



# Waikato Regional Transport Model

Professional  
Services Contract  
WRTM-01

Final Model Build  
Report

August 2010

QUALITY ASSURANCE STATEMENT

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**26 August 2010**

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# 1. THE WAIKATO MODEL BUILDING PROJECT

## 1.1 Objectives

The basic requirement of the project is to build a new Waikato Regional Model and update the existing Hamilton City model so that they are available to evaluate projects, policies and plans to meet the objectives of the LTMA and the NZTS. These objectives include assisting economic development, assisting safety and personal security, improving access and mobility, protecting and promoting public health, and ensuring environmental sustainability.

Accordingly, in addition to forecasting travel demands based on changes in land use, household structures and car ownership for planning future transport infrastructure and services, the model will be developed to enable roading and public transport proposals to be analysed, and changes in transport policies, including travel demand management measures, to be evaluated.

A further key requirement of the project was to develop an integrated forecasting tool that is wholly owned and controlled by the clients.

## 1.2 Report Content

This is the final report of the model build phase of the contract. The contract reporting has been progressively undertaken during the course of the project by means of a series of some twenty technical notes running to over 1000 pages.

As a result, this report documents the model build phase of the project through to completion of the peer review, and is essentially an executive summary of the reports and technical notes. The notes are available on a CD if required.

**Table 1** lists the technical notes including a brief abstract, and also lists the supporting public reports that were required as deliverables under the contract.

## Summary of Reports and Technical Notes

Table 1

### Public Reports

Number	Name	Abstract
	Model Specification Report	This report specified the intended model form at the outset of the study. It contained some unknowns and alternative approaches that were determined during the course of the project and the final report documented these differences, as noted in Section 9 below.
	Survey specification Report	This report specified the data that was to be collected during the survey stages of the project.
	Roadside Interview Survey Report	This report by Traffic Design Group described the Roadside interview surveys.
	Home Interview Survey Report	This report by Opus International Consultants described the Household interview surveys
	Bus Passenger Intercept Survey Report	This report by Gabites Porter described the bus passenger surveys
	Model User Manual	This manual describes all of the data and parameters used in the model and highlights which components are permitted to be modified by the model users.

### Technical Notes

Number	Name	Abstract
1	Land Use Variables	This note summarises the land use data that is used in the generation stage of the models.
2	Waikato Zone System	This note documents the zone system used in the model, with diagrams showing zone boundaries and numbering.
3	Household categories	This note describes the evolution of the household categories used in the generation model.
4	Expansion Factors	This note describes the derivation of the factors used to expand the sample household Interview data to represent the full population, and adjust to the March validation day.
5	Stops to Trips	This note describes the conversion of stops (trip legs) as recorded during the household interview survey into trips as required for the model calibration.
6	HIS deficiency Summary	This note is a record of some issues found with the Household Interview survey.
7	Trip Rates	This note documents the derivation of Trip Rates by category, time period and purpose for the three and four step models.

*Technical Notes Continued*

<b>Number</b>	<b>Name</b>	<b>Abstract</b>
8	Household Distribution model	This note describe the calibration and validation of the household distribution model which estimates the number of households in each of the categories
9	Annualisation Factors	This note documents the derivation of factors to covert the model period results to annual numbers.
10	Trip attraction models	This note describes the derivation and validation of the regression based trip attraction equations.
11	Trip distribution models	This note documents the calibration of the trip distribution functions by purpose, and period for the three-step model and the validation of the distribution stage after application of the gravity model.
12	Three step model validation	This note describes the validation, of the three step model against measured traffic counts and travel times.
13	External model	This note describes the calibration of the external vehicle model.
14	Goods vehicle model	This note describes the way in which the Christchurch commercial vehicle model has been applied for use in Waikato.
15	Four step distribution model	This note documents the calibration of the trip distribution functions by purpose, and period for the four step model and the validation of the distribution stage after application of the gravity model.
16	Mode Split Validation	This note describes the calibration and validation of the mode choice logit model.
17	Four step model validation	This note describes the validation, of the four step model against measured traffic counts, travel times, and public passenger counts.
18	Future model preparation	This note describes the development of future land use, vehicle ownership, and the do-minimum network
19	Future Deficiency Analysis	This note describes the results of applying the future land use onto the do-minimum network.
20	Future Four Step Modelling	This note describes the behaviour of the four step model when used in a forecasting mode.

