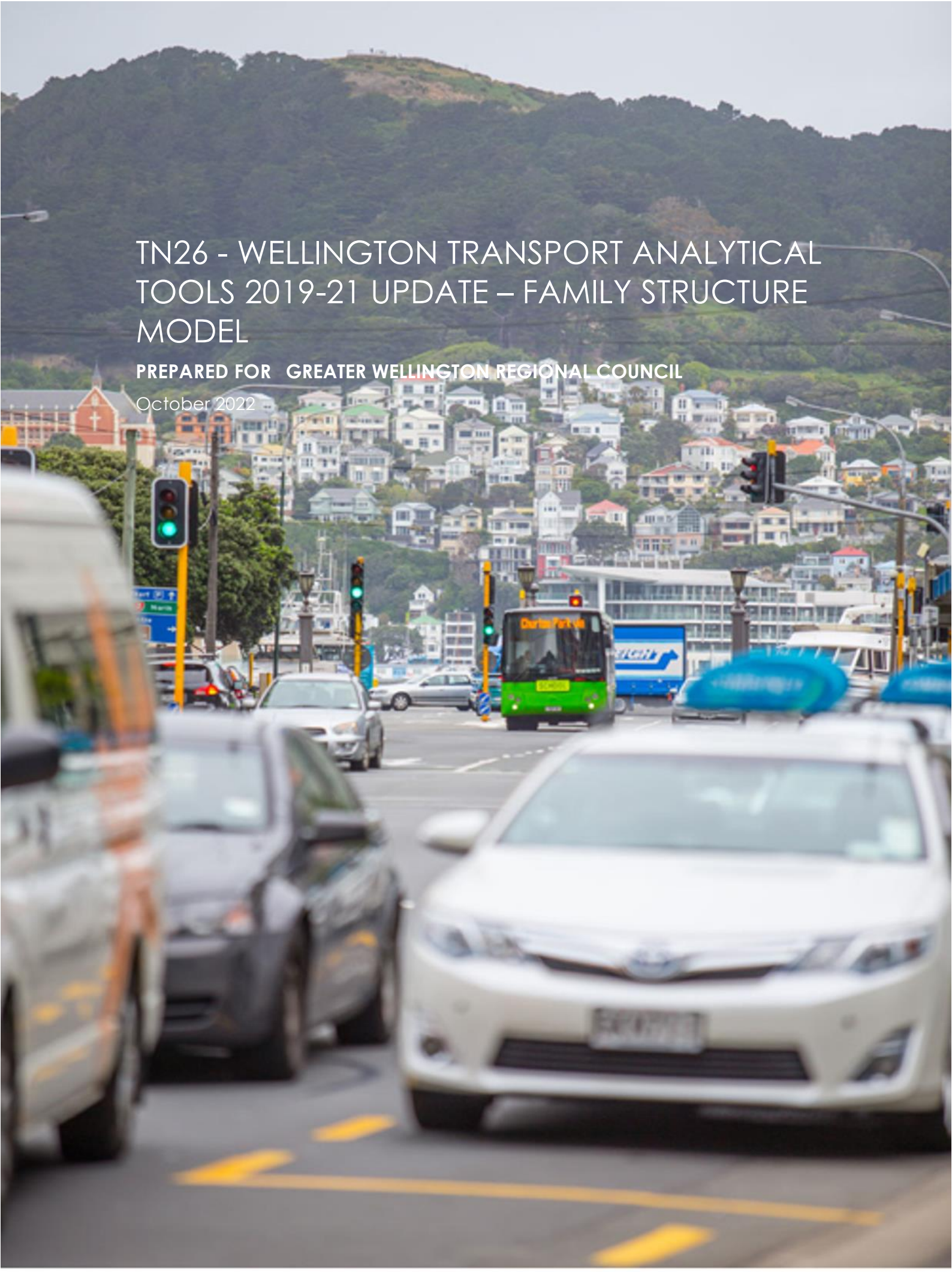

TN26 - WELLINGTON TRANSPORT ANALYTICAL TOOLS 2019-21 UPDATE – FAMILY STRUCTURE MODEL

PREPARED FOR GREATER WELLINGTON REGIONAL COUNCIL

October 2022

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QUALITY STATEMENT

PROJECT MANAGER		PROJECT TECHNICAL LEAD
Ali Siddiqui		Julie Ballantyne

PREPARED BY		
Sophia English		14/10/2022
CHECKED BY		
Julie Ballantyne		14/10/2022
REVIEWED BY		
Geoffrey Cornelis		14/10/2022
APPROVED FOR ISSUE BY		
Julie Ballantyne		14/10/2022

CHRISTCHURCH
Hazeldean Business Park, Level 2, 2 Hazeldean Road, Addington, Christchurch 8024
PO Box 13-052, Armagh, Christchurch 8141
TEL +64 3 366 7449, FAX +64 3 366 7780

REVISION SCHEDULE

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Greater Wellington Regional Council

TN26 - Wellington Transport Analytical Tools 2019-21 update – Family Structure Model

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1. Introduction

This technical note is part of a series documenting the 2019-2022 update of components of the Wellington Regional Transportation Planning Analytical Tools. The higher-level Analytical Tools are maintained and operated by Greater Wellington Regional Council (GWRC), who are the client for this project. This project is being primarily delivered by Stantec and Jacobs, supported by GWRC transport planners.

