34	0	0	0
133	37	18	117	9	43	225	4	16	16	0	19	0	0	0
134	51	30	185	33	61	360	13	58	7	6	45	146	6	0
135	138	114	397	60	160	870	0	52	19	17	75	149	2	0
136	178	108	469	69	153	978	7	53	59	18	111	258	7	0
137	203	118	524	45	151	1041	0	30	46	29	108	255	0	0
138	128	143	358	73	131	834	11	365	104	26	131	0	0	0
139	14	18	56	9	21	117	2	608	109	10	682	0	0	0
140	25	34	37	9	25	129	4	108	1169	56	860	295	90	0
141	154	242	311	91	115	912	0	29	21	21	180	287	8	0
142	166	241	455	151	175	1188	0	146	146	58	331	198	694	0
143	210	204	345	69	108	936	9	48	71	6	184	348	4	0
144	37	24	288	21	86	456	63	65	61	8	90	109	0	0
145	26	82	56	47	11	222	0	219	68	27	1407	0	647	0
146	280	268	377	84	148	1158	6	185	139	10	541	0	703	0
147	135	114	376	75	114	816	18	221	259	4	194	428	8	0
148	128	116	293	58	146	741	0	53	26	4	244	0	1622	0
149	31	9	196	9	58	303	4	50	7	0	30	0	0	0
150	124	127	405	88	137	883	34	87	148	12	314	201	745	0
151	84	84	225	42	93	528	0	31	63	6	125	454	10	0
152	94	77	299	50	114	635	3	68	316	10	338	39	0	0
153	96	71	326	52	121	666	1	13	78	2	70	202	1	0
154	27	21	69	9	15	141	0	129	15	0	62	0	0	0
155	189	144	548	77	187	1146	4	67	42	20	202	319	10	0
156	124	78	304	45	142	693	0	152	144	6	125	136	66	0
157	125	197	268	91	208	889	0	34	57	19	212	302	38	0
158	7	11	15	5	12	50	0	26	43	14	162	0	729	0
159	200	62	593	40	193	1087	3	172	35	38	166	195	13	0
160	156	216	348	105	213	1038	0	619	186	157	487	154	0	0

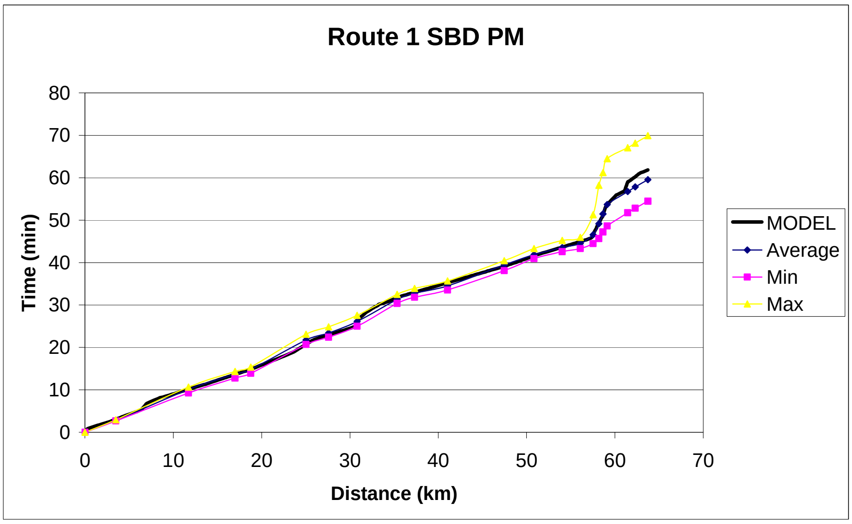
Zone	1 Adult Employed	1 Adult Non-Employed	2 Adults (Min of 1 Employed)	2 Adults Neither Employed	3+ Adults	Household Total	Other	Manufac	Retail	TransCom	Services	primary	secondary	tertiary
161	120	159	282	90	156	807	0	28	16	0	70	292	5	0
162	77	62	293	51	112	594	4	44	15	15	48	0	0	0
163	130	175	264	72	172	813	2	56	67	2	218	435	26	0
164	122	165	250	69	162	768	2	53	63	2	206	80	36	0
165	55	67	145	29	68	364	0	686	264	23	185	202	6	0
166	132	160	351	71	165	878	0	46	18	2	12	0	0	0
167	142	193	293	97	160	885	0	45	67	110	356	217	1382	0
168	195	292	511	168	185	1352	0	101	97	15	455	0	222	0
169	162	55	609	58	226	1109	16	109	50	24	265	553	208	0
170	153	207	392	103	148	1002	0	117	217	29	2015	299	358	0
171	153	175	349	63	138	877	0	9	20	5	366	269	4	0
172	194	184	472	106	172	1128	12	86	67	19	141	155	4	0
173	189	129	484	72	268	1143	4	82	22	19	75	302	65	0
174	144	132	336	81	171	864	0	20	12	11	49	195	0	0
175	265	293	717	111	243	1629	0	105	82	22	751	505	7	0
176	94	113	266	48	98	617	0	71	92	10	201	0	647	0
177	72	97	218	46	87	519	0	24	128	12	230	179	954	0
178	8	10	23	5	9	54	2	123	661	63	1188	586	20	0
179	0	0	0	0	0	0	1	40	216	21	388	0	0	0
180	0	0	0	0	0	0	1	29	158	15	284	0	0	0
181	0	0	0	0	0	0	2	110	590	56	1060	0	0	0
182	2	2	5	1	2	12	2	122	656	62	1179	0	0	0
183	5	6	14	3	6	33	0	22	116	11	208	0	0	0
184	104	52	151	20	58	385	0	424	667	48	355	286	7	0
185	142	104	278	22	80	626	0	200	347	52	220	0	0	0
186	39	52	118	25	47	281	1	75	403	38	724	338	2607	0
187	86	89	283	55	125	636	4	37	38	6	141	0	0	0
188	284	263	613	116	248	1524	0	606	132	102	353	410	62	0
189	97	133	215	55	97	597	4	263	83	109	65	142	61	0
190	180	138	332	53	157	860	1	57	63	6	181	360	87	0
191	168	107	332	37	140	784	5	1244	1186	252	1368	315	78	0
192	109	37	444	40	137	768	1	83	29	5	153	136	6	0
193	221	91	721	67	215	1314	4	100	52	15	156	150	59	0
194	113	39	252	15	83	501	0	187	168	34	119	101	24	0
195	106	85	199	28	77	495	2	1547	1362	293	1095	0	0	0
196	99	80	186	27	72	462	0	429	290	22	256	0	0	0
197	3	2	4	1	1	12	17	1946	1087	918	1139	0	0	0
198	142	97	389	71	176	876	0	37	178	13	193	273	1372	0
199	20	14	55	10	25	123	0	58	276	20	299	178	69	0
200	172	148	530	82	127	1058	13	112	139	21	339	361	86	0
201	127	109	391	60	93	781	8	71	87	13	212	194	123	0
202	102	84	256	66	151	660	11	47	45	6	80	192	4	0
203	141	144	348	87	165	885	4	60	36	21	76	0	0	0
204	164	139	479	99	245	1126	25	65	57	22	190	364	12	0
205	8	6	41	4	15	74	25	19	19	0	46	0	0	0
206	92	114	250	65	45	567	103	177	258	20	247	131	31	0
207	169	220	389	91	91	960	31	98	193	35	192	191	53	0
208	146	168	356	117	65	852	85	287	316	37	382	225	562	0
209	251	363	681	218	163	1677	55	290	428	40	590	392	111	0
210	236	339	635	197	157	1563	40	253	104	7	783	370	122	0
211	501	704	1133	302	313	2951	125	977	1588	178	2073	876	2108	0
212	435	569	909	315	309	2536	92	381	876	109	1231	339	754	0
213	40	21	122	19	19	221	248	35	43	3	39	20	5	0
214	84	47	354	43	68	596	393	118	54	8	96	145	37	0
215	48	28	186	22	25	307	355	55	37	10	82	64	23	0
216	138	55	544	65	138	942	321	142	82	20	300	301	343	0
217	58	28	240	33	50	409	266	305	51	39	206	0	0	0
218	48	26	162	24	25	285	160	29	31	5	31	0	0	0
219	22	12	74	11	12	130	125	23	24	4	24	0	0	0
220	26	14	102	13	22	176	138	24	18	4	41	0	0	0
221	37	20	126	19	20	221	157	29	30	5	30	124	18	0
222	42	20	163	23	30	278	226	124	37	6	62	48	11	0
223	46	25	152	23	24	269	211	36	39	6	38	26	14	0
224	16	8	62	9	10	106	88	24	16	2	18	27	54	0
225	29	13	134	16	26	218	173	124	23	6	62	0	0	0

Appendix B Travel Time Comparisons

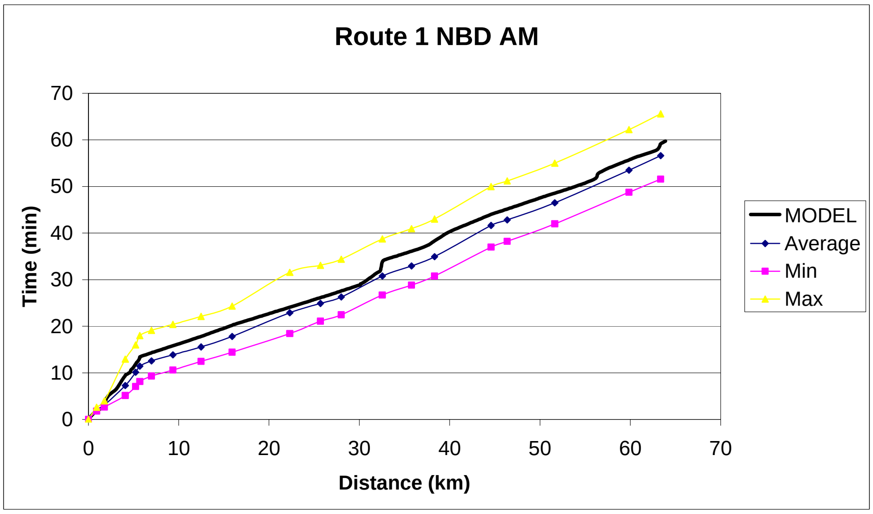
ROUTE 1 SOUTHBOUND - Waikanae Railway Station - Wellington Airport

