Greater Wellington Regional Council

2013 WTSM Update

Technical Note 8: WTSM 2013 Validation

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Greater Wellington Regional Council

2013 WTSM Update

Technical Note

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1. Introduction

This technical note documents the validation of the Wellington Transport Strategy Model (WTSM) as part of the 2013 update of the model. The validation process ensures that the WTSM is a good representation of observed transport patterns in the base year 2013, by comparing output from the model against a range of observed criteria:

- Traffic counts and screenline volumes for light vehicles and medium/heavy vehicles;
- Light vehicle journey time surveys;
- Bus passenger ticketing information;
- Bus journey times;
- Rail count and loading profiles.

As the model is a representation of an average March 2013 weekday to coincide with the 2013 census, observed data used in the validation was sourced for this period as much as possible. When data for other time periods was used, it was adjusted accordingly to match with usual March conditions. This process is explained in more details in "TN1 – Data Collection".

In addition, convergence of the model demand and assignment is also reported to ensure that the WTSM is internally consistent, i.e. the demand that is assigned on the networks produces delays and generalised costs which are in turn consistent with the demand itself.

2. Summary of Investigation

2.1 Summary of 2011 Update

This 2013 update of the WTSM comes only two years after the 2011 update, which included a number of significant changes to the model in addition to the usual update of network, landuse information and economic input parameters. These were primarily designed to prepare the WTSM to work in conjunction with the newly developed Wellington Public Transport Model (WPTM) and were as follows:

- New and more detailed road networks;
- New public transport networks, directly imported from the General Transit Feed Specification (GTFS);
- New transit time functions for public transport;
- New public transport fare calculation.

As a result, re-validating the model to 2011 was a significant effort, as some of the changes had the potential to impact on cost calculation and as a result on trip distribution and mode choice. Extensive investigation on a number of issues was undertaken, which is highlighted in Section 2 of *"TN18 – WTSM Calibration and Validation"* from the 2011 update. As a summary, the measures resulting from this investigation were:

- Proportion of employed people was reduced to account for economic down-turn and a resulting decrease in trip rates;
- All economic input parameters were deflated to 2001 dollars, to scale them back to a range of values the model was calibrated against; and
- A mode constant of 1.2 was introduced and applied to public transport cost matrices as too much PT demand was generated.

2.2 2013 Update

In comparison, this update did not require such significant changes. The network was kept the same except for the inclusion of a small number of schemes that occurred in the 2011-2013 period, economic parameters (fuel costs, PT fares, parking cost, value of time) were updated, and the most notable difference was that the landuse information is now based on the 2013 census, compared with the 2011 landuse which was based on estimates. All these changes are documents in separate technical notes.

As a result, no major intervention was needed for this revalidation, and only two items were investigated:

- Traffic free-flow speeds were determined to be slightly over-optimistic as they are in most cases based on the posted speed limit. In low traffic conditions, this results in most modelled traffic circulating at speeds close to the speed limit, which is unlikely to occur especially in the Wellington urban environment, due the nature of the network (narrow and bendy roads, numerous buses and car parked on the main corridors). After analysis of observed travel times, it was therefore decided to reduce all free-flow speed limits in the model by 5% for highway and rural links, and 10% for urban links. This is consistent with the approach used in mesoscopic traffic models in the region;

- A test was carried out with the removal of the mode constant of 1.2 applied to PT costs which was introduced during the 2011 update. This led to PT demand increasing significantly above observed demand, and as a result this adjustment was kept in.

Most of the focus for this model update was therefore spent on using more reliable sources of data than were used previously, especially for public transport, and this is developed further in this report.

3. Light Vehicles Validation

Validation of vehicle volumes across the network was carried out using the same method as for the 2006 and 2011 updates, enabling direct comparison of the performance of the 2013 WTSM against previous versions.

Assigned volumes for light vehicles (cars and light commercial vehicles) were compared against traffic counts, looking both at individual counts and at total demand across a number of screenlines. The location of traffic counts and screenlines are shown in Figure 1 and Figure 2.

Traffic volume validation uses the difference between observed and modelled volumes, as well as the GEH statistical values, the standard empirical measure used to compare modelled flows against observed traffic counts.

The NZTA Economic Evaluation Manual (EEM) states that:

- At least 60% of individual link flows should have GEH less than 5.0;
- At least 95% of individual link flows should have GEH less than 10.0;
- 100% of individual link flows should have GEH of less than 12.0; and
- Screenline flows should have GEH of less than 4.0 in most cases.

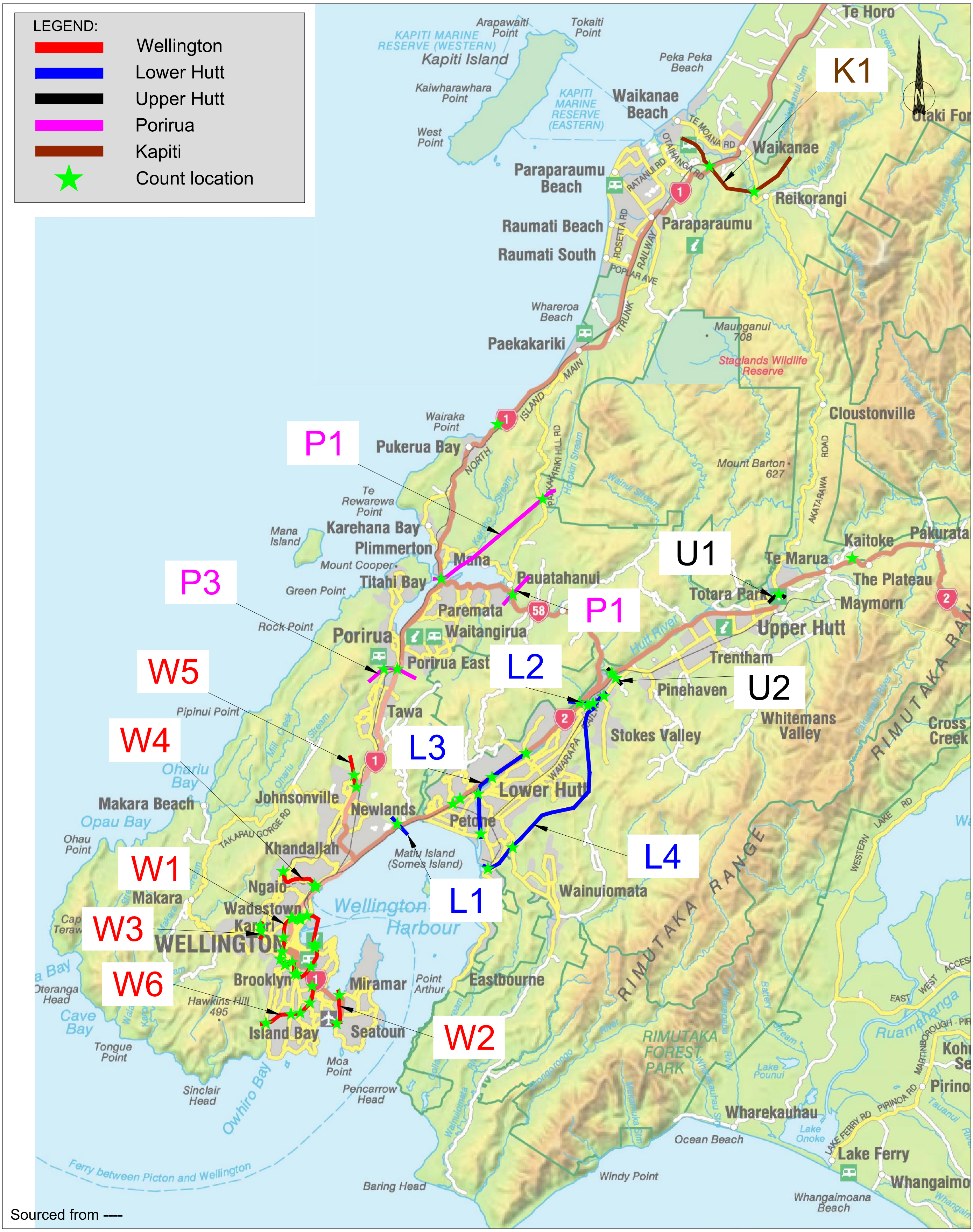
These targets are specified for meso-scopic traffic models rather than multi-modal strategic transport models such as WTSM for which more lee-way is generally afforded, but they can nevertheless be used as guidelines.

Since the development of WTSM, a more comprehensive transport model development manual has been introduced by NZTA that provides validation guidelines for different types of model and by project application. In these guidelines, the WTSM is a “Type A” regional transport model. The criteria and validation targets specified in NZTA’s transport model development guidelines (TMDG) are:

- At least 65% of individual link counts should have a GEH less than 5.0;
- At least 75% of individual link counts should have a GEH less than 7.5;
- At least 85% of individual link counts should have a GEH less than 10.0;
- At least 95% of individual link counts should have a GEH less than 12.0; and
- Screenlines should have a GEH of less than 5.0 for 60% or more of screenlines.

These criteria and targets for regional models are very similar to the EEM equivalents, which have been applied to the WTSM.

The method employed in previous updates of WTSM for the reporting of GEHs was to divide the 2-hour observed and modelled flows by two to generate an “average hour” flow. Guidelines for the use of the GEH statistics do not explicitly stipulate that they require one-hour flows, but this approach was kept nonetheless to ensure the 2013 reported validation could be compared directly with results from previous iterations of the model.



Tuesday, 28 January 2014

Screenlines

TDG

1

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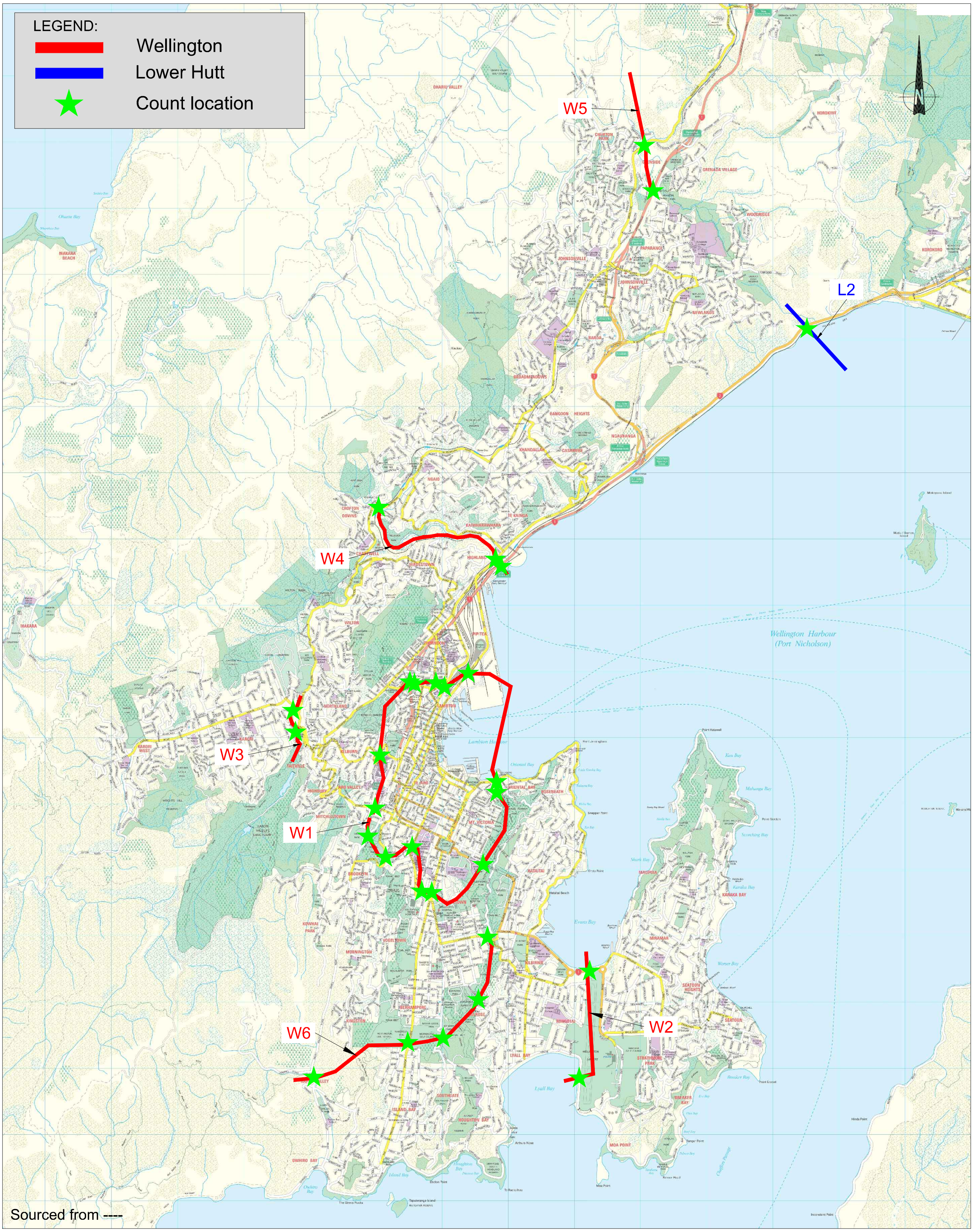

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Screenlines - Wellington City

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2

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3.1 Screenline Validation

This section details the validation of the 2013 WTSM light vehicle volume assignment against total observed demand across the screenlines shown in Figure 1 and Figure 2.

Description	AM				IP				PM			
	Obs	Mod	Diff	GEH	Obs	Mod	Diff	GEH	Obs	Mod	Diff	GEH
W1-CBD in	13,168	13,392	224	1.9	7,285	7,431	146	1.7	8,647	8,651	4	0.0
W1-CBD out	7,220	7,044	-176	2.1	7,292	7,269	-23	0.3	13,036	13,054	19	0.2
W2-Miramar In	1,965	1,854	-111	2.5	1,369	1,282	-87	2.4	1,542	1,555	14	0.3
W2-Miramar Out	1,572	1,438	-134	3.5	1,535	1,284	-250	6.7	2,177	1,907	-270	6.0
W3-Karori out	388	475	87	4.2	34	36	2	0.4	422	511	90	4.2
W3-Karori in	1,242	1,202	-40	1.1	78	36	-41	5.4	1,320	1,238	-81	2.3
W4-Thorndon out	3,068	2,961	-107	1.9	3,335	2,905	-430	7.7	7,319	6,828	-491	5.8
W4-Thorndon in	7,636	7,596	-40	0.5	3,377	3,118	-259	4.5	4,126	3,723	-403	6.4
W5-Churton P out	1,488	1,475	-13	0.3	1,602	1,309	-293	7.7	3,370	2,874	-496	8.9
W5-Churton P in	2,769	3,120	351	6.5	1,585	1,398	-186	4.8	1,918	1,797	-120	2.8
L1-Nga to Pet out	2,255	2,478	223	4.6	1,904	1,908	4	0.1	3,329	3,890	560	9.3
L1-Nga to Pet in	3,340	3,893	553	9.2	1,821	2,001	181	4.1	2,755	2,883	128	2.4
L2-L to U Hutt out	1,461	1,366	-95	2.5	1,289	1,303	14	0.4	3,451	2,579	-872	15.9
L2-L to U Hutt in	3,566	2,648	-918	16.5	1,306	1,305	-1	0.0	1,748	1,601	-146	3.6
L3-L Hutt in	4,119	3,935	-184	2.9	3,126	2,817	-309	5.7	4,508	3,877	-630	9.7
L3-L Hutt out	3,966	3,333	-633	10.5	3,095	2,763	-331	6.1	4,617	4,293	-323	4.8
L4-Wainui-Stoke in	2,842	3,098	256	4.7	1,086	1,380	294	8.4	1,238	1,438	200	5.5
L4-Wainui-Stoke out	841	1,026	186	6.1	1,166	1,344	178	5.0	3,000	3,054	54	1.0
U1-U Hutt N in	972	1,165	193	5.9	432	638	206	8.9	541	734	193	7.7
U1-U Hutt N out	313	603	290	13.6	482	639	157	6.6	1,127	1,105	-22	0.6
U2-U Hutt S out	1,454	1,476	22	0.6	1,169	1,271	102	2.9	2,885	2,130	-755	15.1
U2-U Hutt S in	2,706	2,288	-418	8.4	1,133	1,292	160	4.6	1,661	1,637	-24	0.6
P1-Porirua N out	619	663	44	1.7	1,107	687	-419	14.0	1,727	1,462	-265	6.6
P1-Porirua N in	1,589	1,701	112	2.8	911	722	-189	6.6	1,013	854	-159	5.2
P2-SH58 west	705	827	122	4.4	334	448	114	5.8	770	664	-106	3.9
P2-SH58 east	803	686	-117	4.3	339	419	80	4.1	672	621	-51	2.0
P3-Porirua S out	1,735	1,375	-359	9.1	1,645	1,113	-532	14.3	3,263	2,385	-878	16.5
P3-Porirua S in	2,835	2,570	-265	5.1	1,639	1,186	-453	12.0	2,154	1,672	-482	11.0
Total	**76,634**	**75,687**	**-1%**		**51,471**	**49,306**	**-4%**		**84,330**	**79,019**	**-6%**	

Table 1: Light Vehicles Screenline Validation (1-hour flows)

As can be observed, most screenlines have a GEH below 4, but some also have a high GEH above 12. In most cases, these are the same screenlines that presented issues in previous updates, although some improved while others got worst. Significant variations are explained below:

- Screenline L1 (Petone to Ngauranga) which consists of a single count on SH2 shows GEH of about 9 in the peak direction, with modelled flows being too high. Modelled flows are consistent with WTSM 2011, but observed flows have decreased by circa 8%. This is a significant decrease in traffic over a two year period which does not appear on screenlines further south or north, or when looking at travel times on this section of SH2. This count was reported as being faulty by NZTA and was fixed just before the surveyed period. During processing of the output it was found that the time stamps were wrong, with all recorded volumes being shifted by one hour. This was corrected but it is possible there were other calibration issues with this count. No further investigation was carried out for this screenline;
- Screenline L2 (Lower Hutt to Upper Hutt) is too low in the peak direction, although counter-peak and inter peak validation is very good. This issue was also present in the 2011 model, with the GEH slightly improving. The same issue also occurs although to a lesser extent on screenline U2 just north of SH58. This shows that demand between Lower Hutt and Upper Hutt is too low as screenline L1 to the south and U1 to the north shows too much demand, and P2 on SH58 is only slightly too low. As concluded in the 2011 update, this is likely to be a trip distribution issue but in the absence of new household travel survey data there is no information to support any adjustment;
- Screenline P3 (Porirua to Tawa) is too low for all periods and directions. This is consistent with the 2006 and 2011 models. Given the relatively good performance and different patterns for W5 to the south and P1 to the north, this indicates not enough demand between Tawa and Porirua, either because not enough trips are generated, or the trip distribution does not allocate enough trips between these two catchments. 2013 census journey to work data was checked and showed no fundamental difference from 2006 between Porirua and Tawa. Again in the absence of new household travel data there is no information to support a potential adjustment.