This technical note documents the creation of the family structure model, which is the formation of the two-dimensional population matrix to which trip production rates are subsequently applied.

2. Population by Age

Census data for population broken down into age groups was obtained for the model zones. The population definition used is Estimated Resident Population (ERP) which was obtained by factoring up Census Usually Resident Population (CURP) as outlined in Section 4.2. The age bands were aggregations of the bands used in the Census, and were chosen as such to be representative of lifestyle categories (for example school age, high school/university age etc). The age bands are:

- 0-14 years old
- 15-19 years old
- 20-29 years old
- 30-64 years old
- 65+ years old

The Census data was aggregated into 11 sectors shown graphically in Figure 2-1.

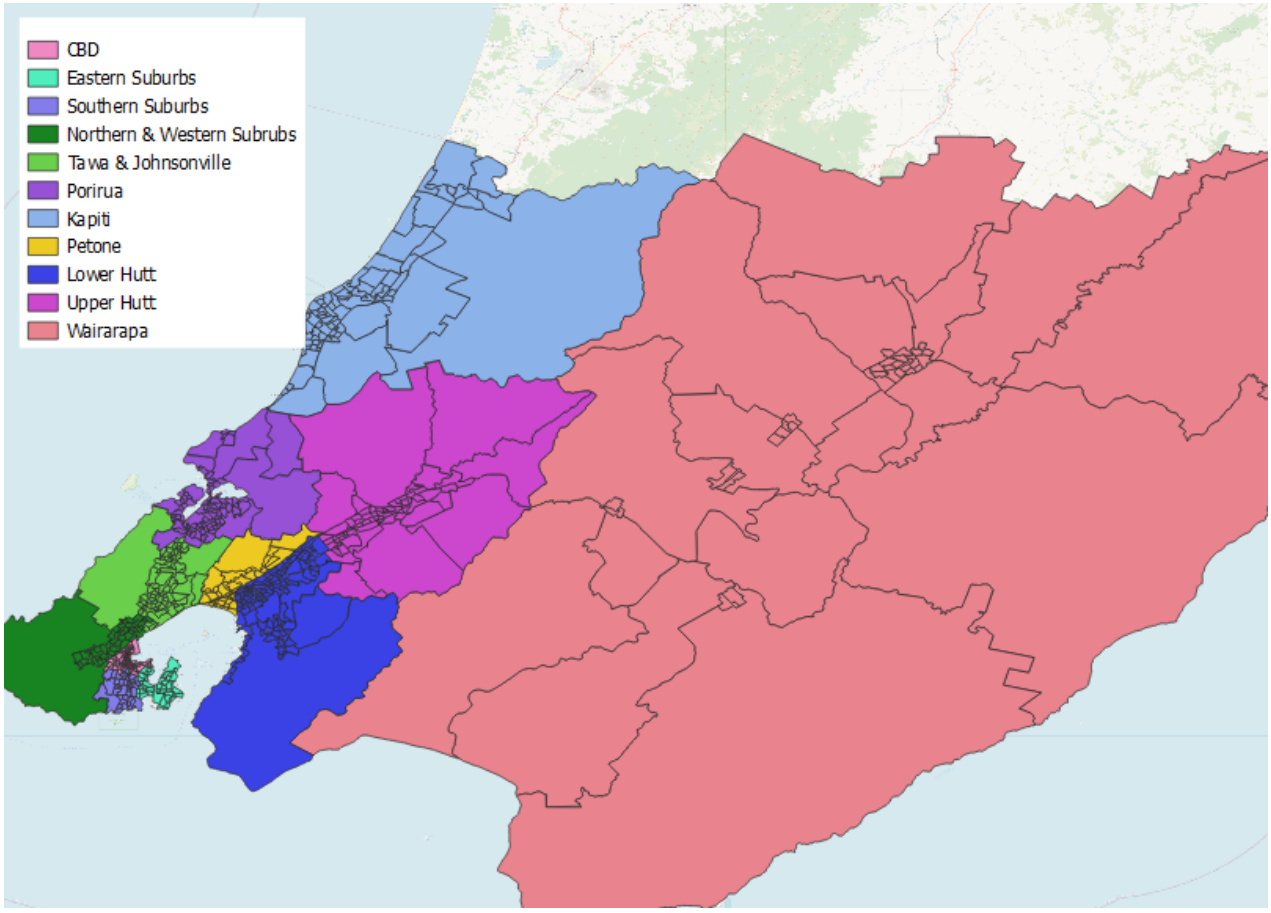

Figure 2-1 11 Sectors

The population by age for the 11 sectors shown in Figure 2-1 can be seen in Table 2-1.

