PALMERSTON NORTH AREA TRAFFIC MODEL

Peer Review Report

(including Beca responses to issues raised)

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for: **Palmerston North City Council**

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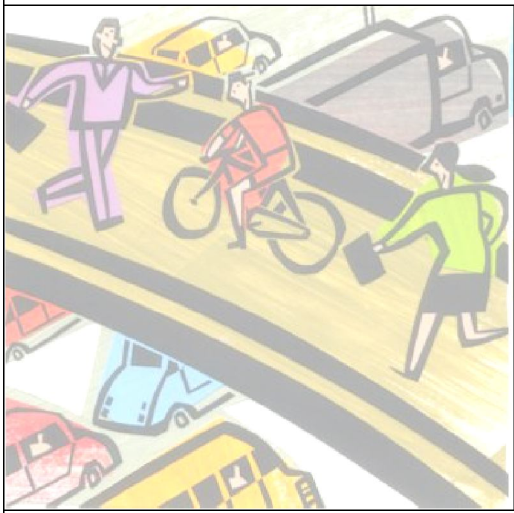
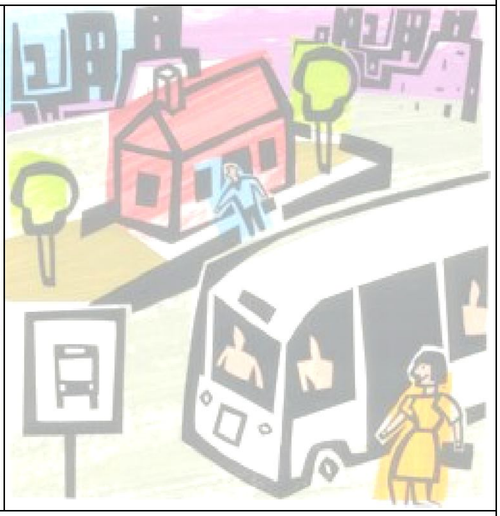
Reference: pncc traffic model peer review v2 jan15





PALMERSTON NORTH
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Version Control

Report Version	Date Issued	Change(s)
v1	28 Nov 14	•
v2	26 Jan 15	• final recommendations table updated with Beca responses to issues raised

1 Background & Scope

1.1 Background

In common with all larger urban areas in New Zealand, the Palmerston North City Council (PNCC) uses modelling techniques to quantify the effects of specific developments, plan changes and policies upon the operation of the transportation network.

Until recently, PNCC used a model for this purpose which was originally developed in the early 1990's using the TModel2 software. The model was updated in 2002 using land use data from the 2001 census and since this time has formed the basis of several studies, including the development of the Palmerston North Transportation Management Plan. The model was further updated in 2007 using data from the 2006 census.

This model had a number of limitations, primarily an inability to simulate conditions outside of a weekday evening peak period and the treatment of commercial vehicle movements as non-home based vehicles. Furthermore, the underlying demographic information upon which the model was based was dated.

For these reasons, PNCC took an opportunity created by the March 2013 census to develop a new traffic model, to fully reflect the changing demography of the district. A modelling contract was advertised in late 2013 and subsequently awarded to Beca Ltd.

The model has been progressively developed, initially with the preparation of a base-year model for a 2013 weekday period.

1.2 Scope & Information Available

This document presents a review of the base-year model validation.

The information available to this review includes:

- Palmerston North Area Traffic Model – Model Development and Validation Report. Revision A, 6 August 2014;
- Email from Alan Kerr of Beca Ltd, dated 9 October 2014, with responses to comments which had been raised in relation to the report above;
- Palmerston North Area Traffic Model – Model Development and Validation Report. Revision B, 5 November 2014[1]; and
- a discussion with the Beca modelling team at a workshop held on 12 November 2014.

For ease of reference, the section headings of this document broadly follow those of the Model Development and Validation Report.