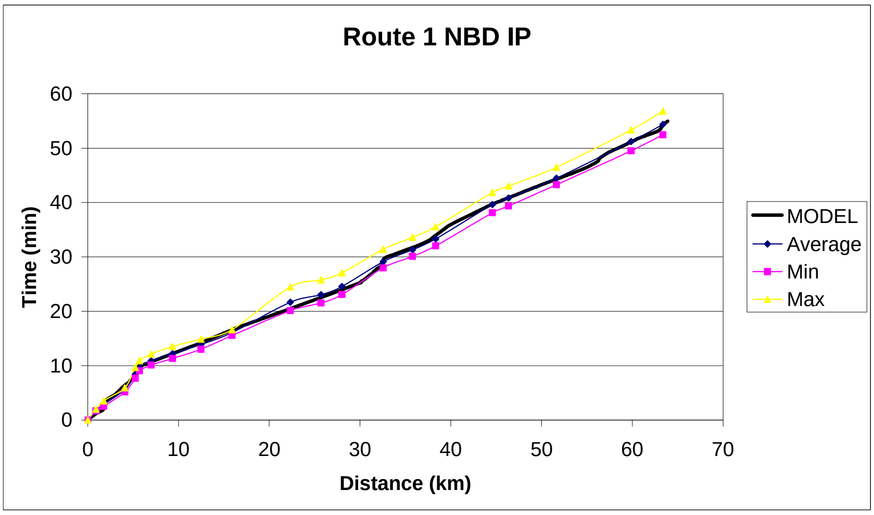


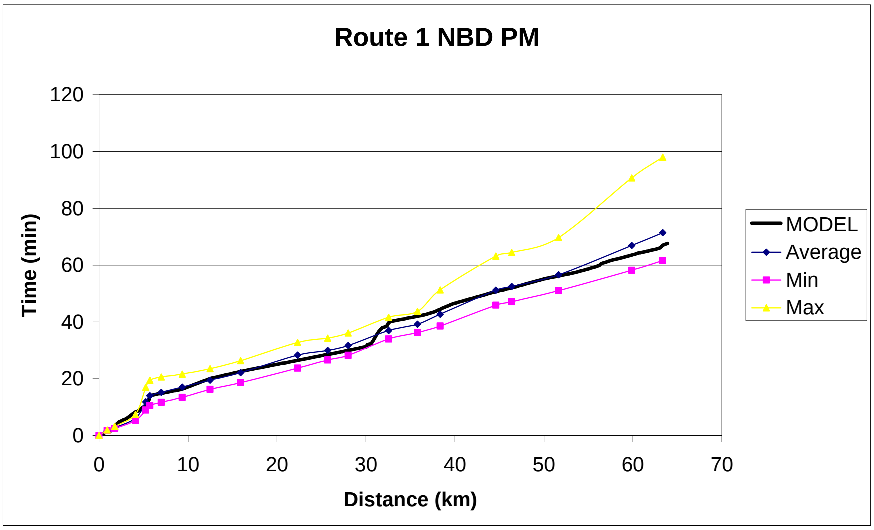




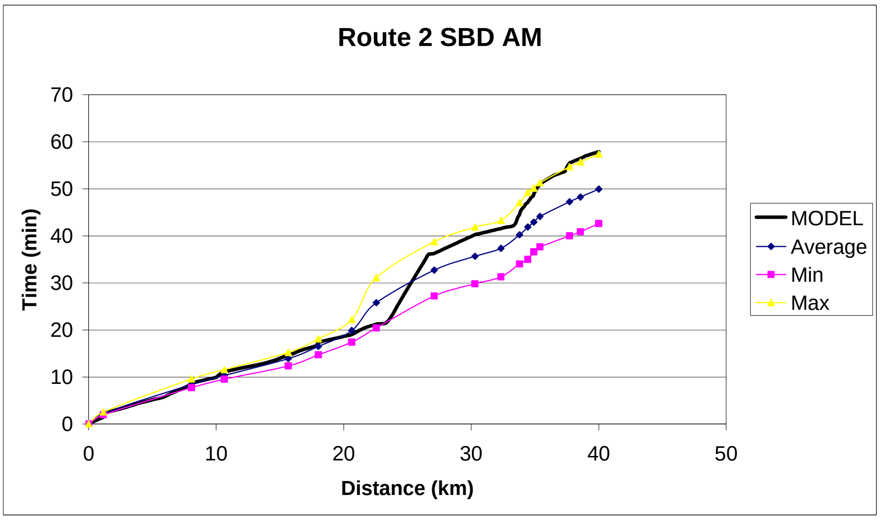
ROUTE 1 NORTHBOUND - Wellington Airport - Waikanae Railway Station

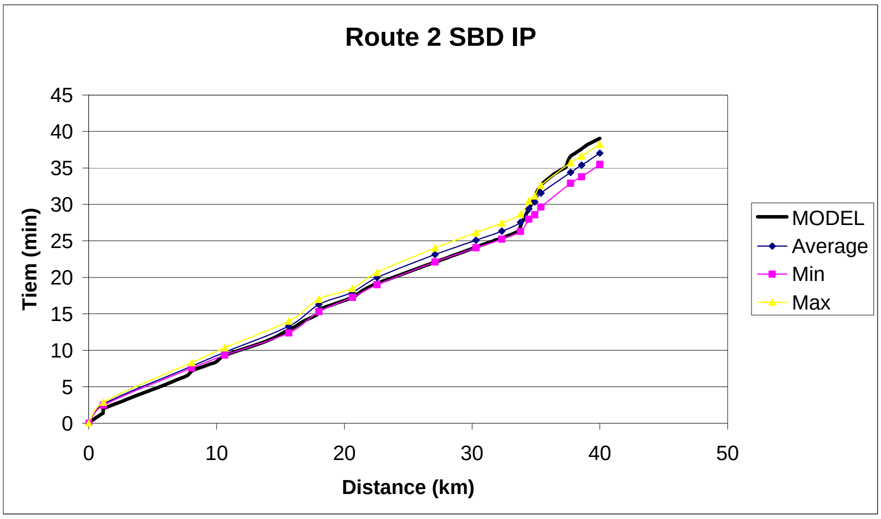


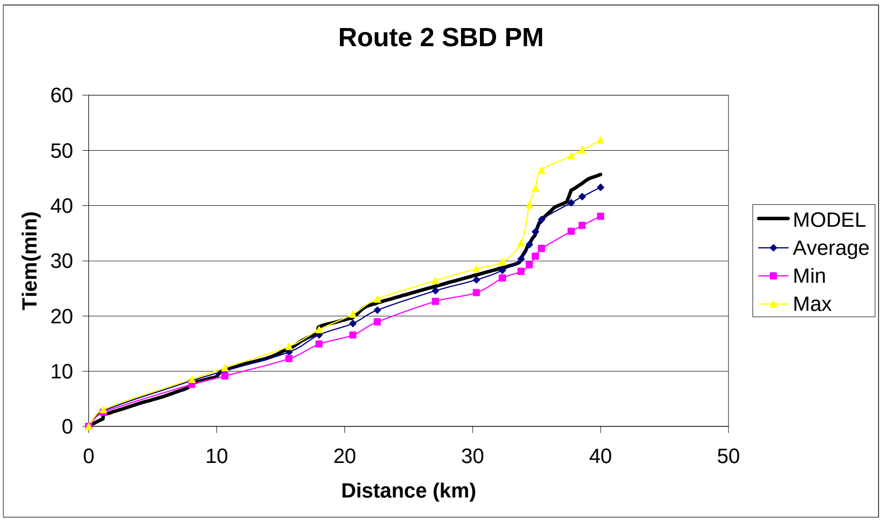




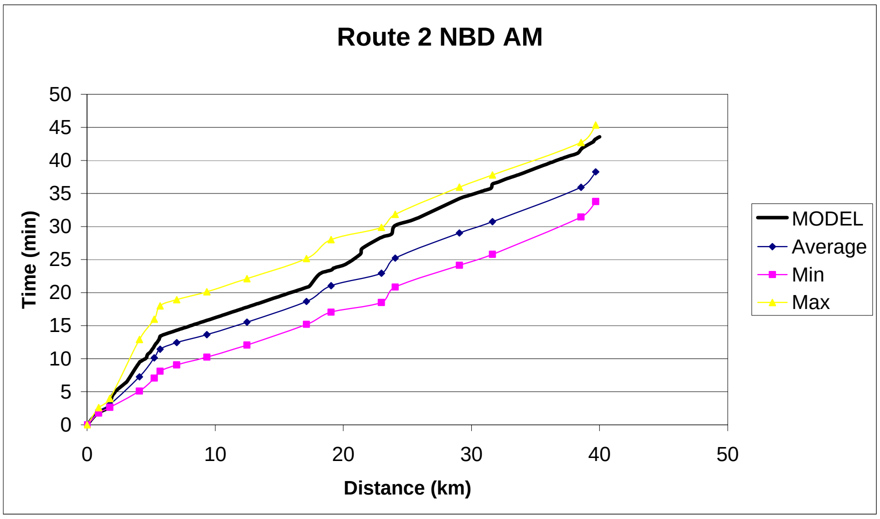
ROUTE 2 SOUTHBOUND - Upper Hutt Railway Station - Wellington Airport

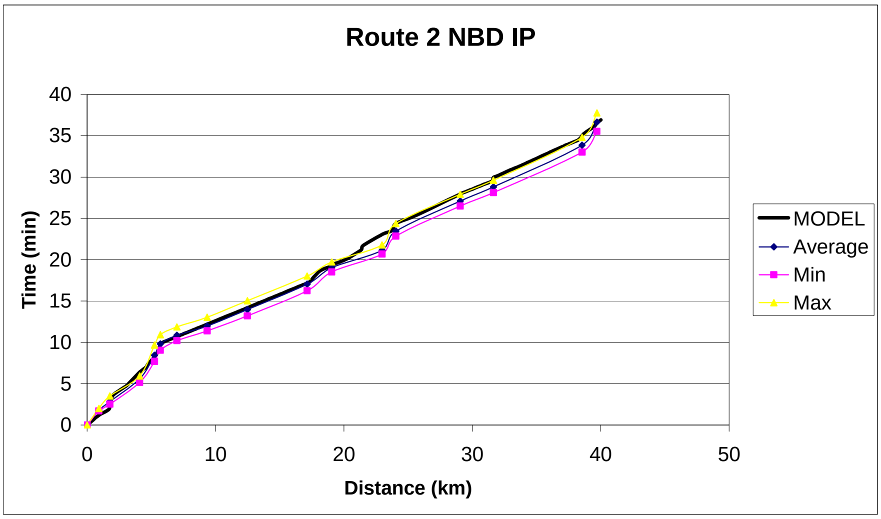


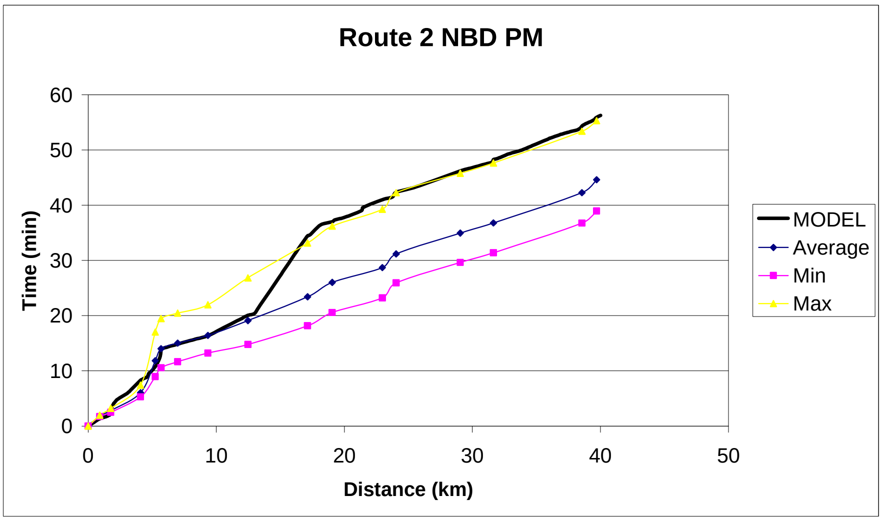




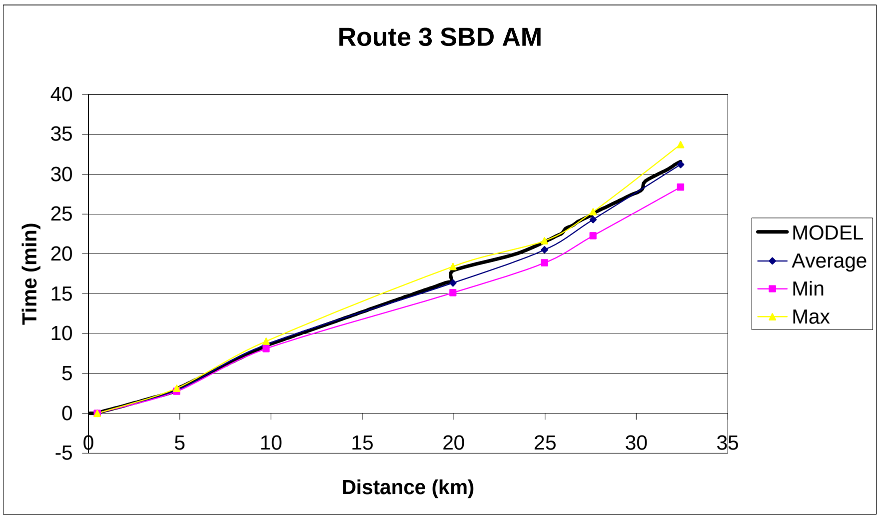
ROUTE 2 NORTHBOUND - Wellington Airport - Upper Hutt Railway Station