Table 2-1 Population by age and sector

		Age Band					
		0-14 yrs	15-19 yrs	20-29 yrs	30-64 yrs	65+ yrs	TOTAL
Sector	CBD	2,368	2,788	13,385	14,172	3,297	36,009
	Eastern Suburbs	6,866	2,167	5,524	17,846	4,274	36,677
	Southern Suburbs	6,587	2,533	9,806	18,683	3,395	41,004
	Northern & Western Suburbs	8,637	2,835	5,239	20,672	4,784	42,166
	Tawa & Johnsonville	11,743	3,712	6,945	27,046	5,787	55,233
	Porirua	14,185	4,146	7,182	26,722	6,891	59,127
	Kapiti	9,805	3,165	4,309	23,640	14,136	55,055
	Petone	5,063	1,454	3,439	12,920	3,073	25,948
	Lower Hutt	17,320	5,545	10,723	37,744	11,460	82,792
	Upper Hutt	9,226	3,027	5,120	21,358	6,609	45,340
	Wairarapa	9,109	2,676	4,284	20,768	9,972	46,810
	TOTAL	100,908	34,048	75,956	241,570	73,678	526,160

3. Population by Vehicle Availability

Vehicle availability is the number of people that live in households with either zero, one, two or three or more vehicles available to that household. Census data for population broken down into vehicle availability was obtained for the model zones.

A synthetic model to allocate population into vehicle availability by household was created and tested against this Census data. The synthetic model takes the average vehicles per person by zone (a model input) and translates this into the proportion of persons within the zone with zero, one, two or three plus vehicles available at their household. This is then applied to the number of persons in each zone. Refer to TN18 – Wellington Transport Analytical Tools 2019-22 update – vehicle availability model dated August 2022 for more information about this synthetic model.

4. Population by Age and Vehicle Availability

4.1 Approach

Population broken down by age and vehicle availability can be extracted from Census data, however it is not forecasted at this disaggregated level for future years. Therefore, the proposed approach is to cross multiply Census population (ERP) proportions by age and Census population by vehicles per household. A simple example of this calculation using dummy numbers can be seen below.

Table 4-1 Example cross multiplication population

		Population
Age Band	0-14 yrs	25
	15-19 yrs	5
	20-29 yrs	6
	30-64 yrs	80
	65+ yrs	20
	TOTAL	136

Table 4-2 Example cross multiplication vehicles per household

	No of vehicles per household			
	0	1	2	3+
Synthetic curve percentage	0.03	0.32	0.43	0.22

When these above two tables are cross multiplied, the result is the population by age group, by vehicle availability.

Table 4-3 Example cross multiplication result

Population		No of vehicles per household				
		0	1	2	3+	TOTAL
Age band	0-14 yrs	0.75	8.00	10.75	5.50	25
	15-19 yrs	0.15	1.60	2.15	1.10	5
	20-29 yrs	0.18	1.92	2.58	1.32	6
	30-64 yrs	2.40	25.60	34.40	17.60	80
	65+ yrs	0.60	6.40	8.60	4.40	20

This calculation was performed using the two quantities of one dimensional Census data at a model zone level. This was compared to two-dimensional Census data and the results analysed outlined in section 4.2 below.

4.2 Check using Census Data

Census data was obtained as a special request from Statistics NZ. This is CURP broken down by age and vehicle availability for the model zones.

This data was processed to:

- remove 'C''s (when sample is too small, Statistics NZ put a C in the cell to ensure the data is not identifiable)

- remove "Other" and reallocate in proportion to zero, one, two, or three plus vehicles per household (allocated to "Other" when the answer was not provided)
- factor from CURP to ERP Census population definition by Territorial Authority (to factor up total to align with definition for future year population projections)

This two dimensional Census data was used to cross check against the cross multiplied one dimensional data as outlined in section 4.1. The results can be seen in Table 4-4 and Figure 4-1.