[1] *(but dated 15 August 2014 on the front page)*

2 General Model Parameters

The key characteristics of the model are:

- a three-stage model (generation / distribution / assignment);
- no mode split element – simulation of traffic movements only;
- 212 zones covering the Palmerston North urban area and adjoining areas;
- base year of a 2013 weekday (between February and November);
- separate AM, Inter-peak and PM peak sub-models;
- separate modelling of light and heavy vehicles; and
- developed using the CUBE Voyager software.

3 Data Sources & Requirements

The process by which matrices of traffic activity were developed was 'synthetic', in that there was no reliance upon the use of directly observed origin-destination information. This is now a common approach in New Zealand, avoiding any requirement for complex and potentially disruptive surveys.

Early in the model development process, it was recognised that this approach would be reliant upon the assembly of good quality information from a number of sources, most significantly census data disaggregated to meshblock level, supplemented by educational roll information and a high density of traffic counts (a number of which intentionally coincided with the 2013 census base-year).

External-external matrix movements were quantified using an innovative approach involving the recording of unique MAC addresses associated with Bluetooth devices. Electronic Road User Charge (ERUC) data was used to develop truck movement matrices.

The road network coding information was collected from a range of sources.

Journey time information has been collected for a range of representative routes across the modelled area using a 'floating car technique', a commonly used and accepted methodology.

In all cases, a range of checks have been undertaken to ensure that the data used is internally consistent.

4 Base Model Specification

4.1 Model Structure

The structure of the model is summarised by a diagram, Figure 3.1. This illustrates a standard three-step model involving generation / distribution / assignment.

The decision not to include a mode-split stage was taken during the scoping of the model contract. This was primarily because patronage rates for public transport in the Palmerston North area are low and the addition of a mode-split function would have significantly added to the complexity and cost of the model while providing little benefit in terms of functionality.

It should be noted that this does not preclude assessments of initiatives to promote the uptake of alternative modes of travel. While the model would not be able to forecast the transfer of trips from road traffic to other modes (or vice versa), it can be used to assess the effects and benefits associated with an assumed reduction (or increase) in vehicle trips on network performance.

4.2 Model Extent

The geographic extent of the model was defined by the model scoping exercise. This appropriately includes the area over which significant travel occurs to and from the Palmerston North urban area. It also extends sufficiently to capture route choice decisions, for example between SH56/57 to the south-west, between SH3/SH57 and between the SH3 Manawatu Gorge, the Saddle Road and the Pahiatua Track.

4.3 Zone System

The study area has been represented with a system of 200 internal and 12 external zones. The zoning system logically uses census meshblocks as its basis, with the smallest zone sizes in areas closest to the centre of the urban area, where greater definition is required.

Sensibly, external zones have been split to differentiate between local and longer distance movements, and a number of empty / spare zones provide flexibility for simulating the effects of future developments.

4.4 Network Representation

Road sections are represented as links in the model. Each link was classified into one of a number of categories depending upon its operating characteristics. The categories then define the lane-capacity and speed-flow (or volume-delay) curves, which are standard relationships successfully applied within a range of other models within NZ.

It should be noted that this categorisation is not based upon the district plan road hierarchy, although a significant degree of commonality can be expected.

Recommendation 1: *a nomenclature issue exists with the road types defined in Table 3.1. In response to an issue raised that the capacity of the 'Arterial' road type appeared low at 1,250 vehs/hour, Beca responded that higher standard arterial roads (such as Main Street and Fitzherbert Avenue) have been coded as 'Rural Low Standard' with a capacity of 1,450 vehs/hour. At the workshop on 12 November, Beca indicated that Table 3.1 would be modified to separately distinguish between 'Arterial Low Standard' and 'Arterial High Standard' road types.*

As a mainly urban network, delays arise primarily at intersections rather than along the connecting links. All intersections were coded by type to simulate delay.

4.5 Base Year and Time Periods

The model development process has recognised the variability in transport activity in Palmerston North associated not only with usual seasonal effects but also the educational year. The base-model period has therefore been appropriately defined as a weekday between February and November in 2013.