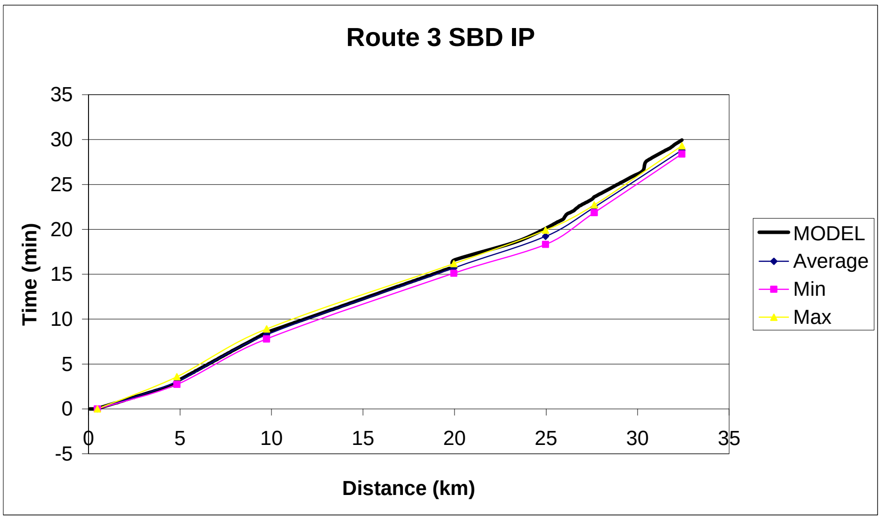


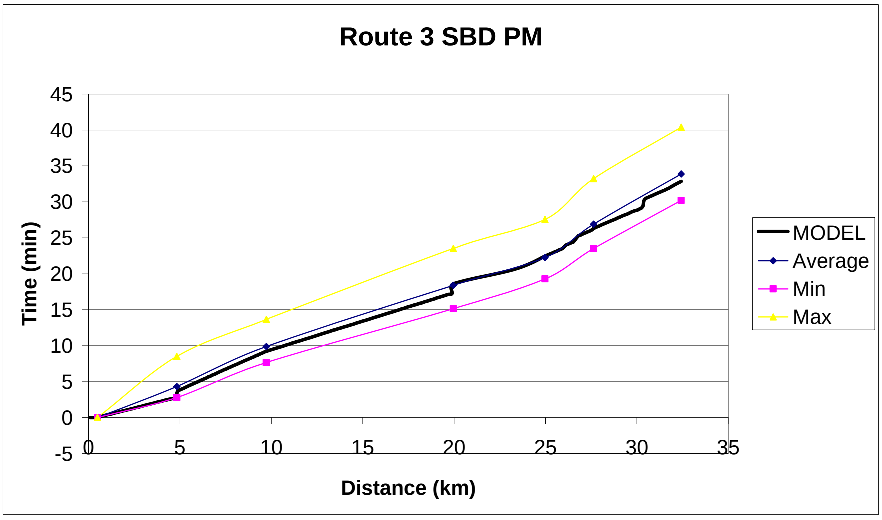




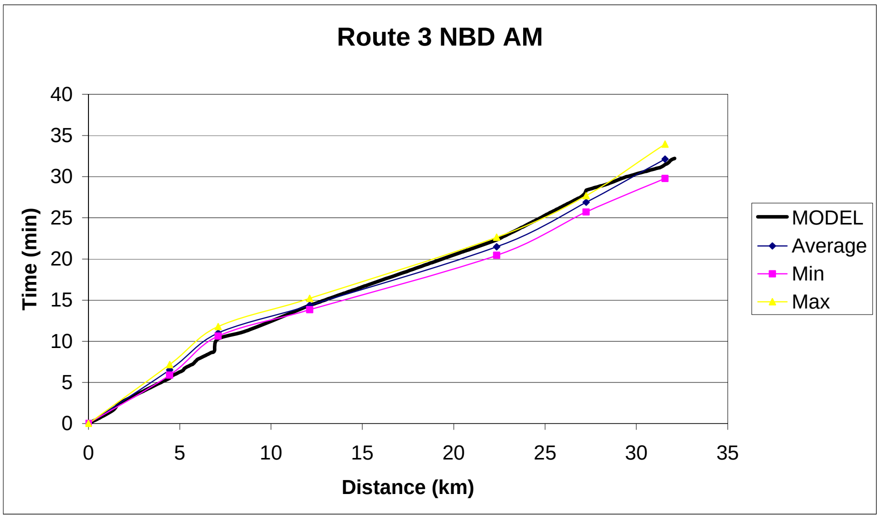
ROUTE 3 SOUTHBOUND - Porirua - Seaview

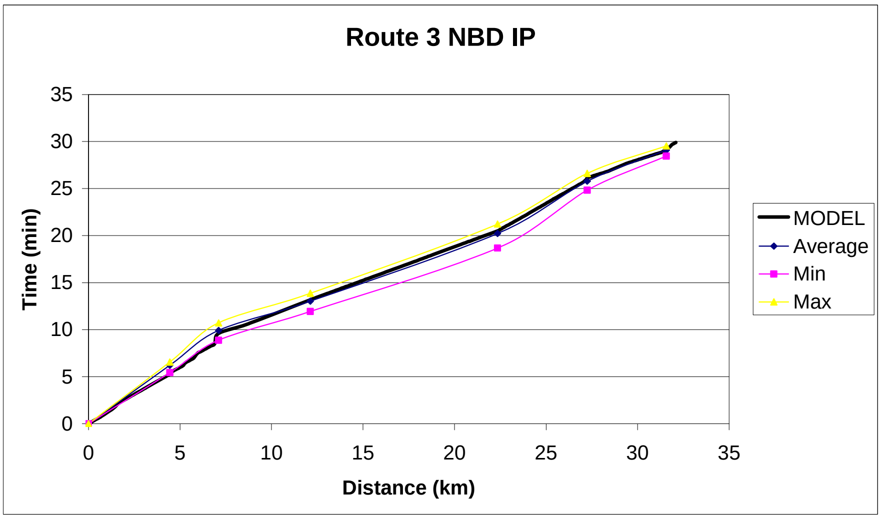


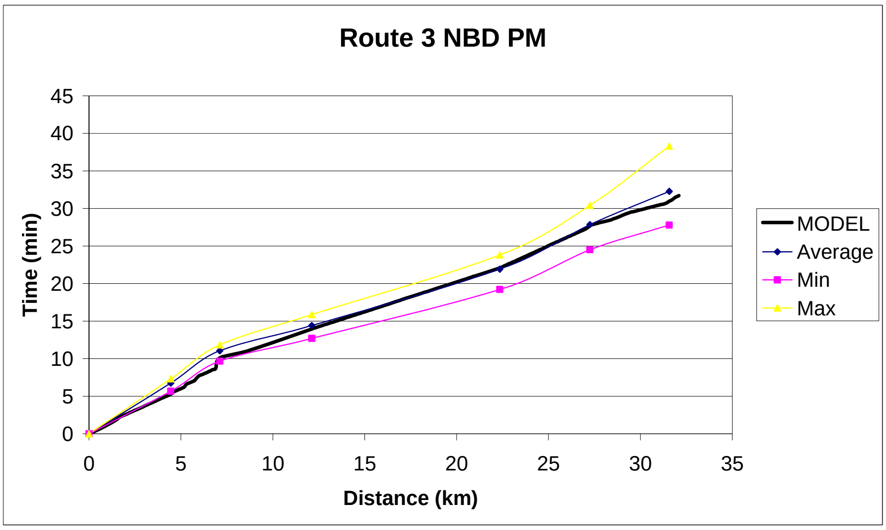




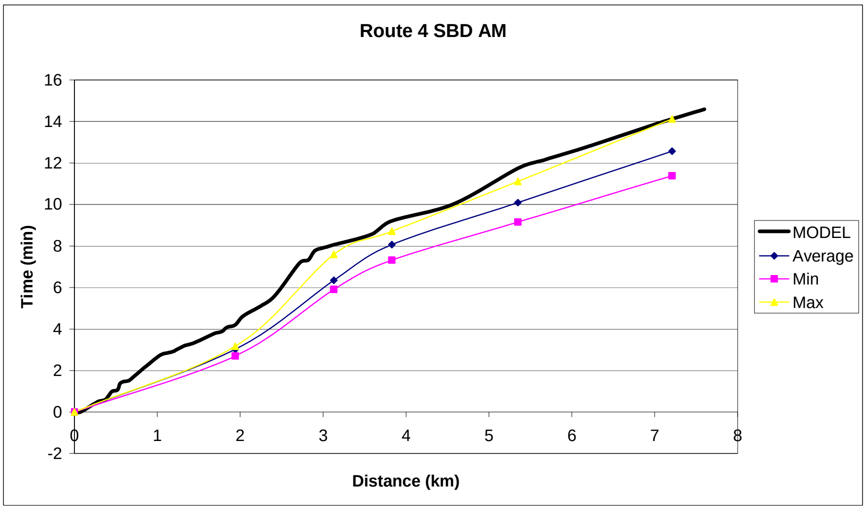
ROUTE 3 WESTBOUND - Seaview - Porirua

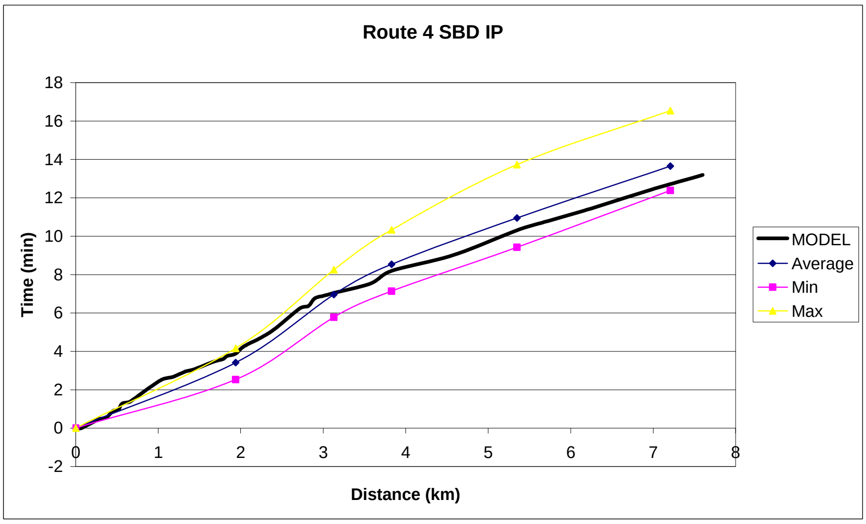


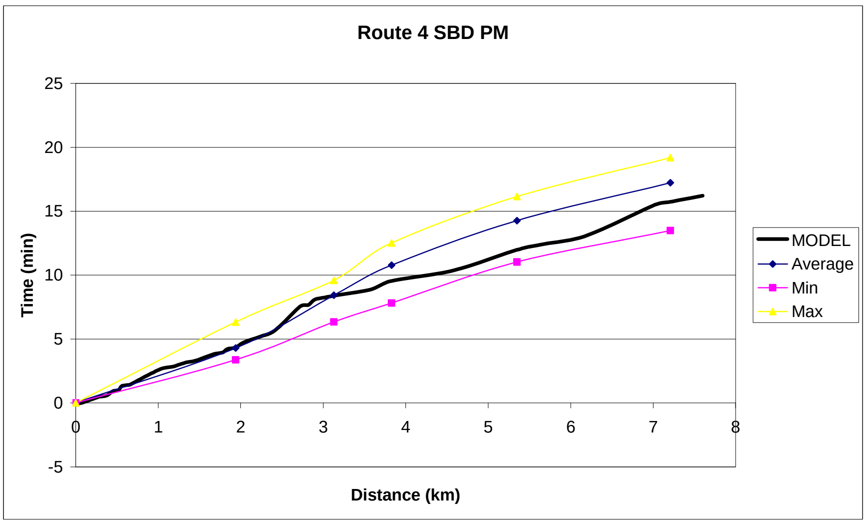




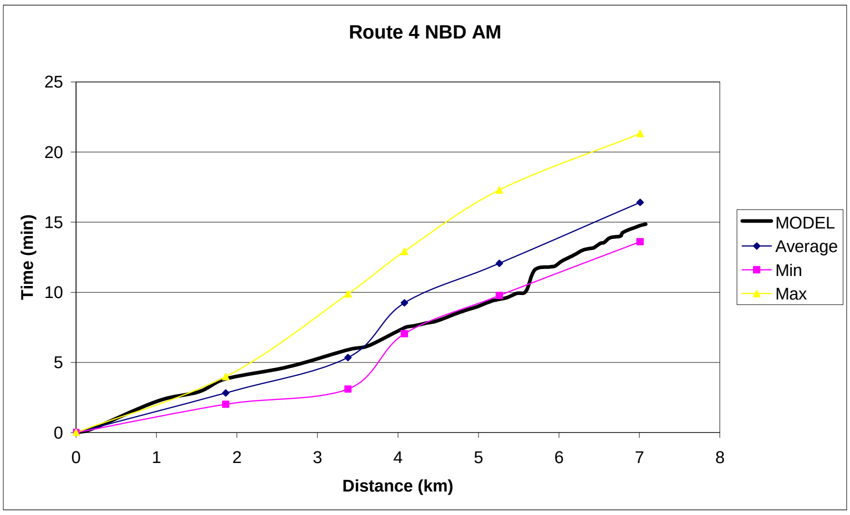
Route 4 - Wellington Railway Station - Island Bay - Southbound

