Waikato Regional Transport Model

2013 Model Update Final Report

Report

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Waikato Regional Transport Model

2013 Model Update Final Report

Final Report

Quality Assurance Statement

Prepared by:

Grant Smith
Principal Consultant

Reviewed by:

Julie Ballantyne

Director

Approved for Issue by:

Julie Ballantyne
Director

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PO Box 8615, Riccarton, Christchurch 8440
New Zealand

P: +64 3 348 3215

www.tdg.co.nz

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1. Project Overview

1.1 Objectives of the Update

It is good practice to revalidate strategic transportation models every five years to correspond with the national Census. The connection with Census is critical as the land use input to the model is derived from Census. The 2011 census was delayed until 2013 because of the Christchurch Earthquake of 2011, and accordingly, the planned WRTM update was also delayed.

Thus the objective of the update was:

> *To re-calibrate and re-validate the WRTM to a base year of 2013, so that it would meet the requirements of the client group of Councils and NZTA for the next 10 years.*

1.2 The WRTM Model Framework

The WRTM framework includes:

- Morning peak (7:00am - 9:00am) three step (i.e. vehicle driver only) model;
- Interpeak (11:00am - 1:00pm) three step (i.e. vehicle driver only) model;
- Evening peak (4:00pm - 6:00pm) three step (i.e. vehicle driver only) model;
- Morning peak (7:00am - 9:00am) four step (i.e. includes vehicle driver, vehicle passenger, public transport and active modes) model;
- Interpeak (11:00am - 1:00pm) four step (i.e. includes vehicle driver, vehicle passenger, public transport and active modes) model.

A four step model estimates demand in units of "persons" and includes trip generation, trip distribution, modal split, and assignment stages. A three step model estimates demand in units of vehicles (i.e. light and heavy vehicles) and includes trip generation for vehicles (or vehicle drivers), trip distribution, and assignment. The four step model therefore includes people travelling on buses, vehicle passengers, and walking and cycling.

The scope of the 2013 update was discussed in a client group workshop in May 2013, and the outcomes were:

- A strong desire for the zones in the model to be refined, which has implications for the model equations;
- That implementing the parking model was not required at this time due to budget constraints; and
- That freight was a key area of interest for transportation planning and so potential model improvements relating to freight should be scoped.

1.3 Tasks in the update

The tasks involved in the update included:

- Task 1: Refine Model Zones from 999 to 2500
- Task 2: Incorporate ability of the model to respond to the price of Fuel
- Task 3: Recalibrate Model Equations (2006)
- Task 4: Assemble 2006 Validation Data
- Task 5: Check 2006 Validation – Light and Heavy Vehicles
- Task 6: Collate 2013 Validation Data
- Task 7: Create 2013 Model Inputs
- Task 8: 2013 Model Validation – Light and Heavy Vehicles
- Task 9: Forecasting (Three Step Model Only)

Essentially, the process followed in the update was to rezone the model from 999 zones to 2500 zones, recalibrate the model parameters and equations from the 2008 survey data using the 2006 model as the calibration and validation base, and then apply the recalibrated model using 2013 census land use data.

In effect 2013 can be considered as a 'future' year, but one where the 'future' land use activity and traffic flows are known and which can be checked. The ability of the model to replicate these flows gives a high degree of confidence that the model can be used for long term forecasting in 2021, 2031, 2041 and 2051.

1.4 Supporting Technical Notes

The documentation of the WRTM model build and validation process has been presented as a series of technical notes, with this brief overview report to link the technical notes together. Updated technical notes will be produced as required to develop a comprehensive suite of model documentation. These notes continue the sequence that was used in the 2008 model build. The notes are:

- Technical Note 26: Trip Attraction Model. This note describes the recalibration and validation of the Trip attraction models for both the 3-step and 4-step models as these are geographically dependent. The opportunity was taken to redefine the purposes during this task. The generation model was not changed as the trip rates are not dependent on the zone structure;
- Technical Note 27: Trip Distribution (3 step) Model. This note describes the calibration and validation of the three step distribution model, including the implementation of a cost based distribution function that incorporates fuel cost;
- Technical note 28: Model validation – 3 step Model at 2006. This note documents the performance of the 2006 model after assignment to the road network, including a comparison against traffic counts and journey times;
- Technical Note 29: Mode Split Model. This note describes the calibration and validation of the multinomial logit mode split model;

- Technical Note 30: Model Validation – 3 step Model at 2013. This note documents the performance of the 2013 model after assignment to the road network, including a comparison against 2013 traffic counts and 2014 journey times;
- Technical Note 31: Future Land Use Variables. This is a short note to document the variables to be included in the future land use files;
- Technical Note 32: Do-minimum Road Works. This note documents the do-minimum roading works to be included in the future WRTM models;
- Technical Note 33: Trip Distribution (4-step) Model. This note describes the calibration and validation of the three step distribution model;
- Technical Note 34: Model Validation – 4 step Model at 2006. This note documents the performance of the 2006 model after assignment to the road network, including a comparison of the vehicle driver matrix against the 3-step model vehicle drivers;
- Technical Note 35: Model Validation – 4 step Model at 2013. This note documents the performance of the 2013 model after assignment to the road network, including a comparison of the vehicle driver matrix against the 3-step model vehicle drivers; and
- Technical Note 36: Long Term Forecasts. This note will describe the land use forecasts for 2021, 2031, 2041 and 2051, including an analysis of deficiencies in the network if no further infrastructure is included.

1.5 Model context

During the course of the update, NZTA published guidelines for transportation modelling[1] which superseded the targets previously contained in the EEM, although the criteria are very similar in both documents.

Perhaps of more importance is that the guidelines include a table of different types of model, and the appropriateness of the applications of those models. In this case, the WRTM has been assessed as a model type "A", which is a regional transport model (3 or 4 step model). However, it performs better than that and Figure x is a modified version of the Table in the guidelines that is customised for WRTM.

PROJECT APPLICATION	WRTM CURRENT PERFORMANCE AGAINST NZTA MODEL CATEGORY						
	A: Regional transport model (3 or 4 stage)	B: Strategic Network	C: Urban Area	D: NZTA Large Project	E: Small area / Corridor	F: Intersection	G: High Flow, Speed, Multi-lane
Area demand responses, Land Use / Transport Planning, Policy Investigations	S	S	S	P(1)	U	U	U
Larger transport scheme feasibility Economics	S	S	S	P(1)	P(4)	P(4)	U
Local Authority transport intervention and land use planning	S	S	S	P(1)	P(4)	P(4)	U
Option testing, design refinement, economics	P(1)	P(1)	P(1)	P(2)	P(2)	P(4)	U
Development forecasting and / or impacts	P(1)	P(1)	P(1)	P(2)	P(2)	P(4)	U
Detailed design and traffic management	U	U	U	U	P(3)	P(4)	P(3)
ITS, incident management, active mode design and impact	U	U	U	U	P(3)	P(4)	P(3)

S = Generally Suitable P = Partially Suitable U = Generally Unsuitable

Notes:
(1): Suitable with local area validation at link level
(2): Suitable with local area validation at turning movement level
(3): Suitable to provide demands to a windowed project model with matrix estimation at turning movement level to form an operational model (non-forecasting) or to a windowed micro-sim model.
(4): Suitable with local area validation to provide demands to a stand-alone intersection model
(5): Where application of operation models results in changes to the network these should be iterated back to WRTM

[1] 'Transport model Development Guidelines' NZTA 2014

2. Model Overview

The model form is essentially the same as that used for the original model build. The major exception is the way in which the mode split is performed as discussed below.

There are two models – a vehicle driver model with light and heavy vehicles assigned separately, and a person model including a mode split step that produced:

- Car driver
- Car passenger
- Bus passenger
- Active modes (walk/cycle)

The Heavy Goods Vehicle and External Models applied to the person model were the same as in the vehicle driver model.