Table 4-4 Two dimensional Census data vs cross multiplied one dimensional Census data results

Age	Car Ownership	Sum of Census - Two Dimensions	Sum of Census - proportions multiplied	Difference		Difference (proportion of total population)
0-14 Years old	0	3,660	5,510	51%	1,851	0.4%
	1	34,354	33,052	-4%	-1,302	-0.2%
	2	48,383	41,941	-13%	-6,442	-1.2%
	3+	14,511	20,395	41%	5,883	1.1%
	TOTAL	**100,908**	**100,898**	**0%**	**-10**	**0.0%**
15-19 Years old	0	2,702	2,594	-4%	-109	0.0%
	1	8,442	11,173	32%	2,731	0.5%
	2	12,900	13,558	5%	658	0.1%
	3+	10,004	6,723	-33%	-3,281	-0.6%
	TOTAL	**34,048**	**34,048**	**0%**	**0**	**0.0%**
20-29 Years old	0	9,504	9,275	-2%	-229	0.0%
	1	21,193	27,279	29%	6,086	1.2%
	2	23,300	26,800	15%	3,500	0.7%
	3+	21,959	12,592	-43%	-9,368	-1.8%
	TOTAL	**75,956**	**75,946**	**0%**	**-10**	**0.0%**
30-64 Years old	0	13,922	15,554	12%	1,632	0.3%
	1	79,108	80,000	1%	892	0.2%
	2	100,993	98,299	-3%	-2,694	-0.5%
	3+	47,547	47,679	0%	132	0.0%
	TOTAL	**241,570**	**241,532**	**0%**	**-38**	**0.0%**
65+ Years old	0	7,440	4,278	-43%	-3,162	-0.6%
	1	33,122	24,785	-25%	-8,336	-1.6%
	2	25,031	30,025	20%	4,994	0.9%
	3+	8,085	14,581	80%	6,496	1.2%
	TOTAL	**73,678**	**73,670**	**0%**	**-8**	**0.0%**

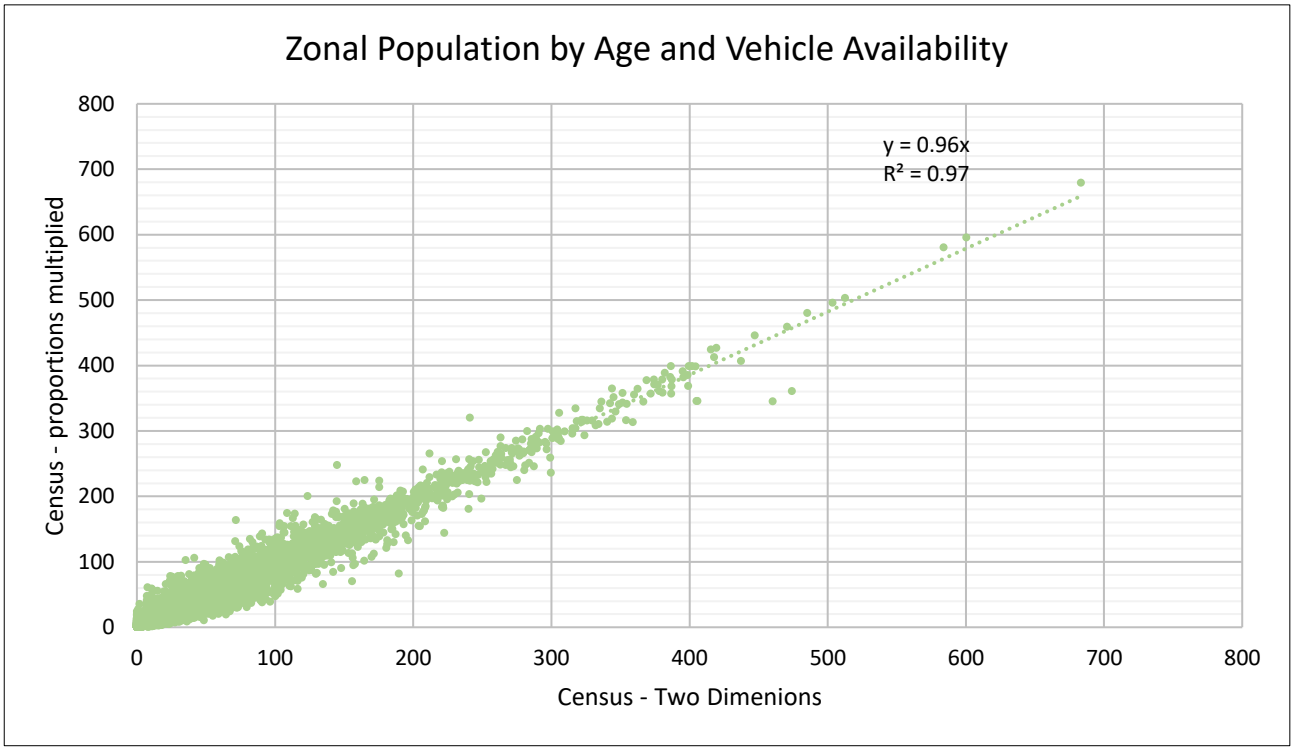

Figure 4-1 Two dimensional Census data vs cross multiplied one dimensional Census data scatter plot

As can be seen in Table 4-4, the results are varied across the different age and car ownership categories with the closest matching disaggregation being 30-64 years old with access to 3+ cars, and the largest difference being 65+ years old with access to 3+ cars with a difference of 80%. When these differences are considered as a percentage of total population, all differences are less that 2% which is a very small proportion of the total.