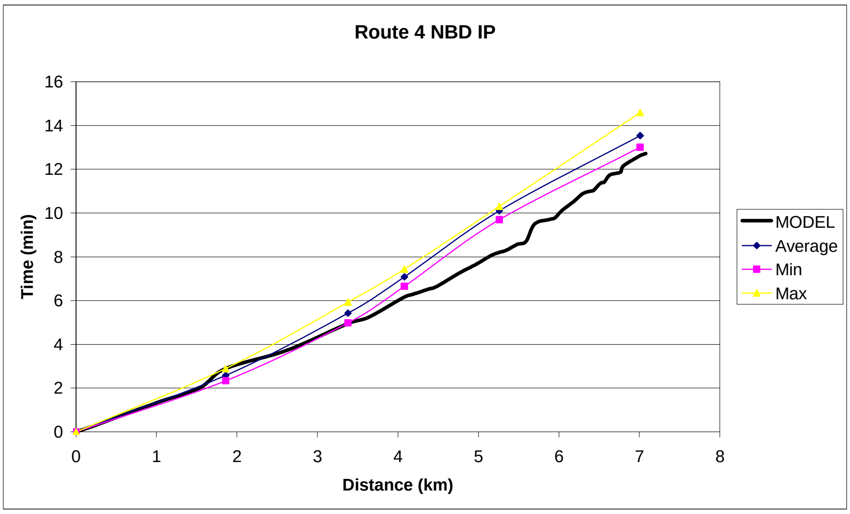


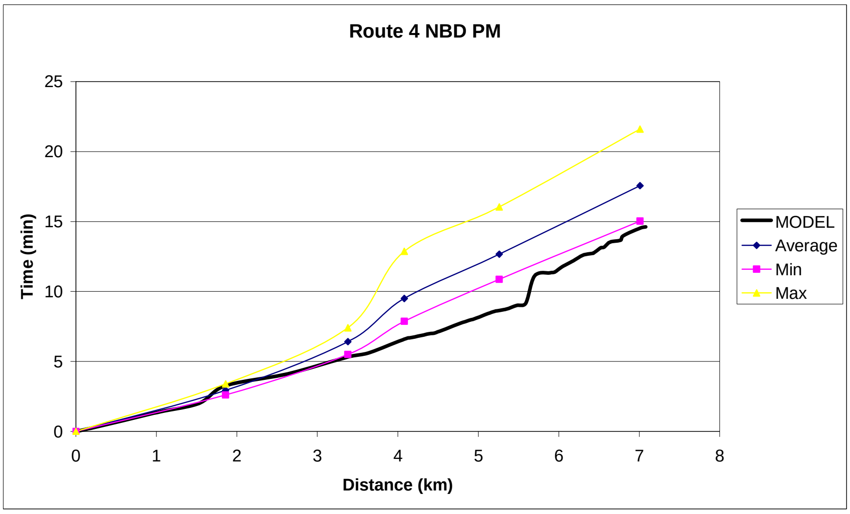




Route 4 - Island Bay - Wellington Railway Station - northbound

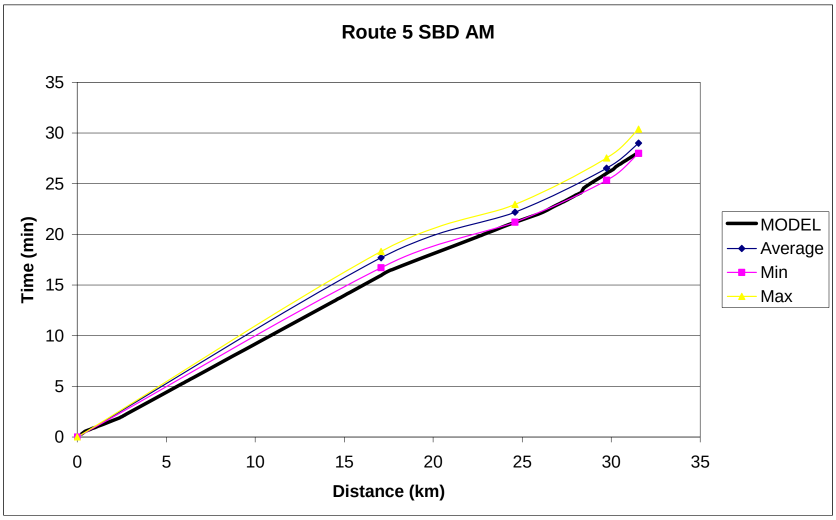


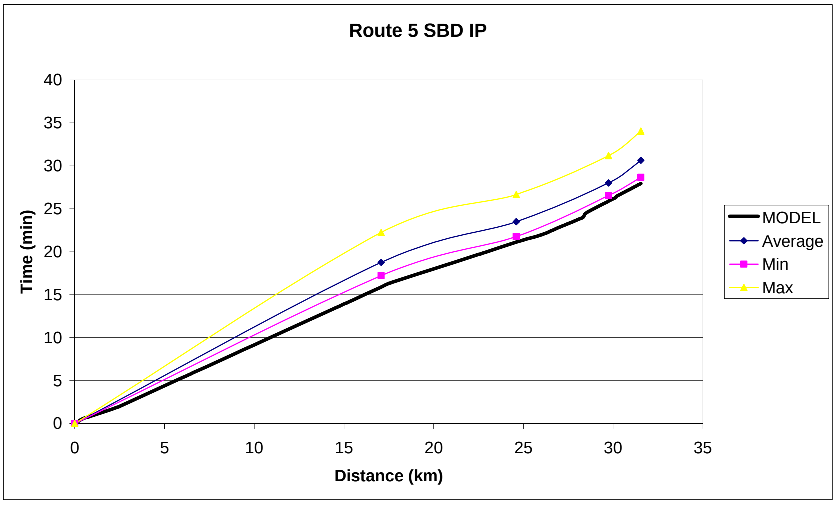


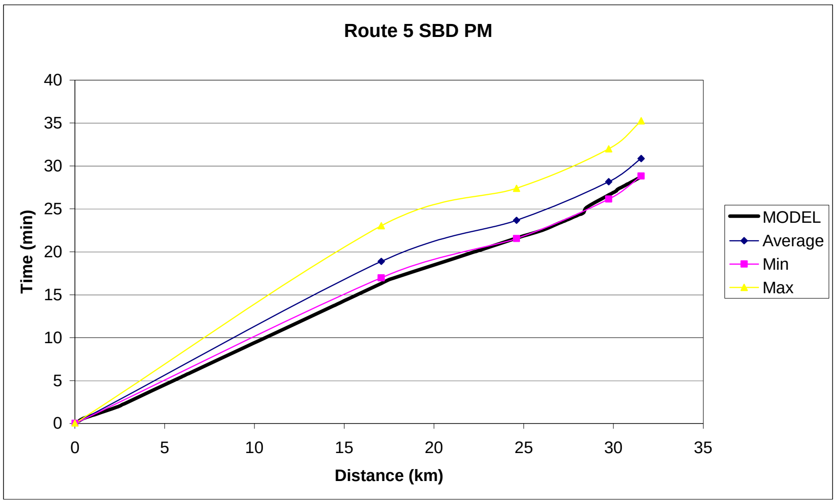


SKM

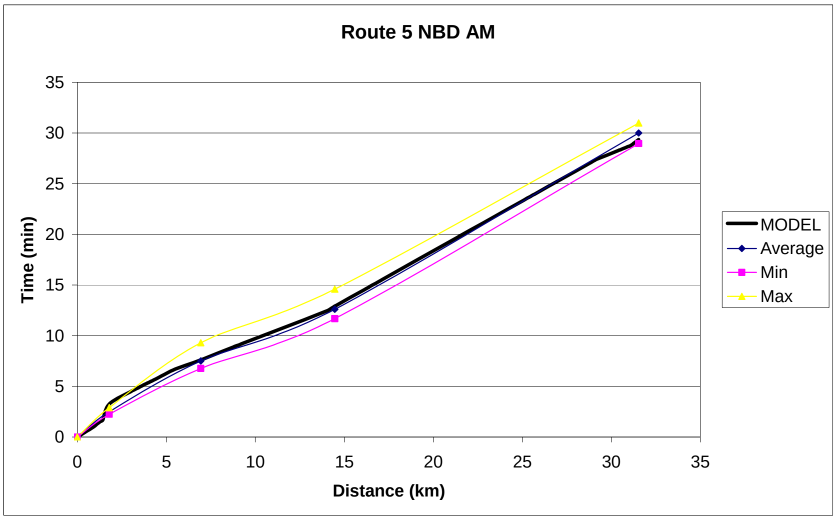
Route 5 Featherstone - Upper Hutt Railway Station - southbound

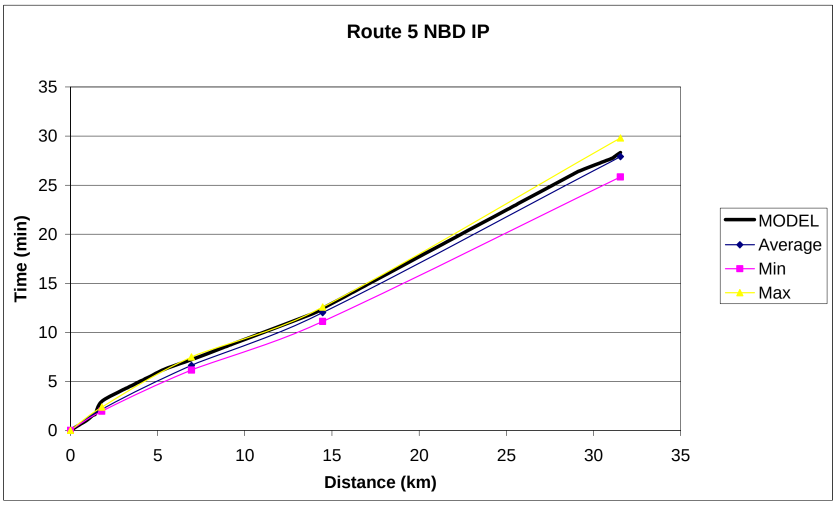


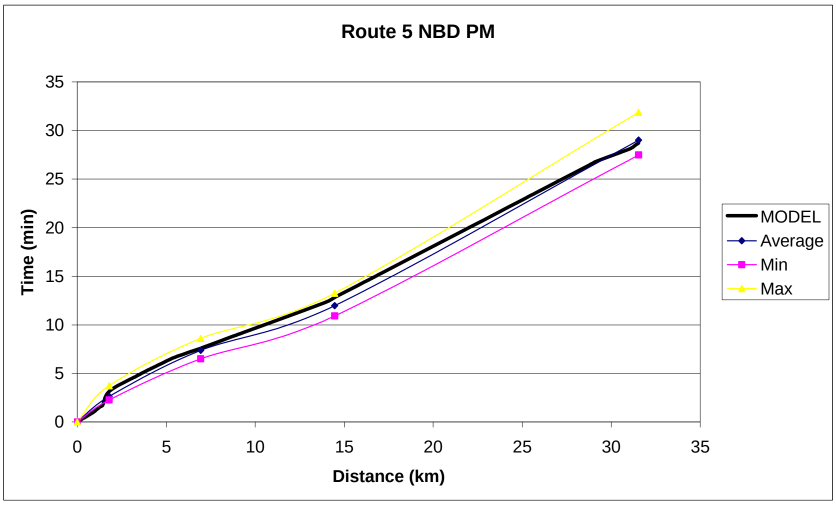




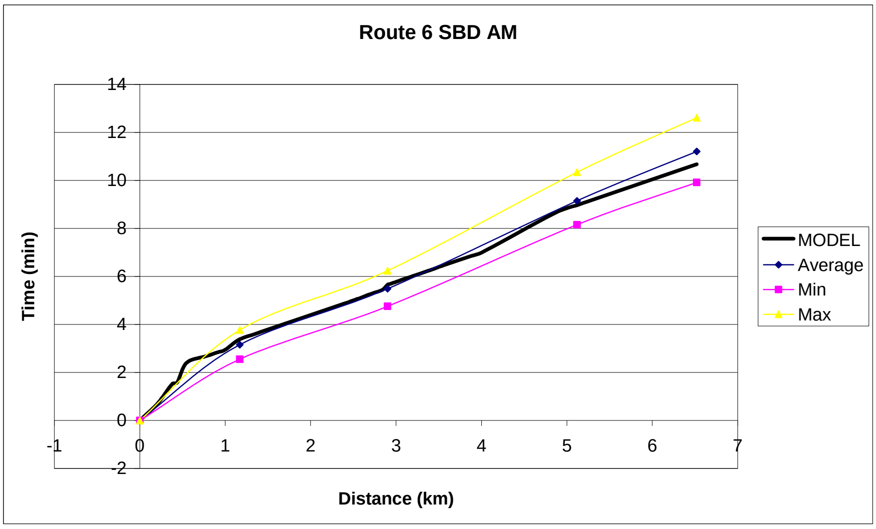
Route 5 - Upper Hutt Railway Station - Featherstone northbouund

