Nelson-Tasman 3 Step Transportation Model Building Report

Prepared by

GABITES PORTER

August 2005
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</tbody>
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CONTENTS

1. INTRODUCTION 1
   1.1 Objectives 1
   1.2 Summary of the Model 2
   1.3 Study Approach 3
   1.4 Report Content 3

2. MODEL OVERVIEW 4
   2.1 Model Form 4
   2.2 The Study Area 6
   2.3 The Road Network 15

3. EXISTING LAND USE AND TRAFFIC DATA 18
   3.1 Existing Land Use (2001) 18
   3.2 Existing Transport Data 30

4. TRIP END GENERATION 40
   4.1 Household Category Curves 40
   4.2 Private Trip End Productions 49
      4.2.1 Morning Peak Private Trip End Productions 50
      4.2.2 Interpeak Period Private Trip End Productions 52
      4.2.3 Evening Peak Private Trip End Productions 54
      4.2.4 Trip Rate Summary 55
   4.3 One Hour Model Period Factors 57
   4.4 Private Trip Attractions 57
      4.4.1 Morning Peak Private Trip Attractions 58
      4.4.2 Interpeak Period Private Trip Attractions 58
      4.4.3 Evening Peak Private Trip Attractions 58
   4.5 Commercial Vehicle Trips 59
   4.6 External Trips 59
      4.6.1 External Traffic Summary 62
   4.7 Total Trip End Generation Summary 62

5. TRIP DISTRIBUTION AND THE COSTS OF TRAVEL 66
   5.1 The Gravity Distribution Model 66
   5.2 The Distribution Function 67

6. PARKING MODULE 68
   6.1 Central Area Logistics Model (CALM) 68
   6.2 Trip Purpose and Parking Durations 68
   6.3 Parking Inventory 70

7. TRIP ASSIGNMENT 71
   7.1 Costs of Travel 71
   7.2 Loading Profile 72
   7.3 Network Links 78
   7.4 Network Intersections 81

8. MODEL CONVERGENCE 85
   8.1 Assignment and Distribution Loop 85

9. VALIDATION 86
   9.1 Network Validation 86
      9.1.1 Morning Peak Validation 92
      9.1.2 Inter Peak Validation 96
9.1.3 Evening Peak Validation 100
9.2 Individual Link Validation 106
9.3 Travel Time Validation 106

10. TRAFFIC RESULTS 114

11. 2031 MODEL 116
11.1 Future Landuse 116
11.2 2031 Trip End Generation Summary 120
11.3 Future Do Something Network 121
11.4 Convergence of 2031 Models 121
11.5 Sectored Trip Distribution 122
11.6 Sectored Trip Distribution

12. CONCLUSION 136

REFERENCES 137

Appendix One: Census 2001 Meshblock To Zone Conversion Table
Appendix Two: Nelson-Tasman 2001 Landuse Data
Appendix Three: Auckland Generation Rates / HBRTS Attraction Coefficients
Appendix Four Parking Inventory
Appendix Five: Traffic Count Validation Output
Appendix Six: Travel Time Validation Output
LIST OF FIGURES