## 2. MODEL SPECIFICATION

The model was detailed in the 'Model Specification Report' written in January 2008, and updated in November and December 2009. This was intended as a 'fluid' report as the model form was subject to change during the build process as the quality and availability of data became apparent.

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 (0700-0900) and an inter peak model (1100-1300). The vehicle driver model also included an evening peak (1600-1800). They were developed to represent the traffic conditions of an average weekday in March 2006.

The model has 900 zones, although only 702 are used with 12 external zones and the balance available for later use.

The geographic area covered by the model is shown on Figure 1, and extends from the Bombay Hills in the north, to Taupo in the south, and includes Rotorua and Tauranga to the east. 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. All road centrelines and the base network attribute coding have been derived from the Environment Waikato GIS system.

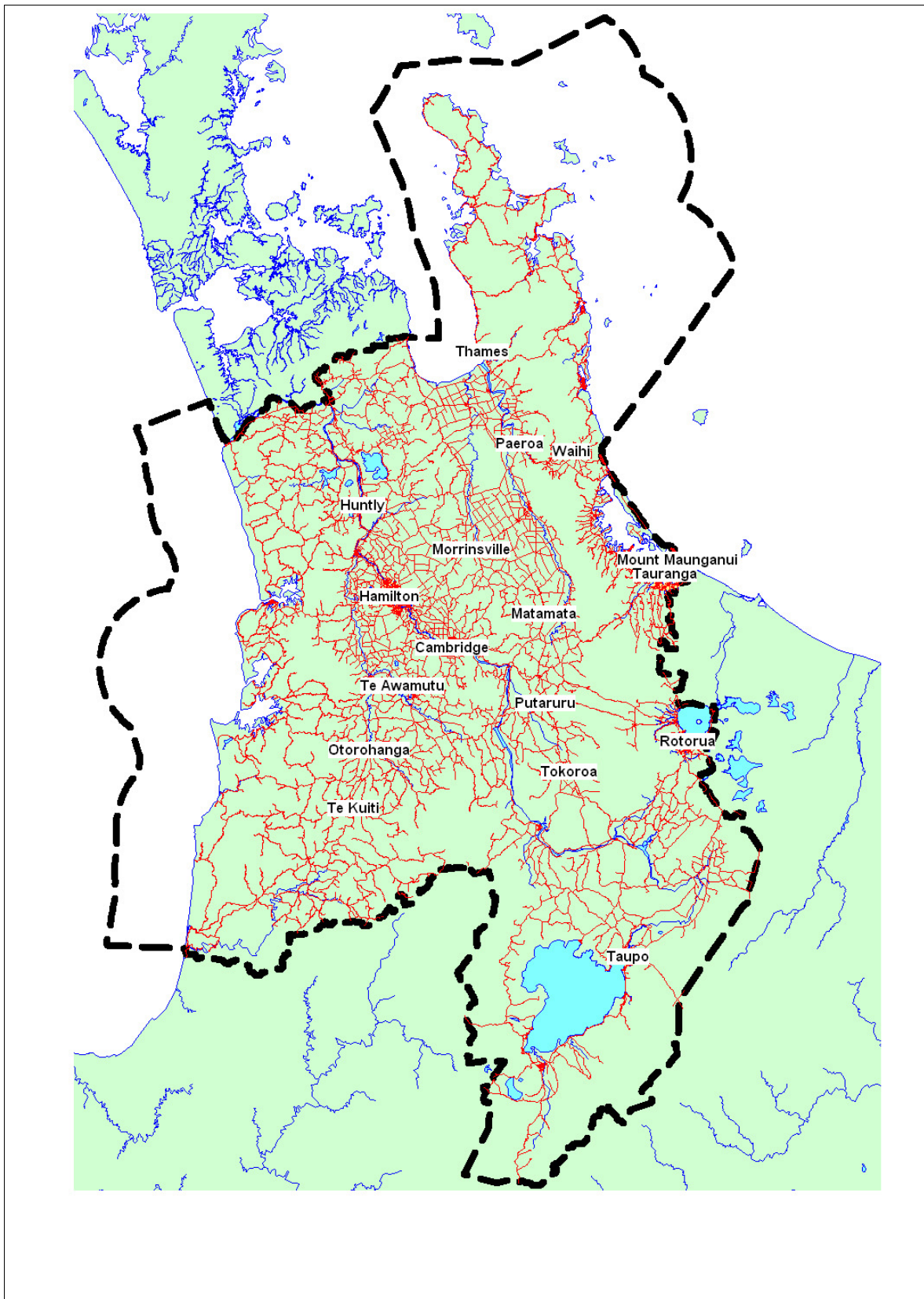
The network covers an area some 300 kilometres from north to south and about 180 kilometres east to west. It contains 20,121 links, and 8,397 intersections.