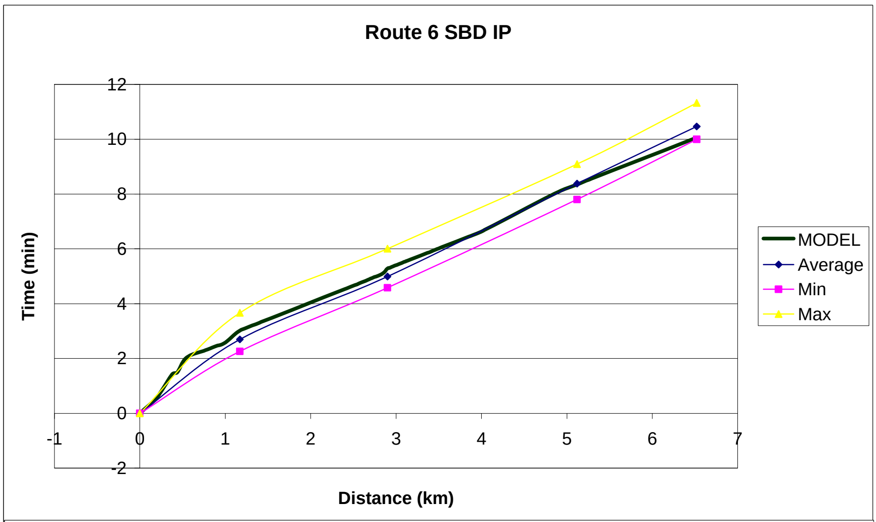


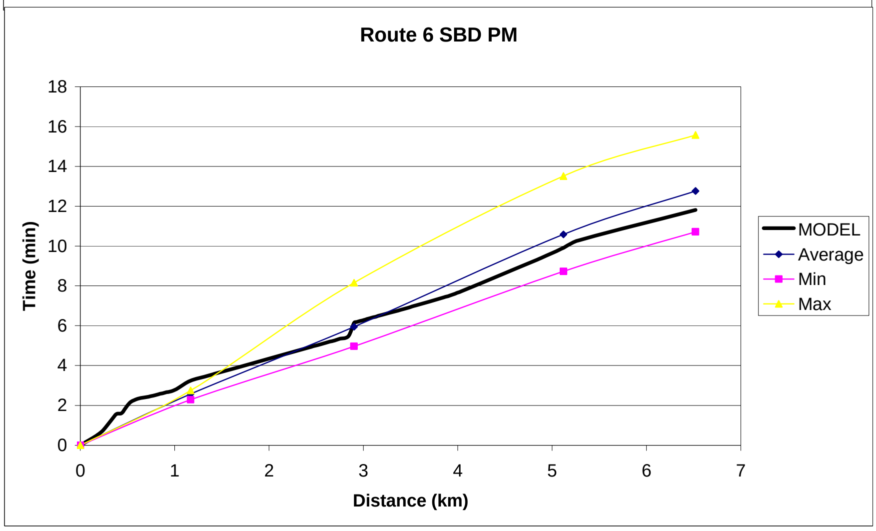




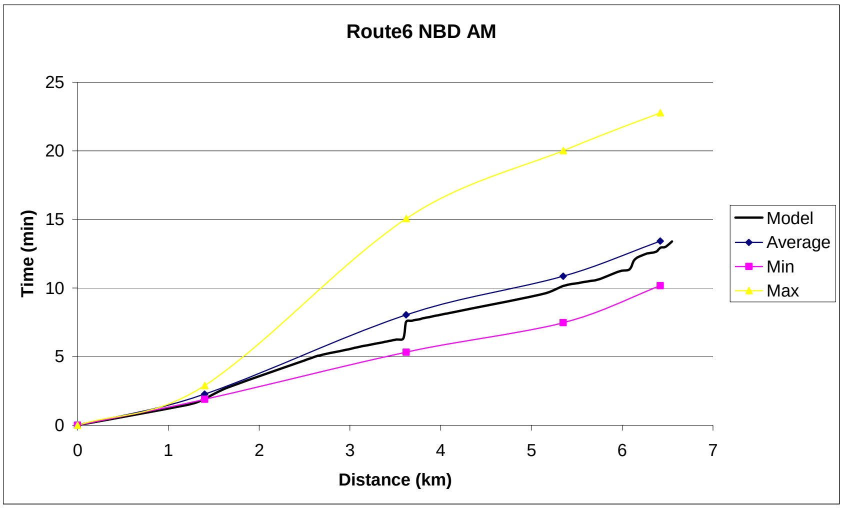
Route 6 Wellington Railway Station - Karori West

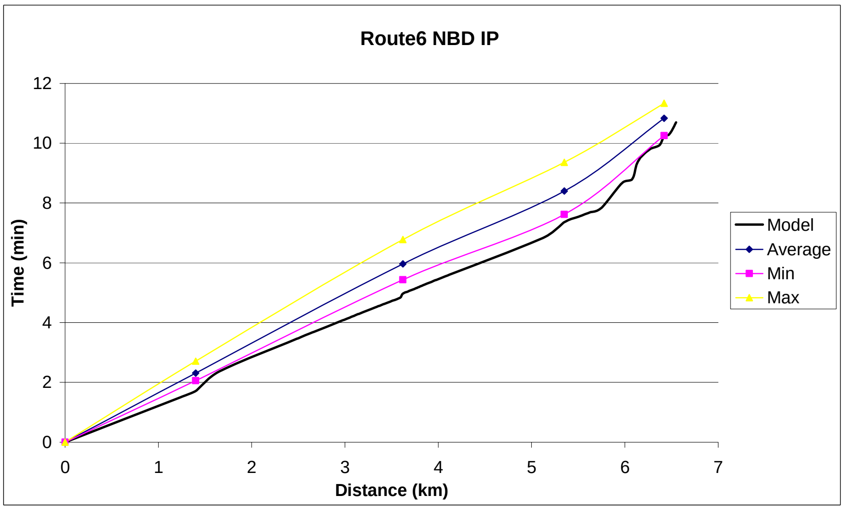


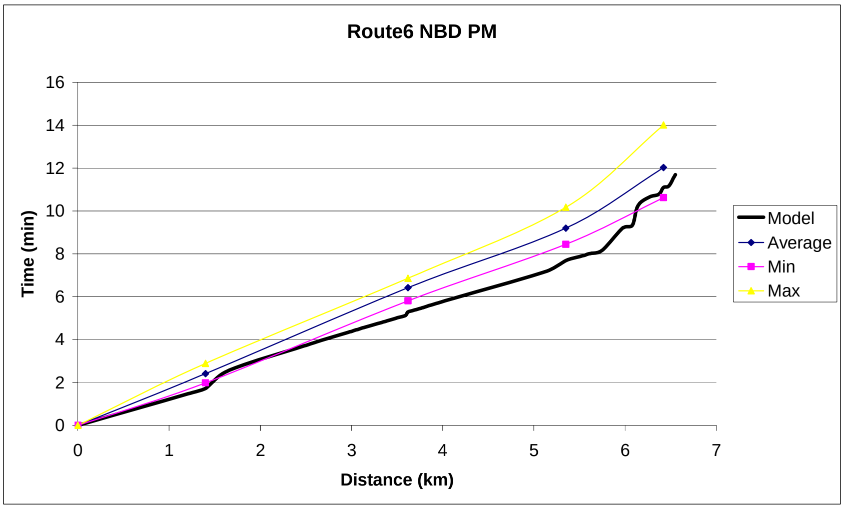




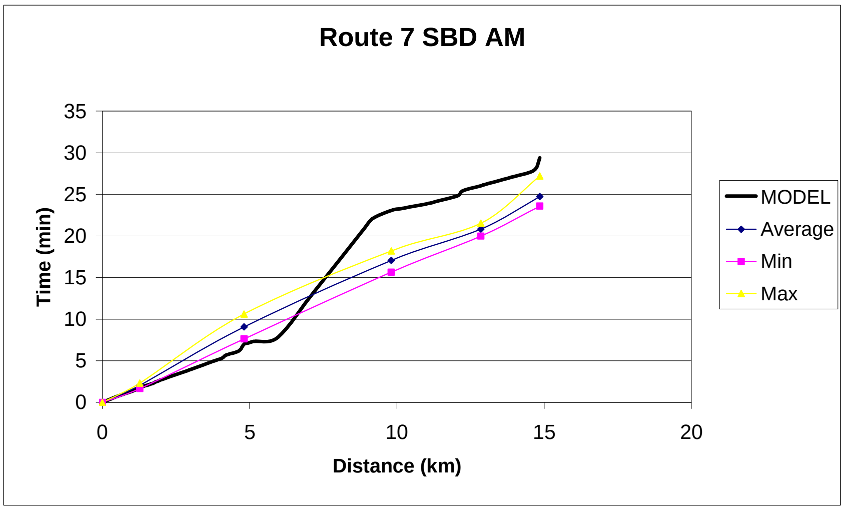
Route 6 Karori West - Wellington Railway Station

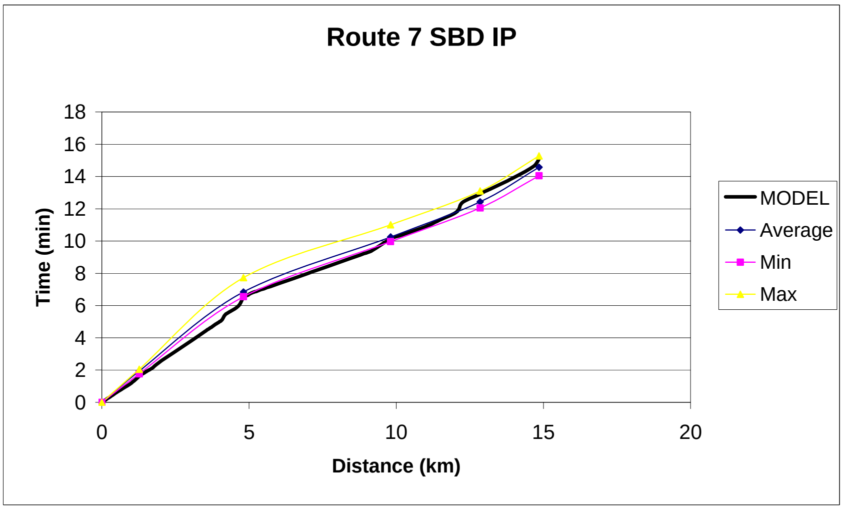


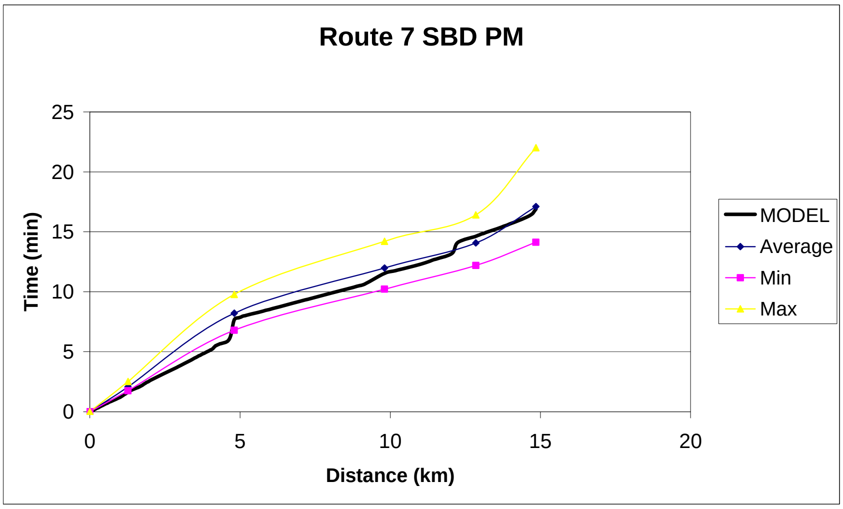




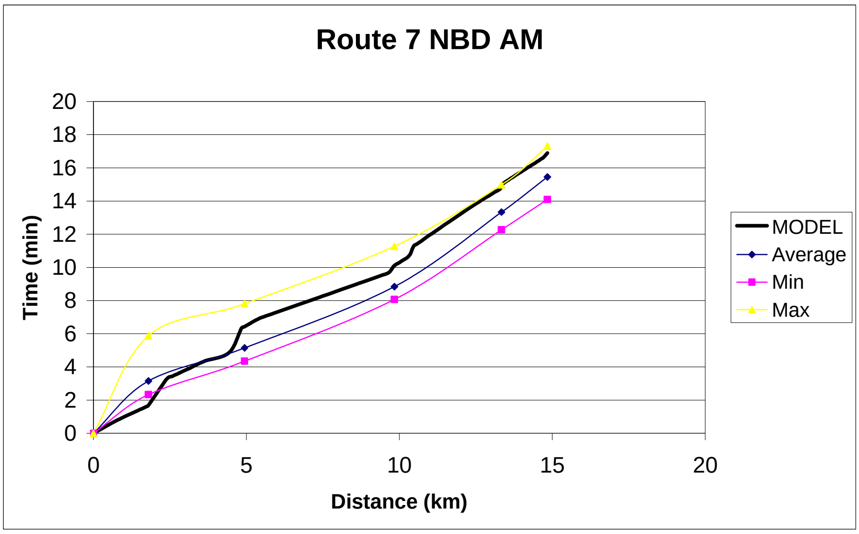
Route 7 White Lines / Randwick Rd - Waterloo quay / Bunny St -Southbound