1. Vehicle Driver Model Components 5
2. 2001 Corridor Study Area 7
3. 2001 Corridor Study Area Detail 8
4. 2001 Model Zones 9
5. 2001 Nelson and Tasman Zones 10
6. 2001 Nelson Zones 11
7. 2001 Nelson CBD Zones 12
8. 2001 Stoke Zones 13
9. 2001 Richmond Zones 14
10. Model Area Road Network 16
11. Model Road Network – Nelson City 17
12. 2001 Total Households by Zones Model Area 19
13. 2001 Total Households by Zones Nelson and Tasman 20
14. 2001 Total Households by Zones Nelson and Richmond 21
15. 2001 Total Households by Zones Nelson CBD 22
16. 2001 Total Households by Zones Stoke 23
17. 2001 Total Households by Zones Richmond 24
18. 2001 Total Jobs by Zones Model Area 25
19. 2001 Total Jobs by Zones Nelson and Tasman 26
20. 2001 Total Jobs by Zones Nelson CBD 27
21. 2001 Total Jobs by Zones Stoke 28
22. 2001 Total Jobs by Zones Richmond 29
23. AADT Growth on SH6 1996-2003 34
24. Seasonal Traffic Analysis 35
25. Daily Traffic Analysis 36
26. Traffic Flow Profile of State Highway 6 Through the Study Area 37
27. 2001 Census Journey to Work 38
29. Person Category Curves 41
30. Vehicle Category Curves 44
31. Summary Household Category Curves 46
32. Correlation Between Model and Census Household Distribution 48
33. All Day Trip Generation Summary 56
34. Number of Trips by Trip Purpose During the Peak Hour of Each Period 63
35. Loading Profiles 77
36. Volume – Delay Curves 80
37. Screenline Locations - CBD 90
38. Screenline Locations - Stoke 91
39. AM / PM Screenline Scatterplots 104
40. INT Screenline Scatterplots 105
41. Travel Time Survey Routes 1A and 1B 109
42. Travel Time Survey Routes 2A and 2B 110
43. Travel Time Survey Routes 3A and 3B 111
44. Travel Time Survey Routes 4A and 4B 112
45. Figure 45 117
46. Future Land Use Projections 118
47. Study Area Sectors 123
48. 2031 AM Peak LOS of Northwest Nelson Area - Do Minimum 127
49. 2031 AM Peak LOS of Central Nelson Area - Do Minimum 128
50. 2031 AM Peak LOS of Southwest Nelson Area - Do Minimum 129
51. 2031 SHOP Peak LOS of Northwest Nelson Area - Do Minimum 130
52. 2031 SHOP Peak LOS of Central Nelson Area - Do Minimum 131
53. 2031 SHOP Peak LOS of Southwest Nelson Area - Do Minimum 132
54. 2031 PM Peak LOS of Northwest Nelson Area - Do Minimum 133
55. 2031 PM Peak LOS of Central Nelson Area - Do Minimum 134
56. 2031 PM Peak LOS of Southwest Nelson Area - Do Minimum 135
<table>
<thead>
<tr>
<th>Table Number</th>
<th>Table Title</th>
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<tbody>
<tr>
<td>1.</td>
<td>Summary of the Nelson-Tasman Transportation Model 2004</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Model Periods</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>Land Use 2001</td>
<td>18</td>
</tr>
<tr>
<td>4.</td>
<td>Measure of Fit - Household Category Curves</td>
<td>40</td>
</tr>
<tr>
<td>5.</td>
<td>Persons/HH and Cars/HH Proportions</td>
<td>47</td>
</tr>
<tr>
<td>6.</td>
<td>Trip Purposes</td>
<td>49</td>
</tr>
<tr>
<td>7.</td>
<td>Morning Peak Period 'Home To' Trip End Production Rates By Purpose And Category Model</td>
<td>50</td>
</tr>
<tr>
<td>8.</td>
<td>Morning Peak Period 'To Home' Trip End Production Rates By Purpose And Category Model</td>