The lowest level disaggregation that should be considered is the population by sector, by age group, and by car ownership. A comparison of the two dimensional Census data and the cross multiplied one dimensional Census data at this level of disaggregation can be seen in Figure 4-2. Note that this figure shows the two dimensional Census data bars as transparent with a black outline overlayed over the coloured bars for the one dimensional Census data. The largest absolute difference is an under modelled population of 2,081 (-29%) for Kapiti, 65+ years and one car available, however this difference is only representative of 0.4% of the total population. All differences are representative of less than 0.4% of the population.

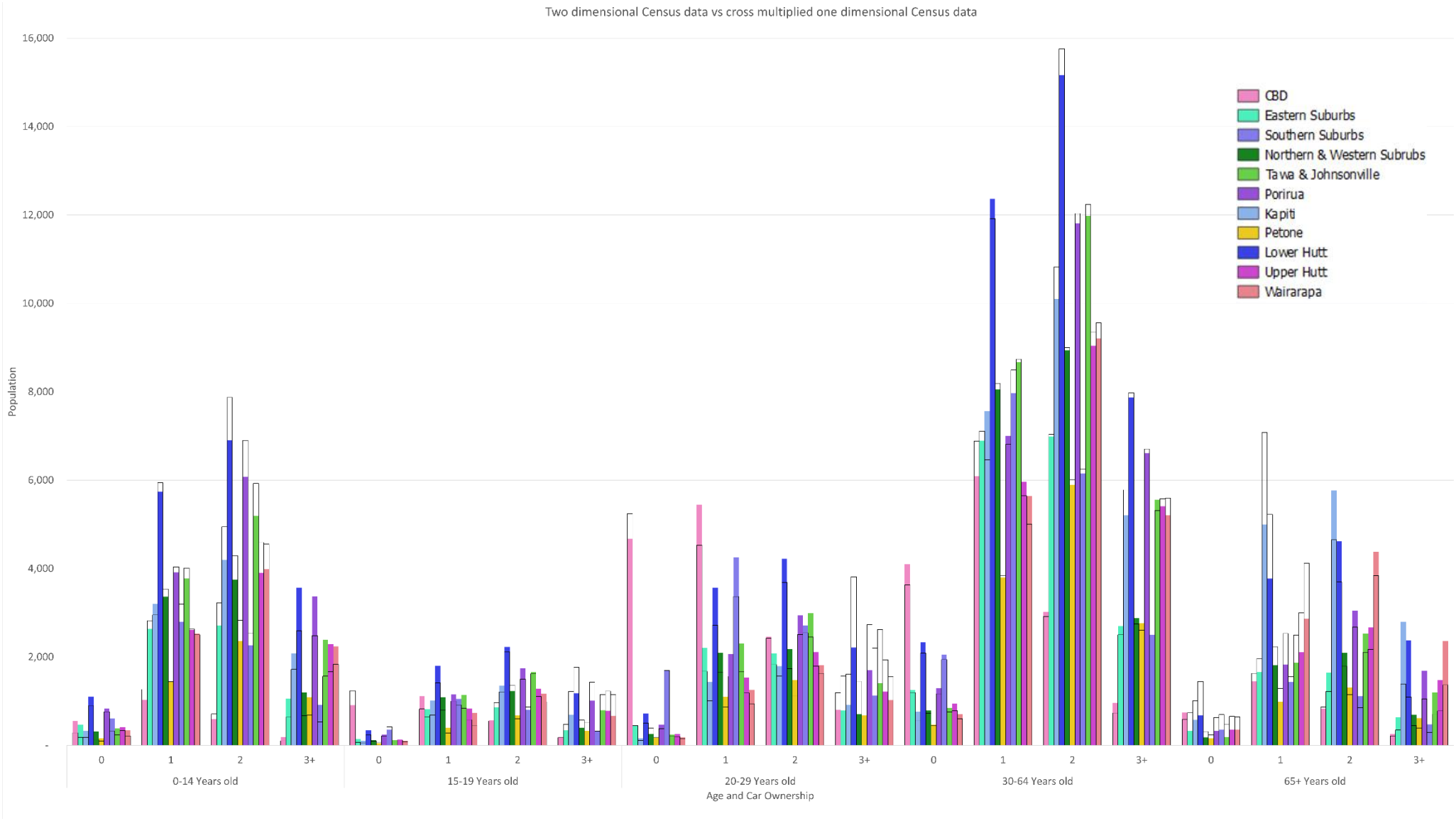

Figure 4-2 Two dimensional Census data vs cross multiplied one dimensional Census data by age group, vehicle type and sector

4.3 Check using Modelled Vehicle Availability

The final step in the cross multiplication process to model the population by age and by vehicles per household was to replace the Census population by vehicles per household with the synthetic modelled vehicles per household as outlines in section 3. The cross multiplication of the one dimensional Census population (ERP) by age and the synthetic vehicle availability by household proportions was compared to the two dimensional Census data as outlined in section 4.2. The results can be seen in Table 4-5 and Figure 4-3.