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

- Generation
- Distribution and
- Road Assignment

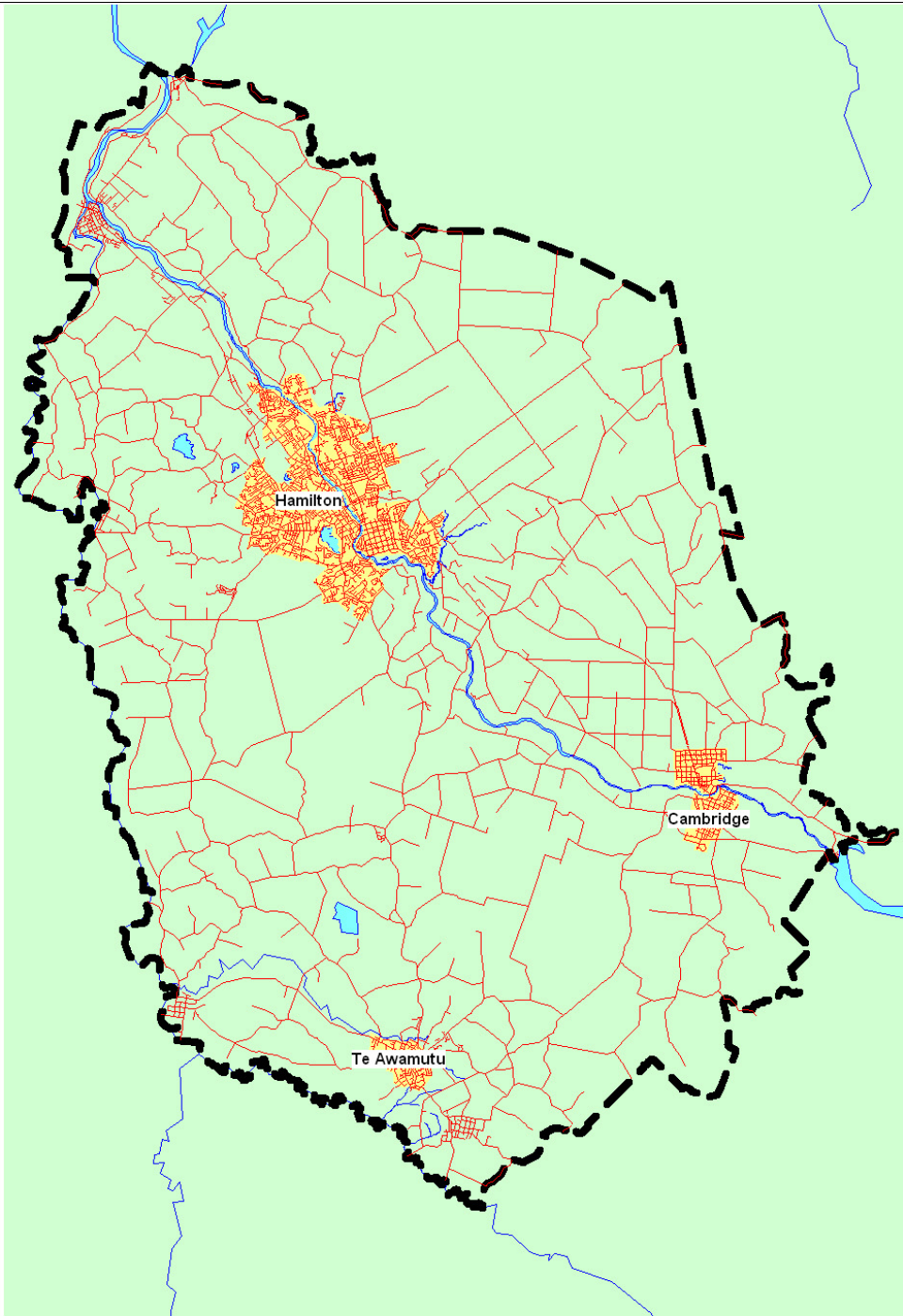
The person trip model adds a mode choice stage, and is commonly referred to as a four-step model. Its components are