<td>51</td>
</tr>
<tr>
<td>9.</td>
<td>Interpeak Period 'Home To' Trip End Production Rates By Purpose And Category Model</td>
<td>52</td>
</tr>
<tr>
<td>10.</td>
<td>Interpeak Period 'To Home' Trip End Production Rates By Purpose And Category Model</td>
<td>53</td>
</tr>
<tr>
<td>11.</td>
<td>Evening Peak Period 'Home To' Trip End Production Rates By Purpose And Category Model</td>
<td>54</td>
</tr>
<tr>
<td>12.</td>
<td>Evening Peak Period 'To Home' Trip End Production Rates By Purpose And Category Model</td>
<td>55</td>
</tr>
<tr>
<td>13.</td>
<td>Morning Peak Private Trip Attractions</td>
<td>58</td>
</tr>
<tr>
<td>14.</td>
<td>Inter Peak Private Trip Attractions</td>
<td>58</td>
</tr>
<tr>
<td>15.</td>
<td>Evening Peak Private Trip Attractions</td>
<td>58</td>
</tr>
<tr>
<td>16.</td>
<td>Commercial Vehicle Trips Generation Rates</td>
<td>59</td>
</tr>
<tr>
<td>17.</td>
<td>External Traffic Generation</td>
<td>61</td>
</tr>
<tr>
<td>18.</td>
<td>External Road Flows 2001</td>
<td>62</td>
</tr>
<tr>
<td>19.</td>
<td>Morning Peak (2hr) Trip End Production Summary</td>
<td>64</td>
</tr>
<tr>
<td>20.</td>
<td>Inter Peak (7hr) Trip End Production Summary</td>
<td>64</td>
</tr>
<tr>
<td>21.</td>
<td>Evening Peak (2hr) Trip End Production Summary</td>
<td>65</td>
</tr>
<tr>
<td>22.</td>
<td>Cost Based Distribution Function Exponents</td>
<td>67</td>
</tr>
<tr>
<td>23.</td>
<td>Trip Purpose by Park Length</td>
<td>69</td>
</tr>
<tr>
<td>24.</td>
<td>Parking Model Variables</td>
<td>70</td>
</tr>
<tr>
<td>25.</td>
<td>AM Peak Period Assignment Loading Profile</td>
<td>75</td>
</tr>
<tr>
<td>26.</td>
<td>Inter Peak Period Assignment Loading Profile</td>
<td>76</td>
</tr>
<tr>
<td>27.</td>
<td>PM Peak Period Assignment Loading Profile</td>
<td>76</td>
</tr>
<tr>
<td>28.</td>
<td>Intersections: Critical Gap and Move-Up Times</td>
<td>82</td>
</tr>
<tr>
<td>29.</td>
<td>Model Convergence</td>
<td>85</td>
</tr>
<tr>
<td>30.</td>
<td>Model Traffic Flow Validation Guidelines</td>
<td>87</td>
</tr>
<tr>
<td>31.</td>
<td>Screenline Descriptions</td>
<td>87</td>
</tr>
<tr>
<td>32.</td>
<td>Morning Peak Network Screenline Validation</td>
<td>92</td>
</tr>
<tr>
<td>33.</td>
<td>Inter Peak Network Screenline Validation</td>
<td>96</td>
</tr>
<tr>
<td>34.</td>
<td>Evening Peak Network Screenline Validation</td>
<td>100</td>
</tr>
<tr>
<td>35.</td>
<td>Individual Link Validation</td>
<td>106</td>
</tr>
<tr>
<td>36.</td>
<td>Travel Time Survey Routes</td>
<td>107</td>
</tr>
<tr>
<td>37.</td>
<td>Network Travel Times</td>
<td>113</td>
</tr>
<tr>
<td>38.</td>
<td>Network Wide Traffic Activity Indicators for 2001</td>
<td>115</td>
</tr>
<tr>
<td>39.</td>
<td>Future Land Use Data Summary</td>
<td>119</td>
</tr>
<tr>
<td>40.</td>
<td>Trip End Comparison - AM Peak (7-9AM)</td>
<td>120</td>
</tr>
<tr>
<td>41.</td>
<td>2031 Convergence</td>
<td>122</td>
</tr>
<tr>
<td>42.</td>
<td>2001 Sectored Trip Distribution</td>
<td>124</td>
</tr>
<tr>
<td>43.</td>
<td>2031 Sectored Trip Distribution</td>
<td>125</td>
</tr>
<tr>
<td>44.</td>
<td>Definitions Of LOS</td>
<td>126</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