Both models were built for a morning peak two hours (7:00am - 9:00am) and an inter peak model. The three step model represents an average 2hours of the 0900 hrs to 1600 hrs period. The four step model needed a specific two hour period (1100 hrs to 1300 hrs) because of the specific routes and timetables in that period.

The vehicle driver model also included an evening peak (4:00pm - 6:00pm). They were developed to represent the traffic conditions of an average weekday in March 2006.

The model has 2500 zones, with 21 external zones and 576 spares available for later use in the future models and any option testing scenarios.

The geographic area covered by the model is shown on **Figure 1** and extends from north of Pukekohe in the north, to Taupo in the south, and includes Rotorua and Tauranga to the east. The 2006 model was extended in 2012 to take in the old Franklin District, and there is now considerable overlap with the Auckland Art 3 model.

Figure 2 shows the more detailed area of Hamilton, Cambridge and Te Awamutu. All roads have been included in the area shown in Figure 2, and in other urban areas except for Tauranga, Rotorua and Taupo. In these areas and the balance of the region, arterial and collector roads have been included. This means that volumes, and volume forecasts, will be available for all of these roads with potential use in RAMM databases. All road centrelines and the base network attribute coding have been derived from the Waikato Regional Council GIS system.

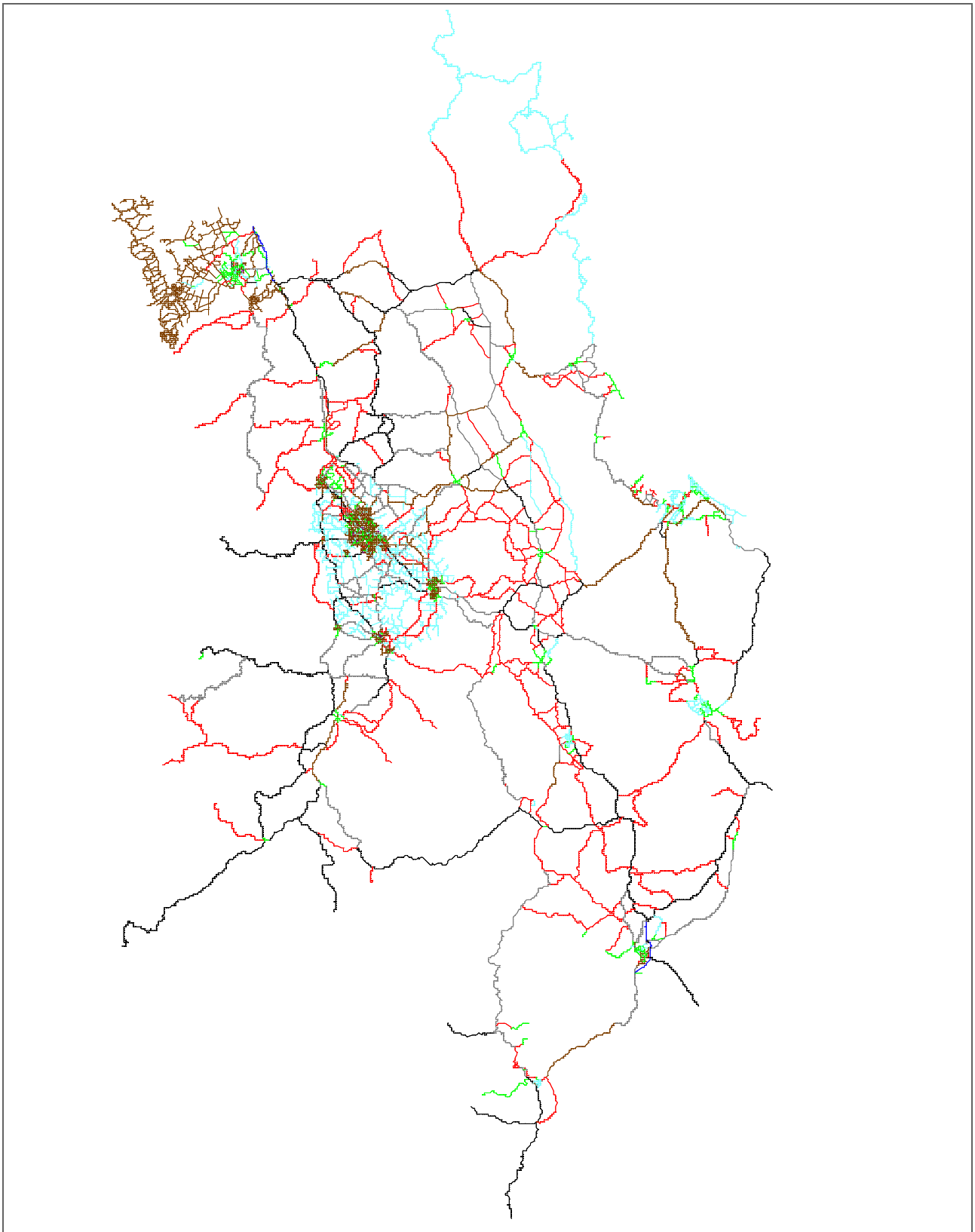
The network covers an area some 300 kilometres from north to south and about 180 kilometres east to west. It contains 27,830 links, and 9,641 intersections.