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



Waikato Regional Transportation Model	<b>Waikato Regional Model Boundary</b>	<b>Figure 1</b>
Gabites Porter Consultants Traffic Design Group		





Waikato Regional Transportation Model	<b>Detail in the Greater Hamilton Area</b>	<b>Figure 2</b>
Gabites Porter Consultants Traffic Design Group		

### 3. DATA COLLECTION

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 – 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.

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.

### 4. PRELIMINARY WORK

In the early phases of the contract, while the surveys were being undertaken, there were a number of tasks that were done in anticipation of the data being available. These involved:

- Defining a zone system and the land use variables that were to be used in the generation model
- Coding the network and its operating characteristics.
- Initial definition of household categories

With the exception of network coding which is covered in the Survey Specification Report, these topics are covered in Technical Notes 1, 2 and 3, and these are essentially a description of the process that was followed.

## 5. DATA ANALYSIS AND EXPANSION

Following delivery of the Household Interview Survey data, this sample needed to be expanded to match the region 'population'. Five expansion factors were required and these are reported in Technical Note 4. They included:

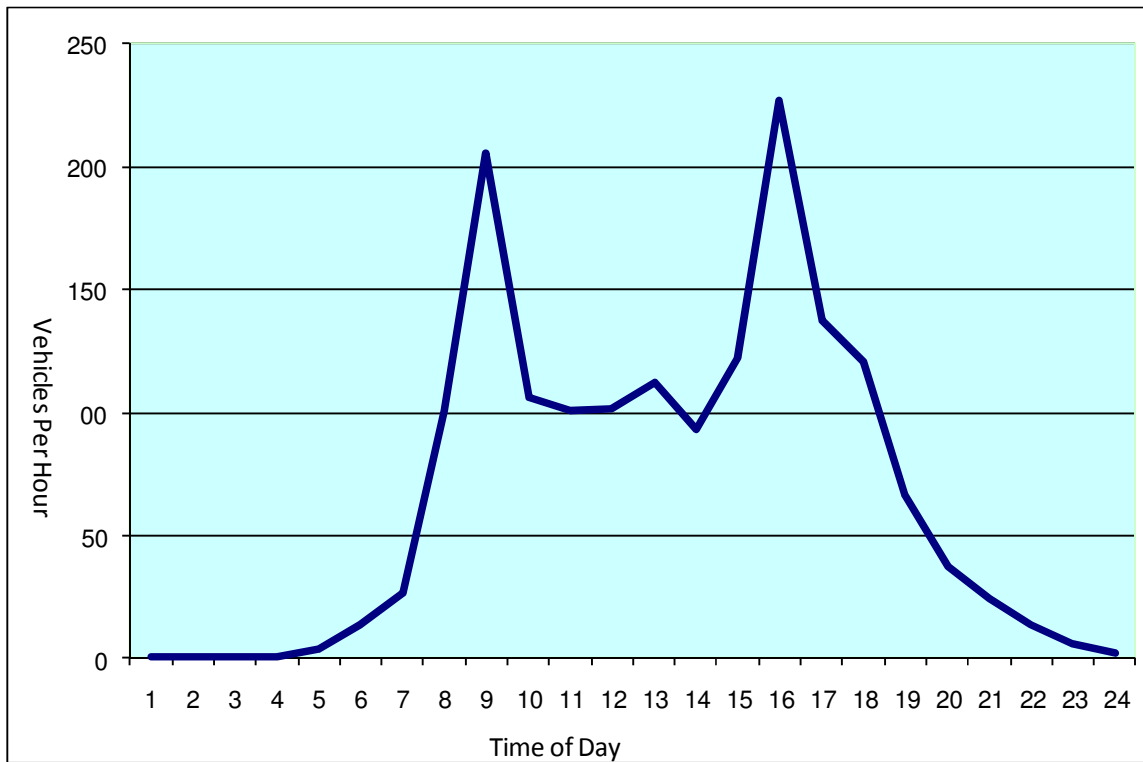
- A geographic expansion factor calculated separately for Rural and Urban Households
- A factor to adjust for household type to match Census data totals
- A factor to adjust for total population to match Census data totals
- A factor to adjust for car ownership to match Census data totals
- A factor to convert from the survey day to an average March weekday