In 2004 Gabites Porter were commissioned to build a transport model for the Nelson and Tasman urban areas. The model is to be used as part of a wider study examining the present and future needs in the study area.

This report details the transportation model relationships and assumptions and is a reference to document the model’s replication of the Nelson-Tasman transport network. The transport model replicates the Nelson-Tasman transport network and forms the basis for project analysis.

The model is fully capable of meeting any demands placed on it of a strategic nature. However, additional local validation checks, including intersection movement validation, will need to be undertaken for any future detailed project analysis involving Transfund.

1.1 Objectives

This report is part of a wider study looking to identify the present and future transport needs along the Nelson to Brightwater corridor and the associated transport network. The wider study provides for the construction of a strategic transport model that can be used for the analysis of options. The purpose of the strategic modelling is to provide an assessment of existing conditions, land use issues, and transport issues.

The model has been designed to allow, where possible, these objectives to be met. However, this report is limited to reporting the process for building the 3-step transportation model. To meet objectives concerning the public transport component of the study a second model was constructed. The document describing how this model was constructed is called the Nelson-Tasman 4-Step Transportation Model Building Report.

The objectives of this report are to document model inputs, outputs, and assumptions for:

- Land use;
- Trip generation;
- Trip distribution;
- Trip assignment;
- Model convergence; and
- Model validation.

It documents the key building blocks of the main tool used in this study; the 2001 Nelson-Tasman Transportation Model.
1.2 Summary of the Model

Table 1 provides a brief overview of the Nelson-Tasman urban area transportation model.

<table>
<thead>
<tr>
<th>Summary of the Nelson-Tasman Transportation Model 2004</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Element</strong></td>
<td><strong>Comment</strong></td>
</tr>
<tr>
<td><strong>Geographic Coverage</strong></td>
<td>The study area covered the Nelson City and Tasman District urban areas. From Hira in the east, to Tophouse in the South, and Motueka in the west.</td>
</tr>
</tbody>
</table>
| **Periods**                                            | Traffic for each of the peak period models is reported in hourly traffic volumes. The generation models have been calibrated separately for each time period and month period. The Nelson-Tasman model comprises three discrete models covering an average weekday:  
- Morning Peak: 0700 to 0900 (Hour reported: 0800-0900)  
- Inter Peak: 0900 to 1600 (Hour reported: 1200-1300)  
- Evening Peak: 1600 to 1800 (Hour reported: 1700-1800)  
- 24 Hour Period: values factored from the individual peaks to represent an average weekday. |
| **Network Detail**                                     | The road network used is derived from the Council GIS representation of the road centerlines. |
| **External Traffic**                                   | The model has been validated using Transit NZ counts at external points as close as possible to the study area boundary. |
| **Vehicle Types**                                      | Vehicle types used in the model include cars and heavy (HCV) and light (LCV) commercial vehicles. |
| **Software Platform**                                  | The model has been developed using TRACKS, which is the proprietary land use and transport planning software developed, maintained and marketed by Transportation and Traffic Systems Ltd. It has been assumed that the reader is familiar with the software, and has read the User Manual as this includes the theoretical background to the algorithms, and hence the models. |
| **Modelling Techniques**                               | This is a standard three-step model comprising vehicle driver trip generation, distribution and assignment. The current three steps are outlined below:  
1. **Private/internal Trip generation.** Private Trip productions are calculated from 20 Household Categories of 1, 2, 3, 4, 5+ persons by 0, 1, 2, 3+ cars calibrated directly from the 1991 Auckland Home Interview Survey (HIS) from the whole of Auckland. Trip Attractions and commercial vehicle generations are calculated from regression derived equations using the Australian and NZ Standard Classification major industry groups and again using HIS data. Existing land use data was obtained from Statistics New Zealand March 2001 Census.  
2. **Trip distribution.** Trip ends are formed into origin/destination matrices using a standard gravity model. A function of cost is used for spatial separation.  
3. **Assignment.** Assignment of trips to the network uses an incremental time slice process. This does not have the convergence issues associated with an equilibrium assignment, and permits intersection delays to be directly calculated during the assignment process. Intersection delays are calculated by movement using algorithms in ARRI123 (SIDRA) and Tanner’s queuing theory extended by Fisk and Tan, and later by Gabites Porter. |
1.3 Study Approach