Table 4-5 Two dimensional Census data vs modelled results

Age	Car Ownership	Sum of Census - Two Dimensions	Sum of Model	Difference		Difference (proportion of total population)
0-14 Years old	0	3,660	6,063	66%	2,403	0.5%
	1	34,354	34,078	-1%	-275	-0.1%
	2	48,383	40,453	-16%	-7,930	-1.5%
	3+	14,511	20,319	40%	5,807	1.1%
	TOTAL	**100,908**	**100,913**	0%	5	0.0%
15-19 Years old	0	2,702	2,729	1%	27	0.0%
	1	8,442	11,494	36%	3,052	0.6%
	2	12,900	13,197	2%	297	0.1%
	3+	10,004	6,631	-34%	-3,374	-0.6%
	TOTAL	**34,048**	**34,051**	0%	2	0.0%
20-29 Years old	0	9,504	8,955	-6%	-549	-0.1%
	1	21,193	26,964	27%	5,771	1.1%
	2	23,300	27,024	16%	3,724	0.7%
	3+	21,959	13,017	-41%	-8,943	-1.7%
	TOTAL	**75,956**	**75,960**	0%	3	0.0%
30-64 Years old	0	13,922	15,574	12%	1,653	0.3%
	1	79,108	80,684	2%	1,577	0.3%
	2	100,993	96,446	-5%	-4,547	-0.9%
	3+	47,547	48,881	3%	1,334	0.3%
	TOTAL	**241,570**	**241,586**	0%	16	0.0%
65+ Years old	0	7,440	3,727	-50%	-3,713	-0.7%
	1	33,122	23,496	-29%	-9,625	-1.8%
	2	25,031	30,606	22%	5,575	1.1%
	3+	8,085	15,853	96%	7,768	1.5%
	TOTAL	**73,678**	**73,682**	0%	4	0.0%