The following table compares the overall levels of screenline validation compared with the 2006 and 2011 updates.

	2013			2011			2006		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
GEH<5	64%	46%	50%	64%	43%	54%	64%	57%	57%
GEH<10	89%	89%	86%	86%	86%	82%	86%	79%	75%
GEH<12	93%	89%	89%	89%	93%	82%	96%	89%	96%

Table 2: Light Vehicles Screenline Validation Summary

Results show that the overall screenline validation achieves similar performance as previous versions of the model.

Using the TMDG guidelines, the 2013 AM peak modelled flows on screenlines exceed the target while the inter peak and PM peak periods do not achieve the target. The inter peak and PM periods would also not have achieved these criteria for the 2006 or 2011 validation, although the 2006 validation was only marginally below. The performance of the inter peak and PM peaks has deteriorated over time in terms of close correlation between modelled and observed, however, the larger discrepancies have generally reduced (with the exception of the PM peak flows with a GEH < 12). This is not unexpected for a large, regional multi-modal model that was calibrated to 2001 travel data.

3.2 Individual Links Validation

In addition to overall demand across screenlines, validation for individual traffic counts was examined and is reported in this section.

Figure 3 to Figure 5 show scattergram plots of observed counts vs modelled flows, as well as the resulting coefficient of determination R^2. Both the EEM and the TDMG recommend R^2 values above 0.85, with the TDMG additionally targeting a line of best fit with a slope between 0.9 and 1.1.

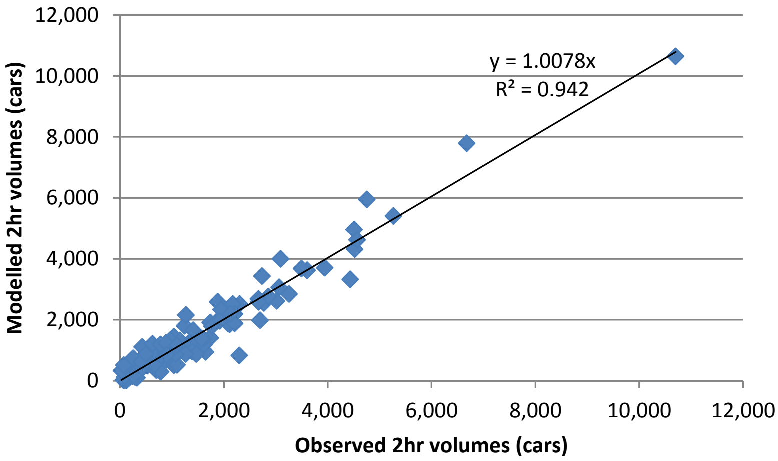


Figure 3: Light Vehicles Individual Count Validation – AM Peak

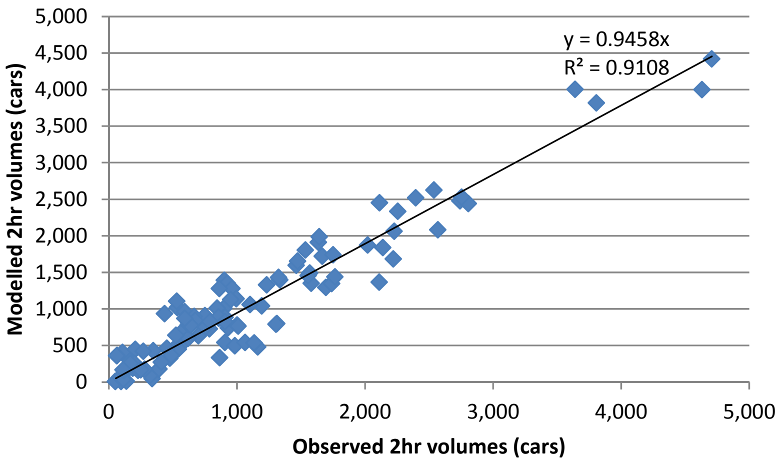


Figure 4: Light Vehicles Individual Count Validation – Inter Peak

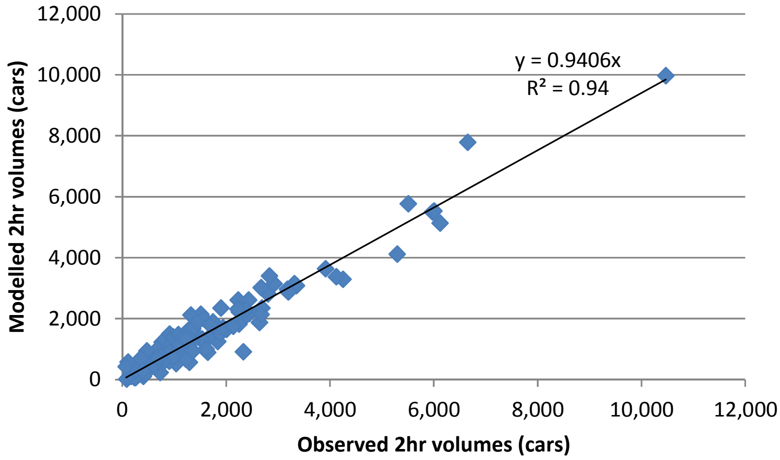


Figure 5: Light Vehicles Individual Count Validation – PM Peak

Table 3 summarises individual count validation, showing overall GEH and R^2 as well as the targets from the two guidelines. Performances for the 2006 and 2011 are shown for comparison.

	Target		2013			2011			2006		
	EEM	TDMG	AM	IP	PM	AM	IP	PM	AM	IP	PM
Counts with GEH < 5	60%	65%	50%	58%	50%	52%	60%	49%	53%	49%	45%
Counts with GEH < 10	95%	85%	77%	83%	78%	80%	85%	79%	86%	78%	78%
Counts with GEH < 12	100%	95%	87%	88%	88%	88%	93%	86%	89%	86%	87%
R^2	>0.85		0.94	0.91	0.94	0.94	0.92	0.94	0.94	0.90	0.94

Table 3: Light Vehicles Link Validation Summary

The scattergram plots and the summary in Table 3 show that all modelled periods achieve similar levels of validation with previous versions of the model. While link flows generally do not meet the targets in most of the peak periods, the R^2 is well above the recommendations of 0.85.

4. Heavy Vehicles Validation

4.1 Screenline Validation

Validation of heavy commercial vehicle (HCV) volumes across the network was carried out similarly as for light vehicles, using the same screenlines. Note that "heavy" includes both medium and heavy commercial vehicles. Results for HCVs have the potential to differ more significantly from previous versions of the model since the 2013 WTSM includes a completely new predictive synthetic model for heavy vehicles.

Table 4 below details the validation of the 2013 WTSM heavy vehicle volume assignment against total observed demand across the screenlines shown in Figure 1 and Figure 2.

Description	AM				IP				PM			
	Obs	Mod	Diff	GEH	Obs	Mod	Diff	GEH	Obs	Mod	Diff	GEH
W1-CBD in	877	572	-305	11.3	521	470	-51	2.3	458	447	-11	0.5
W1-CBD out	509	517	8	0.4	590	502	-87	3.7	743	510	-232	9.3
W2-Miramar In	145	98	-47	4.2	127	80	-47	4.6	124	65	-59	6.1
W2-Miramar Out	87	79	-7	0.8	77	77	1	0.1	73	75	2	0.2
W3-Karori out	34	36	2	0.4	34	36	2	0.4	422	511	90	4.2
W3-Karori in	78	36	-41	5.4	78	36	-41	5.4	1,320	1,238	-81	2.3
W4-Thorndon out	171	275	104	7.0	240	315	75	4.5	303	305	3	0.1
W4-Thorndon in	407	338	-69	3.6	221	255	34	2.2	163	227	64	4.6
W5-Churton P out	70	129	60	6.0	70	133	64	6.3	60	125	66	6.8
W5-Churton P in	87	143	56	5.2	72	127	55	5.5	50	105	55	6.3
L1-Nga to Pet out	160	218	58	4.2	201	240	40	2.7	156	221	65	4.7
L1-Nga to Pet in	247	248	1	0.1	229	195	-35	2.4	144	179	35	2.8
L2-L to U Hutt out	110	123	13	1.2	101	118	17	1.6	147	108	-39	3.5
L2-L to U Hutt in	184	123	-61	4.9	99	109	10	1.0	81	99	18	1.9
L3-L Hutt in	323	257	-66	3.9	270	232	-37	2.4	223	201	-21	1.5
L3-L Hutt out	247	244	-3	0.2	279	243	-36	2.2	289	214	-75	4.7
L4-Wainui-Stoke in	165	99	-66	5.7	81	85	4	0.4	74	71	-3	0.3
L4-Wainui-Stoke out	80	94	14	1.5	73	84	11	1.2	139	79	-60	5.7
U1-U Hutt N in	40	40	0	0.0	44	40	-4	0.6	38	31	-7	1.3
U1-U Hutt N out	50	34	-16	2.5	52	42	-10	1.5	39	33	-6	1.1
U2-U Hutt S out	92	107	15	1.5	83	104	21	2.2	89	94	6	0.6
U2-U Hutt S in	116	110	-5	0.5	86	101	15	1.6	62	89	27	3.1
P1-Porirua N out	54	50	-4	0.6	55	54	-1	0.1	67	48	-18	2.4
P1-Porirua N in	140	54	-86	8.7	79	54	-25	3.0	87	40	-46	5.8
P2-SH58 west	40	49	9	1.3	22	39	17	3.1	23	38	15	2.8

Description	AM				IP				PM			
	Obs	Mod	Diff	GEH	Obs	Mod	Diff	GEH	Obs	Mod	Diff	GEH
P2-SH58 east	32	41	9	1.5	22	36	14	2.6	30	38	8	1.3
P3-Porirua S out	108	116	8	0.8	132	118	-14	1.3	104	109	5	0.5
P3-Porirua S in	126	126	0	0.0	128	115	-13	1.2	82	94	12	1.3
Total	**4,774**	**4,355**	**-9%**		**4,062**	**4,040**	**-1%**		**5,584**	**5,394**	**-3%**	

Table 4: Heavy Vehicles Screenline Validation (1-hour flows)

There are no validation criteria specifically for vehicle sub-sets, however, comparisons to the overall metrics have been undertaken. Results at a screenline level are generally good, with most screenlines having a GEH of less than 5 and all of them being less than 12. The following table therefore compares results from WTSM 2013 with previous versions of the model.

	2013			2011			2006		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
GEH<5	75%	89%	79%	82%	96%	86%	89%	100%	86%
GEH<10	96%	100%	100%	93%	100%	96%	100%	100%	100%
GEH<12	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 5: Heavy Vehicles Screenline Validation Summary

It must be noted that for the 2006 and 2011 updates of the model, the HCV matrices were factored manually to match with observed volumes across screenlines. In comparison, the 2013 HCV model is a synthetic model for which demand is generated and distributed based on a set of equations, and as a result less robust validation should be expected.

However, summary results in Table 5 show that the model performs comparably with 2011 and 2006 versions of WTSM at a screenline level, although there is a decrease of screenlines with a GEH of less than 5.

More detail on the development of the HCV model and its calibration can be found in "TN4 – 2013 Commercial Vehicle Model".

4.2 Individual Links Validation

Heavy vehicle validation for individual traffic counts was examined and is reported in this section.

Figure 6 to Figure 8 below show scattergram plots of observed vs modelled counts, as well as the resulting coefficient of determination, R^2 and the slope of the line of best fit with the intercept forced through zero.

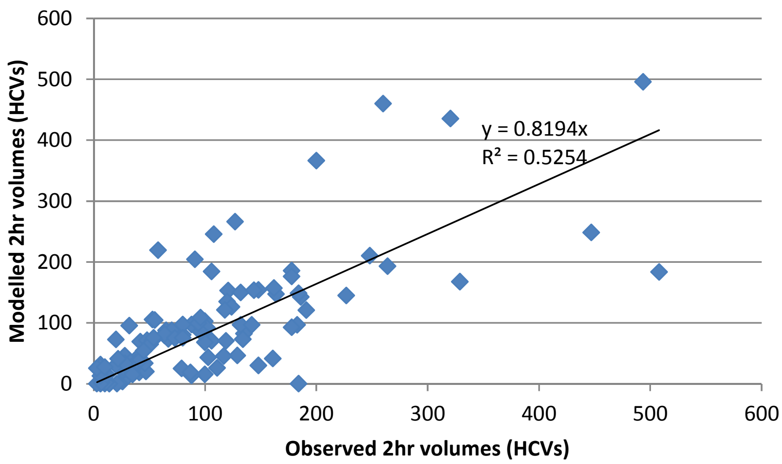


Figure 6: Heavy Vehicles Individual Count Validation – AM Peak

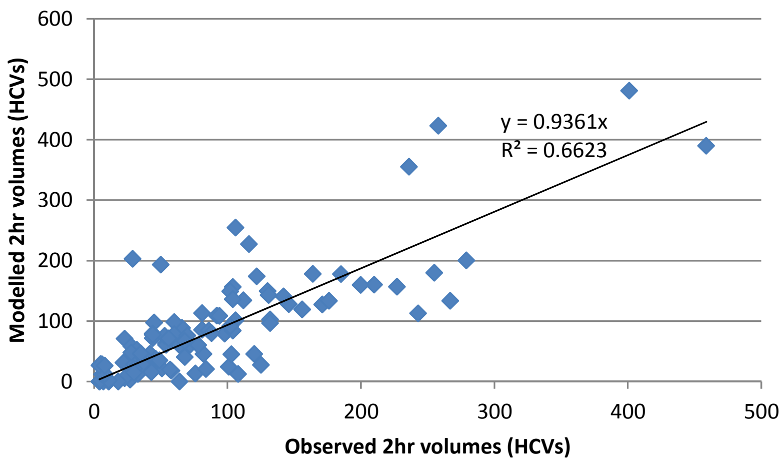


Figure 7: Heavy Vehicles Individual Count Validation – Inter Peak

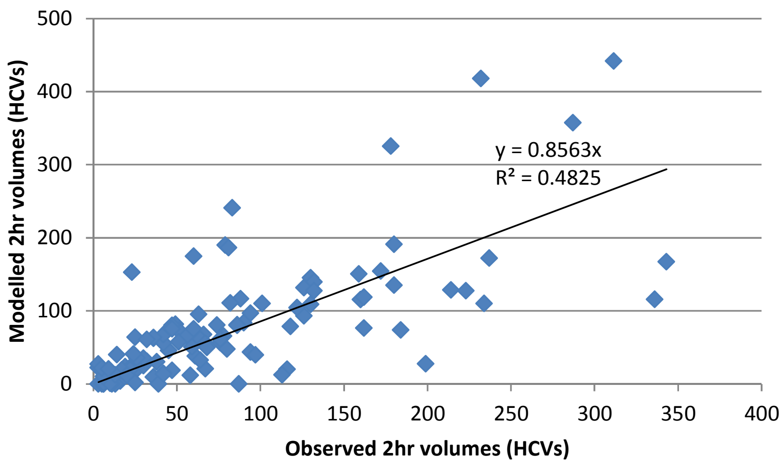


Figure 8: Heavy Vehicles Individual Count Validation – PM Peak

There is a considerable degree of scatter in terms of modelled flows replicating observed. This reflects the relatively low volumes and the challenge of re-producing these flows in a large, regional strategic model. While the discrepancies are large in percentage terms, the absolute magnitude of the differences is small.

In terms of outliers:

- Modelled flows through Mt Victoria Tunnel as too high in both directions for all three peak periods. However, at Cobham Drive, northbound modelled flows are lower than observed in all three peak periods. This is potentially an effect from the distribution, with additional trips compared with observed patterns being generated in the Rongotai and Kilbirnie areas;
- Modelled flows on Waterloo Quay are lower than observed for all three peak periods in both directions of travel. This could be due to either local routeing issues or too few trips to the Port. While the percentage differences are significant, the hourly volumes are relatively small in all cases;
- Flows in both directions on State Highway 1 south of Ngauranga are higher than observed, although flows are low in the peak direction on the parallel Hutt Rd. This is likely an assignment issue as the total number of modelled trips through the corridor reflect observed.

The following table compares results for heavy vehicle link validation from WTSM 2013 with the 2011 version of the model.

	2013			2011		
	AM	IP	PM	AM	IP	PM
Proportion of counts with GEH < 5	79%	87%	83%	80%	85%	80%
Proportion of counts with GEH < 10	98%	99%	98%	97%	100%	98%
Proportion of counts with GEH < 12	98%	100%	100%	99%	100%	98%
R^2	0.54	0.67	0.50	0.66	0.78	0.64

Table 6: Heavy Vehicles Link Validation Summary

The 2013 synthetic model results are remarkably similar to the 2011 factored matrix outputs in terms of GEH statistics for modelled link flows compared with observed. The 2013 modelled flows also meet or exceed the GEH criteria in the EEM and TMDG, however, this is primarily because the commercial vehicle volumes are relatively small in magnitude.

5. Vehicle Travel Time

Vehicle travel time validation was based on the same annual surveys carried out on behalf of NZTA that were used for the previous updates. The routes that were surveyed during weekdays for a March 2013 week are:

- Route 1 – SH1 between Wellington Airport and Waikanae Rail Station;
- Route 2 – SH2 between Wellington Rail Station and Upper Hutt Rail Station;
- Route 3 – Along SH58;
- Route 4 – Between Karori and Courtenay Place;
- Route 5 – Between Island Bay and Wellington Rail Station;
- Route 6 – Between Wainuiomata and Hutt Road.

Table 7 to Table 9 overleaf shows a comparison between modelled and observed travel times for all three time periods for the above routes.

Charts for each route showing the mean, minimum and maximum observed values from the surveys and modelled values, as well as maps of the routes are provided in **Appendix A**. The modelled values should sit close to the mean travel time and lie within the range between the maximum and minimum observed values.