Although the model represents traffic conditions for an average weekday, the evaluation of options requires conversion to Annual Average Daily Traffic (AADT), and then conversion of that to yearly figures. Technical note 9 describes the development of these factors.

Once these factors were applied, the following statistics were derived from the 147,100 households in the HIS survey area.

Trips by Mode		Table 2
Vehicle Driver	989,607	60.8%
Vehicle Passenger	397,398	24.4%
Bus Passenger	18,221	1.1%
School Bus Passenger	30,442	1.9%
Bicycle	26,501	1.6%
Walk	156,877	9.6%
Other	7,443	0.5%
<b>Total</b>	<b>1,626,489</b>	<b>100%</b>

This produces 11.06 person trips per household. The distribution of trips over the day is shown on **Figure 1**.



**Figure 3**  
**Trips by Time of Day**

There are two supporting technical notes – Technical Note 5, a short paper, which describes the process by which stops were converted to trips, and Technical Note 6 which is a commentary on some of the issues with the HIS survey. The latter note was used as part of the quality control of the HIS to assist the client with project administration.

## 6. MODEL CALIBRATION AND VALIDATION

The bulk of the reporting has covered the model calibration and validation, with Technical Notes 7 to 17 dealing with these components of the model build process, as discussed in the following sections.

### 6.1 Trip End Generation

The calibration of household category trip rates from the Home Interview Survey by purpose and time period for each of the three and four-step models is reported in Technical Note 7 and it also contains the trip production validation checks. With one or two minor exceptions, the comparison of modelled against surveyed trip productions show  $R^2$  values are within the range 0.83 to 0.97.

Technical Note 8 describes the household distribution model which estimates the number of households in each category from inputs of zonal household size, number of employees in each household, age structure and car ownership.