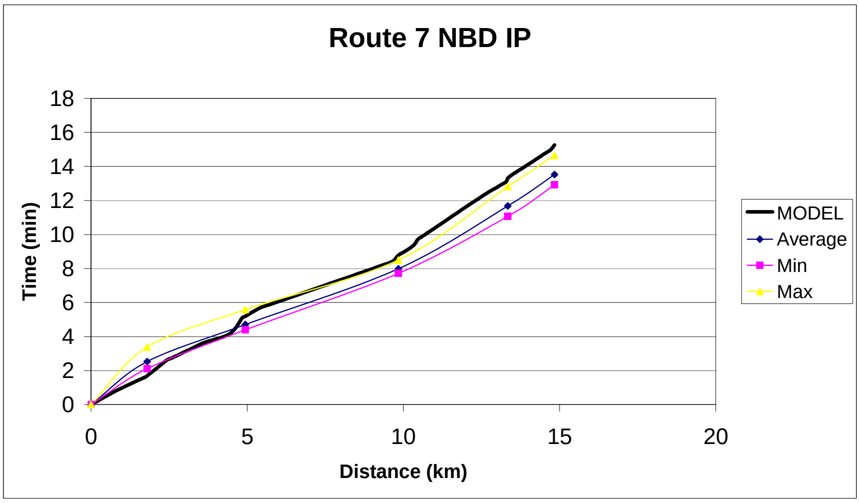


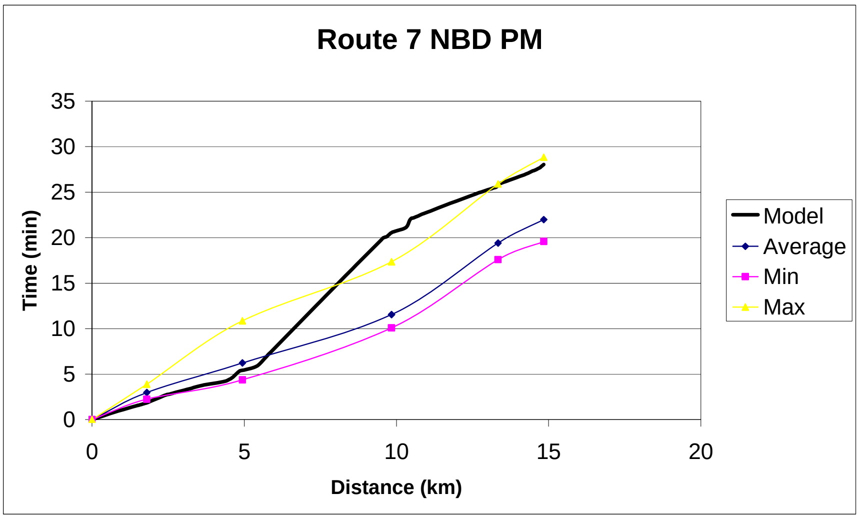




Route 7 Waterloo Quay / Bunny St to Whites Line / Randwick - northbound







Appendix C WTSM Update – New Validation and Forecasting Results File Note

File Note

Date	20 June 2008
Project No	an00832
Subject	**WTSM Update – Validation Results**

1) Introduction

This note follows modifications made to the base 2006 model following Peer Review comments and feedback from GWRC. Key 2006 WTSM validation statistics, related to the modifications, are set out below.

2) Modifications to Base Model

The modifications made to the model reported in the Validation Report are:

- corrections to rail link lengths on the Hutt Line and near Ngauranga,
- in conjunction with this, reduction in the rail speed from 60kph to 55kph between Taita and Ngauranga (following comparisons with timetables),
- modifications to walk link lengths to some stations to more realistic distances,
- reversion to the original p-connector lengths,
- reversion of the rail wait time factor from 0.20 back to the original 0.25, the same as bus and ferry,
- deletion of any outbound p-connectors in the AM peak and inbound ones in the PM peak,
- addition of a vdf code to a minor CBD road, and
- correct implementation of buslanes and integrated fares (used in forecasting only).

3) Validation Statistics

Key validation statistics follow along with some commentary as necessary. The rail inbound boardings are presented firstly, along with information on access to some specific rail stations, as these have been the focus of changes to the model. These are followed by bus screenline data, and then road screenline and travel time data.

- **Rail Boardings**

The figures below show the modelled and observed inbound rail boardings on each line in the AM and IP periods. The observed 2006 data is the same as that used to date, which has been obtained by factoring the 2001 data in each period by fixed amounts based on understood patronage increases. The modelled boardings compare well with the observed, though at Wellington station the modelled is 15% higher than observed in the AM peak

However analysis involving other rail counts on some services (excluding the Melling, Masterton, and Capital Connect services) recently sourced by GWRC indicates that the 2006 observed estimates used in the validation may be low. Comparisons using this data has the modelled patronage at Wellington station 3% and 6% low for Western Line and Hutt Line services respectively.

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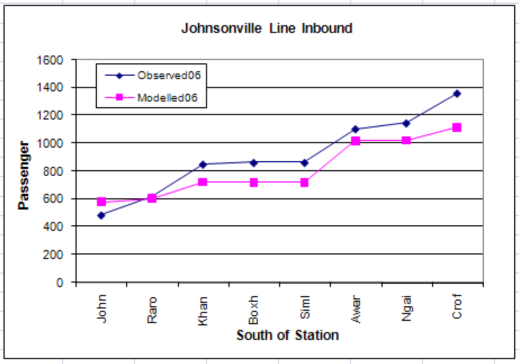
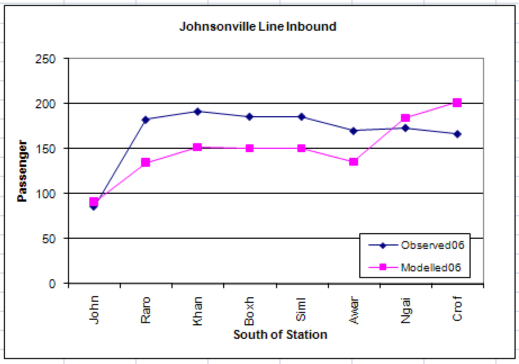
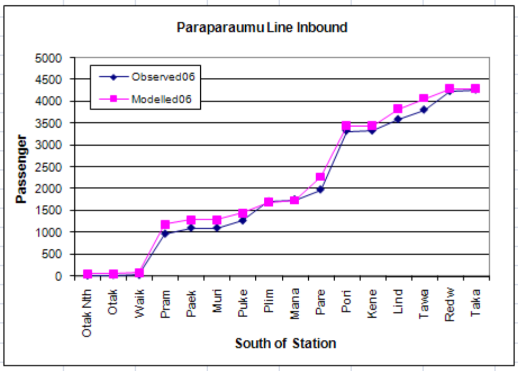
■ **Rail Boardings**

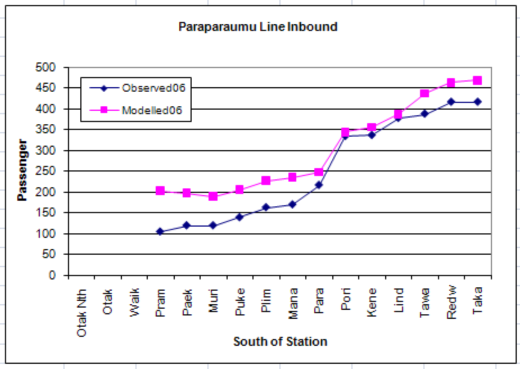
AM

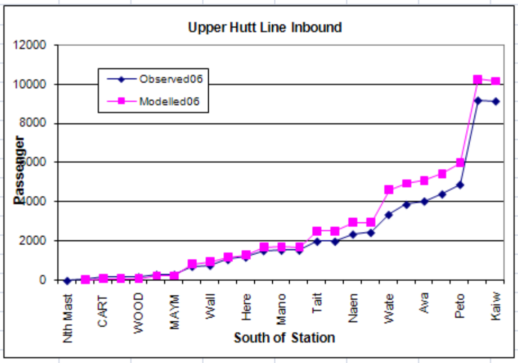


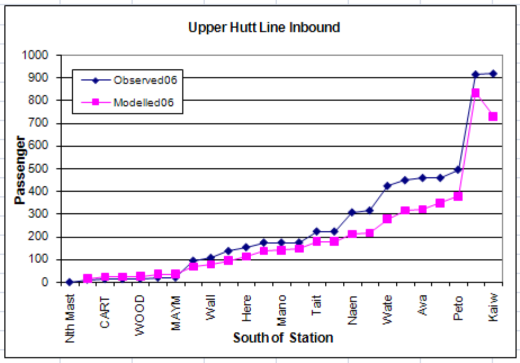
IP











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- **Rail Patronage into Wellington Station**

The following table gives the rail patronage alighting at Wellington Station in the previous validation and the new validation. This indicates an increase in rail patronage of some 10%.

- **Rail Patronage into Wellington Station**

SL	Previous	New	Difference	% Difference
AM	10,292	11,278	986	10%
IP	884	928	44	5%

- **Rail Access**

One aspect raised in the Peer Review was the low or high percentage of p-connector access at some stations[1]. All these access links to all stations have now been changed back to their original lengths. The proportions of p-connector access to stations specifically mentioned in the review (Porirua, Waterloo, Paraparaumu, Linden and Johnsonville) are now between 98 and 100%.

- **Bus Screenlines**

The following tables compare the observed (ETM data) and modelled bus patronages across screenlines, noting that the validation report commented on issues of uncertainty with the observed data.

These results have, compared with those in the Validation Report, lower bus patronage across the W4, W5 L1, and L2 screenlines in the AM peak inbound, which reflects the higher rail patronage. The results below provide a validation at least as good as that previously reported.

[1] The Peer Review referred to these links as car access links whereas they are, in fact, multi-modal access links, that is car (driver and passenger), bus, walk and cycle, and the mix of these modes was used to determine their original weighted average access time and speed.

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- **AM Peak Bus Screenlines**

REMOVED

- **Interpeak Bus Screenlines**

REMOVED

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- **Road Screenlines**

The following tables and graphs present the road screenline validation results, which give the same overall level of validation as in the Validation Report. There are small changes in screenline volumes. For example, screenline L1 (SH2 north of Ngauranga) is 93 vehicles per 2 hours less southbound in the AM peak, and 119 more northbound. Screenline W4, south of Ngauranga, has 198 vehicles per 2 hours less southbound in the AM peak and 95 more northbound.

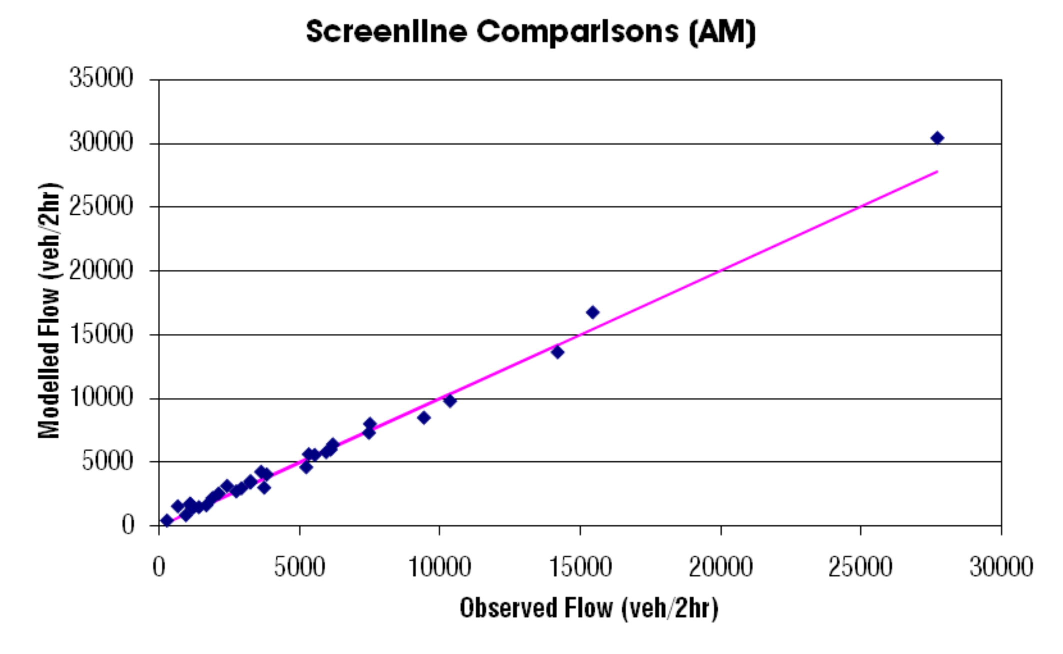
- **Statistics for Screenline Totals**

GEH	AM	IP	PM
< 5	67%	60%	57%
< 10	90%	83%	87%
< 12	97%	97%	93%
Proportion of screenlines with % difference < 10	73%	57%	70%
R^2	0.989	0.987	0.985