Different time periods have been used for the demand and assignment aspects of the model. This is an appropriate technique which seeks to include the dominant trip types whilst properly representing the relatively short peak periods which occur in this area.

Time periods were correctly identified by reference to temporal patterns revealed by count data. Without any severe congestion in this area, such an approach is unlikely to be affected by traffic demands held up at one location appearing significantly later elsewhere in the network.

Figures 3.8 and 3.9 in the report show the process by which the peak time periods at individual count locations were reviewed to identify the overall model peak period. While the approach is clear and there is no reason to indicate that the counts would be in any way unrepresentative, the tables do not reveal the actual count sites used.

Recommendation 2: *identify the count locations used for Tables 3.8 & 3.9.*

An inter-peak modelled hour of 12pm-1pm was identified from the overall inter-peak period of 9.30am – 4pm. As the report notes, inter-peak volumes appear to rise progressively throughout the course of a typical day. While the selected inter-peak modelled period appears to be representative of average inter-peak conditions, no analysis has been provided to support the selection of the 12pm-1pm period, as has been done for the AM and PM peaks. Some commentary should also be provided on the extent to which the counts are directionally balanced in the 12pm-1pm period.

Recommendation 3: *provide justification for the selection of the 12pm-1pm modelled inter-peak period, including a consideration of directional balance in observed counts.*

4.6 Expansion Factors

A set of expansion factors has been derived to estimate daily volumes from those for the constituent modelled periods. This has been appropriately based upon available count information and produces a formula which looks intuitively reasonable.

Importantly, the modelling team has recognised a that the application of network-wide average factors will result in potential anomalies because in practice unique factors apply to each link in the model. A plot of actual vs. estimated ADT values shows a close clustering around the y=x line, although a couple of outlier values exist which are not acknowledged or explained (for which the estimated ADT appears to be around 8,000 vpd against an actual volume of 10,000 vpd).

Recommendation 4: *provide explanation for the two outlier values in Figure 3.10 – where are they and what is the implication, if any, of this under-estimate of ADT values?*

4.7 Trip Purposes

The adopted trip purpose segmentation is appropriate and standard for models of this type.

4.8 Household Structure Model

The disaggregation of households into four size and four car ownership categories is standard practice. A comparison of the observed and estimated household numbers in each category shows a generally good level of correlation.

5 Trip Generation Model

Reference has been made to a wide range of data sources to develop the trip attraction and generation models. All of the data used and the necessary assumptions made during its processing appear reasonable.

As the report notes, the trip generation models require the total number of productions to balance the attractions and some factoring is required to achieve this. The extent of the factoring required is not specified in the report (although in an email it was suggested that this was in the range 0.96 – 1.0).

Recommendation 5: *confirm the extent of factoring required to achieve balance in total attractions and generations.*

The trip production and attraction rates appear reasonable and consistent.

The report describes how external/external and external/internal trips were derived using a combination of Bluetooth and commercial GPS data. As noted in the report, only 1% of trips are external/external.

The model development has recognised a need to address airport-related trips separately, as these would not otherwise be reliably estimated on the basis of employment statistics.

6 Trip Distribution Model

The form of the distribution model is described in detail and conforms to standard practice, utilising a doubly constrained gravity model with conventional impedance and generalised cost functions.

Although the generalised costs shown in Table 5.1 do not appear unreasonable, the derivation of the unit VoT values is unclear.

Recommendation 6: *clarify source of unit VoT values adopted for generalised cost calculations.*

The Home-Based Work (HBW) distribution model has been calibrated against the census 2013 Journey-to-Work (JTW) information, with an acknowledgement that this is reliant upon the JTW information (collected on a single day) being representative of weekday travel patterns. Charts at Figures 5.1 – 5.4 show a good match between the trip length distributions for the HBW and JTW data sets, across different area types, with only a slight tendency for the HBW data to over-state shorter trips of under 5kms.