The vehicle driver model is commonly referred to as a three-step model, with components:

- Generation
- Distribution and
- Road Assignment

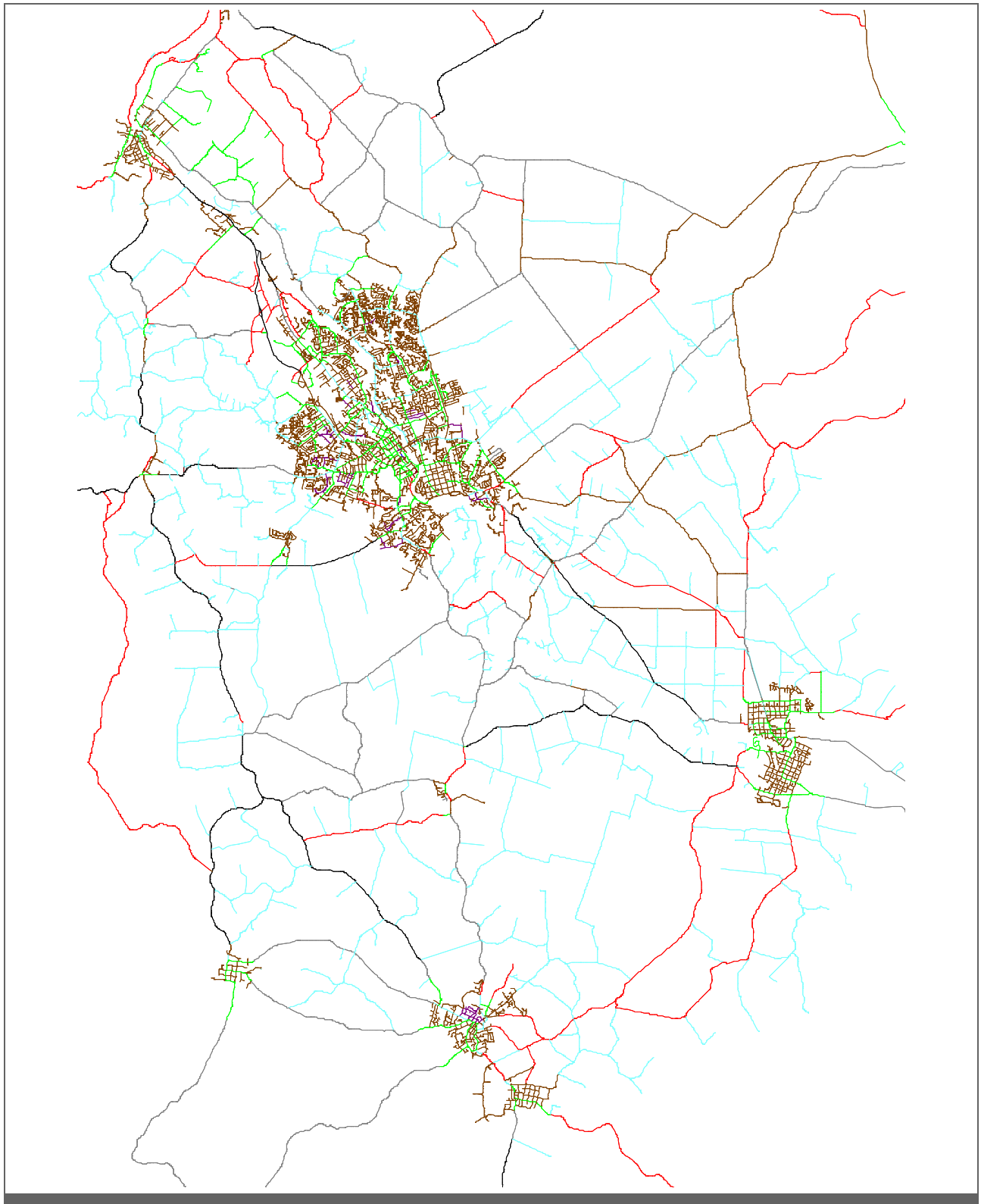
The person trip model adds a mode choice stage, and is commonly referred to as a four-step model. Its components are:

- Generation
- Distribution
- Mode Split
- Road and Public Transport Assignments



WRTM Update
Geographic Coverage

1



WRTM Update
Detail of Hamilton, Cambridge and Te Awamutu

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3. Key Data Sources

3.1 Travel Surveys

One of the key strengths of the model is the data on which it is based. In this project, two major data collection exercises were undertaken to build the original model – namely a Household Interview Survey (HIS) from which to calibrate the generation, distribution and mode split step of the models, and a Roadside Interview Survey (RSI) to calibrate the external components of the model, enable checking and adjustment of any under-reporting of the household interview survey, and to assist with validation.

In addition to these two major surveys, there was also a Bus Passenger Intercept Survey and a series of journey time surveys.

The specification for the data collection contracts was contained in the 'Survey Specification Report' drafted in January 2008 and finalised in June 2008. There are also survey reports for each of the specific surveys.

In summary, however, the HIS covered just over 2000 households, of which 1000 were in the Greater Hamilton area, and the balance were in the wider region. The sample achieved was a little under 1.4% over the region. It included some 20,000 daily person trips representing an expanded total of a little over two million trips per day. Data was collected for both weekday and Saturday travel, although the Saturday data has not yet been analysed. While this data is now getting a little old it is still the latest available until the next HIS is carried out but also with being specific to a single day, rather than an average weekday, it is likely that it will be better than the weekday data already used.

The Roadside Interview Surveys covered 18 sites in one direction only, inbound into the Region. These sites were supplemented by surveys that had been carried out by the Auckland Regional Council for the ART3 model build, and by Tauranga City Council for the Tauranga model build.

No additional household travel surveys were carried out for the 2013 update. It is best practice to update the survey data that informs models like the WRTM every 10-15 years. Therefore new surveys should be scoped as part of the next anticipated model update in 2018.

3.2 2006 Observed Data

3.2.1 Traffic Counts

The traffic counts used in the Update validation at 2006 were the same as those used in the original model build. Although there was interest in separate reporting of Light and Heavy vehicle validation reporting, the historic count data did not support that level of analysis. Accordingly, only 'all vehicle' validation has been reported in Technical Note 28, and discussed further below.

3.2.2 Travel Times

Between the 3rd and 30th March 2009, 11 regional and six urban travel time routes where surveyed. The results were incorporated into the Waikato Regional Transport Model to validate travel times in the morning peak, inter peak and evening peak periods. The locations of the regional routes were presented originally in Technical Note 12, and are repeated in Technical Note 28.