Route	Description	Length (km)	Obs. (mins)	Mod. (mins)	% Diff	Within Range
Route 1N	Airport - Waikanae	64.3	58.3	63.8	10%	Yes
Route 1S	Waikanae - Airport	64.2	81.3	70.1	-14%	Yes
Route 2N	Wellington Station - Upper Hutt	32.8	31.4	35.2	12%	Yes
Route 2S	Upper Hutt - Wellington Station	32.7	43.7	46.4	6%	Yes
Route 3W	SH2 / SH58 to SH1 / SH58	15.1	14.4	15.4	7%	Yes
Route 3E	SH1 / SH58 to SH2 / SH58	15.1	14.6	14.4	-1%	Yes
Route 4N	Wellington CBD to Karori	9.1	22.0	22.2	1%	Yes
Route 4S	Karori to Wellington CBD	7.9	18.5	23.0	24%	Yes
Route 5N	Island Bay to CBD	7.3	15.9	17.7	11%	Yes
Route 5S	CBD to Island Bay	7.5	19.8	17.4	-12%	Yes
Route 6N	Petone to Wainuiomata	10.7	20.9	15.3	-27%	Yes
Route 6S	Wainuiomata to Petone	11.0	20.8	14.6	-30%	Yes

Table 7: Vehicle Travel Time Validation – AM Peak

Route	Description	Length (km)	Obs. (mins)	Mod. (mins)	% Diff	Within Range
Route 1N	Airport - Waikanae	64.3	55.7	58.0	4%	Yes
Route 1S	Waikanae - Airport	64.2	55.4	57.9	5%	Yes
Route 2N	Wellington Station - Upper Hutt	32.8	31.9	31.0	-3%	Yes
Route 2S	Upper Hutt - Wellington Station	32.7	26.9	30.8	14%	Yes
Route 3W	SH2 / SH58 to SH1 / SH58	15.1	14.6	14.3	-2%	Yes
Route 3E	SH1 / SH58 to SH2 / SH58	15.1	14.7	14.1	-4%	Yes
Route 4N	Wellington CBD to Karori	9.1	20.0	20.6	3%	Yes
Route 4S	Karori to Wellington CBD	7.9	17.7	20.8	17%	Yes
Route 5N	Island Bay to CBD	7.3	15.2	15.7	3%	Yes
Route 5S	CBD to Island Bay	7.5	15.8	15.9	1%	Yes
Route 6N	Petone to Wainuiomata	10.7	13.7	14.1	3%	Yes
Route 6S	Wainuiomata to Petone	11.0	14.5	14.4	-1%	Yes

Table 8: Vehicle Travel Time Validation – Inter Peak

Route	Description	Length (km)	Obs. (mins)	Mod. (mins)	% Diff	Within Range
Route 1N	Airport - Waikanae	64.3	68.0	65.6	-4%	Yes
Route 1S	Waikanae - Airport	64.2	67.8	65.8	-3%	Yes
Route 2N	Wellington Station - Upper Hutt	32.8	34.7	42.8	23%	Yes
Route 2S	Upper Hutt - Wellington Station	32.7	33.1	35.7	8%	Yes
Route 3W	SH2 / SH58 to SH1 / SH58	15.1	13.3	14.6	10%	Yes
Route 3E	SH1 / SH58 to SH2 / SH58	15.1	14.5	14.7	1%	Yes

Route	Description	Length (km)	Obs. (mins)	Mod. (mins)	% Diff	Within Range
Route 4N	Wellington CBD to Karori	9.1	26.2	22.5	-14%	Yes
Route 4S	Karori to Wellington CBD	7.9	21.1	22.9	9%	Yes
Route 5N	Island Bay to CBD	7.3	18.3	17.1	-7%	Yes
Route 5S	CBD to Island Bay	7.5	18.8	18.4	-2%	Yes
Route 6N	Petone to Wainuiomata	10.7	14.7	14.6	-1%	Yes
Route 6S	Wainuiomata to Petone	11.0	17.6	15.8	-10%	Yes

Table 9: Vehicle Travel Time Validation – PM Peak

Results show that all modelled journey times are generally a good match with observed and in every case sit within the minimum and maximum observed times, for all three time periods.

Some routes show a relatively higher difference between modelled time and average observed times either on the whole route or on some sections (see **Appendix A)** and these are discussed here:

- Route 1: Validation is good, except on SH1 around Ngauranga where traffic is going faster than observed. This was already noted during the 2011 update and is due to merge delays and blocking back not being modelled explicitly in WTSM;
- Route 2: Validation is good, with the exception of SH2 between Ngauranga and Petone, which is too slow in the peak direction. Peak volumes are very high on this link which reaches capacity in the model, with speed deteriorating markedly. This was already noted during the 2011 update;
- Route 4: Good, with the exception of 4S during the inter peak, which is 17% too slow. This is however just above the maximum observed;
- Route 6: Morning peak journey times are about 30% too fast. This is an area of substantial congestion and high variability of delays, with severe queuing and blocking back occurring along the Petone Esplanade. Assignment in EMME does not model blocking back, potential underestimating delays as a result.

6. Bus Patronage

Bus patronage was also validated against observed flows across screenlines. Again the same screenlines as in 2011 were used to allow for comparison. However, the method used to derive observed patronage was different:

- For the 2011 update, it was noted that "due to the nature of the Electronic Ticketing Machine (ETM) data, it was found to be very difficult to obtain volumes directly" (see section 3.2 in TN19 – WPTM Calibration and Validation from the 2011 update). Bus patronage across screenlines were therefore obtained by carrying out a "Reference assignment", assigning the WPTM observed bus demand matrices on the bus-only network and extracting the resulting volumes;
- For this 2013 update, no full observed demand matrix was available for assignment. However limited ETM data was available for Go Wellington and Valley Flyer services (which represent about 85% of total boardings in the region) including stop boardings and alightings, and fare zones travelled. This time it was decided to utilise this data to extract information about bus patronage on the network. A tool was therefore developed based on the Python programming language that allows extracting the number of bus users boarding, alighting, or passing through any bus stop on the network, with results broken down per service (See **Appendix B** for more details). This tool was then used to calculate the total number of bus passengers through each screenline for the AM and inter peak periods. The only services for which patronage could not be calculated are Mana and Newland services, for which 2011 values were used. These however represent only a small share of total boardings.

As a result of this new approach, observed numbers are somewhat different from the previous update, but the validation is considered to be more robust as a result since modelled volumes are compared against directly observed data. The resulting bus passenger validation is detailed in Table 10.

Due to the highly sensitive nature of ETM data in terms of confidentiality, numbers have been removed and only high-level statistic results are shown.

Description	AM				IP			
	Observed	Modelled	Diff	GEH	Observed	Modelled	Diff	GEH
W1-CBD in				3.9				12.0
W1-CBD out				1.7				0.9
W2-Miramar In				3.9				3.8
W2-Miramar Out				2.9				2.3
W3-Karori out				2.7				2.4
W3-Karori in				5.8				2.2
W4-Thorndon out				4.5				10.8
W4-Thorndon in				12.2				3.8
W5-Churton P out				8.3				4.8
W5-Churton P in				6.8				4.7
L1-Nga to Pet out				6.4				4.2
L1-Nga to Pet in				18.9				3.6
L2-L to U Hutt out				2.6				3.4
L2-L to U Hutt in				8.9				2.1
L3-L Hutt in				4.3				2.0
L3-L Hutt out				3.9				6.0
L4-Wainui-Stoke in				8.5				4.2
L4-Wainui-Stoke out				6.9				11.1
U2-U Hutt S out				8.0				3.2
U2-U Hutt S in				0.0				1.2
P1-Porirua N out				0.0				0.0
P1-Porirua N in				2.6				0.0
P2-SH58 west				0.9				0.0
P2-SH58 east				0.0				0.0
P3-Porirua S out				2.3				0.4
P3-Porirua S in				1.9				0.8
Total			-4%				7%	

Table 10: Bus Patronage Validation

Bus patronage validation is generally good, with most screenlines having a GEH of less than 5.

Movements across W1, which intercepts people heading into and out of the CBD, are very close to observed during the AM peak, although they are too low inbound in the inter peak.

The main issue is too little demand inbound through screenlines W4 and L1 in the morning peak, i.e. not enough bus passengers from the Hutt Valley to Wellington. This was also the case in WTSM 2011, but counts from the ETM data are somewhat higher which exacerbates the issue. This issue might be linked with the slight excess in rail users on the same corridor (see Chapter 8).

Table 11 summarises screenline validation, showing overall GEH performances. Results for 2006 and 2011 are shown for comparison.

	2013		2011		2006	
	AM	IP	AM	IP	AM	IP
GEH<5	62%	85%	81%	65%	73%	77%
GEH<10	92%	88%	96%	96%	92%	88%
GEH<12	92%	100%	96%	100%	96%	88%

Table 11: Bus Patronage Validation Summary

As can be observed, the 2013 WTSM performs comparably with previous updates. The target specified in TMDG for bus passengers validation is for at least 60% of screenlines to have a GEH < 5. This is achieved for both the AM and inter peak time periods.

There is a slight deterioration, particularly in the AM Peak but this is essentially due to the issue noted above, with demand between the Hutt Valley and Wellington CBD being under-estimated.

7. Bus Journey Times

Bus journey time validation was not reported during the 2006 and 2011 WTSM updates, although for the latter it was reported as part of the WPTM development (see section 5.6 in *"TN1 – Network Preparation"* and 5.4 in *"TN19 – WPTM calibration and validation"* from the 2011 update) since the same bus transit time functions are now used in both models. Modelled travel times compare well to observed, demonstrating there is no need to change the transit time functions calibrated in 2011, as is shown in the following analysis.

The WPTM validation compared modelled bus travel times against scheduled times from timetables as it was noted in TN19 (from the 2011 update) that *"it is very difficult to get the travel times for entire routes from the ETM data"*. Real-time information (RTI) data was used only for a couple of routes to compare against observed times, as there were difficulties in obtaining and processing this data.

For the 2013 update, RTI data for all bus services within the region for a full working week period in March 2013 (11th to 15th) was obtained. This data was then processed using a tool developed in Python to extract actual times for all routes, for each time period. More detail on this process can be found in **Appendix C**. As a result, bus travel time validation in this report is based on actual travel times and is therefore likely to differ from reported 2011 validation.

A number of bus routes were selected for validation and reporting which were deemed to represent a good indication of travel times on each of the main bus corridors. These bus routes are illustrated in Figure 9.

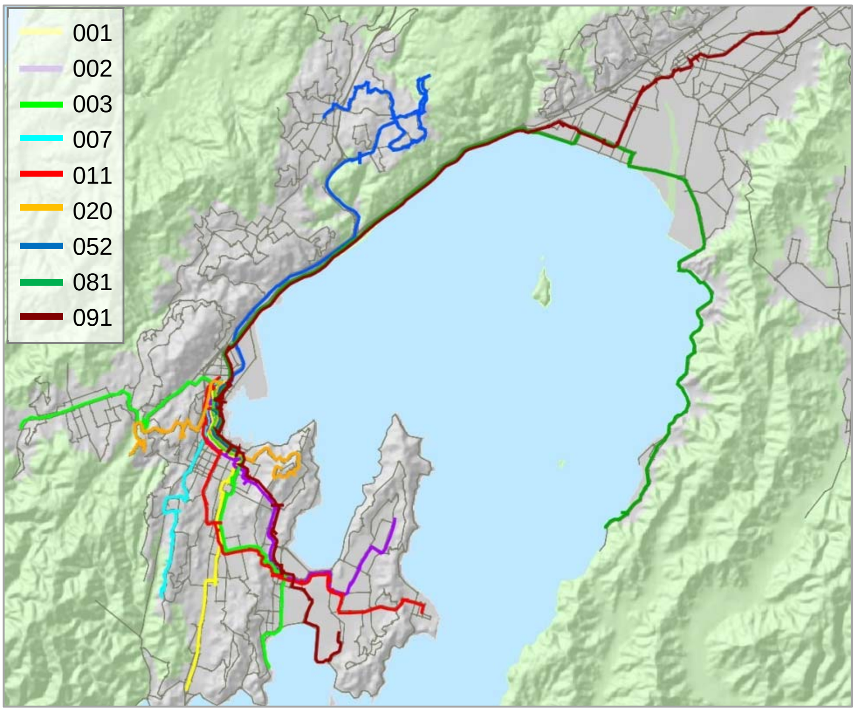


Figure 9: Bus Routes for Travel Time Validation

For each of these routes, average travel times during the AM and inter peak were extracted, as well as the average plus / minus two standard deviations which provides the target range for modelled bus travel times. Figure 10 to Figure 13 show this travel time analysis for a sample of routes in the AM peak. The modelled, average observed, and scheduled travel times are shown, as well as the average +/-2 standard deviations range.

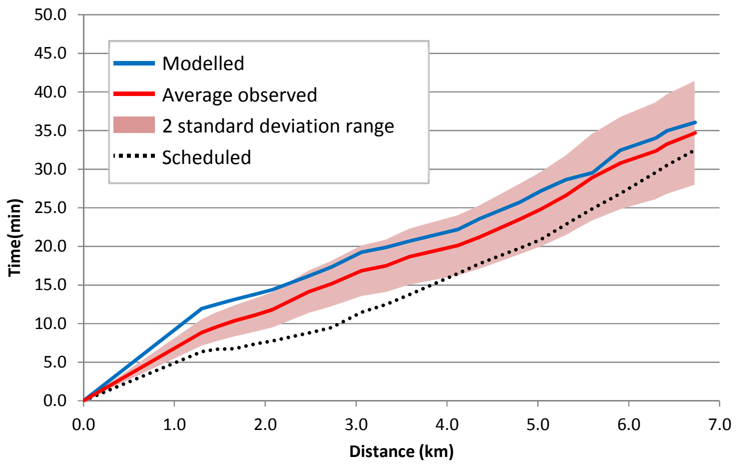


Figure 10: Route 1 Inbound Travel Time – AM Peak

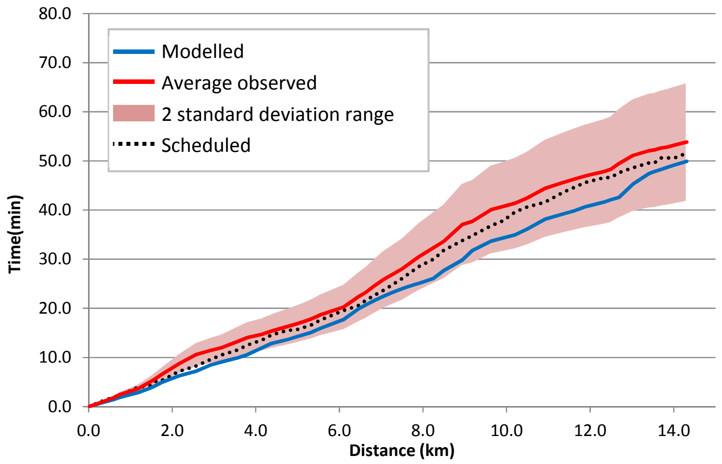


Figure 11: Route 3 Inbound Travel Time – AM Peak

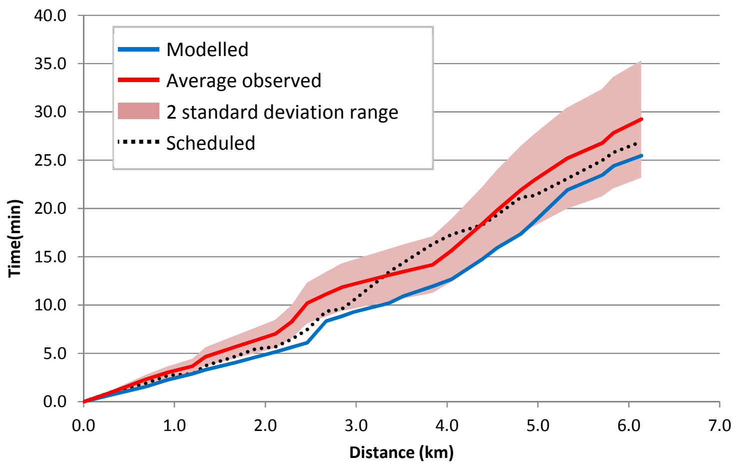


Figure 12: Route 7 Inbound Travel Time – AM Peak

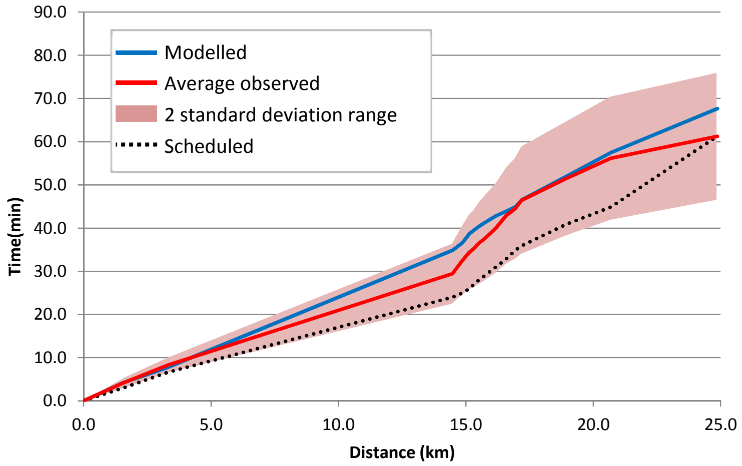


Figure 13: Route 91 Inbound Travel Time – AM Peak

For most of the routes' length, modelled travel times sit within the target range of +/-2 standard deviations, in some cases being a better match to average observed than the scheduled times. Table 12 and Table 13 show the results of this analysis for all routes shown in Figure 9, respectively for the AM and inter peaks, indicating if each route sits within the target range or not.