- **Statistics for Screenline Links**

GEH	AM	IP	PM
< 5	53%	49%	45%
< 10	84%	78%	78%
< 12	89%	86%	87%
Proportion of links with % difference < 20	76%	72%	74%
R^2	0.937	0.899	0.937
RMSE	25%	29%	24%

- **AM Road Screenlines**



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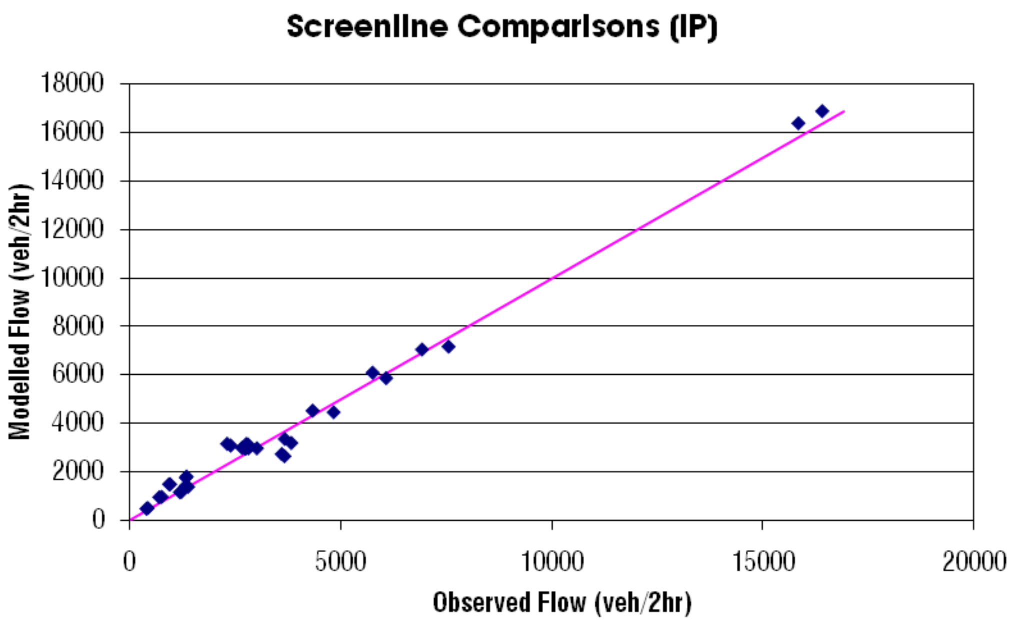
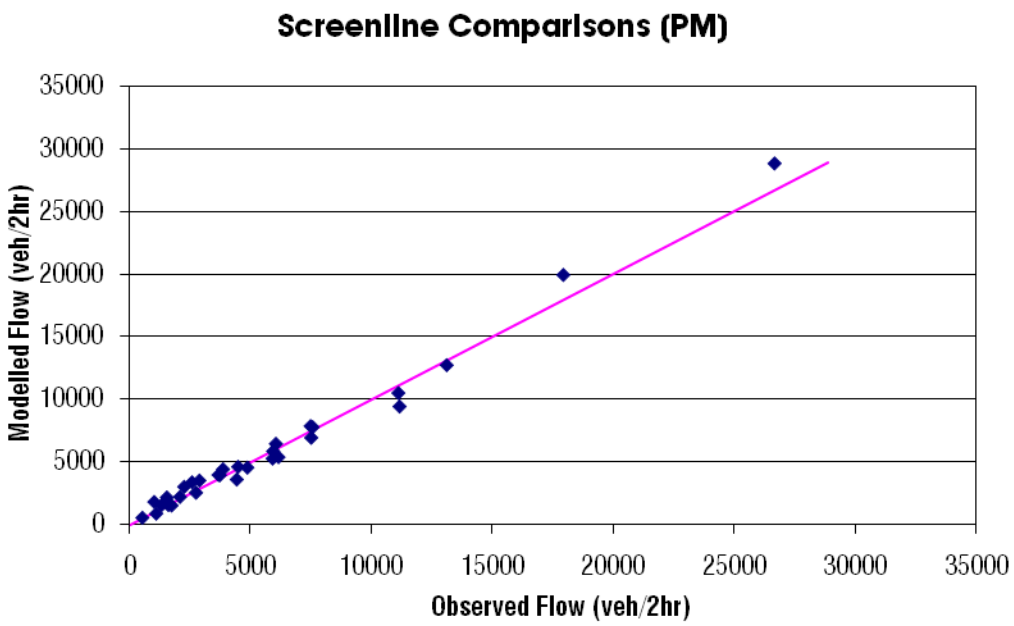
- **IP Road Screenlines**



- **PM Road Screenlines**



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- **AM Road Screenlines**

		AM Peak				
SL	Dir	Observed Count	Modelled Volume	Difference	% Difference	GEH
W1	In	27,718	30,417	2,699	10%	11
W1	Out	15,444	16,728	1,284	8%	7
W2	East	2,934	2,915	-19	-1%	0
W2	West	3,635	4,206	571	16%	6
W3	East	2,422	3,102	680	28%	9
W3	West	1,102	1,696	594	54%	11
W4	North	6,190	6,358	167	3%	1
W4	South	14,195	13,600	-595	-4%	4
W5	North	3,831	3,993	162	4%	2
W5	South	7,474	7,270	-203	-3%	2
L1	North	5,331	5,584	253	5%	2
L1	South	7,510	7,975	465	6%	4
L2	North	3,253	3,357	105	3%	1
L2	South	5,948	5,744	-204	-3%	2
L3	In	10,364	9,765	-598	-6%	4
L3	Out	9,432	8,456	-976	-10%	7
L4	North	6,114	5,951	-163	-3%	1
L4	South	2,119	2,503	384	18%	6
U1	North	666	1,501	835	125%	18
U1	South	1,900	2,146	246	13%	4
U2	North	3,254	3,470	217	7%	3
U2	South	5,241	4,569	-671	-13%	7
U3	East	954	806	-148	-15%	4
U3	West	281	379	98	35%	4
P1	North	1,169	1,399	230	20%	5
P1	South	2,750	2,673	-76	-3%	1
P2	East	1,684	1,579	-105	-6%	2
P2	West	1,417	1,432	15	1%	0
P3	North	3,742	2,964	-777	-21%	9
P3	South	5,542	5,529	-13	0%	0

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- **IP Road Screenlines**

		Interpeak				
SL	Dir	Observed Count	Modelled Volume	Difference	% Difference	GEH
W1	In	16,387	16,893	506	3%	3
W1	Out	15,821	16,394	572	4%	3
W2	East	2,998	2,976	-21	-1%	0
W2	West	2,798	2,975	177	6%	2
W3	East	1,334	1,811	477	36%	9
W3	West	1,315	1,763	448	34%	8
W4	North	6,059	5,873	-187	-3%	2
W4	South	5,739	6,095	356	6%	3
W5	North	3,813	3,197	-616	-16%	7
W5	South	3,659	3,363	-296	-8%	4
L1	North	4,815	4,466	-349	-7%	4
L1	South	4,319	4,529	210	5%	2
L2	North	2,787	3,139	352	13%	5
L2	South	2,748	3,154	406	15%	5
L3	In	7,538	7,175	-363	-5%	3
L3	Out	6,910	7,056	146	2%	1
L4	North	2,294	3,161	867	38%	12
L4	South	2,376	3,092	716	30%	10
U1	North	943	1,492	549	58%	11
U1	South	919	1,492	573	62%	12
U2	North	2,723	2,952	229	8%	3
U2	South	2,644	2,994	350	13%	5
U3	East	384	481	97	25%	3
U3	West	415	511	96	23%	3
P1	North	1,315	1,433	119	9%	2
P1	South	1,368	1,389	22	2%	0
P2	East	688	957	270	39%	7
P2	West	743	971	228	31%	5
P3	North	3,651	2,648	-1,003	-27%	13
P3	South	3,586	2,740	-846	-24%	11

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- **PM Road Screenlines**

		PM Peak				
SL	Dir	Observed Count	Modelled Volume	Difference	% Difference	GEH
W1	In	17,933	19,949	2,016	11%	10
W1	Out	26,663	28,864	2,201	8%	9
W2	East	3,870	4,402	532	14%	6
W2	West	2,890	3,497	607	21%	8
W3	East	1,547	2,144	597	39%	10
W3	West	2,260	2,996	736	33%	10
W4	North	13,112	12,727	-385	-3%	2
W4	South	7,575	7,772	197	3%	2
W5	North	7,512	6,923	-588	-8%	5
W5	South	4,490	4,592	102	2%	1
L1	North	7,484	7,854	370	5%	3
L1	South	6,051	6,432	381	6%	3
L2	North	6,163	5,369	-793	-13%	7
L2	South	3,677	3,948	271	7%	3
L3	In	11,163	9,426	-1,737	-16%	12
L3	Out	11,114	10,497	-617	-6%	4
L4	North	2,589	3,360	771	30%	10
L4	South	5,939	5,844	-95	-2%	1
U1	North	2,087	2,184	97	5%	1
U1	South	1,025	1,786	761	74%	14
U2	North	4,875	4,531	-343	-7%	4
U2	South	3,733	3,925	193	5%	2
U3	East	535	519	-16	-3%	0
U3	West	1,107	850	-257	-23%	6
P1	North	2,749	2,528	-221	-8%	3
P1	South	1,541	1,722	181	12%	3
P2	East	1,327	1,533	207	16%	4
P2	West	1,742	1,502	-240	-14%	4
P3	North	5,915	5,252	-663	-11%	6
P3	South	4,434	3,582	-852	-19%	10

- **Road Travel Times**

The travel times on Routes 1 and 2 (SH1 and SH2) are shown in the following graphs. These show a very similar comparison with observed times as in the Validation Report.

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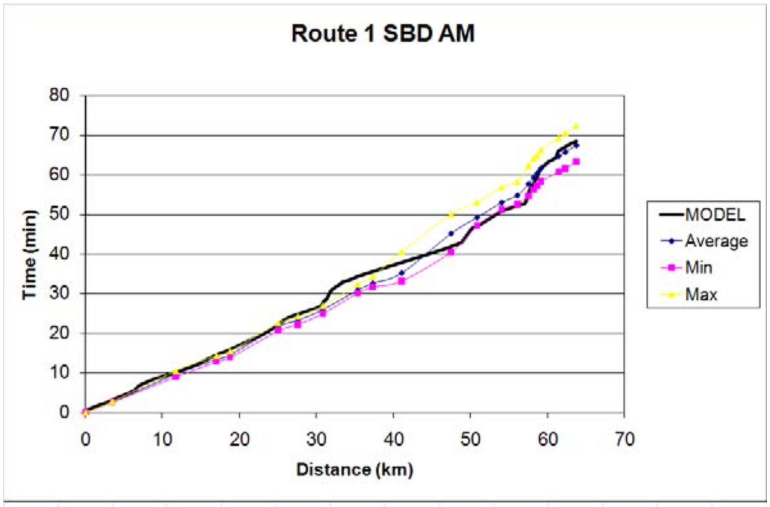
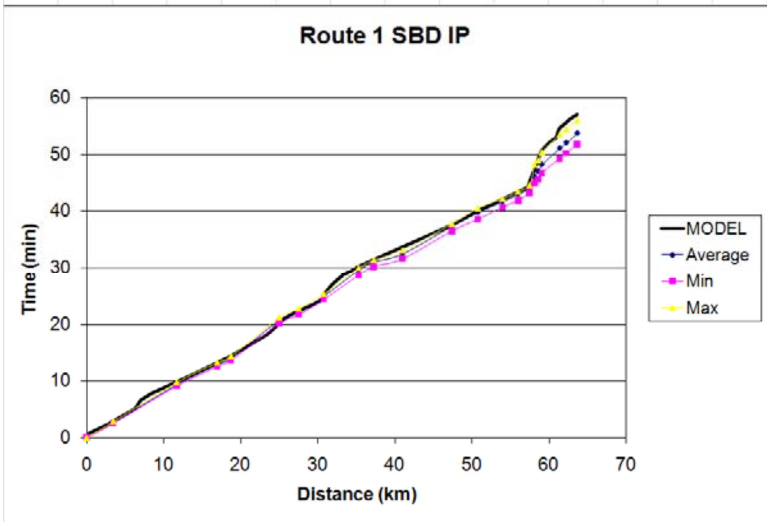
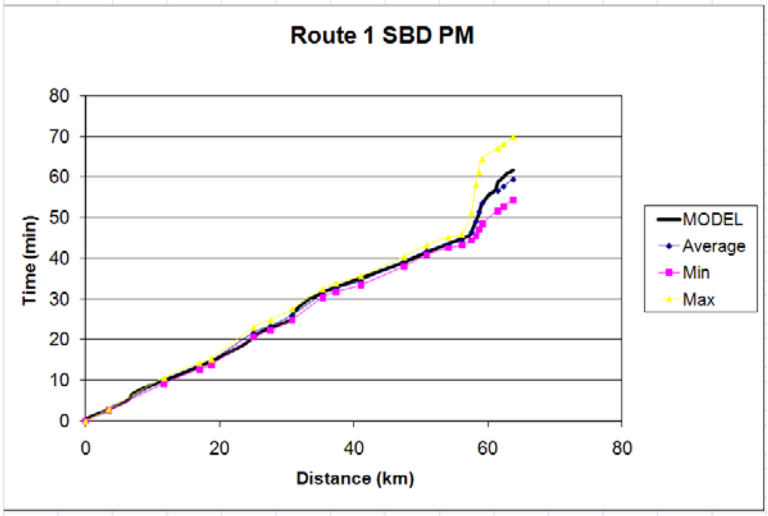
- **Travel Times – Route 1 Southbound**