A transportation model for a given time period comprises a group of linked mathematical formulae that approximate the traffic network and the general behaviour of drivers using it. It is accepted that the analysis may not take into account extremes of human behaviour, nor will it reflect all the subtle complexities of the transport system. Nevertheless the model that has been developed is capable of identifying the more significant factors and is adequate to test adjustments to the road network and land use system, which are likely to show the greatest benefit in relation to their costs.

Three period models, described in Table 2 were developed to undertake the analysis detailed in the study objectives. Each period however is more suited to analysis with the following applications in mind.

<table>
<thead>
<tr>
<th>Model Periods</th>
<th>Application</th>
<th>Validation</th>
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<tr>
<td><strong>Morning Peak</strong></td>
<td>Generation 0700-0900 hrs</td>
<td></td>
</tr>
</tbody>
</table>
  One hour peak: 0800-0900 | Central Area Access | YES |
|               |             | Intersection performance | |
|               |             | Design issues | |
|               |             | Site specific issues | |
| **Inter Peak** | Generation 0900-1600 | 
  One hour peak: 1200-1300 | Intersection performance | YES |
|               |             | Design issues | |
|               |             | Site specific issues | |
|               |             | CBD design | |
| **Evening Peak** | Generation 1600-1800 | 
  One hour peak: 1700-1800 | Intersection performance | YES |
|               |             | Design issues | |
|               |             | Site specific issues | |
| **24 Hour model** | Factored off the three Peak Period models | 
  Reporting overall traffic levels | N/A |
|               |             | Not used in funding applications as the factored model is not validated | |

These models have the same basic zone system and network structure, but clearly are designed to address different questions.

Modelling necessitates a series of compromises because of the constraints of current techniques, or because data is not available by which to utilise the techniques, or because resources are not available at the time. Nevertheless, a model is a ‘living’ tool, which has and should continue to be improved incrementally over the years, as needs dictate and resources permit.

1.4 Report Content

This report, as its title suggests, is designed as a technical document. It is intended to be a reference volume of how the transportation model was built and contains all the information necessary to completely build the analytical system. It highlights the assumptions made, the techniques adopted, and the relationship used. As well, it demonstrates the extent to which the model used was validated.

The report is intended to be of interest to transportation planners and engineers. It is unashamedly technical and uses jargon without apology.
2. MODEL OVERVIEW

2.1 Model Form

Planning of a land use transport system requires that the system can be adequately modelled and the effects of any change can be reliably forecast. A useful method is to build mathematical models that simulate travel behaviour. The land use and traffic modelling used for this model update comprised four sequential stages. That is, trip generation, trip distribution, trip assignment and validation:

1. **Trip End Generation.** The generation of trip ends for each sub area (zone) within the study area. The trip ends were generated according to the pattern of households and employment activity, and then allocated accordingly. The model was based on vehicle trips, rather than person trips. As a result, the modal split phase was inherent in the trip end generation rather than following the distribution stage.

2. **Trip Distribution.** The conversion of trip ends to trips distributed within the study area according to a function and travel cost.

3. **Trip Assignment.** The loading of trips between zones onto the road network as traffic flows.

4. **Validation.** The final stage of the process where the model is checked against observed traffic data to ensure the model is accurately reflecting actual travel behaviour.

The relationships between the different components are summarised schematically in Figure 1. Evaluation and operational impacts of particular projects will be the subject of later reports for Council decision making and funding.