Route	Direction	Observed Average	Observed Average - Standard Deviation	Observed Average + Standard Deviation	Modelled	Within 2 Standard Deviations
1	in	34.7	28.0	41.4	36.1	Yes
1	out	30.3	15.5	45.1	30.3	Yes
2	in	44.4	31.6	57.1	39.3	Yes
2	out	38.4	30.3	46.5	36.0	Yes
3	in	53.8	41.9	65.8	49.9	Yes
3	out	51.6	40.6	62.7	54.8	Yes
7	in	29.3	23.2	35.3	25.5	Yes
7	out	24.6	19.8	29.4	23.6	Yes
11	in	48.3	39.5	57.1	43.3	Yes
11	out	42.7	33.1	52.3	37.0	Yes
20	in	43.6	38.7	48.6	40.8	Yes
20	out	41.9	36.5	47.2	44.8	Yes
52	in	61.7	54.3	69.1	56.2	Yes
52	out	50.0	40.9	59.2	58.5	Yes
81	in	64.4	50.3	78.5	68.0	Yes
81	out	45.3	38.6	52.0	56.6	No
91	in	61.2	49.3	73.2	67.7	Yes
91	out	46.6	39.1	54.1	54.0	Yes

Table 12: Bus Travel Time Validation – AM peak

Route	Direction	Observed Average	Observed Average - Standard Deviation	Observed Average + Standard Deviation	Modelled	Within Standard Deviation
1	in	35.9	26.8	45.1	29.9	Yes
1	out	32.5	25.6	39.4	28.1	Yes
2	in	40.1	30.8	49.4	36.3	Yes
2	out	37.3	31.5	43.1	35.2	Yes
3	in	51.7	44.0	59.5	50.4	Yes
3	out	51.3	37.6	65.0	50.1	Yes
7	in	24.6	21.3	27.9	24.1	Yes
7	out	26.6	21.6	31.6	23.2	Yes
11	in	43.5	36.0	51.0	37.9	Yes
11	out	42.9	36.4	49.4	35.3	No
20	in	41.3	33.2	49.4	39.5	Yes
20	out	41.4	33.3	49.6	40.6	Yes
52	in	49.9	45.2	54.6	53.5	Yes
52	out	45.5	38.8	52.1	55.4	No
83	in	67.2	54.7	79.7	67.7	Yes
83	out	64.0	57.4	70.6	68.6	Yes
91	in	51.9	45.4	58.3	45.4	Yes
91	out	46.9	39.9	53.9	43.8	Yes

Table 13: Bus Travel Time Validation – Inter Peak

Bus travel time analysis shows that in both periods most bus routes are within the target range, although some outbound routes are slightly outside. This is not considered to be problematic.

8. Rail Patronage

This section details the validation of rail patronage in the WTSM, by looking at total boardings and loading profiles on each main corridor (Kapiti line, Hutt Valley line and Johnsonville line).

For the 2011 update, observed patterns were obtained from extensive on-board and station surveys carried out for the development of the WPTM. No such data was available for this 2013 update so boardings and alightings from 2011 were used, factored per line to match with total patronage per line obtained through rail guard counts. This is also the same methodology that was used for the 2006 model update. Since only two years have passed since the last update and no railway line has experienced a change of more than 5%, this is deemed an appropriate approximation.

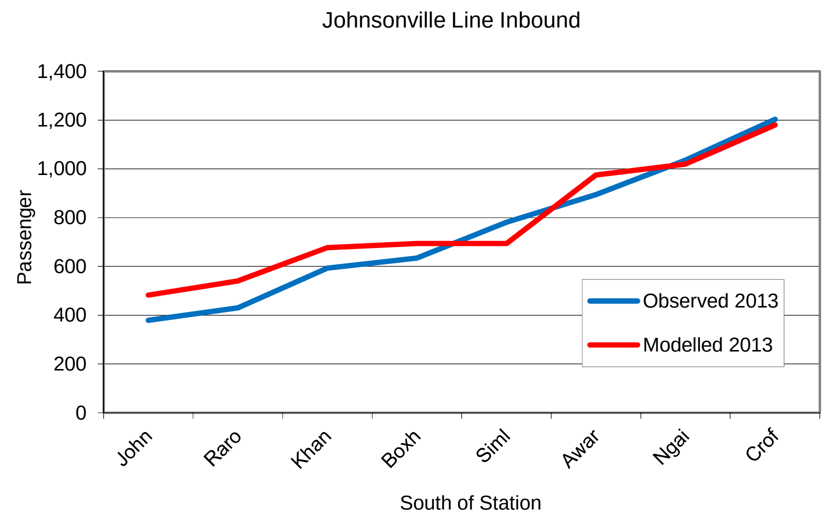
The resulting observed boardings per line are summarised in Table 14 below. These show that overall validation is good in the AM peak, although volumes are 11% too high on the Hutt Valley line. This can be related to the issue reported in Chapter 6 where it was noted that there is not enough bus patronage in the same corridor. This indicates that the model assigns too much demand to rail and not enough to bus in this corridor, possibly as a result of highway travel times on SH2 being too slow, as noted in Chapter 5.

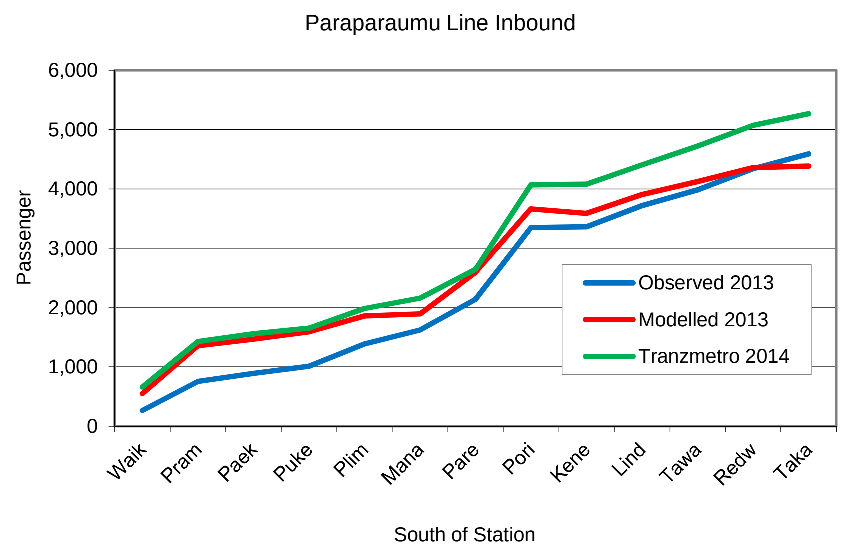
In the inter peak, volumes are circa 20% too high on the Kapiti line and 20% too low on the Hutt Valley line, but this translates to relatively small numbers.

Line	AM Peak – Inbound			Inter Peak – Inbound		
	Observed	Modelled	%	Observed	Modelled	%
Johnsonville Line	1,203	1,181	-2%	123	136	11%
Kapiti Line	4,590	4,387	-4%	331	395	20%
Hutt Valley Line	5,178	5,742	11%	404	321	-21%
Total	10,970	11,309	3%	858	853	-1%

Table 14: Rail Patronage Validation

The observed and modelled loading profiles for each line in the inbound direction are shown in Figure 14 and Figure 15 , for the AM peak and inter peak respectively.





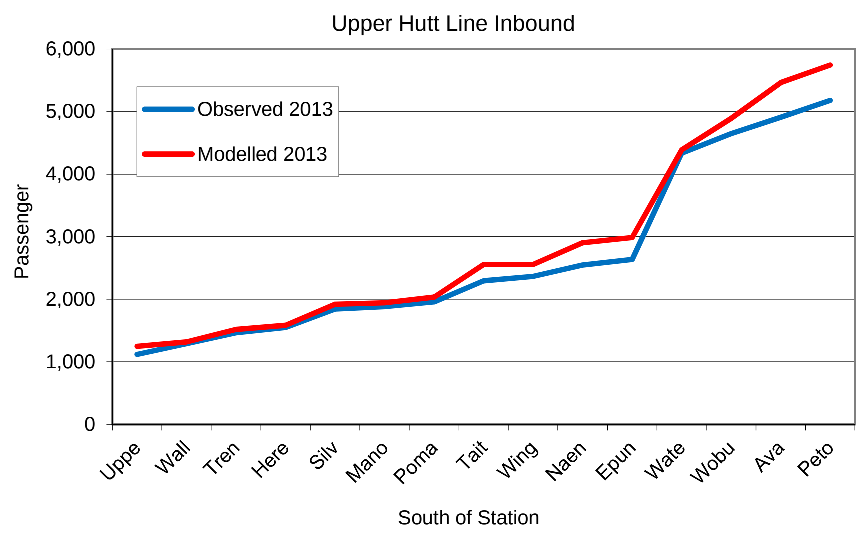
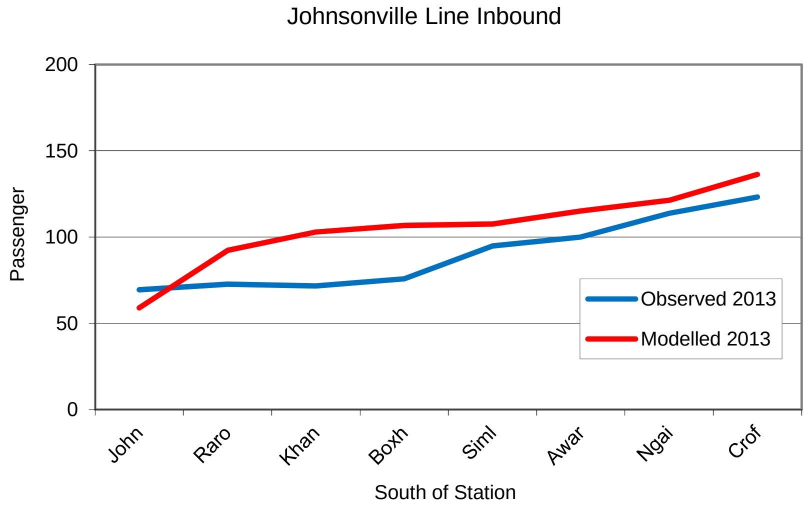
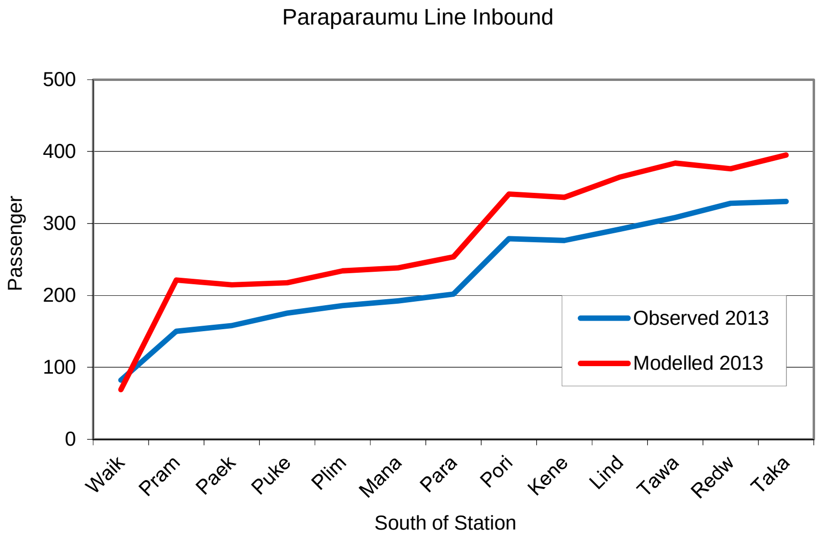


Figure 14: Rail Loading Profiles – AM Peak





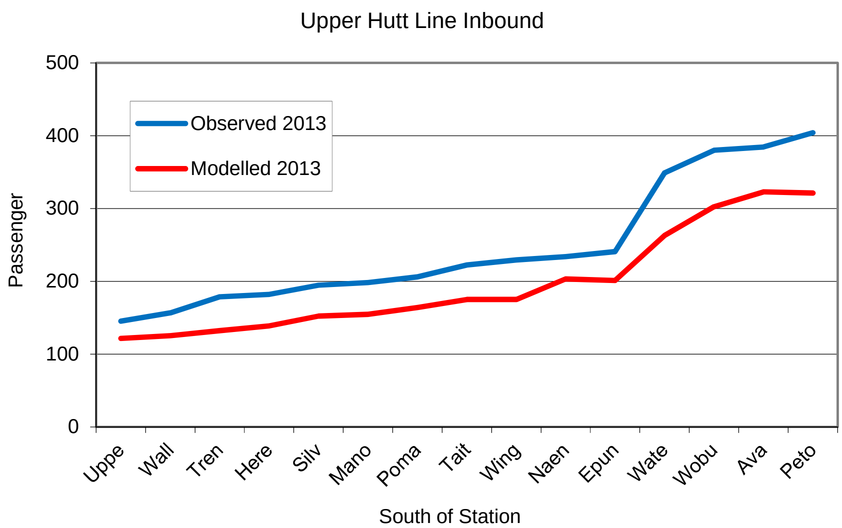


Figure 15: Rail Loading Profiles – Inter Peak

Modelled rail loading profiles during the AM peak are generally a good match with observed, and the results are very similar to the 2011 WTSM. However, a number of observations can be made:

- On the Kapiti line, WTSM shows significantly more boardings at Waikanae and Paraparaumu station than observed volumes. This was also apparent in the 2011 WTSM but is slightly more pronounced now. It was thought that this might be due to the Waikanae station (which had just opened in 2011) and Paraparaumu station experiencing higher levels of growth than the rest of the line which would not be captured using 2011 volumes factored overall. A more recent survey was obtained from Tranzmetro, which counted boardings on the Kapiti line in 2014 and is shown on the graph. This survey was based on counts from a sample of services, expanded to match total boardings and therefore may not be completely accurate, but it does indicate that boardings at Waikanae and Paraparaumu seem to have increased faster than for other stations on the line;
- On the Hutt Valley line, there is a good match until the last two stations (Ava and Petone) which show too much modelled demand. Since there is a degree of competition between bus and rail in this part of the Hutt Valley, this can be related to the issue noted before in this section, likely to be caused by the model assigning slightly too many passengers to rail in this corridor, to the detriment of bus;
- The profiles in the inter peak match observed volumes less closely. For the Kapiti and Hutt Valley lines, this is largely due to too much demand at the beginning of the line (Waikanae for Kapiti and Upper Hutt for the Hutt Valley line), which then continues for the rest of the line, although this translates to much smaller numbers than in the AM peak.

9. Model Convergence

9.1 Demand Convergence

The following figure and table shows the level of demand convergence achieved for each mode and time period, i.e the root mean square (RMS) deviation between each loop of the trip distribution and mode choice models.

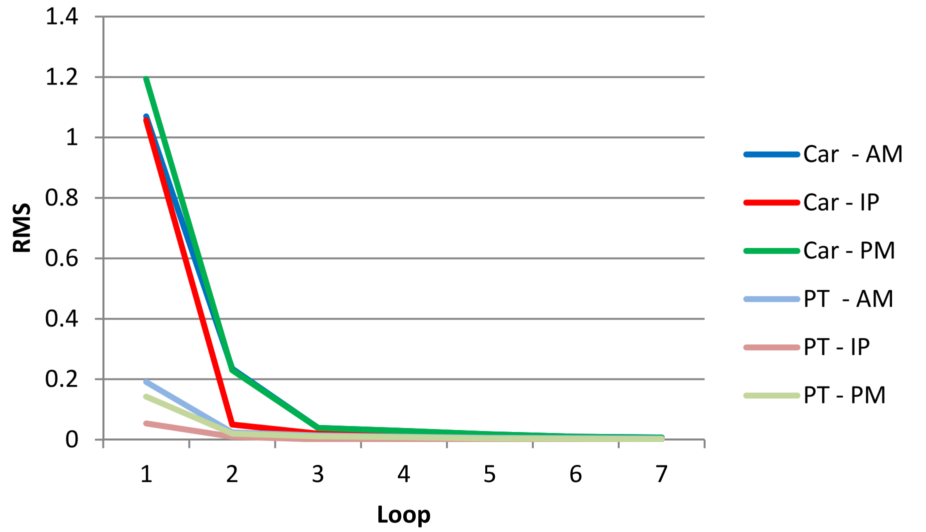


Figure 16: WTSM Demand Convergence

	Car			PT		
	AM	**IP**	**PM**	**AM**	**IP**	**PM**
RMS - Loop 7	0.007	0.004	0.007	0.004	0.001	0.002

Table 15: Final Loop Demand Convergence

The demand shows a high degree of convergence, in line with previous versions of the model.

9.2 Highway Assignment Convergence

Table 16 shows the convergence of the highway assignment model in WTSM for all three time periods. Both vehicle-kilometres travelled and vehicle-hours are shown before each iteration of the update of intersection capacity and at the end of the last iteration.

Results show that all time periods have converged by the 7th iteration.

Intersection Update Iteration	AM		IP		PM	
	veh.km	veh.hr	veh.km	veh.hr	veh.km	veh.hr
0	1,484,322	2,073,274	1,048,030	1,298,001	1,549,833	2,117,348
1	1,482,670	2,033,847	1,047,924	1,293,866	1,549,343	2,093,562
	-0.11%	-1.90%	-0.01%	-0.32%	-0.03%	-1.12%
2	1,482,167	2,016,676	1,047,921	1,294,229	1,549,124	2,096,495
	-0.03%	-0.84%	0.00%	0.03%	-0.01%	0.14%
3	1,482,064	2,015,377	1,047,898	1,294,864	1,549,326	2,101,501
	-0.01%	-0.06%	0.00%	0.05%	0.01%	0.24%
4	1,482,053	2,017,722	1,047,914	1,295,266	1,549,490	2,107,249
	0.00%	0.12%	0.00%	0.03%	0.01%	0.27%
5	1,482,130	2,019,448	1,047,939	1,295,506	1,549,628	2,111,750
	0.01%	0.09%	0.00%	0.02%	0.01%	0.21%
6	1,482,180	2,021,521	1,047,933	1,295,858	1,549,778	2,115,037
	0.00%	0.10%	0.00%	0.03%	0.01%	0.16%
7	1,482,249	2,021,731	1,047,940	1,295,773	1,549,927	2,116,784
	0.00%	0.01%	0.00%	-0.01%	0.01%	0.08%

Table 16: Assignment Convergence

9.3 Link Volume Convergence

Link volume convergence was checked similarly as in the 2011 update. The following table shows the percentage of links with changes in assigned volumes over 5% after successive iterations. In this table "n" is the final iteration, and the last 5 iterations are shown.

	AM Peak	Inter Peak	PM Peak
n-4 iteration	2.7%	0.7%	2.5%
n-3 iteration	1.7%	0.3%	1.7%
n-2 iteration	1.2%	0.4%	0.9%
n-1 iteration	1.2%	0.3%	0.8%
n iteration	0.6%	0.3%	1.1%

Table 17: Link Volume Convergence

The target is for more than 95% of links experiencing less than 5% of change. Results show that this is achieved for all three time periods.

10. Conclusion

This technical note reported the performance of the WTSM updated to 2013, validated against a number of observed patterns.

As much as possible, reliable observed data was sourced and used for the validation, and extensive use was made of large sets of data such as ETM and RTI information. However some level of uncertainty exists for some observed patterns and this must be considered when looking at the performance of the model.