Technical Note 10 reports the derivation of the regression equations used to estimate trip attractions, and the validation checks carried out on the attractions. For those trip purposes with very few trips surveyed, the R-squared values are low. Putting these to one side the majority of R-squared values are over 0.5 with the critical Home Based Work in the peak periods and Non Home Based purposes in the interpeak having R-Squared values of over 0.8.

### 6.2 Trip Distribution

Technical Note 11 describes the derivation of the generalised cost values for each purpose and time period. It also documents the calibration of the inter-zonal impedance functions for the three-step model and the validation of the use of those functions in the gravity distribution formula, including measured and modelled trip time, length and cost frequency distributions. The companion report for the four-step model is contained in Technical note 15.

The three-step model has distribution functions based on time, while the four-step model is cost based to enable the effects of fares and tolls to be included, and to represent the differing values of time perceived for each mode of travel.

### 6.3 Mode Split

The calibration and validation of the logit mode split model is reported in Technical Note 16. The parameters in the logit model were successively adjusted until the modelled mode split was within the values set out in the Model Specification Report. In all cases the match over the total in each mode was within  $\pm 0.1\%$  against a criteria of  $\pm 2\%$ .

## 6.4 External trips and Goods Vehicles

The derivation of the external vehicle model is described in Technical Note 13, and the Heavy Goods vehicle model in Technical note 14. Light goods vehicles are included with private vehicle traffic in the generation rates derived from the HIS, while “heavy” refers to both medium and heavy commercial vehicles.

## 6.5 Assignment

Technical note 12 contains the description of the assignment process, and the validation of the three-step model in terms of traffic flow and journey time comparisons of modelled against measured values. The companion note for the four-step model including a comparison of the car driver mode from both the three and four step models is contained in Technical Note 17.

Also included in these notes are validation checks of bus passengers against the bus passenger Intercept survey data, the car driver sector-to-sector movements against the Home Interview Survey data and the sector to sector movements against the Roadside Interview survey data.

Although all of the component parts of the model need to be validated separately, the validation checks after assignment – that is vehicle flows on the network – are arguably the most important part of the validation process as it brings all of the components together. The screenline validation meets the requirements of the NZTA Economic Evaluation Manual which states that the majority of screenlines meet specified criteria. Across all periods and screenlines these criteria have been met in 70% of cases which constitutes a majority.

Additional validation of traffic movements has included a sector to sector trip matrix check between HIS results and the model where the sectors are defined as territorial local authorities. Further validation checks against roadside interview survey results have also been reported such that the range of strategic validation checks on the model are comprehensive.

Obviously, when project analysis is being scoped during the operational phase of the contract, some local area validation checks should be incorporated and undertaken.

## 7. CHANGES IN MODEL DESIGN FROM SPECIFICATION REPORT TO FINAL MODEL

As noted earlier, the model specification evolved during the course of the project, and the differences are highlighted in that report. A summary of the major changes is provided in the paragraphs below.

### 7.1 Zone Detail

Initially, the concept was to have two models, with one at a relatively coarse zonal level over the whole area, and a more detailed model of the greater Hamilton area.

The conceptual approach to the model changed radically once the HIS data became available, and there was little significant difference between trips rates within the Hamilton model area and the wider region. As a result, there was no need to continue with a separate, more detailed model of Hamilton to be windowed from the full regional model. Instead the necessary detail was included within Hamilton, meaning only one model is required. Detail was also added in Tauranga, Rotorua, Taupo, and the smaller towns of Tokoroa, Putaruru and Matamata

The model will still provide boundary conditions for the detailed 'stand alone' models of Tauranga, Rotorua and Taupo, all of which have very detailed internal zone structures.

There are currently 702 zones in the model with 484 in the Hamilton urban model and the balance in the rest of the region.

### 7.2 Periods

The original concept was to have the coarser regional model as a daily (24hour) model, with three periods in Greater Hamilton. The altered model approach meant that there are period models over the whole region, validated to two-hour flows and travel times. The periods are 0700-0900, 1100-1300 and 1600-1800. A 24-hour network assignment has been built up from the period loaded networks.