A summary of the model versus survey travel times for the WRTM update is included as an appendix tables in Technical Note 28. These tables detail the surveyed mean, maximum, minimum and standard deviations for each route within the Hamilton Urban Area and the Waikato Regional Area. The also detail the percentage difference and absolute difference between the modelled journey times and the surveyed average journey times.

3.3 2013 Observed Data

3.3.1 Traffic Counts

Traffic counts were obtained for 2013, and where possible have been grouped into the same screenlines as were used in 2006. Note that in many cases the screenlines cannot be compared directly with the 2006 screenlines because of sites being in different locations, or excluded for reasons of count availability, data quality, or due to significant changes in the network due to infrastructure works (e.g. Te Rapa Bypass, intersection upgrades (signals) along Wairere Drive and Wairere Drive extension).

Wherever possible, the heavy vehicle counts were identified separately for the purposes of a separate heavy vehicle validation. In order to have heavy vehicle screenlines match the all vehicle screenlines some sites that did not have a separate heavy vehicle count available were estimated based on nearby or similar road types, or for state highways the non-directional heavy split applied to both directions.

3.3.2 Travel Times

Between 5 and 23 March 2014, eight Hamilton travel time routes were surveyed. The results were incorporated into the WRTM to validate travel times in the morning peak, interpeak and evening peak periods.

In addition to these Hamilton travel routes, the model has been assessed against the regional travel routes collected for the original 2006 model build as a check to see that the model reasonably replicates these outer-lying routes as well. This has been performed as a check rather than as validation as it is a comparison of different years.

The travel time routes and the results of the analysis are contained in Technical Note 30.

3.3.3 Public Transport Patronage

Passenger boardings by service an time were supplied by Environment Waikato for March 2013.

4. Model Calibration and Validation - 2006

4.1 Trip Generation

As noted above, the model was refined from 900 zones (999 when Frankton was included) to 2,500 zones in order to make the model more useful for operational as opposed to strategic analysis. This geographic change in the model required the HIS data to be rezoned, and any variables that were geographically dependant to be re-calibrated. At the trip generation stage, trip rates are independent of geography, but the attraction equations are not and were therefore re-calibrated.

The opportunity was taken to redefine the purposes to remove those that had a limited number of trips. In the 2009 model build, the purposes were kept the same in each time period. In this re-build, that convention was dropped, as shown in **Table 1**.

Trip Purposes Used			
2009 Version	**2013 Version**		
All Periods	**AMP**	**INP**	**PMP**
Home Based Work	Home To Work	Home To Work	Home To Shop
Home Based Education	Home To Business	Home To Business	Home To Social/Rec
Home Based Shop	Home To Shop	Home To Shop	Non-Home Based
Home Based Social/Rec	Home To Other	Home To Other	Work To Home
Home Based Other	Non-Home Based	Non-Home Based	Education To Home
Non-Home Based	Other To Home	Work To Home	Business To Home
		Business To Home	Shop To Home
		Shop To Home	Other To Home
		Other To Home	

Table 1: Trip Purposes Used in Different Model Versions

The second difference is that in 2009, the home to and to home purposes were combined. In this re-build, the purposes were kept separate. As a generality the r^2 values are a little higher in this re-build than in 2009, indicating a better model fit to observed data.

As a result of these differences, it has not been possible to directly compare the two models. The results of the re-calibration and re-validation are included in Technical Note 26.

4.2 Trip Distribution

The primary difference in the distribution model (apart from the change in purpose definitions) was calibration of the 3 step model distribution functions as functions of cost as opposed to functions of time calibrated in 2009. The 4 step model also was cost based as in the 2009 model build. Interestingly the exponent of the exponential distribution function

was different between the 900 zone calibration and the 2500 zone calibration, although not significantly so. The results of the three step model calibration are included in Technical Note 27, and the four step in Technical Note 33.

4.3 Mode Split

The approach to the mode split model changed between 2009 and this 2013 update. In 2009, a nested binomial model was adopted, with parameters estimated at each level to achieve the required mode split and response to service changes. In the 2013 update, a single level multinomial logit model was estimated statistically, although some values had to be imposed on the model. Although either method could be used it is believed that the one adopted for the 2013 model update is more mathematically rigorous.