For each criterion, the outcome is summarised below:

- **Traffic counts and screenlines volumes for light vehicles:** Most screenlines and count sites meet EEM criteria and explanations were provided for the ones that don't. In most cases, the issues noted are consistent with discrepancies in earlier versions of the WTSM and can only be addressed through recalibration of the model, for which substantial household travel behaviour data would be needed;
- **Traffic counts and screenlines volumes for medium / heavy vehicles:** The new HCV model was found to perform well at a screenline level, despite its synthetic nature. There was more variation for modelled flows at individual link level, but the results were not dissimilar to the previous years' when the demands were factored;
- **Light vehicle journey time surveys:** Most journey times validate well and all sit between the minimum and maximum observed times. Some issues were noted, which in most cases relate to limitation with the EMME software in terms of representing severe congestion and queuing delay;
- **Screenline volumes for bus passengers:** These were validated using fully observed data from the GWRC electronic ticketing database. Modelled volumes are a good match to observed, with the exception of AM peak patronage from the Hutt Valley to Wellington, which is caused by the model assigning slightly too much demand on rail in this corridor, to the detriment of bus;
- **Bus journey times:** Real time information data was used to validate modelled bus journey times, and these were found to be a good match with observed times;
- **Rail count and loading profiles:** In the absence of detailed boarding information for 2013, 2011 boarding data was used, factored to match total patronage per line. The model generally compares favourably against observed, with the exception of Waikanae and Paraparaumu stations. More recent data indicates that patronage at these stations has increased faster than on the rest of the line, which may explain this discrepancy.

In summary, the 2013 version of WTSM was found to perform at a similar level of validation as the previous 2006 and 2011 updates, comparison metrics for modelled outputs against observed were in the generally order of industry-standard criteria albeit slightly lower than targets, and also comparably with other strategic models in New Zealand such as ART3 in Auckland and CTM in Christchurch.

This level of performance is considered suitable for the purposes for which the WTSM was designed, namely:

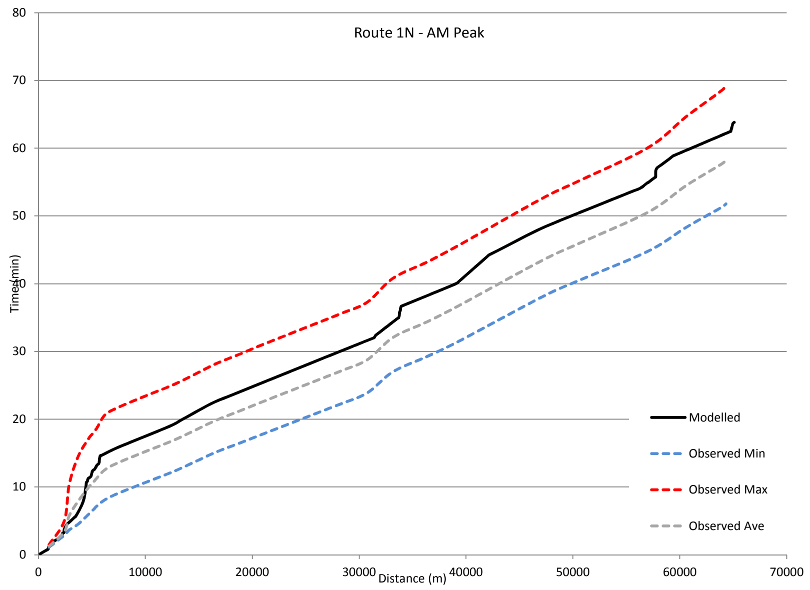
- Development of transport strategy and policies;

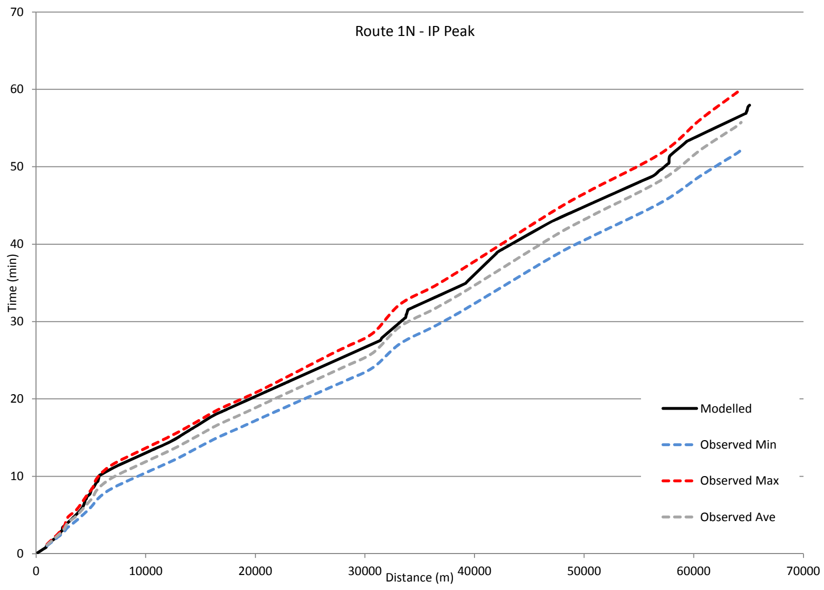
- Multi-modal corridor studies; and
- Providing demand to highway models and to the Wellington Public Transport Model (WPTM) for more detailed project related analysis.

However the same limitations apply as for other strategic models of this nature and corresponding care should be taken when interpreting results from the WTSM. Local area validation may also be required for specific project studies where WTSM is the sole source of economic evaluation data.

Appendix A

Vehicle Travel Time Validation


Route 1N - AM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave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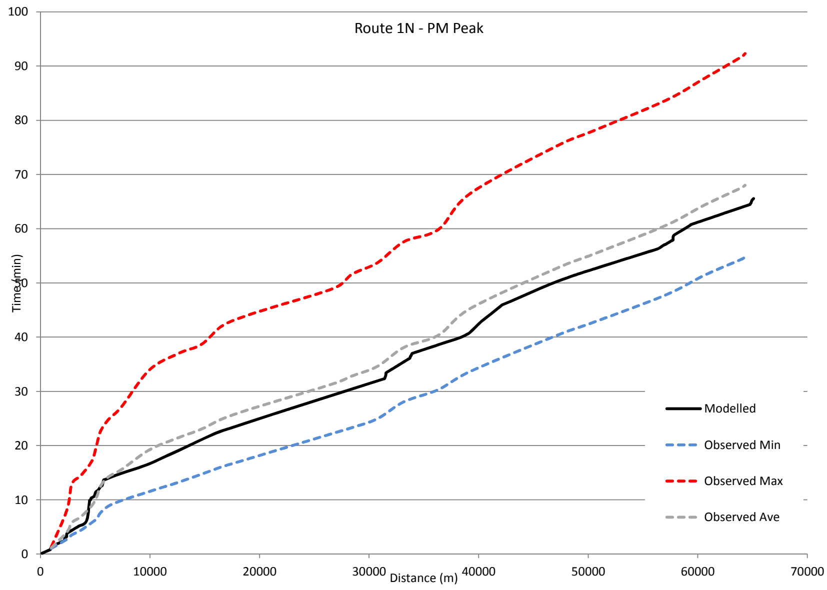
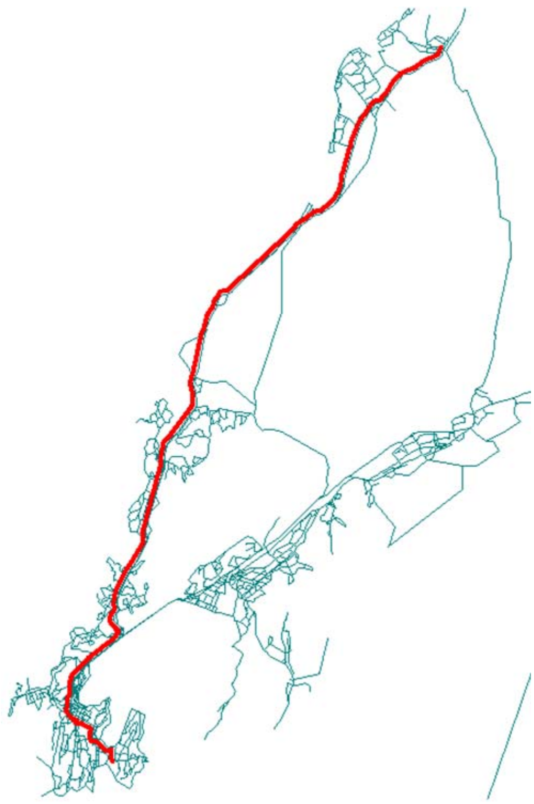
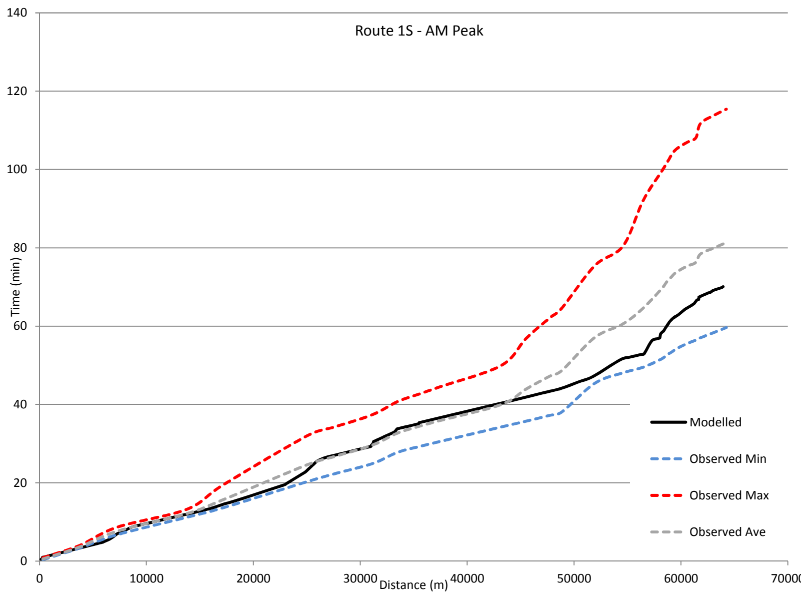
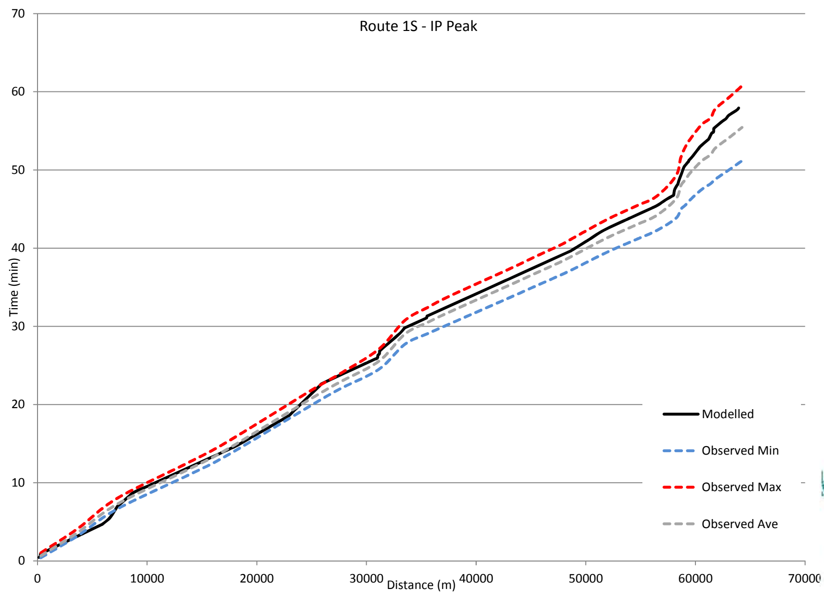
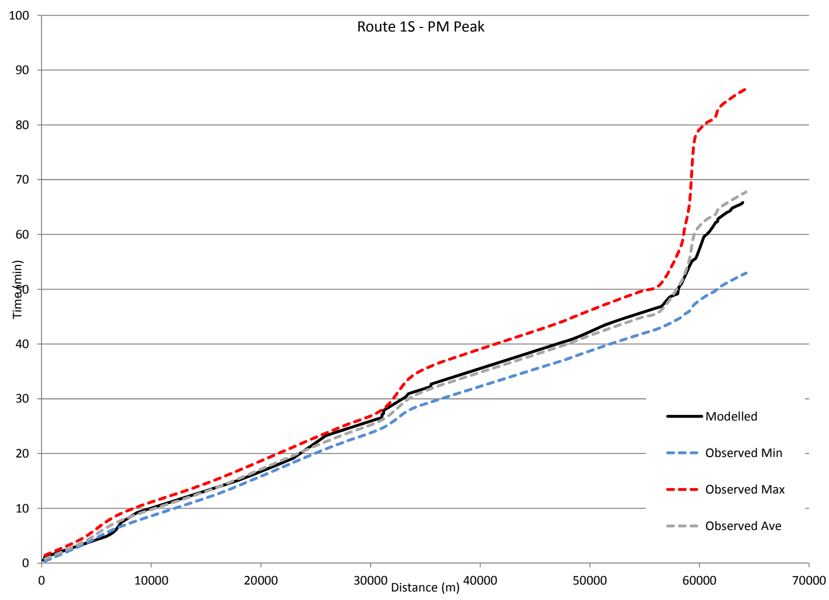
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