### 7.3 Modes

The four step model was originally intended to be confined to the Greater Hamilton Area, but as with the three step model, the four step model has covered the whole region, meaning that all four modes are available over the whole region. As noted earlier, the trip rates are the same between Hamilton and the wider region. Where public transport services are not provided, trips are carried by other modes.

## 7.4 Household Categories

Initially 18 household categories were proposed. In the event, this classification did not work, and a slightly different approach was taken as shown below

*One Adult working*  
*One adult not working*  
*2 Adults working*  
*2 adults not working*  
*Two adults one working*  
*3+ adults*  
*Two Persons*  
*Three Persons*  
*Four Persons*  
*Five or more persons*

## 7.5 Mode Split

The mode choice model was changed a little from that in the original report. Recent work in Dunedin has suggested that a series of binary mode choices are easier to control than the proposed three way choice. Also the distinction between households with no car as opposed to having a car available has also been dropped because of the very small number of trips originating from those households.

Accordingly the structure used is:

Split One – All **person** trips into **Active modes** (walking/cycling) vs **Other**  
Split Two – **Other** trips into **Public Transport** vs **Vehicle occupants**  
Split Three – **Vehicle occupants** into **car driver** vs **car passenger**

Home Based Work and Home Based Education were kept separate with all other purposes aggregated prior to the mode split step.



## 8. USE OF THE MODEL IN FORECASTING

While the performance of the model at the base 2006 year can be compared against measured values, it is also important to test the operation of the model at some future year to check that the model response is as expected.

Technical Note 18 describes the process by which land use patterns for 2021 and 2041 were developed. It is important to note that these are based on the best information currently available and are in line with the 'Future Proof' growth strategy, but they might not be the patterns that emerge following analysis during the operational phase of the project. This note also describes the development of the future 'do-minimum' network for each of the two forecast years.

The key forecast landuse variables are given in **Table 3** below.

Key Future Landuse Variables			Table 3
Variable	2006	2021	2041
Households	210,393	278,665	344,861
Persons per HH	2.73	2.63	2.55
Cars per HH	1.66	1.77	1.81
Employees per HH	1.25	1.05	0.95
School Roll	111,762	120,835	124,100
Tertiary Roll	28,373	34,274	36,739
Retail Jobs	28,430	31,878	36,040
Wholesale jobs	10,193	11,813	13,205
Office jobs	46,464	52,453	59,194
Community Jobs	38,192	42,945	48,589
Total Jobs	271,795	303,427	340,276

Technical Note 19 describes the future network deficiency analysis that arises from running the model using the future traffic demands loaded onto the do-minimum network. This not only provides a useful picture of where additional capacity will be required in the network, but also demonstrated the way in which the model responds in a forecasting mode.

The Waikato network is under significant pressure. Without additional works it is likely to deteriorate significantly over time resulting in considerable congestion and delays to network traffic.

Analysis of the model shows traffic levels will increase significantly over the next 30 years. This will have important implications for the planning of the Waikato transport system.

Over the next 30 years:

- Total trips are expected to increase by 50 to 60%
- Total vehicle kms are also expected to increase by 50 to 60%
- Total intersection delay is expected to increase by up to 220%
- Average trip distances are expected to remain fairly constant

The response of the four step models for future years has been documented in Technical Note 20. This includes mode split results and bus patronage by route.

## 9. MODEL USER MANUAL

The model user manual has been developed to provide the client with a reference document. This manual contains details of the flow of programs, the parameters and data used in the model and a clear description of the values that may be changed by a user, and which are calibrated numbers that should not be changed.

## 10. PEER REVIEW

The model build project and reporting has been peer reviewed by Ian Clark of Flow Transportation Specialists. The Waikato Regional Transportation Model was signed-off and approved for use by Ian on 26<sup>th</sup> March 2010.