According to literature, walk and wait costs for public transport trips are typically twice the ride costs with a transfer penalty being in the order of a five minute penalty. For the WRTM four step validation process, in order to get a closer fit against the number of public transport patrons transferring between services (as recorded in the Bus Intercept Survey) the transfer penalty needed to be increased to 20 minutes in the morning peak and reduced to four minutes in the interpeak. The 20 minute value is well outside the expected range, and a compromise of a 10 minute penalty was adopted for each period.

The calibration and validation process are contained in Technical Note 29.

4.4 Assignment

The assignment process in the two builds is identical. The process for the 2013 model update vehicle assignment is described in Technical Notes 28 and 30, and the public transport assignment in Technical Notes 34 and 35.

There are road assignments for both the three and four step models. The car driver matrices are similar but, of course, not identical, and that is reflected in the resulting assignment. In general, the three step model matches counts better than the four step, and as such it is expected that analysis of roading projects would be carried out using the three step model while the four step model would generally only be used for public transport analysis.

4.5 Validation

Both the three step and the four step models were validated against the same data as that used in the 2009 build, although several more screenlines were added, particularly in Hamilton (see Technical Note 28: Model Validation – 3 Step Model at 2006). A summary of the comparisons against traffic counts is shown in **Table 2**.

MODEL SCREENLINE SUMMARY TO NZTA EEM GUIDELINES - 2006					
		Target	**Morning Peak**	**Inter Peak**	**Evening Peak**
Traffic Flow	+/- 10%	Most	72%	69%	61%
	> +/-10%	Very few	28%	31%	39%
Corr. Coeff.	>0.85	Most	89%	100%	97%
% RMS	<30%	Acceptable	16	24	26
	>30%	Clarify	20	12	10
GEH (on screenline totals)	<4	Most	29	28	22
	>4	Very few	7	8	14
Individual Links	0 - 10k	No daily model created to date			
	10k - 20k				
	20k - 30k				
	30k - 50k				
	50k+				
	GEH < 5	60%	12 of 18	15 of 18	14 of 18
	GEH < 10	95%	13 of 18	16 of 18	9 of 18
	GEH < 12	100%	15 of 18	16 of 18	15 of 18

Table 2: Model Screenline Summary to NZTA EEM Validation Guidelines (TN28)

The four step model was validated against passenger boardings with the results shown in **Table 3**. A comparison of the vehicle driver trips from the three and four step model gave r^2 values of 0.83, and 0.93 for the AM and Interpeak respectively.

PT BOARDING COMPARISON SUMMARY TO NZTA TRANSPORT MODEL GUIDELINES				
		Target	**Morning Peak**	**Inter Peak**
All Individual PT Routes	GEH < 5.0	>50%	58.5%	79.1%
	GEH < 7.5	>60%	84.9%	97.7%
	GEH < 10	>70%	98.1%	100%
	GEH < 12	>85%	100%	100%
Line of Best Fit		Y=0.85x-1.15x	Y=1.05x	Y=0.88x
R^2		>0.80	0.7	0.8

Table 3: PT Boarding Comparison Summary to NZTA Transport Model Development Guidelines (TN34)

5. 2013 Model Forecasts

5.1 Results

As noted above, the 2013 model run is essentially a 'forecast' in that the only changes from 2006 are updates to the network to include changes between 2006 and 2013, and inclusion of the 2013 land use derived from the census. That differs from a more usual forecast in that the land use and networks for the future year are assumed rather than being known.

Also traffic counts and journey times were also measured at 2013.