A sector-sector comparison indicates that this arises partly because trips from the western part of the urban area (sector 3) to the CBD (sector 1) and those within Feilding (sector 10 to 10) are over-represented. Although there is a good correlation between the datasets and an overall difference of only 77 trips in a total of 30,790 (<0.3%), the report would benefit from some discussion of the larger differences shown in the lower part of Figure 5.5 and what implications this might have for the final trips matrices. The lower part of Figure 5.5 is derived by the subtraction of the JTW data from the HBW data, not the other way around as indicated in the title.

Recommendation 7: *provide some discussion regarding the larger differences between the individual sector-sector values shown by Table 5.5.*

Section 5.7 of the report describes how the sectoring system was extended to 15 sectors for the derivation of the K-factors. While this is logical, it is not clear why, for consistency, this 15-sector system was not used for the preceding sector-sector comparisons.

Recommendation 8: *adopt 15-sector system for reporting in Section 5.6 (or explain why this is not possible).*

The final adopted impedance functions in Table 5.4 appear reasonable. The report acknowledges the difficulty in the establishment of accurate values for trip purposes other than HBW but has utilised information from other models to determine appropriate values.

7 Time Period Model

A standard set of procedures is described to derive and apply factors to adjust from the 24 hour trip matrices to those for peak periods and then peak hours.

Reference has been made to the time period/directional factors derived for a number of other models and the final factors applied appear reasonable.

Count data was used to derive factors between peak demand periods and the peak hours. The factors derived for the AM and PM peaks are only slightly above 0.5, suggesting that the peak hour is not much more intense than the whole two-hour period. This seems slightly surprising and it would be of interest if comparisons could be provided with the corresponding factors derived from other models.

Recommendation 9: *compare peak period to peak hour factors with those from other models as a 'reality check'.*

8 Assignment Model

The basis of the assignment methodology is described along with the calculation of the generalised cost function.

The report states that the light and heavy types are assigned separately using differing path building parameters and Table 7.1 shows different toll weights applied to the two categories. It would be helpful if some explanation was provided of how the toll weights were established and the degree to which the overall assignment is sensitive to these values.

Recommendation 10: *provide more information regarding the derivation of the toll weights applied in the generalised cost formulation.*

9 Model Calibration & Validation

9.1 General Approach

A systematic approach has been followed, in which the tasks involved in the calibration and validation stages have been clearly identified and separated.

9.2 Matrix Estimation – Light Vehicles

All synthetic models are reliant upon a degree of matrix estimation, in which the origin-destination movements are adjusted to better reflect observed counts on the street network.

Again, a systematic and closely-controlled approach has been adopted, in which the networks have been thoroughly audited first before the application of matrix estimation in stages in order to identify the optimal level of estimation which avoids excessive change to the 'prior' trip matrices.

The results presented indicate that the extent of change in the matrices is small in all three time periods, not only in terms of the overall number of trips but also the distribution of trips between different journey lengths. A very slight tendency towards an increase in shorter trips (and hence a reduction in the average trip length) is evident as a result of some infilling of movements within the central city area.

9.3 Commercial Vehicle Matrix Development

Commercial vehicle GPS tracking data has been combined with a synthetic HCV matrix to generate HCV matrices. The adjustments which have been necessary as part of this process appear reasonable.

The final HCV matrices are not presented in the report – it would be useful for the final matrices to be provided in a sectored format in order to check that the pattern of movements accords with expectations.

Recommendation 11: *provide sectored HCV matrices.*

9.4 Model Validation Results

Validation has been appropriately presented against the guidelines of the Economic Evaluation Manual (EEM) but also with reference to the draft guidelines prepared by the NZ Modelling User Group (NZMUGS), which are generally regarded as being more relevant.

Relevant validation criteria are presented in Table 10.1. This (and other tables) should clarify that the targets differ in terms of whether they are maximum or minimum values. For the GEH and R^2 statistics, the values shown are minima (i.e. ideally to be exceeded) and for the RMSE the value specified is a maximum (i.e. ideally not to be exceeded).