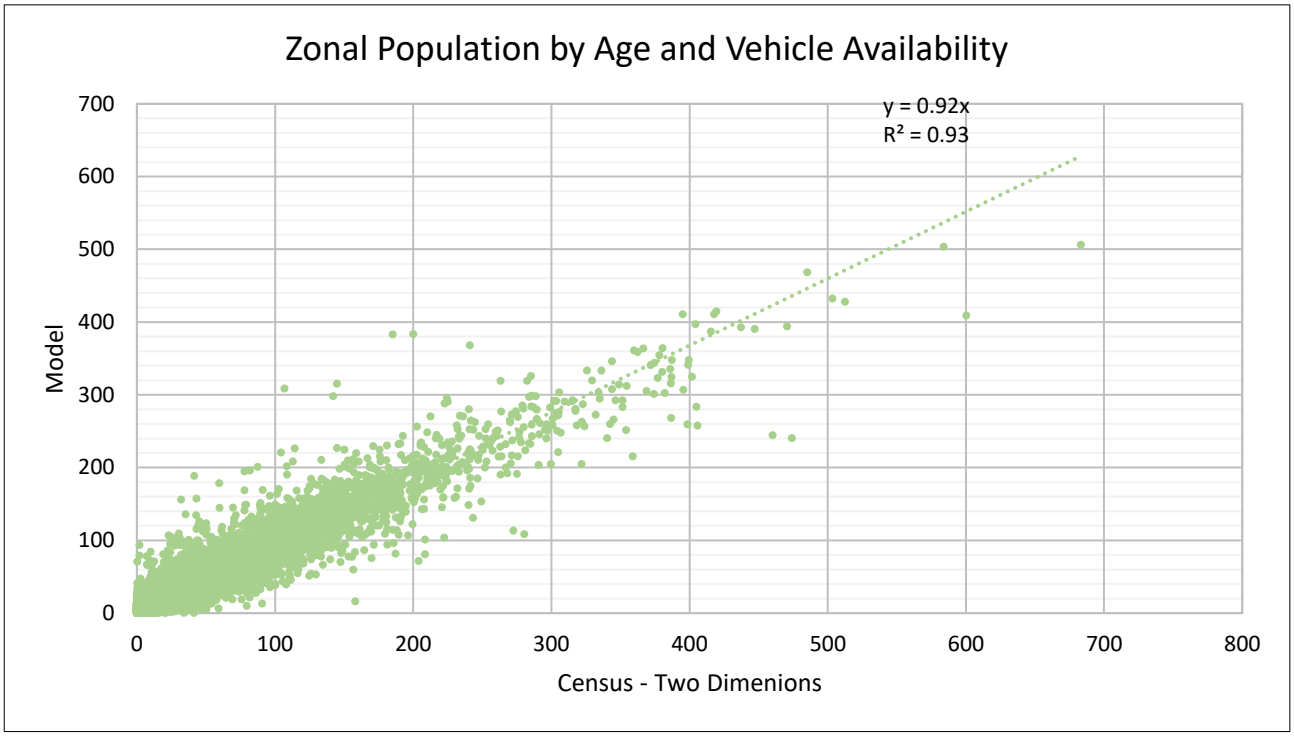

Figure 4-3 Two dimensional Census data vs Modelled scatter plot

As can be seen in Table 4-5, the results are varied across the different age and car ownership categories with the largest absolute difference being 65+ years old with access to 1 car with a difference of 29%. When these differences are considered as a percentage of total population, all differences are less than 2% which is a very small proportion of the total, as was seen in the cross multiplied Census data when compared to the two dimensional Census data.

A comparison of the two dimensional Census data and the modelled by age group, vehicle accessibility and sector can be seen in Figure 4-4. Note that this figure shows the two dimensional Census data bars as transparent with a black outline overlayed over the coloured bars for the modelled data. The largest absolute difference is an under modelled population of 3,235 (-46%) for Kapiti, 65+ years and one car available, however this difference is only representative of 0.6% of the total population. All differences are representative of less than 0.6% of the population which indicates that the model is a good estimate of population by age group, car availability and sector.