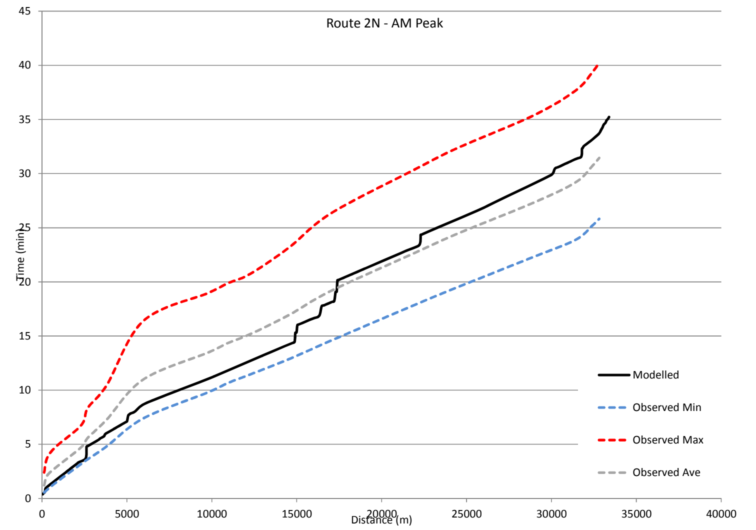

Route 1N - PM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

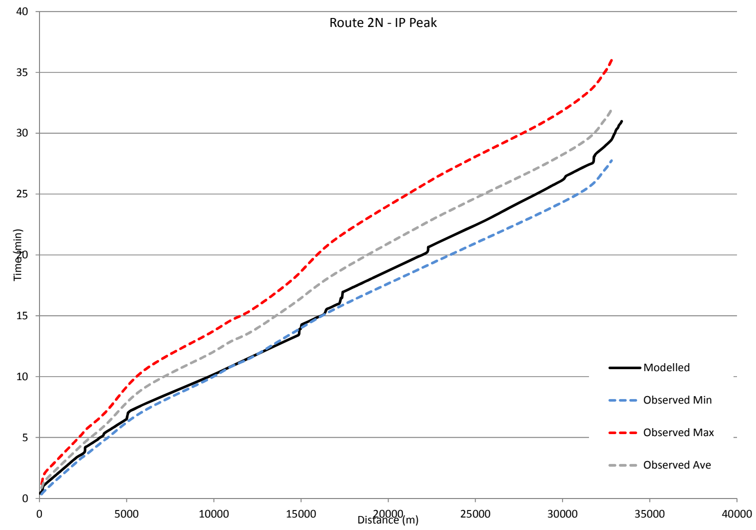


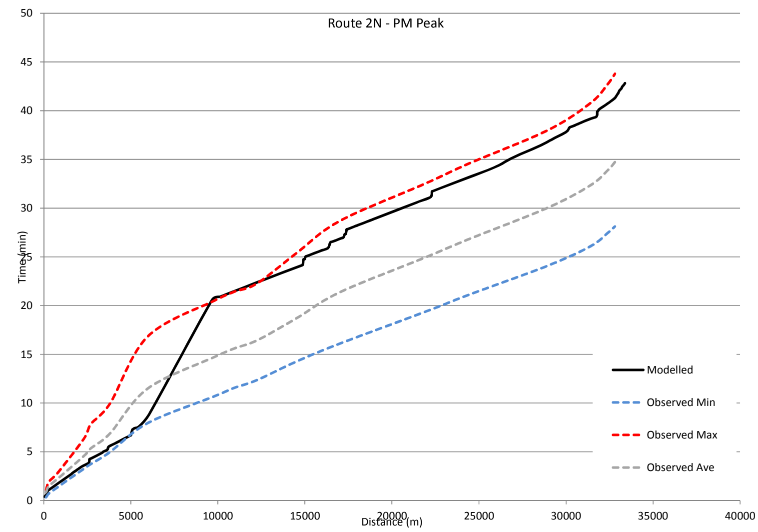

Route 1S - AM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

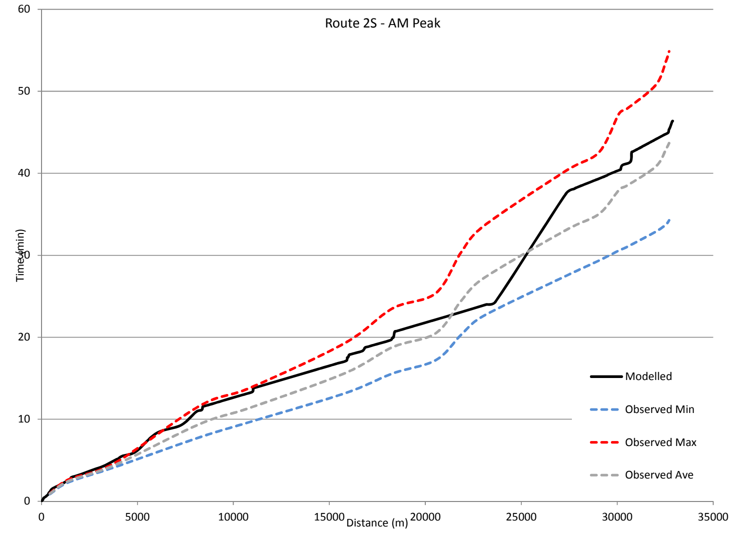

Route 1S - IP Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

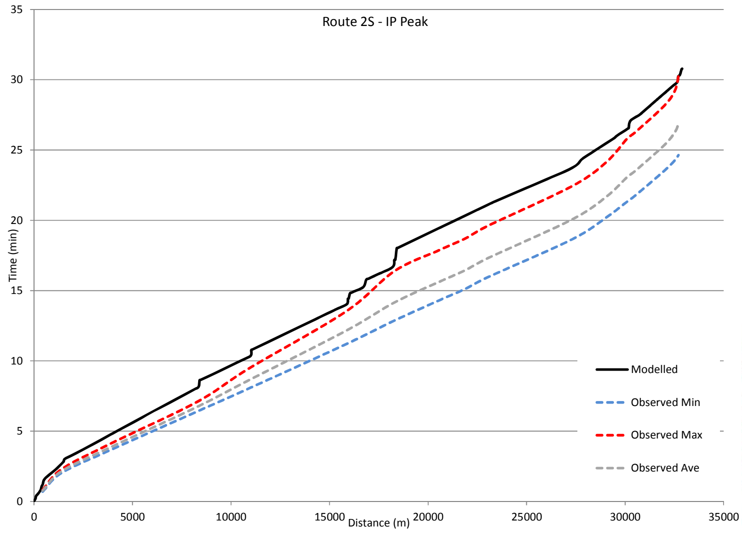

Route 1S - PM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

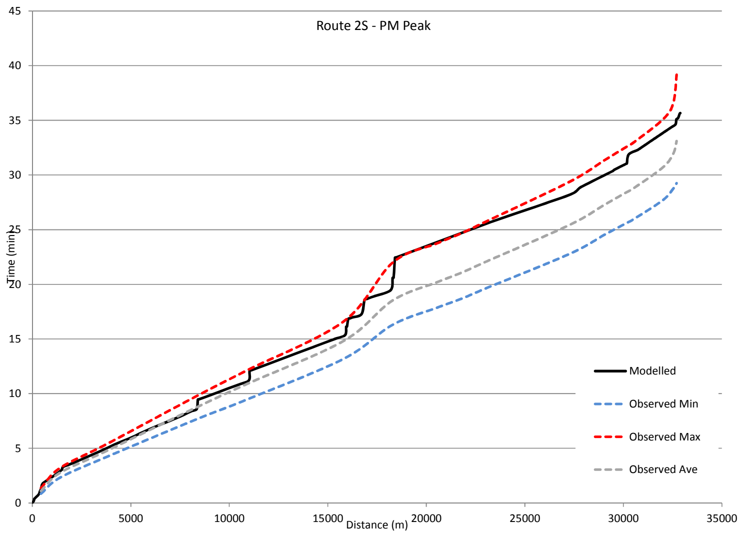

Route 2N - AM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

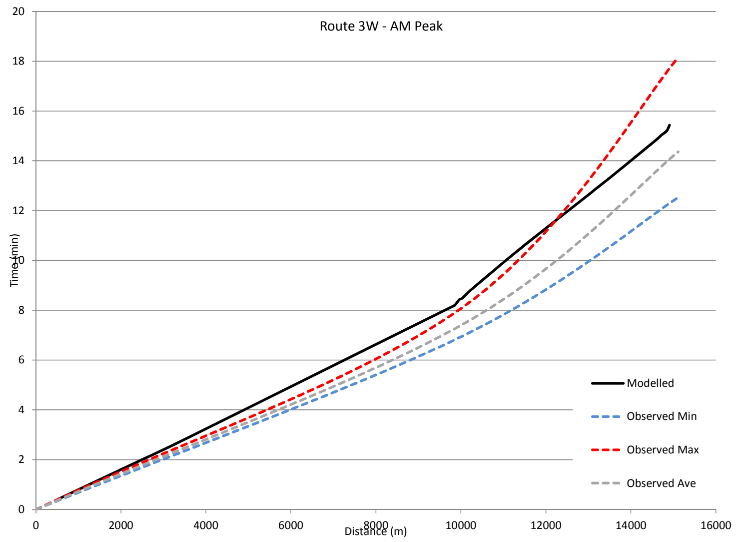

Route 2N - IP Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

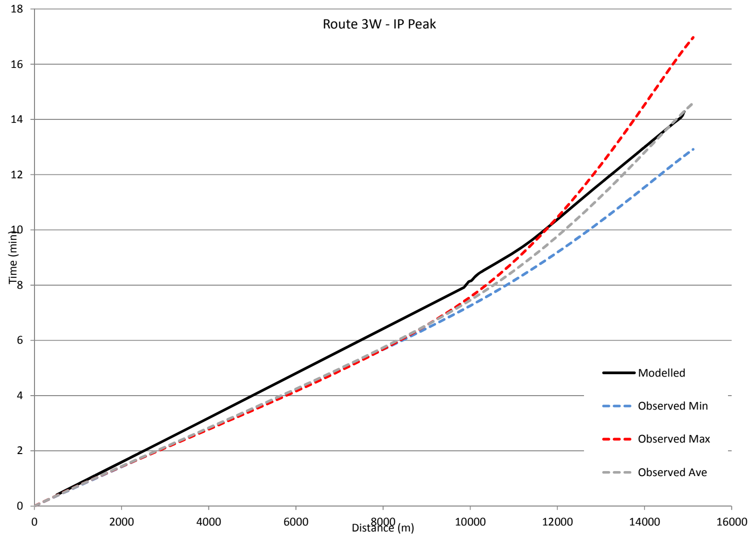

Route 2N - PM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

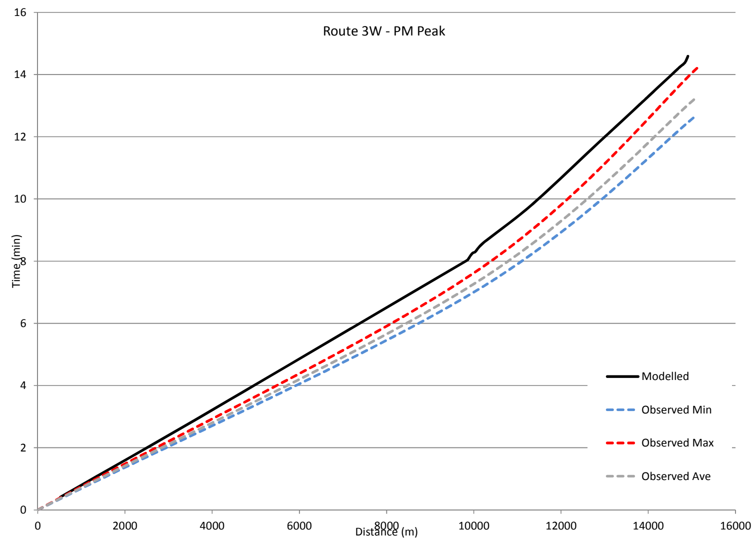

Route 2S - AM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

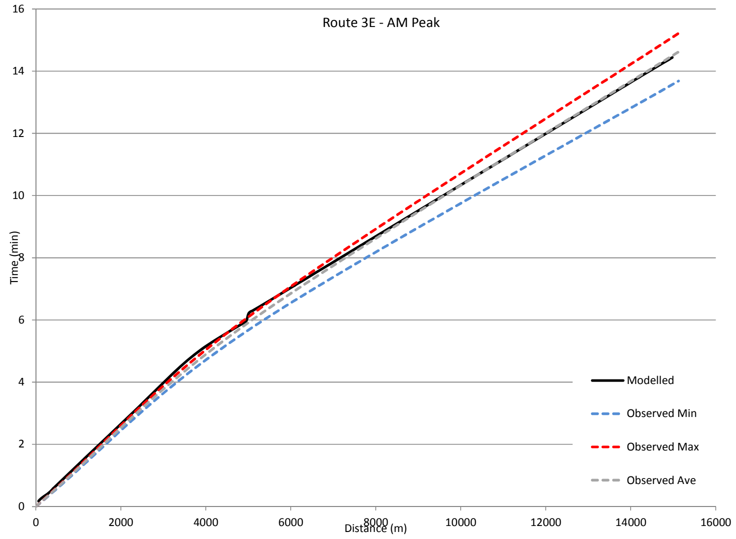

Route 2S - IP Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

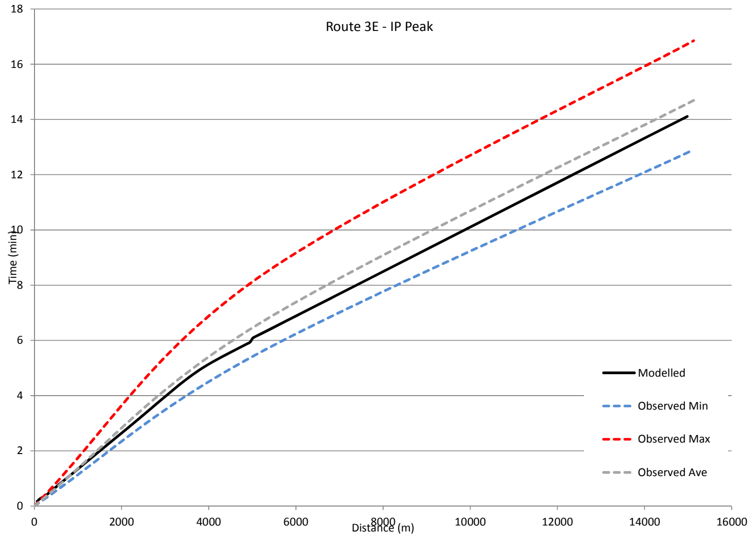

Route 2S - PM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

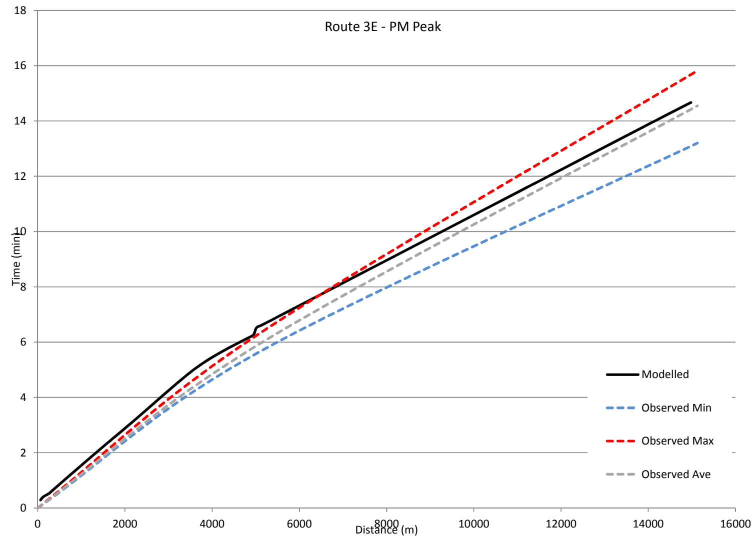

Route 3W - AM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave


Route 3W - IP Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave


Route 3W - PM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave


Route 3E - AM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave


Route 3E - IP Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave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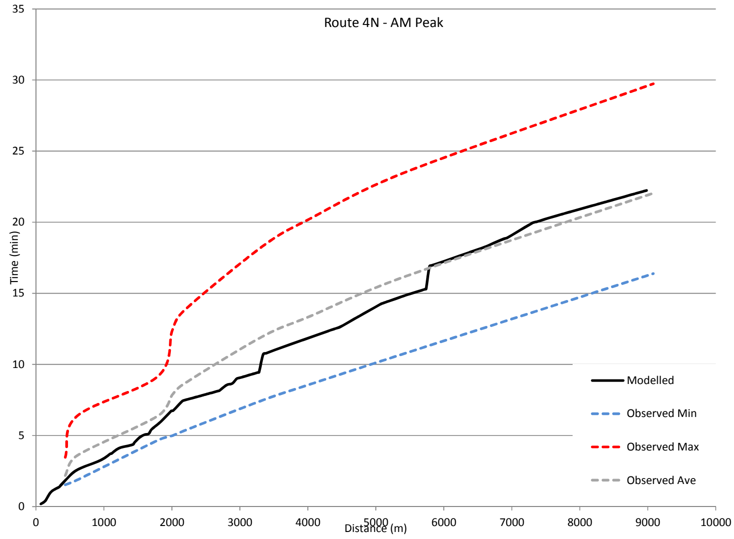
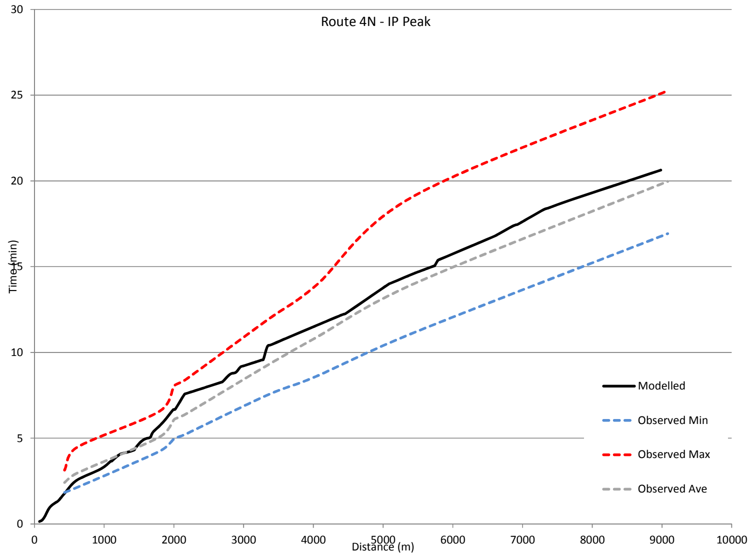
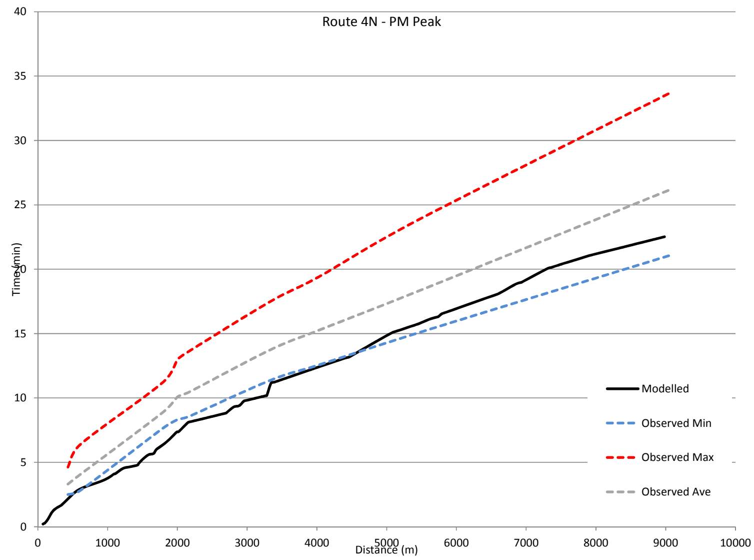
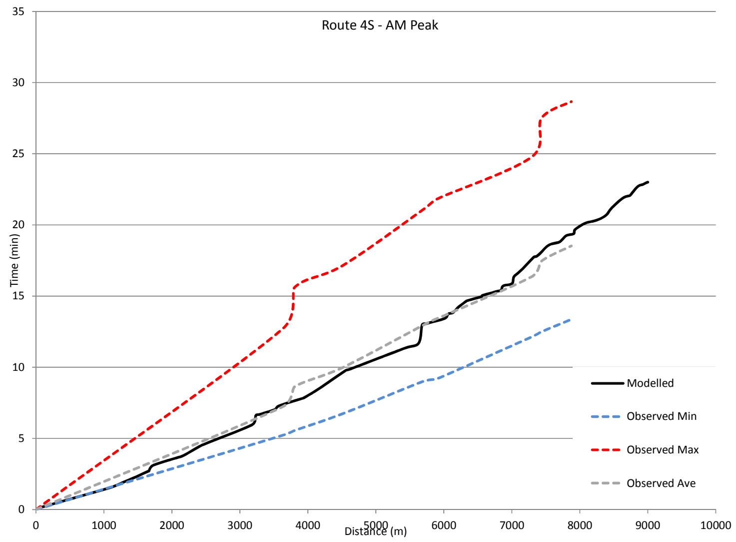
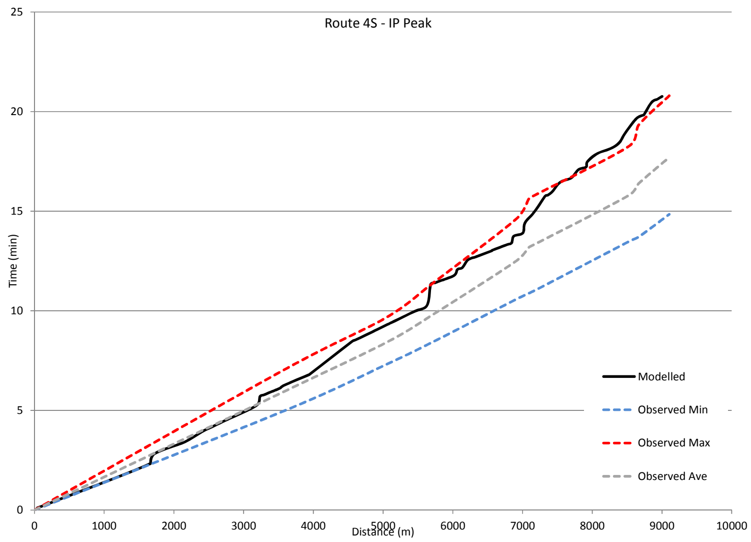
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