Recommendation 12: *clarify status of validation targets in tables.*

The report presents a wide range of validation statistics, differentiated by count sets and level of matrix estimation. Furthermore, recognition has been given to the differing validation criteria by model type as defined by the NZMUGS criteria.

It would be sufficient simply to demonstrate that the relevant link validation criteria for Model Type C (urban area traffic assignment model) were achieved for the 'ME' dataset (which is easily the case), although other results indicate that even without the application of any matrix estimation the (less demanding) EEM criteria would be met.

Scatterplots of observed and modelled count values show a high degree of correlation with no obvious exceptional outlier values.

Reasonable results are achieved for turn validation. As the report notes, this is a greater challenge, given the grid network in Palmerston North which means traffic may easily change route or split over a number of routes which are similar in terms of time and distance. The corresponding scatterplots reveal a number of outlier values which are only addressed collectively in the context of the overall good values of R^2 which are achieved. It would be helpful if these outlier values were separately identified and addressed to provide confidence that routing issues within the grid network are likely to be the explanation (for example, the model exceeding the observed count at one location might be broadly balance by the observed count exceeding the model at another).

Recommendation 13: *provide more information in relation to turning movement outlier values.*

The report suggests some problems associated with the quality of the travel time data collected by PNCC, and with only three survey runs on each route, there is potential for significant statistical sampling variability.

Overall, the degree of journey time validation achieved appears reasonable (as shown by the scatterplots).

It is noted that journey time validation is only presented in terms of the total time observed or modelled for each route. For longer routes, it is possible that under-estimation on one section may be cancelled out by over-estimation on another section, and for this reason the presentation of the results in the form of 'worm diagrams' (which show cumulative time vs. cumulative distance) can be helpful to identify specific locations where modelled journey times differ significantly from observed values.

Recommendation 14: *consider presentation of journey time validation using plots showing cumulative time and distance along the longer routes.*

The report presents validation criteria for the heavy vehicle category. The degree of validation achieved is reasonable, especially when viewed in the context of the development of reliable heavy vehicle matrices being problematic in most models. A number of outlier values are identified and explained in the associated scatter plots.

A consequence of this validation is that the subsequent application of the model for the assessment of any specific projects in areas where there are a significant number of heavy vehicle movements (for example, Tremaine Avenue, NE Industrial Estate etc) may require further work to refine the underlying demands.

A brief description of the convergence statistics is provided, based upon the 'relative gap' between successive iterations of the model. The statistics presented are low, indicating that the sub-models are mathematically stable (which is likely to be partly due to the lack of any significant congestion in the modelled area).

10 Conclusions

This report presents a peer review of a base-year traffic model developed for PNCC.

The process used to develop the model is consistent with industry 'best practice' and, where appropriate, has used innovative techniques (in the form of Bluetooth surveys and the use of ERUC data) to collect travel information.

The base-year model synthetic sub-models required minimal levels of matrix estimation to exceed the draft validation requirements defined by the NZMUGS. These requirements are considerably more demanding that those specified in the NZTA Economic Evaluation Manual.

The Model Development and Validation Report is clear and well structured. While this review has made a number of recommendations, these are minor and relate principally to points of clarification in the documentation.

Overall, the base-year model is well specified and can be regarded as being 'fit for purpose' for subsequent application to forecasting and specific assessments.