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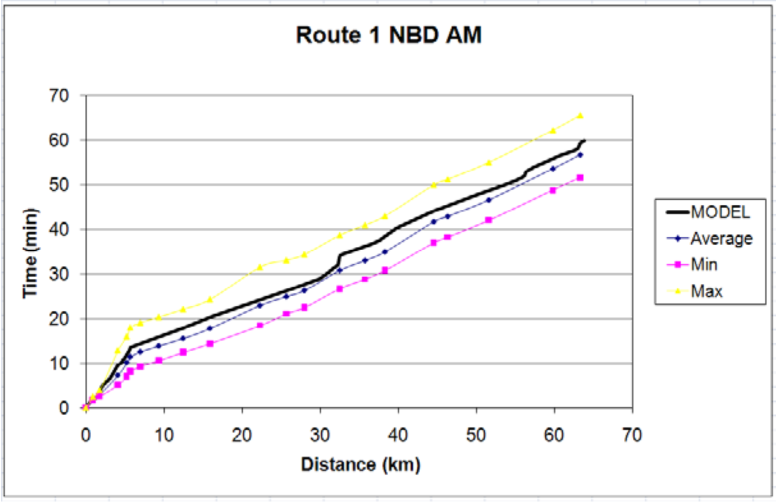
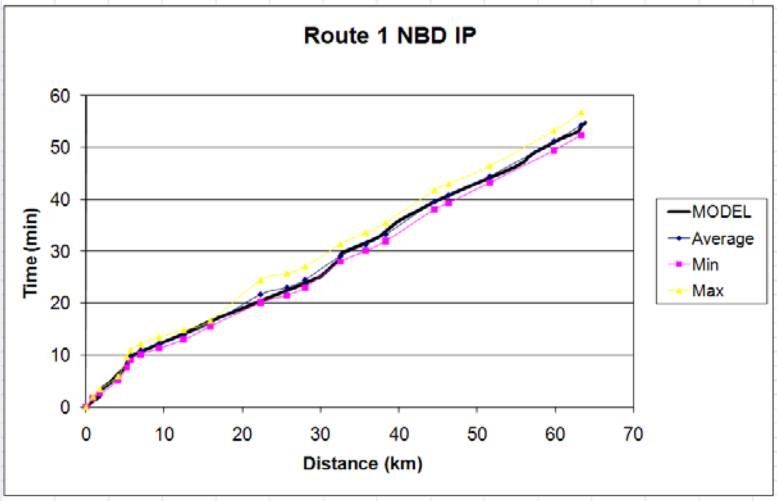
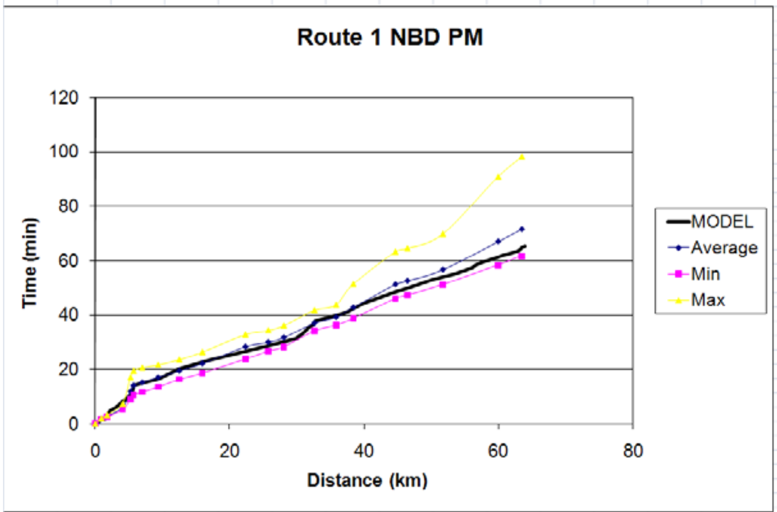
- **Travel Times – Route 1 Northbound**







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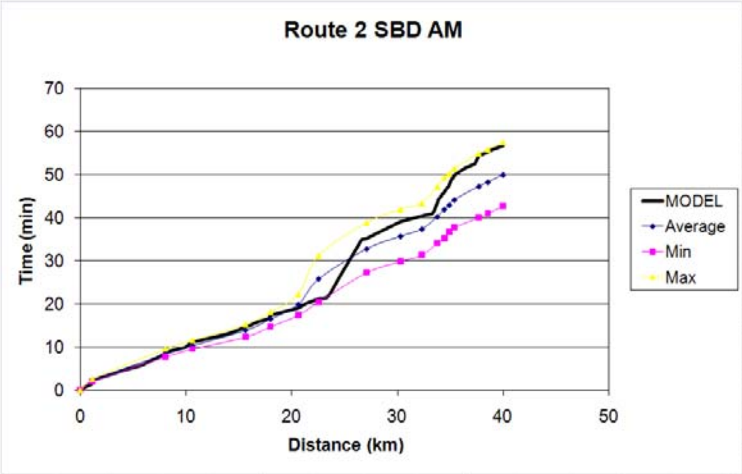
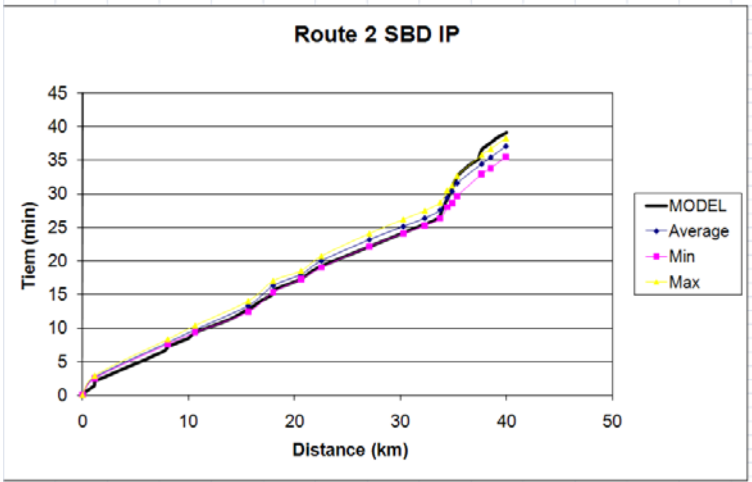
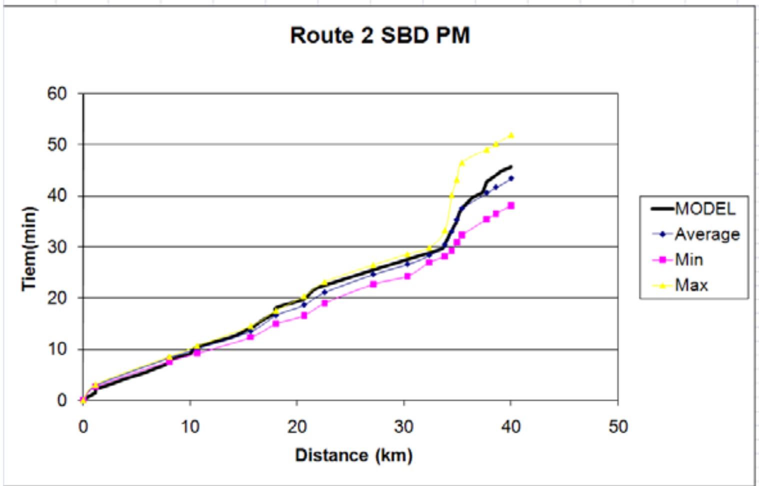
- **Travel Times – Route 2 Southbound**







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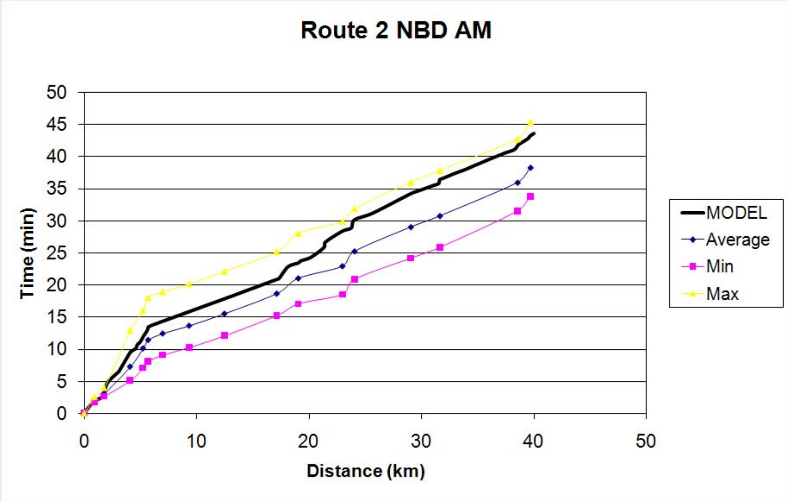
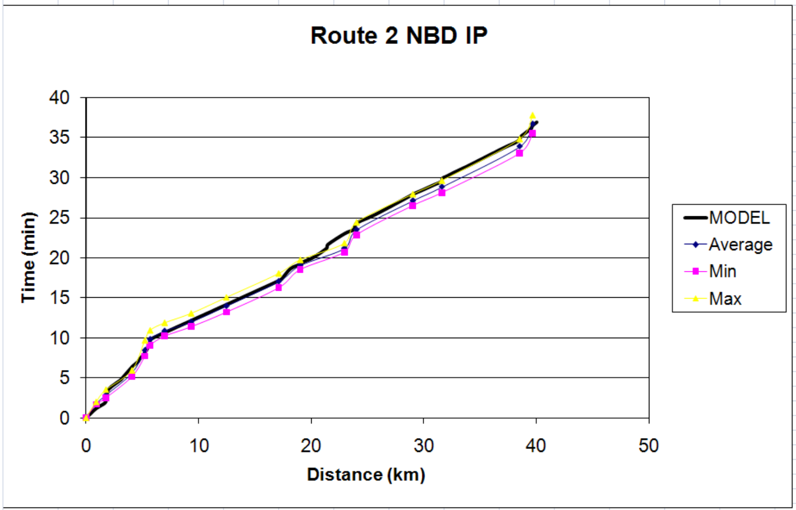
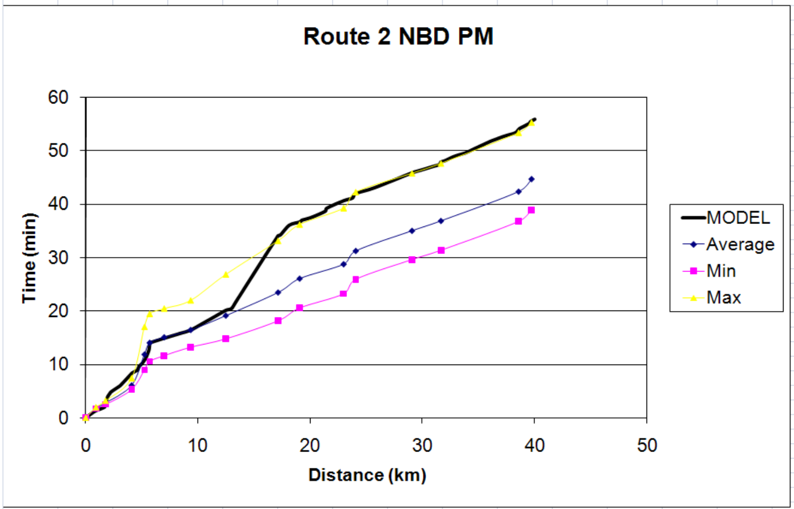
- **Travel Times – Route 2 Northbound**







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