There is an iterative process where the interzonal times and distances which result from the assignment phase feed back into the trip distribution phase. The process can be started by assuming times and distances as initial impacts to distribution, or by assuming initial trips as input to assignment. In any event, the assignment/distribution loop is repeated until there is little or no change in the vehicle hours and vehicle kilometres of travel between iterations. Note that this will only occur if there is sufficient capacity in the network.
Vehicle Driver Model Components

- **2001 Nelson-Tasman Transportation Model**
- **Gabites Porter**

**Figure 1**

**KEY**
- Traffic Model
- Output from Model/Program
- Data Inputs
- Model Parameters

**ZONE FILE FORMULATION**
- Land Use Data

**TRIP END GENERATION**
- Household Vehicle Driver Trip Rates Attraction Formulae

**TRIP DISTRIBUTION (Gravity Model)**
- Distribution Functions
- Unit of Cost of Travel By Purpose

**MATRIX MANIPULATION (Combining & Averaging)**
- Total Trip Matrix

**ASSIGNMENT**
- Loaded Network (Link Flows, Turning Movements)
- Time and Distance Matrices

**Evaluation**

**Operation Impacts and Benefits**
- Vehicle operating costs Fuel use and emission equations

**Physical Network Description: Links and intersections**
- Network Operation Parameters (signal phasing etc)
- Tolls, Linking
- Delay equations and model parameters
2.2 The Study Area

The 2001 Nelson-Tasman Transportation Model covers the area from Hira in the east, to Tophouse in the south, and Motueka in the west. The area of specific interest in this study is the Corridor Study area illustrated in Figure 2 and Figure 3.

The analysis procedures used in this study required that the study area be divided into a number of smaller areas or zones. These zones were set up to be of approximately similar size (in terms of the amount of activity within them).

The zone system adopted for this study is shown in Figure 4, Figure 5, and Figure 6. Some of the zones contain more than one centroid. These were built into the model to allow for possible zone boundary refinement in the future. These figures also show the locations and identities of the external points to the model, and the extent of the transport network.

Where possible it follows Department of Statistics meshblock boundaries, combining them to create homogeneous zones. The meshblock to zone lookup table is contained in the Appendix.

The zone system consists of a total of 650 zones consisting of the following:

- 503 internal land use zones
- 110 Nelson CBD parking zones
- 31 spare zones for future model refinement
- 6 external zones
2001 Nelson-Tasman Transportation Model
Gabites Porter

2001 Corridor Study Area

Figure 2

KEY
- Road
- Land
- Corridor Study Area
Figure 3: 2001 Corridor Study Area Detail

Key:
- Road
- Land
- Corridor Study Area

2001 Nelson-Tasman Transportation Model
Gabites Porter
2001 Nelson-Tasman Transportation Model

Gabites Porter

2001 Model Zones

Figure 4

KEY
- State Highway
- Main Road
- Minor Road/lane
- Land
- Sea
- Green: Zone Boundary and number
- Yellow: Detail contained in separate Figure

kilometers
Figure 7

2001 Nelson CBD Zones

KEY
- State Highway
- Main Road
- Minor Road/lane
- Land
- Sea
- Zone Boundary
- Detail contained in separate Figure

2001 Nelson-Tasman Transportation Model

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GABITES PORTER Transportation Planning and Engineering Page 12
2.3 The Road Network

The road network used for the study is a subset of the overall road system. It includes all major and minor arterials and selected collector and local roads, carefully chosen to allow for public transport routes to be allocated later. Those roads which are included are shown in Figure 10, and Figure 11 and have been mapped to closely match the council's GIS.

Because the network is a true representation of a road, then the distances are calculated directly from the co-ordinate data. This removes the need to manually code distances and also removes the potential for coding errors.