5.2 Validation Checks

A summary of the model screenlines comparison to NZTA EEM guidelines is presented below in **Table 4** and against the NZMUGS validation guidelines in **Table 5**

MODEL SCREENLINE SUMMARY TO NZTA EEM GUIDELINES - 2013					
		Target	**Morning Peak**	**Inter Peak**	**Evening Peak**
Traffic Flow	+/- 10%	Most	83%	75%	73%
	> +/-10%	Very few	17%	25%	27%
Corr. Coeff.	>0.85	Most	97.5%	95%	95%
% RMS	<30%	Acceptable	32	29	33
	>30%	Clarify	8	11	7
GEH (on screenline totals)	<4	Most	36	32	31
	>4	Very few	4	8	9
All Individual Links on Screenlines	0 - 10k	No daily model created to date			
	10k - 20k				
	20k - 30k				
	30k - 50k				
	50k+				
	GEH < 5	60%	85.4%	82.9%	79.7%
	GEH < 10	95%	97.6%	98.0%	97.6%
	GEH < 12	100%	98.4%	98.8%	98.0%

Table 4: Model Screenline Summary to NZTA EEM Validation Guidelines (TN30)

MODEL SCREENLINE SUMMARY TO NZMUGS GUIDELINES					
		Target	**Morning Peak**	**Inter Peak**	**Evening Peak**
Traffic Flow	+/- 5%	>70%	53%	45%	55%
	+/- 10%	>80%	83%	75%	73%
	> +/-10%	<20%	17%	25%	27%
Corr. Coeff.	>0.85	Most	0.925	0.95	0.95
% RMS	<30%	Acceptable	32	29	33
	30-40%	Clarify	4	7	5
	>40%	Inappropriate	4	4	2
GEH (on screenline totals)	<5	>60%	88%	80%	75%
	<7.5	>75%	100%	95%	88%
	<10	>90%	100%	98%	98%
All Individual Links on Screenlines	0 – 700vph	>70%	79%	83%	74%
	700 – 2700	>70%	77%	75%	74%
	2700vph +	>70%	100%	-	75%
	GEH < 5	65%	85.4%	82.9%	79.7%
	GEH < 7.5	75%	93.1%	93.5%	92.3%
	GEH < 10	85%	97.6%	98.0%	97.6%
	GEH < 12	95%	98.4%	98.8%	98.0%

Table 5: Model Screenline Summary to NZMUGS Validation Guidelines(TN30)

The four step model was validated against passenger boardings with the results shown in **Table 6**.

PT BOARDING COMPARISON SUMMARY TO NZTA TRANSPORT MODEL GUIDELINES				
		Target	**Morning Peak**	**Inter Peak**
All Individual PT Routes	GEH < 5.0	>50%	60.0%	76.2%
	GEH < 7.5	>60%	91.1%	100%
	GEH < 10	>70%	97.8%	100%
	GEH < 12	>80%	100%	100%
Line of Best Fit		Y=0.85x-1.15x	Y=0.853	Y=1.004
R^2		>0.80	0.83	0.53

Table 5: PT Boarding Comparison Summary to NZTA Transport Model Development Guidelines (TN35)

The model is within the NZTA guidelines with the exception of the inter peak R^2. Other metrics indicate that the inter peak meets the NZTA Guideline criteria. The results are considered acceptable given the small observed volumes that are being replicated.

A comparison of the vehicle driver trips from the three and four step model gave r^2 values of 0.83, and 0.93 for the AM and Interpeak respectively.

While the model largely meets the validation criteria on a regional basis it is recommended that any specific project work using the model will first employ some local area validation. This local area validation will investigate the models fit to surveyed data in the area of interest for the project, and any adjustments required will be incorporated as necessary, ensuring the ability to retain the overall regional validation throughout the model area as well as local area detail as required. It may be that criteria for different model categories as defined in the NZMUGS guidelines will be more appropriate for project validation, and indeed, I many cases the criteria for Strategic Network or Urban Area models have already been achieved.

6. Longer Term Forecasts – 3 Step Model

The forecasts will be separately documented in Technical Note 36. As of December 2016, the input future year land use was not available and hence the forecasting task could not be completed.

7. Model Sign Off

The model update project and reporting has been peer reviewed by Ian Clark of Flow Transportation Specialists. The final peer review report of the base year model update is attached as Appendix A.

Appendix A

Peer Review Report of Base Model Update