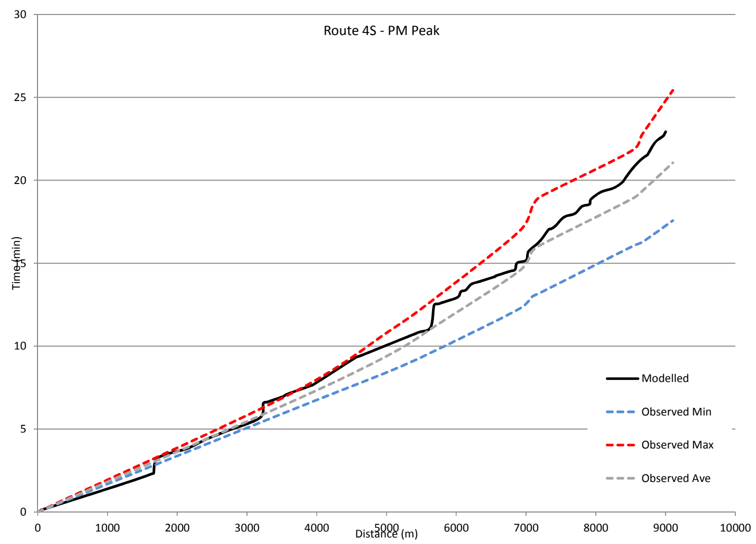

Route 4N - AM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

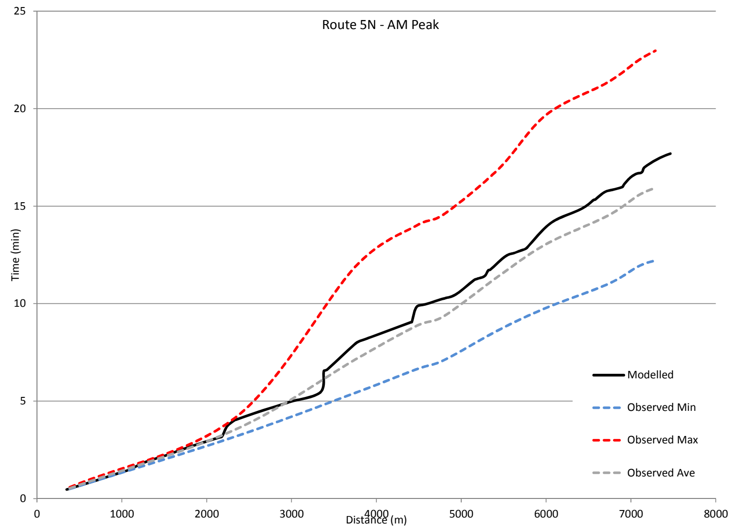

Route 4N - IP Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

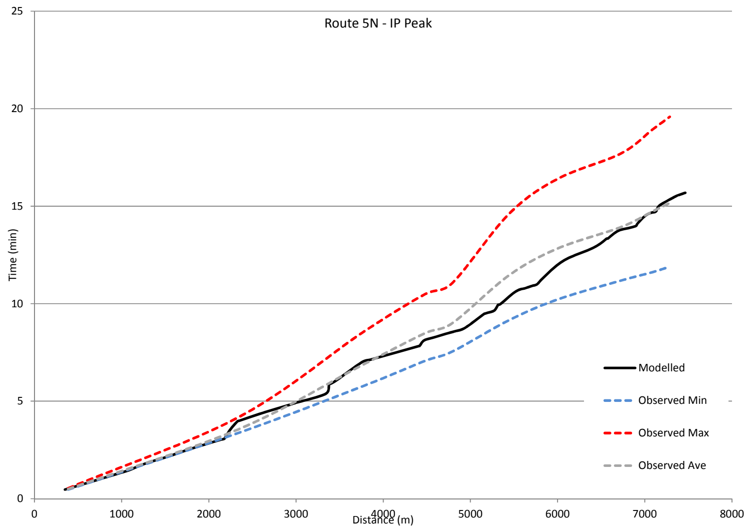

Route 4N - PM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

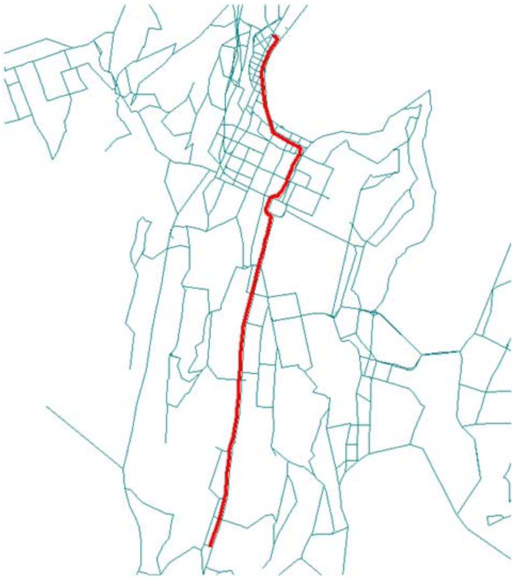

Route 4S - AM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

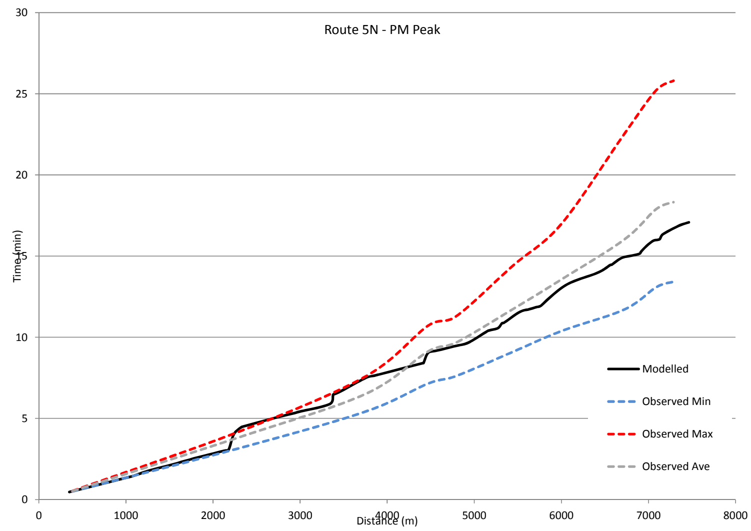

Route 4S - IP Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

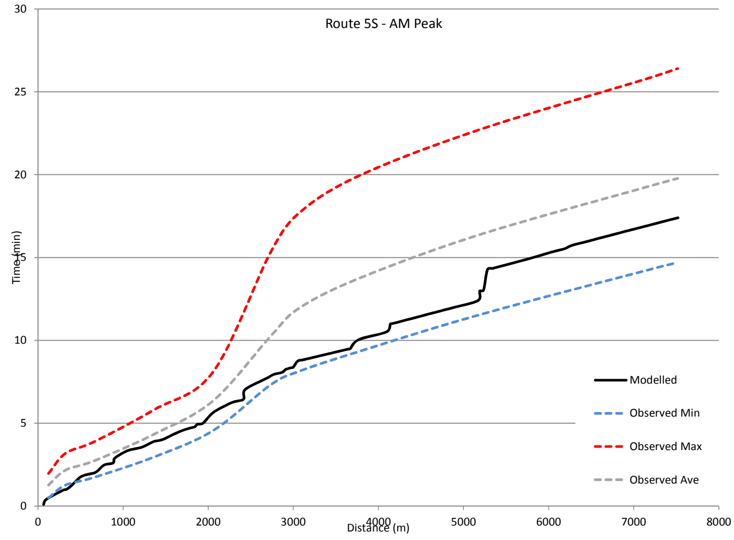

Route 4S - PM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

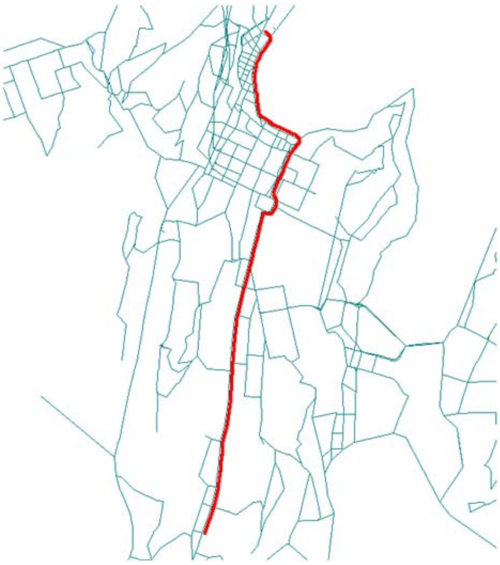

Route 5N - AM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

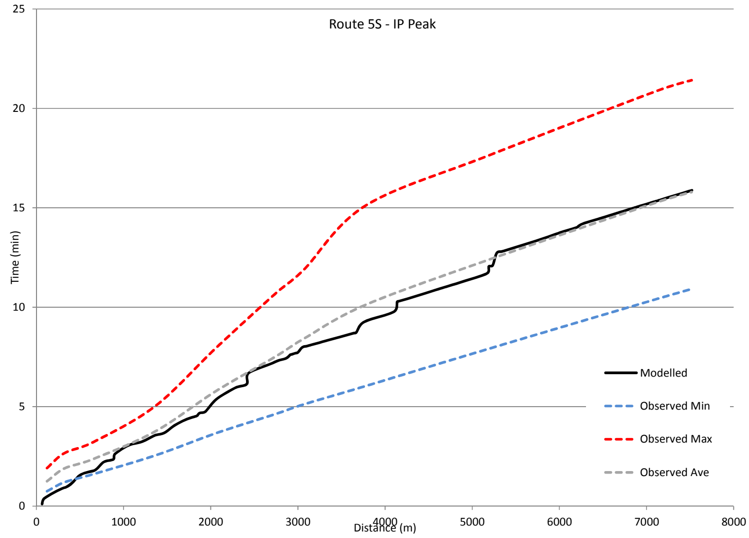

Route 5N - IP Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

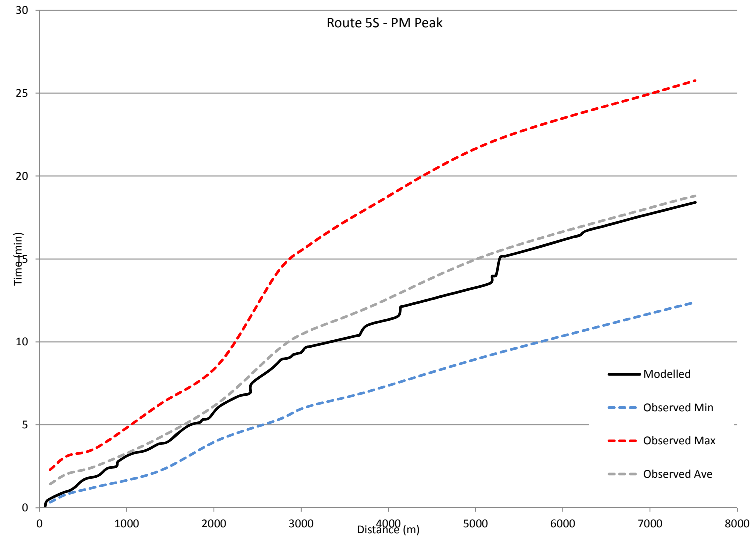



Route 5N - PM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave


Route 5S - AM Peak
Time (min)
Distance (m)
0
5
10
15
20
25
30
0
1000
2000
3000
4000
5000
6000
7000
8000
Modelled
Observed Min
Observed Max
Observed Ave




Route 5S - IP Peak
Time (min)
Distance (m)
0
5
10
15
20
25
0
1000
2000
3000
4000
5000
6000
7000
8000
Modelled
Observed Min
Observed Max
Observed Ave


Route 5S - PM Peak
Time (min)
Distance (m)
0
5
10
15
20
25
30
0
1000
2000
3000
4000
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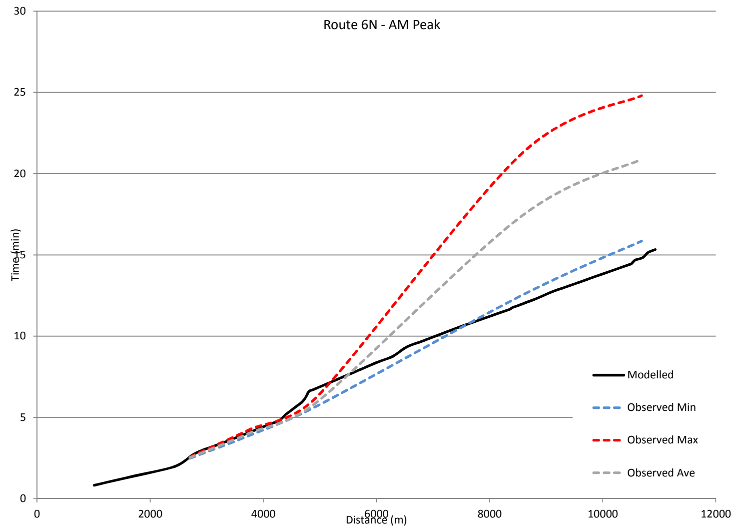
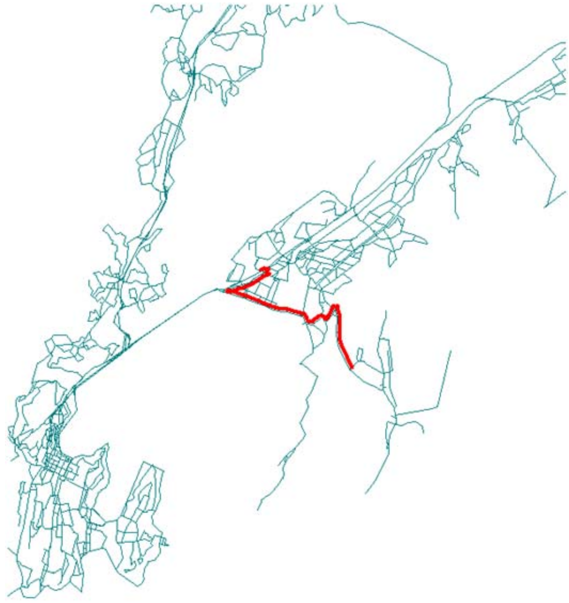
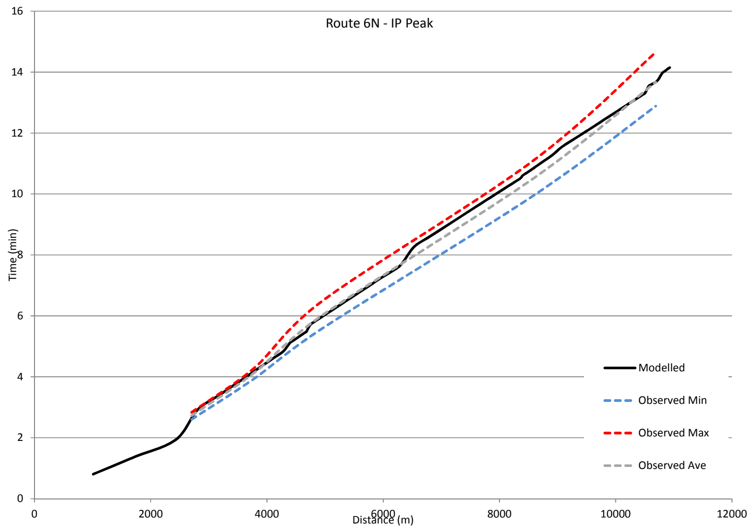
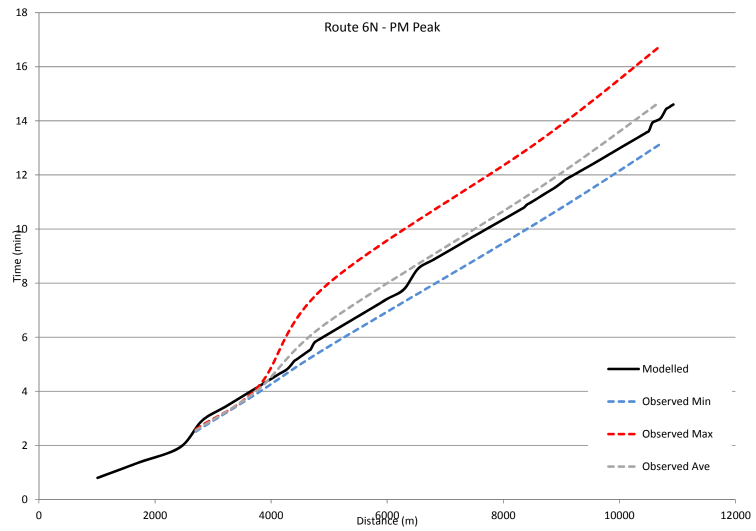
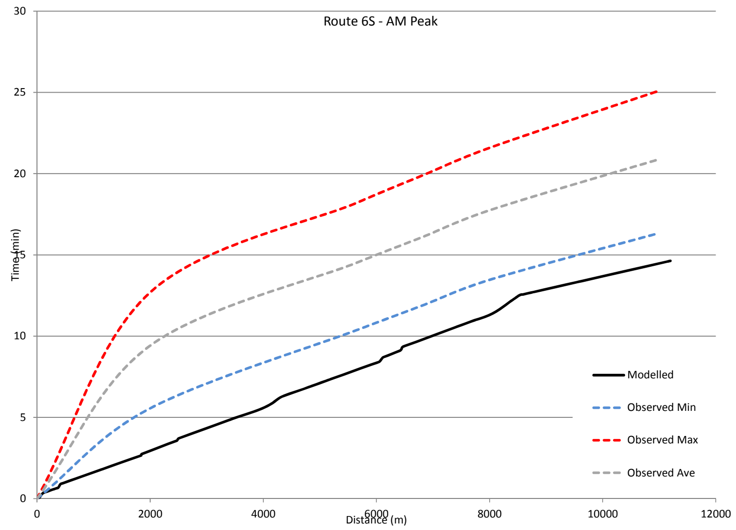
Observed Min
Observed Max
Observed Ave