ANNEXURE A: Audit Trail of Recommended Actions		
Recommendation #	**Beca Response (15 Jan 2015)**	**Action(s) / Comment(s)**
Recommendation 1: *a nomenclature issue exists with the road types defined in Table 3.1. In response to an issue raised that the capacity of the 'Arterial' road type appeared low at 1,250 vehs/hour, Beca responded that higher standard arterial roads (such as Main Street and Fitzherbert Avenue) have been coded as 'Rural Low Standard' with a capacity of 1,450 vehs/hour. At the workshop on 12 November, Beca indicated that Table 3.1 would be modified to separately distinguish between 'Arterial Low Standard' and 'Arterial High Standard' road types.*	*Table 3.1 has been updated in the revised version.*	None
Recommendation 2: *identify the count locations used for Tables 3.8 & 3.9.*	*Figure 2.1 has been updated in the revised version.*	None
Recommendation 3: *provide justification for the selection of the 12pm-1pm modelled inter-peak period, including a consideration of directional balance in observed counts.*	*Included in the revised report (text has been expanded at page 18).*	None
Recommendation 4: *provide explanation for the two outlier values in Figure 3.10 – where are they and what is the implication, if any, of this under-estimate of ADT values?*	*Provided in the revised report. (Figure 3-10 now explicitly identifies these outliers which are explained in the text.*	None
Recommendation 5: *confirm the extent of factoring required to achieve balance in total attractions and*	*Table 4.3 (adjustment factors) is provided in the revised report.*	None

ANNEXURE A: Audit Trail of Recommended Actions		
Recommendation #	**Beca Response (15 Jan 2015)**	**Action(s) / Comment(s)**
generations.		
Recommendation 6: *clarify source of unit VoT values adopted for generalised cost calculations.*	*As stated in the report, VoT values ($/hr) were adopted from the HBC model where the Penlink Toll model was recently developed. These VoT values are also very similar to the Route K toll model.*	*Cannot locate reference in report but explanation is OK*
Recommendation 7: *provide some discussion regarding the larger differences between the individual sector-sector values shown by Table 5.5.*	*Comments are provided for Figure 5.5 in the revised report*	*Values in the HBW table (and so also the differences table, now HBW-JTW) have changed from previous report – this suggests some changes to the model itself (rather than just the reporting). Explanation added which is OK.*
Recommendation 8: *adopt 15-sector system for reporting in Section 5.6 (or explain why this is not possible).*	*As stated in the report, a 15 sector system was developed for the K factors after the analysis of JTW vs HBW comparison. For consistency, Section 5.6 has been updated with the 15 sector system in the revised report.*	*None*
Recommendation 9: *compare peak period to peak hour factors with those from other models as a 'reality check'.*	*TTM and Rodney models are average hour models and Auckland is a two hour model. Hence direct comparison to other models could not be made. Peak factors (AM=0.5578 and PM=0.544) were derived from the actual count data from Palmerston North. We acknowledge that individual (e.g. Linton, university, work, school) activity peaks could be a lot higher but when they are combined across the whole peak hour, we consider that the peaking effect would be reduced.*	*None*

ANNEXURE A: Audit Trail of Recommended Actions		
Recommendation #	**Beca Response (15 Jan 2015)**	**Action(s) / Comment(s)**
Recommendation 10: *provide more information regarding the derivation of the toll weights applied in the generalised cost formulation.*	*First, a weighted average VoT ($/hr) was calculated for each period. Then they were converted to toll weights (TL) in 'minute/cent' units. Toll values should be in 'cents' and these toll weights would convert toll value (cents) to equivalent travel time (minute) values. As there is no toll road in the model, these toll weights have no effect on the assignment results.*	*None*
Recommendation 11: *provide sectored HCV matrices.*	*Provided in the revised report.*	*Information provided – indicates matrix estimation has increased total movements by 12-13%, which is primarily shorter distance movements within the central area (Sector 1), which does not appear to be unreasonable.*
Recommendation 12: *clarify status of validation targets in tables.*	*Included in the revised report.*	*None*
Recommendation 13: *provide more information in relation to turning movement outlier values.*	*Provided in the revised report.*	*None*
Recommendation 14: *consider presentation of journey time validation using plots showing cumulative time and distance along the longer routes.*	*Already provided in Appendix D.*	*OK – although where differences arise the explanation (e.g. bottom p65) is rather vague in terms of whether this might be due to a sampling / survey issue or the model.*