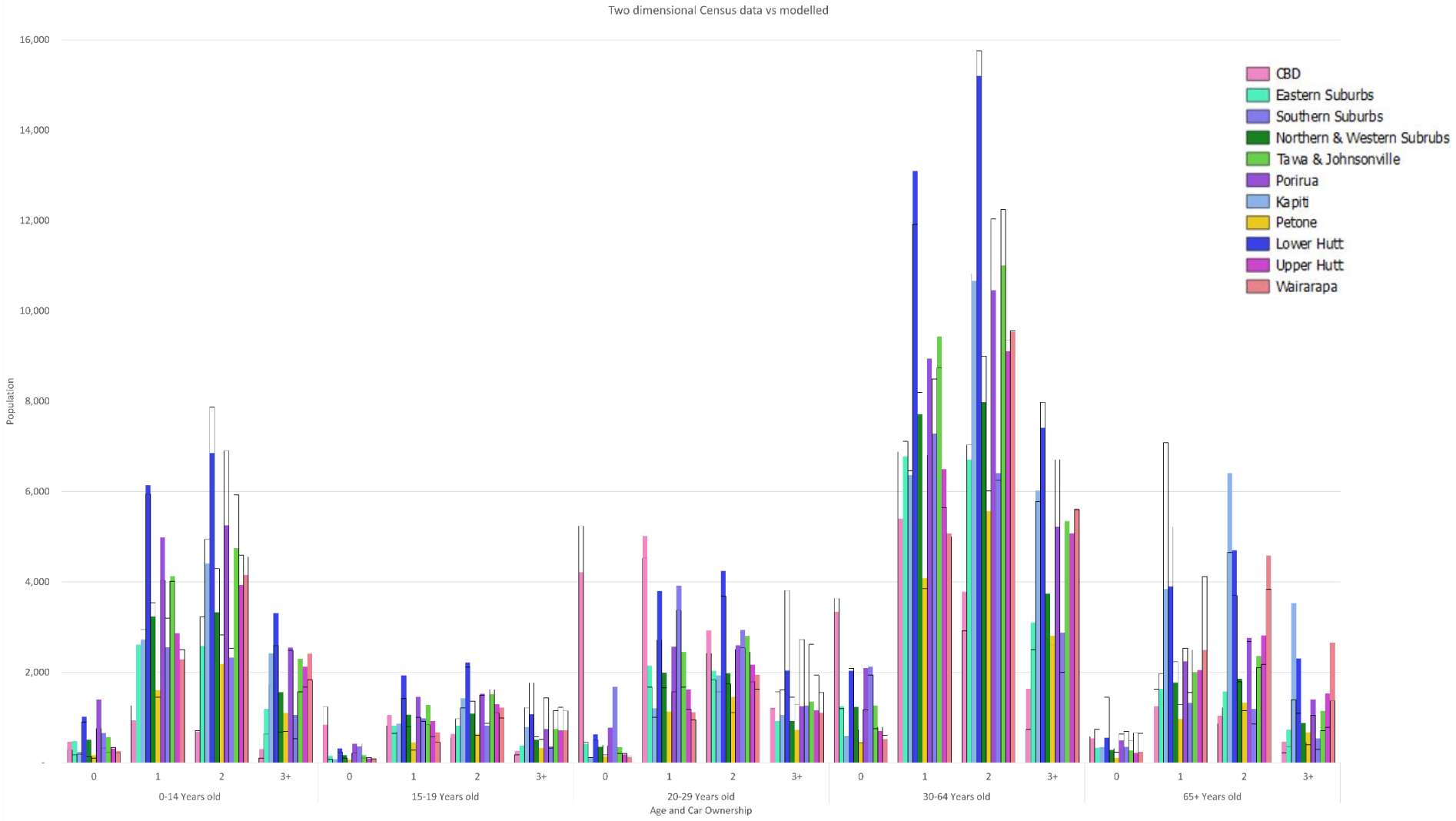

Figure 4-4 Two dimensional Census data vs modelled by age group, vehicle type and sector

5. Summary

This technical note outlined the approach used in the family structure model, which is a two-dimensional population matrix which breaks down population by age group and vehicle availability for each travel zone.

The modelled population is calculated as population by age group (an input to the model) cross multiplied by a synthetic proportion of vehicle availability for 0, 1, 2 and 3+ cars. These vehicle availability proportions need to be calculated using a synthetic model due to the difficulty in forecasting vehicle availability in future years (refer to TN18 – Wellington Analytical Tools 2019-21 update – Vehicle Availability for more information). These modelled populations were compared to two dimensional Census data obtained at the same level of disaggregation and found to be a good estimation, with all differences between modelled and Census data, less than 0.6% of the total population.

This family structure model may need to be revisited and potentially updated or adjusted for particular zones or sectors once the full model is pieced together.

Appendices

Appendix A Comments and Responses

No.	Comment By	Comment	Response
1	Ian Clark, Peer Reviewer	Section 2: age bands. I think we've discussed these before, relating to Waikato. Strictly speaking I would think that teenagers of 15-16 have different travel characteristics than those of 17-19, with some 17 year olds and upwards being able to drive cars. And travel patterns would change for 0-14 year olds, with increasing independence, ability to cycle etc. But I recognise you have to work within the standard census age bands.	Yes, we preferred to retain the Census age bands to maximise transparency for future Census updates. We concur that there will be differences in travel behaviour within the 15-19 years old band. But the HTS should reflect this. While 15-19 years is probably the band with the most variation, there will be similar differences for other bands. For example, 30-64 years old, some will have children while others won't, some will be employed while others won't. This will affect whether school or work trips are made. The model works on averages, and that the behaviour of the people in each age band is reflected in the HTS.
2		This technical note is about the base model, but Section 4.1 refers to future years and I am unclear why, when different car availability will be assumed in the future.	We are explaining that we can get 2018 population by vehicle availability and age, but this information is not available for any future year and hence we have to build a model to forecast what we already have. Let me know if that does not clarify and we will reword the sentence.
3		Another point of detail. The values in Table 4-2 add up to 1.02 – I recognise that the text says that these are dummy numbers, but is just this rounding?	It is rounding, but we have modified so that Table 4-2 sums to 1.00, and have carried these changes through to Table 4-3.
4		I wonder if the statement that all differences are representative of less than 0.6% of the population underplays the significance of accuracy on this topic – if all of the 0.4%s are a bit out, then presumably the model may not validate well. However, the scatterplots indicate a reasonable correlation, and the punchline of the technical note, as with most others in the series, is that the proof will be in the validation, and some modifications to the approach or to particular zones/sectors may be necessary at a later stage.	Agree, it is difficult to know if the inaccuracy in any model component is significant until we bolt them together. We will be able to confirm suitably, or otherwise, at the stage when the model is running. At this point, we will revisit and adjust models as required.
5	Andy Ford	Agree with Ian around 15/16 and 17/19 year old travel patterns being different, but not much we can do given Census data definitions.	Yes, agreed.
6		Lots of old people in Kapiti, lots of young'uns in Wellington CBD – the serious point being the age group splits seem plausible.	Good to know

No.	Comment By	Comment	Response
7		Section 3 refers to the synthetic model (TN18) but my recollection is that this model did not fit for CBD / south, so we have just directly taken the Census data for the base and will need to develop appropriate car availability assumptions for the future models?	The model to predict average vehicles per person per zone did not fit well in the CBD/South, and hence this data will be an input to the model. The text has been modified to make this clearer. The allocation of people to zero, one, two, or three plus vehicle households is still a synthetic model.

Christchurch
Hazeldean Business Park, 6 Hazeldean Road
Addington, Christchurch 8024
PO Box 13-052, Armagh
Christchurch 8141
Tel +64 3 366 7449
Fax +64 3 366 7780

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