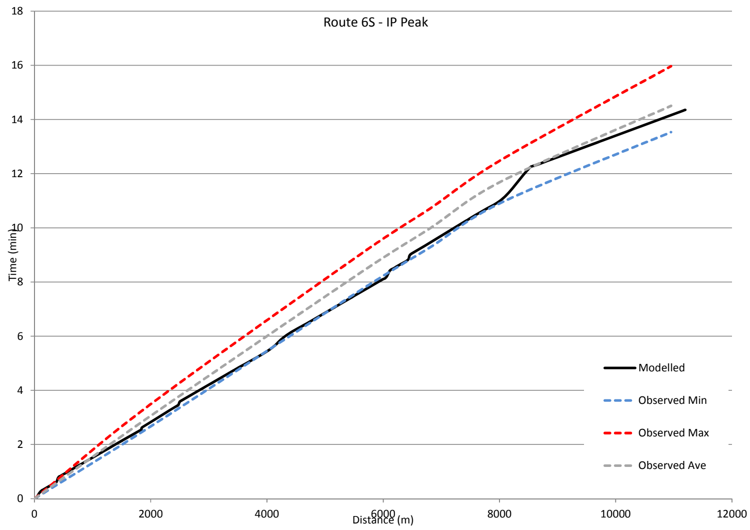

Route 6N - AM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave

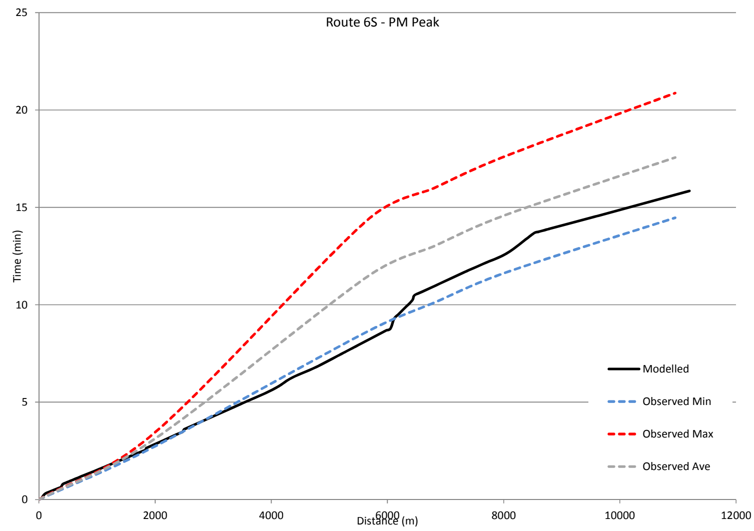


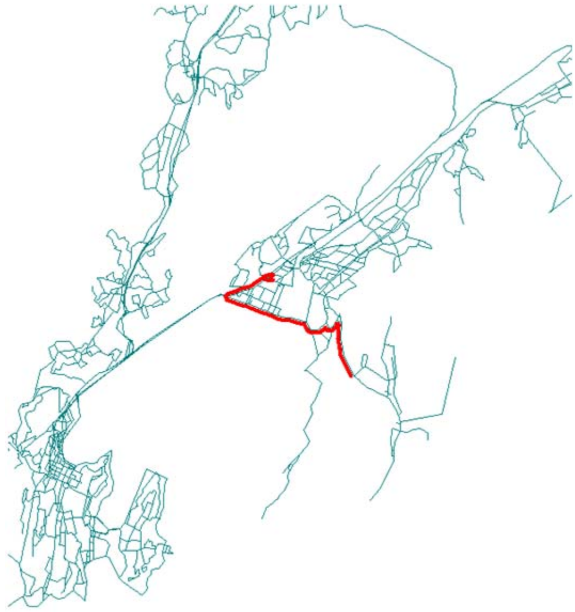

Route 6N - IP Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave


Route 6N - PM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave


Route 6S - AM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave


Route 6S - IP Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave


Route 6S - PM Peak
Time (min)
Distance (m)
Modelled
Observed Min
Observed Max
Observed Ave



Appendix B

ETM Data Processing

B.1 Context

As part of the WTSM 2013 validation, it was necessary to obtain information regarding bus patronage across a number of screenlines in the Wellington region. During the 2006 update of the model, there were some concerns about the ETM (Electronic Ticketing Machine) data used for the validation and the process used to mine it. For the 2011 update, abundant ETM data was available which had been collected for the development of the Wellington Public Transport Model (WPTM) but it was found that due to the nature of this data, it was very difficult to obtain volumes directly. As a result, bus patronage across screenlines was obtained by carrying out a "reference assignment", assigning the WPTM observed bus demand matrices on the bus-only network and extracting the resulting volumes. These volumes were therefore not directly "observed" but this was considered a reasonable approximation.

For this 2013 update, no full observed demand matrix was available for assignment. However Greater Wellington Regional Council regularly collects ETM data for Go Wellington and Valley Flyer services, which is stored on an in-house server and can be interrogated through an external connection in Excel. The interface is basically a pivot table with a numbers of fields available, including date, passenger counts, service boarded / alighted, ticket types, boarding / alightings stop, times and fare zone.

This ETM "data cube" was consequently used to process information about bus patronage on the network in the AM and inter peak periods. This analysis was done through a combination of simple Visual Basic script to export the data from Excel to a simple comma-separated value (csv) format, followed by a tool developed in Python to process the data and extract the relevant information.

The objective of this tool was to let the user specify a bus stop number and time period (AM or inter peak), and return the following information:

- Number of boardings / alightings at selected stop during selected time period. Results are shown for each bus service using this stop separately, as well as total;
- Number of passenger transiting through the selected stop (actually just upstream from the stop), which was a much more involved process. This was necessary to estimate total patronage through a stop and not just boardings and alightings at this stop, in order to derive total volumes across screenlines.

The adopted process is described below.

B.2 Methodology

1. Boarding and alighting data was extracted from the data cube pivot table for a period covering 4 weeks in March 2013, retaining weekdays only. This was done separately for the AM and inter peaks. A simple Visual Basic script was used to then convert this data into 4 csv files (1 for boardings and 1 for alightings, for each time period). Each csv file contains the following fields:
   - Services
   - Direction

- Stop number
- Trips (number of boardings or alightings) per stop

2. The Python script is called by the user, who specifies the requested time period and bus stop. The relevant boarding and alighting csv files are read into Python and formatted.

3. Boardings and alightings are recorded only for stored-value card users i.e. Snapper card. For people paying by cash (which represent less than 10% of all boardings), only the boarding stop is recorded. To account for this, alightings on each route are factored up so that the total alightings match total boardings. This is done on a pro-rata basis of recorded boardings, thereby assuming that the missing data follows the same pattern, which was considered a reasonable assumption.

4. Services (including direction) that use the selected bus stop are identified.

5. Boardings / alightings at the selected stop are calculated for each service identified in step 4.

The next steps determine patronage through a stop. For this purpose, additional data from the General Transit Feed Specification (GTFS) had to be used as a complement to obtain information on the position of the selected stop along a route, which is not included in the ETM data.

6. Using the GTFS, information for all trips is read and formatted. A trip is an instance of a scheduled vehicle for a given service (for example the service 001 starting at 07:35 is a trip). Services also have sub-variants, so two trips for the same service can start or end at different points. Only relevant fields are kept (service, direction, stop, stop_index).

7. An index of all stops on each trip, for each service is built, showing the order in which they occur.

8. For all sub-variants of services that use the selected stop, a list of all stops that are upstream from it is built. These are then aggregated into a single list containing all stops on the network that are serviced by the same services as the selected stop, and are located upstream.

9. All boardings and alightings on the stops identified in step 8 are calculated for each service. The difference between the two is calculated and represents the volume of passengers transiting directly upstream from the selected bus stop.

10. All boardings / alightings and volume transiting through calculated at step 5 and 9 are divided by the number of weekdays included in the dataset to obtain the average March 2013 daily figure which is written in an output text file.

B.3 Comments

The tool was checked against the CBD cordon survey carried out in March 2013, which counted bus passengers heading into the CBD during the 7:00-9:00am period. This analysis showed that using the same 7:00-9:00am filter for boarding times led to lower volumes than surveyed. This is due to the actual travel time between the time people board their services and the time they cross the CBD cordon. Different time periods were tested and suitable results were obtained using the 6:30-8:30am period.

Other discrepancies were found, which included some services being coded in opposite direction in the GTFS and in the ETM data. These were easily identified using the CBD cordon counts and a list of services to reverse was included in the script.

Another issue was the fact that the tool described here can only estimate patronage through a stop for services which actually use it. Express services or the Airport Flyer, which pass in front of but don't actually use a number of stops are therefore not counted. To account for these services, they were first identified by checking on the WTSM network which services pass through a bus stop but don't stop there, then volumes were calculated for the next stop they actually use. For example, to obtain volumes on service 91 (Airport Flyer) at Elizabeth St where it does not stop, volumes upstream from the stop at Courtenay place were used. This introduces some manual processing but applies only to a limited number of services. Solving this issue can be investigated in a final version of this tool.

The resulting comparison is shown in the following table. Results are not expected to be a perfect match since the CBD cordon is just a one-day snapshot and is a manual survey, therefore introducing some margin of error, whereas the ETM data shows a typical weekday averaged over 20 days. For this reason, the CBD cordon count for 2012 has also been included for comparison and to highlight natural variability.

Due to the highly sensitive nature of ETM data in terms of confidentiality, numbers have been removed and only high-level statistic results are shown.

Stop and Route	2012 Cordon	2013 Cordon	*2012-2013 Diff*	2013 ETM	*2013 Cordon-ETM Diff*
4113 - Murphy Street			***14%***		***-13%***
14			*19%*		*-1%*
80			*0%*		*-32%*
81			*38%*		*-18%*
84			*-9%*		*-8%*
85			*9%*		*-16%*
90			*-15%*		*25%*
91			*10%*		*-25%*
4312 - Tinakori Road			***16%***		***-22%***
3			*13%*		*-28%*
13			*-1%*		*-3%*
21			*52%*		*-16%*
4915 - Kelburn Parade			***2%***		***0%***
17			*61%*		*-16%*

Stop and Route	2012 Cordon	2013 Cordon	*2012-2013 Diff*	2013 ETM	*2013 Cordon-ETM Diff*
18			*17%*		*-15%*
20			*153%*		*-11%*
22			*-79%*		*155%*
23			*-91%*		*525%*
47			*-61%*		*86%*
5492 - Thorndon Quay			***-20%***		***23%***
43			*24%*		*-14%*
44			*-10%*		*30%*
45			*-63%*		*69%*
46			*21%*		*-3%*
83			*-23%*		*51%*
5516 - Hawker Street					***-10%***
20					*-10%*
7013 - Cambridge Terrace			***5%***		***-8%***
1			*47%*		*-7%*
3			*-7%*		*13%*
4			*10%*		*-14%*
22			*-5%*		*-13%*
23			*6%*		*-39%*
32			*2%*		*-8%*
44			*-33%*		*23%*
7212 - Elizabeth Street			***4%***		***12%***
2			*22%*		*6%*
5			*-15%*		*23%*
6			*-33%*		*23%*
24			*-10%*		*98%*
25			*37%*		*-20%*
30			*-32%*		*51%*
31			*38%*		*2%*
91			*56%*		*-15%*
7514 - Oriental Parade			***-12%***		***5%***
14			*-18%*		*-11%*
24			*-2%*		*30%*
7711 - Willis Street			***2%***		***-4%***
7			*-8%*		*0%*

Stop and Route	2012 Cordon	2013 Cordon	*2012-2013 Diff*	2013 ETM	*2013 Cordon-ETM Diff*
8			*64%*		*-20%*
9			*-31%*		*16%*
7913 - Taranaki Street			***-14%***		***-4%***
10			*-25%*		*11%*
11			*-5%*		*15%*
18			*-14%*		*0%*
21			*-22%*		*-63%*
47			*100%*		*25%*

Table B1: Modelled vs Observed Bus Patronage

The comparison show that the ETM data, processed following the methodology describes in this note provides an accurate representation of passenger volumes on the bus network. This tool was therefore used to produce the bus volumes for the validation of WTSM 2013, with results divided by 1.08 to adjust for March being higher than average (figure obtained from ETM).

Appendix C

RTI Data Processing

C.1 Context

As part of the 2013 validation of WTSM, information regarding bus travel times on the network was needed to compare with modelled travel times. For this purpose, a dataset containing real-time information (RTI) of journey times for all services was obtained for a full March 2013 working week (10^{th} to 15^{th}).

This data was then exported using a simple Visual Basic script to convert it from Excel into a text format, and then processed through a Python-based tool developed for this application. The methodology followed is described in this note.

C.2 Methodology

1. Due to limitation with the software used to store the RTI database, the data had to be saved in a number of different Excel files. A Visual Basic script was used to extract the relevant data and save it as a comma-separated value (csv) file for each Excel file. The resulting csv files were then combined in a single csv RTI dataset, containing the following information:
   - Service
   - Direction
   - Start time
   - Stop index
   - Stop name
   - Actual run time
   - Dwell time
   - Schedule deviation

   All times are cumulative, i.e. they don't show the actual time between each stop but the time elapsed from the beginning of the trip to each stop.

2. The Python script is called by the user, who specifies the requested bus service (including direction) and time period. The csv file is read and formatted.

3. For each stop of each trip, the previous stop is identified and a new "segment" field is added, which is as follows: *"previous stop"_"current stop".* Here a trip is defined as a scheduled vehicle for a given service, for example the bus on service 001 starting at 07:35 is a trip.

4. For each segment of each trip, non-cumulative times are calculated, i.e. time between the previous stop and current stop only. This includes scheduled and actual times, both with and without dwell time.

5. The segments related to the selected services and time are identified and retained.

6. Identical segments are aggregated (for example all segments between stops 10308 and 10309 for services 1 inbound during the AM peak) and time scheduled, average, maximum, minimum, and standard deviation are calculated.

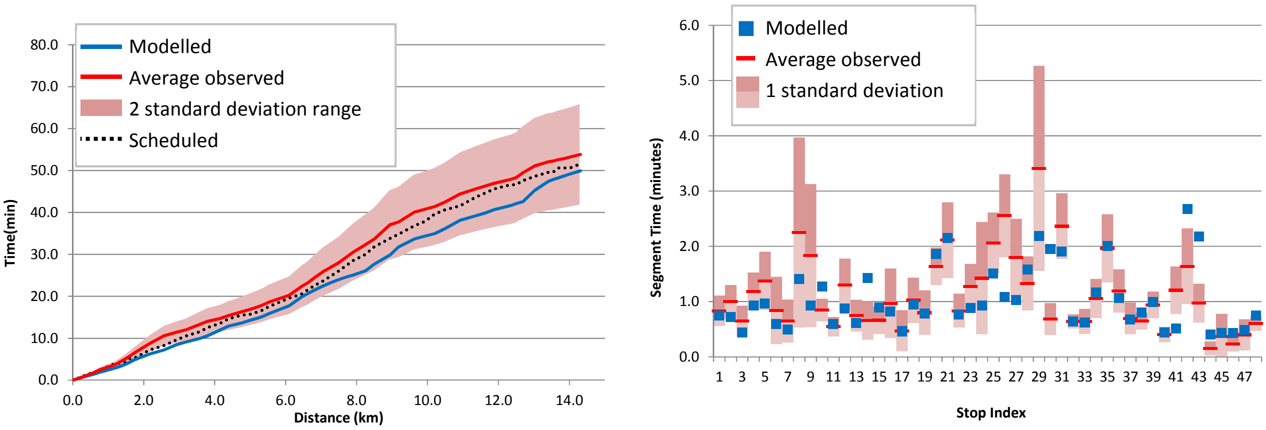
7. Most services on the Wellington network have a few sub-variants, which makes comparing travel times difficult. To address this issue, a list of all variations of the selected service is built, and the main route is identified i.e. the one that has the most occurrences.

8. All segment times calculated in step 6 are returned for each segment in the main route of the selected service, cumulated times along the route are calculated.

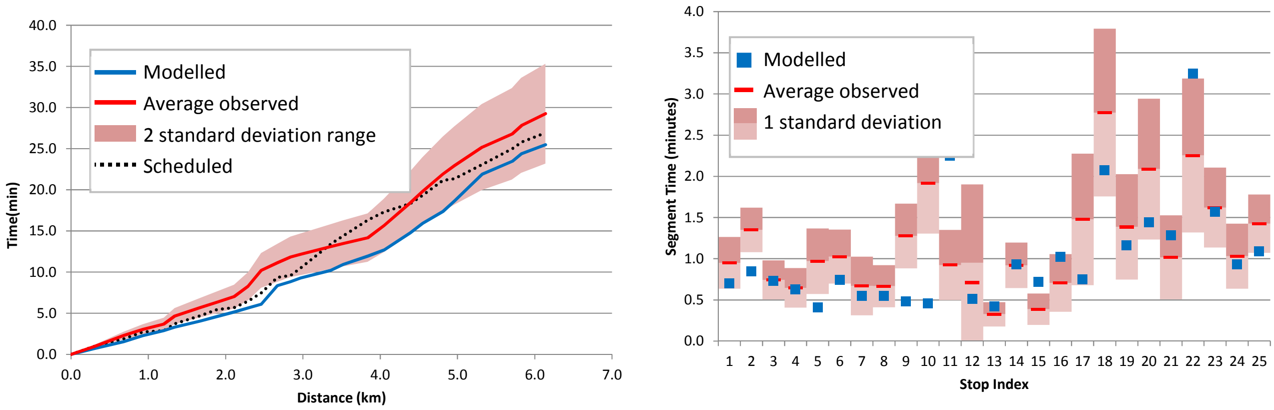
9. Results are output in a text file containing the various times calculated (schedule, average, minimum, maximum, standard deviation, with and without dwell time, per segment or cumulative) which can then be analysed further or plotted in Excel.

C.3 Examples

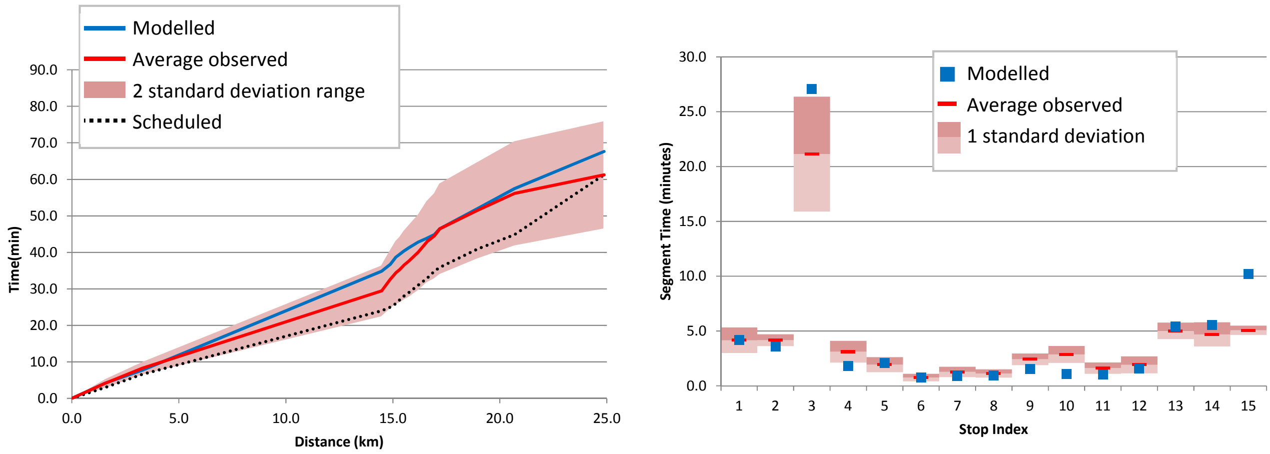
Output from this tool was therefore used to produce the average and standard deviation travel times for the WTSM validation. A number of other analyses can be carried out, including examining more detailed results per segment (see figures below), travel time variability, impact of dwell time depending on time period, etc.



Route 3 Example – Modelled vs Observed Travel Time – AM Peak Inbound



Route 7 Example – Modelled vs Observed Travel Time – AM Peak Inbound



Route 91 Example – Modelled vs Observed Travel Time – AM Peak Inbound