All other components of network coding were prepared from visual inspection or from the Council’s set of aerial photos, for example:

- Link lanes
- Link free flow speeds
- Approach controls
- Approach lanes

All roundabouts and priority intersections were coded into the network. One of the features of TRACKS is the ease of intersection coding, whereby only the lane disciplines are required for priority intersections. Conflicting movements are internally identified from the geometry of the network.
Figure 10

External 650 - SH60 at Riwaka
External 645 - SH6: North of Hira
External 646 - Matai Valley Road
External 649 - SH6: South at Kawatiri Junction
External 648 - Kerr Hill Road @ Tophouse Road

KEY
- State Highway
- Main Road
- Land
- Sea
- Study Boundary

Model Area Road Network
Figure 11

Model Road Network - Nelson City

2001 Nelson-Tasman Transportation Model

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3. EXISTING LAND USE AND TRAFFIC DATA

3.1 Existing Land Use (2001)

Key land use variables used in the model, were compiled from 2001 Census meshblock level to traffic zone level. Table 3 summarises the land use variables used and the 2001 land use totals that apply to the study area. The zonal land use values used for the model are included in the Appendix.

<table>
<thead>
<tr>
<th>Main Land Use Categories</th>
<th>Description of Land Use Categories</th>
<th>Code</th>
<th>Study Area Totals 2001</th>
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<tr>
<td>Residential</td>
<td>Total Households</td>
<td>HH</td>
<td>29,019</td>
</tr>
<tr>
<td></td>
<td>Total Population</td>
<td></td>
<td>75,269</td>
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<tr>
<td>Employment</td>
<td>Agricultural</td>
<td>AGR</td>
<td>4,899</td>
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<td></td>
<td>Manufacturing</td>
<td>MAN</td>
<td>5,806</td>
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<tr>
<td></td>
<td>Wholesale</td>
<td>WHO</td>
<td>1,500</td>
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<td>Retail</td>
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<td>Office</td>
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<td></td>
<td>Community</td>
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<td></td>
<td>Total Jobs</td>
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<tr>
<td></td>
<td>Tertiary Roll</td>
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</table>

There are 47,106 cars in the network and 29,019 households, which brings the Average Number of Vehicles per household (VEH/HH) to 1.62. There are 75,269 people in the study area and 29,019 households, which yields an Average Persons per Household (PER/HH) of 2.59.

Plots depicting the number of household in each zone are included in Figure 12, Figure 13, Figure 14, Figure 15, Figure 16, and Figure 17, and Plots of the total number of jobs by workplace zone are included in, Figure 18, Figure 19, Figure 20, Figure 21, and Figure 22.

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1 At the workplace meshblock the number of jobs available are represented by ANZSIC classification.
2001 Total Households by Zones
Model Area

Figure 12
Figure 14

2001 Total Households by Zones
Nelson and Richmond

KEY
- State Highway
- Main Road
- Road/Lane
- Zone Boundary and Number of Households

1-Households/sq. km
- 1,100 to 2,430 (100)
- 1,040 to 1,180 (47)
- 860 to 1,240 (52)
- 600 to 800 (48)
- 400 to 600 (46)
- 230 to 400 (44)
- 60 to 230 (48)
- 30 to 60 (15)
- 0 to 30 (13)
Figure 15

2001 Total Households by Zones
Nelson CBD

KEY
- State Highway
- Main Road
- Road/Lane
- Zone Boundary and Number of Households

2001 Nelson-Tasman Transportation Model
Gabites Porter
Figure 16

2001 Total Households by Zones
Stoke

Table 16

<table>
<thead>
<tr>
<th>Zone Boundary and Number of Households</th>
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</thead>
<tbody>
<tr>
<td>1,100 to 2,400 (103)</td>
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<tr>
<td>1,100 to 1,399 (47)</td>
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<td>500 to 1,249 (52)</td>
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<td>200 to 249 (44)</td>
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<td>150 to 199 (44)</td>
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<tr>
<td>100 to 149 (44)</td>
</tr>
</tbody>
</table>

KEY
- **State Highway**
- **Main Road**
- **Road/Lane**
- **Zone Boundary and Number of Households**